Communication Profiles for SDR Equipment

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ABSTRACT

This paper summaries and categories the information elements important for defining communication profiles of all relevant actors in a mobile communication scenario, where the information elements include Terminal, User, Service and Network Profiles. Those context information described by the profiles need to be retrieved before the decision process will be started for negotiation air interfaces for SDR Terminal or any other terminal adaptation. To efficiently reduce the signaling overhead, profiles data are dynamically clustered in classmarks by meaningful criteria. Under dynamic classmarks we understand the efficient coding of temporary clusters for profile data. Dynamic classmarks capture all the features of the information entities in an abstract and succinct manner. An XML structure is used for the profiles that reflect the different properties of a terminal, user, network or services.

I. INTRODUCTION

Reconfigurable radio systems will offer the next major step forward in mobile and wireless communications, particularly in the light of the existing many worldwide air interface technologies. The requirements for the reconfiguration process need to be identified [1]. The decision unit that controls the reconfiguration process needs to know information about the current context of the whole system (i.e. information about the main system entities like user, terminal, and network). The instances in the network need to control reconfiguration processes in the terminal. Furthermore, before the reconfiguration process takes place, the capabilities of the terminal must be known and checked regarding to the target mode of operation (e.g. Radio Access Technology). In addition, for mode negotiations or any other adaptation of the service, network and user profiles need to be retrieved before the decision process starts.

In this paper we present a general concept of storing communication context information in profiles and analyse the requirements for terminal capability and status information that need to be stored in a terminal profile. The paper is organised as follows: in section II, the concept of communication profiles is presented, where general issues concerning the use of profiles in wireless distributed middleware supporting automatic runtime reconfiguration are addressed, followed by examples for terminal, user, network and service profiles. In section III the concept of classmarks is introduced followed by an example of possible grouping of terminal features into classmarks. Finally, architecture for efficiently storing profile data information is described. A well-known tree structure, which uses XML to model and transfer the profile data between terminal and the network, is used for the communication profile structure.

II. Communication Profile

A communication profile is the abstraction of all relevant participants in a mobile scenario, as there are the device, its network environment, the user and the available services on different levels ranging from lower layer bearer services to higher level tele- and application services. Every entity or "actor", which is a participant in a mobile system scenario e.g. a terminal, or a user, or a software service, has its own profile of capabilities and features that consists of static and dynamic parts. The dynamic part contains a set of attributes that may change frequently and the static part that stay fixed for a certain period of time some.

Terms concerning communication profiles are defined first:

The Registry

A registry is a database used to store and mange settings and options for the communication profile on the according server or device. This *Communication profile* contains information and settings of all the hardware, software, users preferences, and of the terminal capability. Whenever a change is made or software is installed, those changes are reflected in the profile and stored in the registry. Figure 1 depicts the structure of the communication profiles in the register.

Profiles

Profiles are the abstraction of the context information of the different information entities. Profiles are split into two parts: static part that is constant over the time, such as the ID (name) of the user, and dynamic one that may change frequently, such as the amount of available memory of the terminal. Profiles should be described in a platform independent format that is widely accepted and standardised. Since the attributes of the profiles are constantly changing it is important to design the structure of the profiles extensible. Therefore we recommend to follow the profile structure proposed by the W3C [2] and extend it successively by time.

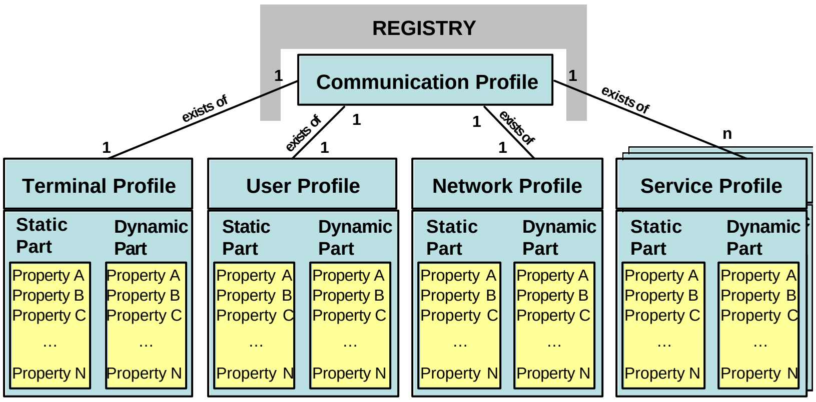

Figure 1, the structure of the communication profile in the Registry

In the following paragraphs the communication profiles of the relevant actors in a mobile communication scenario are described:

A. Terminal Profile

The Terminal Profile contains general attributes describing user interface capabilities that are targeted for choosing a terminal that is suitable for certain applications. It consists of static attributes like display type or screen size and dynamic ones which are describing current hardware status (e.g. remaining battery power) or more specialized attributes describing the terminal's radio capabilities and status (e.g. multi mode/multi RAT capability)

B. User Profile

The user profile reflects both the static and dynamic attributes of the user, like the unique ID, currently selected language or the currently selected privacy mode. All information in the User Profile are retrieved at reconfiguration process based on the user's subscription details or personalised preferences.

C. Network Profile

A network profile handles different underlying network types. Depending on the air interface there is a special profile for every used protocol, which describes characteristics like the Quality of Service (QoS) and information that are needed for accessing the network.

The static features of the Network profile are stored in the Network Bearer Service Profile (NBSP) module, which is part of the system architecture [4]. NBSP is a database offered Bearer Services in each network; it is an essential source for Network Capabilities negotiation and Bearer Services QoS assessment. It presents static information regardless of the cell status and therefore, although being a key parameter during Mode Switch negotiations, it is insufficient for Mode Switching decisions. The dynamic features of the Network Profile provide the current status of the cell and other related information's.

D. Service Profile

A service profile defines different aspects of the final service provision to the user. It deals with issues such as Service Architecture, Service Classification, Service Mapping, Service Negotiation and Service Allocation.
The dynamic features of the Service Profile are contained in the Access Stratum module that is part of the system architecture [4]. The Access Stratum module contains all access specific functionality in each Access Network, which is subject to a certain RAT. It consists of the parts in the infrastructure and in the user equipment as well as the protocols between these parts specific to the RAT and provides real time status of resource availability in the access nodes, subject to cell load. The static features of the Service Profile define the applications that are classified into different groups depending on the Quality of Service (QoS) needed. Four applications have been identified so far:

- Conversational
- Streaming
- Interactive and
- Background classes (services)

III. Communication Classmarks

It should be possible to categories the capabilities and features of SDR terminals according to how advanced they are and which functionality they are able to offer. Classmarks are used to categories mobile devices based on their performance and capability. These criteria could include for example processing power, memory, display properties and screen size as well as interactive capabilities.

Such a classification would be beneficial in way that it would provide end-users with a standard representation of the capabilities and features of a terminal in terms of reconfiguration and if there are to be terminals with different capabilities, the network needs to be aware of the capabilities of each terminal it is serving.
The purpose or the aim of dynamic classmark scheme is to provide the Network in an abstracted manner the terminal capabilities without specifying or constraining future implementation. A refined dynamic classmark scheme filters the terminal dynamic features depending on network estimation of the usage of the feature. The

Table 1, an example of Terminal classmark according to performance

Feature\Classmark	**1**	**2**	**3**	**4**	**5**	**6**
Example	GSM Phone	WAP Phone	Html Phone	I-Mode Phone	UMTS Phone	HiperLan Phone
UI Customization	None	Render	Scripting	Download	Download	Download
Wireless Network Range	Long	Long	Long	Long	Long	Long
Multimedia Capability	None	Pictures	Music	Music	Video	Video
Display Size	Small	Small	Small	Small	Medium	Medium
Control	Limited	Limited	Limited	Limited	Full	Full
Bandwidth	Low	Low	Low	Low	Medium	High
Extensibility	None	None	Upgrade	Upgrade	Expansion	PnP

Networks can estimate/predict the status of the dynamic feature, in this way the transmission of the classmrak will be restrict only to dynamic features that are hardly to be predict and their frequency of change is much higher thus saving bandwidth and reducing the signaling overhead. One example of dynamic feature behavior prediction is the state of battery, knowing which application the terminal is currently running and which kind of battery is used; the network can determine battery stage of charge information. Figure 2 illustrates an example of battery discharge behavior. The network can be trained by updating weights and basis for similar dynamic features.

So far, there are several classmarks used in the mobile communications systems; for example:

- The **GSM classmark** (which consists of several parameters describing the capabilities of the mobile station, including the encryption algorithm, SMS capability, multi band support and the maximum output power level of the MS in a given frequency band)
- The **GPRS multi slot classmark** (which denotes the combinations of receive and transmit slots that the terminal can support)
- **MExE classmark** (which indicate the capabilities of the terminal in terms of screen size, input capabilities, memory and processing power)

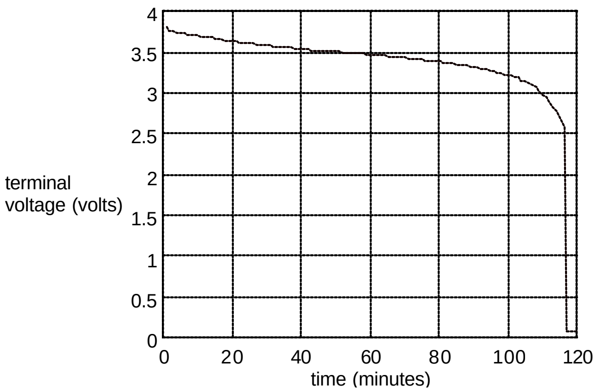

Figure 2, An Example of Battery discharge

A. Terminal Classmarks

Terminal classmark cluster a large number of terminals into groups of similar devices. With technology advancing it is unlikely that the clustering criteria can be standardised based on exact values of profile data. The criteria that can be used to segment terminals into categories is more likely to be dynamically changing. However since classmarks should not be used only for reducing the signaling overhead and network bandwidth but also for service trading decisions, the criteria for clustering should be both dynamical and meaningful.

This can be achieved by defining abstract clustering criteria that can be dynamically populated with concrete profile data values during system runtime.

Table 1 illustrates an example of possible grouping of terminal features into classmarks according to overall performance. This is only useful within one class of device types, e.g. mobile phones.

B. User Classmark

Similar to terminal classmarks, user classmarks are used to categorize end users based on their preferences. This could include for example billing and application type preferences, as well as amount of information and interaction possibilities to be displayed to the users The user classmark is part of the user profile data. In systems with groups of a large number of similar users, classmarks can describe user preferences without transmitting or even know the exact values of each profile element thus saving bandwidth and increasing the accuracy of adaptation to specific users before gathering or configuring their preferences data.

Users classmarks can be used for decisions that involve a wide range of profile data but do not need exact values. Usually this concerns decisions about the user interface (e.g. amount of information and control possibilities displayed) and application/mode usage or notification (what available services to announce, what quality of service to choose)

User classmarks are constructed in the same way as terminal classmarks for similarity reasons. The abstract clustering criteria can be dynamically populated with concrete profile data values during system runtime to reflect changes in user behavior or allow for provider specific configuration.

IV. Communications Profile Structure

A. XML Structure

The XML profiles structures reflect the different properties of a terminal, a user, a network or a service. The profile is stored in a software module, called a registry, which takes care of the management of the profiles, like accessing and efficient update. The structure of the Registry is shown in Figure 3

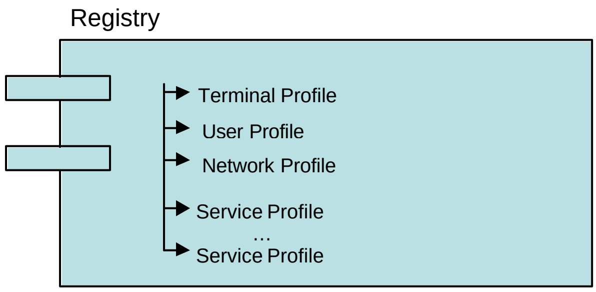

Figure 3, Registry Structure

To maintain a minimum level of redundancy and avoid data inconsistencies most of the data will not be copied, but linked and accessed just in time. For example the user profile can be organised as follows:

The static part will be physically kept on the provider server and the dynamic part will be kept on the terminal since it is often a target of change and therefore would cause high access traffic to the server.

The possibility of keeping the profile data redundant might be not acceptable, because of the synchronisation overhead. Therefore the profile tree is split into two parts that are physically kept on each responsible Registry and are linked vice versa. See Figure 4 below.

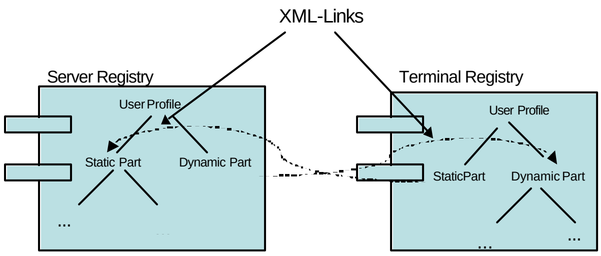

Figure 4, Tree Structures of the profiles

B. *Efficient compression and coding*

To save bandwidth and storage resources, the profile data should be compressed. A better approach to utilise the compression would be first using general binary or text based compression mechanisms instead of specialised binary optimisation mechanism, either for the complete profile data or alternatively only for certain elements that are especially suitable for compression. Second to limit these steps to only parts of the distributed system where bandwidth is especially expensive compared to slight increase of processing power. This might be the case for transmitting profile information between the terminal and the base station. A simple experiment of compressing two different size XML documents (300 bytes vs. 9kb) shows that even not XML optimised compression technology can achieve very good results on reducing necessary bandwidth to transmit profile data for medium size profile data (9kb), while retaining full flexibility, extensibility and integration aspects of the initial text- XML based approach. The XML optimised scheme that separate compression of structure and content information, is significantly more efficient for small size profile data, while retaining XML flexibility and extensibility features (e.g. ignoring unknown tags) even without decompression. To conclude it is not necessary and even disadvantageous to manually optimise the initial approach of using text-based XML to describe profile data by converting the XML structure to a fixed binary data format instead the already existing compression technology should be used to reduce necessary storage or transmission bandwidth and only where necessary (e.g. transmitting profile data between terminal and base station). In this way the original advantages of an XML text based approach (flexibility, extensibility and interoperability) can be preserved.

C. *Distribution of Profile data*

In general profile data is usually stored, where it originates. Links are used to form a completely distributed data model. Since this general approach contains no data replication, no synchronization is necessary however this does not address some important requirement conditions within wireless mobile networks and moreover has some disadvantages regarding used network bandwidth. Wireless networks are unreliable by nature. Terminals might loose their connection from time to time even if they want to be connected (i.e. not switched off). Services that rely on profile data stored in the terminal could of course use a lease-based mechanism to prevent unnecessary resource allocation as well as precipitate abort of a running transaction. This implies that the service needs to wait for the terminal to reconnect before it can continue even if the requested profile data is not very likely to change during the time of disconnection.

A more sophisticated approach would be to store the static profile elements on a location not within the wireless part of the network and the dynamic elements on the terminal. Since static profile data (e.g. screen resolution) never changes or rarely at predetermined points, synchronisation is no issue. This way services can access some of the terminals profile data even if the terminal is temporarily not connected.

The same is valid for static and dynamic user profile data e.g. user subscriptions and "do not disturb" preferences that are stored on the terminal/smart card and the providers network respectively.

Another efficiency issue regarding synchronisation and distribution of profile data is the efficient synchronisation of profile data between locations where the information is produced, stored, consumed or replicated. In the general, profile elements could be distributed on several locations of the system. Data is transparently synchronised on each access by resolving x-pointer connections where necessary. This can be inefficient if the profile data consumer need to query (poll) each time he wants to check whether an element has changed or not. Even more inefficient when the polled element is in fact a sub tree of the profile data structure with several children again distributed on other remote locations and if the consumer is only interested in a small portion of the sub tree.

Two techniques can improve the general approach in this area:

- Specify in more details the part of the profile the consumer is interested in.
- Changed or modified parts of the profile data should be propagated to consumers that registered their interest in the affected area, along with the exact point where the change occurred.

Not in every case it is useful to send the changed data element along with the event notification, especially if the affected data is of reasonable size and not every consumer would decide to poll the changed data after receiving the notification and not every consumer would do it at exactly the same point in time. This way load peaks can be prevented in one producer/many consumer situations. For consumers that need to query every change, e.g. central storage's should be sent the changed data along with the event notification. Addressing parts of the profile data tree should contain addressing single elements without child elements, sub trees, sub tree ranges, depths and sub tree with exclusions. Figure 5 shows how the profile data can be addressed.

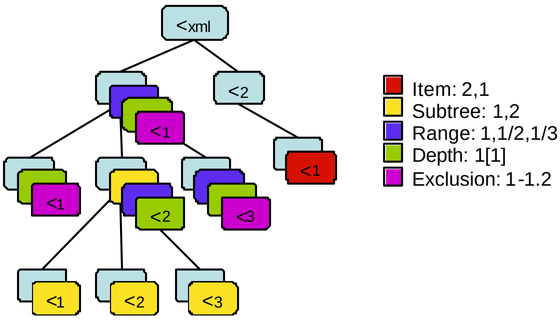

Figure 5, Addressing Profile Data Elements

V. Conclusion

This paper establishes the schematic architecture for reconfiguration terminal involved mobile communications with addressing four types of Communications Profiles (Terminal, User, Service and Network) that reflect communication features, which need to be considered for mode negotiation or other adaptation for reconfigurable terminals. It reflects all the entities that are part of the architecture and all the interaction and information exchanged between different entities. Using capability and status information of the different entities, the profiles are introduced which consists of two parts: the static part and the dynamic ones. The static part remains constant for a certain period of time and the dynamic part may change frequently. The communication profile is stored in a software module, called a registry, which takes care of the management of the profiles, like accessing and efficient updating. An XML structure is proposed for the profiles.

Similar features can be clustered together to form classmarks. Classmarks are shortcuts of the profile data. In systems with groups of a large number of similar devices, classmarks can describe the terminal efficiently and thus reducing the signaling overhead. Since classmarks should be used not only for reducing the unavoidable capacity carrying signaling information in mobile network but also for service trading decisions, therefore the principle to cluster profile data into classmark is meaningful. In further optimisations, efficient methods to compress and code the profile structure are described. Also further attributes can be used to exactly model the requirements for profile data elements such as Access frequency to features, how frequent the feature changes.

For the future work, the modelling profile data elements more exactly by using meta attributes such as Access frequency to features, how frequent the feature changes will be tackled, that will allow for more sophisticated and efficient optimisations strategies.

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