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Abstract

Current Enterprise Resource Planning Systems (ERP) are used to track companies' finances, human resources, and logistics. Upcoming market-driven requirements focus on outside connectivity and up-to-date information supply, including business-to-business support, e-commerce, and virtual enterprises. How can these requirements be met by applying emerging information technologies? This paper focuses on future development of ERP systems emphasizing on technical aspects of information technology application as enabler. It briefly discusses existing research approaches and potential research and development issues.

Keywords: ERP, technology application, workflow, component ware, agents, multimedia, XML,

Introduction

Enterprise Resource Planning Systems integrate company's information concerning supply chains, customers, human resources, finance, and accounting. Functional capabilities of ERP systems are based on information technology and architectural options available during system implementation (Chan, 1999). Concepts for business solutions and information technology depend mutually on each other: Business concepts have to develop further applying options offered by new technologies. The upcoming internet applications for the e-commerce market evinces an impressing example for IT-driven business. Business requirements lead on the other hand to the development of new technologies. The development of database management systems for instance were driven by an ERP application, the bill of material processors. XML is an newer example for application-driven development. So ERP is both, IT-driven and IT-driving. The following paragraphs discuss some ERP-related IT developments, namely middleware technologies and the technology application for interorganizational integration, vertical integration and ERP implementation.

Middleware

The middleware sections discuss the technology application of component ware, agents, workflow management, browsers, multimedia, and virtual reality.

Component Ware

After developing large-scale, non-open, proprietary information systems in the past, the definition of interfaces like the Business Application Programming Interface (BAPI) of the R/3-system is an up to date way to overcome the border of heterogeneous application systems. Because of the necessity to combine best in class modules from different vendors (e.g. BAAN production module and the SAP R/3 finance module), the concept of predefined reusable components has been developed. Component and framework technology can be applied for combining vendors' software with individually programmed software (Braun et al., 1999; Mustafa and Mejabi, 1999; Sprott, 2000). Prototypal implementations have shown that components also enable a better support of interorganizational production planning systems (Braun and Möhle, 1998; Bohrer et al., 1998).

The extensible markup language (XML) is a basic enabler for ERP systems based on component ware. Object request broker architectures with interface definition languages are more powerful technologies to build application systems by combining components. The Enterprise JavaBeans technology supports an efficient intercompany communication (Fellner and Turowski, 1999).

Agent Technology

The technology of mobile agents has been developed for some years. Agents choose particular destination nodes dynamically, based on embedded mobility metadata to perform the required work. So they can provide a way for executable code, program state information, and other data to be transferred to the required host to carry out the necessary actions. An important feature of agents is the ability to negotiate autonomously to obtain an assigned target. First research prototypes of agent applications in ERP environments are implemented, e.g. decentralized capacity management to control supply and demand of individual capacity units with agents (Mertens et al., 1994; Jain et al., 1999; Kirn, 1999; Schnitzer et al., 1999; Zelewski and Siedentopf, 1999).

Java has several features that directly support the implementation of mobile agents. For example, agent mobility requires facilities that convert complex agent structures into a flat binary stream which is suitable for network transmission. The remote system on the receiving side must be able to reconstruct the agent. With Java's object serialization this conversion and reconstruction can be implemented transparently (Wong et al., 1999).

User Interface

System users accustoming to browser interfaces enforces the transition of existing business information systems, including ERP applications, into web applications. These systems present a HTML (Hypertext Markup Language) based interface for user transactions running the presentation tier and parts of the application tier within a web browser with a intuitive handling. A unified interface offers easy means for users to communicate with ERP applications and other applications inside and outside the enterprise. The borders between Intranet, Extranet and Internet, using all the same technologies, starting to get transparent for the user. By applying internet technologies in-house, companies realize a better internal communication and an easier access to information (Dunn and Varano, 1999). Formatted data stored in ERP databases can be linked by XML to heterogeneous kinds of information from various sources to enable an efficient knowledge management, e.g. material master data can be combined with documents referring information concerning that particular material master (Singh 1999).

Multimedia is a more enriched kind of information. Currently Multimedia technologies are common in the private consumer field for games. First serious and sophisticated multimedia applications are used in medical and engineering domains. In business applications multimedia is already used in sales domain to illustrate and advertise products to customers. In e-commerce solutions multimedia information facilitates the access to virtual marketplaces for different participants. Only multimedia integration to ERP databases allows the implementation of efficient business process: e.g. electronic product catalogues should be generated from ERP databases and multimedia information data sources by using internet technologies (Gaede and Schneeberger, 1998).

Due to high interactive and efficient communication qualities multimedia can also be gainfully applied within the industrial production. Photos or design drawings can be stored as a part of the materials master data and work schedules master data to enable figurative presentations of materials and production processes outside the CAD environment. Supervising the production process is another example for using multimedia in production. Production data collection can be enhanced with voice information, pictures, and videos. The documentation of the production processes with more than numerical and alphanumerical data is useful e.g. for quality assurance purposes and error analysis (Kurbel, 1994).

The concept of virtual reality is the most sophisticated user interface currently available. Virtual reality technology is scarcely applied in ERP systems up to now. First implementations support product development, sales promotion, and business process modeling (Leinenbach et al., 1999). By combining the Virtual Reality Modeling Language (VRML) with Java, 3D scenarios can be modeled and accessed across enterprise borders via networks. The well specified, openly available and portable languages can serve as building blocks of cyberspace (Brutzman, 1998).

Workflow Management

At present workflow management systems are mainly used for administrative tasks in office environments. They are only sporadically applied for supporting production processes, i.e. in sales order processing, product development, and quality inspection. More extensive approaches integrate workflow technology as a core mechanism to control process flow in information systems (Rosemann et al., 1999). Especially in ERP systems the workflow integration is beneficial: Work schedules are fundamental ERP data describing the manufacturing activities to produce the industrial output. Production control is based on this information. Work schedules are prestructured process descriptions with specifications of operations and assigned capacity units. Despite of their purpose of material-oriented output, work schedules have similar components as workflow definitions. Therefore it is expedient to treat both kinds of processes by same means. Production control on one side and workflow management of administrative tasks on the other side should be handled with the same system. Synergies can be obtain by combining the advantages of both domains. Workflow technology can benefit for instance from long practical and theoretical experiences of production management, e.g. implementing an organization for process descriptions like the work scheduling department. Integrating workflow technologies in ERP systems overcomes department boundaries between production control in the manufacturing areas and order processes in administrative areas of an enterprise (Loos, 1998). Applying interorganizational workflow technologies with mechanisms like capacity sharing, chained execution, subcontracting, case transfer and loosely coupled workflow offers means even to overcome enterprise boundaries, which is essential for supply chain management and process handling in virtual enterprises (van der Aalst, 2000).

Interorganizational Integration

Discussing interorganizational integration of ERP systems, technology applications for supply chain management, e-commerce, business-to-business, and virtual enterprise systems are focused.

From Data Interchange to Communication

Traditional electronic data interchange (EDI) based on protocols like EDIFACT requires dedicated software to translate and integrate business data. The view is usually focused on replacing paper based transfer by electronic data transfer. The data transfer is mostly made in a bilateral way or provided by expensive Value Added Network (VAN) services. Web information systems enable new forms of business and commerce. Web-based business

will not adapt existing business models and organizations any longer, but will invent fundamental new ones only realizable with a almost ubiquitous communication technology like the internet (Becker et al., 1998; Salam et al., 1999).

Compared with the restrictions of EDIFACT protocols, internet communication based on XML standards is more flexible and offers a better way to adjust technology support to business processes (Pawar and Driva, 2000). The predominating developing environment Java enables distributed applications in which two or more components are cooperatively operating over process boundaries. The simplest form of Java distributed computing are two Java applications passing data over a TCP/IP network connection. The more complex form is the exchange of Java objects (Morgenthal, 1998).

Technology Driven Business Models

Supply chain management requires the integration of vendors, distributors, resellers, and customers. Internet technology allows the participants in a supply web to publish information about their products, prices, and availability on the net. By replacing complex, expensive, and proprietary EDIFACT based solutions with simple, inexpensive, and open ones, the internet will be a marketplace for all participants (Tenenbaum, 1998).

New kinds of web-based services can be offered and the web is used to conduct business online instead of only selling products on the web. Extranets link the resources of a company to its customers, suppliers, and business partners. Web publishing is an important electronic communication tool and the web browser has become the universal interface for accessing business information. Distributed product development is another example for web technology deployment (Hameri and Nihtila, 1997).

Internet-based procurement is an attractive area of e-commerce in the business-to-business (B2B) sector. An example is the SAP B2B procurement component. It supports the procurement of indirect goods and services such as office supplies and travel services. Suppliers list their products in electronic catalogues. Beside the advantage of a quick and reliable conducting based on current information, this component offers additional information, e.g. availability inspection, and multimedial presentation. Such applications should facilitate the communication of business objects based on XML standards (Glushko, 1999; Klüber, 1999). XML increases flexibility and expandability because of its separation of syntax and content. As a result the integration of new business partners is easier than with a bilateral VAN based EDI solution (Segev et al., 1998; Senn 1998). Thus information technology has direct impact on operational business decisions (Weber 1999).

There are several architectures for electronic product catalogues in the procurement and sales area such as catalogues for every internet user, supplier catalogues for special users, mall provider offering market places, and inhouse catalogues using an intranet (Renner, 1999; Lincke and Schmid 1998). A new concept in the environment of e-commerce are virtual communities as a new distribution channel to contact the customers. Potential business partners can get information over a central web site using portal technology. Portals expand the product offer to more than one single supplier. Thereby integration of product catalogues and efficient search strategies are required (Glezer and Yadav, 1999).

Vertical integration

Vertical integration of ERP systems needs technologies that can consolidate data from operational applications and combines the information with external data sources. Data warehouse and data mining are applications for extracting information from databases of current ERP systems. As an example in the field of supply chain management, data warehousing allows customers to understand their supplier relationships by consolidating and classifying their purchasing data. To meet the requirements of extracting remote data like purchasing data from more than one source, warehousing over the web is a new form of analyzing this information (Scott, 1998; Weir, 2000). The term Total Information Solutions (TIS) expresses the necessity of integration of external data and internal data. These systems will enable businesses to monitor and collect data about external business conditions and extract business intelligence (Li, 1999). Extracting information about competitors and their changes in the suppliers' structure is an example for the importance of integrating external and internal information sources (Mertens, 1999).

Implementation

Implementing an ERP system needs to be prospectively managed because of the far-reaching changes ERP brings to companies (Bingi et al., 1999). Software vendors offer technical consulting services and implementation techniques to its customers, since installation and support of ERP systems requires a lot of experience and knowledge. To share the knowledge acquired from different consulting projects, case-based reasoning systems are applied. These systems use case bases to store problem specifications and their solutions, and query the case bases by using a similarity search algorithm (Luttermann and Pfeifer, 2000). To improve the automation of complex business processes, co-operative relations between intelligent agents and end users are implemented. Configuration tools are developed in research projects to support the setup of various user centric business scenarios. (Schinzer et al., 1999).

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