UCWW intersystem

IVAN GANCHEV
[1]Telecommunications Research Centre (TRC)
University of Limerick
Plassey, Co. Limerick
IRELAND
[2]Department of Computer Systems
University of Plovdiv "Paisii Hilendarski"
236 Bulgaria Blvd., 4027 Plovdiv
BULGARIA
[3]Institute of Mathematics and Informatics
Bulgarian Academy of Sciences
Acad. Georgi Bonchev Str., Block 8, 1113 Sofia
BULGARIA
Ivan.Ganchev@ul.ie

Abstract: - This paper describes a Ubiquitous Consumer Wireless World (UCWW) intersystem for future wireless networking, based on a novel generic Consumer-Based techno-business Model (CBM) that enables a loose dynamic (even casual) consumer-type association between mobile users (consumers) and service providers, based on a Third-Party provision of the Authentication, Authorization and Accounting (3P-AAA) service. With this intersystem, the consumers are helped in finding (and using) the 'best' instances of all desired services in a seamless user-driven and user-executed Always Best Connected and best Served (ABC&S) way, anywhere-anytime-anyhow. The main components of the UCWW intersystem are outlined along with their interrelations.

Key-Words: - Ubiquitous Consumer Wireless World (UCWW), Consumer-Based techno-business Model (CBM), Third-Party Authentication, Authorization and Accounting (3P-AAA), Always Best Connected and best Served (ABC&S), Consumer Identity Module (CIM) card.

1 Introduction

This paper describes a Ubiquitous Consumer Wireless World (UCWW) [1, 2] intersystem for future wireless networking, founded on a consumer-based structure rather than on a subscriber-based one. It utilizes the Consumer-Based techno-business model (CBM) that enables a loose dynamic (even casual) consumer-type association between mobile users and service providers – access network providers (ANPs) and non-communications service providers (xSPs) –, based on a Third-Party provision of the Authentication, Authorization and Accounting (3P-AAA) service.

In the UCWW (Fig. 1), the users act explicitly as **consumers**, not as subscribers, as they do not have formal subscriber relationships with the service providers, especially with ANPs. Much like other consumer services, e.g. mShopping, they pay to ANPs for the use of their communications services by credit cards. In addition, the consumers are helped in finding (and using) the 'best' instances of all desired services in a seamless user-driven and user-executed Always Best Connected and best Served (ABC&S) way, *anywhere-anytime-anyhow*. The ABC&S communication paradigm enables mobile users to move seamlessly between different mobile networks (and ANPs) according to their own criteria – e.g. price, quality of service (QoS), quality of experience (QoE), etc. – without interrupting current service sessions, or restarting mobile applications, or losing data.

The UCWW intersystem includes the following main interconnected systems, which are depicted on Fig. 2 and outlined in the next sections:

- A user's mobile device with a consumer identity module (CIM) card;
- A 3P-AAA system;
- A Service Recommendation System (SRS);
- A Data Management System (DMS);
- ANPs and xSPs systems.

2 User's Mobile Device with CIM Card

A typical implementation approach for the identification and authentication of mobile users on mobile devices today is by means of a subscriber identity module (SIM) card inserted in the corresponding device currently in use. In the UCWW, the SIM card is replaced by a new type – a smart consumer identity module (CIM) card – which contains the user's credit card details and utilizes a specific authentication code, provided by a 3P-AAA service provider (3P-AAA-SP) and acceptable by the service providers. This way each service charge, incurred by the consumer, is paid indirectly through that 3P-AAA-SP, who arranges the relevant payment of service usage to the corresponding service provider.

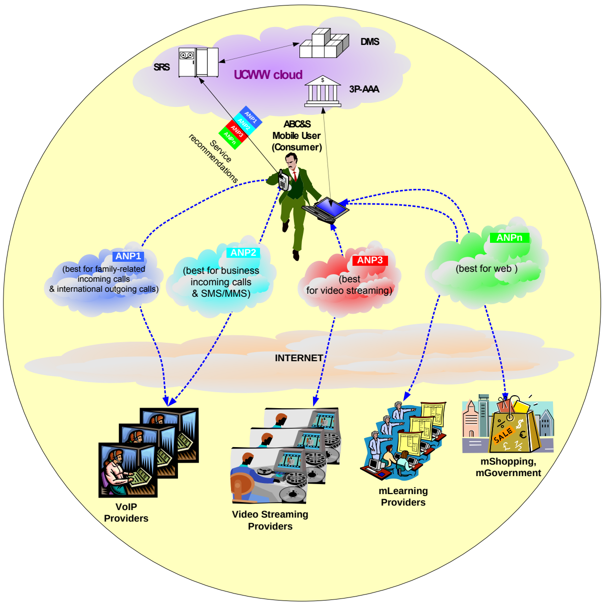

Fig. 1. A high-level view of the UCWW.

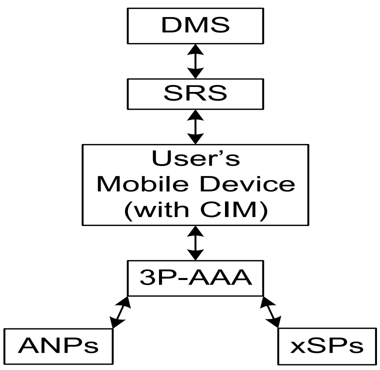

Fig. 2. The UCWW intersystem with the main components.

The CIM card may be a plastic card containing an embedded chip and can be developed by using the 'Java Card' technology [3], which provides highly secure, market-proven, and widely deployed open-platform architecture for the rapid development and deployment of smart-card applications meeting the real-world requirements of secure system operations. A sample CIM card architecture is presented in [4]. The CIM card could be developed and implemented also simply as a virtual card.

3 3P-AAA

A key UCWW element is that it separates out the administration and management of users' one-stop-shop authentication and accounting system from the business of supplying a wireless access network service, and locates it with a 3P-AAA-SP, who is not traditionally a stakeholder in the wireless communications business. Through business agreements with such 3P-AAA-SPs, all types of service providers (including providers of communications services, i.e. the ANPs) can be paid for the corresponding usage of their services by the mobile users who have credit arrangements with one or more 3P-AAA-SP, just as they have one or more credit cards today. Similarly, through such entities, the consumers are able to receive periodic itemized bills for all services where they incur costs, which have been paid indirectly through 3P-AAA-SPs, who periodically produce itemized bills.

The 3P-AAA interface infrastructure's and signaling protocols' standardization program to enable global provision of 3P-AAA services is outlined in [1]. The existing Internet Engineering Task Force (IETF) Diameter protocol [5] has suitable attributes for carrying the 3P-AAA signaling, with some modifications of course. For instance, its base protocol can be extended to support the 3P-AAA functionality via the addition of new commands and/or attribute value pairs (AVP). However, a more attractive standardization route is to define a new 3P-AAA signaling application due to the advantage of not constraining the Diameter core from evolving independently [1].

Fig. 3 presents the functional model of the 3P-AAA system. In addition to the third-party aspect of the AAA provision, another novel element here is the installation of an AAA client directly on the user's mobile device, which is a radical distinction from the traditional Diameter/COPS models. The AAA servers in the ANP and xSP domains also have 3P-AAA clients for communication with the 3P-AAA-SPs' servers, e.g. for the exchange of accounting information, and charging and billing (C&B) information for vendor transactions to consumers. The 3P-AAA client on the user's mobile device interacts with AAA servers of the ANPs and xSPs for mutual authentication and exchange of security credentials. A part of this communication is the signaling to establish authentication securely prior to any service purchase. The authentication scheme is based on the ITU-T's X.509 standard for a public key infrastructure (PKI) [6], which supports strong secure mutual authentication and trusted relationship establishment between communicating parties through simple automatic exchange of X.509 digital certificates, with a minimum number of protocol exchanges. The three-way X.509 option for mutual authentication is employed, as it does not require the communication parties to have synchronized clocks. The established trusted relationship is followed by secure payment of (micro) transactions at the end of the service session.

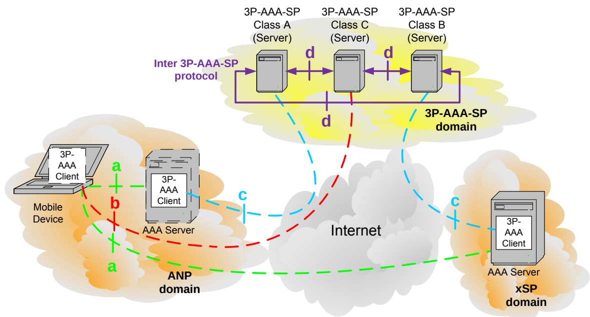

Fig. 3. The functional model of the 3P-AAA system.

For ANPs, the AAA services include accounts and related AAA policies, C&B policies, pricing and rating functions, charging detail records generation, account balances, and the like. For consumers (besides accounts), these may include various types of credit top-up services, billing system configuration functionality, functionalities to enable customer-retention discount and promotional schemes, user-definable account format and layout, etc.

In order to reduce the signaling between 3P-AAA servers and local AAA servers of ANPs (and xSPs) that could lead to a significant network traffic, a C&B agent, downloaded in advance from the 3P-AAA-SP, is deployed in the metering domain of the ANP (and xSP). This agent performs all associated C&B functions. The agent has the functionality to manage a budget (for the service to be supplied to the consumer and any other relevant consumer-account details) along with expending it in response to the provider's (ANP or xSP) metering triggers, sending budget replenish requests to the 3P-AAA server when a budget depletion threshold is crossed, and informing the 3P-AAA server of the total charge at the end of the service session.

4 SRS

To enable a user-oriented, user-friendly, and user-driven ABC&S wireless communication environment such as the UCWW, the mobile users should be made aware of the presence of communications services and mobile services around them. For this, a distributed Service Recommendation System (SRS) [7] finds and recommends to each individual user the 'best' service instances, depending on the current user context, network context, and service context, in a highly personalized and customized way thus facilitating the access to those services through the 'best' available (wireless) connection under the ABC&S communications paradigm. Taking into account the 'big data' aspect of information about (and gathered from) consumers, networks, and services, a cloud-based version of such a recommendation system is envisaged in [8] as being more capable for facilitating the delivery of increasingly contextualized mobile services to support the consumer-choice optimization process.

A special UCWW mobile application [9], installed on the user's mobile device and associated with such a system, is used for finding and recommending to users, and even automatically selecting if the user's profile settings are so set, the 'best' mobile service instances, depending on the current context, including in that decision process the user's personal profile requirements.

The system design, realized through a structured composition of three tiers – a mobile application tier, a web tier, and a cloud tier, is presented in [10]. The flow of context data between the user's mobile device and the SRS (in the UCWW cloud, Fig. 1) is described in [7] along with the mechanism of sending requests and receiving responses from the decision support subsystem, i.e. providing ratings (ranking) of the service providers available for a particular type of service requested by the consumer.

The SRS communicates with the DMS (c.f. next section), keeps updating the user's behavior profiles, user's interests and requirement tendencies, and sends a personalized list of 'best' recommended service instances to each user in a real-time manner by utilizing relevant recommendation algorithms and updated recommendation rules. A recommendation engine acts a central element in this system. It allows uploading the recommendation algorithms to the system and defining/updating the recommendation rules. This engine can be built with a Lambda Architecture for providing real-time recommendations (at the speed layer) and off-time analytical operations (at the batch layer) [11].

The service recommendations provided by the SRS depend greatly on the current context. Besides the context that relates to the mobile services available on offer (i.e. the service's category, type, scope, attributes, cost, current QoS/QoE index, etc.; the request time; the application initiating the request), the context data may relate to the user (e.g., the current location, preferences and profiles, current battery charge and other operational characteristics of the user's mobile device, type of activity, intentions, social interests, the upper bound on the price and the lower bound on QoS/QoE accepted by the user for each particular service, privacy and security requirements, etc.), and/or relate to the constraints of the wireless access network currently utilized by the user (e.g., the communication channel state information (CSI), network congestion level, the current data usage pattern, the current QoS/QoE index, the cost of using the network, pricing scheme, etc.).

Then determining the 'best' service instance at any moment for a particular user is based on a set of context parameter values, categorized in three groups – user-related ($\boldsymbol{u}$), service-related ($\boldsymbol{s}$), and (access) network-related ($\boldsymbol{n}$) –, forming a 3D ($\boldsymbol{u}$, $\boldsymbol{s}$, $\boldsymbol{n}$) context space.

5 DMS

The DMS [12] utilizes machine learning techniques for turning the collected raw data into actionable analytic datasets, i.e., user's behavior profiles, including user's preferences, content consumption preferences, shopping preferences, interest preferences, app usage, etc., abiding by the user-privacy principles. More specifically, the DMS provides 'big data' collecting, processing, analyzing, and consumer targeting operations. It is used for managing consumer identification and generating audience segments, in order to target consumers with most appropriate / 'best' (mobile) service instances. For this, it utilizes real-time users' profiling algorithms and off-time data processing algorithms [11], and is implemented with the Publish/Subscribe design pattern [12].

The DMS facilitates the storage of user data harvested via mobile devices (and other means), and based on the analysis of this data, offers predictions as to the applicability and ABC&S suitability of services to particular users, thus enabling ever-enhanced contextualization and personalization functionalities. Over time the collected data, relating to particular users, can give an accurate view of particular cohorts, based on common interests, repetitive access of particular services, etc. By monitoring this information, the DMS then can accurately predict the types of services most applicable to individuals, and in turn, recommend these to them.

Furthermore, efficient algorithms are applied to facilitate service utilization predictions as part of the UCWW cloud as an alternative to mining the stored data. For instance, [13] proposes a hybrid method that integrates user trust relations with item-based collaborative filtering. This is achieved by incorporating user social similarities into the computation of item similarities. Performance evaluation results demonstrate that the proposed approach achieves better accuracy than the traditional item-based collaborative filtering.

6 Conclusion

Mobile users today need more choice and freedom in using (mobile) services with more flexible service delivery and an ability to move/migrate quickly to more competitive providers who can provide better price/performance options, a wider selection of service offerings, etc. In this regard, the Ubiquitous Consumer Wireless World (UCWW) is a creative proposal, which brings a different approach to the wireless communications business. It provides greater flexibility and freedom to mobile users (consumers), full user mobility among participating access networks, and a greater degree of service choice. Besides these new benefits for the consumers, the UCWW has the potential to stimulate the creation of a number of new interesting business opportunities and to create a more liberal, more open and fairer wireless marketplace for existing and new access network providers (ANPs) and (mobile) service providers (xSPs), allowing their primary business success indicator to shift from subscriber numbers to the volume of consumer transactions. This will increase the range of competitive price/performance and price/quality offerings, specialist and niche service offerings, and so forth, all of which will drive forward innovation in the wireless communications and mobile services market. Once in place, the UCWW will begin to take shape and grow along an evolutionary path yielding social, economic and policy benefits for all stakeholders.

7 Acknowledgment

This work has been accomplished with the financial support of the MES by the Grant No. DO1-221/03.12.2018 for NCDSC – part of the Bulgarian National Roadmap on RIs.

The author wishes to specially thank the TRC Director, Dr. Máirtín Ó Droma, for the fruitful discussions and inspiring thoughts on the subject through many years of joint research, development, and teaching, and long-standing friendship.

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