D2.3.1

Testbed Description

Version 1.0

WP 2.3 Testbed Definition

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Context

Activity 2	**Environment and Requirements**
WP 2.3	**Testbed Definition**
Task 2.3.1	**Testbed Definition**
Dependencies	**It will be the basis for Activity 3 (W.P 3.1 and 3.2) and Activity 4**

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Executive Summary

This Work Package (2.3.1) focuses on identifying and examining various suggested testbeds and a variety of scenarios within each, with the aim to come up with a list of potentially relevant and valid application domains. Therefore Section 2 of the document initiates a first discussion to develop a set of evaluation criteria based on the cases that are identified within The Open Grid Services Architecture document with significant emphasis on Mobile Grid Resources and Knowledge Processing. This section also provides a preliminary specification on what a Mobile Grid is by further expounding the cumulative viewpoints and discussions as undertaken within the Akogrimo consortium.

Section 3 describes three major testbeds – eHealth, eLearning and Disaster Handling and Crisis Management. Each testbed is supported in its description with multiple scenario analyses and each scenario in turn is analysed from the mobility, knowledge and business relevant perspectives. Hereby, the single scenarios give indicators on specific application areas significant for Mobile Grid and Knowledge Processing, which will be compiled to challenging validation scenarios in a second step. A summary of all the scenarios within a particular testbed are then tabulated to determine its appropriateness for enhanced development and promotion in the Akogrimo project.

In addition, several smaller testbeds have also been identified (Section 4) that demonstrate the wide potential of the Akogrimo approach and may be deployable as an application on the Mobile Grid. As these testbeds are divergent from the three major ones described in the previous chapter, they have smaller explanations (less number of scenarios is elaborated) but nevertheless cover a wider range of applications from Mass Customization to Leisure, Travel and Weather Forecast.

Evaluation of all scenarios (and hence testbeds) have been undertaken with two determining factors that are singularly specific and vital from the Akogrimo perspective – the knowledge and mobility factors. Basing the information on the relative mobility and knowledge presence and effectiveness in each scenario, suggests that comparatively the eLearning testbed lacks strength. On the other hand the eHealth testbed in combination with certain aspects (such as emergency care) of the Disaster Handling and Crisis Management testbed indicate a convincing and persuasive argument for further development.

The findings in this document are just the first steps for the decision that will now need to be undertaken by the consortium to finalise the appropriate testbed for prototype development, possible candidates (players) and the architecture.

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Abbreviations

AAA	Authentication, Authorisation, Accounting
Akogrimo	Access To Knowledge through the Grid in a Mobile World
ASP	Application Service Provider
BLEV	Boiling Liquid Expanding Vapour Explosion
CDC	Commercial Data Centre
CUG	Closed User Group
DCV	Deutscher Caritasverband
DHCM	Disaster Handling and Crisis Management
ECG	Electrocardiogram
ED	Emergency Diagnosis
EHR	Electronic Health Records
EO	Emergency Operator
GIS	Global Information Systems
GPRS	General Packet Radio Service
ICS	Information and Communication Systems
KBS	Knowledge Based System
KQML	Knowledge Query and Manipulation Language
LSP	Logistics Service Provider
MDVO	Mobil Dynamic Virtual Organisations
NFC	National Fusion Collaboratory
NGA	Non Governmental Associations
OGSA	Open Grid Services Architecture
OWL-S	Web Ontology Language for Services
PA	Persistent Archive

PDA	Personal Digital Assistant
QoS	Quality of Service
RDF	Research Description Framework
RUS	Resource Usage Service
SIP	Session Initiation Protocol
SLA	Service Level Agreements
SME	Small and Medium Enterprises
UMTS	Universal Mobile Telecommunication System
VC	Virtual Collaboration
VEE	Virtual Emergency Environment
VEHR	Virtual Emergency Health Record
VO	Virtual Organisation
WS-RF	Web-Service Resource Framework

1. Introduction

The 6th Framework program IP *Akogrimo – Access to Knowledge through the Grid in a mobile World* – aims on the *technology level* at the integration of mobile communication into the Open Grid Services Architecture (OGSA). On the *application level* Akogrimo aims at validating the thesis that the vision of Grid-based computing and the future development of Grid technologies as well as the development of Grid infrastructures can and will substantially draw from the integration of a valid mobility perspective.

D2.3.1 is the first Akogrimo deliverable that aims to discover scenarios in every testbed which require mobility on the grid environment with respect to the relevant Grid resources. For this purpose, D2.3.1 is organised in two perspectives:

- **OGSA perspective:**

  To systematically analyse the OGSA standard (Version 1.0 - 7th June 2004) with respect to the Akogrimo vision of knowledge and mobility within Grid and to identify those OGSA specifications that is related to knowledge and mobility (section 2).

  Idea behind: if there are any OGSA use cases or any other OGSA specifications which already refer to the knowledge and mobility vision of Akogrimo, further work on Knowledge and Mobility Grids could be directly built on this.

- **Application perspective:**

  To provide a first evaluation of those testbeds and scenarios which refer to the Akogrimo vision and which are either under consideration already (section 3), or which have been suggested additionally for detailed consideration as possible future testbeds (section 4).

  Idea behind: Until now there is no methodology and even no set of criteria helping to identify knowledge and mobility specific Grid computing requirements. Thus, this report aims to identify first relevant information and then to develop a sound methodology (including the definition of appropriate criteria) for the evaluation of testbeds and scenarios.

By doing this, Deliverable 2.3.1 develops toward a theoretical basis upon which one can decide whether a use case actually requires knowledge and mobility within Grid (it could not be implemented otherwise), and which benefits may arise for that use case from the access to knowledge through mobile Grid technology.

It is, however, important to state that this report does not aim to provide the final basis for these types of evaluations and decisions. Too many aspects, issues, even too many theoretical and conceptual issues are still subject to discussion and also to further research.

The aim of this report is thus to consolidate the current state of the theoretical and conceptual discussions in the field in order to provide a valid platform for further research (also outside of Akogrimo) and to support those decisions within Akogrimo that are required subject to the further progress of the project.

2. Developing towards a set of evaluation criteria

One aim of the Akogrimo project is to find some new Grid challenging scenarios, which refer in a very natural way to the Akogrimo vision of accessing knowledge in a mobile Grid world.

First research has revealed a lot of potential proposals of such new Grid scenarios (details see sections 3 and 4), and three of them are to be selected for further evaluation through the Akogrimo testbeds-related work.

A set of evaluation criteria is thus needed by which we can evaluate each scenario with respect to its potential appropriateness for thriving application-oriented research in Akogrimo. For this purpose, three main groups of potential evaluation criteria can be identified:

1. Criteria based upon the OGSA standard

   OGSA already includes numerous definitions which are closely related to, or which even base upon the vision of a world where mobility (e.g., of humans, robots, sensors, hard- and software, etc.) plays an important role. The first task is thus to identify and analyse these definitions of the OGSA standard (section 2.1).

2. Criteria referring to knowledge challenges

   The Akogrimo vision assumes that, in general, future Grids will provide efficient access to knowledge. Accessing knowledge typically involves (at least to some degree) reasoning capabilities (instead of "simple" queries) based upon a knowledge representation language, assumes the availability of ontologies in order to enable cooperating Grid nodes to understand each other and may also contribute to the modelling and interpretation of contextual information. The second task is thus to identify and analyse those criteria that are well suited to address knowledge-related issues in a Grid world (section 2.2).

3. Criteria referring to mobility challenges

   As the human beings and the technical devices used by them become highly mobile, Grids have to be able to be accessed anytime and anywhere. Therefore for each scenario we have to consider the mobility of customers and users and the possibility for some parts of the Grid infrastructure and the Grid resources to be mobile. The third and the most important task is thus to identify and analyse those criteria that are directly related to the definition of a Mobile Grid (section 2.3).

More detailed explanation for each evaluation is described in the subsequent sections. Section 2.1 explains our evaluation related to the Grid challenges. To summarise section 2.2 presents the results of our evaluation on the knowledge challenges, and finally we evaluate the eHealth and the eLearning testbeds in terms of mobility aspects in section 2.3.

2.1. Evaluation of OGSA Use Cases

This section aims to evaluate the definitions of OGSA with respect to knowledge and mobility. Based on the OGSA specifications we provide the following working definition on what a grid is.

Working Definition – Grid:

> The Grid can be viewed as a distributed, high performance computing and data handling infrastructure, that incorporates geographically and organizationally dispersed, heterogeneous resources (computing systems, storage systems, instruments and other real-time data sources, human collaborators, communication systems), provides common interfaces for all these resources, using standard, open, general-purpose protocols and interfaces, and allows for a shared access among them. It is also the basis and the enabling technology for pervasive and utility computing due to the ability of being open, highly heterogeneous and scalable.

In subsection 2.1.1 each OGSA use case [1] is evaluated in relation to the knowledge and mobility required within the Grid. In addition, subsection 2.2 provides an analysis of the OGSA requirements definitions [2] with respect to knowledge and mobility driven applications.

2.1.1. Relevance of OGSA Use Cases

In the following we discuss the relevance of all use cases listed in the OGSA Use Cases document [1] and provide a first (still qualitative) assessment of the potential relevance knowledge and mobility may have:

1. Commercial Data Centre (CDC)

   Data centres manage several thousands of IT resources, such as servers, storage, and networks. By operating CDCs, management costs reduce and resource utilisation increases. The knowledge aspect is required to manage and control a CDC in an efficient and effective way. In addition to storing data, CDCs are used to store large amounts of formally represented business knowledge. On the other hand, the mobility aspect is not relevant as CDCs are not mobile.

2. Severe Storm Modelling

   This application predicts the exact location of severe storms accurately exploiting the combination of real-time wide area weather instrumentation and large-scale simulation coupled with data modelling. Since data are collected and submitted into the simulation, the knowledge aspect is not relevant in this use case. Besides the primary customer may be meteorologists (who may be mobile as well) mobility is in particular of high relevance to some of the data collecting resources (sensors, police cars, meteorology airplanes, Doppler radar and satellite imaging, etc.). Therefore the mobility aspect is relevant for this use case. It shall be noted here that in this use case there is a tight relationship between mobility of data collecting resources and the time which is available for storm forecast.

3. Online Media and Entertainment

   The application delivers an entertainment experience, either for consumption of content (e.g. video on demand) or interaction between lots of users (such as online games). The entertainment content consists of many different forms (e.g. movie on demand or online games) with different hosting capacity demands and lifecycle. Therefore the knowledge is highly demanded to dynamically manage resources based on workload demands and current system configuration as well as for the user interaction. In addition, mobility is highly relevant as the mobile consumer is often part of the system (Virtual Organisation - VO) interacting with others in order to jointly play a game, to exchange information in an online setting, etc.

4. National Fusion Collaboratory (NFC)

In the NFC project, a VO is defined and devoted to fusion research. Adopting the application service provider (ASP) model, a service provider provides software as well as a set of platforms which are accessible remotely to clients to avoid maintenance costs. Knowledge and mobility aspects are not of high relevance in this use case.

5. Service-Based Distributed Query Processing

   A service-based distributed query processor evaluates queries which are expressed in a declarative language, over one or more existing services (such as database services or computational services) to discover and make use of computational resources on demand. The knowledge aspect is highly needed in this use case to integrate and analyse structured data collections. Moreover, the Grid distributed query service makes use of computational resources to move data from primary sources to analysis tools or to evaluators that join or manipulate the data in a query. Consequently, the mobility aspect is relevant in this use case too.

6. Grid Workflow

   Grid Workflow develops a workflow engine to register new Grid services and create new services by connecting existing services. The knowledge aspect is highly required by this use case since the workflow engine has to interpret the workflow definition and call several other Grid services as specified in the definition. Grid resources and users may be mobile; therefore the mobility aspect is relevant for Grid Workflow.

7. Grid Resource Reseller

   In this use case, Grid resource resellers become mediators between resource owners and end users by reselling aggregated computational resources from resource owners to end users without having to own any resources. Consequently, resource owners are able to concentrate on their core competence (e.g. in maintaining large supercomputers) and avoid providing costly interaction with a large number of end users. This application highly requires the knowledge aspect whereby the reseller has to aggregate computational resources and maintain resource provision by sustaining relationships with upstream providers. If there are Grid resources which are mobile then the mobility aspect is also highly relevant in this use case.

8. Inter Grid

   This use case extends the CDC use case by enabling Grid to operate in mixed operating environments, migrating non-Grid applications to be run on a normal Grid, providing interoperability with Web Services applications and mixing Grid and non-Grid data centres. Both aspects, i.e. knowledge and mobility, may not be of high relevance in this use case.

9. Interactive Grids

   Interactive Grids allows the individual user interface to interact and synchronise seamlessly with processes. As the Grid user has the capability to steer his/her computations and resource needs interactively and dynamically during runtime, the knowledge aspect is highly relevant in this use case. Interactive technology for Grid systems is extremely useful for digital content creation, streaming media, video games, text editing, and e-mail applications. These kinds of applications tend to be used by users anywhere and anytime, consequently the mobility aspect is highly relevant in this use case.

10. Grid Lite

    The goal of Grid Lite is to use the Grid on small devices such as PDAs and cell phones, by identifying a set of essential Grid services that enables small devices to be a part of a Grid environment. While users including their devices may move and access the Grid anywhere, the mobility and knowledge aspect are highly relevant in this use case.

11. Virtual Organisation (VO) Grid Portal

    A VO Grid portal lists all available resources for the members of a VO to ease them in accessing the resources. Both, the knowledge and mobility aspects are of minor relevance in this use case.

12. Persistent Archive (PA)

    PA deals with the technology evolution by providing some abstraction layers which are used to handle mappings between old and new protocols, old and new software systems, and old and new hardware systems. Considering the knowledge and mobility aspects, both aspects are not relevant in this use case.

13. Mutual Authorisation

    In mutual authorisation, the job submitter is allowed to authorise the resource on which the job will eventually be executed. Referring to the knowledge and mobility aspects, these aspects are not relevant for this use case.

14. Resource Usage Service (RUS)

    The RUS keeps track on the resource consumption due to applications, middleware, operating systems and physical (compute and network) resource usage for cost allocation and capacity planning. The mobility and knowledge aspects are not relevant for this use case.

Table 1 summarizes our evaluation on all OGSA use cases which are significantly relevant for mobility and knowledge access respectively.

OGSA 1st tier use case	Significant Relevance for Mobility	Significant Relevance for Knowledge Access
Commercial Data Centre (CDC)	–	X
Severe Storm Modelling	X	–
Online Media and Entertainment	X	X
National Fusion Collaboratory (NFC)	–	–
Service-Based Distributed Query Processing	X	X
Grid Workflow	X	X
Grid Resource Reseller	X	X
Inter Grid	–	–
Interactive Grids	X	X
Grid Lite	X	X
Virtual Organisation (VO) Grid Portal	–	–

Persistent Archive (PA)	–	–
Mutual Authorization	–	–
Resource Usage Service (RUS)	–	–

Table 1: OGSA 1st tier use case analysis

Lessons learned for the eLearning and the eHealth testbeds:

1. eLearning testbed

   In terms of the knowledge aspect, the following use cases are useful for the eLearning testbed, i.e. Commercial Data Centre, Online Media and Entertainment, Grid Resource Reseller, Interactive Grids, and Grid Lite.

   Considering the mobility aspect, the following use cases are useful for this testbed, i.e. Online Media and Entertainment, Service-Based Distributed Query Processing, Interactive Grids, and Grid Lite.

2. eHealth testbed

   The following use cases are useful for the eHealth testbed regarding to the knowledge aspect: Commercial Data Centre, Service-Based Distributed Query Processing, Grid Workflow, Interactive Grids, and Grid Lite.

   Looking into the mobility aspect, the use case Online Media and Entertainment, Service-Based Distributed Query Processing, Grid Workflow, Interactive Grids, and Grid Lite are useful for the eHealth testbed.

2.1.2. OGSA Requirements

The Open Grid Services Architecture Version 1.0 document [2] contains a set of functional and non-functional requirements. We evaluate these requirements in order to provide a first assessment whether each of them is particularly required for typical knowledge-driven and mobility-driven applications.

1. Dynamic and heterogeneous environment support

   Grid environments typically consist of different types of operating systems (e.g. UNIX, Linux, Windows, etc.), hosting environments (e.g. J2EE, .NET, etc.), devices (e.g. computers, instruments, sensors, storage systems, databases, networks, etc.), and services provided by various parties. These heterogeneous and distributed resources have to be interoperable with each other and the Grid has to be able to discover their capabilities and availabilities prior to dispatching the user's job to specific resources. Moreover a mechanism has to be provided by the Grid to cope with unpredictable changes happening in its environment and integrate existing legacy applications which cannot be executed on the Grid, to the Grid environment.

   This characteristic is relevant for knowledge-driven applications. Typically, mobility-driven applications have to deal with a dynamic and heterogeneous environment since different types of operating systems, devices, hosting environments, and services vary in different locations.

2. Resource sharing across different organisations and domains

Grid consists of many resources belonging to various organisations and they are shared across different organisations. Thus policies and authorisation issues have to be handled during the resource sharing, as well as cost for resource usage. In addition, a mechanism should be established to manage resource sharing efficiently. This characteristic is a typical characteristic for both knowledge- and mobility-driven applications.

3. Quality of Service (QoS) assurance

   Grid users are often vitally concerned with achieving particular QoS levels in the virtual systems formed by integrating distributed resources. QoS can be measured in terms of common security semantics, distributed workflow and resource management performance, coordinated fail-over, problem determination services, or other metrics, for example. QoS requirements should be expressed in measurable terms that can be captured in Service Level Agreements (SLAs). QoS assurance is well fitted for typical knowledge- and mobility- driven applications.

4. Job Execution

   User-defined tasks are scheduled and executed by considering their priority and allocation of resources. They have to be managed during their entire lifetimes and exception handling of jobs must be supported. Moreover, the required applications and data have to be deployed to resources and configured automatically in order to prepare the Grid environment for job execution. Job execution is important for typical knowledge and mobility-driven applications.

5. Data Services

   Data services are provided to ease the access to various types of data (such as database, files, and streams) regardless of their physical location. In addition, data consistency has to be maintained when cached or replicated data is modified. Furthermore a Grid has to be able to integrate heterogeneous and distributed data and control access rights at different levels of granularity. Typical knowledge and mobility-driven applications usually have this feature.

6. Security

   Security is essential in the Grid since different members of the Virtual Organisation access specific resources which are required to complete their task. The security problem in a Grid environment is complex because resources are often located in different administrative domains with each resource potentially having its own policies and procedures. Furthermore there are different requirements by users, resource owners, and developers who are creating or adapting their current products and tools to take advantage of the Grid technology.

   The user's (person or another program) expectations are that a secure Grid system will be easy to use, provide single sign-on capability, allow for delegation and support all key applications. The resource owners require that security should specify local access control, have robust security protocol and should be able to integrate with local security infrastructure. Security is typically required by knowledge and mobility-driven applications.

7. Administrative Cost Reduction

   In order to avoid human errors and reduce administration costs, common administrative operations can be automated by establishing policies in the Grid, such as a policy governing how resources are monitored or how business processes such as billing are managed. This characteristic is not relevant for typical knowledge and mobility-driven applications.

8. Scalability

   A Grid system allows for utilising a huge number of resources when the Grid allows the extension to a large scale and optimises parallel job execution to improve the throughput of the entire computational process. This feature is not typical for knowledge and mobility-driven applications.

9. Availability

   The Grid guarantees a high availability of resources and reliable execution environments by exploiting fault-tolerant hardware or cluster systems. Availability is one important characteristic for typical mobility-driven applications, the same holds for lots of knowledge-driven applications..

Based on our evaluation, the overall OGSA characteristics required for typical knowledge and mobility-driven applications can be summarised as displayed in Table 2:

OGSA Requirements	**Significant Relevance for Mobility**	**Significant Relevance for Knowledge Access**
Dynamic and heterogeneous environment support	X	X
Resource sharing across different organisations and domains	X	X
Quality of Service (QoS) assurance	X	X
Job execution	X	X
Data Services	X	X
Security	X	X
Administrative cost reduction	–	–
Scalability	–	–
Availability	X	X

Table 2: OGSA Requirements Analysis

Lessons learned for the eLearning and the eHealth testbeds:

- eLearning testbed

  In terms of the knowledge aspect, these OGSA requirements are required by the eLearning testbed, resource sharing across different organisations and domains, quality of service (QoS) assurance, and data services, security.

  Considering the mobility aspect, the following OGSA requirements are required by this testbed, i.e. resource sharing across different organisations and domains, quality of service (QoS) assurance, data services, and security.

- eHealth testbed

The following OGSA requirements are required by the eHealth testbed with respect to the knowledge aspect: resource sharing across different organisations and domains, quality of service (QoS) assurance, job execution, data services, and security.

Looking into the mobility aspect, the OGSA requirements dynamic and heterogeneous environment support, resource sharing across different organisations and domains, quality of service (QoS) assurance, data services, security, and availability are required by the eHealth testbed.

2.2. Mobile Grid Relevance

Mobility is another aspect in evaluating testbed candidates suitable for our project. In the following sections we describe our evaluation on the mobility aspects of the Grid resources and give a working definition on Mobile Grid.

2.2.1. Grid Resources

Referring to the OGSA specifications [2], Grid resources are those resources supported by some underlying entities/artefacts that may be physical or logical, and have relevance outside of the OGSA context. Examples of such physical entity types include computing and storage hardware (CPUs, memory, or disks) as well as sensors and networks. Logical artefacts include data, licenses, OS processes and application services. These resources are usually locally owned and managed, but may be shared remotely. The configuration and customization is also done locally. Since the actual entities/artefacts can change rapidly, and can be from multiple sources, these resources can be highly variable in their characteristics, quality of service, version, and availability. In the Akogrimo context, the mobility of Grid resources is examined and the impact on the provisioning of service in the Grid is analysed.

Considering mobility, research has to be done on at least two perspectives: Which resources are mobile and how mobility can be supported with respect to the resource type? The second perspective is directed on the type of service carried out by a mobile resource and the affect that mobility has on the resulting service. Particularly, the second perspective is discussed in Work packages 4.2 Mobile Network Middleware Architecture – Design & Implementation and Work package 4.3 Grid Infrastructure Services Layer in more detail. In the following some critical point are described, which are important for the comprehensive testbed and scenario analysis.

Therefore, at first, relevant effects of mobility on service provisioning are examined. The most important point is the availability of services and the associated guaranteed service-level fulfilment. Against this background the question arises as to whether there exist services, particularly higher level Grid management services, which have to be considered as stable, fixed or always available. To be more detailed and precise: can the OGSA core services like Execution Management, Resource Management, Security and Optimisation Framework considered to be available, accessible, etc. by default? Supposing this to be true an analysis of reasonable classification criteria to distinguish between mobile (and consequently unreliable) resources and fixed/non-mobile (and consequently reliable) resources has to be undertaken.

One result of this discussion can be seen in a possible examination of the scenarios whether they run in a completely dynamic environment where no reliable resources can be assumed, at all. Within such an environment even the Grid core services would be established in a way known from mobile ad-hoc networks. Appropriate candidates for these scenarios could be for instance an area after a big disaster, like the tsunami in the Indian Ocean, or a military battleground.

Besides this, the scenario could also demand the access to Grid management services for VO management and process configuration.

2.2.2. What is a Mobile Grid?

The Grid is about hiding the distribution and the access of resources, the processing of tasks and the coordination of performing these tasks against the user. In other words: a Grid provides full transparency in all aspects (computation, communication, coordination, availability of resources, etc.). It provides a platform for efficient and effective cooperation of Grid resources in order to fulfil the demands of a given task and to provide the results of its work via an appropriate output interface to the customer (human, computer, machine, etc.). The same applies if some of or all Grid resources are mobile.

In a mobile Grid, at least some of the Grid resources can be moved from a physical location to another dynamically. This requires a "mobilization tool" e.g. a bicycle, a motorbike, a car or truck, an airplane, a human, a robot, etc. This raises the question whether such a "mobilization tool" is also part of the Grid. A pure "mobilization tool" is part of the Grid only if it exhibits a local interface through which the Grid may access it (e.g., for control purposes). It is however also possible that a Grid resource like a human or a robot is capable of providing a mobilization service, i.e., to transport a mobile Grid resource (e.g., a sensor) from one place to another. In such a case the resource is capable of performing two different roles: a Grid service and a mobilization service. Here we also assume that the mobilization service is part of the Grid if there is an interface through which the Grid may access it (in other words: if it is virtualized as well).

Grid resources provide services to the Grid. They are connected to the Grid through an appropriate interface. These interfaces (we call them Grid interfaces) hide to the Grid by which resource exactly (if there are more than one) the requested service is performed in a particular situation (local Grid resource transparency, see also the definition of Base Resources in OGSA). They provide for resource virtualization. That means: the SLA is bound to the interface of a Grid service which itself is provided by a Grid resource.

Working Definition – Mobile Grid Resource:

> Within this report a Grid resource is named "mobile" if the Grid resource and the respective Grid interface are not bound to a certain location.

Based on this definition we now approach a working definition of a mobile Grid.

Working Definition – Mobile Grid:

> A mobile Grid is a Grid with at least one essential mobile Grid resource. "Essential" in this context means that the mobile Grid resource is actively participating in the Grid so that the resource can take the role of either a service consumer or a service provider. Consequently, the mobile Grid resource is an active member of at least one Virtual Organisation and is involved in executing workflows.

Provided that the technical requirements and preconditions (e.g. wireless communication's bandwidth capabilities) are met it is imaginable that many or even all Grid nodes are mobile. It is important to note that "mobile" does not necessarily imply "wireless" or "low bandwidth" or "can be carried by a person in the pocket". Its only meaning is: it may change its location (e.g., through a mobile platform). Code-mobility will not be considered, further on.

Consequences of Mobile Grid:

Mobile Grid resources are situated in a context. This context is crucial for the execution of workflows. Akogrimo, which promises "access to knowledge in a mobile world", is thus aiming to develop a clear model of resources (incl. humans) and their contexts, preferences, knowledge etc. This would for instance require workflows in the application layer to be aware of humans' physical context, their available communication resources, preferences, knowledge etc. Further consequences of a mobile Grid are the following:

- Workflows may be diffused into the physical environment (e.g. devices and mechanical machinery in a human's physical proximity). This might mean that workflows may be composed not only by web services but also by networks / devices / resources / other workflows / sensors that are dynamically discovered in the humans' changing environment.
- Applications and workflows have to respond to a changing environment – which would require new formalisms and mechanisms for modelling and execution of workflows. Akogrimo workflows have to handle changes to their course of execution when resources disappear, appear, change quality, move, etc. Predefined execution models will not work in a mobile world. This again means that applications in WP4.4 for instance have to be notified about changes in the environment (described in e.g. WP4.1 and WP4.2) and have to be able to reconfigure services at all layers.
- It is not a mobile Grid if a mobile user accesses a stationary Grid through a web interface, because in that case the Grid service is provided through a (stationary) web page, which can be accessed from elsewhere.
- It is, however, a mobile Grid if a mobile user accesses the Grid through his or her laptop (mobile device) if the laptop acts as Grid interface in the above sense.
- It has the ability to deploy underlying ad-hoc networks and provide a self-configuring Grid system of mobile Gird resources conducted by wireless links and forming arbitrary and unpredictable topologies.
- The mobile Grid is achieved by the network and the Grid itself only exploits this. Knowing that the Grid is mobile may allow other things such as location based services to appear.

2.3. Knowledge Access and Knowledge-Based Systems

Akogrimo is about the access to knowledge in a mobile Grid world. This also requires a consideration of those requirements that arise when knowledge-intensive applications are to be supported through the Grid.

Within this section we apply to two different perspectives which each give a particular view to related issues. The first perspective introduces to the reader some rationales concerning the architecture and the reasoning process in knowledge based systems (2.3.1).

In subsection 2.3.2 we discuss relationships between knowledge access in a Grid world and the field of semantic web. These two fields have much in common and also the potential for providing substantial mutual benefits.

2.3.1. Knowledge Access, Knowledge Representation and Reasoning

Talking about the automatic access to knowledge at least assumes that there is a software system containing "knowledge" (instead of data) which does also provide an appropriate interface for knowledge access together with those components needed in order to evaluate a knowledge base against a query. Thus, to clarify, the definitions of knowledge, of interface to a knowledge based system (KBS), and of internal components of knowledge based systems, together with their relevance within the Grid context.

For the purpose of this report we can define knowledge as anything being represented in a computer system (typically in a so-called knowledge base) by using formal knowledge representation mechanisms. Typical examples for knowledge representations (KR) methods are logic, rules, frames, semantic nets. The formal representation of a piece of knowledge is distinct from its interpretation which relates the formal structure to objects, relationships and behaviours in the real world. As an example, consider the production rule

IF father_has_arrived THEN start_preparation_of_marriage

Production rules consist of a logic expression as pre-condition and a specification of an action which shall be performed if the condition is verified. In our case (at least) two different interpretations are possible:

- World of discourse is the "religious world". In that case the statement could mean: the prayer starts the preparation of the marriage, i.e. develops his speech, prepares the church etc.
- World of discourse is "family": In this case father would stand for one of those two persons who are either father of the future wife or father of the future husband. Preparation of the marriage would then mean to prepare all those things at home being necessary so that the family can move to the church at the right in time.

This very simple example already demonstrates some important challenges in knowledge representation and reasoning.

- Knowledge representations are in terms of mathematics (often: logics) formal constructs. They are not standing alone but require an appropriate interpretation. The interpretation depends on the world of discourse to which one applies. Thus, each representation can be evaluated under different interpretations leading to completely different results.
- It is commonly understood today that "knowledge" is an inappropriate term to adequately describe the state(s) of a world of discourse. Thus, modern knowledge bases incorporate now "beliefs" rather than "facts". Often, beliefs represent uncertain or vague knowledge. This requires additional formalisms and lots of additional computational actions in reasoning.
- As it is always possible to provide senseless input to computer system a critical issue is that KBS can not decide by themselves whether their knowledge is appropriate for a given input. This leads to the problem that KBS cannot guarantee for a "graceful degradation". Thus, early KBS assumed that humans are there users, and that these humans exactly know in which cases the KBS can be used. In an automated world (like a Grid), additional resources are thus needed in order to support cooperation of KBS with each other, and/or with other systems. A typical example is ontologies which they themselves are also KBS. This further increases the computational complexity.
- Knowledge access leads to recursive computational structures. In general, the access to knowledge only means to pick a single piece of knowledge (e.g., one rule) from the knowledge base. The evaluation of that rule may require thousands of additional accesses to

the knowledge base or to other knowledge bases within the same or within other systems. Often, recursion leads to multiple accesses to the same piece of knowledge, depending on the dynamic evaluation structure (e.g., proof) of the reasoning process. This makes reasoning processes very time consuming. The component within a KBS that controls reasoning is called an inference engine.

- A critical issue thus is to adequately limit the search space. This is exactly the contrary of what one aims at when providing a Grid infrastructure for knowledge-intensive applications. This is the aim the coordination mechanisms of the Grid infrastructure also necessarily needed to provide algorithms to control the size (and appropriate structure) of search spaces.
- Finally, it is often requested that KBS should not only be able to explain to their users why, and how, but also why they have not achieved their results. Amongst others, this requires that the knowledge base remains unchanged for some time after the reasoning process has been completed. It is unclear how this could be achieved within a Grid world.
- Finally, KBS are assumed to exhibit machine learning capabilities. That means that they are able to adapt their knowledge and their inference strategies by own decisions to changing requirements, to the dynamics of their environments, to the behaviours of their users, etc.

As a first result we can draw that at least an extensive use of cooperating KBS within a Grid would require appropriate protocols, heuristics, algorithms etc. to control decentralized reasoning processes which are not available today.

If knowledge based systems are able to process uncertain or vague knowledge it must be guaranteed that this qualification is not lost during subsequent computations.

Today, standardized access to a knowledge base at least in cooperative system settings is typically performed through statements of a standardized Knowledge Query and Manipulation Language (KQML). The Grid infrastructure should thus support the translation of "traditional" requests into KQML statements (and vice versa). Such transformation processes of course increase the computational complexity and in some cases a full translation is not possible.

```
(tell    :sender ward_assistant_3 :receiver physician_5
         :language KIF :ontology Onthos
         :content (on_station patient_13))
```

In order to support cooperation among knowledge bases speech act based cooperation protocols have been developed. An example is depicted in the following picture.

```
(request :sender patient
         :receiver ward_sys
         :protocol FIPA-Request
         :content  "((action ward_sys (make_appointment)))"
         :language FIPA-SL0 :ontology "Onthos")
(agree   :sender ward_sys
         :receiver patient
         :protocol FIPA-Request
         :content  "((action ward_sys (make_appointment)))"
         :language FIPA-SL0 :ontology "Onthos")
(inform  :sender ward_sys
         :receiver patient
         :protocol FIPA-Request
         :content "((result ((action war_sys
             (make_appointment))
```

```
        (appointment :time 20031201 :place ward_1)))”
    :language FIPA-SL0 :ontology "Onthos")
```

2.3.2. Relations to the Semantic Web

Recently, caused by the developments in semantic web and semantic Grid research, the discussions about knowledge acquisition, knowledge processing, and knowledge management have been carried out in several main directions. On the one side, research is done in the field of derivation of knowledge by classifying, structuring and linking information in media resources (documents, pictures, etc.) under the consideration of a particular situation, the service that requests the knowledge is in. Hence, the research focus is put on analysing documents with respect to the level of structuring of the information the document contains. XML-based document definitions, classifications of concepts for information description and methods as well as data structures for knowledge formalisation are major results.

The second area of discussion resumes the research in knowledge based systems as described in the previous section. The life cycle management and administration of knowledge sources is one aspect. Furthermore, the access to knowledge and the exploitation of knowledge, deliberate reasoning and derivation of new knowledge as well as the tracing of deduction processes are in the centre of interest.

A third area is related to resources providing particular services, especially web-services or Grid-services. Here, the description of a service, its name, parameter values and the specification of the expected outcome has to be considered. It’s intended to automatically determine services that can perform specific tasks. In this field the specifications of the Resource Description Framework (RDF) and several ontology description languages such the Web Ontology Language for Services (OWL-S) have been agreed as a foundation for the Web-Service Resource Framework (WS-RF).

The objective of the Akogrimo project is the development of a new infrastructure for accessing knowledge through the Grid in a mobile world. Consequently, the scope of research about knowledge access is put on infrastructure services to facilitate knowledge based services in the Grid. To support the dynamic binding of services to the workflow description the maintenance of descriptions of services that mobile Grid resources provide in of high relevance. For this purpose context and service level information need to be integrated into the service description. The recognition, configuration, orchestration of services and above all, the negotiation of their access and usage conditions are facilitated. The exploitation of the Semantic Web foundations metadata and (shared) ontologies allow an abstraction of domain specific knowledge at the design of Grid services and the application of this knowledge for application configuration and execution.

One expected achievement of Akogrimo is an extensive integration of a wide spectrum of users and resources. Hence, there arises a requirement to improve the interaction amongst these resources. Especially, in the area of task specifications by service requestors and their transformation into an automatically configured workflow exist requirements that semantic web concepts can meet:

- Formalisation of concepts and the relations among them, the resources knowledge representation is based upon
- Description of services or already orchestrated services the Grid provides, which are used to configure workflows to carry out the specifies task
- Mappings or conversation of the semantics of knowledge concepts and service descriptions
- Interaction protocols between Grid services

These points are of particular relevance because a human user can act as a service requester and service provider in the Grid. The service requests specified by computational Grid services have to be converted into a human understandable format, too.

Knowledge in this particular Akogrimo perspective can be understood as the achievement of the combination of and the access to services in a way that a particular service level and a particular set of knowledge is available to accomplish a defined task.

Based on these considerations, three general criteria can be derived that support the evaluation, witch testbeds and scenarios draw benefits from knowledge processing technologies:

- Due to complexity, uncertainty and volatility in the application domain, the process to accomplish a specific task in Grid system cannot or only incompletely be specified at design time, or has to be adapted at run-time.
- Various resources and human users are highly integrated into the process in the role of a service consumer and provider. Formalized knowledge (rules, constraints, templates, ontologies etc.) has to be used for service configuration, combination, and execution.
- Information about the context a resource is situated in is relevant for the access to the service the resource provides and needs to be used for the service description, or combined with their knowledge base.

2.4. Business Relevance

Mobile Grid technology provides at least the following two advantages:

- From a user's point of view the mobile Grid's most important value added is associated to location transparency. This has two dimensions: (1) the user can access the Grid without knowing where the service actually is, and (2) the Grid is supposed to provide the service in such a way that the local context of the service requester is being considered.
- From a service provider's point of view Grid's most important value added is associated that it can provide local content, location-based services and the like. This extends the capability of a Grid to easily access location-based content from changing geographic locations and even to access location-based content if the object under consideration is moving from one location to another (e.g., a mobile robot).

Thus, another perspective that is important to consider is the understanding of the business relevance of each of the testbeds. While this is an aspect that will be fully examined in a forthcoming work package (WP 3.2) nevertheless it is an important criterion for the development of a testbed. In some of the testbeds (e-health and e-learning) this business potential is inherent and therefore has not been explicitly defined but in the case of Disaster Handling and Crisis Management, the commercial potential is not a primary motivation and therefore merits additional understanding to identify its business significance. Some of the basic and preliminary questions that need to be answered by any of the testbeds would be some of the following:

1. Who is the potential customer?
2. How many customers? Why? e.g., heart attack (Germany only): 300.000 heart attacks/year, approx. 200.000 death within 24 hours
3. What would they pay (e.g., per month) for a mobile Grid based service (e.g. a monitoring or emergency service)?
4. How many new business opportunities? How strong are they?
5. How many (and which type of) third parties collaborating in Grid-based Value Chains?

6. Necessary investments into infrastructure, applications, organisation? Time needed?
7. Technological & Commercial Risks?
8. Number of Transactions
9. Type of Transactions
10. Added Value
11. Reimbursement Potential
12. Coverage of Existing Infrastructure
13. Multiple (non-exclusive) Usage of Resources and Services for Akogrimo

3. Description and Evaluation of Akogrimo Testbeds

In the following chapter, the main testbed candidates are described, which are intended to be the foundation for the later modelling, design, implementation, and evaluation of the Akogrimo approach and technology that will be developed. Within this chapter, the term testbed is not used in a technical meaning of an environment for prototyping, testing, or evaluation purposes, but is rather used from a real world domain centred point of view.

Working Definition:

> Consequently, a testbed is considered as a part of a real world domain which is defined by a set of scenarios characterising the relationships and dependencies of business processes, organisations, and actors as well as technical and non-technical resources.

The testbed is described against the background of the social, economic, and technologic environment of the corresponding domain (see [3]).

Within the next section we specify the two main testbeds eHealth and eLearning as well as an additional testbed candidate Disaster Handling and Crisis Management suggested by the Akogrimo consortium. At first we provide some background information about the real world domain represented through the testbed and give a short motivation for the support by next generation Grid infrastructures. Thereafter several scenarios relevant for the respective testbed are explained. Within each scenario the process flow is described from various perspectives, pretending the process is already enabled by Mobile Grid technologies. Following each scenario description, an analysis of the suitability of the scenario to justify the necessity of applying Mobile Grid technology, and accessing or exploiting knowledge resources is done.

The analysis is limited to a merely reduced set of criteria for both the Mobile Grid and the knowledge aspect in order to justify the usage of the suggested testbeds for upcoming Akogrimo research and development work. The detailed evaluation of the testbed scenarios and the selection of one scenario per testbed for the prototype and demonstrator development are carried out in line with the "Evaluation Scenarios" deliverable. The main criterion related to Mobile Grid can be considered as the mobility of resources relevant (see chapter 2.2) to the application executed in a Grid environment. Starting from the identification of mobile resources and the classification as a Grid resource type, an analysis can be done weather higher level services such a VO-management, orchestration support or workflow execution have to be considered mobility-aware, too. In doing so, the advisement, whether parts of these management services have to be carried out on mobile resources, or context information of mobile resources have to be available for these management services are of particular interest

3.1. eLearning

3.1.1. Background and Motivation

3.1.1.1. Introduction

Future societies and economies are being formed in the classrooms of today. Students need to be both educated in their chosen field and digitally literate if they want effectively to be part of tomorrow's knowledge society. eLearning achieves both aims, but not only for young students, but with the objective to make learning a lifelong endeavour, with people of all ages continuously developing their skills. Here too, eLearning can make a significant contribution, with both workers and organisations transforming the way they learn, interact and work. Moreover, eLearning can promote social integration and inclusion, opening access to learning for people with special needs and those living in difficult circumstances (marginalised groups, migrants, single parents, etc.).

eLearning integrates advanced information and communication technologies into the education system, with the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration. Modern eLearning solutions recognise the importance of learning as a social process, offering possibilities for collaboration with other learners, for interaction with the content and for guidance from teachers, trainers and tutors.

These learner-centred approaches put the learners back in command, with a wealth of learning resources at their fingertips, customised to their individual needs. Teachers and trainers, however, continue to play a central role, using virtual and traditional face-to-face interactions with their students in a 'blended' approach.

This section describes the new eLearning paradigm: the integration of new technologies in eLearning scenarios poses new challenges, and provides new added values very useful for eLearning. The mobile network technology will provide new ways of eLearning usage for a mobile student, while the integration of Grid technologies will provide new applications and scalability to traditional eLearning scenarios. The integration of these individual technologies in eLearning has already been addressed, for example in the scope of the eLeGi (European Learning Grid Infrastructure) IST FP6 project and the MOBIlearn (Next-generation paradigms and interfaces for technology supported learning in a mobile environment exploring the potential of ambient intelligence) IST FP5 project. The innovation raised in the Akogrimo project will be the combination of both technologies for the eLearning scenarios, with the use of the so-called "Mobile Grid" infrastructure.

3.1.1.2. New eLearning Paradigm

Actually, no-one really knows just how we learn! However, we do know that some characteristics and approaches are more likely to be effective in formalized and structured educational programmes. In order to advance effective learning these features must be incorporated into an educational paradigm that focuses on the learner and on new forms of learning. With this approach the learner has an active and central role in the learning process. Learning activities are aimed at facilitating the construction of knowledge and skills in the learner, instead of the memorisation of information. Information transfer will still obviously exist in the new paradigm, but only as a simple component, not the main goal. Accordingly we can say that the new paradigm subsumes the old one in its displacement.

More "complete" knowledge construction occurs through new forms of learning based on:

- The understanding of concepts through direct experience of their manifestation in realistic contexts (i.e. providing access to real world data) which are constructed from sophisticated software interfaces and devices, and represented as services;
- "Social learning" – active collaboration with other students, teachers, tutors, experts or, in general, available human peers, by using different kinds of collaboration technologies, including enhanced presence.

In this approach collaboration is considered as a complex conversational process that goes far beyond a simple information exchange. In order to support such a "ubiquitous conversational process", one must consider the social context where the learning process occurs. Accordingly we do not consider the learner's ability in an abstract way, but relate it to a specific situation (the context). In this ambit the term "ubiquitous" does not refer simply to "anytime / anywhere", but more generally to the ability to support multiple diverse learning contexts and automatically adapt to them.

As we consider human learning as a social process, collaboration implies community membership, it means working together, providing added value, sharing and executing tasks in order to reach a common goal. ELearning is no longer an isolated activity – it implies mutual trust, shared interests, common goals, commitments, obligations, exchanging of services, a genuinely proactive, motivated behaviour.

In order to support ubiquitous, collaborative, experiential and contextualised learning in dynamic virtual communities, a learning environment should provide the following features for learners:

- Collaboration; Socio-constructivist: group working should be routinely supported as well as the more traditional model of the solitary learner – this includes support for self-organising online communities who share common educational goals
- Experiential; Active Learning: learning resources should be interactive, engaging, and responsive – active learning and knowledge formation should be emphasised above simple information transfer;
- Ubiquity and accessibility;
- Wider, more flexible access to educational resources should be provided, often referred to as "anytime/anywhere" learning;
- Multiple different types of devices, interfaces, and network connection types should be supported where possible;
- Contextualised; Adaptive: appropriate learning contexts may be naturally be short-lived, as well as the more traditional static situations such as the classroom and the library – this calls for dynamicity in the creation of contexts.

The pedagogical goals outlined above have highly demanding technical requirements, many of which are also the concerns of distributed systems research. Group working implies shared interactive services and resources, necessitating both concurrency control and awareness of others activities. Active learning requires interactive resources (services) many of which will only be engaging if they are suitably responsive – a quality of service (QoS) issue that depends on many components of a distributed system – the low-level infrastructure (hardware, OS, network), the middleware and the interface software. Concurrency control and interactive responsiveness can make conflicting demands on a system. Real world input, such as live stock market prices, or remote sensing data, makes a network connection mandatory, and this again raises QoS issues such as fault detection, masking and tolerance for the learning environment.

Accessibility, as in "anytime/anywhere", requires availability, which may be supported through replication of resources, but this creates further tensions with responsiveness and concurrency control due to the need to maintain state across replicas. Accessibility also means adapting to available capabilities. For example: can the same learning environment be delivered through low-bandwidth mobile devices and high-bandwidth multimedia workstations? Accessibility also means supporting the special needs of an individual, such as disabilities.

More generally, the individual user should be recognised and catered for, and this personalisation requires semantic tagging and profiling that can be difficult to formulate, both conceptually and in terms of machine representation. Standards efforts have been particularly slow in addressing this problem.

Contextualisation requires a move from the traditional view of an online learning environment as a stable long-lived entity (e.g. during the lifetime of a teaching module) – to one where the environment may evolve and change much more frequently, perhaps even several times a day – a dynamicity that is alien to current eLearning products.

We believe that these technical requirements can best be addressed by building on the open distributed service model that has evolved exploiting Grid and Semantic technologies.

3.1.1.3. Combined scenarios

It is of course essential that a conceptual bridge is provided when moving from traditional learning environments to new ones. In order to demonstrate the suitability of mobile open services environment such as that supported by OGSA to support new learning contexts we consider how traditional *contexts* can be used as metaphors for *learning services*. On the subsequent sections, we list a series of scenarios showing how a service-oriented approach can be used to dynamically create contexts that combine traditional ones. Combinations can feature arbitrary mixes of real and virtual versions of common contexts. The virtualised contexts are metaphors for traditional real contexts that are realised through dynamic service generation. As the exact mix of components required will be determined by numerous factors, often unique to a particular learner at some point on their own learning trajectory, it is important that combinations can be produced dynamically.

3.1.2. Scenario 1: Networking Course by eLearning

3.1.2.1. Scenario description

Pedro is a literature student and has decided to study a Computer Network course next semester. This is a special course offered to students not related to Information Technologies which allows learning basic concepts on networking and focused on the Internet. This course is performed by the use of an eLearning platform. Pedro is a typical Internet user and would like to learn basic concepts related to IP technology.

The eLearning course is based on Internet concepts, covering historical issues as well as basic technical issues on IP technology which allows students to learn how the internet works and basic capabilities to design and configure simple networks.

While Pedro is travelling from Madrid to Paris by train, where he plans to visit the Louvre Museum, he decided to progress in this distance networking course during the long trip.

By using his PDA, he can access to the eLearning platform after being identified in the system and the platform informs him about his status in the course. Next topic to cover is the IP protocol. So, Pedro can read documents on IP addressing available in the platform and perform several network simulations to build medium and large enterprise environments. He is quite interested in enterprise networking because he belongs to a group of three students that must present a design and configuration of a company network to demonstrate they had learnt IP basic topics. The simulator allows him to modify addressing configurations in order to analyse the efficiency in the transmission and switching resources as well as the scalability of the network. The output of the simulator is based on numerical results since the graphical capabilities of his terminal don't allow a high quality video. Pedro doesn't understand some of the results of a case study, so he decides to switch on his laptop and request the platform to provide graphical information of a flow of packets between two hosts. The platform shows in the laptop a virtual reality representation which allows Pedro to see himself riding an IP packet from the source to the destination, learning the reasons for the decisions and the packet modifications in each hop.

By analysing this case, some questions related to IP masks arise and Pedro decides to contact directly to some assistant in real time by using a videoconference application in his PDA. Due to the immediate entrance of the train in a tunnel, the PDA decide to avoid UMTS videoconferencing service and use the public WLAN infrastructure available in the train to contact the assistant by using VoIP without video.

After solving the questions, Pedro decides to establish a connection with his colleagues to try to discuss and hopefully finish the work of this topic. The eLearning platform puts the three students in contact and, taking into consideration their personal work, allows consolidating a unique network design. They use a cooperative network design application provided by the eLearning platform to consolidate the work done locally by each member and to discuss some design decisions. There are some disagreements on the addressing design so they decide to proceed with two proposals to solve it.

They order different simulations with the different solutions to be able to compare them and ask the system to provide network addressing designs of real networks with similar capabilities and environments.

After the process, they agree on a final solution (Pedro finally was right) and decide to submit the addressing design work to the professor and wait for their approval to go further into the last topic of the course: multimedia applications.

3.1.2.2. Analysis I : Relevance for Mobile Grid

In accessing the Grid via multiple nodes e.g. PDA or laptop in fast moving environments (train) to get in contact with multiple distributed infrastructures and applications the student exploits the idea of Grids and mobility. He takes part in a VO in being an active participant of it. The student provides "mobilization service" by carrying a PDA. The PDA, a simple computer hardware resource, facilitates access to the Grid to obtain information, and transmit parameter to launch simulations, but is not a part of the running network simulation. Thus, it takes the part of a service requester. Solely, the videoconferencing capability states a service provided by the resource, but the resource is not shared for multiple requesters, and it's not obviously a part of a higher level service (where e.g. any kind of image analysis or transformation would be done). As a result, the resource is mobile, exploits Grid services, but poses no relevant services to the Grid.

3.1.2.3. Analysis II: Relevance for Knowledge Access

This scenario describes a process that can be predefined. The available services are known. They don't have to be selected or configured dynamically. Context specific information is only needed to select the most suitable network. The process flow itself is not related to the situation the user is in. The only system to be considered as knowledge based is the eLearning platform by itself, but there is no use of knowledge based systems for the configuration of the workflows and processes.

3.1.3. Scenario 2: Featuring Immersive Virtual Reality

3.1.3.1. Scenario Description

A student is learning water table and aquifer behaviour by using an eLearning platform. While he is at home, he studies aspects of the water table and aquifer behaviour by interacting with books and some multimedia resources through the remote eLearning platform. Initially, he connects his PDA to the platform by using a WLAN home network and accesses to introductory books which provide him initial knowledge on that matter. After this basic knowledge, he needs to contact a professor to answer some questions. The professor is busy in a meeting but he proposes to him to answer his questions by using a virtual reality service provided by the platform.

So he decides to use a dynamically generated set of services which are brought together and delivered to the student according to his user profile and current device capabilities to create an immersive virtual reality situation.

He must move to the university to attend a presence lecture, so he changes the session from his home computer to his PDA. When he arrives at the university, the platform informs that the virtual reality environment is ready for use but the PDA capabilities do not allow a virtual reality scenario, so the platform notifies him potential locations where he can perform the immersion.

After that, he goes to the nearest one in which he can interact with the system by using special tools like gloves and glasses, where he explores and develops their own personal understanding and knowledge, without physically move to the real scenarios. This allows him to go deeper on the behaviour and characteristics of aquifer behaviour and water tables.

He experiments different situations, by immersing in different virtual situation exiting in real life. In each virtual site he meets with students and interacts with them. Learning occurs in a natural way by product of experiments and interactions with other students.

3.1.3.2. Analysis I : Relevance for Mobile Grid

Virtuality in this scenario is the main focus. He changes his physical location, but he is more a nomadic user, who settled once, begins the usage of the Grid. The services accessed by student are mainly information, communication, and service locating services. Apart from the service requests and the specification of his mobile computer hardware, the student does not provide any additional information or resources to the Grid. He exploits Grid capabilities like session maintenance, but is not an active service provider himself.

3.1.3.3. Analysis II: Relevance for Knowledge Access

Evaluating this scenario can be done with the same argumentation and results as it was done in the previous scenario. Only user profiles are context knowledge that could be used to a context or user specific configuration of the process described in this scenario.

3.1.4. Scenario 3: Featuring the Virtual Laboratory

3.1.4.1. Scenario description

This year the head of the High School "Akogrimo" has informed the students about a new feature to be introduced during this year. The old laboratory of chemistry has been closed and will be replaced by a quite modern one which will be used by the student. He informs that for this purpose the students will have to access by using a network computer and that it will be possible to attend remotely or in site.

Students access the system by using different terminals: PDA, laptop, PCs, etc. to a virtual laboratory to carry out experiments. There is also an agreement among the high school and multiple entities with supercomputer facilities allowing to specify complex analysis and to test them in different involved entities. Students are identified in the system and a status of their work is stored at their user profile.

During the performance of the test, typically done in groups of three students they have capabilities to discuss among the group members independently of where are located each one and to try to contact the professor to answer some questions. From time to time a synchronization period allows comparing results between groups and getting partial marks.

Sometimes, the output of the virtual laboratory is based on numerical results but in some cases they can also show graphical representations. Depending on the terminal capabilities of each student, the output is adapted. When the students access the laboratory, it informs them about the status of the work in progress, as sometimes it needs long periods of time for distributed simulations or aggregation of information located in multiple sites, to allow the student to break without loosing the work done before.

3.1.4.2. Analysis I : Relevance for Mobile Grid

Multiple, even mobile, resources accessing a simulated, virtual surrounding in a virtual organisation makes the strength of this scenario. The students in this case are involved in a common workflow. Access to their elaborated work is granted for collaboration, reviewing, and simulation. As described these information or knowledge resource are available on the Grid, but not or even preferably not provided straight through the mobile computer hardware. The typical mobility aspect is missing, because the students work in wireless and distributed, but not in moving environments.

3.1.4.3. Analysis II: Relevance for Knowledge Access

The integration of distributed information is a characteristic feature of this scenario. A knowledge processing grid service could facilitate this task. Beyond this no knowledge based process control or workflow configuration is needed. The Grid facilitates the interaction of the users, but no coordination support is provided.

3.1.5. Scenario 4: The Field Trip

This scenario, based on the traditional field trip augmented by appropriate use of information and communication technologies, illustrates experiential, contextualised, collaborative and personalised learning for knowledge creation and sharing. Figure 1 depicts the scenario.

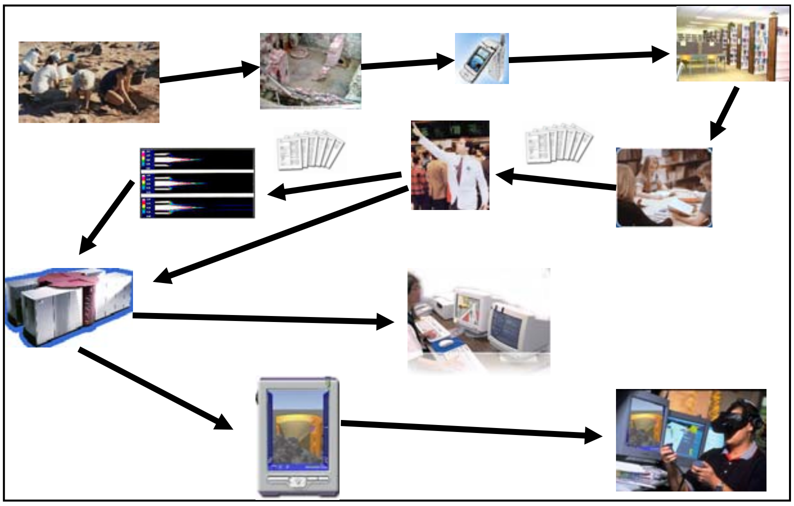

Figure 1: A Technology Enhanced Field Trip Scenario

3.1.5.1. Scenario description

There is a group of students, all equipped with a 4th generation PDA, that for their Archaeology spring exam are working on the Field Trip project. During their activity they store information, experience, emotion, in terms of photos, video clips, text notes, audio comments, etc. The PDA, using the user profile and context dependent information automatically indexed these contents using appropriate metadata. The information collected by all students are send via the appropriate network (the PDA will negotiate with the network service provider operative in that zone which kind of network communication will be used according to the bandwidth necessary, the price, etc.) to the Field Trip (FT) Grid service created by the teacher of the course for their project. The PDA will use user biometric data for secure access to Grid based virtual learning organisation and for data ciphering. The FT Grid service, orchestrating speech to text Grid services (provided by Company A) and advanced semantic tool for text interpretation virtualised as Grid services (provided by Company B), will analyse the student's information comparing them with the learning objective foresees for the project experience and formalised in an ontology based knowledge representation (concepts to be learned, goals to reach, relationships, etc.). It summarises them from the learning point of view in term of progress and weakness to the teacher. It stores all the information in a multimedia repository Grid service. At the end of the day the students working in the field trip meet for sharing their experiences and for consolidating the knowledge acquired. They will use the PDA speech recognition capability for sending commands to the search engine in order to retrieve the information and for their visualisation. During these sessions it is frequently necessary to consult digital libraries (provided by different organisations) for finding new information or for checking some hypothesis done and/or evaluations made about the provenience of discovered objects.

During the daily work in the field trip some collaborative sessions with other students in the school are needed in order to share their experiences. To this purpose the students collect with their PDA some photo of the field trip and the objects discovered and send them to the Virtual Collaboration Grid service asking to make them in 3D. The VC Grid service invokes the high performance 3D modelling and rendering tools (provide by the High Performance Computing Centre of the University) virtualised as Grid services in order to make the 3D reconstruction and rendering them. In order to make more productive the experience the FT Grid service, using the context data and the information collected by the single student, provide them the possibility to discuss with selected (by the teacher) experts on the field (historical period, zone, objects nature, etc.). Moreover, using semantic based Grid service searching and location capability it will provide information about the availability of other groups in the same zone or in different zones but with affinity with their work and belonging to different Grid enabled virtual learning organisations in order to share their experience.

3.1.5.2. Analysis I : Relevance for Mobile Grid

In this scenario, the typical Grid perspective in combination with mobility is described: Changing physical location of nodes, active building of VO and processing of context related information in distributed areas, also the need for timely high performance computing power. The student provides different multimedia information directly over the PDA and other additional input sensors to the Grid. The processing is done by a Grid service. Thus, the PDA and corresponding sensor are becoming a relevant resource to provide Grid services in a VO, actively. Another very important point can be seen in the relocation of higher Grid services (or at least parts of these services) on a mobile computer hardware resource - the dynamic set up and maintenance of Grid services and VOs on the PDA of the teacher in this particular case. All members of the course and the teacher can access and process all collected information. Solely, the shared access to the mobile resource is a criterion not directly needed.

3.1.5.3. Analysis II: Relevance for Knowledge Access

Numerous Grid services described in this scenario are knowledge based services, for instance the service that evaluates the learning progress. The results of this evaluation can be used to advice the next steps the students should do. Additionally, sensor data which describe the field the study is done is also considered in the evaluation of the learning progress. The learning results of each student are prepared, transferred into documents and images, and made available to the other learners in the group.

3.1.6. Scenario 5: English plan

3.1.6.1. Scenario description

A group of students with a similar initial level are in an immersion program that ends with the access to an official certification exam. The program consists on a week trip to New York. Each day the student has to send a report to his/her tutor about a concrete subject and based on the activities program designed by the tutor. The student uses the pronunciation testing service to repeat two or three times the developed report and so improving his/her pronunciation.

For example: A visit to the New York Stock Exchange. During the night before, the student, using his PDA and the hotel Wi-Fi network, consults in the service basic documentation as contextual vocabulary, terms for travelling through the city, online dictionaries, chats and forums, and related work made by other students about similar subjects. The relationship among the students is established taking into account their personal situation, level, etc. When the student ends the reports, he/she accesses to the Evaluators Virtual Network via a voice authentication mechanism, and perform an official exam.

As part of the exam, some students collaborate creating a virtual scenario which reproduces some of the activities taking place during their travel to New York. Besides, the program will be in a language knowledge community, where they can interchange experiences, search information and transform the reports in explicit knowledge available by everyone in the community.

3.1.6.2. Analysis I : Relevance for Mobile Grid

The scenario described can be realized by using Mobile Grid technology. But no essential requirement is described. The user exploits the capabilities of his mobile computer hardware (PDA) to access services provided through the Grid. He transfers audio and video signals to a Grid service and acts as a services requester only. No resource provided by the user is needed to orchestrate a higher level Grid service upon the Virtual Organisation the user is participating in. Mobility can improve the convenience to use the service, but is no prerequisite for the execution of described Grid service.

3.1.6.3. Analysis II: Relevance for Knowledge Access

Like all described eLearning scenarios apart from "The field trip", the knowledge based capabilities are integrated into the learning environment service. A relation to other services and the combination of multiple knowledge based services to fulfil tasks is not obviously needed. The learning guidance is scarcely assisted by any structured process flow. Each learner has a freedom to choose the appropriate learning, or teaching partners and materials. The knowledge is mainly focused on the service requester, the learner, itself.

3.1.7. Scenario 6: How to elaborate a business plan (Harvard pill)

3.1.7.1. Scenario description

A business man, responsible for the opening of an enterprise branch in Japan, must show a business plan to his new partners in a future meeting. His intention is to improve it before the meeting. He has access to the corporative resources that he needs, adapted to the user location and the device used.

Although he is confident about how to create the plan, he downloads to his PDA, using the Wi-Fi network in the airport, a course about how to make a business plan.

During the flight he reads the course and some doubts arise. He connects with a Grid service that allows locating an available tutor on that moment and providing a videoconference service. With the answers, the business man can start working.

When he has an initial business plan, he accesses to a profitability simulator service (one of the active learning services available) where he can match the economics data of his business plan.

3.1.7.2. Analysis I : Relevance for Mobile Grid

The Analysis of this scenario is very similar to the "English Plan" described about. The user consumes Grid services such as Virtual Assistance, Learning Support, or Simulation. The participation in the VO is limited to call the service, provide parameter or configuration information. Mobility and location specific information are of minor importance for the proper service execution.

3.1.7.3. Analysis II: Relevance for Knowledge Access

The given description only requires a static configured information service providing instructions on how to develop a business plan. This knowledge is provided explicitly, but is not exploited to created process where the business man can interactively create the business plan. A combined application of several knowledge based systems can be indispensable to link all information necessary to compile a comprehensive business plan.

3.1.8. Needs for and Benefits from Using Mobile Grid Technology

3.1.8.1. The added value introduced by Grid in an eLearning scenario

The Grid technology was originally designed for e-Science and was primarily concerned with supercomputing applications, but the framework it engendered to realise effective sharing of distributed heterogeneous resources (OGSA: the Open Grid Services Architecture) is now being applied to many other areas, especially enterprise computing and e-Commerce. Reciprocally, by progressing Grid technologies for learning, we will also contribute towards the advancement of the open Grid service model itself, specifically in the learning domain. We see the use of the Grid to support a paradigm shift in pedagogy to advance effective learning as a natural step in the recent historical progress of ICS in learning: Single PC → Internet → Grid.

OGSA leverages open standards including W3C, and provides an holistic view of Grid computing based on the concepts of 'Services', 'Distributed Collaboration' and 'Virtual Organisation'. At this point, future learning scenarios enter the picture: the user-centred, contextualised and experiential based approaches for ubiquitous learning imply the full exploitation of location-transparent access to distributed services such as simulation environments, real-world input, 3D visualisation systems and digital libraries, in the framework of a Virtual Organisation. This allows a transition from current content-oriented eLearning solutions towards a user-centred collaborative model.

The next generation of Grid solutions will increasingly adopt the *service-oriented model* for exploiting commodity technologies. Its goal is to enable as well as facilitate the transformation of *Information* into *Knowledge*, by humans as well as – progressively – by software agents, providing the electronic underpinning for a global society in business, government, research, science, education and entertainment (*semantic aspects*) We refer to these efforts as the "Semantic Grid".

The Semantic Grid brings together Grid and Semantic technologies. Semantic and Knowledge technologies are mainly focused on giving a well defined meaning to resources, services and information dispersed on the Web [8], they provides tools for knowledge representation and management, annotation of data and resources, semantic discovery of services and resources, automatic composition of services and inference over metadata and ontologies. Current technologies, based on industrial standards and initiatives (e.g. UDDI [10], BPEL4WS [9]), allow composition of services with an a priori knowledge of services meaning and processes between services. In contrast, Semantic Web and Knowledge technologies provides an expressive and semantically enriched description of services, by the use of ontology description languages as OWL-S [5], and allows for automatic selection, location and composition of services in order to achieve the required objectives.

In summary, it's possible to develop an OGSA compliant service oriented software architecture and realise a corresponding prototype infrastructure in order to support effective learning environments.

The well known failures of technology-driven eLearning "solutions" experienced in the past must help us to identify features of successful pedagogical models first and then look for technologies which can provide these features.

The pedagogical features we have identified include collaboration, personalization, learner-centricity, context-awareness, realism, personal learning profiles, personal special needs, ubiquity, accessibility and availability. In order to create a framework which can support these features we need to use the key concepts of services, semantics and standards. Services provide us with a flexibility and dynamicity that is foreign to products, standards provide us with the potential for interoperability and meaningful interaction, and semantics give us the crucial ability to imbue machine comprehensible meaning to learning artefacts. This is why new eLearning paradigms need Grid infrastructures and their enabling concepts.

eLearning paradigms based on the use of Grid represent a possible solution for the creation of the future learning scenarios. Two aspects, in particular, are important:

- the *openness* of the architecture, where open means extensibility, vendor neutrality, and commitment to a community standardization process (the need for open standards);
- the *service orientation* and *virtualization*, where the first is related to definition of service interfaces and the identification of protocols that can be used to invoke a particular interface, and the second is related to the encapsulation behind a common interface of diverse implementation, so everything (tools, resources, scientific instruments, activities, etc…) in this environment is a service.

Grid support can be used for the various phases of a Learning scenario design. Authoring tools for the production of learning scenarios can make use of knowledge-based decision making systems to suggest the best pedagogical models and/or activities for a learning scenario, and also use Grid knowledge (e.g. starting skills, personal profiles, etc…) about the actors in the scenario. Furthermore, experts can exploit the collaborative features of the Grid to cooperate in order to model the scenario. In this way, Learning based on Grid infrastructure supports the analysis, modelling and development phases of Learning design documents. Next, the goal of the delivery phase is the understanding of the Learning design document and the execution of its content in order:

- to reproduce the didactical experience for the learner, and
- to supply to the teacher the capability to support the didactical experience.

It's possible to use knowledge in order to bind the learner preferences and the pedagogical model against the appropriate tools, resources and activities available both on the Grid. This can be performed using high-level inference engines to browse:

- OWL-S ontologies indexing core elements of a unit of learning virtualized as services. OWL-S provides three types of knowledge about a service: the profile that describes what the service does, the model that describes how a service work and the grounding that describes how a service can be accessed [12],
- meta-ontologies on the previous ontologies to define cross references between high level figures representing learner preferences, skill, needs and resources/activities.

In some conflict cases, where more than one appropriate resource is found, knowledge based support system can help the expert in the selection. To support interactions among the actors involved in a scenario, trusted group can be dynamically created where learners and teachers can join and resign the scenario.

A Grid-enabled eLearning framework makes available a learning scenario with all its "implicit knowledge" (pedagogical model of the scenario, learning goals of the scenario, resources and activities involved, etc…) as a building block for creation of more complex and interactive learning experiences composed by different scenarios. A learning scenario, once produced and virtualized as a *Grid Learning Service*, can be indexed and stored in a knowledge base, thus becoming a shared unit of knowledge reusable in other contexts.

Summarising, today's Grid related research work (and, in prospective, the Next Generation Grid improvements) can give a lot of benefits to an eLearning scenario. In fact:

- *it is open and standard based* – our vision is based on widely adopted standards and specifications;
- *it is secure* – even if not emphasized in the introduction, eLearning applications have to address many security aspects from both technical and legal viewpoints;
- *it is person centric* – our Grid manages knowledge in order to satisfy learner requirements and preferences also on the basis of what the Grid know about the learner. Also the goal of the learning scenarios is person centric: they try to stimulate group of persons to acquire knowledge in many different fields;
- *it is transparent, easy to use and program*– an expert wishing to produce a learning scenario has only to learn how to use an authoring tool. He hasn't to know tools and resources of the Grid: the Grid itself, by the use of its knowledge, suggests the appropriate core elements available in the Grid. Furthermore, the adoption of expressive languages, as the OWL-S, could be a success factor from a programming viewpoint;
- *it is scalable* – the mechanism for indexing resources integrated with Grid tools for resource management allows for an easy and transparent joining and resigning of "nodes" in the Grid. Furthermore, indexing the resources brings the Grid to have some knowledge about its infrastructure, thus simplifying monitoring and self management of the infrastructure
- *it is pervasive and ubiquitous* – eLearning is a typical application that needs a vision based on the anytime-anywhere-anyhow paradigm inherited from the Grid (in some way, it is part of the Grid paradigm). But, from our viewpoint, the term "ubiquitous" is referred, more generally, to the ability to support multiple diverse pedagogical models and to automatically adapt them.

This is only a beginning, but a very promising one, for utilising advances in information and communication technologies in a principled and structured way, to advance effective human learning.

3.1.8.2. Enhancing eLearning features using Mobile Technologies

Mobile eLearning is addressed to allow students to have the benefits of "classical eLearning" processes outside a classroom. This means they do not have access to desktop computers but have specific or dedicated small devices.

On the other hand, it is important not to forget that learning takes place in a social context [13], collaborative group work and sharing with peers (and others) can be a powerful way of confronting one's own conceptions (preconceptions). Of course, communication is not confined to peer-to-peer. It can involve teachers, experts, experienced colleagues, workmates, friends and family. The mobile environment can make a significant contribution to this process. By facilitating the rapid access to other users anytime/anyplace, sharing contents, knowledge, experiences and gossip, learners can develop 'communities of practice' as well as informal discussion groups, when needed to optimise their learning processes.

As a result, with pervasive and ubiquitous systems it seems possible to help students in their student life and enhance their collaboration with other students.

3.1.8.2.1. Mobile eLearning challenges

There are two main issues related to learning in a mobile environment:

- A first issue is the dependence between information delivered to the user and his local field environment. A major difference between a classical approach for an eLearning user and a new approach for mobile eLearning lies in the increased importance of user context (local environment, location, etc.) and in the way to get the delivered content.

  In a context-independent approach, delivered content should be adapted, in any case, to the end-user agent. There are two required transformations: structural transformations, presenting data specifically adapted to a given user using his user profile (depending on his skill, his knowledge, etc.) and content transformations, adapting delivered content to the possibilities of the device and browser, since the user agent cannot visualize all types of data (due to hardware or software limitations).

  In a context-dependent approach, user mobility offers larger perspectives than just bringing a laptop computer for achieving classical or dedicated tasks. Small devices with storage capacity and wireless connectivity allow shifting eLearning outside the classical classroom: "every time" and "everywhere" a system can assist the mobile user in all his activities and especially deliver information (pedagogical or not) depending on his context (local environment, location, etc.) and profile.

  This complementary information about user context, such as his location, temperature, pressure, luminosity, etc, depends on sensors embedded in the mobile device. For example, an accelerometer located on the end-user makes it possible to know whether he is moving and according to this information, the wearable computer will choose the mode of transmission of the services (posting on screen, or vocal retransmission according to the situation).

  Besides, it is interesting to consider other several relevant information like physical resource like available overhead projectors, free meetings room, etc. close to the learner. In this way it would be possible to transfer the current session running on a dedicated device to the new discovered device – session mobility concept.

  Another possibility that mobility offers is combining presence information with location information. For example, student's project-mates have rights to access his location information, presence information and calendar, although limited to when they are on the university campus. Another example could be presence information updated automatically from free to busy when a student arrives in the meeting room, or from busy to free when he leaves the meeting room.

- A second consequence is connectivity weakness. The user is not always connected or perhaps connected with very poor network quality (e.g. low bandwidth, high delay, packet loss etc), not allowing the transmission of multimedia pedagogical information. This implies a preparation of the pedagogical field mission, storing “all necessary” data on the embedded system.

Furthermore, handheld elements of the mobile environment have very small screens which do not facilitate easy access to text, and small keyboards which make difficult inputting and annotation of content and do not support skim reading, being a real ergonomic concern [14]. It is necessary to reconsider the role of handheld devices, and what kinds of activities are supported against the backdrop of other digital devices and services.

For example, using a PDA to access and read large documents is not an optimal use of the device. However, using the PDA to access documents to download onto a desktop or laptop computer for later perusal is a perfectly feasible activity. Another possibility is vocal reproduction of document.

The emergence of wireless connectivity and small devices allows thinking of other type of applications for education. In general, this will mean ensuring that mobile technologies are used appropriately to exploit their potential, and to support activities which might simply not be possible without them. This is quite a challenge. It is important to recognise that the integration of new tools into existing activities creates dialectic; the tool introduces new possibilities for action, and new constraints which change the way in which the activity is performed.

Since mobile eLearning applications involves geographical context, the wearable computer can provide services depending on user localization. Thus, the wearable computer is a multi-form system to develop to offer multi-modal interfaces for the user, to adapt its activity and interface to the user, to adapt itself to the local context depending on the environment, to adapt the available resources depending on the connectivity and its state, to communicate and store information.

3.1.8.2.2. Requirements

Considering that it is necessary to create a mobile eLearning environment, it is possible to assume that users are students and teachers computer literate.

The requirements for the general mobile environment, aside from other computing environment should be [15]:

- Highly portable, so that it can be available wherever the user needs to learn;
- Individual, adapting to the learner’s abilities, knowledge and learning styles and designed to support personal learning, rather than general office work;
- Unobtrusive, so that the learner can capture situations and retrieve knowledge without the technology obtruding on the situation;
- Available anywhere, to enable communication with teachers, experts and peers;
- Adaptable to the context of learning and the learner's evolving skills and knowledge;
- Persistent, to manage learning over a long period of time, so that the learner's personal accumulation of resources and knowledge will be immediately accessible despite changes in technology;
- Collaborative enabling the learner to collaborate and share knowledge with people in the immediate location and at a distance;
- Easy to use by people with no previous experience of the technology.

Besides these technical requirements, there are additional requirements related specifically with supporting learning. [16] identifies the following educational requirements:

- The learner should be able to offer help to colleagues.
- The system should support institutional, experiential, and problem-based learning.
- Learning should be matched to the learner's context.
- The system should enable learning as construction: facilitating the learner in organizing, annotating and customizing their learning material, knowledge and experience in a rapid and intuitive way, for example, through lists, concept maps and spatial organisations, etc.
- The system should support learning as conversation: supporting interaction and dialogue among learners.
- The system should support learning as apprenticeship: supporting interaction between learners and experts.
- The system should support reflection on experience, including searching for and organizing learning experiences.
- Support should be provided, as appropriate, for self-diagnostic and assessment, thereby supporting learners in evaluating their learning progress.
- By default, a learner should own the material that he/she created or captured.

As a result, the most important requirements for mobile eLearning environment are the following ones:

- Support for communication and collaboration amongst actors (to include learners, teachers, resources, groups etc.).
- Support for capturing information, annotation of documents or resources, personalisation of information and messaging, and all processes essential to learning (e.g. preparation, reflection, archiving etc.).
- Support for voting facilities.
- Awareness of the context in which activities are taking place, to include awareness of other devices in the environment, other people and services.
- Immediate and seamless access to services, resources and people.

3.1.9. Summary of testbed eLearning

The major challenges of the eLearning testbed are the collaboration support of learning or working people, the computer supported guidance of learners in user-defined learning environments, and the combination of learning results and conclusions with real tasks. Grid technologies are required for the audio-visual preparation of learning contents and the connection of real and virtual experiments and environments. The OGSA Online Media and Entertainment use case has very similar requirements to the Grid infrastructure. Extensions have to be considered with respect to streaming capabilities in mobile networks with different QoS levels. Another requirement is the detection of available devices regarding to their location, capabilities and access rights to interact with the eLearning application and represent learning contents. Table 3 gives a short summary of the evaluation results, discussed in the analysis section of each scenario above.

Scenario	Significance of Mobile Grid Support	Significance for Knowledge Access
#1 Networking course	-	-
#2 Featuring Immersive Virtual Reality	-	-
#3 Featuring the Virtual Laboratory	-	-
#4 The Field Trip	X	X
#5 English plan	-	-
#6 How to elaborate a business plan	-	X

Table 3: Comparison of relevance for Mobility and Knowledge Access in testbed eLearning

3.2. eHealth

3.2.1. Background and Motivation

A sophisticated application for Grids in eHealth has to solve problems of resource sharing by virtualization of distributed resources while implementing access policies. It must be always accessible, 24 hours a day. High performance computing is a requirement. Added value from parallelism and computing is sought, not just federated databases. Real-time image composition, for example, is a real need nowadays.

All this must be done respecting data privacy policies, using encryption and filtering so that confidentiality and privacy are guaranteed at any given time.

The Grid has to be OGSA-compliant as well as value-driven. It must address real-world, pertinent problems.

The Grid will gradually substitute current practice – in the short term it will lower costs, improve access and quality; in the long term it will change the way of working.

Potential use-cases in Akogrimo:

- Pervasive vital signals monitoring and real-time analysis
  - Pro-active monitoring of Mobile Patients, real time (Multi-modal image real time on-request composition)
  - Facilitate data access and analysis to Mobile Doctors – emergency support (disconnected Grid environment)
- Clinical e-Training
  - Collaborative clinical studies
  - Interactive distributed image analysis – multi-modal image real time on-request composition (Leverage e-learning resources developed in Akogrimo)
- Connecting e-Science and e-Practice for medical image and signal processing
  - Shared large clinical cases databanks enabling R&D real-time

  - Engage academic computing infrastructures in care provision
  - Deployment of algorithms by academia available to practitioners (e.g.: detectors, image registration, etc.)
- Remote Operation Support and Diagnosis
  - Enable doctors to remotely operate their patients and make diagnosis using different (mobile) devices in different contexts
  - Give doctors the ability to forecast courses of disease with simulation via the Grid from any device
- Bioinformatics workflows
  - Data and computing intensive tasks: design of diagnostic DNA-chips; structural models in proteomics; system biology; etc

Service processes in healthcare are very different (e.g. according to diagnosis, individuality of the patients, locality of the service provision), characterised by extensive autonomy of single actors and frequent intra- as well as inter-organisational fragmentation.

They regularly involve a large amount of widely independent sub process managers (e.g. doctors, nursing services, and patients), who are each responsible for spatial-temporal distributed, but often interdependent stages of the supply chain ("process fragments"). Different diseases are connected to each other which results in various dependencies. Typical are decisions under uncertainty about important patient related and medical parameters, situational dynamic and a high degree of individualisation of the services. Situational dynamics is partly conditional due to the case of emergencies and unanticipated changes in the health state of patients, but frequently also by considerable intra- and inter-process interdependencies. The high state of individualization of medical services is connected to the high relevance of situational dynamics as well as insufficient knowledge on current situations and the expected results of the available decision alternatives. This leads to the fact that medical disciplines after the current state of knowledge can only indicate general rules for the therapy of diseases (Clinical Pathways). These have to be adapted to the concrete, individual situation of single patients (et al: learning from experiences, reusability). This requires capabilities for a dynamically proceeding configuration of a complete medical supply chain (over-all processes), starting from the first appearance of the symptoms to the conclusion of the therapy.

We are used to the fact that everybody has a thermometer at home and is able to use it, whereas MRT-examinations can only be done in hospitals or specialised ambulant radiology departments. The provision of new services has been increasingly set in motion. The digitalisation and the information and communication systems (ICS) support of the healthcare system has led and will continue to lead to the establishment of new and adapted forms of service provision especially in the context of different kinds of patient integration.

Services, which have been applied with conventional analogue methods and on "fixed" locations in former times, can today be provided in a mobile way by the patient himself or under the use of external expertise. This process will continue in the following years, supported by progressive miniaturisation of modalities, further developed sensor technology and ongoing ICS support of healthcare services. The main objective is the situation- and context-specific "enrichment" of health services through the knowledge surrounding the operational processes by ambient intelligence and ubiquitous computing.

3.2.2. Scenario 1: Medical Emergency

Humans are mobile. Their health travels with them. Medical emergencies can happen anywhere at anytime under any situation. Now for such an emergency, what is important?

- Early Recognition,
- Fast Accommodation,
- Exact Diagnosis and
- Specific Treatment

either directly at the scene or a nearby medical facility.

3.2.2.1. Scenario description

A Spanish architect abroad on a business trip, is visiting a building site when he suddenly feels an acute pain in the left side of his chest. Since he has been identified as a patient pertaining to a risk group with diabetes and hypertension, he is wearing a couple of medical sensors forming a local patient monitoring network. He uses his mobile phone to call for assistance and transmits his cardiological data with the help of ECG equipment integrated into his phone. His data is received in an emergency control centre. There a Virtual Emergency Environment (VEE) is automatically constructed, in which *all* information needed for the optimum care of the patient is made available. This information is processed through an embedded processing algorithm and made available to *all* those involved in the subsequent rescue process.

Immediately, the patient's local monitoring equipment (such as the ECG device within his mobile phone) is embedded as a data source into the VEE. An emergency operator (EO) joins the VEE, and the establishment of an audio link to the patient is initiated in the connected Voice over IP network He is supported by an emergency diagnosis (ED) service. This expert system creates a guide of questions to obtain the symptoms optimally, considering all available emergency related information. The EO calms the patient down, supports the patient indicating his symptoms and is responsible for the rescue process supervision. This activity is enabled by a language recognition and translation service in order to overcome the barrier caused by different languages and to facilitate the proper documentation.

Simultaneously, a Virtual Emergency Health Record (VEHR) is created. The patient was previously receiving treatment by his family doctor in Valladolid and at the University Clinic in Madrid and just last week his cardiovascular system was examined by a cardiologist in Stuttgart. All the organisations the patient has been associated with in the past hold a certain part of his overall patient record. The particular records are aggregated by the VEHR service following the referral information, emergency information located on the patient's electronic health smartcard, or health insurance information. They are also made available as a resource within the VEE. The containing data are translated as necessary, and the emergency relevant information are filtered. Hence, allergies, current medications and antecedent treatments or surgeries can be considered on site. To achieve a good information quality the VEHR and the ED service cooperate closely. These historic findings can already be taken into account while the symptoms are determined and together with the current vital data, an initial diagnostic report is compiled by the ED service. Referring to this report, the VEHR is filtered. Consequently, it only contains information relevant to the emergency situation.

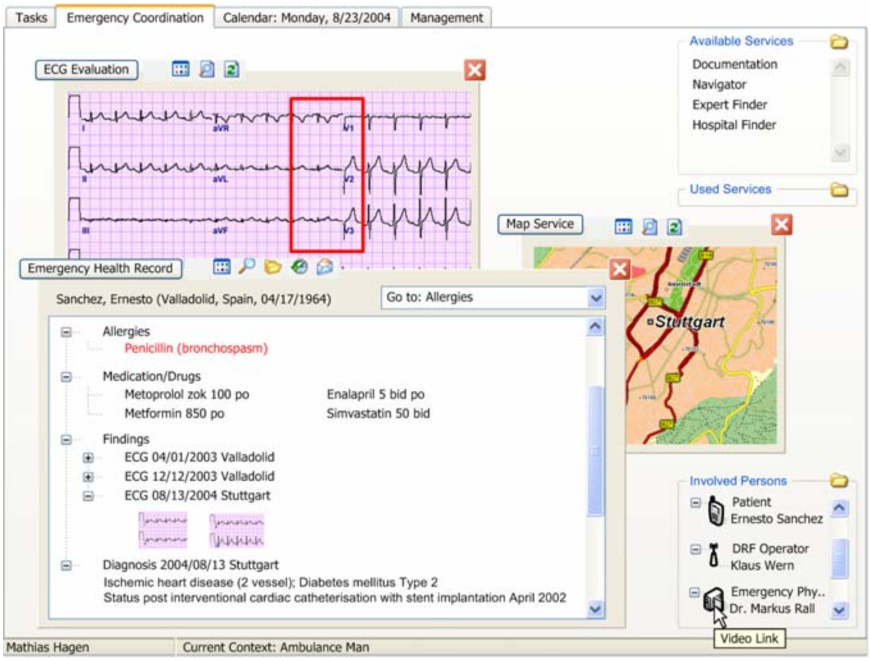

Figure 1: Potential paramedic's view on the VEE

At the same time, the patient's location is automatically identified. According to the patient's equipment and location a satellite based positioning system or a triangulation approach can be used. This information is made available in the VEE through a positioning service. Now the first aid can be organized. There are a lot of medically educated people available either on duty or not and very probably, one of them very close to the patient. Exploiting its location information or a location-based multicast protocol and a navigation service, a first responder and depending on the diagnosis, an ambulance service is determined that can reach the patient the fastest. Both services are available in the VEE too.

Taking the role of the first responder or the ambulance driver under consideration, the emergency operator can grant access rights for the VEE to a particular actor. The actor's equipment such as patient monitoring devices and its location information are registered as a resource with the VEE. Thus, every actor is informed about his role in the emergency process and the current state of the process. As shown in Figure 1, he is provided with a role-specific view on the patient's history and the symptoms and the result of the preliminary diagnosis report. An optimal preparation is provided, because this information is already available to the paramedics on its way to the patient. Like messaging software, all participants in the VEE are visible and can communicate with each other through audio and video links. These links are established on a common Voice over IP infrastructure but the management is done by a Grid service.

On site, medical equipment for patient monitoring is harnessed and language is processed automatically – consequently, any symptoms and findings captured during the examination and treatment are stored in the VEHR, thus facilitating an improvement in diagnosis and documentation. All the data collected by monitoring sensors are analysed and linked together by a Grid service. Finally, a virtual image of the patient is created. The more information accessible the better the diagnosis support by the ED service will be. Depending on the patient's state of health and the diagnosis quality further knowledge sources are incorporated into the VEE e.g.: disease specific experts systems as well an emergency doctor or a cardiologist. Semantic search algorithms are applied to explore the resources according to their capabilities and relative availability.

Taking into account the immediate diagnosis, the distance to travel and available bed space, an appropriate hospital is chosen by a search service. The hospital's casualty unit is informed about the incoming patient and is provided with the patient's medical records. The management of this interface is of particular importance. Only the coordination of the ambulance service and the hospital's resources creates a seamless emergency process and assures an optimal medical care for the patient. For that purpose the resources of the casualty unit are allocated and prepared on time by a particular scheduling service. The medical staffs are informed and obtain access to the VEHR. In parallel to the patient's admission, an emergency documentation report is composed and the VEHR is transferred to the hospital's context.

3.2.2.2. Analysis I : Relevance for Mobile Grid

There are several mobile Grid resources taking part in this scenario:

- The medical sensors including the ECG equipment integrated into the mobile phone enable the Spanish architect to provide his current health information anytime and anywhere.
- Patient's electronic health smartcard which is kept by the Spanish architect anywhere he goes.
- Medical equipment residing in the ambulance.

The services these resources provide are exploited as an input, sometimes even near real-time input, to combined services for analysis or simulation in the Grid. In addition multiple information and media types need to be transferred from mobile devices by using multiple or shared used mobile network connections.

Since these three Grid resources are involved in executing workflows, changing their physical location dynamically, and active members of a virtual organisation, this scenario is highly relevance for mobile Grid.

3.2.2.3. Analysis II: Relevance for Knowledge Access

Various knowledge based systems are applied in this scenario. Especially, the compilation of a report about the patient's history involves several medical information systems, where medical concepts, the corresponding terminologies and the schemas where medical information are stored have to be reconciled. This information determines the composition of the virtual information, directly, by specifying all data and knowledge resources related to the individual disease. Furthermore, the decisions of several actors involved in the emergency are supported. The underlying process is very complex and has to be adapted to for instance, the patient's medical state and location.

3.2.3. Scenario 2: Home Care

3.2.3.1. Scenario description

Mr. Smith is 80 years old and lives alone. He is being treated for lung cancer with chemotherapy. Due to his cancer, he can hardly walk a long distance or drive a car. His children live over two hours away and they cannot regularly escort him to Dr. Lukas, the oncologist at the Katharinen Hospital. However, he wants to live normally in his house, instead of going to the old people's home. Along with his family, he meets Dr. Lukas and speaks to him about the possibly of having to place Mr. Smith in a nursing home.

Dr. Lukas uses his pocket PC to query the German Virtual Home Nursing Agency to find the nearest agencies around Mr. Smith's residence. The system returns four prospective agencies and reports their profiles including staffing levels and survey results. Dr. Lukas shares this information with Mr. Smith and his family. They finally choose the Deutsche Caritasverband (DCV) among the prospective Home Nursing Agencies.

Dr. Lukas transmits Mr. Smith's continuum of care profile to the DCV. The DCV's Electronic Health Records (EHRs) populate a pre-admission module and notify Mark - the Admissions Coordinator and Anna - the Director of Nursing of the admission prospect. Anna reviews the diagnoses, medication orders, treatment orders, and nursing evaluation provided by Dr. Lukas to determine if the DCV can provide any skilled nurses that would qualify Mr. Smith. As Anna needs additional clinical information about Mr. Smith, she requests security permissions from the hospital system to query the hospital's EHRs to review the diagnostic testing, nursing assessments of cognition, and other care related issues. Exploiting Dr. Lukas' information and queried hospital's EHRs, the DCV's EHRs estimate staffing acuity levels, cost per day, and reimbursement rate offered by Mr. Smith's private health insurance. Based on the composite of information on Mr. Smith, Anna approves the clinical appropriateness of Mr. Smith's admission. The DCV's system notifies Mark that Mr. Smith is clinically appropriate for admission.

Upon the admission, the DCV's system creates a virtual team (similar to the Virtual Organisation in Grid terms) consisting of Dr. Lukas and Nurse Barbara as participants. Both of them are authenticated as an approved user of the system. Important information related to Mr. Smith's lung cancer (such as the medication administration record, treatment record, lab reports and x-ray reports) is filtered from the Katharinen Hospital's EHRs and DCV's EHRs. Hence a common view on the filtered information is stored in a virtual EHR. The DCV's system also alerts Nurse Barbara to be the nurse that delivers and oversees the home care for Mr. Smith. When Nurse Barbara receives the alert on her smart phone, she is at a shopping centre. Her smart phone detects a loud background noise around her and the phone adapts itself to increase the alert sound volume, the vibration frequency, and the alert duration. Having noticed the alert, she accesses the virtual EHR to have a look on Mr. Smith's profile using her smart phone. Exploiting the Session Initiation Protocol (SIP) technology, she subsequently calls Mr. Smith, assesses his immediate needs and schedules a first visit to him.

On the day of the scheduled visit, Nurse Barbara checks the patient referral and drives her car to visit Mr. Smith. Since this is the first visit and she doesn't know the way to Mr. Smith's house, she accesses the navigation service through her smart phone. Considering the current traffic and the shortest route, her smart phone "speaks out" the direction (i.e. turn left, right, or straight away) that should be taken to reach Mr. Smith's house. Nurse Barbara then introduces herself and takes a history both medical and psychosocial and as well an assessment of symptoms and patient requirements. She enters the assessment findings into the virtual EHR using the voice recognition service because she is not used to typing sentences on her smart phone due to its small keypad. New information and some changes on the virtual EHR are stored in a temporary virtual EHR and the system will alter the related EHRs (the Katharinen Hospital's EHRs or DCV's EHRs) periodically. This complexity is hidden from the user and the user doesn't need to care about the physical EHRs' location. The system automatically informs Dr. Lukas that the patient had been assisted to by home care and the findings of the initial assessment are now on the virtual EHR.

Before leaving Mr. Smith, Nurse Barbara lends him a PDA equipped with sensors for blood pressure and heart rate examination. She configures the user profile of Mr. Smith on the PDA. Having considered the profile, the PDA automatically adapts its interface to make it as simple as possible and the voice command feature is activated. Since Mr. Smith is already senile, Nurse Barbara also sets the schedule on the PDA to alert Mr. Smith to take his medication and examine his blood pressure and heart rate. His PDA will speak out the required action loudly five minutes before the scheduled time. Furthermore the result of regular blood pressure and heart rate examination are submitted automatically to Nurse Barbara and an expert system specializing in illness prediction. Nurse Barbara then schedules the next appointment in 7 days time and leaves.

Nurse Barbara is now aware of patient requirements and refers him to other members of the team, as required. She decides to add a social worker to the virtual team since Mr. Smith will be unable to resume work in the near future. Her request for a social worker is sent to the DCV's system and a social worker called Ms. Kathy is added to the virtual team. Additionally, Nurse Barbara requests the hospital system for a physiotherapist to teach Mr. Smith deep breathing and coughing techniques. The hospital system assigns Ms. Jenny to give physiotherapy to Mr. Smith and adds her to the virtual team. An SMS is sent to the social worker and physiotherapist to become part of the health care team. Moreover, an SMS is sent to Dr. Lukas to alert him that new members have been added to the team.

Four days before the next scheduled visit, Nurse Barbara receives a danger alert from the expert system. Her smart phone changes its alert behaviour due to the importance of the incoming alert. The backlight of the phone blinks and it plays a siren ringing tone with maximum sound volume. Nurse Barbara suspends her jogging activity, quickly looks into her smart phone, and notices that Mr. Smith suffers from neutropenia (low white cell count) according to the expert system forecast. The expert system predicts that Mr. Smith's immune response will drop quickly and he suffers from a sore throat within five days if there is no early prevention. Reckoning with this prediction, Nurse Barbara initiates a video conference among herself, Mr. Smith and Dr. Lukas to do a tele-consultation.

Mr. Smith walks in a city park when he receives the request from Nurse Barbara to join the video conference. He speaks to his PDA about his acceptance on the request and he can subsequently see Nurse Barbara on his PDA while Dr. Lukas is not connected yet. At the same time, Dr Lukas receives the request when he is on the train going on a business travel. He accepts the request and his pocket PC continuously adapts the video and sound quality to the current network quality of service. When the network signal is strong enough, he can see and listen to Nurse Barbara and Mr. Smith clearly. In the case of a connection with low bandwidth the video is not shown, but he can still listen to them clearly. Furthermore, he can also "seamlessly" continue his "sessions" when he is temporarily disconnected from the network as the train passes through tunnels.

Having established the connection, Nurse Barbara asks Mr. Smith some questions to assess his condition thoroughly. Mr. Smith complains about pain located in the lower back mainly on movement. Then Nurse Barbara takes a full history of the pain and records it to the virtual EHR. To deal with the pain, the nurse suggests Dr. Lukas to review Mr. Smith's medication for a pain control. Considering Mr. Smith's current medication and his health record, Dr. Lukas uses the e-prescription service to check drugs references from the medication databases and make sure the recommended drugs will not have an adverse reaction with the current medication. Finally Dr. Lukas recommends Mr. Smith to take Tramadol SR 100mg twice daily and prescribes the medicine electronically to Bären Apotheke. In addition, Nurse Barbara enters the medication review into the virtual EHR.

Nurse Barbara also informs Mr. Smith and Dr. Lukas about the possibility of Mr. Smith to suffer from neutropenia according to the expert system prediction. Consequently Dr. Lukas orders a blood lab test to the Baumann Klinik electronically. He reviews the lab schedule list and selects the applicable diagnosis to justify the lab from the virtual EHR listing of active diagnoses from Mr. Smith. Finally Dr. Lukas adds the Baumann Klinik to the virtual team so that it can access the applicable demographic, financial, and diagnostic information on the virtual EHR for their information and billing system. The video conference finishes and a lab technician arrives at Mr. Smith's house within two hours to gather the specimen.

Since Mr. Smith is really anxious about his new pain and the forecasting on neutropenia, Nurse Barbara decides to add a psychologist, Mr. Maurer, to the virtual team and subsequently alerts Mr. Maurer about a new referral for Mr. Smith. Concerning the change on Mr. Smith's condition, Nurse Barbara sends an alert to the Physiotherapist, Ms. Jenny to ask her to visit Mr. Smith.

On the next day, the Baumann Klinik informs Dr. Lukas that the lab result is already available and it is stored in the Baumann Klinik's EHRs. Since the Baumann Klinik is already a member of the virtual team, its EHRs related to Mr. Smith are automatically aggregated into the current view of the virtual EHR. Dr. Lukas therefore accesses the virtual EHR, looks into the latest blood test result of Mr. Smith, and confirms that Mr. Smith is neutropaenic. Then he prescribes Neupogen 30 MU/ml injections that are sent to Nurse Barbara with instruction to commence treatment on the present day.

Nurse Barbara checks Mr. Smith's condition on the next day. He feels more comfortable, pain free, and he is able to remain at home. The treating oncologist, Dr. Lukas, is re-alerted. Mr. Smith has saved time and possibly a hospital bed for another more urgent case. A week later, the blood test is repeated after completing a course of Neupogen and the blood appears normal.

Home Care as a social job is intensely characterised by personal knowledge and formal documentation of data. Explicit knowledge management is not noteworthy developed. But it promises an extensive potential for optimisation and an increased added value on evaluation of the Home Care and therefore a relief of the social systems. The broadening of intra- as well as inter-organisational cooperation, the bundling of social services between nursing staff, care services and other providers of social services promises to augment the quality and efficiency in the care sector and at the same time to reduce the input of resources which are necessary.

Relevant actors in this scenario are:

- Patients
- Home Care services
- Centres of care service
- Family doctors
- Emergency medical service
- Doctors and nurses from different hospitals
- etc.

The employees of the today's home care services are per se contact persons for many questions of the shaping of life. But time pressure, difficult or non-existent access to knowledge bases and lack of tools inhibit the use of that knowledge and confidence, which arises from the personal relationship. Close co-operations with established doctors, pharmacists, hospitals, financial service providers, lawyers and notaries especially offer the providers of social services with its access to customers (which are based on personal confidence) an enormous chance to strategically knowledge alliances.

Looking at the operational processes of care staff within the scope of Home Care scenarios, various knowledge related problems in handling can be identified.

Beside the problems with allocation and usage of knowledge (mobile character of the domestic care, lacking knowledge access during the job, lacking gathering, insufficient combination of social, cultural and professional knowledge, etc.), the loss of knowledge by fluctuation of staff is especially important. It is expected that the use of mobile Grid-Services can effectively support different action areas of the domestic care

Starting from a mobile patient data management, aimed on the exchange of knowledge with nurses, doctors and pharmacists (knowledge alliances) the transfer of knowledge to central institutions like centres of care services, which are connected to knowledge data bases, plays an important rule

3.2.3.2. Analysis I : Relevance for Mobile Grid

In this scenario, the corresponding user is equipped with a pocket PC, a smart phone, or a PDA which is always moving together with the user, enables him/her to provide or consume services, and adapts to the context information from the environment. Together, context information and patient monitoring information captured deliver the input to higher level Grid service. Another important point, the mobile monitoring equipment has to be permanently available to the VO and the respective higher level monitoring services, too. Considering these mobile Grid resources, this scenario is of high relevance for mobile Grid.

3.2.3.3. Analysis II: Relevance for Knowledge Access

The processes in this scenario have a high complexity, too. But they are standardized up to some extend by clinical or nursing guideline. Knowledge embedded into these guidelines can be used to keep the treatment processes in the predefined way. The workflow can be coordinated, respectively.

3.2.4. Scenario 3: (Patient) Monitoring

3.2.4.1. Scenario description

João Anónimo is a patient suffering from brain disorders, triggered under unknown stress situations. A challenging clinical case, he has been going in-and-out of the hospitals for the last months trying to obtain a diagnosis for his specific problem. He has done PET, NMR, X-rays, etc. in several clinics in the last months.

Finally, his medical support, Dr. Joana, resorted to active monitoring. João is wired with a portable life monitoring system, measuring a couple of his life signals. Key signals (a small and discrete chip placed near the top of his spine) are monitored and transmitted to a central station, which Dr. Joana programmed to raise alarms in situation she suspects critical.

João carries on with his life: some brain activity, blood pressure and temperature (amongst others) are monitored real time and registered in specific databases.

During a particular discussion at work, the system detects a danger threshold. Joana, at the time was cruising in the Ria de Aveiro, is warned of the situation on her PDA. She takes notice of this, and decides to see in real time the monitored signals. As a precaution, she decides to stop her leisure time and move the boat to port. As João becomes more involved in his discussion, his vital signals give information that is increasingly more worrying. Joana then starts to ask her hospital centre to track the signals, and to provide her with resumed brain activity charts using multimodal image software, built based on existing measurements already taken to João and on the correlated signals being monitored. The Grid fetches the relevant data, based on Dr. Joana's ID and authorization and builds the requested brain maps.

Situation is reaching a crisis apparently as João becomes more and more excited. Dr. Joana calls the National Paramedic service, issues a call for João to be transported to the Hospital Infante D. Pedro and while the ambulance is dispatched, explains the situation to the technical personnel. She is now driving to the hospital, having raised an alarm of an incoming patient. With this alarm, João is notified about the eminent crisis, that he should try to calm down, and that he is being recalled to the hospital. Dr. Joana's assistant, Dr. Filipe, is also recalled to the hospital. Medical information from João is now recalled from the remote databases into the temporary work space to the hospital Grid support centre, optimising future computational requirements.

Once João enters the ambulance better diagnosis tools are connected to his body. Dr. Filipe checks these signals and now is using the multimodal image composition to request similar patient case information stored in different hospitals in the region. The Grid analyses the patterns, and finds a hit in a hospital 50 km away, a case treated by Dr. António. He requests from the Grid a cooperative session with Dr. António, and is introduced to him – António, just leaving his emergency shift has taken the Grid request and engages in conversation with Filipe. Using both their authorizations, they compare the data from the previous and current case and agree on a potential diagnosis to be confirmed by further exams. Dr. António recalls that some colleagues of his at the University of Aveiro had been investigating algorithms related to this case and contacts one of his colleagues asking for help. Dr. Filipe, Dr. António and his colleague, using the algorithm quickly arrive at a diagnosis. Dr. Filipe discusses this with Dr. Joana, and they launch some multimodal image software to exploit the existing data on João, while starting a new battery of tests to the just arrived patient. Fortunately, the diagnosis seems to prove correct and João is now informed of his real medical condition.

Beyond stationary institutions the long-run-monitoring of patients is also an interesting task scenario for mobile Grid-based services. In the course of the miniaturisation and digitalisation of different medical bed-side terminals it will be possible to return to patients a part of their quality of life.

The monitoring of relevant parameters is done mobile and is analysed directly online according to the requirements of the situation. In the incidence of "adverse events", direct process planning and control can occur similarly to the case of the clinical studies. Starting from services of localisation and different possibilities of service levels, patients thus can access service such as:

- Conduction of documentation/analysis of vital parameters
- Endowment with support and instructions to the present persons
- Show the emergency room
- etc.

Thereby services can be differentiated, which are provided prophylactically to citizens to ensure them in the everyday life. Monitoring services to the supervision and compliance of physical critical values can be provided to extreme sportsmen and in cases of emergency support and alarm aid. Beyond this, patients who are critically ill and need constant supervision, regain a bit of mobility. The direct control/adaptation of medical equipment is also possible besides the mere supervision function.

3.2.4.2. Analysis I : Relevance for Mobile Grid

Several mobile Grid resources are involved in this scenario, i.e.:

- A portable life monitoring system measuring a couple of life signals (such as some brain activity, blood pressure and temperature) allows the user to provide information anytime and anywhere.
- A PDA which enables the user to consume services independent of any locations.
- Diagnosis tools in the ambulance providing the current patient's condition during travelling to the hospital.

Considering these Grid nodes as active members in the virtual organisation, this scenario has highly relevance for mobile Grid.

3.2.4.3. Analysis II: Relevance for Knowledge Access

The processes in this scenario have a minor complexity related to the number of actors involved, but the progression of the process is strongly associated with the monitoring results. From this it follows, only the involvement of medical knowledge can assure a proper prediction and the availability of medical resources for an immediate treatment, if necessary.

3.2.5. Scenario 4: Mobile access to health records

3.2.5.1. Scenario description

Any person can travel around the world and has the possibility of having an accident or any health problem in any place. When this happens, the Akogrimo approach will help these persons in order to access their medical information and find relationship between the current problems and their medical history. Even more, the Grid technology could be used to prevent possible illness and act before it appears avoiding and/or minimizing its consequences.

In the same area, it is very helpful to have the medical tests results and analysis also in electronic format. For example, having the X-ray radiography in electronic format can help the doctors to know when patients are improving because the system should compare them and calculate the patients' recovery patterns.

Obviously the Grid computational power will be used for images (like X-ray) comparison/analysis, e.g. pattern recognition and simulation.

In this case the final user is the mobile entity and of course, some other components like ambulances etc, and the Grid is essential for performing some complex calculations, expert systems, distributed information access and real time. Health is the main market of this scenario and the involved actors are any person, public administration, hospitals and service providers (computation).

Some of the needs and applications are result analysis/comparison, illness prediction, and trip assistance. The possibility of doing a X-Ray radiography using a mobile X-Ray device can increase even more the usefulness of this scenario.

3.2.5.2. Analysis I : Relevance for Mobile Grid

To facilitate this scenario, Grid technology is of high relevance to search patient data and compile them to a patient history report. Simulation services can be used to make a case specific, evidence based analysis of the patient’s situation. Different to the emergency and monitoring scenarios, the mobile device is only used to access Grid services. The mobile resource is a mobile computer hardware that is used in a nomadic way. This scenario itself cannot demonstrate the complete potential of Mobile Grid. But the ideas the scenario is based upon can easily be exploited in an extended patient monitoring scenario.

3.2.5.3. Analysis II: Relevance for Knowledge Access

Solely the combination of several patient records to a comprehensive patient history file requires medical knowledge for data integration and their evaluation with respect to current symptoms.

Typically, the workflows needed to access the health records are specified a-priori. There is only a minor need for dynamic workflow adaptation.

3.2.6. Scenario 5: Clinical Trials

3.2.6.1. Scenario description

The co-ordinated cooperation of different actors is necessary for performing clinical multi-centre studies:

- Patients
- Doctors and nurses from different hospitals
- Trial-Monitors
- Documentation officer
- Study Coordination Centres
- Family doctors
- Domestic nursing services
- Emergency medical service
- etc.

The necessity for the coordination of the diagnostic as well as therapeutic measures with high requirements for the mobile disposability often requires inter-hospital and other inter-organisational co-operation with a common base of knowledge. It therefore represents an exemplary scenario which is suitable for our purposes. From a statistical point of view clinical studies are spot tests of test persons and patients. Controlled studies are assumed for the exemplary scenario "Clinical Studies". The aim of controlled studies is the deduction of a generally accepted statement with a value-risk-ratio of 2 or more therapies due to a study result which can be reproduced by a predetermined probability.

In terms of reproducibility of the results follows et al that the statistically, required falling number is determined in the beginning of the studies.

Internationally applied multi-centre studies often allege a complex regulatory framework for the determination which have to be maintained and measures which have to be conducted.

At the beginning of the clinical studies many diagnostic and therapeutic measures have to be coordinated and scheduled, resources have to be allocated and if necessary informed.

In the first step the applicability of the patients is evaluated by wide involvement and exclusion criteria's. The complexity, the topicality and the quality of the available information over potential participants is thereby especially fundamental. Many ontological studies evaluate therapies in connection with changes in the bio rhythm of the test persons.

Amongst these there are chronomodular therapies, which analyse the effect of the combination of different medication in the inter play with its application at different times of day and night.

The participants of the studies are medicated in cycles and are from time to time at home, where they are more or less under self control in ambulant or in stationary therapy.

In this context a number of data has to be collected in real-time and partially critical, documented, analysed and valuated, which can have again a direct influence on the therapy of a single patient or the total process of the multi-centre studies (e.g. at the incidence of so called SAE`s (Serious Adverse Events)).

3.2.6.2. Analysis I : Relevance for Mobile Grid

Once a clinical trail Grid service is established and running, a complex workflow is created where all patients, medical professionals and administrative staff are engaged. The mobility focus is of particular relevance for the integration of the patient into the workflow. The patient is triggered in previously defined or currently calculated periods to provide vital data, and a personal review of its individual health condition and well-being. Both, manual and automatic capturing of these data is required. Considering this situation, the patient provides an individual health evaluation service to the Grid through its mobile computer device. The mobility aspect is crucial, too, because, depending on the study type, the exact adherence to the trail schedule is mandatory. The patient has to be able to provide that information independent of its current location. In the case of an automatic vital data capturing the combination with the patient monitoring scenario enforces the mobility requirement. The captured information is analysed, aggregated and process by various Grid services in order to plan the further trail cycle.

3.2.6.3. Analysis II: Relevance for Knowledge Access

For planning and analysis of clinical trails medical, pharmaceutical and patient-related knowledge with oftentimes proprietary terminologies has to be combined with administrative clinical data such as the availability of resources (devices, professionals etc.). The resulting processes are of high complexity. On the one hand side, the process control has to comply with the trail schedule, on the other hand, the patients reaction on the treatment methods under evaluation has to be considered to.

3.2.7. Scenario 6: Epidemics

3.2.7.1. Scenario description

In the course of the increasing freedom in the European and global travel industry it becomes more important to know how to hinder epidemics and other infections efficiently from a worldwide diffusion through business people, tourists and goods traffic.

A standardised analysis of relevant data could create more transparency here. On the national level it would be reasonable to register exercise cases, annual waves of influenza and other infections. Blood screens, which can be done fast and easily, could supervise and follow its appearance and diffusion. On this basis it would be also possible to define immediately influenza from an ordinary cold. Such a real-time monitoring of data of diffusion allows concerted information to:

- Measures in persons in affected regions
- Avoidance of regions for not infected persons
- Advance information/all-clear of settled doctors
- Advance information/all-clear of hospitals and emergency services
- Advance information/all-clear for border locations, airports, etc
- Initiation of aimed counter measures for control stations/crisis squad

This scenario has also to be seen in interaction with a standardised long-run monitoring of citizens and is another stage of expansion. Involved actors in this scenario are large:

- Healthy persons, risk persons, patients

- Home Care
- Service providers
- Family doctors
- Emergency medical service
- Emergency doctors
- Etc.

3.2.7.2. Analysis I : Relevance for Mobile Grid

The evaluation of mobility within this scenario is strongly related to the region where the epidemic hazard should be evaluated. It is dependent on the development state of the community health system of the countries located in the region. In particular, in developing countries mobile computer devices are the only possibility to systematically analyse the situation and provide the information to the local, national and international health authorities rapidly. Only an immediate, even online, incorporation of new information into dissemination simulation services allow for a precise prediction of the dissemination of an epidemic, and, consequently, can give a good chance to stem the risk. Nevertheless, the single information provider is not embedded in a workflow, and doesn't provide a particular service to the Grid; it just accesses an information capturing service.

3.2.7.3. Analysis II: Relevance for Knowledge Access

In epidemics abatement a lot of different actors are involved. No immediate knowledge-based process support, rather a collaboration environment is needed. The characteristic components of required IT-Systems are data-mining and information services. Knowledge-based systems are suitable to link all required information sources. Expert systems can transfer the knowledge about the accomplishment of recent epidemics to any place in the world.

3.2.8. Needs for and Benefits from Using Mobile Grid Technology

As demonstrated, Mobile Grid technologies offer the possibility of bringing together and employing the necessary:

- Information (such as vital data and medical records),
- Resources (including medical services, their equipment, as well as analysis algorithms and tools),
- Participants (such as the rescue services and paramedics), as well as the
- Required Knowledge (provided by expert assessment and expert systems),

directly at the scene of an emergency.

3.2.9. Summary of Testbed eHealth

The exploitation of Grid technologies in medicine was shown exemplary within the scenarios described above. Thereby, the current and historic medical data of patients, the equipment to collect the data (ECG, X-Ray), and the algorithms (operation planning, image analysis), tools, or knowledge to analyse these data are in the centre of discussion. Exactly these components are the highly distributed, and even mobile, resources that need to be combined to an eHealth-Grid based virtual organisation in order to assure a patient centred medical care, at the best. Starting from medical emergency, over clinical diagnosis and therapy, up to home care and nursing, patients, health professionals and the resources described above are shared with various treatment processes and organisations involved. Only the coordination of the resources following clinical pathways enables the realisation of disease management processes and case specific treatment. Furthermore, the privacy of personal medical data requires continuous and role-specific requirements. As a result, the identification of "The eHealth Grid Service" seems to be minor import, more compelling is the integration of Grid and knowledge based services, highly available on that place most suitable for medical treatment with respect to the patient's situation.

Table 4 gives a short summary of the evaluation results, discussed in the analysis section of each scenario above.

Scenario	Significance of Mobile Grid Support	Relevance for Knowledge Access
#1 Medical Emergency	X	X
#2 Home Care	X	-
#3 (Patient) Monitoring	X	-
#4 Health assistance	-	-
#5 Clinical trials	-	X
#6 Epidemics	X	X

Table 4: Comparison of relevance for Mobility and Knowledge Access in testbed eHealth

3.3. Disaster Handling and Crisis Management

3.3.1. Background and Motivation

A crisis occurs so suddenly that government and emergency organisations are not prepared for the emerging situation. The event has such a large scale that the regular daily routines and systems for communication are not sufficient to handle it. Further, there is no permanent organisation in place to handle the unforeseen situation.

The main consequences of a crisis/disaster are as follows [17][18]:

- There is a lack of control and overview
- A very complex situation
- Many actors are involved. Large amount of information from a variety of sources is available
- Time pressure
- Uncertainty

- Incomplete and inconsistent information.
- Disinformation
- Multiple several actors acting simultaneously that need collaboration in space and time to coordinate their actions and resources
- Often the regular processes for making decisions are insufficient or broken
- Each actor will focus on solving short-term problems as observed from different standpoints
- There is a high interest from external actors such as mass media (newspapers, TV, radio, etc)
- State of lawlessness hindering the Disaster Handling and Crisis Management (DHCM) work may occur

In order to respond to a natural or man-made disaster in a timely and efficient manner, an important challenge is to get a complete view of the situation as soon as possible; the right information must be available at the right time to the right persons such that optimal decisions can be made. Challenges arise due to the scale and complexity of the problem domain, the diversity of data and data sources, the state of the communication infrastructure, and the diversity and dynamic nature of responding organisations. A joint operation requires establishment of ad-hoc Mobil Dynamic Virtual Organisations (MDVOs) involving people from many different organisations for collaboration, cooperation and resource sharing across organisational boundaries in space and time. Decision-makers have to make critical decisions based on information about the situation and available resources. Mobile Grid technology has the potential to contribute to improving disaster handling by providing support for multi-organisational collaboration and resource sharing in space and time for teams solving different challenges (overall management, rescue, evacuation etc), and allowing faster access to accurate information across administrative boundaries resulting is tremendous benefits through saving human lives and property.

3.3.2. Scenario 1: Terrorism on the Railway

The testbed description is divided in several scenes, each addressing distinctive phases of the situation.

3.3.2.1. Scenario description

3.3.2.1.1. Scene 1: An act of Terrorism on Railway

A terrorist organisation hi-jacks a goods train near to a large European city. The terrorists disable the automatic collision avoidance systems on the train and by running the goods train into passenger train they cause a severe collision in an area with high population density near the city centre.

Figure 2: Train collision causing a crisis

3.3.2.1.2. Scene 2: Alarming

Several passengers of the train, eyewitnesses and the railway management team call, send pictures and videos to the ambulance communication centre (113/911/..). By analyzing the information received the ambulance communication centre decides that the situation is an extensive accident that has to be classified as a crisis. It is concluded that a large number of people is injured, trains are off-track and large material damage have been caused. The ambulance communication centre starts to gather information from cameras in the area, available sensor network and continuously monitors the situation. The ambulance communication centre immediately alarms the police department and other emergency departments such that a platform for collaboration can be established.

3.3.2.1.3. Scene 3: Establishing Ad-hoc Mobile Dynamic Virtual Organisations

The police department has the overall responsibility for the DHCM. First, they have to get a confirmation from ambulance communication centre and gather additional information from available data sources in the area, such as wireless railway sensor network, maps, information from the railway company database etc. As soon as the preliminary analysis has been done, the police department initiates establishment of dynamic mobile virtual organisations involving the following actors:

- Ambulance communication centre
- Police department
- Fire department
- Local hospitals
- Railway company
- Department of road maintenance and construction
- Military
- Humanitarian organisations such as the Red Cross
- Water, gas, electricity companies.
- Experts on terrorism

- Experts on gas fire/explosion
- Entrepreneurs (trucks, excavators, etc)
- Accommodation providers (in case of evacuation etc)
- Transportation companies (buses etc. needed in case of evacuation)
- Volunteers already located in the area. Local people can contribute significantly in terms of equipment (notebooks, mobile phones, cameras, cars) and knowledge (doctors, first aid support, technical personnel, etc). Especially in remote areas where the approach of the official authorities will take a long time, their contribution is essential.
- Further, after some time it is seen that it is necessary to involve regional and national resources in the operation team (regional hospitals, fire-fighters, police officers etc).

A local DHCM operation centre that is a MDVO consisting of key personnel from several organisations has the overall responsibility for managing the operation. Head of this operation management team is the police chief. The disaster and crisis scenario has demanding requirements regarding MDVO as several multi-organisational teams have to be established to handled specific tasks e.g. field level operational teams (members from paramedic/ambulance, police officers, fire-fighters, etc), press centre, expert teams (members from industry, universities etc), evacuation team, and so on.

In addition, each of the involved organisations involved in the DHCM operation centre has to establish their own local management teams to handle the resources of the organisation. To illustrate this, a brief description of the organisation at a hospital is included.

The chief surgeon on duty at the surgery department receives the alarm from the ambulance communication centre. In case that she is not reachable, the chief surgeon on duty at the orthopaedic department is alarmed. The doctor receiving the alarm contacts the police department to have the alarm acknowledged and uses the collaboration tool to get initial information about the situation. From the observations made available, the doctor judges the situation to be a medical catastrophe (number of injured people are estimated to be above fifty). The doctor initiates the set up of emergency response teams (ambulance/paramedic teams) that will to go to the site and orders the establishment of emergency rooms at the hospital to handle arriving patients.

A hospital disaster control centre responsible for managing the resources of the hospital and coordinating the operation with other actors is established. This team has the following members:

- Hospital director
- Chief surgeon and senior nursing officer of the surgery department
- Chief surgeon and senior nursing officer of the orthopaedic department
- Chief surgeon and senior nursing officer of the emergency department
- Chief surgeon and senior nursing officer of the psychiatric department

The control centre is supported by a secretariat (logs everything that happens, summarizes the situation at regular intervals etc). The hospital also has to establish a team to handle reception for next of kin, an information centre and teams to handle the internal and external traffic of vehicles and persons at the hospital area. Further, as the situation progresses the need for a field hospital is realized. In addition to the government run initiatives, private industry may take measures to establish teams to response to crisis.

It is obvious that a large-scale disaster requires establishment of multiple MDVOs (volunteers, first responders, field workers, mobile workers, management teams,) consisting of hundreds of people from a large number of organisation that will exist for a long period of time (several days or even weeks) to collaborate on solving a variety of problems.

3.3.2.1.4. Scene 4: Analysis, Priorities and Damage Assessment

The DHCM operation centre has to get an overview of the situation (damage assessment) as fast as possible. The DMVO established to deal with the overall management permits seamless sharing and coordination of information and resources between key people from different organisations. Resources (i.e. storage, applications, services, processing power, knowledge, equipment, cars, etc) and information from multiple distributed heterogeneous sources (databases, sensors, cameras, field observations, images etc) belonging to different organisations are used to establish an overview of the situation.

Hence, a Grid involving a huge amount of distributed resources and information is required. The resources and information involved, includes the following:

- Equipment made available by volunteers in the disaster area (e.g. notebooks, mobile phones, cameras, cars)
- People in the area, victims, eyewitnesses, first responders and mobile field workers (fire fighters, ambulance, ..) carrying different kinds of mobile devices and sensors can contribute valuable information such as field observations in the form of phone calls, voice messages, pictures and videos
- Pictures and video from surveillance cameras in the area (also recorded data prior to the incident is analysed)
- Sensors owned by different organisations (fire/temperature, sensor networks..) can provide useful input (report, monitor, remotely operated)
- Different kinds of maps available from different sources
- Location services (WLAN, GSM, Wi-Fi, GPS) to locate victims, field workers and others in the targeted area
- Various kinds of data from databases belonging to different actors, e.g. passenger list and cargo list from railway company
- Log of communication (phone calls, e-mails etc) made in the area both before and after the incident
- Available resources at different actors (amount and location of people and equipment)
- Computer and network resources available from different organisations
- A communication infrastructure based on heterogeneous technologies available, e.g. IPv6, IPv4, GSM, UMTS, WLAN, WIMAX, ad hoc networks, dynamically created hot spots, etc. The network resources are subject to damage and attacks during the crisis.

A collaboration platform can potentially provide seamless collaboration, coordination, synchronization and resource sharing among MDVOs addressing different tasks such that accurate and timely information relevant for their task is made available. The information needed by different groups is very diverse, e.g. a medical field worker requires detailed information about the state and location an injured person while on the other hand the operation centre needs only to know the total number people with different kinds of injuries at different locations. Mobile Grid technology has the potential to provide support for collaboration tools that bridge the gap between raw data and semantically richer information useful to humans in the context of their task. Ideally, disaster and crisis response need the right information to be made available at the right time to the right person.

Based on the above mentioned resources and information the operation centre performs damage assessment and decides the initial response to the situation. Among the issues the crisis management teams have to solve are the following:

- How large is the affected area?

- How is the traffic situation in the area? Are there any damages to the roads? How should traffic management be handled?
- What are the best transportation routes to the area for different rescue teams starting from different locations?
- Is it safe to send rescue teams to targeted area? How many people are needed for rescue? What kind of skills is required?
- How many people were on the trains?
- How many people are injured and dead in the collision?
- What is the goods train transporting?
- Should people in area be warned? Is an evacuation of the area needed?
- Remote consultation of mobile workers
  - Maps
  - Updated information about the situation
  - Coordination and planning
- Initiate creation of MDVOs to handle specific task.
- Coordinate work with different tasks.
- Make sure that proper information should be available to the mobile rescue teams.

3.3.2.1.5. Scene 5: Team of Experts

About five minutes after the collision a fire in the goods train trucks is observed from information provided by people in the area. From the cargo list it is realized that the goods train is transporting gas (propane) and that the likelihood of a gas leakage is very large. It is therefore realized that the local operation centre does not have the necessary expertise to analyse the related risks. The operation centre sets up a team of experts to analyse the risks related to the gas leakage. The members belong to petroleum companies, research institutes and universities distributed across the nation.

To analyse the situation the team among others requires the following information:

- The leakage area and leakage rate of the two goods trucks carrying gas. From available pictures and video this can be estimated.
- Temperature and pressure in the gas tanks when the collision occurred. This information is available from sensors in the gas tanks.
- The weather conditions at the site.

From analysis and simulation (that requires Grid processing resources?) it is clear that the fire may have enormous consequences since it may cause a BLEV (boiling liquid expanding vapour explosion). In a simulated worst-case scenario, after two hours the gas tanks explode into a fireball with diameter of 500 meters and cause extreme heat radiation in an area of 1400 meters. The expert team also request information about industry in the area where that may cause additional damage if BLEV occurs. Hence, collaboration with company internal crisis operation centres is initiated.

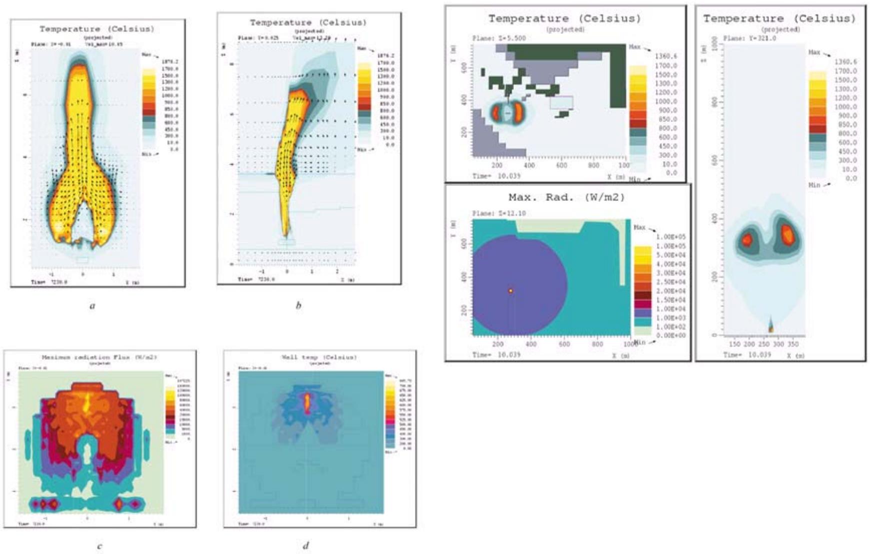

Figure 3: Example of analysis performed

The operation centre needs additional support from the expert team considering evacuation plans and to provide proper information to the fire-fighters about how they should handle the fire. Should the fire be extinguished or should the gas tanks just be cooled down? If the fire is put out, the gas will leak into the area while on the other hand this reduces the possibility of a BLEV.

3.3.2.1.6. Scene 6: Handling Public Information

Every actor involved in DHCM receives a huge number of inquiries from mass media, civilians living in the neighbourhood, tourists visiting the area, relatives of people involved etc. Thus, public information with a common view on the situation has to be provided by every actor. This requires collaboration and coordination of resources among the parties in the operation centre.

3.3.2.1.7. Scene 7: Emergency Medical Services

The situation requires a field hospital to be established as near as possible, but in safe distance from the targeted area. First responders deploy wireless vital-sign sensors to monitor patients continuously and to support decision-making. Patients are prioritized according to their condition. The wireless sensor network help paramedics deciding which patients need immediate treatment, which one benefits from transport to a trauma centre and which patients can safely be delayed or excluded from acute treatment [19]. For patients that need immediate treatment first responders need remote consultations with medical experts located at different hospitals in every part of the country. Doctors at hospitals would be allowed to monitor the state of individual patients both at the field hospital and during transportation such that they can prepare for each case.

Further, the sensors and sensor network could allow aggregate patient information to be gathered by the operation centre such that a global view of the mass casualty situation could be gained as fast as possible. The operation centre could use this information to decide e.g. to which hospitals should different patients be transported. This is vital to ensure that sufficient resources are available at hospitals when a patient arrives.

3.3.2.1.8. Scene 8: Fighting Terrorism

As soon as the operation centre realizes that the train collision was an act of terrorism, an expert team on terrorism is initiated. Could the terrorist act have been avoided? Investigation and pursuance of terrorists starts.

3.3.2.1.9. Scene 9: Mass Evacuation

Based on the first results from the expert team analysing the fire the operation centre decides that the area has to be evacuated. Hence, an emergency alarm has to be distributed to everyone located in the targeted area containing evacuation information, such as public transportation, passable roads and feasible routes etc. This message is broadcasted to everyone in the area using the most suitable communication media (phone, TV, radio, SMS, PDA, e-mail, etc) for each person. It is likely that there are foreign visitor is the disaster area that will need information in other languages.

The mass evacuation is a rather complex problem that requires handling of transportation and accommodation for a large number of people living in and visiting the disaster area. Resources from several additional parties, such as travel agencies, transportation and accommodation companies, have to be used to solve the problem.

3.3.2.2. Analysis I : Relevance for Mobile Grid

This scenario is highly relevant for use of mobile Grids, because of the uncertainty of the situation, the need for fast and concerted actions to get it stable again. In a crisis situation like this a large number of heterogeneous (mobile) systems have to work together with the need for fast and efficient computational power. Also there are a lot of active roles e.g. doctors, firemen, in this situation need that specific services, which are composed in this and for this limited time period until crisis is over. The nodes deliver lots of data about situational context, which is needed by other nodes to react and keep in touch. Also humans (experts as well as eyewitnesses) are strongly involved with their special situational abilities and knowledge through mobile nodes.

3.3.2.3. Analysis II: Relevance for Knowledge Access

In this scenario knowledge plays an important role, because there are many uncertain processes and sub-processes with a high degree of uncertainty. Right knowledge at right place in right time is needed. The number of different involved nodes and interfaces between “man to machine” as well as “machine to machine” is extremely high. So, to reduce uncertainty lots of informational gaps must be filled. There must be a lot of interaction, simulation and contextual awareness to assess the changing situations, e.g. in this scenario called scenes.

3.3.3. Scenario 2: Disasters in Sporting Events

The description of this scenario is confidential and available in the document D2.3.1 Testbed Description – Non-public Scenarios 95[29].

3.3.4. Scenario 3: Fighting Against the Fire

3.3.4.1. Scenario description

Taking into account some parameters like wind, temperature, humidity, vegetation, type of land, cartographic information, etc, and using some models this testbed can help fireman to fight against fire (forest fire, for example). Using some simulation techniques, the Grid will calculate and predict the fire behaviour, giving useful information to the fireman about the affected area, and help to extinguish it. Mobile sensors in the fire trucks and forest guards' vehicles will help to acquire some of the parameters, and re-calculate the fire evolution in real-time.

This scenario can be complemented with the prevention, actuation and people evacuation. In the case of prevention, it will be possible to have some kind of fixed sensors in the forest (that can be connected via mobile infrastructure or not) and/or mobile ones in the forest guards' vehicles. The Grid can calculate the possibility of fire generation in some particular areas and prevent the fire. In the case of actuation using the parameters and models in order to forecast the fire behaviour and inform the best way to extinguish it. In case of evacuation using lots of parameters like vehicles, places to go, availability, water, food, number of people, where are them and where to go, etc, in order to manage the evacuation.

For the mobile entities like fire trucks, etc. it is very important to know their position for controlling the fire.

The Public Administration (Fire and Environment Departments) should be interested in this scenario.

The Grid will be useful due to:

- simulate the fire evolution taking into account the digital models, satellite photography's, and all the other parameters and using complex algorithms
- coordinate all the involved elements: fire trucks, location, water tanks, routes, etc

3.3.4.2. Analysis I : Relevance for Mobile Grid

Fire can change its direction or intense by the influence of weather. Imagine strong winds attack some houses in a small town which is surrounded by forest, it is absolutely necessary to react quick and concrete. People must be warned in between minutes, they must be evacuated, cars for transportation must be available, water to protect their houses is needed, etc. All things based on high dynamic, the inclusion of various people and with changing situations to be aware of. Mobile Grid can support by helping rescue teams by concentration on doing their jobs, so high relevance of mobility is included.

3.3.4.3. Analysis II: Relevance for Knowledge Access

The process of "drawing fires" is mainly related with implicit knowledge of the fire fighters in the meaning of expert knowledge. Implicit means, that they have the knowledge about fighting against fire efficiently and safely. For this scenario it is more important to have explicit (knowledge, that is represented) knowledge about wind, weather and resulting problems. Knowledge about the rapidly changing environment is highest priority for rescue teams, imagine wind changes and they are surrounded by the fire. Also coordination of the involved parties is important. So the need for access to databases, satellite pictures or local weather information calls for knowledge access.

3.3.5. Scenario 4: Resources Management

3.3.5.1. Scenario description

There are some areas in the world that need resources like water, food, or any kind of resources, due to natural disasters, or any other circumstance. The transport management, optimising resources, location systems, best routes selection, NGA (Non Governmental Associations), volunteers, humanitarian aid, ..., should be managed in order to do a fast adaptation to the real needs, be very fast in response time and forecast.

The Grid could be used to calculate the best option about how to manage all of these parameters for the immediate actuation, accessing distributed information, calculating best routes, using systems related with location/position like GPS and GIS and manage food, personal, material, hospitals, cartography and maps, transport and other resources.

The NGA members and volunteers should use mobile terminals and give information about the position (automatically) and the area needs. Sensors can be connected to these mobile terminals providing more information to the central system.

NGA, Public Administrations and international associations and entities like UN, FAO and others should be interested in this scenario. Doctors, police, security forces and others can be actors of this scenario.

3.3.5.2. Analysis I : Relevance for Mobile Grid

The relevance for mobility of Grids is partly given. But this scenario is not detailed enough to reason in which way mobile Grids can supportive In this case it's basically a logistics problem, which can find a solution in logistics information systems. Mostly, defined organisations are considered, just the borderlines between these organisations need to be connected via through a VO.

3.3.5.3. Analysis II: Relevance for Knowledge Access

In accordance to the scenario it cannot explicitly be said, that knowledge access is relevant for using in this. That the use of knowledge access is relevant may occur in the first phases of a natural disaster (e.g. tsunami, hurricane, earthquake, etc.) when confusion and complexity of the moment is the highest. Then, contextual information and coordination instruments can assist.

3.3.6. Scenario 5: Police

3.3.6.1. Scenario description

Mobile Grid Technology to be developed in the Akogrimo project could be used for criminal recognition. For example, a policeman/woman observes a person under suspect, takes a photography using the mobile device, and uses the Grid in order to match the photo with the photo data bases. Then, the Grid could be used for facial recognition and for comparing images (in this case: photos). It should be also used in some security systems using videos/photos/TV.

Collaboration between police forces, citizens and institutions is very important in order to increase the security. Public sector and private security sector should be interested in this testbed.

Mobile devices should have features to catch information making photos and/or voice in any place. One important issue is that the system should allow everybody submitting any request, but there should be some security aspects as well.

This scenario can be extended by:

- Search for stolen cars
- Video surveillance/vigilance/observation in any place (with special focus in airports, commercial centres, train stations, ...)
- Notify public damages to the correct institution (city hall, ...) like broken pavement, traffic lights that don't work, ...
- Personalise videos, films, ... using my face instead of the cinema stars

3.3.6.2. Analysis I : Relevance for Mobile Grid

Relevance in this scenario is understandable high. If a policeman on the street takes a photograph to do an online matching in police databases, you have real mobility, changing environments and situations, involvement of other policemen in a virtual, but also a real organisation. The backend processes have to provide results to all participants, no matter what size or capacity the receiver of the data on the other side has got.

3.3.6.3. Analysis II: Relevance for Knowledge Access

In this scenario may parts of processes be designable, e.g. the pursuit of a burglar. But going in detailed sub-processes it is absolutely necessary to have access to knowledge bases if cooperation of humans, stationary and mobile nodes is admired. Some processes need contextual information about appearance of a person or personal attributes to assure that the right person is caught, so knowledge access is of high relevance.

3.3.7. Needs for and Benefits from Using Mobile Grid technology

Mobile Grid technology provides many benefits to DHCM:

- The DHCM testbed involves many organisations that need to share resources (i.e. storage, applications, services, processing power, knowledge, equipment, cars, etc) and information from multiple distributed heterogeneous sources (databases, sensors, cameras, field observations, images etc) belonging to different organisations to collaborate to solve a very complex and urgent situation.
- Data from sensor networks belonging to different organisations have to be gathered and analysed. It is not possible to know in advance which sensor networks will be needed for a given situation.
- Traditional solutions do not allow collaboration and sharing of resources and information across multiple administrative domains.
- Grid technology can be used to provide a unified solution for actors involved in DHCM.
- Mobility is an inherent part of DHCM; involving victims, eye witnesses, first responders, field workers, experts nation-wide (or even world-wide), key personnel from different organisations (e.g. chief surgeons may be mobile within the hospital during the incident), vehicles (cars, trains, excavators, etc), mobile devices (mobile phones, cameras, sensors, medical devices, etc), etc.

- Access to databases worldwide: This aspect refers to the ability of the mobile staff to have semantic-mediated access to information distributed all over the world. This ability is especially needed in cases where the access to information is time-critical – human mediators may influence the result of the actions.
- A paramedic field worker may request a second opinion or use tele-consultation to access distributed knowledge sources and application of distributed calculations to treat a patient at the site.
- Mobile units and sensors collect and process information locally. However, they are also capable of providing (aggregated) information to a decision support system such that a global view of the situation can be gained. The decision support system may perform complex simulations, extract useful information and statistics, and propose actions for pro-active handling of the emergency situation. The movement of the rescue teams over the terrain, positioning of key-personnel at specific points, evacuation plans, as well as classification of the risks are some of the decisions that should be supported by the system.
- It is obvious that the situation requires a 'Mobile Dynamic Virtual Organisation' to be established instantaneously without an administrative overhead.
- Mobile Grid technology has the potential to provide support for collaboration tools that bridge the gap between raw data from multiple distributed mobile sources belonging to different organisations and semantically richer information useful to humans in the context of their task (based on the context and what the Grid knows about the organisations and persons involved considering personalized knowledge and semantics, ad-hoc, dynamic, mobile and possibly federated formation). Ideally, DHCM need the right information to be made available at the right time to the right person.
- Computer Supported Cooperative Work allows multiple actors in a 'Mobile Dynamic Virtual Organisation' (MDVO) to have a coordinated intelligent decision support. Multiple organisations have to share and manage resources such that actions and plans made are optimal.
- DHCM services have to be pervasively and ubiquitously available - 'everywhere at every time in any context.
- Finally, it is vital that the solution for DHCM is very robust and dependable. Grid technology provides a distributed solution that may be very dependable. However, the dependability and reliability aspects of the dynamically created Grids need to be investigated carefully in the requirement analysis of the testbed.

3.3.8. Business potential

A timely and efficient response to natural or man-made disasters can reduce deaths and injuries, reduce the resulting economic losses and social disruption, and contain or prevent secondary disasters. Mobile Grid technology has the potential to contribute to revolutionise disaster handling by providing support for multi-organisational collaboration and resource sharing for teams solving different challenges (overall management, rescue, evacuation etc), and allowing faster access to accurate information across administrative boundaries resulting is tremendous benefits through saving human lives and property.

3.3.9. Summary of scenarios in DHCM

The scenarios, which characterise the Disaster Handling and Crisis Management testbed have similar attributes as described in the eHealth testbed summary. Particularly, the large scale of fixed and mobile resources that need to be coordinated within a virtual organisation is challenging. Sensor data and diverse context information have to be merged into one model to assess an emergency or disaster situation. For this, lessons learned from the OGSA Severe Storm Modelling use case can be introduced. Typically, multiple emergency response units need mutual access to own, local or remote resources. The dynamic formation and release of single resource groups has to be supported. Scalability, concurrency and prioritisation of resource usage are very important.

Table 5 gives a short summary of the evaluation results, discussed in the analysis section of each scenario above.

Scenario	Significance of Mobile Grid Support	Significance for Knowledge Access
#1 Terrorism on the Railway	X	X
#2 Disasters in Sporting Events	X	X
#3 Fighting Against the Fire	-	X
#4 Resources Management	-	-
#5 Police	X	X

Table 5: Comparison of relevance for Mobility and Knowledge Access in testbed DHCM

4. Description and Evaluation of Further Testbeds

4.1. Mass Customization

4.1.1. Basic scenario based on EwoMacs project

Mass Customization (MC) has been developed as a management strategy in the 1990s. By combining individuality of customized goods with adequate low prices as known from mass production, this concept has been considered to reach high customer's satisfaction. Thus, flexibility and low response times are conditions for the desired variety and customer orientation in businesses [26][25]. Even in scientific work, inter-organisational cooperation between partners in a business network is seen as a main aspect of mass customization [25][27]. This fact does not result from the definition, but it follows from the postulation that every partner in the value chain should concentrate on its core competences. By building up intra-organisational interactions, business networks with multi-phase and spatially distributed value chain processes can be established.

Within the EwoMacs project supply chains in the mass customization shoe industry have been analysed and modelled. The two industrial partners have been Adidas-Salomon AG (sports shoes) and Selve AG (women's shoes). As a result of expert interviews, observation and questionnaires in written form the order cycle and the participating organisations have been evaluated. Based on the results, a typical set of actors for mass customization scenarios was identified (Figure 4). Actors are represented as nodes (circles), and interactions as edges (lines). Technical systems, persons, and organisations are not differentiated in this model.

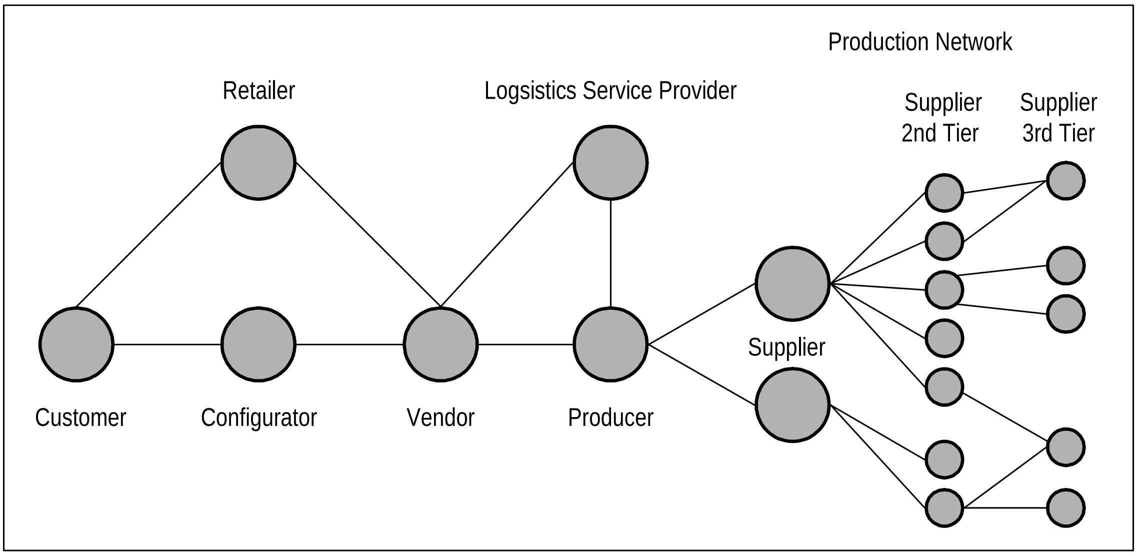

Figure 4: Actors model (based on [21])

Customer: The customer is the demander and consumer of the final product. But, within mass customization, customers are involved more actively in comparison to conventional mass production. Each of them has to express their specific needs and desires in order to produce customized goods on demand. The customer is a partner in the value chain ("customer integration") [28].

Vendor: The organisation that offers customized goods on the market is called vendor ("market maker"). It can also be a selling and marketing focused enterprise with no production plant. Therefore, the real net output ratio is low but there is a high degree of branding activities.

Configurator: A configuration system is the interface between the vendor and the customers. With it, all necessary individualization data must be collected. One the one hand, the customer's product requirements and the values of all product option parameters are identified. On the other hand, a configurations system has to ensure that only valid and complete product specifications are approved for ordering.

Retailer: Retailers often act between customer and configuration system, customer and vendor, or logistics service provider and customer. The latter combination is illustrated in the Figure 4. There, this actor is not involved in the configuration process but only operates as an intermediary.

Producer: This actor is responsible for planning, coordination and execution of manufacturing processes. Depending on the degree of vertical integration, production steps can be made in-house or substituted with external parts.

Supplier: As part of the production network, these actors provide the producer or other suppliers with standardized or customized product components. The producer and the suppliers establish the "production network".

Logistics Service Provider (LSP): This actor assumes the task of product distribution. This is accomplished by interacting with other actors, such as supplier, producer and vendor. While the LSP's interactions with other actors are shown, the internal and interplant logistics processes are not shown in this model. The main task of the LSP is to transport the customized good from the producer to the customer. This can be fulfilled in various ways: for example directly or via the retailer as shown in Figure 4.

Based on the actor's model core processes can be identified. Several activities between the actors take place that are common (not exclusively specific!) for mass customization the shoe industry [22]:

- Pre-Sales stage
    - Product development
    - Configuration system development
    - Capacity planning for existing configuration systems
    - Scheduling customer appointments
- Sales stage
    - Product specification by using a configuration system
    - Order creation and acceptation
    - Preparation of order for manufacturing
    - Estimation of delivery date
    - Procurement
    - Manufacturing

- Supply of material
- Quality check
- Shipping order and distribution
- Delivery to vendor, retailer or customer

• After-Sales stage
  - Customer service
  - Complaints and reclamation
  - Prepare for re-orders

In order to illustrate the assignment of task to a couple of specific actors the basic model as given in Figure 4 can be used. Thus, the activities can be marked out at the interactions between the actors. In Figure 5 this is done exemplary.

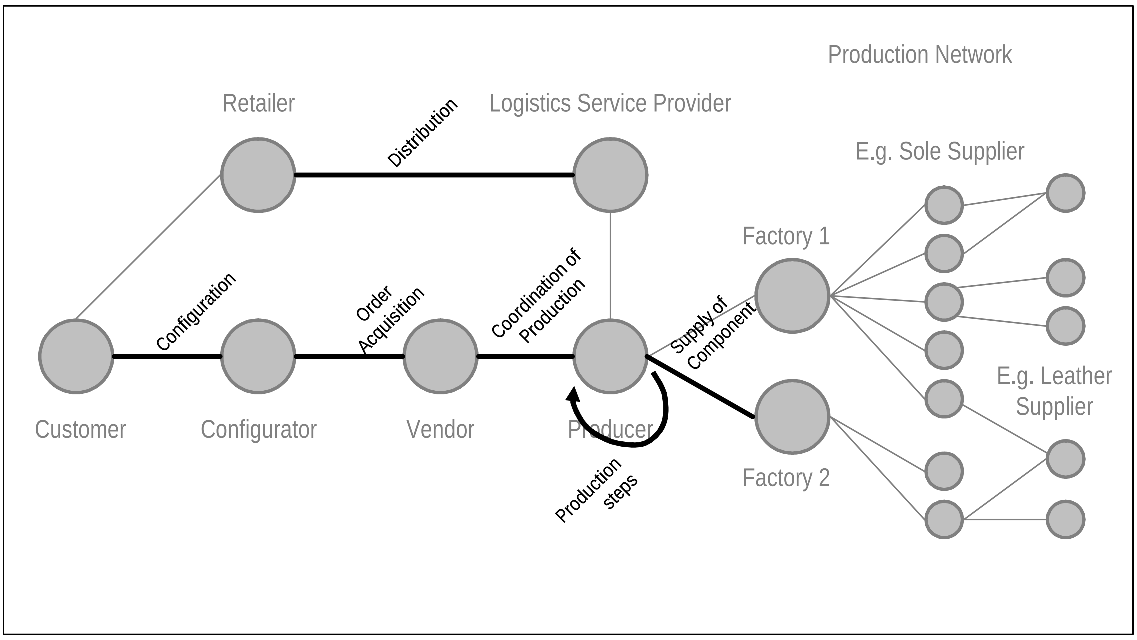

Figure 5: Actors model enriched with activities (based on [21])

The customer uses the ***configuration*** service for specifying the possible individualization parameters. This is an interaction between the customer and the configurator. Since the configuration system can be an autonomous actor, the vendor uses the configurator for ***order acquisition***. By doing so the vendor can obtain new purchase orders for the products offered. The producer is responsible for the overall fabrication and interacts with the vendor for ***coordination of production*** service. The producer is also a simultaneous demander of the service ***supply of components***. If it does not operate all fabrication processes in-house, it will also be a requestor of the ***production step*** service of the sub-producers. Finally, the distribution service is used by actors needing logistical support, for example between producer and retailer. In a model with a greater level of detail all activated listed above should be integrated into the model.

4.1.2. Grid services for supporting mass customization supply web

The described scenario will be the starting point to discuss the potentials of Grid services for parts of the business network. Services can support a particular actor (actor's view) or an interaction between two or more actors (process view). During the development of Grid services three perspectives have to be considered:

- Offerer of a Grid service: *Who has been developing and establishing the service?*
- Requestor of a Grid service: *Who will have benefits from using the service?*
- Provider of a Grid service: *Who makes the service technically available?*

In the following, possible (mobile and non-mobile) Grid services are described. The succeeding list is a result of both using creative techniques and regarding shortcomings in the usual existing IT infrastructure of for mass customization. For each Grid service a name, a description and the assignment to an actor or an interaction is given on the following table.

Nr.	Name Description	Assignment to actors and interactions
1	***Visualization*** Processing geometric data of the product specification for 3D visualization	Customer – Configuration system
2	***Validation of Fitting*** Comparison of 3D product model and 3D anatomical model in the meaning of matching them each other in order to identify fitting nonconformity	Customer – Configuration system
3	***Simulation within Product Development*** Monitoring and evaluating changes of the product model or product components (new material, adjusting geometric data, other product assembling methods etc.)	Vendor, Producer, Supplier
4	***Validation of complexity management*** Comparison of product model (unspecified) and customer order (specified product) in order to check feasibility	Customer, Configuration system, Vendor, Producer
5	***Simulation within order processing*** Estimation of specific management ratios such as delivery date (Customer's view) or date for delivery of product components (Supplier's view)	Customer, Supplier

6	***Computation of anatomical models*** Calculation, conversion and adjustment of anatomical models based on existing date (e.g. use of existing 3D laser measurement of the entire body for determining a specific model of the feet)	

Table 6: Grid services for mass customization supply web

4.1.3. Summary

Scenario	Significance for Mobile Grid Supports	Significance for Knowledge Access
# 1 EwoMacs project	-	-
# 2 Supply web	X	<X

4.2. Tele-working

4.2.1. Corporate Mobile Grid

In some big companies like aerospace, automobile, chemist sector, petrol, engineering and others, some experts can be in different places than the real work is done. These experts use techniques to study the real work and help their colleagues.

For example, a petrol company is drilling an oil well in Saudi Arabia. They send the information to the experts that are working in Finland. In Finland the experts use Grid technology to calculate a tri-dimensional image of the Saudi Arabia subsoil where the company is drilling. With this information (knowing the next ground stratum...), they can help the Saudi Arabian colleagues for drilling the oil well, minimizing the risks, optimising the resources...

The Grid is used for simulations and studies and when any of the experts travel to any other place; they can also start the simulation process and see the results in any place, with the capability to help their colleagues anywhere they are and anytime.

The Grid can be viewed as one Intra-Grid that belongs to all the company as a collaborative environment. We understand this new Corporate Mobile Grid as an improved substitute of the current corporate intranet. It will be an advanced Knowledge Management System, also it will support the employee career development with eLearning tools, and as mentioned as an optimised distributed computational engine to take profit of the company resources independently of where the work necessity takes place. As an engineer needs computational resources in its in-situ work, the whole company could be at his service. This is the first approximation for the company of the future where any employee can access the company resources from anywhere and anytime.

A new iteration of this test bed can interconnect the intra-Grid of one company with any other intra-Grid of any other company allowing interaction between different Grids. These Grids can be Grids of the clients and providers of the company.

4.2.2. Human Grid

Assuming that any person could be a resource provider for a Grid system, and the companies are the Grid clients, the Human Grid scenario should be another possibility for the Akogrimo project.

The companies have work to do and they (or the Grid) can divide this work in several tasks. The people working in their offices, at home, or on the way are the resources for doing the work (Grid providers). Depending on the availability of the people, the assigned tasks, the work to do, the companies' preferences, and so on the Grid assigns the tasks to do to the resources.

In case that any specific task is very urgent, the system will try to finish the task as soon as possible depending on some criteria like knowledge of the task, availability of the resources, split the work, etc.

The way to contact with the resources could be using the mail, phone, mobile phone or any other, but basically the resources are mobile (people).

It is clear that sometimes the best potential resources for doing one specific task can be working in other tasks and it is better to wait until they finish the current task instead of transfer all the information to another resource. In this case the know-how and the previous knowledge and experience are very important. Then, the Akogrimo system could take these constraints into account in order to valuate if it is better to assign the task to an experienced-resource and/or a non-experienced-resource.

The Grid is necessary to access the distributed information and to calculate the task assignment between the resources taking into consideration the work to do, the resources availability, experience, etc, and all the project/resources management (deadlines for each task, predictions, etc.). In this scenario, the possible actors are all any worker, any company etc.

The advantages of this scenario are the distributed network of resources, independently of the location, the possibility that one worker can work for several companies and the same company uses more than one worker (M <-->N), do the same task with more than one worker and compare the results, share resources like secretaries, computers etc.

4.2.3. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Corporate Mobile Grid	-	X
# 2 Human Grid	-	-

4.3. Forecast Applications

4.3.1. Maritime Weather Forecast

Accurate and up to date knowledge of sea state and weather is the key to human safety over the oceans. Moreover, accurate forecasts and real time knowledge of sea state and weather is highly relevant for route planning, scheduling, logistics… thus resulting in fuel savings and time optimisation, avoiding potential accidents.

The idea is to deploy a European service of sea state and meteorological conditions based on an Extended Remote Sensing concept is an Operational Oceanography Network and Decision Support System (DSS) for users worldwide and supported on forth-coming marine Communication infrastructures and GNSS (such as Galileo). Emphasis is on in situ data gathering and sharing, and data assimilation and distribution technologies. In this system, the system users are also the data providers and in the case of big vessels computational capacity providers.

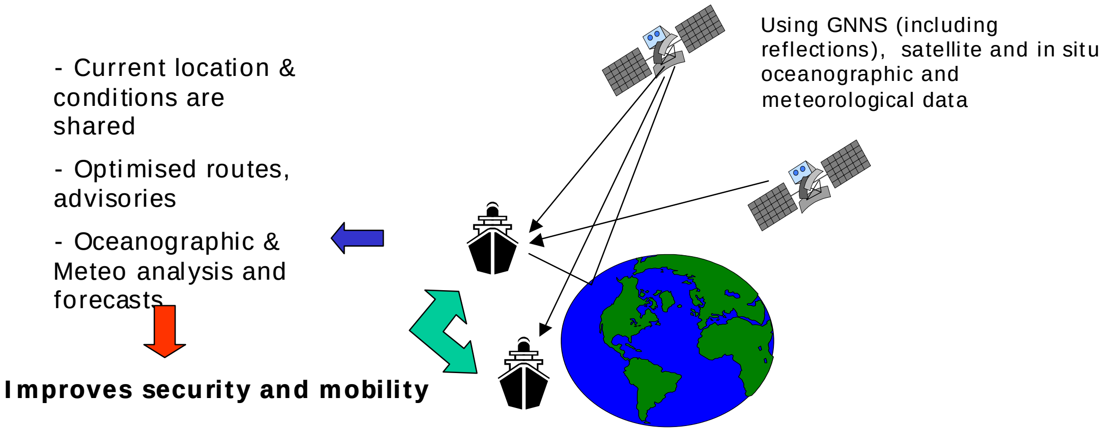

Figure 6: Concept of maritime weather forecast

The system will make use of on-board location services to correctly locate meteorological and oceanographic data gathered in-situ by each user (on board ships) in order to advice the users of current conditions and forecasts.

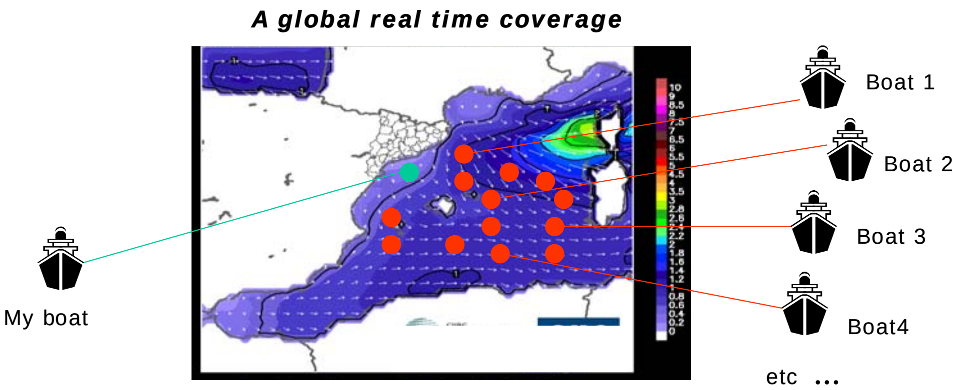

Figure 7: Global coverage where users are also providers.

Thus, the goal is to have efficient systems to share and process the data provided by the ships, including analysis and forecasts, to support marine operations through the provision of optimised routes and oceanographic/meteorological analysis and forecasts in an area of interest to improve security and mobility.

One specific ship is in the Mediterranean Sea, and it is sending information about the weather and sea state. The Data Centre received this information. This Centre can receive information from several ships, and there are several Data Centres in Europe. With the received data, they will use the Grid for weather and sea state forecast. Once all the information is processed, the result will be sent to the users.

The weather and sea state forecast uses real sensors (temperature, pressure, humidity, GNSS-R...) and will be more accurate. All of this information could be "integrated" with the earth weather stations. The Grid is necessary for computational reasons.

The potential market consists of the Shipping Industry, Off-shore Deep Sea Mining, Harbours and Civil Protection Agencies, as well as the recreational boating industry.

The system provides also the vessels location, so it allows having a location and float management system (permitting a company to monitor its vessels float and to the authorities a vessel control system).

The proposed system will dramatically improve overall navigation and in particular the navigation in the European maritime areas, which presents a number of challenges:

- Rigorous weather conditions, requesting yearly all-weather/all-time operation to serve oil-prospecting platforms.
- Intense maritime connections between continental and non-continental Europe for commercial activity. Also tourist exploitation of non-continental Europe. Mainly France-Great Britain, but also Danish, Italian, Spanish and Greek islands.
- Critical circumnavigation of Hornos cape affected by heavy traffic, which results in multiple accidents and casualties yearly reported.
- Relevance of the Mediterranean route towards Suez channel.
- Moreover, Europe (and in particular Spain) has large fishing fleets with heavy dependency on weather conditions and sea state for human save and labour efficiency.
- Increasing relevance of the recreational navigation.

Next scenario iteration should be for finding fishes, and predict their movements.

4.3.2. Traffic Forecast

Any person wants to do a trip and before starting the trip asks to the Grid system about the traffic forecast (depending on the source and destination and the different places to go). The system gives the user the best schedule depending on the traffic previsions, real works, destination and other parameters.

But when the user is in the car driving to the destination, asks again the Grid system for a new traffic forecast because it seems the traffic is not the expected and/or the radio says there are some traffic jams in few kilometres time. Then, the driver wants traffic forecast in real time taking into account the real traffic status, and possible solutions to avoid the potential traffic problems.

It is obvious that the Grid is necessary to calculate and predict the traffic. Some parameters like current traffic should be taken into account meaning that a direct communication with traffic centres is essential. Other parameters like the current location/position (the user is driving to the destination) are very important as well.

4.3.3. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Maritime Weather Forecast	X	-
# 2 Traffic Forecast	-	-

4.4. Logistics

4.4.1. Distribution Companies

In order to optimise the resources and better manage the trucks, boats, planes, etc the distribution companies can use the Akogrimo project for determining the best route, load optimisation, decrease the response time, reduce the delay in deliveries, real-time adaptation, and so on.

All the involved entities like trucks, vans, trains, and planes, etc are mobile. In this test bed the location is essential. The adaptation to the new needs in real-time are the basis of this new test bed.

The involved companies can optimise costs, offer a best service (better than the competitors), and with a response in real time in order to maximize clients in order to better manage the logistics distribution (all the involved components). The actors of this scenario are the final users that want to send one product from one place to another one, focussed in the companies (producers and providers), the transport and logistics companies and others.

The Grid will be used to calculate the best routes (and re-calculate them in real-time) in order to optimise the truck load and minimize the costs.

The mobility of all the elements means that with any new request from any client (to transport any product form one place to another) the Grid will re-calculate the best mean of transport (knowing the current position of each one), predict the delay in collect the product and how this delay/deviation can affect to the current trip (in case of sharing the loan).

The clients can see the transport evolution in real-time (using GIS systems), they can also know a prediction about the foreseen delivery time (in real-time).

A next iteration in this scenario should be that depending on the type of the transported products, some of them could be used with sensors (connected to the Grid system as well). In case of dangerous products, and the current position, the Grid does the necessary actions to contact with the authorities, police, firemen, etc to minimize the possible impact in the area.

This scenario can be also used with one client asking for taxis. Depending on the taxis availability, the current location of the taxi, the current location of the client and the client's destination (and the possibility that the nearest taxi has one or more clients inside, their destinations, if they are in a hurry, etc), the Grid evaluates the best solution:

- share the taxi with other clients and share costs as well
- ask for a free taxi because the destinations are incompatible

4.4.2. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Distribution Companies	X	-

4.5. Leisure

4.5.1. Audiovisual Portal for Mobile Devices

The idea is having a portal dedicated to mobile devices in order to download video, music, games, TV on demand, P2P, on-line health assistance, etc.

This portal has a very powerful search engine that allows finding any kind of information: for example, the user wants to know all the available videos or films where one of the actors says one specific word or sentence. It should be possible to search the word or sentence in any language. This very powerful search engine will use Grid techniques in order to have the best result in a small period of time.

The information is fully distributed and the portal will allow playing games on-line, and the player can also be a mobile player because he can move while playing. If all the on-line players are mobile players, this new concept allows a new set of games where the players' mobility will be taken into consideration.

There are a lot of applications related to tourism, leisure, health, games, video and TV on demand, on-line assistance, cultural and/or sport events transmission, training-courses, etc. The needs are versatile as well, e.g.:

- global audiovisual database in any language in any place
- when people are not at home there is great demand of leisure (like games, etc)
- assistance/help (roadside assistance, medical care, health care, etc) mainly in isolated places

The involved actors in this scenario could be game manufacturers, TV's and broadcasters, audiovisual contents producers, end-users, students, teachers, leisure, etc in the telecom markets and leisure, health, tourism and other markets as well.

In the specific games area, it will be possible to think in new games (new concept of games) and/or new devices to play. Obviously, the Grid will execute complex search algorithms (in the audiovisual contents), distributed in different places, servers and providers.

The big advantage of this scenario is the mobility because the end-user can access all of the portal contents (music, video, TV, games, etc) using their mobile devices in any place. One current constraint is that the communication channel should have enough capacity to support the information transmission, allowing sharing contents between final users.

A next iteration should be that the user of the portal could use the voice for search contents in the music and videos.

4.5.2. Tourism

In the tourism test bed, Atos Origin has detected several different scenarios presented in the following subsections.

4.5.2.1. Introduction

Few years ago, nobody thought that almost everybody in Europe should have its mobile phone and can start or receive a phone call in everywhere at anytime. At this moment, the use of the mobile phone by the European citizen is a common and widespread practice, and it is accepted as usual part of the daily activity.

Travel and tourism are leading applications in B2C, representing nearly 50% of the total B2C turnover worldwide. Internet is used both for information gathering and to order services. Users are becoming their own travel agents and build their travel packages themselves.

Forecasts state that by 2007 30% of all transactions in the European tourism domain will be done via the Internet. Besides this importance of e-commerce in the Travel and Tourism industry it is significant to highlight emotional experiences. Tourism is a medium of curiosity, of creating communities or having just fun, all of which may or may not result into business.

The World Tourism organisation predicts that international arrivals will reach 1 billion by the year 2010, pushing revenues to US$1,550 billion – nearly four times more than current earnings. It represents a cross-sectoral industry, including many related economic sectors such as culture, sport or agriculture, where over 30 different industrial components have been identified that serve travellers. There is a huge importance for regional development due to its small and medium enterprises (SME) structure. For example, in the EU there are around 1.3 Mio hotels and restaurants (9 % of all enterprises). And 95 % of them are very small, i.e., 1-9 employees.

As a summary, travelling becomes more and more flexible.

4.5.2.2. Scene 1: Where Can I Go?

The European citizens are travelling around Europe, and in one specific country they need specific tourism information. They are in one specific place (for example, the Ramblas of Barcelona) and they want to know what is possible to visit in the neighbourhood. They use their mobile handset device to connect to the access point (there are several service providers supplying access points that offer this service in Europe). The access point identifies them and on the basis of the location of the citizen (automatically detected), the citizen profile, the info about the available tourist sites close to the Rambla, and provides a personalized list of sites to be visited (the considered parameters to personalize the list could be many others, retrieved by different provider: weather forecast, traffic, museums timetable, museums overcrowding, etc.). To achieve this result the access point provider will contact different Grid services provided by different entities and administrative domains within the VO, but transparently to the final user.

Having a list of possible target sites, the citizen could ask for a preview of a specific site (some 3D reconstruction could be shown to them, accessing different entities on the VO: maybe someone could provide the simulation engine, some other the hardware to run it, some other else the content to be simulated).

When the citizen decides, he will be provided with the best path to get to the chosen site. The citizen asks for a new service "not to get lost" to avoid to get lost and to arrive on time. This service shows in real-time a map in his mobile handset with his current position, the destination and the path to follow. Even in this case, this action involves different entities: provider of software to evaluate the minimum path, provider of citizen location, provider of specific info to choose the better transportation means, map provider, etc.

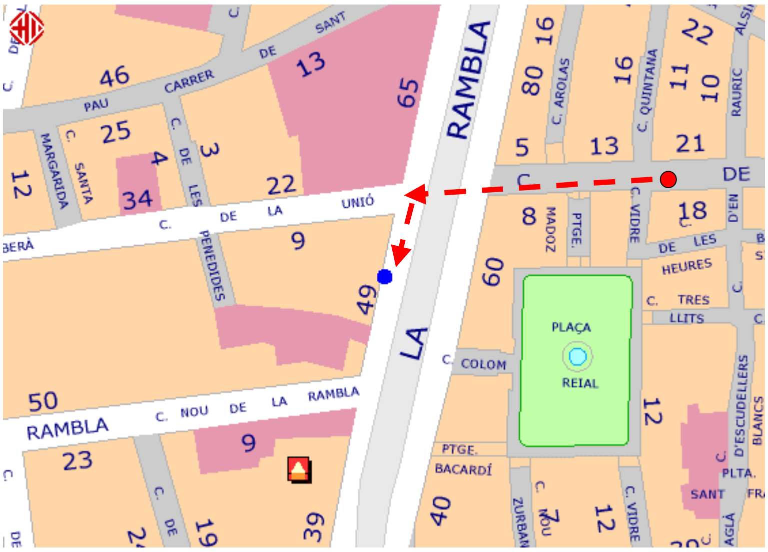

Figure 8: Where can I go?

If they have to buy any ticket to entry, and in order to avoid arriving there and not getting tickets ("SOLD OUT"), they prefer to buy the tickets, just in case. At this moment it appears within the VO also the Bank that accepts the transaction.

Meanwhile, it is almost noon and then the citizen is notified about a list of possible restaurant. The citizen could provide some preferences (e.g. Catalan food, price) and receive a personalized list based on real time info (if restaurant participated the VO, in some way, it could provide the daily menu, how many time to wait for eating, etc).

If our citizen is hungry now, then the nearest restaurant that matches the user profile is chosen. When the citizen takes a choice their personal profile is updated to better personalise future requests.

The above description could be extended for different aspects (e.g. booking of hotels, searching for sport facilities, bar on a beach in a hot summer day and so on.

4.5.2.3. Scene 2: Free Afternoon

A businessman has finished his work early and he wants to finish the day in a planned way, without any concern. This is why he uses his mobile handset device to connect to the access point.

He asks for a complete service from now until end of the day, including restaurant for dinner, cultural activities like typical buildings, museums, theatre, etc with the possibility of guide and transport. The system plans and coordinates all the activities asking several Grid services following his preferences, and showing them the different possibilities. When the selection is finished, the businessman knows that he has reserved one table in the restaurant, and after that a taxi is waiting for him to go to the theatre. Once the play is finished, he can go to a pub to have a drink, and after that the taxi will be waiting for him to go to the hotel.

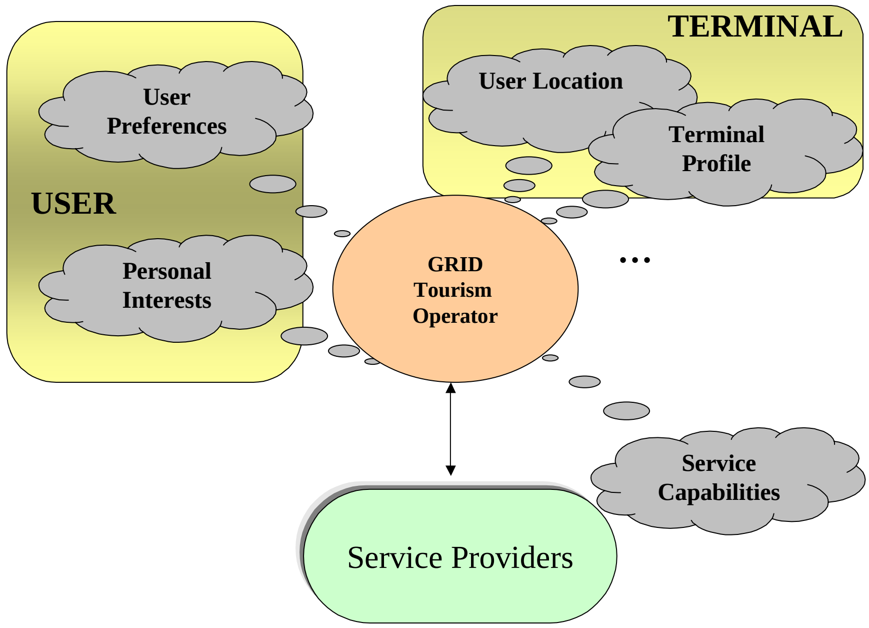

Figure 9: Involved entities

4.5.2.4. Scene 3: Group vs. Individuals

A group of tourists is visiting the city. To avoid the typical problems related to individual preferences (some of them prefer to go to the museum, others to the typical places, etc), each member (or subgroup) follows their tour. But they want to lunch together.

Depending on all the user-preferences, the system decides that Italian food will be OK for all of them and looks for an Italian Restaurant in the area taking into account the current position of all the group members and how to arrive there (distance, transport, etc).

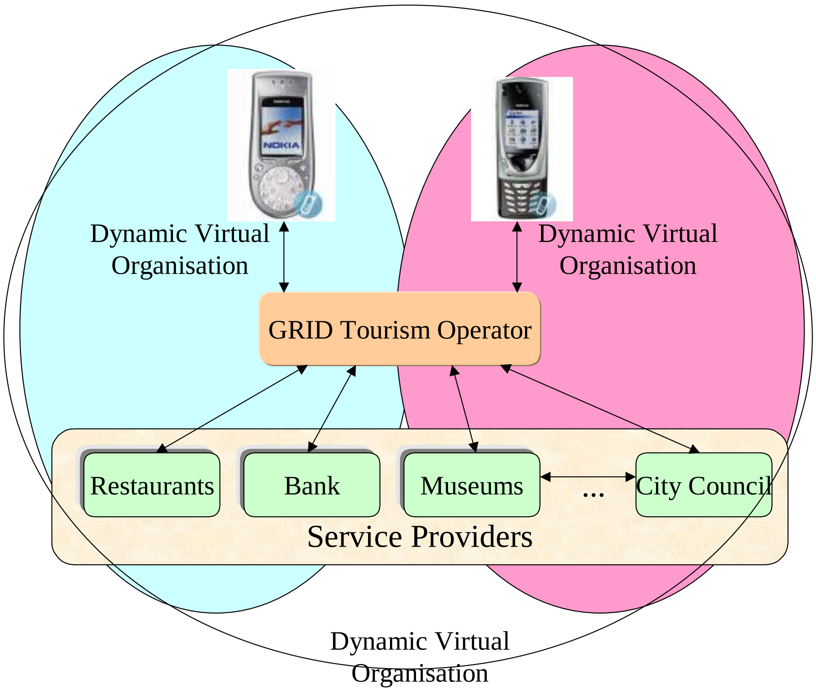

Figure 10: Virtual organisation

4.5.2.5. Scene 4: Coupe in Ireland

A couple is travelling around Ireland using the typical bed and breakfast. They have planned the entire trip, but for any reason the second day they have not arrived to the reserved place. The system should un-reserve the already booked places and re-adapt to the new situation booking new places according to the economic resources, preferences (type of room, with/without TV, with internal shower, etc) and constraints.

Booking could also be done based in a planned route, where the system will extract accommodation information from de little databases spread on the guesthouses.

Booking information would be completed including real time information on interesting temporal activities near the places they are visiting like local holidays, temporal exhibitions, etc.

On-line reservations, real-time, Virtual Organisation in order to access to different service providers, access to temporal information (that can expire in time), tourism agencies, public administrations, anybody is a potential user, leisure, mobile final user, GRID for distributed access and for computational reasons are part of the involved entities in this scenario.

4.5.2.6. Conclusion

In the above scenarios Atos Origin has stressed mobile and context aware aspects (ubiquitous and pervasive) than nomadic aspects. In fact, all the actions are performed while the citizen is travelling taking into account spatial and temporal information in a contextualised way.

Finally, Atos Origin mentions different resource providers (network, information, contents, hardware, software, banks, restaurants, museums, city council, etc.) across the Europe and collaborating in a dynamic VO (or better in different VO organized between them in some way).

It is very important to note that this system can:

- personalize the services (according to the user preferences)
- adaptation based on the user interaction history
- make use of interest of single users as well as groups
- exploit several providers
- be pro-active

Components

- Mobility: Users and access
- Real-Time: to know the traffic, works, weather, special offers, reservations, occupancy, etc
- Grid: different service providers in collaboration to generate the dynamic virtual organisation

Business Model

- users
- operator
- service providers

4.5.3. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Audiovisual Portal for Mobile Devices	-	X
# 2 Tourism	-	X

4.6. Monitoring

4.6.1. Vehicle Monitoring

The description of this scenario is confidential and available in the document D2.3.1 Testbed Description – Non-public Scenarios 95[29].

4.6.2. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Vehicle Monitoring	X	

4.7. Overall Services

4.7.1. Increase the Mobile devices User Interface

In the last years the mobile device functionalities have increased a lot but the way to interact with these mobile devices is basically the same. For example, the mobile phones at the beginning were used to call and that's it! Now they can be used as agenda, calendar, to access to Internet, etc, but the way to interact with them is basically the same: one small keyboard and several function-keys. For example, to enter a note with a phone number it is necessary to press 4 times the same key to write one unique digit (0..9).

From the usability point of view almost everybody has accepted this constraint, but it is clear that the mobile devices user interface has not increased at the same speed than the mobile devices functionalities.

Then, thinking in the way how the mobile devices will interact with the Akogrimo system (it is not defined yet) is seems there will be 2 main possibilities:

- Internet navigation until one specific page, enter some data (parameters) and submit a request
- Specific application at mobile device side. This application should be used to enter the data (parameters the Grid services need) and submit the request. In this case, this specific application avoids all the navigation activities.

But in any case, the user has to enter some data parameters (perhaps in some test beds these parameters can be entered via sensors connected to mobile devices and other possibilities) using the limited mobile handset input devices.

Thinking in using the voice to entering these parameters instead of the typical input devices like keyboard should be a very interesting possibility for the testbed.

Consequently, independent to any application, the Grid technology could be used to translate a voice input to a text input. The Grid translator between voice and text has to provide internal voice recognition in real-time.

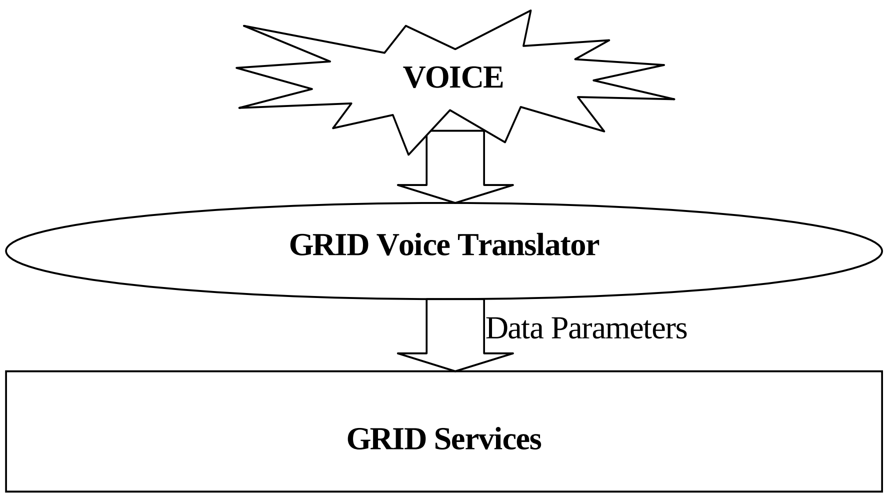

Figure 11: Voice Translator

4.7.2. Universal Translator

Related to the voice recognition and automatic language translators, the Universal Translator could be another Akogrimo test bed. The idea is that the Universal Translator receives voice and/or text as input and the gives voice and/or text as a result. The Grid could be used to have enough computational power for the language translation in order to fit the best translation for each word/sentence.

At this moment there are several automatic language translation techniques that can be used. Trying to run all of them at the same time (using the Grid concept) the result can be better than using one single technique. The combination of the different techniques can increase the translation average.

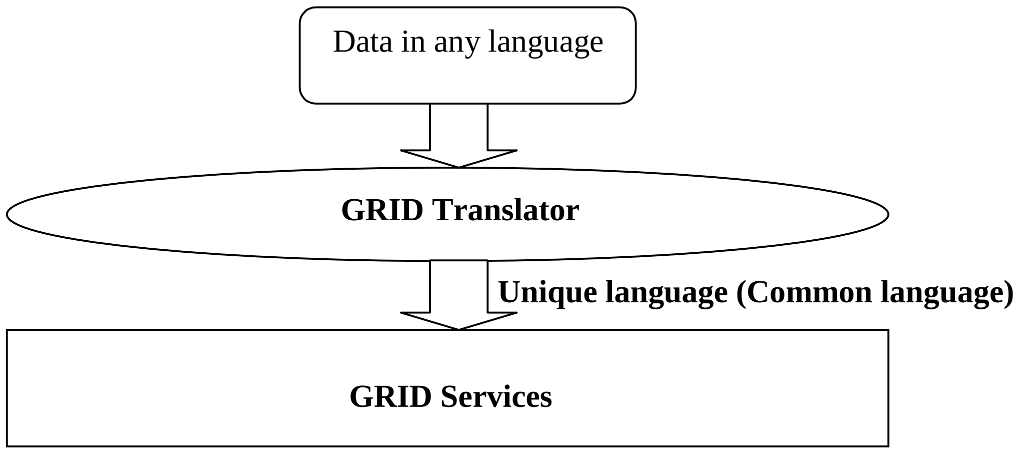

Figure 12: Language Translator

4.7.3. Voice and Language Translator

Taking into consideration, both, the voice translator and the language translator, it should be possible to setup a testbed for user machine interaction via voice in any language.

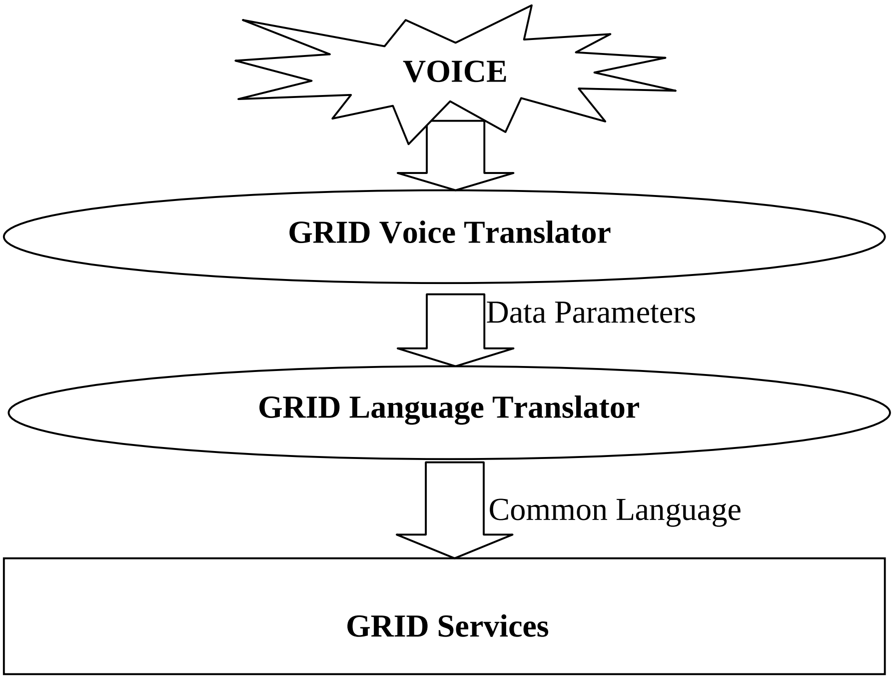

Figure 13: Voice and Language Translator

4.7.4. Summary

Scenario	Significance for Mobile Grid Support	Significance for Knowledge Access
# 1 Increase the Mobile devices User Interface	-	-
# 2 Universal Translator	-	X
# 3 Voice and Language Translator	-	X

5. Summary

This deliverable is about to provide the conceptual base needed to further develop towards a detailed analysis of the essential characteristics of mobile Grids – in order to provide for a well-founded decision of which ones of the testbeds being currently under consideration would most appropriately support the Akogrimo vision of knowledge access in a mobile Grid world.

To this purpose, at first we have done a detailed analysis of the OGSA standard with respect to mobility-related issues, and knowledge. We have further worked out those issues being typically related to knowledge access, and knowledge management within Grid infrastructures. The results are reported in section 2. The discussion has revealed that, due to the current state of the art (and of the OGSA standard in particular) it is still difficult to decide very clearly where exactly the borderlines are between a stationary, and a mobile Grid.

We thus based our distinction between the stationary Grid and the mobile Grid upon whether the interface to a Grid service (interfaces provide for full resource virtualization, thus also for resource mobility) is either stationary or mobile.

Building on this we then did a first, however still relatively weak, evaluation of the suggested testbeds (sections 3 and 4). It will be part of the work of the next months within the project to further operationalise possible evaluation criteria, to build a multidimensional evaluation system, and to undergo a detailed review of each testbed, together with all scenarios suggested.

A preliminary, still very small result is that the eLearning testbed has still some weaknesses with respect to mobile Grid, while the eHealth-testbed and, in particular, the Disaster Handling and Crisis Management testbed seem to have some strong requirements for mobile Grid technology and possess knowledge relevance.

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Annex A. Further Contributions

A.1. Grid requirements

Table 7 contains requirements derived form the OGSA requirements, but on an aggregated level.

Requirements	Description
Dynamic and heterogeneous environments support	Grid systems support large-scale distributed computing among different environments and platforms (operating system, networks, application frameworks…). This is achieved providing the application layer with standard services for resource virtualization, common management capabilities, resource discovery and query.
Resource sharing across different organization and domains	OGSA compliant grids support for standard protocols and schema, global namespace handling, metadata services, site autonomy management. In this way applications can improve their resource sharing in a wide-scale distributed environment.
Common interfaces using standard, open, general-purpose protocols	Grid systems compliant with the OGSA architecture have component services and interfaces based on standard open and general-purpose protocols. This is for achieving modularity, scalability and interoperability in the context of complex and heterogeneous environments.
Coordinated administrative management	Grid applications can use the automation of common administrative operations to avoid human errors and manage very large-scale systems.
Multiple security infrastructure and policy exchange support	Distributed operation across different, independent domains need the support (and the coordination) of multiple security infrastructures. In a grid environment service requestors and providers can exchange security policy information to establish a negotiated security context between them.

Table 7: Aggregated Grid Requirements