Abstract: - Enterprise system integration refers not only to the tasks of integrating data and applications, but to hardware and software products that provide integration frameworks and associated tools as well. Integration has become popular because most traditional enterprise applications and systems were custom-built to address a specific business need. Integration solutions unlock existing assets and share them across multiple applications and business processes, providing the framework for real-time enterprises networks. There are several benefits of using system integration solutions such as immediate cost savings and data integrity enhancement, but integration can also have forward-looking benefits such as an instant, real-time view of all company’s data and operations, which can lead to better and more informed decision-making. There are four basic categories of integration projects or initiatives: Data Coordination, Business Process Orchestration, Business Activity Monitoring, and Composite Application Development. Each of them should be supported by the appropriate integration platform characterized by seven favorable capabilities: Connection, Abstraction, Coordination, Storage, Orchestration, Development, and Management.

Key-Words: - Enterprise system integration, data coordination, business process orchestration, business activity monitoring, composite application development, integration platform, integration appliances, application routers

1 Introduction: What Enterprise System Integration Actually Is?

Integration of enterprise system, applications and data to simplify and automate business processes has become an important focus for many businesses. It refers to both the tasks of integrating data and applications, as well as to software products that provide integration frameworks and associated tools. Integration enables the sharing of data and many or all of business functions across applications [1].

Integration has become popular because most traditional enterprise applications and systems were custom-built to address a specific business need. As enterprises have grown and technology is offering always new and new capabilities, the need to share information across departments and business becomes more critical. Companies are turning to integration to provide a method for interconnecting these distributed and often proprietary systems.

Integration projects come in wide variety of shapes and scopes. Nevertheless, most projects can be classified as belonging to one of following four main categories of integration initiatives:

a) Data coordination/data consistency
b) Business process management/orchestration
c) Business activity monitoring
d) Composite applications development

These four types of integration projects will be a matter of discussion later in the paper.

2 Why Integration Is Needed?

2.1 The Nature of System Integration

To someone not well informed, system integration may seem to be simply one new, fashionable buzzword in business and information technology (IT) environment. But, it is not quite true since there are many good reasons to look at system integration as a real, objective must of contemporary enterprises.

All types of companies today seek to become more agile, responsive and competitive, and to maximize their existing IT investments [2]. In order to do so, they need to unlock information and functionality in individual applications and turn them into shared resource.
Integration solutions unlock existing assets and share them across multiple applications and business processes, providing the framework for real-time enterprises networks. Integration solutions also enable many companies to create a ‘single view’ of all their enterprise data and an infrastructure for insuring that applications can exchange and update business-critical data no matter where it resides.

Another way to look at it is that integration technologies enable an organization’s IT infrastructure and applications to rapidly respond to changes in the business world by providing a dynamic way to streamline, integrate, manage, and govern previously independent business processes [3].

In addition, integration solutions allow businesses to take stand-alone applications and turn them into resources that are available and can be used by other applications or business processes as a part of a composite application, i.e. application that is composed of both new code, processes, or user interfaces along with calls to existing and/or legacy applications and services.

By enabling the creation of composite applications, integration solutions allow companies to rapidly implement new applications while increasing an organization’s return on previous investments by leveraging existing application functionality in new ways.

2.2 The Benefits of System Integration

There are several benefits of using system integration solutions.

One is cost savings, courtesy of streamlined business processes and increased efficiency.

Integration approaches also help contain costs by allowing organizations to continue to use data and functionalities embodied in their existing applications instead of ‘ripping and replacing’ legacy systems [4].

But, integration can also have forward-looking benefits. For example, organizations can gain an instant, real-time view of all their data and operations, which can lead to better and more informed decision-making.

And last but not least, integration products provide the flexibility to quickly adapt business processes to accommodate growth and meet new business challenges as they arise.

2.3 Specific Business Drivers for Today’s System Integration Projects

There are four major reasons why organizations are implementing integration projects [5]:

a) New systems have not replaced legacy systems.

New enterprise applications and systems that have been deployed typically do not replace existing legacy systems and applications, but rather they complement or extend them, often generating a need for integration or connectivity between them.

b) The need to consolidate and globalize.

Mergers and acquisitions have left many organizations with a broad array of mission-critical systems that simply cannot be abandoned or replaced. Instead, integrating them and putting systems in place to exchange information among an organization’s various applications becomes a much more realistic solution. This is particularly true in the case of the Internet usage and implementation of the e-business concept.

c) The search for increased productivity.

Today’s turbulent economic situation has forced many organizations to search for the ways to increase productivity and reduce costs. By using integration platforms to automate existing business processes, transactions and applications, organizations can streamline their business while increasing productivity and reducing costs.

d) Raised expectations from Web experiences.

Regardless of the industry, customers now expect organizations to have a consolidated view of their accounts, transactions, and any other related information – never mind where data actually is. In order to stay competitive, enterprises need to provide better availability of data and applications to both internal users (such as customer service representatives or salespeople) and to external subjects (such as customers or business partners) [6].

2.4 Uses of Systems Integration Solutions

Most traditional enterprise applications were built to address a specific business need. As enterprises have grown, and the need to share information across business units, departments, divisions, and globally throughout the enterprise has become critical, companies are turning to integration solutions to provide a method for interconnecting these distributed and not rare proprietary silos of information systems.

Integration became particularly popular after organizations began deploying packaged enterprise applications. Once companies began deploying these new packaged applications, they soon realized that they need ways to dynamically exchange information between them and between their existing legacy applications [7]. The imperative of data consistency among applications was soon followed by the need to automate and streamline business processes that crossed
between these different systems in order to improve efficiency.

Integration software products evolved to support this new business driver adding support for human interaction and workflow, as well as business activity monitoring and control. It should be noted that processes of monitoring and controlling applications and business processes operates in real-time, rather than loading information into a data warehouse for future analysis.

This evolutionary system integration path allowed organizations to implement entirely new application functionality that builds upon their existing systems, through the development of composite applications and services [8].

3 Basic Types of Integration Projects

It might be better to say that there are four basic categories of integration initiatives: Data Coordination, Business Process Orchestration, Business Activity Monitoring, and Composite Application Development. Many integration projects will include more than one of these categories – a fact that should be considered when choosing an integration platform.

3.1 Data Coordination

Data coordination moves transactional data between applications in order to provide consistency. This core technology set, often referred to as a message broker or integration server, is used as the foundation for every category of integration initiative described above. Data coordination is enabled by technology that connects applications and data stores to a common middleware platform or bus, routes the message-based information between these different systems based on content, rules or subscription and dynamically transforms the data so that it is in the native format of the target system or systems. Data coordination transforms application-specific information into a shared enterprise resource reducing the costs and clerical errors associated with entering and maintaining consistent information across disparate systems.

The result is improved data quality and increased productivity by ensuring consistent data access across all applications.

3.2 Business Process Orchestration

Business process orchestration (also called business process management, or BPM) is the combination of the process reengineering concepts of the 80’s and the workflow technologies of the 90’s.

BPM is focused on modeling and orchestrating the workflow between individual functions in order to automate and streamline previously independent business processes. It can be thought as the ‘integration logic’ of a cross-application workflow [9].

In many cases, BPM is primarily focused on ‘long running’ business processes that may take hours, days, months or longer to complete, as well as business processes that span multiple applications and include interaction with users (often called workflow).

For example, the process of shipping a computer to the customer of a mail-order company or build-to-order manufacturer is a long running business process that starts with the request-to-ship at the computer company’s warehouse and ends when the return period has expired, which might be 15, 30 or even 60 days. The process itself might span both the back-office warehouse application as well as the customer support and order entry applications. Managing long running processes requires that state of the processes be maintained through the entire duration – be that hours, days, weeks, or months.

BPM tools typically include modeling, automation and management components as well. The modeling components allow business analyst to define, view, or manage individual processes without having to understand the underlying technical details of how the process is actually implemented.

Business process management enables organizations to automate and streamline their manual processes and fuse previously autonomous operational, transactional and management systems. The result is a more agile business and efficient business better able to respond to changes in the marketplace.

3.3 Business Activity Monitoring

The goal of business activity monitoring (or BAM) is to provide management with immediate awareness of changing business events across the enterprise, so that appropriate and timely decisions can be made [10]. Real-time, event-driven business activity monitoring solutions provide real-time alerts via graphical dashboards and other notification mechanisms, enabling management to immediately react and intervene when key performance indicators change.

BAM solutions also complement BPM solutions by providing real-time process monitoring capabilities that enable BPM systems to dynamically and immediately react to changes in the business environment.

By using real-time information to remove delays in managing and executing an enterprise’s critical business processes, BAM reduces costs and enables faster execution of business processes.
3.4 Composite Application Development

A composite application is an application or new application functionality that combines the data and functionality of an enterprise’s applications and data stores, adding new business process logic, custom code or application functionality. Composite applications leverage individual functions or business processes within back-end operational systems and use them as components to build new applications or application functionalities.

Composite application development (CAD) uses a service-oriented development approach, whereby existing functions and business processes, available as services, are combined in support of new application functionality.

Composite applications enable organizations to gain greater re-use from existing applications and IT investments [11]. In this way, composite applications facilitate quicker time-to-market for new solutions that rapidly address changing business dynamics and challenges.

3.5 Should All the Categories of Integration always Be Supported?

The answer to this question is quite simple: Yes! Even if the organization does not think it needs all four integration capabilities right now, the chances are it will need them in the future.

New business opportunities breed new integration projects, or what looks like a small project normally expands dramatically in scope once initial business benefits are realized. It is therefore usually better to choose a complete integration platform than to try and assemble and manage all the necessary capabilities piecemeal.

This technology assembly approach may drastically increase the complexity and costs when integration projects evolve and new technologies are required to implement new integration strategies.

4 The Favorable Characteristics of an Integration Platform

There are seven capabilities that a comprehensive integration platform should provide. They are:

- Connection
- Abstraction
- Coordination
- Storage
- Orchestration
- Development
- Management

A brief discussion on these favorable characteristics of the integration platform follows in subsequent subsections of the paper.

4.1 Connection

Connection provides a channel of communication between the integration platform and each of the applications that are being integrated. Most integration platforms achieve connection by using a certain kind of adapters.

Adapters are pre-written pieces of code that work by speaking the native protocols of the target resources and connecting them to the integration platform or message bus. The use of adapters greatly speeds integration and can significantly reduce costs associated with writing code for each connection.

When choosing an integration platform it should be looked at the number and types of adapters it includes. What should be particularly thoroughly considered are the following questions:

- Can the platform connect to all existing applications?
- Is there a mechanism for building custom adapters?
- How easy is it to build and use adapters?

Answers to these questions determine how many and which type of adapters to choose.

4.2 Abstraction

Abstraction is the process of representing the data and functionality of existing applications in some consistent form. This alleviates the need to have to understand and work with the diverse and different protocols, data, and programming models used by each of the applications that are to be integrated.

Some common approaches to abstraction are:

- Using J2EE. This approach can work well for applications and business logic. But the experience gained shows that it is not always as good at dealing with data.
- Using XML and Web services. This approach works well for loosely coupling applications that are already Web service enabled. However, according to some research works, legacy and custom applications may need to be retrofitted with Web service ‘wrappers’.
- Using ‘canonical’ form. Canonical form basically means a standardized representation of the data or functions. Putting something into canonical form would mean that each set of data and application functionality would be translated into a standard format or representation. This approach can be
very flexible and powerful, if the canonical form can be exposed or projected in various standard based object and data formats concurrently, e.g. Java, C++, .NET, Web services, etc.

For this reason, when choosing an integration platform, flexibility of its abstraction needs to be thoroughly considered.

4.3 Coordination
In an integrated system, information is passed between disparate applications in the form of messages. Coordination is the capability to manage the flow of messages in the integrated system. Most integration platforms include message brokers that are responsible for guaranteed delivery, data transformation, and intelligent routing of messages.

When choosing an integration platform, the performance and reliability of the messaging engine is of prime importance, as these will directly affect the scalability and robustness of the integrated system. But, the messaging engine’s capabilities must also be considered that are addressed by the following questions:

- Does the message engine support synchronous, asynchronous, and ‘publish-and-subscribe’ type of routing?
- Does it support content-based routing?
- What data transformation tools are available and how easy are they to use?
- Is the message engine integrated with a message warehouse for persisting all messages?

If the most of these questions allow affirmative answers, the message engine might be considered as one attributed by good coordination capabilities.

4.4 Storage
Integration generates data (metadata, messages, state information of long-running processes, indexes on federated databases, etc.) and every integration platform needs a mechanism for storing, retrieving, manipulating and analyzing data.

Unfortunately, many of integration platforms available at this moment include only rudimentary capabilities for storage. In those cases, in order to gain robust, scalable storage, an external database must be purchased and integrated, thus adding cost and complexity to the integration project.

When choosing an integration platform, the organization should look for one that has built-in shared metadata repository for all the integration touchpoints that will be generated and used by the integration platform [12].

The organization should also look for the solution that has a built-in message warehouse, and pay particular attention to its capabilities for analyzing the message data in support of reporting and activity monitoring.

The most important questions that arise in this context are the following:

- How well does the platform’s storage mechanism support service-oriented development of composite applications?
- Does it support distributed environments?
- Will it impede the overall performance and scalability of the integration platform under heavy load?

4.5 Orchestration
As mentioned earlier in the paper (see Section 3.2), orchestration is just another name for modeling and automating business processes. It can be as detailed as writing the code that tells the messaging engine what to do and when to do it.

However, orchestration normally refers to business process modeling, whereby business analysts define and model graphical process flows without thinking about the underlying coding complexities involved in automating them. The orchestration engine is able to ‘read’ these process models and execute them.

Most integration platforms come with built-in graphical tools for process modeling. A few of them enable standard-based XML-based code to be generated from the process diagrams, thus allowing interoperability with third-party modeling tools.

When choosing an integration platform, the organization has to consider how much flexibility it gives with regard to orchestration. The most important questions looking for answers are:

- Does it provide a powerful graphic modeling tool?
- Does it support interoperability with third-party BPM products?
- Does the integration platform support direct coding of processes, and what scripting language does it use?
- Does it support human workflow interaction?
- Does it have a rules-based engine that provides analysts with a quick and easy ways to define rules that change the process flow?

4.6 Development
In the context of integration, development normally refers to building composite applications and portals, often the ultimate deliverable in an integration project.
Composite applications make use of all of the capabilities of the integration platform described so far, adding new business logic and user-facing front ends to the abstracted services and business processes previously discussed.

When choosing an integration platform, the organization should look for the same capabilities that it wants in any rapid development environment. To find out whether these capabilities are supported by the particular platform, the organization should find answers to following important questions:

- Is the environment easy to use?
- Does the development environment support business process modeling?
- Can all the components of the integration solution be built using the same development environment (e.g., adapters, message maps, transformations, business activity monitoring solutions, etc.)?
- Does the development environment support the development technologies that are already in use?
- Does it work with company’s favorite third-party development tools?

When the answers to these questions are known, it is relatively easy to decide if the platform concerned is the right one to satisfy company’s integration needs.

5 Integration Appliances

5.1 The Background: Network Integration

The only way to truly accelerate application integration projects is by reducing the complexity of the solutions used [13]. Just tweaking existing software-based solutions cannot provide the answer – if it could, it would have happened by now. Instead, a revolutionary approach using disruptive technology is needed to simplify integration and thereby deliver the dramatic cost savings required. A model for this can be found in the simplest category of integration problems, network integration [14].

Although connecting different types of networks together is taken for granted in today’s heterogeneous networking environments, this was not the case in the mid 1980’s. At this time, the enterprise faced its first large-scale integration problem: connecting hosts that communicated using different protocols, such as IPX, AppleTalk, DECNet, and IP, to name only a few. Connecting hosts required each operating system to be modified in order to enable communication, a process that was time-consuming and difficult to maintain until the introduction of the network router. The multi-protocol router communicated using all the networking protocols and was able to seamlessly connect different types of networks.

If a network router could connect different networks in a quick, low-cost, and highly reliable manner, this concept could be expanded to connect applications in the same way. In 2002, the Application Router, a purpose built application integration appliance, was born [15].

5.2 Application Routers

An Application Router is an integrated hardware/software solution. It is a self-contained appliance that contains all the parts required to connect a customer’s internal applications with each other and exchange information with its business partners. It is a solution consisting of three main components:

- Design-time software that allows a customer to graphically build and deploy integrations
- A hardware appliance that provides the run-time environment for integration projects
- A Web-based portal that provides detailed information on all data passing through the Application Router and plus essential information on the health of the router hardware.
The Application Router solves both internal and external integration needs. Application Routers are being used today to solve a variety of application integration problems, as shown in Table 1.

<table>
<thead>
<tr>
<th>Problems Solved</th>
<th>Systems Connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single view of customer</td>
<td>Enterprise Resource</td>
</tr>
<tr>
<td>Real-time analytics</td>
<td>Planning systems</td>
</tr>
<tr>
<td>Real-time inventory synchronization</td>
<td>Customer Relationship</td>
</tr>
<tr>
<td>Creating Service-Oriented</td>
<td>Management systems</td>
</tr>
<tr>
<td>Architecture</td>
<td>All types of databases</td>
</tr>
<tr>
<td>Connecting remote</td>
<td>Flat-files using FTP,</td>
</tr>
<tr>
<td>subsidiaries and branches</td>
<td>XML and Web Services</td>
</tr>
<tr>
<td>Mergers, acquisitions and</td>
<td>Electronic Data</td>
</tr>
<tr>
<td>divestitures</td>
<td>Interchange (EDI)</td>
</tr>
<tr>
<td>Repair &amp; warranty processing</td>
<td>Middleware</td>
</tr>
<tr>
<td>Customer &amp; supplier collaboration</td>
<td>Application Integration</td>
</tr>
<tr>
<td>Retail store integration</td>
<td>And many more…</td>
</tr>
<tr>
<td>Extending Enterprise</td>
<td></td>
</tr>
<tr>
<td>Application Integration to quick-turnaround projects</td>
<td>And many more…</td>
</tr>
</tbody>
</table>

Table 1 – Application integration problems solved with Application Routers

Application Routers can also be used to form an Application Network – an ecosystem of Application Routers that seamlessly communicate with each other to move data across a variety of geographically dispersed endpoints in an enterprise. For example, an Application Router in Japan can extract customer information from a local ERP application and send it to an Application Router in Croatia to update the central ERP system.

5.3 Benefits Offered by Application Routers
A hardware-based approach provides many benefits when compared to traditional software-based approaches to solve integration:

- **Fastest Time to Market:** Out of the box, customers plug in an appliance and create and deploy an integration solution within hours. The integrated tools provide a graphical modeling environment that allows the customer to quickly design and deploy an integration solution without ever having to write code. Because it’s specifically designed for a single purpose, the appliance is by far the fastest way to connect applications. In a head-to-head benchmark study by one of the world’s leading electronics manufacturing companies, the same application integration project was implemented using both an Application Router and a traditional software stack from a leading EAI provider. The result: the Application Router was 75% faster in development time when compared to the EAI solution [16].

- **Lowest Costs:** The Application Router is very different from the software solutions many customers use today. It provides all of the software and hardware needed to solve application integration in one device. It includes all of the necessary connectors, the management and monitoring capabilities, and the ability to connect unlimited endpoints without additional cost. No additional technology is required, making an appliance much more cost-effective to acquire and configure. Also, the hosting costs of an appliance are about 90% cheaper than that of a hardware server. The result? Fortune 500 companies have slashed their total cost of ownership by up to 82% [16].

- **Better Utilization of Skills:** The Application Router is purpose-built for the simpler problems. Thus, it does not require sophisticated middleware programmers to write ‘code’ to implement integration solutions. Instead, a systems analyst or a junior applications developer can configure projects in days and deploy to production in minutes. This way, IT departments can free up their most skilled resources for complex projects while leveraging the other resources for the tactical, point-to-point problems.

- **Simplest Operations and Management:** Application Routers can be 100% monitored and managed remotely from a Web interface. As a result, maintenance, management and repair can be centralized in one location, often offshore. Additionally, because an appliance can be swapped out by simply unplugging one router and plugging in another, expensive trips to perform local troubleshooting are replaced by a simple “repair by replacement” strategy. Also, the Application Router provides proactive alert notifications on data and connectivity errors that helps IT fix the problems before business users report them. The Application Router is the world’s first solution that provides High-Availability (HA) for mission-critical projects right out of the box. Traditional High-Availability solutions take a myriad of specialist resources weeks to assemble, code, test, deploy and
maintain. Yet, the Application Router HA Pair can be installed in under one hour, ensuring no data loss and requiring no manual intervention upon failure – a quantum-leap for all mission critical data centers.

- **Operational vs. Capital Expenditure:** Many companies prefer to amortize the cost of purchases rather than make large up-front commitments. Due to the nature of an appliance, Application Routers can be leased over a three year period and therefore treated as an operating cost rather than a capital expenditure.

Despite its revolutionary approach, the Application Router complements existing integration technologies and improves overall enterprise integration rather than replacing it. Many Fortune 500 companies are choosing Application Routers to augment their existing integration solutions.

For example, one of the world’s largest electronics manufacturers uses EAI technologies extensively for business process integration projects. Recognizing the cost of extending EAI technology to simpler application integration projects as prohibitive, they—like many Fortune 500 companies—have adopted two standards for integration: EAI for process integration and Application Routers for application integration. In such a context, EAI technologies can be viewed as freight trains that use railroad backbones to transport goods (heavyweight business processes) between large stations (endpoints such as ERP and Financials). Application Routers can therefore be viewed as the trucks that transport the goods to and from the major freight train stations. In other words, appropriate purpose-built solutions are applied to the appropriate tasks.

### 6 Conclusion

We hope we have managed to prove the thesis challenged by the title of this paper – that in today’s business environment the system integration is inevitable.

We have discussed the nature and benefits of the system integration, the specific business drivers for today’s integration projects and four basic types of integration projects, as well as the favorable characteristics of an integration platform. We have also analyzed the offerings of a relatively new integration solution – Integration Appliances and among them especially Application Routers.

The analysis of improvements and benefits that can be achieved when the right integration platform is used has strongly convinced us that enterprise system integration really is inevitable.

### References:


