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Context

Activity 2	Environment & Requirements definition
WP2.2	Environment & Project Context
Task 2.2.1	**Socio-Economic Environment**
Dependencies	**Does not depend on any within the Project** **It will be needed as input for Activities 3 and 4**

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Abbreviations

A table with used abbreviations is strongly recommended

Akogrimo	Access To Knowledge through the Grid in a Mobile World
DHCM	Disaster Handling and Crisis Management
MDVO	Mobile Dynamic Virtual Organisation
OGSA	Open Grid Services Architecture
VO	Virtual Organisation

Definitions

Context – (1) when discussing mobile applications (section 3.2.1), we use the term context to refer to the circumstances of the mobile device, including the characteristics of the device itself. (2) This word is also used in the definition of a VO in the OGSA glossary (quoted here in section 3.1), but otherwise not used in this document.

Mobile Dynamic Virtual Organisation – see section 3.2.2

Open Grid Services Architecture – see section 3.1

Virtual Organisation – see section 3.1

1. Summary

The Akogrimo goal of bringing about the foundation for a pervasive, widely accessible, mobile, knowledge-based Grid relies on an effective understanding of the social and economic environment.

Introducing mobility to Grids will bring about not only mobility of service consumers and providers, but also a dynamically changing population of them, which will bring its own challenges.

Although sales of mobile devices are recovering lost ground, it is quite possible that the rate of increase will now decline. Telecoms operators are likely to seek new partnerships and may well actively encourage the ability to provide Grid services through their networks. They already have the infrastructure for presenting a direct interface to the user, a resource which complements the offering of Grid enterprises.

New business entities will emerge, including service aggregators. But the services to be aggregated may well be single purpose and embrace such necessary areas as service publishing, service brokering and service authentication.

Financial implications may include accounting and billing for an invisible resource somewhat analogous to the situation with electricity, which also needs to charge for a complex set of services from a complex set of providers, presenting an apparently simple interface to the consumer.

Further work in Akogrimo will make use of well understood models to develop new business niches and business value-added chains.

The congruence of telecommunications providers and Grid providers in Akogrimo is likely to be a unique opportunity to bring Grid services to a pervasive market.

2. Introduction and context

This report aims to present an understanding of the social and economic environment for Akogrimo.

After discussing the idea of a mobile, dynamic virtual organisation (MDVO) (chapter 3), the report approaches the problem from a Grid-oriented point of view taking into account mobility (chapter 4) and from the point of view of telecommunications operators, needing to offer services such as those which, it is expected, the Grid will enable (chapter 5).

Other relevant work in the Project will be summarised – the market players and the regulatory environment. (chapter 6).

The report then finishes by presenting the opportunity for pervasive mobile Grids within the application domains from which two of the Akogrimo testbeds are being chosen and designed (chapter 7).

3. Conceptual definition of a mobile dynamic VO

3.1. VO concept

The idea of a Virtual Organisation (VO) appears in the literature of organisations [13] [14] before the term became adopted for Grids. These authors discuss opportunities for new organisational structures offered by the Web and replacement of traditional archives by electronic media. The term was then used in [15] to describe the fluid organisational structure the Grid is designed to support.

VOs were then developed as a key concept in the Open Grid Services Architecture (OGSA) [16]. The OGSA glossary [17] contains the following definition of Virtual Organizationss:

- A virtual organization (VO) comprises a set of individuals and/or institutions having direct access to computers, software, data, and other resources for collaborative problem-solving or other purposes.
- VOs are a concept that supplies a *context* for operation of the Grid that can be used to associate users, their requests, and a set of resources. The sharing of resources in a VO is necessarily highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs.

The VO concept has several aspects, including the following:

- It is a set of individuals, organisations and resources that group together for a common purpose which is likely to involve some form of sharing.
- It crosses existing conventional organisational boundaries.
- An individual or organisation may undertake specific roles in a VO.
- An organisation may make some of its resources available by means of a VO.
- A resource could be a low level concept, such as providing compute power which could be used for any software within a given class or some more application-oriented concept such as a business process.
- VO policies are required for sharing resources, for stating conditions under which resources are required or offered and for authentication among the members of a VO and between the VO and the outside world.
- A VO is supported by the idea of services being provided, published and requested.

The OGSA [16] envisages some VOs having a long life, being a management umbrella for short-lived VOs, which form to fulfil a short term task and dissolve, having completed an operative phase. The former can be thought of as being a virtual community and in fact the OGSA document does use this term.

The notion of a virtual organisation supported by the Grid is becoming a practical reality in the scientific field. An example of a VO offering access to scientific resources is the LHC Computing Grid (LCG) at CERN [18]. But the idea of a VO can encompass a wide range of users, experts and application domains and can be extended to consider mobility.

3.2. Mobile Dynamic VOs

In Akogrimo, we introduce the idea of a Mobile Dynamic Virtual Organisation (or Mobile Dynamic VO or MDVO).

3.2.1. Mobility

Mobility introduces the possibility of accessing Grid resources from a mobile device. So long as required authorisation conditions are met, a suitable PDA can act as a client to grid services, by means of a network transport stack that has reduced, but similar interfaces to a fixed device. Web protocols for device adaptation ensure that W3C Cascading Style Sheets (CSS) can assume a presentation method appropriate to the device.

Mobility also includes continuity of service across changes of circumstance. For instance, an individual may start a collaboration using one device and need to move to another while maintaining the collaboration session, without introducing additional security problems, such as a message accidentally arriving on the previously use device due to a race condition. So a VO may involve individuals and organisations some of whom may be on the move and need to connect to the VO resources from wherever they are, whether this be in an Internet café', or using an wireless access point or mobile device. A VO may also involve a collection of roles and sometimes an individual fulfilling a particular one may need to be replaced by another individual - continuity of roles.

In other situations, we may require that the application know about the circumstances and be sensitive to any changes and this is one of the key ideas in Akogrimo. This can be referred to by the generic term context. It includes device characteristics, location (geographical location, which could in principle include height), host network connection, and individual preferences. Changed circumstances may require that an individual may assert that usual authorisation privileges must not apply, because they are on public transport or at a party.

Mobility may apply not only to the service requestor, but also to the service provider.

- Services may be hosted by equipment on a vehicle on the move, which in an emergency situation may be the only reliable, up to date source of certain information.
- A patient may be under medical observation by means of sensors able to communicate elsewhere even though the patient may be leading a normal mobile life.
- A research laboratory conduct a mass experiment which involves many sensors distributed widely and which – if the sensing technology allows this to be done cheaply enough - may sense sunlight, pollution, images or pollen. In this case, loss of some sensors is not a problem is the coverage is detailed enough. In the medical case, the sensors are measuring a specific individual and thus each measurement is vital.

Although some of these can be thought of as service requestors, it may be more useful to turn the concept round and think of these as service providers.

Given this idea, we can also conceive of a mobile VO which includes services that may be mobile.

3.2.2. Mobile Dynamic VO

A VO in OGSA is already dynamic. For instance:

- A service instance in a VO may adapt to changing competition for computing and network resources and to failures of hosting environments or of connections.
- A VO has a life cycle which can manipulated by grid services. It may pass through the stages of identification, formation, operation, evolution and dissolution. If long lived, it is likely to undergo changes during that lifetime. These changes are expected to be available as grid (or web) service invocations.

Clearly a mobile VO inherits these dynamic capabilities. However other dynamic characteristics result from mobility aspects we have already discussed. Therefore a mobile VO could be thought of as collection of individuals, organisations, roles and services which may be on the move, can be substituted in the event of failure, can have changing membership and can be aware of the members' contexts. It is thus apparent why the phrase in full has become mobile dynamic virtual organisation (MDVO). A key problem is to maintain certain things constant – such as policy unless explicitly changed – and persistent – such as a session – while everything else is changing.

The implications of mobile dynamic VOs and mobile grids will be discussed in the following chapters.

4. Grid economics

Nowadays, it becomes clearer that Grids can enhance human creativity by increasing the aggregate and peak computational performance available to important applications and by allowing the coupling of geographically separated people and computers to support collaborative engineering.

This fact can accelerate the deployment of applications that are oriented towards Grid computing. These applications can be distinguished generally into the following categories:

- *distributed supercomputing*, in which many Grid resources are used to solve very large and complex problems,
- *high throughput*, in which Grid resources are used to solve large numbers of small tasks,
- *on demand and utility computing*, in which Grids are used to meet peak needs for computational resources,
- *data intensive*, in which the focus is on coupling distributed data resources and the efficient usage of the data in federated Databases;
- *collaborative*, in which grids are used to connect people under common working environments transparently.

It is clear that the question that arises after the introduction of these applications is: Who are the users for grids? Possibly everyone. But what is meant by everyone? It is definitely a broad scope term covering all the aspects from national Grids (serving a national government), private Grids (for private organizations and commercial enterprises), virtual Grids (serving scientific/academic communities forming common research laboratories) and a public Grid, supporting a market for computational services. Given the fact that the current trends indicate the migration from traditional computing into Grid computing, new working environments, new business models and new aspects for economics will affect the context of today's communities that are involved.

4.1. Introduction to the sharing concept of Grid environments

The basic assumption and motivation for the current research and investment into Grid technology is based on the fact that coordinated access to diverse and geographically distributed resources is valuable. It is obvious that mechanisms are needed that allow the coordinated access to resources, in a sustainable, scalable way that promotes Grid resource sharing across the participating organizations and entities according to the defined policies.

With the proliferation of networks, high-end computing systems architecture has moved from centralized toward decentralized models of control and action; use of economic driven market mechanisms would be a natural extension of this development. The ability of trade and price mechanisms to combine local decisions by diverse entities into globally effective solutions characteristically implies their value for organizing computations in large systems such as Internet scale computational Grids.

The first Grid prototypes have been successful in enabling this scale of sharing academically but this is not sufficient in business environments, which are characterized by time deadlines, financial pressures and quality competition. So it is clear that the question: "who gets what, when and for how much?", is the dominant question on the Business Grid FAQs.

4.2. Grid Resource Allocation and Management

4.2.1. Features of Grid resources

Grid technology enables sharing of computing resources within and between organizations. As a result of this, Grid resources have to be allocated dynamically in response to changing needs, requirements and availability of resources. This allocation is often across budget boundaries and policies, even within single organizations, thus bringing financial questions to the fore. What is a Grid computing resource worth today? What will it be worth tomorrow?

In Grids, resources are perishable (capacity not used now is worthless in the next moment), needs are dynamic and applications require bundles with multiple units of items (CPU, RAM, permanent storage, network bandwidth).

Conventional resources and commodities such as electricity and petrol have a resource value that at the wholesale level is dynamic which applies at the same time to Grid resources as well (although not always in a straightforward manner). Values derive generally from a combination of need and scarcity. User needs are not constant, they change over time and the changes also depend on the timescale and granularity of observation. Needs are also driven by external and irregular events, e.g. reaction to advertising campaigns, seasonality etc... Variations in user needs change resource value very little if the resources are infinite. Of course this is far from reality. On the other hand, resource values are subject to a user competition and their diverse requirements. Financial and commodity markets have long established methods to communicate and prioritize competing needs of many individuals: prices. These are understandable to every single participant and allow the participants to take effective action.

When multiple budget entities share resources, allocation decisions in resource management become also financial decisions. For the potentially large and complex systems enabled by Grids, equivalently robust financial engineering is needed.

4.2.2. Key aspects of Grid resource values

4.2.2.1. The Grid players

The two key players in commercially oriented computational Grid are resource providers and resource consumers. Both have their own expectations and strategies for being part of the Grid. In this Grid economy, resource consumers adopt the strategy of solving their problems at low cost within a required timeframe and resource providers adopt the strategy of obtaining best possible return on their investment. The resource owners try to maximize their resource utilization by offering a competitive service access cost in order to attract consumers. The users (resource consumers) have an option of choosing the providers that best meet their requirements. It is obvious that Grid systems need to offer tools and mechanisms that allow both resource providers and consumers to express their requirements.

These tools and mechanisms must include also the brokers to express their requirements such as the budget that they are willing to invest for solving a given problem and a deadline, a timeframe by which they need results. They also need capability to trade between these two requirements and steer the computations accordingly. The Grid Resource Providers need tools for expressing their pricing policies and mechanisms that help them to maximize the profit and resource utilization. Various economic models, ranging from commodity market to auction-based, can be adopted for deciding pricing strategies. The Grid infrastructure needed to support these Grids are conceived as distributed across organizational systems where users share resources at a scale and with an ease that was not possible before.

Especially, the auction scheme for the determination of the final resource prices seems to be very promising for the Grid economy. Potentially suitable auction models for Grid resources include continuous double auctions, Vickrey, Dutch, multi-unit and multi-item (or combinatorial) auctions. However, individually these approaches do not offer a comprehensive and precise price formation solution. In any case the optimality of an auction mechanism will always depend on the particular deployment environment, not to forget the high profile auctions for 3G licenses have been carried out in many European countries. Two distinct problems arose in these auctions: bidder busts ("winner's curse") and auctioneer flops. 3G auctions in Germany and the UK yielded enormous profits for the local authorities at the expense of the bidders, whereas in Switzerland, the Netherlands, Italy and Austria prices remained well below expectations, disappointing the respective auctioneers.

4.2.2.2. The Grid currency

An issue which concerns the Grid community today is the definition of a Grid currency. The issue is more important for Grids than for earlier distributed systems because commercial Grids cross budget boundaries. In addition managers will face the issue of whether to buy resources on accessible Grids or boxes, and also whether to make their boxes available to the Grids to which their organization is linked. Grids and resources are generally heterogeneous and potentially of arbitrary scale. Scale and heterogeneity are exactly the drivers which led to the establishment of standard monetary units and currency exchange rates in the real economy.

The administration of a particular Grid may choose to introduce prices for a local artificial currency. The administration must then act as a national bank guaranteeing the convertibility of the currency into units of value, i.e. resources or real money. Now who sets the exchange rates and to which unit of value? A currency board? A fixed exchange rate? Most IT administrations will quickly choose to skip the intermediate step of an artificial currency with its trust and convertibility problems and use real money straight away. Using a real currency for Grid resources additionally brings the following benefits: buy/build/lease or upgrade/retire decisions are simplified and the allocation of IT budgets is directly meaningful.

4.2.3. Quality of Service

What QoS is required for tradeable value? Most IT systems today do not support hard QoS guarantees, that is they do not guarantee the properties of a service which influence user experience. Often best-effort service is provided. Approaches which go beyond best effort typically introduce job/packet marking so that different priorities can be assigned to different tasks. How much better the service will be for differentiated service classes is generally hard to determine in advance for large-scale heterogeneous systems and even harder to characterize in absolute terms.

Despite the difficulties of guaranteeing QoS (especially end-to-end), Grid commercialization requires guaranteed property rights at the level at which pricing is done. In a commercial environment, buyers can expect sellers to optimize what they deliver against the QoS guarantees that they provide. We should also make clear at this point that best-effort service has near-zero economic value. In fact the value would be exactly zero if it were not for the assumption that there is a common understanding between the buyer and seller of the service on the quality level to be delivered. Advocates of grid computing envision dynamic near real-time negotiation and provisioning of distributed resources. Existing financial and commodity markets which operate at electronic speed rely on the use of extremely detailed contracts. Computers and applications may be complex but they also have unambiguous definitions. This level of detail is necessary to create the appropriate confidence among users of a highly distributed cross-organizational system that what they get is exactly what they expected to receive. In some cases a tradable asset must be described in statistical terms.

4.2.4. Volatility as Grid attribute

We mentioned earlier that Grid resources are not storable, in the sense that capacity not used today cannot be put aside for future use. The most significant non-IT resource which is also non-storable is electrical power (with the notable exceptions of hydroelectric and pumped storage). In electricity markets, as in several others for non-storables, contracts for future delivery (forward or futures contracts) are the most used and have much higher trading volumes than those for immediate delivery (spot contracts). The explanation for this is that participants want to manage the risk of price/availability uncertainty by fixing the price and availability of a resource in advance. Practical Grid markets will revolve around reservations (forwards) not spot markets. Without inventories, volatility has no real upper limit for non-storable resources. High volatility is not a desirable characteristic for most resource buyers or sellers.

This is also interesting if we think that the volatility aspect will be beneficial for occasional users, brokers and/or resource providers who will wait for cheap spot contracts so as to satisfy their needs or to re-sell them in pre-defined prices that they managed to agree upon "a priori" in previous days with their customers. This uncertainty can be problematic in some cases, but we have to keep in mind that it can be anticipated with very cheap prices and jobs that can bear a small deviation from their deadlines. Of course, statistical models and prediction mechanisms will be developed for an accurate (as much as possible) estimation of the demand, availability and utilization of Grid resources within the various organizational boundaries, an estimation that will allow the elaboration of such risky policies.

4.3. Markets and Virtual Markets

When making a business case for Grid technology adoption the following arguments are common: increased utilization, cost savings, greater allocation flexibility, feasibility of previously impossible computational tasks, etc. These may be theoretically possible but to what extent can an organization practically realize these potential values of a Grid deployment? This is even truer in cases where markets will be created for intra-Grids, that is for the sole purpose of achieving an efficient resource allocation internally.

One set of economic engineering questions that need to be answered in Grid deployments to realize theoretical Grid value, center on market engineering. Questions include the following, which are just a small selection. Should the IT department of an organization be operated as a profit or cost center? How much reselling of resources should be allowed? Is speculation permitted? What level of financial and project risk are users and departments permitted? Are bilateral trades permitted?

Engineering of resource products is another area requiring design. Spot and forward contracts (reservations) may be useful for describing and controlling the theoretical basis of value. These can be automatically assembled to matching user, application, and department requirement profiles both using process tools (multi-stage stochastic portfolio optimization). A complementary approach for providers is to manually design resource product packages incorporating spots, forwards, and quantity and timing flexibility to match user, application and department needs, i.e. construct derivative products.

4.4. Mobile Grid: The emerging Business Models

4.4.1. The ad-hoc Grid

Wireless devices are increasing in numbers, and their power is growing. Wireless laptops rival the power of mainframes just a few generations ago. Cellular and 802.11 networks are increasing the connectivity of these devices. These new devices bring challenges to the Grid paradigm because their mobility will create additional constraints on Grid protocols. Policy as well as technical and business challenges arise from the confluence of Grid computing and mobile and nomadic devices, services, applications, and users.

Mobile Grids inherit the three main characteristics of the general Grid in a wired networking environment that include:

- Geographically distributed and decentralized resource coordination
- Standard and open services and protocols
- Nontrivial QoS support for computing and networked applications.

However, the dynamic ad-hoc nature of a mobile Grid distinguishes it from the fixed Grid, not only concerning the technical requirements, but also the concept upon which the economic and business models will be based. This difference is similar to comparing a residential neighborhood with local shops, to a special event like a big open-air concert. In a residential neighborhood the population is relatively stable: local shops having stable addresses and local customers. Many of these local shops and customers have relationships between them. Of course outsiders will come to the shops, but that's not the norm. This is similar to how devices in a wired grid are relatively stable. In contrast is a special event that has a large transient group coming, and going, similar to how wireless devices will migrate into different local area networks with local services. A special event will have many visitors, some of which will bring services to trade with others, similar to how wireless devices will bring additional services to a local wireless LAN. The greater mobility of wireless devices changes the dynamics of a computing Grid.

The rapid growth of a number of wireless devices, particularly those with ad-hoc networking capabilities, has shown that many users perceive value. If wireless devices and systems are modified to support coordinated sharing and transactions, some of this value could be converted into revenue for service providers of the virtual markets.

4.4.2. Marketplaces

There are several types of market places to consider:

- *Information and Resource Sharing Marketplace:* Wireless Grids can create a virtual market where voluntary users share their information and resources thanks to the networked environments evolved from distributed ad-hoc wireless devices and systems. Like various P2P file sharing network initiatives, Napster, Gnutella, Morpheus, Limewire, Freenet, etc, a wireless grid can evolve as or to a voluntary market place where voluntarily motivated (with their own responsibilities and risks) users come and share their resources. Also, this public place would become a good marketing and meeting place to advertise private sharing opportunity where robust and closed transactions are possible. Again, business values would not directly come from the information and resources shared but from the network values improved thanks to such open sharing in this place.
- *Demand and Supply Aggregation Marketplace:* The Wireless Grid can create business values of information and resources due to aggregated availability of demand and supply coordinated and facilitated through the virtual markets. Examples of such kind business models can be found in distribution and caching for content distribution (Kontiki, Radio Free Virgin), and personal computer resource sharing. Allowance of wireless device access to near-by computing devices or wireless systems for proxy-resources (like cached files and storages) will create places where the aggregation of demand promote the revenue source of this kind business function. Aggregation of shared processing power provides the availability of extensive computing and storage power by sharing unused resource of many personal computers.
- *Collaborative and Cooperative Marketplace*: Wireless Grid networks can provide a space for people to collaborate on projects that require a number of participants. The traditional approach is to use a single computer that stores all data and participants make modifications directly on this central server. Scalability becomes critical especially for the large population collaboration in such places. Similarly the processing necessary to handle these requests can make the application unstable. Ad-hoc based wireless Grid can eliminate these problems by having the processing and the data spread among all the participants. Groove Networks is an example of P2P networks employing resource sharing and coordination for collaborative editing services.

4.4.3. Why Emphasis on P2P?

To create supportable P2P on-line trading and exchange places for any type of resources, the business model of P2P networks should find the ways to examine the reputation of peer and resource, motivate the users to share or exchange those resources, and keep secure account and transactions among peer users. The service provider of this trading and exchange will create its value from the transactions and accounts the users create and make. How to keep up large volume of accounts and transactions is the key issue for the successful virtual market with this type of business model.

4.4.4. SHaring Level Agreement

One of the main operations of virtual market is a SHaring Level Agreement, that describes protocols that define the responsibility of participants within a wireless communications grid.

The concept of a "sharing-level agreement" attempts to define the resource-sharing characteristics of a wireless communications grid, as opposed to the traditional "service-level agreement" which defines a vendor's responsibilities to its customers. Thus a sharing-level agreement not only encompasses the roles and responsibilities of the users within the grid, but also governs the attainment and fulfillment of requested resources. Defining such a protocol would entail addressing unique challenges such as service discovery, user interface definition, user behavior, network management and security, inherent economics and policies as well as determination of the underlying network architecture. Service discovery includes those mechanisms needed to access the set of resources that comprise a specific service required by a user. These mechanisms include identifying the location of each resource, or, if more than one exists on the computation grid, the optimal location from either the grid or the user perspective. With mobile users, the optimal location may be literally a moving target. The virtual market operation of wireless grid focuses on the interactions between agents representing users, services and resources. Service discovery should deal with variables as the location/mobility of the service agent(s) and the capabilities of a located network specific device.

4.5. The desktop Grid – An interesting paradigm for Grid economics

Billions of CPU cycles go unused every day not only in enterprise idle PCs and Workstations but also to desktop computers that are oriented for home use mainly. Typically, a CPU of such users does very little even in cases where the users type in text editors, send e-mails or just read through an interesting paper from their screen. There are really hundreds or even thousands of such PCs in companies (smaller or bigger) that spare their CPU utilisation without having a profit in terms of work produced. Especially, the emerging broadband networks that have reached the end user in his home, accelerate the spread usage of the "always on" mode of interconnection.

It is obvious that such deployment of company and "home-made" idle CPU cycles (as well as memory/disk space, applications, information, files) can introduce a significant benefit in terms of Return of Investment (ROI) and extra "pocket" money for the users that are willing to contribute their resources into the Grid. The set of the desktop approaches for having a commercially exploited Grid seems to win a better place among other commercial or not alternatives.

There are a lot of such paradigms on desktop Grid. The American Diabetes Association uses a grid to simulate the intricacies of health-care plans, culling CPU power from more than 250 of its employees' machines. In the past running these models used to take days, but the deployment of the desktop Grid solution takes some minutes and additionally at a fraction of the cost. In 1997, scientists at the University of California, Berkeley, launched the SETI@home project, which uses an Internet-wide processing grid to analyze radio telescope data in search of extraterrestrial life. Another example is ZetaGrid which is an open source and platform independent secure cycle-scavenging system developed by the IBM Development Laboratory in Boeblingen. ZetaGrid is a cycle-scavenging system which on the one hand protects the participating machines from malicious jobs/users and on the other hand protects these jobs and their data from eavesdropping and modification. Finally, the DeskGrid is a framework that allows ordinary desktop PC's to participate in a department or company grid capable of solving problems from a wide variety of domains. A PC's screen saver notifies the DeskGrid server that the PC is idle and prepared to join the grid. If the PC's owner returns, its task is aborted and given to another idle PC. The server is configurable to support thousands of PC's on the grid, and any number of them can submit jobs for processing.

4.6. Economics from the perspective of operators (mobile and fixed)

4.6.1 Introduction and current situation

Before talking about the economics from the perspective of operators in a grid environment, we consider necessary talking about some issues regarding the current situation of the operators' economics in a global manner. By doing this, we will outline better the future market trends for telecom companies.

Everybody knows the reversal of fortune in the stock exchange valuation of telecom companies over the last decade and its implications, that is, the emergence of an enormous gap between the operator's expectations with respect to the future profitable activities and financial analysts and investor's previsions.

This is exemplified today by the persistent belief in and commitment to third-generation mobile communication of most European telecom operators, the delay in the UMTS implementation and the often over-expensive national licenses obtained by such telecom operators. This situation has damaged their economics and they have had to ask a discount in these licenses to the governments or, in some cases, the sale of the licenses.

Underlying this problem, we also find a significant research gap between, on the one hand, very detailed analyses on mobile communication technologies, their future application potential including the development of new technical standards, and regulatory and legal challenges posed, and on the other hand, what could be called "the economics of mobile communication", an area which – certainly when compared to the economics of information – has not really captured the imagination of many economists. (see [1])

This is a very important question, since with grid technology we could run the same risk, paying too much attention in technological aspects, more than showing the new services and applications in a friendly way to the user, and, consequently, to the society and the market analysts and investors. Therefore, it is key for the operators economics in the new grid market to present their products in a way that they would be easy to use, to understand and to manage for all players in the emerging market. By doing this, the grid technology will be offering to the ICT the possibility of attracting the attention of the economic world.

Taking account of this key aspect, we are going to give our vision of the operators' economics in a grid market.

4.6.2 Economics and technological challenges in a grid environment

Nowadays, the grid technology is in a state that we could name "fixed grid", in the sense which it opposes to the "mobile grid". That is, today, most of grid applications are focused on enhancing computing power in an environment of servers and desktop computers, which differs clearly from the amazing world of future grid applications in a mobile world. This is the reason for dividing this section into two subsections: fixed grid and mobile grid, which could be mapped into fixed operators and mobile operators, but bearing in mind that these two types of grid cannot walk totally separated.

4.6.2.1 Fixed Grid

As we have mentioned in the above section, the main objective of grid technology today is to enlarge the amount of processing power, which will make possible more sophisticated and powerful applications. But this trend is going further away, to the point of considering the computing power like a utility, susceptible to buying and selling, like other public utility services, e.g. water or electricity. At this point, the telecom companies arise in this scenario with two possible roles, i.e. like a consumer of computing utility and like a provider of computing utility. Having into account that in order to offer computing utility, an operator has to own it first, we are going to analyze these cases jointly.

The first question that emerges is: Why is going to be necessary for a telecom company to buy additional computing power and/or new equipment? There are various reasons and these necessities will demand from the operators an investment which will clearly affect to its economics and business models. It is obvious that this inversion has not to unbalance the telecom operators' accounts, therefore new ways of making revenues must be addressed. Furthermore, we can set a correspondence between these necessities and new business models. The reasons for purchasing computing power and his possible ways of making revenues associated are:

1. Today and, probably, in the future, the unique owners and administrators of the network infrastructures are the telecom operators. Then, these companies will have to set out the needed facilities for supporting the new requirements of the grid world, mainly, in the area of OSS and network management. Here, the way of making revenues lies only in the profits coming from a possible increase in the traffic over the network. Besides, this inversion could be considered like an inversion in assets improvement. About the network infrastructures, it has to be noted that today, in the telecommunications business, the trend is to have a unique (or a few) infrastructures provider (the telecom operator for us, in strict sense) and various services providers operating over them. It is possible that some current operators will move to the second role, selling their network infrastructures.
2. The telecom companies are going to be the responsible for setting and managing the network-related middleware systems of such infrastructures which will support the provisioning of different QoS, the mechanisms of AAA and the security functionalities. This, not only offers a possibility of compensating the inversions but it offers an actual possibility of doing very profitable business. This could be performed by offering these functionalities (provisioning of guaranteed QoS, AAA mechanisms and security) to the grid market players (users, service providers, third parties, etc.) in a subscriber model or in a pay-per-use model.
3. The operators could take part in the future grid services provisioning platform, being necessary new equipment investments. If the operator takes part of such a platform, it is supposed that a business is going to happen and the revenue share will be in function of the participation rate.
4. Simply, the telecom companies could purchase computing power with the only intention of reselling it. Here, we can see one of the oldest business in the world, that is, to buy something in order to sell it in a suitable manner.

After enumerating the reasons for acquiring these assets, we are going to enumerate the ways to obtain this new equipment. In principle, we consider three main manners:

1. Hiring or outsourcing this computing power to a grid service provider or any other entity capable of supplying it. This is a controversial option, because telecom operators and other big enterprises are reluctant to put their applications and functionalities in external machines. Furthermore, at the beginning of the grid environment, a telecom operator must not wait for another entity offering grid services, this situation could result in the chicken-egg paradox.
2. Buying this equipment from a computer vendor. This option could be very expensive and risky, because we do not know the future necessities, applications and market trends, both in the grid world and in the hardware development evolution. Choosing this option could result in the new equipment would be obsolete in a short period of time or in a disproportionate acquisition of assets.
3. Forming an alliance with a middleware and information technologies vendor. This is the most attractive option for both companies, and this union could result easily in an entity supplying grid services in multiple ways. Such an alliance would be profitable for various reasons:
    - The telecom companies could access the needed equipment at very competitive prices. Moreover, without considering the possible sale of computing power by the operators, the new emerging grid applications itself will require a huge amount of processing power.
    - The telecom operators could easily become a seller of computing power like an utility, because they could get all type of equipment and middleware systems at any time due to their alliance with the vendor. Thanks to this union, the operators could perform this business with a high degree of safety, scalability and flexibility at very good prices. In this business model, the operators could limit their activity to put the means for managing the named Mobile Virtual Organizations of the grid world, while third parties would be the actual owners of the network infrastructures.
    - The operators and the vendors could easily become a service provider, offering global grid solutions.
    - New potential customers and new business opportunities for both companies could emerge. Besides, this alliance could strengthen in economic terms both partners, and they could undertake more risky and profitable business.

4.6.2.2 Mobile Grid

It is not the objective of this section to enumerate or to imagine the multiple possibilities that the mobile technology and, therefore, the "mobile grid" technology are offering today or are going to offer in the future. However, if we want to say something about the economics in this market, first we must say something about the growing importance of this technology for the people. About this, in the mobilized information society the provision of new individualized information and communication access opportunities is continuously gaining importance. A large part of those new opportunities contribute directly to increase efficiency in production, economic distribution and transportation, but a possibly even larger part will involve increased consumer satisfaction, increased welfare and freedom of communication and exchange, often not fully captured in economists' traditional measures of value added and aggregate gross domestic product. Yet, it is precisely here that the notion of the mobilized information society takes on, to some extent, its full new meaning: a society in which the ease of communication and access to information and data is not just an essential ingredient of economic activity but also of leisure, of household tasks and of the vast array of so-called "non-work" activities, linked to social interactions and democratic expressions. We would argue that the continuously enlarged and easy access to this variety of new virtual goods and services represents to a large extent the new wealth of the 21st century.[1]

For illustrating the movement towards mobile communications, we can see in Figure 1 the fixed-to-mobile expected substitution in Western Europe in the voice domain, that remains the main source of revenue for the telecom companies.

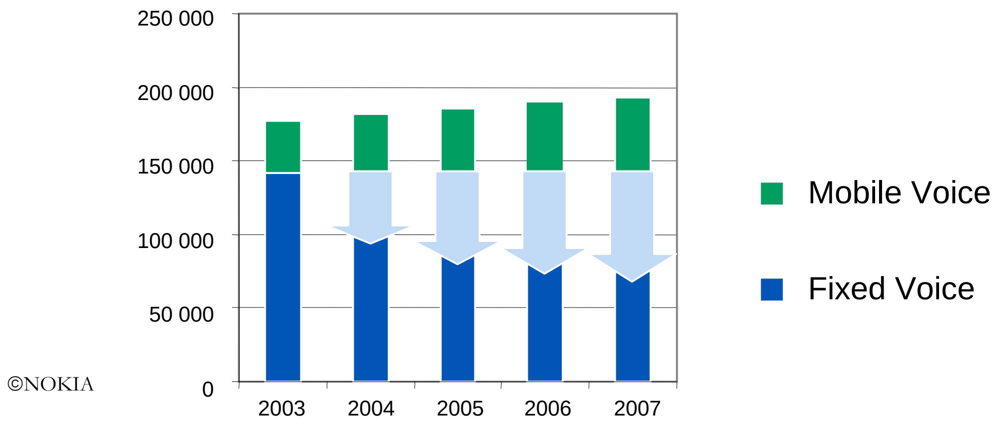

Figure 1: Fixed-to-Mobile Substitution in Western Europe

Having this key question into account, we are going to do some more specific considerations about the economics of "mobile grid" in relation with the mobile operators and their technological challenges, but bearing in mind that the ideas exposed in the previous section have utility in this one, not only for the reality that many fixed operators are at the same time mobile operators, but for the fact that for supporting the applications and services demanded by the "mobile grid" is necessary the acquisition of middleware facilities and computing power, because there will be the same or upper requirements that for the "fixed grid" case, that is:

1. OSS and network management.
2. Provisioning of different QoS, the mechanisms of AAA and the security issues.
3. Due to the great impact of the mobile technology in the current society and the enormous possibilities of business around it, the operators will take part in the future grid services provisioning platform with a high rate of participation.
4. The "mobile grid" market is going to be a market in constant evolution, therefore, the operators will have to be ready technologically for this changes.
5. At the moment, the telecom companies are investing in wideband technologies, and this inversion can be complementary with an inversion in grid technology.

Around the third point above there will emerge the main business opportunities for mobile operators, that is, taking part in a service provisioning platform. Here, the revenues are going to depend on various factors like following:

- Creation of new services and applications which satisfy the necessities of the users, not only in terms of working (growing importance of teleworking, among others) but also in terms of leisure and personal contacts.
- Quickness and security in setting these applications and services.
- Very competitive prices.

- Very clear and detailed invoices.

Besides, there is another business opportunity to be considered for the economics of the operators, that is, the growing market of portable devices in the mobile world. As in the case of getting computing power, the telecom companies could form specific alliances with portable devices manufacturers with the intention of offering specific terminals to access to the new applications and services. This is not new, because it already has been made in the mobile telephony market. It is certain that each time there are more types of personal devices, but it is expected that in any moment of the mobile grid market evolution there will be a more or less generalized mobile device having all capabilities for supporting the emerging applications. At this point, a terminal offered by a telecom operator in collaboration with a hardware vendor will be more reliable for the user than one offered by an individual vendor. This is a possibility of making revenues that the telecom companies must not forget.

4.6.3 General considerations and expectations

Today, the main source of revenue for the telecom companies is the voice and, as we have mentioned before, there is a clear trend towards mobile versus fixed communications. Nevertheless, the average worldwide growth rate in the mobile telephony is declining and, regarding the average revenue per user, after a period of decline, it is starting to increase in Western Europe, in most cases due to an increase of data revenues. It is expected that revenues from data services will continue increasing, and the "mobile grid" applications could hugely strengthen this growth, because the grid services could be considered like the next step in data services. Then, the operators could gradually offer these grid-based mobile services and applications in the same way that data services are offered today, having into account that the services and applications themselves, and their evolution and acceptation by the community of users, can determine the future business models for the telecom companies in an unpredictable manner.

Concerning the sale of computing power by the operators, this is a new business model that can be adopted for both types of operators (fixed and mobile) and for various types of enterprises. In fact, there are already computer vendors starting to offer grid computing pay-per-use cycles. However, due to the necessity of an internet connection for purchasing this computing power, we consider that this product could be offered in a more compact way by telecom companies, because the user could receive a unique invoice regarding to this service, unlike the non-operators case, in which there would be two invoices, one for the internet connection and another one for the computing utility. Then, the telecom companies could offer this computing power together with a suitable internet connection (they could offer it alone, too, like not-operators companies). Within the future service provisioning platform, the telecom companies will can choose between to be or not to be a seller of computing power, in function of their interests but, in any case, we consider that this will be a business model different to all already existing for the operators.

Having into account all of the previous considerations, we can conclude that the grid world will offer to the telecom companies new and multiple opportunities, and in different ways, for making revenues. The operators will can set themselves up as grid service providers, or participate in a grid service platform in coordination with other entities to offer many types of services at various levels. In such a platform, the rate of participation of the telecom companies will depend on their interests and capacities, and will determine their economics and business models.

Finally, we can not outline exactly the operators' economics in the far future, but we can predict a more fine grained and changing economy, with many specific alliances between companies for specific services and applications, probably, a new technological economy.

5. Operator's perspective

5.1. Operators and Current Market Situation

5.1.1. New technologies

Nowadays with the recent launch of UMTS technologies and the huge growth in broadband usage, it seems that new possibilities for multimedia services supplying mobility are emerging. The market is recovering again and this favourable evolution of the market will go on depending on new technologies, like audiovisual services through ADSL (Figure 2), direct access (PLC, cable,...), WiFi technology, VoIP services and UMTS standard mentioned above.

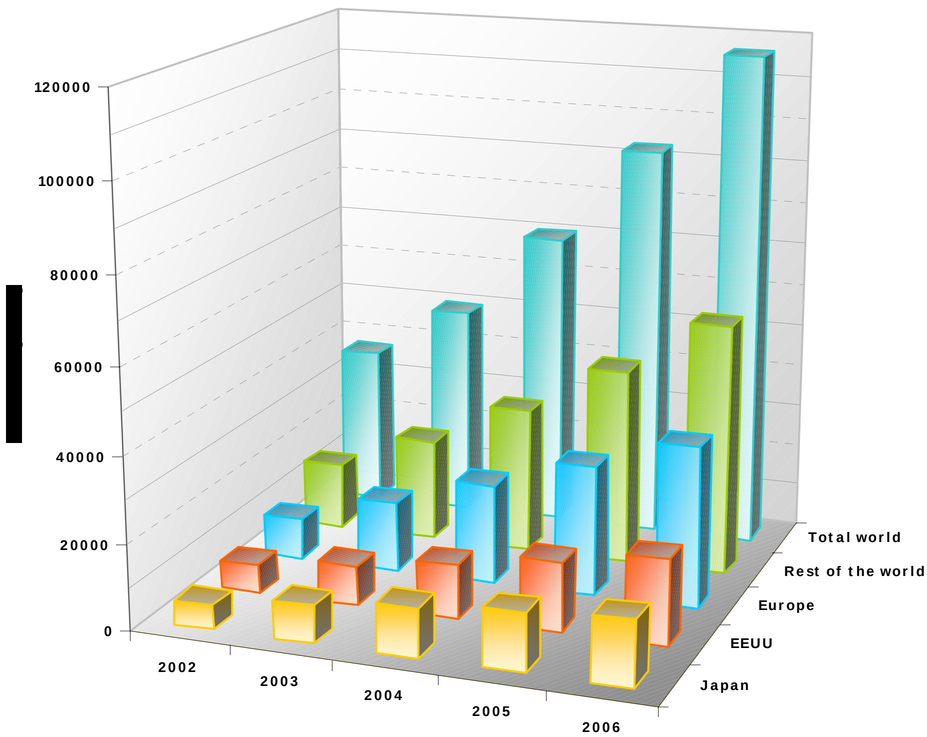

Figure 2: xDSL lines evolution (source: European Information Technology Observatory, 2004)

On the other hand bandwidth is increasingly available, therefore its price decreases allowing a greater investment on the part of enterprises. So the telecommunication companies (telcos) are going more deeply into wireless access making use of UMTS and WiFi hot spots, since this manages to reduce costs and supply employers with mobility, encouraging teleworking.

Also it is important to emphasize the boom of digital television on xDSL which uses current telephone networks, increasing its bandwidth up to a few Mb/second. In this way a broadband integrated multiservice network could be set up without difficulties related to infrastructure (as the copper lines are already available), opening a wide range of possibilities for residential users and small or medium companies.

Many telcos have committed themselves to policy based on development of broadband services through xDSL offering entertainment services as TV digital, VoD, music…, because of hopeful prospect created from the huge growth of xDSL world. [2]

As an example, Figure 3 [3] shows the increase in the number of ADSL subscribers in Spain (these days 60% of the market share matches with Telefónica). Owing to this rising demand Telefónica is working in a leisure and entertainment service called Imagenio, which offers Digital TV, Broadband Internet and Digial Audio [4]. Also other companies like France Telecom in Europe and Horizon.com in USA offer this kind of services [5].

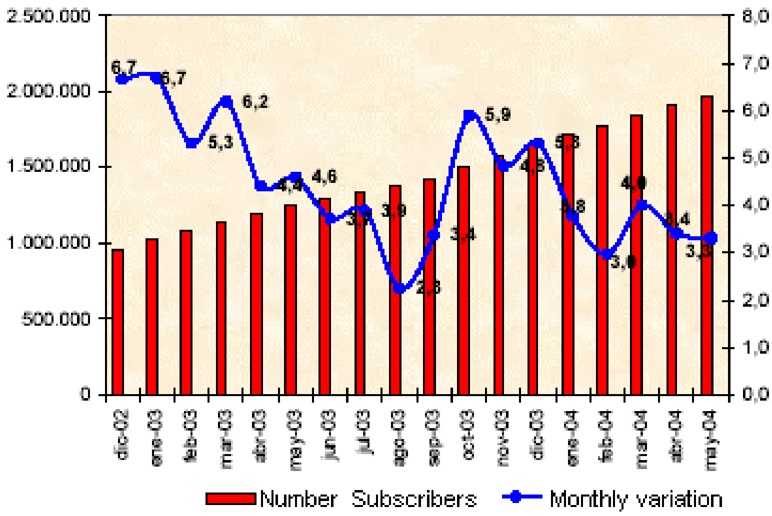

Figure 3: Evolution of ADSL in Spain

The main problem with this technology is the bandwidth consumed by video, but recent studies about MPEG-4 standard and AVC (Advanced Video Coding) affirm that it is possible to transmit TV through xDSL without losing too much bandwidth [6].

In the fixed telephony sector, the principal promoters are broadband services while the revenues gained with services provided by dial-up access have gone down. But mobile segments are gaining ground in telephony, since fixed-line telephony can not offer the necessary future functionality that attracts voice-call customers [7]. During this year the sale of mobile telephones has increased 34.2% in the first quarter compared to the same period of the last year, because the users are replacing their devices by new terminals with more features like camera, colour screen and WAP services [3].

Also, it does not make economic sense to build copper telephony networks in developing countries where such networks do not already exist. On the other hand, traditional wireline and long distance operators have been losing a small but increasing chunk of their business to wireless carriers.

5.1.2. Advances in VoIP

Moreover, over the past few months all major telcos [8], [9] have announced forthcoming VoIP services on dedicated, purpose-built IP networks as a opportunity to increase their profit, therefore incumbents need to participate in this technology if they want to remain in the market. Besides, the use of this technology would involve a saving on internal costs as most enterprises have already invested heavily in IP backbone networks and they could make use of this for internal calls. Therefore a tendency is developing, which substitutes the conventional switched circuits for IP packets [Figure 4] and it will be deeply exploited in the near future.

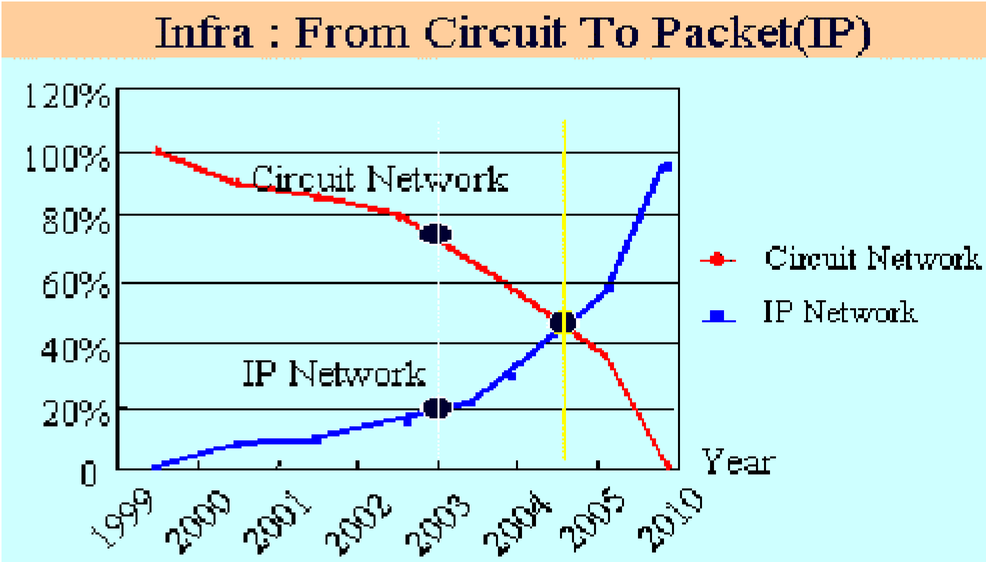

Figure 4: Migration of voice from switched circuits to packets Evolution of ADSL in Spain

With advances in VoIP technology, above all in QoS since it is the field with more problems, the stage where voice calls can seamlessly share data IP lines is finally reached. The telcos are seeing that the growth is in data, not in voice. So, if they want to keep their old customers and go where the revenue streams will grow, they need to find a way to obtain that data business, that is, provide VoIP and profitable data services on the same infrastructure.

5.1.3. Integration of networks

The telecommunications business has changed in some obvious ways since the boom that ended around the year 2000. Cost reduction is a big factor for telcos at the moment so they are looking for ways to consolidate their infrastructures to save money and free up resources in order to develop new services and drive more revenue. It has been a real convergence of IT and telcos, so that more and more telco services are based on Internet Protocol (IP) technologies.

The future vision for communications technology is a converged voice/data/video system using IP. At the centre of this new universe is the IP-wide-area network, with all communications services including voice, data, video, and wireless gravitating around it. It promises significant savings in infrastructure and management costs besides new applications that would be developed around the model of an efficient "dumb" IP network, with very powerful and versatile computing end nodes.

Now, telcos are embracing the idea of achieving a real integration of networks, for example the converged phones, devices that allows reception cellular and wireline calls on the same phone.

5.2. Users and Services

We find three important market segments by analysing market and business scenario:

- Citizen
- Small-sized companies and medium-sized companies
- Big-sized companies and Public Administration

We can make another classification relating to the consumer´s profile and their purchasing power. These are summarized in three modalities, according to service consumer expectations:

- Users who only demand low performance of service use (understanding performance to be, the number of services and/or QoS of demanded services). They do not demand too many requirements of operator, except very low costs of contracted services.
- Users who demand medium performance of service use. There is a difference between these users and the previous ones, because these users demand some more advanced aspects of services, the same way as a slightly different treatment from low facilities users.
- User who demands high performance of service use. They are characterized by a large purchasing power and a predicted average income is superior to the other profiles.

For each segment we try to give a view of which services or solutions are successful and what are the future business sources. We consider that proposals of evolution need to segment and configure service supply in different layers of performance, capacity and QoS. This offer needs to be divided into a range of services with different layers of price. For example, we could think about a voice basic service (like fixed voice) and a star service that adds the possibility of sending and receiving video while on the move .[10]

We connect market segments to consumer´s profile in the table below.

	Low performance	**Medium performance**	**High performance**
Citizens	X	X	
Small/medium-sized Companies		X	X
Big-sized Companies / Public Administration			X

Table 1: Market segments and consumer´s profile

A new source of business is the integration of products, services, applications and contents in a unique platform of services. This platform will act as 'service aggregator' or 'service composer' offering different contents and services to users in an integrated and friendly manner.

An example is Telefónica´s "Unified Messaging" service, which unifies e-mail, voice and fax messages allowing users to send, retrieve and receive messages disregarding the format and the terminal where the user is connected (fixed lines, cellular lines or PCs) [11]. This service allows to retrieve:

- Stored voice messages from different fixed and cellular lines and from a web page.

- Stored fax messages from a web page or phone.
- Stored e-mail messages from fixed or mobile phones.

Another example from Telefónica is the "Mundo ADSL" package, which offers an integrated solution in the context of communications and leisure including new contents and broadband and easy to use services. This package includes unified messaging, instant messaging, videoconference and multi-videoconference service, different sorts of music, videoclips, some musical news, concerts, etc., network games and e-learning [12].

5.2.1. Citizen

Citizens are users who need only low or medium performance services. However there is a predisposition not to pay for basic services, because they expect basic services to be free of charge. We face a scaling problem where there must exist a lot of clients to obtain profit. For example, regarding online services, the possibility of the public interacting with the administration through the Internet is perceived as one of the most interesting actions involving them, but the citizen will not agree to pay as they consider it a public service which has to be free. However, online education or special shopping (which has motivations from daily life) are assumed to be areas where citizens will agree to pay because they believe they obtain personal benefit.

Relating to services which are demanded by citizens, we can distinguish two kinds of services according to who communicates with whom:

- Personal communications (P2P), that is, person to person.
- Content to person (C2P), that is, access services to information.

For each of those sorts of service, a large range of services offered is predicted, from basic service to star service. As services which are offered nowadays or will be able to be offer in the future and advance great business opportunities, we can distinguish the following ones:

- (P2P) Personal communications and related applications and services are likely to be a large development field in the nearest future. The mobile terminal turns into a platform for interactive applications and a basic system of interpersonal multimedia communication. It facilitates chatting and searching for people with similar interests and characteristics. Another example of personal communications is a Social Grid, a free online dating service and decentralized social networking community that helps people meet through Google. Social Grid can help you search throughout the Internet for their "perfect match", people with similar interests, goals, desirable traits and characteristics [19].
- (P2P) VoIP. Related to fixed telephony [20] showing that voice services market is flooded and it is constantly going down, narrowband services have limited possibilities and low profitability and broadband services market is continually growing and developing. So VoIP could be a threat to fixed operators when broadband access to the Internet becomes more widespread, but it is a new opportunity in a new market too.
- (C2P) Digital TV as a means to introduce interactive applications at home.
- (C2P) The mobile terminal as a tool to pay, invading the field of the credit card.
- (C2P) Video game and entertainment software connected to the network.

- (C2P) Boom of applications peer to peer (P2P) in order to share files is promoting the broadband business.
- (C2P) Digital home allows easily to create, use, manage and share digital content in the home. The digital home contains one or more intelligent platforms which can manage and distribute rich digital content to devices like TVs and wireless monitors, and from devices digital still cameras, camcorders, and multimedia mobile phones, providing a seamless interaction among Computer Electronics (CE), mobile, and Personal Computer (PC) devices [21].
- (C2P) Home automation or Domotics. It is all about automating things in your home (home functions), a combination of technology and services for improved living in the areas of safety, comfort and technical management. A central controller (microprocessor) receives signals from controlling devices, then forwards those signals to the appliances and systems in the house you want controlled. The central processor serves as a traffic cop by initiating and/or routing communication signals throughout the house. As the user, you can interface with the system via keypads, touchscreens, panic buttons, TV screens, computers, telephones, handheld remotes or other devices.
- (C2P) Multimedia contents (video, music, education).
- (C2P) E-Commerce favoured by decreasing mistrust of payment is applicable to online operations.

5.2.2. Small-sized and Medium-sized companies

These companies are users who demand medium or high performance services, so an attractive offer will have to be done in order to get most of their buying availability.

We distinguish two sorts of operations:

- Business to Business (B2B), understood as buying and selling relations between companies which are based on technologies of information and communications. As far as B2B opportunities are concerned, we emphasize process optimisation, improvement of QoS, increase of market, decrease of supply time and reduction in costs. All of them have repercussions on improvement of company competitiveness.
- Business to Consumer (B2C). In connection with this sort of commerce, we emphasise the importance of the website addressing merchandising aspects (publicity and information about their products) and fundamentally to e-commerce whether to attract new clients or to sell their own products.

Relating to company management tasks, use of running tools is very important intensified by use of instruments like an intranet.

5.2.3. Big-sized companies and Public Administration

In these cases it is even more important than the previous one to take advantage of big companies' buying availability.

We must pay attention to tools which will enable the integration of services and resources across highly distributed, heterogeneous and dynamic virtual organization within a single enterprise. We are referring to database integration, clustering services, security services, workload management and problem determination.

These above challenges, which are related to the construction of reliable, scalable, and secure distributed systems, derive from the current rush, driven by technology trends and commercial pressures, to decompose and distribute through the network previously monolithic host-centric services .

The continuing decentralization and distribution of software, hardware, and human resources make it essential that enterprises reintegrated the distributed services and data resources with QoS. Enterprises require an increasingly robust IT infrastructure to handle the unpredictability and rapid growth associated with e-business ventures [22].

Neither must we forget the adaptation (increasingly widespread) of employees to teleworking and the need to access to corporate network anytime, anywhere in a safe way and replicate in-office environment

Regarding Public Administration, this also aims at online services for citizens and companies.

5.3. Business considerations

It is very important to clarify what a project like Akogrimo can provide to telecommunication companies in terms of new business opportunities, or increase of current ones. Under the point of view of business, we have identified some relevant topics that can contribute to make Akogrimo attractive to telecommunication companies, and why should be considered.

- Potential customers
- Equipment investments considerations
- Network/Services improvements
- Market roles
- Marketing considerations
- Mobile Grid development leadership

5.3.1. Potential customers

One of the goals of this project is to provide users a pervasive environment that facilitates communications and access to grid resources anytime, anywhere. This requirement will make necessary agreements between network operators, services providers and third party entities, so the number of (direct or indirect) potential users will increase.

Another important consideration regarding potential users is that the development of solutions enabling services like Akogrimo eLearning or eHealth will allow the access to a currently poor exploited markets (e.g. public and private health, education and research institutions, national or local governments) that can result very interesting because the volume of business that these kind of customers could represent would be really significant.

A direct consequence of the increase in customers (that has a significant importance by itself) is the subsequent increase of the number of investors, because a bigger company used to inspire more confidence to Stock Market players.

5.3.2. Equipment investments

Grid concept can be considered as the extensive and intensive use of the distributed and collaborative networks. We can use distributed machines and resources to solve big and complex problems in behalf of powerful and complex equipments. The advantage of having small (and obviously cheaper) machines is clear, the equipment costs will be reduced.

The grid technology provided by Akogrimo will supply also the advantage of the dynamic creation and managing of Virtual Organizations, configured specifically to solve some kind of problems and destroyed when work is finished. No specific equipments to solve specific problems are needed.

In this way one of the consequences of the use of grid is that for the same kind of service intended to offer, the costs are moved from the infrastructures to the software that controls the access and manages mobile grid resources. The hardware usage will be optimised, so we consider that this feature will contribute to reduce infrastructure investments.

5.3.3. Network/Services improvement

The telecom operator has to consider what the offering of mobile-grid services can provide in terms of the enhancement of the network or offered services. This consideration has to be taking into account under several viewpoints:

- Services that are not currently grid based would be enhanced in a significant way. The use of grid technology (the 'gridifying applications') can supply an added value (e.g. in security and speed) that can be noticed by the customers and capable of be billed by the companies.
- The capability of grid technology of acting as 'service aggregator' or 'service composer' could have an obvious impact over the value chain. Service providers are responsible for the single services, but operator (thanks grid technology) is offering them to the user in an integrated and friendly manner.
- The resource optimisation derived from the use of grid technology can have repercussions on network performance.
- The success of mobile services and its penetration in the market can facilitate the development of new ones based on grid and guarantee its acceptance (to a certain degree).

5.3.4. Market roles

The business opportunities that Akogrimo can provide to the network operators can be related to the roles that the telecom companies can have in the market. As we have commented, the use of grid can modify how the services are offered to end users, so in this case the operator is acting as a 'Rich Service Provider'. But real Service Providers or Third Party companies will use an operator's network infrastructures to provide end user services. In this way, grid technology will offer to telecom companies the opportunity of having two main roles in the future telecommunication market: infrastructure provider and service provider. This means that the business opportunities to the telecoms will be multiplied by offering 'end user services' as well as 'intermediate services'.

Analysts (Grid Technology Partners, Ovum, Insight) estimate the total Grid market for 2005 to be in the range 1-4 billion USD. Figures vary partly because there is no universal definition of Grid, and partly because many current Grid activities are non-commercial. Importantly, most analysts predict rapid growth in the Grid market in the next few years.

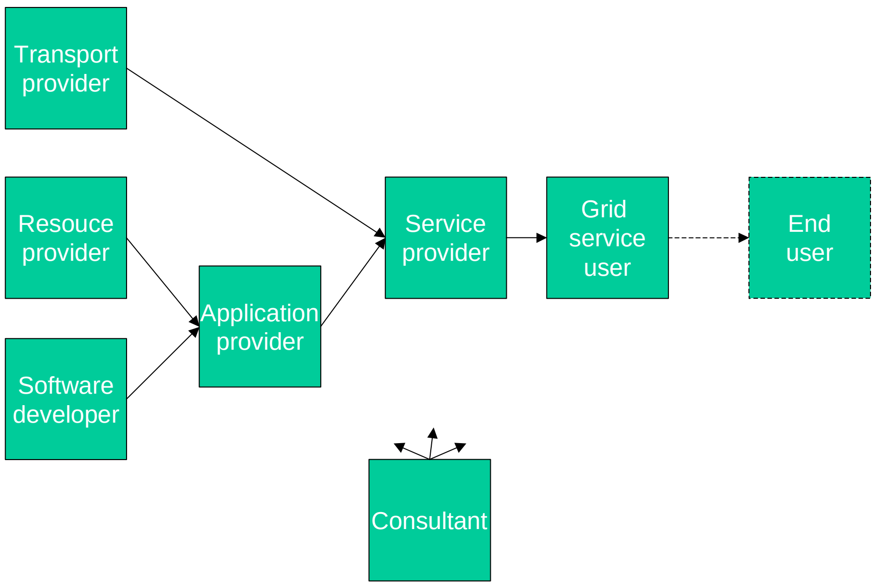

Figure 5 Possible grid value network.

Figure 5 suggests a Grid value chain, in which the following actors are identified:

- **Resource providers:** These provide low-level resources such as data storage and processing power.
- **Transport providers:** These offer data transport between different locations. In the context of Grids, this could include enhancements over best effort IP, such as capacity reservation and ad-hoc VPNs.
- **Software developers:** These develop application-level software for the Grid.
- **Application providers:** Application providers offer access to running instances of application level services.
- **Service providers:** The services providers orchestrate sets of application-level services into useful workflows. They also mediate charging and billing, security and trust between the Grid service users and the other actors.
- **Grid service users:** These are the consumers of the application-level services that the Grid provides.
- **End users:** As indicated by the dashed arrow, the Grid service user may use the Grid for realizing services with a user interface towards its own customers.
- **Consultants:** Consultants provide Grid expertise to the other actors.

Some of these roles could fit well with the business of a network operator. Most major network operators are already present in the hosting and outsourcing market, either directly, or, more commonly, through a subsidiary. Providing Grid resources and application level services should be a natural extension to this business.

The network operator is an obvious candidate for providing data transport for Grids. The enhanced network services that Grids require is an opportunity for increasing service differentiation, and hence margins, in a situation where data transport margins are generally falling due to increased competition and abundant dark fibre. The mobile Grid could also be an important source of mobile data traffic. In this market there is generally less competition and higher margins.

Network operators have unique experience in managing complex, distributed and heterogeneous systems. They also have established billing frameworks, wide-reaching customer relationships, and are generally trusted by the public. For that reason, the network operators should be well positioned to assume the role of service provider.

Network operators are also extensive users of IT services. Some of these services could be implemented cheaper and with more flexibility using Grid technology. This would cut overall costs for the network operator, and also allow the operator to respond more quickly to changing market demands.

A network operator is likely to possess in-depth knowledge of many aspects of Grid technology, as well as unique holistic understanding of the overall Grid value chain. This knowledge could be utilized for offering consultancy services to other actors.

Some business areas regarding the role of Mobile Grid infrastructure provider:

- Companies that use Mobile Grid Network infrastructures to provide end user services.
- Hosting (e.g. location of company's data bases - like customer and product suppliers data bases - into operator equipments, and accessed remotely using grid).
- Computational power
- Network provider.
- Provider of A4C services.

Some business areas regarding the role of Mobile Grid service provider (some of them commented in 5.3.3):

- 'Gridification of applications'.
- Service Discovery & Composition
- Specific applications

5.3.5. Marketing considerations

The European telecommunication market has evolved from one company under government control to the current situation, where there is a real liberalised sector with several companies competing between them. So nowadays the importance of marketing to the operator is crucial in order to increase its market share.

In case the scenarios to be considered in Akogrimo (eLearning, eHealth, DHCM) .become real applications, they could have the capability of improving the population’s subjective perception of the company, due to its attached social contents. This perception improvement has to be taken into account because it could be easily translated into benefits (the people would be willing to subscribe contracts with a company involved in that kind of projects).

5.3.6. Mobile Grid deployment leadership

Akogrimo is intended to connect the network services and the grid world, currently unplugged from each other. The leadership on the grid and network services fusion process will provide to European telecoms a competitive advantage regarding other companies that discarded this possibility, similar to what happened to the GSM deployment.

The know-how that Akogrimo can provide to the network operator regarding grid technologies should set up the basis for opportunities that currently remain hidden, by exploiting synergies that will appear when both worlds work together.

Some studies point out that grid technology will have a privileged role in future networks. Taking advantage of the leadership and the acquired know-how, telcos will be able to offer consulting services regarding grid technologies to other companies.

5.4. Technological considerations

5.4.1. Introduction

Today, it is a reality that Grid computing may transform the Telecom industry. For example, in the U.K., British Telecom recently won a $1 billion contract to upgrade the national health network, connecting the largest hospitals at 100 Mbps. BT will build the network but not run it. IBM announced that it had earned $7 billion with similar contracts for its "on-demand" computer services last year and that it had also saved $7 billion on its own operations.

Perhaps the most obvious application of grid computing within telecom would be in OSS (Operation and Support Systems) and network management. Grid computing techniques will allow the design of self regulating, self healing networks which will allocate bandwidth more effectively to subscribers and will enable the network to respond intelligently to denial of service attacks and other deliberate sabotage, in addition to currently used mechanisms (protection switching, adaptive routing…).

At the same time, one can envision grid computing placing heavy demands on the network as machines working in tandem exchange enormous files with one another, perhaps necessitating instant provision and bandwidth allocation on an unprecedented scale. Mostly grid computing has not stressed networks much to date in terms of latency requirements or sheer bandwidth, but conceivably in the future that could change, which could be a good thing because it could quickly use up overcapacity in the networks.

5.4.2. Service reshaping

Grids will alter the business models for telecoms and reshape the products equipment vendors offer and the software most firms use on networks.

Why? Because with grids, networks can take advantage of layers above Layer 1, the physical layer. They can begin to support applications that can ride on the physical layer and offer them as services. In the British Telecom case, the service provider will recruit existing customers who want to offer access to unused computer resources so that BT can offer "surge" or "on-demand" capabilities to customers. This is the initial step in upgrading the telecom business model.

The next one is to provide applications over the new network. This will require network equipment that can self-provision or self-prioritize traffic so it is handled with platinum QoS or moves to highly reliable hubs in the network rather than unreliable ones. Supporting grids means never dropping key bits of information and crucial connections.

If there is any doubt about this, research networks in the U.S. and Europe are pushing the boundaries of bandwidth use further and want greater control over their traffic on networks. They want support for grids and grid applications. Equipment vendors are waking up to the fact that grid applications require support above Layer 1 and might offer a means to avoid the further "commoditization" of network equipment prices. Also, software vendors are offering middleware to "gridify" applications, so they can be part of grids and run on new networks.

5.4.3. New challenges and mobility

The new mobile multimedia applications will require large storage, bandwidth and computation resources and the handheld devices are limited in memory, computation and power. Furthermore, the mobile nature of the clients leads to frequent tearing down and reestablishment of network connections; the latency introduced by this process causes jitters which may be unacceptable for delay-sensitive streaming multimedia applications. Solutions such as Mobile IP introduce additional latency. While buffering at the client is a usual solution to jitter problems, mobile hosts often have limited memory resources. Also, buffering cannot be used for interactive services with real-time requirements, such as VoIP or gaming.

Under the viewpoint of the telecom operators, these issues represent problems to solve. It´s true that some of the obstacles mentioned above could be overcome through the utilization of new specific devices but we believe that an overall solution by telcos is necessary. One possible solution to achieve real time delivery guarantees in mobile environments is to use connection-oriented services combined with stream buffering in the path of service. Another popular technique is to transcode the incoming stream from the server at a local proxy that can customize the multimedia content based on user characteristics. Since different users require information at different QoS levels and devices may have varying resource/power capabilities, personalized customization of applications can achieve QoS assurance while prolonging the lifetime of the mobile device. The objective would be to use locally available (idle) grid resources to customize multimedia applications for mobile users based on user requirements and device limitations.

Several complications arise in ensuring the effective utilization of grid resources for mobile multimedia services. Firstly since grid resources are intermittently available; optimal scheduling policies must take the availability of grid resources into account. Secondly, the heterogeneity of grid resources and clients complicates the resource management issue. Thirdly, user mobility patterns may not be known. Furthermore, since multimedia applications have QoS requirements (e.g. required network transmission bandwidth, accuracy and resolution of displayed images); an effective resource allocation policy must address the performance-quality trade-off. This trade-off arises since finding optimal local resources for a mobile host that lowers overall network traffic (i.e. improves performance) can introduce frequent switches in the multimedia stream possibly leading to increased jitter (lower QoS).

Summarizing this point, the telecom operators must have into account all of this questions, intending supply global solutions, facilitating the introduction of the new services in a general way.

5.4.4. Technical benefits of Grid

According to research carried out by Quocirca, 52% of large European companies have little or no knowledge of the loading of their existing infrastructure assets, while half of the assets in those companies that do have knowledge of the loadings are heavily under utilised. The adoption of a Grid architecture by the telecom operators could provide the following technical benefits:

- Greater resource utilization leading to a lower cost base.
- Increased componentisation leading to greater functional commonality.
- Less need for application skills.
- Greater up-time and disaster tolerance capability.
- Fewer decentralized solutions and/or departmental solutions.

5.4.4.1. Greater resource utilization leading to a lower cost base

The main technical selling point of a Grid architecture is the minimizing of capacity constraints. By maximising utilisation of existing assets, the pain of upgrading any hardware asset is put off for a period of time. Also, as the Grid is virtualised, the addition of more compute, network or storage assets is far simpler than when dealing with a standard application-based network. The assets are plugged into the Grid, are identified as available assets by the Grid services and are then open for use by the functional assets within the Grid. Self-provisioning of function – where new compute assets are populated with the software required to provide functional assets – is controlled by the Grid management software, enabling the rapid absorption of new assets into existing Grids.

5.4.4.2. Increased componentisation leading to greater functional commonality

The main business benefits for a Grid come from the ease in which business processes can be mapped onto functional assets. The finer grained the functional assets, the more fine grained the business process can be. Also, a fine grained set of functional assets enables a directory of functions to be held which are accessible to technical staff for re-use. As Grids and service-oriented architectures evolve, libraries of basic functions will be able to be purchased from standard software vendors.

If an originating request requires any date functionality, it should call a centralised calendar function. Similarly, if the request requires customer information, it should be able to get it via a set of common functions, rather than through pipe applications. Should a request require a billing engine, this should be available as a callable function. Every time these assets are upgraded, they are upgraded across the whole of the Grid – minimising the need for regression testing and the need for re-integration.

Web service evolution will drive this functionality within a Grid architecture, and the use of UDDIs (Universal Description, Discovery and Integration), other directories and SOAP will drive the capacity for functional asset reuse and commonality.

5.4.4.3. Less need for application skills

The age of the monolithic application is passing. The break down into functional components is gathering pace and will rapidly move to a web services, service-oriented environment. Process skills will become far more important than any specific application skills – which are expensive to pick up and maintain. As the Grid is virtualised, these process skills will be far more business focused than technical, and the lack of need for point management skills also creates a lower skills base cost. The capacity to adapt existing process components within the Grid to support changes in, or new, business processes enables far faster responsiveness to business and market needs.

5.4.4.4. Greater up-time and disaster tolerance capability

The virtual nature of a Grid provides greater inherent resilience. The built in redundancy of the Grid also then leads to better business continuity and disaster tolerance capabilities. Data back up and restores become less of an issue, as back ups can be carried out continuously in the background utilising any spare CPU and network capacity, rather than waiting for that increasingly rare commodity – a quiet period of time sufficiently long enough for a complete image back up or a data replication. Disaster recovery becomes less of an issue – the Grid provides better business continuity capabilities, minimising risks to the company should there be single, or even multiple, component failures within the Grid.

5.4.4.5. Fewer decentralized solutions and/or departmental solutions

Grid architectures provide a means of providing solutions faster and at lower cost. In many organisations, the prescriptive nature of existing architectures and the cost of introducing new functionality has led to departments making tactical decisions to introduce functionality within their environment outside of the IT department's control. Through bringing these point solutions back into a centralised environment, the functionality can be shared, full support can be provided and licensing and maintenance costs can be optimised through the power of centralised negotiations.

5.4.5. Expectations

Commercial network operators such as BT see the grid as a "virtualization" business model across ICT resources that plays to the telcos' strengths in the management of distributed resources.

Companies that have incorporated grid and cluster computing and Web services into their business are seeing positive benefits that will stimulate significant demand for broadband services.

We also have the vendor community moving towards Grid. Oracle's 10g database and application server are optimised for Grid computing. HP is enabling Grid capabilities throughout its product range. AMD is marketing its Opteron processors as ready for Grid. IBM and Cisco have teamed together for a Grid push.

European scientific networks express greater hope. Indeed, astronomical and physics research use grids that require speeds of 100 Gbps and in one case, up to 20 Tbps. By 2010, the European VLBI (Very Long Baseline Interferometry) Network, that uses direct lambda circuits will have speeds of 1 Tbps. The U.S. TeraGrid is using a backplane with 50 Gbps.

6. Market players and regulations

Deeper studies of issues relating to the market have been made in Akogrimo. In this brief chapter, we summarise reports produced on market players (Akogrimo deliverable D2.1.1) and on regulations (Akogrimo deliverable D2.1.2).

6.1. Market players

To achieve world-wide pervasiveness of mobile grid computing needs an approach from both technological and commercial points of view. From the technological point of view, adding mobility to a grid requires a middleware that provides for mobility management as well as supportive infrastructure counting to a global coverage. From the commercial point of view, cooperation with commercial mobile service providers is necessary to achieve global pervasiveness. Should, however, restricted coverage (e.g., metropolitan areas) or simply roaming be sufficient, new trends have brought non-commercial solutions for mobile middleware and non-centric network technology into attention, up to now mainly challenging telecommunication business providers and digital content providers.

The technological evolution and foreseen commercial cooperation will result in a new approach termed the "Akogrimo market", which can be approached by investigating the business of potential Akogrimo market players that have been identified so far. These include: application users, application providers, platform providers, service providers, content providers, and technology providers, the latter ones providing network technology (mobile grid branch), grid technology (computational grid branch), and semantic technologies (informational grid branch). In order to deliver a product in cooperation, business players need to interact. This interaction must be described in a generic manner. For the timeframe of interaction, co-operating players form a "virtual construct" that comes close to the Akogrimo case: the MDVO (Mobile Dynamic Virtual Organization). Therefore, MDVO has been chosen a model for studying the business flow investigation.

Investigating the above-mentioned Akogrimo players provides the reader with an overview on the mobile telecommunication industry, the grid computing industry, and the semantic technology industry. Studies have been made of grid applications and the technology that is the basis for computational, informational, and mobility grid, including so-called disruptive technologies. It is anticipated that Akogrimo is expected to become the key driver to boost business developments for all involved players due to the global and pervasive application of mobile and semantic technologies. It is still uncertain how significant intermediaries/third parties and disruptive technologies will look like, though. This aspect should be investigated in more detail. It is stated in D2.1.1 that a significant market penetration will have consequences for telecommunication service providers and it would challenge the Akogrimo business model, if it were based purely on a provider-centric and client-server architecture.

6.2. Regulations

This evolution to a mobility-aware Grid community will need to be supervised and Akogrimo has to define the system boundaries in order to achieve each goal. All infrastructures and services have to agree with the effective laws in each country.

From the user's point of view the most important will be to assure that all the information sent is confidential and the user can access wherever he is from his mobile device.

From the provider's point of view they must offer billing transparency and provide technological systems to work with grid services.

Thus, an important underlying factor for services, platforms, middleware, and applications offered in a highly competitive market of grids and future mobile grids is determined by regulations, which specify legal constraints to be considered for any public offering, including all roles of developers, providers, and customers, and determines boundaries for security, privacy, data protection, digital rights management, and intellectual property rights.

Driven by user demands of a confidential and secure service delivery of data and services and restricted by provider constraints of legally binding service offers, following detailed regulation guidelines, the Akogrimo study (D2.1.2) from earlier in this project provides the necessary overview on regulation authorities, regulatory areas, and key European as well as selected world-wide regulations, which serve as the basis for the definition of a regulatory guideline to be considered and applied within a competitive wireless and mobile grid environment.

On one hand, the core basis for a country-extending service offering, such as world-wide accessible mobile grid services, is legally constrained by regulation authorities in our world. Driven by the European perspective of the Akogrimo's project, EU-wide authorities are outlined and selected country-specific ones are discussed to determine regulatory players to be considered for any further technical and commercial development. On the other hand, the areas of regulation known so far are focussed with respect to Akogrimo's project goals on telecommunication operators, forming the role of transporting bits and bytes across networks. Furthermore, the area of mobile grid applications will be affected by security and privacy, by data protection directives, and by electronic commerce directives, thus addressing the role of users/consumers and providers. Additionally, digital rights management and intellectual property rights are of key importance for content providers. Finally, to ensure that the European-specific situation on regulations in those areas of Akogrimo's mobile grids is well documented, selected EU countries and the Swiss case are summarized as well. In a brief world-wide overview, key regulation situations within the US, Japan, and Australia are considered as well. Those general areas of regulation and their respective authorities identified within D.2.1.2 are utilized to develop and propose a regulatory guideline, which is applied for selected areas and European countries, showing in a fully structured form all major influences on (a) the mobile market and (b) the grid market envisioned. Thus, this work offers a classified presentation and technical discussion of checkpoints, technical areas of concerns, and potential dangers to be considered, when one of Akogrimo's role will be taken up by a company and shall be instantiated in a commercial manner.

7. Socio-economic analysis of Akogrimo vertical application domains

Since two of the planned testbeds in the Akogrimo Project are in e-learning and e-health, we consider the environment of these two application areas. The testbeds themselves are described in another Akogrimo report.

7.1. E-learning domain <Note: Need the references for citations already present>

Although this section does not aim to provide an in-depth analysis of the socio-economic aspects related to the exploitation of e-learning applications in a mobile grid environment, it will provide some thoughts about the advantages (from a socio-economic viewpoint) of exploiting this future environment in order to provide new ways of learning in informal and formal learning contexts.

In order to put this section into the picture, we would like to summarize here the ongoing world wide debate about the impact of current and emerging technologies on learning that can be understood as a specific topic of the more general discussion related to Ambient Intelligence and its relevance for the development of the future information society.

7.1.1. Brief historical outline

The term e-learning may be trendy, but the concept itself has been around for decades. E-learning is training that takes place through a network, usually over the Internet or a company intranet.

E-learning research arose and has been arising a lot of interest due to the advantages that it should provide in term of time and money saving. In fact, e-learning eliminates costs by allowing, for example, a specialist in Lisbon to train an entire group in Athens without leaving the office, furthermore it also offers more accessibility to the instructor and more flexibility for the students.

The use of technology, particularly Internet-based technology, to support learning promises much. In particular, in relation to the potential it gives the possibility to provide learners with an environment that allows to distribute studies in term of place, time and pace.

In general, technology has always had a big impact on learning development, since the invention of mass book printing by Gutenberg in the 15th century, and when we ask about the impact of every new technology, we can state that the effects is on mass distribution of learning. On the basis of this statement we can say that the phenomenon that introduced a real learning revolution was the diffusion of media that has allowed the birth of distance learning in its modern meaning: with the still picture photography and moving picture cinematography, with radio and visual and oral TV broadcast, learning content was accessible for everyone everywhere.

The biggest barrier to the success of educational media has been the difficulties of students interacting effectively with instructors, an ability inherent in the live classroom.

The explosive growth of the Internet changed the essential character of delivering educational content to remote students, providing the foundation for more advanced elearning solutions based on the effective interaction between learners and teacher. The term “distance learning” and “telematics” were coined to describe the process, which no longer relies on the TV. The Internet is becoming the medium of choice for educators, since it provides elements vital for distance learning, such as on-demand delivery of video, audio, text, and graphics, immediate online access to vast libraries of research materials, real-time or near-time interaction among instructors and students.

With the Internet coming, it seems that the potential is there for creating learning environments that meet the needs of the modern, diverse learner and widen access to higher education still further. Such an environment requires an emphasis on learning rather than teaching, and places the learner at the centre of the process by engaging them in purposeful activity, problem solving, collaborations, interactions and conversations.

It also recognises that learning is social and involves an active learning community of tutors and learners. The range of communication and collaborative tools available enables to provide for the interactions, learner to learner and learner to tutor, needed for feedback, collaboration, support and guidance - something increasingly difficult in face-to-face delivery. This environment provides the potential to make the best of both worlds by combining traditional approaches and activities with technologically supported ones. And, by enabling learners to go beyond the bounds of their specific course in their search for resources and tutors to search for and re-use content across courses and disciplines, we stand a chance of creating truly effective learning environments.

7.1.2. From e-learning to m-learning: the potential of mobile and grid technologies

Richard E. Clark (1983) carried out a meta-analysis of 80 years research on effects of technology on learning and he reports, that there is no empirical evidence on learning benefits from media (the 'no significant difference' statement) which led him to the conviction, that *'media will never influence learning'*, only, in the best case, the cost-effectiveness of learning will be improved. His analogy is the 'delivery truck' where, even replaced by a vessel, the content remains unchanged.

One of his strongest arguments is the 'replaceability' test which shall prove, that ever medium can be replaced by another one with the same learning results.

If this vision could be shared before the emergence of the Internet, today the unique features of the Internet and World Wide Web have the potential to enhance learning activities providing a high degree of interactivity among geographically separated learners and teachers. It is time to overcome the old understanding of distance learning where the media provided only another way to delivery learning contents to the learner (in the first stage, even e-learning has a similar meaning and the Web was only a medium to delivery learning contents through “static” web pages).

The wide diffusion of Internet allows to state e-learning is the state of art for distance learning in Europe today. Anyway technology development never stops then new emerging technologies are supposed to be applied in the next future in order to provide innovative learning approaches. In fact, while the effectiveness of Internet as viable delivery system for distance education learning is largely accepted and its potential to enhance the educational quality of learning activities has been investigating, yet, we assist to the scouting of new technologies to provide new methods of learning and training, as well. This is a phenomenon we have often observed in the past and many times a learning revolution was expected when a new technology has been available.

The next generation of distance learning will be the mobile learning (m-learning). This consideration is justified by the observation that the next dimension of learning and training is the development of wireless communication and wireless learning in society over the coming years. As such, the future is wireless and it is clear that even in the distance learning domain there is an effort to put in place wireless solutions to replace the wired computer scenarios of e-learning today.

Never in the history of technology in education has there been a technology with the universal penetration of mobile telephony. Not only this but mobile phones are technologies that citizens are used to carrying around with them everywhere.

We have to take in account that it is estimated that today there are more than 0.5 billion data-enabled mobile handsets in use worldwide. These mobile handsets will create the first 'always on' generation of technologically enabled citizens who will spend the majority of their time in close proximity to Web access and e-applications. The purpose of next generation learning systems is to harness current and new technologies to provide new methods of learning and training that are available to all who wish to be part of the 'always on' generation.

This is the current scenario and Akogrimo perfectly fits in this frame. In fact, it is clear that today we haven't completely exploited the potential of the e-learning and, at the same time, we are attending the emergence of a new trend that will bring to the achievement of the m-learning.

Looking ahead, it will be crucial to achieve the merging of e-learning and m-learning providing pioneering approaches that will support new learning models based on ubiquitous, collaborative, experiential and contextualised learning.

These approaches will leverage on a paradigm that focuses on the learner and on new forms of learning. The learner will have an active and central role in the learning process and the learning activities will be aimed at facilitating the construction of knowledge and skills in the learner. 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 input) which are constructed from sophisticated software interfaces and devices;
- "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.

It is here that Grid and Mobile technologies enter into the picture because they are supposed to provide the missing features to enable the new forms of learning.

The next generation Grid 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). This process coincides with the collective construction, negotiation and agreement of a semantic for any Information, be it a datum or a program.

Moreover, Grid technologies will facilitate the implementation of CSCL (Computer Supported Collaborative Learning) environments facilitating the development and/or the integration of services for synchronous and asynchronous communication over wireless and broadband network (such as GEANT or Internet2).

Mobile technology will add ubiquitous and pervasiveness to the Grid potential, and in this vision it will not be only a medium to access the Grid, but the mobile devices will be part of the Grid itself that in this way will evolve towards a nomadic system.

It is worth mentioning, the environment of nomadic computing is very different from that of traditional distributed systems. In such environment there is a variety of mobile workstations, handheld devices, and smart phones, which nomadic users use to access data services in the Internet. The outcome is high demands for adaptability of data services. Grid technology is one of the software solutions that may be used to fulfill the demand of "anytime-anywhere-anyhow" access to data services, providing adaptability to available computing and communication resources that vary in tempo-spatial space and short-term predictions of available resources.

7.1.3. Business perspective

It has been estimated that the learning, education, and training industry is over USD 1 trillion per annum worldwide. Much effort is being spent on information technology and its integration within the learning environment. Institutional entity are spending much effort on multi-cultural learning resources and environments.

The learner include home users, nomadic users, institutional users, children and adult users. The variety of learning environments includes standalone, classroom, networked, internet-based, nomadic, federated (groups of resources), distance, collaborative, asynchronous, synchronous, and so on. With all these environments and international participants the emerging of a new generation mobile Grid for distance learning will arise the interest of at least four different target group and potential users:

- The telecommunications industry;
- The e-Learning industry;
- Stakeholders and decision maker in vocational and education training (VET);
- Trainers, students and training organizations

The telecommunications industry has an immediate need for applications and many mobile applications are just being released or are still under development such as mobile commerce (m-commerce), mobile positioning systems (MPS) etc. Learning and training, however, do not figure in most of the mobile application scenarios. The added value provided by the merging of mobile and grid technologies can guarantee the feasibility of glamorous applications in the learning domain that can fed the incessant request for new applications to be delivered in a mobile environment.

The next generation of learning is of vital importance to stakeholders and decision makers in VET. The attractiveness of this learning vision is the capability of harnessing and sharing the almost universal availability of mobile devices to education and training. This widespread availability can be harnessed and exploited to provide access to training opportunities for those who otherwise might be at a disadvantage for geographic (wireless networks span the rural-urban divide), economic (mobile handsets are relatively inexpensive) or social reasons, but mainly to take in place innovative contextualised learning approach, where the learner “achieves” knowledge and skills in an active way instead of simply storing information. The *realism* will be the cornerstone of a such learning environment.

Finally, trainers and training organizations as they plan for their future and seek to devise new lifelong learning and training scenarios for all citizens which will correspond to their life situation.

The needs, for the target groups identified above, is to be prepared for the next generation of learning and training. The development of a mobile grid infrastructure for the provision of nomadic learning will meet this need opening new scenarios for both the telecommunication industry and the developing e-learning. Furthermore it will meet the needs of stakeholders and decision makers VET, and European trainers and training organizations by opening up for them the pathway to the next generation of learning.

7.1.4. Technical issues

The goal of achieving the next generation mobile grid has highly demanding technical issues. They are related to the convergence between two worlds that, on their turn, are continuously evolving and are characterized by the emerging of new technological trends that aim to address the strong technical challenges strictly related to these domains.

For example, the Grid was originally designed for e-Science and was primarily concerned with supercomputing applications, but it is now being applied to many other areas, especially enterprise computing and e-Commerce. To meet this new challenge, the next generation Grid will increasingly adopt the service-oriented model for realising effective sharing of distributed heterogeneous resources (OGSA: the Open Grid Services Architecture), and on this topic there is a great unrest that has been bringing to the convergence between grid services and web services technologies.

In general, the fundamental challenge in nomadic computing is dynamic adaptation in the triad service–terminal– connectivity according to preferences of the end-user. The environment of mobile computing is in many respects very different from the environment of the traditional distributed systems of today. Bandwidth, latency, delay, error rate, interference, interoperability, computing power, quality of display, administrative domain and other non-functional parameters may change dramatically when a nomadic moves from one location to another, from one computing environment to another, from example from a wired LAN via a wireless LAN to a GPRS/UMTS network.

The nomadic end user would benefit from having the following functionalities provided by the infrastructure: information about expected quality of service provided by the environment, a condition based control policy, ability to automatically adjust to changes in the environment in a transparent fashion, adaptability, ….

Among the above functionalities in learning, education, and training environments that use distance (wide area network), distributed (multiple resources acting as a single resource), and nomadic (roaming, sometimes-connected) technologies, the interoperability problem assumes an important relevance

Learning, education, training, and content development often depend upon collaboration and cooperation. Institutions and vendors cannot afford to develop all the necessary learning materials and resources, and thus, organizations must collaborate to reuse and resell learning resources. International standards are critical to the success of collaboration and cooperation among organizations and the reuse of learning services.

The development and use of international standards produces a direct cost savings, and, furthermore, the information technology systems could be used in a wider range of applications, and used more efficiently.

Better, more efficient and interoperable systems, content, and components will produce better learning, education, and training – which has a positive effect upon all societies.

In summary, the mobile grid will meet the technical issues by providing a service oriented infrastructure, based on standards and specification coming from the grid, web service and mobile world. This infrastructure will be the technology glue, seamlessly combining wireless and broadband networks with advanced software solutions for personalised ubiquitous learning, providing the user with a uniform way to access these resources by means of several kinds of devices that could be integrated in the learning mobile grid, as well.

7.1.5. Meeting the Ambient Intelligence challenge

The concept of Ambient Intelligence (AmI) provides a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognizing and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.

In this scenario all activities of human life will be affected by relevant changes that will definitively modify our daily life. As we have introduced above, the learning won't be immune from this revolution and the Ambient will become the virtual collaborative learning community that will be progressively aware of member's needs, preferences and expectations, supporting each member as well as subsets of the community, to construct and increase their knowledge and skills. In the near future, the realisation of this scenario will be synergistic with research activities in different technology fields.

Synergy will be the key factor for the realization of Ambient Intelligence vision and this is exactly what we have outlined as technical challenges related to future elearning scenarios.

This challenge is centred around the notion of NGG, the "Next Generation Grid", that is usually described by experts in the field as a result of an evolution that will allow to build an "Invisible Grid", in which the complexity of the Grid is fully hidden to users as well as developers through the complete virtualisation of resources.

The set of envisioned NGG applications, in addition to "heroic computing", includes now even e-business, e-health, e-government and e-learning. Furthermore the enabling technologies to achieve this vision includes now a comprehensive set of existing and evolving technologies such as Web services, semantic Web, data mining technologies

It is obvious, that this NGG vision embraces domains which are already largely occupied by the mobile communications community. However, as opposed to present NGG visions, the approach of these organizations includes "Mobility" in the broadest sense.

In the following section we are going to develop the sketched out concepts by focusing on two key aspects:

- Social issues and final users expectation with respect to the advantages of the next generation learning
- Market opportunities that can be exploited in the new environment

Furthermore, we'll try to fit these aspects in relation with the learning scenarios that we have been investigating in the frame of Akogrimo.

7.2. E-health Testbed

7.2.1. Introduction

One of the new areas of growing Internet based application is in the field of health care and there is a growing impetus to develop e-business processes for managing this. The healthcare industry is experiencing radical transformation in Europe and has joined the Internet revolution that is sweeping the world [26]. A result of the increasingly widespread deployment of information technology as a core component running across broadband communication infrastructures makes possible the delivery of ubiquitously available and enhanced health care services to patients. Providers are now looking to use this powerful medium to provide efficient, cost-effective health services and care. However, capitalising on the opportunities it offers presents a considerable challenge. While the United States currently leads the way in its extensive use of the net to deliver paid-for healthcare, Europe's usage has been relatively less. One of the reasons for this is the rising costs associated with delivering such a service as consumers are increasingly demanding quality healthcare solutions.

The current situation in the healthcare domain is affected by the exciting fields of medical and technological improvement, increasing patient's requirements and the inversion of the age pyramid (leading to more chronic and degenerative diseases) as well as an increased cost pressure.

Medical progress is characterized by improved diagnosis and treatment methods. In particular, genetic engineering and in-depth imaging techniques (Computer Tomography, Magnetic Resonance Imaging) enables an individual anamnesis, diagnosis and treatment. Another important issue is the impact of technological developments of medical equipment. The increasing trend in miniaturization and the mutual networking of medical devices allows a seamless and permanent monitoring of the patient. Early diagnosis and minimal invasive procedures are possible.

From an economic point of view, the expanded competition between health care provider on different provisioning levels (hospitals, specialists, family doctors, health centre etc), new but expensive medical technologies and the decreased funding of public insurances puts a high pressure on costs. Consequently, the maintenance and extension of quality is one of the most crucial points.

On the customer side, a movement from pure treatment of diseases to wellness can be observed. Health services are used in order to underpin or improve the social situation (selection of a partner, extended professionalism, continuous fitness etc.). The utilization of health services is going to be a regular service available everywhere and every time, i.e. ubiquitous.

The patient is mobile and his health travels with him. Health care services should be available pervasively, integrated into the patient's environment. As already described, miniaturization is an important prerequisite. In the case of a disease or an emergency the patient expects support as fast as possible and tailored to its individual conditions and physical characteristics.

All referred topics are already realized in a vast number of research prototypes and proprietary commercial solutions. But, a transformation into real, continuous and integrated processes among all health service providers is still missing.

E-health refers to all services, quality improvements and economies of scale that are enabled by the digitization and the electronic transmission of data capturing processes and communication processes in heath care. Thus, E-health is a major idea to fulfil the new requirement to health care.

Healthcare Telematics is the subset of E-health and comprises the electronic exchange of case-by-case diagnostic and therapeutic data over a geographic distance [27].

The advantage lies also in better use of existing knowledge or faster update of and access to knowledge for all participants like doctors, nurses or patients. Digitalisation causes some problems, for instance the loss of standards, missing connections between doctor's practice and hospitals or financing problems; data protection or problems with organisational change have not made the implementation and integration easy. Talking Within infrastructure are some key applications e.g. the e-receipt and the e-healthcare card. [27]

Improvements in the following main issues can be accomplished by E-health applications [28]:

- The medical history of a patient is not documented completely or sufficiently for communication purposes.
- The treatment is an addition of diverse diagnosis and treatment processes. There is a lack of integrated health chains.
- Information systems in healthcare are isolated, pursue selective goals, and have an isle character.
- There is more patient information available, than exploited for treatment. An increased availability in the right place, at the right time, to the right degree of detail or aggregation would reduce unnecessary double examinations and patient transports.

In particular, besides improved communications, impulses can be expected in the subsequent areas [33]:

- Hospital and ward information systems (scheduling, utilisation and staff planning)
- Electronic multimedia patient records (integration of picture processing systems)
- Derivation and dissemination of medical knowledge
- Telemedicine (radiology, consultation)
- Citizen-centred services (health information systems, appointment management systems)
- eLearning for medical education (surgery simulation)

There exist different national healthcare systems across Europe. The implementation of any e-Health solution with a European scope has to consider various sensitive interests and different requirements due to national regulatory and laws. Thus the transfer of well-known business models and transaction from other industries is very difficult. Restrictions on information exchange and privacy protection are of particular interest. The following issues have to be considered: Who can communicate electronically with whom? How and under which conditions patient data can be transferred. Whose data can be exchanged, processed, or matched. Which data formats apply? How can patients be identified? [28]

So far, no European country has a national Health Telematics platform established for routine operation. A first approach to tackle these problems is the ongoing discussion within European institutions and national administrations to introduce a European health card. Due to different requirements, no unique specification exists until now. But there are plans for harmonization of the national approaches. [28]

7.2.2. Business perspective

The possibility of creating a successful e-Health market depends on a variety of factors. A few are enumerated below [29].

- Understanding the current and prospective e-Health market in Europe and where the key opportunities for development lie. This potential is huge and pervasive.
- Bolstering online market presence within Europe by providing comprehensive, accurate and reliable health-related information on the Internet.
- Taking full advantage of the opportunities presented by future regulations and hastening compliance with EU e-Health regulations and directives by developing forward looking e-Health strategies
- It is important to understand that patient or citizen centered healthcare is all about access, choice, communication and service provision.
- Legacy suppliers, already working to expand their portfolio and with e-Health Services will be key evolution enablers.
- Electronic Health/Patient records are seen as the highest priority for the adequate development of e-Health networks
- Although health care transactions are becoming increasingly standardized through the use of tried, tested and established guidelines and protocols, healthcare is still a sophisticated mission critical and information sensitive business requiring fundamentally complex systems.
- Owing to the high cost of developing application software and limitations on the scale of the healthcare market, ASP's operating from centralized data centers are likely to be increasingly important aspects of health care IT delivery.
- Health care professionals are increasingly using the Internet as a source of information but not for communication purposes with their patients.
- Applications that require the transfer of images and further require high bandwidth connections are not yet widespread in Europe but are likely to become so as more bandwidth becomes available at a progressively lower cost.
- Telemedicine and remote learning technologies are also developing

7.2.3. Technical issues

In health care there still does not exist a consequent process-oriented thinking. This situation is comparable to the situation in industry about a decade earlier. In order to exploit the potential benefit of healthcare Telematics with respect to better quality and reasonable costs of care, it is mandatory to model / remodel the care chains with all possible / relevant / significant care paths as well as the appropriate corresponding data flows and communication processes.

Existing Information and Communication Technology (ICT) is mature enough for the realization of almost any required application in the field of health Telematics.

These are the most discussed technical topics in e-Health [27]:

- E-Patient Record: It will store patent related data e.g. medication, personal health status, diagnosis results etc. This includes the collection and aggregation of all medical patients data over all departments and also special patients medical situation data. The E-Patient Record can bee seen as a "multi-functional centre" for the management of digital patient treatment in Telematics infrastructure. Without it, it would be impossible to have e-receipt or electronic referrals. Criteria for e-patient records are that they are just used in direct relation to the treatment of patients, that they support medical workflows and allow input and request of medical and also administrative patient data.

- E-Receipt: It will contain information about medication and also latest patient data and helps avoiding medication problems with other drugs.
- Tele-Medicine: This consists of Tele-diagnostics, Tele-radiology, Tele-consulting and e-homecare. It is seen as an enabling technology, because of its potentials of changing healthcare business dramatically.
    - Tele-consulting is a subset process of communication
    - Telematics is the combination of telecommunication and informatics
    - Tele-monitoring/Tele-care: Monitoring of homecare patients.
    - Tele-teaching: Advanced trainings for health professionals.
    - Tele-emergency/Tele-rescue: Fast data processing, documentation and support.
    - Tele-therapy: Therapy with the support of therapists.
- Telematics platforms have the goal to integrate all; everything from consumers and professional issues about medical information (e.g. portals, communities, database, journals) , patient data/telemedicine (electronic patient record or information systems for stationary hospital treatment or ambulant clinical practitioners systems) and commercial transactions (e.g. wellness or beauty-shops, online-drugstores, pharmacies, shops or trading platforms of all kind) related to electronic healthcare
- Knowledge/Content Management: There are numerous possibilities to choose from when managing information and knowledge. These are for instance, systems for document management, groupware systems, asset management, communities and some others that could be useful. For instance digital imaging can also be seen as a subset.
- Digital imaging: In medical treatment there are lots of tasks related with digital imaging or processing of them like ultrasonic or x-ray pictures. Even more difficult are x-ray computer tomography (CT), magnetic resonance imaging (MRI) and nuclear medical treatments. Nowadays most machines develop two- or three dimensional pictures, but they are printed out as hardcopy. Digital imaging needs high requirements to hardware e.g. storage, CPU-power or bandwidth.
- Decision Support Systems: can be used for not well known or un known diseases or in cases when there is information overload for the medical staff.
- Digital image processing:
    - Images can be visualised as 3-dimensional pictures, multi-coloured and close to reality with complex structures and surface or rendering techniques.
    - Virtual endoscope, computer-simulated walk-through the body of a patient
    - Virtual surgery planning, from patient taken pictures runs a surgery simulation on a 3D- Model. This is for teaching and testing different techniques.
    - Multimedia reports, is about the integration of images and reports

- Storage for digital and physical images in hospital are called Picture Archiving Communication System (PACS)

- Computer aided surgery (CAS): This means 3D-Visualisation, surgery planning, documentation, navigation systems for implanting prostheses.
- Networks: For transmission and access in local and inter-local areas networks like Inter, Extra or Intranet is needed. And for the high requirements in medical areas a TCP/IP-based virtual private network (VPN) under the protection of firewalls and different other security mechanisms must be available.

Very often, these solutions remain isolated. Therefore, hard-to-integrate proprietary communication protocols and data formats are still quite common [30].

Most scenarios can be realized on basis of existing legal and financial regulations but too few or very small incentives exist for most of the (potential) users. Publishing the patient data to information systems, e.g. a comprehensive Electronic Patient Record, for different kind of situations and making this information from different information systems accessible for the professional, is the main effort during the next years [30].

Breaks between process steps are scarily supported by technology (e.g. patient transfer from Operation Room to Intensive Care Unit (ICU)). Computer systems are used as Point-of-Care-Systems (e.g. Patient Data Management in ICU) or as Clinical Information Systems (mainly for administrative purposes). Planning, execution and monitoring of complete patient courses is not supported. The patient's treatment is fragmented due to progress in medicine and technology. The fragmentation problems can be solved with strategies for physical-spatial and logical-informational integration.

Integration moves from data exchange over semantic interoperability and functional interoperability towards service-oriented interoperability. Middleware concepts have been specified covering all interoperability levels. Approaches with a different history and a different maturity state like CORBA, HL 7 (Health Level Seven), DICOM (Digital Imaging and Communications in Medicine), GEHR (Good European Health Record), and openEHR converge [30].

DICOM: Digital Imaging and Communications in Medicine; standard for vendor-independent exchange of medical images and related information, defines data structures (e. g. file formats for medical imaging modalities and network services for clinical applications (e. g. image transmission, archive access, printing, workflow support). DICOM has originally been developed for PACS (Picture Archiving and Communication System) applications in radiology but presently also covers fields such as cardiology, pathology, ophthalmology, dentistry and dermatology. In addition to medical imaging, DICOM also covers the management of 1D signal (ECG (Electrocardiogram), EEG (Electroencephalogram), Ultrasound audio etc.) and structured information (reports, measurements).

HL7: Health level 7 is a specification for a health data-interchange standard designed to facilitate the transfer of health data resident on different and disparate computer systems in a health care setting. HL7 facilitates the transfer of laboratory results, pharmacy data and other information between different computer systems. HL7 is not designed to support the transfer of the entire patient record and does not support the transfer of image data (such as from a PACS). Integration with DICOM is examined in order to provide interoperable

Commercial EHCR systems available on the market do not or almost do not regard any available open EHCR models or (pre)standard. One of the reasons is that the available open standards are not mature enough to be applied on market solutions.

7.2.4. Meeting the Ambient Intelligence challenge

Current medical networks are fixed and tied to building health service providers. Consequently, they don't comply with mobility requirements of patients and medical doctors. With respect to technological progress, especially in the field of mobile networking and communication medical data, knowledge can be made available, captured and exchanged at the Point-of-Care.

Emphasis is put on patient monitoring. Continuously captured data can be used to:

- monitor insulin and cholesterol level
- inform the patient about proper posture and work movement during the labour and sports activities
- track pulse and blood pressure

Besides medical information, other context specific information such as current activities that the patient is presently involved in on a daily, weekly or monthly routine pattern can be drawn on more detailed analysis resulting in an improved decision support.

7.2.5. Social issues

Europe's large publicly funded healthcare providers are characterised by low cost and high quality of service. However, new demographic trends of an ageing population and a reduction of tax takes as the working population is diminishing in number means that the current level of health spending is unsustainable

For over thirty years, in medical informatics, the e-Patient-Record is the main goal to have. Neither a wide-area deployment nor use was accomplished until now. The development and introduction is a complex process between patients, medical facilities, insurance funds, pharmaceutical industry and legislator. A common consensus between all parties is needed under the supervision of political restrictions. By focusing on the optimisation of healthcare communication processes and business processes the e-Patient-Record is absolutely necessary.

But, society's reaction on the E-Patient-Record is not yet foreseeable. There is still discussion on where the data should be stored - in medical facilities or placed on a chip. This chip could be carried in a plastic card or be implanted in the patient! The chances to realise the second option are not high, because it's a cultural denial. But if it could be used as key to administrative data or emergency data, it has to have security options to stay safe that not unauthorized person can have access to the data.

A cultural change for all parties is needed, so that everyone is responsible and sensitised for their own data. On the other hand patients are strongly empowered, because they get the rights for own data and the ability for autonomy. This means more power to the patients. But, do all patients want to use it and are capable of? Doctors fear that they lose close patient-relationships. But in general, the E-Patient-Record opens up many other opportunities e.g. decreasing costs or time if responsible data storage and management is guaranteed.

7.2.6. User perception

The deciding factor for the success of telematics platforms in the health care sector is their acceptance by health care providers and by the insured. Only in this case can the theoretically possible saving potentials and quality improvements on paper be transferred to real life

Strong drivers (e.g., consumer demand, positive pilots, increased security and privacy with the Health Insurance Portability and Accountability Act, and establishment of guidelines and protocols) currently promote online patient-physician communications (OPPC), but physician adoption remains low [31].

Key Questions

- Which factors prevent doctors from adopting OPPC?
- How often are online physicians planning to use online consultations in the next 12 months?
- Which type of payment for online consultations do doctors prefer?

7.2.7. Market attractiveness and competitive advantages

Vendors Need to Move Quickly to Gain Competitive Advantage. With the opportunities available for cost savings and for the development of new markets, vendors interested in healthcare delivery through the Internet will need to have firm strategies in place before the competition gets too fierce. Vendors looking to access new markets in the EU [32] must keep in mind that many Europeans do not speak English as a matter of course. Currently, since much of the data available on the Internet is in English, this could pose a strong challenge.

With some of the biggest opportunities existing in European countries where English is not widely spoken, enterprising vendors that translate their offerings into other European languages could steal a march on new entrants that have the difficult task of building out their offerings.

7.2.8. Business models

Currently, e-Health constitutes all the business activities that generally constitute all e-commerce activities. These have four major forms [33] right now – portals, connectivity sites, B2B and B2C.

- **Portals** - e-Health portals and websites are the medical representative of the company on the internet and are designed to provide free but significantly helpful information and guidance to the consumers.
- **Connectivity** - One of the unique developments of e-commerce is businesses that link information systems seamlessly. Health e-commerce connectivity initiatives include internet accessible EMRs, assessment of provider quality based on clinical outcomes, and use of quality data in physician selection. Revenue is generated by the transaction fees. Thus, companies will exact transaction fees from the principals involved when data are

moved over the Internet to health plans, physicians, hospitals, clinical laboratories, pharmacies, consumers, and other participants involved in health care financing, marketing, or delivery.

- **Business-to-Business e-commerce** - Health e-commerce B2B models are currently only extensions of general business e-commerce. Examples of these are biotechnology web sales directly to providers and the sale of refurbished medical equipment through online auction. Manufactured products are often sold in this way, but services, such as consulting or benefits management, are slowly gaining popularity and are beginning to be sold as well. Physicians and hospitals may adopt this model to target health plans that are developing or renegotiating provider panels. Physicians receptive to the Internet and looking to practice medicine outside a group structure may find the direct contracting of services, possibly through an online auction mechanism, an attractive option for building practice volume.

- **Business-to-consumer e-commerce** - A B2C model allows consumers to purchase health products ranging from vitamins to health insurance. Although the direct marketing of health care products to consumers is not new, the Internet can target potential consumers based on diagnosis or treatment of a medical condition. Portals already examine users' keywords from an Internet search and display related advertisements.

8. Conclusions

This report has included considerations of: the regulatory environment (in summary); the new economic models that are brought about by the changing connectivity resulting from mobile communications combined with the transient services on the Grid; new business entities and monetary models; and an increasing interest in Grids on the part of telecommunications operators who see an opportunity to offer more complex services to their consumers.

The congruence of telecommunications providers and Grid providers in Akogrimo is likely to be a unique opportunity to bring Grid services to a pervasive market.

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