An initial exploration of mobile work

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Sammendrag/Abstract:

The IMiS-DNV project is concerned with exploring and evaluating organisational and technical possibilities in computer networks for mobile workers. This effort will be done by first gaining knowledge about characteristics of mobile work through interviews and observations. This knowledge will then be tested through development and evaluation of a prototype that shall support mobile workers. Its main aim is to point out and delimit a possible solution space for Det Norske Veritas (DNV) in supporting mobile workers.

This report has two objectives:

1. Present some results from the interviews and the analysis.
2. Outline an empirical basis for delimiting the technical solution space.

We do not intend to present neither a set of user requirements nor an empirical analysis of the work processes where mobile computing will be used. We want, however, to ground our discussions of possible technical solutions in daily practical work, not only in the technical possibilities available.

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1. Introduction

1.1 Background and goals for the IMiS-DNV project

The IMiS-DNV project is concerned with exploring and evaluating organisational and technical possibilities in computer networks for mobile workers. This effort will be done by first gaining knowledge about characteristics of mobile work through interviews and observations. This knowledge will then be tested through development and evaluation of a prototype that shall support mobile workers. Its main aim is to point out and delimit a possible solution space for Det Norske Veritas (DNV) in supporting mobile workers.
Within the project we will use the following definition of a mobile workers:

- *Mobile workers at DNV are persons that work a significant part of their time away from their home base.*
- *An employee's home base is the DNV office where the person is normally located. This means one of the 280 DNV offices in 100 countries.*

Technology is not included in the definition, but a technical goal for the IMiS-DNV project is to provide seamless computer support to mobile workers. The concept of seamlessness is defined in the IMiS feasibility project from the users' point of view. The ultimate goal for the users is that the system will recognise the users whenever they log on, on any network, with any equipment, at any time, with the application in a given state and have them adapt in the best possible way given these contexts. This definition gives the project a broad focus that we must deal with. The starting focus includes:

- *Both mobile and stationary technologies,*
- *that may be connected permanently to a network or just for shorter periods of time,*
- *the network capacity may vary from low to high bandwidth, and*
- *the network connection may be wired or wireless.*

The definition of mobile workers does not put any constraints on the actual work to be done when the worker is in the «field». The work does not necessary has to be of a mobile character. Mobile workers may, by this definition, work at the same place over a longer period of time. The requirement is that they work away from their home base. Of course the definition does not exclude work when moving around either. We can divide mobile work in three categories:

- *Mobile work while moving*
- *Work at different places*
- *Work at a fixed place (away from home base)*

Examples of the first category is a ship inspectors that walk around controlling different parts of ships or consultants working while travelling for example by train. The second category may be consultants visiting different customers, or employees working from home. One example of the last one is a DNV employee that works for a longer period of time at the same place outside his home base. We believe that giving mobile workers access to resources via computer networks while away from the home base will give additional support for doing their work and for keeping in touch with colleagues.

1.2 Characteristics of mobile technology

Satyanarayanan (1996) presents four constraints that are characteristic for *mobile computing:*

1. *Mobile elements are resource-poor relative to static elements.*
2. *Mobility is inherently hazardous*
3. *Mobile connectivity is highly variable in performance and reliability*

4. Mobile elements rely on a finite energy source.

The first constraint is important for IMIS-DNV project. Today, many systems are built to fit into the latest models of desktop computers. The desktop computers will as a rule have better resources available than mobile technology. This means, in many circumstances, that the systems must be modified to be able to run in a mobile environment.
The second constraint concerns the physical risk of mobile work:
A Wall Street stockbroker is more likely to be mugged on the street of Manhattan and have his laptop stolen than to have his workstation in a locked office be physical subverted. In addition to security concerns, portable computers are vulnerable to loss and damage [Satyanarayanan (1996)].
The third constraint concerns network connectivity. It is hard for mobile workers to predict the possibility to connect to the network and the quality of service available. In some places a high bandwidth network may be available for the mobile workers, and in other places the bandwidth is not available at all. Still the mobile workers must get their work done.
The most of the mobile equipment are based on batteries as energy source. In situations where the mobile worker is dependent on energy from batteries, it is important that the computer configuration is sensitive regarding power consumption.
These four constraints illustrate just some of the technological problems in the IMiS-DNV project. Many of these problems are hard to solve. Still, we believe that organisational concerns are more important with respect to benefit from investing in mobile technology.

1.3 Objectives for the report

This report has two objectives:
1. Present some results from the interviews and the analysis.
2. Outline an empirical basis for delimiting the technical solution space.

We do not intend to present neither a set of user requirements nor an empirical analysis of the work processes where mobile computing will be used. We want, however, to ground our discussions of possible technical solutions in daily practical work, not only in the technical possibilities available.
This report is the first in a series of three. The second will deal with scenarios for mobile computing, and the third will discuss the technical architecture and a plan of action to try out one of the scenarios (or a combination) in practice.
The primary target group for this report is DNV's project participants in the IMiS-DNV project and the potential test users of the mobile-working prototype. Still, people outside DNV that have interest in mobile technology and mobile work can also read this report.

1.4 Outline of the report

The next chapter gives a short introduction of DNV. The chapter is meant for readers that do not know DNV's organisation. Chapter three outlines the method used in the analysis of potential users' work activities and some findings from the analysis. Chapter four presents possible future scenarios for mobile work. In chapter five we present requirements and the scope for a mobile architecture. Chapter six concludes this report.

2. Det Norske Veritas

In this chapter we will give an introduction of Det Norske Veritas. It will be a high level introduction, and can be skipped by readers who know DNV. Chapter 2.2 presents some critical IT-tools used by mobile workers at DNV.

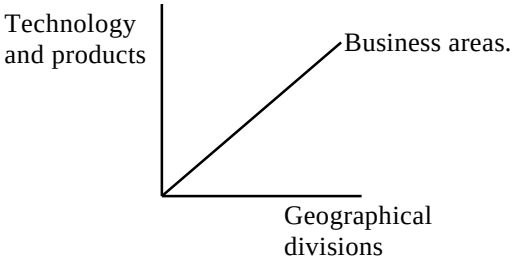
2.1 DNV's organisation

Det Norske Veritas (DNV) is an independent, autonomous foundation established in 1864. DNV has 4,400 employees and 300 offices in 100 countries. The employees are from 67 different nationalities. DNV is one of the world's leading maritime classification societies. The objective is to safeguard life, property and environment. DNV provides three types of services:

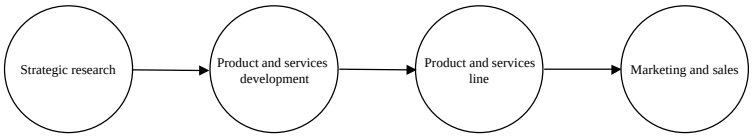
- *Classification. That is to develop and maintain rules and standards for safe ships and offshore drilling and production units, and to verify compliance with these rules during design, construction and operation.*
- *Certification. DNV is accredited to certify companies with respect to different standards, for example ISO 9000. The main difference from the classification services is that the certification is grounded in standards developed by organisations outside DNV.*
- *Advisory services. DNV gives advisory services regarding technical solutions, training and safety, environment and quality management.*

The organisation is build up around different divisions. The divisions can be described around three axes. The divisions "Technology and products" and "Business areas" (See figure) develop strategic guidelines, products and services. These guidelines, products and services are sold to the customers by the geographical divisions. The geographical divisions are:

- *Division Asia Pacific*
- *Division Nordic Countries*
- *Division Europe and Africa*
- *Division Americas*



The main direction in DNV's business process is showed in the following figure:



The project has identified types of mobile works in all of these phases in the business process. In the next chapter we will present and discuss some findings regarding mobile work at DNV.

2.2 Critical applications for mobile workers at DNV

Critical tools should be accessible from the field to harvest benefits of the investments. In this context, critical tools are the applications the consultants use to do their work. DNV has spent a large amount of money investing in IT-tools. The rest of this chapter will discuss some of the critical applications that should be available from field. Today, these applications are not easily available

from filed. In chapter 1317300.1.1315280 we will discuss the importance of availability of these applications from field.

2.2.1 Companion

The consultancy departments store information about correspondence with their customer in "Companion", which is an important tool for the consultants.
"Companion" is DNV's configuration of a product called SalesMaker from Software Innovation. Companion has functionality for handling information related to customers. Companion is build around several modules that can be configured for different use. The main rationale behind Companion is to have a shared database where all information about activities related to customers are stored. This includes activities from initial marketing to post-sale follow-up. The most central module in companion is the "contact module" where the users store information about business contacts, including companies and individuals. Other important modules are:

- *Segment*. Used for generating distribution lists based on specific criteria.
- *Prospect*. Used for registering all prospects centrally, including updated information about customers, contact people, and prices. Also used for merging relevant information into offers.
- *Product*. A catalogue of product assortment. It is easy to maintain, including a direct link to compiling an offer.
- *Budget*. Used for recording budget data and producing graphical representations of sales budgets.
- *Project*. Used for handling market campaigns/projects requiring follow-up.
- *Activities*. Activities related to contacts, market campaigns, and sales offers.
- *Sales history*. Supplies a useful basis for actively maintaining your relations with your customers and other contacts.
- *Document*. Used for creating and retrieving incoming and outgoing documents, as well as internal memos. Documents can be created in integrated word processors, spreadsheets and presentation applications.
- *Sync*. The Synchronisation module (database replication) offers business travellers an updated link to their organisation's database.

3.3.2 Nauticus

Nauticus is a project that develops information models and software about a ship's lifecycle. The information model will be focused on the classification activities requirement for updated and relevant information with respect to safety. It shall also be available for the ship owners and shipyards while they for example repair or maintain ships.

3.3.3 MS-Outlook

DNV uses MS-Outlook as generic communication tool. Outlook is a desktop information management program that helps users organise and share information on their desktop and communicate with others. Outlook can support the users by:

- *Managing personal and business information such as e-mail messages, appointments, contacts, tasks, and files, as well as track activities.*
- *Sharing information with a group by using e-mail, group scheduling, public folders, etc.*
- *Sharing information with other Office programs, and browse and find Office files from within Outlook.*
- *Connecting to and share information across the World Wide Web.*

It is also possible to use programming options to customise Outlook.

3. Work activities of some mobile workers

In this chapter we will present the approach used in the analysis of potential users' work activities and some findings from the analysis.

3.1 Approach

Five persons were selected as participants in a brief analysis of their work activities and work settings. The participants consisted of one consultant and one secretary, one manager and one researcher in the strategic research department, and one manager from the information systems department. The consultant and the managers may be categorised as mobile workers proper (see next section). Many researchers travel considerably, and for the time being they may be expected to show some of the same requirements for mobile support as the mobile workers. The secretary provides essential staff support from the home base, and the picture will not be adequate without this information.

Selection of respondents was exploratory. We wanted a broad overview of many types of work practices in order not to cut off job related needs too early. Later, for instance during requirements development and possibly testing, a specific job category, for instance consultants, may be appropriate.

The techniques used were semi-structured interviews and one session of observation. An interview guide, based on sociotechnical principles, was mailed to the participants before the interview, and transcripts of the interviews were corrected and approved by the respondents. In the observation session on researcher accompanied a consultant during a visit to a customer.

The following outline of some typical job situations is based on the interview transcripts and notes from the observation. In addition we draw on previous experiences from similar analyses, and the literature.

3.1.1 Categories of mobile workers

In this section we will give a brief introduction to different job categories that can be regarded as mobile workers at DNV. The categories are consultants, inspectors, managers and employees working from home.

Consultants

DNV has several consultancy departments. The employees in these departments are often located at or visiting their customers' premises. This means they spend a significant part of their time away from their home base. The consultants' primary resources are their knowledge. The computer support they use are often office tools such as Word, Excel and PowerPoint. They may also use some communication support like mobile phones and e-mail.

Several possibilities exist regarding how the consultants may be supported by the IMiS-DNV project. One scenario equips the consultants with mobile computers and communication tools, for instance a portable PC with a GSM mobile phone and a modem. In this case the consultants have all the necessary equipment to communicate with their home base. Because of the low bandwidth available with this solution, multimedia information will be difficult to transmit via the network.

Another scenario does not equip the consultants with mobile technologies. Instead the consultants "borrow" a computer in the customer's network. If this computer is connected to the Internet, the consultant may communicate via Internet. Depending on the task at hand, many possible solutions exist that may support the worker seamlessly. This can be done from solutions based on World Wide Web, but also on solutions based on virtual private networks. *A virtual private network* is a solution where the user connects to a LAN over the Internet or other public networks. When the user is

connected, the computer environment will be the same as it would be when the user is logged on to the local network.
Through the IMiS project, the consultants may get access to:

- *Assistance on demand/Just-in-time training*
- *Take part in internal discussions at DNV*
- *Other internal resources at DNV, for instance the knowledge database developed in the Nauticus project.*

Inspectors

The discussion above about the consultants is also valid for the inspectors at DNV. An inspector controls whether ships or other technical installations meet security requirements. The inspector carries out in-service inspection of ships and mobile offshore units. The main difference between the consultant and the inspector is the work environment. The inspector's work environments are often ships and offshore units. This environment is frequently characterised by mud and oil spill. Possible solutions range from support of pre- and post inspection work to computer support while doing the actual work. Computer support for the pre- and post inspection (i.e. preparing the inspection and make the reports after the inspections), may be based on the same solutions as for the consultants. Computer support for the actual inspections could benefit from use of "wearable computers". Research topics are mainly the same as for the consultants apart from the differences in work environment. A possible new research topic may be «wearable computers».

Managers

Managers at DNV have a high travel and meeting frequency. Managers may therefore be considered mobile workers. During travelling they often cross different time zones, and the travels vary in duration. Because of the travelling activities, it is hard to organise internal meetings. A research topic is therefore how mobile technologies can support management activities and management meetings, like distributed meetings. Many of the research topics are also relevant for the discussion about the consultants.

Home workers

A last example of «mobile workers» is people working from home, also called tele-commuting. We can assume that the home worker has a stationary PC located at home with some kind of network connections. This can be modem connection via ordinary telephone lines, ISDN, connection via cable-tv network, etc. We may also assume that other family members will use the home PC to other activities, which may raise security issues.

3.1.2 Interviews and observations

The empirical material for this section consists mostly of transcripts of interviews with five respondents and one period observing one consultant at work with a customer. We have focused on *job situations*, in the sense of activities that are found in all the transcripts and are recurring, rather than doing any kind of work process analysis.
The job situations are described in more detail below. The purpose is to provide examples to illustrate the different scenarios, and to ground our suggestions in real-life activities.

3.1.3 Job situations

Four job situations emerge from the present empirical material:

- *To contact co-workers to get information or solve a problem.*
- *To schedule a meeting*
- *To produce and transmit documents*

- *To distribute or gather information*

These job situations are tentative. Other groups of mobile workers may display additional job situations that are equally important. It is also likely that the job situations are too coarse-grained, i.e. they encompass too many sub-activities. It may be more suitable for the analysis to split e.g. »3. Produce and transmit documents» into two job situations: "3a. Produce documents" and "3b. Transmit documents". Furthermore, the present job situations are to some extent overlapping. For instance, gathering information is often a sub-activity of producing documents.
Each job situation varies from instance to instance of the category. It is more complicated to schedule a meeting when the group is large and not co-located than with a small, co-located group. The analysis below intends to surface some of the variability. The functionality required will have to take this into account.

To contact co-workers to get information or solve a problem

The situation occurs whenever a person needs an answer from another person, or she has to inform another person about some matter. It can be carried out in a number of different modes: synchronous/asynchronous, with or without computer support. The variability is briefly outlined below:

- *Contacts may be* single *or* multiple. *Single contacts occur when e.g. a mobile worker contacts a secretary to inquire about messages, while multiple contacts may be of the broadcasting type: «does anyone know how to deal with this problem?»*
- *Contacts may be* synchronous *or* asynchronous. *Phones and netmeetings on the one side, and fax, email, and varieties of BBS on the other side. The* type of information *exchanged may vary from brief exchanges of plain text/voice to complicated drawings etc.*
- *Different types of information may also have different* degrees of urgency.
- *Contacts may be directed both* externally*, to customers, suppliers etc, and* internally*, to DNV co-workers, HELP-desk and other support staff. The* accessibility *of persons is an essential question. People travel, they work part-time, they are away in meetings, - all of these constitute limits to accessibility. Accessibility should, when possible, be a question of personal choice, but for those who want to be accessible, several tools should be provided: fax, phone, email, NetMeeting etc.*
- *To some extent, the need for information for mobile workers may be planned. Necessary files like plans, agendas etc. may be downloaded on a laptop before travelling. However, people forget and they may discover too late that an important file is missing. Furthermore, the need for information may be highly* unpredictable: *«you never know when you will need that particular piece of information».*

To schedule a meeting

To schedule a meeting requires negotiations between the people who are involved. For the analysis, we will extend the job situation to scheduling activities in general. The job situation then includes both scheduling of people's appointment (meetings, tasks to be done etc.) and scheduling of shared resources (rooms, equipment etc.).
The scheduling task increases in complexity with *number of persons* involved. Negotiations require simple and rapid *feedback* and may sometimes require lengthy rescheduling. Similar to the previous job situation, *accessibility* of persons is a key question since mobile workers are not co-located. "Out-of-office" messages may help in reducing trial-and-error. Remote access to Outlooks scheduling services is also useful, provided that the schedules are fully updated and used by everyone (which is not the case today).
Overview of meeting rooms with technical facilities and opportunities to electronically allocate rooms may be useful. Remote access may reduce the need for delegation of the scheduling task.

To produce and transmit documents

Producing documents and transmitting them is a characteristic activity of knowledge based work. Depending on the type of document and the production process involved, the need for equipment and connections vary. It is basically a single-person job, but frequently includes co-operation (Job situation 1 and 2) and information searching (Job situation 4) in the preparatory stages.
The task may vary in *degree of urgency*. Some documents need to be produced and transmitted within submission deadliness, like contracts or bidding or timesheets. Documents may be aimed at both internal and external receivers, and the *types of documents* may range from simple text-based memos to possibly large and/or complex graphical or multimedia presentations. The spectrum requires highly different transmission capabilities.
The *accessibility of information* is another variable. Retrieving the information may depend on another person to search and transmit, or it may be directly accessible from connected databases, intranet or one's own files. Similarly, the *reliability* of the information may vary, depending upon e.g. whether handbooks are updated.

Distribute and gather information

This job situation differs from the first situation in the sense that one *distributes information* to a group of persons, not only to a specific co-worker. To *gather information* in this context means to search for information in archives, databases, regulations etc. without the involvement of another person.
On the distribution side, the *size of the group* is of importance. To reach a large group may for instance require access to directories. Furthermore, the *stability* of the group points to the need for meticulously updated directories in case of changes, and for easy reestablishing of group membership. The need for *feedback* may also be important, for instance when the distributed information calls for hearings, or concerns changes of dates and time for specific events. As in previous situations, the distributed information may be directed internally and externally as well as mixed, which calls for security considerations.
Gathering information is to a large extent dependent on access to the relevant databases, intranet information or other media. At present, the important databases are not accessible for mobile workers.

3.2 Requirements of mobile IT-use

This section discusses a selection of problems, requirements and possibilities for IT-supported mobile work. The aim is to provide a context for future technical solutions proposed in the IMIS-DNV project. The discussion is based on findings from the empirical work and knowledge from the research filed "mobile computing".
Mobile IT-use differs from traditional desktop computing in several respects:

- *Work. Mobile work is extremely situated, since the environment in which work will take place is impossible to anticipate fully. The workplace is not in the mobile associate's domain. Thus, mobile applications require an advanced pre-fetching strategy to make sure the relevant selections of data and programmes are replicated and cached on the mobile devices, if a reliable connection to the host network cannot be guaranteed.*
- *Infrastructure. There is limited access to resources, since the mobile workplace is not fully configured for the (unanticipated) tasks, and remotely, because connections are unreliable. Hence, unless a reliable connection to the host network can be guaranteed (e.g., by a customer-provided internet connection), the mobile associate will have to either:*
  1. Bring along a subset (cache) of data and programs that might be needed.
  2. Work on a framework into which the data proper can be inserted at a later stage

  In both these cases, synchronisation is vital. In the first case, replicated data must be inserted into a centralised database, in the second case, centralised data will have to be treated by replicated operations.

- Technology. *Support for mobile work is always inferior to desktop computing since there are physical and practical limitations as to how much can be carried by mobile associates. Even if mobile computers continually improve their vital performance, so does desktop computing, and* tasks *tend to be defined by the potential of state-of-art stationary equipment. Therefore, the possibility of using the mobile platform as a remote-controlling panel to the central resources should be supported.*

These requirements are discussed in detail below. Chapter 5 discusses the general architectural framework for implementing support for mobile IT-use.

3.2.1 Work

The IMIS-DNV project aims primarily to develop new ways of *IT-use*. This means that using existing technologies in better ways, as well as proposing new technologies for future development, falls within the scope of the project. With this philosophy, studies of mobile associates' working situations became a necessary starting point, especially because mobile work is significantly different from work that is primarily stationary.

Planning impossible?

From our empirical work, it can be shown that mobile work frequently comes to depend on remote, human or technical, resources. For instance, people need to ask a question to a colleague, or they come across information that they know someone else would benefit from having. They also need to access databases or use programs that may, or may not, be available from remote work support, such as lap-top machines.

Mobile work mainly takes place in an environment previously unknown to the associate, and it always comes under strong influence from the needs and desires of the customer. Mobile work comes into play only when work cannot be conducted locally, in other words, the complete context for the task cannot be established before one is "on location". Therefore "you never know when you need some info" or where it has to come from.

Scheduling meetings is an important part of mobile work, and it typically happens towards the end of a mobile working session. Inasmuch as other people are being considered for participation in the meeting, one either has to contact them directly, which is sometimes difficult because the potential participants are either themselves mobile, or executives with low accessibility, or access shared calendar and diary systems. In the latter case, again, remote access to information and programmes are prerequisite.

Producing documents and transmitting them is a characteristic activity in knowledge based work. Depending on the type of document and the production processes involved, which, in the case of mobile work cannot always be anticipated, the need for equipment and connections vary. Unless all equipment or data needed to do the job can be carried along, improvisation in document management and production becomes an inherent aspect of mobile work. Examples of document types that people mentioned were needed or contributed to are:

- *Formal letters, agreements, timesheets, course material,*
- *Course diplomas, invoices, travel bills*
- *Reports, plans, handbooks, overheads, memos, intranet-based information.*
- *Contracts, agendas, reports, plans, assessment forms, web-based information*

We also documented a need for database access, intra/internet-based information, formal plans, quality handbooks, private files, etc.

Document preparation is basically a single-person job, but frequently includes co-operation and information searching in the preparatory stages. Since many tasks pertaining to mobile work are initiated in the remote workplace, it is therefore reasonable to assume that this task could be accomplished more productively with effective mobile computing support.

Critical applications and field work

As mentioned in section 2.2, critical business tools should be accessible from the field to harvest benefits of the investments. Critical business tools are applications consultants use to do their actual work. DNV has spent a large amount of money investing in IT-tools. Today, many of these tools are used only when the mobile workers are located at their home base. The interviews indicate that if these systems become easily accessible from the field, DNV may increase their benefits for at least three important reasons:

- *The mobile worker needs to register data only once*
- *Improved quality of the data stored in the systems*
- *Easier access to up-to-date information*

In the rest of this section we will elaborate consequences of not having easily access to the critical applications mentioned in chapter 2.2.

Companion

In chapter 2.2.1 companion was shortly presented.

Companion is not easily available from the "field" because of different limitations. These limitations appear because of technical issues in Companion and in VerIT 3.0[1]. The technical issues will be discussed in detail in the report about the technical design, but the problems appears mainly from problems with database replication in Companion and the management of software resources in VerIT.

Since Companion is not easily available from field the consultants must wait until they return to their home base before updating the system. The consultant must therefore enter the information twice. First, in their personal systems (paper, palmtop, or laptop) at the time of the event. Second, the consultants must enter the same information in Companion on return to their home base. The double entry may lead to a chain of consequences shown in Figure 1.

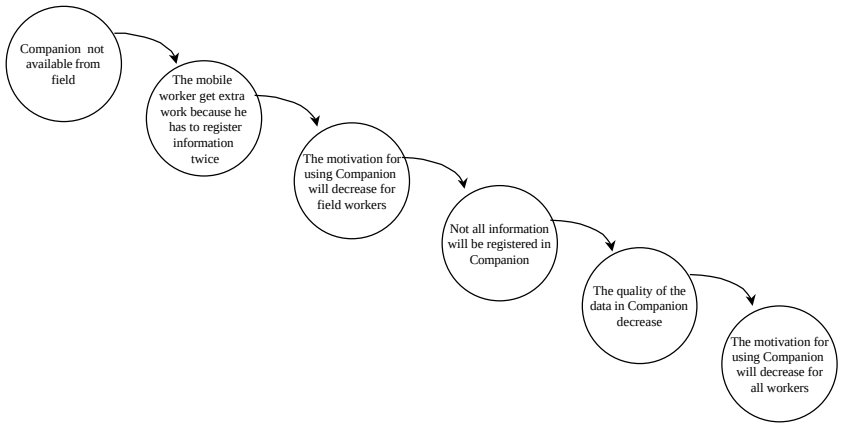


Figure 1: Possible chain of consequences

The chain of consequences shows the importance of having direct access to Companion from the field. Direct access will reduce extra work, and the consultant will get easier access to information about customers. Companion should function satisfactorily for the mobile workers in both connected and disconnected mode. When the mobile workers have access to a stable network connection with adequate bandwidth, they should be able to work with Companion in the same way as when they are located at their home base. Pre-fetching and delayed updates must be supported in Companion if it shall function in disconnected mode. Pre-fetching and delayed updates raises some questions, however:

- *What needs to be pre-fetched?*

[1] VerIT 3.0 is the name of the current network and computer configuration at DNV. The configuration is based on NT-computers in a TCP/IP based network.

- *Shall the whole Companion database be replicated on to the client machine or just a specified part of it?*
- *How shall version and concurrency control be handled?*
- *Who is responsible for solving conflicts when synchronising the different versions of the database? Is it possible to do this automatically or must the user solve the conflicts?*

Another problem regarding Companion is that it does not have any process support. This means that there is not any direct link between the current work process, for example the certification process, and Companion. The design of Companion is based on a flexibility perspective. This means that users can do everything from every place in the application. The result is that the users need experience with the product before they can use it easily. There also exist problems with the technical implementation of Companion at DNV today. There are problems regarding scaling and replication of the Companion databases.
The project will in the next phase of the project try to make Companion available from field.

Nauticus

Nauticus will probably be an important system in the business process at DNV in the future. Since it will be a significant information source for inspectors and advisors at DNV, it will be important that it works satisfactory from the field. Most of the problems mentioned about making Companion available from field are also valid for Nauticus. This includes disconnected and connected operation, synchronisation etc. From a mobility perspective, Nauticus also have to handle graceful degradation with respect to bandwidth capacity. This is because the Nauticus database contains multimedia information and technical drawings.
The project group believes that Nauticus will be a more successful tool if it will function from field.. If not, the argumentation in Figure 1 can also be applied for Nauticus.

MS-Outlook

Since MS-Outlook is DNV's generic communication tool, it is important that mobile workers can use Outlook from the field. Outlook is heavily used at DNV, both as an e-mail client and electronic scheduling system. As mentioned in section 3.1.3, scheduling a meeting may be difficult for mobile workers. Using an asynchronous co-ordination tool, like Outlook, may make this kind of co-ordination work easier for both mobile workers and people working at the home base. As for the other systems mentioned in this chapter, it is important that these communication systems work both in connected and disconnected mode. MS-Outlook must also work satisfactory under both high and low bandwidth conditions.
Some issues with respect to making these applications available from field will be discussed later in this chapter and in chapter 5.

Assistance on demand

Since mobile work is not predictable, the worker can not plan and train for every possible situation. In some situations the mobile worker may need to get assistant to get the job done. This may be a consultant who needs assistant about a customer-related situation, or it may be an inspector that needs an answer on a technical problem. The project group believes that the mobile workers should have possibilities for get assistants on demand. The assistant on demand service must include the possibility to contact both computerised knowledge databases and human experts.
A possible business benefit of an assistance of demand service for DNV is that it may reduce training cost. With a good organisational and technical infrastructure for mobile worker, they may get assistants when the problem occurs instead of be trained to handle all possible future situations. This type of functionality can be characterised as "Just in time training". The project group believes that there is much to save especially for the ship inspectors. They can send information about a damage or a technical problem, either synchronous or asynchronous, to an expert. In this way they can figure out which actions that must be taken. Another possibility is that the mobile workers connect to a

knowledge database where they can get information about similar problems. Of course the mobile worker can get assistance via mobile telephones, but using the possibilities in a computer network will give additional benefits. Example of benefits is the possibilities to transfer images or videos that shows the actual problems. This can help the involved persons in the communication situations. Another advantage is that assistance can be given both synchronously and asynchronously.

3.2.2 Infrastructure

Mobile IT-use does not necessarily entail mobile computing, in many cases the mobile associate is better served by using an internet-enabled workstation. Eventually most customers have such equipment, or it can be leased for a longer period, or simply used at an internet-café. Still, many of the concerns raised in this report apply.
We will assume, however, that mobile work will eventually be supported by portable equipment, and aspects pertaining to this infrastructure will thus be treated in some detail in the following subsections.

Connected versus disconnected operations

Computer networks have become a crucial part of the computer environment. Many applications have been developed in a client-server architecture. Many of these applications take the computer network for granted, in the sense that if the network is not available, the application cannot run. «The network is the computer» is a slogan used in the computer and telecommunication industry, but still there are many years of research and development until this will be true for mobile users. Today, the rule is that the mobile users will not have continuous network access. The mobile users may have access to a modem and a telephone line, but most of the time they will not be connected. There are several reasons for this:

- *A continuous connection from the field is expensive*
- *Using a telephone line will often block incoming calls*
- *Wireless infrastructure has not good enough coverage and quality*

The IMiS-DNV project believes that this will be true for many years. Therefore, applications for mobile users must be designed to work in disconnected, weakly connected and connected mode. This implies that the users download and upload documents and other types of data when they are connected. The application must handle version control and manage conflicts. Conflicts will happen when two or more users edit the same document at the same time. This is equivalent with the «lost update» problem from database theory. The version control system should also have mechanisms for notifying mobile users if a document stored on the client is changed on the server.
To summarise: it will not be feasible to provide network access anytime and anywhere. However, it will be feasible at some time in some places.

Unreliable connections

In a mobile environment, network connection cannot be guaranteed, although we assume that in most cases it is to a large extent possible to *predict the work situation*. Experienced mobile associates are likely to know whether they will be able to use the Internet at the remote workplace, or if a GSM connection is likely to sustainable throughout sessions. It turns out, however, that most connections, and certainly wireless networks, are less reliable than could be desired.
One important requirement of mobile IT-use is, thus, that it should be able to handle unreliable connections, for instance by caching data that is needed, or delaying transmissions and updates until the system is on-line. Interrupted sessions will have to be *undone* and *rolled back* in a safe manner.

Synchronisation of data on different equipment

We have seen at DNV that mobile users often work with several computers. They may have a desktop computer in their office, and one laptop or palmtop when they are mobile. They may also

have a computer at home. Multiple computers may cause problems because of version control. The users (or the system) must therefore always keep track of on which machine the last version of a document is located.
Mobile workers need different equipment for several reasons. First, stationary computers have better ergonomy than mobile computers. The screen of a desktop computer has better quality, and the keyboard is easily adjustable. Second, modern desktop computers will as a rule have better computing capabilities than a laptop. A third reason for different equipment is that it may be cumbersome to set up the mobile computer.
As a consequence, mobile users must synchronise documents, databases, and applications on the different computers. The user or the system must always know where the latest versions are stored. Different versions of an application should also be synchronised on the mobile computers, because the data format they use may not be compatible.
Having one main storage for the data can solve the synchronisation problem. The mobile worker (or the system) must then remember to store all documents in the main storage. The storage should be accessible from the different physical networks used by the mobile worker. The main storage should also be covered by the organisation's backup system. The users must be responsible for the synchronisation of documents. In a Microsoft environment, «My briefcase» may serve as an assistant for this purpose.

Navigation and retrieval

Because of the alien (and sometimes even hostile) nature of mobile workplaces, accessing the required information or people is not the only problem, albeit a significant technical challenge. On the application level, *searching, localising and retrieving* becomes just as crucial. From someone else's office, locating a document on one's desktop without visual access and manipulation can be cumbersome. Everyone who has tried instructing someone else to locate a manual or electronic document is painfully aware of this. The spatial and local organisation of information are considerable aids for retrieving relevant information (Suchmann & Wynn, 19xx).
The detachment of the need for information, from the familiar organisation of it, introduces a need for strong navigational support, in order for the mobile worker to be able to connect and access resources across a mobile network.

Network security

Clearly, a paramount concern for all commercial companies, in terms of remote access to the central information resources, is security. There are several requirements:
The most essential is ensuring that only authorised personnel can access selected programmes and data.
Also, the system will have to secure the transmissions, such that messages cannot be monitored and tampered with by unauthorised users and processes.
Finally, the completeness and timing of transmissions will have to be maintained, even across unreliable network connection.

3.2.3 Technology

In situations where the mobile associate relies on portable terminals, several concerns are brought to the fore.

Suboptimal performance

Processing capacity and interfaces of mobile computing devices will, we assert, always we inferior to those offered by desktop computing. Even significant improvements in mobile technology are related to similar innovation on the desktop, and the supported tasks are mainly defined by the capacity of stationary equipment. For example, most palmtop computers today are vastly inferior to the ones used to run earlier versions of Word on an MS-DOS platform, even if that was thought improbable 5

years ago. However, at the same time, desktop machines have multiplied their processing power, and the software as well as productivity expectancies have adjusted to these increments. Requirements of compatibility with desktop tasks and computers means that the gap in performance between palmtop computing desktop computing remains unchanged: Word 97 does not run a palmtop, and Word4 will, unless filtering and social protocols introduce discipline, become incompatible with people and programs with which the mobile associate co-operates. Some improvements can be traced in isolated cases, for instance, Windows CE "pocket" applications for palmtop computers are largely compatible with Windows 97 applications, but this is not a general solution, at least not in a mobile environment characterised by unanticipated needs.

Proxy representation

One interesting challenge for mobile work is how to enact presence in a remote environment. This is a common problem in applications that purport to support co-operative work, since the participants in some ways must make their actions and intentions know to the group. One requirement, much discussed in CSCW literature, and with clear reference also to the problem of localisation of human resources in the remote environment, is that of maintaining an awareness of the availability and activities of potential collaborators. This is needed, often, to establish sessions.
During sessions, in particular where synchronous updating of a common artefact or document is entailed, the need for a proxy representation is called for. Turntaking and floor-control depends on participants having some presence in the virtual workspace. Furthermore, when changes are being made, the group will have to made aware of who is making the changes, possible conflicts with updates made by other members, and a strategy for negotiating content and participation. With limited processing capacity and display quality, this becomes a particular requirement for mobile computing. Since many tasks already, and certainly in the future, will depend on bandwidth and graphics intensive applications, some sort of data mobility will have to be supported. Data mobility means that the semantic content of a medium or data-element can be translated and re-represented using a different, and perhaps less demanding, syntax. This requirement should also bee seen in relation to the Quality of Service needed and delivered, if bandwidth or processing capacity does not support a given format, it will need to be negotiated, and, either transformed or excluded, without significant loss of task-support.

Personal mobility

The requirement of personal mobility means that mobile associates should be able to continue working with applications from arbitrary terminals. Examples of part support for this requirement is the NT remote desktop, Network Computer technologies, and the GSM chip in mobile telephones.

Session mobility

In many situations, mobile work is not only globally mobile, in that the user moves from his home base to a remote site to do the work, but also that work is mobile locally, within a session. In the ultimate support for mobile work, live and persistent sessions should be moveable between terminals, without having to re-establish the working context.

3.2.4 Advantages of mobile IT-use

Mobile IT-us has many advantages, many of which are related to the requirements discussed above. For instance, interaction is local and close to the customer. This means that the quality of creative work and problem solving can benefit from direct input and immediate feedback. In addition, and this is particularly important when distances are great, mobile computing allows local processing without the delay of data transmission between the client and a remote server. Mobile work encourages new and potentially productive organisational forms, such as we have described in the Scenarios chapter. The various requirements and the cost of implementing them should therefore always be assessed on the background of organisational needs.

4. Tentative scenarios of IT support for mobile workers

4.1 Working with scenarios

Developing and discussing scenarios is a particularly fruitful approach for exploring the space of problems and solutions for a project. This project's objective is to investigate the possibilities of supporting DNV mobile associates in their work. One important part of this endeavour is to implement and evaluate prototypes for mobile work. Any technical contribution should build on a clear understanding of the existing application domain and its users. Preliminary studies have been carried out within the IMIS-DNV project, but a more focused, deep effort will be needed to design a *production* system. There is a need to narrow the scope of the project. Furthermore, design is about envisaging future IT-use. The scenarios are part of this process, as instruments for finding out *what the project's prototypes should try to achieve, how and for whom.*
The section of the report explains how the scenarios are being developed, and relates the nature of each to a framework of design considerations. The scenarios are intended to cover realistic, yet potentially futuristic technological possibilities. On the process level, scenarios should explore several different organisations and cultures of work, since technological and institutional changes tend to be related. DNV is a large enterprise that influences and adapts to trends in society and working life, thus, we have also attempted to include a wider set of issues, such as an increasingly mobile lifestyle, flexible institutions, globalisation and a networked organisation of work.
The remainder of this section chapter outlines some scenarios that we think span an interesting and relevant space of potential applications for mobile DNV associates in the future.

4.2 A framework for developing DNV scenarios

The scenarios can be categorised according to the organisation of information resources (databases as well as people), the infrastructure and the fundamental modus of work. It is important to be aware, however, that these aspects will to a various and combined degrees constitute actual work situations. Creating scenarios is a matter of design rather than reporting. Thus, we are working on scenarios that explicate a combination of the following categories, applied to the active working situation towards, for instance, a customer:

- ***Centralised or decentralised information resources:*** *At one end of this dimension, databases and the co-operative work force pertaining to a mobile DNV associate in a given situation, can be found in one authoritative location, e.g., at Høvik. At the other extreme, they are completely decentralised and under the control of its local owners.*
- ***Connected or disconnected:*** *This dimension represents the available infrastructure; can the mobile associate connect synchronously to the information resources, or will updates have to take place asynchronously. In most real cases of synchronously connected infrastructures, the supporting systems will have to handle graceful degradation toward asynchronous connectivity.*
- ***Co-operative work or individual work:*** *In one case we can envisage an organisation of the DNV enterprise that encourages mobile associates to work more independently, i.e. as autonomous agents toward customers. On the other end of this dimension, co-operative working arrangements involving several other people within DNV (or even, without) could be the preferred mode of operations.*

The following figure graphically represents this potential space of DNV mobile applications. It is also a useful reminder that the metrics offer by this framework is continuous, rather than discrete.

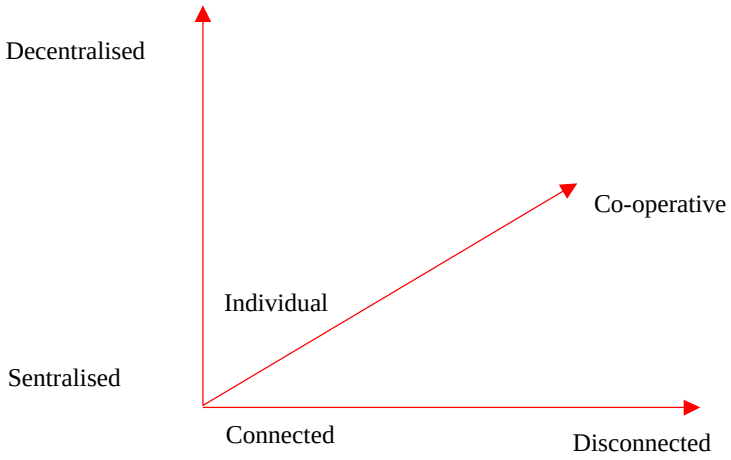


Figure B: The solution space of the scenarios

However, for the purpose of developing and discussing the scenarios we have sought a clear separation between the scenarios and each of its constituting categories. We can discern, from the framework, eight typical application scenarios for mobile work in DNV. Although we do not intend to provide a detailed account of each scenario, awareness of their existence and character could prove a useful conceptual tool for designing a prototype for the IMIS-DNV project. The following table, thus, summarises the scenario proposals coming out of the framework suggested above:

No.	*Name*	*Information resources*	*Infrastructure*	*Mode of operations*
1	Satellite	Centralised	Connected	Co-operative
2	Operator	Centralised	Connected	Individual
3	Fighter pilot	Centralised	Disconnected	Co-operative
4	Consultant	Centralised	Disconnected	Individual
5	CyberGroup	Decentralised	Connected	Co-operative
6	Sharing	Decentralised	Connected	Individual
7	Networking	Decentralised	Disconnected	Co-operative
8	Market	Decentralised	Disconnected	Individual

Table A: The list of scenarios

Before these scenarios are briefly outlined, we have to point out that neither of these, in isolation, represents, in our opinion, a “better” future organisation of work at DNV. We are not trying to predict the future, neither do we, at least, not yet, assign a quality rating to any of the scenarios. The ambition of this exercise is to develop and discuss a space of possible organisational and technological approaches to mobile work in DNV.

4.3 Satellite

In the satellite scenario, the group of people working together are mainly preparing and working towards the customer from Høvik Headquarters (HHQ). When a mobile associate goes out to work at the customer’s site, the remaining members of the group at HHQ support him in real-time.

4.4 Operator

This scenario involves individual work as the prevalent mode of operation. To access the common, centralised information resources to resolve a need for assistance, the mobile associate has to remotely access and update on items within HHQ. Many “organisational memory” approaches today

are aligned with this scenario, in which consultants remotely access and update information (without co-operation) through a shared information space.

4.5 Fighter pilot

Similar to a fighter pilot, in this scenario the mobile associates prepare for work in a co-operative mode at HHQ, before going out to the customer. Whilst in the field, since a mobile connection cannot be assumed, people are on their own, until they return to HHQ and can be debriefed for the benefit of the group.

4.6 Consultant

This scenario is very close to the widespread organisation of work at DNV today. Information resources can be found at HHQ, each consultant prepares individually and cannot connect again during the working session at the customer's site. The endeavour is mainly individual and other people are likely to be educated about the case only if they ask.

4.7 CyberGroup

In the CyberGroup scenario, information is distributed amongst the mobile associates, and most people are working elsewhere. Thus, HHQ's size is reduced and its role is mainly to facilitate the virtual groups. People within these tightly coupled groups depend on each other's support, and therefore they are continuously connected. Information is under local control, and is placed into a context through negotiation and mutual support.

4.8 Sharing

This scenario is similar to the previous one, except that work is mainly individual. Thus, information will have to be accessed in a traditional database fashion, eventually with only a limited set of automatic constraints imposed by the owner. It is similar to the Operator scenario with information resources distributed, rather than centralised.

4.9 Networking

Networking is mainly decentralised and disconnected during sessions at the customer's site. In this scenario mobile DNV associates rely on formal and informal personal networks of contacts to provide assistance, before and after sessions. One can imagine that such networks will consist of external consultants as well as DNV associates, loosely coupled together by their ability to provide mutual support. In the network, people know each other's abilities.

4.10 Market

In this final scenario, human and technical resources are distributed unevenly among very loosely coupled consultants, without participation in a co-operative network. Technical connectivity (between) sessions would have to be improvised, and it is not unlikely for this scenario (and examples can already be found in the so-called *information economy*) that information is bought and sold between people who do stand-alone projects for DNV.

4.11 Summary

This chapter has introduced use of scenarios to explore possible problems and solutions for an IMIS-DNV prototype supporting mobile work. Eight scenarios have been briefly outlined. The purpose is to inspire a discussion about current and future concerns of this project, and the eventual scope of

prototypes and empirical investigations. Selected scenarios will be further elaborated in a separate report.

5. Models for mobile IT-use

A set of conceptual models for candidate architectures is introduced and outlined in this chapter. The chapter is divided in two sections. In section 5.1 we will present an architecture that is possible to implement during the IMiS-DNV project. In section 5.2 a general model for mobile IT-use is presented.

5.1 Short-term support for mobile work

As a preliminary result, which also is designed with the strategy for further research in this project, we have formulated two design alternatives that utilise existing technology to support mobile work in a better way. Our approach is to test and tailor both solutions to the production environment of mobile consultants within the area *advisory services*, implement both solutions in co-operation with a small number of consultants, thus enabling a longitudinal empirical study of mobile IT use in DNV. For both proposals, the process support system *Companion* is at the core of our efforts.
The first solution entails replicating data from the central (to the department) Companion database onto the consultants' lap-top. The primary contribution of this effort is to develop strategies, rules or algorithms for intelligent replication of only a subset of the database, since carrying a complete mirror would be to cumbersome, time-consuming and a potential threat to security. Judging from the interviews, it also seems that the technical and organisational implementation of a distributed Companion would benefit from input from the IMIS-DNV project. Although the supplier, as well as DNV members, claims that Companion supports remote access and replication, this solution does not seem, currently, to be working at DNV. The following model is an abstract representation of this solution to supporting mobile work with a replicated database and Companion client running, for instance, on a laptop computer.

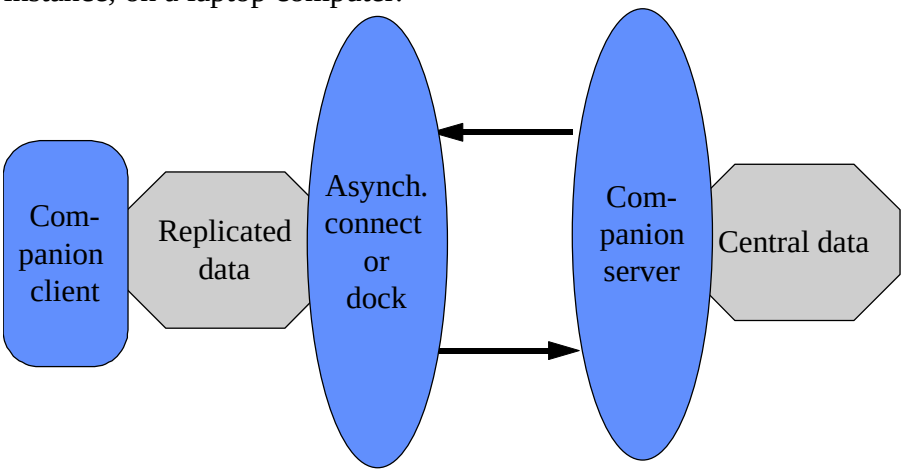


Figure 3. Client-server model with (part) replicated database

The next technical solution that we are currently experimenting with involves remote access from the customers' site across the Internet. The Companion application runs centrally, at DNV's host computer only, and only the user interface would be shared across the network. This solution, outlined by the model in Figure 4.
Figure 4, can be implemented using a product called *Tarantella.* Tarantella runs an X server within a web-browser, from anywhere on the Internet. VerIT applications can thus display their interface by emulation of NT on a Unix host. Emulation and access to a Unix host is part of the product services, and we are currently looking into the licensing scheme for Tarantella.

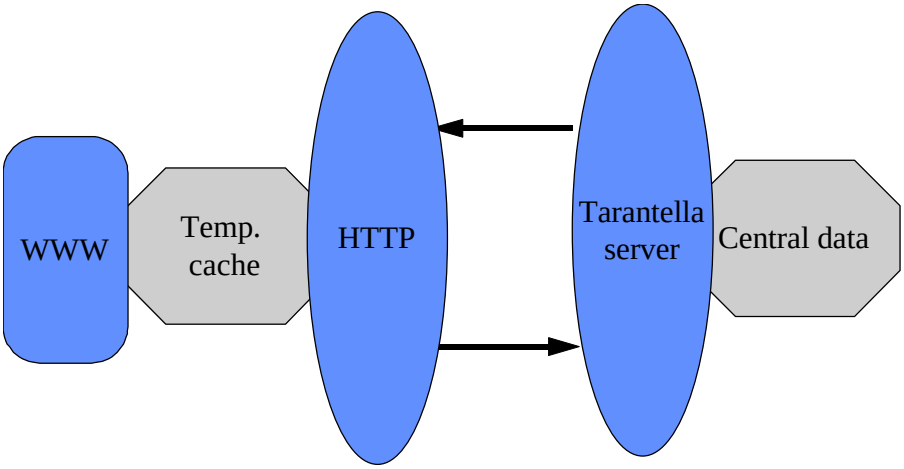


Figure 4. Sharing the interface across the net

In cases where the mobile associates can access an Internet host from the customer site, this solution will avoid many of the technical problems inherent to mobile work, since the full application functionality and database can be made available.

5.2 Developing a more general model for mobile IT-use

The two technical solutions that are proposed in this chapter are not sufficient. They cover only a subset of the working situations that mobile work at DNV currently, and in the future, will comprise. A more general approach is needed to adequately cover the problem and solution space implicated by the scenarios outlined in the previous chapter.
Proposing a general model for mobile IT-use is guided by the two main technical constraints, discussed above:
Only a partial selection of information resources can be replicated, because mobile devices have limited capacity, and even if that capacity is extended, one cannot anticipate which data need to be pre-fetched.
A reliable connection cannot be assumed, since mobile networks are not always available. Thus, changes in replicated data may have to be asynchronously updated, or operations on central data may have to be queued and carried out upon resuming the connection.
By combining these two dimensions, we can define a space for mobile IT-use with four categories of problems.

	Connected	*Disconnected*
Data-in-cache	1) Immediate Change and Update	2) Immediate Change, queued Update
Data-not-in-cache	3) Fetch, before Change and Update	4) Queued Fetch, eventually Scripted update

Each problem is discussed further in the following section, and an abstract model for resolving each is suggested. For all models, the technical environment is assumed to be one of a client application running on a remote computer.

5.2.1 Immediate Change and Update

Within this model, data can be cached, but this is seldom necessary since the client is connected to the server throughout the session. Thus, the client performs its (replicated) operations on the central data and no need for synchronisation arises.

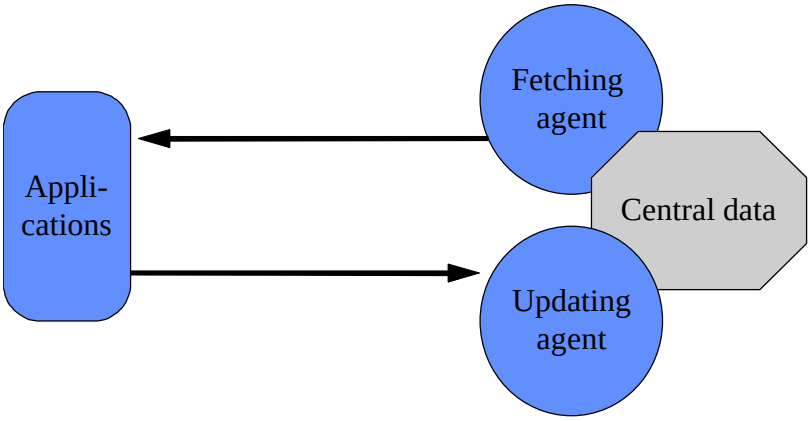


Figure 5. Immediate change and update

Notice the different between this model and the Tarantella-based solution proposed above: Within this model a local client has to be installed on the mobile device, whilst in the above scenario, Tarantella would simulate that effect by replicating the user interface only.
Another issue for future discussion is the granularity of locking, and size or complexity of the material that is changed. One can easily envisage situations in which it would not be possible to work throughout a longer period without caching, or securing control over multiple, related items in the database. These scenarios are dealt with in the model "Fetch, before Change and Update" in Figure 7 below.

5.2.2 Immediate Change, queued Update

This is a variation of the above mode, in which data *needs* to be cached, or pre-fetched, because the anticipated mode of work does not furnish a connection to the central host.
The operation of the model is characterised by being able to immediately read and manipulate data from the cache, however, updates are not globally valid before they have been synchronised with the server.

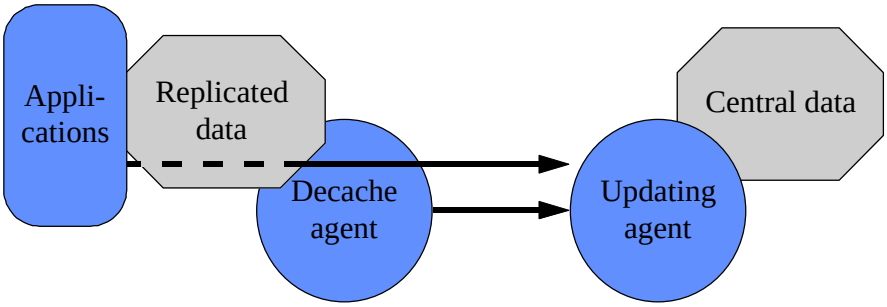


Figure 6. Immediate Change, queued Update

This models needs an implementation that provides easy and relevant pre-fetching of data, and securing a queued execution of operations upon resurrecting of a connection to the server. The traditional approach would only involve replacing older items in the central database with newer items from the replicated database, but it is reasonable to assume, and it is certainly a researchable issue, whether this is sufficient in application that support co-operation rather than individual work. We suspect that a greater awareness of the actual operations on the data will be needed to complete synchronisation of a medium for co-operative work

5.2.3 Fetch, before Change and Update

In many cases, for instance if the material to be refined through computational work is complex or have many parts in relation, current locking strategies may be insufficient. Co-operative work also often involves longer sessions of working with pertaining data items that traditional transactions can

efficiently describe. Therefore, an architectural strategy is needed that takes into account the need for local caching of data even when a connection is in place.

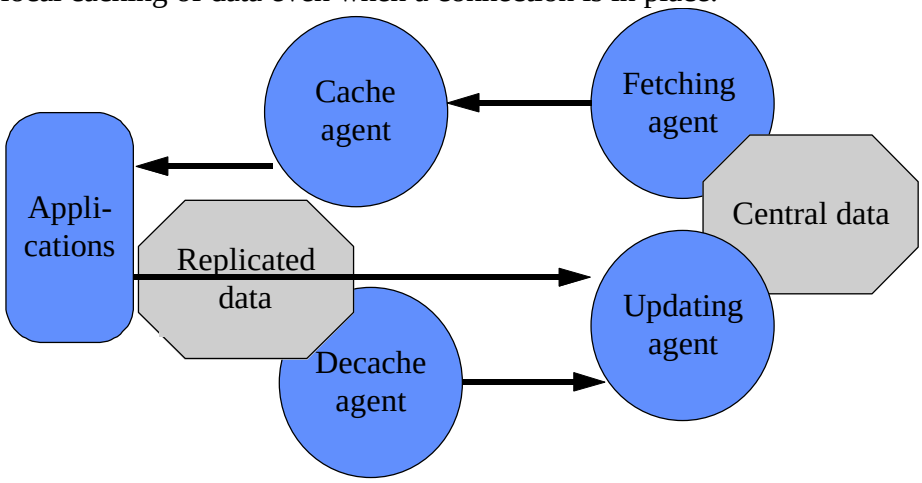


Figure 7. Fetch, before change and update

This model can also deal with situation where users want to make sure that they will be able to complete their operations on a set of data-items, even if the connection is disturbed or the central data changed by someone else. This figure will need a replication store and decaching strategy similar to the model illustrated in Figure 6.

.

5.2.4 Queued Fetch, eventually Scripted update

The final model is designed to work in situation where a connection is not in place, and the relevant data has not been cached. It is not practical or possible to replicate the complete (set of) databases that are needed, or fully anticipate the needs to mobile work. Hence, these types of situation will sometime arise. This model supports a strategy of working either on "dummy" data or a script that at a later stage can instruct the central repository about how to synchronise or negotiate the changes that should have been made to the data.

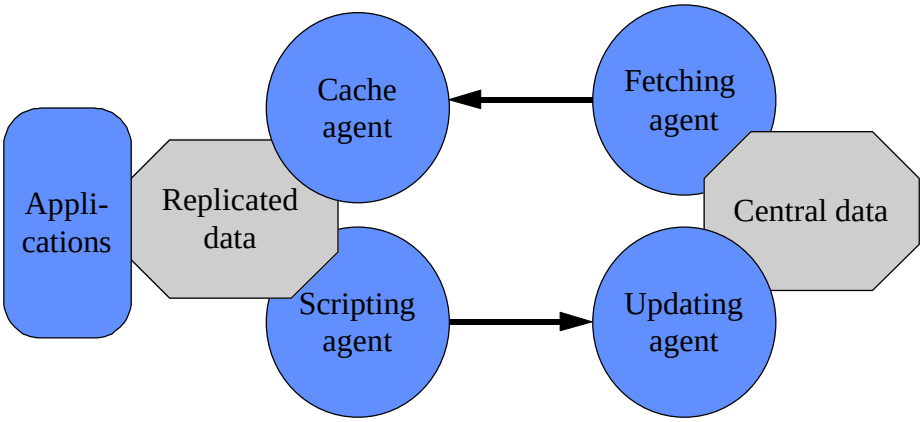


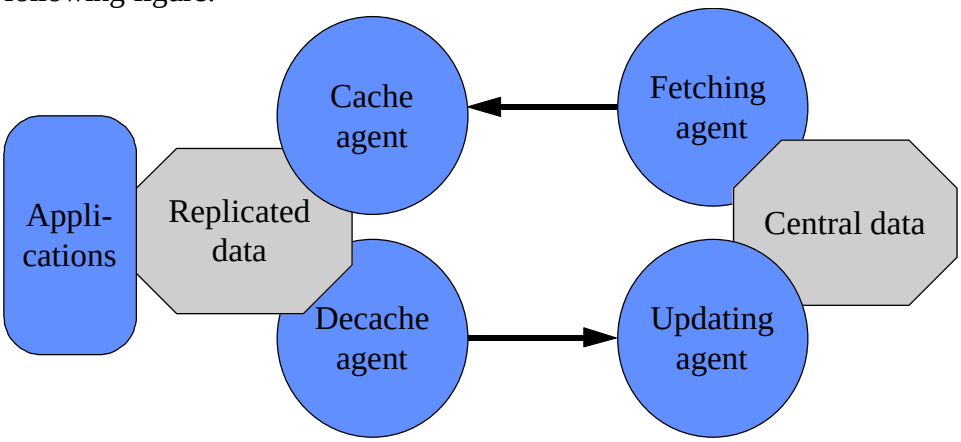
Figure 8.Queued Fetch, eventually Scripted update

Clearly this is not a model that can be implemented for all types of situations, and more research is needed to investigate the potential scope and effects of using this technology. In its most futuristic guise, this model could potentially be implemented *using "intelligent" agent* technology. A simpler version could be enacted by *pushing scripts* that had been adapted to the circumstances by the mobile associate, onto the server, or, more advanced, *by delayed operation in interactive applets*.

5.2.5 Generalising the models

By allowing each agent to determine when to act, for instance to autonomously decide upon immediate or delayed update (for instance, if the connection is not in place), and force a temporary

cache even if data is available on-line, these models can be generalised into one, as shown by the following figure:



5.2.6 Security issues

Based on the models and scenarios outlined in earlier sections, we will classify some of the most important security requirements and try to identify some key architectural requirements that follow. There are three main players involved in the scenarios; the home base or DNV, the mobile worker and the customer.
The main security goals of DNV are:

3. to output only data that the mobile worker or the customer is authorised to see,
4. to ensure that the data is properly protected during transmission, and
5. — maybe most importantly — to protect its network and internal resources from all kinds of unauthorised access.

All this require a number of security enforcing functions and components depending on both the general security policy of DNV and the type of data and applications used.
DNV must first of all have a proper *access control* at the perimeter of its internal network. This includes both a secure remote access functionality, which control the access for the mobile workers, and some kind of firewall architecture which control the access for other types of internet services, such as mail. There are several workable remote access solutions to choose from, and we can not at present time make a specific conclusion on this. There are also several firewall architectures to conceive. But in a scenario where DNV pushes output data to a dedicated server (for the mobile worker or customer to pull down), a dual-homed bastion host, perimeter network kind of firewall architecture would be preferable. In this case DNV should push output data to a server, such as a web-server, in a de-militarised zone.
Next, DNV must base all its services to mobile workers and customers on proper *authorisation*. The authorisation may depend on both the mobile worker and the customer, and DNV will therefore need a *user profile* database that describes and decides on the access rights and privileges of the mobile worker, and perhaps also a similar *customer profile* database.
Both the remote access service and the authorisation must be based on proper *authentication*. Although several authentication mechanisms are possible, for instance use of certificates, memorised or one-time passwords etc, we will point out that the signing capability inherent in (most) certificates make this option very well-suited. A *Code signing* capability may for instance be necessary in some scenarios.
DNV must also have a proper level of *traceability* associated with the services offered. This require auditing and perhaps also non-repudiation functionality.
And finally, DNV will want to protect data during transmission. It may be necessary to protect data with respect to both integrity and confidentiality. The latter can only be achieved by the use of cryptography. Cryptography can be added at different protocol layers, but since cryptography may be needed for many types of services, the application layer is perhaps not applicable. SSL or perhaps

IPSEC technology may be used in stead. At the moment we have focused most on the use of SSL. The required strength of the algorithms and the appropriate key length will depend of the types of data and services used.

The mobile worker

The mobile worker carries a lap top or palm top around, and it is important to protect the data stored on these machines properly. A lap top or palm top may easily be stolen or lost, and some kind of a file encryption or disk encryption is likely the best solution.
The mobile worker must support the security functionality required by DNV as described above. Smart cards could be used both for authentication, signing and encryption purposes and is well suited for mobile work situations.
The mobile worker may also need a set of user profiles or security envelopes to bring around in order to adopt in a flexible and secure manner. One solution is to use PKCS 12, which is a standard that specifies a portable format for storing or transporting a user's private keys, certificates, miscellaneous secrets, etc.

Customer

The customer will have its own security policy. In cases where the customer will receive or fetch output data from DNV, or the mobile worker is connected to the customer, it is important that the security architecture is flexible enough to adopt to specific customer policies. A customer may for instance only allow a very restricted set of services through a firewall, only recognise a limited authentication mechanisms etc. Flexibility is hence a important design criteria.

Some concluding remarks

At the current stage of the project, it seems that these security requirements are best met by the use of public key technologies. This means that DNV must establish and run a *Public Key Infrastructure* (PKI), and issue certificates for its mobile workers. This seems worthwhile. Certificates can be used for authentication, signing and encryption purposes and can also be verified by customers through trusted third parties. SSL which is perhaps is the most flexible and widely deployed solution, also require certificates.
Note that due to American export restrictions, there is currently a 40 bit symmetric encryption key length restriction in many cryptographic applications and protocols, such as Netscape SSL. 40 bit encryption may be inadequate in many situations.

5.2.7 Summary

This chapter has introduced a platform for developing advanced, general support for mobile work. The approach is based on fieldwork and ideas for scenarios presented earlier, in particular in showing how mobile work can be distinguished from a traditional, stationary conception of work. Some requirements for mobile work was listed, and we have also in this chapter proposed two solutions for supporting mobile associates that can be implemented using today’s technology. The discussion of architectures for mobile work support and the proposal of a general model should be seen as supporting the implementation of current and future solutions for mobile work in DNV.

6. Conclusion

This is the first report of three that summarise the results from the interviews, the analysis of mobile work at DNV and initial work with design. The next two reports will elaborate some of the scenarios and the design of architecture for IT support for mobile work. Through interviews, observation and analysis we have grounded our work in practical experience gained by mobile workers at DNV. Some of our main findings are:

- *The systems must work both in connected and disconnected mode*
- *Synchronisation of information stored on different equipment is important*
- *Business critical applications must be available for field workers*
- *E-mail and scheduling systems are important co-ordination tools that must be supported from field*
- *Seamless connection to DNV's computer network across different physical networks is important*
- *Assistants on demand should be supported*
- *Security issues will become more important with mobile IT-use*

In this report we have suggested two solution for supporting mobile workers using current technologies. The first solution handles a solution based on that the mobile workers use own portable equipment. This implies that the necessary software is installed on the client machine along with a replication of necessary data from the server. This requires mechanisms for synchronisation of the data. The second is based on a solution where the mobile worker borrows a PC that is connected to the Internet. Through this PC the mobile user can run programs in a web-browser.
In the report we have also suggested a general model for developing mobile aware applications and some security issues are described.