

Extending the Information System Lifecycle through Enterprise Application Integration: A Case Study Experience

Marinos Themistocleous, Zahir Irani and Jasna Kuljis

*Department of Information Systems and Computing
Information Systems Evaluation and Integration Network Group (ISEing)
Brunel University, Uxbridge, UB8 3PH, UK
{Marinos.Themistocleous; Zahir.Irani; Jasna.Kuljis}@brunel.ac.uk*

Peter E.D. Love

*We-B Centre, School of Management Information Systems,
Edith Cowan University, Joondulap, WA 6027, Australia
p.love@ecu.edu.au*

Abstract

Enterprise Application Integration (EAI) technologies support a direct move away from disparate systems operating in parallel towards a more common shared architecture, where systems evolve and merge together. Such an emergence however, presents a paradigm shift in the way that Information System (IS) lifecycles are viewed. The integration of IS in-line with the needs of the business is altering IS identity and extending their lifecycle. This makes evaluating the full impact of the system difficult, as it has no definitive start and/or end. The authors demonstrate, through a case study of IS applications within an e-Government framework, that EAI can be used as a portfolio of technologies that improves infrastructure integration. However, in doing so, the authors create the need to re-think traditional IS-Lifecycle norms.

Keywords: Integration; EAI; Lifecycles; Case Study

1. Introduction

E-government has becoming a political imperative at local, national and international level. The growth of the Internet and public access to information has prompted government agencies at all levels in the mid-1990s into publishing their strategies on the web. This has created a muddle of information and policies with no clearly defined audience. E-Government encompasses a wide range of services, such as: dissemination of information, commerce with the private sector, services to individual citizens and businesses and participatory democracy, with information systems operating at the genesis of such provision. However, it is here where much of the problem lies, as over the last decades many government driven

policies have resulted in the implementation of various applications [technologies] to support processes.

The real value from the use of Information Systems (IS) comes with the integration of disparate applications in a way that supports efficient processes across the whole value chain; within an e-government framework [1, 2]. Yet, many of these individual applications have not been developed in a co-ordinated way but were often adopted as a result of the latest technological innovation resulting in a set of complex incompatible systems with diverse information formats, heterogeneous computing platforms, and various programming models [3]. Recently however, a new generation of software, termed Enterprise Application Integration (EAI) has emerged. EAI specifically addresses integration problems from a technical perspective, and provides a more flexible and maintainable IS. Increasingly EAI is having a significant impact on IS lifecycles.

EAI incorporates technologies that range from message brokers and adapter(s) to ebXML. Such a diverse portfolio of technologies has resulted in much confusion centring on integration terminology. Themistocleous *et al.*, [4] have gone some way towards classifying the various terminologies used to explain enterprise integration. In this paper the authors attempt to demonstrate, through a case study of applications within an e-Government framework, that EAI can be used as a portfolio of technologies that improve infrastructure integration. However, before empirically testing this conjecture, the paper explores the impact of EAI on traditional views of IS lifecycles, as such technologies set out to support the integration of once disparate systems, thus, expanding their lifecycle and resulting sets of benefits, costs and risks.

2. Information Systems Evaluation: A Moving Target

Irani [5] suggests that there has been a continuous expansion of the boundary surrounding the evaluation of information systems. The change can partly be attributed to new technology (increased scope, functionality and flexibility due to technologies such as EAI) and its social impact on organizational IS infrastructures. Such issues, together with the many interacting socio-technical dimensions that support an organization, require decision-makers to have the skills to evaluate elements of technology and also to assess its impact on the future of the organization, its people and customers.

The impact of new technology on organisations may be due to integration links with existing and future systems, benefit realization, stakeholder exploitation, cost (direct and indirect) management and risk minimization [13]. Indeed, much resistance towards the adoption of new technology can be attributed to the legacy of failed intra and inter organizational IS [6].

Land [7] defines evaluation as '*a process to examine notions of value and worth*'. So evaluation is a subjective process, which is undertaken to assess the value of an object or the merit of a situation. According to House [8], evaluation is a central issue in western societies, and has become an intrinsic part of human thought. Many authors [9-11] maintain that evaluation is an integral part of management practice in organisations, and that both intuitive and explicit evaluations support management decision-making. Evaluation should be central to any resource allocation activity [possibly embedded within a capital budgeting process] with the objective of maintaining or improving business/ process performance. Land and Hawgood [12] point out that IS evaluation serves a number of different objectives that include:

- A mechanism to financially justify a proposed system or new infrastructure. It is necessary that evaluation during this stage provide the organization with informed information on the outcomes of maintaining or installing a system. Clearly, such outcomes need to be achieved in terms of the organisations' interest;
- To act as a framework that allows the comparison of competing projects for scarce organisational funds. Using investment appraisal techniques such as those economic approaches identified by Irani and Love [13] it becomes possible to select from among different types of projects, the most suitable to best fit organisational requirements [financial];
- A control mechanism to support senior managers in the management of resources through benchmarking and improved project management. Such an evaluation process can provide a set of measures

needed by the organisation to exercise control over the project;

- A mechanism for organisational learning and improvement. Performance indicators and measures can act as comparisons of the actual achievements realised. They can also provide feedback for the organisation through a learning experience for future system building capabilities.

The 'roll-out' of IS remains costly and difficult to implement. Yet, there has always been a rush to adopt the latest technology to improve capability and performance within an organisation's marketplace [14] or indeed, for government mandates for the pursuit of integrated government infrastructures – e-Government. For example, Enterprise Resource Planning (ERP) has been adopted by both the public and private sectors often in haste, to address integration and system uniformity problems [15]. ERP vendors promoted their enterprise systems as integrated suites (i.e., a set of modules) that could cover up to 80% of an organizations' IS requirement. However, as these systems were adopted by public and private sectors, many realised that the packaged solutions fell short of their initial expectations. Attempts to parameterize ERP packages to support business requirements then tended to become the norm. Customization, however, has been difficult, as ERP systems are monolithic solutions, offering limited flexibility and often not designed to collaborate with other applications. Indeed, many of these problems have motivated companies to search for alternatives and this has prompted EAI technology-based solutions.

In today's environment of electronic markets and business, EAI is used to incorporate custom applications, packaged systems and e-business solutions into a flexible and manageable business infrastructure. EAI addresses the need to integrate both intra and inter-organizational systems through incorporating functionality from different applications. It combines traditional integration technologies (e.g. database-oriented middleware, interface-based technologies, distributed object technologies etc) with new application integration technologies (e.g. adapters, message brokers) to support the efficient incorporation of IS into the business domain. EAI results in supporting data, objects/components and business process incorporation.

The positioning of EAI within the IS evaluation arena, is being seen by many as having a number of profound impacts on systems development life cycles. Evidence from Themistocleous and Irani [16], and Puschmann and Alt [17] suggests an increased trend towards incremental system development through the use of EAI technologies (rather than software architects following traditional lifecycle methodologies).

3. EAI Bridges the Weaknesses of Traditional Systems Development Life Cycles

The literature is full of criticisms of *why* and *how* system development approaches have failed to provide solutions to the problems of developing robust and flexible IS. Much of this is due to a lack of ability to provide a suitable framework for management in its pursuit of setting and realising corporate strategic and tactical objectives. Yet, as such business objectives change due to demands of the customer and the business environment, new systems are often designed to follow the old tested, traditional 'safe' system models, rather than challenging the status quo and opting for a more radical integrated approach. EAI, however, provides an alternative by integrating one system with another. The end result is a new single (combined) IS that offers increased flexibility and software reuse through the adaptability of EAI technologies. Further motivation for this incremental system development approach comes from advancements in new technologies that support system integration, such as reuse of software code.

A traditional view of system development is based on the computerization of business processes once non-value added activities have been removed. Yet processes change and are subject to re-engineering in-line with changes in business direction or government legislation, and the emergence of new technology and resources. However, it is not easy to modify and re-write information systems, though the use of EAI challenges this narrow view. Avison and Fitzgerald [18] consider user requirements that translate into the output driven design of many IS as a weakness of the traditional development processes. Some requirements direct the output design and structure of the data and information produced by the system. This causes a fundamental problem – such systems are often inflexible. Moreover, the resulting structures are often rigid. This provides grounding for our argument that *traditional life cycle models are changing, as a result of technologies that support their integration with other systems*. Information systems that benefit from integration with others can arguably be viewed as no longer having a definitive start and end. Instead, they are evolving entities that grow and develop over time, in tune with the business environment. Therefore, information systems are adopting a more organic living structure that instigate inward looking changes as well as forcing the organizations to react to outward looking marketplace forces.

4. Theoretical Background of EAI

Enterprise Application Integration is a relatively new research area and many issues related with it are still

under investigation. EAI combines a variety of integration technologies such as message brokers, adapters and application servers, to build a centralised integration infrastructure [19]. In recent years EAI vendors have developed their own EAI packages to facilitate the integration efforts. Such an evolution has dramatically reduced the time for integration, as developers prefer EAI packages to individual integration technologies. Consequently, developers have managed to overcome the confusion that surrounds the capabilities of each one of the [25-30] integration technologies. However, the developers should be aware of the capabilities of the EAI packages and the range of integration problems they address. This is because EAI vendors developed their packages to facilitate the integration tasks in specific areas. For instance, many EAI packages support the incorporation of ERP systems. Nonetheless, none EAI package facilitates the integration of all ERP solutions. The explanation for this is that some EAI vendors provide solutions (e.g. integration adapters) for SAP R/3 and some other for another ERP software (e.g. Baan). Puschmann and Alt [17] suggested that organisations often adopt more than one EAI software package to build their integrated IT infrastructure. Therefore, the overall integration cost is increased but, it is still much less compared to the cost of the point-to-point bespoke solutions [20].

At a technical level, Themistocleous [21] empirically validated that integration is achieved through four layers namely: (a) Connectivity; (b) Transportation; (c) Transformation and (d) Process automation. The first layer creates points of access between the applications and the EAI infrastructure. The second one transfers the application elements (e.g. data, objects) among EAI infrastructure and applications. The Transformation layer translates and reformats the application elements into a recognisable format for the target(s) systems. The last layer is responsible for business process automation and integration. Depending on the requests and information it receives, it triggers all appropriate applications or tasks to integrate a business process [22].

Organisations follow different strategies when introducing application integration solutions. According to Themistocleous and Irani [20] organisations may follow either a *Strategic* or an *Opportunistic* approach. Some companies implement an alternative business strategy that focuses on an integrated model (e.g. developing a global integrated infrastructure instead of maintaining several independent infrastructures). In doing so, they make appropriate changes to their IT infrastructure and redesign their business processes to support this strategy (Strategic approach). Strategic EAI adoption is correlated with process centric integration [23] as enterprise wide and/or cross enterprise integration

requires the redesign, automation and incorporation of business processes.

Yet, some companies adopt EAI solutions to solve their organisational problems without designing an enterprise or cross-enterprise wide integrated infrastructure. However, they adopt EAI to overcome point problems (*Opportunistic approach*). For instance, Edwards and Newing [1] report that British Airways faced problems in understanding and analysing market place and customer needs. The business information infrastructure consisted of heterogeneous systems that stored huge quantities of data. Nonetheless, data was not consistent and the systems could not be combined or produce the information required for decision making. As a result, British Airways took the decision *not* to integrate the whole organisation but, to integrate all data sources needed for supporting decision-making. Hence, it could be said that in the case of British Airways there was an *opportunistic introduction of EAI* that was based on data centric integration.

The type (loose or tight) of the integration forms another critical issue that should be addressed by organisations when taking decisions for integrating their IT infrastructures. Based on these two types of integration inter-departmental systems (or even inter-organisational applications) can form: (a) loose-coupled systems through which they share information or (b) tightly integrated chains where there is a higher degree of process dependency. The differences among loose and tight types of integration are well explained by Themistocleous and Irani [24].

4.1. Enterprise Application Integration in the Public Domain

Public domain organisations introduce ICT reactively (compared to private sector organisations). This may be attributed to the bureaucracy and the culture that exists in many public authorities. However, there are cases where local authorities (or governments such as Singapore) proactively adopt ICT technologies to boost their economy [25]. In other cases, the authorities wait till a technology becomes mature and then push the private sector to adopt this technology. An example of this is the Clinton Presidency with its 'National Performance Review' of the federal bureaucracy [26] that led the way and pushed organisations to use EDI, Internet and ICT technologies. The Clinton Presidency forced all organisations to use electronic commerce technologies when doing business with the US public domain. Part of this policy was the famous 'EDI or DIE' directive, which was adopted to emphasize this policy.

The adoption of Enterprise Application Integration by public organisations does not significantly differ from other ICT technologies. Today, there are only a few cases

of EAI adoption in the public domain published in the normative literature (most of them discuss EAI in healthcare) [27]. The lack of published cases can be interpreted in many different ways. Some explanations could be that (a) EAI is not mature enough as a technology; (b) EAI has not been widely adopted by a critical mass of private companies. Consequently, many public organisations wait (reactively) to justify their decisions on EAI adoption based on the outcome of EAI implementations in the private sector; (c) many private enterprises integrate their IT infrastructures due to competition [20]. The lack of competitive pressures in the public sector also slows down the adoption of EAI.

It can be claimed that there is a similarity between EDI and EAI in terms of competition. According to Chwelos *et al.*[28] and Emmelhainz [29] competition is a major factor in EDI adoption. Likewise, Themistocleous [22] and Themistocleous and Irani [24] empirically validated that competition is an influential factor in EAI adoption. Also, Themistocleous *et al.*[30] draw parallels among EDI and EAI at technical level as, both EDI and EAI are integration technologies that are (a) based on the same concepts (extract, translate, transmit) and (b) aim at automating business processes. The differences between the two are many including (a) EAI can achieve business process integration whether EDI does or does not and (b) EAI produces more flexible and maintainable solutions.

An examination of the motivations that has led the public domain to adopt EDI technology indicates that public authorities have turned to EDI to (a) improve their transactions and communication; (b) speed up their business processes and (c) provide better services to enterprises. The limitations of EDI technology (complexity, lack of integration with internal systems) encouraged the public domain to turn to Internet technologies. However, Internet is not a panacea as it does not adequately support the integration of intra and inter-organisational systems. The authors *suggest* that in the near future parts of the public domain will turn to EAI (and web services) to integrate their systems, and thus further speed up and integrate business processes and provide better services to citizens and organisations.

4.2. IT Infrastructures in the Public Domain

The public authorities have implemented many applications to support their business activities, but these individual applications were not developed in a co-ordinated way but in stead evolved as a result of the next latest technological innovation [31]. This has led to incompatible systems with integration problems. Both private sector companies and public authorities consist of a set of complex islands of technology with diverse information formats, heterogeneous computing platforms, and various programming models [3]. These organisations

have attempted to overcome this problem by interconnecting manually their disparate applications. But integration means much more than simply interconnecting all the islands of technology. And, connectivity was insufficient due to the fact that individual applications were not designed to interoperate. There were two more basic problems for integration: (a) each island has its own meaning of enterprise objects (e.g. citizens) and (b) each island has data that overlaps data in other islands. This partial redundancy generates significant data integrity problems [31].

In the 90's the public domain has turned to ERP implementations in an attempt to overcome the Year 2000 (Y2K) problem and automate its business processes. Although ERP systems have addressed the former they only provide a partial solution for the integration problem[30]. This is because ERP systems were not designed to integrate disparate systems but rather to replace them to achieve integration [32]. There is an increasing demand to integrate the IT infrastructures in the public domain. This demand comes from different categories of stakeholders like employees and managers of the public domain, citizens, and private companies. All of them seek to ease their transactions with the public authorities. It can be presupposed that this demand for integration forms internal and external pressures respectively, which consist of influencing factors for the adoption of EAI technology [33]. Consequently, the authors suggest that the sooner the public domain takes into consideration other influential factors for EAI adoption such as cost, benefits and barriers the sooner they will make a decision for EAI implementation.

5. Case Data

The data been reported herein are derived from a real life *on going* project in which three entities participated including a team from(a) Brunel University; (b) a large software vendor and (c) local government. For confidentiality reasons the real names of the software vendor and the local government can not be reported. Instead the authors employ the coded-names (a) Softcom (b) LG (local government) respectively to refer to these entities.

LG is a big borough that lies in the area of greater London. Its IT infrastructure consists of numerous information systems such as environmental services, education, property, social services etc. The IT infrastructure is not integrated and thus, it causes a lot of technical, managerial, organisational and operational problems to LG. Similar problems were reported in normative literature and thus, the categories of problems reported herein support previous published evidences [1].

At the end of the 1990s LG took the decision to introduce an ERP system to overcome the Y2K problem

and provide better services. Also, LG was aiming at integrating its business processes through an ERP solution. LG purchased ERP modules (e.g. human resources, financial) from Softcom and recently, they deployed a CRM system that has incorporated with modules like complaints, street care and council tax and housing benefits. All these packages provided by Softcom have improved the citizens' satisfaction and speeded up business processes. Nonetheless, there was a lot of scepticism regarding the integration of Softcom applications with non-Softcom systems. The ERP packaged and CRM software can communicate each other but have limitations as they can not exchange information with non Softcom applications.

The insufficient nature of the existing IT infrastructure and the need for integration led LG to revisit its e-government and customer service strategy. One scenario was to phase out the non-Softcom applications and replace them with new one. However, such a solution will cost millions of pounds to LG. There is also no time, money and justification to eliminate the functionality of reliable systems. Also, the risks associated with such an exercise are high. On the other hand, the IT department was seeking possible solutions through integration. The IT management was persuaded that integration can happen technically and can deliver measurable business *benefits* to LG that are *worth the costs*. Thus, the IT management formed an ambitious vision aiming at: (a) enabling integration internally and externally; (b) achieving effective and efficient joined up government and (c) enabling electronic request and delivery of services. An interpretation of the data shows:

- the possible benefits that EAI delivers to organisations and
- why LG estimates that there will be a return on investment

Thus supporting the decision making process for EAI adoption. This is in accordance with literature findings suggesting that benefits and costs consist of influencing factors for EAI adoption [33]. Further significant evidence deals with the lifecycle of the existing systems. The integration of existing with new applications will allow LG to extend the lifecycles of its systems and enrich their functionality through EAI. In addition, LG will extend the benefits derived from the use of its existing systems.

As the plans for integrating LG were not completely justified, its top management suggested a demonstrator be run and to evaluate the outcome. Another reason to run a pilot project was the high costs of, and the limited successful cases of, EAI application in the public domain. The pilot demonstrates that the integration (a) is technically feasible and (b) can deliver significant benefits to LG. Such a decision is supported by the literature [17, 34].

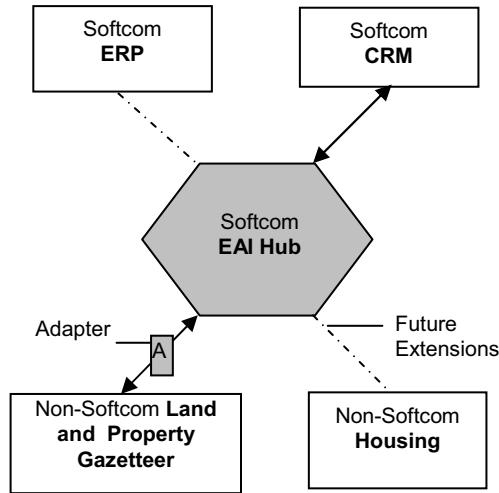


Figure 1: The Pilot Project

LG hoped that central government would recognise the success and importance of the project and award it ‘National Project’ status. Such funding would be very important in supporting the ongoing roll-out of the integration across LG and beyond the scope of the demonstrator.

The cost of the project has led LG and Softcom to collaborate with Brunel University. The collaboration between LG-Softcom and Brunel is that Brunel students provide very rigorous and high quality ICT development skills and they are considerably less expensive than private sector consultancy input. The cost of the pilot project was estimated at £110,000. On this basis, an EAI technical team was created consisting of three consultants from Softcom, four MSc and one PhD student from Brunel University and one LG manager. In addition, a business process reengineering team was formed at LG. At a higher level, there is a project board in which four managers from LG, two from Softcom and two members of Brunel academic staff participate. Both LG and Softcom funded the project. Softcom financially supported the project as it is seeking to exploit the outcomes. At the present time, Softcom implements EAI platforms but its solutions lack functionality in the area of public domain IS.

The pilot project started in March 2003 and has six months duration. Initially, LG had the intention to reengineer and integrate 15-25 business processes. After discussing these plans with the members of the project board, LG has been persuaded that it is not financially and timely feasible to reengineer and integrate all these processes in six months. Hence, the board took the decision to focus on a single business process and integrate all systems involved in this process. The pilot project follows a process centric approach and attempts to

loosely integrate the applications.

It was also clear from the beginning that the board members have different perspectives and ideas for this project. LG managers were/are ambitious and endeavour to put much effort to demonstrate that EAI can provide the solutions needed by their organisation. Due to their limited knowledge of EAI they proposed plans that were too ambitious and not feasible. Softcom managers proposed solutions that could be implemented faster and easily by saving time and money. Nonetheless, such propositions did not meet all requirements for this project. Brunel representatives approached the problem from another point of view. Their ideas were based on literature and their experience from other EAI implementations. The derived propositions could not be fully implemented due to cost limitations. Finally, after long discussions the project board came to a common consensus.

Parameters	Findings
Problems caused by the non-integrated IT infrastructure	<ul style="list-style-type: none"> • Technical • Managerial • Organisational • Operational
Type of Integration	<ul style="list-style-type: none"> • Loose coupling systems • Process centric • Hub and spoke oriented
Type of project	<ul style="list-style-type: none"> • Pilot/demonstrator
Factors influencing EAI adoption decisions	<ul style="list-style-type: none"> • Benefits • Costs • Vendor Support • EAI maturity / Lack of EAI cases
Impact on organisational structure	<ul style="list-style-type: none"> • Reallocation of 15 employees
Benefits	<ul style="list-style-type: none"> • Return on Investment • Extended Information Systems' lifecycles • Business process integration • Speed up business process • Reduce data redundancy

Table 1: Summary of Findings

The demonstrator aims to show that Softcom packages like CRM and ERP can be integrated with non-Softcom applications such as land and property gazetteer. Figure 1 depicts the architecture of the pilot project.

As illustrated in Figure 1 an EAI infrastructure based on a hub and spoke mechanism is configured to integrate applications. Non-Softcom applications such as the Land and Property Gazetteer (LPG) are linked to the EAI hub. Series of EAI adapters are currently being developed to convert LPG’s application elements into the EAI hub standardised format. In the near future the housing system and the ERP modules will be integrated with the hub. LG estimates that there will be 80% reduction of data

redundancy and internal information as a result of integration. In addition, LG estimates that the integrated system will lead to the reallocation of 15 employees. The benefits from this reallocation will be up to £300,000. The reallocation of employees implies that there will be organisational changes as an outcome of integration. This evidence is also in accordance with previous published cases on EAI. All the main evidences derived from this case are summarised in Table 1.

6. Conclusions

Enterprise Application Integration software specifically addresses integration problems from a technical perspective, and is having a significant impact on IS lifecycles. It combines a variety of integration technologies to build a centralised integration infrastructure. EAI addresses the need to integrate both intra and inter-organizational systems through incorporating functionality from different applications.

There is an increasing demand to integrate the IT infrastructures in the public domain. EAI can be used as a portfolio of technologies that improve infrastructure integration, as the authors demonstrated through a case study of applications within an e-Government framework. The project involves three parties; a team from Brunel University; a large software vendor and a local government (a big borough in the area of greater London).

The case study has not yet been completed; however, there was already sufficient data available to draw some conclusions on benefits in employing EAI. Based on the preliminary results of integration the local government already anticipate a reduction of data redundancy and internal information. In addition, they estimate that the integrated system will lead to the reallocation of a number of employees and consequently to the organisational changes. It is too early to say what would be the overall financial benefits to the organisation; however it is already obvious that the integration will lead to a significant cost reduction.

7. References

- [1] P. Edwards and R. Newing, Application Integration for e-Business. 2000, Business Intelligence 2000: London, UK.
- [2] S. Jones and Z. Irani, IS evaluation in the UK public sector: Emerging research themes and issues, Proc. 2003 Americas Conference on Information Systems (AMCIS 2003), Tampa, Florida, USA, 2003.
- [3] T. Klasell and S. Dudgeon, Enterprise Application Integration. 1998, Dain Rauscher Wessels: New York, USA. p. 1-71.
- [4] M. Themistocleous, Z. Irani, and A. Sharif, Evaluating Application Integration, Proc. Seventh European Conference on Evaluation of Information Technology (ECITE 2000), Dublin, Ireland, 2000, 193-202.
- [5] Z. Irani, Information Systems Evaluation: Navigating through the Problem Domain, Information and Management. 40(1):2002, 11-24.
- [6] M. Sumner, Critical success factors in enterprise wide information management systems projects, Proc. SIGCPR '99, New Orleans, LA, USA, 1999, 297-303.
- [7] F.F. Land, IS Evaluation: Recent Trends, Keynote Speech, Proc. NUKAIS Information Systems Evaluation Seminar, Leeds Metropolitan University, 2001.
- [8] E.R. House, Professional Evaluation: Social Impact and Political Consequences.(Sage, Beverley Hills, California, USA, 1993.
- [9] H. Mintzberg, Planning on the Left Side and Managing on the Right, Harvard Business Review. 1976(July-August):1976, pp. 54-62.
- [10] R.S. Kaplan and D.P. Norton, The Balanced Scorecard: Measures that Drive Performance, Harvard Business Review. 1992(January- February):1992, pp. 71-81.
- [11] L. Introna, Management, Information and Power.(Macmillan, London, UK, 1997.
- [12] F.F. Land and J. Hawgood, A Multivalent Approach to Information Systems Assessment., in Information Systems Assessment, N.B. Andersen, Editor. 1987, North Holland.
- [13] Z. Irani and P. Love, The Propagation of Technology Management Taxonomies for Evaluating Investments in Information Systems, Journal of Management Information Systems. 17(3):2001, 161-177.
- [14] P. Rajagopal, An Innovation-Diffusion View of Implementation of Enterprise Resource Planning (ERP) Systems and Development of a Research Model, Information and Management. 40(2):2002, 87-114.
- [15] K. Hong and Y. Kim, The Critical Success Factors for ERP Implementation: An Organizational Fit Perspective, Information and Management. 40(1):2002, 25-40.
- [16] M. Themistocleous and Z. Irani, Evaluating Application Integration: An Exploratory Case Study, Proc. Seventh Americas Conference on Information Systems, (AMCIS 2001), Boston, Massachusetts, USA, 2001, pp. 1376-1380.
- [17] T. Puschmann and R. Alt, Enterprise Application Integration - The Case of the Robert Bosch Group, Proc. the 34th Hawaii International Conference on System Sciences, Maui, Hawaii, USA, 2001, [CD Proceedings].

- [18] D. Avison and G. Fitzgerald, *Information Systems Development: Methodologies, Techniques, and Tools*.(McGraw Hill, London, UK, 1995.
- [19] D. Linthicum, *Enterprise Application Integration*. First ed.(Addison-Wesley, Massachusetts, USA, 1999) 377.
- [20] M. Themistocleous and Z. Irani, *Benchmarking the Benefits and Barriers of Application Integration*, *Benchmarking: An International Journal*. 8(4):2001, 317-331.
- [21] M. Themistocleous, *Evaluating the Adoption of Enterprise Application Integration in Multinational Organisations*, in *Department of Information Systems and Computing*. 2002, Brunel University: London.
- [22] M. Themistocleous, Z. Irani, and P. Love, *Enterprise Application Integration: An Emerging Technology for Integrating ERP and Supply Chains*, *Proc. Tenth European Conference on Information Systems (ECIS 2002)*, Gdansk, Poland, 2002, pp. 1087-1096.
- [23] L. Carrier, *Managing at Light Speed*, *IEEE Computer*. 32(7):1999, 107-109.
- [24] M. Themistocleous and Z. Irani, *Novel Taxonomy for Application Integration*, *Benchmarking: An International Journal*. 9(2):2002, 154-165.
- [25] G. Doukidis, M. Themistocleous, W. Drakos, and A. Papazafeiropoulou, *Electronic Commerce*.(New Technology Publications, Athens, Greece, 1998.
- [26] US Government, *National Performance Review: Re-Engineering Through Information Technology*. 1993.
- [27] Anonymous, *Catawba Memorial Hospital - Hickory*, North Carolina. 1999, International Data Corporation.
- [28] P. Chwelos, I. Benbasat, and A. Dexter, *Research Report: Empirical Test of an EDI Adoption Model*, *Information Systems Research*. 12(3):2001, 304-321.
- [29] M. Emmelhainz, *EDI: A Total Management Guide*.(Van Nostrand Reinhold, New York, USA, 1993.
- [30] M. Themistocleous, Z. Irani, and R. O'Keefe, *ERP and Application Integration: Exploratory Survey*, *Business Process Management Journal*. 7(3):2001, 195-204.
- [31] M. Stonebraker, *Integrating Islands of Information*, in *EAI Journal*. 1999. p. 1-5.
- [32] T. Davenport, *Putting the Enterprise into the Enterprise System*, *Harvard Business Review*. 1998(July-August):1998, 121-131.
- [33] M. Themistocleous and Z. Irani, *A Model for Adopting Enterprise Application Integration Technology*, *Proc. Working Conference on the Adoption and Diffusion of IT in an Environment of Critical Change (IFIP WG8.6)*, Sydney, Australia, 2002, pp. 61-76.
- [34] M. Themistocleous and Z. Irani, *Evaluating and Adopting Application Integration: The Case of a Multinational Petroleum Company*, *Proc. Thirty-Fifth Annual Hawaii International Conference on System Sciences, (Hicss 35)*, Big Island, Hawaii, USA, 2002, [CD Proceedings].