Characterization of Mobile Services in Heterogeneous Communication Environments

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Abstract. The term "service" is quite overused in the telecommunications research area. This paper continues previous research by the author toward a better understanding of the service concept. The term service in this paper means the "something" that a human user receives from the computing environment that includes mobile and fixed devices, various kinds of interconnected networks forming a larger whole, and a variety of existing software. The main concern of this paper is to derive a set of essential properties of services within heterogeneous networks. It also defines the relationships among established properties and references each of them to a certain functional layer within a service conceptual model. Finally, this paper represents an example of "service content value"-based classification and the service characterization framework using an ontological representation

1 Introduction

There is no doubt that the communication world is evolving into a so-called pervasive computing environment, meaning that computers and electronic devices are so intrinsic in everyday life that people no longer realize how much they use these technologies. Of course, this also means that everything is interconnected, so users can be recognized regardless of their locations or the devices they are using. This concept results from the variety of application services and electronic devices available and the options provided by networks, interoperability, seamless roaming, context awareness and personalization.

The convergence of fixed and mobile networks brings us to interoperability solutions regarding the first stages of the networks' confluence and a new age of the Internet with a shared core but heterogeneous access networks along the edge. The achievement of these goals presumes an extended evolution in both technological areas. Nevertheless, the mobile and fixed networks remain distinct. For example, the "Wireless Internet" does not exist globally yet and requires the wider spread of UMTS; but even when these tasks are completed, the wireless Internet still will be different from the traditional Internet.

The diversity of networks is, however, a challenge because modern technologies that deal with network content can be implemented much easier in a new network than through upgrading the existing one. It is clear that, for small-sized mobile devices, the current Internet content is to be updated and huge amount of new content

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needs to be provided. However, one essential goal of current research is to decrease the necessity of the updating of content as much as possible, so “essential generic functionality for mobile applications should be implemented in the infrastructure” [1].

One of the very important concepts to be understood is the notion of service in the context of a heterogeneous communication environment [2] note that this term is quite “overloaded” and that it is important to understand its complex meaning. In the area of wireless mobile communications little research has been devoted to the question of service characterization and categorization [3], [4] yet and even these researchers consider service from some particular point of view.

The main purpose of this paper is to define the set of essential characteristics of services provided in heterogeneous networks, and parts which can be represented by any networking standard. The characteristics of services should be defined in abstract way and represent fundamental properties, but not existing instances labeled by some standard. It is also important correlate the properties and to define their interrelationships based on some structural model of the network or service.

This paper seeks to use a complex approach to categorize services by their essential properties, and to link the categories to each other and to existing instances of suggested concepts. In preparing this work, it was studied a wide range of papers and websites that describe current services and some still under research and development [5], [6-12]. The categorization given within this paper can be understood as an ontology of a service in its most conceptual sense within the computer networks domain and is intended to be used by telecommunication networks to further improve their functional separation and openness.

3 Characterization Basis

When discussing the variety of services in future communication networks, it is appropriate to divide services into two major categories – vertical and horizontal. This division is presented in [13], where it is recommended to pass from vertical services like the SMS, cableTV and PSTN to horizontal ones, which would represent parts of network functionality (access, transport, service network, etc.). Such transition is a common trend in the telecommunication world and represents a high degree of flexibility compared to the current situation.

The *vertical service* (complex service) is a functional complex that works in communication network and has value and content intended for the human user. Vertical service is usually quite complex and consists of all constituents of the communication network functionality (transmission, routing, representation, etc.). *Horizontal service* is a set of service primitives all working on the same layer of abstraction (functional layer) and providing the network with similar or complementary functions (see Fig.1).

The conceptual idea presented in the figure 1 has its practical implementation in the existing Internet, where layers of OSI reference model are fixed and clearly defined as well as each of service primitives. However, the existing division does not meet the needs of mobile and wireless communications, nor does it take into account many recent scientific and industrial developments. Therefore a need exists for

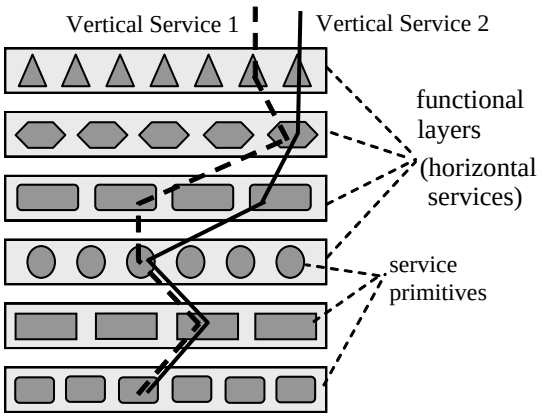

Fig. 1. Assembling the vertical service

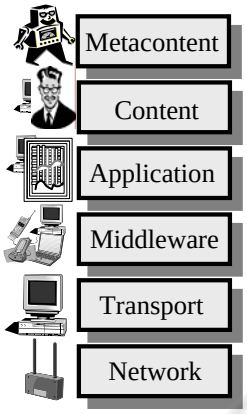

Fig. 2. Communication service reference model

reconsidering the current understanding of computing networks with respect to the emerging technologies, such as mobile and wireless networks.

In this paper, the model described in [2] and represented on the figure 2 is used as a basis for characterization. In principle, any kind of reference model can be utilized, but the chosen one is particularly suitable from the service provisioning point of view. It introduces a conceptual view on the service and consists of the horizontal services, shown as model layers briefly described below.

The *network layer* is needed to provide communication capability between two network nodes – perform mobility, scalability, routing, handover, format transformation, load balancing, medium access control and other functions concerned with the transmission of traffic node-by-node from the source to the destination. The *transport layer* of the reference model represents the transport service in a mobile/fixed heterogeneous network in an end-to-end macroscopic scale. The principal idea of the *middleware layer* is to provide the functionality that will allow applications to avoid a majority of the problems that arise within the heterogeneity of the communication environment. According to [2], the middleware scale provides service portability, device and user mobility, and make them seamless for end-service applications. The *application layer* provides and represents service content to the end-user. Another aspect of the application layer functionality concerns the AAA issues that are specific for the concrete service. The *content* of service is what the user actually receives. In other words, content is the *service value*. The *metacontent* describes the service in terms of metadata for easy machine retrieval, analysis and use.

The research results described in the following section establish a set of essential properties of a complex service provided in a heterogeneous network. The collection must allow for the classification of all, or a majority of, the existing complex services and distinguish the services from each other according to their characteristics. In addition, the set of properties should be essential and allow for the exclusive classification of services.

3 Complex Service Essential Properties Derivation

3.1 Mobility

One of the most crucial properties of service in modern networks is *mobility*, which is well described in [14]. There are three types of mobility: service mobility (the movement of the same service from one network/device/user to another), device mobility (the same device is moving across different networks), and user mobility (the same user moves across different devices).

Device mobility support requires additional functionality (roaming, device mobility tracking), mainly in the network part of the complex service functionality. Service can be such that it is provided for mobile user(s), stationary user(s) or in an ad hoc manner. Since device mobility is the most popular and widely used type of mobility, let's use this corresponding property as simply mobility.

Service mobility and *user mobility* can be characterized by the two properties of a complex service: *network* and *consumer*, which are addressed on the middleware layer of service provision. The following separation: can be done with respect to the network: *local network services, cross-network services, multi-network services.*

Local network service is service that is provided only in the home network and cannot be transported to any other network, due to a technical or advisability reason. *Cross-network services* are those that can be provided in the home network as well as in a host network; the latter can represent another telecommunication standard. *Multi-network services* always engage two or more telecommunication networks standards.

The *consumer* property accomplishes a set of service properties describing mobility issues and represents the addressee of the service. The classification of services based on a consumer property is to be used in the provision of the AAA functionality on the middleware layer – internetworking and co-operation issues: *human-addressed services, terminal-addressed services, unaddressed services*.

A *human-addresses service* means that the service is to be provided to the actual human(s), regardless of the terminal he/she is using (e-mail, reservation services, etc.). A *terminal-addressed service* is to be provided to the concrete terminal(s) without taking into account the user's personality (speech call, remote diagnostics, location-based services, etc.). *Unaddressed services* can be provided in an unauthorized way to every entity in the network (advertising, emergency, news, etc.).

3.2 Network Architecture

When considering the service provision in heterogeneous environments, it is necessary to distinguish the networks from an architectural point of view. Despite the fact that networks are interconnected, service is usually targeted to one or another type of network architecture or a certain set of them.

Based on the current variety of computer network standards, we would derive the following groups of general network architectures: Cellular, Satellite, Wireless LAN, Wireless PAN, Broadcast, Fixed. The given set represents the modern network architectures domain and with respect to the *architecture* property of vertical service belonging to network layer of complex service reference model.

3.3 Traffic Flow Shape

Each complex service considered in this paper includes an information exchange between network nodes participating in a service provision, consuming or communication process. The corresponding functional layer, which is responsible for handling data traffic on a logical level, is a transport service. Structure and behavior describe, from a traffic point of view, the properties of the transport service.

Behavior represents the dynamics of the service. The following general types of traffic behavior are seen: *static, dynamic, real-time*.

Structure of the traffic flow reflects the "relationship" between its sources and destinations (the transport session architecture). The following structures of macroscopic traffic flows can be considered in fixed and mobile network domains: *one-to-one* (unidirectional, bidirectional), *one-to-many* (multicast), *one-to-all* (broadcast), *many-to-many* (conferencing).

3.4 Application Properties

A complex service, when meant for the human user, always has an application(s) that performs actions that particularly conclude this concrete service and provide a user interface. There are many characteristics of applications from various points of view. Let us derive two essential properties of a complex service with respect to its application(s), specifically describing it in a mobile heterogeneous network environment: context and execution.

The *context* property describes the common situations in which the service is used or which influence its execution. With respect to a service application context, the following types of services could be established: *location-based services, mobility-dependent, disconnection-sensitive, user terminal/class specific, and network specific.*

Another important characteristic of the service application(s) is its execution pattern, which we define as an *execution* property of the service application layer. With respect to the application execution pattern, complex services can be: *client-server, peer-to-peer, distributed, third-party, download.*

The *client-service* type of execution supposes that the principal part of the computational efforts is executed on a server; *peer-to-peer* service means that two network users communicate directly without a coordination unit; *distributed* service is executed in several parts in various places in the network; *third-party* type of execution assumes the participation of three parties: the service consumer, the service provider, and the telecommunications operator, which provides the accessibility to service; *download* service means that all components of the service are first downloaded to the user's terminal and then the service is executed locally.

3.5 Service Content

The *content* of a complex service is the only horizontal layer of the reference model [2] that does not introduce any physical entities into the network, unlike the applications, hardware, or middleware procedures. While it is abstract, it remains a very important property of a complex service. Actually, the target of the entire service

provisioning process is precisely the provision of content to the user. Consideration of services from content point of view is very important in marketing issues, AAA schemes planning, business models design, etc. Many classifications of services in communication environments are based on the content that sometimes places technologically the same services into completely different categories. In some cases it is reasonable, in other cases it is not. However, content as a characteristic of service should be always taken into account. Two properties of content considered essential are *user* and *value*.

Depending on the intended user group, application developers should design a user interface and serving capabilities of communication service. That is why it is important to separate such property of communication service content as *user***.** The following general categories can be distinguished: *private customer, collective user, service provider, communication device manufacturer, telecommunication operator.*

The *collective user* means that a service is addressed to several persons considered as one and paying as one, for example, business users, family members, etc. The *communication device manufacturer* has produced the device through which the user is served by the service provider. The *telecommunication operator* normally maintains the communication line between the service provider and the user, although sometimes it may perform the functions of the service provider as well.

Content *value* is what the user actually receives by the service. It can be information, data, communication or control capability, or any combination of these. Based on the list of functioning and emerging services provided by various networks, we derived this set of service content types*: communication, information, assistance,*

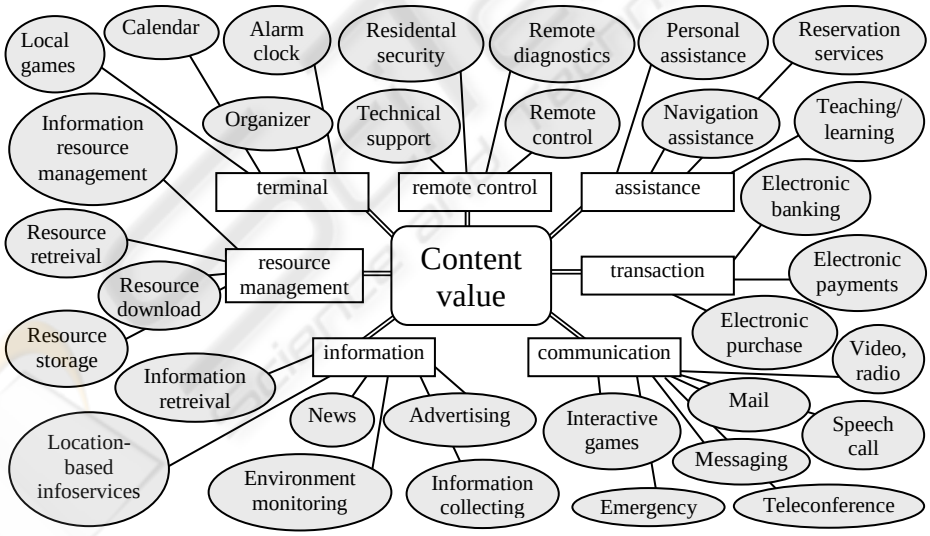

Fig. 3. Content value-based service classification

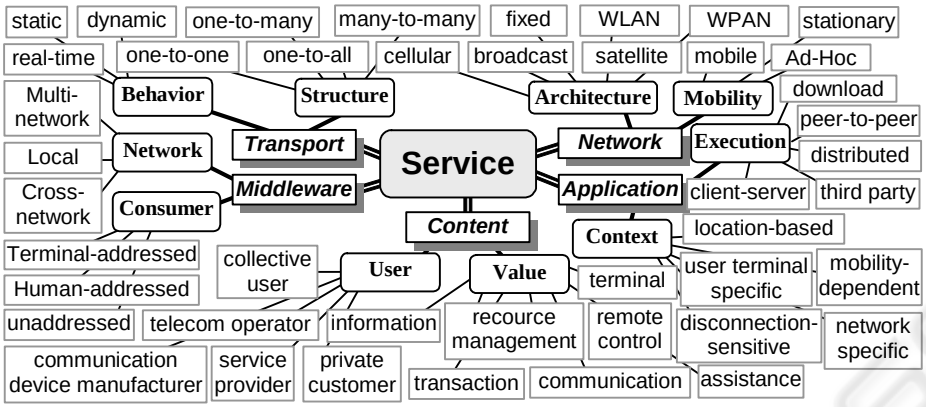

Fig. 4. Characteristics of service in heterogeneous communication environments

transaction, remote control, resource management, terminal. Figure 3 classifies the selected set of existing services with respect to the content value viewpoint. *Communication* means that two or more network users exchange some piece of data; the *information* type reflects the situation in which the user retrieves some information from the network; *assistance* is a challenging type of content that implies the existence of some entity that guides the user within some period of time, type of activity or until some goal is achieved (navigation assistance, e-learning, personal assistant); *commerce* represents services with a high level of security and a transactional type of functionality; *remote control* refers situations when the user controls the physical or logical devices through the communication network in real time or off-line; *resource management* is concerned with applications representing, usually, the user interface to network resources and allows users to create, modify or destroy network information resources, such as databases, files, information storage, etc; *terminal* type of content value represents applications that are executed on the user's terminal and do not interact with a network while execution.

All presented characteristics of complex service to be provided in heterogeneous computer network are visualized (relatively to the selected reference model) on the figure 4.

5 Conclusions

The service that a user receives by being connected to a heterogeneous networking environment via a communication device can be understood in many different ways, depending on the point of view. This paper presents a conceptual study of service, and describes its essential properties and the interrelationship of these properties. The defined set of properties is correlated with a chosen service reference model in order to place each service property on the general map in telecommunications area.

The proposed characterization framework can be used, first of all, in service classification efforts. One of such classification examples is represented in figure 4 and is based on a service content value property.

The key goal of this work was a comprehensive overview of existing and emerging services within heterogeneous environments. Such an overview is very useful for extracting knowledge about a service from the service itself and from service provisioning mechanisms. It is also valuable when needing to satisfy one or all of the requirements of service provisioning, such as ubiquitous access – the capability of a terminal to access diverse communication networks; *cross-network mobility* – the seamless roaming among diverse access networks; *service portability* – the adaptation and reusability of existing services across multiple communication systems; *context awareness* – the dynamic service adaptability to changing user and network conditions; and *independent service creation* – the separation of service creation from the specifics of service delivery in every communication network.

The primary value of this work is seen in taken the service characterization approach and categorization from various viewpoints rather than in assigning labels for concrete entities (properties and types of services).

The results obtained in this work are still subject to further improvements. However, even now they can be used as one of the inputs in areas such as context utilization, service portability provision, middleware development, heterogeneous network integration, and adaptive services support, among others.

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