Evaluating and Adopting Application Integration: The Case of a Multinational Petroleum Company

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Abstract
Many organisations use a diversity of information systems such as custom applications, e-business solutions and Enterprise Resource Planning (ERP) to support their organisational and financial business processes. However, this diversity of heterogeneous and in many cases incompatible systems coupled with the absence of integrated enterprise architecture is considered a restricting factor in the automation of business processes and thus, cause a plethora of integration problems. In attempting to overcome such issues, organisations are turning to a new category of integration software called Application Integration (AI), which results in flexible and manageable Information Systems (IS) and infrastructures. Application integration is achieved through the incorporation of functionality from disparate systems using a variety of integration technologies such as adapters and message brokers. In attempting to explore the area of AI, this paper discusses the adoption and the impact of application integration on organisations. In doing so, the case study of a multinational petroleum company that adopted an AI solution is presented. The case study presented in this paper shows that system design takes up to 60% of overall project time when integrating systems due to the reengineering of business processes. In addition, the majority of systems are phased out and the redundancy in functionality is significantly reduced.

Keywords: Application Integration, Evaluation, Case Study

1. Introduction to Application Integration
In recent years, there has been dramatic social, political, economic and technological change, which has had a great impact on organisations. Such change has turned enterprises to adapt to new business environments (e.g. global markets), and adopt advanced technologies to support new and often innovative ways of doing business (e.g. e-business). Information Technology (IT) coupled with Enterprise Resource Planning (ERP) and Electronic Commerce (EC) have supported large-scale business transformations, and forced enterprises to change their structure, functionality and business strategies (Timmers, 1999). Although, organisations have attempted to adopt computerised solutions to automate and integrate their business processes and information systems they have not succeeded. The reason for not achieving integration, is that for many years organisations developed applications to solve their point problems. Therefore, applications were not developed in a co-ordinated way but, have evolved as a result of the latest technological innovation (Inmon, 1999; Themistocleous and Irani, 2000). As a result organisations consist of a set of complex islands of technology, with diverse information formats, heterogeneous computing platforms, and various programming models (Swenson and Cassidy, 1993).

The integration of intra-organisational and inter-organisational systems can be facilitated through a new class of integration software called Enterprise Application Integration (EAI) or simply Application Integration (AI) (Themistocleous et al., 2000). Application integration supports the development of flexible and manageable IT infrastructure by incorporating functionality from disparate applications. According to Linthicum (1999) application integration is the

‘unrestricted sharing of information between two or more enterprise applications. A set of technologies that allow the movement and exchange of information between different applications and business processes within and between organisations’

Linthicum (1999, p.354)

Themistocleous et al., (2001b) report that a significant business benefit of application integration is the reduction of overall integration cost. This can be attributed to the decrement of both integration time and maintenance costs.

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Application integration leads to return on investment (ROI) as it provides a flexible, manageable and maintainable enterprise infrastructure that supports changing business and technical requirements. Based on an integrated enterprise architecture, companies can increase their productivity and provide better services for their customers and improve their relationships with their clients (Ruh et al., 2000). Application integration supports strengthened supply chains and improved relationships and collaboration between organisations and suppliers. Other benefits include the provision of a centralised point of control, the reduction of skills level required to integrate applications, faster time to marketing and increased market share.

This paper approaches application integration through a case study in order to investigate and evaluate its adoption. The authors describe and analyse existing adoption practices of application integration. In doing so, focusing on Strategic and Opportunistic adoption practices. The paper then discusses the case data, starting with the problems and the need for integration. Thereafter, the application integration adoption and software evaluation is discussed. The case study ends with the presentation and the analysis of the integrated system development.

2. Application Integration Adoption – Existing Adoption Practices

Carrier (1999) distinguishes integration structure into Data Centric or Process Centric. Carrier (1999) defines data centric as the automation and integration of data flows that are exchanged between information systems. It does not however, focus on improving and reengineering business processes. Data centric integration results in shortening the time cycle of business processes and however, if the processes are poorly designed or include errors, the data centric integration will simply increase the frequency of occurrence these errors. One of the purposes of data centric integration is to create mappings between data exchanged among disparate systems, to facilitate data exchange and manipulation among systems. Based on this type of integration, organisations increase their functionality and performance, as IS becoming capable to process and combine data from various applications. Therefore, significantly reducing manual integration processes (e.g. manual data mapping and formatting). For instance, Electronic Data Interchange (EDI) supports data centric integration and allows automatic data mapping, transmission and processing from source application format to target using an EDI standard (e.g EDIFACT). More advanced data centric integration mechanisms include message brokers and adapters (Ring and Ward-Dutton, 1999). Figure 1 illustrates data centric integration as a means of automating and integrating data flows from a source application to a target. When application integration technology is adopted, adapters are frequently used to map data between applications or provide the libraries for formatting data in the right format. Also, message brokers can be used to receive, format and distribute appropriate data sets to target applications based on business logic and rules.

![Figure 1: Data Centric Integration](image)

Process centric integration deals with the automation of business processes by integrating functionality from disparate applications. According to Linthicum (1999; 2000) and Morgenthal and La Forge (2000) process integration is the highest level of integration possible, as it requires the collaboration and incorporation of all involved systems at all levels (e.g. data, components, interfaces and messages integration etc). Although, process integration pieces together data and applications, it does not mean that data centric integration achieves process incorporation.

In some cases data centric integration may result in process integration (e.g. the data integration of an electronic ordering application with a back-office system may result in order process integration) but this is not a fixed rule. For example, the integration of a database with a decision-making system enriches the functionality of the system by providing more integrated data but, it may not result in integrating and automating the decision-making process.

Themistocles and Irani (2001a) support that organisations may follow two different strategies when adopting application integration solutions. These strategies deal with either the Strategic or the Opportunistic adoptions of application integration. Some companies implement an alternative business strategy that focus on an integrated model (e.g. develop a global integrated infrastructure instead of having several independent infrastructures). In doing so, they make all the appropriate changes to their IT infrastructure and redesign all their business processes to support this strategy (Strategic adoption). This approach is also

![Figure 1: Data Centric Integration](image)
supported by literature findings such as Brown (2000), Kalakota and Robinson (1999), and Linthicum (2000). Such literature suggests that organisations redesign their business processes and IT infrastructure to develop an integrated IT Infrastructure which will allow them taking advantage of AI technology. Hence it would be said that strategic AI adoption is correlated with process centric integration as enterprise wide and/or cross enterprise integration requires the redesign, automation and incorporation of business processes.

Yet, some companies adopt application integration solutions to solve their organisational problems and do not design an enterprise or cross-enterprise wide integrated infrastructure. However, adopt application integration to overcome point problems (Opportunistic adoption). For instance, Edwards and Newing (2000) report that British Airways faced problems in understanding and analysing market place and customer needs. The business information infrastructure was consisted of heterogeneous systems that stored huge quantities of data. However, data was not consistent and the systems could not combine or produce the information needed 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 would be said that in the case of British Airways there was an opportunistic AI adoption that was based on data centric integration. As a result the authors support that opportunistic AI adoption may follow either process centric or data centric integration, depending on the point problem being solved.

3. Case Study

The name of the organisation been studied can not be published due to confidentiality reasons and as a result, the authors of this paper adopt the name TABCO Incorporation. TABCO Incorporation is a multinational petroleum company with more than 100,000 employees operating in more than 135 countries worldwide. The company is organised into 5 core business divisions including:

- oil,
- gas and power,
- chemicals,
- renewables and
- exploration and production.

A Chief Executive Officer (CEO) heads each core business with broad overall responsibilities. The CEOs report to a committee of managing directors made up of executive directors serving on the boards of the parent company.

During recent years, TABCO Incorporation has merged and acquired subsidiaries, operating independently but complying with the same set of business principles. The service companies provide a range of specialist advice and resources, and principles to ensure that all companies perform to the same high level in the economic, environmental and social domains. Each subsidiary has its own Information Technology (IT) infrastructure, and as a result causes a lot of technical and organisational problems to existing systems, which in many cases are complex, heterogeneous and incompatible. The TABCO Incorporation faces a number of problems including:

- **Operational problems:** The organisation is consisted of up to 1500 custom applications and more than 90 ERP systems. Getting data from custom systems is difficult, as the majority of these systems have incompatible and heterogeneous data structures and formats. In addition, there is a lot of compatibility problems when retrieving data from ERP systems. Although, the majority of ERP systems were purchased from 2 ERP vendors, TABCO Incorporation has difficulties in retrieving and processing data, as these systems are running on various platforms that have different software versions. For example, the organisation has problems in retrieving data from an SAP module running on a mainframe X.400 and processing them in another SAP system running on a different platform or having a different software version. In addition to this, there are restrictions of both custom and ERP systems as they are not capable to manipulate all types of data.

- **Delays:** The diversity of Information Systems causes delays in giving information as applications are not integrated, and a lot of work has to be done manually. For instance, data from one system has to be printed out and then re-entered in a different format to a target system. The reason for this is that the target system has its own data structure and/or it is based on different operating systems.

- **The amount of subsidiaries and/or the diversity of systems involved in serving clients have resulted in no single face to customers. For example, various types of customers’ data are required to support systems with the same functionality. As a result, customers should provide each subsidiary with different data types to fulfil similar processes. Only a few systems require the same data to perform the same functions around the organisation. In addition, the delays in giving information and the absence of a single face to customers have also resulted in low customer satisfaction. TABCO Incorporation has realised that the non-integrated nature of systems cost the organisation money and time, as the organisation has to spend a lot of money to support and maintain all these systems. Moreover, the inability of TABCO Incorporation to efficiently serve customers has an extra cost as it leads to lose of sales and thus, customers turn to competitors.
3.1 Application Integration Adoption

The problems reported in the previous section, and the cost of maintaining and running the existing systems have led the organisation to seek more efficient solutions for their IT infrastructure. Internal consultants after reviewing a number of existing and new technologies (e.g. AI) and studying similar cases, they were persuaded that application integration could provide a significant solution to their problems. In doing so, providing a more efficient, flexible and maintainable IT infrastructure.

Internal consultants initiated the development of a global integrated IT infrastructure, which was proposed to integrate and automate all business processes in TABCO Incorporation. The idea was based on a strategic adoption of AI, as it would provide solutions to existing problems and help the organisation developing a flexible and manageable IT infrastructure. Internal consultants discussed this approach with IT director who took the responsibility to introduce it to the managing board. Although, the idea for integrating the organisation was interesting, the managing board rejected it for the following reasons:

- Previous integration attempts were not successful and there was a preconception regarding integrated solutions. The organisation has invested nearly 1 billion UK pounds in less than 10 years to adopt ERP systems that support the integration and automation of business processes. However, nearly once per year, the IT department proposed a new idea for automating businesses processes and thus, regularly sought funding. Although, the managing board supported the proposed ideas none of them have provided a reliable solution to problems.

- Board members believed that existing systems were too complicate to be integrated. The reason for this was that such systems were (a) based on different operating systems, (b) had heterogeneous and incompatible nature, (c) did not support common standards and (d) were not developed to collaborate or incorporate with other applications.

- The proposed solution was estimated to cost up to 150 million UK pounds which was exaggeratedly high and therefore the managing board could not risk this huge amount of money.

After failing to introduce an integrated infrastructure, both IT department and internal consultants revised their initial plans. Their belief was that a strategic adoption would provide a significant solution to TABCO Incorporation problems. However, they preferred to follow an opportunistic approach to propose 4 independent AI pilot projects. Through these pilot projects the IT department could evaluate application integration, demonstrate AI benefits and test whether AI should be adopted by the organisation. Moreover, the IT department attempted to solve existing technical problems (e.g ERP systems redundancy) through the proposed pilot projects. In contrast to the initial proposal for the development of a global AI infrastructure, the cost for the implementation of the proposed pilot project was much less. In addition, the proposal for the pilot projects would reduce risks, as these projects would be pilots, and not a permanent solution but an evaluation tool. Consequently, the managing board accepted the new proposal and supported the implementation of the 4 application integration pilot projects.

3.2 Evaluation of Application Integration Software

Before proceeding to the implementation of the pilot projects, the IT department should selected an appropriate AI software for the development of these projects. Marketplace confusion around AI products caused many problems to the selection of AI software, as there is a plethora of AI products promising integration with no single product addressing all integration types (e.g. data, component, custom, e-business applications etc) (Themistocleous and Irani, 2001b). In addition, although AI vendors promote their software packages as ‘plug and play’ solutions there is no AI product offering an ‘out of the box’ automated integration (Zahavi, 1999). All AI products require implementation and customisation as each of them have their own advantages and drawbacks. In addition, many middleware vendors promote their software tools as AI solutions, which also causes confusion in the AI marketplace. For all these reasons, the IT department, took a decision to evaluate AI packages in-house in order to select the most appropriate. Thus, a group of internal consultants studied and analysed the characteristics of AI products and set up a list of up to 100 evaluation criteria. Then, a group of experts evaluated application integration solutions according to these criteria.

The list below is a subset of the criteria that were used for the evaluation and selection of AI software. Among others the evaluation criteria included:

- **Total cost of ownership.** This cost includes the cost of purchasing an AI package, the annual licenses cost, development costs and maintenance.
- **Up front cost.** The start up cost should not be high which is translated in minimum changes and extensions of existing infrastructure (hardware cost).
- **Global presence.** The vendor should have global presence or should have representatives around the world.
- **Flexibility.** The adopted AI packaged should be able to respond to changes in the system’s environment.
- **Maintainability.** The overall solution provided by the adoption of the package should allow changes without causing problems to other applications or systems.
### Global scalability
The package should provide scalability in integrating organisation’s systems around the globe. This means that the adopted packaged should provide high performance as greater demands are placed upon it, through the addition of extra computing power.

### Product maturity
The AI software should be mature enough and should eliminate risks.

### Integration capabilities
The adopted AI software should be appropriate for the integration of custom, packaged and e-business applications.

The last criterion presented above (integration capabilities) was important for the justification of the AI software selection, as TABCO Incorporation could not accept an AI solution that presents difficulties in integrating the organisation’s existing systems (ERP, custom, e-business). Before selecting the AI software, the IT department took the decision for adopting SAP modules as the ERP system of the pilot projects. This decision was taken as the IT department tried to overcome the redundancy of ERP system functionality that TABCO Incorporation faced due to mergers and acquisitions. The reason for phasing out other ERP packages (e.g. JDE) and selecting SAP was justified, since the majority of ERP implementations in TABCO Incorporation was based on SAP modules. Furthermore, the organisation was satisfied by the functionality of SAP modules and prefers it to the other packages. However, the decision made by the IT department for SAP modules predetermine the decision for the adoption of AI solution. SAP has a close collaborator with an AI vendor called CrossWorld whose software solutions achieve integration among SAP modules, e-business applications and legacy systems (Gilbert and Sweat, 1999). In addition, CrossWorld’s software complied with the majority of evaluation criteria set by TABCO Incorporation and it can collaborate with other software solutions to achieve process integration. Based on these, the expert group made the decision that CrossWorld’s integration software could be adopted for development. Also, TABCO Incorporation adopted IBM’s Message Queuing Series Integrator (MQSI) as message broking software. Both software solutions can collaborate and provide a reliable platform for integrating TABCO Incorporation’s applications.

#### 3.3 Pilot System - Integration of e-business, Custom and ERP Applications

The 4 pilot projects were designed as part of the initial plan that proposed a strategic adoption of AI for the development of a global integrated IT infrastructure. As mentioned above, the existing infrastructure of TABCO Incorporation includes a variety of systems such as ERP, custom applications (e.g. legacy systems, databases, datawarehouses) and e-business solutions (e.g. e-Procurement). As a result, the pilot projects attempted to integrate these types of systems based on 4 different projects. In this section, the first AI pilot project is presented and then analysed.

The first pilot project started in January 2000 and finished 9 months later (September 2000). The aim of this project was to prove that application integration can be used to piece together various types of applications such as legacy systems, e-business solutions, databases and ERP applications. Initially, pilot system analysis and design took place with the IT department spending much more time than in traditional systems design. More specifically, the IT department spent 60% of total pilot implementation time on system’s design with 40% on system’s development. The reason for this was that application integration required business processes reengineering, which takes a longer time as a number of systems has to be changed or phased out to support an integrated process. The more systems collaborate to automate a process the more difficult is to redesign the process.

The development of the pilot system was divided in 3 implementation phases. Initially, a number of web applications (e.g. e-supply chain management) were integrated with SAP modules using a Hub and Spoke integration mechanism. In a hub and spoke mechanism, a number of applications are connected to a central hub (message broker) that contains the rules for connecting application together (Duke et al., 1999; Zahavi, 1999). A Message Broker was used and based on the hub and spoke mechanism to move messages from one application to the other by changing or translating the format of messages to support the needs of the target application. The message exchange is based on an asynchronous Hub and Spoke communication model, which enables applications to operate independently without forcing source applications to wait to receive the results of their requests. Message brokers integrate multiple business process and applications through supporting data and messages transformation, message filtering and routing. In addition, they provide rule processing capabilities, hosting business functions, message translation engines and bridges to many different platforms and applications (by using pre-built AI adapters or existing APIs) (Linthicum, 1999).

During the first phase, data from ebusiness applications were formatted based on HTML and XML standards and send to a web server. The web server sends the messages to the hub (message broker), which reformats the data based on SAP’s data or objects structure. Then the data are sent to SAP modules and processed by the system. The results are then passed through an Application Programming Interface (API) to the hub and spoke message broker and then to web applications. Figure 2 illustrates the phase 1.
As illustrated in figure 3, a legacy application was incorporated with the other systems (ebusiness applications – SAP) through the central hub during phase 2. In many legacy systems, the user interface is the only available mechanism to access data, logic and processes (Andrew, 1998; Van Den Heuvel et al., 1999). A category of tools called Wrappers were used to reuse useful business rules and data from existing applications and (or) to ensure integrity between new and existing systems (Robertson, 1997; Serain, 1999).

Screen Wrappers (or Scrappers) are a type of wrappers that are used to encapsulate (extract) data from user interfaces and transform them into raw data (screens as data) or objects (screens as objects) (Noffsinger et al., 1998). In doing so, they use mapping techniques to map the user’s interface information to raw data or objects. In the case of TABCO Incorporation, legacy data are mapped and transformed into data or objects, sent to the central hub and then forward to either ebusines applications or SAP.

The last phase of the first pilot project focused on the integration of a database with the rest integrated systems (ebusiness, SAP and legacy). In this phase, interface drivers (e.g. ODBC) were used to simplify database access. When an application needs data from the database, it sends a request to a central hub. The hub retrieves data using interface drivers and then reformats data into target’s application format and transmits them to target application. Likewise, an application may update one or more database tables with new data records. Figure 4 depicts the implementation of phase 3.

The implementation of the first AI pilot project provided advanced capabilities to the IT department and increased the functionality and efficiency of the information systems. A number of business processes were redesigned, automated and integrated by pilot system. The IT department used this pilot system to run various business cases and demonstrate systems...
functionality and benefits. Among other, the integrated pilot system is able to run the following case:

A customer accesses a web application through Internet to place an order. Before confirming the order, the web application should check both stock availability and customer record. Thus, the web application contacts the hub and makes a request for the information needed. The hub retrieves the data from both the database that handles customers’ records and the legacy system that deals with stock availability. Then it sends these data to the web application. If there is no problem with the order, the web application updates the customer record in the database as well as the stock availability at legacy system following the same procedure. In addition, it sends all financial details to SAP’s financial module and order details to SAP orders module. When the order is packaged and is ready for delivery, the appropriate SAP module contacts the hub to transmit this information to the web application. The latter triggers the delivery process by sending customer details to web based application (delivery).

The integrated infrastructure resulted from the implementation of AI pilot project 1 increases organisation’s performance and systems efficiency and functionality as it automates business processes and integrates applications. The integration provides more understanding and control of business processes, as activities have been improved through reengineering. The integrated infrastructure reduces the redundancy of systems, components and data and eliminates manual integration tasks that results in reduced employees, tasks, and systems that are needed for process fulfilment. The pilot system provides more reliable data and it is more flexible as integration was achieved with minimum changes to systems code. As a result the systems are more manageable and maintainable. The advantages of the pilot system 1 were so significant that led the managing board to take the decision for a strategic adoption of application integration before the end of AI pilot projects 3 and 4.

### 3.4 The Global Application Integration Solution

After evaluating the results of pilot projects the IT department made minor adjustments to its initial proposal for strategic adoption of application integration.
As illustrated in figure 5 the global AI solution is geographically divided in 3 big integrated subsystems including Europe, America and Pacific-Asia. Each of these regional subsystems integrates the applications and processes from all subsidiaries that are based in its region. For instance, all European companies of TABCO Incorporation should integrate their applications using the European Hub and Spoke infrastructure. All ERP systems from all subsidiaries will be phased out and transfer their functionality to the regional ERP solution. Thus, only 3 SAP systems will be customised automated and integrated based on the functionality and the processes of the existing 90 systems that are currently used.

Based on the model of pilot project 1, each regional subsystem will integrate custom applications (legacy, databases, data warehouses etc) and ebusiness solutions with SAP modules. Regional subsystems may have a number of hubs in order to integrate properly all applications. It is estimated that 90% of custom systems will also be phased out with nearly 150 legacy systems remaining operable around the globe. The global AI system requires a lot of business process reengineering. Based on pilot projects experience, TABCO Incorporation estimates that the 60% of overall time will be needed for system design. It is also estimated that 300 employees will work on the global AI project and they will absorb a big portion of the total budget which is estimate up to 150 million UK pounds. The project started in May 2001 and it is estimated to finish after 3 years.

4. Conclusions

For many decades organisations attempted to overcome their organisational and technical problems by developing information systems that focus on point problems. These applications were not developed in a co-ordinated way but were evolved as autonomous and heterogeneous systems. In addressing this, a new generation of software called Application Integration is allowing organisations to overcome their incorporation problems through integrating functionality from disparate applications. As a result, AI provides integration solutions for custom, packaged and ebusiness systems.

Existing practices for the adoption of application integration focuses on Strategic and Opportunistic adoption. A strategic AI adoption attempts to developed an integrated IT infrastructure by reengineering business processes and piecing together all information systems and processes. In a strategic adoption business processes are improved and automated where a lot of information systems are phased out as a result of the integration. An opportunistic adoption is based on solving point problems and results in partial integration solutions.

In this paper, the authors present the case of multinational petroleum organisation that follows a strategic adoption of application integration. Initially, the managing board rejected the proposal for AI adoption, as it was too risky and cost too much (150 million UK pounds). However, the IT department revised its plans for AI adoption and proposes 4 pilot projects which were accepted for funding from managing board. Although, these 4 pilot projects based on the initial plan, they were following an opportunistic approach as they focused on solving point problems.

Through, the pilot projects the IT department attempted to solve existing technical problems (e.g. ERP redundancy) and to demonstrate the benefits of AI. In doing so, the IT department gave much attention to the selection of AI software and designing pilot systems. Based on the case study presented it is claimed by the authors that system design takes much more time when integrating systems rather than developing a new one. The reason for this is that business processes be integrated and through AI have to be redesigned. Case study data presented in this paper shows that system design takes up to 60% of overall project time when integrating systems. Another important conclusion derived from this case study is that the majority of existing systems are phased out when the integrated system is introduced. For instance, TABCO Incorporation automates and integrates its business processes and systems by piecing together only 3 ERP and 150 legacy systems instead of 90 and 1500 respectively.

The integrated system increases organisation’s performance as it automates the business processes and incorporate functionality from custom, ERP and ebusiness applications. The integrated system reduces operational cost as the majority of systems were phased out, manual tasks eliminated and maintenance cost less. The system provides more flexibility as integration was achieved with minimum changes to systems code. Therefore, the systems are more manageable and maintainable. The benefits of integrated pilot projects were so significant that led the managing board to support the adoption of a global integrated system before the 4 pilots finish. This shows that the strategy of IT department to employ pilot projects in order to solve existing problems and demonstrate the benefits of AI can be used as an alternative way to persuade the managing board.

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