Searching for e-Business Performance Measurement Systems

David Barnes¹ and Matthew Hinton²
¹ School of Management, Royal Holloway University of London, Surrey, UK
² Open University Business School, Milton Keynes, UK
david.barnes@rhul.ac.uk
c.m.hinton@open.ac.uk

Abstract: Organisations of all kinds continue to expand their involvement in e-business. This requires considerable financial investment in IT, in processes and in people. It might be expected that there would be a concern to ensure that performance measurement systems are capable of justifying these investments, and of evaluating their worth once implemented. The paper describes research aimed at determining the exact nature of such e-business performance measurement systems and the benefits that accrue from their use. The research uses a case study methodology to report the performance measurement practices of twelve potentially exemplar organisations that have made efforts to develop distinctive performance metrics for e-business. Qualitative data was collected from interviews with key informants from each organisation. Additional data came from company documents. The cases reveal a variety of approaches to e-business performance measurement, with no common framework apparent. Whilst there is considerable disparity in the level of success achieved in developing suitable measures, there is evidence of a common concern to link e-business performance to organisational objectives. However, there is a general reluctance to embark on major overhauls of existing performance measurement systems. The paper discusses the possible reasons for this and the implications for future developments in e-business performance measurement practices.

Keywords: e-business, performance measurement systems, IT evaluation

1. Introduction

Electronic business (E-business) is the use of Internet-based information and communication technologies (ICTs) to conduct business (including sharing information, maintaining relationships and conducting transactions) within and between organisations (Poon and Swatman, 1999). Over the last decade organisations of all kinds have rushed to join the online e-business community. By 2005 e-business was commonplace in British business practice. According to the European Commission, British use of the Internet in business was the highest in Europe with over 98% of British firms having some kind of online presence and e-business accounted for 14% of business turnover (E-business watch, 2005).

In order to participate in the new online business environment, businesses have had to make significant financial investments, not only in the necessary technologies but also in the processes and people necessary to operate them. Whether evaluating e-business investment proposals or monitoring the resulting online business operations requires the existence of an appropriate performance measurement system. It might have been expected that there would have been a widespread concern about whether these investments have yielded the expected improvements in performance. Associated with this, one might also have expected some kind of debate about the adequacy of existing performance measurement systems for the online environment. As Straub et al. (2002: 117) argue, “The unique characteristics underlying the Web may in some cases require new metrics or at least the careful evaluation of existing ones to facilitate the development of innovative solutions to emerging problems”. It is therefore surprising to discover a relative dearth of academic literature in the field. Marr and Neely’s (2001) study of performance measurement practices in e-businesses remains a rare example of empirical research. Their study paints a picture of e-businesses measuring many different dimensions of performance. Yet, they report near universal dissatisfaction with existing measurement systems. This leads the authors to “question the appropriateness of existing performance measurement systems in today's (digital) economy” (Marr and Neely, 2001: 214). Whilst many e-business researchers have argued that new kinds of performance measurement are needed for e-businesses (e.g. Tonchia, 2002), it is far from clear how, or even if, existing models of performance measurement need to be modified to make them suitable for the online environment. Nor is there any consensus amongst practitioners as to which measures are effective for measuring e-business performance (Hinton and Barnes, 2005a).

There is an evident need to identify the features of an effective e-business performance measurement system. This report describes research that aims to do this. The approach it follows is to study the performance measurement practices of exemplar organisations that seem to have had some success in developing
performance measurement systems suitable for the online environment.

2. Literature review

Recent years have seen something of a revolution in performance measurement with the development of “balanced” or “multi-dimensional” performance measurement frameworks. Of these new frameworks, the Balanced Scorecard (BSC) has become pre-eminent (Kaplan and Norton, 1992). Marr and Schiuma (2003: 680) claim that the BSC is “the most influential and dominant concept in the field” is given weight by Neely’s (2005) review of recent performance measurement research. He notes its impact on practice, citing research showing that anything between 30 and 60 per cent of firms have adopted the BSC in some form, and on academic research, in which Kaplan and Norton’s writings on the BSC have dominated the citations in articles on performance measurement. The BSC was first presented as a tool for organising performance measures into four key perspectives (financial, customer, internal process, innovation). Since then, it has grown into a device for controlling the implementation of strategy by linking the performance measures to organisational strategy and goals (Kaplan and Norton, 2000). It might be expected that performance measurement systems used in leading e-businesses would also be based on the BSC. As a minimum it might be expected that an e-business performance measurement system would be based on a range of measures, other than the usual financial ones, and would seek to link e-business decisions and actions to organisational objectives and strategy.

There are some criticisms of the rush to adopt the BSC and of the increased attention to performance measurement more generally. These centre on the costs associated with measuring what can often amount to literally hundreds of things at any one time. As Neely and Austin (2000) note, “a measurement crisis is looming - measurement madness... the problem is that society is obsessed with measurement.” Neither as Franco and Bourne (2003) argue is there much evidence to support the assertion that the BSC or other performance measurement systems have much of an impact on organisational performance.

Reviewing the wider e-business literature, it is possible to identify a number of factors that an e-business performance measurement system should be concerned with:

- The performance of the website (Zeithaml et al., 2000; Barnes and Vidgen; 2001)
- The performance of business processes (Hinton et al., 2003; Wu et al., 2003)
- The performance of customers (Hinton et al., 2003; Wu et al., 2003; Minocha et al., 2004; Voss, 2003)
- Linking e-business performance to business strategy (Chang et al., 2003; Porter, 2001).

3. Research methodology

The aim of the research was to investigate the performance measurement systems in operation in a number of exemplar organisations that were operating performance measurement systems suitable for e-business. A case study method was deemed the most suitable approach, as it is well suited to investigating contemporary practices within organisations (Yin, 1994). Gathering data of sufficient quality for this study required the identification of appropriate informants within suitable organisations. Previous survey-based research undertaken by the authors had identified a number of individuals who claimed that their organisations were operating e-business performance measurement systems (Hinton and Barnes, 2005b). Nine managers were identified from this group. An additional group of organisations were targeted from amongst the 2005 winners of the UK government’s annual national DTI E-Commerce Awards. All winners must demonstrate they have achieved tangible gains by using the Internet or other ICTs and are likely to comprise leading edge practitioners in e-business. A further three companies agreed to participate from this group. The principal method of data collection in the research was via face-to-face, semi-structured interviews with a key informant in each organisation. A framework based on a standard set of question topics was used by the interviewers in order to focus and bound the discussions (Miles and Huberman, 1994). Additional data came from company documents.

4. The case results

The findings from the twelve case organisations are briefly described below. Pseudonyms have been used and some case data disguised to protect confidentiality.

4.1 Lawco

Lawco is a large corporate legal practice employing 3,000 lawyers in more than 20 countries. They operate a number of online services including some that support the work of its own staff; some that offer generic help in particular industries and some that facilitate transactions with individual clients. Lawco aims to
use online working to achieve significant cost and time advantages. They want to use ICT to support their aim of being in the top two providers to each market segments that they serve. The company uses a business case approach to ICT investment appraisal. Lawco has metrics for the technical performance of its websites, including availability and processing times. The company monitors all costs very closely on a daily basis, including the costs associated with its ICT operations. However, the company tries to evaluate performance in ICT against business objectives. This remains a significant challenge due to the many associated intangibility factors.

4.2 Teleco
This case investigated a product development department within one of the world’s largest telecommunications companies. The department, whose members operate predominantly in a virtual environment, uses an online workflow management system to monitor progress on its various projects. The system provides a broad range of performance metrics for cost, quality, and time. These metrics are linked to the company’s strategic aims and objectives through its strategy and vision, which are cascaded down the corporate hierarchy to shape departmental objectives. The main benefits of the online performance measurement system are the speed with which figures are reported and that they are available to everyone on the team via any Internet connection. All departments are required to develop five-year plans, which are linked to specific financial, market, and product performance targets. This is, however, problematic in an environment where technology develops very quickly and product lifecycles are typically 18 months to two years.

4.3 Softco
Softco is a provider of specialist customised software, principally to business clients, with offices in Europe, North America and the Far East. Externally, the company’s main objectives in its use of e-business are brand building and to strengthen its relationships with its customers. It uses its website for promotional marketing and for after sales support, rather than sales transactions. Internally, it uses e-business technologies to support remote working and promote integration across its various sites. It makes extensive use of the Internet for sales administration, human resource management and for joint working on documents by staff at different locations. Softco does not generally have any separate specific e-business measurements. The company is managed against corporate level financial measures, which are cascaded down to individual departmental metrics, which are also mostly financial. There is no attempt to isolate costs or revenues associated directly with any particular e-business activity. Neither does Softco do detailed financial analysis for ICT investment proposals. But it does monitor operating costs, staff usage and satisfaction levels of particular applications after their introduction to evaluate their success.

4.4 Materialsco
Materialsco is the European division of a large multi-national. The company sells high specification materials to OEMs whose products operate in highly demanding environments. The industry in which Materialsco operates is being driven to use e-business by the OEMs in three ways: electronic bidding for contracts, electronic exchange of documents and production scheduling (including placing, tracking and tracing orders). Materialsco aims to use e-business to improve customer service and reduce staff costs. It does not have separate measures for e-business, treating it as integral to its normal business operations. All capital investment proposals, including ICT, are subject to a rigorous financial appraisal process requiring approval at the corporate headquarters. Internally, each stage of Materialsco’s operations performance is measured against a weekly plan, in terms of time, volume and cost. Externally, performance is measured against each customer’s requirements for delivery and quality. Additionally, customer satisfaction is measured quarterly through online questionnaires, which record numbers of on-time and late deliveries, concessions or rejections, and paperwork queries, etc. No additional measures have been adopted as a result of moving to e-business.

4.5 Seaside hospital
Seaside Hospital is a large NHS general hospital serving a local population of around 300,000 in England. The hospital has recently introduced e-business technologies into its materials procurement and management systems. The objective is to improve both operating efficiency and service levels. Materials are scanned using barcode technology when it is withdrawn from stock at the point of use within a ward or operating theatre. On withdrawal, the system automatically orders a replacement. The order is then sent to a centralised system, which automatically generates an e-mail acknowledgement. Orders are delivered to the hospital’s central store, prior to distribution to local stocking points. More frequent and more reliable deliveries will enable stock levels to be reduced. In recent years, the NHS has been subject to performance monitoring based on a system of government imposed targets. This has
resulted in top-down cost saving targets being imposed throughout the hospital, including materials procurement. Local managers, however, have adopted a bottom-up approach to performance measurement within the materials management. It is not always clear how these are two approaches are linked. The performance of hospital’s materials management staff is monitored in terms of the delivery of materials to the wards, including any materials shortages. No attempt seems to have been made to link this performance to patient treatment rates or quality of care.

4.6 Port authority

The Port Authority is a public body charged with the responsibility of managing the navigable waters of one of the UK’s largest ports. The Port Authority uses e-business in a number of ways. Firstly, an online system for ships’ manifests (i.e. details of their cargoes). This information is provided by shipping lines for use by Customs to authorise offloading, charge duties etc., and by freight forwarders arranging onward handling. This system automates a previous paper-based system, speeding up the process, cutting costs and improving accuracy. Another system operates as a database for ships and shipping movements. The Authority uses this primarily to manage the movement of pilots for ships entering or leaving the port. Additionally the Authority’s own website posts important information for all uses of its waters. The site includes an Extranet for key users of the port such as terminal operators, dredging companies, etc. The Port Authority aims to use the technology to improve its efficiency. It has a set of higher-level performance metrics for its operations that link to its mission statement. It is trying to extend these to its use of e-business. The measures developed to date centre around systems availability, number of users and satisfaction with the Authority’s services.

4.7 LG union

LG Union is one of the UK’s largest trades unions with over one million members, employed mostly in local government. The union has a national website and a linked regional site. The latter operates autonomously, owned and run by the members. Both sites currently have only a low level of interactivity for open access, aimed principally at members. However, the union is currently rolling out support systems for its own employees to facilitate remote working (e.g. for case workers). The union’s aims in adopting web-based technology are to provide a better service to the members and operate more efficiently, particularly with regard to peripatetic staff. Corporately, the union’s most significant measures of performance are membership growth, its effectiveness in protecting its members and the efficiency of its delivery of services. The union has attempted to utilise the balance scorecard a template for performance measurement. However, it is difficult to link these performance measures with the use of e-business.

4.8 Insureco

Insureco has developed software that enables insurance business to be conducted online. It sells this to insurance companies. The system is essentially an Internet based tool that enables insurance businesses and their channel partners (insurer, broker, agent) to quote, bind and manage insurance products online in real time. The company makes investment decisions using a business case approach, targeting a pay back over two or three years. They evaluate performance of investments post implementation to ensure there is a return. If this is not the case, then efforts are made to enhance the income. Insureco uses very traditional methods to manage performance. Sales targets are the most important measure. Many aspects of internal processes are driven by regulation. However, the driver for the company is keeping costs down. The adoption of e-business helps this. Accordingly, Insureco tries to match performance metrics with its online activities. Online marketing activity is scrutinised and conversion rates of firms signing up for their e-trading platform. Measures used to monitor performance afterwards are very traditional for the insurance industry. Customer quotes are monitored and repeat purchasing and customer retention rates measured. However, the relationship-driven nature of business alleviates the need for direct measurement of customer satisfaction. There are also measures for the technical performance of the website.

4.9 Intergov

Intergov is an inter-governmental organisation funded by 30 countries. It also has relations with some other countries, business and labour organisations and a wide range of non-government organisations. Intergov provides a forum in which governments can work together to address and identifying policy solutions for the challenges of globalisation. Its e-business activities are concerned with information sharing between its own staff and those of its member country governments. It has its own online information system that enables many thousands of officials to access and share a wealth of information on policy and committee work. Use of the Intergov private Internet network enables approved clients to securely access internal
documentation, as well as its publications and statistical products. They can also participate in discussion groups and other online services. Intergov’s aim for its use of e-business is to achieve increased member satisfaction and its approach to performance measurement links to this. It relies on the use of surveys with its members to assess its performance.

4.10 Educo

Educo is an online business selling learning support materials, mostly workbooks that comply with the UK’s National Curriculum. Its products are bought by schools and parents. Workbooks are purchased online and provided in electronic format, for purchasers to make their own hard copies. Educo’s business model relies completely on its use of e-business and it could not be successful without this technology. This also enables Educo to provide ongoing support for its customers. Its website has three distinct areas, each designed for one of its three customer groups: teachers, parents, and children. The aim is to create supportive communities in each area. Educo does not engage in any formal capital investment appraisal. It does have lots of performance measures, particularly those concerned with the customer side of its operations and website performance. Financial measurement concentrates on sales because most costs are fixed. The most important measure used to monitor performance is monthly turnover. The company does not formally monitor cash flow or study the bank accounts, because this is a cash rich business with no debts.

4.11 Wealth Bank

Wealth Bank is the subsidiary of a global financial services group. It provides private banking services to wealthy customers through a network of several hundred client advisors. Although it remains a traditional bricks and mortar bank, Wealth Bank has developed two main e-business activities. Firstly, its clients can view their accounts and portfolios online via the bank’s website. However at the moment, clients cannot execute their own transactions on the website. Transactions have to be executed by a Wealth Bank client advisor. Secondly, it has established a Wealth Bank product platform “bank-for-banks”. This enables financial intermediaries, and other banks, to get access to the full range of Wealth Bank’s products and services. The company’s motivation for e-business is cost reduction and increasing speed of response. It also aims to improve customer service by providing online access to real-time data for its clients. The bank uses a net present value (NPV) approach to assess its e-business investment proposals. It also uses NPV in post-investment appraisal. Wealth Bank benchmarks against its competitors in measuring the performance of its e-business processes. It measures customer performance in e-business through the quantitative measurement of website clicks. It applies the same measures in e-business as in traditional business, where its measures are underpinned by the Balanced Scorecard.

4.12 Trainingco

Trainingco is a small company that designs bespoke training solutions for corporate clients. They use e-business in two ways. Firstly, they use an online project management software within their own operations, which is especially helpful in the management of their many virtual teams. Secondly, they incorporate e-learning technologies into their training packages for their clients. Trainingco does not have any formal method for appraising capital investments in new technology. Neither does it appear to have any form of performance measurement for its internal operations. Because of its size many aspects of internal performance are evaluated informally. It uses project management software as the basis of its operational management. The extent of the use of this depends on clients. Some are more rigorous in its application than others. They select which tools to use dependent upon the circumstances. Financial performance measures are the most important ones for driving the performance of the business. Costs are constantly reviewed and projections made. Formal financial reviews are conducted monthly for each project. A post-project review is invariably held to determine how they could improve. However, it is very difficult to separate out the e-business component of overall project performance.

5. Cross case analysis

The main findings that emerge from a cross case analysis are:

- The case organisations tend to assess investment proposals for e-business in the same manner as any other capital investment proposal. Large and/or relatively financially sophisticated organisations tend to assess investment proposals for e-business in the same manner as any other capital investment proposal using formal financial methods (e.g. payback, DCF or NPV) to do so. However, evidence from the case of one large and sophisticated organisation (Lawco) demonstrates that it is possible to view e-business differently due to the difficulty of quantifying its intangible benefits.

- Only some of the case organisations had performance metrics in place appropriate to
their expressed aims for their use of e-business. Some had some appropriate e-business metrics, whilst others had none.

- The case organisations appear to have adopted an ad hoc approach to the development of e-business performance metrics. E-business performance metrics included website and technology performance metrics, e-business process metrics and customer metrics.
- All but two of the organisations, measure more than one aspect of performance. However, no organisation had a comprehensive portfolio of e-business performance measurement system. There tended to be a discernable focus to e-business performance measurement (finance, customers or processes).
- Some of the case organisations relied on existing metrics to monitor e-business performance. Some adapted existing metrics. Some introduced completely new e-business performance metrics.
- Whether or not e-business performance metrics are linked to higher level organisational measures seems to depend on whether links already exist within an organisation’s performance measurement system.
- There is no evidence to suggest that case organisations have undertaken a reconsideration of the merits or otherwise of existing organisational performance measurement systems in the light of the advent of e-business into their activities.

6. Discussion

From the literature review, it was expected that an effective e-business performance measurement system would encompass a range of different measures, including non-financial as well as financial measures. This was to some extent born out by the case findings, in that all but two were measuring more than one aspect of e-business performance. Examples of the metrics used included those associated with website performance, e-business processes and customers. However, the case organisations generally appear to have adopted an ad hoc approach to e-business performance measurement. No organisation had a true portfolio of e-business performance metrics. Furthermore, there tended to be a discernable focus for their e-business performance measures, such as financial metrics, customer metrics or process metrics. However, there was never any sense of balance between the measures used. Any mention of the BSC was notably absent in any of the interviews except in the case Wealth Bank.

The literature also suggested that an effective e-business performance measurement system would link e-business performance to strategy. However, only some of the case organisations had performance metrics appropriate to their aims for e-business. Only some of the case organisations had e-business metrics that linked to higher level measures. Thus, there was scant evidence that the BSC or similar framework been used to ensure that e-business performance measurement was linked to organisational strategy.

The case organisations have adopted an incremental approach to amending their existing performance measurement systems for e-business. They seemed to have made as few changes as possible, utilising or adapting existing metrics. In the few instances where completely new e-business metrics were introduced they were simply added to the existing set of performance measures. There is no evidence that case organisations have undertaken any kind of review of their existing performance measurement systems to determine what changes might be needed for e-business. Similarly, capital investment appraisal for e-business was treated no differently from other business decisions. In only one case (Lawco) was the normal capital investment appraisal processes set to one side for e-business investment.

The prime conclusion from the investigation is that the organisations studied did not demonstrate the kind of performance measurement practices with regard to their e-business activities that might have been expected from the literature. We are therefore left to speculate why this is the case.

One possible explanation is that organisations may be concerned about the difficulties and costs of adapting existing performance measurement systems for e-business, and are not convinced about the benefits that may ensue. This is in line with emerging concerns in the literature about the costs of measurement. However, it was far from clear that many of the case organisations had taken a decision not to embark on major changes to their performance measurement systems in a deliberate and considered way. In most of the cases, the impression was given that very little consideration had been given to changing performance measurement systems for e-business.

It may be that practitioners do not view e-business as requiring revolutionary changes in their
business practices. This would accord with a view that e-business is now just business. May be the view from within organisations is that the much heralded impact of e-business was just so much hype. May be that the changes required to accommodate e-business were not so great. May be businesses just took whatever changes were necessary in their strides. It may be that for the case organisations, the impact of e-business is not yet that important to merit a complete overhaul of their performance measurement systems, and so incremental adaptation and change suffices for the moment. Changes due to e-business are still on-going and organisations face continuing uncertainty about the impact of changing technology. As such, the prevailing view with regard to e-business performance measurement is one of “wait and see”. May be more significant changes will be required to provide the spur to more radical and comprehensive changes in e-business performance measurement systems.

7. Conclusions

Given that e-business has been heralded as being the cause of major disruptive change, we were expecting that these organisations would have given considerable attention to the challenge of adapting their performance measurement system to e-business. This proved not to be the case. We expected these organisations to have at least undertaken a systematic review of their existing performance measurement systems. Also, given the publicity associated with the BSC in recent years, we expected any changes to performance measurement systems to be underpinned by this or another similar framework. This also proved not to be the case. Although some of the features of the e-business performance measurement systems were characteristic of the BSC, such changes that had been made were essentially ad hoc and incremental in scope. There was a marked reluctance to embark on major overhauls of existing performance measurement systems. This was surprising.

Thus, there are two major conclusions from the research. Firstly, organisations do not currently feel the need to make major changes to their performance measurement system for e-business. Rather they are content to make incremental changes. Secondly, it appears that best practice advice in performance measurement, as exemplified by the BSC, may be much less influential than often thought to be, certainly within the e-business environment.

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References


Evaluation of Content Management Systems (CMS): a Supply Analysis

Clara Benevolo and Serena Negri
DiTEA, University of Genoa, Italy
benevolo@economia.unige.it
serena_negri@hotmail.com

Abstract: Content management systems (CMS) provide an optimal solution by organising information and, mostly, creating and managing an enterprise’s knowledge. Nevertheless there is a big confusion about the functionalities that characterise CMS and about the differences with less performing products such as web content management systems, document and records management systems and enterprise content management systems. This paper aims to show the mismatches between companies’ needs and those information management products, which are often called CMS even if they are not.

For this reason the authors first make a theoretical comparison between the functionalities of CMS and those of the systems they are often confused with. Then they show the results of an empirical research on 22 products offered by international vendors. By using an original scheme, enterprises’ needs in terms of information collection, management and publication and of knowledge management are compared with the functionalities of the aforementioned systems. The result consists of performing definitions for CMS and the other systems for managing information. Content Management products are analysed, compared and evaluated by using a special table created to point out the actual functionalities of the products offered on the market, despite vendors’ declarations. Moreover the highlights are displayed in a matrix to evaluate the level of personalisation-flexibility of the different products. The paper conclusions show how, on the demand side, companies’ needs are growing in a confused framework; at the same time the supply side keeps on feeding this confusion, reducing company satisfaction in regard to knowledge and information management.

Keywords: Content management, web content management, enterprise content management, knowledge management, ICT supply and demand

1 From data to knowledge: challenges in enterprise management

Data, information, content and knowledge are terms often used as synonyms, but which actually have a precise meaning which distinguiishes one from the other. In this paper we adopt the approach given by Boiko (2002) and the most commonly accepted definitions.

- **Data:** small piece of information, without any “human” connotation (significance, context, etc.); it can be collected in file or stored in database. It is an elementary unit to be handled.

- **Information:** any form of recorded communication, like any kind of text (articles, books, etc.), sounds (music, conversations, etc.), images (pictures, draws, etc.), movements (video, animations, etc.), computer files (Word documents, PowerPoint presentations, etc.), which can contain, at the same time, all or none of the “human” connotations. Therefore, just about anything can be considered information, including data. Information allows data to be interpreted and find hidden meanings and unexpected relations.

- **Content:** information becomes content when it is used for one or more purposes. Its value is the sum of its primary form (information), application, usability, significance and uniqueness. It is information plus a layer of data that sets it in a specific context.

- **Knowledge:** the state of mind of the person who owns information, not just a communication; it is the condition of knowing something with the confidence due to a practical experience.

Considering the four concepts as parts of a speech, data represent the single words, information is a sentence, content is the sentence in a specific context, knowledge is the state of mind of the person who has read or heard the sentence and has understood it. Speaking of information means that a person owns a concept to communicate, he transforms it in words, sounds or images through a creative and intellectual work, and records it on any support. The difference between data, information, content and knowledge is particularly important to understand the challenges of managing the content of an enterprise with ICT. For example, computers were built to process data and not content. As Boiko (2002) notices, ten years ago people used computers to load, process and output data, while nowadays they use them to search and output content. Otherwise, for computers only data exist. Computers use information separated in its primary elements (data) risking to lose the original
meaning and the context in which information was inserted. To manage information by a computer it is necessary to separate it into a set of elements, or metadata, that permits it to be treated as information and not as data. To manage content it is necessary to put information into a context (Boiko 2002:9).

In practice, content is information enriched with data. Basically content is a suite of structured data that a computer can organise in a system for their collection, management and publication. Until computers can manage content, people will have to find ways to use technologies for data management to collect and distribute content. From this derives the enterprise’s challenges in creating and managing knowledge both through the processes of creating, distributing and sharing individual wisdom (Nonaka and Takeuchi 1995:97-114; Von Krogh, Nonaka and Nishiguchi 2000:97-98,89-109), and through the realisation of an efficient information system in the enterprise. From this point of view, the need to manage information and content find an initial answer in knowledge management projects and, partly, in content management ones, which enterprises of any productivity sector and dimension often find themselves contending with (Di Bernardo and Rullani 1990; Capaldo et al 2004). Using a CMS an enterprise can strengthen the diffusion of internal knowledge externalising tacit wisdom owned by the single person inside the system, who interacts with the other company members: everyone can reach information collected in the system and transform it into knowledge to share through the creation of new information.

2 Content management

2.1 Definition

Content management (CM) is one of the instruments that an enterprise needs to own to implement a knowledge management project. It is a system of methods and techniques to collect, manage and publish content in a company. From this perspective, CM does not come along with computers, but from the invention of writing and the foundation of the first libraries. What has determined the subject's actuality is the conjugation of CM and information technologies as an answer to the exponential proliferation of documents and information that has come with Internet technologies and the World Wide Web. In this paper we define content management as a system of methods and techniques to automate the processes of content collection, management and publishing using information technologies (McKeever 2003:687-688; Boiko 2002:65). CM bases its logic on the separation of content and its format. Content management systems provide to control the creation and the distribution of information. They permit the knowledge and the monitoring of the value of information and also to decide the receiver (acceptor) and to manage the transmission of those data.

2.2 Lifecycle

A CMS, as represented in figure 1, consists of three phases: information passes through the collection system, where it is transformed in content components, then through the management system, a kind of complex database where components are stored, and, lastly, through the publication system, where information is automatically transformed into publications (Boiko 2002:83). The three areas are often largely overlapped and work in strict relation with each other (Boiko 2002:81; McKeever 2003:686-687).

2.2.1 The collection system

The collection system consists of the instruments, the procedures and the human resources that have to obtain the content, which will be managed in a second time, and to elaborate the single parts, which constitute content before they are ready for publication. The processes involved are (Boiko 2002:83-84):
- Authoring, to create content;
- Acquisition, to acquire information;
- Conversion, to filter the content, created or acquired, from the superfluous layers of information and translate it into a specific mark-up language;
- Aggregation, to separate content into components to which is assigned a tag, so as to be able to insert that content in the chosen metadata system;
- Collection services, programs and functions that support the collection system.
2.2.2 The management system

The management system is responsible for content storage and for the instruments utilised to find and organise the same content and metadata collected in the first phase of the lifecycle. This system comprehends the repository, administration and workflow functions that allow one to know which content the enterprise owns and where it is. In practice the management system permits one to find the answer to any question about content, its collection, or the publications created from it.

2.2.3 The publishing system

The publishing system extracts content from the repository and automatically creates from it the final publications, not only designated for an external audience, but also and mostly for enterprise internal communications (Boiko 2002:104, 887). The outputs are not only websites, but also any publication that could be electronic (CD-ROM, newsletter), or print (newspaper articles, leaflets,), or syndication (the payment distribution of content on the internet). “A publication is information that you release that you’ve unified and that has the following characteristics: a purpose, publishers, an audience, a set of messages, authorship, content, structure, cycles” (Boiko 2002: 507-508). The heart of the publication system are templates (Boiko 2002a:104, 519-534, 889), i.e. programs that substitute the manual work of adapting the neutral content of the repository to formats and structures typical of specific publications. In particular, a template is used for: linking CMS with the final release of a publication; handling at the same time both the static and the dynamic parts of a publication; automatically constructing publication pages; creating more publications from a single content; using logic to define how content needs to be treated; containing other templates.

3 Content management products

Our purpose is to trace the borderline between the products which actually are CMS by the definition given and the ones, which descend from CMS but present different characteristics. In fact, vendors often define CMS very different products, sometimes specialised in just one area, but that pretend to support the entire lifecycle. The different product called “content management systems” can be classified in four macro-categories analysed below (Mescan 2004:54-55; Robertson 2004; Robertson 2003).

3.1 Content management systems

They are the systems presented in the previous paragraph and which we refer to as the “true” content management system. Figure 2 highlights the completeness of the functionalities offered by CMS.
3.2 Web content management (wcm) systems

WCM comes from enterprises’ need to organise and update the high volume of information published on their website. Implementing a WCM software allows for managing a great amount of content (from text to sound, from images to videos) using simple and flexible instruments. WCM are the systems more commonly (and wrongly) called CMS. The misunderstanding is because CMS result from the application of WCMS to all the company’s content (e.g.: management of all enterprise’s content and not only the information to be published on the web, multi-channel ready publications, etc.).

3.3 Document management (dm) and records management (rm) systems

Document management (DM) is one of the first disciplines born to manage high volumes of documents in their original format making easier their collection and storage (Robertson 2003; Amami and Beghini 2000:6-19). DM systems are the electronic correspondent of librarians. DM can be defined as a system able to help organisations in managing document creation and storage by a centralised repository and a workflow based on prefixed rules and metadata. Records management (RM) systems are applications able to manage high volumes of documents both in paper and electronic format through secure storage and access methods, cross databases and precise rules for document conservation (Robertson 2004). RM systems are the electronic correspondent of archivist. In general, neither DM systems neither RM ones own any content publication functionality (Sprehe 2004:54-62; Frost 2001:34-37; Medina and Fenner 2005:20-22).

3.4 Enterprise content management (ecm) systems

ECM represents an integrated approach to manage all enterprise information (paper documents, data, reports, websites and all the digital asset). An ECM comprehends strategies, instruments, processes and knowledge a company needs to manage its information asset, independently of their format (Smith and McKeen 2003:647-659). The functionalities that characterise ECM systems come from the fusion between document management, records management and web content management systems, focusing on information collection and management (Frost 2001:34-37). Table 1 and figure 3 compare the functionalities offered by the analysed systems. In particular, in table 1, publication services of DM, RM and ECM systems are marked with “(X)” because they are not core functionalities, not always offered by the vendors and, if existing, they are not well developed. It is clear that the only complete product is CMS.
## Table 1: Comparison between the major functionalities of CMS

<table>
<thead>
<tr>
<th>MAJOR FUNCTIONALITIES</th>
<th>CM</th>
<th>WCM</th>
<th>DM</th>
<th>RM</th>
<th>ECM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authoring</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Acquisition</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conversion</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Aggregation</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Collection Services</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repository</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Workflow</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Publication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Template System</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publication Services</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
<td>(X)</td>
<td></td>
</tr>
<tr>
<td>Website support</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Other media support</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Figure 3: Areas of competence of CMS products (comparison)

#### 4 The survey

##### 4.1 Survey purpose and object

The purpose of our survey (carried out in spring 2005) originates from the absolute absence of precise and generally recognised definitions to delimit the areas of competence of the different products offered in content management market. The consequence is that enterprises find it hard both to choose which system to adopt and to compare the products offered on the market. The survey’s objective is the set of products called ECM, offered by the world major players. We have verified the effective functionalities offered by these products trying to redefine them using the CM types analysed in the previous paragraph (CMS, WCM, DM, RM). The selected products are offered by 22 international companies (vendors with revenues of $10 million or greater), which offer ECM systems. These companies have been analysed by Gartner Inc., the world leader company in research and analysis in the IT sector. In its Magic Quadrant for Enterprise Content Management Gartner positioned the vendors by intersecting their ability to execute with their completeness of vision (Shegda et al 2004) (Figure 4). We have selected the products considering, for each company, only the one having the greater number of functionalities in terms of number of phases of information lifecycle involved.
4.2 Evaluation table

To analyse, evaluate and compare the selected products we have realised a screening chart. This way we were able to verify if the functionalities of CM lifecycle were offered or not (the aspects considered were much more articulated than the one in figure 2). The functionalities taken into consideration are listed below.

Collection:
- Support to authoring process
- Support to acquisition process
- Automatic format conversion
- Support to aggregation process
- Information reusability and consistent content segmentation into metadata

Management:
- System security
- Content storage in a neutral format
- Automatic indexing
- Simple and rapid research system
- Utilisation of standard technologies and languages
- Simple content modifying
- Document versioning
- Content management through a single interface
- Management of all type of formats
- Possibility of automatic updating
- Possibility of automatic deletion
- Compatibility with other applications
- Content condivision with other applications
- System scalability
- Automatic workflow
- System simple and flexible
- Security of all content approval processes

Publication:
- Template utilisation to create publications
- Automatic content conversion
- Support to simultaneous creation of more publications
- Advanced personalisation system
- Support to multiple-language interface

We have, moreover, evaluated the specialisation level of the surveyed functionalities. At the end of the analysis of each area we assigned a grade of...
completeness based on the number of functionalities surveyed (low, medium, high). Lastly, we have evaluated the level of personalisation offered by the single product, a very important aspect for this survey. This characteristic refers to the possibility for the enterprise-client to obtain a solution with just a few functionalities of a product or many of different products. This will mean being able to evaluate if a vendor offers content management products (as defined earlier in this paper), or products of different type.

5 Survey results

The survey on the products offered by the Gartner’s Magic Quadrant vendors was able to highlight, given the definitions accepted in this paper, which kind of content management systems are offered on the market. In particular, we have compared both the definition given by Gartner for enterprise content management systems and the one given by vendors for their own products with the one adopted in the present work. The results are synthesised in table 3.

The main products offered are ECM systems, since between DM, RM and DRM (systems given by the sum of DM and RM functionalities) we have noticed four products of which the collected material was evaluated as incomplete (represented as “(X)”). The boxes in red (dark) mean that there is correspondence between the definition given by the vendor and ours. The whole product analysis has been articulated in three parts, to highlight the type of product offered by each vendor, the specialisation in the different areas of information lifecycle for each type, and the personalisation and flexibility level offered in a comparison of all products selected.

5.1 The products offered

In the first part of the survey, we have evaluated if the definition of the selected products given by Gartner (ECM systems) and the vendors (different systems depending on the specific case) corresponds to the definitions accepted in this work. To understand the kind of system offered, we have considered, for each product selected, the number of functionalities of the information lifecycle and their specialisation in order to highlight the core areas of the different CM solutions.

The results are the following:

- CMS – The products evaluated as CMS are those offered by EMC (Documentum), Vignette (V7) and Cimage NovaSoft (e3). Cimage NovaSoft product, e3, is not completely finalised, since, in the publication area, the multi-channel support is not well developed (mainly marketing communications are addressed). By its very nature a CMS product needs to offer a number of functionalities from “medium high” to “high” in all phases of information lifecycle. EMC and Vignette products can be classified with sufficient confidence as CMS, since they offer a profound specialisation in the functionalities offered, and on their websites numerous technical information is available to guarantee a completeness of vision.

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>CMS</th>
<th>WCM</th>
<th>DM, RM, DRM</th>
<th>ECM</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FileNet</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hummingbird</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>IBM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interwoven</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stellent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vignette</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xerox</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyland Software</td>
<td></td>
<td></td>
<td></td>
<td>(X)</td>
</tr>
<tr>
<td>Microsoft</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oracle</td>
<td></td>
<td></td>
<td></td>
<td>(X)</td>
</tr>
<tr>
<td>SAP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cimage NovaSoft</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spescom</td>
<td></td>
<td></td>
<td></td>
<td>(X)</td>
</tr>
</tbody>
</table>
WCM – None of the products judged by us as WCM are defined the same way by the respective vendor. In particular, Microsoft (Content Management Server 2002) and RedDot (XCMS) name their products CMS, while SAP (NetWeaver) call it an ECM. In the first case the absence of correspondence between the definitions can be easily explained with the original erroneous consideration of WCM as content management systems par excellence. In the second one it is harder to understand the different evaluation of SAP product. We propose two hypothetical explanations: it is possible that some characteristics were not considered during the analysis (maybe because just mentioned in the brochures), or it is possible that SAP has a different way to consider the specialisation of some functionalities that has brought us to consider WCM core characteristics, and not of a ECM. Anyway, even in case of a misunderstanding, the SAP product would not be considered an ECM but a CMS, given its capability of supporting more publications.

DM, RM – The products offered by Hyland (Onbase) and Hyperwave (IS/6) result as DM systems, both defined by the vendors ECM solutions. The Hyperwave product can be effectively considered a DM system and not an ECM because the vendor itself declares that does not offer solutions to cover all information lifecycle, but just the functionalities in which it excels, that are the ones offered by document management systems.

RM systems are offered by Hummingbird (Hummingbird Enterprise), Oracle (Enterprise Manager 10g), Spescom (eB), eiStream (G360 BPM Suite). Hummingbird product is defined as a CMS, but it owns very limited functionalities in the collection and publication systems (it supports only web publication), while the management system is very well developed (great number and well specialised functionalities for storage and retrieval). For these reasons we consider our evaluation of the solution as an RM system to be correct. DRM products are offered by Xerox (Knowledge Sharing products, the equivalent of DRM systems), Meridio (Meridio 4.3) and Tower (TRIM Context), all defined as DRMs by the vendors too. They cannot be considered only document management systems because they have very specialised storage functionalities, often referred to specific and strict rules related to the storage of enterprise documentation. At the same time they cannot be considered records management systems because they have specific collection capabilities, absent in this kind of system (e.g. support to the authoring process).

ECM – Lastly we have classified as ECM the product offered by FileNet (FileNet P8), IBM (Content Management), Interwoven (Enterprise Content Management), Open Text (Livelin), Stellent (Universal Content Manager), Mobius (ViewDirect TCM) and Day (Communique). FileNet, Interwoven and Open Text define their solutions as ECM systems, our same evaluation. On the contrary, IBM, Stellent, Mobius and Day name their products CMS: it is not correct to consider the Mobius product as a CMS because it does not offer sufficient specialisation in the different areas of the lifecycle (publication in particular, since, even if it supports more media, it is specialised in web publication). Instead, in the other cases, the definition of CMS is incorrect because those solutions support only web publications.

The final result is that ten of the twenty-two Magic Quadrant companies have defined their products coherently with the definitions accepted in this work for the different types of content management systems. The twelve companies left claim to offer complete CMS (six) or ECM systems (six). Nevertheless, please note that four products which claim to offer ECM solutions do not have a complete evaluation because of the poor information available.
5.2 Specialisation in the different areas of information lifecycle

In the second part of the survey we have evaluated, for each type of content management system, company strategies in terms of more specialisation in just one area of the information lifecycle, or in terms of less specialisation but covering all areas. To do this we have compared the percentage of functionalities in the three areas of the lifecycle (e.g. 100% in collection if the product has all functionalities of the collection system) through a three-dimensional histogram which permits the three values of each product to be compared at the same time. These graphs show company specialisation strategies for collection, management and publication, and, in particular, if they tend to offer more complex solutions in terms of number of functionalities, or products ad hoc with fewer functionalities but very specialised in one area.

Figure 5 shows CMS products. We notice that EMC offers a complete and very specialised product, Vignette offers a product with many functionalities in all lifecycle phases, Cimage NovaSoft has a product with a good number of functionalities in collection and management but a scarce publication area. The result is that the first company has chosen to be specialised in all lifecycle areas, indifferently; the second one is specialised in the entire cycle, but focusing on just some functionalities; the third has preferred to concentrate its offer on fewer functionalities in the three areas of the lifecycle. Notice that a product, to be defined as CMS, does not need to possess all the functionalities of the information lifecycle, but just some specific ones which distinguish it from the other typologies.

Figure 5: CM products
Figure 6: WCM products

Figure 6 shows WCM products. Microsoft, SAP and RedDot products seem to have the same level of specialisation and number of characteristics (low in collection, medium-high in management and medium-low in publication). This means that WCM systems offered on the market are very similar, partly because the “critic” functionalities are fewer than CMS ones, partly because it is quite an old market niche, out of which grew the possibility of expanding the technology for managing all enterprise data, and not just the ones dedicated to the web.

Figure 7 shows DM, RM and DRM products. Only three products possess functionalities in the publication system (the ones offered by Hummingbird, Xerox and Hyland). Collection and management phases are in the same proportion. The result was predictable, since document and records management systems are specialised in the mentioned areas.

Figure 7: DM, RM and DRM products
Figure 8: ECM products

Figure 8, lastly, shows ECM products. There are three types of products: FileNet, Interwoven and Mobius ones present a medium-high specialisation level in the different areas (a very well developed management system, a collection system with a pretty high number of functionalities and a relevant presence even in the publication); IBM, Stellent and Day products have a very well developed management system, a medium developed collection and a poorly represented publication system; Open Text product presents high level of specialisation in management and publication and a medium level in collection. Anyway, to have an ECM system a product must be medium-high specialised in collection and management, while its presence in publication is less important, as it is limited to a support of web publications (internet, intranet o extranet).

5.3 Evaluation of personalisation – flexibility

Lastly, we verified the existence of a correlation between the number of solutions offered per product (modules which compose the product) and the level of completeness of information lifecycle (number of functionalities of the whole lifecycle offered by the product), to explain the actual market trend. The two variables proposed are intersected in the matrix in figure 9. Solutions refer to the number of functionalities, considering the entire information lifecycle, that a product owns, to measure the personalisation capabilities. Completeness refers to the number of modules that compose the product and it is utilised as a measure of the product flexibility, which means its capability of easy and rapid adaptation to the client's needs.
Figure 9: Personalisation – flexibility Matrix

The products which offer the highest grade of flexibility and personalisation are the ones in the upper right quadrant, where the number of solutions and functionalities is greater. In that quadrant figure EMC, Vignette, IBM, Mobius and Hummingbird products. This means that here we find CM and ECM systems and (just one) DRM. In the bottom right quadrant figure products which offer a high number of functionalities but a limited number of solutions (Interwoven, Open Text, Day, FileNet, Xerox, Stellent, Hyland, Cimage NovaSoft, Meridio and Microsoft products, in practice any type of CM system). In the upper left quadrant are located products with a limited number of functionalities but with a high number of solutions (only eiStream product). Lastly, in the bottom left quadrant appear products with both few functionalities and few solutions (SAP, Spescom, RedDot, Hyperwave, Tower and Oracle products, which are DRM and WCM systems).

The first observation is that a great number of the selected products are located in the two quadrants with a medium-high number of functionalities. This means that the companies are moving towards omni comprehensive solutions.

Secondly, looking at the entire matrix we notice another characteristic: going from the upper right corner along the diagonal which connects that point with the origin of the axes, we notice that CMS are in the upper right end, going down we find the ECM systems and at the bottom left end there are WCM, DM, RM and DRM systems. This consideration confirms that vendors tend to move their offer from specific products to solutions with an ever-growing number of functionalities, so as to be able to better respond to the clients’ need of personalisation without making great changes to the original product. Personalisation is becoming the synonym of many integrated modules (or solutions) which can be combined in order to respond to clients’ needs.

6 Conclusions

The great success of CM products, as our analysis shows, is in contrast with the market characteristics. The most evolved CMS offer opportunities regarding the three specific areas (collection, management and publication) but, generally, the system is effectively specialised in one area only. This is because the enormous market potentiality and the weak entrance barriers, in terms of starting costs, have attracted many companies which offer very simplex and low competitive systems. An organisation should carefully evaluate the different products on the market, trying to select the one which best responds to its specific needs and agree with the vendor on a personalised solution (Robertson 2004) but few client-enterprises understand that a content management solution is much more than a software (The Gilbane Report 2003:3).

Nowadays, much of the interest in developing CMS is referred to the possibility of creating easily manageable websites of great dimensions. Actually the potentiality of content management systems are greater, mainly in terms of company support in managing all the phases from content creation to its storage and publication in many formats. A content management system answers to the need of integrating information with knowledge, as to reach a better decision process. At the same time, a CMS permits creation costs of
information and knowledge to be minimised, maximising their value. The need to adopt a CMS is, firstly, to find an answer to the challenge of managing, modifying and updating a big volume of information. The need to use the same content on different media with different characteristics requires suitable systems of collection and management. Lastly, CMS make personalisation very easy to reach, with the advantage of communicating in different ways, depending on the target. Moreover, there is no standard and commonly accepted definition for Content Management. The trouble is that, not only do vendors of so-called CMS actually offer very different systems, but even enterprises interested in content management systems do not call them correctly, without a precise idea of the functionalities to request. Until companies are able to clearly define the product they offer/are looking for, in talking about content management, finding the most appropriate solution will be very hard work.

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Evaluating Motivational Factors Involved at Different Stages in an IS Outsourcing Decision Process

Linda Bergkvist¹ and Björn Johansson²
¹Department of Information Systems, Karlstad University, Sweden
²Jönköping International Business School, Jönköping University, Sweden
Linda.Bergkvist@kau.se
Bjorn.Johansson@ihh.hj.se

Abstract: This study evaluates factors involved at different stages in an IS outsourcing decision process. From a theoretical perspective, the motivation for IS outsourcing is often described as a result of three factors: cost reduction, access to technological expertise and focus on core competence. The aim of this paper is to evaluate motivational factors in an outsourcing decision process. The study uses a literature review and a retrospective case study of an outsourcing project in a large Swedish organisation. The idea is to evaluate if there are different factors involved at different stages in an IS outsourcing decision process. It has been found that the cost perspective is often used as a way of motivating the start of the process as well as the result of the process. However, during different stages other factors are involved. The results, based upon the case study, show that the size and reputation of the provider as well as thoughts about the provider’s ability to deliver required capability is more important than cost reduction. It can be argued that the impact of IS outsourcing on performance and value of an organisation’s IS function can be both positive and negative. To minimise the odds of a negative result, this paper contributes with an evaluation of motivational factors involved at different stages in an IS outsourcing decision process. If they are duly addressed, the chances of a successful IS outsourcing process will improve significantly.

Keywords: IS outsourcing decision process, motivational factors, case study, stages in decision-making process

1. Introduction

In this paper we focus on motivational factors that appear when organisations outsource their IS functions. Generally speaking, outsourcing means using external providers for managing one or more business activities (Lacity and Hirschheim 1993). Dibbern et al. (2004) state that there is a clear difference between general outsourcing and IS outsourcing – the difference being that IS outsourcing is almost always noticeable throughout the organisation. Furthermore IS is not a homogenous function but rather it affects in some way, almost all of an organisation’s activities. As a result, the significant difference is that IS outsourcing is not easy since information systems are involved in many business related processes. This makes it a rather difficult task, which also is oftentimes reflected in research papers and popular magazines. An article presented in a Swedish popular magazine claims that IS outsourcing fails in about 60 percent of all cases (ComputerSweden 2005). A report quoted in Lonsdale (1999) and McIvor (2000) shows that only five percent of the companies included in the survey achieved significant benefits from IS outsourcing. The common denominators seem to be lack of proper management, unclear expectations in the relationship between the provider and the client, and a lack of formal decision-making processes. Similar conclusions are made by De Loof (1995), who argues that a system-wide analysis is rarely performed prior the decision-making of IS outsourcing. De Loof points out that this stage is of great importance to avoid problems in the future. An IS outsourcing decision has long-term impact and should therefore be based on a long-term IS strategy that takes the business strategy into consideration. Clearly, the decision process of IS outsourcing is of great importance.

Earlier research have examined the decision process of IS outsourcing as a single stage. The difference and contribution of this paper is to split the IS outsourcing decision process into five steps and see how different factors motivate management during the decision process. The aim of this paper can be said to be twofold. First, to find out, through a literature review, which factors are motivational during an IS outsourcing decision process. Second, to evaluate, by using a retrospective case study of an IS outsourcing project, whether or not these motivational factors are relevant during the IS outsourcing decision process and how the motivational factors change. The remainder of the paper is structured as follows: the second section presents the research methodology providing a description of how the study was made. It is followed by a presentation of theoretical and empirical findings. Based on these findings, section four presents and discusses how different factors are involved at different stages in an IS outsourcing decision process. Finally conclusions and further research are presented.
2. Research methodology

The perspective used in this paper is client management and focus is on which factors influence the IS outsourcing decision process at an organisational level. To arrive at presented conclusions, a literature review has been done complemented by a case study. The review has emphasised existing research on IS outsourcing and more precisely the factors motivating the process and in particular the decision process. The literature was collected through searches in databases belonging to the IS area. Words used during the search were IS outsourcing, decision, decision process, outsourcing, evaluating process, motivational factors, and outsourcing process. By reviewing citations of relevant articles prior relevant work was identified. The search continued until the amount of applicable work had reached a more mature level and when further searches did not turn up with anything new and relevant. The chosen literature consists of popular magazines, normative books, papers and empirical studies. This selection of sources provides views from different disciplines, which we believe enrich the results presented. The review in this paper summarises relevant literature and describe the factors seen as motivational during the IS outsourcing decision process. To compare the theoretical findings a case study was executed in the form of a major outsourcing decision project in an organisation called MeLo (Messaging and Logistics). The outsourcing project was one purpose of an initiative, called EffectIT, to increase the effectiveness and efficiency of the organisation’s IT, including IT use, governance, management, and operations. The data on the organisation and the project was collected through semi-structured interviews with the CIO of the IT-unit and the Chief Controller of the case organisation. Additional data comes from annual reports from 2001 to 2004 and information on MeLo’s website. Data was also gathered from an internal report on the outsourcing project. From empirical data, descriptions of the outsourcing project have been generated by listening to tape-recorded interviews and comparing statements with the notes that were taken during the interviews as well as with the other documents. This means that statements in the interviews as well as in the documentation have been compared with each other to gain a higher understanding of the context of the statements. The analysis of the generated description aimed at identifying factors seen as motivational with background to the literature review but also to find new factors motivating management during the IS outsourcing decision process.

3. Results

In this section we describe the results from the literature review as well as MeLo’s outsourcing project.

3.1 Literature review

From a theoretical perspective the initial motivation for IS outsourcing is often illustrated as a result of three factors: cost reduction, access to technological expertise and focus on core competence (e.g. Ketler and Walstrom 1993, Cronk and Sharp 1998, Lacity and Willcocks 2001, Bahliv and Rivard 2005). Sometimes these factors are used by management as justification for IS outsourcing without them really having considered why outsourcing is an alternative for the organisation. The signed contract should favour both parties. The provider’s stability...
Linda Bergkvist and Björn Johansson

(McFarlan and Nolan 1995), reputation and mentioned quality are also of great interest (Diromualdo and Gurbaxani 1998, Gupta and Gupta 1992). A survey done by a Swedish IS outsourcing provider shows that the most important factor when a Swedish organisation chooses an outsourcing provider is the provider’s reputation (ComputerSweden 2006b). It is also important that the provider understands the client’s business strategy and goals, which will increase the possibility to achieve the client’s aim. When deciding upon an outsourcing provider, it is according to Ketler and Walstrom (1993) consequently important to consider questions like: what experience the provider has from outsourcing; how familiar the provider is with the client’s industry; is the provider addressing future plans for upgrading the technology and is the provider likely to remain in business for the duration of the contract?

It is also critical for management to consider which business activities belong to the core of the organisation. When deciding upon this it is important that all involved parties are present. Communication about what is going to be outsourced or not is crucial for a successful IS outsourcing process (Lacity and Hirschheim 1994b). The strategic business functions should be kept in-house. The risk is otherwise that the organisation loses control over its strategic core activities (Ketler and Walstrom 1993). From this view it is important to realise that IS outsourcing is not just about saving money, rather it is about making strategic decisions about which IS functions to outsource to stay competitive (Lacity and Hirschheim 1994b). This means that a match between the IS outsourcing strategy and the overall business strategy is of great importance.

3.2 The outsourcing project of MeLo

The section describes a major outsourcing project in an organisation called MeLo. MeLo is a large public Swedish organisation that focuses on Messaging and Logistics. The structure of the organisation consists of six different business units (BU): Market communication, Administrative communication, International mail, Outsourcing, eCommerce and logistics, and Individual. In addition to these BUs there are three units acting as support units: IT, Production, and Support. In 2003, MeLo made the decision to use an external partner for hosting of IT. An outsourcing project started in 2002 and it was completed in 16 months and resulted in a contract for six years that was signed with a major provider of IT. The IT outsourcing decision-making process was conducted as a project, which comprised five steps: 1) request for information and invitation of tender, 2) tender invitation, 3) evaluation of tenders, 4) agreement proposals and due diligence, and 5) negotiation. A timeline for the project is depicted in Figure 1. The project will be described using the five steps as headings. We have chosen to mention every single activity by name but we only describe the activities, which generate contributions to the study.

Figure 1: The timeline for the outsourcing decision project of MeLo.

3.2.1 Request for information and Invitation of tender

This step constituted three main activities: 1) producing the request for information, distribution and evaluation of the information, 2) producing a business case that described an outsourcing case, and 3) the development of a tender invitation. A business case was developed based on an analysis of the effects of outsourcing. From the business case the decisive reason for the EffectIT steering committee to suggest outsourcing was that the committee judged the probability of decreasing the costs more likely in the outsourcing option. There was then a decision in the executive committee that the project could start the process of outsourcing. The development of the tender invitation was done in parallel with the other activities during this step. This activity consisted of collecting facts regarding existing IT resources. In the investigation it was found that differences between applications were high, meaning that every one was unique with unique demand of service level and management. In this stage of the project it was expressed that the hardest thing to do was to judge future demands
of IT in the organisation. At this time it was also found that a lot of employees had negative feelings about outsourcing and did not like the idea. The main objection was that it would increase difficulties with developing services delivered from different units. But also that it could affect client data security negatively. However, it was hard to know if requested service from the outsourcing deal was at the right level. Major work was done to find a model that would describe how the work should be done so that the external provider was encouraged to consolidate resources and at the same time give MeLo high flexibility and a possibility to only pay for the capacity it used.

3.2.2 Tender invitation
The next step was tender invitation. This step consisted of three main activities: 1) construction of a package with additional information for the invitation of tenders, 2) answering of questions from possible providers, and 3) planning and preparation for the evaluation of tenders. There were questions from possible providers after one week. During this phase there were 230 questions of different range and complexity. It was not possible for the project members to answer the questions without additional information and help from employees at the different BUs. The BU that was most needed for this was the IT BU, which had been unenthusiastic to the project from the start. However, at this stage the negativity changed and the IT BU people were more positive. The plan and preparation for tender evaluation was seen as an important step which consisted of creating an organisation that had the necessary competencies and resources for doing high-quality evaluation. At this time, there was a consultant working on the outsourcing project. Since the consultant was employed by a consultancy working with outsourcing, some stakeholders thought this was not a good arrangement. The reason for this was that there existed a possibility that it could affect the potential providers in their openness and in their bids. Another reason was that the project group wanted to have transparency in the evaluation and did not want to have problems with the tender secrecy.

3.2.3 Evaluation of tenders
There were four main activities in the step: 1) evaluation of tenders, 2) develop a “short-list”, 3) the start of preparing the contract, and 4) preparation of due diligence. The evaluation of tenders was made in a sequential way starting with individuals reading the tenders and forming opinions of the tenders. The opinions were then analysed and reviewed in teams and questions were prepared for each potential provider. The next stage was a daylong presentation by each of the potential providers. The final stage of this activity was to make an updated analysis and a judgment with a motivation for why the teams evaluated as they did. The result of the evaluation activity was then put together and analysed in a smaller group. The role of this group was to develop a short-list. At this stage in the project there were six potential providers. The evaluation resulted in two providers being dismissed at this stage; both because of their weak economic and financial status. One of the providers was too small. If the provider had been awarded the contract, it would have represented 80 per cent of the provider’s turnover. This was seen as too risky. The result of this work was a short-list with two providers presented. The next activity in this step was to prepare the contract. There was a decision made that stated that MeLo should present a proposal for contract and that this should guide the negotiation. During the development of the invitation of tender it was realised that there was a need for a clearer description of what the hosting part consisted of. It was also found that there was an unclear description of which services that were demanded. All this resulted in the proposal becoming a whole new document with a new structure and a partly new content. However, there was still a high level of insecurity regarding what MeLo needed and demanded in the future.

3.2.4 Due diligence and agreement proposals
The next step in the project constituted two activities: 1) to conduct a due diligence with the two potential providers from the short-list, and 2) to create the proposal of agreement. The conduct of due diligence meant that the providers were given full access to all necessary information. They got access to a room with computer facilities and all necessary information and documentation covering inventory, agreements, contracts, descriptions over systems and so on. The providers also had the possibility to visit all data centres used and to interview employees. The due diligence resulted in more questions from the providers which the project and the BUs tried to answer. The ambition was to have full openness during this stage. The work with developing the proposal agreement continued and it was found that content of the agreement was not such a hard task, except for information regarding hosting of software applications. This part of the proposal was especially hard because it was found that the original description was not good enough. MeLo also wanted to have a model for the fee of the services that reflected what was considered
“normal” in a competitive market. There was an appendix constructed that aimed at solving this, but there still existed some uncertainty if this was the most ideal description and if the proposed model for fee payment was the best solution.

3.2.5 Negotiation
The finally step of the outsourcing project was the negotiation with the providers. The step consisted of three activities: 1) negotiation preparation, 2) final negotiation, and 3) the delivery to the provider that were finally chosen. After the distribution of the proposal of agreement to the two providers, they had the opportunity to prepare for the final negotiation by getting more known with the proposal and to ask questions and make comments. They were told to state the price of the required services. They were also expected to say which parts of the proposal they did not accept and what parts they wanted to negotiate. After one month of preparation the EffectIT steering committee decided to give the project permission to start the final negotiation with the two providers.

The negotiation took place at an external law firm. The negotiation group consisted of two purchasers, an internal lawyer, two external lawyers and one person from the IT BU. The group was led by the purchasing executive of IT. In addition to these people the group was supported by employees that had expert knowledge regarding the area that were under discussion at that moment. The final decision was made a week before the contract was signed and the chosen provider was selected on the basis of the outcome of the negotiation. The documentation regarding the transfer of the resources was polished and a project team was set up to handle the transfer.

4. Discussion
In this section findings from theory and practice are discussed, first separately and then together to compare them and present differences and similarities. From the literature review a couple of factors were found that are seen as motivational during the IS outsourcing decision process. The factors are not divided according to the stages of the MeLo project since it was difficult to separate them into similar steps as in the project. The reason for this is, as described in the introduction, that outsourcing literature to a high extent emphasises the decision process as a one step of the outsourcing process. The list below shows factors found in the literature seen as motivational from a client management perspective.

- Cost savings
- Access to external technological expertise
- Focus on core activities and/or competencies
- Predictable IS costs
- A well-worked contract
- Close communication between involved parties
- A trustworthy relationship between client and provider
- The provider’s reputation
- The provider’s knowledge about the client’s organisation
- The provider’s ability to deliver needed capability
- The outsourcing strategy as part of the overall business strategy
- The client’s control over core business activities
- Outsourcing used as a competitive tool
- Communication about outsourced IS functions

Although an attempt to divide the factors into steps has not been done it is clear when reading the literature that factor 1, 2 and 3 above motivate management in an early stage of the IS outsourcing decision process. Through the description of the MeLo project the next section aims to identify symptoms of factors seen as motivational during the steps of the IS outsourcing decision process. The purpose is to confirm the factors found through the literature review but also to find new factors motivating management during the outsourcing decision process. In table 1 are motivational factors found in the analysis summarised.

Table 1: Summary of motivational factors viewed by management during the IS outsourcing decision process – an empirical perspective.

<table>
<thead>
<tr>
<th>Factors seen as motivational from a client management</th>
<th>Request for information and invitation of tender</th>
<th>Tender invitation</th>
<th>Evaluation of tenders</th>
<th>Due diligence and agreement proposals</th>
<th>Negotiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost savings</td>
<td>Communication and participation among concerned parties</td>
<td>Provider should be able to meet requirements connected to</td>
<td>Let the provider get familiar with the organisation’s</td>
<td>Communication among involved parties</td>
<td></td>
</tr>
<tr>
<td>Future demands of IT</td>
<td>Let the provider get familiar with the organisation’s</td>
<td>Specialists</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
That the cost perspective is of importance in an early stage of an outsourcing project is supported both in the literature review as well as by the steering committee for EffectIT. The steering committee judged that the difference between retaining the IT functions in-house or to outsource was that the outsourcing case was more likely to decrease costs. This was the main motive that led to the project being able to start the process of outsourcing. It was at this stage also important to discover future demands of IT, which was seen as one request when choosing a suitable provider. Other requests that were mentioned during this stage were that MeLo wanted a provider that could offer high flexibility and required capability at the right price. During this point of the project it was also found that a lot of the employees were negative about the project. One reason for this was the concern about the provider’s ability to carry out the functions as they were in-house. Another reason for this negativity could have been that the project and its intentions had not been communicated among the concerned. One effort to meet these negative feelings was workshops with the units most negative to outsourcing and later in the project let the provider get familiar with the organisation’s business processes.

During the activity of tender invitation it was seen that the negative feelings among the employees at the IT BU decreased since they were involved in the process and were seen as important. This motivates the need for communication and participation of the ones concerned by the project. At this stage there was also an initiative to terminate cooperation with a hired outsourcing consultant. The main reason for this was a wish to achieve openness during the tender evaluation which can be seen as one step for reaching a trustworthy relationship. When the project reached the step of evaluation of tender demands on the future provider became clearer. Considerations about how the provider would fulfil future development, the provider’s ability to remain in business for the duration of the contract and the size of the provider’s organisation were seen as important. Again the question about future needs came to play a significant role, which was probably connected to the demand of the provider’s ability to meet future IT demands.

Due diligence and agreement proposals concentrated on short-listed providers and the process of letting them becoming familiar with the client’s organisation. This step was characterised by openness and trust and was seen as an opportunity to create a long-term partnership. It was also mentioned that there existed a wish to get IT costs predictable and “normal” in a competitive market. The last step, negotiation, could be seen as ideal as the negotiation involved all parties concerned in the outsourcing decision process. An example of this was when the group discussed a special area of the organisation the group was supported by employees that had expert knowledge in that certain area. By performing these steps, the result turned out to be a well-worked contract. Table 2 presents motivational factors found both in theory and in the empirical data. The table emanate from table 1. Motivational factors found in the literature review and not mentioned in the case study are represented in bold. They are also placed in that step of the project where they are seen as most likely to occur.
Table 2: Comparison of the motivational factors – a theoretical and empirical perspective.

<table>
<thead>
<tr>
<th>Factors seen as motivational from a client management perspective</th>
<th>Request for information and invitation of tender</th>
<th>Tender invitation</th>
<th>Evaluation of tenders</th>
<th>Due diligence and agreement proposals</th>
<th>Negotiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost savings</td>
<td>Communication and participation among concerned parties</td>
<td>Provider should be able to meet requirements connected to IT development, contract duration and size</td>
<td>Let the provider get familiar with the organisation’s business processes</td>
<td>Communication among involved parties</td>
<td></td>
</tr>
<tr>
<td>Future demands of IT</td>
<td>Transparency between provider and client</td>
<td>Future IT development needs at the client’s organisation</td>
<td>Shaping a trustworthy long-term partnership with the provider</td>
<td>Specialists participating during contract negotiation</td>
<td></td>
</tr>
<tr>
<td>The provider’s ability to meet needed capability and flexibility</td>
<td>Trustworthy relationships</td>
<td>The IS outsourcing strategy is part of the overall strategy</td>
<td>Predictable and “normal” costs in a competitive market</td>
<td>Well-worked contract</td>
<td></td>
</tr>
<tr>
<td>Communication to spread the intentions about the IS outsourcing initiative</td>
<td>Focus on core activities and/or competencies</td>
<td>The provider’s reputation</td>
<td>The client has control over core business activities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Conclusions and further research

When comparing the motivational factors found in the literature and the ones from the case study, we can see differences and similarities. It is found that the cost perspective is of great interest in an early stage and so also are the future needs of IT. We believe from both theoretical and empirical research that what management means by future IT requirements can be met by getting access to external expertise. This is one way of fulfilling future demands. Communication is seen to be important and insufficient communication could lead to a catastrophic result in an IS outsourcing decision process. Communication is needed to spread information among those involved and to reach consensus about contractual questions. It is also seen that the relationship with the provider becomes more and more important during the decision process. A relationship distinguished by openness and trust motivates a long-term partnership. The provider’s stability in the market, its reputation and its ability to meet the demanded capability are also of great interest from a management client perspective. The factor cost savings, seen as most motivational in the beginning of the process, is not longer in focus and it seems that the relationship with the provider and its characteristics are more important the longer the decision process goes. Costs are of course also on the agenda in the end but perhaps instead of saving money it becomes more important to make costs predictable and normal from a competitive stance. These are the similarities between the theoretical and empirical views.

The differences are that the theory mentions focus on core activities and/or competencies as an important factor during the early stage of the IS outsourcing decision process. This factor is not clearly mentioned in MeLo’s outsourcing project. Instead the outsourcing project was an initiative to become competitive in the IT area. The case study further mentions that the size of the provider is important which was not found in the literature. The theory also emphasises that the IS outsourcing strategy should be part of the overall business strategy, which we found to be missing in the case study. The main conclusion from the study is by being aware of the factors that motivate and influence the IS outsourcing decision and by being aware of how these change during the process managers can make better decisions that can result in more successful IS outsourcing.

Future research from this study could be to categorise presented factors according to Lacity and Hirschheim’s (1994a) categorisation. They suggest that factors influencing the outsourcing decision process could be grouped as motivational, financial, technical, strategic and political. Doing that would probably increase the
knowledge of how different factors influence the decision process as well as how decision-makers act in a decision process of IS outsourcing.

5.1 References


The Implementation of a New Student Management Information System (MIS) at an Irish Institute of Technology – An Ex Post Evaluation of its Success

Marian Carcary¹, Ger Long², and Dan Remenyi³
¹Limerick Institute of Technology, Ireland
²Waterford Institute of Technology, Ireland
³Trinity College Dublin, Ireland
marian.carcary@lit.ie
glong@wit.ie
dan.remenyi@tcd.ie

Abstract: This paper is a case study examining the impact of the introduction of a large-scale student ICT system into an Institute of Technology (IoT) in Ireland. The system in question addresses all functions related to the ongoing administration of student affairs. It was implemented as part of a national project driven by the Department of Education and Science and the Council of Directors of the IoTs to standardise the ICT systems of the IoT sector. However, system introduction was problematic and it was necessary to support the new system with a number of additional software tools. The case study considers how well the current ICT arrangements satisfy the IoT’s requirements and it identifies remedial action for future success.

Keywords: ICT evaluation, ex post evaluation, ICT problems, ICT benefits, functional-operational match, ICT in third level education

1. Introduction

There are 14 Institutes of Technology (IoTs) serving the third level education sector within the Republic of Ireland. These IoTs have recently undergone an extensive transformation of their ICT systems. A national project launched by the Department of Education and Science and the Council of Directors of the IoTs performed a nationwide implementation of a suite of integrated Information Systems for library, human resources, finance and student management functions. This case study evaluates one IoT’s ICT project and in so doing addresses the Institute’s experiences of the new Student MIS. The student system is an American product and offers functionality for course and subject management, student data, admissions application processing, student registration, maintenance grants payment, accounts receivable and fees assessment, examinations and academic history, student progression and graduation. The case study outlines some of the system implementation issues, their impact on the Institute and an analysis of the fit between functional system capabilities and the Institute’s requirements. This case study (Remenyi et al, 1998) was carried out through a series of one-hour interviews between the 22 and 28 March 2006. Ten members of staff offered their experiences including project team personnel, system end-users and members of the academic staff.

System implementation on a national basis was carried out in a series of stages referred to as waves. The Institute described here was a participating member of the first wave, with the system start-up date being September 2002. Prior to the project, student data was managed on a number of un-integrated databases and legacy systems, which were limited in functionality and gave rise to a number of problems. Hence, the new student MIS was perceived as offering potential to improve this situation. The student MIS resulted in benefits and problems Institute wide. Many of the problems have been addressed through additional custom built systems that meet specific administrative needs. These are linked to the student MIS’s underlying database and this more advanced implementation offers greater capabilities and potential to significantly improve organisational operations. In addition to evaluating what has been achieved, this study also considers steps required for continued future success.

2. The student MIS project within the institute

Two distinct attitudes were displayed towards the introduction of this system. It was either welcomed or seen as a threat. Some felt that the new MIS would offer a significant improvement over the legacy systems. Others were apprehensive, demonstrating reservations towards change. There existed concerns regarding the implementation effect of the new MIS on user workload and the complexity of the system.
Probably because the project was driven by the Department of Education and Science on a national level, Institute staff were uninvolved in the system selection process. Their involvement and consultation throughout the project was also minimal. Emails were distributed by management staff and the project manager outlining to system users general information on the nationwide implementation. The Directors of the individual IoTs simply signed up to the system when it was selected by a central, national working group. According to a number of system users:

“there was an overwhelming feeling that the system was imposed from the top down”,

“there wasn’t a lot of information about the system initially so it was very much going into the unknown” and “it came in over night without anyone really having full warning”.

Training sessions prior to system start-up were the staff’s first introduction to the system. This resulted in some confusion about the system and what it could do. There were calls for greater communication with end-users and administrative staff on the changes that would take place and the impact it would have. The following sections outline key aspects of the MIS project.

2.1 The project team

Within the IoT, a project team consisting of a project manager, two technical team members and two functional “super user” personnel was created. This team was under significant pressure to meet the September 2002 deadline for the rollout of student registration. They were involved in the clean up of legacy data, data conversion, provision of on-going training and support and system implementation and development. Their main source of support was a central helpdesk in Dublin. There was frequent interaction between the Institute and this service desk, to solve problems encountered, provide training on different software releases, and negotiate system change requests. This project team was in place for 2 years and 4 months, and was disbanded approximately one year after the implementation was finalised. It has been replaced by an MIS unit which supports the technical aspects of 4 MIS developments were primarily in the area of critical activities such as student registration, and processing of grant payments and examination results.

2.2 System implementation

The Institute’s implementation of the student MIS was commissioned for September 2002. The process was carried out over one year and the implementation strategy applied was a “big bang” approach for first year registration. Implementation of the remaining modules was phased in accordance with the cycles that occur during an academic year. This approach was chosen as parallel running with the legacy systems would give rise to data integrity and end-user ownership implications, and would require greater resourcing. This conformed with the template for systems’ implementation prescribed by the national project board. Servers for the student MIS were initially locally hosted and supported within the Institute. These have now been centralised as part of the national agenda, with servers managed by a server-hosting organisation in Dublin. This change has given rise to concerns over loss of control over data, communications and response time for mission critical activities such as student registration, and processing of grant payments and examination results.

2.3 In-house developments

Following implementation, significant additional work was undertaken by the technical team in order to meet Institute specific needs. These developments were primarily in the area of reporting. The student MIS was weak in its report offerings; its reports were generic in nature, and did not meet individual IoTs exact requirements. They were slow, inflexible and restrictive, and could not be amended, saved or e-mailed. This was critical as staff previously had access to an advanced reporting facility in their legacy systems. According to one team member:-

“If you want a successful system, you can’t pull away everything and say you’re not allowed to have any of that anymore. Here’s your new and improved system that doesn’t do any reporting really at the moment”.

The problem was solved by importing the existing systems reports and linking them to the MIS database through Open Database Connectivity (ODBC). Today, more than 200 or 300 reports have been developed to cater for exam parchments, single subject certificates, registration forms, exam timetabling, exam entry letters etc. 99% of reporting in now Institute
specific which offers greater flexibility to end-users. In-house development work is on going. Thus, while “a step backwards” was experienced initially, the Institute now has an advanced implementation. Greater levels of development have taken place in comparison to other IoTs, with a custom built system now working in tandem with the student MIS.

2.4 Training and support

End-user training commenced in March 2002 and was provided by the Institute’s project team. Initial sessions addressed an introduction to the MIS and system navigation, and were followed by specific training on student registration and other specialist tasks. Users were trained on the remaining functional modules as they were utilised throughout the academic year. Post system start-up the functional project team members provided a call centre support service, addressing user queries or problems and talking staff through system functionality. The support provided was “hand holding” in nature to help develop end-user confidence and encourage system adoption and ownership. The technical members of the project team were relied upon for database administration and problem solving, and development of additional reports and forms. At present, end-user training is not provided due to the disbandment of the project team. The training initially received is insufficient for staff movement to different positions. No functional training structure exists for staff in new, specialised job roles. Rather, other end-users assist in passing on knowledge which may have become “filtered or watered down”. According to one system user:-

“it’s such a complex system, it can do so much. Really anybody that comes into a job where this system is being used needs to have training before they sit in the chair to try and do the job”.

Further, many processes within the Institute follow an annual cycle, hence the need for refresher and on-going staff training. Some staff demand a greater overview of the system and how their work impacts other areas. System users are still unaware of the MIS’s full capabilities; hence the lack of formal training is considered as disadvantaging the Institute as a whole.

2.5 Reaction to the student MIS now

Following system start-up, end-users demonstrated both frustration and fear towards the new student MIS. Staff lacked system knowledge; hence they were unable to resolve many issues due to its integrated nature. There was a tendency to blame the system, sometimes quite erroneously, for any complaints end-users had. The system was not user-friendly in nature and it radically changed some end-user’s work routines. There was resistance to take ownership of certain administrative processes that were no longer performed by the project team. Further, many of the system benefits such as improved quality procedures, provision of audit trails, and improved Institute planning and analysis were delivered on a higher managerial level, not immediately apparent to the system end-users. Such issues are characteristic of any system changeover. While there remain elements of reluctance to use the system in some areas, in general staff have accepted it. Attitudes continue to improve as staff develop greater familiarity with its capabilities but the system does need to be further exploited to better advantage the Institute. However, without the in-house developed reporting system, the Institute’s implementation of the student MIS would not be as advanced.

3. The student MIS: An evaluation of its impacts

The student MIS has resulted in a significant impact on Institute-wide operations. As yet no formal ex-post system evaluation has been carried out. However, an administrative review examining the procedures surrounding student administration has addressed the impact of the MIS in supporting this work. A full evaluation however, would enable the Institute to address any shortcomings and further capitalise on the systems potential. The problems and benefits surrounding the system are discussed in the following sections.

3.1 The problems at system start-up

Table 1 identifies the problems experienced in the Institute at the time of system commissioning. Many of those factors are characteristic of any complex system implementation. The problems are listed in terms of those identified most frequently by informants with the number of individuals identifying the problem shown in brackets. The table also categorises the problems according to informant type. For example, from the table it is apparent that system usability and resistance to change are both identified by 9 of the 10 individuals interviewed. Both problems are most recognised at a project team level being identified by 5 such stakeholders. The following discusses each problem experienced in detail:-
Table 1: System Start-up Problems

<table>
<thead>
<tr>
<th>Problems at System Start-up</th>
<th>Stakeholder Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>System usability (9)</td>
<td>Management</td>
</tr>
<tr>
<td>Resistance to change (9)</td>
<td>Management</td>
</tr>
<tr>
<td>Team Pressure (7)</td>
<td>Management</td>
</tr>
<tr>
<td>Business process re-engineering (6)</td>
<td>Management</td>
</tr>
<tr>
<td>System Glitches (6)</td>
<td>Management</td>
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<tr>
<td>Problematic Effects of integration (5)</td>
<td>Management</td>
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<tr>
<td>Performance drop (4)</td>
<td>Management</td>
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<tr>
<td>Change requests (4)</td>
<td>Management</td>
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<tr>
<td>Americanised System (3)</td>
<td>Management</td>
</tr>
<tr>
<td>Lack of Knowledge/Familiarity (2)</td>
<td>Management</td>
</tr>
<tr>
<td>Modularisation Issues (1)</td>
<td>Management</td>
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</tbody>
</table>

System Usability: Poor system usability was reported as one of the most negative issues surrounding the MIS at the time of system commissioning. Problems experienced centred on the system’s unintuitive nature, poor navigational abilities, unwieldy and multi-formed screen layouts, spread of data through numerous forms, haphazard naming conventions and limited data validation and search facilities to mention a few. Particularly in the early days, it was regarded as a complex system that was not user-friendly. The problem was most evident on a project team and end-user level. These were the two groups impacted most by usability-related problems – administrative end-users in using the system to facilitate their day-to-day tasks and team representatives in supporting user problems and queries.

Resistance to Change: Resistance to change was identified across all informant categories. This problem was exasperated by system complexity, by staff's familiarity with their existing systems, and the fact that legacy applications were exactly matched to their job roles. There was reluctance to take ownership of certain new administrative processes. Much of this negative attitude was linked to fear of a new system being introduced.

Team Pressure: In the ex post phase, the project team worked in both an implementation and a support role. They were under significant pressure to develop a custom built reporting system; they tested and improved functionality; and further provided on-going training and support. Due to the nature of the work involved, this problem was most evident on a team level.

Business Process Re-engineering: No formal process analysis and re-engineering were conducted prior to implementation. However, the system required a change in administrative operations and the introduction of new procedures to match the system’s model. Staff not only had to adopt new system functionality but had to simultaneously change their policies and procedures and introduce new work practices and processes, for which they were unprepared. For example, students were now registered at an individual subject level as opposed to a course level. It is surprising that this issue was recognised mainly on a project team level, rather than the user level which was most impacted by changes in work practices. Perhaps it is explained by their increased workload as the mismatch between system and staff processes lead to development of an additional custom-built system to “fill the gaps”.

System Glitches: Problems existed in areas of the system resulting in the need for manual workarounds to carry out day-to-day tasks. These inadequacies were predominantly focused around examination and accounts functionality. These problems impacted end-users and academics in using the system and project team members in resolving issues through rollout of numerous patches or development of in-house alternatives.

Problematic effects of integration: Due to system integration, relatively small problems in one area generated greater issues and problems elsewhere. For example, a change to a student’s registration record had implications for fee assessment giving rise to incorrect transactions in student accounts. Users were unaware of their work impacts on other areas, being unfamiliar with the “big administrative picture”. It was “a cultural shock” for staff in that data entry at registration needed to be correct in order for examinations to be properly processed.

Performance drop: Using the student MIS to perform day-to-day work tasks was time consuming. Because the MIS was multi-screened, and the design of registration documentation no longer matched the layout of the input screens, the data entry process was materially slowed.
Staff worked longer hours and additional administrative staff were required to register students in the first year as greater volumes of data were captured. Work performance was also slowed initially while staff became familiar with the new system and work practices.

**Change requests:** The inflexibility and bureaucracy of change requests was an issue of contention and frustration. For any improvement or localisation required, the Institute needed to compete with the opinions of 14 other IoTs. Only those changes requested by the majority were considered by the central support team. According to one team member, the Institute had a larger volume of more radical change requests, the majority of which were unanswered. A marginally greater number of team members suggested this as a problem experienced, perhaps due to the level of additional in-house developments required.

**Americanised system:** The student MIS was designed for the American education market. In some cases, it did not ideally suit the Institute's needs or have relevance to the Irish third level education sector. Unnecessary changes to staff work practices were required as the system could not be adapted to match the operations of the Irish IoTs. It was identified as a problem by project team, academic and end user categories, each of whom were directly affected in system usage.

**Lack of knowledge/familiarity:** Despite tailored training, administrative personnel lacked understanding of the system’s capabilities, of its cross-functional impacts, of the data recorded and information produced, and made mistakes in system usage. Much disruption stemmed from the fact that the MIS required integration of the different functional areas. Staff required much functional team support in the initial stages to develop confidence levels. Hence, this problem was mainly experienced by the end-user informant category.

**Modularisation issues:** At the time of system commissioning, the Institute was not modularised. Because the new MIS was a modularised system, aspects of it needed to be rewritten or re-configured. For example, it calculated the overall student’s average mark on the basis of subject credits. This did not match the Institute’s normal work practices and gave rise to problems for academic staff members.

### 3.2 Current problems

As outlined in section 2, the student MIS has been enhanced significantly since its initial rollout through a series of custom built in-house developments. As a result, many of the original problems have been overcome. However, a number of concerns remain and table 2 identifies these issues. The table is similar to that outlined above in that it lists problems, categorised by stakeholder type, in terms of those identified most frequently by informants.

**Table 2: Current Problems**

<table>
<thead>
<tr>
<th>Current Problems</th>
<th>Management</th>
<th>Project Team</th>
<th>End-User</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training (6)</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Software glitches (5)</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Functional team (5)</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Staff Turnover (4)</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lack of integration between systems (3)</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Training:** At present, a training structure does not exist within the Institute due in part to a lack of financial resources and disbandment of the functional project team. This impacts the entire organisation. A lack of system knowledge and awareness of new developments, and unfamiliarity with processes run irregularly adversely affects the Institute's ability to leverage advantage from the system and exploit its potential.

**Software glitches:** Problems in the system's underlying functionality have not been significantly alleviated since time of system commissioning. Issues continue to surround examination and accounts functionality and have yet to be resolved by the national central project board. These pose the greatest problem at project team level due to the additional work they create.

**Functional team:** While the Institute has an MIS unit to maintain technical aspects of the system, it does not have a group to support day-to-day administrative needs. This problem affects both team and end-user informant categories due to the lowered response to user demands and the increased pressure on remaining team resources.

**Staff turnover:** A further problem is constant staff turnover. Many administrative personnel work in specialised positions, such as registration, admissions, accounts, and require specific
training for those areas. The issue of maternity leaves or availability of higher-grade positions can result in staff movements, resulting in knowledge loss for specific tasks. The absence of ongoing training for those impacted by role changes magnifies this issue.

Lack of Integration between systems: Integration between the student and the other MIS applications for Finance, HR and Library functions is not fully achieved. Data is simply passed between applications through a series of interfaces, data feeds and file transfers. The interfacing of all systems requires significant maintenance, testing and rework when any application changes take place and adds to the workload of project team personnel.

Table 3: Current benefits

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
<th>Current Benefits</th>
<th>Management</th>
<th>Project Team</th>
<th>End-User</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficial Effects of Integration (9)</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Benefits of in-house developments (6)</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Improved Data Standards (5)</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Volume and nature of data stored (5)</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Functionality related benefits (5)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Basis for the future (3)</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Improved planning and analysis (2)</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Improved quality procedures (1)</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Beneficial Effects of Integration: The student MIS is an integrated system, storing all student information in one single data store. This offers beneficial knock-on effects, with real-time, streamlined data accessible across various modules. The MIS helps to break down functional divides and fosters liaisons between departments such as registration and examinations that previously worked in isolation. Security aspects are maintained through the provision of access rights, which prevent user groups from changing the system. This and the system’s links with other MIS applications develops the concept of being part of one organisational operation. Project team members account for greater than 50% of those who identify integration as a key benefit. This may be due to the fact that technical team personnel were previously responsible for supporting disparate applications. The integrated nature of the student MIS eliminates the need for such work.

Benefit of in-house development: Due to significant in-house developments, it is perceived by project team members and system end-users that the Institute has benefited from a “more advanced implementation of the system”. According to one end-user, without such in-house development “we wouldn’t be able to do our day-to-day business”.

3.3 Benefits of the student MIS

Despite the problems experienced ex post, the Institute has realised material benefits from the student MIS implementation. These are the result of greater system integration and capabilities, and improved volume and integrity of data, and should be seen as the joint result of the purchased package and the in-house developments working together. Table 3 outlines the most common positive effects that emerged from an open-ended discussion with informants, listed in terms of those identified most frequently and categorised by informant type.

Improved data standards: The MIS has improved data standards within the Institute. Due to the system’s rigid rule-based nature, it forces users into greater levels of accuracy and assists in resolving duplicate records with the result that information supplied is more consistent, structured and of an improved standard. The benefit is most recognised by project team members, which may be due to a reduced need to clean data because of the system’s integrated nature.

Volume and nature of data stored: The student MIS offers a more extensive data store that captures more student related data. This enables the Institute to track student’s performance throughout their academic careers. This greater information can be used for more detailed reports and statistics and is also of use to specialised departments such as learning support.

Functionality related benefits: Within the Institute, the principle functionality related benefits include student registration at an individual subject level, the linking of subject instances to an Approved Course Schedule (ACS), resolution of duplicate records and exam related efficiencies and statistics. Such benefits have lead to a number of organisational efficiencies such as optimised resource utilisation and improved costing.
Basis for the Future: The MIS and its underlying Oracle database present the Institute with a technological foundation. It provides an integrated platform, offering capabilities for on-line applications and automation. This benefit is identified by project team members since the in-house technical resources can develop additional applications to further enhance the system.

Improved Planning and Analysis: The system’s greater volumes of accurate data facilitate improved future Institute planning. Studies such as unit costing and greater organisational analysis are more straightforward. As outlined by one team member:

“a lot of the benefits are not to the users on the ground who are doing data entry; a lot of the benefits are at the higher level of bringing things together and having it a lot more uniformed”.

Improved Quality Procedures: The Institute reports improved academic quality standards through better data transparency, traceability and audit trials. This benefit is recognised by the management informant category. Quality assurance is of greater concern to the managerial levels of IoTs. For legal and ethical reasons, they need to comply and fulfil the service they purport to deliver to students.

3.4 Dis-benefits of the student MIS

Ex post evaluation reveals the following:

National Agenda: Due to server centralisation in Dublin, the Institute has experienced a greater loss of control. Greater levels of bureaucracy exist in that it is more formally tied to a common centralised system and a national development agenda. There exists a feeling that

“we have to wait until the slowest person comes up to the line before we can do anything and that’s a big disadvantage”.

This inflexibility means the Institute cannot presently progress with aspects of functionality they desire, such as the provision of student online registration to further automate the system.

Increased Work Levels: The Student MIS has increased the workload of staff members, with greater levels of data entry and system maintenance required. For example, student registration on individual subjects has multiplied the work involved in the administrative office.

Increased Resources: The resources needed to support the system have increased. A permanent team is required for performing both technical and functional tasks. Constant training, system development and evaluation are required. However, when the necessary resources are not provided on a national level, it disadvantages the Institute as a whole.

3.5 Problems and benefits: The chain effect

It is no surprise given the comprehensive integrated nature of the student MIS that many of the problems and benefits experienced are connected and linked in a chain-like or snowball effect. Figure 1 graphically depicts how the various system impacts are connected.

4. Functional-operational match analysis

Changeover to the student MIS was hindered by issues such as Institute specific requirements and the systems inherent functionality. The following functional-operational match analysis examines the extent to which the MIS now meets the Institute’s functional requirements and the extent to which the Institute utilises the full system capabilities. The analysis points towards a certain degree of functional-operational mismatch, reasons for which are put forward throughout the section. Prior to examination of the degree of functional-capability match, Figure 2 provides an overview of the core system functions and its operations in managing student administrative processes.
4.1 An examination of functional capability exploitation

Many potential benefits of the student MIS remain unrealised. Despite the availability of comprehensive functionality for addressing all aspects of student administration, within the Institute only the baseline foundation system is implemented, with work ongoing in streamlining basic operational processes. This platform needs to be further enhanced, through greater investment of resources for system and report development. As outlined by one team member:
Marian Carcary, Ger Long, and Dan Remenyi

“There’s probably a lot that it hasn’t been utilised for, and there’s probably a lot more you can do that we don’t know about”.

System end-users are unfamiliar with the broader functional capabilities and concentrate solely on their core work activities. According to one administrative staff member:-

“It’s a disadvantage to put any system on somebody’s PC and you can’t use it to its full potential or you don’t know what it’s capable of doing”. “It’s an improvement on our old system and I think that really we should have explored the bigger, fuller potential of what it can do for us”.

Many areas of the system remain unutilised due to in-house developments. The MIS in many cases is used solely for data entry purposes, with much of the output being derived from custom built reporting systems. According to a project team member, any of the areas that are used are being used to their maximum potential, through the aid of these in-house developments. The extent to which the various functional modules are exploited is as follows:-

Table 4: Functionality Exploitation

<table>
<thead>
<tr>
<th>Module</th>
<th>Exploited Functionality</th>
<th>Unexploited Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalogue</td>
<td>Stores all course and subject data</td>
<td>Needs further exploitation for semesterisation and modularisation</td>
</tr>
<tr>
<td>Approved Course Schedule (ACS)</td>
<td>Old and amended ACS stored</td>
<td>Lecturers attached to a course and rules pertaining to a course not recorded</td>
</tr>
<tr>
<td>Sections and Blocks</td>
<td>Exploited – Instances of subjects i.e. lectures, practicals, tutorials recorded</td>
<td></td>
</tr>
<tr>
<td>CAO interface</td>
<td>Used for loading different rounds of CAO offers. Ratings recorded</td>
<td>CAO reporting is via the in-house system</td>
</tr>
<tr>
<td>Admissions</td>
<td>Records data for direct and CAO entries. Records subjects applied for, offers made and withdrew.</td>
<td>Direct entry interface unutilised. Reporting, letters and listings are via the in-house development</td>
</tr>
<tr>
<td>General Person</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>General Student</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>Registration</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>Grants</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>Accounts Receiveable</td>
<td>Mainly used for data entry</td>
<td>Many areas unexploited due to complexities and deficiencies. Invoices and statements produced on in-house development. Electronic integration between accounts receivable and the finance system unexploited</td>
</tr>
<tr>
<td>Examination</td>
<td>Used for exam grades, historical marks, Grade Point Averages, exam broadsheets etc.</td>
<td>Exam spreadsheets produced on in-house system; exam results are issued online but not via the student MIS</td>
</tr>
<tr>
<td>Academic History</td>
<td>Exploited</td>
<td></td>
</tr>
<tr>
<td>Web for faculty</td>
<td>Unexploited – results remain recorded by school administrators</td>
<td></td>
</tr>
<tr>
<td>Letter Generation</td>
<td>Unexploited – letters and reports produced via the in-house system</td>
<td></td>
</tr>
<tr>
<td>Graduation</td>
<td>Unexploited</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Not exploited for strategic higher level analysis and reporting</td>
<td></td>
</tr>
</tbody>
</table>

Many of the above areas that remain unexploited represent a perceived source of benefit that is currently not brought to fruition. Failure to fully exploit system capabilities can be linked to a number of factors:-

- **Staff Knowledge and Resources:** Contributing factors are related to a lack of administrative staff knowledge of further system capabilities and the timeframe required for familiarity to be achieved. This is linked to the scaling back of project teams and the resulting training problem that
emerged in the ex post phase. The Institute explicitly cites the lack of resources as key in failing to explore the system’s fuller potential and implement further modules.

- **Ability to Meet Requirements**: The inability of some modules to meet requirements and lack of system tailoring by the national project board to meet IoT specific needs are further factors in the failure to capitalise on system capabilities. The national board largely has a phased approach for system development, which is restrictive for the urgent requirements of the Institute.

### 4.2 An examination of the extent of institute requirements met

The ability of the student MIS modules to meet requirements is significant in the Institute’s degree of system exploitation. The core MIS package capabilities did not ideally match the Institutes needs and required a more “Institute specific flavour”. The extent of requirements met by the baseline system is estimated by a managerial figure at 20%. Core functionality is too generic and deficit in reporting capabilities; hence the system is used primarily for data storage while all reporting, manipulating and controlling is done in-house on the additional custom-built system that suits specific needs. Table 5 outlines the extent to which the various modules meet the requirements of the Institute.

**Table 5: Extent of Requirements Met**

<table>
<thead>
<tr>
<th>Module</th>
<th>Requirements Met</th>
<th>Requirements Unmet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalogue</td>
<td>Meets past</td>
<td>Questions</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td>surround the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>future needs of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>semesterisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and modularisation</td>
</tr>
<tr>
<td>Approved Course</td>
<td>Does not meet</td>
<td>the demands of</td>
</tr>
<tr>
<td>Schedule (ACS)</td>
<td></td>
<td>modularisation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complex in handling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>elective subjects</td>
</tr>
<tr>
<td>Sections and Blocks</td>
<td>Meets</td>
<td>CAO reporting is</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td>external</td>
</tr>
<tr>
<td>CAO interface</td>
<td>Meets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td></td>
</tr>
<tr>
<td>Admissions</td>
<td>Meets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>requirements -</td>
<td></td>
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<tr>
<td></td>
<td>complimented by</td>
<td></td>
</tr>
<tr>
<td></td>
<td>in-house reports</td>
<td></td>
</tr>
<tr>
<td>General Person</td>
<td>Stores multiple</td>
<td>Does not cater for</td>
</tr>
<tr>
<td></td>
<td>names, addresses</td>
<td>custom data items</td>
</tr>
<tr>
<td></td>
<td>and historical</td>
<td>such as for</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>apprentices.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Navigation is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>complex</td>
</tr>
<tr>
<td>Examination</td>
<td>Meets past</td>
<td>Requires further</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td>development for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>modularisation.</td>
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<tr>
<td></td>
<td></td>
<td>Pre-broadsheet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>process which</td>
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<tr>
<td></td>
<td></td>
<td>compiles exam data</td>
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<tr>
<td></td>
<td></td>
<td>runs on an Institute</td>
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<td></td>
<td></td>
<td>basis and needs to</td>
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<td></td>
<td></td>
<td>be co-ordinated for</td>
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<tr>
<td></td>
<td></td>
<td>all Schools. No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>facility for</td>
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<tr>
<td></td>
<td></td>
<td>recording FETAC</td>
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<tr>
<td></td>
<td></td>
<td>results. Does not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>address pass by</td>
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<tr>
<td></td>
<td></td>
<td>compensation</td>
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<td></td>
<td></td>
<td>awards or failed</td>
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<tr>
<td></td>
<td></td>
<td>subjects elements.</td>
</tr>
<tr>
<td>Accounts Receivable</td>
<td>Meets past</td>
<td>Does not meet</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td>requirements. Small</td>
</tr>
<tr>
<td></td>
<td></td>
<td>changes in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>registration or a</td>
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<td></td>
<td></td>
<td>rate code result in</td>
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<td></td>
<td></td>
<td>incorrect</td>
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<tr>
<td></td>
<td></td>
<td>transactions on a</td>
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<tr>
<td></td>
<td></td>
<td>student’s account.</td>
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<td></td>
<td></td>
<td>Incompetent in</td>
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<td></td>
<td></td>
<td>handling student</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or Institute</td>
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<td></td>
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<td>invoicing.</td>
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<td>Addressed by in-</td>
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<td></td>
<td></td>
<td>house developments.</td>
</tr>
<tr>
<td>Maintenance Grants</td>
<td>Meets requirements -</td>
<td>custom built for</td>
</tr>
<tr>
<td></td>
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<td>Irish market.</td>
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<tr>
<td></td>
<td></td>
<td>Ensures grant</td>
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<tr>
<td></td>
<td></td>
<td>records are</td>
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<tr>
<td></td>
<td></td>
<td>consistent with student fee</td>
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<td></td>
<td></td>
<td>assessment rules and</td>
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<tr>
<td></td>
<td></td>
<td>rate codes</td>
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<tr>
<td></td>
<td></td>
<td>Contract assignment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>process is slow</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Marian Carcary, Ger Long, and Dan Remenyi

<table>
<thead>
<tr>
<th>Module</th>
<th>Requirements Met</th>
<th>Requirements Unmet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Generation</td>
<td>Does not meet requirements</td>
<td></td>
</tr>
<tr>
<td>Graduation</td>
<td>Does not meet requirements</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>FAS interface is unworkable. Aspirations for greater system automation, yet building blocks for online applications do not exist</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 The systems operations mismatch gap

From the above analysis, a degree of systems-operations mismatch between the capabilities of the system and the requirements of the Institute is apparent. This mismatch impacts on the extent to which the system can effectively serve student administrative needs. The ability to overcome the inconsistencies experienced depends on a number of factors:

- Site autonomy over the student MIS
- Degree of adherence to the common national standard versus in-house development.
- Degree of in-house development resource capability

**Site autonomy.** The ability of the Institute to overcome functional shortcomings and develop the system to meet specific requirements is restricted by limited site autonomy. Being under the remit of a national centralised project structure, it is restricted in its ability to customise the system due to the national requirement for a common standard and the need to submit requests for changes required.

**Degree of adherence to a common national standard versus in-house development.** IoTs under the remit of the central project structure are tied to a standard that can be supported on a national basis. However, the central development of the system to which one better matches the Irish education model is excessively slow. Development time for mission critical reports and for applications outside the full-time student population cohort is unacceptable and based on priority demand. Further, any development is generic rather than customised to IoT specifications. Hence, many IoTs have diverged to some extent from the common standard. This is primarily in developing external reporting capabilities that link to the MIS’s database. For example, the Institute has produced an advanced additional reporting system that involved developing/rewriting 200-400 made-to-measure reports in-house to meet day-to-day business needs. This divergence from the common standard has assisted in it benefiting from a more advanced implementation of the system than many other IoTs. In addition, these developments do not compromise the integrity of the student MIS as they are additional external developments as opposed to software customisations.

**Degree of in-house development resource capability,** while the existence of a technical MIS unit is advantageous, a lack of resources is apparent to a certain extent with the removal of functional team members. This disadvantages all organisational levels and:-

- Impacts on the Institute’s ability to advance the system for future projects such as modularisation and semesterisation, and tailor it for the different student cohorts now being attracted.
- Impacts on the extent to which unutilised functional modules can be further investigated and exploited.
- Impacts the extent to which staff can be trained in the greater capabilities of the system and to which more efficient ways of work can be found.

### 5. A review of the student MIS implementation

During the past four years, the Institute has benefited from an advanced system implementation. In many ways, successes experienced are a function of the effort expended on in-house development to compliment the MIS. The need for such development was due to a number of factors:

This project started poorly. The evaluation process for software selection was not optimal; criteria did not reflect an in-depth analysis of system capabilities or a reflection of variances between IoTs. Hence, there was a missed opportunity to streamline all IoTs towards a common mode of business. The lack of consultation and the absence of a statement of requirements from the IoT made necessary a large amount of additional work. There was limited formal vision as to the type and value of the benefits which could be derived from the introduction of the student MIS. It appears that the critical nature of reporting to the business of the Institute was not highlighted when the package was being considered.
It was a top down decision made at national government level to purchase and implement this specific student MIS. However, the system was not ideally matched to the Irish IoT, being Americanised and unintuitive in nature. This made necessary a large amount of in-house additional work. The system should have development work completed and reports in-built before it was rolled out to the sector. Some staff maintain that a custom-built system, centred on staff needs and priorities would offer greater advantage.

Despite the Department of Education’s desire to implement one common system, diversion in practice means that each IoT has its own specific customs. It is difficult to impose a common system on IoTs that emphasise different student offerings and ways of doing business. It is further difficult to impose such a system on one individual IoT where the nature of its courses differs greatly. The acquisition of one package for 14 different IoTs meant that the system would inevitably have inadequacies in each location. Even developments provided by the central project board served as a compromise, not accommodating exact Institute requirements. As one officer of the Institute said:-

“a system that was going to deal with more that just your own college, I suppose was never going to be ideal for you no more than it was going to be ideal for anybody else because it’s just the nature of the different ways the colleges all do their business”.

Some flexibility was required for tailoring towards Institute specific processes.

Development of requirements was sometimes slow with the result that many IoTs needed to produce their own solutions. With similar problems experienced, a greater pooling of resources among the IoTs would have provided for more timely developments.

Appropriate levels of end-user involvement and consultation did not take place. Consideration for current work practices did not occur. There was a feeling that the student MIS was imposed from top managerial levels and a greater level of communication to administrative staff was demanded:-

“it came in over night without anyone really having full warning”. This gave rise to greater levels of negativity and deterred against end-user buy-in.

Even when the project team was appointed it does not appear that it was properly staffed and resourced. It was continually pressurised to meet the deadlines of the national implementation schedule. The demand for a larger project team was more apparent here that within other IoTs due to its greater volume of in-house development. Management expectation of the implementation duration was too short. The functional project team members were also removed too early from the project. The disbandment of the functional team marked the end of on-going user training and training of staff filling new job roles.

The Institutes processes were never formally re-engineered to match the underlying model of the MIS. Hence, staff not only had to adopt a new system but had to change how they operated and introduce new practices.

The decision to centralise the servers in Dublin seems to have been made without any concern for the views of the IoT.

There is little understanding on a national level of the amount of on-going activity required to ensure project success. This is especially demonstrated by the lack of on-going training and resources for system development and support. Hence, system implementation and exploitation is slower.

Staff movement was critical during system stabilisation and remains so today. It should have been structured in a manner whereby staff had to remain in a specific functional area for a number of years, or were at least provided with specialist training for administrative job role changes.

6. Student MIS: A source of advantage or disadvantage

The student MIS is perceived as both a source of advantage and disadvantage. Some believe that greater benefit would be realised if a custom-built system for the Irish IoTs was developed. However, the MIS has improved the Institute’s operations significantly, providing an integrated platform and solid foundation for the future. It’s more structured and accurate information can be used for higher-level analysis and strategic purposes. The Institute has undoubtedly benefited from a more advanced implementation due to the extensive degree of in-house developments.

7. The way forward

Realising further rewards requires the Institute to focus on a number of tasks. Nationwide, there is need for greater resource investment. In
comparison with other IoTs, the Institute, through its MIS unit, has more resources to support the MIS. It needs to capitalise on this by re-introducing a functional team. It is disadvantaged at present in that no functional personnel remain to support administrative staff and processes. A full-time functional team is required to address queries, perform data checks, provide on-going training, exploit system capabilities and provide staff with greater understanding of the system. On-going staff training must be recommenced and a detailed user manual developed. This would enable greater functionality exploitation and provide for administrative personnel delivering an improved service to staff and students. The area of data integrity needs to be re-addressed. Following project team disbandment, some staff have lapsed in their data entry quality, with the result that data errors now exist. Further data checks need to be performed to maintain and improve integrity. Greater validation is demanded to combat mistakes. The functionality currently unused needs to be researched in depth to determine its value to the Institute. Functionality empowering academic staff to record their student results would reduce the workload on school administrators during exam time. This area needs to be implemented.

8. Conclusion

This paper discusses the significant impact had by the student MIS on the Institute since its implementation in 2002. It is clear that the system’s potential has not been fully exploited and its implementation was conducted under conditions which were not ideal. System usage is complimented by an extensive in-house custom-built system, as the MIS in many areas did not meet functional requirements and lacked in reporting capabilities. Reporting is a mission critical activity, which is today carried out almost entirely on the Institute’s in-house developments. As a result of this additional system, many areas of the baseline student MIS remain unused. This jeopardises to a degree the nationwide desire to maintain a common standard. To date, attention has focused on streamlining core operations; thus some peripheral functions are overlooked. Further benefits would be experienced in exploiting other modules as within the Institute there is significant desire to further automate manual administrative processes. This is particularly in the area of online applications such as student registration. The further exploitation of system potential will only occur however with the re-instatement of a functional team to support administrative staff and the provision of on-going training. This combined implementation offers the Institute significant potential going forward, provided the underlying data remains accurate. It offers the reward of strategic informational usage and analysis for greater planning and direction of Institute operations. This advanced implementation represents a key source of success in the arsenal of the Institute’s computerised support tools.

References

Auditing the Data Confidentiality of Wireless Local Area Networks

Peter Clutterbuck, Terry Rowlands and Owen Seamons
Business School, University of Queensland, Brisbane, Australia
p.clutterbuck@business.uq.edu.au
t.rowlands@business.uq.edu.au
o.seamons@business.uq.edu.au

Abstract: Wireless Local Area Networks (WLANs) provide many significant advantages to the contemporary business enterprise. WLANs also provide considerable security challenges for network administrators and users. Data confidentiality (ie, unauthorised access to data) breaches are the major security vulnerability within WLANs. To date, the major IT security standards from the International Standards Organisation (the ISO/IEC 17799) and the National Institute of Standards and Technology (the NIST Special Publication or ‘SP’ suite) have only a superficial coverage of WLAN security controls and compliance certification strategies. The clear responsibility for WLAN managers is to provide network users with best practice security strategies to mitigate the real risk of unauthorised data access. The clear responsibility for IT auditors is to ensure that best practice security practices are in place and that operational compliance is consistently achieved. This paper describes a newly researched software auditing artefact for the evaluation of the data confidentiality levels of WLAN transmissions – and therefore by extension for the evaluation of existing security controls to mitigate the risk of WLAN confidentiality breaches. The paper describes how the software auditing artefact has been evolved via a design science research methodology, and pivots upon the real time passive sampling of data packets as they are transmitted between mobile users and mobile transmission access points. The paper describes how the software auditing artefact uses these sampled data packets to produce a very detailed evaluation of the levels of data confidentiality in effect across the WLAN. This detailed evaluation includes specific identification (for network managers) of the types of software services operating across the WLAN that are not supported with the appropriate data confidentiality controls. The paper concludes by presenting an analysis of the results achieved during beta testing of the auditing artefact within a university production WLAN environment, together with a brief description of WLAN best practice security.

Keywords: Security, WLAN, confidentiality, auditing, 802.11.

1. Introduction

The use of computing and telecommunication technologies has revolutionised the design of business practices over the past two decades. Amongst these computing and telecommunication technologies wireless local area networks (WLANs) are increasingly providing significant advantages to the contemporary enterprise. The WLAN concept allows any data entry/retrieval device to be moved to any location within a mobile cell (defined as that geographical area in which the strength of the mobile signal ensures its easy recognition and consistent integrity). WLANs facilitate ready deployment, simplification of office infrastructure requirements, and adoption of mobile and nomadic work patterns. WLANs enable roaming employees to have access to applications and information on demand. WLANs also directly encourage the design of more streamlined business processes. The sales function can unfold at any location throughout the store via wireless connections between multiple point-of-sales machines linking with centralised order-processing servers (Dennis 2002). The sales function is also evolving via wireless networks to focus on the nomadic customer (Sabat 2002). The stocktaking function becomes more efficient when the relevant personnel are mobilised within warehouses and supermarkets and operate bar-coding devices to update centralised inventory lists via wireless connections. Many more examples of such efficiencies provided by WLANs are outlined in (Sabat 2002). All of these business process redesigns allow a more flexible customer-staff relationship and provide the basis for the rapidly emerging business paradigm of M-Commerce, defined as “any transaction with a monetary value either direct or indirect that is conducted over a wireless telecommunications network” (Sabat 2002). The business drivers outlined above have caused WLANs to become more pervasive (Tsalgatidou 2001). The Information Systems Audit and Control Association (ISACA) has stated that the use of Personal Digital Assistants (PDAs) is widespread and is likely to increase. Dataquest has recorded that worldwide PDA shipments were 11.4 billion units in 2004. These demand trends in turn have caused the cost of WLAN adoption to drop by significant margins.

Confidentiality is an essential network security quality of service parameter. Confidentiality is defined in ISO/IEC 27001 as “the property that
information is not made available or disclosed to unauthorised individuals, entities, or processes.” ISO/IEC 27001 and (Garfinkel 2002) state that confidentiality must be assured (where relevant) for all network transmissions. WLANs pose a confidentiality vulnerability not usually encountered with guided (ie, wired) networks. This vulnerability occurs because wireless signal spread is physically dictated by the cell concept and not necessarily by the architectural design of business accommodation or the availability of wired access points. Consequently a wireless signal can ‘leak’ past the physical perimeter of a business enterprise and into public airway space. This same signal leakage may also occur within the sizable public contact areas provided by many businesses within their infrastructure perimeter. This scenario offers significant opportunity for the unauthorised and non-detectable introduction of wireless devices within the wireless cell space of an enterprise. These wireless devices are then the launching pad for confidentiality attacks on the business network. These attacks, known as “Drive by Hacking” are well described in (Hinde 2001).

The motivation for the research described in this paper is the design and testing of an innovative software auditing artefact that evaluates the data confidentiality levels of WLAN transmissions – and therefore by extension mitigates the risk of WLAN confidentiality breaches. The paper describes how the software auditing artefact has been prototyped via a design science research methodology (Hevner 2004), and operationally pivots upon the real time passive sampling of data packets as they are transmitted between mobile users and mobile transmission access points. The software auditing artefact uses these sampled data packets to produce a very detailed evaluation of the levels of data confidentiality in effect across the WLAN. This detailed evaluation includes specific identification (for network managers) of the types of software services operating across the WLAN that are not supported with the appropriate data confidentiality controls. This paper unfolds in the following format. Section two discusses WLAN protocol design and describes why this design proves to be problematic in terms of data confidentiality. Section three discusses the design science research methodology and the conceptual design of the software auditing artefact produced via the methodology. Section four presents an analysis of the results achieved during beta testing of the auditing artefact within a university production WLAN environment. Section five describes best practice security solutions for a WLAN environment. Section six concludes the paper.

2. WLAN overview

The major wireless standards are published by the Institute of Electrical and Electronics Engineers (IEEE). IEEE802.11 (WLAN) has become more popular than other protocols (eg the European Telecommunications Standards Institute’s High Performance Radio Local Area Network) defined within an overall WLAN context (Frankel 2006). The IEEE 802 wireless suite also defines a range of protocols for other wireless network topologies. The Wireless Personal Area Networks (WPAN) topology describes small-scale wireless networks that require little or no infrastructure (Sabat 2002). A WPAN is typically used by a few devices in a single room (eg, print service, keyboard or mouse connectivity). WPAN standards include 802.15.1 (Bluetooth), 802.15.3a (Ultrawideband) and 802.15.4 (ZigBee). The Wireless Metropolitan Area Network (WMAN) topology provides connectivity to users located in multiple facilities that are generally within a few miles of each other. IEEE 802.16 (better known as WiMAX) is a WMAN standard. IEEE 802.11 is well suited for most intra-office wireless networking scenarios and has become dominant within the WLAN market (Gast 2005). IEEE 802.11 is the WLAN protocol under analysis in this research. This section will firstly present an overview of 802.11, and then analyse the 802.11 security focus.

2.1 IEEE 802.11 overview

The initial IEEE 802.11 standard (also know as Wireless Fidelity or Wi-Fi) was published in 1997. That standard has since been updated in 1999 and 2003. The current standard has been accepted by the American National Standards Institute (ANSI) and has also been adopted by the International Organisation for Standardisation (ISO) as ISO/IEC 8802-11:2003. The IEEE 802.11 standard uses the Media Access Control (MAC) protocol Carrier Sense Multiple Access with Collision Avoidance. An overview 802.11 bandwidths, frequency spectrums, and release timetables is shown in Table 1.
Table 1: Summary of IEEE 802.11 WLAN technologies

<table>
<thead>
<tr>
<th>IEEE Standard</th>
<th>Maximum Data Rate</th>
<th>Typical Range</th>
<th>Frequency Band</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11</td>
<td>2 Mbps</td>
<td>50-100 metres</td>
<td>2.4 GHz</td>
<td>Not compatible with 802.11b; more expensive to implement than 802.11b</td>
</tr>
<tr>
<td>802.11a</td>
<td>54 Mbps</td>
<td>50-100 metres</td>
<td>5 GHz</td>
<td></td>
</tr>
<tr>
<td>802.11b</td>
<td>11 Mbps</td>
<td>50-100 metres</td>
<td>2.4 GHz</td>
<td>Equipment based on 802.11b has been the dominant technology</td>
</tr>
<tr>
<td>802.11g</td>
<td>54 Mbps</td>
<td>50-100 metres</td>
<td>2.4 or 5 GHz</td>
<td>Backward compatible with 802.11b</td>
</tr>
</tbody>
</table>

Table 1 does not include all current and pending 802.11 amendments. For example, in November 2005, IEEE ratified IEEE 802.11e, which provides quality of service enhancements to IEEE 802.11 that improve the delivery of multimedia content. The IEEE 802.11n project is also currently considering four proposals for IEEE 802.11 enhancements that will enable data throughput of at least 100 Mbps.

2.2 802.11 security

The IEEE 802.11 variants listed in Table 1 all include a security architecture known as Wired Equivalent Privacy (WEP). The fundamental goal of WEP was to provide a level of security comparable to that of wired LANs. The design of WEP assumed the major categories of threats facing the WLAN paradigm were identical to those posed to guided (ie, wired) LAN networks. Consequently the design of WEP focused upon providing authentication, confidentiality, and integrity controls for all transmissions between a wireless user and a WLAN access point. It should be noted that the designers of the original 802.11 standard only ever intended WEP to make it difficult to break into a WLAN – the designers did not intend WEP to provide military levels of access. Section 8.2.2 of the 1999 IEEE 802.11 standard states the following in relation to 802.11 WEP design objectives (quoted verbatim):

- It is reasonably strong: The security afforded by the algorithm relies on the difficulty of discovering the secret key through a brute-force attack. This in turn is related to the length of the secret key and the frequency of changing the keys. WEP allows for the changing of the key (K) and frequent changing of the Initialisation Vector (IV).
- It is self synchronising: WEP is self-synchronising for each message. This property is critical for a data-link-level encryption algorithm, where “best effort” delivery is assumed and packet loss rates may be high.

- It is efficient: The WEP algorithm is efficient and may be implemented in either hardware or software.
- It may be exportable: Every effort has been made to design the WEP system operation so as to maximise the chances of approval, by the U.S. Department of Commerce, of export from the U.S. of products containing a WEP implementation. However, due to the legal and political climate toward cryptography at the time of publication, no guarantee can be made that any specific IEEE 802.11 implementations that use WEP will be exportable from the USA.
- It is optional: The implementation and use of WEP is an IEEE 802.11 option.

In retrospect, the designers’ goal of a “reasonable” level of security was a mistake (it should be noted that the work “reasonable” was dropped in the marketing campaign for the initial promotion of IEEE 802.11 – and WEP was simply described as “secure”). The contemporary security community promotes only two types of security: strong security and no security (sometimes described as open security). The WEP design proved to be inadequate for one main reason: the relative ease of intercepting WLAN transmissions (and also inserting spoofed transmissions into the transmission stream). This relative ease of interception is caused by the omni-directional transmission propagation of a WLAN as contrasted with the constrained/guided transmission propagation of a traditional LAN. This means that an attacker in a WLAN simply needs to be within range of the WLAN infrastructure (ie, a wireless sender or receiver), whilst in the wired LAN an attacker would need to gain physical access to the LAN (ie, physical access to a wired connection point). The security consequence is clear: a WLAN is more vulnerable to confidentiality breaches (eg, eavesdropping) than a traditional guided/wired LAN.

WEP uses the well regarded RC4 symmetric encryption algorithm to mitigate the confidentiality
risk inherent in WLAN transmissions. The WEP standard specifies that the symmetric key used within WEP-implemented RC4 should include a 24-bit value known as an initialisation vector (IV). It is this value that has caused much of the security concern that has since been documented about WEP. As early as 2001 (Fluhrer 2001) showed via experiment that an eavesdropper could deduce the base RC4 key by obtaining a relatively small number of packets within a WLAN communication session. Shortly after (Stubblefield 2002) reported that the experimental approach of Fluhrer (2001) had been used to mount a successful attack against a production WLAN system. Many more successful WEP attacks have been since described (Airmagnet 2004). (Cam-Winget 2003) summarised the security community’s assessment of WEP by stating: “The security goal of WEP is data confidentiality equivalent to that of a wired LAN. WEP fails short of this objective…” The vulnerabilities within WEP are further exposed by the emergence of a suite of open source WEP-cracking software tools (Ossman 2004).

The IEEE response to the WEP vulnerabilities was the formation of the 802.11i (Security) group, a body charged with the total overhaul of security within 802.11. The 802.11i group’s security review, however, would prove to be a long term project over several years. As an interim security measure, a non-profit industry consortium of WLAN equipment and software vendors (the Wi-Fi Alliance) began work on a more robust WLAN security specification in 2002. In October 2002 the Wi-Fi Alliance released the first specification of a body charged with the total overhaul of security within 802.11. The 802.11i group’s security review, however, would prove to be a long term project over several years. As an interim security measure, a non-profit industry consortium of WLAN equipment and software vendors (the Wi-Fi Alliance) began work on a more robust WLAN security specification in 2002. In October 2002 the Wi-Fi Alliance released the first specification of a body charged with the total overhaul of security within 802.11. The 802.11i group’s security review, however, would prove to be a long term project over several years. As an interim security measure, a non-profit industry consortium of WLAN equipment and software vendors (the Wi-Fi Alliance) began work on a more robust WLAN security specification in 2002. In October 2002 the Wi-Fi Alliance released the first specification of 802.11i standard, the Wi-Fi Alliance specified WPA2 in September 2004 to completely comply with the IEEE 802.11 standard as amended by IEEE 802.11i. Official support for WPA2 in Microsoft Windows XP was rolled out on 1st May 2005 (some driver upgrades for network cards may be required). As from March 13, 2006, WPA2 certification is mandatory for all new devices wishing to be Wi-Fi certified.

3. Research experiment overview

The motivation for the research experiment described in this paper is the design and testing of a software auditing artefact that evaluates the data confidentiality levels of WLAN transmissions. This section will firstly discuss the design science framework that has been adopted as the research methodology for this experiment. The section will then describe the logical design and network positioning of the software audit artefact that was prototyped during the experiment.

3.1 Research methodology

Design science is one of the two paradigms (the other being behavioural science) that characterise much of the research in the Information Systems discipline (Hevner 2004). In the design science paradigm, knowledge and understanding of a problem domain and its solution are achieved in the building, application, and evaluation of a designed artefact. (Hevner 2004) differentiates design science from routine design by stating: “The difference is in the nature of the problems and solutions. Routine design is the application of existing knowledge to organisational problems… On the other hand, design-science research addresses important unsolved problems in unique and innovative ways or solved problems in more effective or efficient ways. The key differentiator between routine design and design research is the clear identification of a contribution to the archival knowledge base of foundations and methodologies.” In addition to the crucial differentiation between routine design and design research, (Hevner 2004) proposes the following heuristics to assist the research community in understanding the requirements for effective design science research:

In June 2004 the IEEE finalised the 802.11i standard – specifying security components that work in conjunction with all Table 1 standards. The IEEE 802.11i standard includes many security enhancements that leverage existing mature and proven security protocols. The 802.11i standard introduces the concept of a Robust Security Network (RSN), which is defined as a communication association/session between two WLAN entities that fully implement 802.11i. An RSN provides verifiably strong security in the areas of confidentiality, integrity, availability, and access control. The 802.11i standard takes a two-track approach to addressing the security weaknesses that had existed within WEP. Its major components are two new link-layer encryption protocols. The first, the Temporal Key Integrity Protocol (TKIP) was designed to bolster security to the greatest extent possible on pre-802.11i hardware. The second, Counter Mode with CBC-MAC Protocol (CCMP) is a new encryption protocol designed from the ground up to offer the greatest level of security. The 802.11i standard is industry-accepted as strong security (Gast 2005). In conjunction with the ratification of 802.11i, the Wi-Fi Alliance specified WPA2 in September 2004 to completely comply with the IEEE 802.11 standard as amended by IEEE 802.11i. Official support for WPA2 in Microsoft Windows XP was rolled out on 1st May 2005 (some driver upgrades for network cards may be required). As from March 13, 2006, WPA2 certification is mandatory for all new devices wishing to be Wi-Fi certified.
Design science research requires the creation of a purposeful artefact for a specified problem domain.

- The artefact is represented in a structured form that may vary from software, formal logic, and rigorous mathematics to informal natural language descriptions.
- The artefact must yield utility for the specified problem, and this utility must be evaluated. The artefact must be innovative – solving a heretofore unsolved problem or solving a known problem is a more effective way.
- The artefact must be rigorously defined, formally represented, coherent, and internally consistent.
- The design process should comprise a ‘build-and-evaluate’ loop that is typically iterated a number of times before the final artefact is generated.
- The research results must be communicated effectively.

Design science – and all heuristics outlined above – have been used to produce the audit software artefact described in the next section.

### 3.2 Audit software artefact logical design and network positioning

The audit software artefact produced within this research is designed to evaluate the data confidentiality levels of WLAN (802.11) transmissions. The network positioning of the artefact and its logical design is now discussed with reference to Figure 1.

Figure 1: Audit software tool – Network positioning and logical architecture

Figure 1 shows a typical WLAN within an overall context of a wired (guided) LAN and Internet connectivity. The WLAN comprises one or more wireless access points (APs) which in turn wire back to the wired LAN backbone. The wired LAN backbone itself connects to the Internet via one or more routers. The WLAN reception boundary (from each AP) is within the range 50 – 100 metres. The only positioning requirement for the audit software is that its host (routinely a wireless enabled laptop) is within the reception boundary of a targeted AP. All mainstream operating systems (e.g., Windows XP) routinely report WLAN signal strength to the nearest AP – this is a ready guide to the appropriate positioning of the audit tool.

The overall logical design of the audit tool comprises a low level Copy Engine and a higher level Analysis Engine. The Copy Engine places the wireless network card of the host into RFMON mode – thereby ensuring the network card captures all WLAN packets (i.e., control, management, and data packets) as they are transmitted between mobile users and mobile transmission access point. The Copy Engine is a Win32 Open Source port of libpcap – a widely used network programming Application Programming Interface (API) for...
capturing/imaging network packets (within wireless and wired networks). The Copy Engine may be configured to operate on a temporal sessional basis (i.e., copying packets for a defined time period) or on a packet count sessional basis (i.e., copying packets until a defined count is reached). The captured network packets are then saved to file storage for subsequent processing by the Analysis Engine. The Analysis Engine comprises three main categories of software: a read module (the input of data from file storage), a suite of protocol analysers, and a logger module (the output of data to file storage). The heart of the Analysis Engine is the suite of protocol analysers which process the captured network packets (imaged by the Copy Engine) with a logic and sequence which is now described with the assistance of Figure 2.

**Figure 2:** Packet structure and protocol analysers

Figure 2 shows the structure of the generic data packet which is of most interest to the audit tool of this research. The audit tool views each packet as a bit stream comprising a series of headers and data payload. This structure follows the Open Systems Interconnection (OSI) model from the International Standards Organisation (ISO). The 802.3 Ethernet header is not always present – it only occurs where the wireless transmission forms a ‘bridge’ between wired (Ethernet) LANs (the audit tool however must allow for this possibility). The Analysis Engine uses each protocol analyser in two ways: (1) to test certain bit/byte values in the appropriate header; and (2) to search for the occurrence of certain string (i.e., text) values within the data payload. A highly abstracted algorithmic description of the operation of the Analysis Engine and each protocol analyser is as follows:

**INITIALISATION:** Set all global count variables uses in statistically reporting this set of WLAN transmissions to 0. The global count variables are as follows:

TOTAL: The total number of packets analysed in this sample.

OPEN-HTTP-AUTHENTICATION: Indicates Basic Authentication (part of the HTTP protocol) has been used. Basic Authentication effectively transmits passwords in plain text and is therefore breaches confidentiality best practice.

OPEN-HTTP: Indicates HTTP is carrying plain text (or MIME encoded) payload.

WEAK: Indicates WEP encryption (i.e., static keys) has been used.

STRONG-IPSEC: Indicates Encapsulating Security Payload (ESP) – the encryption protocol of IPSec (IP Security). The dominant protocol used within Virtual Private Networks (VPNs)

STRONG-KERBEROS: Major authentication protocol – all credentials are strongly encrypted.

STRONG-TLS/SSL: SSL (Secure Socket Layer) is the major security protocol – used heavily with HTTP. TLS (Transport Layer Security) is the IETF standardised version of SSL.

STRONG-S/MIME: S/MIME (Secure MIME) is the dominant protocol for email security. S/MIME uses a specifically defined mime type ("pkcs7-mime") to carry encrypted data.

OPEN-MS-FILE-TRANSFER: Indicates the presence of a Microsoft File System transfer via Server Message Block (SMB) over NetBios and TCP.

**LOOP:** For the next packet imaged by the Copy Engine do the following:

- **Step 1:** Is the packet a data frame (i.e., not a WLAN control or management frame).
  - NO - increment TOTAL by 1 and return to LOOP.
  - YES – is the protected bit set?
    - YES - increment WEAK-WEP and TOTAL counts by 1.
Discard the packet and return to LOOP.

o NO - continue to next step.

- Step 2a: Does the packet contain an IP header? NO, increment the TOTAL global count by 1. Discard the packet and return to LOOP (the audit is not interested in non-IP protocol packets – these cannot carry user data (eg, protocols such as ICMP, IGMP, ARP). YES – continue to next step.

- Step 2b: Does the IP header show the protocol field is set to IPSec encryption? That is, protocol field is set to 50 indicating Encapsulating Security Payload (ESP)? YES, increment STRONG-IPSec and TOTAL by 1. Discard the packet and return to LOOP. NO – continue to next step.

- Step 3: Does the TCP/UDP header show the port field contains any one of the following values:

  88 (Kerberos authentication port) – increment STRONG-Kerberos and TOTAL by one – return to LOOP.
  443 (HTTP over TLS/SSL) – increment STRONG-TLS/SSL and TOTAL by one – return to LOOP.

- Step 4: Does the TCP header show the port field contains any of the following values:

  25 (SMTP email) – does the data payload contain the string “pkcs7-mime”?
    YES - increment STRONG-SMIME and TOTAL by one – return to LOOP.
    NO – increment OPEN-SENDING-EMAIL and TOTAL by one – return to LOOP.
  80 (HTTP) – does the (HTTP) data payload contain the string “Basic”?
    YES – increment OPEN-HTTP-AUTHENTICATION and TOTAL by one – return to LOOP.
    NO – increment OPEN-HTTP and TOTAL by one – return to LOOP.
  110 (POP email) – does the data payload contain the string “pkcs7-mime”?  
    YES – increment STRONG-SMIME by one – return to LOOP.
    NO – increment OPEN-RECEIVING-EMAIL by one – return to LOOP.

END LOOP – all packets have been analysed – call the logger module to output results.

The logger will output two audit reports that will be discussed in the next section.

4. Research evaluation

The overall evaluation of the software audit tool is made against two critical success factors: innovation and utility.

4.1 Innovation

The discussion of Section 3 presented innovation as a major criterion in classifying good design science research. (Hevner) outlined innovation as follows:

“design-science research addresses important unsolved problems in unique and innovative ways or solved problems in more effective or efficient ways. The key differentiator between routine design and design research is the clear identification of a contribution to the archival knowledge base of foundations and methodologies”.

The problem domain (confidentiality within WLANs) for this research is not new. Confidentiality is considered historically as a fundamental focus (with authentication and integrity) within IT security (Garfinkel 2002). Section 2 has also described the evolution over several years of WLAN confidentiality controls. The literature review conducted with this research, however, has verified that no existing confidentiality audit compliance controls for WLANs have been based on software-automated real time packet analysis. (The heavily used packet monitoring tools Ethereal and tcpdump are very much designed for network administrator manual analysis of packet characteristics). Indeed the increasing influential ISO/IEC 17799 (the Information Security policy control instrument) and ISO/IEC 27001 (the Information Security compliance certification instrument) still exhibit only very superficial coverage of WLAN security compliance. It is also noted that the real time packet analysis methodology of this research fits very well with IS security audit best practice as described in ISO/IEC 27001. That is, the audit
methodology within this research is non-intrusive to network productivity/bandwidth, resistant to attack, and active in identifying control weaknesses (as contrasted with a reactive audit strategy whereby the absence of attacks – not the absence of weaknesses – is reported).

4.2 Utility

The utility of this research will be discussed in terms of the results returned via the beta testing of the audit tool within a university WLAN environment. The results from the audit tool comprise two main reports: (1) a statistical overview of confidentiality levels (Table 2); and (2) a detailed report of those transmissions where non-secured user data has been detected (Table 3).

Table 2: Statistical overview of WLAN confidentiality levels

<table>
<thead>
<tr>
<th>Confidentiality Level (1, 2, or 3)</th>
<th>Total Packets</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Open system (no encryption)</td>
<td>93897</td>
<td>NetBios and SMB, HTTP Authentication, HTTP Plain, SMTP Email, POP/IMAP Email</td>
</tr>
<tr>
<td>2 Weak Encryption</td>
<td>8345</td>
<td>Wired Equivalent Privacy (WEP)</td>
</tr>
<tr>
<td>3 Strong Encryption</td>
<td>57945</td>
<td>IPSec (Layer 3), SSL/TLS (Layer 4), Kerberos (Layer 7), S/MIME (Layer 7)</td>
</tr>
</tbody>
</table>

Table 2 shows the overall results of beta testing the audit tool over twenty-four sampling sessions (each session of 30 minutes). A total of 160187 transmissions were sampled of which nearly 59% (93897) were open transmissions. Within the ‘open’ category there were 792 network file system transfers, and a total of 1084 email transfers. Perhaps of most concern were the 1897 passwords transferred unsecured via HTTP Authentication. The dominant form of strong encryption was via IPSec (most likely across a VPN).

Table 3: Detailed transmission report of non-secured user data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Vulnerability Type</th>
<th>Client Address (IP:Port)</th>
<th>Server Address (IP:Port)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 May 06</td>
<td>12.56pm</td>
<td>HTTP Auth.</td>
<td>192.168.12.87:12389</td>
<td>192.168.2.3:80</td>
</tr>
<tr>
<td>3 May 06</td>
<td>12.59pm</td>
<td>SMTP</td>
<td>192.168.12.87:13567</td>
<td>192.168.2.4:25</td>
</tr>
<tr>
<td>3 May 06</td>
<td>1.43pm</td>
<td>SMTP</td>
<td>192.168.12.87:13568</td>
<td>192.168.2.4:25</td>
</tr>
<tr>
<td>3 May 06</td>
<td>1.51pm</td>
<td>POP</td>
<td>192.168.12.68:11324</td>
<td>192.168.2.5:110</td>
</tr>
</tbody>
</table>

Table 3 shows a small sample of four entries from the detailed transmission report of non-secured data. The report identifies the vulnerability type and also the client/server addresses (both IP and port). This detailed transmission report provides (at least) one main security purpose. The report identifies the server that is involved in creating the vulnerability. For example, entry 1 in Table 3 shows that a web server is still serving web pages under HTTP Authentication (ie, plain text exchange of passwords). This should not occur in a secure production environment – the preferred strategy is to always request authentication within an SSL session. It is also apparent that the detailed report provides very useful trend information.

5. Best practice

The previous sections of this paper have highlighted the chequered development of WLAN security. Whilst the most recent 802.11i/WPA2 security specification is considered strong (Gast 2005), it is also clear that the take-up of this specification requires the upgrading of network card hardware. Additionally, 802.11i is a complex specification and its full adoption within any network requires a system administrator to focus upon design issues at several levels (i.e., the data link layer, network layer, transport layer, and the application layer). This complexity is clearly a significant challenge to administrators and network owners. Within this context of relatively slow transitional progress to full 802.11i / WPA2 adoption, this section will now focus on best practice in the two main areas of WLAN
deployment: (1) public wireless hotspots and (2) corporate networks (offering WLANs).

5.1 Public wireless hotspots

WLAN technology was developed about the same time that the Internet was expanding rapidly. It is not surprising that the two technologies have become closely linked. A public wireless hotspot is any location (e.g. airport, hotel, coffee shop) where any person with 802.11 hardware capability can legitimately connect to an access point (possibly for a paid fee) and receive broader network/Internet connectivity. Whilst this may prove to be a rich service delivery model in the near future (in principle it means that 802.11 could compete with the existing cellular phone infrastructure), the service model adoption has proven to be problematic for two main reasons (Edney 2004): the fax machine problem (i.e. a lack of user ‘critical mass’) and also the multiparty barrier problem (i.e. multiple stakeholders combining to deliver the service and each/every stakeholder requiring healthy financial returns). Notwithstanding the service model growth challenges, it is important to appreciate the organisation of public wireless hotspots – and the consequential security implications. The logical organisation of public wireless hotspots is shown in Figure 3.

![Figure 3: WLAN hot spot organisation](image)

The subscribers and access point equipment shown in Figure 3 are standardised IEEE 802.11 equipment. This means that the hot spot organisation is based very much upon a “no new hardware/software” paradigm – hot spot users/subscribers are most reluctant to use any hotspot service that requires specialised hardware installation or software downloads (Edney 2004). Typically the subscribers and access points do not use any data link layer encryption (i.e. no WEP or RSN/WPA2 security). The hotspot controller of Figure 3 is the critical infrastructure in the overall WLAN hotspot operation. Typically the hotspot controller will perform the following functions:
- Coordinate user authentication
- Collection of account and billing information
- Collation of usage time and subscription time statistics

- Provision of local IP addresses
- Access to World Wide Web services
- Access to Domain Name Services

The authentication server of Figure 3 is typically accessed and facilitated via Web protocols. The most common approach to date is to require user login via a Web page. This approach requires the subscriber to connect/associate with an access point and start his/her Web browser. The first Web request initiated from the browser will be directed by the hotspot controller to the authentication server. The authentication server will complete the necessary login process – and from this point on (subject to certain subscription time settings) each user web request will then be routed to the appropriate destination service by the hotspot controller. The security implications for WLAN hotspot users centre very much upon the
confidentiality risks posed by open security (i.e. no data link layer encryption) IEEE 802.11 deployment. The most direct confidentiality risk is the passive viewing of private or commercially sensitive data during transmission across the (hotspot) WLAN – this has been evidenced within our audit tool beta testing described in Section 4 of this paper. A second important risk shown up within our research is the active attack against the shared file system of a WLAN user. Many popular operating systems (including Windows XP) provide default share directories. The operating system will ‘advertise’ the shared directory via network broadcasts and this strategy provides a most popular method of sharing data for small businesses and home users. These network advertisements pose a serious security risk when a subscriber commences a WLAN hotspot session without firstly ‘unsharing’ the shared data repository. The WLAN hotspot security risks outlined above are best mitigated at the present time via personal firewalls and virtual private networks (VPNs) – and in the future via the deployment of IEEE 802.11i. A personal firewall operating on a subscriber’s computer can easily be configured to allow only TCP/IP packets to exit/enter the subscriber’s computer. This protocol suite is required for Internet/Web use – but does not routinely facilitate LAN based computer-to-computer communication (which includes directory sharing). This should manage the risks posed via shared file systems. A VPN creates an encrypted tunnel through any network that is considered to be unsecured (i.e. the Internet). A typical use for a VPN tunnel is to connect an employee to their company’s intranet. The VPN encrypts all TCP/IP communications whilst those communications are traversing the unsecured network(s). The VPN concept is most useful when a subscriber wishes to communicate with only one destination (e.g. the corporate network) – but is problematic if communication is required concurrently with several destination networks. The most comprehensive (but still a future focused) solution for hotspot WLANs will be the broad-based adoption of IEEE 802.11i. This solution will leverage built-in operating system support to allow the subscriber to choose the most suitable form of user-authentication and data link layer encryption – and thereby mitigate the confidentiality risks to within acceptable levels.

5.2 Corporate networks WLAN deployment

The best practice deployment of a WLAN within (onto) a corporate network requires two conceptual steps to ensure a professional level of protection:

- Isolate (potentially) hostile traffic from all sensitive corporate traffic and canalise (i.e. force traffic down a well defined route) this traffic through a small set of well protected and comprehensively logged fixed entry points.

- Deploy defence in depth via (1) the authentication of all traffic using an access point and (2) the strong encryption of all data transferred between each WLAN client and each access point.

The ultimate implementation of the above points would also create a firewall within each WLAN access point. However this solution does not scale well – and may mean an unsupportable level of work within the context of a corporate network. A more scalable solution is now discussed with respect to Figure 4.
Figure 4 shows that the isolation of (potentially) hostile traffic is achieved via the use of corporate switches to create a Virtual Local Area Network (or VLAN) as per IEEE 802.10. The alternative to a VLAN is to run new LAN cables to all access points and create a single new LAN – however this solution is not optimal in terms of time and cost. Whilst the VLAN solution is still vulnerable to several attack vectors (including ARP spoofing), it is still clearly preferable to allowing traffic from access points to intermix with other corporate traffic. The canalisation of (potentially) hostile traffic is then achieved (as shown in Figure 4) via the deployment of a firewall at the point at which VLAN (and therefore WLAN) traffic enters the corporate wired LAN. The second conceptual step for strong security is the creation of defence in depth – comprising data link layer strong encryption (for confidentiality) and access control. The strong encryption is implemented via RSN/WPA2 security operating between each wireless access client and each access point. The access control is achieved using the IEEE (access control) 802.1X and suitably constructed X.509 digital certificates operating across each wireless client, each access point, and a corporate Radius server.

Conclusions

The clear responsibility for WLAN administrators is to provide network users with best practice security strategies to mitigate the real risk of unauthorised data access. The clear responsibility for IT auditors is to ensure that best practice security strategies are in place and that operational compliance is consistently achieved. WLAN security is complicated by the open nature of the wireless signal propagation which in turn creates a confidentiality vulnerability. The development of WLAN protocols with robust confidentiality controls (ie, encryption) has been problematic. Indeed it is only very recently that a verifiably robust solution has been specified (802.11i) – and this solution will take time to roll out across WLAN services and users. Best practice security strategies for WLANs are routinely agreed within the IT industry (Garfinkel 2002) to comprise strong data encryption of transmitted packets. In the general WLAN transmission case, this strong encryption may be provided by 802.11i (layer 2) or VPNs based on IPSec (layer 3). Higher level (ie, layer 4 and above) more specific encryption solutions centre upon SSL/TLS for HTTP, Kerberos for secure authentication, and S/MIME for secure email. It remains very unclear within the IT industry, however, as to how the level of WLAN operational compliance with these best practice methods may be gauged and reported. This research has developed a software audit tool to analyse the level of confidentiality within a production WLAN system. The audit tool is innovative, non-intrusive on network productivity/bandwidth, controlled against attack, and active in its analysis and reporting of security vulnerabilities.
References


IT Evaluation Frameworks – Do They Make a Valuable Contribution? A Critique of Some of the Classic Models for use by SMEs

Pat Costello, Andy Sloane and Rob Moreton
University of Wolverhampton, U.K.
p.costello@wlv.ac.uk
a.sloane@wlv.ac.uk
r.moreton@wlv.ac.uk

Abstract: Given the plethora of frameworks and models available in this area, not all could be evaluated here. This paper takes seven popular frameworks and examines aspects of IT evaluation with particular emphasis on Small to Medium Enterprises (SMEs). The frameworks were selected from the most well known of IT evaluation research including Delone and McLean, 1992, Seddon et.al. 1999, Farbey et.al, 1999, Levy et.al., 1998. Most of the frameworks were developed for large organisations and therefore those chosen were evaluated for their applicability to the world of SMEs. These are categorised into four areas: people issues, technology focus, evolutionary position and management aspects. The conclusion is reached that the use of a multi-framework is needed for all organisations. This presents severe difficulties in larger organisations, as the problems of communications can be a stumbling block to completing the evaluation. However, this paper proposes that SMEs may find it easier to take parts of ‘tested’ frameworks used by larger companies and apply them. The communication links within SMEs are neither as complex nor as highly developed as in large organisations that may make this an appropriate approach.

Keywords: IT evaluation, IT Value, SMEs, frameworks, models.

1. Introduction

Thornton (1997) states that when it comes to measuring the value of IT that the commercial world is split into three, those that view under-performing IT investments as a problem; those that view under-performing IT investments as a defining condition of the complex world we live in and those that are in denial that IT moneys are not being wisely spent. This at least tells us that there is a major problem as far as defining the value of IT investment is concerned. Large organisations have for many years wrestled with the problem of evaluating their IS / IT and attempting to justify the implementation of the latest project to the Finance Director. So far they have had very little success in this area. The most lasting observation is that it is not possible to cost the total impact of an IT project. Researchers have also brought vast amounts of methodologies, frameworks, models and discussions to the debate. A review of IT value articles (Chan, 2000) provides strong evidence of a schism between the use of quantitative and qualitative measures in IT-value research. There is a real need for a framework that encompasses all of the aspects recognised as relevant in the “Great Information Systems Benefit Hunt” (Farbey et. al., 1993). Many Information Systems (IS) researchers have turned their attention in recent years to study SMEs and their use of IT (Ballantine, 1998, Dans, 2001, Kingswell,1999, Levy et. al., 1998). SMEs form a very important part of UK and European business and have the ability to impact in a major way on customers and suppliers.

IS theorists believe that IT investment should be made in the context of IS / IT strategy and should support business strategy (Galliers et. al., 1987). However SMEs generally lack strategic planning as a management tool (Anderson and Lawrie, 2001) and this alone will have a major impact on their decisions. The tendency in most SMEs is to view IT investment as a cost (Levy et. al., 1998) and to expect it’s application to reap short-term benefits with little thought to long-term value. Levy and Powell (1999) found that only one SME in a survey of twenty-five demonstrated that IT /IS can add value in the same way as in larger organisations. At one end of the scale very little use is made of strategic information from Information Systems (IS) in SMEs, whilst some recent start up companies are totally dependent on IS for their existence. Levy et. al., (1998) claim that IT investment in the latter can be very high initially, but then declines as the lack of resources prevalent in all SMEs become apparent. In the study it was shown that industry sector had no impact on the findings. Should SMEs measure the effect of IT at all? There are those who believe that there is little point as many of the benefits are so intangible as to be incalculable. SMEs in particular tend to believe that technology will improve matters and do not always address the process improvements, trying instead to automate
the existing ones. Remenyi et. al. (1991) state that the search for the 'IT effectiveness metric is the modern day equivalent of the Holy Grail', Ryan and Harrison (2000) and Dans (2001) echo this. Remenyi (1991) postulates that as organisations reach higher levels of maturity in their use of IT, evaluation becomes increasingly more important to senior managers. Many SMEs have yet to reach that level of maturity. Most SMEs are looking for short-term improvements to operational performance. They lack "the ability to strike a balance between long-term development and short-term operational pressures" (Anderson and Lawrie, 2001).

Socio-technical factors are an important part within the more widely accepted evaluation frameworks. Many researchers (Brynjolfsson and Hitt, 1996) have called for additional research to identify "hidden costs and benefits" that are not necessarily included in the traditional evaluation methods that are used to investigate the correlation between IT Investment and business performance. The majority of frameworks developed in recent years have come to recognise the importance of taking a socio-technical perspective (Strassman, 1988, Remenyi et. al., 1991, Willcocks, 1994, Bannister and Remenyi, 2001). Research carried out by Jackson and Sloane (2006) has shown that organisational culture and human resources have a major impact on the adoption of new systems and are therefore included in their new model for e-commerce adoption.

2. Categorisation of frameworks

This short analysis is based on preparatory work for a PhD study and practitioner assessment made during work carried out by the authors on 4 projects with SMEs in the West Midlands (WM), a project with SMEs from diverse sectors across the Shropshire Marches area of the UK and two years working on secondment within the WM ICT Cluster of SMEs. Seven frameworks were examined for their pertinence and usefulness for SMEs. The frameworks chosen were those that appear the most frequently in IS research and in IS education in this area. It is apparent from the literature that most frameworks have a particular focus. It was therefore decided that the most appropriate method of analysis was classification. Although many of the frameworks include elements from more than one of the chosen classifications the frameworks are discussed in the light of their main focus. Therefore although they may relate to other categories this has largely been ignored for this study to aid clarification. The focal points have been divided into four categories: People Issues, Technology, Management and Evolutionary Position. Later frameworks have attempted to link the various aspects into new frameworks for example Farbey et.al.'s (1999) IT Benefits Evaluation Ladder, attempts to link strategy and system implementation guidance. Seddon et. al. (1999) realised that the emphasis of many frameworks was on the 'system' and has attempted to link the individual stakeholder role in evaluation and the system evaluation.

2.1 Categories:

2.1.1 Technology

Technology is at the heart of IT evaluation and most frameworks are designed to evaluate the benefits of an IS or a defined aspect of a system. More recent frameworks have started to include the term 'technology' or 'IT' (Farbey et.al., 1999). Many SMEs do not see the 'system' or IT as separate entities. Therefore, technology will be a reference to any hardware, software or telecommunications that the organisation uses to conduct business or support business activities.

2.1.2 People issues

People issues are often at the forefront of the 'softer' benefits and dis-benefits discovered by many researchers. They are important whatever the size of the organisation and also the most expensive resource; but have a particular impact on SMEs who are resource deficient. No evaluation framework analysis would be complete without recognition of this particularly difficult area. The importance of the stakeholder in the evaluation method used and the benefits discovered have also been highlighted (Seddon et. al.1999).

2.1.3 Evolutionary position

Nolan's (1973) 'Stages of Growth model' formed the basis of debate and research over many years, but is now widely adopted and accepted by academics and practitioners, particularly following the development of further models in this area (Earl, 1983, Galliers and Sutherland, 1994). Many organisations can be at many levels of an evolutionary growth cycle, with different applications, at different times. This area is so inextricably linked with strategy that it is imperative. SMEs lack any emphasis on strategy, a framework that enables them to position themselves on the evolutionary 'ladder' aids them in also deciding where they want to be.
2.1.4 Management

SMEs and in particular owner/managers do not place any emphasis on ‘managing’ their company (Costello and Reece 2005). Those who work with SMEs experience difficulty when attempting to relieve owner-managers from actually ‘doing’ the work, when real benefits could be achieved by just managing the company. Yet the performance and growth of SMEs is highly dependent on the competence and capabilities of its managers (Kingswell, 1999). Most SMEs grow under their own momentum until they reach a plateau of maturity when they either stagnate and struggle financially or with appropriate advice they develop, compete and mature. Management is important to a SME for this reason alone. Most organisations will place more emphasis on one of these aspects over another. It was found that large organisations may view frameworks and models in a number of different ways. These were categorised in order of importance:

- Evolutionary Position
- People Issues
- Management
- Technology

Giving the most emphasis to evolutionary position, asking are we at a stage in development when we can cope with this? Do we have the necessary skills? The justification for this is that the larger the organisation the more likely they are to address strategy (Galliers, 1991) and the less important the problems of the technology become as they may already have the skills needed for the implementation. The higher up the evolutionary ladder an organisation is the more likely they are to see the technology playing a supporting role to the business environment (Farbey et.al., 1999). SMEs, however, are more likely to prioritise them in the following manner:

- Technology
- People Issues
- Management
- Evolutionary Position

The cost and the problems of implementing the technology itself and the immediate associated problems are likely to be high on the SME list of priorities. They rarely have the expertise to cope with implementation alone and are also very dependent on outside consultants for help with their choice of technology. It is often only with hindsight that an attempt is made to make the technology ‘fit’ the organisational requirements (Costello et.al., 1999). Evolutionary position in SMEs is largely ignored as strategy is rarely considered (Dans, 2001). There are frameworks that do not fit easily into this classification system and there are aspects that are outside the realm of these four areas. However, as the analysis is from a SME perspective it has been significantly simplified to reflect the simpler structure in small companies.

3. Analysis of frameworks

Farbey et. al. (1993) uses Mintzberg's (1983) ‘Structure in Fives’ adapted to reflect the various organisational structures and their impact on an IT project. The original model was developed by concentrating on the purposes of each of these parts and meshing that with the purpose of any new IT implementation and how that affected Mintzberg's people structure. The framework allows for an organisation wide view of benefits. The intention in the framework is for organisations to examine individually the various parts of the organisation and select aspects of the framework that are appropriate to them. Then to use them to help formulate the questions to discover, manage and predict the outcomes and as a result measure the benefits associated with new IT / IS implementation. The ability to select individual parts, makes elements of this framework helpful for a SME, however, there are also aspects, which are not. Depending on the size of the SME many of the benefits listed will not be seen, for example: ‘flatter organisation or reorganisation of the management structure’. Some benefits the framework enables to be predicted would be viewed as advantageous whatever the size of the organisation. The Strategic prediction: ‘improved strategic link to customers including: speed and effectiveness of response, customer's access to the company's database and retrieval facilities’ (Levy and Powell, 1999) has become a reality for many organisations with the growth of the Internet as a tool for this method of transaction, where EDI may have failed. This framework gives the ability to consider the benefits of IT taking an organisational perspective. Many SMEs do not take this view and are often locked into a continuous round of what they see as step-wise improvements, when they are merely perpetually playing ‘catch-up’. The ‘people’ elements of the impact are often more relevant to SMEs than larger organisations as there are fewer people resources. This means that if one person is unhappy with the introduction of new IT or new processes it can have larger repercussions. The consequence of these repercussions would be relatively greater.

Seddon et. al. (1999) developed an IS effectiveness matrix based on a critique of Delone and McLeans’ (1992) IS Success Model which, although distinguishing between individual and organisational impact, does not go far enough and only looks at evaluation of IT from the ‘system’
perspective. The discussion postulates that when different individuals evaluate a system they do so on behalf of different stakeholders and therefore different results are obtained. The matrix developed allows the classification of 30 different dimensions of measurement of IT evaluation. Criticisms include the observation that although this research is a valuable contribution to the literature there is no space in the matrix for combining the business processes with the use of IT which is often so inextricably linked as to be difficult to evaluate separately. There may be an argument that although the classification may help in designing the valuation process, without evaluating the business processes it supports, no true value can be realised. However, the matrix is relatively simple to use, as there are comparatively fewer stakeholders within the SME situation. Some parts of the grid may be superfluous but it does allow simple diagnosis of an appropriate method to use depending on the technology to be used and the stakeholder involved. The matrix will also allow for identification of the type of system to be implemented and then classification of the stakeholder. This will avoid wasting time searching for benefits that have the wrong significance. Its main use for a SME is as a timesaver in identifying who and what is involved in the evaluation. In most SMEs if a ‘quick and dirty’ fix is required to justify expenditure this matrix would appropriately identify the emphasis that may be placed on the evaluation to give the results that are ‘perceived’ as being justified and often the perceived success is the only conclusion that is required (Powell, 1992).

Delone and McLean (1992) developed the IS Success Model from the recognition that there is a need to measure the success of an IS implementation and also a responsibility to measure its impact on business performance. There is acknowledgement that there are others areas outside of the model e.g. organisation strategy, but it is still widely accepted. They recognised that there is a difficulty in separating out the impact of IT on business performance from other factors. To the criticisms in the literature could be added the premise that it does not take into account any IT technology that may pre-exist the implementation that may also have an impact on the new IS itself. However, in spite of criticisms it has also been widely used for empirical research (Ballantine et. al., 1996). The framework has been developed a number of times (Kennerley and Neely, 1998, Seddon and Kiew, 1996) and more recently minor adjustments by the authors themselves (Delone and McLean, 2003). Another criticism highlighted by the literature is that it does not take into account any external variables for example: the environment. There is room for interpretation of the six main categories and the results will be dependent upon this interpretation. It does however show us how IT/IS can impact on business performance. The model is intended (as many) to evaluate one specific IS but could easily be used to evaluate IT infrastructure or used by a SMEs. Seddon and Kiew (1996) recognised that because IS success means many things to many people that if a single measure of IS success is required, User Satisfaction, as defined in the Delone and McLean model, is ideal as a general-purpose perceptual measure of IS success. It may however be argued that as many SMEs margins are very small they cannot afford the ‘luxury’ of using a measure as ethereal as this. That User Satisfaction does not come into the equation, as users must just ‘learn to like it’. Porter’s (1984) model is arguably the most well-known business model used for identifying value and costing benefits that create and sustain an organisation’s competitive advantage. The value chain is intended for use both to help formulate strategy and develop the steps required to implement that strategy. However, strategy formulation is known to be understudied in SMEs (Dans, 2001) and yet research by Andersen (2001) shows that there is a direct link between strategic planning and business performance. The value chain has been used in numerous scenarios to produce a cost advantage and this alone is an incentive for SMEs as most cite cost cutting as the main reason for new IT projects.

Porter (1984) has already identified that using generally available technology will not give an organisation a competitive advantage, yet SMEs are often several stages behind in their use of IT. The value chain could allow SMEs to conduct comparative analysis within their industrial sector. As using the value chain requires them to identify value activities in great detail and seek out new ways of gaining (or sustaining) competitive advantage. Using the value chain to identify activities can help SMEs to identify those activities that involve IT and can therefore help with decisions with regard to where IT can be upgraded / replaced / introduced. Kaplan and Norton (1992, 1993 and 1996) developed the Balanced Scorecard (BSC) to try to address the growing need for more than financial measures of business success. Their discussion relates to the fact that there has been an obsession with financial measures of performance that have led to financial methods of management; this framework was intended to address that gap. The theory of the BSC was based on the concept of Information Economics introduced by the work of Parker and Benson (1987). It was applied
practically in the area of IT evaluation in research carried out by Grembergen and Bruggen (2000). The Balanced Scorecard (BSC) is now being implemented in part by SMEs (Anderson and Lawrie, 2001) as in its original form the extensive measures called for are superfluous and seen as unnecessary in SMEs where the smaller management structure facilitates easier communication. What the BSC gives SMEs is the strategic stance that they lack. Many researchers have begun to realise that there is no simple link between IT and business performance. It has been identified that most benefits are distilled through operational process indicators (Lillrank et al., 2001) and therefore it is advantageous to measure IT in its operational terms and to identify the link between operational and financial benefits.

Levy et al (1998) offer a framework which is not a classical evaluation framework but one used to classify SMEs according to their use of IT/IS and thus predict the impact that the IT/IS will have on the business. The matrix has an efficiency quadrant which focuses on the financial control of the business and no integration with business strategy; a co-ordination quadrant which focuses on improving customer care through cross-functional databases; a collaboration quadrant which shows an increased sophistication of IT/IS use and the use of EDI and email to communicate with customers and where often the IS will be part of business strategy and finally the innovation quadrant where the complete integration of business strategy with IS strategy is seen. Changes to business processes and people skills are seen as an integral part of this. This framework is included here as there are so few models intended specifically for SMEs. The matrix is deliberately simple in its approach to reflect the reduced complexity of the SME situation. Levy et al’s (1998) broad-brush approach to categorisation of the IS/IT used is useful to show the focus within the organisation and assumptions may be made about the perceived value of IT as well as the actual value placed upon it by the organisation. It is also possible to show the maturity of the organisation in their use of IT. This would then show the SME by inference the degree of effort that may need to be extolled to implement any new system. E.g. the more sophisticated the type of IS the more effort in skills and knowledge is needed, the more planning for its use, etc. As organisations in the innovation quadrant need to have made huge changes in their business processes and skill set in order to achieve the integration suggested. Levy et al’s (1998) research with 26 companies showed that only one SME fell into the innovation quadrant of their matrix. Most SMEs are looking to reduce costs but many are beginning to investigate adding value and in this context the framework is useful to the SME in also highlighting their motivation and raising awareness. Farbey et al’s (1999) Benefits Evaluation Ladder work acknowledges that not only is it not always possible to measure costs and benefits but there are varying levels to which the costs and benefits will be realised. Farbey et.al. (1999) state that classifying “the use” of IT may be of fundamental importance in selecting suitable evaluation methods. The initial focus on operational efficiency that an organisation has is relatively simple to evaluate in comparison with the focus on strategic issues that are the sign of more mature IT users. One of the features of this type of framework is that they increase understanding and awareness; very few are frameworks for action. Most frameworks also have a time element and it is expected that organisations will follow the ascent through the framework over a period of time. However, most SMEs are attempting to take the leap to a higher point straight from their first implementation of IT, particularly those buying applications that have the capability of combining back office transaction processing with the front office desk top and reporting capabilities of quite complex Management Information Systems (MIS).

Farbey et al. (1999) offers a valid starting point for evaluation in SMEs with the use of this framework. It will not only allow them to see where they are from the point of view of evolutionary position, but also to look at where they would like to be, which is the starting point of strategic planning as defined by Ward (1996). This framework will introduce that concept to them and give a purpose to their IT implementation and help with the choice of evaluation method. It has been cited that the reason for the success or failure of an IT project is the poor quality of an organisation’s decision-making process (Farbey et al., 1993). If proper evaluation is not carried out then the result can be less effective decision making, as the results of the evaluation should inform the decisions. Often organisations blame everything else except the actual decision that was originally made. In using this framework SMEs can at once see the ‘riskiness’ of the project they may be undertaking and assess the benefits possible in light of this.

4. Summary of frameworks

Categorisation of the framework was a logical process as it has been identified that categorisation is the most usual approach to research in the study of social science type problems (Tsoukas, 1994).
Table 1 shows a summary of the categorisations proposed by this paper and suggests the primary and secondary focus for each.

Table 1 Summary of the categorisations

<table>
<thead>
<tr>
<th>Category Framework</th>
<th>Technology</th>
<th>People Issues</th>
<th>Management Aspects</th>
<th>Evolutionary Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farbey Structure in Fives</td>
<td></td>
<td>X</td>
<td></td>
<td>O</td>
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<tr>
<td>Seddon IS Effectiveness Matrix</td>
<td>O</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Delone and McLean Information Systems success Model</td>
<td>X</td>
<td></td>
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<tr>
<td>Porter Value Chain Analysis</td>
<td></td>
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<td>X</td>
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<tr>
<td>Kaplan and Norton Balanced Scorecard</td>
<td>O</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Levy Analytical Framework</td>
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<tr>
<td>Farbey Benefits Evaluation Ladder</td>
<td>O</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

X = primary focus  O = secondary focus

When a SME has decided on the overall focus for an investment then this may indicate the evaluation model that may be of potential use. Although in some cases an organisation may be better served by using a combination of frameworks depending upon the measurement sought. An example of this may be a company who want to ensure that they are moving to a higher evolutionary position but also realise the benefit of an approach that includes financial measures and customer satisfaction. In this overly simplistic demonstration the company might use both the Kaplan and Norton approach along with Levy’s analysis. However, a significant amount of awareness raising is still necessary before many of these frameworks can be transferred. Researchers need to be developing effective and appropriate methods now and guiding SMEs in their use. Most SMEs purchase IT for short-term reasons although many of us would interpret those reasons as strategic. SMEs do not recognise the reasoning of strategy, neither do they recognise the detrimental effect an unsuccessful purchase may have on their business. Most feel that purchasing IT is a necessary evil. A pilot survey conducted by the authors during 2006 with 15 SMEs revealed some surprising facts that support the need to help SMEs understand the need to evaluate. In the survey SMEs were asked what their last 3 IT purchases were and the reason for those purchases. The 43 purchases documented were grouped as follows:

- Replacement for current IT: 7
- New employee requirements: 7
- Mobile working: 9
- Increased capacity: 4
- Needed to fulfil contract: 6
- Extra Functionality: 5
- Other: 5

Excepting category 1 and 2 all other categories could be viewed as strategic reasoning. When asked if the purchase had been successful for the business 33% said very successful, 61% said successful and 6% said no change. None of the surveyed companies said that the purchase had not been successful. Yet when asked if they had measured that success only one company had conducted any kind of evaluation by measuring Return on Investment (ROI). The majority felt that it was not necessary, Company A commented:

“The user's good reaction and the low cost meant we did not feel it necessary”

However, Company A had not purchased their IT for a strategic reason but for a new employee requirement. Company B had purchased a web server, a significant investment for a small company they stated their reason for purchasing was as a marketing investment which is a strategic reason. Stating that the purchase had been successful yet they acknowledged having no plans to evaluate that purchase. When asked about how they would know it was a successful purchase they stated:

“We will only know when we have recovered costs through new orders”

With no plans in place to measure this it may prove very difficult for the company to do so. Most companies in this study were unaware of any evaluation methods or models other than ROI. Having a categorisation of the available frameworks and being able to mix and match those frameworks would go a long way towards helping these SMEs.

5. Conclusion

There are a plethora of IT evaluation frameworks available for business. However, there is no one model that can claim to cover all of the necessary variables. SMEs form an important part of the
majority of supply chains and many are highly dependent upon technology to remain their customers’ preferred supplier (Costello and Reece, 2005). Therefore a short analysis and appraisal of some of the more popular evaluation frameworks is presented here in an attempt to assess their usefulness to SMEs. This approach is proposed as a pre-cursor to further debate on the usefulness of categorisation of existing frameworks. Furthermore, there is a need for empirical evidence to support this view. It is suggested here that it is possible to use existing frameworks alone or in combination. An organisation would need to decide on their priorities and then selects the framework that is most applicable to their priorities in order to determine the most appropriate measurement. Although the field of IT evaluation is vast there are still many calls for more research and after twenty years there is still no definitive answer to many of the questions posed or indeed an effective, all-encompassing framework for IT evaluation. This paper again confirms that there can be no unique way of measuring the value from IT but it will depend upon the focus that an organisation perceives is their ‘value’. This emphasis will also change as the organisation progresses within the evolutionary lifecycle. This may mean that the search for a particular framework or the amalgamation of existing ones may not be appropriate or achievable. However, if the organisation first decides its priorities and selects appropriate frameworks (or parts of) the value of the IT evaluation approach may be recognised

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A Framework for the Evaluation of Meta-Modelling Tools

Lutz Kirchner and Jürgen Jung
University Duisburg-Essen, Essen, Germany
lutz.kirchner@uni-duisburg-essen.de
juergen.jung@uni-duisburg-essen.de

Abstract: Meta-modelling tools are an important prerequisite for the utilisation of domain specific languages. They allow for the tool-supported definition of modelling languages and can be used to generate specific editors for the application of a language. However, due to the variety of tools on the market and their inherent complexity, it is a difficult task to select a tool, which suits a set of given requirements best. In this paper we suggest a framework, which comprises a set of criteria for the evaluation of meta-modelling tools. The framework can be used to assist the tool selection process and hence help to minimise the risk of choosing an inadequate tool for a given application scenario.

Keywords: Meta-modelling, meta-modelling tools, tool evaluation, domain specific languages

1. Introduction

Modelling is of increasing importance in the context of the development and management of information systems. Models are used for the specification of software as well as the description of business processes. In addition, they serve as a basis for software development and workflow management. The syntactical rules for creating a model are defined by a modelling language. Popular modelling languages are the Unified Modelling Language (UML), the Entity-Relationship-Model (ERM), and Event-driven Process Chains (EPC). Modelling languages can be specified in various ways. For a large variety of potential model applications, domain specific languages (DSLs) are of increasing relevance. They are able to fill the gap of applicability, which is left open by general-purpose languages (GPLs), like those mentioned above, due to the DSL’s semantically richer concepts. DSLs are specifically tailored for one domain, which comes with several advantages (see paragraph 2). A predominating approach for specifying (graphical) modelling languages, like e.g. DSLs, is based on meta-models, which are in fact models of modelling languages.

Tool support is a paramount prerequisite for an efficient modelling process. Due to the literally infinite number of possible DSLs, it is uneconomical to create a specialised modelling tool for every language. Hence, the usage of a meta-modelling tool, which can provide tool support for the definition and application of a DSL, seems to be an attractive option. There are a number of tools on the market, which differ substantially in their approach to meta-modelling as well as their capabilities and features. Since meta-modelling tools in general are of significant complexity, it is hard to determine which tool is suitable for a given application scenario. Hence, a methodical approach to the evaluation of candidate tools in form of a conceptual framework is desirable.

This paper introduces a framework for the evaluation of meta-modelling tools. It comprises a set of categorised criteria, which serve to identify and document mandatory and optional features of the tools. We applied this framework to a number of meta-modelling tools, which we plan to use for the realisation of special tools concerning the modelling of IT-landscapes and resources in general. However, before introducing the framework, we want to briefly outline the notions meta-modelling and meta-modelling tool as well as some fundamental differences between domain specific languages and general purpose languages (GPLs) in the next paragraph. Following, we discuss the evaluation framework and its set of criteria. Additionally, we suggest a generic evaluation process. The framework will be exemplarily applied to two concrete tools, before we conclude by summarising the gained insights and give an outlook to future research.

2. Terminology

The notion meta-modelling describes the act of creating a model of a modelling language, thus defining its abstract syntax and semantics (cf. Geisler, R., Klar, M. and Pons, C. 1998 and Gitzel, R. and Hildenbrand, T. 2005). Furthermore, we regard a meta-modelling tool primarily as a modelling tool that allows for performing meta-modelling, i.e. defining the abstract syntax and – to a lesser degree – the semantics of a modelling language. Additionally such a tool has to provide facilities to define a concrete syntax (i.e. notation), and allow for the creation of user models. This definition is intentionally kept broad, but nonetheless it provides us with an adequate guideline for the selection of candidate tools for the evaluation. The modelling languages mentioned above (UML, ERM, EPC) can be used for the depiction of any
kind of domain. These languages are called general purpose languages since they are largely domain independent due to the provision of generic concepts on a semantically low level. By contrast, domain-specific languages contain language features, which are suitable only for one specific domain and hence can comprise semantically richer concepts than GPLs. Examples for DSLs are languages for modelling the firmware of mobile phones, a negotiation protocol or IT-architectures. A number of reasons, why DSLs potentially provide significant advantages compared to GPLs can be found in various publications (e.g. in (Esser and Jannek 2001) and (Luoma, Kelly and Tolvanen 2004), among others). A DSL usually provides application related concepts, which a GPL does not (e.g. a concept Computer instead of the generic concept Class in the context of the modelling of IT-resources). The use of such domain specific concepts can decrease the number of errors in a model and thus increasing model quality, since their semantic correspondence with the depicted real world concepts is usually straightforward. Hence, a user model will be more vivid in many cases and easier to comprehend for a domain expert. Additionally, a meta-model of a DSL includes rules, which regulate the use of model elements according to the specifics of a domain. This holds e.g. for the creation of relations between certain model elements. Such rules can be enforced by a modelling interface, which was created by a meta-model elements. Such rules can be enforced by a meta-modelling tool on the basis of DSL’s meta-model. Another benefit results from a more specific and therefore effective code generation from models. Due to their limited applicability, DSLs are usually not supported by conventional modelling tools. The lack of tool-support can be leveraged by the use of a meta-modelling tool.

3. Evaluation framework

The suggested framework for the evaluation of meta-modelling tools consists of two top level categories of evaluation criteria, whereas the second category includes three subcategories:

- General Evaluation Criteria for Software Tools
- Evaluation Criteria for Meta-Modelling Tools
  - Tool Architecture
  - Modelling Language Specification
  - Modelling Language Application

In the following paragraphs the criteria, which belong to the respective categories, will be discussed.

3.1 General evaluation criteria for software tools

This category contains criteria, which are of interest for the projected purchase of almost any kind of software tool, regardless of its area of application. Due to their general nature, we discuss these criteria very brief in this paragraph.

Cost related: costs, hardware requirements and variants. Typical costs related to software are related to its acquisition and operation. The latter includes primarily costs for licenses and support (updates, hotline). The hardware, which software requires to be executed, is also responsible for the generation of costs. The higher the hardware requirements are, the more expensive the according hardware components become. Furthermore, a tool can be available in several variants, which differ in terms of their range of functionalities. The purchase of optional features often results in a higher license price. Hence, it has to be evaluated, whether a certain functionality is required.

Usability: ergonomics and documentation. Ergonomics addresses the compliance of a tool with software ergonomic standards. These describe guidelines for the design of menus and dialogs, the information presentation, and the user interface in general. An example for such a standard is the ISO 9241 Usability Standard. It deals with various aspects of software ergonomics in paragraphs 10—17. If the software complies with such standards, the time and effort involved in learning to work with a tool can be significantly reduced. In a similar way, the quality of the available documentation has an effect on the time, which is needed to familiarise with a tool and utilise its full potential. Possible sources of documentation are manuals, online and context sensitive help functions, hosted forums, hotlines, among others. These documents can be available in various languages.

(Un)Installation. Concluding the general criteria, the installation and uninstallation process of a tool has to be examined. The installation should be scalable according to the user’s needs, whereas the uninstallation should be complete and clean.

3.2 Evaluation criteria for meta-modelling tools

The evaluation criteria in this paragraph deal with aspects, which are of particular interest for meta-modelling tools. The category is divided into three subcategories, which serve to analyse a tool’s architecture and cover aspects relevant for the specification and application of modelling languages.
3.2.1 Tool architecture

The overall architecture of a meta-modelling tool is a basic factor, which determines its performance and flexibility. The following criteria serve to evaluate a tool's architecture.

General architecture: modularity. It is difficult to determine which concrete architecture is the most advantageous for a meta-modelling tool. In general, a modular tool design is expected to provide a higher flexibility compared to monolithic approaches. This holds especially with respect to future updates from the tool vendor and possible user modifications. A tool should provide modules responsible for storing information about the meta-meta-model, meta-models and models as well as for providing model persistency (database and persistency mechanisms), a model viewer and a model builder. Due to tight integration of the models on the various abstraction layers, all models are typically managed in one module. An example for such a modular architecture is described in (Karagianis and Kühn 2002). The authors introduce a generic component-based architecture for meta-modelling tools, which originates from similar requirements.

Model management: model storage mechanism and configuration management. Regarding model management, a configuration management for the meta-models and user models should be implemented. The management of versions and variants of models, as well as a rollback function are desirable. Thus, transparency regarding the project progress is provided and the redoing of certain work steps as well as the starting over from older versions possible. Strategies for the solution of version conflicts have to be implemented as well (automated as well as dialog-based). As a strategy for model storage and therefore a basis for configuration management, a repository which provides built-in security and transaction mechanisms seems advantageous. Collaborative work on a project will largely depend on the availability of these features.

User defined extensibility. User defined functions can enhance the usability of a modelling tool. These functions may be added by using internal languages or addressing the tool’s external application programming interface (API). Complemented functions can range from user implemented model analyses to the modification of the user interface, among others. An onboard language provided by the tool can offer the necessary expressive power for implementing the desired features. If none is provided, the API has to be used. However, it has to be possible to access all model-specific data and model elements through the used interface, from both model- and meta-level. Beside the power of the extensibility features, the simplicity of using them should be reviewed. Some tools provide extension mechanisms, which require the use of proprietary, sometimes little documented scripting languages for the implementation of user functions, whereas others can be programmed using standard languages like Java. The latter usually reduces the familiarisation time, presumed that basic knowledge of the programming language is existent.

Tool integration. Another criterion of this category deals with the means of integration with other tools, a meta-modelling tool may provide. On a technical level, the integration with modelling tools can be achieved by supporting exchange formats (e.g. XMI) or providing interfaces in order to exchange models transparently to the user (Schloegel, Oglesby and Engstrom 2002). This can be accomplished by implementing plug-ins, using the API of external tools. However, beside the exchange format, an important aspect for the integration is the compatibility of the modelling languages or meta-modelling languages respectively, since without it a successful exchange of models cannot be achieved. Additionally, integration with office applications or external editors can be useful for including documentations in or running programs from a model.

3.2.2 Modelling language specification

This set of criteria focuses on the evaluation of concepts, which are related to language specification tasks.

General approach to meta-modelling. There exist different approaches to the definition of the syntax and semantics of a modelling language (Esser and Jannek 2001; Hofstede and Proper 1998; Luoma, Kelly and Tolvanen 2004). E.g. a grammar-based approach (e.g. with Extended Backus-Naur Form; EBNF) can be used to describe a language's syntax in a formal and precise way. However, this tends to be a time consuming and complicated approach and thus is only recommended, if it is planned to base formal proofs on a model created with the resulting language. For defining visual modelling languages comprising graph-like structures, a meta-model-based approach is preferable. That approach is only semi-formal, but offers the advantage of avoiding a paradigm shift regarding the meta-model and its instances, compared to a strict formal definition (Frank 1999). This results in a more intuitive meta-modelling process and therefore tends to foster model quality. In this context a tool may allow for a varying number of
abstraction levels – or layers – of modelling. However, the provision of at least an explicit meta-model and a model layer is mandatory.

**Definition of language concepts: syntax and semantics.** The way a tool addresses the definition of the language concepts on the meta-layer is also an important evaluation aspect. First of all, a tool should differentiate between the abstract and concrete syntax of a concept. The abstract syntax (at least for graph-based languages) defines node and edge types with their respective properties. In this context, a tool should provide an automated check for the correctness of a meta-model against the background of the meta-meta-model. According to Jung and Kirchner (2005) it should be possible to define constraints, which e.g. prevent circular relations or enforce bipartite graphs on model-level, among others. The concrete syntax of a language defines graphical representations of nodes, edges and various properties of model elements. Properties can be listed inside the symbol of a model element or be located externally. Further possible features are the definition of docking points for elements, different routings of edges, a different graphical representation of the same concept according to the context and user preference (e.g. a UML interface displayed as a circle or a rectangle), or the combination of edges to complex edges. The latter refers to edges, which connect more than 2 nodes like in organisational charts or the generalisation relationship in UML. Which representation options a tool should provide, strongly depends on the kind of modelling languages it is used to implement. However, in general it can be stated, that the more complex notations can be implemented, the more visual expressiveness a language may hold.

Complementing the syntax definition, a tool may provide means of defining the semantics of a modelling language. This can be achieved by mapping language concepts to an adequate modelling language or a common programming language (Hofstede and Proper 1998), which possesses concepts with well defined semantics (e.g. Petri nets). However, due to the complexity of the implementation of such concepts, significant tool support in this area can not be expected yet. Alternatively, a concept’s semantics can be specified with an onboard scripting or a constraint language, like the OCL (Object Constraint Language), or by attaching natural language comments to the meta-model elements.

### 3.2.3 Modelling language application

The criteria introduced in this paragraph deal with aspects of the application of modelling languages. Generation of modelling tools and predefined modelling languages. First, a tool should provide a language specific user interface with an editor including specially tailored menu items, which support an intuitive modelling process with a previously specified modelling language. Furthermore, the provision of a number of predefined, common GPLs (e.g. UML or ERM) would be desirable. If these languages are already adequately implemented, there is no need to redefine their meta-models or to purchase complementary tools. They can be used as provided, analysed (e.g. in a teaching scenario) or extended (e.g. UML with stereotypes or user profiles).

**Model transformation.** Since modelling often is an intermediate step in a process aiming at constructing information systems, it should be possible to transform a model into other representations. The transformation target can be other visual modelling languages or, more frequently, implementation-level documents. The latter (i.e. source code generation) would allow for the transformation of object models to a programming language (e.g. UML to Java) or workflow models to workflow schemata among others (Oberweis 1996). E.g. (Jung 2004) presents a meta-modelling tool-based approach for generating XPDL-compliant (XML Process Definition Language) workflow definitions from business process models. For analysis purposes the automated construction of models on the basis of source code may be supported, too. The rules for every model transformation should be user definable in a flexible way to ensure an appropriate mapping of one language to the other, e.g. using included scripting languages.

**Simulation.** The usability of a model can be significantly enhanced, if it can serve as a basis for simulation. Especially in the area of business process and workflow modelling, simulation is a pivotal application of a model (Jung 2003; Zelm 2003). Simulation can serve to analyse projected as well as existing domains for weak spots and bottlenecks, which decrease the overall performance of the modelled system. In (Nikoukaran, Hlupic and Pail 1998) a framework for the evaluation of simulation software is introduced, which in extracts can also be applied to evaluate the simulation capabilities of a meta-modelling tool. Particularly, the criteria for input, execution and output are of interest in our context. Input deals with the possibilities that a tool provides for assigning data relevant for simulation to model elements and for defining additional functions, which influence the simulation execution. The control of the execution should
The output of the result should be available in textual as well as graphical form, and should be stored permanently in a database. This leads to the following short summarisation of basic simulation requirements, which a tool should fulfill:

- simulation input
  - Definition of simulation functions
  - Assignment of (instance-related) data to model elements
- Simulation execution
  - Control of execution parameters (steps, speed, general control)
- Simulation output
  - Various result representations (textual, graphical)
  - Permanent storage of results for future reference

**Metrics.** As an instrument for a basic measurement of a model’s quality, metrics can be used. Generic metrics, e.g. for counting the number of instances of a type, may be predefined. Especially in the context of object-oriented modelling exists a large number of metrics (Henderson-Sellers 1996). Other metrics may be specified by the user with respect to the application to specific user defined modelling languages and models. Metrics can help to improve the quality of a model by providing an early warning mechanism, hinting at possible weak spots in a model. The implementation of their management should cover their creation, modification and storage.

**Model documentation.** To conclude the description of the framework, this criterion deals with the issues of documenting a model or metamodel respectively. For an online distribution of a model’s documentation the report format should be navigable (hypertext-based). This can be implemented e.g. by PDF or HTML files. Additionally, popular document formats (like e.g. MS-Word DOC, plain text) may also be supported, since a user can easily include a report into his own documents. To generate an appropriately detailed documentation, the generator has to have full access to all relevant parts of a model. The resulting level of detail should be user definable and therefore adjustable to the intended application of the documentation. Further means of documentation can provide prints of models. Functions like scaling and tiling of models as well as a comfortable preview mode should be implemented.

### 4. Sample evaluation

To ensure a successful evaluation process, the application of the above introduced framework should be guided methodically. We suggest a rather simple process model which consists of the following steps:

- Determine the application scenario of the meta-modelling tool and make it explicit to all participants involved in the evaluation
- Determine the relevance of each evaluation criterion with respect to the application scenario
- Review every meta-modelling tool selected for the evaluation with respect to each criterion
- Assess the results and select the most appropriate tool

We illustrate the usage of this process model by an excerpt of the documentation of an evaluation process which we already conducted. In this context we introduce the two most promising meta-modelling tools: MetaEdit+ (http://www.metacase.com) and Cubetto (http://www.semture.de). These tools have been selected because on the one hand they were developed by commercial vendors and ready for the market, but on the other hand free of charge for our specific application. Other tools have been excluded since they are research prototypes (ConceptBase1, H2 Toolset2) or not explicitly offered as meta-modelling tools (ADONIS3, Metis4). The evaluation has been performed by two researchers who worked closely together during the application of the framework. However, its applicability in conjunction with a larger group of participants was not tested yet. In this case it may be necessary to supplement the above process model with additional activity steps, which regulate the coordination of the group’s individuals to avoid communication problems and as a consequence inconsistencies in the evaluation results. In general, to guarantee an adequate level of quality, it is recommended that an evaluation is being conducted by persons who have at least basic knowledge of meta-modelling tools and some evaluation experience. Additionally, all participants have to share a common understanding of how to apply the evaluation framework.

**Application scenario of the meta-modelling tool.** A meta-modelling tool is required in order to develop a modelling tool for the application in the area of

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1. [http://www-i5.informatik.rwth-aachen.de/CBdoc/](http://www-i5.informatik.rwth-aachen.de/CBdoc/)
2. [http://www.wi.uni-muenster.de/improot/is/pub_imperia/doc/1771.pdf](http://www.wi.uni-muenster.de/improot/is/pub_imperia/doc/1771.pdf)
IT-management. Several languages have to be implemented. First, a business process modelling language, which has been developed at the author’s institution, is needed. Furthermore, a resource modelling language and a language for the modelling of IT-landscapes are to be implemented. The provision of predefined languages for the modelling of software systems (like UML and ERM) is considered relevant, whereas common process modelling languages (like EPC) are of less importance. The resulting modelling tools are planned to be used in lectures and tutorials as well as in research projects. License costs for the meta-modelling tools and runtime licenses for the generated modelling tool should be minimal (close to zero).

Relevance of evaluation criteria. The relevance of some of the criteria we used for the evaluation is presented in table 1. The first column lists the identifying number of each criterion and the second one its name. The third column contains a four scaled quantifier representing the relevance of the criterion (3: very important; 2: important; 1: less important; 0: unimportant). License costs are regarded as very important, because there exist no funds dedicated to the purchase of a tool. Please note, that a high relevance of costs does not imply a positive interpretation of higher costs. A complete uninstallation is regarded as unimportant because the selected tool is intended to be used for an extended time period. This of course only holds when a tool update does not require a previous uninstall of the older version (which we presume at this point). Predefined modelling languages are regarded as very important (their existence is mandatory). Nevertheless, this criterion has not a single quantifier but a quantifier for each language separately. There are languages which should be implemented (EPC are of high value) and others which are “nice to have” (PN). UML and ERM are mandatory languages. They both have to be implemented “ready to use” by the meta-modelling tool. Simulation is not regarded as very important because we do not plan to perform analyses on this basis in the near future. Nevertheless, simulation is an important instrument whose availability in future versions of a tool may become a required feature. Metrics represent a less important functionality. We are not planning to use them for the time being, but this also might change in the future.

Table 1: Relevance of selected criteria

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Quantifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>License costs</td>
<td>3</td>
</tr>
<tr>
<td>1.3.2</td>
<td>Complete Uninstallation</td>
<td>0</td>
</tr>
<tr>
<td>2.3.1.2</td>
<td>Predefined Modelling Languages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Event-driven process chains (EPC)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Petri nets (PN)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unified Modelling Language (UML)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Entity-Relationship-Model (ERM)</td>
<td>3</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Simulation</td>
<td>2</td>
</tr>
<tr>
<td>2.3.4</td>
<td>Metrics</td>
<td>1</td>
</tr>
</tbody>
</table>

Tool evaluation. The evaluation results of two tools are displayed in table 2. We used a rating scale ranging from 0 (does not fit our need at all) to 10 (perfectly fits our needs). MetaEdit+ is not free for academic users but there is a special discount of 90% of the list price. This has been rated as ‘5’ because there are a number of free tools and only a few are with costs. Cubetto is free of charge and therefore rated with ‘10’. Both tools can be easily removed from the system by deleting there installation directories (10 points for each tool). MetaEdit+ only provides UML as a predefined language. Consequently EPC, PN and ERM are rated as 0. The recently specified UML 2.0 is supported except for two minor diagram types which we do not need at the moment. Cubetto fully supports EPC including relationships to other diagram types (e.g. organisational charts, ERM) but does not include PN. ERM are included but in the form of the rather unwieldy original notation by Chen. We usually use a simplified and more modern ERM notation. Hence, ERM in Cubetto is rated 5. The implementation of the UML does not conform to UML 2.0. Only 5 out of 13 diagram types are supported, and the model editor is rather flawed. Simulation is neither implemented in MetaEdit+ nor in Cubetto. Both tools do not directly support the modelling of instances and the animation of process models. Consequently, both tools are rated zero. The determination of metrics is not directly supported by MetaEdit+ and Cubetto. However, each offers a scripting language. The language of MetaEdit+ primarily supports report generation. Its features comprise the generation of text and the navigation over model elements. It does not support iterations (for- or while-loop) and is therefore not Turing-complete. Cubetto uses JavaScript as a scripting language – which is Turing-complete.
Nevertheless, all queries regarding metrics have to be implemented by the user.

Table 2: Tool Evaluation (Excerpt)

<table>
<thead>
<tr>
<th>Number</th>
<th>MetaEdit+</th>
<th>Cubetto</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>1.3.2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2.3.1.2</td>
<td>- EPC</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- PN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- UML</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>- ERM</td>
<td>0</td>
</tr>
<tr>
<td>2.3.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.3.4</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Result assessment and tool selection. The preliminary result of the evaluation is shown in Table 3. The values in the fourth and the sixth column are computed by multiplying the tools rating by the quantifier. Cubetto scored 172 points and MetaEdit+ 165 (note, that the score includes results which are not listed in the tables). This result was taken into account during the decision process for one of the tools. With respect to the criteria in table 3, Cubetto has lower costs and includes more predefined modelling languages than MetaEdit. But, the implementations of ERM and UML are far from perfect. Hence, it would be necessary to re-implement these languages in order to meet our requirements. This and the better overall usability lead to our final decision for MetaEdit+.

Table 3: Preliminary evaluation result (Excerpt)

<table>
<thead>
<tr>
<th>Number</th>
<th>Quantifier</th>
<th>MetaEdit+</th>
<th>Cubetto</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>1.3.2</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>2.3.1.2</td>
<td>- EPC</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- PN</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- UML</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>- ERM</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2.3.3</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.3.4</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

5. Summary

In this paper we suggested the use of a framework for the evaluation of meta-modelling tools. After an introduction to the topic and a short discussion of meta-model related terminology in paragraphs 1 and 2, the framework is introduced in paragraph 3. It consists of general and meta-modelling tool specific criteria. An exemplary application of the framework is demonstrated in paragraph 4. The value of such an evaluation framework not only depends on the covered criteria, but also on the expertise and background of the evaluating person. The determination of the relevant criteria and their significance to the intended area of application, as well as the application to the candidate tools, usually requires some background in meta-modelling and at least basic knowledge of the characteristics of possible target domains. Hence, the process in paragraph 4 could be extended by a complementing first step: the determination of the group of persons, who are suited best for the evaluation. The criteria presented in this paper are by no means complete, but should nevertheless allow for selecting a tool, which fulfills the given requirements. However, future work includes the documentation of additional criteria. E.g. the support of meta-modelling patterns, or the compliance with a meta-modelling method may be examined. It is important to note, that the results, as they are displayed in tabular form in this paper, usually should not be used without any interpretation in order to reach a decision. The results for every single criterion should be considered. The quantifiers, which value the importance of a criterion, often mirror the subjective opinion of one or more individuals. Hence, they have may be adapted according to the requirements and preferences of the user. Nonetheless, our framework proved to be very useful in the process of determining the most suitable meta-modelling tool for our planned application. It will be further developed and complemented in the future.

References

Proposal of a Compact IT Value Assessment Method

Przemyslaw Lech
Faculty of Management, University of Gdańsk, Poland
Przemyslaw.Lech@lst.com.pl

Abstract: This paper contains a proposal of a compact IT value assessment method. It follows the assumption that most methods available for the public are either described in a very general manner or concentrate on one of the evaluation aspects only. The proposed method relates the evaluation approach to the main IT initiative characteristics, such as the investment purpose and IT element to be implemented. Based on these criteria, the evaluation process is shaped by putting emphasis on the relevant evaluation aspects and choosing the relevant evaluation methods. The method design is focused on the ease of use and practical relevance so it can be used by IT practitioners to assess IT initiatives in their organisations. The paper finishes with the case study of the method usage in a mid-sized production enterprise.

Keywords: IT value assessment, IT evaluation, practical method, case study

1. Introduction

Although a large number of IT value assessment methods is available (Renkema and Berghout 1997), still, many enterprises do not use any structured evaluation approach while judging their IT investments (Love and Irani 2004) and if they do, the selection of methods is often limited to the simple cost – benefit analysis tools (Bannister and Remenyi, 2000). Discussing this phenomenon, Bannister and Remenyi (2000, p. 232) conclude that "either theory has completely lost touch with reality, the theoreticians have failed to get their message across to practitioners, or the body of theory is still very immature and in all probability far from complete." While these authors have stressed the second possibility, it seems that the first statement is also at least partially true. This paper will try to respond to this statement by introducing a simple and ready to use framework for assessing the most important economical aspects of IT initiatives. The aim of this framework is to help enterprises in conscious decision-making concerning IT initiatives. To meet the requirements of practical relevance and ease of use, it concentrates on the most important IT value aspects and intentionally ignores the others.

2. Practical relevance as a critical success factor

Academic researchers in the IT field are beginning to understand that their work is far away from business practice. Practitioners do not read academic journals and do not attend academic conferences. This is surely not because practitioners neglect the necessity of learning and acquiring new knowledge. The IT world is changing so rapidly that every reasonable practitioner in this field understands the importance of constant learning. If someone needs proof, it is enough to visit a good seminar or congress dedicated to practice. If the practitioners search for new sources of knowledge, want to learn, and still are not present at the academic conferences and are not academic journals’ readers, the only conclusion might be that Bannister and Remenyi (2000) were right saying that theoreticians have lost touch with reality. Benbasat and Zmud (1999) have also noticed this fact while analysing the MISQ audience. There is absolutely no doubt about the need of theory building research which might not be directly practice-relevant but then there should be a lot of practical research done based on that theory as well. Davenport and Markus (1999) have concluded that the research in the IT field should contain high science, applied theory and practical research in equal proportions. To answer the question on how to increase the practical relevance of the study, it might be beneficial to examine the theoretical concepts successfully incorporated into the practice. Two examples may be Business Process Reengineering (Davenport 1993, Hammer and Champy 1993) and Balanced Scorecard (Kaplan and Norton 1996). Those examples have several common characteristics which are absent in many other academic books and papers:

- The ideas are based on field experiments – the authors were actually doing the exercise in living companies before describing it in a book or article (it is worth mentioning that at least one of the authors in both cases had a consulting background),
- The ideas are ready to use – with enough time and energy, one can take the book and introduce the idea described in it into her/his organisation.

Complying with those two rules should significantly increase the practical relevance of the research. Examining the existing books and papers on IT evaluation, one can come to the conclusion that it is difficult to find examples of ready-to-use methods suitable for evaluating a
4. Evaluation method formulation

4.1 What and how to evaluate – the general approach

The two factors constituting the IT business value identified above are:

- Support of the enterprise’s business goals,
- Direct return on IT investment.

Those two aspects of IT value are certainly present in the existing evaluation methods. Multi-criteria methods, like Information Economics (Parker and Benson 1988) or ‘5 pillars method’ (Murphy 2002) include the ‘strategic match’ and ‘direct return’ as the evaluation parameters. Treating strategy as the ‘black box’ and assigning one rank only, which states whether the IT initiative supports the strategy or not, seems strongly insufficient. Neither of these methods give indications on how to calculate the direct return. If the evaluation method is to be used in practice, both aspects should be explored in far more detail. The evaluation should answer the detailed questions about what business goals, related to which business processes are supported by the IT solution, how important these goals and processes are in the value creation and to what extent the IT solution is necessary to achieve them. Information Economics evaluates some other IT initiative characteristics from the business and technology domain. All the characteristics from the business domain, except for risk, should be reflected by the company’s goals’ analysis. Enterprises may undertake IT initiatives for many strategic, as well as operational reasons. Moreover, usually one initiative would be undertaken for more than one reason and the list of possible IT initiative goals is infinite. By limiting the number of evaluated factors ‘ex definitione’, one can thus miss the important information. The only characteristic from the business domain that would not come out of the IT initiative goals is the risk. Risk, defined as the uncertainty of achieving the desired goals, has to be incorporated into the evaluation model.

The technology evaluation of business-oriented IT initiatives seems to be less important now than it was in the early 1990’s, when multi-criteria evaluation methods were designed. This is because of two main reasons:

- Most IT packages are now available for all leading technology platforms,
- The technology is changing so fast that most enterprises do not treat technology as a fixed, strategic choice.

The technology in my opinion should be evaluated mostly from two perspectives:

3. Definition of IT value

As Bannister and Remenyi (2000) pointed out, to be able to assess value, one has to clearly define it. Those authors have discussed the notion of value in detail, citing many definitions, from which the most straightforward one is given by Parker and Benson (1988), stating that IT value is the ability of IT to enhance the business performance of the enterprise. Generalising this definition, one could say that IT value is the ability of IT to support the enterprises’ business goals. The business goals will vary from enterprise to enterprise and so the value definition presented here will also be flexible. Of course for most profit oriented enterprises the main goal is to grow and sustain long-term value for the shareholders (Read et. al. 2001, p.11). This value is achieved by the application of a suitable strategy which delivers the answers to the question what tangible and intangible assets should be combined with what processes to create value for a customer (the amount that a customer is willing to pay) that is higher than the cost of creating it (Porter and Millar 1985). If one accepts this definition of value, based on Porter’s value chain (1985), it becomes fairly easy to determine the way IT can support the value creation process:

- It can support the strategic and operational goals and thus create value indirectly by allowing the enterprise to act according to the strategy.
- It can generate positive or reduce negative cash flows by decreasing costs, increasing revenues or shortening the operational cycles (from cash to cash) and thus create value directly.

The weights assigned to those two aspects of value and the way they should be evaluated depend on the characteristics of the IT initiative to be evaluated, such as the investment purpose, the IT element to be implemented and the benefit/cost types.
The investment purpose is the general factor determining what should be measured. If the investment is a must-do – which means that it is either required by law or is an industry standard, then the main strategic goal lying behind is clear and fixed: ‘staying on board’. This business goal is achieved when the functional requirements of the IT initiative itself are fulfilled. The achievement of the IT functional goals (meaning: achievement of the desired functionality of the IT system) is the first evaluation criterion. The business survival investment does not have to be directly profitable as the main benefit from this kind of IT initiatives is the possibility to continue the (possibly profitable) business activity. The cost revenue optimising criterion for such investment should thus be to obtain the desired goal at minimum costs. Direct profitability evaluation can be therefore made for costs only.

The business improvement IT investments are undertaken to achieve operational business goals, which may or may not be directly related to the main strategy of the enterprise. If they are, the IT initiative should be evaluated in the same way as the one that helps to gain competitive advantage. If they are not, the effect of the IT initiative should provide direct benefits that exceed costs. Direct profitability will be the central aspect of the evaluation. Of course, the IT initiative will provide the desired direct benefits only when the operational goals are achieved, so this aspect has to be measured too. Moreover, the role of IT in the achievement of the operational goals may differ from case to case. If the achievement of these goals is not possible without the evaluated IT initiative, its importance will be greater than when it plays only the supportive role and the business goal could be achieved without the IT project. The goal dependency on the IT project will be the third called the ‘meta approach’ (Bannister and Remenyi 2000) or ‘contingency model’ (Serafeimidis and Smithson 1999). In the next section, the indications for creating the evaluation model, based on the main IT initiative characteristics, will be presented.

4.2 Determination of evaluation strategy

The summary of the IT initiative characteristics to which the evaluation method is related in literature is available in (Lech 2005). From the analysis of those characteristics it becomes clear that the main one is the reason for IT investment. The purpose of implementation determines the general evaluation strategy and strongly affects the next steps. The proposal of the purpose – evaluation technique mix is available in (Remenyi et. al. 2000, p. 66). Those general indications must be converted into the more detailed rules of evaluating each of the IT initiative’s aspects listed in the previous section. The proposal of a relation between investment purpose and the way those aspects should be evaluated is presented in Table 1.

Table 1. Investment purpose – evaluation strategy own elaboration, based on: Remenyi et. al. (2000)

<table>
<thead>
<tr>
<th>Investment purpose/type</th>
<th>Goal measurement</th>
<th>Direct cost/revenue measurement</th>
<th>Key success indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>business survival</td>
<td>IT initiative functional goals (goal achievement)</td>
<td>costs</td>
<td>achievement of the functional costs at the expected cost level</td>
</tr>
<tr>
<td>(must-do investments)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>business improvement</td>
<td>operational business goals (goal dependency on the IT initiative, goal achievement)</td>
<td>revenues/costs</td>
<td>operational goals achievement, revenue/cost ratio &gt;1</td>
</tr>
<tr>
<td>(operational investments)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>competitive advantage</td>
<td>strategic business goals (goal dependency on the IT initiative, goal achievement)</td>
<td>costs or revenues/costs</td>
<td>strategic goal achievement</td>
</tr>
<tr>
<td>(strategic investments)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>capacity improvement</td>
<td>IT initiative functional goals (goal achievement)</td>
<td>revenues/costs</td>
<td>functional goals achievement</td>
</tr>
<tr>
<td>(infrastructure)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
aspect of the evaluation. Strategic investments are undertaken to enable or support the realisation of the enterprise’s strategy. Therefore most business benefits come from the strategy, not from the initiative itself. The main evaluation effort should thus be put into assessing the dependency of the strategic goals on the IT project and the degree to which the strategic goals have been achieved. Direct benefits from IT are less important here and in many cases it seems reasonable to track the project costs only.

If the investment has the purpose of increasing the technical capacity, then the achievement of the functional goals (technical specification) will be the main success and thus also evaluation criterion. Achieving these goals may cause some direct benefits (like IT infrastructure maintenance cost reduction) so the cost/benefit analysis should also be performed. An additional benefit will be the option for further development and this may also be assessed in the extended evaluation process. The investment purpose analysis answers the question to what aspects of the IT initiative the main focus of the evaluation should be set. In the next section, the evaluation framework will be presented together with the indications as to what elements of this framework should be used depending on the investment purpose.

4.3 Goal support measurement

The main value of IT comes from creating the possibility of doing the business in a way, which would be impossible without it. Therefore in that case, IT does not create the value directly but acts as an enabler for value-creating business actions. What should be thus measured, from the IT perspective, is:

- The degree to which business goals are dependent on the IT solution (goals’ IT dependency),
- The degree to which business goals are achieved (goals’ achievement).

The first aspect can be evaluated both before (ex-ante) and after the IT investment (ex-post). The business goals achievement can be assessed only during the ex-post evaluation.

4.3.1 IT initiative goals’ identification

The first step here is the identification of all business goals related to the evaluated IT initiative. If the business need for IT investment comes from the enterprise’s strategy, there is a tool available, allowing to identify and initially evaluate IT initiatives that satisfy this need: the ‘strategic readiness report’ by Kaplan and Norton (2004). It provides a list of IT applications needed to accomplish the strategic business goals coming from the balanced scorecard, together with the overall rating, stating whether the application is already in place, under construction, needs to be enhanced or developed from scratch. Those applications which have been identified as new or requiring major enhancements constitute a list of strategic IT investments. The main strategic goals which should be achieved with the help of those IT initiatives are also available from the strategic readiness report. However, to be complete, the list has to be worked out in more detail. The strategic goals rarely happen to be achieved directly: more often they would be a result of achieving a set of operational goals. If this is the case, the list of IT initiative business goals should be expanded with these operational goals. The operational goals should be then related to the functional goals of the IT project, stating how the business goals will be realised in the information system. The procedure of converting the strategic business report into the IT initiative goals list is illustrated by figure 1:

The goals above the dotted line come directly from the strategic readiness report, whilst the ones below were added during the IT initiative evaluation process. If the enterprise does not use a balanced scorecard to illustrate its strategy, the list of the IT initiative goals would have to be made independently. For strategic IT projects it will look exactly the same as the one presented on the right-hand side of figure 1. For business improvement initiatives, the list will usually contain only operational business goals and functional goals of the IT project. For business survival and capacity improvement projects, the list might contain only functional goals.
4.3.2 Evaluation of business goals’ IT dependency

Having the list of business goals related to the IT initiative, one can start to evaluate the dependency of these goals on IT. This evaluation will be performed mostly for strategic and business improvement investments. The evaluated IT project can play different roles in the achievement of business goals: it can be indispensable for the business goals to be achieved, can play only supportive role, be neutral or even may hinder their achievement. There seems to be no other way of evaluating this aspect than by ranking. The proposition of the ranks is presented in table 2:

Table 2. Ranks for dependency of business goals on IT initiative

<table>
<thead>
<tr>
<th>Rank</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>A goal cannot be achieved without the IT initiative.</td>
</tr>
<tr>
<td>2</td>
<td>IT initiative will strongly facilitate the achievement of the business goal. Goal achievement without the IT initiative is theoretically possible but there is strong probability that the result will be weaker.</td>
</tr>
<tr>
<td>1</td>
<td>IT initiative has supportive role in the achievement of the business goal. There</td>
</tr>
</tbody>
</table>

The overall rank will be calculated as the mean of the ranks for business goals related to the IT initiative. If the overall rank for the initiative considered to be strategic is 2 or more, this means that its role in accomplishing the strategy is high and the business value should appear primarily as a result of the strategic initiatives. The evaluation should focus on goal achievement and cost control. If the rank is less than 2, it means that the initiative has only a supportive role for strategy attainment and should rather be treated as a business improvement initiative. Further
evaluation should concentrate on direct profitability and business goal achievement. For IT initiatives considered to be operational (business improvement), the overall rank shows its significance in accomplishing the desired goals. If the rank is 2 or more, the initiative should be undertaken. If the rank is less than 2 it is necessary to study carefully all the other options of achieving the desired goals and choose the one with the optimal efficiency.

4.3.3 Evaluation of IT initiative goals' achievement

The next step during ex-post evaluation is the evaluation of the goals' achievement. This evaluation concerns both business and functional goals. If the business goals' list is prepared based on the strategic readiness report, then each of the goals has some kind of measure assigned to it in the balanced scorecard. If the goals do not come out of the strategic readiness report, then the measures should be assigned to them during the IT initiative goals identification. During ex-ante evaluation, it is necessary to examine each of the goals separately and design the measurement system for each of them. If the enterprise is using some kind of performance measurement system, then this system should be used to evaluate business goals. Functional goals are usually described during the requirements gathering process (which is part of the software engineering that is not the subject of this paper) in such a way, that it is relatively easy to determine, whether the goal is achieved or not.

4.4 Cost, revenue and risk measurement

A lot of work has been already done to identify and classify the IT costs and benefits (Irani 2002, Lucas 1999, Murphy 2002; Remenyi et. al. 2000; Renkema 2000). The list of benefits and costs varies from case to case and must be determined for each IT investment individually. Following Zuboff's (1988) classification of IT benefits, to identify possible benefits one has to formulate and answer the questions like:

- What processes will be automated?
  - What will the process cost reduction be?
  - Will there be any process error reduction and what is the average cost of an error?
  - Will it shorten the process time and what will be the value of finishing the process sooner?
- What new, currently unavailable information will be provided by the IT initiative and what is its value for decision making?
- What information will be available in a shorter time than now and how will it affect the decision making (and the expected value of these decisions)?
- What resources will be released due to the process automation and new information?
- What new products and services will be available thanks to IT and what is their value?
- How will IT affect the quality of service, customer care, contacts with customers and how could those be valued?

A good way of structuring the benefit search is to perform the business process analysis workshop, during which each process is analysed with the use of the questions listed above. The list of the questions is of course open and has to be modified during the workshop, according to the current life scenario. Activity-based costing can be a helpful tool in searching for business process cost reduction as well (Roztocki and Weistroffer 2004). Cost identification seems to be an easier task although it is not necessarily the truth (Maanen and Berghout 2002). At least main costs, like licence fee, hardware cost, implementation fee, maintenance cost are in most cases direct, simple costs, easy to identify and value. After the preparation of the benefits and costs list, it is necessary to choose the appropriate measurement method. The description of the commonly used evaluation methods and the process of assigning the method to each cost and benefit is described in (Lech 2005). The last issue is the risk. From the practical point of view, it is more important to identify and manage the risk than to assess its value. The easiest way of incorporating the risk factor into the evaluation model is to reflect each of the benefits and costs as a range with assigned probabilities rather than a fixed value.

5. Field study

The methodology of evaluating IT investments presented above will be illustrated by a field study, performed in a medium-sized production company. The information for this field study was gathered during the life project, carried out according to the methodology presented above in which I was a project leader and leading consultant.

5.1 Description of a company

The company is the country leader in the production of external identification systems. The company produces and installs signing systems for petrol stations, shops, banks etc. Most of the production is made to order and the orders are usually short and non-repetitive. Being the technological leader in the country, the company...
Przemysław Lech

does not have problems with sales of its products. The main problem that the company faces is the lack of production capacity not allowing it to accept all the orders. Due to this fact, the company has come the conclusion that implementing a new ERP system would be the solution to this problem. The evaluation has been performed to find out if the implementation of the ERP system would add value to the company.

5.2 Evaluation process description

The evaluation has been performed in the following steps:

- Workshop with the CEO to determine the business goals of the enterprise.
- Preliminary analysis of the existing IT environment
- Business process modelling workshop (direct benefits search)
- Analysis of the:
  - Support of the business goals by the currently performed business processes – proposal of the process change,
  - Support of the processes by the current IT environment,
  - Possibility of supporting the processes with the ERP system.
- Value analysis:
  - Goals achievement,
  - Direct payback.

During the business goals’ workshop the following main goals have been identified:

- Increase the production capacity usage by better organisation of the production process (benchmark from a similar company in another EU country stated that there is a possibility to increase the capacity usage by 40 %),
- Keep the currently applied short lead times,
- Keep the possibility to accept orders for non-standard products and offer short lead times for them,
- Eliminate delivery delays,
- Allow the company to analyse the profitability of each order.

The analysis of the currently used IT systems has revealed that the enterprise is using a homemade solution that has most of the functionality needed for production and material planning. Thus a workshop has been performed to find out, how this system is used to support the business processes. The business process-modelling workshop gathered key people from all departments. Each process was examined from the following perspectives:

- Process improvement:
  - How is the process performed now?
  - What could be changed in the process itself to make it better?
  - What inputs from the other processes are necessary to make the analysed process better?
  - What information is necessary to make the process better?
- Process support by IT:
  - How is the process supported in the current system?
  - What is the reason for not using the available system functionality?
  - How should the system be supported by IT (model approach)
  - How could the current system be improved to support the process better?
- Process value:
  - What is the process value for the customer and how will it be improved if the process is changed and properly supported by IT?
  - What is the process cost and how can it be reduced?
  - What resources does the process use and how these can be reduced?

The data gathered during the workshop has formed the basis for the next analytical steps. It became clear that the problem with low production capacity usage emerges not from the lack of IT support but from organisational problems. IT tools allowing proper material and capacity planning were available in the currently used system but they were omitted by the employees. The ERP system would not solve the problem as it could be omitted as well. It became clear that to support business goals, it is necessary to implement organisational procedures that will force people to input the information about the production process into the system. The value analysis of the two IT variants (enhancements to the current system and implementation of ERP) has been done based on the information gathered during the workshops.

5.3 Results of IT value analysis

The summary of the value analysis is given below. As the IT investment is clearly a business improvement one, it should be performed only if the revenue/cost ratio is more than 1. The aspects to be evaluated are:

- Operational business goals support,
Direct payback. Business goals support were evaluated with the use of the ranks presented in Table 2:

Table 3. Evaluation of business goals support

<table>
<thead>
<tr>
<th>No</th>
<th>Business goal</th>
<th>Current system</th>
<th>ERP</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increase of the capacity usage</td>
<td>2</td>
<td>3</td>
<td>The use of ERP might lead to the capacity usage increase up to 40% but can cause longer lead times (detailed BOMs needed) and decrease elasticity in accepting non-standard orders. The use of the simplified production planning in the current system should cause the capacity usage increase by 20%.</td>
</tr>
<tr>
<td>2</td>
<td>Keep short lead times</td>
<td>2</td>
<td>-1</td>
<td>The usage of MRP procedure will lengthen the lead times as the detailed BOM and work routings is needed for the new products before the production start.</td>
</tr>
<tr>
<td>3</td>
<td>Accept non-standard orders</td>
<td>2</td>
<td>-1</td>
<td>as above</td>
</tr>
<tr>
<td>4</td>
<td>Eliminate delays</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Enable profitability analysis</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

The current system supports the business goals better than ERP.

Possible direct benefits were identified and those, for which it was feasible, were assigned a monetary value. The expected value of the revenue increase due to better capacity usage was estimated as 1 200 000 EUR per year. The reduction of non-rotating stock was estimated as 40 000 EUR per year. Some other possible benefits like transport cost optimisation, better assembly and post sales service planning were identified but it was impossible to assign a value to them. Thus the measurable benefits were estimated to be 1 240 000 EUR per year. The cost analysis of the two variants gave the following results:

Table 4. Estimated costs related to the usage of the current system

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare and input BOMs and routings for each new product – simplified version (1 employee)</td>
<td>15 000/year</td>
</tr>
<tr>
<td>Real time input of all information concerning production (material issues, material returns) (1 employee)</td>
<td>15 000/year</td>
</tr>
<tr>
<td>Necessary enhancements in the current system (internal IT department) 3 months</td>
<td>4 000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>34 000</strong></td>
</tr>
</tbody>
</table>

Table 5. Estimated costs related to the ERP implementation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare and input BOMs and routings for each new product – full version (2 employees)</td>
<td>30 000/year</td>
</tr>
<tr>
<td>License</td>
<td>180 000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>25 000</td>
</tr>
<tr>
<td>Implementation</td>
<td>240 000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>475 000</strong></td>
</tr>
</tbody>
</table>

Providing a similar level of benefits, the usage of the current system is less costly than implementation of ERP. The overall recommendation is to enhance the currently used system as it supports the business goals better and provides better ROI than the ERP suite.

6. Summary

The main aim of this paper was to propose a framework for creating practically relevant, easy to use evaluating methods that would help enterprise managers in taking reasonable decisions concerning IT investments. To keep it as simple as possible, the framework concentrates on the two aspects which seem to be the most important in creating business value of IT: support of the enterprise’s goals and direct payback. It relates the IT initiative aspects that should be the subject of evaluation as well as the success criteria, to the investment purpose. It then gives the indications on how to determine the business goals related to the IT initiative and evaluate the support of these business goals with IT. It provides some fingertips for the search of direct benefits as well. The use of the method was illustrated by the field study, which proved its usability for decision making at least in the case being the subject of this study. Of
course the method presented here would not solve all real-life IT investment decision problems but it supplies the framework for further development and research.

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Evaluating Enterprise Systems Implementation Methodologies in Action: Focusing Formalised and Situational Aspects

Daniela Mihailescu¹, Sven A. Carlsson² and Marius Mihailescu¹
¹Jönköping University, Sweden
²Lund University, Sweden
daniela.mihailescu@jibs.hj.se
sven.carlsson@ics.lu.se
marius.mihailescu@jibs.hj.se

Abstract: Enterprise Systems (ES) are among the largest and most important Information Systems (IS) an organisation employs. Most ES are rented or bought as COTS (Commercial Off The Shelf) software. The use of COTS leads to a distinction between the development of the ES software—done by ES software providers, like SAP and Microsoft—and the implementation of ES software in a specific organisation. Implementation of ES are often associated with problems like higher implementation cost and longer implementation process than anticipated. To improve ES implementation, ES providers increasingly support their ES software by, in part computer-based, implementation methodologies. The paper presents an ES implementation evaluation framework called ES Implementation Methodology-in-Action. The framework integrates two complementary views: 1) a technology view, focusing on the formalised aspects as expressed in the ES implementation methodology (the content of the methodology), and 2) a structural view, focusing situational aspects as expressed by the implementers (the users of the implementation methodology) including implementers, implementation context, ES software and other individuals participating in the implementation project. Using document studies and interviews with implementers we show how the framework can be used to evaluate ES implementation methodologies. We evaluate one well-known ES implementation methodology: SAP’s ASAP.

Keywords: Enterprise Systems Implementation Methodology, Evaluation Framework, Implementation Methodology in Action, Methodology Evaluation

1. Introduction

Enterprise systems (ES) are application software packages developed by ES software providers. ES are alternatives to custom-built software. An ES is implemented in an organisational context using a more or less formalised and adjusted implementation methodology. Most ES vendors have developed vendor specific implementation methodologies. The existing literature on ES implementation methodologies describes mainly the implementation methodology developed and recommended by one of the major ES vendors: SAP’s Accelerated SAP (ASAP) methodology. The existing lack of evaluations of ES implementation methodologies reduces practitioners’ and researchers’ possibilities to comprehend the characteristics, the significance, and the usefulness of ES methodologies. This paper addresses this shortcoming by: 1) developing an ES Implementation Methodology-in-Action framework to be used for evaluating ES implementation methodologies, and 2) by using one case, SAP’s ASAP methodology, shows how the framework can be used to evaluate specific ES implementation methodologies. The remainder of the paper is organised as follows: In the next section (Section 2) we present our research approach. Our ES Implementation Methodology-in-Action framework is presented in Section 3. In section 4 we apply the framework on SAP’s ASAP implementation methodology. This is followed by discussion, contribution, and further research.

2. Research approach

Using current ES and Information Systems Development literature we through an iterative process developed an ES Implementation Methodology-in-Action framework. The framework integrates two complementary views: 1) a technology view, focusing on the formalised aspects, and 2) a structural view, focusing situational and contextual aspects. The framework can be used to evaluate a specific ES implementation methodology or it can be used to compare different ES implementation methodologies. To illustrate the usefulness of the framework, we used the framework to evaluate a specific ES implementation methodology, namely SAP’s ASAP implementation methodology. The primary data collection method for the evaluation study was semi-structured interviews with ten experienced ES implementers. The interviews elicited the respondents’ views on and experiences of ASAP. The interviews were done in the fall of 2004 and each interview lasted between 30 minutes and two hours. Documentation was the second data source. Documents provided by some interviewees, SAP’s web pages, a SAP conference (Managing SAP Projects 2004) and published articles and
books were used. Data for addressing the formalised aspects (discussed below) of the ASAP implementation methodology came mainly from documents; and for addressing the structural aspects interviews and documents were used.

3. ES implementation methodology-in-action framework

The study of ISD methodologies is a core theme in the IS discipline (Jayaratna, 1994; Fitzgerald et al., 2002, livari et al., 2004). The ISD methodologies addressed and studied have not been ES implementation methodologies, which is the focus of this paper. In the ISD methodology evaluation literature there is a primary focus on the formalised aspect of methodologies (Truex et al., 2000), but a second focus emphasising the situational aspect and how methodologies are enacted and used in practice is emerging (Fitzgerald et al., 2002; livari and Maansaari, 1998; Mathiassen, 1998). Studies indicate that methodologies are applied by practitioners in a rather pragmatic way resulting in a unique instantiation of a methodology for each ISD process (Fitzgerald et al., 2002; Truex et al., 2000). Based on the ISD literature, we suggest that our framework should combine the two current views on methodologies: 1) technology, i.e. the formalised aspect, and 2) structure, i.e. the situational aspect. Each view highlights significant but different aspects of methodologies. The technology view focuses on the methodology per se and its formalised aspect, i.e. content and roles as prescribed by methodology designers. The structure view focuses situational aspects and considers how methodologies are used in practice (contextual use). The integration of these two views provides a high-level lens for conceptualising methodologies and for developing our ES Implementation Methodology-in-Action framework. The Method-In-Action (MiA) framework (Fitzgerald et al., 2002) underpins our framework (Table 1).

Table 1. Framework based on the method-in-action framework (Fitzgerald et al. 2002)

<table>
<thead>
<tr>
<th>Conceptualisation of methodology</th>
<th>Formalised aspect</th>
<th>Situational aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology as a technology</td>
<td>Methodology content and its roles</td>
<td>Methodology as a structure</td>
</tr>
<tr>
<td>Components</td>
<td>Implementers Implementation context</td>
<td>Implementers Implementation context</td>
</tr>
<tr>
<td>Integrated Methodology conceptualisation</td>
<td>Enterprise Systems Software</td>
<td>Enterprise Systems Software</td>
</tr>
</tbody>
</table>

The formalised aspect provides de-contextualised and practice-detached general knowledge about the implementation methodology. This aspect is represented by the content and roles prescribed by the methodology designers. The situational aspect and related components, i.e. implementers, implementation context and the enterprise systems software (ESS) emphasise specific features which vary in different degrees from one implementation project to another. For instance, the characteristics of the implementation context, i.e. uniqueness, complexity, and uncertainty, along with the characteristics of the ESS, i.e. purpose, complexity, and degree of novelty, are specific to each project. Implementers’ competences, i.e. knowledge and skills necessary to manage the project and map business processes into the ES, as well as the ability to use the methodologies, are individually. Our ES Implementation Methodology-in-Action framework is depicted in Figure 1.

In the next section we use the framework to evaluate SAP’s ASAP implementation methodology. SAP AG, the largest ERP provider, has developed and recommends the use of ASAP, which represents the de facto standard for implementing SAP solutions. The ASAP methodology was released in June 1997 and by year 2003 it was integrated in a tool named Solution Manager and in all SAP installations without charge.
Figure 1. ES implementation methodology-in-action framework

4. ASAP-in-Action

The evaluation of the ASAP implementation methodology is structured according to the components included in the framework in terms of formalised and situational aspects followed by the integration of these two aspects, i.e. ASAP implementation methodology in action.

4.1 Formalised aspect of ASAP implementation methodology

ASAP implementation methodology is recommended to implementation partners and customers in order to facilitate and support a structured, efficient, and accelerated implementation of SAP solutions. ASAP specifies necessary project management activities and development tasks sequences, as well as methods, techniques, tools and services. The majority of implementation partners customise, i.e. add, adapt or supplement parts of the original methodology and develop their own methodology, so-called Powered ASAP. The implementation methodology can be customised to fit a specific project scope and a type of solution by choosing different roadmaps with related content, i.e. activities and templates, which might be dynamically adapted by using integrated implementation tools. These implementation tools are integrated with the application software and should lead to a rapid implementation and optimisation of the ES by providing guidelines and accelerators in order to manage the implementation process, configure/customise mySAP application software and produce related documentation (Ghosh, 1999). Since the content of the tools is dynamically adapted and integrated with the application software, the implementation tools are regarded as one of the key components of ASAP implementation methodology, which is based on the continuous business engineering approach. This underlying approach implies 1) an ESS implementation based on a Reference Model along with the use of integrated accelerators, 2) implementing organisation compliance with the standardised and competition-neutral process flows embedded in the enterprise systems software, and 3) the “optimisation” of the enterprise systems software. The content of ASAP implementation methodology is summarised in Table 2.

Table 2. The content of ASAP implementation methodology

<table>
<thead>
<tr>
<th>Content</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>Continuous Business Engineering – business process innovation through technology and IT practice and rapid implementation of flexible and market-based organisation structures in enterprises with related data processing support</td>
</tr>
<tr>
<td></td>
<td>- goals: Standardise, structure and guide a rapid and efficient implementation of SAP solutions in organisations</td>
</tr>
<tr>
<td></td>
<td>- assumptions: An enterprise should accept the embedded ‘best practices’ wherever possible; a</td>
</tr>
</tbody>
</table>

www.ejise.com  ISSN 1566-6379
Content  Description
common frame of reference, i.e. a business blueprint, is created by using a Reference Model which incorporates standardised and competition-neutral process flows and can be used as a starting point to solution and adjusted to a specific situation in this way preventing the modelling effort from starting from scratch and so profit from the experiences of other enterprises
- process model: linear sequence of phases for entire implementation life cycle: Discovery, Evaluation, Implementation and Operations
- conceptual model: process oriented

Methods  
- ASAP Roadmaps including activities, deliverables, role descriptions, additional guides and accelerators as well as associated techniques and tools
- Iterative Process Prototyping (IPP) with a focus on process design based on Reference Model and Prototyping

Techniques  
- Event-controlled Process Chain (EPC) represents the basis for all process modelling activities and structures and assures consistent specification of process requirement, i.e. describes process flow of events, tasks and processes

Tools  
- accelerators and comprehensive application platforms for structuring and supporting the construction and maintenance of the business blueprint and implementation phases
- examples: SAP Solution Composer, ASAP Roadmaps, SAP Solution Manager

Services  
- accessed through the operation sections or triggered dynamically depending on the configuration status of a solution

The formalised aspect of an implementation methodology is represented by its content along with its roles. The roles are summarised in Table 3.

Table 3. ASAP’s roles

<table>
<thead>
<tr>
<th>Role Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>To have a transparent approach which helps to integrate, harmonies, coordinate, structure, control, guide and follow up components that make an implementation successful, i.e. a rapid delivery of the system and working as a team to reduce implementation time, costs and risks</td>
</tr>
<tr>
<td>2.</td>
<td>To describe all activities in an implementation and make sure that nothing is left out by offering project plans well in advance for execution and ensuring the quality of the work by being an integrated part of the quality assurance system</td>
</tr>
<tr>
<td>3.</td>
<td>To include the entire technical area to support technical project management and address things like interfaces, data conversion and authorisation earlier than in most traditional implementations</td>
</tr>
<tr>
<td>4.</td>
<td>To achieve better results by using accelerators and best practices which cover both hard facts, i.e. what to do, as well as soft facts, i.e. who, when and how to do things</td>
</tr>
<tr>
<td>5.</td>
<td>To help implementers to understand the context, facilitate their communication with customers and the work with an organisation in change and handle unexpected changes in a project</td>
</tr>
<tr>
<td>6.</td>
<td>To win credibility and trustworthiness and reduce resistance</td>
</tr>
<tr>
<td>7.</td>
<td>To meet requirements in order to be certified by vendors and be accepted by customers</td>
</tr>
<tr>
<td>8.</td>
<td>To promote knowledge management, e.g. to gather knowledge on how to organise and run implementation projects and document the knowledge</td>
</tr>
</tbody>
</table>

It should be noted that there is an underlying rational view in ASAP’s roles, but some of the roles draw attention to understanding, knowledge, and communication, which are related to the enactment of a methodology in an actual project. They highlight the situational aspects of ASAP, which are presented next.

4.2 Situational aspect of ASAP implementation methodology

The components, which reveal the situational aspects of a methodology, are: the implementers, implementation context, and Enterprise Systems Software (in this case SAP’s MySAP).

Table 4. Perceived personal competences by implementers

<table>
<thead>
<tr>
<th>Personal Competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Commitment, motivation, inquisitiveness in order to ask relevant questions, collect information and understand the context</td>
</tr>
<tr>
<td>2. Creativity, experience and professional knowledge, i.e. business and technical, necessary to find the</td>
</tr>
</tbody>
</table>

4.2.1 Implementers

Implementers’ business competences—including organisational, strategic, business process and project management competences—were emphasised by the interviewees as critical. The stressing of business competences and personal competences echoes the result in Zwieg et al.’s (2006) and Gartner’s (2006) recent studies on changes in IT competencies. A summary of competences perceived as critical by implementers are presented in Table 4.
The competences stressed by the interviewees are related to understanding of the context, suggesting workable solutions, gaining trust, and ability to work in project teams. The interviewees argued that general business competences will remain significant in the future and even increase in importance. Furthermore, personal and technical knowledge and skills are also important. The interviewees stressed that the implementers must be able to transform their general knowledge and skills into contextual practice and actions. The implementers play a central role in how an implementation methodology is used. The interviewees also stressed implementers capability to develop good relationships to other project stakeholders (a situational component) is critical for implementation projects.

### 4.2.2 Implementation context

Implementation context has different meanings and degrees of influence. The influence can be direct or indirect. A direct influence on implementers’ decisions and work with a methodology is from the context, which is characterised by uniqueness, complexity, and uncertainty. These characteristics are reflected on two levels: project and organisation. The characteristics of a project, i.e. the scope and goal of a project along with the implementation approach, are considered significant to elucidate expectations and perceptions of project participants, both implementers and customers, related to 1) the degree of organisational change and 2) the extent to which the application software needs to be configured/customised. The characteristics of an organisation, summarised in Table 5, are complementary to project characteristics. Thus, the project and organisation characteristics are on the one hand considered to help implementers to understand and recognise the characteristics of the context and on the other hand to influence the roadmap, resources and time necessary to accomplish the tasks during the implementation process.

<table>
<thead>
<tr>
<th>Characteristics of an organisation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Culture and structure</td>
<td></td>
</tr>
<tr>
<td>2. Business values and specific strategic aspects</td>
<td></td>
</tr>
<tr>
<td>3. Degree of standardised processes and use of standardised components</td>
<td></td>
</tr>
<tr>
<td>4. Customer’s understanding of own organisation</td>
<td></td>
</tr>
<tr>
<td>5. IT infrastructure</td>
<td></td>
</tr>
</tbody>
</table>

### 4.2.3 Enterprise systems software

The purpose of mySAP application software is to make use of technological advances and support the business requirements of an adaptable business. It automates and supports the business process but most importantly it enables changes, e.g. business process change, in an organisation based on best practices. SAP’s first generation of ERP application software was intended to offer a centralised infrastructure to ensure both internal and external functionality within the boundary of an organisation, based on client/server architecture. The development of SAP’s second generation of ERP application software is intended to offer a web-enabled infrastructure to support collaborative processes. This latest business solution offered by SAP comprises three parts 1) an integrated application platform, SAP NetWeaver; which includes implementation tools, 2) a well defined and tuned business core functionality existent in enterprise systems software, mySAP ERP, and 3) additional enterprise systems extensions to support collaborative processes, mySAP Solutions. The integrated characteristics of these applications are intended to ensure the transition towards process innovation technology based on Web services and Enterprise Service Architecture (ESA). The Enterprise Systems Software as presented in this section is associated with a high degree of technical and social complexity and a possible high degree of novelty. These features motivate and influence the implementation methodology enactment.

### 4.3 ASAP implementation methodology in action

According to the interviewees, in order to take full advantage of the underlying approach, the
adherence to integrated implementation tools which automatically adapt the content of existent roadmaps to the characteristics of a project and type of solution is recommended. In this way the actual implementation process takes place in compliance with the sequence of phases provided in the Roadmaps and the adaptation of the implementation methodology is restrained. However, implementers have the possibility to influence the content of activities and individualise the templates related to each phase. Through formal or informal transactions with other project stakeholders they understand the context by using the Reference Model embedded in the ESS as baselines. The implementers reflect on formal activities or those which occur spontaneously in their work and enact the ASAP implementation methodology-in-action. The enactment implies that implementers apply their competences and adapt the use of ASAP implementation methodology in a particular project and by using it take appropriate action:

- Learn and improve their competence;
- Manage the implementation process over time, e.g. phases, formal and unexpected activities, methods and techniques with defined milestones and deliveries;
- Identify, design and model a business blueprint based on the Reference Model embedded in mySAP with regard to regulations and characteristics of the implementation context;
- Configure and/or customise mySAP, e.g. parameter settings and/or addition of extra features to the software by writing program code as well as modules and/or system integration;
- Update the formalised methodology over time in terms of phases, activities, templates, methods, techniques and tools as well based on their own experiences and/or regulations from their organisation;
- Communicate, collaborate, and negotiate with project stakeholders, e.g. managers, users and other implementers involved in a project.

In the our ES implementation methodology framework the use of implementation methodology was considered to be influenced explicitly or implicitly by a formalised implementation methodology, the implementation context and the enterprise systems software and enacted by implementers. The interviews suggest that the implementers’ actions and project stakeholders’ actions influence the use of an implementation methodology. As discussed previously the characteristics of a project, i.e. scope and goal of a project along with the implementation approach, are considered to influence the roadmap, resources and time necessary to accomplish the tasks during the ESS implementation process. Figure 2 summarises ASAP in Action.

Figure 2. ASAP implementation methodology in action
The framework integrates both formalised and situational aspects and highlights the components which influence (continuous arrows in Figure 1) the use of the implementation methodology, and implementers’ actions (dashed arrows in the figure) which occur through the use of implementation methodology in the ESS implementation process. The components which influence the use of the methodology are implementers, organisational and project context, formalised methodology, project stakeholders and the enterprise systems software.

5. Discussions and conclusions

In this paper, a framework which draws on current views on methodology-in-action has been developed and used to evaluate one implementation methodology (ASAP). We argue that an implementation methodology is characterised by both formalised and situational aspects. These two aspects emphasise different features.

Although ASAP in many cases is requested by customers the opposite case exists as well, e.g., the organisation where the application software is implemented uses its own or other methodologies than ASAP. However, according to all interviewees, the different ES implementation methodologies on the market seem to be similar to ASAP. The main differences between them are considered to be 1) the number of accelerators, which is significant in order to identify when and what to do, 2) the integrated tools and prototyping, which support and have an significant importance during the ESS implementation process and 3) some fixed principles specific to the ESS, in this case SAP’s software, that need to be taken into consideration. The integration of formalised and situational aspects is considered to highlight the characteristics of an implementation methodology and is regarded as necessary in order to increase our understanding of this concept and reduce possible misunderstandings and confusing research results.

The incorporation of implementation methodology into tools integrated with the application software has the effect of structuring and standardising the implementation process by enforcing a particular set of phases, activities and necessary documentation upon implementers (Truex and Avison, 2003). In this way, the implementer is guided through the configuration process of the enterprise systems software. This may explain interviewees’ perception that the configuration is less arduous than the design of solution, i.e. the process identification and modelling.

ASAP implementation methodology, like other formalised methodologies, provides support for explicit knowledge. Accelerators and implementation tools may be regarded as knowledge repositories for organisations and implementers who reuse and update templates with knowledge from earlier projects. However, the use of a methodology and the ability to deal with unexpected events is more a question of tacit knowledge which is primarily related to implementers’ personal competence in terms of creativity, motivation and inquisitiveness, which cannot be easily planned and learned. For implementers a methodology represents a tool, which shows how to reach the solution, but they have to put this instrument into action and help the organisation to understand the complexity of the environment and the solution, to change behaviour and mature through a transparent process during the implementation.

6. Contributions and further research

The framework developed in this study has a number of implications for research and practice. Building on current views on method in action integrated with insights from Information Systems Development and Enterprise Systems research, a framework for evaluating ES implementation methodologies has been proposed. The practical contributions aim to broaden and deepen implementers and users understanding of implementation methodologies by offering an integrated view of the characteristics of such methodologies. The underlying approach of the implementation methodology implies a rapid enterprise systems software implementation based on a Reference Model along with the use of integrated accelerators and implementation tools. These features along with the integration between implementation tools and the enterprise systems software may stimulate the utilisation of implementation tools in order to facilitate and improve the implementation process. In consequence, the implementers may change their way of working in order to improve the outcome (implementation success) of their efforts. However, the use of the implementation tools cannot ensure an automatic improvement of the implementation process, which is influenced by the characteristics of several components, implementers and other project stakeholders, the implementation context and the enterprise systems software.

For the users at the implementation organisation, understanding the features of an implementation methodology may help them in defining expectations and deciding to adopt, adapt, or
reject the use of the implementation methodology depending on the nature of the implementation situation. Thus, they have to be aware of both formalised and situational aspects of the implementation methodology since the value of the implementation methodology per se does not automatically lead to a successful implementation process. User empowerment and the question of adopting or not adopting the integrated implementation tools is a topical issue which implementing organisations need to pay attention to. At the same time, each organisation has to consider the alternative of acquiring or outsourcing indispensable competence during as well as after the implementation. In order to be able to optimise and innovate the business processes through an effective use of implementation tools is important. In consequence, a better understanding of the implementation methodology concept is relevant not only for the implementers but also for the users at the implementation organisations.

The framework suggested in this study appears to be useful for evaluating a particular type of implementation methodologies in terms of its characteristics and its use. Furthermore, since the implementation methodology is relevant not only for the implementers but for the users at the implementing organisations as well, it would be especially interesting to study the implementation methodology from the users’ perspective. In this sense, implementers’ role as coaches and the way the knowledge can be transferred to the users in an effective way could be further studied. This perspective is particularly important since many organisations have implemented enterprise systems software and are in the optimisation phase which request competence to handle the business processes in an innovative way to sustain the growth and competitiveness of the organisations. In this study we used the framework to evaluate ASAP. Further studies can use the framework to study other ES implementation methodologies in action. It can also be used in comparative studies, where different ES implementation methodologies are studied and compared.

References


Gartner (2006) "How to Lead and Manage the IT-Literate Workforce", Research report, ID Number G00138404.


Abstract: Although some important technological developments have been achieved during last decade, information systems still do not answer efficiently enough to the continuous demands that organisations are facing – causing a non-alignment between business and information technologies (IT) and therefore reducing organisation competitive abilities. This paper proposes sixteen metrics for the Information System Architecture (ISA) evaluation, supported in an ISA modelling framework. The major goal of the metrics proposed is to assist the architect previewing the impact of his/her ISA design choices on the non-functional qualities of the Enterprise Information System (EIS), ensuring EIS better align with business needs. The metrics proposed are based on the research accomplished by other authors, from the knowledge in other more mature areas and on the authors experience on real world ISA evaluation projects. The metrics proposed are applied to an e-government project in order to support the definition of a suitable ISA for a set of business and technological requirements.

Keywords: Information system architecture metrics, information system architecture evaluation, enterprise information system, ceo framework, e-government project evaluation.

1. Introduction

Though Information System Architecture (ISA) is currently recognised as an essential step in the process of building Enterprise Information Systems (EIS) aligned with business needs, there are not tools that assist the Information System (IS) architect in accessing (during “design time”) the impact of his or her decisions on the global ISA qualities. Moreover, other ISA stakeholders that might have limited knowledge on ISA matters (as business people, software engineers, infrastructure experts) do not have simple methods or tools to quickly and automatically evaluate an ISA in respect to a set of desired IS qualities driven from the business context. The authors' research pretends to provide ISA stakeholders the tools for assessing ISA qualities ensuring EIS suitable to business needs. Firstly, recognising the need for a coherent way of representing ISA, in Vasconcelos et al. (2001), the authors proposed a set of Enterprise modelling primitives (the CEO Framework), extended later into an UML profile for ISA modelling – regarding information, application and technological information system concerns (Vasconcelos et al. 2003). Afterward the ISA modelling framework have been tested in real world case studies (Vasconcelos et al. 2004a) and enriched considering other IS characteristics (Vasconcelos et al. 2004b) – this research step confirmed the need for tools capable of supporting the architect while building the ISA and quickly accessing his or her design choices. More recently, considering that the evaluation topic is a quite mature issue on the software engineering domain, the authors classify several software evaluation approaches in order to consider its applicability for ISA evaluation and adapted some software metrics to the information system context (Vasconcelos et al. 2005). In this paper the authors present theirs recently developments on ISA evaluation by proposing and explaining the foundation of a set of metrics for ISA evaluation. The ISA modelling framework that supports the evaluation metrics is introduced in section 2. In section 3 the authors proposed a coherent set of ISA evaluation metrics, relating ISA qualities and ISA components. In section 4 the metrics proposed are applied to an e-government ISA project. The conclusions and future work are presented in section 5.

2. CEO framework for ISA modelling

In section 2.1 we introduce the Information System Architecture (ISA) major concepts and relations. In section 2.2 we introduce the CEO framework for ISA modelling; this framework is used in section 3 for supporting the metrics proposed for ISA evaluation.

2.1 Information system architecture

Information System Architecture (ISA) is a part of a vaster field of architectures and models relevant for the organisation. Considering the architectural level, one can distinguish the following architectures:

- Enterprise Architecture.
- Information System Architecture (ISA).
- Software Architecture (SWA)
Software Architecture (SWA) main study area is on how programs or application components are internally built (Carnegie 2000). At this level it is import to considered the objects and classes needed for implementing the software. SWA is a quite stable and mature field. Enterprise Architecture is a group of models defined for getting a coherent and comprehensible picture of the enterprise (Tissot et. al. 1998). The models define different “perspectives or viewpoints from which the company is considered, focusing on some aspects and ignoring others in order to reduce complexity” (Vernadat 1996). Thus, a model of the company can contain several activity, process, organisation, information and behaviour diagrams of the company. Enterprise architecture is considered a vaster concept than ISA, which includes business strategies and processes, besides Information System (IS) models that support them. Usually, at enterprise architecture level, IS are consider “simple” resources used in business (as people, equipment and material, etc.) – e.g., (Eriksson et. al. 2000) and (Marshall 2000).

Finally, Information System Architecture (ISA) addresses the representation of the IS components structure, its relationships, principles and directives (Garlan et. al. 1995), with the main propose of supporting business (Maes et. al. 2000). Spewak in Spewak et. al. (1992), argues that the ISA description is a key step in ensuring that IT provides access to data when, where and how is required at business level. Thus some of the potential benefits of an ISA are:

- IS complexity and interfaces cost reduction (Cook 1996), Spewak et. al. (1992).
- Ensures IS flexible, durable and business oriented (Zijden et. al. 2000).
- Allows the evolution and introduction of new technologies according to the strategy of the business plan (Cook 1996), (Spewak et. al. 1992).
- Provides the means for business, IS and IT components alignment (Zijden et. al. 2000).
- Ensures greater efficiency using IT, namely by providing: a controlled development and maintenance cost, more application portability, and more flexibility in changing and upgrading technological components (Open 2003).

In the 80’s, software architecture (SWA) and ISA where considered synonymous. Only in last decade the need for manipulation of concepts that overwhelm the description of how a system is internally built emerged. Zachman framework (Zachman 1987), is defined has the first important sign that SWA has not enough.

Quoting IEEE (1998), ISA level should be high. Thus, ISA is distinguished from software representation and analysis methods (as E-R diagrams, DFD), presenting an abstraction of internal system details and supporting organisation business processes (Zijden et. al. 2000). Sassoon, discusses the concept of “IS urbanisation”, emphasising, like in city planning, the need for models that guide the evolution and growth of IS robust and independent of technological trends (Sassoon 1998), ISA usually distinguish three aspects, defining three “sub architectures” Spewak et. al. (1992):

- Informational Architecture, or Data Architecture. This level represents the main data types that support business.
- Application Architecture. Application architecture defines applications needed for data management and business support.
- Technological Architecture. This architecture represents the main technologies used in application implementation and the infrastructures that provide an environment for IS deployment.

Identifying and defining the major data types that support business development is Informational Architecture major propose Spewak et. al. (1992), DeBoever (1997). Inmon (2000) characterises data (the support of the information architecture) through different dimensions: primitive vs. derived, private vs. publics and historical vs. operational vs. provisional data. Inmon (2000) argues that the ISA should be influence by the data characteristics. The second architecture level, defined by DeBoever (1997), is the application (or system) architecture. This architecture defines the main applications needed for data management and business support. This architecture should not be a definition of the software used to implement systems. The functional definition of the applications that should ensure access to data in acceptable time, format and cost is this architecture main focus Spewak et. al. (1992). Application architecture defines the major functional components of the architecture. Spweak proposes a methodology – Enterprise Architecture Planning (EAP) – able to define application architecture from informational and business requirements Spewak et. al. (1992). Using Spewak methodology and Zachman framework several institutions have been proposing adaptations that best answer to its needs – interesting case studies are Information System Architectures in the American Federal Government (FEAF 1999), DoD Technical Reference Model (DOD 2002), Treasury Enterprise Architecture Framework (Business 2002), among others.
Technological architecture defines the major technologies that provide an environment for application building and deployment. At this level, the major technological concepts relevant for the IS are identified – as network, communication, distributed computation, etc. Spewak et. al. (1992).

### 2.2 The CEO framework

The CEO Framework (Figure 1) aims at providing a formal way of describing business goals, processes, resources and information systems and the dependencies between them. It is composed of three separate levels, each of which provides adequate forms of representing the notions about the layer being described (Vasconcelos et al. 2001).

![Figure 1. Goal / process / system framework](image)

In the first level, the aim is at describing the current set of goals that drive business. These goals must be achieved through one or more business process. The business processes are described at the second level and must exist in order to satisfy one or more goals. Besides serving goals, business processes interact with resources in order to do work and may be supported by information systems. The information systems layer aims at modelling the components of the system that support business. The modelling language used to implement the CEO Framework was UML (Unified Modelling Language). As UML was initially designed to describe aspects of a software system, it had to be extended to more clearly identify and visualise the important concepts of business, namely by use of stereotypes – for further detail on UML extension mechanisms see OMG (2004). Due to size restrictions, we will not do a full presentation on the CEO Framework (for further reading, refer to Vasconcelos et al. (2001)). Figure 2 presents the UML metamodel defined for the CEO Framework.

![Figure 2 - UML metamodel of the CEO framework](image)

In order to model ISA key concepts, the «Block» component was specialised. The key concepts for the Information System Architecture are:

- Information Entity – person, place, physical thing or concept that is relevant in the business context;
- IS Block – Application architecture main aim is on the functional components characterisation. At application level, the IS Block (or Application Block) notion is the founding concept. IS Block is defined as the collection of mechanisms and operations organised in order to manipulate organisation data.
- IT Block – Technological architecture addresses a large variety of notions, caused, on the one hand, by the continuous

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technological evolutions and, on the other hand, by the need for different specialised IT architectural views – as security, hardware and software development architectures. In order to encapsulate this diversity, this framework uses the “IT Block” concept. IT Block is the infrastructure, application platform and technological/software component that realises (or implement) an (or several) IS Block(s). IT Block defines three major sub-concepts:

- **IT Infrastructure Block** – represents the physical and infra-structural concepts existing in an ISA: the computational nodes (as servers, personal computers or mobile devices) and the non-computational nodes (as printers, network, etc.) that support application platforms.

- **IT Platform Block** – stands for the implementation of the services used in the IT application deployment.

- **IT Application Block** – the technological implementation of an IS Block. At this level is relevant to consider the kind of IT Application Block (namely presentation, logic, data and coordination block), and its “technological principles” (like if it is implemented using components, modules, OO principles, etc.), among other characteristics.

- **Service** – is an aggregation of a set of operations provided by an architectural block. A generalisation of the web service notion (W3C 2002). We consider three distinct services in an ISA:
  - **Business Service**. A business service is a collection of operations provided by IS Blocks that support business processes.
  - **IS Service**. The set of operations provided by an IS Block to others IS Blocks defines the IS service.
  - **IT Service**. The technological services provided by application platforms are the IT services (Open 2003).

- **Operation**, the abstract description of an action supported by a service. Thus, operations are the minor level concept relevant in an ISA.

**Figure 3** describes how these high-level primitives are related, in a UML profile for ISA. For further detail please refer to Vasconcelos et al (2003).

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**Figure 3.** Information System CEO framework metamodel (Vasconcelos et al. 2003)

### 3. Information system architecture evaluation

In this section we propose a set of metrics for ISA evaluation. In section 3.1 we identify the information system qualities that might be measure in an ISA. In section 3.2 the authors propose a set of ISA evaluation metrics.

#### 3.1 Information system qualities

As discussed in Vasconcelos et al. (2005), the qualities attributes that are important in software
evaluation are also significant in ISA evaluation. The accuracy and suitability of an architecture is analysed considering several quality attributes. Bass (1998) and Clements (2002) propose the following:

- **Usability** – user’s ability to utilise a system effectively;
- **Performance** – responsiveness of the system – the time required to respond to stimuli or the number of events processed in some interval of time;
- **Reliability** – ability of the system to keep operating over time;
- **Availability** – proportion of time the system is up and running;
- **Security** – system’s ability to resist unauthorised attempts at usage and denial of service while still providing its services to legitimate users;
- **Functionality** – ability of the systems to do work for which it was intended;
- **Modifiability** – ability to make changes to a system quickly and cost effectively;
- **Portability** – ability of the system to run under different computing environments;
- **Variability** – how well the architecture can be expanded or modified to produce new architectures that differ in specific, preplanned ways;
- **Subsetability** – ability to support the production of a subset of the system;
- **Testability** – ability to observe results and control the components internal state in order to identify system faults;
- **Conceptual Integrity** – vision that unifies the design of the system at all levels (ability of the architecture do similar things in similar ways);
- **Building simplicity** – ability to implement the defined architecture;
- **Cost** – System Cost;
- **Time to market** – Time required to implement the architecture.

At Enterprise System Architecture level, other qualities become relevant, as Information System/Business alignment (ISA accurateness to the business needs), Information System/Strategy alignment (ISA support for the enterprise strategy) or Interoperability (ability of an ISA to interact or support different technologies – technical Interoperability – or support different information architecture implementations – syntactic Interoperability). These quality attributes might be: observable during execution (as usability, performance, reliability, availability, security and functionality), non-observable during executing (as Modifiability, portability, variability, subsetability and testability), architectural quality attributes (as conceptual integrity and building simplicity) or business quality attributes (as cost and time to market). The qualities are interrelated, and enhancing one will likely degrade or enhance others – for instance performance is likely to degrade scalability – for further detail on this subject please refer to Gillies (1992) or Khaddaj and Horgan (2004).

### 3.2 Information system evaluation metrics

In this section the authors propose a set of ISA evaluation metrics. These metrics were defined based on the research accomplished by other authors (specialists in certain areas – e.g., security, scalability, portability), on the adaptation of the evaluation knowledge from other more mature areas (e.g., software engineering) and on the authors experience on real world ISA evaluation projects. The authors argue that with these metrics the architect has a set of indicators on the impact of each of his or her decisions during the process of building an ISA and, therefore, he or she will be better equipped to build EIS align with a set of desired qualities. The following template is used to describe the metrics proposed.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Metric Acronym</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Metric Name</td>
</tr>
<tr>
<td>Computation</td>
<td>Description on the metric algorithm or formula</td>
</tr>
<tr>
<td>Scale</td>
<td>Scale of possible values for the metric</td>
</tr>
<tr>
<td>Architectural Levels</td>
<td>Architecture levels relevant for this metric</td>
</tr>
<tr>
<td>ISA Primitives and attributes</td>
<td>Architectural primitives and attributes used in the metric computation</td>
</tr>
<tr>
<td>ISA Qualities</td>
<td>Enumeration of the “architectural qualities” related with the metric</td>
</tr>
<tr>
<td>Support</td>
<td>Rational that supports the metric proposed and its relevance for measuring the ISA qualities</td>
</tr>
<tr>
<td>Example(s)</td>
<td>Presentation of ISA evaluation simple examples by applying the proposed metric</td>
</tr>
<tr>
<td>Acronym</td>
<td>NPOS (or NPOS_{ISA})</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Name</td>
<td>Average Number of Possible Operating Systems</td>
</tr>
<tr>
<td>Computation</td>
<td>The Average Number of Possible Operating Systems is computed by counting, on each application (&quot;IT Application Block&quot;), the number of possible operating systems (families) and dividing it by the number of applications.</td>
</tr>
</tbody>
</table>
|         | \[
|         | \text{NPOS}_{ISA} = \frac{\sum_{i=1}^{\#\text{"IT Application Block"}} NPOS_i}{\#\text{"IT Application Block"}}, \text{ where} |
|         | NPOS_i – is the number of possible operating systems families that the "IT Application Block" supports |
|         | \#"IT Application Block" – is the number of "IT Application Block" in the ISA |
| Scale   | $[1, +\infty]$ |
| Architectural Levels | Technological Architecture |
| ISA Primitives and attributes | Primitive: "IT Application Block" - Attribute: possible operating systems |
| ISA Qualities | The Portability and Technical Interoperability of an EIS tend to increase with this metric |
| Support | The portability and Technical Interoperability in an ISA increase with the number of possible platforms where ISA components are able to operate (Sarkis and Sundarraj 2003, section 3.2.1). From a software engineering perspective, the portability of an operating system is a major indicator on an application portability (Roulo 1997); in the same way, the technical portability of an EIS, represented by an ISA, is measured by this metric as the average of the software applications' ("IT Application Block") portability. |

**Example(s)**

**Example ISA A**

| "IT Application Block" | Possible Operating Systems: [Linux, Windows, UNIX] |
| "My Application A" | |

POS_{ISA} = \frac{1+1}{2} = 2

**Example ISA B**

| "IT Application Block" | Possible Operating Systems: [Windows] |
| "My Application A" | |

POS_{ISA} = \frac{1+1}{2} = 1

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The Average Number of Distinct Technologies for Information System Services is computed by counting for each «IS Service» the number of «IT integration Services».

\[
\text{NDTIS}_{\text{ISA}} = \frac{\sum \# \text{«IT Integration Service»}_i}{\# \text{«IS Service»}},
\]

where:

\# «IT Integration Service» \(i\) – is the number of «IT Integration Service» that implement the «IS Service» \(i\)

\# «IS Service» – is the number of «IS Service» in an ISA

<table>
<thead>
<tr>
<th>Acronym</th>
<th>NDTIS (or NDTIS_{ISA})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of Distinct Technologies for IS Services</td>
</tr>
</tbody>
</table>

Scale: \([1, +\infty)\]

Architectural Levels:
Application Architecture and Technological Architecture

ISA Primitives and attributes:
Primitive: «IT Integration Service» - Attribute: technology

ISA Qualities:
The Portability and Technical Interoperability of an EIS tend to increase with this metric

Support:
The technical interoperability of a software architecture increases by providing the same interface in different technologies (Sarkis and Sundarraj 2003, section 3.2.1). In the same way, with this metric the technical interoperability and portability of an EIS is analysed as the average of the Technologies that each application interface provides.

**Example ISA A**

1. **IS Service**: Sales Volume
2. **IT Integration Service**: technology = {.NET API}

\[\text{NDTIS}_{\text{ISA}} = \frac{1}{1} = 1\]

**Example ISA B**

1. **IS Service**: Sales Volume
2. **IT Integration Service 1**: technology = {.NET API}
3. **IT Integration Service 2**: technology = {SAP API}
4. **IT Integration Service 3**: technology = {XML API}

\[\text{NDTIS}_{\text{ISA}} = \frac{3}{1} = 3\]
<table>
<thead>
<tr>
<th>Acronym</th>
<th>NIE (or NIEISA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of (Different) Implementations of an Information Entity</td>
</tr>
</tbody>
</table>
| Computation  | The Average Number of (Different) Implementations of an Information Entity is computed by counting, for each «Information Entity», the number of possible implementations in «Low Level Information Entities».
| Equation     | $$\text{NIE}_{\text{ISA}} = \frac{\sum \text{NLLIE}_i}{\#\text{«Information Entity»}}$$, where: |
|              | NLLIE$_i$ – is the number of «Low Level Information Entities» that are related to the «Information Entity»$_i$ by the «implements» relation |
|              | #«Information Entity» – is the number of «Information Entities» in an ISA |
| Scale        | $[1, +\infty)$ |
| Architectural Levels | Information Architecture |
| ISA Primitives and attributes | Primitive: «Low Level Information Entity» |
|              | Primitive: «Information Entity» |
| ISA Qualities | The Syntactic Interoperability of an ISA will increase by the decrease of this metric |
| Support      | This metric measures the number of different implementations that exist for each information entity. According to Inmon (2000), for each information entity ("top level") there might be other entities that implementing it ("low level information entity"). The existence of different «Low Level Information Entities» points to syntactic incompatibilities for that «Information Entity» (e.g., by using different formats or attributes in the implementation of the information entity). |

**Example ISA A**

Example(s)

<table>
<thead>
<tr>
<th>«Information Entity»</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Low Level Information Entity»</td>
<td>Address</td>
</tr>
<tr>
<td>Street</td>
<td>Door number</td>
</tr>
<tr>
<td>City</td>
<td>Zip_Code_Part1</td>
</tr>
<tr>
<td>Zip_Code_Part2</td>
<td>Zip_Place_Designation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>«Information Entity»</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Low Level Information Entity»</td>
<td>Social Security</td>
</tr>
<tr>
<td>Street</td>
<td>Zip_Code</td>
</tr>
<tr>
<td>City</td>
<td>Town</td>
</tr>
<tr>
<td>Zip_Code_Part1</td>
<td>Zip_Code_Part2</td>
</tr>
<tr>
<td>Zip_Place_Designation</td>
<td>Street_Type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>«Information Entity»</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Low Level Information Entity»</td>
<td>Health Care</td>
</tr>
<tr>
<td>Street</td>
<td>Door number</td>
</tr>
<tr>
<td>City</td>
<td>Zip_Code</td>
</tr>
<tr>
<td>Zip_Code_Part1</td>
<td>Zip_Code_Part2</td>
</tr>
<tr>
<td>Zip_Place_Designation</td>
<td>Street_Type</td>
</tr>
</tbody>
</table>

$$\text{NIE}_{\text{ISA}} = \frac{3}{1} = 3$$

**Example ISA B**

Example(s)

<table>
<thead>
<tr>
<th>«Information Entity»</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Low Level Information Entity»</td>
<td>Address</td>
</tr>
<tr>
<td>Street</td>
<td>Door number</td>
</tr>
<tr>
<td>City</td>
<td>Zip_Code</td>
</tr>
<tr>
<td>Zip_Code_Part1</td>
<td>Zip_Code_Part2</td>
</tr>
<tr>
<td>Zip_Place_Designation</td>
<td>Street_Type</td>
</tr>
</tbody>
</table>

$$\text{NIE}_{\text{ISA}} = \frac{1}{1} = 1$$
<table>
<thead>
<tr>
<th>Acronym</th>
<th>NSITPLB (or NSITPLBISA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of stateful «IT Presentation Block» and «IT Logic Block»</td>
</tr>
</tbody>
</table>
| Computation      | The Average Number of stateful «IT Presentation Block» and «IT Logic Block» is computed counting the number of «IT Presentation Block» and «IT Logic Block» that its attribute “state” value is “stateful”.  
  
  \[ NSITPLB_{ISA} = \frac{\# SITPLB}{\# «IT Presentation Block» + \# «IT Logic Block»} \]  
  
  \#SITPLB – is the number of «IT Presentation Block» and «IT Logic Block» that its attribute “state” value is “stateful”.  
  
  \# «IT Presentation Block» – is the number of «IT Presentation Block»  
  
  \# «IT Logic Block» – is the number of «IT Logic Block» |
| Scale            | [0; 1] |
| Architectural Levels | Technological Architecture |
| ISA Primitives and attributes | Primitives: «IT Presentation Block», «IT Logic Block», «IT Data Block», «IT Coordination Block»  
  
  Attribute: state |
| ISA Qualities    | The scalability of an ISA tends to increase with the decrease of this metric. |
| Support          | The Scalability of an EIS is increased if business and presentation components do not keep the state (since it will be easier for implementing new parallel instances of these ISA components) – BEA (2006).  
  
  The Scalability of an ISA tend to grow if the «IT Presentation Blocks» and the «IT Logic Blocks» do not preserve the application state (stateless) – the «IT Data Blocks» should be the ones to keep application state. |
| Example(s)       |  
  Example ISA A  
  - «IT Presentation Block»: WebSite  
    - state = “stateless”  
  - «IT Logic Block»: Store Logic  
    - state = “stateful”  
  - «IT Data Block»: StoreData  
    - state = “stateful”  
  
  \[ NSITPLB_{ISA} = \frac{1}{1+1} = \frac{1}{2} \]  
  
  Example ISA B  
  - «IT Presentation Block»: WebSite  
    - state = “stateless”  
  - «IT Logic Block»: Store Logic  
    - state = “stateless”  
  - «IT Data Block»: StoreData  
    - state = “stateful”  
  
  \[ NSITPLB_{ISA} = \frac{0}{1+1} = 0 \]  

André Vasconcelos, Pedro Sousa and José Tríbolet
<table>
<thead>
<tr>
<th>Acronym</th>
<th>NSC (or NSC_{ISA})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of security components</td>
</tr>
</tbody>
</table>
| Computation | The Average Number of security components is computed counting all the «IT Blocks» which attribute “security” value is “YES”.

\[ \text{NSC}_{ISA} = \frac{\#\text{SITB}}{\#\text{«IT Block»}}, \] where:

\[ \#\text{SITB} – \text{is the number of «IT Blocks» which attribute “security” value is “YES”} \]

\[ \#\text{«IT Block»} – \text{is the number of «IT Block»} \]

<table>
<thead>
<tr>
<th>Scale</th>
<th>[0; 1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural Levels</td>
<td>Technological Architecture</td>
</tr>
</tbody>
</table>

| ISA Primitives and attributes | Primitive: «IT Block»
| Attribute: security |
| ISA Qualities | The security of an ISA tends to increase with this metric increasing. |
| Support | The ISA security is increased by putting security elements on it, as IDS, firewalls, etc (Rito 2004). This metric considers this fact. |
| Observations | This simple to compute metric is provides a quick first overview on the potential (miss of) security of an ISA. However, this metric does not considers the role of the security components on the ISA. |

<table>
<thead>
<tr>
<th>Example(s)</th>
<th>Example ISA A</th>
<th>Example ISA B</th>
</tr>
</thead>
</table>

- **Example ISA A**
  - «Server»
    - :Application Server
  - «Network»
    - :Firewall
      - security = “yes”
  - «Server»
    - :Data Server

  \[ \text{NSC}_{ISA} = \frac{1}{3} \]

- **Example ISA B**
  - «Server»
    - :Application Server
  - «Network»
    - :LAN
      - security = “no”
  - «Server»
    - :Data Server

  \[ \text{NSC}_{ISA} = \frac{0}{3} = 0 \]
<table>
<thead>
<tr>
<th>Acronym</th>
<th>NSCBITAB (or NSCBITABISA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of security components between «IT Application Blocks»</td>
</tr>
<tr>
<td>Computation</td>
<td>The Average Number of security components between «IT Application Blocks» is computed counting, for each «IT Application Block», the minimum number of «IT Blocks», which attribute “security” value is “YES”, that are between that block and all the other «IT Application Blocks».</td>
</tr>
</tbody>
</table>
|            | \[
| NSCBITAB_{ISA} = \frac{\sum_{i=1}^{\#IT\ Application\ Blocks} \sum_{j=1}^{\#IT\ Blocks} \min \{\ #SITB_{ij}\ \}}{\ #\ «IT\ Application\ Block\ »^2}, \quad \text{where:}
| Min(#SITB_{ij}) – is the minimum number of «IT Blocks» which attribute “security” value is “YES” that are between «IT Application Block» \(i\) and «IT Application Block» \(j\). |
| Scale    | \([0, +\infty)\) |
| Architectural Levels | Technological Architecture |
| ISA Primitives and attributes | Primitive: «IT Block» Attribute: security |
| ISA Qualities | The Security of an ISA tends to increase with this metric. |
| Support  | The ISA security is increased by putting security elements on it, as IDS, firewalls, etc (Rito 2004). This metric, is not limited to counting the number of security components but it also considers, for each application component, the number of security components that isolate it from other components. |
| Example(s) |  |

**Example ISA A**

```
| «Personal Computer» |
| «Application Block» |
| «IT Application Block» |
| «Sourcing Interface Client» |
| «PC Platform» |
| «Network» |
| «Firewall» | security = yes |
| «Server» |
| «Application Server» |
| «Warehouse Business Component» |
| «J2EE Application Environment» |
| «Data Server» |
| «Data Server» |
| «Warehouse Data Component» |
| «DBMS» |
```

\[
NSCBITAB = \frac{(1+2) + (1+1) + (1+2)}{3^2} = \frac{8}{9}
\]

**Example ISA B**

```
| «Personal Computer» |
| «Application Block» |
| «IT Application Block» |
| «Sourcing Interface Client» |
| «PC Platform» |
| «Network» |
| «Firewall» | security = yes |
| «Server» |
| «Application Server» |
| «Warehouse Business Component» |
| «J2EE Application Environment» |
| «Data Server» |
| «Data Server» |
| «Warehouse Data Component» |
| «DBMS» |
```

\[
NSCBITAB = \frac{(1+1) + (0+1) + (0+1)}{3^2} = \frac{4}{9}
\]
### Acronym
LCOIS (or LCOIS\textsubscript{ISA})

### Name
Average Lack of Cohesion in «IS Blocks».

### Computation
The Average Lack of Cohesion in «IS Blocks» is computed counting the number of sets of information entities that are used by distinct functionalities of the same application (provided by operations in «IS Blocks»).

\[
\text{LCOIS}_{\text{ISA}} = \frac{\sum_{i=1}^{\#\text{IS Block}} \#\text{LCOIS}_i}{\#\text{«IS Block»}}, \text{ where:}
\]

- \#LCOIS\textsubscript{i} – is the number of sets of «Information Entities» that are used by «operations» distinct of the «IS Block» \(i\).
- \#«IS Block» – is the number of «IS Blocks»

### Scale
\([1, +\infty)\)

### Architectural Levels
Technological Architecture

### ISA Primitives and attributes
- Primitive: «IT Block»
- Attribute: security

### ISA Qualities
The security of an ISA tends to increase with this metric.

### Support
This metric measures the correlation between application blocks and the information entities used in that application block. It is quantified by the average of the number of sets of information entities that are used by distinct operations of the same application.

#### Example(s)

**Example ISA A**

```
   「Information Entity」
    :Customer
  C   R
    「Operation」:
    :Create
    :Manage  Customers
   「IS Service」
    「IS Block」
      :ERP

   「Information Entity」
    :Employee
  C
    「Operation」:
    :Create
    :Manage  Customers
   「IS Service」
    「IS Block」

   「Information Entity」
    :Supplier
  C
    「Operation」:
    :Create
    :Manage  Suppliers
   「IS Service」
```

\[
\text{LCOIS}_{\text{ISA}} = \frac{1 + 1}{1} = 2
\]
### Example ISA B

![Diagram of Example ISA B]

\[
\text{LCOIS}_{\text{ISA}} = \frac{1 + 1}{2} = 1
\]

<table>
<thead>
<tr>
<th>Acronym</th>
<th>NOIS (or NOIS(_{\text{ISA}}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Number of Operations in «IS Blocks»</td>
</tr>
<tr>
<td>Computation</td>
<td>The Average Number of Operations in «IS Blocks» is computed counting the number of operations on each «IS Block» divided by the number of «IS Blocks»</td>
</tr>
</tbody>
</table>
| Formula         | \[
\text{NOIS}_{\text{ISA}} = \frac{\sum_{i=1}^{\#\text{IS Block}} \#\text{operation}_{\text{IS Block}_i}}{\#\text{IS Block}}, \text{ where:}
\]
| \# «IS Block»    | is the number of «IS Block» i. |
| \# «IS Block»    | is the number of «IS Block» |
| Scale           | (\(\emptyset\); \(+\infty\)) |
| Architectural Levels | Application Architecture |
| ISA Primitives and attributes | Primitive: «IS Block» ; «operation» |
| ISA Qualities   | The **modificability** of an ISA tends to be reduced with the increase of this metric |
| Support         | The simplicity of adapt/alter operations in an ISA to new business demands is maximised when the impact of changing each operation is reduced to a certain application block («IS Block»). This metric measures this fact. |
| Example(s)      | Example ISA A | Example ISA B |
The Average Service Cyclomatic Complexity is computed considering the average, number of dependencies between «IS Blocks» subtracted by the number of «IS Blocks» that support the service, for each service.

$$\text{SCC}_{\text{ISA}} = \frac{\sum e_i - n_i + 2}{\text{# «Business Service»} + \text{# «IS Service»}}$$

where:

- $e_i$ – is the number of dependencies between «IS Block» for the service $i$.
- $n_i$ – is the number of «IS Blocks» that support the service $i$.

The complexity of an ISA tends to increase with this metric. The modificability of an ISA tends to decrease with the increase of this metric.

### Support

Like McCabe (1976), for the software engineering area, considering that the higher the number of paths in a program, the higher its control flow complexity probably will be, in Vasconcelos et al. (2005) is proposed a similar metric for evaluate the complexity of an ISA in the support of the business services – considering that the complexity, for each service, is measure by the difference between the number of dependencies and applications involved.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>SCC (or SCCISA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Service Cyclomatic Complexity</td>
</tr>
<tr>
<td>Computation</td>
<td>The Average Service Cyclomatic Complexity is computed considering the average, number of dependencies between «IS Blocks» subtracted by the number of «IS Blocks» that support the service, for each service.</td>
</tr>
<tr>
<td>Scale</td>
<td>1 – ∞</td>
</tr>
<tr>
<td>Architectural Levels</td>
<td>Application Architecture</td>
</tr>
<tr>
<td>ISA Primitives and attributes</td>
<td>Primitive: «IS Block»; «Business Service»</td>
</tr>
<tr>
<td>ISA Qualities</td>
<td>The complexity of an ISA tends to increase with this metric. The modificability of an ISA tends to decrease with the increase of this metric.</td>
</tr>
<tr>
<td>Support</td>
<td>Like McCabe (1976), for the software engineering area, considering that the higher the number of paths in a program, the higher its control flow complexity probably will be, in Vasconcelos et al. (2005) is proposed a similar metric for evaluate the complexity of an ISA in the support of the business services – considering that the complexity, for each service, is measure by the difference between the number of dependencies and applications involved.</td>
</tr>
</tbody>
</table>
Example ISA A

\[
\text{SCC}_{ISA} = \frac{8 - 4 + 2}{1} = 6
\]

Example ISA B

\[
\text{SCC}_{ISA} = \frac{2 - 1 + 2}{1} = 3
\]

<table>
<thead>
<tr>
<th>Acronym</th>
<th>RS (or RS(_{ISA}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Average Response for a Service</td>
</tr>
<tr>
<td>Computation</td>
<td>The Average Response for a Service is computed by considering the average of the number of «IS Blocks» that might be used to support each «Service»:</td>
</tr>
</tbody>
</table>
|         | \[
|         | RS_{ISA} = \frac{\sum_{i=1}^{\#\text{Business Service} + \#\text{IS Service}} \#\text{IS Block}_i}{\#\text{Business Service} + \#\text{IS Service}}, \text{ where:} \]
|         | \#«IS Block»\(_i\) – is the number of «IS Blocks» involved in supporting service \(i\). \]
|         | \#«Business Service» – is the number of «Business Services». \]
|         | \#«IS Service» – is the number of «IS Services». |
| Scale   | 0 - \(\infty\) |
| Architectural Levels | Application Architecture |
| ISA Primitives and attributes | Primitives: «IS Block»; «Business Service» |
| ISA Qualities | The complexity of an ISA tends to increase with this metric |
| Support | Similar to the software metric “Response For a Class” – see Chidamber and Kemerer (1995) and Basili (1996) for further details – that computes the number of methods that can potentially be executed in response to a message received. In Vasconcelos et. al. (2005) this metric is proposed (Average Response for a Service) and it computes the number of «IS Blocks» that might be used to support a service. In recent researches Sousa, Pereira and Marques (2004) suggest that each business process should be supported by the less number of applications as possible – this is also measure by this metric. |
Example ISA A

\[ RS_{ISA} = \frac{4}{1} = 4 \]

Example ISA B

\[ RS_{ISA} = \frac{1}{1} = 1 \]

### Acronym

**NE** (or **NEISA**)

### Name

Number of Entities

### Computation

The Number of Entities (of an ISA) is computed by counting the number of «Information Entities».

### Scale

\([0, +\infty)\]

### Architectural Levels

Information Architecture

### ISA Primitives and attributes

Primitive: «Information entity»

### ISA Qualities

The Maintainability of an ISA tends to decrease with this metric increase.

### Support

According to Género, Poels and Piattini (2003), this metric is strongly related to the Maintaining of an ISA.

#### Example(s)

**Example ISA A**

- **NEISA** = 3

**Example ISA B**

- **NEISA** = 2
<table>
<thead>
<tr>
<th>Acronym</th>
<th>NR (or NR&lt;sub&gt;ISA&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Number of Relations</td>
</tr>
<tr>
<td>Computation</td>
<td>The Number of Relations of an Information Architecture is computed by counting the number of relations between «Information Entities»</td>
</tr>
<tr>
<td>Scale</td>
<td>(0, +∞)</td>
</tr>
<tr>
<td>Architectural Levels</td>
<td>Information Architecture</td>
</tr>
<tr>
<td>ISA Primitives and attributes</td>
<td>Primitive: «Information entity»</td>
</tr>
<tr>
<td>ISA Qualities</td>
<td>The Maintainability of an ISA tends to decrease with this metric increase</td>
</tr>
<tr>
<td>Support</td>
<td>According to Género, Poels and Piattini (2003), this metric is strongly related to the Maintaining of an ISA.</td>
</tr>
</tbody>
</table>

**Example(s)**

**Example ISA A**

```
 «Information Entity» Customer
 |<-- buys
 «Information Entity» Store
 |<-- Placed in
 «Information Entity» Product
```

NR<sub>ISA</sub>=3

**Example ISA B**

```
 «Information Entity» Customer
 |<-- goes to
 «Information Entity» Product
```

NR<sub>ISA</sub>=1

<table>
<thead>
<tr>
<th>Acronym</th>
<th>CPSM (or CPSM&lt;sub&gt;ISA&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Critical Process - System Mismatch</td>
</tr>
<tr>
<td>Computation</td>
<td>The Critical Process - System Mismatch is computed by counting the number of critical business processes supported by «IS Blocks» that also support non-critical business processes and the number of non-critical business processes supported by «IS Blocks» that also support critical business processes</td>
</tr>
</tbody>
</table>

\[
\text{CPSM}_{\text{ISA}} = \frac{\#\{\text{Process}_C \in \text{ISBlock}_{\text{NC}}\} + \#\{\text{Process}_{\text{NC}} \in \text{ISBlock}_C\}}{\#\{\text{Process}\}}, \text{ where:}
\]

- \#\{\text{Process}_C \in \text{ISBlock}_{\text{NC}}\} – is the number of critical processes supported by «IS Blocks» that support other non-critical processes
- \#\{\text{Process}_{\text{NC}} \in \text{ISBlock}_C\} – is the number of non-critical processes supported by «IS Blocks» that support other critical processes
- \#\{\text{Process}\} – is the number of processes

| Scale   | (0, 1) |
| Architectural Levels | Business Architecture and Application Architecture |
| ISA Primitives and attributes | Primitive: |
- «IS Block»;
- «Process» - attribute: Critical =\{Yes, No\}
## ISA Qualities: Business-Application Alignment

### Support

As described in Sousa, Pereira and Marques (2004) the critical business processes should be supported by different applications than non-critical business processes.

### Example(s)

<table>
<thead>
<tr>
<th>Example ISA A</th>
<th>Example ISA B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&lt;is_block&gt;</strong> Production System</td>
<td><strong>&lt;is_block&gt;</strong> ERP</td>
</tr>
<tr>
<td><strong>&lt;business_service&gt;</strong> Manage Production</td>
<td><strong>&lt;business_service&gt;</strong> Manage HR</td>
</tr>
<tr>
<td><strong>&lt;process&gt;</strong> Assemble Car Components</td>
<td><strong>&lt;process&gt;</strong> Update Vacations Timetable</td>
</tr>
<tr>
<td>Critical = YES</td>
<td>Critical = NO</td>
</tr>
<tr>
<td><strong>&lt;is_block&gt;</strong> HR System</td>
<td><strong>&lt;is_block&gt;</strong> ERP</td>
</tr>
<tr>
<td><strong>&lt;business_service&gt;</strong> Manage HR</td>
<td><strong>&lt;business_service&gt;</strong> Manage HR</td>
</tr>
<tr>
<td><strong>&lt;process&gt;</strong> Update Vacations Timetable</td>
<td><strong>&lt;process&gt;</strong> Update Vacations Timetable</td>
</tr>
<tr>
<td>Critical = NO</td>
<td>Critical = NO</td>
</tr>
</tbody>
</table>

### Computation

\[
\text{CPSM}_{\text{ISA}} = \frac{0 + 0}{2} = 0
\]

\[
\text{CPSM}_{\text{ISA}} = \frac{1 + 1}{2} = 1
\]

### Acronym

**NAIE** (or **NAIE_{ISA}**)

**Name**

Average Number of Applications per «Information Entity»

**Computation**

\[
\text{NAIE}_{\text{ISA}} = \frac{\sum_{i=1}^{\# \text{Information Entity}} \# \text{ISBlocks} \in \exists \text{operation} \text{ CUD «InformationEntity}_{i} \}}{\# \text{«Information Entity»}},
\]

where:

- \(\# \text{ISBlocks} \in \exists \text{operation} \text{ CUD «InformationEntity}_{i}\)}\) is the number of «IS Blocks» in which exists an «operation» that CUD (Creates, Updates or Deletes) the «information entity» \(i\).

- \(\# \text{«Information Entity»}\) is the number of «Information Entities»

### Scale

\((-\infty, +\infty)\)

### Architectural Levels

Information Architecture and Application Architecture

### ISA Primitives and attributes

Primitives:
- «IS Block»
- «Information entity»
- «operation»

### ISA Qualities

Information Architecture – Application Architecture Alignment

### Support

According to Sousa, Pereira e Marques (2004) each information entity should be managed by a single application.
André Vasconcelos, Pedro Sousa and José Trbolet

Example ISA A

```
«Information Entity»
:Customer

«Operation»
:Create
Customer

«Operation»
:Update
Customer

«IS Block»
:CRM
```

\[ \text{NAIE}_{\text{ISA}} = \frac{1}{1} = 1 \]

Example ISA B

```
«Information Entity»
:Customer

«Operation»
:Create
Customer

«Operation»
:Update
Customer

«IS Block»
:StoreSystem

«IS Block»
:CRM
```

\[ \text{NAIE}_{\text{ISA}} = \frac{2}{1} = 2 \]

### Acronym

**IESSM (or IESSMISA)**

### Name

*Information Entity - System Security Mismatch*

### Computation

The Information Entity - System Security Mismatch is computed considering the number of information entities with high-level security requirements supported in «IS Blocks» that also support information entities without high security requirements and the number of information entities with low-level security requirements supported in «IS Blocks» that also support information entities with high level security requirements.

\[
\text{IESSM}_{\text{ISA}} = \frac{\# \{ \text{InformationEntity}_{s} \in \text{ISBlock}_{NS} \} + \# \{ \text{InformationEntity}_{NS} \in \text{ISBlock}_{S} \}}{\# \{ \text{InformationEntity} \}},
\]

where:

- \( \# \{ \text{InformationEntity}_{s} \in \text{ISBlock}_{NS} \} \) – is the number of «Information Entities» that its Security attribute value is {Yes} supported in «IS Blocks» that support other «Information Entities» which Security attribute value is {No}; where an «Information Entity» is “supported” by an «IS Block» if and only if exists at least one «operation» provided by the «IS Block» that CUD the «Information Entity».

- \( \# \{ \text{InformationEntity}_{NS} \in \text{ISBlock}_{S} \} \) – is the number of «Information Entities» that its Security attribute value is {No} supported in «IS Blocks» that support other «Information Entities» which Security attribute value is {Yes}; where an «Information Entity» is “supported” by an «IS Block» if and only if exists at least one «operation» provided by the «IS Block» that CUD the «Information Entity».

- \( \# \{ \text{InformationEntity} \} \) – is the number of information entities.

### Scale

\( \{0;1\} \)

### Architectural Levels

Information Architecture and Application Architecture

### ISA Primitives and attributes

**Primitive:**
- «IS Block»
- «Information entity»: Attribute: Security = {Yes, No}
- «operation»

### ISA Qualities

**Information Architecture – Application Architecture Alignment**

**Support**

According to Sousa, Pereira e Marques (2004) applications should manage information entities of the same security level.

**Example(s)**

**Example ISA A**

![Diagram of ISA A]

\[
\text{IESSM}_{\text{ISA}} = \frac{1+1}{2} = 1
\]

**Example ISA B**

![Diagram of ISA B]

\[
\text{IESSM}_{\text{ISA}} = \frac{0+0}{2} = 0
\]

### Acronym

**NUIEA** (or **NUIEAISA**)  
**Name**

**Average Number of Unused Information Entity Attributes**

**Computation**

The Average Number of Unused Information Entity Attributes is computed counting the number of attributes in information entities that are not used in any Read (R) «operation».

\[
\text{NUIEA}_{\text{ISA}} = \frac{\sum_{i=1}^{\# \text{Information Entity}} \sum_{j=1}^{\# \text{Attribute}} \text{attribute}_{ij} \text{ NOT R(\forall \text{operation})}}{\sum_{i=1}^{\# \text{Information Entity}} \# \text{attribute} \in \text{InformationEntity}_{i}}
\]

, where:
André Vasconcelos, Pedro Sousa and José Trbolet

\[
\sum_{i=1}^{\#\text{Information Entity}_i} \sum_{j=1}^{\#\text{attribute}_j} \text{NOT} \bigl( R(\forall \text{operation}) \bigr) - \text{is the total number of attributes of «Information Entity» } i \text{ that are not read (R) by any «operation»}
\]

\[
\sum_{i=1}^{\#\text{Information Entity}_i} \#\text{attribute} \in \text{InformationEntity}_i - \text{is the total number of attributes in all the «information entities» of the ISA}
\]

\#«Information Entity» - is the number «information entities»

<table>
<thead>
<tr>
<th>Scale</th>
<th>Information Architecture and Application Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural Levels</td>
<td>Information Architecture and Application Architecture</td>
</tr>
<tr>
<td>ISA Primitives and attributes</td>
<td>Primitive:</td>
</tr>
<tr>
<td></td>
<td>- «Information entity»</td>
</tr>
<tr>
<td></td>
<td>- «operation»</td>
</tr>
<tr>
<td>ISA Qualities</td>
<td>Information Architecture – Application Architecture Alignment</td>
</tr>
<tr>
<td>Support</td>
<td>According to Sousa, Pereira e Marques (2004) all the information entities’ attributes should be read for, at least, a business process.</td>
</tr>
</tbody>
</table>

Example ISA A

- «Information Entity»
  - Product
    - productName
    - productColor
  - R(productName)
  - «Operation»
    - Get Product List

\[
\text{NUIEA}_{\text{ISA}} = \frac{1}{2}
\]

Example ISA B

- «Information Entity»
  - Product
    - productName
    - productColor
  - R(productName, productColor)
  - «Operation»
    - Get Product List

\[
\text{NUIEA}_{\text{ISA}} = \frac{0}{2} = 0
\]

4. An ISA evaluation case study

In this section we briefly describe a real case study where some of the previously proposed metrics are used in the process of building, analysing and improving an ISA in a Portuguese e-government project. We start by describing the global project goals, in section 4.1, and then (in section 4.2) we focus on presenting how the CEO modelling framework and metrics supported the ISA definition for a project phase. In section 4.3 we present a short discussion on the case study results.

4.1 The enterprise life cycle project

In order to improve government services for enterprises UMIC - Knowledge Society Agency (a Portuguese governmental organisation) set out the Enterprise Life Cycle Project. This project’s major goals are:

- Implement an “Electronic Enterprise Folder”, dematerialising and providing enterprise information that currently is disperse and sometimes incoherent in different government organisations, through the Internet.

- Reengineer, improve and accelerate the Firm Start-up Process – that by the time of the project definition took, in average, between 27 and 65 days.
- Reposition and reorganise the government departments in order to provide a best, cheaper and agile service to enterprises and entrepreneurs.
- Implement the Enterprise Portal, the preferred channel for government services to Enterprises.

In the meantime of this project definition and kick-off, another initiative was implemented: The “On the Spot Firm”. This initiative makes possible for entrepreneurs to create a company in just one office (one-stop office) in a single day (currently the average time is 1 hour and 14 minutes). Thus “The Enterprise Life Cycle Project” was split into two major phases; a first phase that pretends to implement the “Enterprise Portal” and to make the “On the Spot Firm offline process” also available online (in the Enterprise Portal). The second phase is expected to achieve the other project goals (as implementing the “Electronic Enterprise Folder”, Repositioning and reorganising the government departments and reengineering the Firm start-up Process). In this article we will focus only on the first phase of the project (since the second one is still starting).

4.2 Selecting the “right” ISA
The “on the spot” firm start-up process major difference to the traditional company creation process is that the members of the future company may only choose the company name from a set of pre-approved firm names and a set of pre-approved association packs. Currently the entrepreneurs can create an “on the spot” company only on physical desks. This project first phase will also make available this process on the Internet – the process is described on Figure 4.

**Figure 4. On the spot firm start-up process**
Considering that an application that supports the “offline” on the spot company start-up process already exists, two major options were analysed before implementing the company start-up process online. The first option (“Architecture A”) considered was to used the “On the spot firm” application to support the online creation of a company in the Enterprise Portal and use this application to directly (“point-to-point”) integrate with the other government departments’ information systems – see Figure 5.
Another option considered (ISA “B”) was to implement an integration/interoperability layer that would be globally responsible for the “company creation online business process”, integrating with the different applications (namely the “on the spot” application, for getting the available pre-approved firm names) – see Figure 6.
Figure 6. ISA "B" for the online company creation process
Both architectures were analysed using some of the previously metrics.
For the Information Entity - System Security Mismatch metric applied to architecture A (Figure 7) (considering the presented simplified architecture, with only two information entities) we have:

$$\text{IESSM}_A = \frac{\#(\text{InformationEntity}_A \in \text{ISBlock}_A) + \#(\text{InformationEntity}_B \in \text{ISBlock}_B)}{\#\text{InformationEntity}} = \frac{1 + 1}{2} = 1$$

And the Information Entity - System Security Mismatch metric, for (simplified) architecture B (Figure 8), value is:

$$\text{IESSM}_B = \frac{\#(\text{InformationEntity}_A \in \text{ISBlock}_A) + \#(\text{InformationEntity}_B \in \text{ISBlock}_B)}{\#\text{InformationEntity}} = \frac{0 + 0}{2} = 0$$

For the Average Number of Applications per «Information Entity» metric, for ISA A we have:

$$\text{NAE}_A = \frac{\sum \#\text{ISBlocks} \in \exists \text{operation} \text{ CUD «InformationEntity»}}{\#\text{InformationEntity}} = \frac{2 + 1}{2} = 3$$

And for ISA B the Average Number of Applications per «Information Entity» metric is:

$$\text{NAE}_B = \frac{\sum \#\text{ISBlocks} \in \exists \text{operation} \text{ CUD «InformationEntity»}}{\#\text{InformationEntity}} = \frac{1 + 1}{2} = 1$$
These metrics point that ISA B has a better align between its application and information architectures than ISA A.

In terms of complexity, two metrics were used: The Average Response for a Service metric and the Average Service Cyclomatic Complexity metric.

The Average Response for a Service metric (considering only the three business services described in Figure 9 to Figure 14, for simplicity) for ISA A is:

\[
RS_A = \frac{\sum \# \text{«IS Block»}}{\# \text{«Business Service»} + \# \text{«IS Service»}} = \frac{2 + 6 + 5}{3} = \frac{13}{3}
\]
For the Average Service Cyclomatic Complexity metric for ISA A, we have:

\[
SCC_A = \frac{\sum_{i=1}^{n} e_i - n_i + 2}{\# \text{Business Service} + \# \text{IS Service}} = \frac{(4 - 2 + 2) + (8 - 6 + 2) + (6 - 5 + 2)}{3} = \frac{11}{3}
\]

And the Average Service Cyclomatic Complexity metric for ISA B is:

\[
SCC_B = \frac{\sum_{i=1}^{n} e_i - n_i + 2}{\# \text{Business Service} + \# \text{IS Service}} = \frac{(6 - 3 + 2) + (8 - 6 + 2) + (8 - 6 + 2)}{3} = \frac{13}{3}
\]

Thus, these metrics indicate that ISA B is slightly more complex than ISA A.

**Figure 9.** Available firm names list collaboration diagram (ISA A)

**Figure 10.** Online firm start-up collaboration diagram (ISA A)
Figure 11. Offline on the spot firm start-up collaboration diagram (ISA A)

Figure 12. Available firm names list collaboration diagram (ISA B)

Figure 13. Online firm start-up collaboration diagram (ISA B)
In order to evaluate the security of both ISA, from a technological perspective, the technological architecture of ISA A and ISA B were modelled (Figure 15 and Figure 16) and two metrics were applied.

The Average Number of security components metric values for ISA A and ISA B are:

\[
\text{NSC}_A = \frac{\text{\# SITB}_{\text{«IT Block»}}}{59} = 10.17\%
\]

\[
\text{NSC}_B = \frac{\text{\# SITB}_{\text{«IT Block»}}}{102} = 10.78\%
\]

And The Average Number of security components between «IT Application Blocks» metric values for ISA A and ISA B are:

\[
\text{NSCBITA}_A = \frac{\sum_{i,j} \text{\# IT Application Block}_{ij} \cdot \sum_{i} \text{\# SITB}_{ji}}{\sum_{i,j} \text{\# IT Application Block}_{ij}^2} = \frac{19 + 8 + 8 + 8 + 8 + 8 + 8 + 14 + 14 + 14 + 14 + 43}{14^2} = 0.93
\]

\[
\text{NSCBITA}_B = \frac{\sum_{i,j} \text{\# IT Application Block}_{ij} \cdot \sum_{i} \text{\# SITB}_{ji}}{\sum_{i,j} \text{\# IT Application Block}_{ij}^2} = \frac{64 + 53 + 53 + 53 + 53 + 53 + 53 + 53 + 53 + 69 + 69 + 69 + 69 + 90 + 63 + 63 + 63 + 63 + 63 + 63 + 63 + 63 + 79 + 79 + 79 + 79 + 79}{24^2} = 2.68
\]

These metrics point that ISA B has a higher security level than ISA A.
Figure 15. Technological architecture A
4.3 Discussion

The metrics used in the previous section point that:

- ISA A has a worst alignment between its application and information architecture than ISA B;
- ISA A is less complex than ISA B;
- ISA A is less secure than ISA B.

Considering that this phase of the project had a high level of pressure on its implementation timeframe, the complexity quality was considered of highest importance. Thus, since the Interoperability layer was not available, the ISA adopted for this first phase was ISA A. However, the project is now going to the second phase with several business and technological enhancements – like online creation of companies with names formulated online by the citizen (instead of picking up from a set of pre-approved ones), Electronic Folder on all the information available on the enterprise (after creation), among others. For this next phase the team is going to implement an ISA similar to ISA B, previously described.

5. Conclusions and future work

In this paper the authors proposed a set of ISA evaluation metrics, namely: Average Number of Possible Operating Systems, Average Number of Distinct Technologies for IS Services, Average Number of (Different) Implementations of an Information Entity, Average Number of stateful «IT Presentation Block» and «IT Logic Block», Average Number of security components, Average Number of security components between «IT Application Blocks», Average Lack of COhesions in «IS Blocks», Average Number of Operations in «IS Blocks», Average Service Cyclomatic Complexity, Average Response for a Service, Number of Entities, Number of Relations, Critical Process - System Mismatch, Average Number of Applications per «Information Entity», Information Entity - System Security Mismatch and Average Number of Unused Information Entity Attributes. Some of these metrics were applied in an e-government ISA evaluation project and revealed to be useful on the process of selecting the most appropriate ISA for a set of desired qualities. With these metrics, as described in the case study in this paper, the architect has a...
set of indicators on the impact of each of his or her decision during the process of building an ISA. However, the authors recognised that much more testing on the metrics should be developed in order to assess its merit and significance. Currently, in other projects these metrics are being applied and improved. The implementation of a tool for automatically evaluate ISA according to a set of qualities is also a planned future work.

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References


Federal Enterprise Architecture Framework, version 1.1., September 1999


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1 Some facts presented in this case study were changed for security and confidentiality reasons.