A new mobile service architecture addresses future mobile business environments

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***Abstract*—Uncertainties in the mobile business environment increases. Mobile services are no longer provided by a single company acting as a complete service provider who controls the suppliers. Cooperation between actors from industries outside traditional telecom arena increases the complexity of deployment interfaces. This paper describes a new mobile service architecture addressing today's and future mobile business environments and defines the critical topics for future research**

***Index Terms*—Architecture, business models, market scenarios, mobile applications**

I. Introduction

MobiLife Integrated Project, part of the Wireless World Initiative (WWI) in IST-FP6 [1], aims to bring advances in mobile applications and services within the reach of users in their everyday life by innovating and deploying new applications and services based on the evolving capabilities of the 3G systems and beyond. Business modeling is one of the key areas in MobiLife project and was done in parallel with user centric technology driven application and service development. The practical value of MobiLife research is highly dependent on the applicability of the results in the real life. In this context architecture issues become critical.

Mobile business as a very promising industry is in the middle of changes choosing its paths to the future. Mobile applications and services can have a great impact on the efficiency, productivity as well as the capability to create new kind of services in several industries. However, it is not so obvious how to exploit the new possibilities brought by mobile technology to create valuable services. In this context, the business modeling focused research and the necessary understanding of key perception inhibitors which need to be addressed in future sustainable business models becomes significant and thus motivated.

A business model can be seen as a planning tool that is essential for every company and also in case the services are provided in cross-company collaboration in complex value nets. In the MobiLife project, we followed the component based business modeling approach and developed a conceptual framework that identifies those components. Customers are essential to any successful business and the business model have to take into account what types of **user/customer** benefit the company seeks to provide. The **products and services** (offering) component definition includes all relevant value elements for the company value proposition. In future mobile business models the key question is related to the **earnings logic** and how to make money with the business. The assumptions made regarding these business modeling components profoundly influence the model's strength and viability on the marketplace. The performance of a company is included in the **resources**, **suppliers or a network of suppliers**, **organisation from architectural point of view,** and **processes for providing the services'** components. Especially the development and changes in technological resources and business as well as in service architectures can be seen as important drivers of the future mobile business (Figure 1).

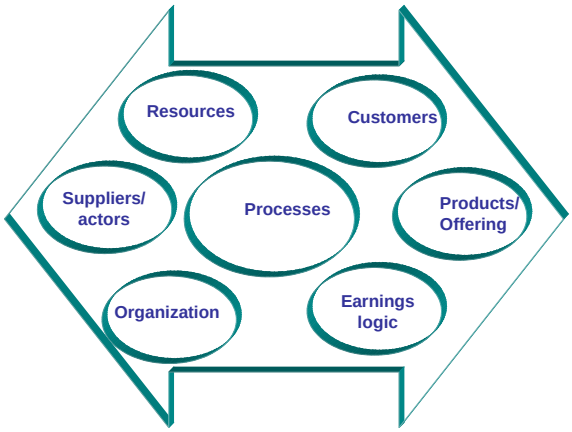

Figure 1: Business model framework.

Success of services depends on the choice of a certain business model but also on the **future environment** in which the model is deployed. The project has used **scenario definitions** as tools for describing future environments. These descriptions have been used to further analyse the mobile technology based generic business models defined during the project. They have also been used in crystallizing the **architectural requirements and definitions**. Especially the focus was put on the **functionalities of enabling advanced mobile services** supporting multimodality, context awareness, and personalization, while maintaining privacy of users as well as in provisioning those services.

The company has to make several assumptions regarding the business environment while modeling the business. We have developed environmental descriptions based on two main variables "business growth potential" and "changes in business logic and industry structures". This scenario thinking provided us insight into the possible "fit" of different kind of business models and how they could be deployed. As a key learning from the research done we propose that the different architectural domains and careful architectural specifications are the key enablers of the future development thus necessary for future mobile services. Business interfaces between different market actors and roles, service interfaces and technical interfaces are important in the architecture definitions.

The aim of this paper is to present the outputs of **two specific research tasks** and answer two research questions:

- **How do mobile business environments change?**
- **How can the MobiLife architecture tackle the challenges of the changing mobile business environments from today towards the future?**

This paper is structured as follows. First, we shortly introduce the business modeling and architecture definition research processes followed in MobiLife project and highlight the advantages in combining them. In the third section we describe the basic characteristics of the business scenarios defined during the research. There, we select the two scenarios the "Old Rules" and the "Wind Turns" as the relevant scenarios for describing the business modeling and the architectural challenges in the remaining document, as they describe how organisations behave in two opposing marketplace dynamism situations. In section four we analyse the main challenges that the two scenarios place to business modeling from architecture point of view. In section five we describe how the MobiLife architecture supports the mobile service business modeling. This is further clarified with an exemplary scenario application in section six. In the concluding section seven we suggest some interesting topics for further research.

II. RESEARCH PROCESS AND METHODS

In this study, we have applied the following two research processes: The business modeling process and the architecture definition process. These processes are described in this section.

A. Business modeling process

The business model concept has a fragmented nature in the academically oriented literature and thus it remains more or less under-conceptualized [2] [3] [4]. The notion of a business model is frequently applied especially in the information and communication technologies (ICT) literature [5]. In MobiLife project, we have followed the component based business modeling approach. It focuses attention on how all the elements of a business fit into a working whole. The main motivation for using a component based approach comes from the strategy literature [6]. All components included in a business model are also used in the strategy definition of a company. We have developed a conceptual framework that identifies the key components. We used applications and services designed in the MobiLife project for clarifying the description of these components, for defining how they interact and for revealing the most challenging aspects in business modeling. The definition of the components is described in the Table 1.

Business Model Component	**Component description**
User/customer component	Defines what type of customer benefit a firm seeks to provide
Products/ services component	Defines which customer value creation has to be reflected
Earnings Logic component	Spells out how companies create revenues
Resources component	Defines use of technology, capabilities to exploit resources
Suppliers/actors component	Describes how actors co-operate
Organizations/ architecture component	Takes into account governmental and architectural questions
Processes component	Concretizes the provisioning of the service

Table 1: Business model components

The business modeling process included also defining an approach to the marketplace. The opportunities and threats in the future marketplace paint a picture of those topics that have to be taken as assumptions in defining from the business model components for a firm benefiting mobile applications in a business performance. However, the market potential for future mobile services is highly uncertain and the use of scenario method in future marketplace dynamics analyses provided us insight to the possible environments. We were especially interested in the impact of these environments on business modeling. In this paper we apply the findings to point out the importance of architecture in different environmental scenarios.

B. Architecture definition process

The architecture definition process specifies a set of functional components to provide mobile service developers with a well-defined environment for the creation of new mobile applications and services. While established platforms for service development and provisioning exist for the fixed telecommunication environment, this is not the case for the mobile environment. Service developers have still no reference application programming interface to make use of features for next generation mobile services, which include multimodality, service adaptation, context awareness, personalization, while taking privacy and trust into account. Having this in mind, the MobiLife architecture working group specified a reference model for mobile service provisioning (Figure 2). A detailed specification overview is given in [7]. In this document, only a rough description is provided. The MobiLife reference model should satisfy the requirements that exist today for mobile service development and provisioning while allowing adaptation to expected market developments.

The reference model is the architectural description of the functional components. In addition, the reference model describes how the functional components interact and how they are structured in subcomponents.

On the left side of the figure, you can see the user that uses a (mobile) device, on which user agents are running, to access MobiLife applications and application services. The small box on the left side depicts MobiLife applications and application services (SER). Users interact with MobiLife applications, which use MobiLife application services to yield their functionality. MobiLife application services themselves use MobiLife infrastructure functions in their implementation.

When simply referring to "services" in this document, this always means SER, i.e. MobiLife application and application services. The top the figure depicts external Data Sources (DS) that deliver (sensor) data to user agents

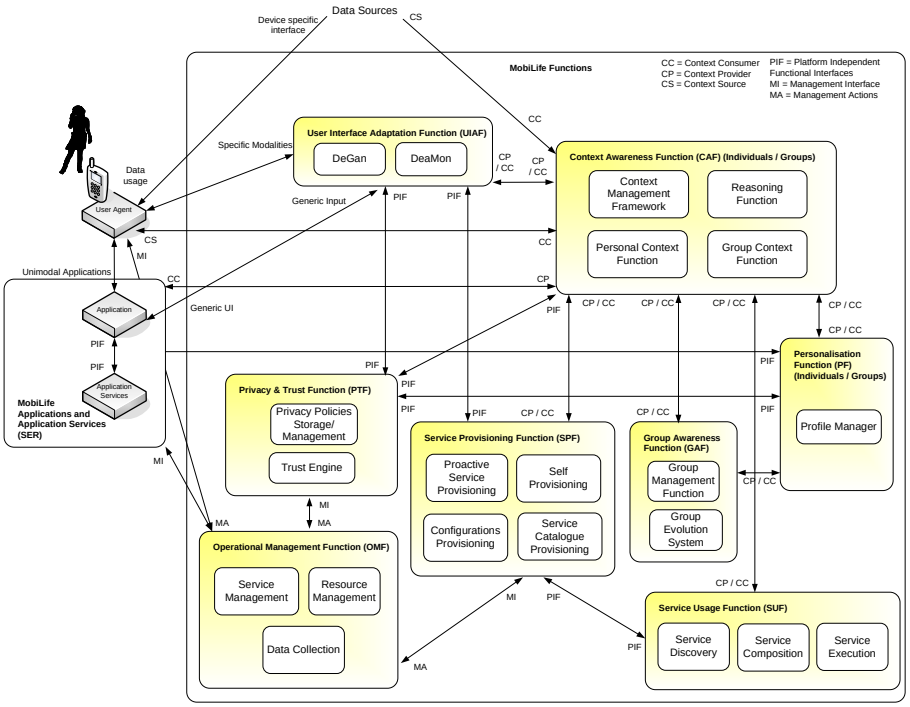

Figure 2: MobiLife Reference Model

and to MobiLife components.

The big box 'MobiLife Functions' depicts the MobiLife service infrastructure, defining the MobiLife framework services. Mobilife application services are built using the MobiLife framework services. The MobiLife service infrastructure provides the reference model and the basics for the development of application services willing to use one or more elements and functionalities offered, e.g. context awareness, personalization, group management and privacy and trust.

All functions in the figure have dependency relationships with others, which are illustrated using arrows. At the ends of the arrows, the following roles of the components are given:

- Context Providers (CP) are defined in the Context Awareness Function (CAF) (see below). CPs encapsulate context data for consumption by CCs.
- Context Consumers (CC) are also defined in the CAF. CCs consume context data provided by CPs.
- Context Source (CS) are also defined in the CAF. CSs are devices that deliver raw data, e.g. sensors.
- Platform Independent Functional Interfaces (PIF) represent interfaces that do not rely on a specific technology.
- Management Interfaces (MI) represent platform independent interfaces with the role of providing interfaces that allow the management of the respective component.

Management Actions (MA) represent management actions that the Operational Management Function (OMF) can execute.

The MobiLife Reference Model consists of the following functions:

- Privacy and Trust Function (PTF)
- Personalization Function (PF)
- Context Awareness Function (CAF)
- Group Awareness Function (GAF)
- User Interface Adaptation Function (UIAF)
- Service Usage Function (SUF)
- Service Provisioning Function (SPF)
- Operational Management Function (OMF)

The Privacy and Trust Function (PTF) is represented by a Trust Engine component and by a functional block with Privacy Policies Storage/Management.

The Trust Engine has a layered structure and acts in a pervasive way in the enforcement of the privacy rules defined by the user and the existing system policies. The Trust Engine inspects every interaction in the MobiLife system involving user data and allows or denies the access to the data based on the specified policies (system and user policies).

The Personalization Function (PF) enables adaptation of mobile services and applications according to personal and group needs and interests. It offers a Profile Manager to manage user and group-related profiles and preferences.

Service adaptation means transformation of service content based on individual, service-specific user/group models within a given context. Service-specific user/group models, i.e. user/group profiles, can be either created manually or via profile learning (part of CAF Reasoning Function).

The Context Awareness Function (CAF) takes care of raw, interpreted and aggregated context data. This function handles context data related to individual users and to groups of users. It supports the service developer by providing users' and groups' current context information through well-defined interfaces. To determine the situation of a user and/or a group entity, and to enable context aware services that provide relevant information depending on the user's/group's task, the Context Management Framework (CMF) [8] defines representation, exchange, interpretation and reasoning of raw context data from various sources: terminal devices, sensors, the collaborative objects

surrounding the entity and the entities preferences. The use of a standard representation and exchange framework for context data abstracts from the need for each context source to define independent representation models for allowing raw context data to become context information.

PCF and GCF are CP implementations that deliver context data related to individuals and groups respectively. They both comply with the specification defined in CMF.

The Group Awareness Function (GAF) is the ingress point for all MobiLife application services and framework services related to group state information provisioning and to group lifecycle aspects. The GAF provides means for the management of group lifecycle aspects (Group Management Function) as well as the automatic creation and deletion of groups (Group Evolution System).

Users may use different devices to access MobiLife applications, even concurrently, each device supporting different input and output modality services, different connectivity, and with different capabilities. To face this problem without creating a specific user interface representation for each device, the MobiLife service infrastructure must support user interface adaptation. Within MobiLife, this function is realised through the User Interface Adaptation Function (UIAF). The UIAF provides functionalities to allow service developers to make services available through multiple devices using multiple modalities.

The Service Usage Function (SUF) covers all aspects related to the service usage; in particular it covers every step in the 'timeframe' between service discovery and service offering. The SUF covers the components Service Discovery, Service Composition and Service Execution. Service discovery allows discovering services related to the user's current context and user preferences. It depends on the SPF to get information on available MobiLife applications and application services for discovery and composition. When services are deployed in the Service Execution component, they can finally be started.

The Service Provisioning Function (SPF) deals with how services can be proactively offered to a user. It provides information about available MobiLife applications and application services through the Service Catalogue Provisioning. It stores application and application service information in terms of description, properties, semantic information, etc. SPF supports configurations made available by the service provider concerning user terminals for the correct usage of a specific application Next, SPF has functionality is to advertise applications automatically or proactively to users/groups, without any user/group request or interaction, defined in the Proactive Service Provisioning components. Finally, SPF provides functionalities to manage the user-service profile and service subscriptions through the Self Provisioning component. This allows to keep track of user's service usage behavior and to automatically recommend services to users based on this history data.

The Operational Management Function (OMF) performs operational management of MobiLife applications, application services, and related configuration of resources.

The reference model specification follows a loosely-coupled approach and the service oriented architecture (SoA), while taking existing infrastructures like the IP Multimedia Subsystem (IMS) into account. The loosely-coupled approach and SoA allows easy adding new functional components to the architecture and also enables to remove components without violating the operation of the remaining ones. The major enabler for this is the CMF that specifies the low-level interface for component data exchange and Remote Procedure Calls functionality. Using this specification, each functional component of the MobiLife reference model provides pieces of functionality and context data to the whole infrastructure, forming an integrated but flexible platform. For functional components that require very special high performance interfaces, additional specifications beside the CMF are described. This is e.g. the case for operational management of the functional components.

The specification of the MobiLife reference model provides novel functionalities for mobile service developers and providers. To still enable an easy deployment into operators environments, the mapping the IMS was analyzed. The mapping of the particular functional components in the MobiLife reference model to components of IMS is described in [24][25][26], enabling the reuse of subscription databases, etc. of operators and still provide novel MobiLife applications to customers.

III. BUSINESS SCENARIOS

The mobile business sector is often characterized as turbulent environment [9]. In order to survive this turbulence, organizations need the ability to develop new business models fitting new circumstances rapidly. They have to take into account dynamics on the marketplace in market offerings, customer demand, technologies and regulation.

Scenario methods have been widely used in business research in general [10], and in managerial business practice. We followed a similar approach within MobiLife, developing four contrasting suppositional scenarios that form an excellent platform for discussing the future marketplace dynamics. The MobiLife business scenarios follow the short term challenges and the scope of the scenarios is purely for MobiLife business modeling purposes. These scenarios have been used as tools for further analyzing MobiLife technology based generic business models. They deal with the uncertainty of the environment and give us insight into several business modeling choices. They may not be seen as forecasts [11].

Business growth potential and changes in business logic and industry structures are among the key uncertainties that have large impact on the viability of mobile business models in the current and future marketplace [12]. Each MobiLife scenario is noticeably and fundamentally different in some valuable way and describes the different extremes of how the future could develop**.** The scenario descriptions are based on several drivers in economy, business, industry, society, user and technology. They concentrate on the future business environment within the European Union.

Input for the scenario descriptions come from various

sources, including economic data published, e.g., by European Central Bank, the outcome of WWI-projects, studies in various universities, and expert interviews from the field. We discussed potential elements and indicators in our scenarios during several workshops with experts within the MobiLife project and chose to include those indicators in the scenario descriptions that had both a high impact on mobile business models and a high amount of uncertainty associated. The dimensions - business growth potential and change in business logic and industry structure define the extremes in our scenario descriptions.

In the scenario "Survival Battle" the business growth potential is insignificant. Also the changes in business logic and industry structures can be regarded as insignificant. There is no enlargement in the EU. Eurozone monetary is tightening. Both domestic and foreign demand is decreasing. Companies strive to defend their existing position. In order to avoid unprofitable operations they look for structural rearrangements and focus on rationalization. Innovativeness is related to "survival".

In the scenario "Old Rules" the changes in business logic and industry structures still remain insignificant. However, the business growth potential can be regarded as significant. European GDP will exceed 2 % per year. Inflation remains below 2 % thanks particularly to wage increases that will remain below productivity costs. EU enlargement is creating acceleration in domestic demand and consumer spending is continuing stable or even growing. Growth is sought mainly through traditional means carried out by making intra-industry rearrangements and enhanced efficiency. New innovations are launched to expand the existing services. Investment activity is moderate. Traditional players and roles reassert their position on the marketplace in all industries.

In the scenario "Wind Turns" the changes in business logic and industry structures are significant. Interest rates will rise significantly. Rising fuel and labour costs will heighten inflation. More work is moving to Asia creating unemployment in the EU. Industry structures are being crossed, technology drive the convergence. However, there are new entries to the market although the growth potential will remain insignificant. The changes in consumption habits support demand. These new companies see business opportunities on the marketplace; they innovate value-added services with new business models.

In the scenario "Eye of the Tornado" the growth of the global economy is rapid and it creates business growth potential. The changes in business logic and industry structures are significant. The EU enlarges, becomes stronger player in world market. Export is doing well giving new possibilities also for labour market. The networked and powerfully developing global economy and open technology standards build a new foundation for industry consolidation and business reinvention. The triumph of new open standards provides open playing field: easy to access new markets, easy to access alternative information sources. Innovations focus on new areas of services. Some of these make a spectacular success while others fail jus as spectacularly. There is a constantly ageing but really well off and culturally differentiated population in EU countries.

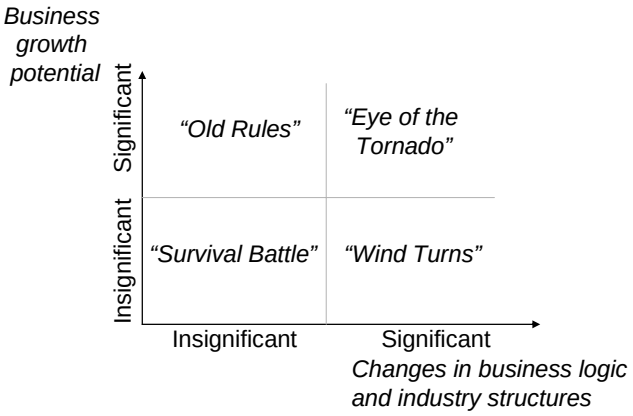

Figure 3: Crystallized macro level scenarios

The scenario descriptions "Old Rules" and "Wind Turns" describe how organisations behave in two opposing marketplace dynamism situations. The amount of factors behind each scenario is huge. It is important to focus only on those which have high uncertainty and high impact on business modeling discussion. The explanatory power of these indicators is thus related to the MobiLife project objectives. Those indicators which do not have impact on assessing the business models in the scenarios (Old rules, Wind Turns) have been left out of the description. In this paper we focus the discussion especially on those research results that have impact on the architecture component definitions in a business model.

In the moderately dynamic marketplace changes occur frequently, but along roughly predictable and linear paths. Typical for that market are relative stable industry structures such that market boundaries are clear and the players (e.g., competitors, customers) are well known. The new services are added to the business in the context of the existing rules and routines. In this environment products and services are extended to include new functionalities and the actors form a vertical structure to provision the services. We describe this environment in the "Old Rules" scenario.

In very dynamic marketplace the change becomes nonlinear and even less predictable. Market boundaries are blurred, successful business models are unclear, and market actors are ambiguous and shifting [13]. The overall industry structure is unclear. In these markets development necessarily rely much less on existing knowledge and much more on rapidly creating situation-specific new knowledge. Organizations rely on limited routines. They are looking for new ways to collaborate in modeling the business to meet the opportunities on the marketplace. We describe this environment in the "Wind Turns" scenario.

IV. CHALLENGES THE TWO ENVIRONMENTS PLACE TO THE ARCHITECTURE AND GOVERNANCE

A. Business modeling components from architecture perspective

The "Old rules" and the "Wind turns" scenarios place quite different kind of requirements to the business modeling and especially to the modeling components.

In the "Old Rules" scenario the end user (user/customer component) can access the services by using several

customer service channels and get a full package in one step. The important trust and privacy functionalities are provided by operator. The products and services (products and services component) available for him/her are complete, stable and long-lasting on the market. Service development is driven by easy migration from existing services. Information model is taken care by one actor and clearly defined. One actor – usually an operator – is billing the user/customer and dividing the revenue with supplier and subcontractors. The operator receives profit from sub-contractors products and services as well as from advertisements (earnings logic component).

The resources in the "Old Rules" scenario are large (resource component). Human resources include business as well as customer supporting system and customer relation management. Technologies used for providing the services are based on investment. New technologies are developed to enlarge the use of existing services. Capacity to provide the services is taken care by one actor. In this environment scenario an operator is in dominant role and makes the agreements with subcontractors – usually as long-term partnerships (supplier/value net component). The processes (process component) used for provisioning are fixed and stabilized, based on limited number of process components. Operator's aim is to increase productivity in the business context and enhance customer service, access and experience.

In the "Wind Turns" scenario users have the possibility to buy all services one-by-one and integrate them by themselves (user component). The amount of service providers/actors is large and the roles require standardization. Each actor should deliver the service immediately (products/services component). Self-provisioning and configuring are required. Each actor/role has to provide the user the trust functionalities based on parallel information flow and clear identity policies. Users have to take care of the privacy by themselves with the help of the legal system. In quite many cases the user is unknown and so is also the service provider. The service and information is provided by several actors and there will be continuous changes in the products / services available. Information model is divided in several roles / actors and need to be synchronized between these actors. Service information history is also divided to several actors. Each role/actor takes care of their own bill according to its specific earnings logics (earnings logic component). The user's personal profiles are used to define the advertisements he/she receives. If the user/customer is unknown to the actor, the dept collection is quite impossible and there is a risk of credit loss.

The resources (resource component) used to provide the services in the "Wind Turns" scenario change according to the changes in the markets, to the efficiency and affectivity needed for the service provisioning. The new mobile functionalities are based on personalization, context awareness, group-awareness technologies. It is very easy for the new actors to enter the market. However, it is also easy to exit from the market. The end user is quit often part of the service network. Capacity needed for service provisioning have to be settled with supplier contracts on the market (supplier component). The industry structure is horizontally organized and it is very difficult to form a common service agreement. The processes in service provisioning are flexible, and adaptable to network actors' processes. Predefined and standardized interfaces are requested. The remarkable number of actors and processes mean that process development and management requires a lot of resources (process component).

Both environmental scenarios described above from business and service architecture point of view mean quite different kind of challenges for the architectural questions. The requirements of governance questions, information management, provisioning the service, resource usage as well as regulative topics differ.

The MobiLife architecture and how it supports the future business modeling challenges in different environment scenarios are described in chapter V. We will next describe more deeply the governance and legal issues.

B. Governance and legal issues

The governance deals with understanding the existence, boundaries and internal organization of the firm. To provide mobile service, typically multiple actors have to work together to create value for the end user, including network operators, content providers, service providers, network manufacturers etcetera. This requires governance mechanisms capable to organize these players. We define governance here similar to Jones et al. [14] as the mechanisms used to coordinate, safeguard and adapt the activities of a network of actors. These mechanisms may involve hierarchical power or legal contracts [15], but may also include more social types of mechanisms including trust, reputation, collective sanctions, social ties, goodwill, etc. [16] [17].

A general trend in mobile business that makes governance an important but potentially complex issue is that boundaries between telecommunications, Internet and media industries are currently fading, transforming the orderly, static telecommunications value chain into a more complex and dynamic value net [18] [19]. Within MobiLife, we expect that these value networks will become even more complex as new roles are required including those of personalization provider, identity and trust provider, context information provider, and group awareness provider. The shift towards more complex value networks continues especially in the "Wind Turns" scenario. Furthermore, what is increasingly happening is that customers no longer have a passive role, but value creation is becoming user centric and demand driven, a trend continuing also in the "Wind Turns" scenario. This additionally complicates governing the activities in a value network.

Nowadays there is mostly one nodal actor who has most power in the value network, i.e. the network operator. This operator commonly decides which content providers and service providers are allowed to offer services over its network. However, in the "Wind Turns" scenario, the power of the operator fades, so hierarchical power alone does no longer suffice to organize activities. This may well lead to more cooperative types of relation in these value networks, making social issues as trust, reputation, and social ties

become increasingly important. A related issue relevant for governance in MobiLife type of value networks is that of moving from a walled garden model that is contemporarily used in mobile business by most operators towards more open models as envisioned in the `The wind turns' scenario. This calls again for different ways of governing activities than it is done today.

In summary, we expect that ceteris paribus governing activities in MobiLife type of value networks will involve cooperation of many different players, which may well impose requirements on the technical interfaces and architecture used in these networks. In the "Wind Turns" scenario, an increasing number of players and the changing role of users will increase pressure on existing governance modes, and as a result put even more requirements on effective architectures and interfaces.

The legal issues are challenging in business modeling and especially in the architecture definition. Especially, privacy and data protection law is highlighted in the scenarios. MobiLife underlines issues related to personalization and adaptation. For example, the user profiles are often personal data that needs to be processed in accordance with data protection directives and laws.

Other important legal areas will be intellectual property rights, especially copyright, and contracts. MobiLife studies have emphasized the adaptation of content. That is useful and required by presented technical solutions. However, a copyright-owner may in some jurisdictions have an exclusive right to modify the copyrighted content. If the content is copyrighted, then permission is needed to adapt it. A purely technical modification that does not affect the information content, but only data, is usually legal, but if the modification changes the information, then it requires the consent of the copyright-owner. [20]

V HOW DOES MOBILIFE ARCHITECTURE SUPPORT THE MOBILE SERVICE BUSINESS MODELING

A. Architecture support for the "Old Rules" scenario

In the "Old Rules" scenario the traditional actors, most importantly mobile operators, are still in the lead. We expect that they will combine service components from multiple providers and offer them as a complete package to its customers. In order to remain successful, operators needs to extend their current services with new technology and utilize their strengths to produce secure and reliable services to a large customer base, and the ability to provide certain enabling services like payment and authentication services.

In the future, as the services get more complex, there will be more required service components and more parties producing those. The operator needs to have interfaces and processes in place to utilize these service components and interact with the providers. It needs to utilize its current strong position towards its suppliers in order to control the interfaces and maintain a leading position in the supplier network.

The Enhanced Telecom Operations Map® [eTOM] is a tool for describing processes between companies that produce a service in a value net. It provides a reference point for internal process reengineering needs, partnerships, alliances, and general working agreements with other providers. For suppliers, eTOM outlines potential boundaries of software components to align with customers' needs and highlights the required functions, inputs, and outputs that must be supported by products. Although eTOM has specific focus to telecommunication type of services, i.e., services related to providing connectivity, the model can also be applied to application-oriented services studied in MobiLife.

Critical processes in inter-organisational interfaces (supplier-customer) are related to strategy and product management (e.g. defining and implementing value-net interfaces, identifying partners and making agreements), and to operations (management support, delivery of services, problem handling and billing).

The MobiLife architecture can meet the challenges of the two environment scenarios described in this paper. However, the environment has clear impact on the applicability an in the following we discuss it using the service oriented architecture structure.

1) Business Interface Analysis

The architecture development is driven by easy migration from existing services and architecture. The MobiLife architecture maps to IMS to include existing services. By providing well-defined interfaces on the other hand, new services can rely on interface specifications to offer their functionality connected to existing services. This way, new services can be connected to the current services with proprietary solutions and interfaces. The IMS mapping approach allows the implementation of new interfaces while taking care of the old ones.

Concerning the requirements for device features, on the business interface level for the "Old Rules" scenario the feature is needed that every end user's device must maintain personal configurations when the device is changed, and the interaction between devices must be guaranteed. The Personalization Function (PF) provides a central profile storage that is context aware and takes privacy and trust into account. This central storage should either be accessed all the times when dealing with personal configurations, or replicated whenever a user gets a new device. As the profile management is context aware, personal settings and interests are always related to current devices (device information is part of the context). Beside these device dependent configurations, PF supports default settings shared for all devices. The settings are provided centrally through the Service Provisioning Function (SPF). SPF supports configurations made available by the service provider concerning user terminals for the correct usage of a specific application. The particular devices interact through the User Interface Adaptation Function (UIAF) that provides device management features and synchronises device usage over MobiLife services and applications.

2) Service Interface Analysis

To offer complete packages to customers, operators need to be able to combine service components form multiple providers but to combine all data for central maintenance and billing. Through the MobiLife Operational Managemet Function (OMF) and the Context Management Framework (CMF) interface specifications, operators can easily add new enablers and providing central billing through

component logging. The particular components log their activity and send the information to the OMF as defined in eTOM processes. This information may be used for central invoicing and billing

Maintenance is provided as described in the eTOM processes through OMF, to which all components of the service infrastructure have to provide defined interfaces and data. Thus, as MobiLife services are clearly related to the service infrastructure components, part service maintenance is done through OMF. Additionally, the Service Provisioning Function (SPF) enables service maintenance. SPF supports configurations made available by the service provider concerning user terminals for the correct usage of a specific application, advertises service automatically or proactively to users/groups, and manages the user-service usage profile and service subscriptions through the Self Provisioning component. OMF and SPF together enable the storage of customer relationship information and service usage data.

Context data management is one of the most important issues for novel mobile services and applications. Related to this are individual and group profiles and preferences. The Context Awareness Function (CAF) takes care of raw, interpreted and aggregated context data. This function handles context data related to individual users and to groups of users. It supports the service developer by providing users' and groups' current context information through well-defined interfaces. It specifies the components Context Management Framework (CMF), Personal Context Function (PCF), Group Context Function (GCF) and Reasoning Function (RF). To determine the situation of a user and/or a group entity, and to enable context aware services that provide relevant information depending on the user's/group's task, the CMF defines representation, exchange, interpretation and reasoning of raw context data from various sources: terminal devices, sensors, the collaborative objects surrounding the entity and the entities preferences. The use of a standard representation and exchange framework for context data abstracts from the need for each context source to define independent representation models for allowing raw context data to become context information. PCF and GCF are CP implementations that deliver context data related to individuals and groups respectively. They both comply with the specification defined in CMF. The Operational Personal Context (OPC) describes personal context data tailored for user's current context. The Operational Group Context (OGC) defines the same for groups. The RF offers reasoning functionalities for context inference and interpretation, including a recommender system. A service developer will use high level context information, containing low level context data, to make the service application behave in context aware manner. For example, a service application might deliver personalized news to users and groups in particular situations.

Finally, on the service interface level, the storage of historical service usage data is important. This includes user data (ID, Method of payment) and profiles and preferences of users and groups of the service and applications components (service package in use, level of service). The Personalization Function (PF) offers a Profile Manager to manage user and group-related profiles and preferences. Part of this preferences can be the service package in use and service level agreements, to that this information allows service usage regulation. Service component usage for payment is a different scope and covered through the OMF data logging features.

3) Technical Interface

The underlying implementation of the functional components and service enablers can be done as developers like, as the open Context Provider / Context Consumer (CP/CC) interfaces of the CMF following platform-independent open standards, using XML and SOAP Web Services. The CMF specifications are public available, and to make CMF components manageable through OMF and make them run with novel MobiLife service and applications, providers have to follow them. The CMF specification is open and easily extendable, so the technology interfaces can be changed along the changing environment.

B. Changes in the "Wind Turns" scenario

How could the MobiLife loosely-coupled functions (such as personalization and context awareness) be provided by independent service providers?

In the "Wind Turns" scenario we would have a fragmented marketplace of modular, easy to combine layers and components, which imply opportunities for autonomous businesses to provide innovative applications as separate products. The leading service provider would probably be a new entrant providing the most innovative solution. Complexity of orchestration in the value network will be high because of differences in the level of standardisation.

Examples of potentially independent service products could include the MobiLife loosely-coupled functions such as personalization and context awareness. These services would have standardized technical and well understood business interfaces. In order to justify those services as separate businesses, they would need to be able to serve multiple specialized application services and businesses providing those.

1) Business Interface Analysis

As information and data are shared among multiple independent service (enabler) providers, the issue needs to be addressed how each provider can take care of information management. The Personalization Function (PF) and the Context Management Framework (CMF) define a shared information model. They allow distributed data management. Information management for business processes is covered in eTOM in the SID (Shared information and data model), which is adopted in the MobiLife Operational Management Function (OMF).

Mapping service usage with users and their profiles is a big issue in the "Wind Turns" scenario. This information is needed to enable target marketing. All Context Providers (CPs) / MobiLife service enablers have to provide access to their logged usage data, as specified in the MobiLife reference model. The Context Broker (CB) knows of all available CPs, as each CP has to register in the distributed CB database to be available for services to use. Through

checking the CP registry for a particular CP, and accessing CP's data logging interface, the Operational Management Function (OMF) can keep track of service usage. The log information can be filtered for particular users.

In the "Wind Turns" scenario, services are handled and managed by independent vendor/ company, so how can one get knowledge if they drop out of the value chain? Technically, the drop-out of a service enabler results in logging entries and alerts at OMF. But, this might lead to not service malfunction, which can only be regulated on the organisational level. Technically, this topic cannot be covered.

Requirements for resource usage concern the scalability of services through different geographic areas (local regulation). Through the Context Broker scalability, resource usage can be distributed to specific geographic areas. Requirements for regulative topics concern the issue that privacy elements have to follow current legislation in different countries, which is quite a challenge. This must be covered in the Privacy and Trust (PTF) function and is still an important research issue.

2) Service Interface Analysis

Several roles/actor service interfaces have to be clear, components must offer functions which are well documented and easy to use, all parameter- and return values has to be defined, and interfaces between the roles, users self-provisioning. The MobiLife components are well documented in the MobiLife Reference Model description. Additionally components have to follow the CMF documentation guidelines.

Concerning the adaptability of services, back-ups in different servers or even back-up services must be provided by different vendor (one day part of the value chain may be gone). There is no specific specification in the MobiLife reference model to cover this issue. Instead, each provider of service enablers should use state of the art technologies for installing and running these components with backup systems. There exist well established components for Web servers that cover these issues.

In the "Wind Turns" scenario it becomes more complicated to organize service usage, service discovery, service offering in heterogeneous service environment. Technically, there is no difference to the approach described ion the "Old Rules" scenario concerning service usage, discovery and offering. The MobiLife reference model specification covers these issues already in a distributed manner, allowing central monitoring and billing.

Finally, components are needed for online provisioning and mediation and payment. For this, services can be developed based on OMF interface access. It's not directly part of the MobiLife service infrastructure.

3) Technical Interface

Especially in the "Wind Turns" scenario, the problem of where the execution, of services happens becomes important. Portability within end devices has to be guaranteed. No common, agreed technology exists so far. Should the common technology be defined and how it is even possible to connect several techniques with each others. Would it be easier to use only a few, or even one, and is that possible? Because of data exchange reasons, where connectivity is needed anyway, many MobiLife components run server based. Particular functions that interact with the user should run on the end users' devices, e.g. UIAF. The platform heterogeneity is a big problem, and cannot be solved by the MobiLife reference model. This problem is covered in approaches like Java, or the Windows .NET platform.

C. How can MobiLife results proceed the future environmental evolution?

The main aspects in the MobiLife architecture that enable to keep track of future developments are the SoA approach in connection with the platform neutral XML and SOAP technologies. Each component is responsible for its own lifecycle management, and offers service interfaces. These service interfaces follow a well defined specification, and cover beside the main functionality that the component provides also service interfaces for component management. This included scalability, as well as data logging interfaces. This open specification approach paves the way to the future. Service providers can act independent of each other, but also form central service access and billing points if they want to. Thus, after an organizational and contractual agreement, the technical requirements exist for providing arbitrary service environments to the end users.

VI. EXEMPLARY SCENARIO APPLICATION

Context Watcher is a mobile application running on Nokia Series 60 phones (some of its key features are also included in a ported version called Personal Context Communicator that runs on MS Windows Mobile terminals and has been developed for the Italian project trials).

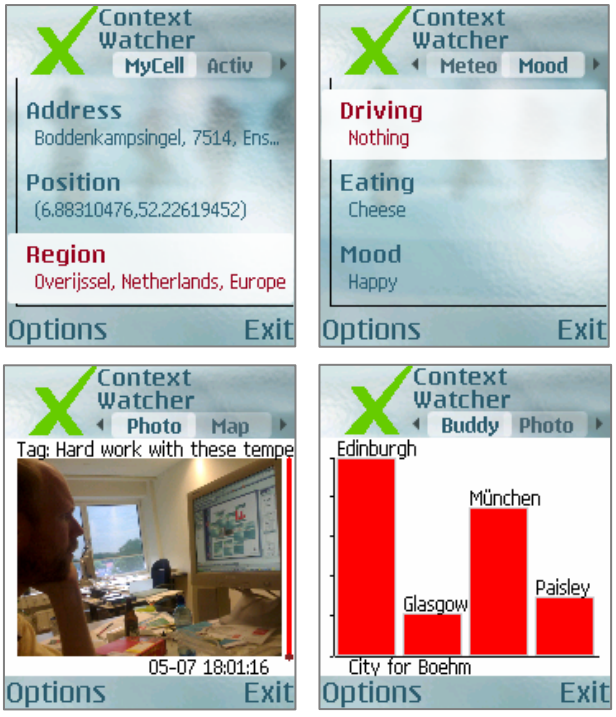

Figure 4: Context Watcher screenshots: using cell id for location identification; mood, presence and experience; context pictures taken submitted to a sharing platform (Flickr); graphical context representations (visited cities)

Its aim is to make it easy for an end-user to automatically record, store, and use context information, e.g., for personalization purposes, as input parameter to information services, or to share it with family, friends, colleagues or other relations, or just to log it for future use or to perform statistics on her own life. E.g., it can be used to create automatic context bits for one's own blog, so that one's friends can easily see what one has been doing over the last days, including a summary of the pictures that one has made. The Context Watcher application is able to record information about the users, such as:

- Location (GPS-based and/or GSM cell based);
- Mood, availability, safety (based on user input);
- Activities and meetings (based on reasoning);
- Body data (based on heart and foot sensors);
- Weather (based on a location-inferred remote weather Context Provider);
- Visual data (pictures enhanced with contextual data);
- Books you have read (using the camera to record 1D bar codes).

The Context Watcher application is a good example of an offer that would be likely typical of the "Wind Turns" scenario. Its technical design and development, as demonstrated by the work done in the MobiLife project, could well start from the initiative of a very small group of software engineers and computer scientists with an interest in context awareness and adequate knowledge of standard IT programming languages (Python in the case at hand). No huge investments on the infrastructure side would be needed, at least until the application is offered to a small audience and without relying on the large scale promotional actions that are usually taken by mobile operators or manufacturers when they launch a new service or a new device.

The Context Watcher innovativeness might be driven by technology but still it would be represent something new and different on the market, as it readily exploits some concepts and ideas from the research environment and bring them into an application that extends the mobile devices capabilities.

In any case, the user-centred approach and work of MobiLife, in which great emphasis is given to real-life trials involving end-users, shows also that even technology driven innovations might be steered towards promising directions once the users get some clue through actual usage about their potential or possible different evolution, even if they were not intended by the original designers – to an extent that someone claims that end-users have often a prominent but overlooked role in the innovation process. This is extensively discussed and well documented e.g. in [22].

The distributed architecture of the Context Watcher application, with special regard to the integration of several different external providers of context information, as well as its extensions on independent Web-based services via standard and open interfaces (such as in the cases of photo sharing on Flickr and or buddies location on Google Earth) makes it a good example of the articulated value networks that would emerge in the "Wind Turns" scenario.

On the other hand, the characteristics highlighted above does not exclude in principle that such an application would not comply at all with the "Old Rules" scenario. In that case, such an initiative might more probably born out of some cooperative research conducted by operators and manufacturers; extending the mobile device capabilities thanks to context information would be still interesting for them; yet it would be more unlikely that the application would start to roll freely in unexpected directions, as the promoters, being the dominant players on the market, would take great care in controlling its evolution and make sure that a sound business case is always in place from the very beginning.

Following the MobiLife reference model and Context Management Framework (CMF) architecture, the Context Watcher is a typical application where arbitrary service enabler providers can contribute functionality without restrictions on the technical side. This functionality is provided in form of Context Providers. It's simply added in the Context Watcher user interface by adding new tabs that provides access to this functionality. New Context Providers can make use of existing Context Providers, e.g. the Location Provider that knows users' current locations, but could also stay completely independent. Through the data logging feature of each particular Context Provider, the data usage can centrally be logged (if contractually allowed), thus providing the basic information for billing. If the independent service providers want, they can send separate bills to the service user, or bundle the billing at an extra service provider. This bundling satisfies the needs of the "Old Rules" scenario, while the complete separation covers already the looming "Wind Turns" scenario in telecommunication service provisioning. More information on the Context Watcher is available in [21] and [23].

VII. CONCLUSIONS AND TOPICS FOR FURTHER RESEARCH

In this paper we have provided findings of the importance of architecture in different environmental scenarios in modeling the business. We have discussed and conjoined the results of two research processes in MobiLife-project. Business modeling process provided a component based framework and two scenarios of the future mobile business environments to be used in modeling the business. The architecture definition process specified a set of functional components to provide mobile service developers with a well-defined environment for the creation of new mobile applications and services.

The change in the environment is described with the scenarios "Old Rules" and "Wind Turns". The "Old Rules" scenario describes an incremental development of mobile services. The "Wind Turns" scenario describes nonlinear less predictable environment. They place quite different kind of requirements to the definition of business modeling components and especially to the architecture used in the future mobile service.

As we have seen, the MobiLife service infrastructure fulfills the requirements for novel mobile services today through providing a well defined extendable interface for mobile service provisioning. To be able to make use of the telecommunication infrastructure and to enable operators

introduce new services easily, the MobiLife service infrastructure specifies a mapping to the IP Multimedia Subsystem (IMS) components. These operators are still in lead in the "Old Rules" scenario, thus the service infrastructure has to support their needs and requirements for mobile service provisioning. Beside the IMS mapping, the "centralized control" of the environment is relevant for them. This is provided through specified interfaces for scalability, management and logging at the context components, and collected by the Operational Management Function as defined in the eTOM processes. When the "Wind Turns", the traditional operators might not remain the only players on the ICT market as described. New providers have the interest to easily contribute own services, independent from the operators. For this, a migration process in the MobiLife service infrastructure is needed. As described, this migration towards the "Wind Turns" scenario is already covered in the loosely coupled SoA approach of the specification. If new service providers do not want, they don't have to attach service offering, billing, etc. to leading providers. They can start their own components with context interfaces, keep track of their maintenance, and keep the data logging on their own. They have to register their components in the service infrastructure (Context Broker) to make it discoverable and usable for applications like "Context Watcher", but technically they can remain completely independent from other providers and operators, assumed that end users' devices have IP access to the (decentralized) MobiLife service infrastructure. That's what the MobiLife service infrastructure allows. Organizational and contractual regulations for sure are hurdles that have to be solved by new providers.

The results underline the fact that to make the mobile service development to happen the understanding of the business, service, and technology interfaces in the architecture is needed. Analysis of how the business models mutate in the two described scenario environments from architecture point of view could bring new insight and contribution to the co-evolution of business actors. Especially the following topic could be research further:

- How to support SMEs to become application service providers
- Value chains, earning logics in "Wind Turns" environments
- Challenging enablers in (e.g. monitoring/billing) in "Wind Turns" environments
- Privacy and Trust in "Wind Turns" environments

The impact of the innovative mobile technology on the development of future business models can be regarded as significant. However, we are confident that our analysis has provided tools to continue the modelling work.

ACKNOWLEDGMENT

The work has been performed in the framework of the IST project IST-511607 MobiLife, which is partly funded by the European Union. The authors would like to acknowledge the contributions of their colleagues from Nokia, Alcatel-CIT, Ericsson AB, LM Ericsson, Hewlett-Packard Italiana, Motorola Ltd, Motorola SAS, NEC Europe, Siemens SpA, DoCoMo Euro-Labs, Elisa, Fraunhofer FOKUS, University of Helsinki, Universität Kassel, University of Surrey, NEOS, Telematica Instituut, UNIS, Suunto, BLStream, Helsinki University of Technology and Telecom Italia.

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