Recent Advances in Process-Driven Intranets and Extranets for Concurrent Engineering

Walt Scacchi
Fluor-Scacchi Associates
Newport Beach, CA 92663
Wscacchi@rcf.usc.edu

OVERVIEW

I will focus on addressing computational engineering processes as software components for concurrent engineering of complex systems. These components can be configured into an organizational process architecture that serves as a reusable framework for developing a CE information infrastructure. Process-driven Intranets then serve as a distributed development and run-time support environment for the framework.

PDIs can span organizational boundaries. Since PDIs in different organizations may be interconnected, then *process-driven extranets* can be created and deployed. PDIs and PDEs enable the design, integration, and enactment of *virtual enterprises for CE* When a community of virtual enterprises emerges and begins to support engineering transactions among these enterprises, then virtual markets can appear, as can different kinds of computational economies.

My experience leads me to believe that CEPs are viable components for CE. Furthermore, CEP components address an orthogonal set of issues compared to those addressed by other potential CE technologies such as CORBA/DCOM, EDI technical data transaction standards, Java, ActiveX and others. Subsequently, the potential value of CEPs can be assessed independent of choices made in using or evolving other CE technologies. Thus, CEPs merit consideration as a foundational software technology for enterprises interested in CE, while PDIs/PDEs merit consideration as the basis for developing and deploying CEPs within and across enterprises.

BACKGROUND

Let's start with the following observation: Many businesses in both the private and public sector are beginning to move the buying and selling of their products or services to wide-area networks. Consequently, the value of electronic commerce transactions over the World Wide Web is now forecast to grow beyond $300 billion within the next five years.

The largest share of this value is for business to business transactions conducted over extranets. Businesses will increasingly look for simple and effective ways to hook-up and integrate their information and workflow to facilitate interorganizational engineering processes. Extranets are Web-based information systems that support transactions between businesses using a wide-area network. As such, we want to understand what extranets can be, and how they can be put together to interconnect and support engineering processes between different businesses.

With this in mind, let's turn to review what's going on with CE to help see where extranets fit in.

What products and services are likely to be bought or sold over different wide-area networks? Perhaps to no surprise, computer system components and related items have become commodity products that are easily and frequently purchased over the Internet. Companies such as Dell are leading the way with Web-based PC sales. Companies such Kingston Technology in PC memory modules, Bay Networks and Cisco in network interface cards, hubs, routers and switches are exercising their Web sales channel. In contrast, companies with large sales forces, such as Compaq, IBM and HP are not likely in the near term to move into Web-based PC sales as a major product distribution channel. But all of these companies and others in the computer industry can be expected to expand their post-sales support and help-desk services using the Web. Perhaps these will evolve into significant revenue channels in the long term.

PC software upgrades such as those for Netscape and Microsoft Web browsers dominate low-cost/no-cost software purchases on the Web, while thousands of vendors for other PC software products are also exploiting Web sales or distribution channels. Thus selling and buying PC hardware and software has become a major force

0-7803-4778-1/98 $10.00 © 1998 IEEE

stimulating and driving the growth of Electronic Commerce on the Internet. Nonetheless, we can also expect growth in transaction volumes for products that are primarily information, such as books, newsletters, periodicals, software, and others to also help stimulate CE on the Internet.

Business-to-business engineering transactions for cooperative R&D projects will constitute an emerging market for CE over the Internet/WWW. However, the requisite software application componentry and infrastructure to facilitate this is unclear. For a variety of reasons, it seems that many heterogeneous technological solutions will be put forward as contenders. Therefore, businesses will seek to exercise autonomous choices that best serve their strategic interests when selecting software technologies to support their CE.

On the Internet, as well as on intranets and extranets, HTML is the language used for organizing the presentation of information. It is low-cost, simple to use (with modern content production tools), and benefits everyone who serves the Web. However, it is a flat, untyped formatting language. It is often a poor choice to define the structure, format, and layout of the technical data and information structure required for CE. The new XML document definition language is intended to supplant HTML as the preferred medium for presenting, soliciting, and capturing business transactions on the Web. XML will enable the migration of EDI conventions for defining engineering transaction documents into formats compatible with the Web and CE. This in turn should also stimulate the growth of CE on the Internet.

Engineering transactions are embodied in structured data types and documents. EDI and XML enable the definition of these materials in electronic or computer-processed media. Engineering processes create, store, update, or archive transactions using data type definitions and documents. Thus, it should be possible to imagine electronic engineering processes, or alternatively, computational engineering processes, that can create, store, update and archive CE transactions conducted over the Internet.

CEPs are engineering processes performed by people using process-based computing systems. CEPs specify a sequence of actions that different people perform using CAD/CAE/CAT support systems that consume their required inputs in order to produce the provided outputs. As such, CEPs can either automate low-level work steps like file transfers, or help to guide/support people performing more complex activities. This means CEPs are particularly helpful to people that may be new or unfamiliar with the details of what must be done to complete complex engineering transactions. CEPs thus hold the potential to amplify the skills of people at work. Beyond this, CEPs can also serve as a medium for capturing and refining how engineering processes are designed, reengineered or continuously improved.

CEPs are a kind of software componentry. These components can model, support and execute engineering process activities within an organization, such as purchasing or sales tasks. They can also interconnect and coordinate engineering processes across organizations to support inter-organizational workflow. CEPs can be specified using high level scripting languages (Java, Visual Basic, Tcl, Perl, etc.) [6] or proprietary systems designed for modeling and executing CEPs.

CEPs specify a control flow sequence of actions (or transactions) that different organizational actors perform using available application tools that consume their required inputs in order to produce the provided outputs. In addition, CEPs are internally represented as directed attributed graphs that can be externalized as semantic hypertext networks [1,3,2]. This enables navigational traversal that in turns provides a familiar mode of user interaction for browsing and enacting CEPs. Furthermore, using the capabilities of scripting languages to glue applications and tools together with their typed input and output allows CEPs to be interpreted (or executed) with computer support. Thus we find that essentially any computer-supported business can be specified and executed to some degree using CEPs.

CEPs link and integrate the products, people/roles, applications, heterogeneous information repositories and network-computing environment through an *organizational process architecture* [7,5]. An OPA serves as a conceptual and representational framework for specifying how individual CEPs can be configured and interconnected through their inputs, outputs, and other bindings [2,4]. As a framework, it is possible to compose appropriate CEPs that provide computer-based support for common engineering processes such as purchasing, accounts payable,

accounts, receivable, and other corporate financial operations [7]. Such a framework of CEPs may then be reused and specialized in different organizational settings. Thus, OPAs provide a foundation for organizing CEPs as reusable software components for integrating complex enterprises.

CPBs and OPAs are computational representations that can be interpreted. They also serve as prescriptive guidelines for how people in organizational settings perform their work. As such, we can characterize the kind of run-time environment that can support the development and execution of CEPs and OPAs. These are called process-directed intranets [8].

Companies like Action Technologies, FileNet, and Staffware are among those evolving their group-work, workflow or document management products to support business processes that can be delivered and performed through Web browsers. On the other hand, companies like Intelligent Systems Technology Inc. have already demonstrated support for CEPs using Java applets that can be deployed over the Web. Overall, this trend suggests that it will become possible to deliver and support CEPs using intranets or extranets. Further discussion of how CEPs may be employed and supported using Intranets can be found in the report [8].

PDIs denote a network of application and repository servers, data transformation mediators, and end-user clients (Web browsers, integrated tools, and helper applications) that traverse a distributed semantic hypertext [3,5]. PDIs in different organizational settings can be configured and interconnected to form process-directed extranets that realize virtual enterprises [4,5,8]. Thus, it is possible to rapidly prototype and engineer PDIs and VEs across their life cycle in a wide-area environment [7]. Similarly, PDIs and VEs can support the redesign and reengineering of complex business processes to which they are applied [8].

Beyond this, we can expect to see new Web-based service providers emerge that can interconnect processes from different external sources or vendors. This will enable the formation of *virtual enterprises*. VEs represent the composition of CEPs located in different firms that are brought together to provide value-added offerings that none of the CEPs can alone offer. This may often be used to support the provision of contracted services or engineering processes that interconnect a network of specialty sub-contractors. This seeks to maximize the financial and strategic benefits of partnering and alliances that can be supported through rapidly established sourcing arrangements. In a world where new ventures and new business units emerge to seize untapped market opportunities, the ability to negotiate and form VEs seems a promising direction for exploitation.

Extranets provide the basis for developing, operating and sustaining virtual enterprises. When extranets grow to be able to directly model and execute CEPs, then they are called process-driven extranets. Process-driven extranets represent an important new arena to develop, deploy, and support a new generation of engineering systems that will enable the largest share of CE between businesses over the next five years. PDEs thus represent a means for creating and enacting a New World of virtual enterprises for business to business CE.

Finally, CEPs, OPAs, PDIs, and VEs are software technologies that are essentially neutral to the choice made for lower-level software interoperability mechanisms and data definition standards. Technologies and standards such as CORBA/DCOM, Java, ActiveX, EDI technical data transaction standards and others are not necessary for CEPs. Alternatively, it is unclear whether these technologies and standards are necessary or sufficient for specifying or executing engineering processes in a coherent and tractable manner. However, these technologies and standards can be accommodated within CEP technology. In short, CEPs, OPAs, PDIs, and VEs can be developed and executed with or without the software technologies and standards noted above. Thus, it seems reasonable to posit and discuss how CEPs can serve as a foundational software technology for CE along side of the other technologies and standards that have been proposed so far.

REFERENCES

[1] P.K. Garg and W. Scacchi. ISHYS: Designing Intelligent Software Hypertext Systems. *IEEE Expert*, 4(3):52-63, 1989.

[2] P. Mi and W. Scacchi. A Meta-Model for Formulating Knowledge-Based Models of Software Development. *Decision Support Systems*, 17(3):313-330. 1996.

http://www.usc.edu/dept/ATRIUM/Papers/Process_Meta_Model.ps

[3] J. Noll and W. Scacchi. Integrating Heterogeneous Information Repositories: A Distributed Hypertext Approach, *Computer*, 24(12):38-45, December 1991. http://www.usc.edu/dept/ATRIUM/Papers/Distributed_Hypertext.ps

[4] J. Noll and W. Scacchi. Supporting Distributed Configuration Management in Virtual Enterprises. in *Software Configuration Management*, R. Conradi (ed.), Lecture Notes in Computer Science, Volume 1235, Springer-Verlag, New York. 142-160, 1997. http://www.usc.edu/dept/ATRIUM/Papers/DHT-SCM7.ps

[5] J. Noll and W. Scacchi. Supporting Software Development Projects in Virtual Enterprises. *Journal of Digital Information*, (revised version, to appear). http://www.usc.edu/dept/ATRIUM/Papers/DHT-VE97.html

[6] J. Ousterhout. Scripting: Higher-Level Programming for the 21st Century. *Computer*, 31(3):23-30, March 1998.

[7] W. Scacchi and P. Mi. Process Life Cycle Engineering: A Knowledge-Based Approach and Environment. *Intern. J. Intelligent Systems in Accounting, Finance, and Management*, 6(1):83-107, 1997. http://www.usc.edu/dept/ATRIUM/Papers/Process_Life_Cycle.html

[8] W. Scacchi and J. Noll, Process-Driven Intranets: Life-Cycle Support for Process Reengineering, *IEEE Internet Computing*, 1(5):42-49, September 1997. http://www.usc.edu/dept/ATRIUM/Papers/PDI.ps