VIRTUAL ENGINEERING TEAMS: STRATEGY AND IMPLEMENTATION

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Lars Line, Assistant Professor
Agder College. Affiliated to Program on Applied Coordination Technology at the Norwegian University of Science and Technology in Trondheim
email: lars.line@hia.no , http://www.pakt.ntnu.no/~ll/

SUMMARY*: A medium-sized and distributed (16 regional offices) Norwegian engineering company (ASPLAN-VIAK) has started a transformation to exploit the potential of digital information and communication technology for organising knowledge work in new modes. The effort does not only challenge technology, but also organisational systems and social constructs. The paper discusses a philosophical, technological and social context for a full-scale experiment, and also summarises some experiences. The study indicates that virtual teams are becoming an interesting and viable way of organising knowledge work. The author believes that virtual teams will be a common and natural organisational form for companies who wants to be part of the open information society.*

KEYWORDS: *Virtual Engineering Teams, Knowledge Work, and Co-ordination*

1. INTRODUCTION

It is commonly believed that technological developments will provide a digital environment for collaboration in virtual groups, leading to new ways of conducting projects. However, current solutions are still relatively complex, inflexible, unintelligent and support only low bandwidth communication. Despite the above-mentioned shortcomings of current solutions, commercially available technologies already offer a variety of functions. For companies that consider virtual groups as a mean of value creation, this study indicates that there is no reason to wait for the advent of more sophisticated tools and technologies. Personal computers, local and wide area network technology are more than adequate to support considerable virtual teamwork.

It is well known that engineers were among the first to utilise computers. At first computers were used for advanced calculations and analyses. Today we have tools to assist us with almost any task and most engineers produce their own reports and drawings by means of a computer. The use of computers and networks as a medium for communication is yet not common. Table 1 illustrates this history (based on personal experiences) and the conceivable future based on the extrapolation of current trends.

A question could be asked: "to what extent can we utilise experiences from the ‘tool revolution’ to meet the ‘communication revolution’, which represents a paradigm shift? The immediate reflection is that we will overestimate the importance of technology, process automation and workflow support. Social scientists has coined the word "*technology determinism*" as an expression of the naive belief that all problems are technical, and technology is the solution to all problems (Andersen, 1995). The core of virtual teamwork is communication, and communication is not a technical matter but a social and organisational one. We expect team members to work close together and develop social and professional relations even if they are not physically co-located. The author believes that communication technology will not replace social proximity and this type of proximity will still be needed to establish trust and confidence in social, face-to-face surroundings. On the other hand, communication technology is the key enabler for virtual teamwork. It becomes imperative to take a cross-disciplinary approach, without underestimating neither technical nor social issues.

Virtual teamwork challenges the disadvantage imposed by physical distance. Solutions must be found within the available economical and technological boundaries and we must balance the effort between technological and social issues.

	1985	1996	2000+
Source of Information	Customers Colleagues Product catalogues Books, articles and journals Skills and knowledge	Customers Colleagues Product catalogues Books, articles and journals Skills and knowledge	Customers Colleagues Network Skills and knowledge
Equipment	Calculator Drawing board	PC and software LAN	Multimedia, portable computer or network computers. Global network
Methods	Manual calculations and drawings	Automated and semi-automated computer calculations. Computer drawing and modelling	Modelling and simulations
Media for communication	Face- to- face Telephone Paper (drawings and documents)	Face- to -face Telephone Paper (drawings and documents) Data files	Face- to- face. Multimedia network
Information items	Paper (drawings and documents)	Paper (drawings and documents) Data files	Data Models Multimedia, compound documents

Table 1: Engineering with Computers

This paper describes a strategy for companies who want to organise virtual teams. The last part of this paper describes how a Norwegian engineering company has adopted the strategy with 300 employees located throughout 16 regional offices.

2. A STRATEGY FOR VIRTUAL TEAMWORK

The following basic elements are used as a framework for presenting and discussing the virtual teaming strategy:

- Rationale - why and what;
- Infrastructure - a house of information services;
- Work structure - a project information model;
- Competence - coaching and continuous learning;
- Empowerment - an open philosophy for collaboration.

To summarise these points, the explicit formulation, understanding and acceptance of the rationale are imperative for motivation and guidance. The rationale has to be discussed and understood not only at the executive level but also at the group and personal level (‘what’s in this for me’).

Computers as a medium for communication and co-operation are a rather new area, flooded by systems and services and new concepts. The presented house of services is intended as guidance for a basic infrastructure to support virtual teaming.

The project information model is an aid to highlight barriers for both formal and informal communication.

Coaching and training are always important to change processes. Competence is included as a separate point in the strategy in order to emphasis its importance. Change is not only to learn a new tool for doing the old job, but also to learn new ways of working and to test new supporting tools. Another important aspect is how to utilise the new services to support the learning process. The change is not temporary , it is becoming permanent.

Finally, empowerment, elimination of boundaries, and trust are basic factors for true teamwork.

2.1 Rationale - why and what

A rationale for implementation should be established at the start of the project since virtual teamwork in the first place will impose extra cost and inconvenience compared to co-located teams. The involved persons should know why they are using this process or methodology and what the company wants to accomplish. The rationale has to be discussed and understood not only at the executive level but also at the group and personal level.

The executive level rationale is the overall or strategic reason why the company wants to organise work in virtual teams. To ensure resources and support during implementation, the rationale should be discussed and committed to by the management.

The rationale presented below is taken from the case company. The company strategy contains four objectives where the ability to conduct projects using virtual teams is stressed.

Acquisition and dissemination of competence: The product of a consulting firm is competence and the capability to apply their competence to provide solutions for and add value to customers. The ability to develop and disseminate new knowledge is therefore crucial. Virtual teamwork is considered as a central arena for this process.

Capacity; Virtual teams is a way of increasing the capacity of a company and thereby enable the company to take on larger (and possibly more advanced and better paid) projects.

Extended area of service: Extend the market by enabling all regional offices to take on projects requiring expert knowledge only available in other offices. To be part of a larger professional and resource network is important to attain this objective.

Resources: The workload in any office varies over time and is often out of phase among the offices of an engineering practice. Virtual teams could be an option to balance workload over time.

The rationale at group (discipline, office or project) and personal level is likely to be expressed in a different wording and may very well be in conflict with the overall rationale. These «lower level» rationales must be identified, argued and negotiated or at least considered when projects are started. For illustration, some positive and negative group and personal rationales from the case study are quoted:

> *"Successful completion of this project will show that I can be part of a team even if I m not co-located with the rest and give me an opportunity for several new and interesting assignments."*
>
> *"I don t trust the architects at that office, they ve let me down before."*
>
> *"We won t give away that part of the project. It s an opportunity for us to gain experience and be able to offer that kind of services."*

2.2 Infrastructure; a house of information services

The "House of Services" is a way of putting technology together to form an infrastructure for virtual teamwork. Most engineers know how to set up a traditional office or engineering environment. Networked computers as a medium for communication and collaboration is a novel and not comprehended concept by most engineers. The information technology (IT) vendors offer a continuous flow of bits and pieces of hardware and software but it has been found experientially in this case study that they are of little assistance in creating a working, digital environment tailored to the needs of virtual teamwork.

Even the Computer-Supported Cooperative Work (CSCW) literature does not provide much support, because the majority of research have been focused on specialities like "collaborative writing", "work flow support", video conferencing or group decision systems.

The House of Services described below is based on experience gained from the case study and is targeted at a

small to medium sized (SME) engineering or consulting company. The focus is on services that are important to virtual teamwork. The proposed approach is not the final solution, but more a starting point for developing a digital environment where we can move in and start virtual teamwork.

Engineers are basically *information* workers. Engineers collect and process information and produce new information as basis for decisions. In the process they are constantly in interplay with other professionals. Engineers receive and convey information and knowledge and use a wide range of theories, methods, tools, and services.

The House of Services is a way of relating the set of project needs to a set of available information services, where we feel professionally comfortable and efficient. The composition and use of these services are based on our physical environment, available resources, competence, physical distance and the organisational and human relations to those with whom we interplay. If we alter some of these conditions, we will try to adapt to the new situation and change the range of services.

The difference between virtual teams and co-located teams is the "distance factor" between team members. One attribute of the distance factor is the speed by which we can exchange physical (information) objects. An obvious answer to providing physical information is to exchange digital information. This will impose new technical difficulties that must be solved in the available services.

The second "attribute" of the distance factor is the complexity of the data: creative, deep and rich communication requires common and convenient access to broadband aids for representing information, like drawings and white boards. In the digital world, we need both substitutes as well as new types of services to support this kind of communication.

The last, but perhaps most important "attribute" of the distance factor is the quality of the communication pipeline: we must reduce the possibility of errors while maintaining the quality of informal human communication. Direct informal communication is an important channel for technical information, coordination, and social interaction. Services like telephone and video conferences are available, and there is tremendous technical research and development effort on the use of telecommunication for sustaining social proximity and interaction. Still this is an area where present technology does not provide all the envisioned support for virtual engineering teams, and we need other solutions.

The following communication needs are deduced from the above discussion:

Technical	• Access to project information (objects). • Access to common reference information. • Support for rich technical communication. • Support for coordination
Human	• Support for rich human communication and social interaction

Before discussing a link between functional needs and technical solutions, some general considerations regarding service quality are made. Quality is in many respects a relative and subjective measure. However, if the following factors are not satisfied, it is not realistic to expect people to use computers and networks for everyday and critical communication:

- Ubiquity
- Concurrency
- Stability
- Conceptually simple and user-friendly

Ubiquity: The communication tools must be easily accessible by all users. Desktop or mobile personal workstations are considered as a prerequisite.

Concurrency: A communication session is often triggered by a phone call, an impulse or some other reminder. The need for a time-consuming procedure in order to start the session is not acceptable. This calls for a multitasking, graphical user interface (GUI) operating system, like MS Windows NT, or 95.

Stability: Stability and robustness are essential to trust. Enthusiastic users can tolerate some problems, but gen-

erally the system must be as reliable as the power supply.

Conceptually simple and user-friendly: We have many modes of communication and we use a lot of tools. When we introduce new tools for communication it is essential that the concepts of these tools are easily understood and easily used.

GroupWare is software and hardware for shared interactive environments (http://www.consensus.com/groupware/definition.html). The unOfficial Yellow Pages of CSCW (TOYP, 1995) comprise 11 categories and over hundred products for the -CSCW.

The orginal CSCW groups have been condensed into 7 categories of services. The services are linked to the communication needs by the matrix in Figure 1. The following section describes the services and discuss how or if they should be implemented in the House of Services.

	Filing system	Messaging	Conferencing (news)	Application sharing	Video conferencing	Web	Work Flow support
Access to project information objects	x	x	x			x	
Access to reference information	x		x			x	
Support for coordination		x			x	x	x
Support for rich technical communication				x	x	x	
Support for rich human communication					x		

Figure 1: Communication needs vs. services

Filing system is a basic service that, with acceptable capacity and functionality, must be accessible to all team members. A filing system can be regarded as storage for different types of information objects. Software applications as well as operating systems are moving in an object-oriented direction. We already see a lot of general functionality inspired by object oriented philosophy and the next generation of network operating systems is expected to be "truly" object oriented (http://www.microsoft.com/ntserver/info/future.htm)

A filing system may be based on the general functionality embedded in the operating system and Internet protocols. Alternatively a specialised system might be developed or procured. Many groupware products offered today are in fact filing systems with added functionality. The functionality that is typical added includes workflow information or routing, improved access control, revision handling or linkage of objects, annotations and other extra information. The choice of a specialised system must be counterbalanced by the loss of general functionality and the classic problem that proprietary solutions exclude the general technological development.

The basic functionality of the filing system is storage and retrieval. Structure and naming conventions are the normal mechanisms to support this purpose. An interesting option is the ability for the users to build ad hoc alternative structures to access the filing system (the shortcut feature in Microsoft Windows 95 is an example of such ad hoc alternative structures). The possibility to search for information (by content, type or attributes) is constantly improving and may make us less focused on predefined structures.

A distributed filing system that interconnects several local area networks poses new demands on functionality and the system metaphor. The system metaphor used in local area networks, a letter (disk identifier, C:\, L:\, etc) that identifies the storage location is no longer sufficient. We must access the resources through unique identifiers. The functions that access remote resources must be aware of the capacity and attributes of the connection. A user that (perhaps unconsciously) starts an operation that can take considerable time, should be given a clue that

something is going on and an option to cancel the operation.

The filing system implemented in the case company is based on a local area network in each office. The data area is structured according to engineering discipline and project. Guidelines for file name conventions are distributed to all employees. Inter-office access is provided by preconfigured FTP (File Transfer Protocol) client applications. A catalogue service that indexes the most common document types and aggregates information from all offices is planned as the next extension of the system.

Mail is a simple service to implement and manage. The standardisation of the mailing protocols and the maturity of the client applications has reached a level were it is easy and quite problem-free to use mail and attachments. Convenient address lists lower the initial barrier and raise the quality of the service, and easily configurable post lists extends the applicability.

We already see a massive development on several "mail" areas; increased selection of available object types in the message body, agents that automates and performs intelligent operations on incoming and outgoing messages, encryption, receipts, signatures, fax and pager gateways and mail journals or archives. Some of these functions can be implemented without consequences for the basic service while others like rich body content, encryption and receipt requires the sender and the recipient to follow the same standard. There is currently no general accepted standard for this extended functionality. To avoid problems in a virtual engineering team, the recommendation is that mail is regarded as an informal and efficient service to exchange messages and information objects. The mail system in the case company is based on Internet standards (SMTP, POP3, and MIME)

Conferencing: In principle, a conference is a structured database of threaded messages (discussion groups). The difference between the conferencing offered by groupware products and the original Usenet News service is primarily the available object types in the message body. This added functionality might be decisive for whether conferencing is considered to be an efficient service. However, the basic characteristics of conferencing have not changed. A number of studies have pointed to the difficulties in implementing successful application of conferencing (Orlikowski, 1992), (Cole, 1995). There are also examples of conditions under which conferencing has been successfully applied (Orlikowski, 1995), (JITOL, 1995). These studies points to commitment to contribution by key personnel and importance of the discussed subjects as crucial factors. Professional networks are good candidates for support by conferencing. For the case company, a news server with the possibility for MIME attachments is available.

Application sharing: Application sharing is used in this context as a generic term to describe a class of services that shares the screen windows among two or more users. Several techniques are used to implement this functionality. The main difference is between bitmap and functional-oriented solutions. The former is more stable and can cross operating system borders but the available options are reduced and in most cases the refresh rate is not as good as with the functional-oriented solutions. The latter provides not only sharing of pictures (presentations), but of functions and representations.

Application sharing is easy to use and easy to understand. The experience so far in the case study is that application sharing can dramatically increase the quality of a technical discussion. Other interesting areas of application are support and remote control (see Chapter 3). Similar findings is also reported by a study of application sharing in the Norwegian Post Administration (Bergan95).

For the case company, Norton PCANYWHERE32 is used for remote control of servers and we have started to experiment with MS Netting for support, coaching and technical discussions.

Workflow technology: There is no clear cut between workflow technology and the other types of groupware. The split is somewhere in between the generic, ad hoc procedures and the totally captured and automated procedures.

Work flow technology spans from simple forms routing to advanced environments with intelligent agents that monitors and notifies team members about important design changes (Londono, 1991), (Shade, 1993). Advanced workflow technology is interesting because it can automate monitoring of identified dependencies. It does still not address the coordination needs of small and informal teams of knowledge workers. Knowledge intensive work processes are open, and have to be defined and executed simultaneously. Formal creative techniques are focused on the process structure, not on the information flow or content. Simple workflow technology may be

used to optimise "back office" routines and it may contribute to formal project coordination.

Except for standard project management and economy, no dedicated workflow technology is implemented in the case company.

Videoconferencing: VC is marketed as the technology that imitates social proximity and enables rich human communication. In many ways this is the weak link in the proposed House of Services. It would have been a real pleasure to say that VC is the perfect solution to handle the need for rich, robust communication described earlier. The answer is unfortunately not that simple. Cost is the first major barrier. VC at every user desk is presently beyond the acceptable level for most companies. It is the author's general impression is that the technology does not offer enough added value compared to the available alternatives, such as application sharing, telephone meetings and face to face meetings. There are however, examples of projects claiming that VC is the key to success for virtual teaming (British Petroleum Virtual Team Project (Greenes, et al, 1995)). VC certainly adds a dimension to communication and it is a clear candidate for inclusion in an extended house of services.

Web: The World Wide Web is basically a concept for hypertext organising of information objects in an Internet environment. The basis is a set of communication protocols and a standard for hypertext documents originally made for sharing of information in heterogeneous environments. The web is in itself an interesting phenomenon. The potential is, however, the huge economic impact of developing web- (and Internet-) based technologies for media and entertainment. The technologies may provide mechanisms for 'playing any kind of game', that in turn might be applied for engineering business purposes (Vanier and Turk, 1996).

To what extent HTML and web technology should be used to sustain daily cooperation between team members, is not that easy to answer. The advantage is that information published in HTML is easily and directly accessible by anyone with a computer and an internet connection. Currently, important drawbacks with HTML are that you cannot use the ordinary authoring and editing tools in a collaborative process and it is very complicated to make comments in HTML documents. This picure is somewhat blurred by the rapid technological developement. HTML authoring tools are approaching the level you expect from a modern word processor (Microsoft Frontpage or Netscape Gold). At the same time all major software vendors are striving to implement web functionality into their products. Among other, Autodesk, Microsoft and Lotus have released web functionallity "add on's" and have announced that the next version of their products will be tightly integrated with the web.

As a result, a team that needs "web functionality" to share information may find it more convenient to use "web extended" applications, such as those described above, instead of using new tools and new formats (HTML). The WWW is, at present, basically a hypermedium for accessing reference information. Due to the many interesting characteristics, the enormous commercial success, and the rapid technological development of web technology, it will probably play a very different role in the near future.

For the case company, an external web server as well as internal web servers at all offices are installed. Currently the web servers are mostly used for company presentations and relatively static information. Some pilot teams are experimenting with active use of web technology in project work.

The proposed house of services is illustrated in Figure 2. The foundation, transparent network and GUI operating system is argued mainly from the service quality.

For the case company, the network is implemented as TCP/IP above ISDN. This is a solution with relatively low initial costs, acceptable and extendible capacity. There are some conflicts between the virtual line switched nature of ISDN and the packet switched TCP/IP Frequently, small packets must be avoided since the cost is charged according to connected time. Workarounds can be configured but the users should be informed about the possibility that all lines might be occupied so that they do not experience this as error or instability.

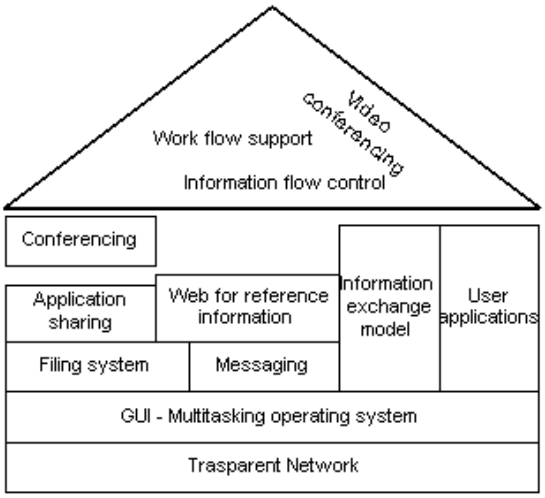

Figure. 2: House of services.

ISDN is an existing and economically viable solution. For some of the larger offices, the cost of ISDN has surpassed the cost of frame-relay (leased lines), and the infrastructure will probably be extended to a mix of frame-relay and ISDN. The possibility for configuring load sharing between ISDN and frame-relay is also interesting for scaling of the capacity. Possible extension of the services include high capacity, multimedia communication and improved connectivity calls for high capacity packet switched networks with priority demand like ATM or broad band ISDN

The information exchange model is the link between the user applications (the object types) and how the objects fit in to the information process. We must address this in order to be able to exchange, inspect and annotate objects and not sub-optimise processes by introducing incompatible object types.

Some months ago the word Intranet was coined as an expression of a company wide network based on Internet technology. The proposed house of services is built on Intranet services, in fact we are heading steadily towards the "Full Service Intranet" as described in a recent Forrester report (Forrester, 1996). As argued above, this is partly because the available services are seen as core services for virtual teamwork, and partly because this solution is regarded as the key to open, flexible, and cost efficient solutions for the future. Another important issue is that this set of services is rapidly becoming generally available. This is especially important to small projects where the cooperation with external partners or customers represents an increasing percentage of the total work. The company has already established dedicated ISDN access to their Internet server for some project partners.

2.3 Work structure; a project information model

The project information model serves two purposes: first, it highlights the formal information exchange that could hinder virtual teams, and second, it highlights informal communication needs and relations based on a match between the required type of competence and the individual competence profile.

Tasks, information flow between tasks, and the need for access to reference information is important to the formal (planned) flow of information. A model describing the formal flow of information can be extracted from an ordinary project management model. The dependencies among the tasks must be identified and described so that they characterise the flow of information. In addition it may be important to describe dependencies to (physical) reference information (catalogues, standards etc.). Data flow diagrams with annotated flows may give a good visual picture of the process. In some cases it may be important to sub divide the activities and describe the formal flow of information between the different roles.

The informal flow of information is mainly due to one of the following:

- **Tempo:** Direct contact awaiting formal information --"beta information".
- **Clarifications:** Direct contact to clarify issues in the formal information.
- **Competence:** A team member needs support or education to solve an assigned task. A junior/senior relation

represents the clean or extreme version of this situation.

The informal aspect of the model focuses on competence because tempo and clarification to a large extent will follow the same patterns as the formal information.

The following objects are central to this model:

- Role - Lowest level of task breakdown.
- Competence register - A (structured) container for defined competence objects.
- Person register - A container for objects representing the available persons.
- Competence - a definition of a specific skill or experience.

Competence objects linked to the roles shows the competence required to fill the role. Competence objects linked to a person shows the persons competence profile.

It may be difficult to visualise all aspects of the model in one figure. A data flow model is probably best suited to illustrate information flows between persons. Competence mismatch is probably best visualised by a role model.

The object structure of the model is shown in Figure 3, using OMT (Object Modelling Technique) notation (Rumbaugh, 1991).

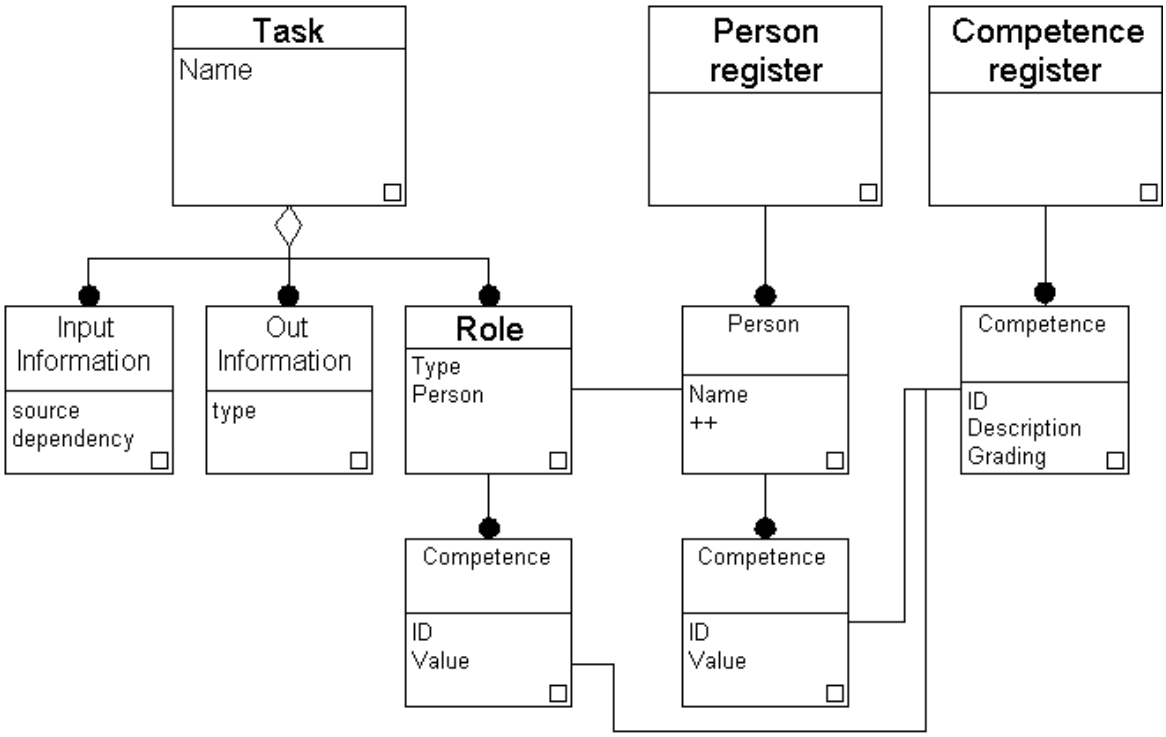

Figure. 3: Formal and informal flow of information.

The model assumes that extra information (like person<->office) can be extracted from the project management model or a personnel file.

In its simplicity, the model illustrates that a task receives and produces information (that in turn can be received by other tasks).

A dependency attribute on the "input information" and a "type" attribute on the out information are included to characterise the information flow.

The "Role" object is assigned a "Type" attribute and a reference to the "Person register". It may be relevant to have restrictions on the "Type" attribute (a task must have one and only one responsible, etc.). The "Competence

objects" are linked to the "Competence register" by the "ID" attribute. The "Value" attribute is a scale referring the grading defined in the corresponding "Competence register" object.

Competence in roles represents required competence, while competence in the person register represents competence profile. Negative mismatch represents a need for support or education and a potential informal flow of information.

Heuristic rules are used to calibrate the model. Examples are given below:

- Exchange of physical objects is counterproductive (cost and time) if it occurs often and in both directions.
- Exchange of complex information that calls for rich communication is negative.
- A safe and established procedure for digital exchange of information is positive.
- Need for continued access to the same physical reference information is negative (requires duplication and replication)

These rules may also be used for ad hoc queries:

- Show all tasks that are performed on separate locations and require exchange of physical objects.
- Show all tasks where the roles are assigned to persons in different locations
- Show support requirements where the assigned support personnel is in a different location

It is probably neither realistic nor necessary to employ this model to all split location projects. The intention is that this model, after calibration with experience, can give valuable information of potential problems and that it will indicate considerations to be taken when planning virtual teamwork.

2.4 Competence; coaching and continuous learning

Overview

*"A place where people continually expand their capacities to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to learn together" (*Senge, 1990).

Senges vision of a learning organisation is appealing, and most people would like to work in such an organisation. His book has become a classic in the field of learning organisations and his thoughts and philosophy are a good foundation for pragmatic approaches to continuous improvement. Richard Karash (Karash, 1995), formulates the following definitions, with reference to Senge:

> *Knowledge:* Capacity for effective action
> *Learning*: Increasing knowledge, that is, increasing capacity for effective action.
> *Learning Organisation*: When the organisation as a whole and the people who comprise it are continually increasing their capacity to produce the results they really want to produce.

Then it may be asked, what are the problems at hand regarding creating virtual engineering teams and do we have some answers to the following questions?

> Are people not interested in learning and personal development?
> Have we done an investment and are not able to document the benefit?
> Are the services not in use?
> Are the services extensively used by some while others not have started at all?
> Do you see a lot of opportunities but are not able to "sell them" to the rest of the organisation?

Case Study

To address these questions, we have to look at what actually happened in Asplan Viak (see section 3 for details). After the network and services had been implemented, the person responsible for the IT at each office was instructed in how to operate and use the services. The implementation and education at each office was left to the regional management.

As a result the use of the systems varies according to the location: at some offices everybody are "up and running ", and services like mail, WWW and FTP are used extensively, at other offices only a few are using the services whilst others hardly know about their existence.

Is this success or failure?

To some people and measured against some of the goals (see section 2.1) it is a success. They have grasped the opportunity, learned a lot and are using the services actively in their day to day work.

The goal about establishing a common house of services, used by all employees, is not yet achieved. This is not a trivial problem. The traditional approach with introductory courses and hands-on training is probably not a complete approach. Most people must "know how" to use a service, in order to dare or choose to use this service. To "know how" is, however, not the same as "to do". They must also "know why", this is to see the services as a convenient tool for solving a task.

Coaching

Borstad, (Borstad, 1996) calls for a new approach for implementing cooperative IT services. He discusses solutions like "Intervening mediators", "Participatory approach" and "coaching". These are all sensible solutions that may be used in different situation. Due to the large variation in implementing conditions (cost, competence, available resources etc), the value of general guidelines is limited. A solution or strategy must be made for the problem at hand. Available resources, the need for a solution (driving force), the importance of "critical mass" and general competence level are among the important factors. Not all changes can be designed, directed and conducted in a quick sweep.

To complete the mail example from Asplan Viak, now 70 to 80% are using mail regularly. They are now capable to discuss, based on own experience, the value of added functionality and the importance of general availability and mail etiquette (like; read your mail regularly or put in a holiday message if you are not available). The call for general availability and acceptance is now strong and the necessary actions will be taken in a short time. The open question is if this "natural dissemination" was the best solution or whether a strong push to reach this situation as quickly as possible would have been better and even possible, considering all costs, benefits and barriers.

An interesting lead to this debate is a recent announcement from Statoil, The Norwegian State Oil Company (http://www.statoil.com). They are planning to buy a Multimedia home PC with Internet connection for all employees, bundled with an individual commitment to participate in a training program covering basic IT knowledge and use of Internet services. Statoil spends approximately $14000 per employee per year on IT solutions. I see this initiative as recognition of the importance of basic skills and awareness of open cost efficient Internet solutions.

Type of User affect Coaching Techniques

The following categorisation of users is based on observations from the initial implementation. The intention is to illustrate some effects that we must consider and utilise.

- The early adapters and creative users
- The normal users
- The late adapters

The early adapters are "self propelled". They understand the concepts and learn the tools on their own. They are an important resource both in the initial phase and the continuing development. They should be encouraged and credited for giving support. On the other hand it is equally important that they understand that the other type of users don’t need or want advanced options and that they don’t use advanced techniques that cause trouble.

The normal users understand when being told and after having some exercise. They use the services straightforward but without curiosity, and they do not "research" the new possibilities.

The late adapters need attention. It may be hard to uncover whether they have problems grasping the concepts or whether they resist using it for some other reason. Resistance may be caused by fear of not being able to adapt (and thereby expose them by doing silly things), fear of their own work position or maybe they don’t agree that the company should use resources on this new technology. To uncover and discuss the problems may be the key for solving it. The most difficult (but often cutest) are the users who are firmly convinced that computers have soul and own will. As replied from a senior engineer (just before retirement): *It s no use, I ve tried everything, but the computer decides what to do*.

Advanced Coaching Stage

An important focus for further research is *How to utilise the network and the services to sustain and improve learning processes.* This is a wide area and there is a lot of research and commercial activity that addresses this problem (and market) from different angles. Again we face a situation where the problem is not purely technical, but just as much social, organisational or pedagogical. Anyone with experience from education knows the importance of commitment from the students.

On the other hand, we also know the importance of well planned and well implemented teaching, and as educators we constantly experiment with techniques to trigger effort and improve the results.

My argument is that this technology has a great potential for improvement on continuous learning, especially with respect to lower the barrier of distance and to improve the flexibility in the accomplishment. To a large extent, I have adopted the terms and the key elements from the EC research program JITOL (JITOL, 1995) (Just In Time Open Learning): flexible learning, responsibility for own learning and continuous development.

My current plans is to participate in two pilot projects and through this gain further experience and knowledge. The first case is to support a planned process where the objective is to change the work procedures and production lines for a group. The selected case is to move all the landscape architects into a digital production environment.

The objective of the second project is to support continuous professional development and improve the support for junior personnel for a selected group and field.

Commitment, responsibilities and allocation of necessary resources are vital in both cases. Application sharing is intended a central role, but other services like mail, conferences and web technology is an important part of the total picture and will be used where applicable.

2.5 Empowerment; an open philosophy for collaboration

*"Whether it is research and development, company management, or any other aspect of business, the active force is "people." And people have their own will, their own mind, and their own way of thinking. If the employees themselves are not sufficiently motivated to challenge the goals of growth and technological development there will simply be no growth, no gain in productivity and no technological development" (*Inamori, 1985).

Inamori focuses motivation as a key for "tapping the potential of people". Motivation is also a key element in my interpretation of empowerment. The other key element is to create an environment where people are given the opportunity and support necessary to realise their potential.

To illustrate that there are no "turn key" solutions to this, I will recapitulate an example from Asplan Viak.

In a group meeting it was decided that an employee who had been with the company for several years, and who repeatedly stated firmly that he wanted to start digital production, was to be given this opportunity. Computer equipment and software was purchased and he was offered the standard solution for support and education. At the same meeting it was decided that there was currently no room in the budget to realise a similar solution for a recently employed female engineer.

Two months later I visited the first employee with his new equipment and noticed that the computer was turned off. He had not started to use it. *"I m overloaded with project work and none of the projects are suitable for pilot projects"*. Shortly after I observed the female engineer working on a drawing on a colleague's computer. *"No matter what, I must learn to work with CAD, I can t continue with manual production. It s inconvenient not to have my own computer and I sometimes have to work in the evenings. On the other hand I get a lot of help and support when I use my colleague s workstations."*

The "empowered" person did not grasp the opportunity while the "restricted" one reached the goal with no formal support or backing. Without discussing the full causal connections in the example, it is obvious that motivation and responsibility for one's own situation and development plays a major role.

Two elements that are important to "tap the potential of collaboration", open philosophy and basic attitude to co-operation, are presented in the following.

The basic principle in an "open philosophy" is that all information is available to all employees. We require an argument as to why information should be restricted, not as to why you need access to it. This is important both as a positive signal and to lower the barrier for using others work and expertise. This is based on trust and we need guidelines on how to inform and give credit for the use of others' information. Suitable reactions to misuse of this trust should be established in order to avoid jeopardising the system when such situations occur.

According to (Orlikowski, 1992) and (Singh, 1992), competitive individualism is counter cultural to group technology and virtual teams. An evaluation of whether co-operation and information sharing are rewarded or penalised by the incentive system of the company, may give important information of potential barriers for collaboration.

3. IMPLEMENTATION OF THE STRATEGY

Asplan Viak a.s is a Norwegian consulting company organised in six independent subsidiaries. The Group has 280 employees in 16 regional offices throughout Norway as well as several staff members working on projects abroad. Anchored in Norway's leading circles within the fields of municipal engineering, geographical information technology, and environmental planning, the Group offers a broad range of products and services.

The rationale for establishing a company network is given in section 2.1. The project started late 1994 and in January 1995 six offices in the southern region were connected with ISDN lines and the TCP/IP protocol. The initial functionality was FTP utilising preconfigured graphical FTP clients and Windows NT FTP servers. Based on the experiences from this project it was decided to connect all offices with this technology. Simultaneously the company experimented with an Internet gateway, mail and web servers. The company started to build arguments as to why it should have an Internet connection with mail and web services. The following incident "closed the sale": The manager in the Southern region was working on a tender for a water supply project in Zambia. He asked if our company had e-mail and it was confirmed that it had a test configuration. A mail with an attached draft of the tender was sent to the local partner in Zambia. An annotated version of the tender was returned shortly after. In this way the two companies worked in parallel with developing the tender. The simplicity and efficiency of the communication astonished the manager.

The configuration of the Intranet is shown in Figure 4. Each office is equipped with a TCP/IP router with ethernet and ISDN port, FTP- web- and mailserver. The Internet gateway has a router with several ISDN channels and TCP/IP filtering. A common Internet server is situated outside the filter. (http://www.asplanviak.no).

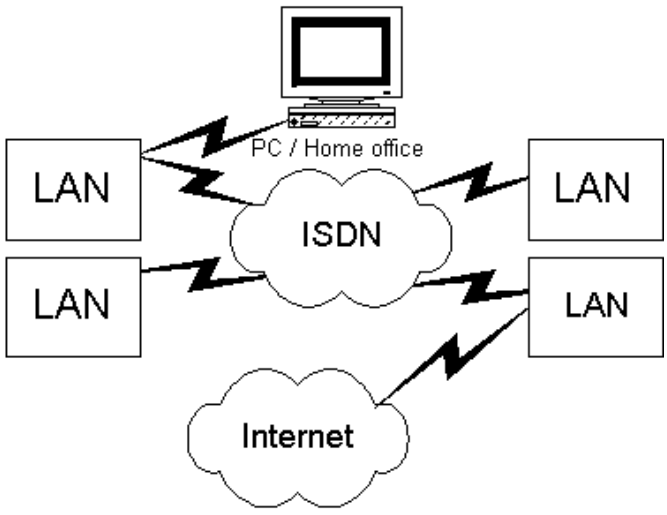

Figure 4: Intranet configuration.

The process of installing and configuring the servers took longer time than expected due to lack of commitment

from some of the offices and that the effort needed to coordinate and instruct the persons responsible for IT from 16 offices was underestimated. In the middle of the process, a new group manager was engaged. He put forth a date for completion of the installation. Application sharing software was installed on all the servers (easy to install and configure). The company then completed the installation and configuration of the server software within a week. The experience from this remote installation and configuration is that it is extremely efficient. Except for a bit slow screen refresh, it is experienced as sitting in front of the computer. Combined with a telephone connection with the operator in front of the remote computer, this tool is also an efficient aid in educating the regional operators. Another interesting observation is that one needs to have commitment and deadlines in order to get thing done, at least in a project-oriented company.

The installation was completed in March 1996. The basic training of all personnel was scheduled for April and May. Two disciplines are selected for further research and application of the strategy. Both groups are represented in all regions and they have expressed a need for cooperation.

The road engineering and transportation-planning group have all their project information in digital form. They see a trend towards demand for expert competence and larger projects with tighter schedules.

The landscape architects are on the doorstep of digital production. They foresee a need for a professional network to sustain this process. They also perceive the professional network as a way to strengthen their identity and expert competence as a small group in a large engineering company.

In the following excerpts from the case study I report and comment typical feedback and experience from this initial phase. Finally, the experiences are summarised in some general reflections that will be carried on to the work ahead.

The following quote illustrates the reactions from employees who have awaited the solution and starts extensive use as soon as it is available.

> *"This is the best that has happened to this company for several years. There is no longer a problem to cooperate with and assist the junior engineers at the district offices. We send documents back and forth in seconds. It s just like they were sitting here. The only shame is that we can t go out for a beer afterwards."*

Other incidents illustrate emerging possibilities that allow efficient ad hoc solutions. For example:

> *"I was contacted by a colleague from the eastern region. They had received a dataset for the GIS system but were not able to import it to the PC version of the software. They were under pressure and didn t know what to do. He transferred the data and I read it into the UNIX system. The data was formatted according to the old standard. I exported it in the new format, notified him, explained the problem and told him what I had done. Shortly after I received a notification with "all problems solved, thanks for the assistance".*

Open and general tools may, when used with creativity, sustain processes that not are built into the tools. The following illustrates how the file system and mail sustained both workflow and coordination, by means of simple agreed procedures.

> *"Three of us, all from different offices, were working together on a report. We were sceptical about how to coordinate and cooperate when not co-located. We started with a kick-off meeting where we decided a rough outline and an initial division of responsibilities. The report was divided in one file for each section and the responsibility and status was indicated with initials and a code postfix to the filename. In the early phase we coordinated by occasional e-mails and telephone calls. As the deadline approached and we had to work more intensive with the report, we decided to start each day with a short e-mail telling current work status and the schedule for the day. Together with some telephone conferences, the annotation feature in the word processor and a meeting to finalise the report, this worked surprisingly well."*

After a presentation of the Intranet and the available services to a meeting with all the landscape architects, one of the senior architects replied:

"This seems very interesting and promising, but how can we expect to utilise this efficiently when we have daily problems with internal standardisation and the robustness of the LAN?"

This is a classical conflict. We resist taking the next step and use new or unknown tools when we are unconfident with the foundation. Such problems should be addressed and cleared as far as possible.

The following incident, reported by a junior engineer, underpin the need for training if you expect new tools and methods to be used in stressed situations:

"I was working on a letter to a customer and needed a second opinion from a senior engineer at the main office. I phoned him and said that I had mailed the letter and asked if he could comment on it. He was stressed and not in the best mood, he replied: "Fax it at once, I have enough problems to cope with, I can t fiddle with that mail thing""

After a demonstration of FTP and mail with attachment, the following question is often raised:

"What is the need for file transfer when we can mail and attach a document?"

Orlikowski, (Orlikowski, 1995) refers to this understanding of concepts as *technological frames*. When someone is presented to two new and overlapping concepts, where one is simpler and more appealing than the other, they hope that they can forget the "complex" alternative. The principle advantage of the "complex" method must be stressed. In this case that one can retrieve information from a remote site without assistance.

These observations illustrate some planned and emergent results of new technology. At the same time, some of the problems related to introduction of new technology are identified. Regarding the case company, I have a clear opinion that the adoption of virtual teaming at the moment is not constrained by technology or available services. The challenge is to convey a technological frame for understanding of the concept and basic operating skills. This is the foundation where we have achieved a common house of services. From this foundation we can work to assist individuals and groups which regard virtual teaming as a mean of value creation.

4. CONCLUSIONS

Information technology is approaching a level of connectivity and sophistication where it provides a digital medium for distributed knowledge work. Successful application of this technology is no more a pure technical matter, but more a matter where organisational and social issues play a major role, even in engineering work.

A Norwegian engineering company has started to implement virtual teams based on networked computers providing standard services, and plans to extend both the bandwidth of services and the connectivity by transformation to Intranet technology.

The future of the company will rely on being a part of the open, information society, doing business by providing high-quality engineering work in a social and virtual environment of the winning team.

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