the enterprise's evolution of practice. However, this simple HR example indicates how many different components are usually involved in a complex procedure.

In a loosely coupled messaging system, the other involved components would subscribe to the HR application's message to a relevant form for their individual applications. In other words, each receiving component takes what it needs from the HR application's message, and converts it to a meaningful form for its application. To do so, an application messaging system will deliver messages to the appropriate components (look at the Application Messaging Processor in the *PeopleSoft* Internet Architecture on Figure 5-1).

When possible, applications should communicate in loosely coupled fashion. If a transaction needs data from another system to continue, or if an end user is waiting for a response, the integration point will tend to require tight coupling. For the broader range of application integration, including most system-to-system or business-to-business communication, loosely coupled integration based on messaging is sufficient.

MOBILE INTEGRATION

Wireless networks transport information between thin clients and content providers. Mobile clients have limited screen, keyboards, and storage; therefore servers must play a strong role in solving these problems. Other problems are caused by the small bandwidth, usually between 9,600 and 19,200 bps, which is responsible for slow data transfer and long delays, and higher latencies of responses to users.

To minimize these problems, some standards are evolving, such as:

- Wireless Application Protocol (WAP) for mobile Internet applications
- NTT DoCoMo's i-mode protocol (Japan) widespread in the marketplace

WAP was developed by Ericsson, Nokia, Motorola and UP (now Openwave) in September 1997. WAP applies Internet protocols when possible but departs from them to address limits of wireless communication. Because the wireless provider may be dropped by the end-user, WAP orients a Wireless Session Protocol to a content provider. It means that an enterprise

may have its own WAP gateway which is partially in a firewall and is accessible also from a LAN environment.

The browser-based clients are of the following types:

- WAP-enable phones and Personal Digital Assistants (PDA)
- Smart phones
- Mobile e-mail devices

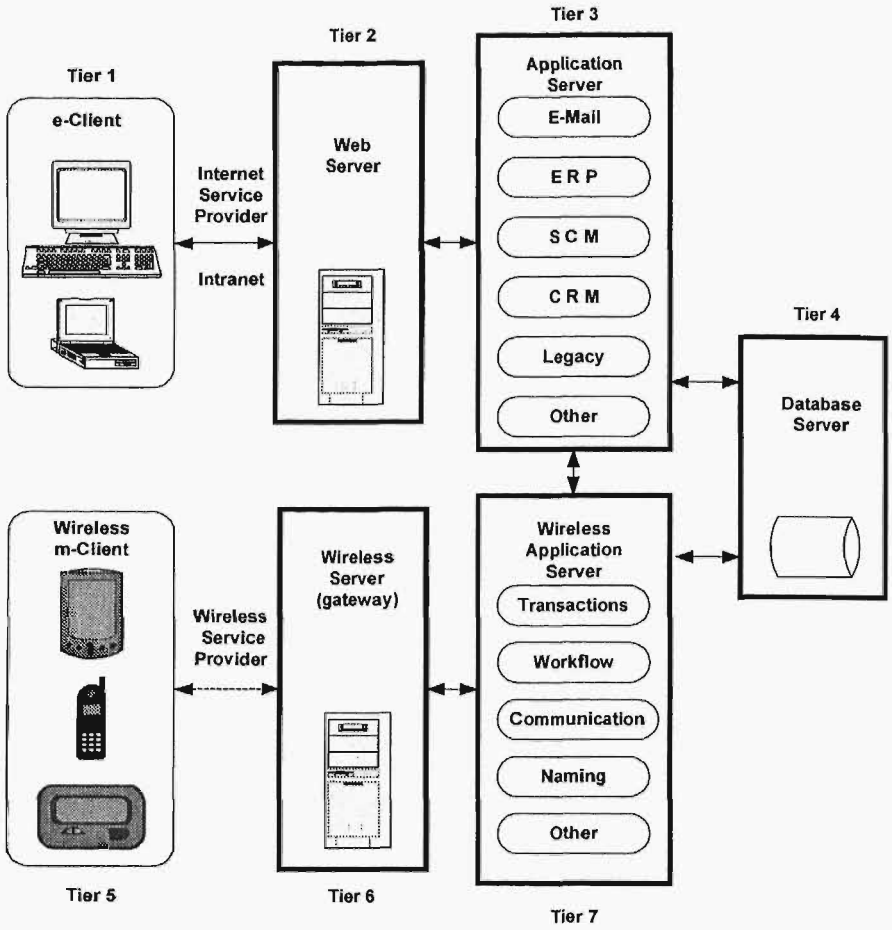
Each of these devises handles information programmed in one of the following languages:

- HTML (Hyper Text Markup Language) - most of Web-based home pages are coded in it, applied by MS Windows CE
- HDML (Handheld Device Markup Language) designed mostly for cell phones to receive stock quotes, news headlines, and e-mail
- cHTML is applied by cell phones and PDA's made by Japanese firms
- WML (Wireless Markup Language) is based on XML and supports both text and images, including formatting, layout commands, and navigation through stored home pages

Because many companies invested in the Web infrastructure, they want to transmit HTML-based information to mobile devices. There are two ways of delivering an enterprise-based HTML content to mobile devices through the application of:

- Transcoders which translate an enterprise's HTML/XML content to mobile devices that are driven by their own data protocols and network constraints,
- Wireless Server (a gateway from a carrier to an enterprise) and Wireless Application Server, which is specialized in mobile applications and is also a link to an Enterprise Application Server, as it is shown in Figure 5-14.

Figure 5-14: The Architecture of Electronic and Mobile Enterprise



The electronic and mobile enterprise needs the information infrastructure to be composed of seven tiers. This infrastructure should secure the following situations (PriceWaterhouseCoopers, 2001):

- An employee within an office building uses a mobile device over the wireless 802.11 LAN.
- As the employee walks out of the building, the device automatically switches to a cellular/packet data network.

- As the employee enters the airport, the device communicates with an access node to get a high-speed network connection.

- After boarding the plane, the employee uses the onboard phone system, LAN or wireless LAN to achieve network connection.

- While the employee is driving in areas with weak wireless cellular/packet networks coverage, the mobile device interfaces with the employee's network-enable phone, using it as a modem to get a network connection via circuit-switched cellular.

ENTERPRISE INTEGRATION

The enterprise integration means that multiple applications are deployed in different countries, on different platforms, and even on different releases of the same technology. At the same time enterprises are dynamic, as they grow, shrink, reconstruct and improve, and as a result their systems are subject to constant change. Enterprises are also diverse, since their large organizations are sets of smaller groups – each with its own priorities, culture, and degree of autonomy.

Enterprise-wide applications, even standing alone, are expensive and difficult to implement. Connecting them together is also expensive, and the expense increases exponentially as more applications come together through more expanded networks. The better the integration of applications, the more money it saves for the enterprise.

At one time, it was a popular idea that the application integration could be done through the replication and distribution of databases. However, it was found also that applications are too complex for database replication to satisfy the users' requirements. Database technology provides only a partial solution to the problem of integrated applications. The correct solution is the solution exemplified by *PeopleSoft*'s Internet Architecture, which integrates enterprise components through the four-tier computing environment of the extended enterprise.

From the extended enterprise point of view, its applications provide the following opportunities:

- SCM – optimizes relationships with business partners and reduces costs of goods sold,

- ERP – facilitates internal operations and increases productivity,
- CRM – optimizes business relationships with customers and increases service effectiveness,
- MIS – supports executives in making satisfactory decisions,
- KMS – supports executives in making optimal decisions,
- E-Biz – optimizes commercial transactions,
- WFS – streamlines internal operations, shortening the fulfillment time,
- E-DMS – optimizes the use of information content in decision-making,
- E-Mobile – allows for fulfilling tasks anytime, anywhere,
- EUC – allows the end-users to be more productive and better informed.

The first step in enterprise integration and moving towards the extended enterprise is to understand that all the above applications should be integrated. The first who have understood this premise have been ERP vendors, who expanded their software packages into new applications.

Oracle and *J.D. Edwards* have been the most aggressive vendors in this regard, adding capabilities in both SCM and CRM in 1999. Focusing on customer management, Oracle has launched a front-office suite offering functionality in all three CRM segments as well as integration with the company's ERP applications. The company has also launched a Supply Chain Planning application targeted at the manufacturing industry, and has entered into partnerships with EAI vendors *TSI* and *TIBCO*.

J.D. Edwards has focused on adding supply chain capabilities to its ERP suite, agreeing to acquire a major SCM vendor *Numetrix* and entering into a partnership with *IBM* and *SynQuest* to develop supply chain solutions for the manufacturing industry.

SAP has moved into the extended enterprise application space, partnering with SCM software vendor *Aspect Development* and launching a Web-based sales configuration engine. SAP also acquired a 9.7% stake in *Catalyst International* and announced that the two companies have entered into a strategic alliance to develop Supply Chain Execution solutions for mySAP.com.

PeopleSoft has also begun to move aggressively in 1999, agreeing to acquire CRM vendor *Vantive* and partnering with Supply Chain Execution vendors *Optum* and *McHugh*.

The second step in developing the extended enterprise is to understand which technology one must use to integrate applications from different vendors. The following architecture levels of the integration strategy provide these technologies (described in detail in Chapter 7):

- Business Architecture:
  - BPI – Business Process Integration,
  - B2B, *e.g.*, e-commerce,
  - e-Market Integration

- Application Architecture:
  - Legacy systems integration,
  - Middleware software,
  - EAI – Enterprise Application Integration,
  - Workflow-driven integration,
  - e-Mobile integration

- Network Architecture:
  - LAN,
  - MAN,
  - WAN,
  - GAN

- Technology Architecture
  - Development tools,
  - Server architecture,
  - Transaction management,
  - Database gateways,
  - Messaging integration points,
  - Messaging services, e.g., IBM MQSeries, Microsoft Message Queuing Services (MSMQ), SAP's Application Linking, IBM CICS transient data queues, etc.,
  - Object models,
  - Object Request Brokers,
  - Web processors,
  - Interfaces,

- Standards; CORBA, EJB, DCOM, BizTalk, .NET,
- Other.

It is not surprising that when "Extended Enterprise" software vendors accelerated efforts to introduce new software packages, they selected acquisition or partnering strategies rather than internal development as the preferred means of obtaining the necessary intellectual capital and technological infrastructure. For example, EAI software vendors first acquired smaller technology leaders, e.g., EAI vendor *New Era of Networks (NEON)* acquired five integration technology vendors and entered into an alliance with *BEA Systems*, a provider of integration and networking software. In consequence, SCM and CRM vendors have also been active in expanding their product offerings via acquisitions and strategic alliances. For example, SCM vendor *Aspect Development* is in a partnership with i2 technologies. The same consolidation process takes place among consulting firms, which in order to provide the integrated services on the extended enterprise merge with the niche firms, e.g., CIBER – a management consulting firm acquired by Waterstone Consulting, specializing in SCM and CRM solutions.

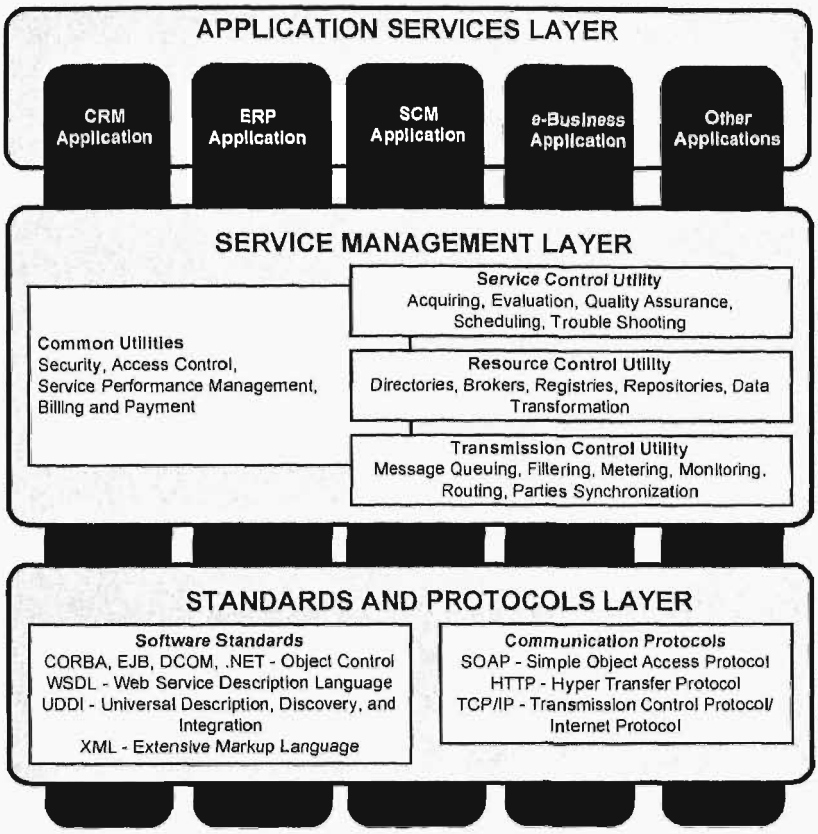
WEB-DRIVEN INTEGRATION

The Web technology allows the transformation of the IT strategy from a proprietary to outsourcing solution. The model of the Web out-sourced services architecture is shown in Figure 5-15. The Web is the mechanism of integrating out-sourced and in-house applications and services.

The Web Outsourced Services Architecture has three layers (Hagel and Brown, 2001):

1. The Standards and Protocol Layer is composed of software and communication standards including UDDI, which is an XML-based registry for businesses worldwide to list themselves on the Internet. Its ultimate goal is to streamline online transactions by enabling companies to find one another. Included is also SOAP, which supports a program running on one kind of operating system to communicate with a program running on another kind of operating system;

Figure 5-15: The Web Outsourced Services Architecture



2. The Service Management Layer provides key supervising services allowing the access, transfer and quality control of outsourced applications through the enterprise's Web;

3. The Application Services Layer integrates a mix of proprietary and outsourced applications (SCM, ERP, CRM, and others) for day-to-day operations supporting end-users' business processes.

INTEGRATION COMPLEXITY

Attention to each of the EII's layers and the integration strategy's architecture levels reveals the complexity of the integration approach towards the

enterprise. Figure 5-16 illustrates this complexity. The following analysis highlights some issues of this complexity.

- Business Architecture
  Assume that number of business processes in an average enterprise is about 100 and each one can interact with each other. It means that the number of interactions is i=(100-1)100:2=4950. The number of states of each interaction, assuming only two (*on* and *off*) is s=2^n, where n=100, and s=infinite.

Figure 5-16: The Matrix of e-Enterprise's Integration Strategy

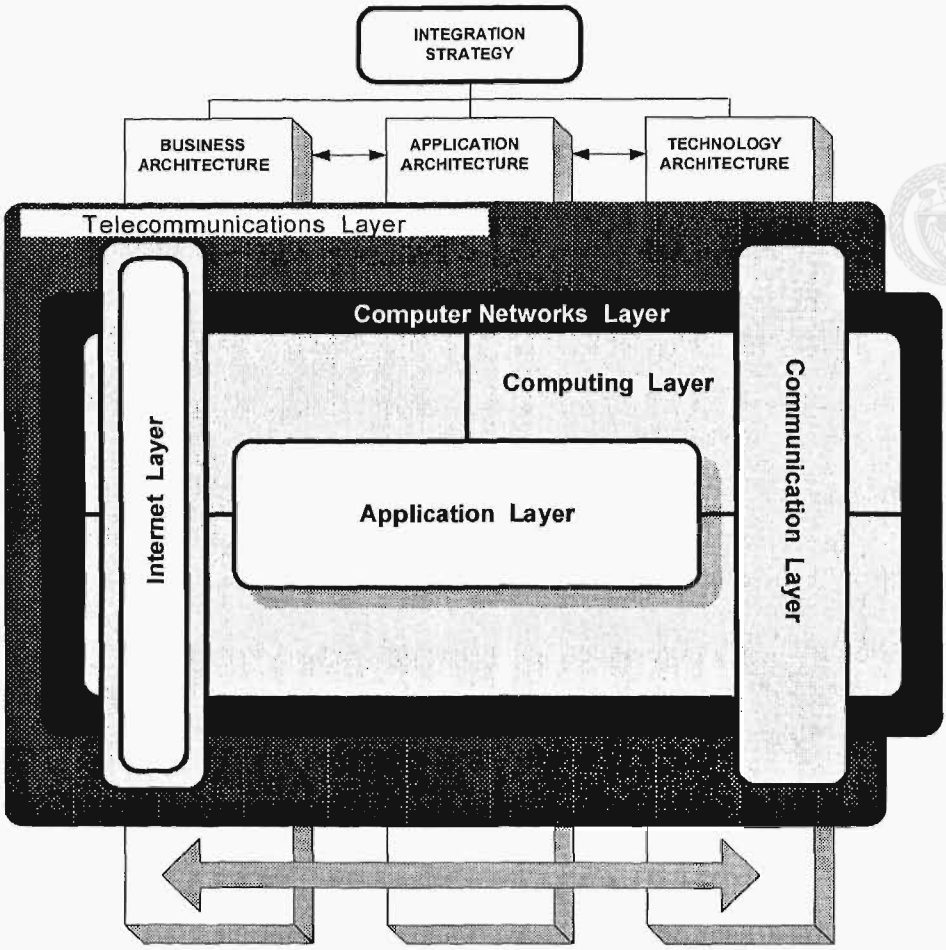


Figure 5-16 The Matrix of e-Enterprise's Integration Strategy

- Application Architecture
  The number of major applications (Figure 6-9) is 8 (we exclude EUC and e-Mobile) and each one can have about 1000 components. In every application the number of interactions among components is i = (1000 – 1)1000 : 2 = 499,500. The number of states of these interactions is infinite. However, applications can interact between each other, so their number of interactions at the very aggregated manner is i = (8 – 1)8 = 56.

- Technology Architecture
  Assume that number of major involved technologies is about 20, hence, their number of interaction i = (20 – 1)20 = 380.

The number of elements in the extended enterprise is about 1000+ and the number of their interactions is at the level of 500,000+, which means that such an enterprise becomes very complex. It is difficult to conceptualize such an entity, even more difficult to design such an organization, and it is extremely difficult to operate and maintain such an enterprise.

This analysis indicates that integration issues cannot be identified only with the technology architecture, but should also be reflected in the business and application architectures.

The integration project should solve the following issues:

1. The integration solutions should be planned in-house, but some of their systems can be outsourced,

2. The development of all harmonized layers of the EII,

3. The Application Architecture should support the Business Architecture,

4. The Technology Architecture should support the Application Architecture,

5. The selection of component standards between CORBA, EJB, DCOM or .NET should begin all development tasks.

It is important to notice that some major problems can be associated with the integration:

1. Integration may solve some current problems, but what about the next generation of the extended enterprise's growth's requirements?

2. The Application Architecture may work fine in the online mode but may trigger some problems in real-time operations.

3. There is confusion in choosing the correct development tools since none can fit all needs.

4. The development of the integrated enterprise can be relatively easy for an experienced staff, but major problems may occur during the systems testing and operations phases.

It is also important for leaders of the extended enterprise to take the broader approach towards the integration by considering the following challenges:

1. Choose which is more strategic for your company: the internal integration of systems or the external integration with stakeholders?

2. Choose between re-engineering of the enterprise's business processes and outsourcing those processes, e.g., human resources process.

3. Choose between re-engineering business processes and the re-use of some existing solutions in order to avoid the development process of new solutions.

4. In the case of mergers and acquisitions, choose between integrating all sources of the same information and selecting one source as the common solution for all users.

The enterprise integration by IT is a business process itself. It usually takes place at the following levels (*www.butlergroup.com.uk*):

- Plug-and-Play – integration between applications that share common business components, business interface, and technology,

- Well-Defined – integration between applications with well-defined, but incompatible components and interfaces, for example package-to-package from different vendors,

- Undefined – integration of in-house legacy, and new in-house built with each other or with a package application,

- Complex – multiplexed integration of multiple sources with complex rule-driven integration.

Based on the presented analysis, companies should balance immediate requirements with long-term integration needs. As there are thousands of ERP implementation projects and hundreds of EAI implementation projects – it is not hard to notice that the opportunity for growth in this lucrative area exists.

FURTHER TRENDS

Modern enterprise is about 400 years old, but its information model or more specific – electronic model – is just emerging in the 2000's. Perhaps it will take another century to conclude its theory and practical solutions.

The framework of such an electronic enterprise is sketched in this book; however, its implementation will require wise leadership, skillful staff members, abundant resources, and the will to take the risk with such an undertaking. The benefits should be realized in the areas of the company's improved competitive position, better profitability and productivity. On the other hand, the complexity of the e-enterprise will require mature management supported by the skillful "IT back-office" and a healthy balance between the range of outsourcing and in-house IT services.

CONCLUSION

The progress in the enterprise evolution is driven by the goal of integrating all applications into one coherent complex, operating in real-time. This is gradually achievable through the application of:

- Web technologies which electronize the Enterprise Information Infrastructure,

- Mobile connectivity and applications which make an enterprise operating in real-time,
- Standards for information processing in a distributed environment through the Web,
- Integration techniques at the level of computerized business processes' components (tightly and loosely coupled integrations) which also apply Web services to accelerate the information flow among multi-vendor information technologies in different locations,
- Integration strategy which has to design plans for the integration of business, application, and technology architectures.

The goal of integrating the EII is the greatest challenge for most large organizations. The majority of these organizations which acquired a variety of IT solutions (software and hardware) along with in-house developments created a diverse portfolio of disconnected solutions.

During the mid 1990's, specialized middleware products were developed to meet the increased demand for the EII integration. This topic will be discussed in Chapter 7.

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ENDNOTES

1 Java servlets are essentially server-side applets (mini applications) which enable Web servers to communicate with back-end systems. Introduced in 1997, servlets can provide Web-based access to data; for instance, processing data from an HTML form and returning a response. Several servlets can be chained together to handle requests that may involve a series of steps. On the client side, a new extension to the servlet technology are JavaServer Pages (JSP) – allows Java business applications to be inserted into HTML or XML pages. At run-time JSP's are compiled into servlets for execution.

2 Location transparency is a general principle of distributed systems; it is not only CORBAS' unique principle.

3 Microsoft identifies the application of COM and DCOM embedded in Windows as DNA – Distributed Network Architecture or COM-DNA.

4 COM – a model for binary code developed by Microsoft. It enables programmers to develop objects that can be accessible by any COM-compliant applications. Both OLE and Active X are based on COM. OLE – Object Linking and Embedding is a compound document standard developed by Microsoft. It enables programmers to create objects with one application and then link or embed them in a second application. Embedded objects retain their original format and links to the application that created them. Support for OLE is built into Windows and Macintosh Operating System. The description of DCOM is based on the vendor's documentation available on the Internet.

5 In 2000 Microsoft introduced the Windows 2000 DNA standard which very soon was replaced by .NET standard.

6 Microsoft's approach towards network services is described in more detail; however, one must mention that other vendors such as IBM, Sun Microsystems, Oracle and others provide similar solutions, embedded in

their proprietary technologies. Due to Microsoft's Windows and Internet Explorer popularity, its solutions deserve good attention.

7 Perhaps this strategy has something to do with the threat of breaking Microsoft into two separate companies.

8 This is an example of PeopleSoft's solution.

9 This is an example of PeopleSoft's solution.