Architecture for User-aware Network Self-configuration

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Abstract

The IST project Simplicity intends to develop and evaluate a series of tools, techniques and architectures enabling users to customize and use devices and services with minimal effort. In this view, a key role is played by the user profile. The profile of a Simplicity user is stored in the so-called Simplicity Device (SD). In this framework, network operators might be able to exploit user data in SDs and enhanced capabilities of Simplicity-enabled mobile terminals to facilitate the control (e.g., load balancing) of heterogeneous access networks. This work presents an architecture and procedures to accomplish this automated process. The availability of a user-aware network control would significantly strengthen operators' interest in having a Simplicity System.

Keywords

Users' profiles, network monitoring, management policies, access network control.

1. Introduction and basic concepts

This work has been carried out in the framework of the IST project Simplicity [1] [3][4][5]. Simplicity stands for Secure, Internet-able, Mobile Platforms LeadIng CItizens Towards simplicitY. Users today employ a variety of different terminals and devices to ubiquitously access a range of different services. Users who attempt to exploit the services on offer have to deal with multiple procedures for configuring devices, multiple authentication mechanisms and passwords, multiple billing and payment procedures, multiple access technologies and protocols. This creates an enormous burden of complexity, which is likely to limit the use of the services themselves. The main goal of Simplicity is to simplify the process of using current and future services. The project intends to develop and evaluate a series of tools, techniques and architectures enabling users to customize and use devices and services with minimal effort. To this end, Simplicity provides each user with a personalized profile, stored in a so called Simplicity Device, SD, (either a physical device or a virtual device accessible over the Internet). Ideally, a user who plugs the Simplicity Device into a terminal gains transparent access to a personalized working environment including network storage and services, which are automatically personalized to meet the needs of the user in his/her current location/context. A key attribute of Simplicity is re-configurability, at various layers. In fact, to integrate different paradigms from the user point of view, it is necessary to break, as much as possible, logical wires that still tie mobile users to networks and services, also at upper layers. To enable this full-spectrum re-configurability, our system encompasses three main components: the Simplicity Device (SD), the Terminal Broker (TB) and the Network Broker (NB).

The role of the SD is to store user's profiles, preferences and policies. It also stores and allows the enforcement of user-personalized mechanisms to exploit service fruition, to drive automatic adaptation to terminal capabilities, and to facilitate service adaptation to various network technologies and related capabilities. The SD could be implemented as an enhanced SIM in a mobile phone equipped with Bluetooth to communicate with terminals/devices to be personalized or as a Javacard to plug into the target terminal.

The TB is the entity that manages the interactions between the information stored in the SD and the terminal. The TB enables the SD to perform actions like terminal capability discovery, adaptation to networking capabilities and to the ambient, resource and service discovery, adaptation of services to terminal capabilities.

The NB has the goal of providing support for service description, advertisement and discovery. Moreover, it orchestrates service operation among distributed networked objects, taking into account the issues related to the simultaneous access of several users to the same resources, services, and locations. It also allocates resources, and manages value-added networking functionality, such as QoS and mobility support.

Summing up, our system results from the combination of the SD with a brokerage framework (that in turn includes TB and NB). The brokerage framework will use policy-based technologies (e.g., policies for mobility support, QoS, security, SW downloads) to orchestrate and adapt network capabilities, taking account of user preferences, terminal characteristics, and network status.

Heterogeneous services, terminals, and networks create a burden of complexity not only for end-users but also for operators who have to devise and implement procedures for effective performance guarantees, load balancing, efficient resource exploitation, congestion avoidance, fairness, fault tolerance, adaptive topology and so on. Thus, any simplification of management procedures in this heterogeneous framework would be more than welcome. For achieving this purpose, we can potentially make use of the Simplicity user profile and brokerage framework.

Our goal is to design a self-controlled access network, where hosts and network devices require a minimum amount of manual configuration by network operators (spontaneous networking) and technical effort from users. This self-administration capability should not be affected by changes in traffic patterns or in network topology. This objective lead us to design a distributed system able to take decisions locally as much as possible, so as to limit the scope of traffic engineering actions and the amount of signaling through the overall network.

In this paper, we propose procedures able to track both the current state of access network resources and the current actual and potential service demand. The outcome of this monitoring action is the picture of the status of available resources (access network context) and service demand, which allows configuring the network in order to provide an optimized usage of resources. This set of information is the input to a procedure able to drive mobile users towards the most appropriate point of access to the network [2], thus avoiding congestion on particular access segments and under-utilization of other ones.

2. SD-aware network control

The typical goal of a network manager is to optimise network performance in terms of QoS (users' side), throughput and load balancing (operator's side), pre-empting critical situations and minimising the load on human operators. In general, network control actions will depend on users' side information, on the spatial distribution of users over the area covered by the network, and on the characteristics of the network, such as network topology, network resources, and available tuning capabilities. If these data are largely unknown, control actions will be essentially reactive. Our goal is to have the highest possible amount of data available as input to the decision engine to improve performance in a proactive way with respect to a legacy system. In this regard, the process of collecting useful data could be easily achieved by exploiting specific features of Simplicity: (i) capabilities of SD-enabled terminals, and (ii) user profiles and preferences.

In more details, users may provide the NB (the policy decision point, PDP) with inputs (through the SDs) to influence the actions of the operator management framework, which is in charge to suitably drive users in accessing services. On the other side, the TB is in charge of assisting the network, by providing inputs to the NB as regards the access network context (e.g., the radio access technologies currently perceived by the terminal), and by acting as policy enforcement point (PEP) if needed (e.g., switching from an access point to another). In addition, the NB has to be able to monitor the status of radio resources, e.g., retrieve from access points the amount of bandwidth currently available.

This aggregated set of information made available to the NB is used by the decision engine to re-distribute the mobile terminals according to specific operator policies (e.g., load balancing). The whole process is depicted in Figure 1.

The selection process may be invoked: (i) when the terminal is turned on, (ii) periodically, according to specific operator's policies, and (iii) when a handover is needed.

Dynamic network and traffic configuration should be self-constructing. Network performance should be monitored on-line so that, if background proactive control does not provide satisfying results, operator policies can trigger reactive actions.

We assume that the NB may be either centralised and residing in a specific network entity or distributed over a number of entities (e.g., access routers), each one controlling a limited section of the access network. In the former case, the single NB has to know the status of the whole network, so that the NB can suitably control all terminals in the network.

More details on architectures, procedures and performance evaluation regarding Simplicity network control can be found in [6].

A demonstrator of this proposed system is currently being produced to show the feasibility, benefits and interest of the Simplicity approach.

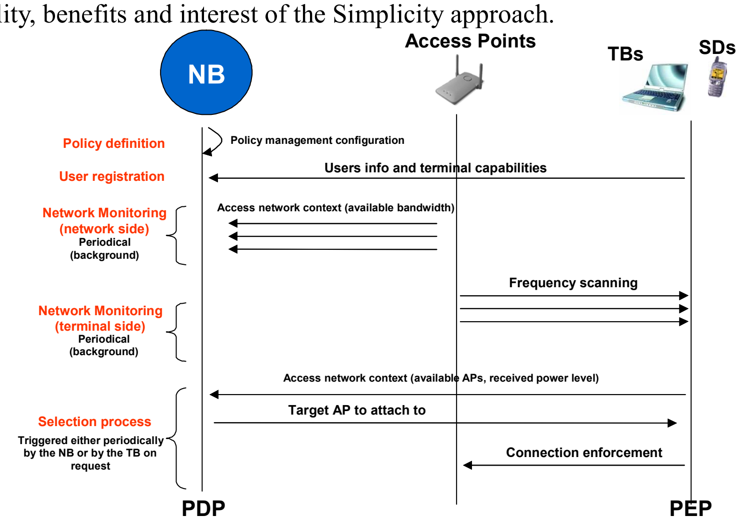

Figure 1: SD-assisted network control, message sequence chart.

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