Charging and Billing in Vehicular ad hoc Network: High Availability Architecture and Technical Interface Specification

Mohamed Darqaoui, Slimane Bah, and Maroune Sebgui
Cole Mohammadia d'Inge´nieurs Electrical and Communication Laboratory Rabat, Morocco
Email: darqaoui.med@gmail.com, Slimane.bah;sebgui@emi.ac.ma

Abstract —Actually in vehicular ad hoc networks, no archi-tecture is deployed for high availability of charging and billing functions, unlike traditional mobile and fix networks; thus, the VANET service providers need to control their rendered services when the VANET user move to an external domain(3GPP, VANET or infrastructure-less networks).In this paper, we present a high level solution in term of architecture and interfaces in order to make charging and billing of services available even out of vehicular domain.

Index Terms—Vanet, charging, billing, context awareness, charging and billing system, roaming, diameter

I. Introduction

In telecommunication world charging and billing are two complicated functions belonging to the Intelligent net- work(IN) [1],[2]. The Intelligent Network is a service specific architecture intended for mobile as well as fix Telecom net- works. The concept of IN is simply based on the idea of separating the Services Control Functions (SCP) from the Services Switching Functions (SSP). Charging and billing functions are the critical part in IN architecture[3]; Charging refers to collecting data related to the service usage and calculating the price while billing function generate the bills and process their payment.

Nowadays VANET becomes a very interesting field for the operators desiring promoting their services in vehicular envi-ronment. The interest has been increased with the integration of cloud computing concept in the vehicular network [4] allowing the possibility of offering multiple services to the vehicle owners ranging from safety to entertainment services. In VANET networks charging end users enjoying these services requires a convergent and flexible charging and billing system. Moreover Combining the cloud computing with vehicular ad hoc networks allowed to cloud service providers to implement their own charging and billing solutions. The implementation of such systems is not simple and cannot be performed with the same manner as in the classic fix and mobile networks (PSTN, 3G, LTE, IMS.) due to the nature of VANET network namely the high speed of nodes, the frequent disconnection between nodes as well as the rapidly changing topology [5].

Manuscript received March 12, 2018; revised October 16, 2018.
doi:10.12720/jcm.13.11.648-653

Some works have been done in this sense [6], focusing on secure billing schemes, authentication and accounting (AAA) procedures inside vehicular cloud computing, but no work address the issue of how to keep controlling charging a vehicle using VANET service when the latter moves from vehicular environment to another domain (ie 3GPP network, other VANET network, infrastructure-less...), in other words how to make charging and billing function available even outside VANET infrastructure?

To overcome the previous limitation, this work aims to present a high level architecture with technical interface spec-ification description in order to enable the high availability of charging and billing for VANET services.

The remainder of the paper is organized as follows; We first give an overview on charging and billing in vehicular ad hoc networks, we discuss related work and its critical, afterwards we describe, in Section III, our solution in term of architecture and interface specification. We conclude our work in section V.

II. Charging and Billing in Vehicular Ad Hoc Networks

A. Background

To control their resources usage in real-time and generate revenue for the services they provide, telecom companies have recourse to charging and billing system. Actually in fix/mobile networks (PSTN, GSM, UMTS, IMS) the service providers use convergent and flexible charging system. The current implementation of charging and billing system in mobile networks is a part of Intelligent Network (IN) [2]. The concept of IN was introduced to simply separate the service control function from the service switching function, the first step to do so, is to remove the service data from switching nodes in the network and locate it in a centralized database. The next step is to separate the service logic from the switch function and install it in independent node. the charging and billing system constraints a back end for intelligent network, it is a critical and complicated part, its role is to use the charging data collected from the network, to immediately deducts the fee, calculate the price and generate the bills. The charging data contain the necessary information about the services used by the user such as the user account number, user authorized services, user's balances.

From among the popular protocols used nowadays in the most of charging and billing systems, is Diameter protocol [7]. Diameter protocol, a successor of the RADIUS protocol used for generic authentication authorization and accounting (AAA) functionality as well as message content specification, stored in data structures called Attribute Value Pairs (AVP).

Many applications are built by using the base diameter protocol, therefore to uniquely identify each application IANA gives the Application-Id to each application. Examples of these applications are: Diameter Credit Control [8], Diameter Session Initiation Protocol (SIP), Diameter network Access Server(NAS)...Moreover, for each application many interfaces could be existed.

For charging and billing purpose the most used diameter application is Diameter Credit Control (DCC), for real time interaction between an Online chaging system (OCS) and a service provider, to control and/or monitor all charges related to the service usage. Several interfaces use DCC application namely the Gx, Gy, Sy [9]

B. *Requirements and Critical Overview of Existing Solutions*

1) Requirements: In ad hoc networks the idea for charging and billing is completely different; implementing the archi- tecture described in the previous subsection for the classic Fix/mobile networks is not acceptable and not adequate for the vehicular environment VANET. Vehicular networks char-acterized by high mobility involve a very flexible charging and billing architecture.

We identified main charging and billing requirements to be fulfilled by a charging and billing system in order to carry out its basic tasks in vehicular ad hoc network:

(a) The VANET charging/billing system should take into consideration the high speed of vehicles in terms of controlling the charging process and ensuring its high availability.

(b) The VANET charging/billing system should be exible. In fact, due to frequent disconnections, the charging solution needs to be aware of the underlying environment updates and adapt to the network topology changes.

(c) The VANET charging/billing system should allow the roaming of the charging function between different VANET providers or between VANET and other networks. In fact, when a vehicle travels long distance it is not unusual to traverse different VANET infrastructures belonging to different domains. A service should be charged continuously and accurately in this context.

2) Related work: To the best of our knowledge there is no solution dedicated to VANET environments for billing and charging issues. However, some research works have addressed this problem in peer-to-peer and MANET networks. Authors in [10] propose the MMAPPS (Market-Managed Peer- to-Peer Services) charging solution for peer-to-peer networks. The MMAPPS accounting and charging system addresses, mainly, the issue of accountability in peer-to-peer environ-ments and associated problems. The work [11] proposes a Secure Charging Protocol (SCP). SCP aims at answering the complex authentication, authorization, accounting and charg-ing (AAAC) problem in MANET. It provides a view based on a dierent business model. This later has been adjusted to cope with technological changes. The work also addresses the improvements made to the SCP protocol in terms of Quality of Service (QoS) and User Interfaces. The work in [12] proposes a solution for charging in MANET. The solution enables charging without any access to external networks. For example, when a communication is initiated by a mobile communication device within an ad hoc network, a small initiation fee is stored securely on the device, typically on a smart card. Transfer of the charging information may then occur more or less automatically and/or when the device reaches a coverage area of the operator network. When the network operators system receives the charging information from a communication device (i.e. when it comes into contact with the infrastructure) the corresponding account is updated and charged with the activities that have occurred since the last update. The work in [6], propose billing protocol over attribute-based encryption in vehicular cloud computing. In this work the architecture is based on the cloud computing network, which means that the charging and billing function is a part of cloud service provider architecture.

3) Analysis and discussion: Generally, the works discussed above provide a suitable charging and billing solution for peer-to-peer networks and ad hoc environment but did not meet the requirements highlighted previously. Specially, the peer-to- peer architecture proposed in [10] does not consider mobility and then does not meet the requirement (a) and (b) in term of flexibility and high availability. The SCP protocol proposed in the work [11] has only addressed the security issue in charging process assuming an existing solution. As far as the work in [12] is concerned, it does not take into consideration the requirement (b) and (c). In fact, this work focus on updating the operator charging system with data collected during off- line charging. The cooperation between the off-line and online charging systems is not considered. Therefore, when a node roams from an environment with VANET infrastructure to an environment where the infrastructure of VANET is absent (i.e. no RSUs and no possible connection with external networks) the charging process is interrupted. Similarly, when the vehicle traverses different autonomous VANET systems the charging is interrupted or may not be possible to update the operator charging system. Therefore the high availability of charging and billing is not considered at all. The proposed architecture in the work[6] does not meet requirement (c) too, it consider a basic charging and billing scheme for services offered by cloud providers inside VANET , but does not take into consideration the case when a vehicle in a call or data session... moves from VANET to another network (3gpp networks, an other VANET or Infrastructure-less); the VANET service provider lose the charging data when the vehicle leaves the VANET infrastructure and generally the session is interrupted.

In the next party we propose a flexible architecture in order to enable high availability of charging and billing of VANET services.

III. Charging and Billing: High Availability Architecture for VANET

A. Business Model

VANET as a new technology is coming with a new concepts especially regarding business part. VANET could be deployed according a business model, in this model we distinguish generally three partners; VANET provider, operator and end user.

The VANET provider is the party which deploy the infrastructure of VANET (roadside units, VANET-enabled vehicles...) it can be for example a manufacturer.

The operator is the service provider, it is the party marketing services through VANET, example of operator is telecommunication company providing internet access or cloud computing provider offering cloud service. The operator can also take on the role VANET provider.

End user: the OBU Unit installed in the vehicle enabling VANET communications.

B. Architecture

From the service provider's business point of view, losing charging data and/or freely use the network re-sources(bandwidth) is a cost lost. Therefore, completely and continuously control the service usage is a main target in the operator business strategy. For this purpose, we propose a high level architecture in which the high availability of charging and billing data is guaranteed. Two situations involves the high availability architecture;

1. When the vehicle is under VANET charging and billing system (VCBS) leaves the VANET network to another net- work (3GPP, other VANET network)

2. When the vehicle is under VANET charging and Billing system leaves the VANET network to an infrastructure-less environment.

Both Situations will be separately detailed in the next subsections.

1) VANET-online charging to non-VANET online charging roaming architecture: Nowadays, 3GPP networks cover a large surface in urban and rural area, unlike VANET infrastruc- ture for which the urban area has high priority and takes more importance. Therefore, When VANET user initiates a VANET communication(call, internet session,...) the VANET charging system(VCBS) start to collect the charging data, and once the vehicle leaves the original VANET domain and enter the 3GPP or other VANET domain, the vehicle could be attached to the new domain network then the charging and billing functions are switched from VANET infrastructure to the charging and Billing system of 3GPP/VANET network(CBS), (Fig. 1).

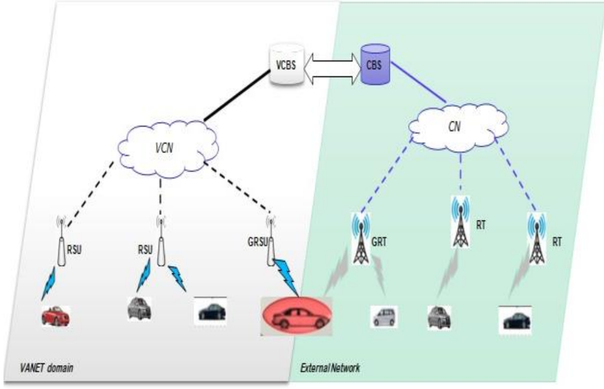

Fig. 1. High Availability architecture: VANET-To-3GPP roaming.

The description of our architecture is as follow:

Road Side Units (RSUs): Beside their main relay function, there are in charge of collecting charging data.

Gateway Road Side Units (GRSU): Insure the charging and billing data handover if no direct link existed between VCBS and CBS

Vehicular Core Network (VCN): Consist of other VANET entities such as authentications servers, proxy servers, routers.

Vehicular Charging and Billing System (VCBS): perform the charging and billing functions

Radio Transmitter (RT): Radio transmitter examples in 3GPP system are: BTS, NodeB.

Gateway Radio transmitter (GRT): its function is to insure the handover process

Core Network (CN): Consist of entities such as databases , switches and routers of 3GPP system

Charging and Billing System (CBS): performs the charging and Billing functions i.e On-line/Off-line charging in 3GPP network

We notice that in case the VANET network and 3GPP network belong to the same service provider, a common charging and billing system(CCBS) is also possible. The architecture above have to fulfil these requirements;

(a) Roaming agreement between originating VANET network and destination Network

(b) A Context aware original and destination network

(c) A Context aware vehicle

The context awareness mechanism allow to the systems to sense their physical environment, and adapt their behaviour accordingly. In our architecture this mechanism is invoked to allow the VANET infrastructure especially road side units (RSUs) to continuously capture vehicle's GPS positions.

In the situation when the vehicle roaming is from VANET to 3GPP/VANET network where roaming agreement exists between service providers, the RSU compare the collected vehicle's GPS positions with predefined GPS positions of VANET domain edges stored in the RSU's database, when the vehicle reaches these edges the road side system informs the VANET charging and billing System(VCBS), end the charging process and detach the vehicle.an other approach can be used, the signal power based handover; when the signal power or SNR(Signal to Ratio) between vehicle and GRSU reaches some threshold values and the signal between vehicle and GRT is better, the vehicle detach from VANET and attach to 3GPP network. Before the detach procedure, the VCBS send transparently the subscriber's charging profile to 3GPP charging system, thus when the vehicle finish the attach operation to the 3GPP network, it can be charged normally and enjoys 3GPP services.

Signaling flow (Fig. 2):

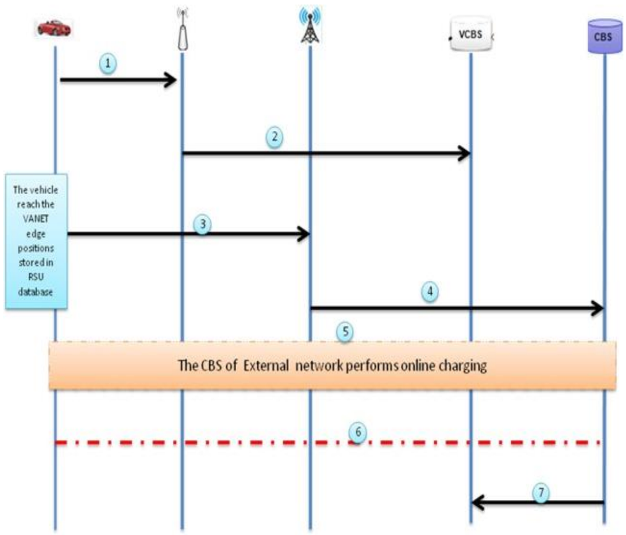

Fig. 2. VANET-To-3GPP roaming charging signaling flow

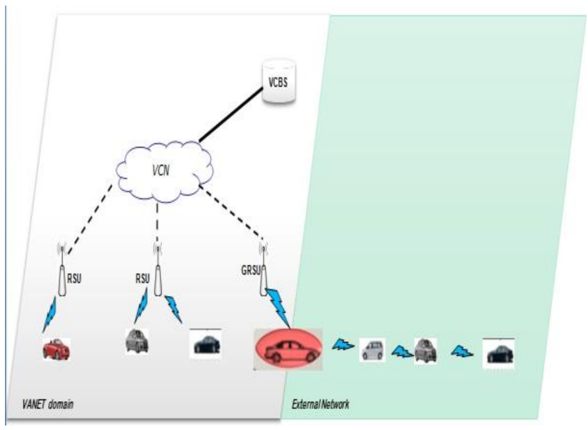

Fig. 3. High Availability architecture: VANET-To-Infrastructure-less Roam- ing.

1: The vehicle is attached to RSU and under VANET charging

2: The RSU collect charging data and send it to VANET charging and billing System (VBCS)

3: The vehicle reach VANET edges GPS positions stored in RSUs database and vehicle switch to the External network RT (Radio Transmitter)

4: The vehicle is attached to 3GPP network and, the RT transfer the charging data to the Online charging and billing system CBS

5: The Charging is performed by the online charging of External network

6: The session is ended or interrupted

7: The charging and billing system of external network transfers the charging and billing data to VANET charging and billing system (VCBS) for final update. (Fig. 3)

In this situation the high availability of charging and billing will be ensured by a unit installed in the OBU of vehicle; the charging function is a part of operating system running on the vehicle and use a secured smart card or virtual storage, we call this system Prepaid Payment System (PPS). The requirements for such architecture are below:

(a) Vehicles OBU equipped with secured Prepaid Payment System (PPS)
(b) Context aware VANET
(c) Context aware vehicle

Context awareness is also required in this situation, when the vehicle reaches the VANET edges, the edges's GPS positions captured by the RSU match the positions stored in its database table, then the RSU query the charging profile from VANET charging and billing system(VCBS), upload it in the vehicle charging unit(PPS) and end the charging process, thus the charging function is switched from VANET infrastruture to Prepaid Payment System (PPS) running on the vehicle. The update of user's charging profile is performed once the vehicle has access to VANET infrastructure.

The signal power based approach can also be used in this situation.

Charging signalling flow for such system is as described in Fig. 4.

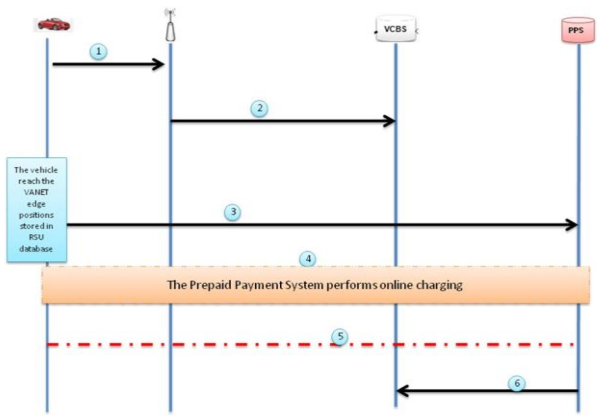

Fig. 4. VANET-To-PPS switching charging signaling flow

1: The vehicle is attached to RSU and under VANET charging

2: The RSU collect charging data and send it to VANET charging and billing System (VBCS)

3: The vehicle reach VANET edges GPS positions stored in RSUs database and switch to PPS mode

4: The vehicle is under PPS charging

5: The session is ended or interrupted

6: When the vehicle gains access to network next time the PPS system send the charging data to VCBS for further and final treatment.

C. Interface Technical Specifications

As described in the section II, DIAMETER is actually the most used protocol for charging especially in mobile networks, it support roaming function and it is also the more adequate for our suggested architecture. Two interfaces are required: We use Diameter Credit Control Application (DCC) for basic charging function, and subscription query application for user profile query.

For basic charging function, the Gx interface of diameter credit control is used while for subscription query function, a simple protocol for retrieving subscriber profile data from a database is used, a such protocol is SOAP/XML, it is xml based protocol to let applications exchange information over HTTP in a platform-independent manner.

In accordance with the two proposed high availability charg-ing architectures, Gx interface is implemented between RSUs and VCBS; the RSU collect, in real time, charging data related to the service usage, construct these charging data in special file format and send them to VBCS. The VBCS receive and decode the charging data and extract the charging information for deduct fee and balance account update then generate the bills. The SOAP/XML based interface is implemented, in VANET-To-3GPP roaming situation, between VCBS and 3GPP CBS, during the handover procedure the VCBS send the subscriber's charging profile to 3GPP CBS, if direct link existed between VANET charging system and 3GPP charging system (Fig. 6), in some case the service providers use separated charging and billing system, so the charging profile is transferred from the VCBS to 3GPP CBS trough the Vanet core network; the RSU download the profile from VCBS and send it to 3GPP CBS trough 3GPP access (GRT) and Core network CN (Fig. 5).

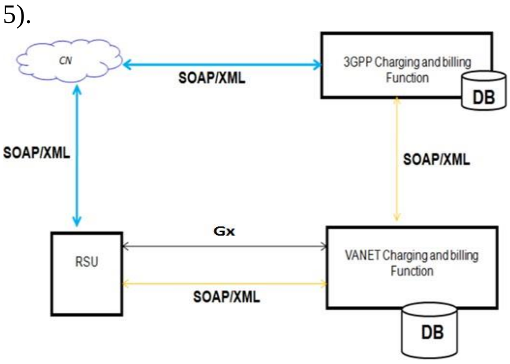

Fig. 5. Gx and SOAP/XML interfaces for VANET-To-3GPP Roaming.

In VANET-To-Infrastructure-less roaming situation, the SOAP/XML protocol is used between the RSU and vehicle's OBU to transfer subscriber charging profile when the vehicle reaches the VANET edge's GPS positions stored in GRSU database (Fig. 6).

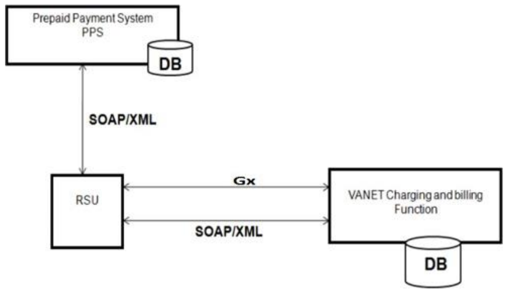

Fig. 6. Gx and SOAP/XML interfaces for VANET-To-Infrastructure-less Roaming.

IV. Conclusion

VANET actually constraints a very interesting domain for the service providers investments, services such as voice, inter- net access, value added services. Could be an important source of revenues. Therefore, implementing charging and billing for service control is mandatory. Moreover, ensuring the high availability of charging and billing of these services is also a main purpose in service provider's business strategy. Since no work address this issue, we present in this work a high level architecture which allow to service providers to control their services even when the VANET user leaves VANET infrastructure. Our target in the future step is simulation of our work in term of architecture and interfaces.

References

[1] DE/SPS-03015. ETS 300 374-1. Intelligent Network (IN), Intelligent Network Capability Set 1 (CS1), Core Intelligent Network Application Protocol (INAP), September 1994.

[2] T. Boyd and R. Gillman, "Intelligent networks," *IEE Colloquium on Network Management and Signalling*, London, 1990, pp. 9/1-9/2.

[3] T. Grgic and M. Matijasevic, "An overview of online charging in 3GPP networks: New ways of utilizing user, network, and service-related information," *Int. J. Network Mgmt*, 2013.

[4] M. Whaiduzzaman, M. Sookhak, A. Gani, and R. Buyya, "A survey on vehicular cloud computing," *J. Netw. Comput. Appl.*, vol. 40, pp. 325-344, April 2014.

[5] S. Zeadally, R. Hunt, Y. S. Chen, *et al*., *Telecommun Syst.*, 2012, vol. 50, p. 217.

[6] L. Nkenyereye, Y. Park, and K. H. Rhee, *J Wireless Com Network*, 2016, p. 196.

[7] Internet Engineering Task Force (IETF), RFC 6733, September 2003.

[8] RFC 4006, Diameter Credit-Control Application, August 2005.

[9] M. Cheboldaeff, "Interaction between an online charging system and a policy server," in *Proc. Tenth International Conference on Network*, pp. 23–28.

[10] R. Kuhne, G. Huitema, and G. Carle, "Charging and billing in modern communications networks a comprehensive survey of the state of the art and future requirements,"

IEEE Communications Surveys and Tutorials, vol. 14, no. 1, pp. 170-192, First Quarter 2012.

[11] J. Giro, B. Lamparter, D. Westho, L. R. Aguiar, and J. P. Barraca, *Implementing Charging in Mobile Ad-hoc Networks, Electrnica e Telecomunicaes*, vol. 4, no. 1, Oct. 2004.

[12] A. N. Plymoth, Bjor Plymoth, Amelie Plymoth: Charging, in Ad Hoc Communication Networks, Sweden, 2009.

Slimane Bah holds a Ph.D. from Concordia University - Canada. He also holds an M.Sc. in computer science from University of Montreal and an engineering degree on networking from ENSIAS - Morocco. His research interests include service architectures and mobile ad-hoc networks. Cur-rently, he is a professor at Ecole Mohammadia d’Inge ́nieurs University Mohamed V Rabat- Morocco.

Marouane Sebgui hlods a Ph.D from Ecole Mohammadia D Ingenieurs University Mohamed V Ra- bat. Currently, he is a professor at Ecole Mohammadia d’Inge ́nieurs University Mohamed V Rabat-Morocco. His research interests include Electronics and Communications Engineering.