"Smarter" Online Charging for Over-The-Top Services by Introducing User Context

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***Abstract*—Exposing the fundamental network capabilities on behalf of the mobile network operator may offer innovative way for the service providers to provide more user-oriented services. The network capability we focus on is online charging, and in particular the lack of functional relationship between the online charging and the service delivery processes (other than the obvious one, reducing the available credit). With the goal to make better use of the knowledge about the users which is available to the operator, we identify and examine the user-related information that can be found at various functions in the mobile network as a whole. Current 3GPP specifications enable the online charging system to retrieve some of this information but this potential has not yet been used to the fullest, for example, when considering multiple concurrent services and service adaptation. We propose a model of managing and using the user charging context, based on "smarter" use of information available to the operator. We illustrate the proposed approach by a use case involving an adaptive multimedia service the behavior of which is influenced in a positive way by user context based online charging.**

I. Introduction

Mobile network operators' (MNO) ability to provide Internet access to their users has enabled third party service providers to offer Over-The-Top (OTT) services. The MNOs act as a "bitpipe" for delivering such services (e.g., Facebook, Skype, or various smartphone applications). All other "smart" service-related functions (e.g., service configuration determination or QoS management decisions) are being handled by OTT Service Providers (SP). Additionally, the MNOs usually charge their users only for using the network for OTT service delivery, being limited to offer the users charging models suitable for such services. However, unlike the OTT SP, the MNO possesses various information regarding the users which may influence the course of OTT service provisioning through smarter charging. This information is, e.g., a list of other parallel services in progress, agreed price discount policies, or a list of access networks that are available to the user depending on his current location. From now on, this information will be referred to as the User-related (Charging) Context (UCC).

A key problem in current mobile networks, as illustrated in a simplified way in Fig. 1, is the unclear (or non-existent) functional relationship between the online charging process, the UCC, and the OTT service being provisioned. (By *online charging* process we mean a real-time process of calculating a cost, expressed in units acceptable for network management processes, of a given service consumption.) Online charging function as well as all UCC knowledge is situated in the user's home network (i.e., a MNO with which the user has a contract). Online charging process charges the user for using the home network's resources when accessing the OTT service (1). Next, online charging may indirectly affect the service in progress (by, e.g., denying resource authorization for the OTT service due to the user's depleted budget) (2). The fact that the user is using this OTT service modifies the overall UCC (3), which finally may affect online charging process of the given service or any other parallel service in progress (4).

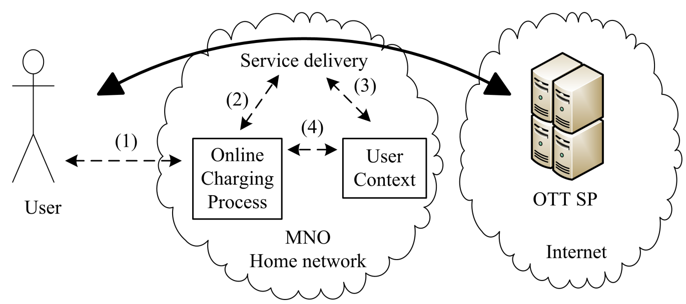

Fig. 1. Relationship between an online charging process, a user context, and an OTT service provider

This work addresses a part of the problem explained above regarding the relationship between the UCC and the online charging process of the OTT service (4). Our research is based on the specifications of the Third Generation Partnership Project (3GPP) functional entities, especially the Online Charging System (OCS) [1]. The goal of the work is to define a model and the possible use case scenarios in which the UCC knowledge may be utilized for "smarter" online charging of the UTT services.

In an environment where Internet access is becoming a commodity, one way of increasing a user perceived quality is to offer more customized services to the users, that match their current needs and abilities, resulting in increasing the users' "value for money" experience. With this motivation, in this work we envision a charging system which is able to recognize the potential incoming charging events that may influence the course of service and can thus avoid service termination by, for example, switching to the modified service version based on user preferences.

The rest of the paper is structured as follows. Section II briefly elaborates on the latest research and standards work regarding online charging systems and explains the user-related information they use for charging. Section III lists various user-related information that may be retrievable from various 3GPP functional entities, included in the UCC, and used for smarter online charging. In Section IV a model of collecting, managing, and using the UCC in online charging is proposed. The presented model enables the UCC to be used by both the MNO's online charging process and the third-party OTT SP. Section V presents use case scenarios justifying the benefits of including the UCC in online charging of the OTT services. Section VI concludes the paper.

II. Related work

This section presents current works related to online charging in a multi-provider environment and discusses them with respect to the approach proposed in this paper.

The Online Charging System (OCS) [1], stands as a central function for online charging within the 3GPP. Fig. 2 illustrates 3GPP's Release 11 OCS functions as well as reference points that exist between the OCS and other 3GPP functions. OCS consists of four functional entities: an Online Charging Function (OCF), an Account Balance Management Function (ABMF), a Rating Function (RF), and a Charging Gateway Function (CGF). By using the standardized interfaces, it is connected with other functions/nodes across the 3GPP network, e.g., Call Session Control Functions (CSCFs), Application Servers (AS), and Policy and Charging Control functions. The OCS is also connected with the Recharging Server and the Operator's Post Processing System for billing purposes. One of drawbacks of the current OCS specification is that it uses a limited set of user context for charging, e.g., tariff information or available credit information.

Several solutions for online charging in a multi-provider environment have been proposed in research.

Koutsopulou et al. [2], propose an architecture in which Charging, Accounting, and Billing (CAB) functions are deployed within a network of a third trusted party. By using a CAB gateway, charging data is collected from various entities that participate in service delivery, but belong to different administrative domains. By using open application programming interfaces, service providers can define their accounting and charging policies. The CAB system is mostly designed to be used for offline (i.e., non real-time) charging purposes.

Bormann et al. [3] propose a context-aware charging and billing mechanism, as a part of the project entitled Local Mobile Services (LOMS). They develop a system that enables providers of local mobile services to offer their services to end users by using a larger network operator's infrastructure. These services are often context-aware (e.g., aware of a user's location), thus enabling service providers to offer and utilize charging models that take the given context in consideration.

Within the Ambient Networks Project [4], Huitema et al. [5] define the architecture that supports negotiation mechanisms in accounting, charging, and billing, called *Compensation* architecture. The key idea is to allow for automated and dynamic negotiation about relationships between parties known or unknown to each other, and to realize the negotiated agreement in a near real-time. Without a need to establish business agreements, the architecture enables negotiation of, e.g., tariffs and time of payment between the parties. A charging system to be used in this environment is defined, too. The model does not include a discussion about the utilization of any kind of user context.

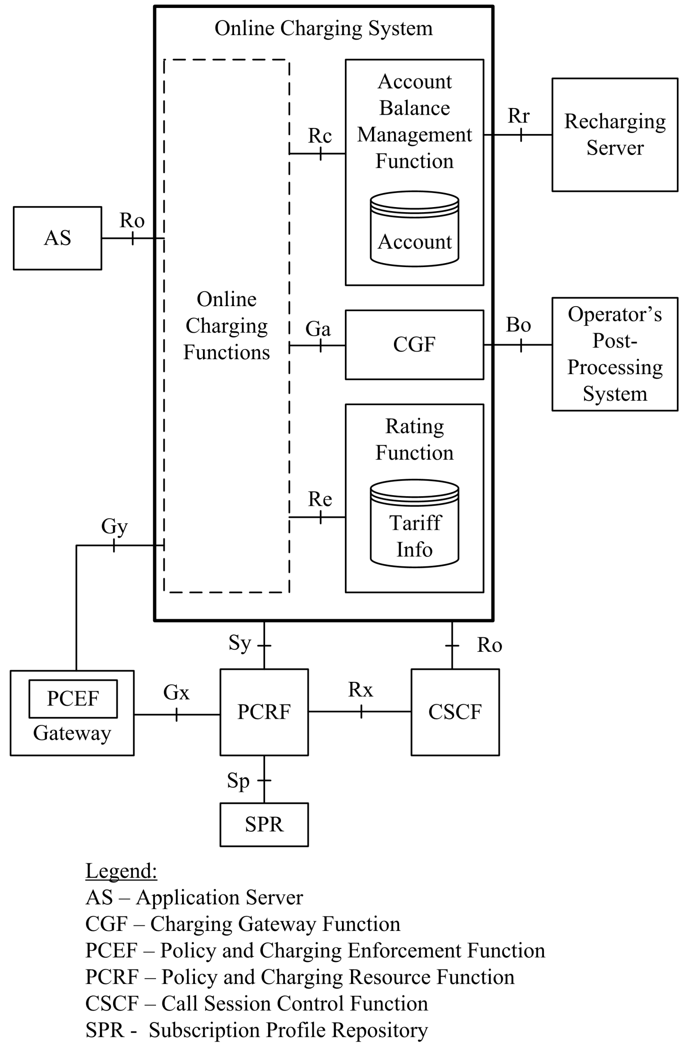

Fig. 2. OCS: existing functions and reference points

Simultaneously with the growing number of stakeholders and new business relationships, the market is flooded with numerous charging models and available tariffs, and offered to end users. Cheboldaeff [6] explains known approaches in organizing various charging models, such as service buckets and discounts use, and highlights charging related issues when using these approaches. The model presents a step forward in providing an added value of the OTT services to the MNOs, but lacks a more detailed business model specification.

The presented approaches lack a comprehensive view on user-related charging information available in the network. Our research differs from the related work in examining how this information can be used for "smarter" charging, while adopting and applying the requirements and limitations for charging (posed by inter-domain agreements between stakeholders) as the approaches in the related work.

III. User-related information available in a 3GPP network

This section elaborates on the various 3GPP functions that contain the information that may be considered as the user context. A discussion about the OCS's ability to retrieve the information by using (preferably) standardized interfaces is also included. Each of the functions and reference points depicted in Fig. 2 are described in the following text in light of their possible use for user information retrieval.

Table I lists groups of user information and shows at which network function the information is stored.

User ID can be used to uniquely identify the UCC. For this purpose any of the identifiers that can be associated with a particular user may be used. Such identifier is the International Mobile Subscriber Identity (IMSI), stored at the Home Subscriber Server (HSS).

Rich presence information [7] and user preferences are stored at one of the application servers (if enablers of location and/or preference services exist in the network) and may be retrieved therefrom. For example, the user location is stored at the location enabler. OCS is connected with application servers via a Ro reference point [1]. Ro reference point uses Diameter protocol [8].

All account-related information (e.g., available credit or used tariffs) is already stored at the ABMF and TF functions, which are parts of the OCS.

According to [9], a *subscription* describes the commercial relationship between a subscriber (an entity that is engaged in a subscription, usually an end user), and a service provider. 3GPP TS 23.008 [10] specifies the information that is considered as subscription data, as well as the list of network functions used to store the data. Additionally, 3GPP TS 32.140 [11] defines a subscription management architecture. The subset of the subscription information, which is in this model considered as the user context, is stored at the HSS and the Subscription Profile Repository (SPR). In the current 3GPP specifications release (i.e., Release 11), there exist no reference points between the OCS and those functions. However, we assume that future OCS systems will have access to the subscription information (or selected parts of it). This assumption is based on the existing efforts in 3GPP to ease access to information by functions that require it. A notable step in this direction is the specification of the User Data Convergence (UDC) architecture, TS 23.335 [12].

The information about active service sessions per user is stored at the OCS, but only as a list of currently used services. A richer information about each active session can be retrieved from the Call Session Control Functions (CSCF) and the Policy and Charging Resource Function (PCRF), by using (with certain functional modifications) Ro and Sy interfaces, respectively. In our previous works, we proposed a rich session description information, called the Media Degradation Path (MDP) [13], that can be used for advanced session decision mechanisms. OCS modifications for MDP use have been proposed in [14].

The information about the user's device hardware and software capabilities can be identified by using the International Mobile Station Equipment Identity and Software Version Number (IMEISV) [15]. The IMEISV is stored in the subscription profile (and hereby in the SPR). Additionally, it is exchanged between the user device and the Policy and Charging Enforcement Function (PCEF). The OCS may retrieve the IMEISV (with certain functional modifications) via the PCRF and the Sy reference point. Sy uses Diameter protocol.

The list of available networks as well as policies determining when to switch between access networks and under which conditions is considered as subscription data [10] and may be retrieved from the SPR. This data is used in an Access Network Discovery and Selection Function (ANDSF) [16].

All statistics-related information (average daily traffic, mostly visited web pages, etc.) may be derived from the Charging Data Records (CDRs) which are generated during the charging process and contain all information related to the service session. CDRs are generated at the OCS, but additional function is required for generating statistical data out of CDRs.

IV. A model of UCC management and use

The goal of the model specification is to identify a framework in which the UCC is managed (including collection, storage, structuring, and terms of context access) and used, given the two key limitations. The first limitation is posed by existing business agreements (i.e., Service Level Agreements, SLAs) between the participating stakeholders that in most cases prevent random information exchange without any constraints. Instead, in most cases only the agreed information is allowed to be exchanged. The second limitation is posed by the privacy-sensitive nature of content that is contained in the UCC, particularly the end users' private information (e.g., location, rich presence information, available budget). Therefore, from the perspective of an end user, the business model must assure controlled dissemination of UCC to any of the included parties, as well as controlled use of the UCC in online charging.

Three types of stakeholders are identified in the model: an user, a Primary Service Provider (PSP), and (one or more) third-party SP(s). The user is a natural person that receives the OTT service via his/her MNO's infrastructure. Primary service provider (PSP) is a MNO that has a business relationship established with the user, usually by means of a Service Level Agreement (SLA) [17]. The UCC information is contained within the PSP's network. In 3GPP, a network under the jurisdiction of the PSP is also known as a Home Environment [9]. The OTT SP provides a certain service to the user, but

TABLE I

A LIST OF USER INFORMATION MAINTAINED ACROSS NETWORK FUNCTIONS

Group of user information	**Responsible network function(s)**	**Remark**
User ID	HSS	Any permanent user identifier may be used
Rich presence and user preferences	Application servers	Enablers required in the network
Account information	OCS	Available at ABMF and TF
Subscription	HSS, SPR	Interfaces with OCS not specified
Active service sessions	OCS	Only a list of services available
Session data	CSCF, PCRF	Amount of information depends on session description richness
Devices information	SPR, PCEF	Retrievable by using IMEISV from PDP context or session description
Available networks	SPR	Stored as data related to ANDSF
Statistics	CGF	Contained in raw CDR data, requires further data processing

requires only the PSP's network resources for delivering the service to the user.

The model follows the one-stop-responsibility concept [18], as explained next. Figure 3 illustrates business relationships between the stakeholders, established via Service Level Agreements (SLA). The user has the SLA established only with his/her PSP, defining overall rules for service provisioning no matter if the used services originate from the domain of the PSP or from a third party service provider. To enable provisioning of services provided by third party providers to its users, the PSP may or may not have additional SLAs established with third party service providers. These additional relationships (if they exist) are not visible from the end user's perspective.

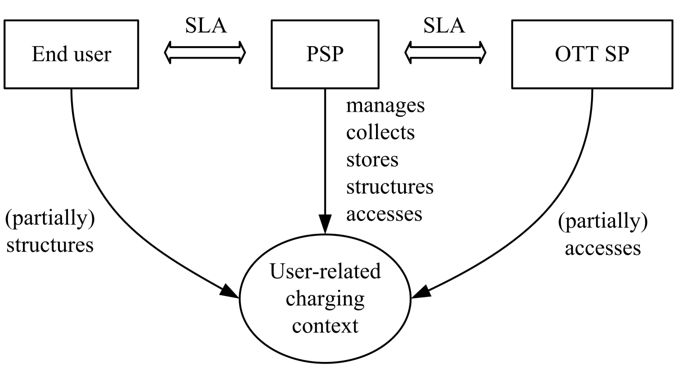

Fig. 3. A model of UCC management and use

Fig. 3 also illustrates management and other operations that are allowed on the UCC by the participating stakeholders, including data collection and storage, context structuring, and context access. The UCC is situated at the OCS within the home environment of the PSP, which allows PSP to have full control over the UCC, i.e., to perform all available operations. The end user is able to participate (partially, to an agreed extent) in context structuring, while the third party Service Provider is able to access the UCC (partially, depending on the access terms agreed with the PSP). All operations are in more detail discussed next.

A. Data collection and storage

Data collection refers to collecting the UCC information from various functional entities in the network by using standardized interfaces, or by gathering specific data directly from end users, if such option is enabled. Data storage refers to storing the collected information at the OCS by using the predefined context structure. Data collection and storage operations are under the jurisdiction of the PSP. In addition to these operations, the PSP is also responsible for updating the information periodically.

B. Context structuring

Context structuring refers to the stakeholder's ability to include or exclude certain information in or from the UCC and hereby define the layout of the context structure. For instance, hardware capabilities of the user's mobile device may be included in the UCC, but only when the user is not roaming. Additionally, context structuring allows defining a privacy policy for each type of information separately, and to state which stakeholder is able to access the information. In this model, context structuring operation is allowed to be performed by the end user and by the PSP. However, in most cases this operation is performed only by the PSP depending on its general management policies and based on the terms agreed with the user (and stored in the SLA). In special cases the user may directly include and/or modify certain personal information (e.g., current mood or a spending limit) by, for example, logging in the PSP's web page. Context structuring enables the PSP to build UCC structures that differ in context information which is included for different users.

C. Context access

Context access refers to the stakeholder's ability to retrieve (parts of) the UCC and use it for charging-related purposes. In this model the PSP has full access to the UCC (the structure of which is defined in the *context structuring* process). Therefore, the PSP may use the available UCC for making any charging-related management decisions within the home environment. However, assuming that (parts of) the UCC may not be shared with third parties without the end user's consent, the third party service provider has access only to the part(s) of the UCC that have been allowed by the end user or the PSP given their privacy policies.

D. Context based charging model

In standard online charging process, service authorization and cost calculation are performed continuously during the service session that is being charged. Charging process is started in parallel as the service session is initiated, modified if service session parameters are modified, and ended once the service session is terminated. In order to support "smarter" charging that would be UCC-aware, in this model we introduce the context monitoring process which takes place in parallel with the online charging process. Fig. 4 shows extended architecture of the OCS, introducing the Context Monitoring Function (CMF) and the Rt reference point. While the online charging process takes place at the Online Charging Function (OCF), context monitoring process takes place at the CMF. The CMF is connected with the OCF via Rt reference point.

As online charging process is initialized (due to the new service session initiation), the charging system identifies the UCC parameters, called *monitoring data*, that will be monitored while the service session is in progress. The parameters include a subset of the overall UCC whose potential change may affect the particular service in progress. After the online charging process is initiated, monitoring process starts as well. The monitoring data are continuously tracked (e.g., in regular time intervals that may either be fixed or defined during the initialization phase). If any change in the data values is identified, a trigger is raised by the context monitoring process. The trigger causes a notification to be sent to the OCF, which then forwards it to the network function that controls the service session (e.g., an OTT service provider). If the responsible network function decides to modify the service, the charging parameters of the online charging process are modified as well. If any other change of monitoring data occurs during the service session, this scenario is repeated. Finally, the monitoring process is terminated as the online charging is ended, followed by removal of the monitoring data.

V. A USE CASE SCENARIO: MUSIC STORE SERVICE

To illustrate the functionality of the model, we present a use case scenario of UCC usage that improves provisioning of an imaginary service named Music Store Service (MSS) (Fig. 5). The MSS acts as the OTT service, but also utilizes the UCC knowledge. It allows users to browse popular music albums, listen to selected albums via an audio stream, preview songs by receiving 30-seconds short clips, and buy albums.

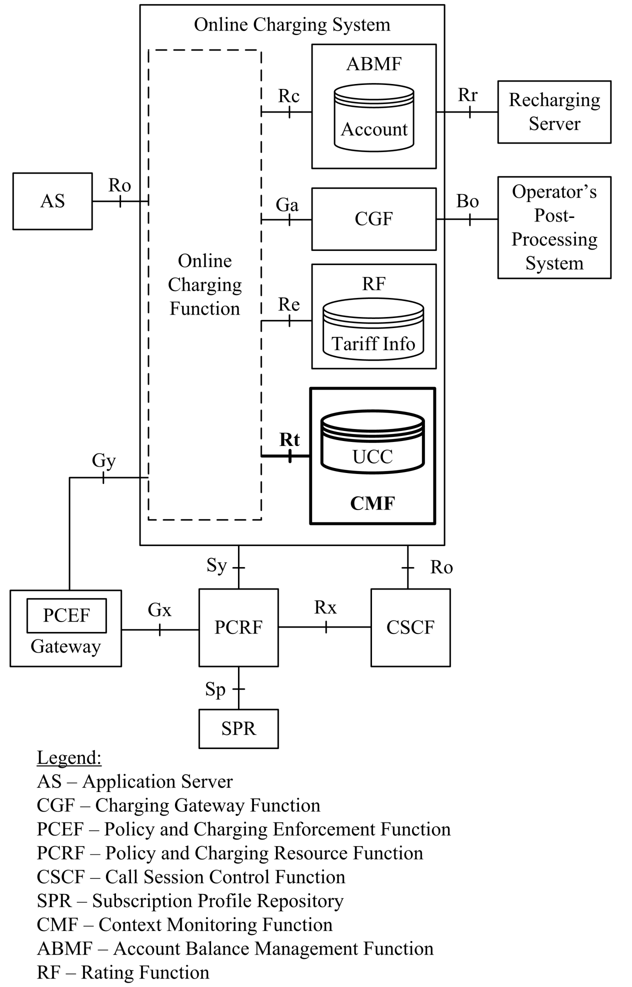

Fig. 4. Online charging and context monitoring: extended OCS functionality

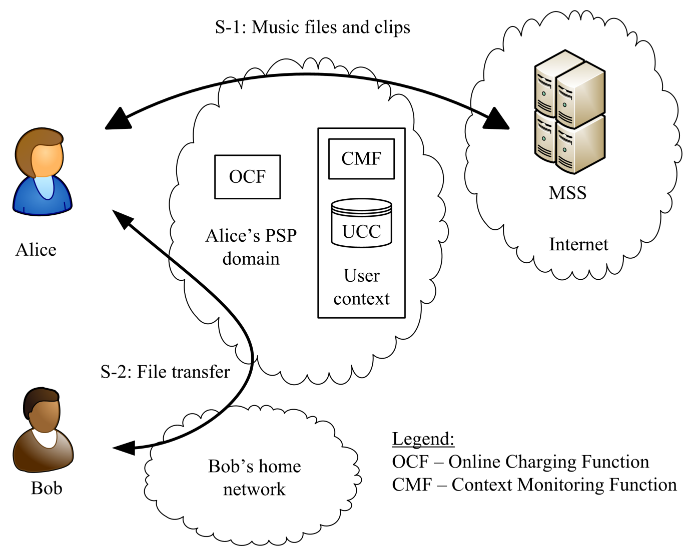

Fig. 5. A use case: actors and key functions

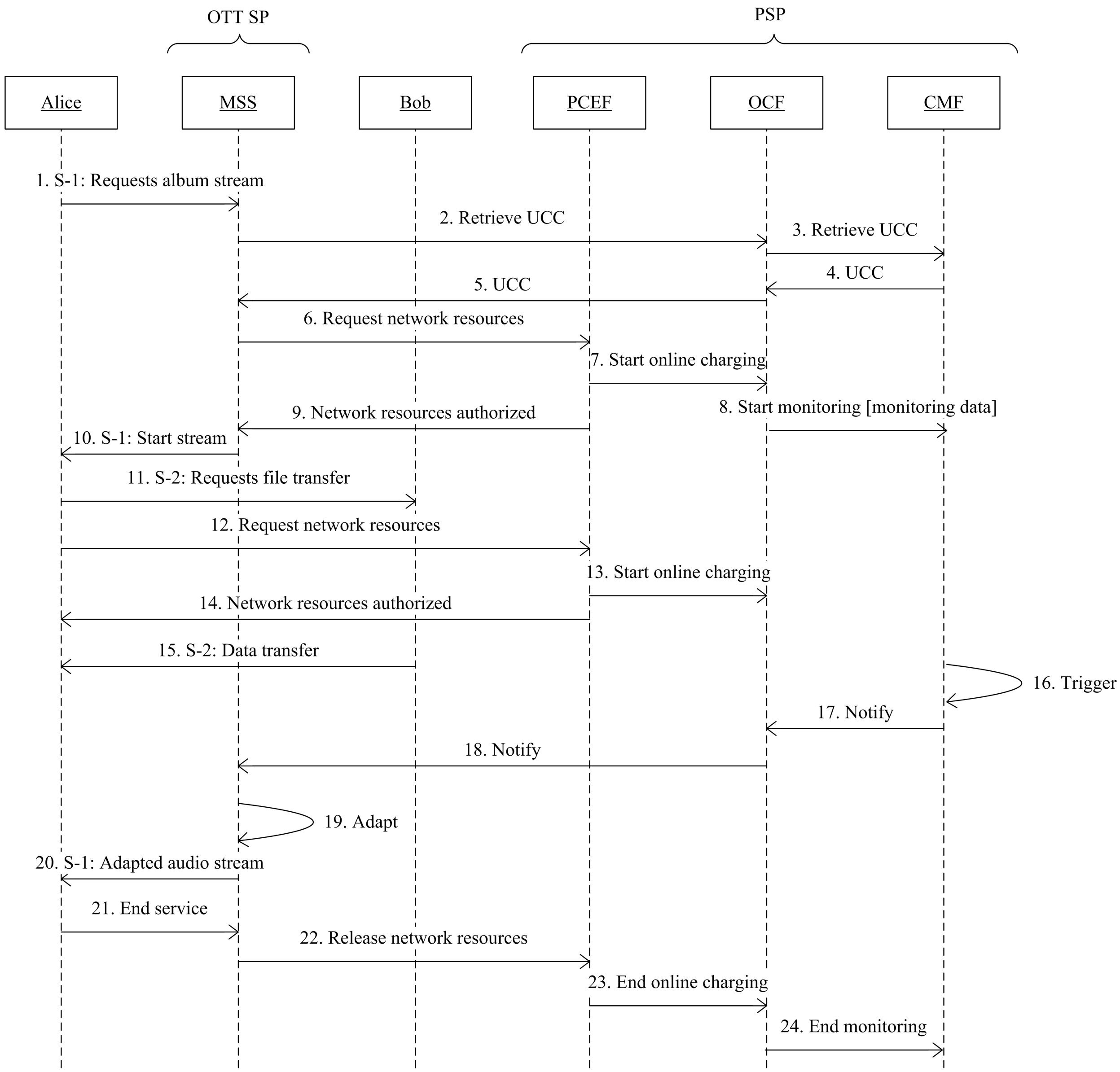

Fig. 6. Music Store Service: a high-level signaling scenario

The MSS has been designed in such a way that it provides a contextual service adaptation. Contextual adaptation is realized by providing the user with different service content depending on his UCC. In this case, the MSS may offer the song preview option instead of album streaming option to the user, if it realizes that the UCC has changed while the user listens to an album.

The use case involves two users, Alice and Bob, as depicted in Fig. 5. Alice is in this example situated in her PSP's domain and listens to music files and clips provided by the MSS. While enjoying the music, Alice sends a file to Bob, and is being charged for using both services. PSP's functional entities used in this scenario are: the OCF (an internal OCS function responsible for charging Alice for using network resources), the CMF (an internal OCS function responsible for context monitoring and UCC storing), and the PCEF (a network node responsible for network resource reservation). The MSS has the UCC exchange agreed with Alice's PSP via SLA. Within that agreement, the MSS is able to receive Alice's UCC, consisting of one parameter called "budget status", i.e., a description of available money on Alice's account. "Budget status" is in this case an enumerated variable $\{$*green*, *yellow*, *red*$\}$: *green* means there is sufficient budget on Alice's account, *yellow* means the budget is low, and *red* means the budget is completely spent.

The high-level signaling diagram describing the scenario is shown in Fig. 6. The scenario starts when Alice requests the audio stream in order to listen the album of her favorite band. The MSS, after receiving the request (1), retrieves the UCC from the CMF (2-5), and identifies that Alice's "budget status" is marked as *green*. Therefore, it requests networks resources to be reserved by the PCEF (6). The PCEF initiates online charging for the requested service (7) and monitoring process is initiated (8). Then, network resources are authorized (9) and the audio stream is initiated towards Alice containing full audio track of the album Alice has requested (10). After a while, while the audio stream is in progress, Alice initiates a file transfer to Bob containing images of their wedding, and is charged for network resources that are used to deliver the file to Bob (11 - 15). File transfer results in draining a large amount of money from Alice's budget, causing the "budget status" to be changed to value *yellow* (16). The CMF notifies the OCF (and consequently the MSS) that the change in "budget status" has occurred (17, 18), since the audio stream is still in progress.

The main goal of the MSS provider in this case is to finally sell the album to the user, because that transaction brings him profit. Therefore, after being notified about Alice's *yellow* status, the MSS estimates that there is a better chance of selling the album later if the end user listens to 30-second clips of all remaining songs instead of listening in full only to one or two following songs, and not being able to listen the rest of the songs at all. Therefore, Alice is queried whether she agrees with the contextual adaptation of the service. She does, and the content provided by the service is adapted accordingly (19). Then, the modified audio stream is continued (20), now providing only 30 seconds of every remaining song. Finally, the service is successfully ended (21), network resources released (22), stopping the charging process (23) as well as the monitoring process (24). This scenario assumes there is enough money to conclude the adapted service configuration, but not enough to successfully conclude the original service configuration. However, even if the budget were nearly depleted, another adaptation might take place, or the service would end. From the Alice's point of view, she experienced a better value for money given the offered adaptation option(s).

This scenario is feasible in the current 3GPP OCS with certain modifications in functional entities and reference points as explained in the previous section. UCC-related information may be collected from various functional entities in the network as described in Section III, mostly by using Diameter protocol. Finally, the model and the scenario proposed in the paper is compatible with the online charging authorization procedures and requires no additional modifications.

VI. Conclusion and Future Work Discussion

In this work we examined a user context stored at various functional entities of the user's MNO, and how the context may be used for providing "smarter" charging of OTT services. The presented model of context management and use takes into consideration key requirements (identified in the related works) for using this information in a multi-provider environment. A new functional entity used to perform context monitoring and store the UCC has been proposed within the 3GPP OCS, called the CMF. The important user benefit of including the UCC in charging and charging-related processes is the user's increased *value for money* experience of the consumed OTT services.

In the future work we will put an accent on specifying the structure of the UCC, as well as on proposing mechanisms that will enable a more controlled dissemination of user's private information to third parties.

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References

[1] *Telecommunication management; Charging management; Online Charging System (OCS): Applications and interfaces*, 3GPP Std. 32.296, Rev. 7.0.0, 2006.

[2] M. Koutsopoulou, N. Alonistioti, E. Gazis, and A. Kaloxylos, "Adaptive charging, accounting, and billing system for the support of advanced business models for VAS provision in 3G systems," in *Proc. 12th IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications*, vol. 1, 2001, pp. 55–59.

[3] F. C. Bormann, S. Flake, and J. Tacken, "Business models for local mobile services enabled by convergent online charging," in *Proc. 16th IST Mobile and Wireless Communications Summit*, 2007, pp. 1–5.

[4] "Deliverable d26-g.2: Validated composition and compensation architecture," Ambient Networks Project, 2007. [Online]. Available: http://www.ambient-networks.org

[5] G. Huitema, R. Kuhne, U. Meyer, H. Ensing, A. Zugenmaier, A. Bibas, O. Karasti, F. J. Rumph, and J. Siljee, "Compensation: Architecture for supporting dynamicity and negotiation in accounting, charging and billing," *Computer Communications*, vol. 33, no. 15, pp. 1823 – 1833, 2010.

[6] M. Cheboldaeff, "Service charging challenges in converged networks," *Communications Magazine, IEEE*, vol. 49, no. 1, pp. 118 –123, January 2011.

[7] A. Westerinen, J. Schnizlein, J. Strassner, M. Scherling, B. Quinn, S. Herzog, A. Huynh, M. Carlson, J. Perry, and S. Waldbusser, "Terminology for policy-based management," RFC 3198, 2001. [Online]. Available: http://www.rfc-editor.org/rfc/pdfrfc/rfc3198.txt.pdf

[8] P. Calhoun, J. Loughney, E. Guttman, G. Zorn, and J. Arkko, "Diameter base protocol," RFC 3588, 2003. [Online]. Available: http://www.rfc-editor.org/rfc/rfc3588.txt

[9] *Vocabulary for 3GPP Specifications*, 3GPP Std. 21.905, Rev. 10.2.0, 2010.

[10] *Organization of subscriber data*, 3GPP Std. 23.008, Rev. 11.3.0, 2012.

[11] *Subscription Management (SuM) requirements*, 3GPP Std. 32.140, Rev. 10.0.0, 2011.

[12] *User Data Convergence; Technical realization and information flows; Stage 2*, 3GPP Std. 23.335, Rev. 10.0.0, 2011.

[13] L. Skorin-Kapov and M. Matijasevic, "A QoS negotiation and adaptation framework for multimedia services in NGN," in *10th International Conference on Telecommunications (ConTEL)*, June 2009, pp. 249 – 256.

[14] T. Grgic and M. Matijasevic, "Online charging in IMS for multimedia services with negotiable QoS requirements based on service agreements," *Int. J. Intelligent Information and Database Systems*, vol. 4, pp. 656–672, November 2010.

[15] *Numbering, addressing and identification*, 3GPP Std. 23.003, Rev. 11.1.0, 2012.

[16] *Architecture enhancements for non-3GPP accesses*, 3GPP Std. 23.402, Rev. 11.2.0, 2012.

[17] *Framework of a service level agreement*, ITU-T Recommendation E.860, 06/2002.

[18] *EQoS - A Common Framework for QoS/Network Performance in a multi-Provider Environment*, EURESCOM Std. P806-GI Deliverable 1, September 1999.