Trusted Convergence Operator – A Conciliate Solution to Accounting, Charging and Unified Billing in 4G Networks

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***Abstract*—4G networks or what it is rightly called today future networks could be treated as a composition of complicated heterogeneous networks. These heterogeneous networks on converged platform provide access to varied services over an IPv6 core. Charging, accounting and Billing are a few such major issues with such networks. Currently the users are confined to utilize the services provided only by their home network providers. Convergence would provide freedom to use compounded services from varied network operators. This paper discusses a Convergent Framework Architecture (CFA) which provides a unified bill to the user for all his compounded usage across varied network operators. The CFA introduces a trusted third party operator called the Convergent Network Operator (CNO) for unified billing and convergence monitoring. Sessions offering services are monitored to achieve a transparent charging, accounting and unified billing provisions. We have illustrated the functionality of the CFA over an IPv6 core integrated infrastructure. Transparent financial transactions and unified bill provisions have been realized utilizing remoting concepts in the prototype. The Open Business Model discussed would thrust development of future technologies; provide better Quality of Service (QoS) not only at competitive prices but also providing independence to the users and the network operators.**

***Index Terms*—4GNetworks, Convergent network operator, Convergent framework architecture, Handoff management unit, Ipv6 , Unified billing.**

I. Introduction

Currently users are all Service Provider bound. They enjoy services provided by their home network operator. Rapid development in access platform technology and information technology has given birth to 4G networks or beyond 3G networks [31]. 4G networks need to eliminate for the user to be location bound or service provider bound. The consumers would have the freedom to select a service or services provided by one or many providers and obtain a single bill based on their usage. 4G networks would converge on an IPv6 core [7]. Multiple Network Operators offering varied services would have to rely on a common trustworthy platform to manage, monitor and account for the usage of consumer's services [27]-[24].

These heterogeneous networks would pose huge billing and accounting challenges.

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Presently the charging schemes for mobiles are quite simple and are driven by the network operators to lure new consumers and maintain their existing consumers. Consumers are charged based on their usage and subscription. The inter network operator services have not been integrated except while on roaming. With the emergence of 4G networks the entire paradigm would result in an integrated billing architectures where consumers would be charged based on their usage of services via a single bill. A sample 4G network is as shown in Fig1.The services used could be from a particular network operator or from others. These kinds of architectures would result in consumer independence, better services, better quality and better support systems. The rapid developments in terms of the user equipment like mobiles, smart devices, hand-held terminals etc. have contributed greatly by accelerating the realization of 4G networks [28]. The development of advance technologies like LTE and Wi-MAX will realize high speed switching with high quality of service and greater functionality.

The (CFA) presented in this paper would address many issues related to the billing, accounting and a single bill for varied service usage from varied operators. The CFA would also provide freedom to the users in selecting varied operators for varied services, the transparent nature of the CFA would also thrust development of better communication technologies and add to the overall business growth. The convergence of the CFA is governed by the Convergent Framework Operator (CFO) which is established by the local or global governing bodies like the IEFT, 3GPP. The CFA considers all the network operators (NWO) with its service providers and other operational partners as a single entity.

The paper is organized as follows:

The section-1emphasized on the need for Convergent Framework Architecture, Section-2 reflects the related work carried out towards convergence, billing and charging mechanisms for upcoming generation mobile networks. The CFA and its operation are discussed in detail in the section-3. The section-4 discusses the mathematical approach to derive single bill concept. A small prototype realization to analyze and understand the functional requirements of the CFA is discussed in Section 5. The conclusions of the work presented are given at the end.

II. Related Work

Billing and charging systems from its emergence [11] have used various architectures for realization. Acceptance and

realization of new architectures is a question of harmonizing the cost and benefits of deployments both to the users and the network operators. The deployments need to comply with the legal norms, with the customer needs and also need to reap profits to the network operators. The new architectures are generally demand driven. The growing demand gives birth to new protocols, new designs and new technologies leading to betterment of the current deployments. Another factor for consideration is whether the current deployment of services and features offered could be provided for a lesser cost, this thereby encourages the acceptance of new service oriented Architectures. Currently consumers of the current mobile technology are bound to a single network operator. Inter Network Agreements exist to support roaming [18]. A network Operator would ideally consist of an Access Provider, Transport Provider, Content Provider and service Provider. Many service Level Agreements (SLA) exists between them to comply with fair and transparent billing procedures [24].

The 3G network deployments have business models that are: Network Operator Centric Business Model, Content Aggregator Centric Model [9], and Content Provider Centric Business Model [2]-[9]. Many billing models exist with the

Network Operator for fair billing and charging, like compensation architecture [5], an UNMTS based billing architecture [9]-[10], and reusable ticket based architectures [26]. These architectures are established as per the 3GPP standard [1]. Many networking giants like CISCO, HP, AT&T and other commercial solution providers have efficient and scalable billing architectures which are currently in use with network operators [13]-[21]. Convergent Service Platform [3]-[16]-[23] with open service architectures [17] [4]-[27] could be considered as a solution to these issues which could benefit both the network operators and the users. Governing organizations such as 3GPP and other telecommunication standardizing bodies such as IRTF, IETF, ITU, ETSI, WG5, AAA and AAARCH need to be involved to realize a convergent platform. The convergent platform would integrate over an IPv6 packet switched core [28]-[4].

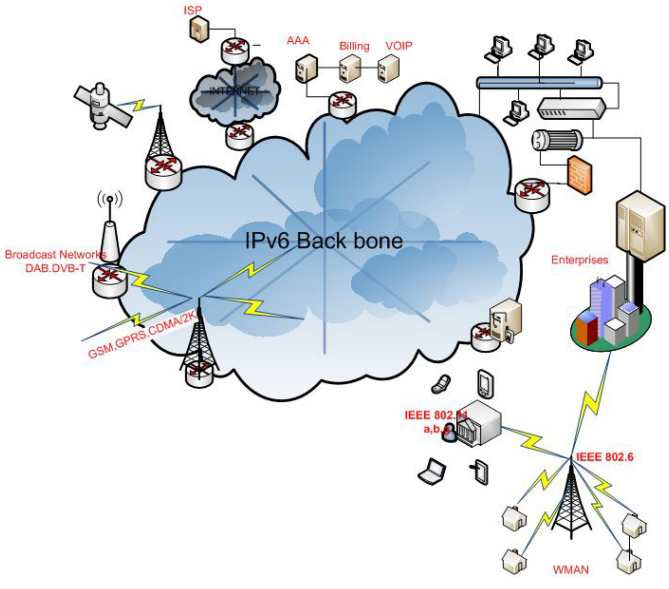

Fig. 1. 4G Network

The Charging and Billing architectures of 3G network and beyond (4G networks) pose many challenges. To address the problem, a flat rate billing system is proposed for 3G and beyond Networks when compared to the traffic based charging currently used [29]. It is foreseen, that the emergence and the need for a secure , reliable and trusted third party entity is to facilitate the convergence of multi operator networks over the IP core platform currently existing. The use of a secured third party or an independent entity for convergence and billing maintenance is also proposed by many researchers. The ANWIRE project proposes the use of an external third party agent for maintenance of authentication, authorization and accounting (AAA) servers [8].

Diameter Attribute Value Paris protocol [12] was built to extend the existing AAA server deployments for billing and accounting. Network Intra Operating Agent architecture [24] capable of managing Intra Network Operators using various service level agreements (SLA), integrated WLAN, CDMA2000 and Satellite Networks. However this architecture lacked scalability and reliability. Charging Accounting and Billing service built over an Open Service Interface addresses the users or consumers requirement for a one stop billing provision [27]-[20].

It is understood that external entities are required to monitor and provide convergent services obtained from various network operators to users. The CFA discussed below is designed to address many issues with respect to single user node billing, financial transaction security, distribution transparency, and grievance management from both the users and the network operators. As the CFA would provide financial assurance to the network operators and the user nodes, it has to be monitored or established by local or global governing bodies such as 3GPP, IEFT, IRTF etc.

III. Convergent Framework Architecture

4G networks would offer varied services from varied network operators. Intra Network operator transactions currently exist while on roaming. To enable complete convergence where users could select their preferred service from the preferred network operator and also realize a single bill concept the CFA is proposed. The CFA consist of 3 main entities:

1. Convergent Network Operator (CNO)
2. NetWork Operators (NWO)
3. User Nodes or Terminals (UN)

The CNO converge the entire 4G network over an IPv6 core. It is assumed that the CNO is a trusted entity having service level agreements (SLA) between all the network operators offering varied services. The CNO is responsible for the realization of a single bill per UN providing financial assurance to the NWO for the usage of services it provides.

The NWO is said to embody the following components [3]

1. Access Providers
2. Transport Providers
3. Content Providers
4. Service Providers

It is assumed that the NWO maintains SLA with all its units and the CFA considers the NWO as a single entity

offering varied services through its physical distribution network. The pricing of the services offered by NWO is independent of the CFA and the dynamics of competitive pricing is decided by the NWO itself. The NWO just provides the Charging Function (CF) through a cost matrix.

The CFA provides freedom to the UN to select the varied services offered by varied NWO. The UN could also obtain subscriptions from various NWO's; opt for pre-paid, post-paid schemes on offer. The UN would get a single bill for the usage of the services used. The usage of services similar or dissimilar may be from varied NWO's. UN identification is a critical requirement for the realization of CFA. 4G network users would be identified by their International Mobile Subscriber Identity (IMSI). It is assumed that the CFA identifies the UN by their IMEI and IMSI which are considered unique and the user obtains a single bill for all the services used on the considered UN.

The CFA provides a fair and transparent business model to both the consumers with their UN and the NWO's. This model could be considered as an open business model and it would accelerate the provision of enhanced Quality of Service (QoS). In order to provide better QoS and retain UN's the NWO's would need to enhance their current technology and service offering propelling technological development. With this business model we could expect emergence of better technologies and cumulative business growth in other allied industries as well.

Basic Operation of the CFA

The Operation of the CFA could be explained in 3 Phases:

A. Session Initialization Phase

B. Service Execution Phase

C. Accounting and Billing Integration Phase

The CFA incorporates the monitoring, billing and charging functionality based on the sessions created by the UN. Every session is monitored and the UN obtains a unified bill based on the session usage. Let M denote a set *m* independent network operators and N be a set of *n* network services offered. Each network operator $M_i\{i \square 1,2 \ldots m\}$ provides some or all of the *n* services of N. Let P denote the set of *p* user nodes availing services from the NWO.

The basic operation of the CFA is explained below:

A. Session Initialization Phase

The UN p_i where $i \square \{1, 2, 3 \ldots .p\}$ Request For a Service (RFS) n_i from a NWO m_i. The RFS is considered as an event. An event may vary from making a call, sending a Short Message Service (SMS), E-Mail access etc. Once the NWO receives RFS from the UN p_i for a service n_i The UN's location is detected and obtained from the Event Detection Point (EDP). The NWO ascertains whether it could provide that specific service n_i at that Location Area Code (LAC) requested by UN p*i*. This operation to determine the Location Service (LCS) to map specific service for that respective location is carried out by the Service Management Unit of the NWO. If the service could be provided, a session is created. Every event initiates a session. Every event begins with the User Node Identification (UNI) information transmission. The UNI is assumed to consist of the IMEI and IMSI. The UN interacts with the physical network maintained by the Interface Management Unit of the NWO. Once the NWO receives the UNI it checks its User Management Unit for any subscription purchased, special pricing offered for the service n_i. The NWO provides the UNI and the information from the User Management Unit to the CNO. If the UN has purchased a subscription the information is confirmed by the CNO after verifying the UN subscription validity details from its User Management Unit of the CNO. If the UN has no subscription or has a special price offering from the NWO the CNO stores the UN's RFS into the User Management Unit of the CNO. Based on the UNI information the CFO ascertains whether the UN is a pre-paid customer or a post-paid customer. If the UN is under the pre-paid scheme, a Session Validity Time (SVT) based on the balance is calculated and provided to the NWO. If the UN is under the post – paid scheme the User Credit Rating (UCR) is provided to the NWO. This operation is performed for accounting transparency. Once the UN credentials are established the NWO provides the charging function (CF) to the CNO for accounting and billing. The CF is also updated to the Converged Charging Function (CCF) maintained by the CNO. A similar CF notification is sent to the UN for confirmation of charge acceptance. Once the acknowledgment is received with confirmation, the session is activated.

B. Service Execution Phase

The session once established with the NWO m_i is monitored by the Session Management Unit. Through the session established the NWO m_i provides the service n_i according to the RFS. The session established for service execution may abruptly be broken by either the user or due to network errors. In such case the Session Management Unit saves the Session Details and provides it to the CNO for further handoff operations. If the session is terminated normally the session details are provided to the Accounting Section of the NWO.

Handover Management is another important and critical factor considered in the designing of the CFA. The handoff management unit (HMU) is embedded into the CNO in the CFA. Once the user credentials are established, and the RFS can be serviced by the NWO m_i, the NWO verifies whether the session is a new one or is a continuation to a session services by another NWO. To ascertain the session type the NWO queries the CNO for the User Session Update (USU). The CNO verifies with its Accounting Management Unit whether a Charged Data Record of the UN p_i considered exist for the same service. The CDR are all time stamped and stored in the accounting management unit of the CNO. If a CDR of the UN p_i for the same service n_i exists within a time interval Δt it could be considered as a possible handoff. The possibility of the session to be a handoff is conveyed to the NWO. The NWO sends a message to the UN querying for Session Restoration or New Session. Once the service execution of specific session is completed; those service utilization details are provided to the accounting session.

C. Accounting and Billing Integration Phase

Every completed session has a corresponding CF associated with it. The CF is established by the NWO and may vary from operator to operator. The CFA considers the NWO to provide their independent charging function using their Charging Framework. The charging of services could be considered based on one of the following parameters [3]:

1. Session Time Based Charging
2. Session Volume Based Charging
3. Session Event Based Charging/ Session Flat Charging
4. Session Content Based Charging
5. Session QoS based Charging
6. User Subscription or User Credentials based Charging

Based on the UN p_i and the RFS n_i the charging function may vary. The Session Management Unit of the NWO provides the base units utilized by p_i for service n_i to be considered for charging. The base units to be monitored for the service n_i is provided by the Charging Framework of the NWO. The Session Management Unit of the NWO monitors the user session and in accordance with the Charging Framework. The NWO provides the base units or parameters utilized to be considered for charging of the session. For example, in a video call, it could be a time based charging session. The Session Management unit provides the time units to the Charging Framework where the Charging Collection Function (CCF) is established containing the units chargeable, and the per unit price.

The charging Data Record (CDR) which is a product of the Chargeable Units and the CF per unit is generated in the Accounting Section of the NWO. The CDR is sent to the Accounting Management Unit of the CNO. The various CDR's obtained by the CNO are used to update the Converged Usage Function (CUF) matrix. The Accounting Section of the CNO computes a unified bill by aggregating all the CDR pertaining to the UN's. This is considered as the Accounting and Billing Integration Phase of the CFA operation.

The security parameters and the protocols for secure communications are established in the Security Framework Layers of the CNO and the NWO. The CFA enables a single bill generation per UN. On receiving payments towards the usage of services offered or services to be offered, the CNO distributes the received amount amongst the NWO's based on the UN's usage. All the financial transactions are realized through the Payment Gateways available with the CNO and the NWO.

Network Error occurrences or infrastructure malfunctions cannot be ignored in such a huge converged 4G networks. Such errors would result in grievances from both the UN's and the NWO's. A Reporting Management Unit is maintained in the CNO to record all the disparities reported by the UN's or the NWO's. The Reporting Management unit is responsible for resolution of payment and billing discrepancies to enable transparent and rewarding business model for 4G networks. This error management unit although is very critical but surprisingly not much work has been done towards providing solutions.

The CNO provides a platform for convergent billing and availability of various services from varied NWO. To provide convergence, the CNO maintains its infrastructure and the cost incurred for such convergence, has not been discussed. This cost could either be borne by the consumers like a transaction fee or by the NWO based on the volume of business generated. For example, in BANKING, it could be envisioned as the cost towards using financial convergent networks like VISA and MASTERCARD networks, where financial institutions are charged based on the volume of transactions. This additional charge would be negligible to the volume of business generated; freedom provided to the consumers of 4G services and the business opportunities for NWO's and allied businesses.

The CFA discussed above provides an entirely new approach to resolve the issues related to convergent charging and billing solution yet providing opportunities for overall business growth.

IV. Charging and Unified Billing Model

In the CFA the CNO is responsible for generating the unified bill to UN's. This is done based on the details of the CF's and the service usage details relative to the UN's obtained from various network providers. This section would discuss the approach adopted by the CNO to derive the unified bill. Let us consider a 4G converged network having *m* NWOs and each NWO offering n services and these services used by *p* UN's.

The accounting management unit of the CNO considers the Converged Charging Function (CCF) and the Converged Usage Function (CUF) for bill generation represented as

$$CCF_{(m\times n)} = \begin{bmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{bmatrix}$$

$$CUF_{(m\times n\times p)} = \begin{bmatrix} u_{11p} & \cdots & u_{1np} \\ \vdots & \ddots & \vdots \\ u_{m1p} & \cdots & u_{mnp} \end{bmatrix} \begin{bmatrix} u_{112} & \cdots & u_{1n2} \\ \vdots & & \\ u_{m12} & & u_{mn2} \end{bmatrix} \begin{bmatrix} u_{111} & \cdots & u_{1n1} \\ \vdots & \ddots & \vdots \\ u_{m11} & \cdots & u_{mn1} \end{bmatrix}$$

Consider the i^{th} NWO maintains CCF[i][1:n] and CUF[i][1:n][1:p] matrices at its location. Every RFS initiates a session over which the NWO provides the requested service and a CDR is generated. For every CDR generated, the NWO has to update the part of CUF matrix for the usage of requested service by the UN. Every NWO should also update the CCF matrix whenever there is any change in the services or their tariffs.

The Unified Bill for k^{th} user is computed at the CNO level as follows:

1. CDR for individual services used by the kth user are given as

$$CDR[i][j][k] = CCF[i][j] \times CUF[i][j][k]$$
$$i \in [1, m], j \in [1, n]$$

2. Unified Bill is given by

$$UnifiedBill[k] = \sum_{i=1}^{m} \sum_{j=1}^{n} CDR[i][j][k]$$

3. This approach will also enable the CNO to provide information on the break-up of unified bill among NWOs. The UN will get information on how much it has been charged for all the services used from a NWO. The bill information for an ith service provider for kth user is given as:

$$Cost\_wrt\_SP[i][k] = \sum_{j=1}^{n} CDR[i][j][k]$$

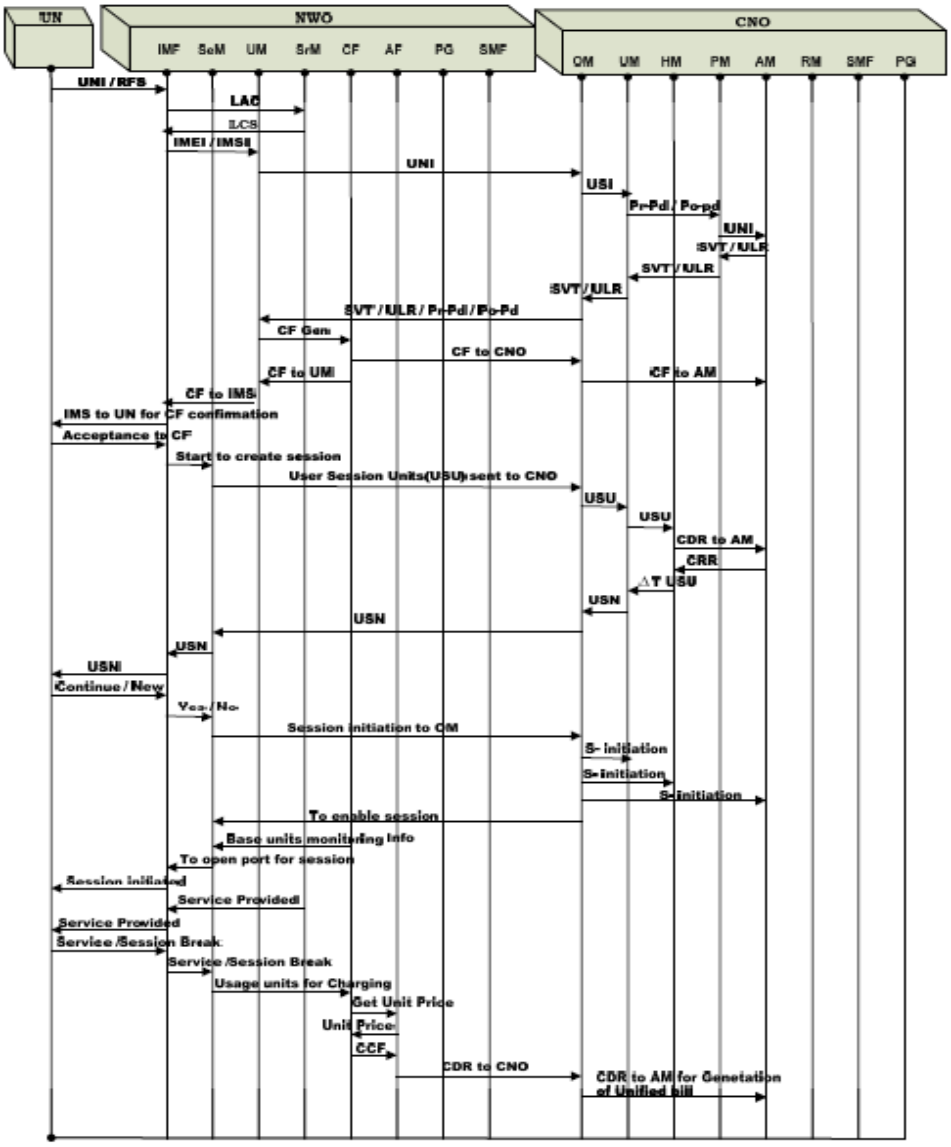

Fig. 2. Basic Operation of CFA

V. Experimental Study

The realization of the CFA is a complex undertaking dispersed over a very large converged 4G network. To prove its functionality, check the feasibility and for better understanding of functional requirements, a prototype was developed using C# .Net. The CFA provides convergence and the UN are billed based on the sessions through which services are offered. Sessions are initiated by the UN based on RFS. All the requests are assumed over the IPv6 core. To accommodate such functionality we have considered service oriented architectures (SOA) for the implementation of the prototype. Inter NWO communications and communications between the NWO and the CNO are implemented using the remote client server concepts. This application could also be integrated over a private cloud integrated over IPv6 architecture. Our tested shown in figure 3 consists of 3 Windows 2008 Servers assumed to be NWO1, NWO2 and NWO3. The CNO too was implemented on a similar server. The NWO's and the CNO were connected over an IPv6 infrastructure. The UN requests for a service to a NWO over the IPv6 core. The validity and the authenticity of the UN are verified by the NWO and the CNO. Each NWO has a varied CF for the service it offers.

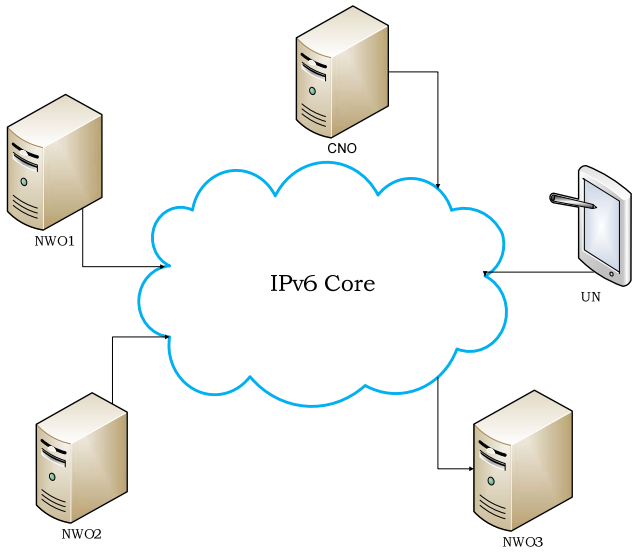

Fig. 3. Test Bed Setup used for evaluation

The test UN sends an RFS to all the NWO_1 in the test bed. A session is started which sends the RFS from the UN to the NWO_1. The NWO_1 initiates a session with the CNO using .NET Remote session. The NWO_1 responds to the RFS from the test UN. The CFs gets varied for every NWO. The

test UN sends similar RFS to the other NWO. The RFS patterns are varied and the capability of the CNO to unify and account to the varied usage of the test UN through NWO_1, NWO_2 and NWO_3 are studied. All the data transactions within the CFA are secured through cryptographic means. It was found that the prototype architecture is highly robust and network failures induced such as abruptly disconnecting the UN had minimal effect to the stability and accountability. The prototype developed was capable of accounting for the usage of the UN across varied NWO's. The operation of the test CFA could be well understood through sequence diagram shown in Fig 4.

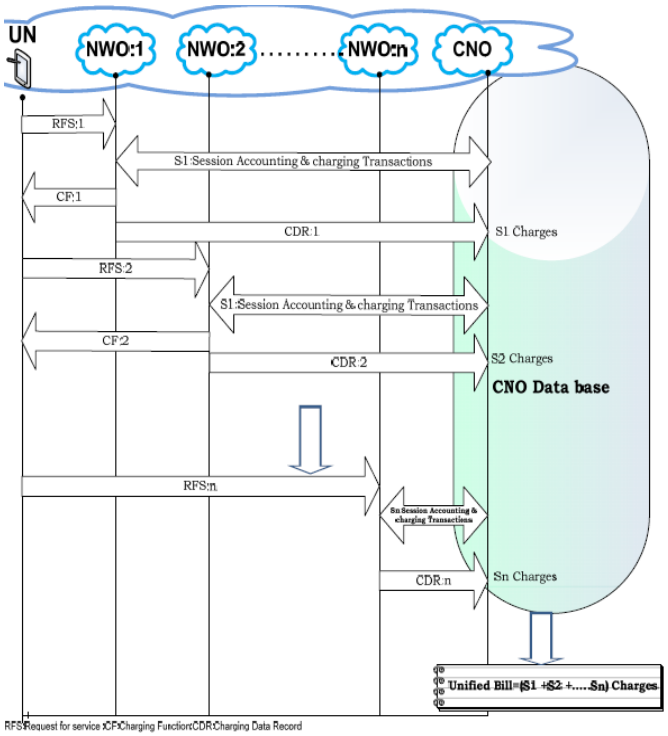

Fig. 4. Unified bill generation

VI. Conclusions

Convergence could be considered as a key factor towards realization of 4G networks. Currently the users are network operator bound and can use the services offered by their home operator alone. In this paper we have introduced a governing body, the Convergent Network Operator providing Network Operator with their service offerings and the users converged over an IPv6 network. The Convergent Framework Architecture discussed in this paper provides a unified billing structure for the users along with the independence in obtaining different services from varied network operators. The experimental study discussed proves the possibility of such architecture for unified billing generation. The framework also describes a transparent financial model benefitting both the network operators and the users. This kind of a convergence would bring about robust technological developments owing to cumulative business growth targeted towards provision of better services to the users at highly market competitive charges. The realization of such architecture completely relies on the establishment of convergent network operators by local or global governing bodies and may have much higher requirements to achieve complete convergence.

References

[1] 3GPP TS 32.250 V8.0.0 (2008-12): 3rd Generation Partnership Project, Technical Specification Group Service and System Aspects; Telecommunication management, Charging management, Circuit Switched (CS) domain charging, (Release 8)

[2] Rajeev prasad, vasileios skaldan "Interconnection and Billing Policies for Personal Networks"ISSN 0085-7130, Telenor ASA 2007, Telektronikk 1.2007

[3] Soo-Duek Kim, Seon-Ho Park, ChangSup Keum, Tai-Myoung Chung, "A Study new Challenge for Billing System in Converged Service Platform" Networked Computing &Information Management(NCM), 2010,Sixth International conference, ISBN: 978-1-4244-7671-8, INSPEC Accession Number: 1153089 Date of current version:16 September 2010

[4] Peyman TalebiFarda, Terrence Wongb, Victor C.M. Leung "Access and service convergence over the mobile internet – A survey" ; Elsevier Publications, Computer Networks -54 (2010) 545–55.

[5] George Huitema , Ralph Kühne , Ulrike Meyer , Henk Ensing , Alf Zugenmaier , Alain Bibase, Olavi Karasti , Frens Jan Rumph , Johanneke Siljee "Compensation: Architecture for supporting dynamicity and negotiation in accounting, charging and billing" Elsevier Publications, Computer Communications 33 (2010) 1823–1833.

[6] Guest Editorial: Research advances for the mobile payments arena, Elsevier Publications, Science direct.com, Electronic Commerce Research and Applications 7 (2008) 137–140

[7] Prakash.S , C.B.Akki , Kashyap Dhruve , "Handoff Management Architecture for 4G Networks over MIPv6", International Journal of Computer Science and Network Security, VOL.10 No.2, February 2010

[8] N. Alonistioti1, N. Passas, A. Kaloxylos, H. Chaouchi, M. Siebert, M. O'Droma, I. Ganchev, C. Bader Faouzi; "Business Model and Generic Architecture for Integrated Systems and Services: The ANWIRE Approach" (White paper); Proceedings of WWRF 8bis meeting, February Bijing, pp. 26-27.

[9] Ary B D, Debrei G, Imre S,(2005) "Real-time Charging in Third-generation Mobile Networks"In: ConTEL 2005. Proceedings of the 8th International Conference on Telecommunications, Zagreb, Horvátország, 2005.06.15-2005.06.17.pp. 239-245.

[10] John Cushnie: Charging and Billing for Future Mobile Internet Services, First Year PhD Research Report, September 2000

[11] Vassiliy Kornev , "Choosing a platform for a billing system" ; Master's Thesis, 2008 , Department of Information Technology , Lappeenranta University of Technology.

[12] Alexandros Tsakountakis *, Georgios Kambourakis, Stefanos Gritzalis ; "A generic accounting scheme for next generation networks" ; Elsevier Publications , Computer Networks 53 (2009) 2408–2426

[13] Cisco Public Information 2009; "Cisco Mobile Service -Aware Charging Increases Operator revenue http://www.cisco.com/en/US/products/ps6401/index.html

[14] George Huitema , Ralph Kühne , Ulrike Meyer , Henk Ensing , Alf Zugenmaier , Alain Bibas ,Olavi Karasti , Frens Jan Rumph , Johanneke Siljee; "Compensation: Architecture for supporting dynamicity and negotiation in accounting, charging and billing "Elsevier, Computer Communications 33 (2010) 1823–1833 http://dx.doi.org/10.1016/j.comcom.2010.06.003

[15] Paul Gerhardt Schierz , Oliver Schilke , Bernd W. Wirtz ; " Understanding consumer acceptance of mobile payment services: An empirical analysis" , Elsevier Publications , Electronic Commerce Research and Applications 9 (2010) 209–216.

[16] Frank Bormann, Stephan Flake, Jürgen Tacken; "Convergent Online Charging for Context-aware Mobile Services" , 21st International Conference on Advanced Information Networking and Applications Workshops (AINAW'07) 0-7695-2847-3/07 , IEEE Computer Society.

[17] Sasu Tarkoma , Jordi Rovira , Erwin Postmann , Hariharan Rajasekaran , Ernö Kovacs ; "Creating Converged Services for IMS Using the SPICE Service Platform" , ICIN 2007 ,October 2007

[18] Vangelis Gazis , Maria Koutsopoulou , Charalampos Farmakis , Alexandros Kaloxylos ; "A Flexible Charging & Billing Approach for the Emerging UMTS Network Operator Role" Applied Telecommunication Symposium-April-2001,PP 21-26

[19] Jan Ondrus, Yves Pigneur , "Towards a holistic analysis of mobile

payments: A multiple perspectives approach" Elsevier Publications, Electronic Commerce Research and Applications 5 (2006) 246–257

[20] Maria Koutsopoulou , Alexandros Kaloxylos , Athanassia Alonistioti , Lazaros Merakos ; "A Holistic Solution for Charging, Billing & Accounting 4G Mobile Systems" Vehicular Technology Conference, 2004. VTC 2004-Spring. 2004 IEEE 59th, Volume: 4 10.1109/VETECS.2004.1390676, Page(s):2257 - 2260

[21] HP Real-time Charging Solutions; HP IUM Charging Manager, Communications media and Entertainment Solutions, 4AA2-0490ENW, June, 2008;www.hp.com/go/cme

[22] Tomi Dahlberg , Niina Mallat , Jan Ondrus , Agnieszka Zmijewska ; "Past, present and future of mobile payments research: A literature review" , Elsevier Publications , Electronic Commerce Research and Applications 7 (2008) 165–181

[23] NGOSS Life Cycle and Methodology; GB927, version 1.1, Tele-Management Forum April 2004

[24] Shantidev Mohanty , Jiang Xie , "Performance analysis of a novel architecture to integrate heterogeneous wireless systems" Elsevier Publications , Computer Networks 51 (2007) 1095–1105

[25] Key Pousttchi ; " A modeling approach and reference models for the analysis of mobile payment use cases" , Elsevier Publications , Electronic Commerce Research and Applications 7 (2008) 182–201

[26] Yaohui Lei, Alejandro Quintero, Samuel Pierre; "Mobile services access and payment through reusable tickets" Elsevier Publications , Computer Communications 32 (2009) 602–610

[27] Maria Koutsopoulou , Alexandros Kaloxylos , Athanassia Alonistioti , Lazaros Merakos , "A Platform for Charging, Billing & Accounting in Future Mobile Networks", Elsevier Computer Communications, Computer Communications 30 (2007) 516–526.

[28] Pablo Vidales , Glenford Mapp , Frank Stajano , Jon Crowcroft , Carlos Jes´us Bernardos ; "A Practical Approach for 4G Systems: Deployment of Overlay Networks" Proceeding TRIDENTCOM '05 Proceedings of the First International Conference on Test-beds and Research Infrastructures for the Development of Networks and communities IEEE Computer Society Washington, DC, USA ISBN:0-7695-2219-X doi:10.1109/TRIDNT.2005.4

[29] Jarmo Harno "Impact of 3G and beyond technology development and pricing on mobile data service provisioning, usage and diffusion" Elsevier Publications, Telematics and Informatics 27 (2010) 269–282

[30] M A Bihina Bella, J.H.P. Eloff, and M.S Olivier, University of Pretoria, "Requirements for Next-Generation networks billing systems"; SATNAC September 2004.

[31] Ring, Jared W. and Foo, Ernest and Looi, Mark H. "A Secure Billing Architecture for 4G Wireless Networks"; In Clark, A. and McPherson, M. and Mohay, G., Eds. Proceedings AusCERT Asia Pacific Information Technology Security Conference (AusCERT2007): Refereed R&D Stream, Gold Coast.

[32] Ralph Kühne , George Huitema , Georg Carle "A simple distributed mechanism for accounting system self-configuration in next-generation charging and billing", Elsevier Publications, Computer Communications (2010) , Accepted 22 October 2010 , Available online on www. ScienceDirect.com

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