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The Study of IMS Functionality in Femtocell Environment

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***Abstract*— In this paper, the deployment of IMS functionality in femtocell environment is investigated and overviewed. Femtocell is a small cellular base station designed for use in residential or small business environments. It allows service providers to extend service coverage inside of our home, especially where the existing access is limited or unavailable. In the mean time, the IMS, as emerging framework of fixed and mobile convergence, provides the functionalities that accommodate current and future services in wired and wireless networks (e.g. voice, video and data transfers). Configuring the IMS framework in new approach of network architecture such as femtocell and designing the femtocell network to support IMS services is quite demanding. Some possible network design will be discussed. In this paper we concern on the investigation of IMS SIP signalling when it works on femtocell environment. Another critical issue such as the delay properties of session establishment signalling is also interesting to be discussed. The IMS-based and Cellular-based approaches for the integration of femtocells system and IMS core network are discussed.**

***Keywords*— Femtocell, IMS, SIP signalling, FMC, 3G, 4G**

I. INTRODUCTION

IP Multimedia Subsystem (IMS) is a new framework, basically specified for mobile networks, for providing Internet Protocol (IP) telecommunication services. The IMS standard defines a generic architecture for offering Voice over IP (VoIP) and multimedia services. It is first specified by the Third Generation Partnership Project (3GPP/3GPP2) and now being embraced by other standards bodies including ETSI/TISPAN. The standard supports multiple access types– including GSM, WCDMA, CDMA2000, wireline broadband access and WLAN [1].

Particularly for each wireless access technology, the current active standards describe the IMS functionality in normal wireless network coverage such as macrocell and microcell. Femtocell, as a new emerging wireless network environment which has a very small coverage, is not yet accommodated in the standard.

A femtocell is a small cellular base station designed for use in residential or small business environments. It allows service providers to extend service coverage inside of our home, especially where access is limited or unavailable. In the mean time, The IMS provides a framework that accommodates current and future services in wired and wireless networks (e.g. macrocell architecture). However, there is no evidence so far how the IMS works in new approach of network architecture such as femtocell.

At the beginning of April 2009, the Femto Forum, 3GPP and the Broadband Forum have announced that the world's first femtocell standard has been officially published by 3GPP, paving the way for standardized femtocells to be produced in large volumes and enabling interoperability between different vendors' access points and femto gateways. The new standard, which forms part of 3GPP's Release 8, and interdependent with Broadband Forum extensions to its Technical Report-069 (TR-069), has been completed by the close cooperation between 3GPP, the Femto Forum and the Broadband Forum [2]. In spite of this announcement, it hasn't clear enough how the IMS system works on femtocell network environment hence the space for investigation and research is still extensively open and challenging.

In this paper, the deployment of IMS service in femtocell environment will be investigated and overviewed. Two possible network designs will be proposed. The main focus is to investigate the effective and efficient IMS Session Initiation Protocol (SIP) signalling when it works on femtocell environment. Another critical issue such as the delay properties of session establishment signalling of source and correspondent nodes is also taken into account.

The organisation of this paper is as follow. In section II, the general idea of femtocell network is described. In Section III, the IMS operation, signalling in IMS and Session Initiation Protocol in IMS is expressed. In Section IV, the integration of IMS in to femtocell is outlined including our proposal in the integration mechanism. The conclusion of the paper is in Section V.

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II. FEMTOCELL NETWORK OVERVIEW

In the recent years there has been an increasing demand for mobile traffic due to the large nomadic population and the type of applications to be employed. This has motivated that the near-future 4G networks must enhance their efficiency in terms of spectrum, energy and cost with the higher-speed data traffic.

Macrocell network deployments have been effective in providing coverage for voice and low-speed data traffic. So, the implementation the 4G services in conventional macrocell may encounter many technical challenges.

Macrocells are characteristically good at providing area coverage, but are not as effective in providing high data rates per area due to their typically large coverage. While there have been many different approaches made to improve the spectral efficiency of macrocells and provide the required capacity in the future, macrocells are still generally limited due to the shared bandwidth.

There are many technical studies in [3][4][5][6] exposing the outstanding potential of femtocells in terms of supporting high-speed data rate, increasing the network capacity, saving energy and providing benefits from the social end economic side, indicating the femto-based networks as a substantial technological breakthrough on future mobile networks

Femtocells are defined broadly in this context as low-cost, low-power cellular base stations that operate in licensed spectrum to connect conventional, unmodified mobile terminals to a mobile operator's network. The ranges of femtocells are in the tens of meters. They utilise broadband DSL or cable Internet connections for backhaul back to the operator's core network.

Femtocells were initially designed for residential use to get better indoor voice and data coverage, improving at the same time the macrocell reliability and promise to be a cost-effective solution and additionally, increase the peak-bit rate in low coverage areas. However, the self-optimisation and coverage principles can be extended beyond this initial deployment scenario to include campus, enterprise and metropolitan zone deployments, as shown in Fig.1.

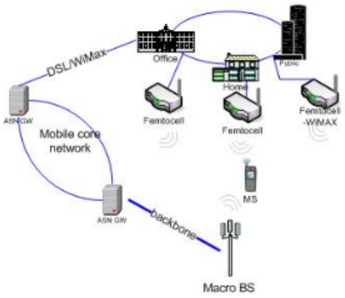

Fig. 1. An example of femtocell network

A femtocell can be considered as the cellular equivalent of a WLAN access point which is connected via ethernet to the home router. The femtocell's traffic would be backhauled over IP back to the operator's core network using the customer's broadband connection e.g. DSL cable or WiMAX. The functionality of the radio access network (RAN) such as the Radio Network Controller (RNC), Serving GPRS Support Nodes (SGSN) and Gateway GPRS Support Nodes (GGSN) can be integrated into the femtocell base station itself. This flat femtocell architecture is called a "collapsed RAN" [3]. A scenario deployment of a femtocell overlay with a macrocell underlay is illustrated in Fig.2.

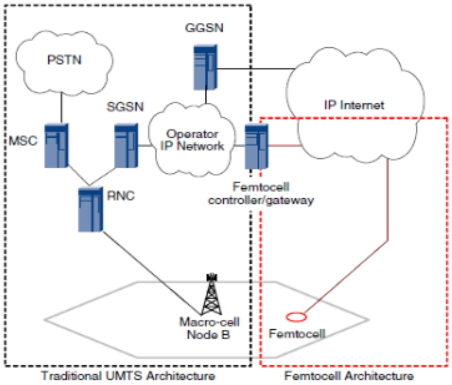

Fig. 2. Overview of femtocell architecture [3]

Femtocell deployments however, have several design challenges, particularly in lower layer functionality. Femtocells and macrocell (that are connected through an IP-based backhaul link) use the same spectrum, originating interference and imposing additional horizontal handover issues that need to be administrated. A massive deployment of femtocells will pose serious issues on the radio interference management between the macro and femto layers and among neighbouring Femto Base Stations (Femto BS).

A wide scale deployment may become another issue since it will result in a very large number of Femto BSs and cells compared to conventional macro cellular network base stations. Because of this, the usual practice of performing careful cell planning and optimisation prior to the deployment of a cell would be prohibitively expensive for femtocell deployments. Instead, the femtocells must have the ability to auto-configure their radio parameters such that the impact on the macro cellular network is minimised. The aim of this is that the users themselves would be able to plug in and power up femtocells in their homes, much in the same fashion as one would set up a WLAN access point.

In addition, beside the lower layer issues, the femtocell should also reliable for supporting the higher layer protocols e.g. SIP protocol that is used by IMS. Thanks to the exploitation of all IP platforms in femtocell, therefore the IMS's services and applications seem feasible to be implemented in femtocells network. However, the integration of IMS and femtocell is still not clear since the standard is not available yet. The integration of IMS functionality in femtocell network is the aim of our work on this paper. The SIP signalling delay in IMS session establishment process is examined as the performance indicator.

III. IP MULTIMEDIA SUBSYSTEM

A. *IMS Operation*

IMS provides more efficient service provisioning capabilities. When a user registers on the IMS network, a subscriber service profile (SSP) is downloaded by the S erving-Call Session Control Function (S-CSCF) from the Home Subscriber Server (HSS). The SSP contains service-related information and identifies the services that need to be provisioned. If multiple services need to be implemented, it determines the order in which they are provisioned. The SSP also includes the address of the server (or servers) that must execute the subscriber's request. This approach allows IMS to serve as a re-usable service infrastructure by letting providers control and manage the complexities involved in service filtering, triggering, and interaction [7]. Network operators can integrate services for both packet-switched and circuit switched networks into a single session, and users can add multimedia services to existing services in real time.

Fig. 3 depicts the layered architecture of IMS represents how IMS logical functions interact to support a few sample applications.

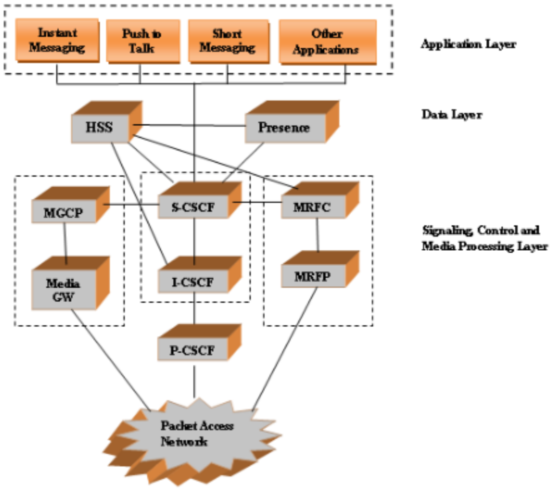

Fig. 3. Layer architecture of IMS

Functionalities that are required for supporting multimedia real time services, such as service creation, registration, invocation and execution are incorporated in the service architecture of IMS. Among these entities, IMS contains multiple SIP proxies called Call Session Control Functions (CSCFs) with following roles: P-CSCF (Proxy-CSCF) which is the first contact point in IMS and interacts with GGSN (Gateway GPRS Support Node) i.e. the access point from UMTS to external networks, for policy control and resources allocation, I-CSCF (Interrogating-CSCF) which acts as a SIP Registrar and is responsible for routing sessions to appropriate S-CSCF (Serving-CSCF), and finally S-CSCF which performs session control and service trigger.

B. *IMS Signaling*

The Session Initiation Protocol (SIP) is used as a signalling protocol in IMS environment. The SIP protocol is defined in RFC 3261 [8] which have functionalities on registration, session establishment, session management and participant invocation, including creating, modifying, and terminating sessions with one or more participants.

SIP signalling is the primary method for user registration and session control in the IMS architecture. The CSCF is the core signaling server in the IMS networks architecture. It acts as both a SIP Registrar and stateful SIP proxy server [9]. Fig. 4 depicts the signalling procedures in the IMS procedure.

This procedure starts with the user's SIP REGISTER request being sent to the visited P-CSCF. Due to air interface bandwidth limitation, messages are compressed before being sent out by the user and are decompressed at the P-CSCF. If multiple S-CSCFs exist in the user's home network, an I-CSCF needs to be deployed for selecting an S-CSCF for serving the user session. In this case, the P-CSCF resolves the address of the user's home I-CSCF using the user's home domain name and forwards the REGISTER to the I-CSCF. After the I-CSCF sends a User-Authorization-Request (UAR) to the HSS, which returns available S-CSCF addresses, the I-CSCF selects one S-CSCF and forwards the REGISTER message.

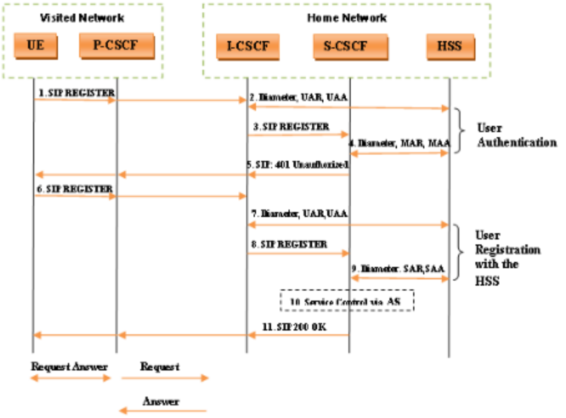

Fig. 4. Signaling message flow of registration

C. *Delay Properties in IMS Signalling*

The SIP signalling between IMS's client and IMS core network (CN) is done in the basis of SIP request/response. Client will first send a particular SIP massage for particular request (for instance the session establishment) when it needs a service from the IMS-CN. The service is established or denied upon the response from the P-CSCF in the IMS-CN.

Fig. 5 shows the session establishment flows in case a source terminal wants to establish a session with the destination terminal. Let's assume that the IMS's clients, act as source and destination terminals (ST/DT), are connected to the femtocells network. The both terminals may be WiFi/WiMAX terminals or 3G UMTS/LTE terminals.

The ST generates a SIP INVITE request and sends it to the P-CSCF. The P-CSCF processes the request; for example, it decompresses the request and verifies the user's identity before forwarding the request to the S-CSCF. The S-CSCF processes the request, executes service control which may include interactions with Application Servers (ASs) and eventually determines the entry point of the home operator of User B based on User B's identity in the SIP INVITE request.

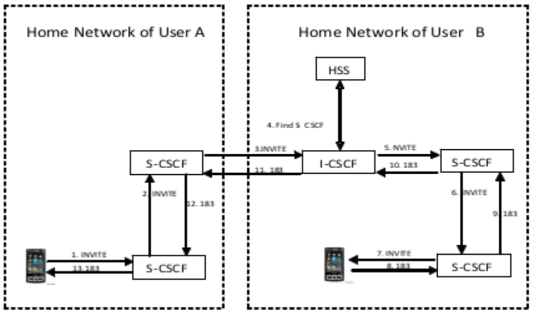

Fig. 5. Session establishment flows

I-CSCF receives the request and contacts the HSS to find out the S-CSCF that is serving User B. The request is passed to the S-CSCF. The S-CSCF, which is in charge of processing the terminating session, may include interactions with AS and eventually transmits the request to the P-CSCF. After further processing (e.g., compression and privacy checking), the P-CSCF transmits the SIP INVITE request to DT. The DT generates a response – 183 Session Progress – which is sent back to source terminal following the same route. After a few more round trips, both, ST and DT, complete the session establishment and they are ready to start the application (e.g., voice calls).

D. Delay Performance of IMS Session Establishment in Macrocell

The ITU specification E.721 [10] defines the average delay for three connection types: local connection (3.0 sec), toll connection (5.0 sec) and international connection (8.0 sec). Another standard that is important to taken into consideration is ITU Rec. G.114 [11] that specified the network delay for voice application in packet networks.

In fact, there are 67 SIP messages exchanging for a complete session establishment process in IMS. It needs the network connection reliability to avoid the delay. Based on our previous work in [12] the delay in IMS is decomposed into three parts: *transmission delay*, *processing delay* and *queuing delay*. Thus in our considered scenario, the end-to-end communication delay can be calculated as:

$$D_{total} = D_{trans\text{-}femto} + D_{proc} + D_{queue\text{-}femto}$$

The transmission delay is affected by the underlying protocols used by SIP (e.g. UDP, TCP, or RLC). The processing delay, in addition, is determined at all entities in the IMS signaling path, i.e P-CSCF, I-CSCF, S-CSCF in both home and visited networks, plus the Home Subscriber Server (HSS) where the subscriber's profile is stored. Finally, the queuing delay is provided by the queue mechanism in both transmission and receives buffers. Since the transmit buffer can be assumed as the delay free buffer, the macrocell is assessed to contribute in transmission and queuing delays.

Based on the results of our previous work in [12], the delay performance were vary depend on the access technology used. The assessment of IMS session establishment end-to-end delay can be determined in three network access scenarios: the first scenario was the WiMAX access where the both ST and DT are connected to IMS-CN through WiMAX macro Base Station (BS). The second scenario was the UMTS access through nodeB Radio Access Network (nodeB RAN). In the third scenario, the ST is assigned as WiMAX and the DT is UMTS.

The typical and assumed values for this assignment are expressed at Table I.

TABLE 1
PARAMETERS, DESCRIPTION AND VALUES

Symbol	Parameter description	Value
ρ	Utilization	0.7 for HSS 0.4 for other entities
T, τ	Frame Duration or Inter-frame time	20 ms (UMTS) 2.5 ms (WiMAX)
μ	Processing rate for each SIP message	250 packet/s
p	Probability of a frame being in error	0.02 (constant)
D	Propagation delay	100 ms for UMTS 0.27 (4 Mbps) 0.049 (24 Mbps)
k	Number of frame	5 (constant)
n	Maximum number of RLC	3
L	IP address length in bits	32
S	Machine word size in bits	32
N_m	Number of User	5000

With the given typical values of transmission, when the source and destination terminals are WiMAX terminals, the typical transmission delay is very small and can be neglected. On the other hand, in case of UMTS, the typical transmission delay is approximately 1ms (at 19.2 kbps) and 0.4 ms (at 128 kbps). In case of UMTS-WiMAX scenario, the typical transmission delay value is about 0.5 ms (UMTS-19.2 kbps) or 0.2 ms (UMTS-128 kbps)

The typical processing and queuing delay values are approximately 0.67 ms and 0.225 ms, respectively. Therefore, the total value of IMS session establishment delay in all end-to-end scenarios can be observed as follow:

- WiMAX - WiMAX: around 0.9 ms (at 4 Mbps and 24 Mbps).
- UMTS - UMTS: 1.31 ms (at 128 kbps) and 1.88 ms (at 19.2 kbps).
- UMTS to WiMAX: approximately 1.4 ms and 1.1 ms at 19.2 kbps and 128 kbps respectively.

The results indicated that the processing delay contributed the major delay of the session establishment procedure. However, the lower channel rates of in transmission, which is related to macrocell performance, also have a major impact on the transmission delay (interested reader may find the detail description of delay on IMS session establishment process in reference [12]).

These results give us bright evidence how important a base station or a radio access network is. Analogous, the femto access point or home BS in femtocell network should have the better performance than macrocells (BS and nodeB) to give a better delay performance for the whole system.

IV. IMS – FEMTOCELL INTEGRATION

We consider two approaches for integrating the femtocells system to the IMS core network. First, the integration of femtocell to the IMS core network through a Mobile Core Network (Cellular-based femtocell). Secondly, the direct integration between femtocell system and IMS core network by using all IP connectivity (IMS-based femtocell). The both approaches can be seen in Fig. 6.

With improving QoS delivery on IP transport, UMTS 3GPP has been migrating both signaling and bearer transport from traditional Signaling System 7 (SS7) to IP. Based on this achievement, the SIP/IMS core network with all functionalities of IMS can be integrated directly to the femtocells by using all IP connectivity. We much more recommend the direct integration to provide an efficient integration of IMS core network and Femto Base Station.

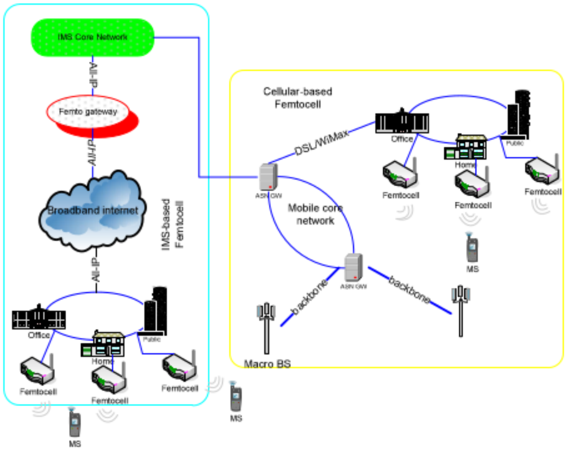

Fig. 6. Proposed IMS – Femtocell integration

In cellular-based femtocell approach, the integration through Mobile-CN brings some benefits in term of Radio Resource Management (RRM). In a conventional mobile network the radio resources are centrally managed. The main disadvantage is the scalability issues since traditional RNCs were not designed to support millions of femto base stations. However, this will not be the case for femtocells networks since the RRM is much more autonomous. The functionalities of RRM will be distributed to femtocell base station hence the scalability improvement, lower system complexity and the lower signalling overhead, can be achieved.

The deployment of femto gateway provides standard Iu interface, integrates femtocells into radio and core networks. This Femto gateway creates a virtual Radio Network Controller (RNC) interface to the legacy network. It occurs without requiring any changes to the core network elements. The Femto gateway features Iu/IP interfaces to the core network as well as Iu/IP interface to the CPE. This integration approach will resolve the RNC overload issue as well as the interoperability issues with the legacy networks, however it cannot expand to offer new IP based services.

IMS-based femtocell mechanism, on the other hand, leverages a SIP based VoIP network for cost-effective delivery, while interworking with a cellular core to extend legacy circuit switched services. In this approach, the femto terminal converts 2G/3G signals from the mobile into appropriate SIP based messages over IP and interfaces to a SIP-MSC inter-working function (IWF) which connects to IMS core network through internet by all-IP connectivity.

Integrating femtocells directly with the IMS core offers definite advantages [13]. There is no scalability issue since the mobile core network is completely offloaded, and as femtocell traffic scales the mobile operator avoids the need for core network infrastructure upgrades. The solution is able to offload IP based calls completely to the IP or IMS network. Traffic latency challenges are mitigated as the number of hops is minimal. In addition, the use of all-IP in the core network significantly reduces the opex for carriers. This architecture is forward-looking as it simultaneously solves the near-term 3G coverage challenge while also providing long-term options for delivering rich IP-based innovative services via an IMS core that leverages femtocells.

Despite the fact that, the IMS-femtocell integration by using IMS-based approach seems have some limitations i.e. the lack of standards-based support for security, mobility, and supplementary services.

The security procedures that need to be concerned particularly in the authorization, authentication and accounting (AAA) phases during the network entry process. Two types of authorization may be applied i.e. the conventional network-based authorization and a novel scenario that allow the subscriber to perform the authorization procedure to another subscriber (as on the Bluetooth pairing procedure).

On the mobility side, several requirements have to be met in order to achieve a seamless femto-to-femto and femto-to-macrocell handovers.

Finally, the circuit switched supplementary services (such as call barring, call forwarding, voicemail, USSD, SMS) should be interworked between SIP/IMS from the CPE and the existing implementation of supplementary services in the circuit switched network. Other services such as call waiting, 3 way calling and conferencing calling using existing feature servers in deployed VoIP or IMS networks should also be interworked.

V. CONCLUSIONS

In this paper, we studied the integration of IMS functionality in femtocells environment. As happened in Macro BS, the femto BS may provide the delays mainly in transmission and queuing delays. In addition, though we have proved that lower channel rate contributed the major part of transmission delay as examined in macro base station, but, we believe that the femto BS will have a better delay performance since its limitation of coverage and cell capacity may gain the higher-speed of bit rate. Two wireless acces technology, i.e. WiMAX and 3GPP/LTE are the best option for femtocell's technology platform since both provide higher bit rate and higher bandwidth. Two mechanisms are proposed for the integration of femtocell system and IMS core network, i.e. through a mobile core network and direct integration using all IP connectivity. We strongly recommend the direct integration since it gives many benefits.

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REFERENCES

[1] 3GPP TS 29.163, "Interworking Between the IP Multimedia (IM) Core Network (CN) Subsystem and Circuit Switched (CS) Networks".

[2] "3GPP publishes first femtocell standard". Published on Telecoms Europe (http://www.telecomseurope.net) .

[3] Ho, L.T.W., Holger, C.,"Effect of User-deployed, Co-channel Femtocells on The Call Drop Probability In A Residential Scenario" The 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'07), 2007.

[4] Chandrasekhar, V; Andrews, J.G., "Uplink Capacity and Interference Avoidance for Two-Tier Cellular Networks," Global Telecommunications Conference, 2007. GLOBECOM '07. IEEE , vol., no., pp.3322-3326, 26-30 Nov. 2007.

[5] Claussen, H., Ho,L.T.W., Samuel, L.G., "Self-optimization of coverage for femtocell deployments," Wireless Telecommunications Symposium, 2008. WTS 2008 , vol., no., pp.278-285, 24-26 April 2008

[6] Chandrasekhar V., Andrews, J.G, Gatherer A., "Femtocell Networks: a Survey", IEEE Communications Magazine, vol. 46, no.9, pp. 59-67, Sept. 2008

[7] Ulvan, A and Ulvan, M., "IP Multimedia Subsystem – IMS : Converged Network Architecture for the Intelligent Interaction of Network Applications and Services". Proceeding of The International Workshop on Digital Technology, 2007. ISBN 978-80-8070-786-6.

[8] J. Rosenberg, H. Schulzrinne, G. Camarillo, A. Johnston, J. Peterson, R. Sparks, M. Handley, and E. Schooler. SIP: Session Initiation Protocol. RFC 3261, June 2002

[9] 3GPP. Signalling flows for the IP multimedia call control based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (Release 5). TS 24.228 (v5.15.0), September 2006.

[10] ITU-T E.721. Series E : Overall Network Operation , Telephone Service, Service Operation and Human Factor.

[11] ITU-T G.114. Series G: Transmission Systems and Media, Digital Systems and Networks.

[12] Ulvan, M., Bestak, R., "Delay Performance of Session Establishment Signalling in IP Multimedia Subsystem", In Proceeding of The 16th International Conference on Systems, Signal and Image Processing (IWSSIP 2009), Chalkida, Greece, June 2009.

[13] Singh, M., "Integrate Femtocells with Existing Wireless Infrastructure", Feature Article, Continuous Computing, www.ccpu.com.

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---

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