A NEW CHARGING AND BILLING MODEL AND ARCHITECTURE FOR THE UBIQUITOUS CONSUMER WIRELESS WORLD

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Abstract. *In a Ubiquitous Consumer Wireless World (UCWW) environment the provision, administration and management of the authentication, authorization and accounting (AAA) policies and business services are provided by third-party AAA service providers (3P-AAA-SPs) who are independent of the wireless access network providers (ANPs). In this environment the consumer can freely choose any suitable ANP, based on his/her own preferences. This new AAA infrastructural arrangement necessitates assessing the impact and re-thinking the design, structure and location of 'charging and billing' (C&B) functions and services. This paper addresses C&B issues in UCWW, proposing potential architectural solutions for C&B realization. Implementation approaches of these novel solutions together with a software testbed for validation and performance evaluation are addressed.*

Keywords: Third-party authentication, authorization and accounting (3P-AAA), charging and billing (C&B), consumer-centric business model (CBM), ubiquitous consumer wireless world (UCWW)

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1. Introduction

The accounting aspect in the use of telecommunication services is an essential business component. It must be supported by clearly defined charging and billing (C&B) mechanisms. In general, a C&B system means an infrastructure used to meter resource usage on service equipment and to monitor and collect the usage data generated by metering devices for accounting and billing purposes. The billing process renders the collected resource usage data into a bill. Observing the charging and billing systems that have been used in wireless networks it may be noted that these systems change as the wireless technology and communications environment evolves.

Tried and tested accounting, C&B mechanisms are in place for the legacy 'subscriber networks', both for the fixed and wireless communications networks. In fact this robust business model, where the "home" access network (AN) has control over AAA and the associated C&B systems, is one of the main attractions and strengths of these networks for the ANPs.

In the UCWW [2, 6, 7] – a wireless AN technology independent environment – the business model focus is changed from being subscriber-based and networkcentric as in the legacy networks, to a consumer-centric techno-business model (CBM). With it, expectations such as full mobility of wireless access users among different networks and network providers using a single fully portable identity may be realized. This kind of mobility will be user-driven in ways where users may freely choose the networks and services which better match their own ‘always best connected and served’ (ABC&S) profiles [4]. A simplified illustration is provided in *Figure 1*. Making this freedom complete means users will pay for services on a transaction-by-transaction basis. Such consumer-centricity is achieved mainly through a re-distribution of the AAA infrastructure and responsibilities. A key UCWW enabler is the creation of an autonomous third party AAA (3P-AAA) service and service provider infrastructural entity [2, 7].

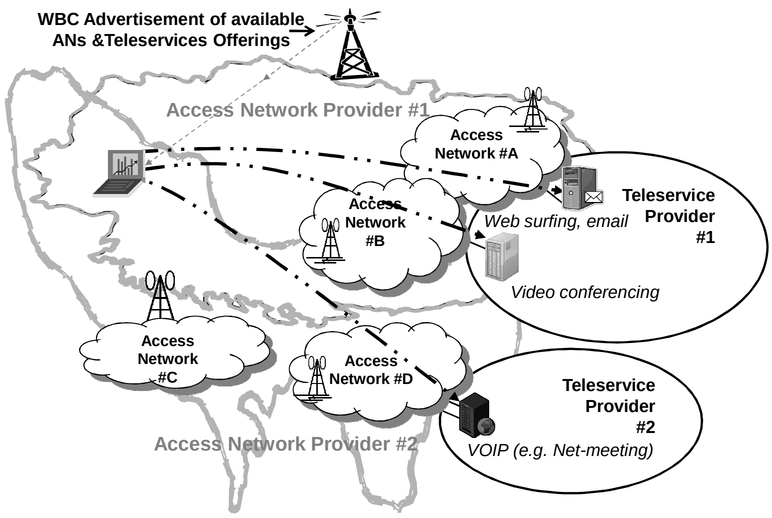

Figure 1 - UCWW environment illustration

Along with this AAA restructuring, all the C&B functions need to be re-visited, re-structured and re-distributed in a coherent logical and reasonable way.

This paper seeks to address some key aspects of this goal. The form of the new C&B service architecture solution proposed here is one that in part can work under the administration of the 3P-AAA-SPs and hence may be referred to as 3P-C&B services. It is a possible rather than definitive solution, catering for many of the new C&B requirements arising in an UCWW environment.

The rest of the paper is organized as follows. Section 2 describes the 3P-C&B principles and briefly reviews existing technology. Section 3 presents the design aspects of the new C&B architecture. Section 4 details the proposed proof-of-concept simulation testbed. Section 5 concludes the paper.

2. Charging and billing in a UCWW

Reviewing the historical technological trends in respect of C&B, two main standardization lines can be distinguished: (1) the Third Generation Partnership Project (3GPP) – Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN), and (2) the Internet Engineering Task Force (IETF) along with the Internet Research Task Force (IRTF).

3GPP-TISPAN standardized the Signaling System 7 (SS7) based Core Intelligent Network Application Protocol (INAP) for charging systems in GSM networks and the Customized Applications for Mobile network Enhanced Logic Phase 2 and Phase 3 (CAMEL2 and CAMEL3) protocol for the same in UMTS systems. The standardized models were the Online and Offline charging. When the IMS was introduced, the 3GPP specified the Open Device Access (OSA) standards which opened the UMTS infrastructure to third-party Application Servers (AS). The OSA also specified a charging interface – the charging Service Capability Feature (SCF) [3] – to make it possible for third-party AS to charge for the use of their services.

The IETF formed an AAA Working Group. Later the IRTF Authentication, Authorization and Accounting ARCHitecture (AAAArch) group standardized the authentication and authorization procedures and worked out different authorization models. Some results of this work are the generic AAA frameworks, the Network Access Server (NAS) authorization model, Remote Authentication Dial-In User Service (RADIUS) and DIAMETER authorization and accounting messaging frameworks.

The early data-oriented wireless networks created their C&B systems using the NAS-based model with a RADIUS server and RADIUS accounting messages. The charges were calculated by subscription and based on either the network usage time or volume used. This model could not facilitate prepaid charging systems. To fill this gap the IRTF AAAArch group specified the DIAMETER Credit-Control (CC) Application [1]. This utilizes the generic AAA mechanism for charging purposes. Nowadays, data-oriented wireless networks in the main utilize this charging framework.

A 3P-C&B service

Considering a consumer in UCWW getting a wireless access service from an ANP, the basic accounting and C&B logic flows along the following lines. The ANP keeps track (an account) of the consumer’s service usage and mounting charge (charging which is driven by metering the service, or simply a flat charge). When the consumer ends the service usage, a bill is composed with all the details, and sent to the consumer’s 3P-AAA-SP with the consumer’s previously supplied acceptance of the conditions of service supply. The 3P-AAA-SP pays the charge directly to the ANP, or to the ANP’s 3P-AAA-SP, attaching a reconciliation tab for this bill; different payment possibilities exist. This tab is used to cancel the complementary reconciliation tab in the ANP, or in ANP's 3P-AAA-SP. For the latter payment approach, the ANP will have sent it the complimentary reconciliation tab. Such is a possible accounting C&B logic flow when all is functioning correctly. If something goes wrong, e.g., consumer's 3P-AAA-SP fails to pay or there is a claim of overcharging, then it should be possible to fall back on detailed service usage accounting and charging records. A distribution of the organization and management of this activity between the ANP and the consumer's and ANP's 3P-AAA-SPs is required. This paper looks at a sharing arrangement, expressed in schematic form in *Figure 2* for ANP and TSP service usage.

Here the multi-class 3P-AAA architectural model, corresponding to foreseeable major market sectors for the 3P-AAA business, is followed: "Class A" for ANPs, "Class B" for TSPs and Value-Added Service Providers (VASPs), and "Class C" for consumers-users; [7].

Network service usage and teleservices usage create their own streams of accounting records. The accounting record streams are forwarded to the appropriate 3P-AAA-SP domain to which the ANP and TSP/VASP are registered.

Consumers may use more than one teleservice in parallel, represented as a multiplication of the single teleservice usage case, and may use multiple ANs. Each ANP and TSP generate separate accounting streams related to each individual AN service and teleservice usage. Illustrated in *Figure 2* are examples of AN and teleservice usage charging interactions where the 'service equipment' in the ANP or TSP/VASP, via the local AAA Server provides the C&B accounting records to the relevant 3P-AAA server corresponding to the service usage; and provides these also to the consumer's 3P-AAA-SP (not shown).

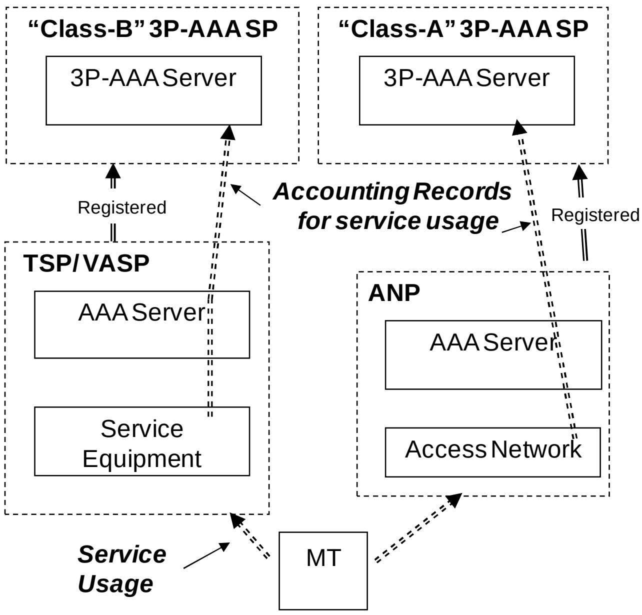

Figure 2 – Accounting record streams for networks and teleservices usage

3. Third-party charging and billing architecture

This section proposes a generic 3P-C&B architecture based on the generic 3P-AAA architecture. An outline of the idea was described in [10] and shown in *Figure 3*.

In 3P-AAA based accounting, the accounting policies – which contain the metering, metering measurements, and metering data collection policies – are stored on the 3P-AAA-SP side and are pulled on the local AAA server in the ANP or TSP/VASP domain.

Figure 4 depicts the proposed generic 3P-C&B architecture. Three main architectural parts can be distinguished here:

1. *Credit Control Server A/B*: It is located in the 3P-C&B domain of the "Class A" or "Class B" 3P-AAA-SP (for the sake of clarity, the ANP domain and corresponding "Class A" 3P-AAA-SP are omitted from *Figure 4*). The latter controls the service usage and interacts with the "Class C" 3P-AAA-SP for exchange of monetary units from the consumer account to fund the network or service usage.
2. *Credit Control Client (CCC or 3P-CCC)*: It is located in the TSP/VASP domain (and likewise the ANP domain) for reporting the service usage and enforcing granted quota on service usage.
3. *Credit Control Server C*: It is located in the 3P-C&B domain of the "Class C" 3P-AAA-SP (consumer's 3P-AAA-SP) for controlling the monetary unit usage on the consumer account.

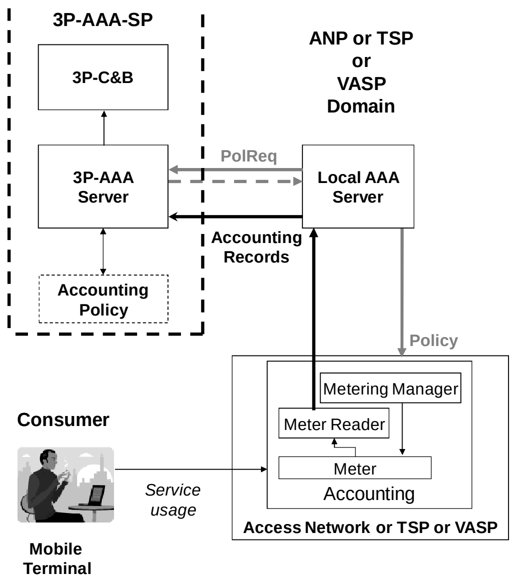

Figure 3 – Generic 3P-AAA architecture

A new Inter-3P-AAA-SP signaling protocol is needed to serve this generic 3P-C&B architecture. The main design goal for this signaling protocol is to support the charging interactions between different types of 3P-AAA-SPs and to carry the 3P-C&B information elements such as (1) consumer account data (profile, counter) to 3P-AAA-SP charging processes, (2) debit & reservation data on consumer balances, (3) update information on consumer profile & counter data, and (4) Charging Detail Records for billing purposes. A Diameter implementation of this protocol has been designed.

4. Simulation testbed design and results

The Network Simulator 2 (NS-2) [8] has been chosen for simulating the 3P-C&B operations. No other simulator has been found that seemed to have any particular advantage over NS-2. The decision on choosing the simulator was mostly based on the simulator's support of transport-layer protocols, on which a new Diameter application could be built (the Diameter has been chosen as the main implementation framework for the 3P-C&B). The support for the Stream Control Transmission Protocol (SCTP) was of most concern. NS-2 can support SCTP though a model developed at the Protocol Engineering Laboratory, University of Delaware [5]. To implement the 3P-C&B application, the ANP/TSP client and "Class A/B/C" 3P-AAA-SP server applications, the openDiameter [9] was chosen. This is an open-source implementation of the Diameter protocol, which supports the Diameter Base Protocol and many standardized Diameter applications such as the Diameter Network Access Server (NESREQ) Application, Diameter Extensible Authentication Protocol (EAP) Application, Diameter Mobile IPv4 (MIPv4) Application, and Diameter Credit Control (CC) Application. The openDiameter supports both TCP and SCTP transport-layer protocols and implements the Transport Layer Security (TLS) for each of these. *Figure 5* illustrates the designed 3P-C&B testbed.

The software testbed components are examined in more detail in the following paragraphs.

ipDrv NS application

The IpDrv application is used to connect 3P-C&B Diameter applications to the NS simulator. In NS-2 terms, it is a C++ application object. It is configured for an IP address or IP address pair (in the case of SCTP failover configuration). This application is responsible to receive IP packets from the physical IP sockets and pass these packets on the created network simulation. Then, when the NS simulation generates IP packets to the assigned IP address, these packets are forwarded to the physical IP sockets.

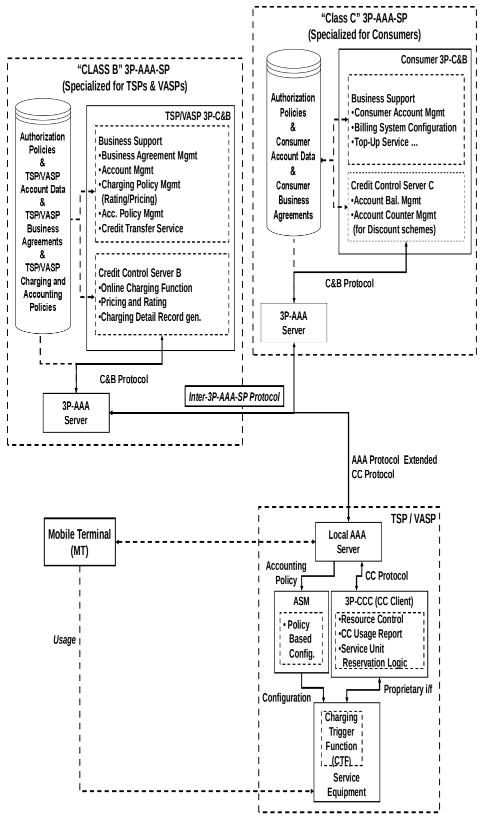

Figure 4 - Generic 3P-C&B Architecture

ANP component

It is the provision of an access network and access network provider's infrastructure. Before a mobile terminal (MT) may avail of a teleservice, it must have a point of attachment in the access network. In our testbed an access network consists of:

--MT, with a client software enabled for 3P-AAA functionality.

--3pApn 3P-C&B client application: It simulates the MT network usage, and communicates this usage through the Diameter CC protocol to the 3pCabA server application. The 3pApn is an openDiameter application.

--ipDrv: An NS application, as described above, connecting the 3pApn Diameter application to the NS simulator.

TSP component

It includes the provision of a teleservice capability (the service equipment) and a TSP's infrastructure. The MT accesses a TSP's teleservices via the ANs. The testbed simulation of the TSP environment includes the following:

--3pTsp 3P-C&B client application: It simulates the MT teleservice usage, and communicates the teleservice usage through the Diameter CC protocol to the 3pCabB server application. The 3pTsp is an openDiameter application.

--ipDrv: A NS application as described earlier. It connects the 3pTsp Diameter application to the NS simulator.

3p-AAA-SP Class-A component

To provide network access services to MTs, an ANP normally must be registered and certified to a “Class A” 3P-AAA-SP. The environment in the testbed consists of:

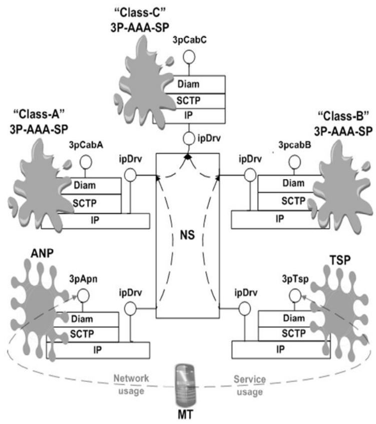

Figure 5 – 3P-C&B Testbed

--3pCabA 3P-C&B server application: It receives from the 3pApn 3P-C&B application the generated CC messages and according to the ANP-specified Accounting and Charging policies it translates the CC usage messages into Inter-3P-AAA-SP protocol messages for real monetary reservation and debit on the consumer’s account.

--ipDrv: An NS application as described earlier. It connects the 3pCabA Diameter application to the NS simulator.

3p-AAA-SP Class B component

To provide teleservices to MTs, a TSP (VASP) normally must be registered and certified to a “Class B” 3P-AAA-SP. The environment in the testbed consists of:

--3pCabB server application: Its responsibility, functionality and service description is as per 3pCabA above.

--ipDrv: as above, but for 3pCabB.

3p-AAA-SP Class C component

To obtain AN services or teleservices, an MT must be registered and certified to a “Class C” 3P-AAA-SP.

The environment in the testbed consists of:

--3pCabC 3P-C&B server application: It is responsible to authorize monetary reservation and monetary debit operations received from the 3pCabA and 3pCabB Diameter applications via exchange of Inter-3P-AAA-SP protocol messages. The same mechanism is also used by the server application to receive the consumption reports (CDR).

--ipDrv: as above, but for 3pCabC.

In our simulation scenarios we measured the parallel usage of AN communications services and teleservices. We applied simple charging rules which provide flat rating in terms of teleservice usage and AN usage. We assumed that the different 3P-AAA-SP domains are connected via the Internet. To simulate this, we used different end-to-end delays such as 10ms, 50ms, 90ms, and 170ms. The preliminary results identified high network latency problems when the Inter-3P-AAA-SP messaging involves Internet usage. To reduce the effect of this problem, a new concept using a Charging Agent has been proposed in [11]. This agent is downloaded from the 3P-AAA-SP domain to provide the charging functions in the TSP/ANP domain. There it imports the charging rule set from the 3P-AAA-SP and relevant segments of the consumer's account into the metering domain.

5. Conclusions

In this paper, a generic third-party charging and billing (3P-C&B) architecture solution has been proposed to serve as a framework to build charging and billing services in the ubiquitous consumer wireless world (UCWW). The main charging scenarios that may occur in the UCWW have been identified. A new Inter-3P-AAA-SP signaling protocol has been proposed to facilitate the charging interactions between different third-party authentication, authorization and accounting service providers (3P-AAA-SP). The overall design of the Inter-3P-AAA-SP signaling has been completed by providing an information model for protocol messages and a suitable Diameter mapping. Simulation testbed design and possible enhancements of the 3P-C&B design have been discussed. Naturally it is envisaged that such a protocol will eventually have to be part of an open global standard.

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