E-WORK: ENABLING DISTRIBUTED TEAMWORKING FOR NEW PRODUCT DEVELOPMENT ACTIVITIES

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Abstract

The e-business “revolution” has generated many business opportunities. Much for current research and developments initiatives have primarily focused on the development of enabling technology, methods and standards to support buying and/or selling products and services over the Internet. It is now increasingly recognised that the next generation of e-business solutions need to support close, seamless and fluid collaborative work practices between partners within a value chain using the ubiquitous web technology. This has generated a “rush” to porting business operations and enabling technology to the “Internet”. This has led many solution providers to integrating their e-commerce and enterprise groupware solutions to support collaborative work. Based on an on-going research focusing on the support of virtual teamworking in dynamic organisations, this paper presents initial work on action research to understanding the NPD of in-vehicle telematics systems. The paper will present an action research to understand the general characterisation of change and its impact on virtual teamworking in NPD. This will be followed by a brief description of the NPD collaboration issues resulting from the case study findings. Finally the paper will conclude with a proposed e-work support system’s requirements.

1. The Age of Virtual Teamworking

It is generally recognised that modern manufacturing organisations need to adapt to the constantly changing business environments, technologies and customer requirements. The opportunities and threats presented by globalisation have increased the requirement of companies to improve their responsiveness to their evermore fragmented and sophisticated customer-base.

Over the recent years, many management and technological innovations have been adopted by manufacturing industry including; concurrent engineering and virtual enterprises. Many proponents of virtual enterprise approach have depicted the virtual enterprise as a response to the speed and globalisation Forbairst (1996), Goldman et al. (1995) and Skyrme (1996). The

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1 A value chain can be defined as an integrated demand and supply chain.
2 A virtual enterprise may be temporarily set up with the objective of making one particular type of product or delivering one particular type of service. When the market for that product or service declines, the virtual enterprise dissolves, its members finding new partners to pursue new opportunities.
adoption of the virtual enterprise approach is only now possible in view of the impressive improvement of the telematics technology enabling for instance, virtual teams to communicate and share information Browne et al. (1999). Many strategic drivers for the adoption of a virtual organisation model include;

- Sharing infrastructure, R&D, risk, and costs is an important potential benefit as it enables smaller organisations to become an active participant in the increasingly complex and expensive research required for New Product Development.
- Linking complementary core competencies by collaborating more effectively allows an organisation to retain their independence and continue to develop their core competencies.
- Reducing concept to cash time through sharing of specialised resources. Access to a wide range of specialist resources allows companies to reduce the time to get an idea to market. This is increasingly important as organisations are facing increasing global competition and therefore need to develop ideas as quickly as possible to gain a business advantage.
- Increasing facilities and apparent size of an organisation. Virtual organisations allow companies to present a unified face to large corporate buyers which enables companies to access markets, which they would have struggled to break into previously.
- Increase the flexibility of the organisation. A virtual organisation will allow the enterprise to be re-shaped and change its members according to the project or task in hand. As the pressures increase on organisations to diversify it’s product range increase this increased flexibility will become increasingly important.

However, the virtual enterprises approach has its own hurdles to overcome including;

- The potential dangers posed by staff isolation. Supporters of this view include Jackson (1999) who has suggested that virtual teams that never meet face to face may not be the ideal arrangement for product development due to the absence of frequent and rich interaction as well as the requirement for high levels of trust within the team.
- Security risks to participating organisations. Having a distributed virtual enterprise leads to a requirement to assess carefully the security risks of distributed workers. This is obviously vitally important for companies involved in highly sensitive New Product Developments.
- Fears and feuds in distributed working environments. The effect of having members of teams in differing locations, time zones and cultural backgrounds generates difficult group dynamics. This may possibly lead to problems, which will ultimately affect the performance of the group.

Despite these recognised hurdles, a recent DTI (1999) report emphasises the need for UK companies to adopt R&D best practices, in that, they will have to seek out knowledge developed elsewhere in the world, and form R&D partnerships to develop innovative products and services. This will have to be underpinned by the virtual teamworking and digital technology.
This paper outlines results of a preliminary work to develop a process map of distributed engineering design (e-work) prior to software implementation. To end, an industrial case-study of In-Vehicle Telematics Systems (IVTS) product development has been used. The paper will briefly present our research methodology and approach for process modelling, together with an early software prototype of an integrated development environment for IVTS. This will be followed by a set of requirements for distributed e-work.

2. A Review of current Enterprise Groupware Technology

Groupware has developed out of the discipline of Computer Supported Cooperative Work (CSCW) since the mid 1980s. CSCW is a multi-disciplinary field of drawing from psychology, sociology, management and computer sciences.

The market for Groupware was worth over $3,000,000,000 in 1997 and is expected to grow considerably in the future as organisations seek to achieve the perceived benefits that closer collaboration between individuals / teams / organisations is seen to deliver.

Groupware itself typically consists of a set of “foundation technologies” including:

- Multimedia Document Management
- Asset sharing including; data, information and knowledge sharing
- Workflow
- Email
- Conferencing
- Scheduling

There are a number of problems with current Groupware applications, which have been identified as seriously hindering the adoption of collaborative technologies:

- Specialised solutions for specific problems
- Lack of flexibility
- Limited Integration between Groupware applications
- Need for migration to the Internet protocols

Blythin et al. (1997) when discussing the evaluation of Groupware implementations suggests that even after a number of years’ experience in projects involving the use of Groupware it still remains difficult to reach any simple conclusions as to their “success” in a commercial context. The above problems are affecting organisations adopting Groupware in view of:

- Specialised solutions to specific problems do not adequately take account of the increasing requirement for ever rapidly developing/dissolving collaborations between organisations.
- A lack of flexibility in Groupware applications often means that users have to follow rigid steps in terms of using the software, which may ultimately lead to frustration as well as lowering productivity levels.

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3 In the next section of this paper we document the findings of a case study into the development of an In-Vehicle Telematics Systems (IVTS). This case-study has enabled us to document the multi-layered approach which needs to be taken in the development of an e-work solution to the New Product Development problem.
• A lack of integration between Groupware applications lowers team productivity if they are involved in multiple projects, teams etc.
• The migration to the use of internet protocols has brought about the potential danger of legacy data / systems for Groupware users

To cater for virtual team’s diversity of their adopted working practices, dynamic organisational structuring and technology, Groupware solutions need to facilitate a “user-friendly” customisation to adaptation to changes in user requirements, technology and standards. This long-standing goal is furthered by the “dot.com rush” -- to exploiting the business potential of the ubiquitous World Wide Web technology, which has generated a plethora of often-embryonic technologies.

3. Research Methodology

In a research attempt to understand business process changes and information requirements for virtual teamworking, we conducted a case-study to model distributed design processes, information flow, and enabling technology requirements. A mix-mode of action research and retrospective modelling and analysis of completed projects was used to understand;

• NPD process map – defining the stages and interactions involved from first ideas to completion of design.
• Roles and actors – defining the roles, responsibility of actors (designer) involved in an NPD process.
• Resources – defining required resources management including; documents, specifications, CAD diagrams and software access control and distribution.
• Changes – defining process, technology and resources changes and their impact on the process.

4. Distributed Design Scenario

“In-Vehicle Telematics Systems” (IVTS) can be considered as a sub-set of in-vehicle systems that combine both telecommunications and information technologies to support for instance; driver’s information systems, vehicle navigation and tracking systems, and collision avoidance systems. Examples of IVTS can range from a Global Positioning System (GPS) or remote engine diagnosis system, right up to a complex network information system complete with a voice recognition system, which may be used to send and receive e-mail and text messages and access the Internet.

IVTS product development is a multi-disciplinary process, and often requires close collaboration of many organisations. This domain presented an interesting case-study to model distributed product development activities.

This section will present a brief description of process modelling techniques used for this study.

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4 Such an activity often requires contributions from several design perspectives including; industrial design, software and hardware design, systems integration, telecommunications and manufacturing
4.1 Process Understanding

The Role Activity Diagram (RAD) notation provides a flexible approach to model complex hierarchical business processes and workflow. A full description of the RAD is beyond the scope of this paper. The RAD was applied here to model the design process as hierarchical collaborative activities – defining the roles (functions or actors) associated with a given design process, together with all the activities, and decisions they have to undertake to achieve specified goals. Figure 1 illustrates a simplified NPD process map of the detailed design phase.

Quick reference card for the RAD notation

![Quick reference card for the RAD notation](image-url)

Figure 1 (Ould 1995)
4.2 Data Requirements Analysis
In view of the complexity of the design process, it was required to employ many modelling approaches including a viewpoint-oriented modelling approach, which was adopted to define the resources (design data and information) required by different designers. This provides the organisation of design and process data in terms of views. For the purpose of this paper, Figure 2 illustrates these views using the analogy of the protocol stack from the OSI 7 layer model, in which the lowest level or view (Physical layer) is concerned with physical entities and the highest level or view is concerned with the more abstract concepts.

OSI 7 Layer Model | IVTS Design Layers
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Application layer | HCI / ergonomics design layer
Data link layer | Electrical / electronic design layer
Physical layer | Mechanical design layer

Figure 2 OSI 7 / IVTS Layer Analogy

4.3 A Framework for In-vehicle Telematics Systems Design
In line with current product development best practice, the study indicated that IVTS development is primarily a configuration management problem, in which “off-the-shelf” components are configured to produce a required system.

Figure 3 describes the overall architecture of a software prototype, which was developed to support the generation of IVTS solutions. The prototype system provides a graphical user interfaces to a collection of software modules and applications.
Below is a brief description of the main elements of the system.

- **Design Configuration Manager**: enables the generation of IVTS design solution and models, which could be used by other analysis tools. (Fig. 4)
- **Design Catalogue**: contains IVTS sub-component information, data and design resources. This acts as a server for the design configuration system (Fig. 5)
5. NPD Collaboration Issues Resulting From The Case Study

Throughout the development and trial of this framework and its application to a “real” design problem, several issues were raised, which provided an insight into how our framework may be further developed and extended to support a collaborative design process spread across different enterprises. We consider each of these issues further below and offer suggestions to provide a collaborative approach to IVTS design.

- **Design Resources**: As remarked previously, the design of IVTS is largely a configuration management problem and as such it is reliant upon a combination of sub-components, which are both compatible and taken together fulfill the requirements of the system. In order to carry out the configuration, the designer requires design resources as well as the more “static” component data. These resources may occur as models, simulations and even animations. In a multi-enterprise project, both sub-components and their design resources are likely to be Internet resources. The integration of sub-components and their design resources can be achieved by adopting an object model and if they are to occur as Internet resources then CORBA technology may possibly prove useful.

- **Design Decisions**: The choice of the optimum design solution is an activity, which is best not carried out in isolation - indeed it should be a group-based activity. This calls for the use of Groupware products, which allow designers to collaborate and work as a group in choosing the best design. Several products are available to facilitate group work, such as Lotus Notes and GroupSystems. However, for these
products to be of use, they must be integrated into the design framework, which they are intended to serve.

- **Design Management:** The design process is likely to result in several design variants and each variant will undergo incremental change as it is developed. This calls for a design management system, which can track and control changes and present each collaborative designer with an up-to-date version of any design variant. This requirement can be met through the use of a version control system, such as the Concurrent Version Control System (CVS), but such a version control system will only prove effective if it is integrated into the design framework so that it can be used, with ease, by the designers.

In summary, we have mentioned our IVTS design framework and commented on how the framework could be improved to support a collaborative design process.

### 5.1 Requirements for Effective E-Work Collaboration for New Product Design

As well as the specific requirements needed to develop the IDE package into a multi-user system there are also a number of generic issues, which must be addressed, if virtual design teams are to become a business reality;

- **A Requirement for organisational change:** There are numerous definitions of cooperative systems. Ramage suggested that one such definition is “a combination of technology, people and organisations that facilitates the communication and coordination necessary for a group to effectively work together in the pursuit of a shared goal, and to achieve gain for all its members.” Ramage, (1996), P5. An important aspect to this definition is the fact that people and organisation structure plays as an important part in a cooperative system as the technology itself. We should not concentrate on the technical aspects of virtual teamworking at the expense of business / organisation aspects.

- **Adapting To Changing Circumstances:** Oriezy has described self adaptive software as “it modifies its own behaviour in response to changes in the environment. By operating environment, we mean anything observable by the software system, such as end-user input, external hardware devices and sensors, or program instrumentation.” Oriezy et al., (1999), P55.

- **One of the weaknesses of existing Groupware is the fact that it does not adapt to it’s operating environment.** Could adaptive software with the capability to understand the requirements of the users in terms of user interface, information requirements etc. help to solve the problems associated with Groupware ?.

- **If the rapidly responding virtual team / organisation is to become a commercial reality the software needs to able to reflect changes in the environment by using adaptive techniques.** The Distributed Centre for Excellence in Software Engineering (DiCE 1999) has suggested a number of ways this software may be developed in the future.

- **Overcoming the effects of information starvation / overload:** A successful virtual team must find the correct balance between information starvation and information overload. It is argued that the efficient transfer of data in not enough and that
volume and pace that information is exchanged will overwhelm people. Chan et al. (1999) suggests that this is especially true when the information exchange is across organisational boundaries. Taleb-Bendiab et al. (2000) has also found that information overload has negative effects on project quality and lead-time. One potential solution emerging from this problem may well be based on providing a “just in time” information system and may well require an adaptive software approach.

- Weaknesses in the Web: The web would be an ideal solution to developing the industrial case study into a true collaborative NPD package for a number of reasons, which have been defined by Reiff (Reiff);
  - Inexpensive
  - Simple and adaptable interface
  - Unrivaled Distribution
  - Cross-Platform capability

However work by Fielding et al. (1998) suggests there are still a number of enabling technologies, which are missing from today’s web architecture for large-scale collaboration including:

- Links as first class objects and a client architecture for hypermedia communication between viewers of a multitude of data formats
- Component-based client architecture with hypermedia workspace manager and data-specific handlers
- Versioning of resources
- Remote locking, linking and access control

6. Conclusions and Further Work

The experience of the case study has been invaluable in terms of understanding the nature of the design process. Without this understanding it would be impossible to move to the development of the virtual design team.

The value of virtual teams for New Product development is in itself a matter of some debate. Recent reports produced by companies such as the Aberdeen Group (2000) suggest that Collaborative Product Commerce (CPC) is the next business solution that will increase market dominance.

Despite the many obstacles, which presently exist hindering the true collaborative NPD, the potential gains mean that overcoming these obstacles is of paramount importance for the modern organisation.

Our related research has considered the process of designing IVTS and more particularly the provision of support tools in the form of a design framework, which will complement the design process. The scope of this project meant that it was developed initially for single users. However, we hope that in the future this can be extended to allow dispersed organisations to participate in the design process.
References


Ould, M.A., 1995, Business Processes: Modelling And Analysis For Re-engineering And Improvement, Cichester: John Willey and Sons.


