# STRUCTURE AND MANAGEMENT OF SDR SYSTEM PROFILES

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## ABSTRACT

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). 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 service adaptation, network and user profiles need to be retrieved before the decision process starts. In this paper the schematic architecture for terminal reconfiguration involved in mobile communications will be established. All the entities that are part of the architecture and all the interaction and information exchanged between different entities will be reflected. Using capability and status information of the different entities, Communication profiles are introduced. Based on the user profile, terminal profile and service profile that the user applies; features are clustered into different sets called classmarks that are encoded into concrete values representing the characteristics of the features.

## 1. INTRODUCTION

Re-configurable Radio systems is expected to play a critical role in the area of mobile/wireless communications by increasing flexibility; reducing deployment as well as operation and maintenance costs; creating new business opportunities and employment; facilitating enhancement and personalization, etc [1]. Software defined radio (SDR) or re-configurable terminals will be the strongest candidate to give the answer of how to utilize the radio resources and meet the optimal user satisfaction.

In this paper a general concept of storing communication context information in profiles is presented. Then a proposal for the terminal profile together with examples for user, network and service profiles are presented. We illustrate with some features the conceptual ideas of profiles. An 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 presented.

For enabling an efficient signaling between network and User equipment, all profile content will be captured in different sets called classmarks. For the presented classmark concept; the classmark concepts in GSM and UMTS are taken into account as a reference. To further optimise the management of the communication profiles and signalling, efficient methods for compression and coding and dynamic classmark in which the capabilities and status information of the SDR terminal are abstracted into classmark created during the course of the session so that a fast decision would be taken in the process of reconfiguration are described.

## 2. COMMUNICATION PROFILE STRUCTURE

The profiles are the abstractions of the context information of the different entities in a mobile scenario, such as the user, the terminal, the services and the network. These profiles are split into static features that are constant over the time, such as the ID (name) of the user, and dynamic ones, such as the amount of available memory of the terminal. They must be described in an independent platform format that is widely accepted and standardized. A registry on the according server or device manages the data access and storage of a communication profile. A registry is a database used to store settings and options for the communication profile. It contains information and settings for all the hardware, software, users, and preferences of the device. Whenever a user makes changes or installs software, the changes are reflected in the profile and stored in the registry. Figure 1 shows the structure of communication profile, as it is stored in the registry.

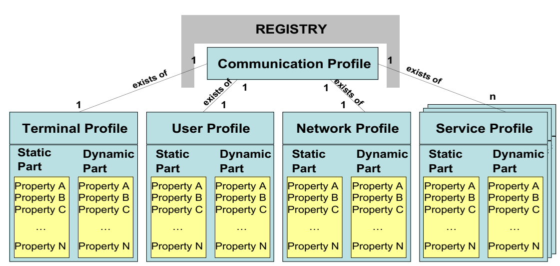

**Figure 1, the structure of the communication profiles in the registry.**

It is important to mention that things are constantly changing and therefore it is important to design the structure of the profiles extensible. We therefore recommend following the profile structure proposed by the W3C and extending it successively by time [3]. In the following subsections the different sets of communication profiles are presented. An XML structure that is used for the profiles, which reflect the different properties of a terminal, user, network or services, is also described.

## A. Terminal Profile

The terminal profile concerns attributes/features that describe the user interface capabilities, which are targeted for selecting a terminal that is suitable for certain applications. Profiles are composed of static features that are staying fixed for a certain period of time like display types or screen size and dynamic attributes that may change frequently such as current hardware status or the terminal radio capabilities. Changing the terminal radio capabilities, i.e. reconfigure the terminal between different radio interfaces (GSM-UMTS) implies a reconfigurations at different levels: Baseband, RF, protocols [5]. For example in the baseband reconfiguration the functionality, behavior and performance of the baseband transceiver chain will be redefined. It is envisaged that baseband re-configurations may involve change in Modulation-Demodulation, FEC encode-decode, and so on. This would be necessary if the terminal is to be re-configured to operate a different standard to that currently in use. For example, if the terminal is to be re-configured from operating the GSM standard to UMTS-TDD, then the baseband sub-system will need to be re-configured so that the digital signal processing block of the physical layer would run the UMTS-TDD standard as opposed to the incumbent GSM. Reconfiguring the terminal from one standard to another implies an important set of actions at hardware level will take place. These changes in the terminal radio capabilities are reflected in the dynamic part of the terminal profile.

## B. Service profile

One of the key points in reconfiguration process is the service negotiation, in order to ensure service provision in the targeted system, as otherwise it would be a waste of time and resources to reconfigure to a system that were not capable to provide the expected user's services.

Services are described by attributes which define service characteristics as they apply at a given reference point where the user accesses the service. In the service profile different aspects, which determines the final service provision to the user, are defined such as service architecture, service classification, service mapping, service negotiation and service allocation [6]. The dynamic features of the service profile are the real time status of the resources availability in the current access network that is subject to the cell load where as the static features of the service profile defines the application offered that is subject the QoS.

Four QoS classes have been identified so far:

- Conversational
- Streaming
- Interactive and
- Background class

## 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 and information that are needed for accessing the network. The static features of the network profile are stored in the network database (Network Bearer Service Profile (NBSP) [7]) that offers bearer service in each network. This database is an essential source for network capability negotiation and Bearer Services QoS assessment. The network bearer services (static part of the network profile) provide the capability for information transfer between access points and involve only lower layer functions (capabilities/attributes).

The dynamic features of the Network Profile provide the current status of the cell and other related information.

## D. 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 personalized preferences. In Table 1& Table 2, examples of a set of attributes for the static and the dynamic part of the user profile are given.

## E. XML structure

The communication profiles 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 XML structure of the profile in the Registry is shown in the figure below.

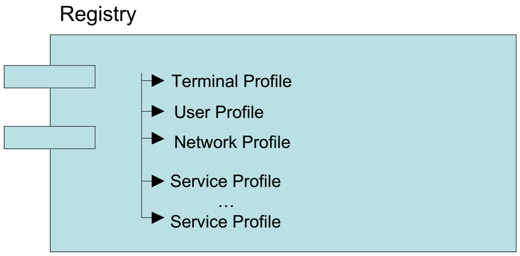


**Figure 2, the registry structure**

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 organized 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 synchronization 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 3 below.

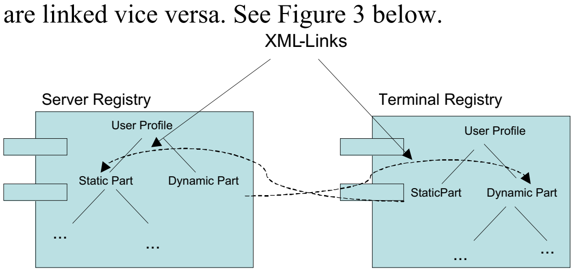


**Figure 3, Tree structure of the profiles.**

## 3. MANAGEMENT OF THE PROFILES

During the establishment, configuration, observing or controlling the current connections and radio connection release procedure, the network should know the up-to-date information of the terminals, e.g. power, potential load added to the network, priority, etc. All the required information depends on the radio connection status, states and network types. On the other hand, the heterogeneity nature of the required terminal, the considerable amount of expected information stream in order to fulfill the required information from the network side highly decrease the efficiency of radio resource management. In this section detailed requirements regarding efficient storage and management of profile data are described.

In the first stage a novel classmark concept for the profiles data management called: 'Dynamic Classmark' will be discussed, which highly increases the signaling efficiency between terminal and network. Then strategies for efficient coding and compression of the proposed profile structure will be discussed that will have impact on both the amount of resources needed for storage, processing power to access and the bandwidth necessary to transmit profile information within a distributed environment.

### A. Dynamic classmark

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 feature usage. The networks can estimate/predict the status of the dynamic feature, in this way the transmission of the classmark will be restricted only to dynamic features that are hard to be predicted 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. In the network, similar dynamic features behavior can be stored also the network can be trained to update weights and basis for similar dynamic features. Dynamic classmark scheme can be described based on finite number of stages that are specified for the classification of classmark. In each stage, the value of classmark has a different meaning.

The stages of classmark (classmark-stage) can be upgraded according to the priority, upgrade frequency, access frequency and the accuracy of attributes of the features required by the network. The features can be clustered independent to the OSI layers. Once the network requests the information from the UE, the UE sends the classmark in the current stage. With the information decoded from the classmark, the network will judge its next action or even trigger the UE jump to the required stage. However, the stage is independent to the UE's actions, it is only related with the classmark and the value of the classmark when it is to be generated.

The features of the UE side consists of hardware capability, capability of accessing to the potential radio access technologies, the user preferences, the applied service type, etc. All these features should be as input parameters to the radio resource control functions; in order to assign a reasonable radio link, reconfigure an on-going radio link, multiplexing number of connections or even release or discard an unsatisfied connection. In order to effectively increase the signaling efficiency between the UE and network, the features should be classified into different groups, where only one group of features appears in one stage when the network requires the information corresponding to this stage. The principle to classify the features is based on their properties. The static ones should be asked first, e.g., user identification and terminal capability; then the more dynamic features should be asked. However, there are number of features are not necessary to be asked, e.g. the maximum display size, although it is static, if the user only applies for the voice service, this feature is not necessary to be transmitted to the network. So, in the design procedure, the 'maximum display size' should be a feature being asked after the 'user preference' and 'service application'

In order to model the stage-based classmark clearly, a finite-state-chart illustrating the stages and the related features and classmarks are depicted in Figure 4. Since it is designed that the network may trigger the UE to jump to arbitrary stage by leaving any stages, a default idle stage is introduced in Figure 4.

The network triggers the UE by transmitting the stage-trigger command. Once the UE receives the command, it sends the classmark corresponding to the current stage, e.g., once the UE receives '001' shown in the figure above, it should submit its up-to-date features in stage 1 represented by the classmark to the network.

The network must take into account the user preferences for assigning possible radio link to a connection. The UE can be connected to a single RAT only, or even can be simultaneously connected to more than one RAT. In this case, the traffic splitting command, the joint load control and joint scheduling algorithm described in [8] should manage the simultaneous connections. In the second case, the UE must have the ability to access to the relevant RATs determined by the 'Terminal radio access capability' feature. During the communication procedure, number of features will be frequently asked. Either the UE or the network can abstract the frequently requested features to cluster them into a new stage defined classmark, as depicted in Figure 5

However, before the classmark value is sent to the network, the definition of the classmark and the meaning of classmark should be agreed by the network and the terminal sides.

### B. Efficient Methods for Compression and coding

To save bandwidth and storage resources, the profile data should be compressed. A better approach to utilize the compression would be first using general binary or text based compression mechanisms instead of specialized binary optimization 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 optimized 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 optimized 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 optimize 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). This way the original advantages of an XML text based approach (flexibility, extensibility and interoperability) can be preserved.

## 4. CONCLUSIONS

In this paper the the information elements important for defining communication profiles of all relevant actors in a mobile scenario, i.e., the Terminal, User, Service and Network Profiles are gathered and analysed. For the gathered information elements " Communication Profiles", efficient structure for data storage and efficient management of the data are described. 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. A strategy for abstracting the capabilities and status information of different entities into classmarks is introduced. The concept of Stage based classmark reduces efficiently the signaling overhead between the network and UE.

## 5. ACKNOWLEDGEMENT

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**Table 1, User Static Profile**

| Attribute | Range | Explanation |
|---|---|---|
| ID | String | The unique ID of the user |
| Home | String | The address of the user |
| Cost/billing preferences | String | Indicates whether the user is more interested in cost of transactions or speed of transactions. |

**Table 2, User Dynamic Profile**

| Attribute | Range | Explanation |
|---|---|---|
| Provider | String | The provider of the user for billing purposes |
| Language | String | The users language(s) preferences |
| Privacy Mode | Boolean - 'yes', 'no' | Indicates whether the user wants their identity kept secret |
| Accept Download | Boolean - 'yes', 'no' | Indicates whether the user will accept downloadable software |
| Know/already visited Locations | Boolean - 'yes', 'no' | Is the user new to a given location |
| Movement speed | Float (m/s) | How fast is the user moving (through the cells) |
| Average number of incoming/outgoing calls for a day | Integer > 0 | How likely is an incoming/outgoing call |
| Appointments/ Time Schedule | String | Used to extrapolate dynamic requirements |
| Health condition | String | Heartbeat, breath frequency etc. might be used to monitor critical health situations, detect high priority emergency calls etc. |

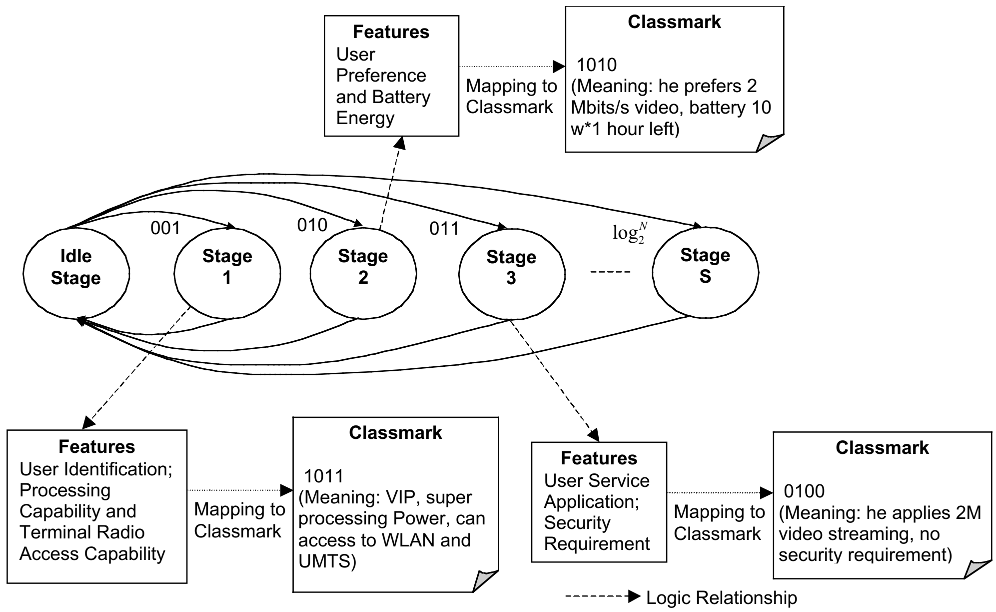


**Figure 4, Classmark described by stages and their representative features**

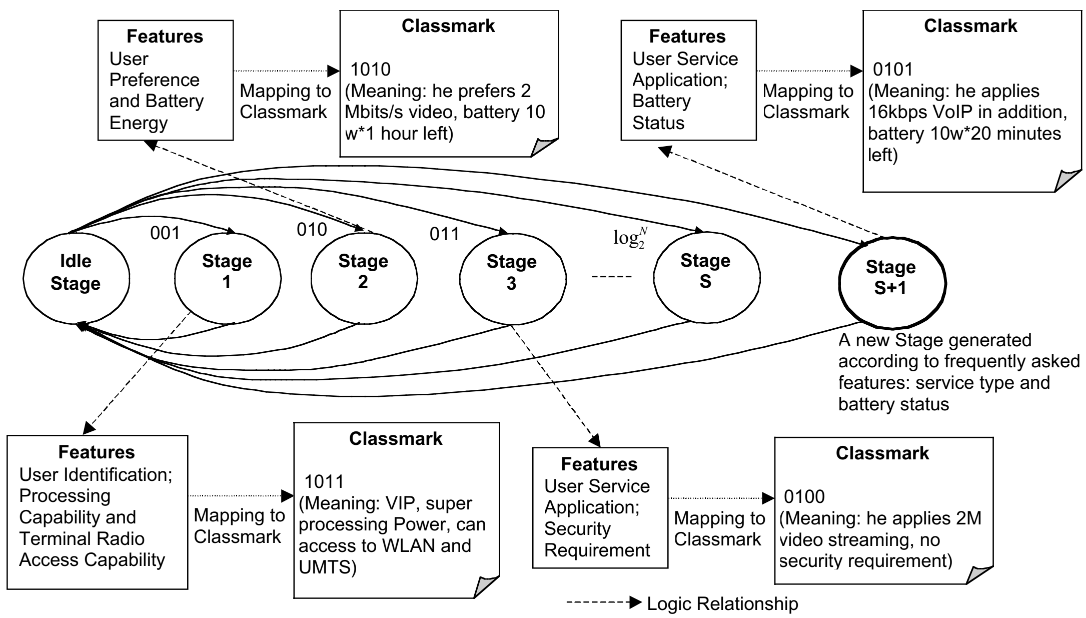


**Figure 5, Dynamic creation of classmark**