Horizontal and Vertical Integration of Organizational IT Systems

B. Wangler
Department of Computer Science, University of Skövde
Sweden

S.J Paheerathan[1]
Department of Computer and Systems Science, Stockholm University/KTH
Sweden

Abstract:

Legacy information systems are usually tailored to support particular business functions, such as payroll or purchasing, and are as a consequence usually difficult to integrate. However, companies of today strive to streamline their business processes (intra- as well as inter-organizational). This gives rise to a strong need for much better integration of systems (existing as well as new in-house developed systems or packaged ERP solutions) across functional boundaries and in line with the business processes. This paper surveys and discusses methods and technique to achieve such horizontal integration as well as vertical integration between different operational and management levels in an organization.

1. Introduction

Organizations and their IT-support have traditionally been structured around business functions where each function is supported by its own information systems. These applications may be recent or old. It is not rare to have application systems that are 10 – 20 years old, if not more. As a consequence, they have been built using different technologies, such as different languages, different protocols, even running on different platforms, and all aimed to support well the business within the functional area they were originally designed to support.

Competitive businesses of today need to have computing support to business processes that are not restricted to a single business function, but usually cut across many such functional areas and are liable to change over time. Furthermore, such business processes are often required to support running the business electronically over the Internet not only for presenting the data but also for enabling electronic

[1] On leave from Institute of Computer Technology, University of Colombo, Sri Lanka

commerce transactions. These trends demand for the integration of current functionally oriented systems in the lines of business processes. For many companies this integration needs to be delivered within short time in order to ensure the competitiveness of the businesses.

The need to reduce the cycle time of business transactions premeditated to gaining competitive advantages also encourages inter-organizational co-operation. Globalization of businesses and mergers between enterprises of related interests are some other factors that drive the interests toward business processes beyond the interest of a single institution.

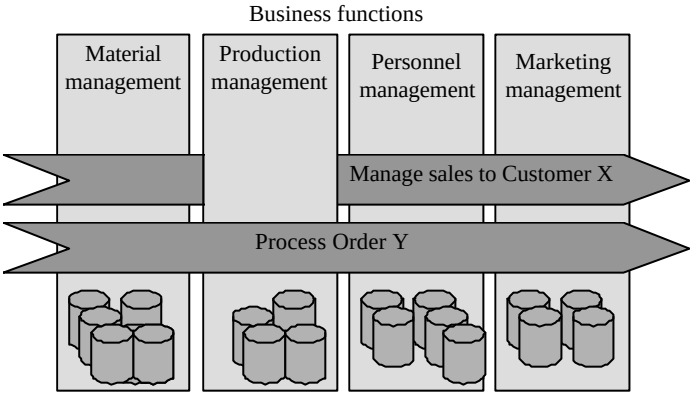

Figure 2. Process Orientation

These trends give rise to new requirements on software applications and their integration, including the incorporation of existing legacy applications and Commercial Off-The-Shelf (COTS) products in the formation of new business processes. In addition, systems on different management and control levels within an organization need to interact. For instance, process control systems need to be fed with control information and to forward data to higher level systems such as enterprise resource planning systems and data warehouses.

2. Approaches to application integration

Though there are different approaches adopted by organizations for the application integration, a more complete categorization based on the market segmentation of software tools and technologies for application integration can be defined with the following six levels [1]:

- Platform integration using technologies such as messaging, Remote Procedure Calls (RPC), Object Request Brokers (ORB) and mechanisms such as publish and subscribe etc.

- Data integration using database gateways or data warehousing technologies.

- Component integration with transaction management, application services, business logic integration facilities achieved through application servers

- Application integration through adapters, rules and content based routines, and event based data translation

- Process integration with process and workflow modeling,

- Business to business integration, with EDI/XML and supply chain integration and on-line trading brokers

The approach applicable for a particular integration project depends on the need for integration, positioning of the business in its competitive market place and the maturity of the technology used.

The lowest in the category is the platform integration, which provides connectivity among heterogeneous hardware, operating systems and application platforms. Technologies that provide platform integration range from messaging, which can only facilitate asynchronous connectivity between applications, through Remote Procedure Calls (RPCs) providing synchronous connectivity to Object Request Brokers (ORBs) that, combined with messages, can provide both types of connectivity.

Data integration is generally of two types. The first includes database gateways enabling data access to heterogeneous data stores using Structured Query Language (SQL). This approach demands for the knowledge of underlying database schemas during application development. The second category in data integration is with tools for extracting, transforming, moving, and loading (ETML tools) data originally designed to support data warehouses after bypassing logic of the original application designed to access the database. These solutions are even found enhanced through messaging support and to provide meta-data management and data cleansing capabilities and may be associated with graphical user interface tools to draw the relationship between applications.

Component integration enables new functionality to be combined with ERP packages, and legacy systems with provisions for load balancing and fault protection, connection pooling, state and session management, security and data access to relational and non-relational sources through application servers.

Application integration is achieved with a reusable framework, which combines a collection of technologies. This collection usually includes underlying platform integration technology, event integration through message brokers facilitating data translation, transformation and rules based routing, application interface integration provided to leading ERP packages through application adapters etc. The frameworks are added value by providing facilities to abstract the complexity of creating, managing and changing the integration solution.

Process integration approaches while requiring all the integration services mentioned so far, provide the highest level of abstraction and adaptability by enabling business managers to define, monitor, and change business processes. Business processes model the information flows across systems and organizational boundaries. Middleware products supporting this level of integration enable business managers achieving this through a graphical modeling interface and easy to handle declarative languages. Changes to generated integration solutions can be made, simply by changing the respective business model via the same graphical interface and declarative language and regenerating the solution.

Business to business (B2B) integration facilitates the extended enterprise concept by enabling the integration of systems beyond the corporate boundaries of an enterprise. For example, systems at suppliers' sites and customers' sites can be combined with systems at enterprise's site to create an extended business process for practicing e-business. Though the EDI was the traditional approach to make conversations between enterprise systems, now trends point towards using XML as a solution for providing the lingua franca of e-business. B2B integration solutions are commonly provided using two approaches [1]. One is to take the process integration approach to define business processes across the organizational boundaries and the other is through the creation of technologies for brokering exchanges in on-line trading communities.

There are many commercial middleware products available in the market to help in application integration. The more advanced and business process oriented of these tools are usually referred to as Enterprise Application Integration (EAI) software [2].

EAI products completely or partially automate various aspects of the process that enables custom built and/or packaged business applications to exchange business level information. A complete EAI product offers the connectivity services provided in middleware products, the data transformation services provided in ETML products, and the process management services provided in workflow products [3].

3. Realities in enterprise application integration

In addition to the categorization of integration approaches based on a market segmentation of tools and technologies for application integration as presented above, we see three different forms of enterprise application integration:

- between different systems supporting different functional areas of a business. We refer to this as horizontal intra-organizational integration.

- between systems on different control and managerial levels of an organization . We refer to this as vertical intra-organizational integration.

- between systems of different organizations. We refer to this as inter-organizational integration.

Whatever the tools and technologies adopted during integration, it is problems having to do with these dimensions we face in integrating different systems already running in an enterprise or at collaborative sites.

Though the common problems to be addressed in every application integration project include handling differences in data formats used by different candidate systems, resolving the protocol differences during communication between them, there are specific problems and issues associated with each specific integration dimension.

3.1. Horizontal intra-organizational integration

A typical example of horizontal integration is Supply Chain Management, in which an organization tries to optimize the complete set of activities of order entry, purchasing, production, shipment etc. in order to minimize the lead-time and costs for production, and at the same time maximize value for the customer.

Figure 2 shows four business processes each spanning a number of applications or processes. The gray area depicts the organization in question. Rectangles depict applications or sub-processes. Process no 1 takes place completely inside the organization. No 2 starts inside and finishes outside. No 3 starts outside and finishes inside. No 4 leaves the organization at one point but comes back before finishing such as may be the case if a separate company takes care of delivery before the original company checks that the invoice has finally been paid. In the course of the process, queries and one-way messages are sent, answers and one-way messages are received, timers are set and run-out.

The current trend towards componentization of software causes functional systems to be split up into smaller pieces, each responsible for its own task or service. By combining these task-oriented components in new and different ways, organizations are able to design and introduce new services or service combinations. Moreover customers should be able to specify themselves the service combination they want. For example, it should be possible in the ordering process to specify which combination of services as regards e.g. delivery and payment methods one wishes. This calls for the ability of enterprise application integration software to dynamically introduce or restructure business processes.

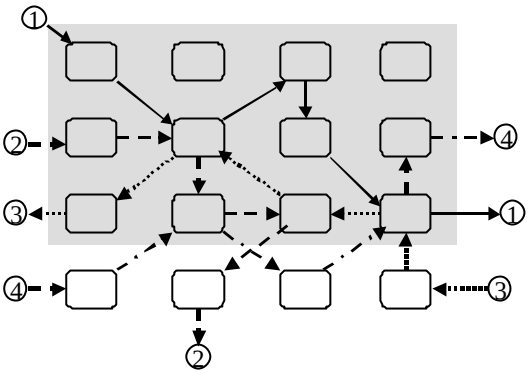

Figure 2. Business processes affecting various applications and processes within (dark area) and outside an organisation.

Many enterprises have taken an expensive ERP path for integration by acquiring packages from vendors like PeopleSoft, SAP, Baan, etc., with increased hopes for interprocess chain integration. Some enterprises have seen Y2K as a catalyst to replace an ageing IT infrastructure with modern ERP systems [4]. Further, it is common to find enterprises with ERP applications supporting a part of some process chains together with legacy systems serving other requirements in the same domain e.g. by incorporating functionality that refers to multiple organizational levels.

Replacing the entire information systems portfolio of an enterprise with ERPs is neither possible nor economical due to the following reasons. Firstly, there is no ERP solution that will provide all the functionality an organization requires and therefore some custom applications will be present among the candidate applications for integration. Even if it were possible through a combination of different ERP packages to complement the inadequacy of coverage, not every enterprise would be willing to depend on such solutions. Secondly, there is always a tendency to maximize the returns of the past investments on information systems. Throwing away some expensive items for some fancy reasons is not an attractive action in business, which is usually aimed to reduce its spending unless the spending promises profitable outcome. Furthermore, businesses are always alert to changes and the amount of change that may be introduced by a complete replacement will simply be intolerable in many cases. These facts prove that the presence of legacy is unavoidable during an integration projects.

Though many ERP packages provide standard interfaces or connectors to connect systems, they are usually built as monolithic solutions [5]. It follows, that the support provided by them is often inadequate and that a main challenge during horizontal integration will be to connect different systems that include the categories

of legacy systems, newly in-house developed applications, and COTS, into more or less complete processes and to do so within the timeframe permitted by the business concerned. The solution should favor quick changes to implemented business processes, as business may demand for such changes due to the stiff competition it faces.

A feasible way of achieving horizontal integration at the level of sophistication we are seeking will be with EAI products supporting the application integration level and levels above it as referenced in the categorization of application integration approaches presented in Section 2. Though many middleware products enable integrating applications built using recognized ERP packages and legacy applications with recognizable interfaces, and there are many legacy wrapping tools for preparing legacy applications for integration, a complete plug-and-play situation is still impossible. In these circumstances, the only option available is to handle the task through extensive coding work.

As indicated before, a recent trend in integration is that the business processes that should be compiled do not require the incorporation of the complete applications. Instead in many cases only selected functionality of existing applications are the ideal candidates for incorporation. Though achieving this level of integration will greatly enhance the effectiveness of integrated solutions, the technological support for this task and support from current legacy systems is found to be limited.

3.2. Vertical intra-organizational integration

Vertical intra-organizational integration is aimed to integrate systems implemented at different administrative levels of an organization. Though it is not uncommon to incorporate the functionality at different levels of an operational system into a single application , the normal is to see different systems implemented to address business functions at different management levels.

As an example, a typical function in any company is “production”. In manufacturing industry this function may, at the lowest level, be controlled by process control systems and computerized NC machinery using proprietary formats of data and messages (See Fig. 3). Frequently they use different operating systems and utilize different networking technologies. These systems need to be fed with control data stemming from higher level planning and scheduling systems while the lower level applications need to collect data and pass them upwards. For example, a company implementing some modules of some ERP package still requires using its current MES (Manufacturing Execution System) and EMTL systems.

Hence, vertical intra-organizational integration may demand the flow of data between candidate applications in both directions. While the feed control data are to flow downwards from systems at higher levels to operational control systems, systems at the lower level need to collect information about results and send them

upwards in order to support decision making at higher level management systems such as for purchasing. In data warehousing oriented environments this is to be done periodically in order to feed data to a data warehouse. In this process data may have to be cleaned such as to equalize definitions and to improve the quality of data. Furthermore, data may have to be pre-aggregated along several dimensions. This calls for a separate data staging activity as part of upwards transfer of information. Whereas the data staging files may be fed with data as it is created, the final update of the data warehouse would take place periodically, e.g. once a day. In this process several steps involving user interaction may be needed in order to analyze, improve, and complement the data.

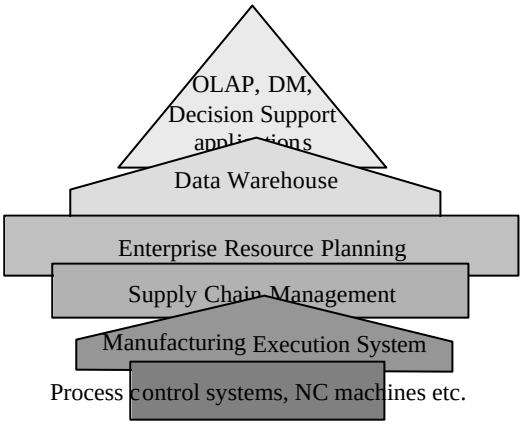

Figure 3. Different layers of systems needing integration.

A wide range of approaches and technologies as well as products based on them is available for vertical integration. These range from relatively comprehensive process brokers to message brokers and such things as single function data transformation tools or even data warehouse oriented solutions. Whatever is used, a product, a combination of products and programming, the integration solution is also influenced by the economy and the level of expected sophistication of the solution.

3.3. Inter-organizational integration

The trend among organizations towards making commerce electronically tends to change the original interaction patterns between enterprises, in particular in their roles as customers and suppliers. Enterprises need to exchange information electronically in order to collaborate and negotiate. The influence of Internet, and the availability of middleware technologies now enable the businesses to exploit the opportunities to connect applications spreading across multiple enterprises. Supply-chain logistics and fulfillment companies integrating with their customers'

fulfillment and shipping systems, or financial services firms integrating with underwriters and retailers of financial products, are a few examples of this multi-enterprise integration.

The key issue in inter-organizational integration is to get the data operations of one application of an organization matching with another application of another organization. Though the Electronic Data Interchange (EDI) has now been used for this purpose, the complexity and restrictions of e.g. the EDIFACT standards limits the use of EDI for large organizations. XML stands a better chance of becoming standard for transfer of data and meta-data between applications with its loosely coupled document model and with the new XML based transaction servers facilitating document transfers back and forth between businesses. XML is also proving its ability in letting the enterprises to structure and exchange information without rewriting their existing systems or adding large amounts of heavyweight middleware.

But the actual state of inter-organizational integration today falls short of what is really needed to achieve an efficient multi-enterprise business process. Inter-organizational business operations are still mostly handled through call-center operators keying e.g. in the relevant back-office order-entry system. Large volumes of business transactions over the Internet are received today via relatively unreliable FTP, requiring handcrafted error-handling programming. Furthermore, many of the application-integration solutions today rely upon proprietary technologies and are therefore not well adapted for use in an e-business context.

The shifting focus of application integration from inside the enterprise to multi-enterprise integration introduces a different variety of requirements and priorities. Some requirements are refinements of approaches that have evolved for EAI, but there are still many differences. One such is the stronger emphasis that is put on security issues. Another is the increased need for an integrated support for Internet application architectures, such as application servers that support Enterprise JavaBeans (EJBs), CORBA etc. The distinction between EAI solutions and application servers becomes fuzzier in the context of inter-organizational integration, to such an extent that a new culture referred to as Internet Application Integration (IAI) is emerging.

4. Process Oriented Solutions in Application Integration

Traditional strategies to achieve application integration are through hard-coding these services within applications to be integrated. These approaches while resulting at heavy programming work to application developers, is liable to extensive maintenance when the integration solution require changes.

Alternatively, an approach using a middleware software layer providing various broker services between the different information resources has gained appreciation.

In consequence, a whole lot of commercially available middleware tools to help in this integration have appeared in the market.

At the same time, customer requirements for application integration are also maturing and increasingly becoming (a) decentralized, as distributed computing architectures and technologies complement the increasing IT influence of lines of business managers, and (b) coordinated, as batch connections are increasingly replaced with real-time systems to support the industry move from the management of transactions to the management and re-engineering of business processes [3].

EAI products completely or partially automate various aspects of the process that enables custom built and/or packaged business applications to exchange business level information. EAI is not middleware. EAI is not workflow. EAI is not data transformation as found in data warehousing (ETML products). Each of these types of products offers a solution to a specific piece of the general business problem. Rather, EAI is a combination of the technologies employed in these kinds of products. A complete EAI solution employs the connectivity services also provided in middleware products, the data transformation services also provided in ETML products, and the process management services also provided in workflow products [3].

In the long run, EAI will ease the burden and lower the costs of application integration by providing a level of automation not traditionally available for the integration of applications. This may be achieved by further eliminating the requirement for programming during integration and help achieving the integration at the business process level in contrast to the data or functional levels.

Current trends in the EAI space are driven by three major forces according to industry specialists [6]. The first is the move towards doing things at a higher level i.e. at a business process level, hence facilitating process integration [2]. The second is an increasing proliferation of packages which makes the integration opportunities more predictable. The third is extending the process orientation beyond the corporate walls and delivers the full promise to e-business by integrating customers, suppliers and partners while transferring the controls to parties outside the organization enabling the business to enjoy the benefits of an extended business.

Industry experience demonstrates, that process orientation allows organizations to solve more complex business problems and be more competitive. Business process integration provides mechanisms for transferring content between two business processes that act as sender and receiver. The content can be of any type and may consist of several different combined contents, e.g. a physical product together with paper or electronic information. Process integration interfaces of an EAI product can be managed by a Business Process Broker

A Business Process Broker will provide functions for synchronizing events into one business transaction, handling parallel business transactions, mixing email (person to

person) and application (machine to machine) messages in one business transaction. It will, hence, be possible to build Process Management Systems that align the IT-support to the business processes. Advantages of this alignment are that people and systems can be linked together in the processes, and that decisions based on business rules may be facilitated and even automated. The impact of process design can be increased, and business processes can be changed and managed in a simpler way through graphical interfaces while accommodating run-time modifications to business processes. A Business Process Broker facility of an EAI product provides a higher level of abstraction than a Message Broker provides under similar conditions, by giving users the ability to define integration requirements through workflow and business process models [7].

The management of business processes is a key issue in process orientation and will greatly improve the effectiveness of such integration efforts when it is combined with facilities to simulate the use of process models before the implementation. Simulation of business processes will enable business managers to identify potential bottlenecks before the system is implemented. Collection of real-time data on the performance of processes for use in analysis, and facilities to re-implement a previous solution quickly in case it is found to be more favorable, will further improve the support to today's businesses.

One of the key players in the EAI market place, Viewlocity, aims to improve their EAI products through extensive research in these directions [7]. The ProcessBroker project [8] run by Viewlocity and SYSLAB[2] of the DSV particularly takes further the process-oriented aspects of EAI in order to address the requirements engineering, modeling and architectural needs of the concept.

5. Concluding remarks

Ending up, we may conclude that differences between the requirements posed by horizontal, vertical and inter-organizational integration are smaller than one perhaps would expect. The differences there are concern such things as the fact that vertical processes may involve a more disparate collection of applications, i.e. systems for detailed control of low-level processes and machinery mixed with batch-oriented system for loading data into databases aimed for strategic and tactical management. Inter-organizational processes are special in that they involve autonomous organizations thereby posing specific demands concerning e.g. security and the fact that process integration should still allow for some independence in the way that individual companies prefer to make business

While the possible disparities between applications to be integrated in a horizontal integration effort can be considerable, the opportunities for this kind of integration

[2] Systems Developemt Laboratory, Dept. of Computer and Systems Science, Stockholm University/KTH

are brightening due to vendors such as CrossWorlds, Forte, Extricity, HP, Viewlocity, and Vitria. However, it is not only novel software solutions that are needed. These have to include graphical interfaces allowing for comprehensive and easy-to-understand ways of describing, designing and managing processes including the various actors, systems and people that are involved. They also need to be complemented with methods and guidelines helping the user in the analysis and design of processes and data models. Business analysis methods such as EKD (Enterprise Knowledge Development) [9] by Bubenko et al. offer a good starting point for this work. Work by Johannesson and Perjons [10] represents a first attempt to enhance such methods with design principles specifically targeting application integration.

Acknowledgement

This work was performed as part of the project ProcessBroker [reference to web], a joint project between SYSLAB and Viewlocity. SYSLAB's participation in the project is sponsored by Swedish National Board for Industrial and Technical Development, NUTEK.

References

1. Beth Gold-Bernstein, "EAI Market Segmentation", EAI Journal, July/August 1999.
2. Torun Lidfeldt, White Paper: Middleware, Datateknik 3.0, nr 7, 25 nov 1999 (in Swedish).
3. Katy Ring, Enterprise Application Integration: Making the Right Connections, White paper, 1999, http://www.ovum.com/ovum/news/apiwp.htm.
4. Jeanne W. Ross , The ERP Path to Integration: Surviving vs. Thriving, EAI Journal, February 2000, http://www.eaijournal.com/ERPIntegration/ERPPath.htm.
5. David S. Linthicum, Integrating SAP R/3, EAI Journal, February 2000, http://www.eaijournal.com/ERPIntegration/IntegratingSAP.htm
6. Colleen Frye, Middleware Moves Up a level, Application Development Trends, Oct 1999, http://www.adtmag.com/pub/oct99/fe991002.htm
7. Processbroker consortium, A Process Broker Architecture for Systems Integration, white paper, Nov. 1999, http://www.dsv.su.se/~pajo/arrange/Publications/publications.html.
8. Processbroker Consortium, Project Proposal, Nov. 1998, http://www.dsv.su.se/~pajo/arrange/index.html.
9. Bubenko, J. A., jr, D. Brash and J. Stirna (1998). EKD User Guide. Dept. of Computer and Systems Science, KTH and Stockholm University, Electrum 212, S-16440, Kista, Sweden.
10. Paul Johannesson, Erik Perjons, Design Principles for Application Integration, Proceedings of 12th Conference on Advanced Information Systems Engineering, Stockholm, June 2000.