Virtual engineering backbone - Coordination by design

Line L.[1]

ABSTRACT

This paper discusses a conceptual framework for a construction-engineering network. The concepts are based on experience from a medium sized and distributed Norwegian engineering company (ASPLAN-VIAK) and ideas from socio-economic research and applied coordination theory. Critical success factors for establishing a virtual organisation that can take advantage of the potential and opportunities offered by modern information and communication technology are focused.

KEYWORDS: Virtual Engineering Teams, Knowledge Work, and Coordination

INTRODUCTION

Large multinational companies like General Electric, Boeing and Ericsson have for several years utilised virtual engineering teams. The motivation is to have access to the best possible competence even if the competent people are geographically dispersed. The competence is accessed and utilised wherever it might be located. We also see huge structural changes and new organisations that are entering the marked in totally different branches. An example from Norway are the grocery stores that during the last five years changed from being 50% individual stores to now over 90% is incorporated in four large supermarket chains. Three of these chains are run by franchising principles. The main argument has been to offer known brands to a low price.

The organisation of construction engineering in Norway has been very stable for several years. Based on trends from other sectors and experiences with virtual teaming in Asplan Viak, a Norwegian Architectural and Engineering Company [Line96], the author argues that networked organisations are likely to penetrate this marked in the near future.

This paper discusses a conceptual framework for a construction-engineering network and focus on principles and key services. The proposed network can be pictured as a backbone with independent companies at the nodes. Physically the backbone is established on a technological infrastructure providing several common services. The author advocates the following elements as critical success factors:

- A viable business idea
- An organisational concept that match this idea
- Technological solutions compatible with the organisational concept
- Embedded governance and coordination in the design of solutions

A socio-economic framework for characterisation and evaluation of networks is presented [Klein95]. The proposed concept are presented and discussed according to the framework.

The author focus is how to design and implement services to support the organisations goal. Key services are presented and discussed.

The presented model offers a possibility for short time increase in revenues. More

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important, the organisation is closer to being part of the open, information society, doing business by providing high-quality engineering work in a social and virtual environment of the winning team.

NETWORKED ORGANISATIONS

In this section, networks are positioned in relation to other mechanisms for coordination and cooperation and a framework for characterisation and evaluation of networks is presented.

During the last decade, a great deal of research has been focused on the different kinds of IT enabled network. This problem has been approached from several angles. Socio-economic research focuses on describing the network's characteristics in relation to hierarchy and markets [Klein95]. Concurrent engineering and coordination technology focuses on team building and interplay among knowledge workers [Londono91], [Singh92]. The effects of communication- and computer technologies on network relations and the way these technologies in turn are affected and developed by network relations have been focused upon to a varying extent. My focus is technology-oriented. In other words, it deals with the ways in which technology can be developed and configured to support the type of relation we wish to establish. The presented framework is an aid to characterise and evaluate the organisation and human relations.

The framework, based on research by Stefan Klein [Klein95], is briefly presented in three steps:

- Networks are positioned in relation to other forms of coordination and cooperation.
- An extensive list of network properties and attributes is given.
- The interrelations between the attributes are investigated and aggregated into a simple framework.

The term "network" is generally applied to a structure of links between actors in a social system. In this context, it is used in the narrower sense of an IT-enabled inter-organisational network.

Networks in relation to other forms of coordination and cooperation.

> *Defining characteristics of interorganizational networks are collective actions of sovereign organizations that share resources and have a common governance structure, a cooperative climate, and a linking information and communication infrastructure. Whether conceived as a hybrid or distinct form or as a point on a continuum between hierarchies and markets, networks represent an alternative form of economic coordination.* [Klein95]

Klein pinpoints social integration as a main component of networks compared to the other mechanisms. Even if this is the dominant functional scope, networks also incorporate functional properties of the other forms.

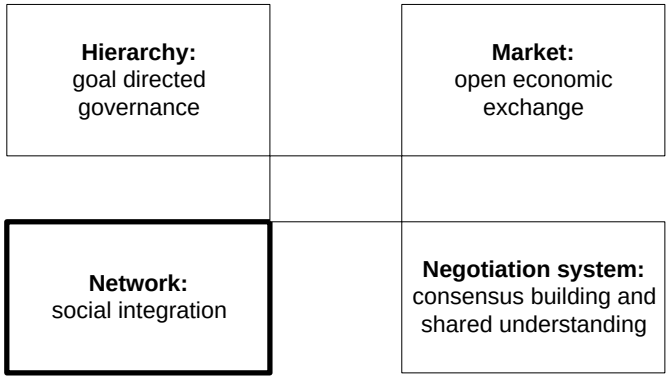

Figure 1: Stylized functions of mechanisms for economic

coordination

Networks encompass to a varying degree the adaptive potentials of markets, the goal attaining functions of hierarchies, and the consensus maintaining functions of negotiations. In other words, even more than markets or hierarchies, networks have to be understood as multilevel combinations of coordination mechanisms. [Klein95]

Network properties

Network properties: *dimensions and attributes* [Klein95]

transaction attributes	
Uncertainty	Medium level of uncertainty, non-contractible aspects (innovative, accurate, high quality, time critical transactions) salient
asset specificity	Specific investments, High risk of losing critical assets, esp. know how - endangered by opportunism
product description	Complex product descriptions or Volatile price information and numerous restrictions
rules of exchange	Relational contracts, formalization, standardization
Coordination	Information exchange and governance mechanisms
Incentives	Virtual size: increased market power and position, access to external resources, Flexible structure, independence, autonomy and control
Governance attributes	
Contractual arrangements	Relational, self-enforcing contracts
Safeguards against opportunism	Contractual bonds, resource dependence, (long-term) commitment among the parties, interest in long-term stability, balance of interest, trust, reputation, history of interactions, peer pressure
conflict resolution	Negotiations, mediator, procedural rules, reciprocity, litigation only as last option
concept of control	Decentralized control, monitoring facilities, personal responsibility
Organizational arrangement	Moderately informal, determination of scale and scope of common activities, Often focal organization (superintendent, hub-spoke), IT infrastructure
Attributes of the alignment	
Ties	Often multiplicity of ties: task, procedural, technological, financial, Salience of informal, decentralized and horizontal relations
Integration	Linked autonomous, but interdependent actors, operational interdependency, Knowledge links, mutually learning organizations
tone/climate	Mutual benefit, partnership, sometimes antagonistic cooperation
time frame	Medium to long range commitment towards cooperation - limited scope provides natural breaking point
Stability	Stability through combination of economic rationale, governance structure, social ties and shared world-view
Flexibility/ adaptability	Structural adaptability (two level games), loose coupling
Attributes of culture and world view	
context assumptions	Encapsulated competition, inter-network competition, cooperative setting, compatible goals
Strategy	Shared strategic vision, at least for projects covered by the cooperative arrangement
norms, values	Moral economy, social relations place constraints on individualistic optimizing
Mechanisms of mutual adaptation	Learning, negotiations, reevaluation and redefinition of the network goals

This extensive list of properties covers a wide range of network characteristics. The list is however too comprehensive to be used as a framework for evaluating networks. The interdependencies of the properties are therefor examined and aggregated to a simpler framework.

The Framework

The proposed framework is based on Parsons AGIL scheme.

In his analysis, Klein further divides each of the four subsystems into the four dimensions that reflect the functional profile of adaptation, goal attainment, integration and latent pattern maintenance. For my purpose, where the framework is used as a reference for interpretation and discussion of the proposed concept, I will mainly refer to it at this top level.

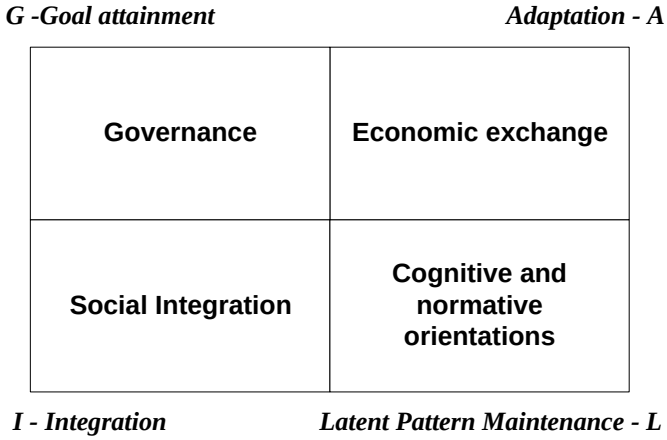

Figure 2: Generic Functions of Inter-organisational Networks within the AGIL schema

THE PROPOSED CONCEPT

The proposed concept can be pictured as a backbone with independent companies at the nodes. Physically the backbone is established on a technological infrastructure providing several common services. The markets are also indicated in the picture to illustrate the importance of minimising market conflicts. For the purposes of further discussion, it is also assumed that all nodes are small- to medium-sized engineering companies.

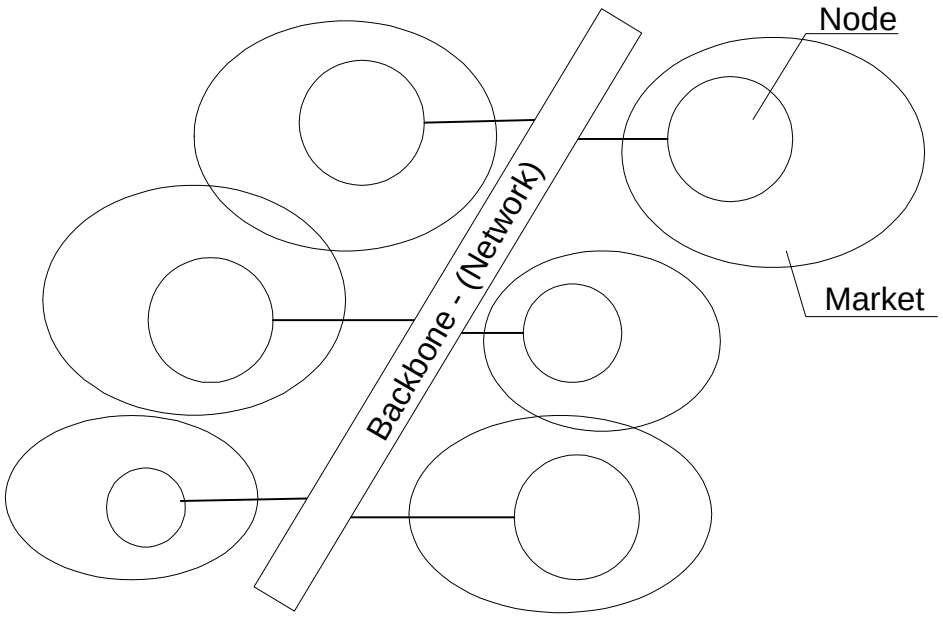

Figure 3: Backbone with independent companies at the nodes.

The main ideas behind the concept are:

- Extended market by participation in or responsibility for larger, multi-discipline projects.
- Access to efficient infrastructure for cooperation with customers and partners.
- Access to pooled information

- Access to a larger pool of knowledge
- Virtual size, small economic unit but advantages of economies of scale

These effects constitutes the business idea. Pre-conditions and ideas for making this work are the subject of the remainder of this article.

In the following, the concept is detailed and discussed according to the framework. To tie the general framework closer to the actual case, I will also use level of cooperation, in the discussion (see figure 4).

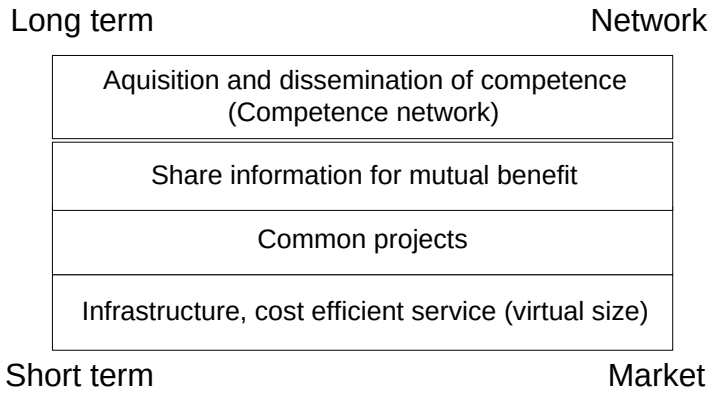

Figure 4: Levels of cooperation

A – Economic exchange

Economic exchange is a central component of the network. I will discuss the following factors under this functional dimension:

- Virtual size
- Project cooperation
- Adoption and flexibility

Virtual size: Virtual size is based purely on the economic advantages of large volume purchasing but also pooling of competence for the development of new services and as a means of keeping up with technological developments. It is also possible to co-operate on support services such as accounting and project economy. These elements correspond to the first level of cooperation, close to marked relations. There is little need for integration and co-operation and the benefits can be reaped immediately. Virtual size in relation to having access to a large “pool” of knowledge is more difficult to realise and presupposes co-operation at a higher level.

Project cooperation: Projects are the core and common denominator of all consulting companies. If the network fails to realise substantial project work involving several of the nodes, then the concept will never leave the first level of cooperation. This is due to the fact that the employees use 80 to 90% of their time on project work. They are committed to complete the tasks they have signed up for (or been assigned) and all other tasks are given second priority. Project work entails intense communication, which in turn foster trust and build relationships. This mechanism is so strong that it cannot be replaced but only supplemented with other methods. Strategy, cooperative services, minimal formalities and efficient transactions are crucial to initiate required project cooperation:

The nodes must have a strategy where there is genuine need to participate in network projects or a market demand for resources they can access through the network. In other words, the nodes must view the network as a strategically important market or pool of resources .

It must be easy and practical to have close cooperation with resources from other nodes.

This aspect is discussed in the SERVICES section.

There have to be minimal formalities related to using resources from other nodes and the economic key figures should reflect the reduced overhead. Simplified and standardised concepts for contracts and automated transactions are instruments. For these instruments to work, there has to be trust (I), a common perception of the task and the expected quality (L) and procedures to deal with breaches of the expectations (G). A concept for realisation is presented in the section *Services-Automated coordination and transaction mechanisms.*

Adoption and flexibility: Important attributes and aims of a network are adaptability and flexibility. However, these are typical long-term effects that can only be triggered by an active and functional network. If trust and reputation is not established through active project cooperation, it is not very likely that one will be able to gain benefits in an acute crisis.

G – Governance

At a strategic level, governance is about goal setting and procedural and structural arrangements to support goal attainment. Everyday governance is about decisions and arrangements that support interplay and give room to solve and complete normal tasks.

The idea is to embed governance in the design of the organisation, technology and relations. In the following I will discuss aspects of these to forms of governance and present ideas of how this can be achieved.

Strategic governance

> *A common strategy or business idea is the constitutive element of a network that articulates the vision and the goals of the cooperative arrangement. The fact that the network parties are autonomous and pursue their own strategies poses a permanent challenge to the network strategy which has to have both a clear focus and the requisite flexibility. [Klein95]*

In this way governance is embedded in the idea and the design of the network. The idea is based on the assumption that the network parties (nodes) regard each other mainly as partners with mutual interest of cooperation. Mechanisms to minimise and solve market conflicts are vital. On the other hand, we must be careful to enforce regulations that limit creative and innovative nodes.

> *Institutional arrangements and governance structures are needed to deal with the complexity of the network relations and to ensure the implementation of strategies. Usually a separate umbrella organization is established to deal with the issues of network management. However, these structural arrangements have to reflect the network strategy and the constraints resulting from the fact that the network participants are autonomous organizations. They have to combine flexible institutional arrangements, limited power, and medium-term commitment of the participants. As the participating organizations relinquish some of their managerial sovereignty and some control over their own organizational boundaries, they are particularly concerned about the development of the networks boundaries and very sensitive about emerging governance structures.* [Klein95]

Klein points in the above quote to important considerations regarding the constitution of a governance structure. Even with the best intentions, there are bound to be conflicts in a dynamic organisation. My personal experience is that network borders are very sensitive, especially when the involved parties have different strategies on expansion versus consolidation. The rapid development of computer and telecommunication technology is also a potential conflict zone that may need governance decisions.

Everyday governance

The goal is to have a smooth everyday interplay with efficient solution and completion of

tasks. In the paper "*The Self-governing Internet: Coordination by Design*" [Gillet96], Gillet discusses how Internet, which is often portrayed as anarchy, in fact is an efficient and successful solution to enormous coordination problems.

> *It draws an analogy to an organisatonal style in which a manager sets up a system that allows 99% of day-to-day functions to be handled by empowered employees, leaving the manger free to deal with the 1% of exceptional issues. [Gillet96]*

The analogy with the Internet should not be taken too far. However, I find it interesting to discuss the four principles for Internet coordination, as summed up by Gillet, in view of everyday coordination and governance for the proposed network.

• ***Value interoperability***. *The success of the Internet depends on a shared belief in the importance of interoperability. Erosion of this belief could be the single biggest threat to the Internet's future. More widespread understanding of the importance of this shared value is therefore critical.*

Interoperability has been a nightmare for inter-organisational digital cooperation. Internet technology is the first open breakthrough for this problem and its success illustrates the importance of this issue. Interoperability must not be misinterpreted as rigid, static and detailed standards.

• ***Automate coordination***. *Use protocols whenever possible to automate interactions. Automate conformance monitoring and error handling as well.*

The analogy is not entirely relevant here since we are discussing a network of people and not computers. The form of coordination described above would result in an inflexible bureaucratic system. Nevertheless, it is my opinion that the protocol analogy is valid in that we can attain a high level of "automation" by expanding the concept with standard operating procedures, standard agreements, a common understanding of reality and support of workflow applications. See also: *Services-Automated coordination and transaction mechanisms*

• ***Distribute power, control, initiative, and authority - but still interoperate***. *The philosophy of IP is that minimally coercive collective systems work best. The art of IP is designing the right interface so that standardized interaction and local control can comfortably coexist.*

It is easy to accept the value of interoperability. Interpreted as technical interoperability, standards, protocols and interfaces are identified as important conditions. Interpreted as human interoperability, *Social integration* (I) and *cognitive and normative orientations* (L) are added to the conditions.

• ***Expect change***. *Adapting to change is the norm. Build systems that will be flexible in the face of change, even though this approach has short-term costs.*

My argument will be that this aspect or attitude is as important to human interplay as it is to programmatic interplay. From the human point of view this involves competence and attitudes to change.

The above discussion shows that the mechanisms providing everyday government of the Internet can be transposed to the proposed network and give important guidance for everyday governance.

I – Social Integration

Social relations and trust are important for the development and stability of networks. Trust is developed within a multiplicity of ties, personal acquaintance, formal and informal social networks and reputation of the network partners. Intense communication fosters social integration, project cooperation is the central arena for this. Social integration and cooperative spirit compensate for weak control mechanisms.

I will not discuss in more detail how to achieve and maintain social integration. My point

is that since social integration and trust is a basis for an active and function network, this should be reflected in the design of services.

L – Cognitive and normative orientation

> *The network parties are viewed as interpretation systems that act according to cognitions and normative orientations. Therefore, shared values and shared assumptions within a consistent conceptual context are necessary preconditions for developing consensus among network parties about common goals and strategies.* [Klein95]

These aspects are detailed in the following points:

The situation has to be perceived as cooperative in general. Long-term and intangible benefits do not rule everyday decisions. Short-term cooperation and exchange must be perceived as a positive sum game.

The stability and adaptability of the strategy depends on shared goals. Differences in vision and perception of the competitive context hamper the continuous adoption of the strategy.

A shared organisation culture is a characteristic feature of networks. This culture is manifested in style and conventions of communications and is often different (or dominated by one part) from the participants' internal company culture.

The self-reflexive concept of the network: This concept encompasses assumptions about all functional aspects of the network and represents something like a network model and identity.

Moral values: Moral values provide additional orientation. The actors define, tacitly or explicitly, a range of "acceptable actions"

SERVICES

Physically the backbone is established on a technological infrastructure providing several common services. The purpose of this section is to discuss which services are important and how they should be modelled to support cooperation.

I have previously presented this concept as "A common house of service" [Line96], I believe this concept is still valid and have carried out studies which partially support the concept (see figure 5). In this company, application sharing and web have not yet taken off, but they are on the threshold of a development that leads me to the view that these will be core services.

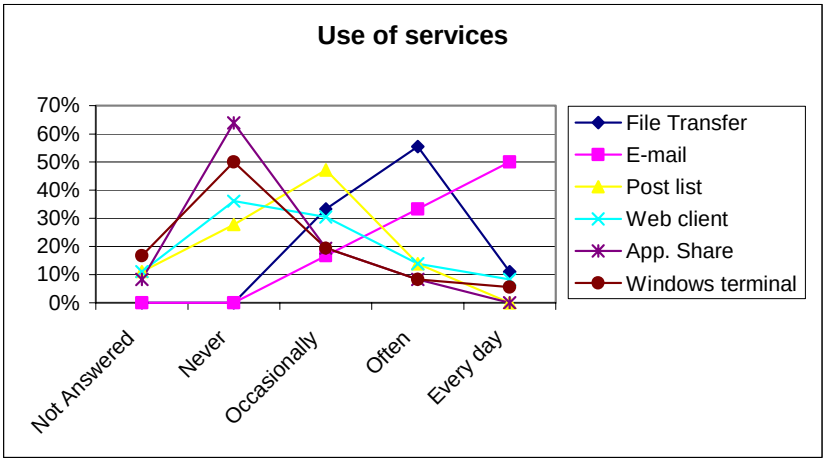

Figure 5: use of services in Asplan Viak (response to web survey 36 answers of 100 possible)

For this reason I have chosen to concentrate on the new aspects of this concept compared to the setting presented in [Line96]. The scope is extended to a network of independent (but cooperating) companies and it is the intention to establish a virtual cooperative zone

where also partners and customers can participate in project work. Two new and important aspects arise from this sentence.

- What are the values in the network and how can they be protected (without spoiling the chances for cooperation)
- Cooperation across company boundaries involves formal, practical and financial obstacles.

The concepts presented here are partly based on experience from obstacles to cooperation between subsidiary companies in the AV group.

These two new elements is incorporated in the revised "house of services" as shown in figure 6. Compared to the original house, this can be interpreted as moving *information flow control* and *work flow support* from the roof down to active service. Technologically, web is on its way down from an information retrieval service to becoming a part of the foundation.

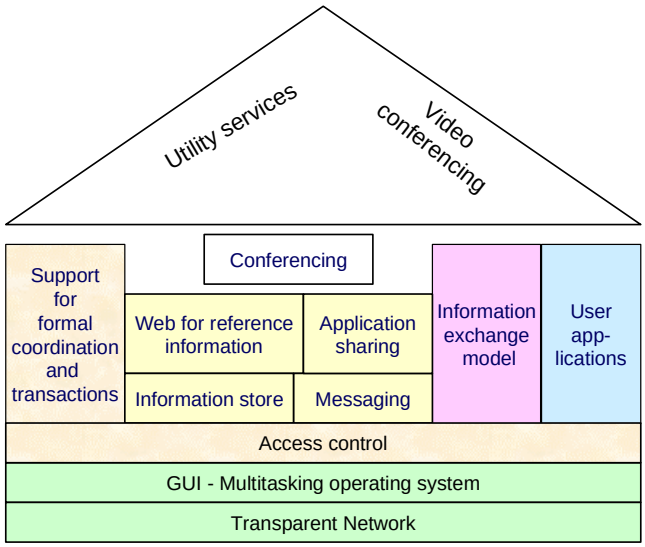

Figure 6: Revised house of services

In the discussion of the two new elements I will also exemplify how to implement and consider the following principles:

- Organisationally and technologically compatible solutions.
- Embedded coordination and governance.

Experience from Asplan Viak and studies of groupware implementation [Orlikowski95] have shown that when the physical infrastructure is established and the employees become familiar with the basic services, some will see emerging possibilities and start to solve existing tasks in new ways. I believe this illustrate an important aspect of distributed control and initiative. Some of these services may in time turn out to be indispensable.

What are the assets of the network and how does the network protect it's assets?

The value of an active and functioning network is first and foremost that a new and better way of creating value for the customers and the node companies has been developed. This interplay, based on relations among the actors and supported by communication services, cannot be stolen. Nor does exposing this achievement to others diminish the competitive advantage.

The network will however comprise information that represents value to some of the actors. This might be experiences from a completed project that represents a competitive advantage for new projects or confidential information owned by customers. How to achieve acceptable and efficient protection with minimum deterioration of the cooperative conditions, is discussed in the following.

Access control

My experience is that access control is an important issue with a huge impact on the employees' ability and willingness to co-operate and share information through digital channels. Too strict access control is expensive and complex to implement and manage. It is an obstacle to cooperation in general and particularly when it comes to deployment of new tools and techniques. Just as importantly, too strict formal access control probably entails so much inconvenience that it will be bypassed.

> *"Shields are seldom broken, they are outflanked"* [Ølnes97].

Too loose access control can be just as devastating to cooperation by digital tools and methods. We must be confident that the information is not exposed to people who should not have access to it. This view on access control and its importance to cooperation is underpinned and exemplified in the following.

A zone- or group-based model view is commonly used as a basis for an access control assessment.

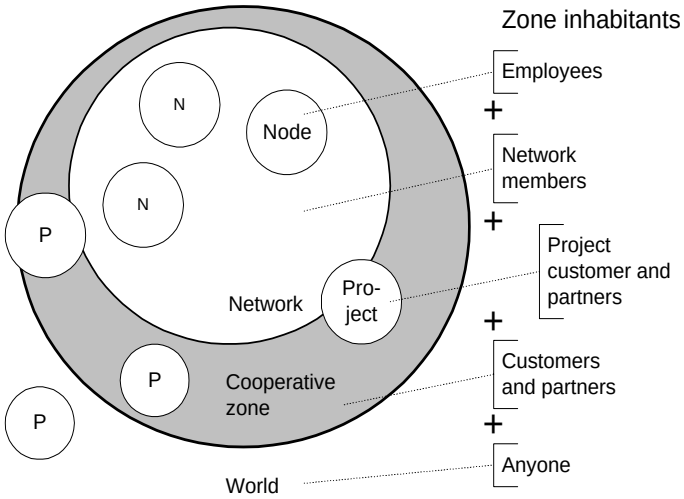

Figure 7: Access zones

The world shield: When a company has an Internet connection, the world shield is literally a shield against everyone. The fact that several million people from all over the world have access to an infrastructure that makes them able to attack you, spy upon you and destroy your information is frightening. So far, the history of Internet has shown that the chances for such random hostile attacks are small.

An assessment of the necessary strength of this world shield should consider the sensitivity of the available information and to whom this information is of value. A strict configured firewall, both with respect to available information and the accepted protocols, limits the possibilities for "digital cooperation". Tools like MS Netmeeting need a relatively loose configured firewall. The solution to efficient information sharing is either to move the project outside the firewall (and rely on normal authentication mechanisms) or to establish direct links or "safe encrypted tunnels" between the cooperating partners.

The cooperative zone: The situation is different in the zone inside the firewall. Here we know the persons and we can assume that they are not criminal. Why then do we need access control? What do we want to achieve? How can we ensure that the designed system works as intended? To simplify the discussion I will not deal here with highly sensitive information and personal data subject to authoritative regulations and concentrate on normal technical project cooperation.

We want to establish and operate in a "cooperative" zone comprising people representing different companies and interests (customers, partners and employees). Naturally, there will be some requirements to restricting access to information. In this zone we want project personnel to have easy access to all possibly relevant information whilst ensuring that they are comfortable with sharing their own information. In order to achieve this, they must be able to easily assure that shared information is not accessible to people who should not

have access to it. A “need to know” philosophy meets this latter requirement but it is a negative signal to cooperation because it requires somebody to evaluate whether or not information is of interest to you. In addition it will be expensive to implement and manage and the structure is likely to be complex to remember and maintain. Probably the greatest drawback of a too strict philosophy is that it will impose practical difficulties that the project personnel cannot accept. Faced with this problem, they will search for alternative solutions where access restrictions are a low-priority objective.

My proposed philosophy is: We need an argument as to why information should be restricted, not as to why it should be available. Experience from Asplan Viak is that this philosophy is generally accepted. A simple model for the default access level is important. For this project-oriented organisation, the default access is all employees, project partners and project customers. How easy it is to retrieve the information is also, at least of emotional importance.

> *Index servers has been installed in some of the offices in Asplan Viak. Both completed and ongoing projects were indexed. Free text search in the project archive was demonstrated to the employees. Generally they were impressed and found this to be an interesting possibility. However, several saw this as a new dimension to information sharing and they felt a need to reconsider the limit and guidelines for use of open available information.*

The example of the index server also illustrates another practical issue regarding access control. We do not just have one information store and one mechanism for accessing information. A complete information system may comprise several file systems, databases, mail system, groupware applications and web sites. A user may then have to deal with several authentication realms and maybe unsynchronised pairs of user names and passwords. This situation lowers the effect of an authentication system. At present it seems like *Lightweight Directory Access Protocol* (LDAP) is moving towards a de facto authentication standard. This will hopefully solve the problem of several authentication realms.

Support for formal coordination and automated economic transactions

The presented model is extracted from a total model for project management and economy currently under development in Asplan Viak. The core of the system is a modern transaction based administrative system built on a standard SQL database. The objectives is:

- A scalable procedure from small informal projects to relatively large multidiscipline projects involving employees from several subsidiaries.
- Focus on early corrective action and conflict solution. Require improved quality and fast aggregation of status information.
- Simplification of tasks and improved quality in performance (includes all involved personnel)
- Automation and standardisation of transactions between subsidiaries.

I have chosen to go straight to the core of the model that is, *active roles*, *transaction status* and *commitment*s. This is not complete, chronological or logical, but necessary in order not to drown the idea in details.

Active roles:

Team member (TM): Register used time as correct as possible. Regularly estimate necessary remaining time needed to complete the task.

Project leader (PL): Follow up and initiate corrective actions in vs. customers and team members. Report to MA when in need for assistance.

Project controller (PC): Follow up (push) and assist PL and TM. Assist in conflicts and correct errors. Report to MA.

Manager (MA): Approve initial commitments. Assist PL and TM with unresolved conflicts. Assist PL with corrective actions vs. customers (renegotiations etc).

Transaction status

Registered hours (and expenses) are assigned on of the following status codes:

NAW NAR	Not accepted, waiting Not accepted, resolved	N hours, no debit
ANI AW AI	Accepted, not to be invoiced Accepted, waiting Accepted, ready for invoice	A hours, debit to project
I	Invoiced	I hours, credit to project

Commitments

CC Commitment vs. customer (contract)

CPL Committed by PL vs. TM (time accepted as debit to project)

CTM Committed by TM (estimate of time needed to complete task)

The project leader controls CC and CPL. By doing this he implicitly controls the status of registered hours. Hours within CC are automatically accepted and suggested for invoice. Hours between CC and CPL are accepted but are not to be invoiced. The team member controls CTM. By adjusting this figure, he estimates (implicit commitment) what he needs to complete the task. By exceeding CPL without having signalled this in due time by adjusting CTM, he has not fulfilled his obligations.

The figure bellow shows the hour registration form (TM) and the project follow up form (PL). All figures (CC,CPL and CTM) can be annotated.

Project	Commited		Hours in week 5							Used		Remaining	
	CC	CPL	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Per.	Total	CPL	CTM
45.3450-Groos Renseanlegg	200	250	8	8	5	4	3			28	128	122	180
43.7618-E18 Kristiansand	NA	40				4	2			6	14	26	
44.8080-Snartemo	80	80								0	0	80	
44.1220-GeoInternett					3		6			9	9	-9	30
										0			
Sum			**8**	**8**	**8**	**8**	**11**	**0**	**0**	**43**			

Figure 8: Manhour registration form

		Committed					Used		Invoice				Remaining	
	Person	Customer (inv) hours	kr/h	Project hours	kr/h	Team member	Total	period	Invoiced	NTB Inv	To Inv	Waiting	Hours	kr x 1000
A	Lars Line	300	550	300	250		230	30	200		28	2	70	39
A	Jonas Fjeld	100	460	140	230	148	140		100	40	0	0	0	0
N								**8**						0
A	Henrik Mathiesen	40	660	40	400	60	2	2	0		2	0	38	25
							0		0		0	0	0	0
S	Hours	440		**480**		208	**372**	40	300	40	30	2	**108**	
U	kr x 1000 charge		**237**			273	**192**	**18**	**156**	18	17	1		**64**
M	kr x 1000 cost				**123**	133	**91**		73	9	8	1		

Key figures	CC/CPL		Invoiced/used		CC/CTM	
Surplus (krx1000)		114		66		104
Surplus (%)		193%		172%		178%

Figure 9: Project follow up form. White columns indicate possible action

The model does not directly cover all project contracts and relations. Requisite flexibility can be achieved by adjusting the implied meaning of the commitments and supply with

comments. Direct flow of information is required to keep up with the tempo in the projects.

OTHER ASPECTS

Education and training in use of the new services and the new form of interplay may be a significant barrier. In Asplan Viak [Line96], some groups and employees started to exploit the opportunities without training or guidance. Others were reluctant because they did not know what buttons to push or they did not understand the consequence of their action. I see now trivial and standard solution. Each situation must be evaluated. Priority, attitudes and motivation are decisive for the necessary action. Failing to address this may jeopardise the whole concept.

The rapid IT and telecommunication technology represents a constant pressure on the physical infrastructure and the implemented services. Commercial actors will offer similar services to the cooperative zone. I the network parties not have reached a higher level of integration and mutual benefit, the arrangement may erode.

CONCLUSIONS

Current Internet and groupeware technology has reached a level were it is possible, within a moderate economic framework, to establish services that will give a broad basis for a close and efficient cooperation.

The following elements are presented and underpinned as critical success factors for establishing a virtual organisation which can take advantage of the potential and opportunities offered by modern information and communication technology

- A viable business idea
- An organisational concept that match the idea
- Technological solutions compatible with the organisational concept
- Embedded governance and coordination in the design of solutions

The presented concepts and ideas are based on experience from Asplan Viak [Line96], socio-economic research [Klein95], [Gillet96] and the authors personal experience from several year as a practitioner engineer. Some of the theoretical work has been in cooperation with Program on Applied Coordination Technology at the Norwegian University of Science and Technology in Trondheim, Norway.

The presented model offers a possibility for short time increase in revenues. More important, the organisation is closer to being 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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