



## **Analysis of Integration Technology Adoption: a Case for Enterprise Application Integration for Healthcare Organisations**

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### **Abstract**

A continuous technological innovation in software has brought development in integration technologies that promise the real time enterprise-wide systems integration. Healthcare organisations continue to struggle with integration challenges. However, much confusion regarding the adoption of integration technologies still remains. To provide a clear perspective about integration technologies, a discussion is presented on these technologies such as Electronic Data Interchange (EDI), Enterprise Application Integration (EAI) and Web Services. EAI has emerged to provide significant benefits to organisations. From a technical perspective, EAI addresses integration problems at all integration levels (e.g. data level and process level) by providing a flexible and manageable IT infrastructure. From a business perspective EAI reduces the overall integration cost due to the reduction in integration time and maintenance cost. This paper attempts to present the advantages and disadvantages of these technologies. Furthermore, a comparative analysis of these technologies is presented. Thus, it can facilitate to healthcare organisations decision-makers during the adoption of integration technologies.

**Keywords:** Healthcare, Integration Technology, EAI

### **1. Introduction**

The computerisation of healthcare records has been around since the early 1960s, when hospitals first started using computers. Since then, incremental developments have taken place within healthcare industry, with IT playing an increasingly significant role in the delivery of computerised patients records, adoption of Internet along with other networks (e.g. intranets and extranet), integration approaches asynchronous transfer mode (ATM) networks and telemedicine [1]. The extensive use of IT in healthcare organisations has resulted in the development of various information systems (IS). These have been deployed at different levels, ranging from computerised patients' record to department-specific decision support systems [2].

According to Xu *et al.*, [3] information systems that manage the healthcare organisations data

and process have been developed with different technologies. This has resulted in healthcare organisations being left with the islands of technologies that are difficult to integrate. As a result, the need for integrating these systems has increased enormously [4]. Thus, several integration standards, systems, projects such as Health Level 7, CEN/TC251, Synergy Extranet (SynEx), and Synapses have been deployed in healthcare organisations to address integration problems. Implementation of these integration approaches has provided significant benefits to healthcare organisations [5]. However, there are still many problems relating to their adoption. Among other problems, the cost of healthcare integration standards is high and the level of interoperability remains very low according to Carr and Moore [6]. The integration of the heterogeneous IS in healthcare is needed to support various issues such as:

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- ❖ Clinical and administrative tasks
- ❖ Reduced Medical Errors
- ❖ Reduced Cost
- ❖ Patients' data security
- ❖ Healthcare process integration and
- ❖ Utilisation of valuable legacy systems

Many other organisations have adopted integration technologies such as EDI, EAI and web services. To make the proper decisions towards the adoption of the technology, that can be a well match to their systems. However, the decision is not simple since each of the integration technologies includes different IT strategies and characteristics. Enterprise application integration has emerged to overcome integration problems at all levels in a more flexible and manageable way [7]. It provides the infrastructure to rapidly connect and interface information between intra-organisational and inter-organisational applications [8]. EAI can support healthcare

organisations to improve clinical and businesses processes. In this paper, the authors, have attempted to present description of integration technologies along with their advantages and disadvantages. After that a comparative analysis for the integration requirements is presented. The factors for the adoption of EAI in healthcare organisations are then discussed. Thereafter the integration of healthcare information systems with EAI is described with respect to the way they can be integrated at both an internal hospital level and externally with other hospitals, primary health care providers and with other stakeholders.

## 2. Description of Integration Technologies

In an attempt to provide a clear perspective about integration technologies, this section discusses integration technologies such as EDI, EAI and web services with their advantages and disadvantages presented in (Table -1).

Technology	Advantages	Disadvantages
<b>Electronic Data Interchange</b>	Increase closeness in supplier customer relationships [17] Quick response to trading partners [18] Reduced clerical error [19] Allows improvement in business performance and efficiency [20] Elimination of labor-intensive tasks [21]	Requires high initial capital investments[17] Requires compatible hardware at both ends [17] Increases the risk in the process of conducting commercial transactions [20]. Implementation is not simple [20] Difficulty of quantifying the return on Investment [22]
<b>Enterprise Application Integration</b>	Improve customer relationships [11] Achieve better return on investment [11] Increases the overall performance of the supply chain [23] Achieves businesses process integration [24] Reduced integration cost [24]	High level of investment [12] No single EAI product solve all integration problems [25] Complexity concerns [12] Requires EAI skill [25] Integration technologies are confusing [26]
<b>Web Services</b>	Reduce development and deployment time [27] Low implementation cost [28] Reduce the maintenance complexity [28] Require less programming skills [28] Less risk of project failure [29]	Requires high customisation [30] Lack of transaction support [28] Performance is not mature [30] Lack of user interface [15] Security is a problems [12]

### **2.1 Electronic Data Interchange**

In the past many organisations have used EDI approach to exchange their business documents in an integrated way [9]. This refers to the computer-to-computer exchange of business documents electronically, between or within firms in a structured machine-retrievable data format that permits data to be transferred without re-keying from a business application in one location to an application in another location. Although, EDI achieves data integration but it is a complex and invasive technology that does not achieve process integration and does not provide the required flexibility and maintainability [10].

### **2.2 Enterprise Application Integration**

EAI systems have emerged to overcome the limitation of enterprise resource planning (ERP) systems through providing an integrated organisational infrastructure. It has been introduced as a solution to intra and inter-organisational systems and process integration. For various reasons it results in more organised business process, achieves return on investment, increases collaboration among partners, achieves data, object and process integration and reduces the cost [11]. EAI aims at integrating individual applications into a seamless whole, enabling business process, and data to speak to one another across applications [12]. EAI can efficiently incorporate custom applications, packaged systems and e-business solutions into a flexible and manageable infrastructure[13].

### **2.3 Web Services**

Web services approach is relatively new integration technology. It is a distributed computing paradigm and allows applications written in diverse languages, and running on multiple platforms to interoperate and integrate more easily and less expensively than other traditional methods [14]. The Web service protocols are built on top of application-level

network protocols like hypertext transfer protocol, simple mail transfer protocol, and file transfer protocol. There are various problems that have been reported regarding web services adoption such as: Inexperience in architecting web services, changing internal organizational culture to embrace web services, multiple standards for implementation, immature technology and security concerns [15].

## **3. Comparison of the Integration Technologies**

Given the focus of this paper i.e. the adoption of EAI technology, it is imperative to compare EAI with other integration technologies such as, EDI and web services. Themistocleous [16] presented several integration requirement factors, such as maturity, flexibility, scalability, portability, reusability, maturity, complicity, non-invasive, performance and real time. These factors are based on the characteristics of EAI technology, and provide the support to the organisation, when organisations are deciding to adopt the integration technologies. Description of these characteristics is illustrated in Table 2. In addition to these, from the literature in the area of integration technologies the authors have identified several other characteristics that can also provide support to draw the comparison between integration technologies, such as transaction, security and levels of integration. Description of these characteristics is illustrated in Table 2 as well. In addition to that, international standards organisations ISO-9126 standard, documents highlights software qualities including functionality, reliability, usability, efficiency, maintainability and portability. These qualities are proposed to measure the high-level software qualities. Thus, this applies to integration technologies software solutions as well. Thus, the authors have illustrated the comparative analysis of these technologies in (Table-2).

Characteristics	Description	Technologies		
		EAI	EDI	WS
Maintainability	Britton and Doake [31] suggest that maintainability is an important characteristic of software technologies. It refers to the capability of software applications to allow changes without causing problems to other components or systems. In integration area, technologies should lead to the development of solutions that could be easily maintained.	✓		✓
Flexibility	There are three types of flexibility: flexibility in functionality, flexibility in modification, and flexibility in use [32]. The first two types of flexibility describe the capability of rapid adjustments with minimal effort and the capability to operate well in many different environments. In the context of integration technologies, flexibility supports both flexibility in functionality and modification.	✓		
Scalability	Scalability describes the ability of an information system to provide high performance as greater demands are placed upon it, through the addition of extra computing power [24].	✓	✓	✓
Portability	Portability allows a software solution developed for one platform to run on an entirely different platform. Portability is closely related to the concept standards and plays a significant role in the cost effectiveness of information systems	✓		✓
Reusability	Reusability refers to the capability of using existing components or software solutions to build new applications. Reusability, has an important role in application integration as it reduces the implementation time and cost. It results in more flexible, manageable and maintainable systems [33].	✓	✓	✓
Maturity	Maturity shows whether an integration technology is mature or not. The more mature an integration technology, the better it is. The reason for this is that analysts and developers trust more mature technologies than immature one.	✓	✓	
Complexity	Complexity describes whether an integration technology leads to complex or simple solutions. Often, complex integration solutions are not preferred as they increase development and maintenance costs.	✓		✓
Non-Invasive	Many organizations seek for non-invasive integration technologies and solutions. The reason for this is that invasive technologies (like RPC) extend the code of interconnected applications by adding new modules that support integration efforts. As a result, the less changes required the better value achieved for integration as cost, effort and complexities are eliminated and flexibility and maintainability are increased [34].	✓		✓
Performance	In some cases integration technologies achieve integration but the performance of the overall solution could be low. As a result, this requirement seeks to describe whether the performance of an integration solution is low or not.	✓		
Real Time	Real time requirement refers to the capability of integration technologies to support transactions that require up to the second data latency [24]. Data latency defines how current the information needs to be. As mentioned in previous paragraphs real time integration is important for e-business applications.	✓		✓
Security	Adoption of integration technologies have provided tremendous benefits to the organizations, and have also created significant and unprecedented risks to the organizations, such as security. Organizations heavily depend on IT security measures to avoid data tampering, fraud, inappropriate access, disclosure of sensitive information, and disruptions in critical operations.	✓	✓	
Transaction	Transaction refers to concurrent access of data shared amongst multiple components, to perform operations on that data. Such distributed access of a single resource of data, and access to distributed resources from a single application component be treated as one unit of work. Further more it implies to commercial activates e.g. ordering, invoicing, etc. in contract to pure information and knowledge sharing [35].	✓	✓	
Levels of Integration	Integration refers to the sharing of information between dissimilar computing systems and applications. Linthicum [24] suggest that integration can be achieved at different levels (e.g. data level, object level, and process level).	✓		

Table 2: Comparison of Integration Technologies

#### **4. Motivations for the Adoption of Enterprise Application Integration**

The advantages and disadvantages presented in Table 1 and the comparison of the integration technologies analyzed in Table 2 provides the support and clear concept regarding the adoption of EAI in healthcare organisation. Thus, to better understand the factors that motivate the healthcare organisations to adopt EAI, this section summarises these factors, which are influencing the adoption of EAI in healthcare organisations, like technical, cost, medical errors, decision support system, and security and confidentiality of patients' data. A description of these factors is presented below:

**Technical:** The various integration approaches adopted in healthcare organisations mainly focused on the technological aspects, solving the connection problems between applications and devices to exchange information. ERP systems have been used to solve integration problem but have many drawbacks. In addition, the integration approaches are based on message-based technologies such as Message-Oriented Middleware (MOM) and XML. Since messages can only solve the basic communication problem between the systems. Thus, communication mechanism can not achieve integration of the systems and can not provide interoperability, without meeting the requirements of healthcare organization as a whole

**Cost:** To introduce new technology, one of the major concerns of senior management is the cost associated with the change. In this context, healthcare organisation have a lack of money for IT infrastructure. According to Anonymous [36] most hospitals have budgets between £3 to £15 millions for IT implementation. Therefore, the healthcare organisations are looking for cheap integration solutions, so that they can provide better healthcare services to the citizens. The integration efforts made so far, are based on customised interfaces [37]. Development and maintenance of customised interfaces to integrate diverse systems is very costly and time consuming. Each interface requires more time and high cost for the development and

maintenance [38]. Therefore, there is a need for technology that reduces integration costs. However, Puschmann and Alt [38] states that a significant benefit of application integration is the reduction of overall integration cost.

**Medical Errors:** Patients' safety and medical errors are becoming one of the highest priorities in healthcare systems across the world. According to the Institute of Medicine (IOM) US report that, as many as 98,000 people die every year in US as a result of medical errors, which is more than the combined number of deaths from breast cancer, AIDS and motor vehicles [39], whereas in the UK according to a report by National Patients' Safety Agency (NPSA) it is estimated that 850,000 incidents and medical errors occurring every year. Likewise 64 persons die every day in UK hospitals due to medical errors. Most of the errors occur due to the limitations of information systems in healthcare organisations [40]. For instance, patients' are given inappropriate medications or doctors can not make accurate diagnosis, as important information can not be received, due to the non-integrated IT infrastructure.

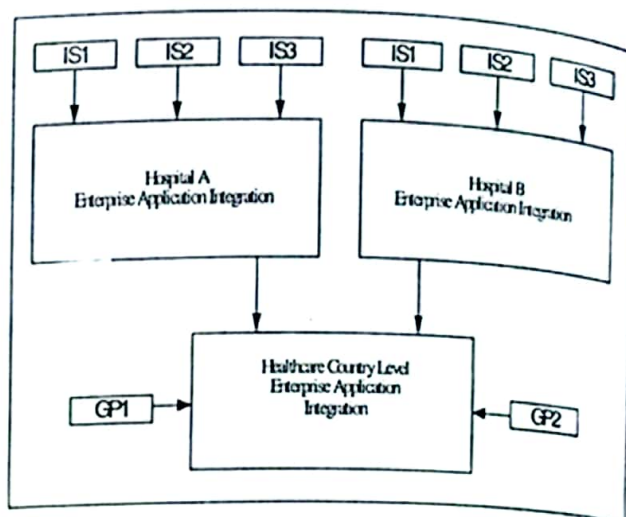
**Clinical Decision Support:** In most of the organisations, decision support systems are used at the management level. In healthcare organisations decisions support systems are referred to as clinical decision support systems. Healthcare organisation needs to improve decision-making process for the patients' treatment in real time. This can be achieved through an integrated IT infrastructure. However, a number of clinical applications such as artificial intelligence, neural networks, and fuzzy logic techniques are being developed to provide support to physicians for clinical decision making [41]. As a result, hospitals must build hospital-wide infrastructure to obtain data from different sources and then convert into useful information and apply them for the decision making process [42]. In addition, decision support requires higher levels of integration for the exchange and sharing of patients' data between various decision support applications, to generate warnings, provide

diagnostics suggestions and offer treatment advice [43].

**Security and Confidentiality of Patients' Data:** Huston [44] states that security and confidentiality of patients' data has always been important. In an open and distributed processing environment, access control and authentication mechanism have very important role in healthcare organisations [45]. As patients' data may contain some of the most sensitive information such as the emotional problems, psychiatric care, sexual behaviours, sexually transmitted diseases, HIV status, physical abuses and so on. Access to such information must be controlled because disclosure to irrelevant users can harm the patients'. Patients and citizens must be assured that their information is held securely and shared based on appropriate legal, ethical and technical processes. There is therefore a need for a technology that provides security approaches to the healthcare organisation.

### 5. EAI based Integration Approach for Healthcare Organisations

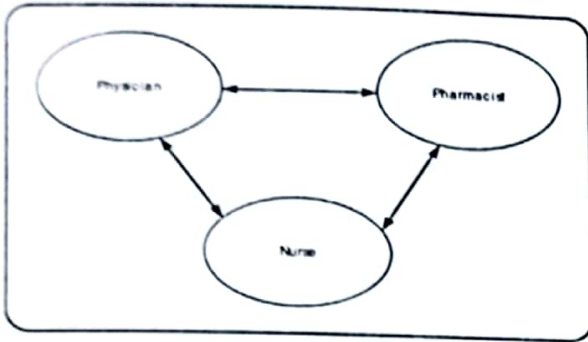
Enterprise application integration aims at integrating individual applications into a seamless whole, enabling business process, and data to speak to one another across applications [46]. EAI specifically addresses integration problems from a technical perspective, and provides a more flexible and maintainable IS infrastructure [47]. In addition to that Stal [12] states that EAI provides a flexible infrastructure to integrate heterogeneous platforms. All these literature evidences support that EAI can be used to create an integrated infrastructure in healthcare organisations. Raghupathi and Josph [41] report two key dimensions of systems integration in healthcare organisations (a) internal integration of the systems and (b) external integration of the systems. Irani *et al.*, [13] suggest that EAI provides solutions to intra and inter-organisational systems integration.



**Figure 1: Integrating Healthcare Information Systems through EAI Technology**

Thus, in Figure 1 the authors have illustrate the integration of disparate and autonomous information systems that exist in healthcare organisations at (a) internal (hospital) level (b) at external country level with other hospitals, GPs and other stakeholders using EAI technology.

Internal systems integration represents the integration of internal systems of the hospitals by using EAI to improve clinical and businesses process that cross multiple departments and organisational boundaries and involve multiple healthcare professionals. Let us consider the complex network of tasks and applications involved in the inpatient medication management. The internal closed loop medication management process flow depicted in Figure 2 involves a triangle of professionals, physicians entering the medication order, pharmacists reviewing and verifying the order and nurses administrating the medications. All of them use different clinical applications that display the information in a format that is relevant to their specific purposes. In most of the cases the supporting applications are not integrated. The end result is a complex process that causes medical errors and results in the deaths of patients. Clearly an EAI that supports businesses process management can provide process and information integration [13].



**Figure: 2 Internal Medication Management Process**

In addition to that internal hospitals integrated infrastructure provides the facility to share data among different applications connected with each other. Functioning of these applications eliminate the duplication of data entry at different department levels. Additionally, other complicated and data intensive healthcare process that can also benefit from the internal integration of healthcare information systems with EAI. Furthermore, physicians will be able to focus on healthcare delivery. By having the most relevant information including up-to-date medical evidence at the point of care, that will enrich care delivery. Physicians and patients will have more time together free of distractions such as searching for traditional paper records. The reporting that every physician has to do will be accurate and timely, but also simple and automated. External systems integration represents countrywide integration with other hospitals systems, GPs, government's bodies and other stakeholders. This type of integration can provide significant benefits to hospitals and the patients'.

External integration infrastructure can save the patients life, If hospitals are interconnected with each other and the record of all the patients' can be viewed form anywhere in real time, in such situations or the life of the patients' can be saved by appropriate and timely treatment. Additionally, healthcare processes that can benefit from EAI integration include claims clearinghouses, revenue cycle and other areas such as Supply Chain Management (SCM), Customer Relationship Management

(CRM) and real time monitoring of clinical and businesses process.

## 6. Conclusions

The adoption of healthcare information systems at various levels in healthcare organisations are developed in different computer languages, compiled on different platforms, executed on different hardware, and have different data structures, types and formats. These information systems were not developed in a coordinated way but evolved as autonomus and hetrogenous systems. Thus, in most of the cases these information systems function independently and do not share their data and process. As a result, this raises the need for integration. Therefore, several integration approches are adopted in healthcare organisations to overcome the integration problem. Integration of existing systems represents one of the most urgent priorities of health care information systems that allow the whole organisation to meet the increasing clinical, organisational and managerial needs.

In the description of integration technologies the authors have provided the detailed discussion on these technologies. In doing so, the advantages and disadvantages of the integration technologies have been presented. After that the comparative analysis of these technologies is presented. This analysis has been based on various integration factors such as maturity, flexibility, scalability, portability, reusability, maturity, complicity, non-invasive, performance security, integration level, transaction and real time. This analysis provides a clear vision that EAI is the technology, which can provide the support for all these factors. As a result, the authors have identified the factors such as technical, cost, medical errors, decision support system, and security and confidentiality of patients' data that motivate the adoption of EAI in healthcare organisations. EAI can support to integrate different information systems at the internal hospital level and at external country level with other hospital and GPs. The internal hospitals integrated infrastructure provides the

facility to share data among different applications connected with each other. Functioning of these applications will help in reducing the medical errors and save the human lives. Further, healthcare organisations can benefit from using EAI to improve processes that cross multiple departments and organisations boundaries and involve multiple healthcare stakeholders

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