The impact of enterprise application integration on information system lifecycles

Zahir Irani (Corresponding author) E-mail: zahir.irani@brunel.ac.uk

Information Systems Evaluation and Integration Network Group (ISEING),
Department of Information Systems and Computing,
Brunel University,
Uxbridge
UB8 3PH,
UK

Marinos Themistocleous

Information Systems Evaluation and Integration Network Group (ISEING),
Department of Information Systems and Computing,
Brunel University,
Uxbridge
UB8 3PH,
UK

Peter E.D. Love

We-B Centre,
School of Management Information Systems,
Edith Cowan University,
Churchlands,
Perth,
WA 6018,
Australia

Abstract

Information systems (IS) have become the organisational fabric for intra-and inter-organisational collaboration in business. As a result, there is mounting pressure from customers and suppliers for a direct move away from disparate systems operating in parallel towards a more common shared architecture. In part, this has been achieved through the emergence of new technology that is being packaged into a portfolio of technologies known as enterprise application integration (EAI). Its emergence however, is presenting investment decision-makers charged with the evaluation of IS with an interesting challenge. The integration of IS in-line with the needs of the business is extending their identity and lifecycle, making it difficult to evaluate the full impact of the system as it has no definitive start and/or end. Indeed, the argument presented in this paper is that traditional life cycle models are changing as a result of technologies that support their integration with other systems. In this paper, the need for a better understanding of EAI and its impact on IS lifecycles are discussed and a classification framework proposed.

Keywords: Enterprise application integration; Lifecycle; Infrastructure

1. Introduction

The ubiquitous nature of Information systems (IS) and its ever-changing underlying technology requires organisations to stay aware of technological innovation. One of the reasons for embracing e-business has been to integrate existing organisational IS and automate business processes within and between supply chain members. Yet, for a considerable period of time, the integration of systems has been a barrier to business process automation, as no single integration solution has been available to piece together disparate systems. Recently, however, new generation software, termed enterprise application integration (EAI), has emerged that specifically addresses integration problems from a technical perspective, and leads to more flexible and maintainable information systems. Notwithstanding, it is becoming increasingly apparent that EAI is having significant impact on IS lifecycles.

EAI incorporates functionality from many IS using technologies such as message brokers, adapter(s) and XML. As a result, much confusion exists about integration terminology. Unfortunately, each definition proposes a different range of technologies. Although it is worth mentioning that Themistocleous et al. [30] have gone some way towards classifying the various terminologies used to explain enterprise integration. Nonetheless, this paper attempts to present taxonomies of EAI technologies. These are based on a critical analysis and evaluation of existing case studies from the EAI literature. However, before discussing them, the authors refine the traditional views of IS lifecycles.

2. Information systems evaluation: a moving target

Understanding IS evaluation is a complicated process and ever-changing [15]. Irani and Love [16] suggest that there has been a continuous expansion of the boundary surrounding the domain. The change can partly be attributed to new technology (increased scope, functionality and flexibility due to technologies such as EAI) and its impact on organisational IS infrastructure. Such issues, together with the many interacting socio-technical dimensions that support an organisation, require that its decision-makers not only have the skills to evaluate the elements of the technology, but also to assess its impact on the future of the organisation and its people. The impact may be due to the integration links with existing and future systems, benefit realization, stakeholder exploitation, cost (direct and indirect) management and risk minimisation. Indeed, much resistance towards the adoption of new technology can be attributed to the legacy of failed intra-and inter-organisational IS [26].

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 organisations marketplace [24]. For example, many organisations have adopted enterprise resource planning (ERP) in haste to address integration and system uniformity problems [14]. ERP vendors promoted their enterprise systems as integrated suites (i.e. a set of modules) that could cover up to 80% of an organisation's IS requirement. However, as these systems started to be deployed, many organisations began to realize that the packages fell short of their initial expectations. Companies have therefore attempted to parameterise their ERP packages to support business requirements. Customisation, 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 a surge of 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-organisational 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 and message brokers) to support the efficient incorporation of IS into the business domain. EAI results in supporting data, objects/components and business process incorporation. In positioning EAI within the IS evaluation arena, it is being seen by many as having a number of profound impacts on systems development life cycles. Evidence from Themistocleous and Irani [27] and Puschmann and Alt [23] suggests there is an increased trend towards incremental system development rather than software architects following traditional lifecycle methodologies.

3. Bridging weaknesses of traditional systems development life cycles with EAI

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 goals. 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 approach. EAI, however, provides an alternative by integrating one system with another. This results in a new single (combined) IS that offers increased flexibility and software reuse through the adaptability of EAI. 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 computerisation of business processes once non-value added activities have been removed, yet processes change and are subject to reengineering in-line with changes in business direction and the emergence of new technology and resources [5]. However, it is not easy to modify and rewrite IS through the use of EAI challenges this perspective.

Avison and Fitzgerald [1] 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 the fundamental problem—such systems are often inflexible. Moreover, the resulting structures are often rigid.

This provides 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. Thus, IS are adopting a more organic living structure that instigate inward looking changes as well as forcing the organisations to react to outward looking marketplace forces. Thus, questioning traditional norms of acceptable and predictive system development models.

4. Enterprise application integration: scope, impact and classification

There is however confusion about the integration of IS, which has led to a debate about the types of IS that can be integrated through EAI. Grimson et al. [10] have suggested that the term EAI is limited to the integration of ERP systems (e.g. ERP to ERP), while Duke et al. [8] suggest that it supports the incorporation of all packaged applications. Contrastingly, Ruh et al. [25] report that EAI does not only piece together packaged systems but also intra-organisational IS. While Zahavi [32] suggests that EAI supports both enterprise and cross-enterprise application integration. Differences in the interpretation of EAI indicate that there is a need to clarify and define the dimensions (range) of application integration technology.

Regardless, however, there is little discussion of the impact of the adoption of EAI on IS life cycles. A taxonomy is presented in Figure 1. This will enable managers to identify technologies that can be used for enterprise and cross-enterprise applications, which can lead to the development of an integrated infrastructure that supports intra-and inter-organisational applications.

Insert Figure 1: Taxonomy for enterprise application integration.

We believe that the taxonomy presented in Figure 1 will allow managers and solution-developers to understand the scope and impact of application integration, as well as allow it to be used as a tool to support the investment decision-making associated with integrating disparate systems. Such integration highlights the need for decision-makers to consider non-traditional perspectives, such as those identified and classified by Irani and Love [17]. The taxonomy suggests that EAI should no longer be viewed in terms of traditional financial return, etc. but from the benefits resulting from integrating systems, etc. together, with the costs associated with the alternative of having to develop new systems and/or buy package solutions, and the risks of doing nothing in a competitive and changing marketplace.

4.1. Component 1: intra-organisational application integration

Packaged and custom systems are classified as subcategories of intra-organisational applications [11]. A custom application is generally designed to address a specific point problem and therefore cannot be adopted by another company. Brodie and Stonebraker [3] report that customised systems or legacy were developed to resist modification and evolution to meet business requirements. According to Zahavi [32] most legacy systems follow a monolithic model in which data, logic and interfaces are not separated but are built together. In contrast to custom systems, packaged solutions follow a three-tier architecture model where data is separated from business logic and interfaces, and can therefore be easily updated or modified [31]. In addition, packaged systems like ERP solutions were based on generic business requirements and processes, and not on the requirements of a specific organisation [13]. Often, one packaged system (e.g. SAP) will be adopted by several enterprises without much customisation thus, simplifying any form of development at the cost of differentiation. However, Davenport [6] reports that packaged systems do not allow much customisation, and thus, organisations often have to change their business processes and strategy to suit the packaged system. This may reduce the benefits possible from using ERP software.

It is in the area of intra-organisational IS that much of the value of adopting EAI is found. Whether it is a customised legacy system that has much historical data and is based on dated technology or a packaged business solution, there is still much scope to develop integration links with disparate systems that must together.

4.2. Component 2: inter-organisational application integration

Inter-organisational integration seeks to incorporate cross-enterprise business processes and systems throughout a supply chain. Kalakota and Robinson [18] suggest that e-business solutions form part of this sub-category. Linthicum [19] explains that application integration incorporates e-business through the same category of technologies (e.g. message brokers, adapters and XML) that support intra-organisational integration. The literature classifies integrated applications according to the degree (loose, tight) of integration achieved [20]. This categorisation is important, as companies tend to follow one or the other degree of integration when incorporating their e-business systems. The authors suggest the division of interorganisational application integration into extended enterprises, and virtual enterprises.

The first represents loosely integrated e-business applications (e.g. e-supply chain management), where the need for the development of a homogeneous cross-enterprise integrated infrastructure is not too important. In this case, organisations extend their business activities through e-business solutions, and try to incorporate loosely with external partners. However, the other (virtual enterprise) sub-category refers to tightly integrated e-business applications where integration is very important, with a number of enterprises sharing common data and processes. In this case, there is an attempt to function as one (virtual) organisation. The justification for this approach is, in many cases, to support the common processes more efficiently, because real-time information is needed. This is made possible through the use of EAI, however the integration of back-office systems with e-business solutions may be the outcome rather than its original purpose.

4.3. Component 3: hybrid application integration

Helm [12] suggests that business-to-consumer (B2C) solutions present no challenge for integration among business partners. However, several authors suggest that, in some cases (e.g. e-stores), there is a need to integrate B2C applications with other interorganisational solutions (e.g. suppliers, distributors, bank, etc.) [2]: inter-organisational systems have an important role in supporting the functionality of an e-commerce application and, as a result, they need to offer sufficient integration with other applications, some of which may be legacy or package solutions.

The main users of B2C applications are companies that own an application (application service providers and shop-provider) and Internet users (consumers) that communicate with these applications [7]. In some applications (e.g. e-services), consumers subscribe once (by paying electronically or not a fixed amount of money to a bank) and then use the system for a specific period (e.g. 1 year). During this period, the owner of the B2C application provides services to the customer without the need for an external entity (e.g. supplier). Consequently, there may be no need to integrate this type of systems with external partners–companies, as there are no external companies. However, other types of B2C applications function like extended or virtual enterprises. For example, many e-store applications require integration across enterprises, as they incorporate banks', suppliers' and distributors' systems. With this in mind, a new subcategory, hybrid application integration that includes B2C applications at the same level as intra-and inter-organisational application is proposed. Table 1 summarises its probable characteristics.

Insert Table 1: Characteristics of the sub-categories of the taxonomy

5. Case data: a multinational company

By using EAI technologies, IS life cycles can be extended. This is illustrated by considering the experience of a multinational that traditionally operates in the automotive sector. For confidentiality reasons the substitute name MACom will be used. It has about 200,000 employees in 132 countries and has an annual turnover of s 31.6 billions. The organisation has 250 subsidiaries and affiliated companies in 50 countries. MACom has 185 production plants worldwide, 43 locations in its home country with the rest in Europe, Africa, Asia, Australia and North, and South America. MACom also holds interest in 37 joint-venture companies. The worldwide activities of MACom are divided into four business units–sectors namely: (a) automotive equipment; (b) communication technology; (c) consumer goods; and (d) capital goods.

5.1. Background to integration problem

During the last decade, tremendous changes in trading conditions forced MACom to become more efficient and competitive. It believes that a flexible infrastructure is required to maintain and expand its business. The need for an integrated and flexible IT infrastructure was required because its existing infrastructure was causing numerous performance and scalability-related problems. These problems became an obstacle for MACom: they prevented the company from implementing its strategic business goals.

For example, MACom could not support its goal of closer collaboration and coordination of inter-organisational business processes within its supply chain. This held the organisation back from achieving competitive advantage and reducing its cost base.

5.1.1. Technical problems

The IT infrastructure was and is heterogeneous and consists of hundreds of incompatible systems. As a result, MACom faced significant integration problems when attempting to migrate its existing custom-built applications in SAP R/2 to SAP R/3. Another problem was the incorporation of best-of-breed ERP modules to SAP R/3. MACom purchased the ‘best’ ERP modules that were available. Thus, MACom combined modules from different vendors irrespective of potential integration barriers. Unifying these systems became a problem, since most modules were incompatible. In addition, each module was customised in a unique way to communicate with other existing legacy systems. Thus, it was difficult for MACom to reconfigure and piece together all the modules that run on the mainframe-based SAP R/2 to the non-mainframebased SAP R/3. In addition, there was a redundancy of data and functionality, as many applications store similar data or run systems that overlap in functionality. In each subsidiary, applications were customised in a unique way (based on financial laws and regulations of the home country). Many systems stored data for the same entity (e.g. a specific customer), resulting in data redundancy. Non-integrated infrastructure caused additional problems to the organisation, since it could not achieve supply chain and eProcurement integration. Therefore, MACom could not support closer collaboration with its suppliers and customers.

5.1.2. Financial problems

IT infrastructure could not accomplish tight collaboration at an intra-and inter-organisational level. This resulted in a loss of sales, since MACom could not efficiently support its customers or coordinate its activities with its suppliers. Another important financial problem was the high operational cost of the existing IT infrastructure. MACom believed that it was not cost-effective to support a large infrastructure, with overlapping functionality. The maintenance cost of such an infrastructure is high, presenting additional financial barriers. MACom estimated that the costs of managing the new required interfaces would be tremendous. It estimated that the time to configure one interface will be about 15–20 men per day. This time will be much more since each interface should be altered when an interconnected system is changed. This indicates that point-to-point connectivity leads to extravagant solutions with expensive maintenance cost.

5.1.3. Managerial problems

Since multiple applications store data for the same entity (e.g. a specific supplier) management could not retrieve the most updated data for this entity and therefore had problems in decision-making. MACom required flexible, cross-organisational core business processes, such as: (a) development; (b) controlling; (c) sales; (d) quality management; and (e) finance and accounting, which had to be based on a homogenous and flexible IT infrastructure to allow the organisation to be more flexible in adapting to the changes of the business environment. Existing IT infrastructures could not efficiently support core business processes and, therefore, become an obstacle to achieving business goals. In addition, the strong need for the integration of inter-organisational business processes required the integration of new systems into existing infrastructures. In order to streamline business processes between the organisation and its trading partners, MACom used eProcurement systems and online stores. Nonetheless, there was a need for better collaboration among trading partners. There was also a strong need to integrate SCM and CRM systems for suppliers and customers.

However, the existing IT infrastructure cannot support this requirement due to its non-integrated nature. These problems are summarised in Table 2.

Insert Table 2: MACom—problems of the non-integrated IT infrastructure

Our analysis of the problem at MACom suggests that there are several important factors that include:

- external pressures, such as increased competition and a requirement for closer collaboration with trading partners;
- the limitations of the existing IT infrastructure;

- cost factors that are related with the maintenance of existing infrastructure;
- cost factors that are associated with the development of non-flexible and manageable point-to-point solutions.

5.2. EAI solution developed

The aim of the project was to prove that application integration could be used for the development of a standardised, flexible and maintainable infrastructure that integrates both intra-and inter-organisational business processes and applications. For that reason, the project attempted to test whether EAI supports a robust IT infrastructure that achieves: (a) closer collaboration with customers and suppliers and (b) better coordination of business processes. Another target of the project was to demonstrate possible benefits and highlight barriers to application integration. The project took 6 months and was designed to incorporate custom and packaged applications integration. The reasons were that:

- MACom consists of a vast amount of custom systems (more than 2000);
- packaged systems such as SAP R/3 'govern' the overall functionality of the organisation, as the majority of important processes run on packaged systems;
- most e-business modules are designed to collaborate with other existing systems and, therefore, are easier to be pieced together.

One of the main objectives of the project was to increase coordination in demand planning. Therefore, the project was designed to integrate seven business processes among business units and another five processes at inter-organisational level (MACom, customers and suppliers). These processes are summarised in Table 3.

Insert Table 3: Business processes that were integrated during MACom's EAI project

The project was developed at a European level with such employees as: (a) staff from the IT departments of MACom and its business units; (b) internal consultants; (c) external consultants; (d) IT support; and (e) staff from MACom's suppliers and customers.

Apart from the technical staff, a number of managers from involved companies and business units had an important role in the project, which was based on process centric integration, requiring the incorporation of both applications and common business processes of all participants (MACom, MACom's customers and suppliers). Therefore, the organisation did much business process reengineering with its customers and suppliers. MACom estimated that 70% of its overall time on the project dealt with system design and business process reengineering. The implications of this overhead are far reaching, and have affected the way that MACom will approach future design methodologies.

At a technical level, application integration was adopted to connect MACom's customers and suppliers with its business units. Consequently, the organisation developed an integration infrastructure called Business Bus. As illustrated in Figure 2, it integrates the SAP R/3 system with custom-built systems that deal with material management. At an inter-organisational level, it also incorporates systems, based at MACom's suppliers and customers that are used to automate common business processes.

Insert Figure 2: MACom's EAI project—integration configuration for a business unit.

Figure 2 shows the configuration of one business unit using the EAI infrastructure. Internally the advanced planner optimiser functions in an integrated way; (a) demand planning; (b) production planning and detailed scheduling; (c) deployment; (d) global ATP; and (e) supply network planning are all pieced together and share common data. The global ATP sub-module communicates with SAP R/3 and retrieves data from other modules, such as sales, orders and inventory control. These modules are continuously updated with data provided by customers and suppliers (e.g. an order). Data that are retrieved by global ATP are then forwarded to APO sub-modules (e.g. production planning, deployment) and support demand planning in analysing and optimising data. Moreover, APO and/or SAP R/3 modules exchange and/or retrieve data from other applications (e.g. material management, customer applications) that are significant for the functionality of APO or SAP R/3.

The integration scenario, based on a process centric approach, governed the whole integration efforts, since integrators should incorporate all parts of the process that run on many systems. As a result, integrators started piecing together the first part of a process running on one system and then incorporated the next logical part of the same process from another system. This task was repeated until all parts of the same process were unified.

Insert Figure 3: MACom's EAI project—the integrated infrastructure.

Figure 3 presents the overall application integration architecture in which multiple business units are integrated with multiple customers and suppliers.

6. Conclusions

Technology in the form of EAI now supports the evolution of information systems in-line with the changing needs of the business and supporting a reaction to shifts in trading conditions and strategies. Now IS can be integrated with other, once disparate, systems to form a more comprehensive IS infrastructure. Indeed, this paper has presented the argument that traditional life cycle models are changing as a result of EAI technologies that support their integration with other systems. However, there remains much confusion surrounding terminology in the integration literature, which has led to a debate about the capabilities and scope of application integration technologies. This prompted the authors to identify and define the range of applications technologies in terms of types, as well as to categorise the types of systems that can be integrated through EAI. This has resulted in a taxonomy that categorises and explains the types of applications that can be integrated with existing technologies at three levels: intra-and interorganisation, and hybrid. Using a case study, the authors identified the problems associated with application integration and demonstrate that EAI technologies can be used for the development of a standardised, flexible and maintainable infrastructure.

The authors believe that the EAI taxonomy is a suitable tool for managers in evaluating and implementing ERP technology within and between customers/ suppliers in their supply chain.

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Dr. Zahir Irani is a chair professor of information systems evaluation in the Department of Information Systems and Computing at Brunel University (UK). Professor Irani has coauthored a textbook on information systems evaluation and written over 150 internationally refereed research papers that have appeared in leading international journals such as the European Journal of Information Systems, Journal of Management Information Systems, Information and Management, International Journal of Production Economics and International Journal of Operations and Production Management. Professor Irani retains close links with industry and is a non-executive director to a leading engineering company. He consults for international organisations such as Royal Dutch Shell Petroleum, DERA, BMW and Adidas. Professor Zahir Irani reviews research proposals submitted to both the European Commission and the National Science Foundation (NSF) in the USA.

Dr. Marinos Themistocleous is a lecturer at the Department of Information Systems and Computing at Brunel University. He holds a PhD in ‘adopting and evaluating enterprise application integration (EAI)’ from Brunel University. He also holds a master of science (MSc) on information systems management and a bachelor degree on computer sciences, both from Athens University of Economics and Business. Dr. Themistocleous is well known in the area of e-business and enterprise application integration (EAI). He has extensive research experience and participated in more than 25 different research projects (EU funded and Greek projects).

Dr. Peter E.D. Love is an associate professor in the School of Management Information Systems at Edith Cowan University (Australia). He has an MSc in construction project management from the University of Bath in the UK and a PhD in operations management from Monash University in Australia. He has coauthored/edited four books and has authored/co-authored over 200 internationally refereed research papers, which have appeared in journals, such as the European Journal of Information Systems, Information and

Management, Journal of Management Information Systems, International Journal of Production Economics, International Journal of Operations and Production Management, Project Management Journal and International Journal of Project Management.

Figures:

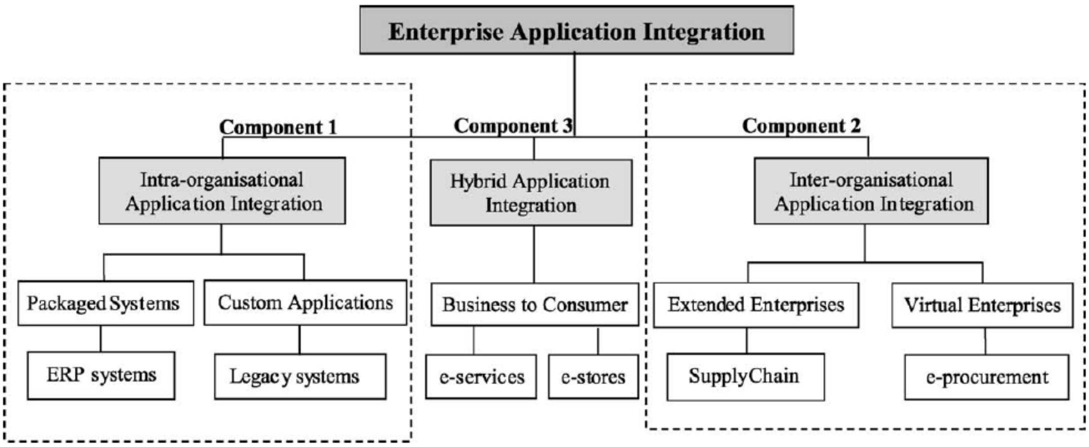

Figure 1: Taxonomy for enterprise application integration.

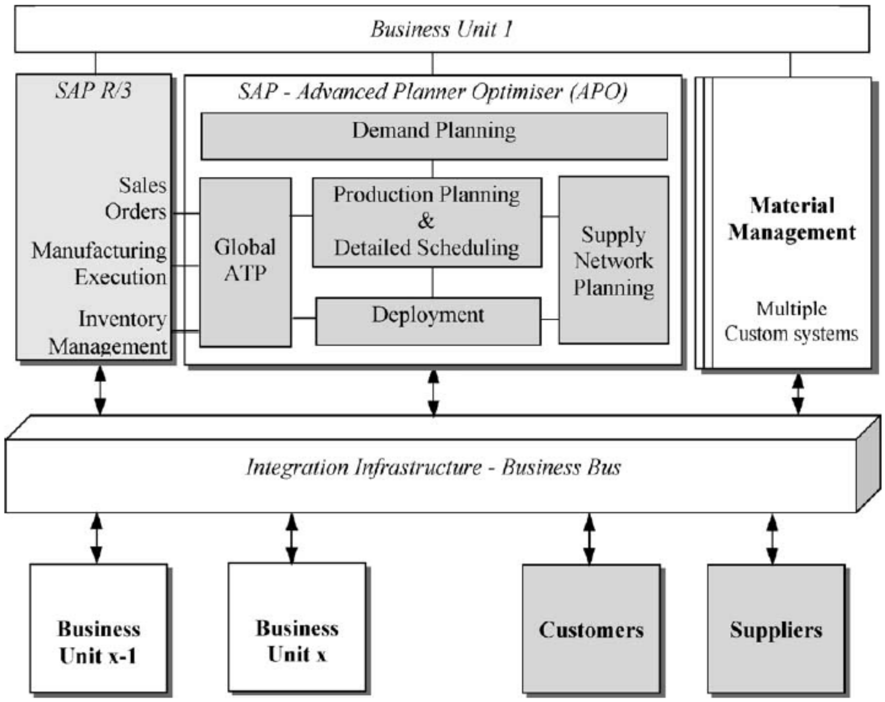

Figure 2: MACom's EAI project—integration configuration for a business unit.

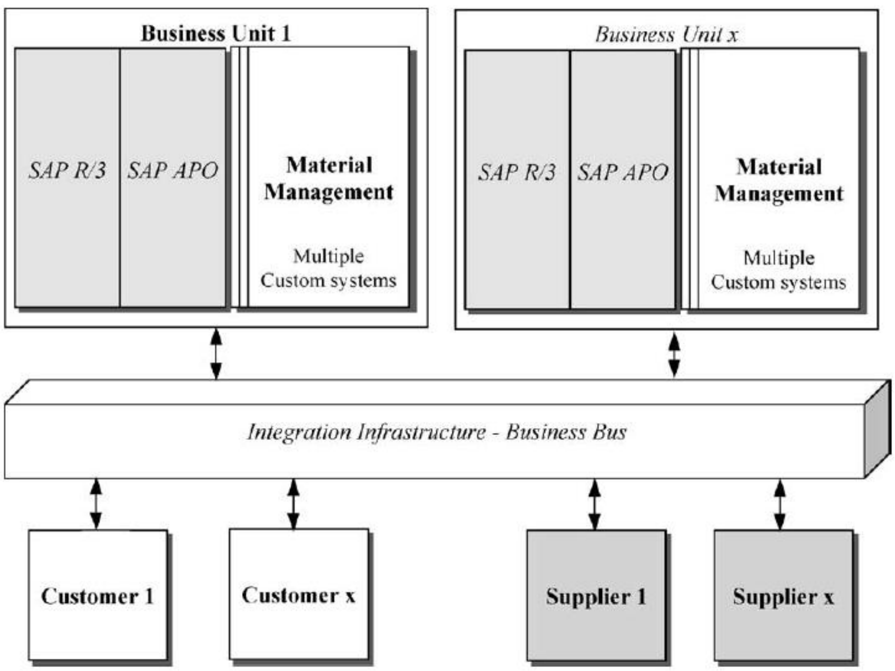

Figure 3: MACom's EAI project—the integrated infrastructure.

Tables:

Table 1: Characteristics of the sub-categories of the taxonomy

Characteristics of the sub-categories of the taxonomy

Category of application integration	Characteristics	Reference
Intra-organisational	Integrates enterprise applications	[4,20]
	Integrates packaged and custom systems	[9,25]
	No transactions with external users or partners	[12,29]
Hybrid	Integrates business to consumer applications with IT infrastructure	[28]
	Internet users purchase products or services. Hybrid AI applications support the transactions by integrating internal systems *or/and* external partners	[7,18]
Inter-organisational	Integrates cross-enterprise applications with IT infrastructure	[19,32]
	Integrates business-to-business applications	[21,22]
	Based on the degree (loose, tight) of integration it is separated	
	Extended enterprises (loose integration)	[12,23]
	Virtual enterprises (tight integration)	

Table 2: MACom—problems of the non-integrated IT infrastructure

MACom—problems of the non-integrated IT infrastructure

Integration drivers	Problems
Technical	Problems in migrating existing applications (legacy and custom-built) to SAP R/3
	Problems in incorporating best-of-breed ERP modules
	Problems in supporting supply chain management integration and eProcurement integration
	Problems in providing a homogeneous IT infrastructure
	Difficulties in maintaining the IT infrastructure
	Redundancy of data and applications
	Traditional interconnectivity approaches have a high complexity
Financial	Existing infrastructure has a high operational cost
	Traditional interconnectivity approaches have a high cost
	Lost of sales
Managerial	Existing infrastructure cannot efficiently support management
	The inability of existing infrastructure to provide data accuracy causes problems in decision-making
	The non-integrated infrastructure was a problem for the collaboration and coordination of cross-enterprise and enterprise wide activities and processes
	Problems in integrating intra-organisational business processes
	Problems to integrate business processes with customers and suppliers

Table 3: Business processes that were integrated during MACom's EAI project

Business processes that were integrated during MACom's EAI project
Intra-organisational processes
Series sale
Sales samples
Development/product data management
Sales planning and distribution
Controlling
Pricing
Guarantee and quality management
Inter-organisational processes
Customer relationship management
Supplier relationship management/eProcurement
Supply chain management
Collaborative product commerce
Business management