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Features of Femto Convergence Server Using SIP

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Abstract

Femtocell Convergence Server comes from the 3G(third Generation) CDMA (Code Division Multiple Access) standards. It is a network element which interworks between the CDMA core voice network and femtocells. In this paper, all the existing technology of femtocells with their characteristics are explained. In this technology, two main network models are used to support the circuit switched services. One is SIP/IMS (Session Initiaition Protocol/ Internet Protocol Multimedia System) network model and second is Legacy network models. The basic protocol used in this technology is SIP protocol. SIP is an signaling protocol, that controls the voice and video calls over Internet Protocol (IP). The Femto Convergence Server is a carrier-grade and scalable product that supports some standard interfaces including; standard mobile interfaces to HLR (Home Location Register), Supports SIP to existing IP infrastructure, Supports standard IMS interfaces to HSS (Home Subscriber Server).

Keywords: Femto Convergence Server (FCS), Session Initiation Protocol (SIP), Internet Protocol Multimedia System (IMS), Femto Access Point (FAP), Code Division Multiple Access (CDMA) and Real Time Transport Protocol (RTP).

1. Introduction

For Femtocell convergence, using the home broadband network femto enables single number voice and messaging services delivered over the IP/SIP/IMS network to the femtocell. Some key values including; Voice convergence, Messaging convergence, Single number access across networks and devices, Femtocell handover & mobile dual ring.

In Femtocell, "Femto" means 10^{-15} [4]. Femtocells are much smaller than the Macrocell cellular towers. A Femtocell i.e. based on the mobile network technology, is a low- power access point. It provides wireless voice and broadband services to customers in the home or offices. Through direct IP connections, Femtocell Convergence Server handles many thousands of femtocells, which are encrypted with IP sec and decoded by a IPSec Security Gateway [7].

Femtocell has two interfaces; Air Interface and Internet Interface. Air interfaces are; UMTS (Universal Mobile Telecommunications System), CDMA2000, LTE (Long Term evolution). Internet interfaces are; DSL (Digital Subscriber Line) and Cable.

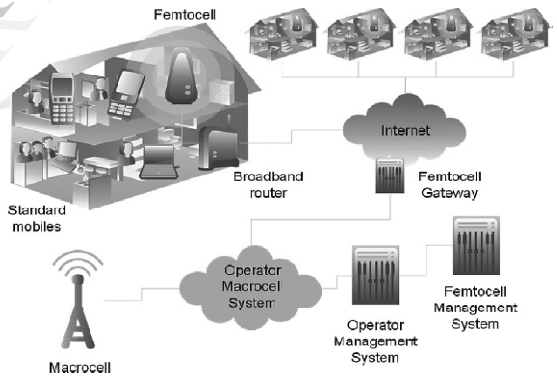

Figure 1. Femtocell Network Architecture

In Figure 1, the femtocell connected to the mobile operator's network via a standard broadband connection. Usually, a single femtocell will deliver voice services to at least four to five users simultaneously within the home or offices, while allowing more to be connected to the cell and accessing services such as text.

In Femto Convergence server, SIP request/response methods play an important role. Using SIP request/response method, SIP call flows of mobile operator's network can be handled [1]. SIP requests are the codes used for communication. SIP request methods are shown in Table 1;

Request name	Description
INVITE	A client is being invited to participate.
ACK	The client has confirme the invite request.
BYE	The call has been terminated by callee or caller.
CANCEL	Cancels the pending requests.
OPTIONS	Queries the server for its capability.
REGISTER	Registers the client according to the address in the To header with the server.
PRACK	Provisional confirmantion/acknowledgement.
SUBSCRIBE	Subscribing the message for an Event of Notification.
NOTIFY	Notify the subscriber of an event.
PUBLISH	Publishes an event to a Server.
INFO	Sends information that does not modify the session state in the middle of a session..
REFER	Asks client to issue SIP request (call transfer.)
MESSAGE	Sends instant messages using SIP.
UPDATE	Without changing the state of the dialog modifies the state of a session.

Table 1. SIP Request Methods

SIP responses specify a reason phrase and a reason phrase is defined with each response code. SIP responses are shown in Table 2;

Response Name	Description
1xx	Provisional responses
2xx	Successful responses
3xx	Redirection responses
4xx	Client failure responses
5xx	Server failure responses
6xx	Global failure responses

Table 2. SIP Response Methods

The main attributes of Femtocells are; Uses mobile technology, Operates in licensed spectrum, Generates coverage and capacity, Over Internet-grade backhaul, Permits low prices, Fully managed by licensed operator, Self-organising and self-managing. There are many reasons why customers are demanding femtocells as the services an economies that can be provided by using them but there are many challenges in achieving these potential. Some difficulties are; Market challenges, Radio and Physical challenges, Network challenges, Regulatory challenges. The network architecture of femtocell supports some key requirements; Service Parity, Call Continuity, Security, Self-Installation & Simple Operational Management and Scalability [8].

In any femtocell network architecture, there are three common network elements; FAP (Femtocell Access Point), SeGW (Security Gateway) and FMS (Femtocell Device Management System). So, femtocells are not simple standalone devices. But they should be integrated into the mobile operator's network to ensure optimal performance and to enable seamless service across both femtocell and macrocell networks.

2. Related work

As the Femto Convergence Server is an IMS SIP Application server that interfaces to the S-CSCF (Serving Call Session Control Function) using the ISC (IMS service Control) interfaces. FCS is the centralized SIP registration server [9].

The main work related to Femto Convergence Server is to handle the mobile operator's networks call flows using SIP request/response methods. Before the description of the SIP call flows, let's take a look at how SIP user agents register with a SIP registrar.

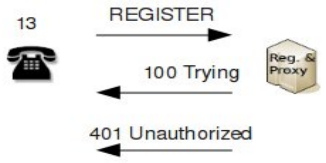

Figure 2. Phase 1, SIP Registration

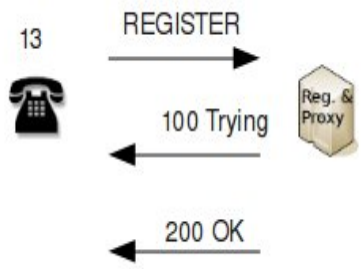

Figure 3. Phase 2, SIP Registration

This is how SIP user agents register with a SIP registrar in two phases shown in Figure 2 & Figure 3. In Phase 1, registrar server will immediately reply with "100 Trying" (a provisional response). It indicates that the user agent needs to authenticate. So it responds with "401 Unauthorized" (Client failure response). In second phase, the registrar server will again reply with "100 Trying" and will compare the two MD5 (Message Digest) hashes. If they match, the registrar will reply with "200 OK" and insert to the location database.

After Registration, let's take a look at a typical SIP call flows shown in Figure 4, Figure 5 & Figure 6. We will take a scenario with a SIP proxy server involved [5].

For example; a user at the SIP telephone with no. 121 dials the no. 122, then 121 does not know the IP address of 122 but it knows the SIP proxy IP then user agent will compose an INVITE request & send it to the proxy. The body of the INVITE request carries an SDP (Session Description Protocol) message, the called party will need to send its RTP (Real Time Transport Protocol) stream to the caller. Then the SIP proxy responds with "100 Trying" and then forwards the INVITE request to the target telephone.

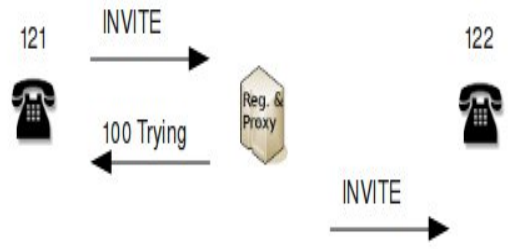

Figure 4. INVITE Request

After that 122 starts ringing & sends the response "180 Ringing" to the proxy and then proxy will forward it to 121. The called user picks up the phone and his/her phone sends "200 OK". The body of the contains an SDP message so that the caller knows where to send his/her RTP stream after that proxy forwards the response to the caller. The caller (121) confirms the receipt of "200 OK" with ACK message then proxy forwards the ACK to 122. At this point, the call has been established and both parties can start sending their RTP streams.

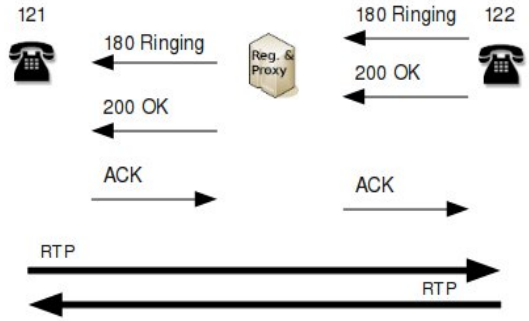

Figure 5. 180 Ringing

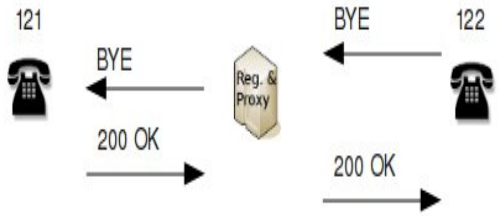

Figure 6. 200 OK

When one of the users hangs up, his/her phone sends the request BYE and proxy forwards the message to other party. The other party responds to BYE request with "200 OK" then both parties will stop sending RTP data and the call is over [6].

By using these types of call flows, mobile network features can be handled. In this paper, MO calls, MT calls and supplementary features of mobile network will be discussed.

3. FCS Network Models and Call Scenarios

Femtocells are the devices that deliver the both Circuit Switched and Packet Data Services when connect to a mobile operator core network. For Circuit Switched services, there are two distinct models; SIP/IMS model and Legacy Network model shown in Figure 7 [15].

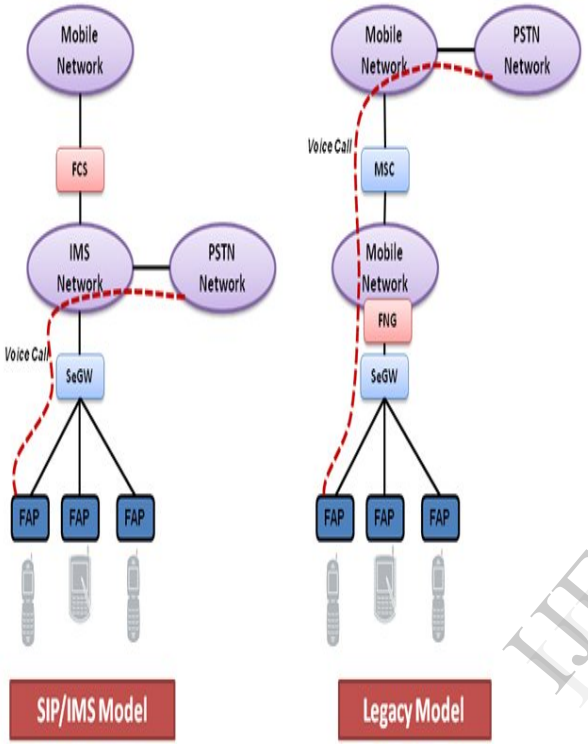

Figure 7. Femtocells Network Architectures for supporting voice

SIP/IMS Model: In this model, the femtocells connects to a new core network of the mobile operator. Femtocells behave towards the SIP/IMS network like a SIP/IMS client by transporting the voice traffic over RTP and by converting the circuit-switched 3G signaling to SIP/IMS signaling. The main components of SIP/IMS model are; Femto Access Point with SIP/IMS client, SIP/IMS core network and Femto Convergence Server.

Over Femtocells, the SIP/IMS model is a forward looking approach for delivering services. It can also be used to offer converged fixed-mobile services to both fixed-line phones and mobile devices. As FCS is the main key component of SIP/IMS, support of active handoff is done through FCS. It acts as a peer MSC (Mobile Switching Center) in the mobile core network.

Legacy Model: In this model, the femtocell connects directly to the existing mobile operator core network. For UMTS femtocells, 3GPP standards use the legacy core network model. The main components of Legacy network Model are; Femtocell Access Point, Femtocell Network Gateway and Security Gateway. When SIP/IMS network is not already in place then the Legacy network is easier to deploy, since it allows the operator to reuse the existing mobile core network. In this model, support of active handoff is done through the legacy MSC. Currently, the legacy network model is not supported in CDMA femtocell standards.

In CDMA networks, via the security gateway, femtocells can connect to the PDSN (Packet Data Serving Node). This is possible because without any modifications, existing PDSN's can handle a very large number of femtocells.

The main feature of the femtocell is that it supports the emergency calling services. It supports emergency services even for those users who are not authorized to use the femtocell.

The basic features of the femto convergence server are; Voice & Messaging Services, Subscriber Registration & Authentication, Supplementary services, Session handoff, Regulatory services and VoIP & IMS Support.

The main focus is on the following sections: MO (Mobile Origination) Call, MT (Mobile Termination) Call, Call Waiting, Call Barring, Call Hold, and Three-way Call.

Call Setup & Disconnect: In successful call setup & disconnect;

- User A calls User B.
- User B answers the call.
- User B hangs up.

Call Setup & Hold: In successful call setup & hold;

- User A calls User B.
- User B answers the call.
- User B puts User A on hold.
- User B takes User A off hold.

Simple Hold: In successful simple hold;

- User A calls User B.
- User B answers the call.
- User B places User A on hold.
- User B takes User A off hold.
- The call continues.

Call Hold with Consultation: In successful call hold with consultation;

- User A calls User B.
- User B answers the call.

- User B places User A on hold.
- User B calls User C.
- User B disconnects from user C.
- User B takes User A off hold.
- The original call continues.

Call Waiting: In successful call waiting;

- User A calls User B.
- User B answers the call.
- User C calls User B.
- User B accepts the call from User C.
- User B switches back to User A.
- User B hangs up, User A ends the call.
- User C notifies the User B of remaining call.
- User B continues the call and answers the notification.

Three-way Calling: In successful Three-way calling;

- User A calls User B.
- User B answers the call.
- User B puts User A on hold.
- User B calls User C.
- User C answers the call.
- User B takes User A off hold.

So these are some basic positive scenarios that is developed and tested in this paper.

4. My Contribution

Improvement of Femto Convergence Server already being done by various technologies and protocols. I am just using these technologies to improve the mobile network features using SIP protocol by developing and testing. My main part is to firstly understand the technology accurately. Area of this paper focused only on the successful delivery to the customer. The mobile network features requires testing before delivering it to customer like Functional Testing, Feature Testing, Automation Framework Update, New Automated Tests, Network and IP Redundancy Testing, Regression and Stability Testing.

To achieve this goal, some software specifications are required. For backend, C/C++ programming language is used and for testing part, TCL/TK scripting language is used. Generally, for Automation, scripts are written in TCL/TK scripting language. Emacs/Vim for editor, G++ compiler, inhouse automation tools for testing, SIPP for call scenarios and clearcase for code repository and MySQL for database and Valgrind for Memory leaks. To achieve the call scenarios perfectly, Software Development Life Cycle Model (Figure 8) and Software Testing Life Cycle Models (Figure 9) were used.

Software Life Cycle Model:

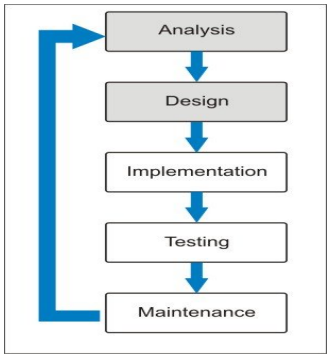

Figure 8. Software Development life Cycle

This model explains how software is developed.

Analysis: Analyzes the end-user information needs.
Design: Describes desired features including screen layouts, process diagrams, pseudocode and other documentation.
Implementation: The coding is written here.
Testing: Collects all the code together into a testing environment and then checks for errors, interoperability and bugs.
Maintenance: This is the longest stage, it maintains all the changes, correction and additions.
By using this cycle, I developed the call scenarios using C programming language. After Developing the features testing was done manually and automation both.

Software Testing life cycle Phases:

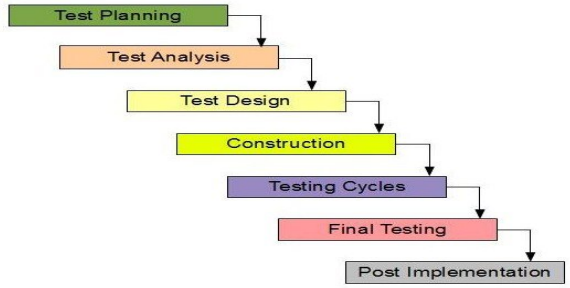

Figure 9. Software Testing Life Cycle

This model explains how testing can be done. Firstly for test planning, test cases are written. After that design the framework for testing then construction of test cases and after final testing there will be post implementation. The Test Objectives will include the following sections; Mobile Origination Call (MO

Call), Mobile Termination Call (MT Call), Call Waiting, Call Barring, Call Hold, 3-Way Call. The testing will be done via test automation framework which will be enhanced to support the required configuration changes at FCS and to support the respective call flows.

Wireshark, network analyzer is used to analyze the call scenarios.

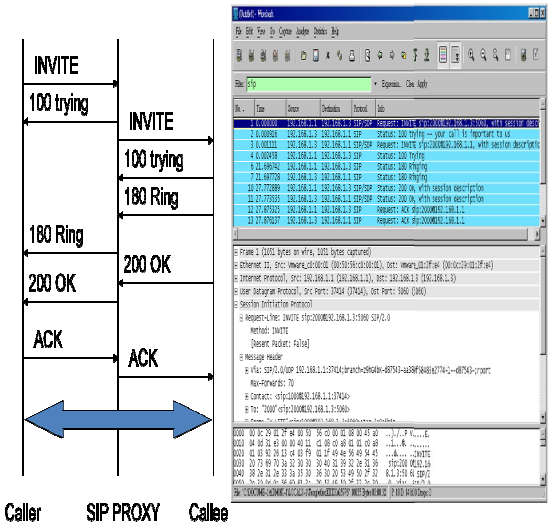

Figure 10. Call Establishment flow using Wireshark

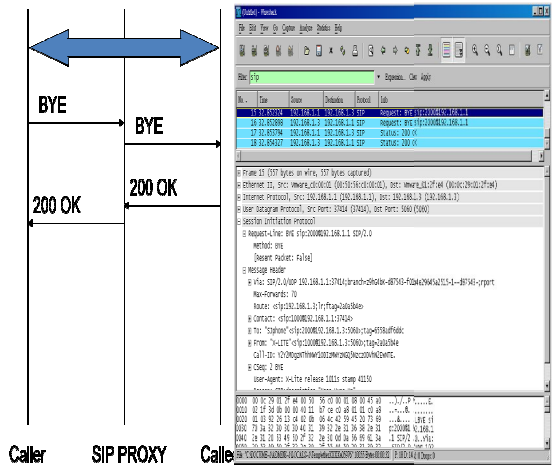

Figure 11. Call Termination using Wireshark

Automation Framework: TCL/TK scripting language used in automation framework. It is use for testing the end-to-end scenario using sip and ss7 interfaces.

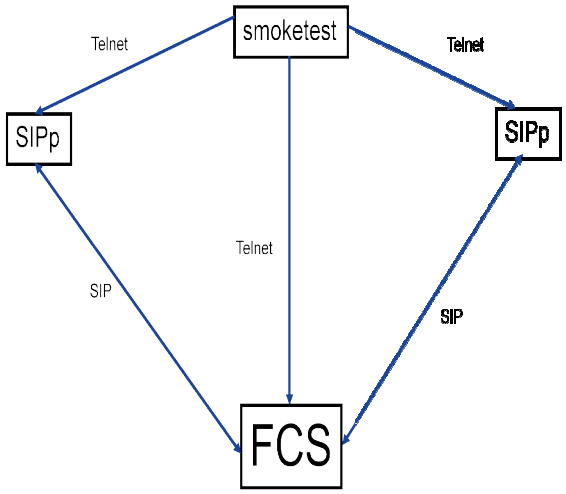

Figure 12. Automation Framework

This is the framework that explains how automation can be done. Using telnet, SIPp uses the smoketest written and with the help of SIP protocol it is automated on the femto convergence server.

SIPp: SIPp is a free Open Source test tool for SIP protocol and used for performance testing and traffic generation.

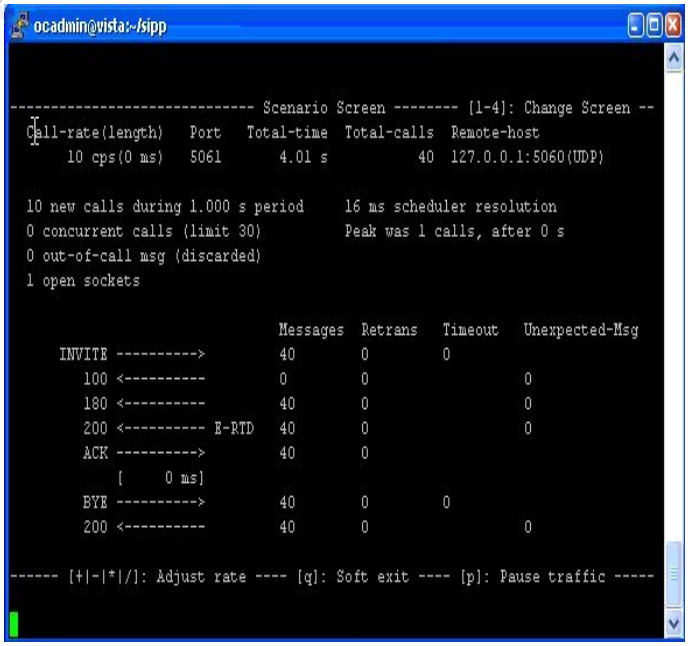

Figure 13. SIPp scenario

So my main role is to develop the call scenarios and to test them perfectly without any bug before delivering it to the customer.

5. Conclusion

From this area of research, I conclude that femtocells have increasing number of high data rate applications and have the potential to provide high quality network access to indoor user at low cost. The main purpose is to provide the correct information about mobile networks to the Intelligence agencies. The CALEA (Communications Assistance for Law Enforcement Act) standards purpose is to enhance the ability of law enforcement, an Intelligence agencies to conduct electronic surveliance by allowing Federal Agencies to monitor, broadband internet, VoIP traffic, and all telephone in real time.

This paper is helpful for the beginners to get an idea about the SIP call flows & their features, FCS technology, their merits and demerits. The future work is to improve the efficiency of this proposed work and wanted to add SMS features also.

References

[1] Roserberg et all. SIP: Session Initiation Protocol. RFC 3261, IETF Network Working Group, June 2002.

[2] CALEA: IETF RFC 3924 https://tools.ietf.org/html/rfc3924

[3] SIPp Basics: http://sipp.sourceforge.net/

[4] Shao-Yu Lien; Hou-Hsun Lee; Sung-Yin Shih; Pin-Yu chen; Kwang-Cheng Chen. Network synchronization among femtocells, GLOBECOM Workshops (GC wkshps), 2011 IEEE.

[5] HONG-PENG WANG, TIE-JUN ZHANG, and XIAO-ZONG YANG. Enabled SIP-Based Multimedia Services with MPLS Technology in Ad Hoc Wireless Networks.

[6] Xiuwu Zhang, Weimin Lei, Wei Zhang. Using P2P Network to Transmit Media Stream in SIP-based System.

[7] Yixue Lei, Yongsheng Zhang. Efficient Location Management Mechanism For Overlay LTE Macro and Femtocells.

[8] 3GPP TS36.300 E-UTRAN Overall Description v9.0.0

[9] 3GPP S2-094867 New WID for Local IP Access & Internet Offload Vodafone, China Mobile, Verizon Wireless, AT&T, Huawei, Qualcomm Europe, Alcatel-Lucent, NEC, Starent Networks, Samsung, Cisco, Airvana, LG Electronics, Panasonic.

[10] 3GPP TS 32.225 Telecommunication management; Charging management; Charging data description for the IP Multimeia System (IMS)

[11] El Sawda, S.Univ. Paris VI, Paris, France Urien, P.; El Sawda, R. A trust communication with SIP protocol. Computer Systems and Applications (AICCSA), 2010 IEEE/ACS International Conference.

[12] Mungan, D. Elektr. Ve Elektron. Muhendisligi Bolumu, Ozyegin Univ., Istanbul, Turkey Ferazoglu, G.; Sunay, M.O. On the importance of application based scheduling for femtocell access points. Signal Processing and Communications Applications Conference (SIU), 2012.

[13] Khaled Elleithy and Varun Rao. Femto Cells: Current Status and Future Directions.

[14] Haddad, Y.; Porrat, D.; Femtocell: Opportunities and challenges of the home cellular base station for 3G; Proceedings of IEEE Global Telecommunications conference, 2007. Washington DC, USA, pp. 3317-3321.

[15] Chandrasekhar V. and Andrews J, Gatherer A; Femtocell networks: a survey; IEEE Communications Magazine, Volume 46, 2008.

[16] Mikko Makela; Helsinki University of Technology; Telecommunications Software and Multimedia Laboratory. Signaling in Session Initiaition Protocol.

[17] Kario, Janne. 2002. Session Initiation Protocol Security. Seminar study. Helsinki University of Technology, Telecommunications Software and Multimedia Laboratory. Espoo.5 pp.

[18] Implementing Intelligent Network Services with the Session Initiation Protocol; Jonathon Lennox, Henning Schulzrinne and Thomas F. La Porta, Columbia University Computer Science Technical Report CUCS-002-99, Jan 1999.

[19] A White paper by Siemens Communications Enterprise Systems Division; SIP The Session Initiation Protocol For Enterprise SIP Solutions.

[20] Fuxjager, P. FTW, Telecommun. Res. Center Vienna, Vienna, Austria Fischer, H.R.; Gojmerac, I,; Reichl, P. Next Generation Internet (NGI), 2010 6th EURO-NF Conference.