Collaborative Innovation through Distributed Engineering Services

Mathias JOHANSON
Alkit Communications AB
Sallarängsbacken 2
SE-431 37 Mölndal, Sweden

and

Magnus LÖFSTRAND, Lennart KARLSSON
Division of Computer Aided Design
Luleå University of Technology
SE-971 87 Luleå, Sweden

ABSTRACT

Rapid advancement in information and communication technology in recent decades has presented new opportunities for carrying out sophisticated engineering work in distributed teams, using tools and techniques collectively referred to as Distributed Collaborative Engineering (DCE). This kind of on-line collaboration not only cuts costs due to reduced travel, but also fosters innovation in product development, by bringing together groups of people in collaborative teams with complementary competences, that would otherwise be difficult to realize. Moreover, the convergence of technologies for telecommunication and information technology now makes it possible for companies specialized in collaboration technology to deliver sophisticated services for DCE, which can be purchased by engineering companies on a pay-per-use basis. By outsourcing the installation, management and support of the collaboration tools, the engineering companies can focus on their product development projects while harnessing the full potential of DCE to become more efficient and competitive. We believe that this new way of conducting engineering work will be an important key to innovation in the future. In this paper, we analyze the requirements for delivering DCE as a service and describe the implications this has in terms of systems design, business models and competence requirements. Furthermore, in addition to the primary return on investment in DCE services, we cite cost reductions and reduced CO_2 emissions as further benefits.

Keywords: Distributed Engineering Services, Convergent Technologies, Engineering Innovation, Functional Products

1. INTRODUCTION

In order to be competitive in a globalized market, product development companies need to improve their efficiency by making use of geographically distributed resources, such as engineering staff, production facilities, consultants, suppliers, etc. A crucial challenge is to alleviate the negative effects of geographical distance by using sophisticated network-based collaboration tools. The main motivation is the need for increased collaboration in distributed teams beyond what is economically and ecologically feasible with travel or co-localization of resources; however, there are also other concerns, such as the need for reduced CO_2 emissions (resulting from excessive travel and suboptimal resource utilization) and improved social conditions for employees.

Another crucial challenge for product developers in a global environment is how to support customer influence in the design and development processes. Swift response to customer needs and flexibility in the production and development processes to accommodate for increased customization of products through open innovation [1] will be one key to success in the global competition. Moreover, the next-generation products will in many cases be a complex combination of hardware, software and services, constituting *functional products*. Design and development of such functional products will require an even wider range of skills and competencies, attainable only through close collaboration among several organizations in global partnerships. This will require improved tools and methods for distributed collaborative work throughout all phases of the product development process.

Although a considerable academic consensus exists regarding the need for increased distributed collaborative work, industrial practices in this area are still far behind the technological state of the art in collaborative work. A key reason for this is that the use and maintenance of the tools and infrastructure for distributed collaborative work have appeared to be much more complex than what was initially believed. Moreover, new modes of collaboration require changes in work processes and organizational structure; something which is inherently challenging.

In response to these challenges we propose a service-based model for distributed collaborative engineering, wherein a service provider takes full responsibility for delivering the hardware, software, network, technical support and maintenance of the system supporting the distributed work.

By providing the tools and concepts needed for efficient distributed collaborative engineering and design as a service and relieving the companies of the complex management of technology and big investments in technology and know-how, the threshold for getting started with distributed collaborative work is lowered. The return on investment becomes easier to quantify and the effects in terms of improved efficiency appear earlier, making it easier for the companies to take the decision to invest. Distributed collaborative work supported by computer-based tools and broadband computer networks enables collaboration across time zones. The opportunities for "round-the-clock" development, where the participants of a global team are distributed over two or more time zones, can lead to improved efficiency and reduced time to market. However, in order to be successful, this requires new work processes, with high demands on swift handovers of activities between team participants in different time zones.

If product development companies can reduce development time for taking the next generation products to the market, the economic benefits are huge. Particularly for large companies with distributed resources (personnel, production facilities, etc.) the opportunities for shortening development cycles through advanced technology for distributed collaborative work are significant. For smaller companies working in dynamic partnerships with other companies, distributed collaborative work can be an important enabling technology.

Recently, a new driving force for distributed collaborative work has appeared; namely, the widespread awareness of climatic change due to the greenhouse effect. Companies are beginning to realize that they need to limit their emissions of greenhouse gases resulting from excessive travel, not only for goodwill reasons, but also because political actions will be undertaken to force companies to limit their travel. Such limitations will make technology for distributed collaborative work even more desirable.

We believe that distributed collaborative work in general, and distributed engineering work in particular, present a huge potential for companies to be more competitive by utilizing geographically distributed competence and other resources while limiting their travel. However, a major obstacle in establishing distributed collaborative work environments at companies is that the required software, hardware and network services demand a lot of competence in terms of installation, administration and management. Engineering companies tend to be reluctant to invest in such complex technology if it cannot be justified economically in a very short term. Furthermore, many companies that have tried to implement distributed collaboration methodology in their organization have failed due to the complexity of operating the technology involved. In this paper, we propose development of tools and methods that enable lucrative sale of services for distributed collaborative work.

2. SERVICE-BASED DISTRIBUTED COLLABORATIVE ENGINEERING

We believe that a business model based on providing a *function* or a *service* instead of the hardware and software components themselves will be much more desirable from the customer's point of view. The provider of the distributed collaborative engineering service will have to take responsibility for a lot of different complex technological components and guarantee a well-functioning service, around the clock, 365 days a year (or as stipulated in the service level agreement). In order to undertake such a venture, companies specializing in computer software and methods for collaborative work will likely have to team up with one or more partners, perhaps a network operator and a hardware supplier. In forming such alliances, a number of interesting opportunities arise together with a number of non-trivial technological and business-oriented challenges that must be addressed.

At the division of Computer Aided Design (CAD) at Luleå University of Technology (LTU), research is being carried out concerning methods and tools for distance-spanning innovation and distributed collaborative engineering (DCE) in product development and education [2] and simulation-driven design [3, 4, 5]. Previous research at the Division of Computer Aided Design [6, 7] suggests that, because of the variety of challenges in functional product development, a scenario approach that gives the team members a similar starting point is desirable, based on user needs. Furthermore, three issues regarding tools and tool usage in distributed engineering have been identified:

- Which customers and customer scenarios are most relevant to support, given the requirements of developing DCE services and selling them as a function?
- Exploration of additional new simulation-driven methods and tools that facilitate other user needs than audio and video that may be used in early concept stages is beneficial. Such user needs include tools for design space exploration, i.e., to define the limitations that exist for the design team.
- Tolerances for problems related to the tool rather than to actual work decrease [8].

Another area of research is functional product development where development is focused on developing hardware and systems for optimized delivery of a function or a service [9, 10, 11].

3. RELATED WORK

Functional product development is a way to form what Nordström and Ridderstråle [12] call a total offer including both tangible and intangible assets, such as knowledge, financial offer, service deals, etc. Normann and Ramírez [13] argue that it is no longer possible to draw a distinct line between products and services, as all products include services vital for their value. Matear et al. [14] review the varying definitions of services and note that services may be characterized in many ways. Moreover, they identify that intangibility, inseparability, heterogeneity and perishability traditionally are used to distinguish services from physical products. Matear et al. further note that “other characteristics, which may be used to classify services, include the time and place of service delivery, the level of customization versus standardization [15], the role of technology in service delivery [16], durability [17] and the complexity of the assets needed [18].”

The characteristics of services as discussed by Matear and others above are interesting to analyze in the perspective of DCE services. DCE services are inherently intangible, inseparable, heterogeneous and perishable (in the sense of Matear et al.), the time and place of service delivery can be seen as “anytime, anyplace”, and the level of customization versus standardization can vary substantially depending on the type of collaborative work and other circumstances such as requirements further discussed in Section 4.

Current related product offers

The idea of providing advanced communication services, with a service-based business model is not entirely novel. For instance, HP markets a system known as HP Halo [19] that delivers high-quality videoconferencing for top management meetings. This product is provided (mainly) as a service wherein HP has complete responsibility for installation, management, support, network operations, etc. Similarly, Cisco Systems has a high-quality video-conferencing product known as Cisco TelePresence [20], which is marketed with more or less the same business model. These two products have two things in common: their target application is top management meetings (high-quality video and little more besides), and they are extremely expensive. In contrast, the distributed engineering service proposed here supports not only high-quality video, but also advanced shared visualization and data-sharing technologies. Moreover, we believe that it is possible to deliver these services with much less expensive hardware, using a software-based system running on ordinary PC workstations. Another difference is that we envision a “pay-per-use” business model, compared to the flat-rate pricing of HP and Cisco.

In contrast to the two high-end services from HP and Cisco, several companies offer less demanding services by providing software clients that the users install and manage. Such products include WebEx [21] and Adobe Connect [22]. These web-based services are much less expensive; but on the other hand, the service provider does not take full responsibility for the performance of the service; rather the customer will have to do a lot of installation, configuration, troubleshooting and so on by himself. Moreover, these services are not at all customized to the customer’s needs, but merely provide a general user interface for all collaborative tasks.

Service-oriented companies like IBM and SAP have also implemented work concerning distributed collaboration services. However, these efforts have yet to be developed more for synchronous engineering applications.

4. REQUIREMENTS FOR SERVICE-BASED DCE

In order to realize a system supporting distributed collaborative engineering based on the service-oriented approach described above, a number of technological, methodological and business-strategy issues need to be resolved. To do this, we have identified a number of requirements, based on discussions with potential end-users of the service-based DCE platform, and potential suppliers of DCE services.

Business-strategy requirements

Business and strategy considerations include:

- Systems management tools are required for monitoring the performance of the various components of the system in order to be able to respond to various possible technological problems with the network, computers, peripheral devices and software components.
- Which customers and customer scenarios are most relevant to support, given the requirements of developing DCE services for delivery of function?
- Is it necessary for the service provider to collaborate with other partners to be able to supply a total collaboration offer? If so, how should such a collaboration consortium be put together?
- Given the requirements of the new way of selling DCE products, a subsequent challenge is to develop and evaluate a set of customer and usage scenarios which the service provider (and a possible consortium) may support.
- Thereafter, it is necessary to develop metrics to quantify the benefits customers gain from using functional product DCE services, methods and technology.
- How should profit sharing be carried out within a possible consortium? Conceivably, it will depend on the customer and usage scenarios as well as on the degree of business risk accepted by each consortium partner.
- Which risk and profit considerations need to be made considering the possibility of a DCE service not delivering according to agreement?
- How can we ensure that selling a distance collaboration service does not negatively influence other potential business of the service provider?
- Given all of the points above and the technology-related challenges below, how should the business agreements be formulated in order to ensure a win-win situation for the service provider and the customers paying for a total distance collaboration service?

Technological requirements

When providing a collaboration environment as a service instead of individual hardware and software components, the design of the technological components themselves is affected. For instance, much more attention must be given to the reliability and fault-tolerance of the systems, since the supplier will be held responsible for the performance of the service. On the other hand, less attention might be devoted to user-friendly installation procedures, since the system will never be installed by the end-user. Some necessary technological developments that can be identified are given below.

- Systems management tools are required for monitoring the performance of the various components of the system in order to be able to respond to various technological problems with the network, computers, peripheral devices and software components.
- Automated quality assessment tools are required in order to provide the best possible service.
- Sophisticated online user support and helpdesk mechanisms are necessary, since the support is indeed part of the service being delivered.
- Traceability is an important feature, so that in case of malfunctions the provider can trace the cause of the fault to determine who is responsible. Trace logs

are also important for error detection, prediction and prevention.

- Information security mechanisms are very important in commercial engineering applications. Valuable confidential information must be protected from illicit eavesdropping, and the infrastructure must be protected from malicious attacks. This is especially important when a service-based business model is used, since the service provider will be held responsible in case the security is compromised.
- When a service provider is monitoring and managing the infrastructure used for the communication of sensitive data, it is vital that a relationship of trust exists between the customer and the operator.

From the requirements discussed above it is clear that realization of a total offer for distributed collaborative engineering, delivered based on a pay-per-use business model, is a non-trivial challenge that will require both technological and business related developments.

Competence requirements

When distributed engineering is delivered as a service, the organization carrying out the collaborative work does not need to maintain the competence associated with installation and management of software and hardware, network management, fault detection, etc, since this knowledge will now be supplied by the service provider. Instead, the engineering company can focus on building knowledge about how to collaborate efficiently in the field in which the company is active. This said, however, there will always be a need for some degree of competence overlap, since the customer must have at least a basic understanding of the technology upon which the service is based, and the service provider must have a general understanding of the collaborative work supported.

For the customer, the competence requirements concerning technology are likely to include a general system understanding in order to understand differences between true errors, which are to be reported to the service provider, and handling errors (which may for example be manifested through feedback and echo).

For the service provider, the technological competence requirements are more specific. The service provider must be able to monitor the system in use to deliver the agreed upon service regarding operational status. He should also be able to log what actions have been carried out on the hardware.

5. CONCLUSIONS

A successful realization of a distributed collaborative engineering service will make distributed work more attractive for engineering and design companies. This will stimulate collaboration between companies, which in itself will foster economic growth. Moreover, by alleviating or even eliminating the negative effects of geographical distance on inter-company collaboration, businesses in less densely populated regions and in remote areas, will stand a better chance of surviving the global competition. Thus, rural regions will benefit. Another effect is that SMEs that would otherwise be unable to compete for major orders due to lack of critical mass can take advantage of virtual networks and inter-organizational collaboration tools to compete with the big corporations.

When DCE is delivered as a service by a service provider that takes full responsibility for the performance of the software, hardware and network, the customer can devote full attention to the work at hand, in this case product development work. Focusing on the core business is generally a good way of improving efficiency, and we believe this to be true for DCE services as well. This opens up a field of opportunity for DCE service providers to do profitable business.

Although the greatest benefit of distributed collaborative work services for product development companies is the possibility of shortening development cycles through improved efficiency, we believe that investments in DCE services can be motivated solely from a cost reduction perspective, considering the savings possible when reducing the need to travel.

In addition to making it possible to lower the overall cost by trading travel for DCE, the latter alternative will make it easier for the customer to keep track of costs, since there will be a fixed price tag per hour of collaborative work, instead of a lot of different costs associated with travel, productivity loss due to jet-lag, etc. Moreover, as compared to travel, it is much easier to allocate the optimal amount of time for the collaborative work.

Reduced demand for travel also has other positive effects, such as reduced CO_2 footprint and reduced strain on professionals who travel. Moreover, by using DCE services, more people can be engaged directly in the collaborative work, and interpersonal interactions can be initiated more frequently than what is feasible if travel is required. In the long run, we believe that this will not only affect organizational structure, but will also foster innovation and improve the wellbeing of the people involved in the collaborative work. In this paper we have focused on distributed engineering work (typically product development), but we believe that much of the conclusions will also hold for other fields of work where there is a similar need for interpersonal communication and collaboration.

6. REFERENCES

[1] H. Chesbrough, **Open Innovation: The New Imperative for Creating and Profiting from Technology**, Harvard Business School Press, Boston, 2003.

[2] M. Löfstrand, M. Johansson, **User-driven design of a flexible distance education environment: rationale, lessons learned and future implications**, International Conference on Creating, Connecting and Collaborating through Computing, Poitiers, France, 2008.

[3] R. Sinha, C. Paredis, V. Liang, P.K. Khosla, **Modeling and simulation methods of engineering systems**, Journal of computing and information science in engineering 1, pp. 84-91, 2001.

[4] U. Sellgren, **Simulation driven design, -A functional view of the design process.**

Licentiate thesis. Royal institute of technology, Sweden, 1995.

[5] N. Bylund, **Simulation driven product development applied to car body design**, Doctoral thesis, Luleå University of technology, Sweden, 2004.

[6] M. Löfstrand, T. Larsson, L. Karlsson, **An activity based simulation approach to functional product development**, Challenges in collaborative engineering: CCE '06, Prag, Czech Republic, 2006.

[7] M. Löfstrand, **Functional Product Development Challenges Collaborative Working Environment Practices**, Special Issue of the Journal: International Journal of e-Collaboration, State of the Art and Future Challenges on Collaborative Design, 2008.

[8] K. Holtzblatt, S. Jones, **Contextual Inquiry: A Participatory Technique for System, Design**, Participatory Design: Principles and Practice, Hillsdale, New Jersey, 1993.

[9] T. Alonso-Rasgado, G. Thompson, B-O. Elfström, **The Design of Functional (Total Care) Products**, Journal of Engineering Design 15 (6): pp. 514-540, 2004.

[10] M. Löfstrand, T. Larsson, L. Karlsson, **Demands on Engineering Design Culture for Implementing Functional Products**, ICED 05, August 15-18, Melbourne, Australia, 2005.

[11] L. Karlsson, M. Löfstrand, A. Larsson, T. Larsson, P. Törlind, B-O. Elfström, O. Isaksson, **Information Driven Collaborative Engineering: Enabling Functional Product Innovatio,**. CCE05, April 13-15, Sopron, Hungary, 2005.

[12] K. A. Nordström, J. Ridderstråle, **Funky Business – talent makes capital dance**, BookHouse Publishing, Stockholm, Sweden, 1999.

[13] R. Normann, R. Ramírez, **Designing Interactive Strategy - From Value Chain to Value Constellation**, Wiley, U.K., 1994.

[14] S. Matear, B. Gray, T. Garrett, K. Deans, **Moderating Effects of Service Characteristics on the Sources of Competitive Advantage - Positional Advantage Relationship**, ANZMAC 2000 Visionary Marketing for the 21st Century: Facing the Challenge, 2000.

[15] C. Lovelock, S. Vandermerwe, B. Lewis **Services Marketing: A European Perspective**, Prentice Hall Europe, 1999.

[16] P.A. Dabholkar, **Technology-based service delivery**, Advances in Services Marketing and Management Research and Practice, T.A. Schwartz, D.E. Bowen and S.W. Browns, eds. JAI Press, 241-271, 1994.

[17] A. Wilson, **The Marketing of Professional Services**, London: McGraw Hill, 1992.

[18] S. Bharadwaj, P.R. Varadarajan, J. Fahy **Sustainable competitive advantage in service industries: a conceptual model and research propositions**, Journal of Marketing, 57, pp. 83-99, 1993.

[19] http://www.hp.com/halo, Accessed 2008-11-17.

[20] http://www.cisco.com/telepresence, Accessed 2008-11-17.

[21] http://www.webex.com, Accessed 2008-11-17.

[22] http://www.adobe.com/products/acrobatconnectpro, Accessed 2008-11-17.