

ERP Overview¹

Information in large organizations is often spread across numerous homegrown computer systems, housed in different functions or organizational units. While each of these “information islands” can ably support a specific business activity, enterprise-wide performance is hampered by the lack of integrated information. Further, the maintenance of these systems can result in substantial costs. For example, many of the older programs cannot properly handle dates beyond the year 2000, and they must be fixed at a steep cost—or replaced.²

While the Y2K bug has been fixed over time (at an estimated cost of \$600 billion worldwide), the lack of integration is a pervasive problem. Consider, for example, Boeing, which relies on hundreds of internal and external suppliers for the millions of components needed to build an airplane. The goal of putting the right parts in the right airplane in the right sequence at the right time was managed at Boeing by four hundred systems that were designed in the sixties and were all but integrated. Information inconsistencies were prevalent and the systems were not synchronized. As a result, parts often arrived late, idling partially-built airplanes on Boeing’s assembly lines. In 1997, as Boeing faced unprecedented demand for its aircraft, these problems became unbearable, and the company’s manufacturing ground to a halt. Boeing was forced to shut down two of its major assembly lines and take a \$1.6 billion charge against earnings. Boeing has since replaced these systems by an integrated Enterprise Resource Planning (ERP) system based on commercial, off-the-shelf software.

With the advent of E-Business and the need to leverage multiple sources of information within the enterprise, ERP software has emerged as a major area of interest for many businesses. Back-office enterprise software has its roots in the 1960s and 1970s, as computing power became affordable enough for companies to automate materials planning through MRP and financial processing through payroll and general ledger software. MRP, short for Material Requirements Planning, was developed in the

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early 1960s at IBM and had become the principal production control paradigm in the U.S. MRP consists of a set of procedures that convert forecasted demand for a manufactured product into a requirements schedule for the components, subassemblies and raw materials comprising that product.

MRP is limited to controlling the flow of components and materials, and does not lend itself to more complete production control and coordination. The next generation of manufacturing software, known as MRP II, was developed to address this shortcoming and to further integrate business activities into a common framework. MRP II divides the production control problem into a hierarchy based on time scale and product aggregation. It coordinates the manufacturing process, allowing a variety of tasks such as capacity planning, demand management, production scheduling and distribution to be linked together.

However, even MRP II is primarily a specialized tool designed to serve the needs of the manufacturing function within a company. Its data and processes are not integrated with those in the rest of the enterprise, such as marketing, finance and human resources. ERP entered the scene to facilitate information sharing and integration across these different functions and to operate the enterprise more efficiently and effectively, using a unified data store and consistent processes.

I. What is ERP?

ERP is a software architecture that facilitates the flow of information among the different functions within an enterprise. Similarly, ERP facilitates information sharing across organizational units and geographical locations.³ It enables decision-makers to have an enterprise-wide view of the information they need in a timely, reliable and consistent fashion.

ERP provides the backbone for an enterprise-wide information system. At the core of this enterprise software is a central⁴ database which draws data from and feeds data into modular applications that operate on a common computing platform, thus

² This problem is known as the “Y2K bug.”

³ In recent years, ERP system started supporting inter-organizational linkages as well.

standardizing business processes and data definitions into a unified environment. With an ERP system, data needs to be entered only once. The system provides consistency and visibility—or transparency—across the entire enterprise. A primary benefit of ERP is easier access to reliable, integrated information. A related benefit is the elimination of redundant data and the rationalization of processes, which result in substantial cost savings.

The integration among business functions facilitates communication and information sharing, leading to dramatic gains in productivity and speed. Cisco Systems, for example, harnessed ERP to help it become the market leader in the global networking industry. Cisco's ERP system was the backbone that enabled its new business model—Global Networked Business—based on the use of electronic communications to build interactive, knowledge-based relationships with its customers, business partners, suppliers and employees. In the process, Cisco doubled in size each year and reaped hundreds of millions of dollars in both cost savings and revenue enhancements. Autodesk, a computer-aided design software company, reported a decrease in its order fulfillment times from two weeks to 24 hours after installing an ERP system. Similar examples abound in today's business environment.⁵

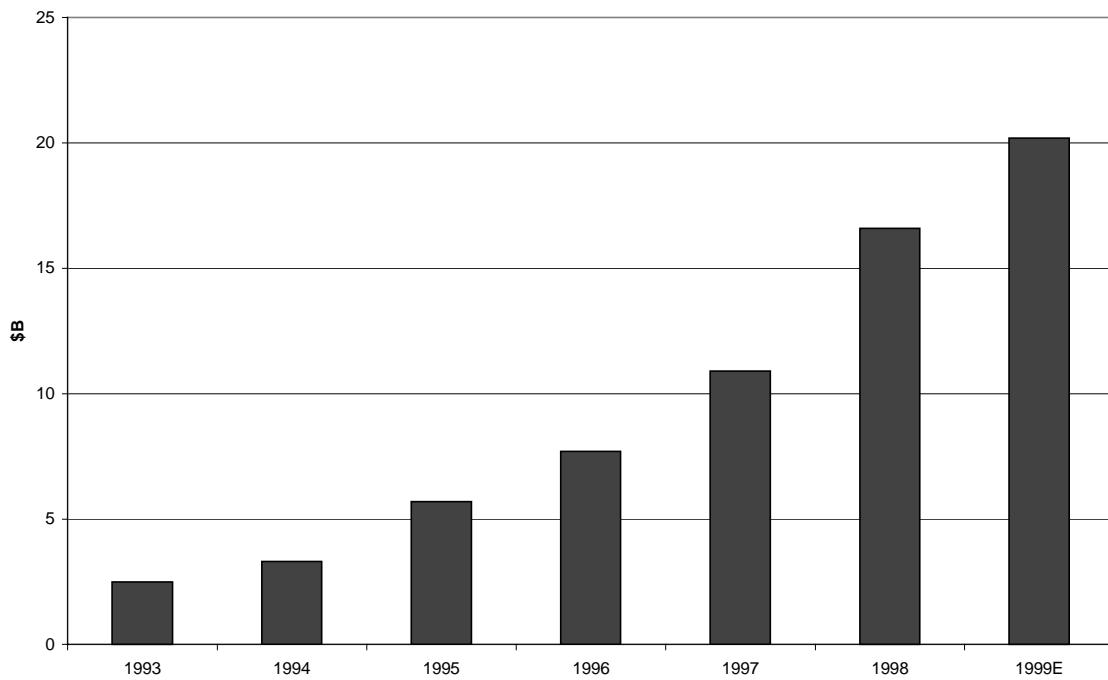
Based on the promise of tightly-integrated corporate functions, globally optimized decisions and fast and easy access to accurate information, enterprise software has become an essential part of the operations of large businesses in many industries. By 1998, over 20,000 firms around the world spent \$17 billion on enterprise software, following annual growth rates that ranged from 30% to 50%.⁶ In addition to direct spending on the software itself, companies often spend a multiple of licensing costs on services related to implementation and maintenance. Companies are beginning use enterprise software to automate front-office activities such as sales and marketing, call center operations, product configuration, lead-tracking and customer relationship management.

⁴ The database may be physically centralized, as in earlier mainframe-based system, or it may be distributed, as is typically the case today.

⁵ As discussed below, not all ERP implementations are as successful.

⁶ Source: AMR Research, *ERP Software Report*. As discussed below, the ERP market experienced a substantial slowdown in 1999.

Figure 1: ERP Software Market Revenues, 1993 - 1999



II. Growth of the Enterprise Software Industry

A number of trends drove the growth of the enterprise software market. First, as discussed above, an integrated information architecture improves business performance. Once a major company in an industry adopts enterprise software, competitors may be compelled to follow suit to stay competitive. Second, there has been a major shift towards the use of packaged applications. This is partly related to the “Y2K bug” and the European Union’s conversion to a single currency, which induced companies to replace their legacy systems with packaged software—effectively “outsourcing” the solution to the ERP vendor. Third, many companies were abandoning legacy software due to the demands of electronic commerce and front office applications on the front end and linking to suppliers and business partners at the back end. Similarly, the emergence of ERP-based “vertical applications” that address the enterprise software needs of a specific industry have caused many companies to purchase ERP packages. Finally, rapid advances in computer and software technologies combined with the explosive growth of the Internet have led many companies to rethink their business practices, to put a greater

emphasis on their use of IT, and to invest in a more robust enterprise architecture.⁷

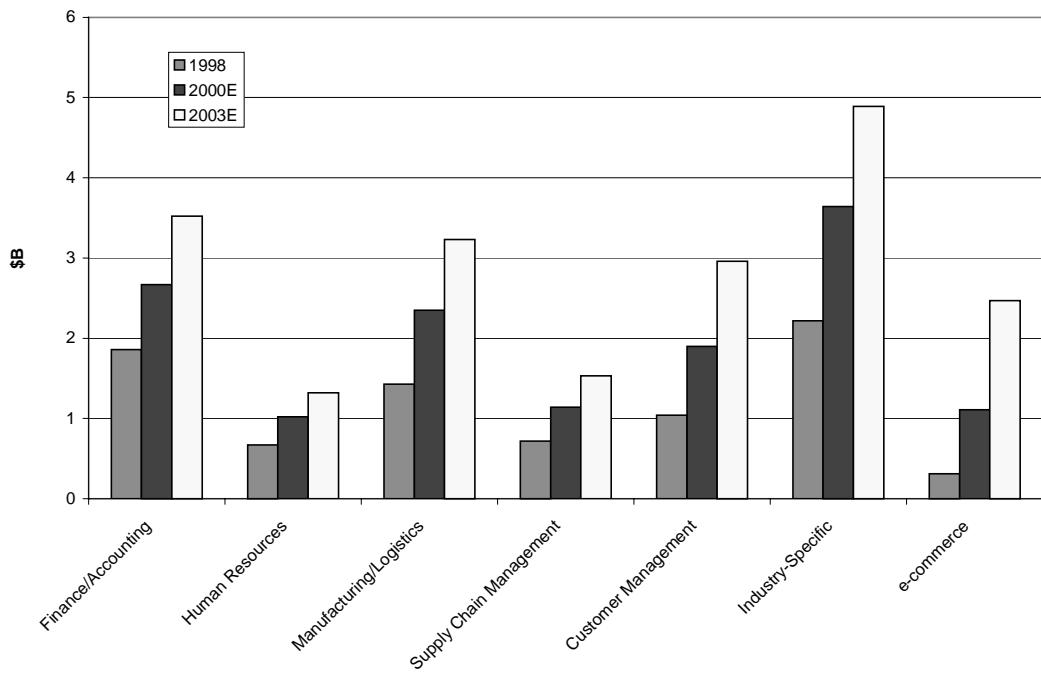
Competition in the enterprise software business is fierce, with hundreds of software producers fighting for market share. The market has both companies that offer an integrated suite of applications and those that address specific business process. The first group consists of five companies known in industry parlance as JBOPS — J.D. Edwards, Baan, Oracle, PeopleSoft, and SAP AG. These companies attempted to create “end-to-end” solutions for the entire enterprise, hoping that corporate customers will purchase almost all of their critical enterprise applications from a single vendor. The reasoning behind this strategy is twofold. First, it is increasingly important for enterprise applications to communicate and interact with each other seamlessly. For example, a company can commit to a more reliable delivery time if its sales order entry and manufacturing software packages are integrated; if the same vendor produces all of the software, applications can integrate more tightly. Second, customers may prefer to rely on one major vendor for most of their software needs, because having a single vendor simplifies contracting and relationship management and creates a single point of accountability for all software problems.

On the other hand, scores of companies that make innovative products compete to provide software solutions for customer relationship management, supply chain management, electronic commerce and purchasing. These companies offer software that can be “bolted on” to the existing ERP backbone and, together, provide a flexible “best-of-breed” portfolio of solutions in different areas. Players in the area of customer relationship management include Siebel Systems, Clarify, Remedy, Epiphany, Broadvision and Trilogy. These firms produce software to help with customer support, product configuration, one-to-one marketing and sales-force automation. Leaders in e-commerce software are too numerous to list (and the list changes on a daily basis), but some examples are GE Information Systems, Sterling Communications, Ariba Technologies and Commerce One. Supply chain management software helps companies optimize their production processes and logistics across the entire supply chain; i2 Technologies and Manugistics are leaders in this area. The size of the packaged

⁷ Additional recent trends are discussed in the last section of this Note.

application market by category, and market forecasts for the years 2000 and 2003, are shown in Figure 2.⁸

Figure 2: ERP and ERP-Related Packaged Application Market, 1998-2003



The “end-to-end” and “best-of-breed” approaches are not mutually exclusive. Some of the larger ERP companies are acquiring smaller players to fill the gaps in their “end-to-end” solutions, whereas others focus on developing interfaces at the front and back end of their ERP offerings.

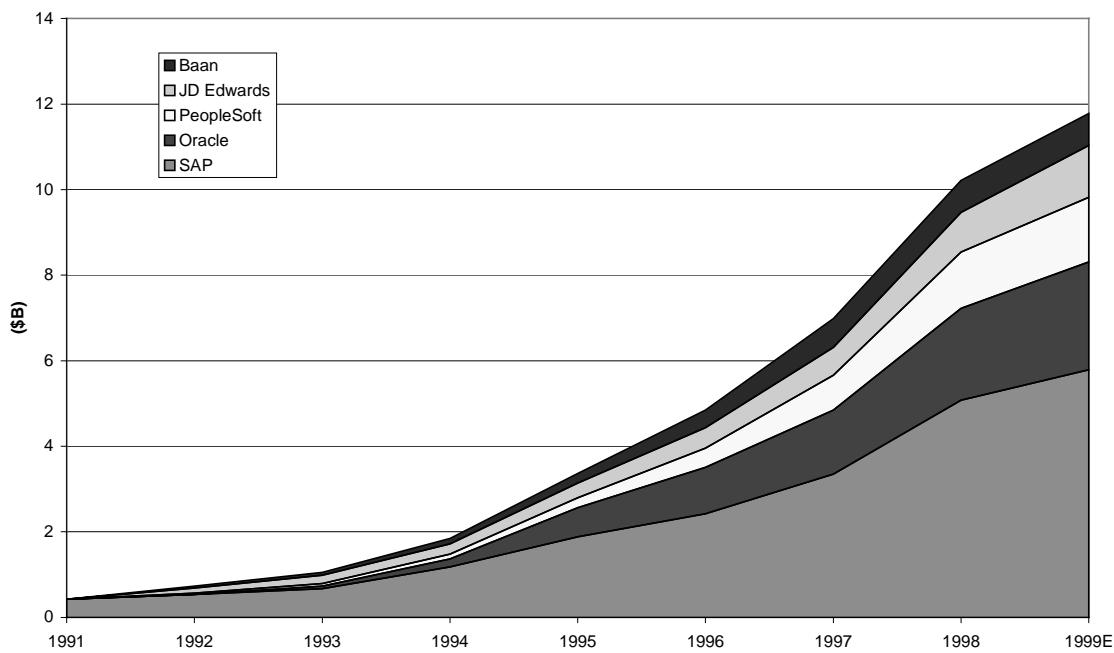
III. ERP Software Vendors

Throughout the nineties, SAP has been the ERP market leader with the four other JBOPS vendors rounding out the top five. Figure 3 shows total revenues of the top five ERP firms.⁹ These companies are briefly described below.

⁸ Source: Forrester Research reports.

⁹ Source: Company annual reports and author's analysis.

Figure 3: Sales of Major ERP Vendors



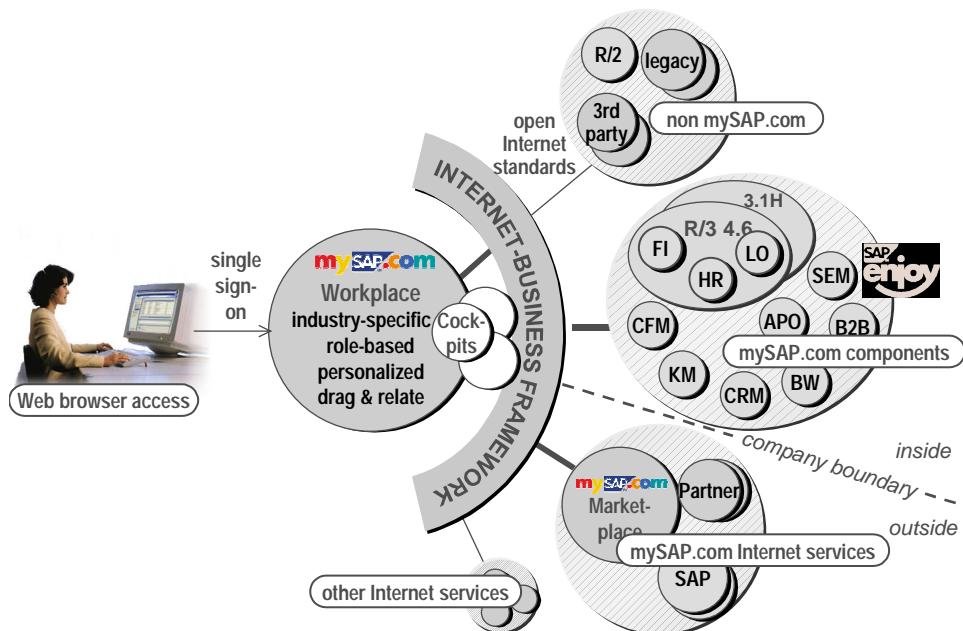
SAP AG: The leading ERP package vendor, with a 32% market share in 1999, is SAP AG (SAP stands for “Systeme, Anwendungen, und Prudukte in Datenverarbeitung” or Systems, Applications and Products in Data Processing). SAP AG was founded in Germany in 1972 by five engineers who wanted to produce integrated business application software for the manufacturing enterprise. Seven years later, the company launched its first enterprise software, R/2, which was designed around a centralized, mainframe-based database. SAP’s client/software product, R/3, was introduced in 1992 and quickly came to dominate the ERP software market.¹⁰ In 1999, SAP AG was the third-largest independent software vendor in the world, serving over 11,000 customers (with more than 20,000 installations) in over 100 countries.

Leveraging its leading position in the ERP market, SAP developed vertical, industry-specific business solutions for 19 industries. These industry “solution maps” provide functionality from SAP and its partners for complete, end-to-end industry-

¹⁰ The structure of SAP R/3 is discussed in the next Section.

specific processes.¹¹ SAP followed the lead of focused niche players, and in 1999 it extended its ERP offering to include customer relationship management, data warehousing and supply chain management modules. SAP recast its entire set of offerings around the Internet, borrowing the “business portal” concept (called mySAP.com Workplace in SAP parlance) to organize all information around the user’s role in the enterprise, and adding functionality for business-to-business and business-to-consumer electronic commerce. SAP started the mySAP.com Marketplace, an electronic inter-company trading community for buying, selling and collaborating within and across industries. SAP’s new Internet-centric approach is shown in Figure 4.

Figure 4: The SAP Business Portal: mySAP.com (source: SAP, 12/99).



Oracle: The heavyweight of the database software market, Silicon-Valley-based Oracle is the world’s second largest software company. It has built a solid enterprise applications

¹¹ Examples are SAP Automotive, SAP High-Tech, SAP Aerospace and Defense, SAP Banking, SAP Insurance, SAP Utilities etc.

business, which accounted for \$2.5 billion of the firm's \$9.3 billion 1999 revenues. Second to SAP in the enterprise software market, Oracle applications serve over 5,000 customers in 140 countries. Oracle has been a leader in refocusing its ERP solutions around the Internet, and it launched a barrage of electronic-commerce and Internet-based business-to-business software applications while the other JBOPS companies were slow to react to the changing marketplace. Further, Oracle was the first JBOPS company to integrate front-office applications with its ERP offering.

PeopleSoft: Started as a software firm for human resource management in 1987, Pleasanton-based PeopleSoft gradually expanded its software to cater to other corporate functions. The company's revenues grew to \$1.3 billion in 1998—up forty-fold from \$32 million in 1992 (sales are expected to remain flat in 1999). PeopleSoft's ERP system provides enterprise solutions for finance, materials management, distribution, supply chain planning, manufacturing and human resources. In 1996, PeopleSoft acquired Red Pepper, a producer of supply chain management software, and in 1999 it acquired Vantive for its customer relationship management offering.

J.D. Edwards: Founded in 1977 by three partners from an accounting firm, Denver-based J.D. Edwards addresses business processes in finance, manufacturing, distribution/logistics and human resources, and encompasses the entire supply chain from planning and scheduling through execution. Growing from \$120 million in revenues in 1992 to \$944 million in 1999, the software maker has served over 5,000 customers in over 100 countries. Its OneWorld system is considered to be more flexible than its competitors', and the company made headway in smaller enterprises. And, rather than build its own customer relationship management system, J.D. Edwards developed tight integration with Siebel's leading offering.

Baan: The Baan Company was founded in The Netherlands in 1978 making financial software. Baan's products have been simpler to use than SAP's, leading to the company's growth in the early nineties. Today, the company operates in 80 countries,

serving more than 2,800 customers. Baan's net revenues have increased from \$47 million in 1992 to \$736 million in 1998. The Baan Series is its primary enterprise system, which incorporates a variety of functionalities from sale order management and manufacturing to supply chain management. Since October of 1998, Baan suffered a series of setbacks including management turmoil, accounting irregularities, multiple-quarter losses and CEO turnover.¹²

Choosing the right ERP package is not easy. The selection process starts with an identification of system scope, business objectives and business processes. Some ERP packages provide better solutions in certain functional areas. For example, SAP began as manufacturing software and still excels along that dimension. Moreover, different ERP vendors have experience in different industries, and offer solutions that are geared to those industries. Figure 5 summarizes the recommendations of Benchmarking Partners' consultants on industries that are well-served by the different ERP packages.

Figure 5: ERP packages and the industries they serve

	Aerospace/ Defense	Automotive	Consumer Packaged Goods	Electronics	Industrial/ Manufacturing	Oil/Gas	Pharmaceuticals
Baan Series	•	•		•	•		
J.D. Edwards One World		•	•	•	•	•	•
Oracle Applications	•	•	•	•	•	•	•
PeopleSoft		•	•	•			
SAP R/3	•	•	•	•	•	•	•
% ERP Penetration	10-15	5-10	35+	40+	35	30	20

A major consideration in choosing a package involves the management style of the firm. Even the most flexible ERP packages are based on a model of doing business that may not align with the firm's desired business model. For example, Dell Computer

¹² Baan had four different CEOs over the two years from 1998 through 2000.

found that the SAP R/3 system it had licensed would not fit its highly decentralized management style. Time-to-implementation is another issue that might be critical, especially in light of the impeding Y2K date change. Technical issues ranging from the hardware platform that the ERP package will run on to the set of currencies and tax rules supported by the package need to be considered carefully, and the stability and future viability of the ERP vendor are becoming important considerations as well.

The implementation of ERP packages is a major effort. Licensing the package is only the beginning—ERP implementation costs include consulting, process redesign, data conversion, training, integration and testing. A Gemini Consulting survey of 220 companies in a wide range of industries found that the average SAP R/3 implementation effort consumed 141 person-months and cost \$7.5 million. While most companies surveyed were pleased with the outcome, many ERP implementations are problematic, characterized by cancelled or scaled-back projects, late deliveries, budgets overruns and hampered processes. Hershey Foods, the US largest candymaker, went live in July 1999 with a companywide \$112 ERP system¹³ that left many retailers empty-shelved. Hershey incurred significant losses when its order fulfillment problems could not be fixed in time for Halloween, then Christmas. Whirlpool switched to a new SAP platform over the 1999 Labor Day holiday; the combination of large order volumes and a software problem resulted in the loss of about 10% of orders entered to the system.

It can get worse. FoxMeyer Drug, once the fourth largest distributor of pharmaceuticals in the US, went out of business following its implementation of SAP. FoxMeyer bet its future on a massive SAP implementation projected to save \$40 million a year. After two-and-a-half years and more than \$100 million in costs, FoxMeyer could process less than 1/40 of its orders—with multiple problems. In August 1996, FoxMeyer, once a \$5 billion company, went bankrupt. FoxMeyer's bankruptcy trustee sued SAP AG and Andersen Consulting, the systems integrator in charge of the effort, for half a billion dollars each (both deny any misconduct).

¹³ The system included SAP R/3, Siebel and Manugistics software, which went live simultaneously throughout the company.

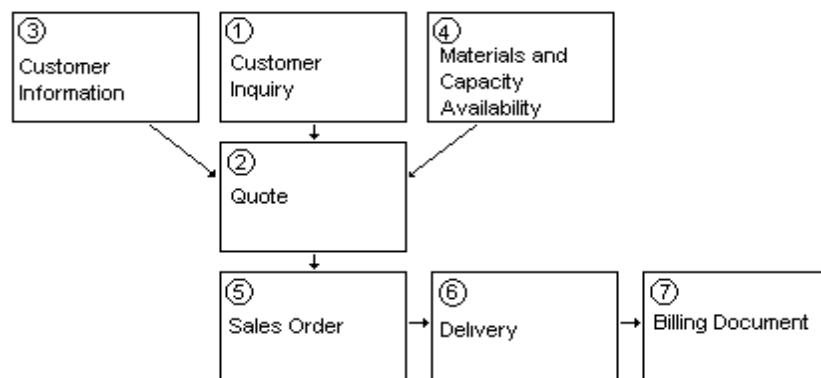
IV. The Leading ERP Package: SAP R/3

SAP R/3 is a general-purpose platform with options that enable it to be configured for the specific needs of each customer without changing the R/3 code. This does not mean that SAP R/3 is a plug-and-play solution. In order to implement SAP R/3, the system must be configured to specifically meet the organization's process requirements. This is a complex and lengthy process, which can take years to implement. The organization, the business process and all transaction details must be explicitly modeled and entered as settings in about 8,000 configuration tables.¹⁴ The user defines precisely her organizational units, processes, transactions, the different SAP R/3 screens, reports etc.

SAP R/3 consists of modules (discussed in detail below) that may be used separately or bundled together. This enterprise system has an open architecture that allows third-party solutions providing other functionality's to be "bolted on" to the SAP backbone. All the modules work in an integrated fashion, so different parts of the enterprise use the same data at the same time. The software can also link business processes between companies worldwide, for example between a supplier and a customer in different countries.

IV.1 Example: Integrated Order Process

Figure 6: SAP R/3 Order Process Stages



¹⁴ The tables have standard default settings, but companies typically need to change them, and each change has a ripple effect on other values and tables.

The SAP R/3 database integrates all data items, so entire processes use the same data, seamlessly passed from step to step. Consider, for example, how the order fulfillment process is managed by SAP R/3. As seen in Figure 6, when a customer inquires about a potential purchase (1), SAP R/3 creates a quote (2) including price and delivery date. The quote takes into account what the system already knows about the customer (3), about the item and about inventory and materials availability (4), which are in the SAP R/3 database. As a result, the prices, delivery times and delivery terms are based on up-to-date information and may be specific to a customer or an order. If the customer accepts the quote, SAP records a sales order (5), including pricing and delivery terms. The order then goes into production, triggering the entire order fulfillment process. SAP automatically sends the relevant data where it needs to go,¹⁵ so delivery can be automatically scheduled (6). The customer's credit limit can be automatically checked by the system, and the collection process can be managed through the system as well (7).

IV.2 SAP R/3 Modules¹⁶

SAP R/3 is composed of a number of modules that are fully coordinated and integrated.

The modules are:

SD - Sales and Distribution module supports sales and distribution processes, with functions for pricing, order processing and on-time delivery. It has a direct interface to the Materials Management (MM) and Production Planning (PP) modules described below. This enables an integrated process that involves checking customer credit, ensuring materials and production capacity are available to satisfy an order at the time it is placed, executing the order, and automating the billing process. This module also facilitates an analysis of sales and delivery performance using standard metrics that are defined within SAP R/3.

¹⁵ That is, to the SD module. See SAP R/3 module description below.

¹⁶ Readers not interested in SAP R/3 details may want to skip this Section.

MM - Materials Management module is designed to support the procurement process and to optimize the logistics pipeline within the enterprise. It enables automated supplier evaluation and can lower procurement and warehousing costs with accurate inventory and warehouse management, and integrates invoice verification. The module is designed to support foreign trade processing, such as customs declarations, as well. Tools for inventory control and purchasing information help to identify trends and developments.

PP - Production Planning module supports production planning, manufacturing processes execution, analysis and production control. This application covers the production process from the creation of master data to production planning, MRP, and capacity planning, right down to production control and costing. It supports a variety of manufacturing processes including repetitive, make-to-order and assemble-to-order production. Quality management, laboratory information systems and data analysis functions are also available.

FI - Financial Accounting module collects all the data relevant to financial accounting, from transactions to accounts, into an integrated General Ledger. It provides comprehensive, consolidated financial reports and ties together the different pieces of financial data, Accounts Payable, Accounts Receivable and Asset Management. It also provides an up-to-the-minute basis for enterprise-wide control and planning, giving a “snapshot” of the enterprise. The FI module supports international accounting standards such as GAAP and IAS.

CO - Controlling module includes a variety of planning and control tools for enterprise control systems, following a uniform system of reporting. It provides comprehensive reports to support most common cost-accounting problems, as well as the capability to put together additional reports.

TR - Treasury module is a comprehensive solution for financial/treasury management.

EC - Enterprise Controlling module continuously monitors metrics and performance indicators on the basis of specially prepared management information.

IM - Investment Management provides integrated management of investment projects. Projects are tracked from planning through execution to settlement, including pre-investment analysis and depreciation simulation.

PM - Plant Maintenance and Service Management module handles planning, control, and processing of scheduled maintenance, inspection, special maintenance, and service management.

QM - Quality Management module monitors, manages and tracks all processes relevant to quality assurance along the entire supply chain, coordinates inspection processing and initiates corrective measures.

PS - Project System module coordinates and controls all phases of a project, in direct cooperation with Purchasing and Controlling, from quotation to design and approval, to resource management and cost settlement.

The order process described above requires coordination between different modules of SAP — materials management (MM), production planning (PP) and financial accounting (FI), which are fully integrated and use the same data throughout the process.

IV.3 Linking SAP R/3 to Other Applications: BAPIs

SAP does not solve everything. For example, the firm's forecasting or customer relationship management processes may not be modeled within SAP. Where SAP does not provide a solution, it is possible to "bolt-on" another application to attain the required functionality.

SAP has an open, component-based architecture that enables integration with other applications. This architecture consists of two key elements:

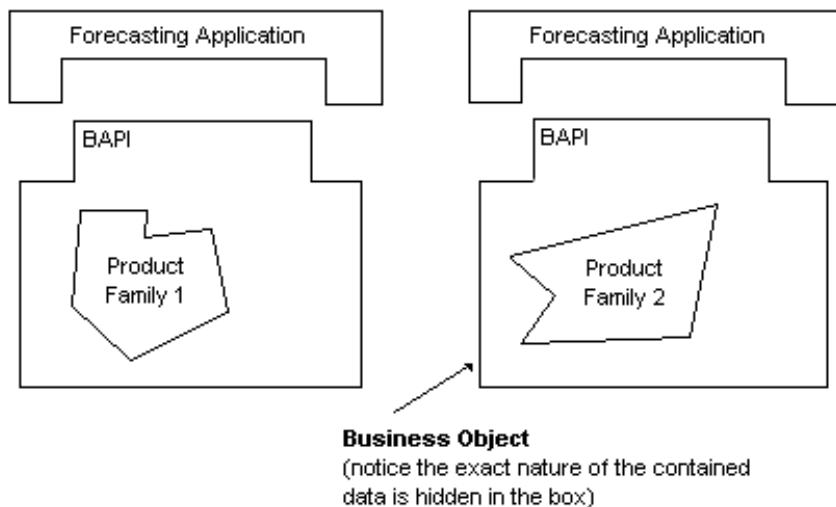
1. SAP Business Objects are essentially "black boxes" that contain SAP R/3 data

- and business processes, while suppressing the details of their data structure or specific implementation details, and
2. BAPIs (Business Application Programming Interfaces) define how the application links to SAP R/3. The result is a standard method of communication between SAP R/3 and other applications.

Business Objects are the business-application versions of real-world entities, such as a sales order or an employee. The core of the business object is the actual data (for instance, an employee's name and id number.) The interface is a set of clearly defined methods, each specifying what operations can be performed on this data (including the possibility of altering it).

A BAPI is a method of an SAP business object, which enables external access to SAP R/3 data and processes. Figure 7 illustrates how business objects and BAPIs function. For instance, if an application performs demand forecasting by exponential smoothing, the application can examine quantity demanded in the past, product by product, even if products have different data items.

Figure 7: Interfacing to SAP R/3



V. From ERP to E-Business

In the last decade, ERP software has exploded into the global business landscape. To remain competitive, companies must leverage their information assets across the entire enterprise, and ERP packages promise to provide the required enterprise-wide backbone. The unified framework provided by ERP packages and the business processes they support are the result of a balancing act between standardization and discipline on the one hand, and flexibility and agility on the other. This balance is being tipped by the increasing emphasis on front-end, customer-focussed applications, and by the growing importance of electronic commerce and inter-enterprise business networks. As a result, the traditional inward focus of the large, traditional ERP players had to change. Oracle's chief executive, Larry Ellison, put it bluntly as follows:

We blew it in the 1990s. By running applications on the client, client/server was meant to put information at your fingertips. But all we did was to create distributed complexity and fragmented data. CEOs have come to hate IT, because they can't get what they want from it. Burger King put an SQL Server database in every hamburger store, but they still couldn't answer the question, "how many Whoppers are we selling each day?" ERP as an industry missed the boat. It focused on automating processes, not on getting information to key decision-makers... So how do we do it now? We've learned from the Internet that you don't put shared applications on the client and that you centralize complexity. You consolidate your data. The unchanging appliance accesses the dynamic applications of the network.¹⁷

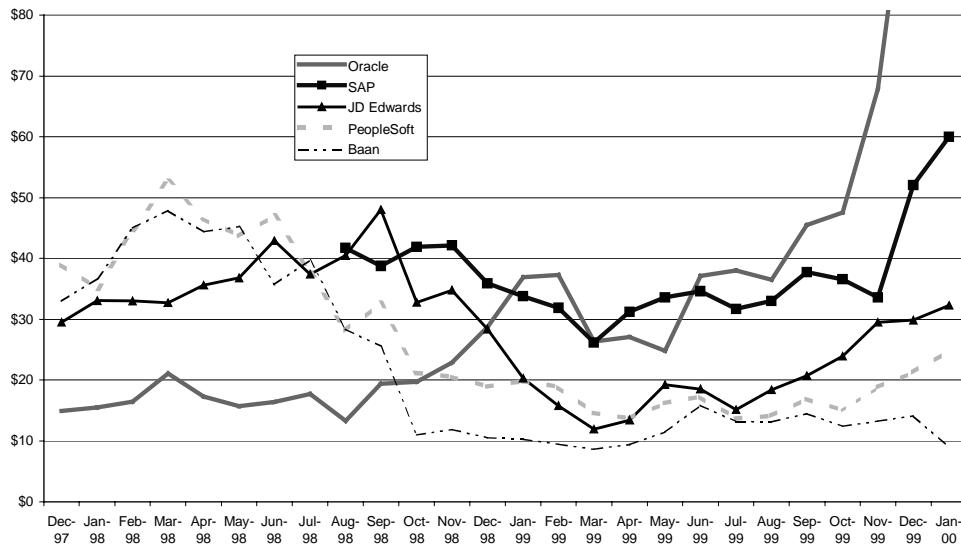
With the advent of E-Business, companies are using the Internet to make connections with their suppliers, customers and trading partners. This shifts the emphasis from the traditional internal focus of the ERP vendors to an external orientation, increasing the importance of both Business-to-Business and front-office applications, which have been traditionally "bolted on" to companies' ERP backbones. The fortunes of the leading ERP vendors changed along with the changing marketplace, and ERP package sales significantly slowed down in 1999 (see Figure 3).¹⁸ Over the last quarter of

¹⁷ Ellison's comments (*The Economist*, June 26, 1999) refer both to the leading ERP vendors and the Client/Server Computing paradigm they follow.

¹⁸ In addition to the shift from ERP to E-Business, the slowdown was caused by the maturation of the ERP market (by 1999, about half of the potential large-company ERP market had already been penetrated), as well as by the Y2K problem, which caused IT managers to shy away from major new installations.

1998 and for most of 1999, the stocks of traditional ERP vendors were in a tailspin, with the exception of Oracle¹⁹ (see Figure 8). By January 2000, an investment in the ERP companies in August 1998²⁰ would yield a gain of 44% for SAP and 678% for Oracle, compared to losses of 20% for JD Edwards, 11% for PeopleSoft and 68% for Baan (the S&P 500 Index gained 50% over the same period). The ERP package vendors promise to broaden their offerings to fulfill the promise of E-Business, but only time will tell whether they will manage to extend their architectures to satisfy the new demands—or whether today's ERP systems will become tomorrow's legacy systems.

Figure 8: Adjusted Stock Prices for ERP Vendors



¹⁹ Recall that only a fraction of Oracle's sales come from ERP and, further, Oracle correctly foresaw the increased importance of the Internet, front-line applications and business-to-business connections—and was the first to act.

²⁰ When SAP listed on the New York Stock Exchange.