THE MOWAHS CHARACTERISATION FRAMEWORK FOR MOBILE WORK

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ABSTRACT

This paper describes a framework used to characterise mobile work in order to elicit functional and non-functional requirements for a mobile process support system. The framework is a tool for specifying and analysing mobile scenarios in detail, resulting in a characterisation of scenarios. This characterisation will indicate requirements to the software architecture and services the system should provide. In addition, the framework will indicate non-functional requirements like network capacity, network connectivity, security. To show the practical usage of the framework, we have applied the framework to a scenario describing a mobile researcher. As far as we know, there are no similar frameworks.

Keywords: Mobile computing, mobile work, process support, software architecture.

1 INTRODUCTION

Mobile computing devices are now a part of everyday life. These devices offer possibilities for supporting both planned and unplanned mobile work. Mobile work does in this context mean work where people have to be at a specific location to reach their goal. The range of mobility can be everything from within a building to travelling world wide.

In January 2001, a Norwegian research project called MObile Work Across Heterogeneous Systems (MOWAHS) [3], sponsored by the Norwegian Research Council, was initiated. The focus of this project is to investigate how to provide process support for mobile work using different kinds of equipment (ranging from a small mobile phone, or PDA to laptop/desktop PCs). An initial goal of the project is to find characteristics that can define and describe mobile work. In [5], mobility is divided into physical and logical mobility. This classification is at a very coarse level, and was not very useful for classifying mobile work. From a more practical point of view, mobile work can be classified into hardware mobility, software mobility and combined mobility [7]. Although this classification is more detailed, it focuses too much on what functionality the end-system should have. We therefore decided to look for characteristics that could be used to describe mobile work scenarios, rather than the end-systems to support such scenarios. To find these characteristics, we suggested different attributes that could be used to describe mobile work processes. We then divided the useful attributes into groups that resulted in the framework that is presented in section 3.

The aim of the MOWAHS characterisation framework is to produce requirements for an end-system supporting mobile computing. Such an end-system can be a process support system for mobile work consisting of a server or a set of servers, some mobile clients (laptops, PDAs, mobile-phones etc.), and human resources required to carry out a work process. The characteristics of the framework will give requirements to the architecture (topology, connectivity, network, type of client(s), type of server(s), reliability, security, performance, etc.), to services needed, and requirements for hardware to be used.

The rest of the paper is organised as follows: Section 2 relates our framework to other similar frameworks, while section 3 describes our MOWAHS characterisation framework for mobile work. Section 4 gives an example of how the framework can be applied to a scenario and the corresponding results, while section 5 concludes this paper and gives some indications for further work.

2 RELATED WORK

Many research papers on mobile work have proposed a support system for specific mobile work scenarios, resulting in the development of tailor-made systems. Other papers have attempted to give an overview of characteristics of mobile computing based on state-of-the-art technology.

Zimmerman [9] suggests the ”MOBILE” framework to determine when mobile computing technology should be used to solve challenges related to mobility. This framework focuses on current technology and software development trends in mobile computing. Related common scenarios discussed include news reporting and hotel operations. The

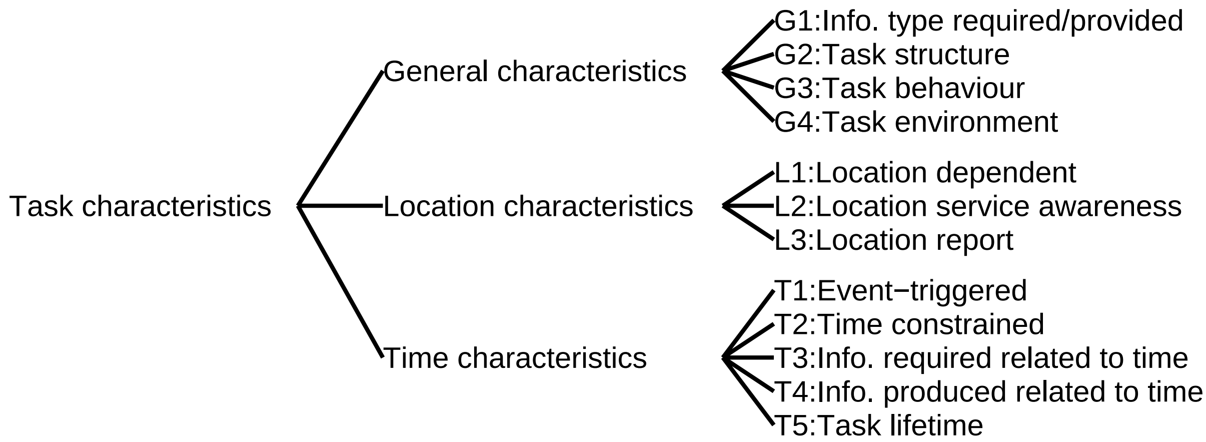

Figure 1. An overview of the MOWAHS characterisation framework for mobile work

framework provides a useful overview of necessary support needed for specific mobile environments. However, the framework does not provide any guidelines for how to develop or design systems for mobile support.

Satyanarayanan [6] identifies four constraints of mobile computing which mainly are concerned with limited resources, physical security (e.g hazards), communication and durability issues. Another approach is proposed by Forman and Zahorjan [1] who examine three basic features of mobile computing including wireless communication, mobility and portability. These two approaches provide different ways of addressing mobility issues. The former focuses on connectivity issues, while the latter deals with Quality of Service (QoS), such as network bandwidth and device durability.

Rakotonirainy [4] discusses current and future technology (e.g CORBA, mobile IP), adaptable to mobile computing environments. For this, he presents a scenario revealing the limitations of current technology. Although characteristics of mobile work can be derived from this approach, he does not provide a comprehensive framework for characterising mobile work environments.

The related work mentioned above mainly focuses on the technical parts of mobility including mobile hardware, limitations, and benefits. Our framework focuses on the mobile work itself and tries to derive the functionality, architecture and hardware required to support specific mobile scenarios. In a real mobile work situation there are more factors than mobile technology to consider. Examples are co-operative work and time and location constraints of the tasks themselves. In addition, our framework can be used to divide mobile scenarios into groups with similar characteristics.

The MOWAHS characterisation framework has not a formal basis for describing mobility. In [8], the notation UNITY is extended to formally describe mobility. The goal of the extension is to establish a formal specification and design technique that can accommodate the concepts of place, time, and action in a manner consistent with the design requirements for mobile systems.

3 THE MOWAHS CHARACTERISATION FRAMEWORK

Figure 1 shows an overview of our framework illustrating how it can describe a task of a mobile scenario through several attributes. The task characteristics are divided into three main categories: general, location and time. From the framework, we can derive both non-functional and functional requirements for mobile computing. We believe that the usage of such a framework will allow us to explore typical classes of mobile work with different process and transaction support. Further, the ability to identify similarities among different scenarios, allow us to reuse software systems. These systems should not only support one specific scenario, but also groups of related scenarios. However, we do not claim that the MOWAHS characterisation framework for mobile work covers all possible attributes used to describe mobile work.

To evaluate the different characteristics in the framework, we use a nominal scale (1-5). Higher values indicate more complexity in terms of system requirements, while lower values indicate none or less complexity. Some of the characteristics do not use the full scale, only the values 1, 3 and 5 to get a uniform representation of extreme values.

The framework should be applied to a mobile scenario focusing on one role and one task at a time. The tasks will usually vary in importance for a specific user. In our framework, each task must be assigned a weight on a scale 1-5 (very low, low, medium, high, very high). After analysing several tasks, the mobile process characteristics can be determined based on the weights of importance for each task. The mobile process characteristics are established by calculating the mean value of each characteristic for every task and role. In addition, a *complexity indicator* is calculated for the whole scenario. The complexity indicator is the mean value of all process characteristics. Note that the process characteristics are not statistical values, but should be used as an indicator of complexity in a mobile support system. Below, we indicate the process steps for applying our framework.

```
1. Select the mobile scenario
2. Identify different roles in the scenario
3. For each role; identify tasks and
   responsibilities
4. For each task:
   a) Assign task weight
   b) Characterise the task using the
      characterisation framework
5. Applay the process characteristics:
   a) Calculate weighted mean values for
      each characteristic
   b) Calculate an overall scenario
      complexity indicator
6. Derive system requirements and
   priorities from the process
   characteristics
```

The rest of this section describes the framework in more detail.

3.1 GENERAL CHARACTERISTICS

The general characteristics are used to describe task structures and attributes that are indirectly related to mobility. The words in parenthesis describe the possible answers and measurements of each characteristic element.

G1 **Information type required/provided** *(1 None, 2 Text, 3 Audio, 4 Picture, 5 Video)*
G1 is used to establish the type of information needed to perform a task. The information involved can be required/provided by the system, by people, or in combination. This property is used to decide the level of QoS for communication, and the client capability. In addition it specifies the media that the system must support.

G2 **Task structure**
This item describes how tasks are organised and how they are related:

G2.1 **Decomposable** *(1 No, 3 Uncertain, 5 Yes)*
G2.1 is used to decide whether the task is composed of sub-tasks or not. This can be used to decide if the end-system needs to support hierarchical compositions of tasks.

G2.2 **Part of sequence** *(1 No, 3 Partial, 5 Yes)*
G2.2 specifies if a task has order dependencies with respect to other tasks. This will decide if the end-system needs specification of execution order (typically a state-machine).

G2.3 **Collaboration type** *(NA[1], Client/server, Peer-to-peer, Broadcasting, Ad-hoc)*
G2.3 is used to specify the type of collaboration among task executors. This property can be used to determine system architecture/infrastructure, system coordination, and collaborative system services.

G2.4 **Cooperation with other task(s)** *(1 No, 3 Partial, 5 Yes)*
G2.4 defines whether a task must be coordinated with other concurrent tasks during execution or not. This can be used to specify the needs for cooperation and coordination among tasks, and needs for cooperative transactions.

G3 **Task behaviour**
This item describes how a task is created and terminated:

G3.1 **Pre-planned** *(1 No, 3 Partial, 5 Yes)*
G3.1 describes to what degree a task is planned in beforehand. This can be used to decide the needs for communication and back-end support, and support for on-the-fly planning and creation of tasks. If a task is pre-planned, information required for a specific task can be provided in beforehand on a mobile device.

G3.2 **Accomplishable** *(1 No, 2 Low, 3 Medium, 4 High, 5 Yes)*
G3.2 is used to define how much of a task that usually can be completed, and this will decide the needs for transaction support in the end-system and how the end-system must handle exceptional cases, and possible delays of termination.

G4 **Task environment**
This item describes demands on the task environment.

G4.1 **Security demands** *(1 None, 2 Low, 3 Medium, 4 High, 5 Very high)*
G4.1 specifies if the task requires a secure environment for system communication and execution (e.g. secure information handling on client, in the communication channel and on server). This can specify the level of protection against malicious access, virus attacks, theft, and denial of service.

G4.2 **Secrecy demands** *(1 None, 2 Restricted, 3 Confidential, 4 Secret, 5 Top secret)*
G4.2 specifies the level of protection from external insight to the definition and execution of a task and task environments (e.g. military operations, confidential information, privacy). This property can be used to decide the level of data encryption, access to the servers and clients, and protected communication.

G4.3 **Reliability demands** *(1 None, 2 Low, 3 Medium, 4 High, 5 Very high)*
G4.3 defines demands for stable execution of tasks (e.g. for critical tasks like establish or retain connection to emergency systems).

3.2 LOCATION CHARACTERISTICS

The location characteristics are used to specify if a task or back-end system support depend on geographical locations.

[1]NA = Not Applicable

The following items are used to describe location characteristics:

L1 **Location dependent** *(1 No, 3 Partial, 5 Yes)*
L1 describes to what degree a task must be executed at a specific location. This can be used by the end-system to decide what services are needed for the task execution at a specific location. This may also be used to decide what physical equipment is required to perform the task.

L2 **Location service awareness** *(1 No, 3 Partial, 5 Yes)*
L2 specifies if a task can exploit services provided at the location. The task may dependent on services provided (e.g. printer, fax, etc.) to be executed or terminated. L2 can be used to determine the location dependent services that are needed in the end-system.

L3 **Location report** *(1 No, 3 Partial, 5 Yes)*
L3 identifies if a task must report its location to the system (e.g. by using GPS, GSM etc.). This can be used to decide the mobile equipment and services needed, and if a location reporting service should be part of the mobile client.

3.3 TIME CHARACTERISTICS

The time characteristics are used to investigate the temporal properties of a task, and the system support for these properties. The creation and execution of tasks may require timely coordination between an end-system and the task executor. These properties (excluding task lifetime) can be used to determine the required connectivity (communication) between the end-system and mobile clients. All the characteristics may imply requirements for extended transaction support (e.g. synchronised information flow, postponed commitments etc.). The following items are used to describe time characteristics:

T1 **Event-triggered** *(1 No, 3 Partial, 5 Yes)*
T1 is used to decide whether a task is triggered by an event or not. This property can be used to imply the need for instant access to information resources and services. The property may also require a re-scheduling and/or redefinition of existing tasks.

T2 **Time constrained** *(1 No, 3 Partial, 5 Yes)*
T2 is used to describe if a task must be executed at a specific time or within a specific timespan. This property can be used to decide how the system should be synchronised. A time constrained task may also demand support for re-scheduling of tasks and if a task is achievable or not, related to time constraints.

T3 **Information required related to time** *(1 NA, 2 Low, 3 Medium, 4 High, 5 Real-time)*
T3 describes how important the information required to execute the task is related to time. This property can be used to determine the connectivity and the bandwidth needed to transport data from a server to a mobile client.

T4 **Information produced related to time** *(1 NA, 2 Low, 3 Medium, 4 High, 5 Real-time)*
T4 describes how important the information produced by the task is related to time. This property can be used to determine the connectivity and bandwidth needed to transport data from a mobile client to a server, or other clients.

T5 **Task lifetime** *(1 Short, 3 Medium, 5 Long)*
T5 is used to describe the expected lifetime of a task. For example, short may mean less than 1 hour, medium between 1 hour and a working day (8 hours), and long more than one working day. This scale can be adjusted or changed in respect to the specific scenario. The task lifetime property can be used to determine the connectivity (on-line/off-line), the type of transaction support needed (e.g. long, nested transactions with a need for relaxed ACID[2] properties.), and the response time of the system.

4 THE FRAMEWORK APPLIED TO A SCENARIO

This section presents the results from applying our framework to a mobile work scenario.

4.1 MOBILE RESEARCHER SCENARIO

The scenario we have used as a test case for our framework is a mobile researcher participating at a conference. We have not only considered the current practice, but also included possible technological enhancements to existing tasks. Each task has been assigned a weight of importance (1-5).

The mobile researcher typically performs these tasks:

S1 **Prepare a presentation** which involves using available information (e.g. the paper to be presented and some addition background information) to produce a presentation that will be given at a conference. *Importance: 4 High*.

S2 **Perform a presentation** which involves talking to an audience in a specific room using available equipment to aid the presentation. *Importance: 5 Very high*.

S3 **Listen to a presentation** which involves being in a specific room at a specific time listening to and making notes about the presentation. The notes can be written on paper, a laptop, a PDA, or other suitable devices. This task should also record audio or video, that may be transmitted (using a network connection) to colleagues not being at the conference. *Importance: 3 Medium*.

S4 **Read a paper/book** which involves reading some text written on paper, presented on a laptop, presented on a PDA or on another device, and making notes of interesting parts of the text. This task can possibly involve downloading the paper/book from a server. *Importance: 1 Very low*.

[2] ACID stands for Atomicity, Consistency, Isolation and Durability

Char.	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Weight	4 High	5 Very high	3 Medium	1 Very low	2 Low	3 Medium
G1	4 Picture	4 Picture	5 Video	4 Picture	4 Picture	1 None
G2.1	3 Uncertain	1 No	1 No	2 Uncertain	3 Yes	1 No
G2.2	5 Yes	5 Yes	1 No	1 No	1 No	1 No
G2.3	NA	NA	Peer-to-Peer	NA	Peer-to-Peer	NA
G2.4	1 No	1 No	5 Yes	1 No	5 Yes	1 No
G3.1	5 Yes	5 Yes	3 Partial	1 No	3 Partial	3 Partial
G3.2	5 Yes	5 Yes	4 High	4 High	4 High	5 Yes
G4.1	2 Low	2 Low	1 None	1 None	3 Medium	1 None
G4.2	1 None	1 None	1 None	1 None	2 Restricted	1 None
G4.3	2 Low	4 High	3 Medium	2 Low	3 Medium	1 None
L1	1 No	5 Yes	5 Yes	1 No	1 No	5 Yes
L2	1 No	1 No	1 No	1 No	1 No	1 No
L3	1 No	5 Yes	1 No	1 No	1 No	3 Partial
T1	1 No	1 No	1 No	1 No	1 No	1 No
T2	3 Partial	5 Yes	5 Yes	1 No	3 Partial	3 Partial
T3	3 Medium	4 High	1 NA	1 NA	2 Low	1 NA
T4	3 Medium	1 NA	5 Real-time	1 NA	2 Low	1 NA
T5	3 Medium	1 Short	3 Medium	5 Long	5 Long	1 Short

Table 1. The framework applied to the scenario

S5 **Write a scientific paper** which involves writing about an idea, results and/or some specific experiences. This task requires having sufficient information available (e.g. papers describing related work, technical reports, etc.) that should be a part of the paper. To write the paper, the researcher can use pen and paper, a laptop, a PDA or another device. The task might also include cooperation, and coordination with other authors of the paper. *Importance: 2 Low*.

S6 **Talk to conference participants** which involves meeting people at a specific place at a specific time. Talks can result in new ideas (that should be written down on napkins, PDAs, mobile phones etc.) or trading of business cards (either using electronic devices or paper cards). *Importance: 3 Medium*.

4.2 THE FRAMEWORK APPLIED TO ALL TASKS

The results of applying the framework to each task of the scenario (S1-S6) is shown in table 1. The task characteristics in the table are only denoted by a letter and a number (see section 3 for a full description).

Table 1 shows that the three tasks S1, S4 and S5 are not necessarily mobile, since they are location independent (L1). S2, S3 and S6 require the task executor to move to a specific room (conference room or similar) to reach the goal of the task. Further, the table shows that the two tasks S3 and S5 involve interaction with other tasks and task executors (G2.4). If we consider the demands for these tasks (S3 and S5) to information required/produced related to time, we discover that that S3 has the highest resource demands (T4). In addition, S3 is also location dependent. This means that S3 is hardest to support in terms of both software and hardware (including network).

4.3 SUMMARY OF PROCESS CHARACTERISTICS

Table 2 shows a summary of the task characteristics where the tasks are seen as a part of a process. All results except G2.3 in the table show mean values of the six tasks (S1-S6).

Table 2 shows that the six tasks in the scenario are using different media types (G1), and are partially organised and pre-planned. This implies that mobile clients do not need to have a permanent network connection, but may work asynchronously. This again means that the mobile clients must carry data required to perform the tasks as well as data created or manipulated by the task. The calculated complexity indicator for this scenario is 2.50, indicating a medium to low complexity of the mobile process support system.

4.4 SYSTEM DESIGN DISCUSSIONS

From table 2 we can deduce the system support needed to implement a mobile process support system for this scenario. The end-system should provide:

- Support for handling the media types text, pictures, and audio/video. This includes functionality to create, store, present, and transmit the corresponding media.
- Support for decomposing tasks, sequencing tasks, and for allowing cooperative tasks. This means that the system should provide functionality to plan, organise and execute individual and group tasks.

Characteristics	Result	Comment
G1 Info.type req/provided	3.66 Picture	Audio+Video needed for S3
G2.1 Decomposable	3.00 Uncertain	Only S5 are fully decomposable
G2.2 Part of sequence	2.00 No/Partial	
G2.3 Collaboration type	Peer-to-Peer	Required in S3 and S5 if several authors
G2.4 Coop. with other task	2.11 Partial	Required in S3 and S5 if several authors
G3.1 Pre-planned	3.89 Partial	Most of the tasks are (partially) pre-planned
G3.2 Accomplishable	4.67 Yes	S3, S4 and S5 might not complete
G4.1 Security demands	1.72 Low	S5 required most security
G4.2 Secrecy demands	1.16 None	S5 requires **restricted** secrecy
G4.3 Reliability demands	2.56 Medium	S2 requires high reliability
L1 Location dependent	3.44 Partial	S2, S3, and S6 are location dependent
L2 Location service awareness	1.00 No	
L3 Location reporting	2.44 Partial	In S2, must notify when presentation begin
T1 Event-triggered	1.00 No	
T2 Time constraints	3.78 Partial	S2 and S3 must follow conference agenda
T3 Info. required related to time	2.39 Low	S2 has high requirements
T4 Info. produced related to time	2.22 Low	S3 has real-time requirements
T5 Task lifetime	2.44 Medium	The task lifetime range from short to long

Table 2. Summary of the Process Characteristics

- Support for peer-to-peer collaboration between task executors. This means that the system should provide an infrastructure for transferring data directly between clients of the system. The network should have capacity to transfer audio or video streams between clients on-line. Other kind of information could be stored on-demand at the clients for later batch transmission.
- Specific support for security, secrecy and reliability is not considered as important for the end-system. We assume that the available network and operating system will provide sufficient support.
- Support for scheduling and execution of tasks at specific times.

From table 1 we know that the tasks S2, S3 and S6 are location dependent. These tasks must be carried out in specific places to meet people. However, the execution of these tasks does not require any software location services from the end-system.

Further we can deduce the client requirements (both hardware and software):

- Audio/video recording, storing and manipulation (e.g. buffering, filtering, scaling, compression, formatting).
- Presentation of multi-media.
- A fast and reliable network connection that is wireless or fixed (depends on the conference room facilities).

Because of the multi-media requirements mentioned above (task S3), the mobile client in our scenario must reside on a high capacity computer (e.g. a laptop with recording capacity). If the audio/video transmission of S3 is not needed, it is sufficient to use a low capacity computer as host for the mobile client (e.g. a PDA). For the receiving host of multi-media information, a PDA can be sufficient (current technology). The PDA must then support multi-media and network connectivity.

In the development of the mobile process support system, the weights of the tasks as presented in table 1 can be used as a starting-point for a project plan. Each task can form a Use Case, and the weights determine the importance of the Use Cases [2].

5 CONCLUSIONS AND FURTHER WORK

In this paper we have presented a framework to characterise mobile work. We have shown that this framework can be applied to derive software and hardware requirements for a mobile process support system.

To get more experiences with and to validate our framework, we will consider these options:

- Try the framework on more scenarios to improve/extend the framework to cover mobile work in as many areas as possible.
- Try the framework on already implemented systems, to compare the requirements (both functional and non-functional) that are derived from the MOWAHS framework against implemented solutions. This may validate the framework and improve the outcome from applying the framework.
- Establish a prototype system based on the proposals given from applying the framework. The prototype

should support mobile work processes in as many scenarios as possible.

- Try out the prototype in real cases, preferably in scenarios where stakeholders may have benefit from using such a system. The prototype should be tried on a range of mobile devices, both in on-line and off-line modes.
- Establish interfaces to other back-end support and legacy systems for mobile work.
- Establish transaction models that can provide special support required in mobile process support systems.

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