ANWIRE visions of architectures for adaptable services in the wireless Internet

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1 Preamble

This contribution intends to initiate a common understanding of a generic service adaptation environment to be able to identify necessary generic service elements. It aims to bridge between the finalized WG2 Whitepapers on Adaptability [6] and Ambient Awareness [7] and the new Whitepaper on Generic Service Elements.

The results presented here were obtained as part of the European IST Project ANWIRE (Academic Network for Wireless Internet Research in Europe, IST-2001-38835 ANWIRE) [1], [3]. ANWIRE is a thematic network established by academic and industrial partners from various EU countries acting in two main overlapping research tracks: i) Wireless Internet and ii) Reconfigurability. ANWIRE aims at organizing and coordinating parallel actions in key research areas of Wireless Internet and Reconfigurability and promoting and disseminating Wireless Internet and Reconfigurability solutions, in order to make them available to the research and industrial community.

The coordination activities encompass common efforts and tasks for covering open issues identified in the various specialized areas, relevant to the provision of a coherent integrated framework in next generation systems. The work is organized in Task Forces, each one of which focusing on a specific thematic area. The thematic area of task force 4 is "Architectures for Adaptable Services" [4]. In ANWIRE we assume that services offered tomorrow to mobile users will be personalized, context-aware and adaptable. Among our goals is the identification of the requirements and main functional building blocks for architectures for adaptable services.

2 Introduction

With the development and deployment of wireless networks, substantial evolution is observed in the area of telecommunication service provision. Users will soon expect to have access to a wide variety of personalized, context-aware services at any time, from any place, and from any terminal device. In this context, mobility of users, devices and software components can occur, leading to changes in the environment of these entities. Moreover, services can be highly dynamic, with users requiring support for novel tasks and demanding the ability to change requirements on the fly. Consequently, support for adaptation is required from the service provision system.

The remainder of this paper is organized as follows: in the next section, we define the terminology used and present assumptions made on adaptable service provision support. In Section 4, we introduce the adaptation process. Section 5 is dedicated to the identification of the main service elements required in the service provision platform to support the adaptation process. We discuss relationship with ongoing WWRF Working Group 2 activities in Section 6 and we conclude in Section 7.

3 Definitions and assumptions

We define a "**service**" as a set of functions and facilities (related to applications, telecommunications facilities, contents, products, etc) offered to a user by a provider, according to an implicit or explicit service agreement [2].

Several definitions of adaptability were given in [5]. We adopt the following: “A*daptation* means change in the system to accommodate change in its **environment**. More specifically, adaptation of a software system *(S)* is caused by change *(d_E)* from an old environment *(E)* to a new environment *(E’)*, and results in a new system *(S’)* that ideally meets the needs of its new environment *(E’)*. Formally, adaptation can be viewed as a function: *E x E’ x S ®S’, where meet (S’, need (E’)).*
A system is adaptable if an adaptation function exists.”

Adaptable service may be obtained through adaptation actions that are performed by logic within the service or by an external entity (e.g., service adaptation middleware platform).

In the remainder of this paper, the following general assumptions are made: Service access and usage may involve several cooperating actors such as service providers and network operators. The service adaptation middleware platform consists of logic that may reside in different administrative domains and can support adaptation actions reflecting the policies of the various actors.

A service is comprised of one or more components that are assembled (or composed) to form the service. Services can in turn be composed to form a composite service. Service components may be distributed over the various nodes of the service provision infrastructure. For example, a service may be distributed over the user terminal, the service provider and one or more intermediaries.

Note that adaptation may require actions at different times of the service lifecycle. At design time, the service designer must anticipate adaptation decisions and strategies and design the various versions of the service or the service "components" accordingly. The designer may also anticipate that the service may be composed with other services. At deployment-time, appropriate middleware intelligence adapts the service to the execution environment by choosing the versions of the service or the service components that should be deployed and how they should be distributed over the various platform elements.

Once the service is deployed in the service platform, it may be used. During the service initialization time, after the user has requested service access, the service is initially configured to best match the user requirements and the execution environment. This initial configuration of the service is a form of adaptation. Then at runtime, during service operation, the service may have to dynamically adapt to user requirements and environments changes. It should be noted, that the process of service *personalization* is an adaptation activity.

4 Adaptation process

The overall service adaptation process can be modeled by an adaptation loop represented in Figure 1. Note that the adaptation loop captures the adaptation process as performed both at initialization time and at runtime.

In the figure "box 1" depicts the service and its execution environment. In this work the term "execution environment" is purposely used in a broad sense covering:

- User preferences, location, identity, presence information, history.
- Physical and social environment such as presence of other people, other devices, indoor or outdoor operation, date and time.
- Technological environment such as terminal capabilities and, network infrastructure capabilities.
- Service characteristics, configuration and settings.

Prior to any adaptation action, the system in charge of adaptation must be aware of the value of various execution environment parameters and of any change in this execution environment. For example, if a user decides to continue executing a service on a device that is different from the device on which the service was initially started, then there is a significant change in the environment corresponding to that of the operating device. A change in user's connectivity due for example to the user mobility is an other example of change in the execution environment.

Some changes in the environment may not be relevant to the adaptation process and should be ignored. Some changes may only be relevant if correlated to other changes. This is why the parameters to be monitored must be identified, and all changes perceived in the execution environment must be analyzed. This intelligent environment monitoring and analysis functionality is captured by "box 2" in Figure 1 that materializes the need for the adaptation logic to be always able to capture and interpret the changes in the execution environment.

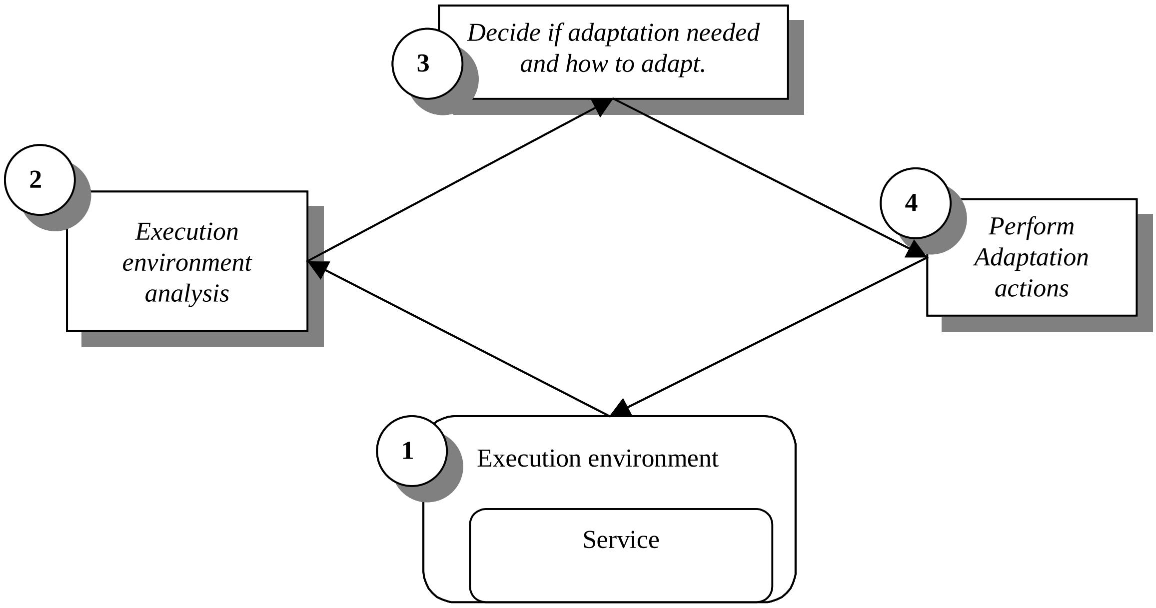

Figure 1-Service Adaptation Loop

If the analysis concludes that an observed context change should lead to service adaptation, then the system must decide of the nature of the adaptation to be performed and how they should be performed. This is depicted by "box 3". Notably, the environment analysis phase is closely related to the adaptation decision-making and could be considered as a pre-processing function for it. The decision of whether or not an adaptation is needed is usually made with respect to clearly defined adaptation policies. Adaptation policies are generally expressed in the form of a collection of "if *condition* then *action*" statements. The decision box may therefore prescribe a series of actions that correspond to service adaptation. The execution of the adaptation actions is depicted by "box 4". Adaptation may be relative to the service behavior, presentation or content. Examples of adaptation actions are changing execution parameters, service replacement, service component change, addition or replacement, service component migration, service composition, media stream adaptation, data filtering and transcoding.

5 Services elements required by the adaptation process

The adaptation process that we just described assumes that a number of basic services are available from the service adaptation middleware. Furthermore, the adaptation process cannot be carried out without a number of important supporting services that act in a complementary manner to main adaptation functionality. In the present section, we provide a list that results in our first attempt at identifying these services.

5.1 Main adaptation services

The main adaptation services presented in this section implement the basic functionality of the adaptation loop of section 4 and form a service adaptation middleware that is able to implement service adaptation management based on policies by various stakeholders.

5.1.1 Execution environment analysis

Facilities are required to monitor, filter and analyze the changes in the execution environment that are significant for adaptation.

The service adaptation middleware uses existing infrastructure and capabilities to retrieve environmental information (e.g., open network APIs, context servers). From the middleware point of view these functions act as service enablers for the adaptation service. The added functionality related to execution environment handling concerns processing of environment data. This processing may include transformation from various interchange formats (e.g., XML, RDF) to a form that facilitates unified handling as well as various semantically important tasks such as aggregation, inference, and correlation. To perform this added functionality already existing service enablers can be also utilized.

5.1.2 Policy-based adaptation decision-making

Adaptation decisions are based on environmental information (e.g, terminal capabilities, user preferences and status, network characteristics, ambience). Their main output is the specification of the optimal new state of the adaptable entity, which is reflected in the entity’s *profile* (metadata). Decisions may also comprise information related to *how* adaptation actions shall be activated/performed. Decision-making is performed according to context-dependent algorithms, which actually comprise the *policies* of the owner/administrative authority of the adaptable entity (e.g., service developers or providers in the case of mobile applications). Thus, mechanisms to describe, deploy and maintain adaptation policies for various parties (e.g., service providers) need to be established [8]. Adaptation policies are generally expressed in the form of a collection of "if *condition* then *action*" statements. The adaptation decision logic should ensure that the applied adaptation policies do not compromise the stability of the system (e.g., the system does not oscillate too quickly between a number of transient states).

5.1.3 Policy-based adaptation initiation and control

5.1.3.1 Adaptation entity control

The control of the adaptable entity (e.g., a service) enables the service adaptation middleware to perform a variety of adaptation operations, as they are prescribed by the adaptation decision logic. Such operations may include a wide variety of actions such as modification of operational parameters, update/replacement and physical re-allocation of service components. These operations are accomplished through appropriate functions aka “adaptation enablers“. The availability of these enablers is taken into consideration during the adaptation decision-making process.

5.1.3.2 Content management

One adaptation realm is the content of the service. Here we can distinguish syntactic and semantic adaptation. *Syntactic* adaptation concerns the format and syntax of the content provided to the user and may involve complicated actions that, however, do not alter its semantics. It can be done through QoS adaptation of streams and by data transcoding. *Semantic* adaptation relates to the meaning of the adapted content (e.g., localization/personalization, filtering for security/privacy issues). It is done, for example, by a simple re-parameterization of the data, by data filtering and also by a major replacement of content.

5.2 Supporting services

This section relates to services that may not be part of the main adaptation logic, but are crucial for enabling adaptation.

5.2.1 Execution environment monitoring and data retrieval

Facilities are required to retrieve data relative to the execution environment that will be subsequently used for its analysis. Among these facilities is the information relative to the infrastructure, e.g. the network QoS or the terminal capability, and such things as a location service that gives the location of the user and a presence service that provides information about other users and devices in the environment; further information sources which provide physical conditions of the environment like weather, daylight, temperature or even biometric information (blood pressure etc) may also be available.

5.2.2 Profiling

Facilities are required to capture and manage various profiles including: user profile, role and preferences (for personalization); terminal capabilities; network infrastructure capabilities; service description. In ANWIRE, as of today, we define five profiles: terminal profile, user profile, network profile, user access profile (relative to access network) and service profile. We are currently discussing the introduction of an additional profile relative to information on the ambience. A unified way to process and interpret the various profiles taken into consideration is an important issue.

5.2.3 Service management

The service management requires the ability to ***describe*** services, service components and service compositions, to ***discover*** services and service components, to ***create***, to ***compose*** and to ***deploy*** services (components), and last but not least to ***control*** the service (component) execution.

5.2.4 Operation support

Adaptation processes must be coordinated with the operation of the services, since service adaptation may require re-synchronization with the service operation itself. This includes aspects such as QoS provision, charging/billing and accounting services, provisioning of privacy and security on various levels, support for interdomain roaming and also with session management issues.

6 Mapping the ANWIRE view to the WWRF Reference Model

The previous sections briefly introduced the current work of the ANWIRE project Task Force on Adaptable Service Architectures that is closely related to the ongoing activities in WWRF WG2. We believe that there are many similarities and also many complementary aspects addressed in both organizations. As a first step, in order to bring the activities in line, we tried to work the “adaptation enabler” aspect into the WWRF “Cake” [9].

From our understanding three main functional entities are involved in an adaptation system. First the entity that derives and delivers information about the environment. This information feeds the second actor, which is kind of an Adaptation “Kernel”. It holds the Adaptation Intelligence, i.e. it decides on the necessity of an adaptation, plans it and finally initiates and controls the desired adaptation process. The third actor is the entity that provides the adaptation function and performs the adaptation itself.

We further believe that these three functional entities shall be designed and implemented so that they are completely independent from each other. Even more, the entities of the first and the third entity are typically not dedicated only to service adaptation. However, they enable the adaptation kernel to perform the adaptation service and their availability is therefore required by any adaptation system. We denote them “(Adaptation-) Service Elements”. To be more specific, Service Elements are the

"Points of Service", i.e. the entities that interact directly with the Kernel representing the enabling service, irrelevant if they only mediate the service or if they provide it by their own.

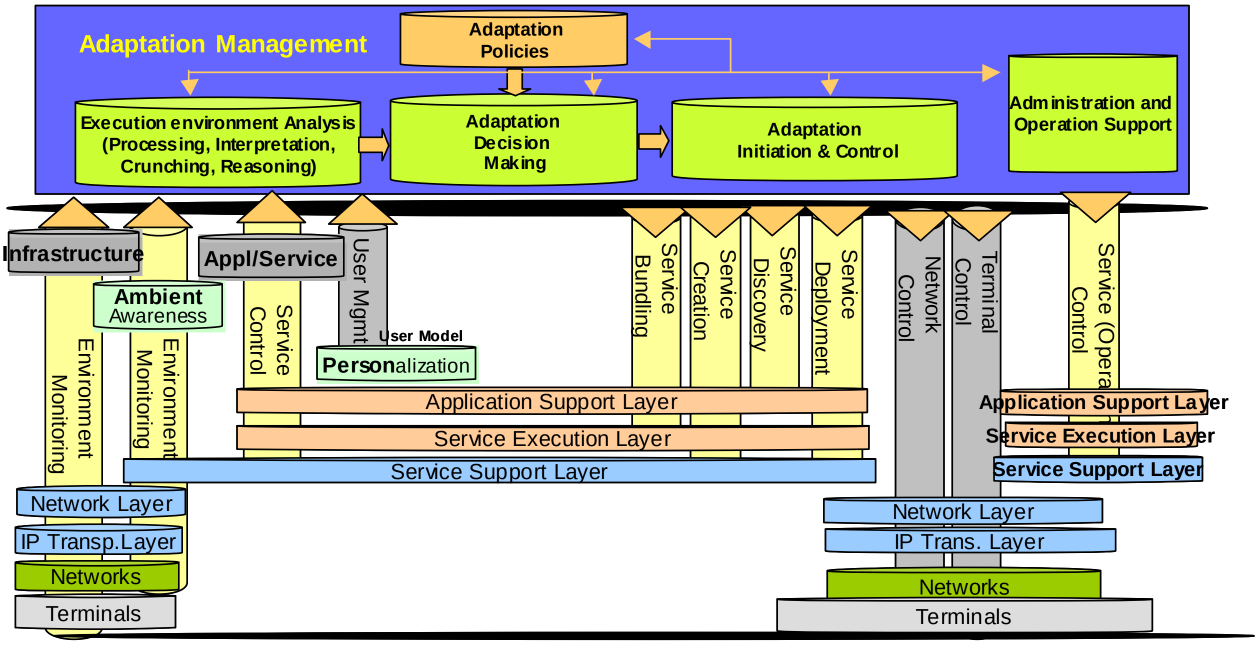

Figure 2 ANWIRE Adaptation Model within the WWRF Framework

Figure 2 outlines our view how the ANWIRE model could be mapped to the WWRF "Cake". This figure is not intended to supplement the WWRF Cake, it can be considered as a projection of two overlaying planes of (adaptation-) service system models.

For this projection we adopted the service element columns from the Cake. However, we didn't follow the view that they are crossing each layer. We believe that a layered approach like it is discussed in the WWRF requires specific, layer-to-layer interworking, and does not follow the approach of having vertical service elements horizontally secluded throughout all layers. Therefore we "chopped" the strict shape of the Cake.

Service elements that appear in the Kernel, provide information on the Infrastructure, the Ambience, the Service & Content and the User itself. The Ambience and the Users Information naturally map to the "Ambient Awareness" and "Personalization" WWRF Cake entities. For the Infrastructure (referred to as "Computing Context" in the Ambient Awareness Whitepaper) and for the user information we did not spot a direct counterpart in the Cake (therefore colored in grey). The data flow is depicted by an arrow towards the adaptation management. Arrows can also be considered as dynamic profiles, provided to the adaptation management.

On the right side we see mainly the service elements of the WWRF Cake related to service management (creation, deployment, discovery etc) as relevant for our model, enriched with new -grey- columns connected to the Infrastructure. Since the adaptation management is invoking these Service Elements, the arrows here point towards them.

Whereas these Service Elements provide the adaptation function, the rightmost column "Service Control" corresponds to our view on the necessity of coordination with the service operation. Hence this Service Element (which is actually considered as placeholder for a variety of Service Elements) does not directly perform adaptation, but updates the service provisioning operation, which might need to adapt itself according to the performed service adaptation. Therefore one could say that this Service Element performs *indirect* adaptation.

It must be noted, that, up to now, we only addressed how a generic adaptation service is embedded into a Service Environment, making use of independent Service Elements. Future steps will be to apply the discussions about Service Elements to those ones dedicated to and residing *inside* the Adaptation management. We think that these Elements, although being fundamental parts of the "Kernel", must also be available to external entities, to enable them to make use of single Service elements.

7 Conclusion

In this paper we introduced the ANWIRE view of a generic service adaptation environment, especially the aspect of service elements that corresponds to the WWRF Generic Service Element Model (see [9]). We discussed the approach for mapping this view to the WWRF Reference Model.

The intention here is to initiate a common understanding of a service adaptation environment to be able to identify necessary generic service elements. This common understanding should promote the service adaptation realm in the ongoing discussion on generic service elements in the WWRF, and bridge the gap between the already finalized WG2 Whitepapers on Adaptability and Ambient Awareness and the new Whitepaper on Generic Service Elements.
In this early stage of the work, we could only tackle some relevant issues in a quite general matter; further discussions and collaboration between ANWIRE and WWRF are now welcomed to reach the pursued goal.

8 Acknowledgements

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