VOIP CASE STUDY FOR AN IMS-BASED INTERWORKING BETWEEN WLAN AND UMTS

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مُسْتَخْلَص

يتجه مستقبل شبكات الاتصالات نحو التقارب بين أوساط الإرسال وشبكات الاتصالات، ونحو الانقسام بين مقدمي الخدمات ومقدمي خدمات الشبكة مما يعزز خدمات الوسائط المتعددة ويجعل المستخدم أكثر أريحية في استخدام شبكات الجيل التالي (NGN)، إلا أنه لا يمكن التوصل إلى هذه الرؤية الجديدة في ظل البنيات التحتية الحالية إلا بدمج شبكات الاتصالات . وتعتبر شبكات النظام العالمي للاتصالات المتنقلة (UMTS) والشبكات المحلية اللاسلكية (WLAN) من أكثر شبكات الاتصالات شيوعًا في الوقت الحاضر، لذلك تم التركيز عليهما في عمليات الدمج المستخدمة. تم اقتراح نظام بروتوكول الانترنت المتعدد الوسائط الفرعي (IMS) لتنفيذ عمليات الدمج حيث أنه يضمن جودة الخدمات ألا وهي نقطة أساسية في عالم الشبكات . مع العلم بأنه في شبكات الجيل التالي سيتم استبدال صوت تشبيك الدوائر التقليدية بارسال الصوت عبر بروتوكول الانترنت (VoIP)، حيث ستقدم كل الخدمات عبر بروتوكول الانترنت (IP). لدراسة الآثار المترتبة على الدمج بين شبكات UMTS و WLAN على أساس IMS ، تم تنفيذ محاكاة باستخدام محاكي OPNET الإصدار 11.5. ونفذ سيناريو التكامل وتم تعريف خدمة الصوت (VoIP). وأظهرت النتائج أن الـ VoIP قد تم تطبيقه بنجاح في أسلوب الدمج الجديد .

ABSTRACT

The future of communication networks goes toward convergence of media distribution and networks, and split between the service providers and the network providers. This will enhance the multimedia services and make the user more comfortable in using the Next Generation Networks (NGN). This new vision could be accomplished only if an interworking between the communication networks is applied. Since the Universal Mobile Telecommunication System (UMTS) and the Wireless Local Area Network (WLAN) are the most common communication networks nowadays, so the interworking is focused on them. The IP Multimedia Subsystem (IMS) is the most successful proposed scenario for the interworking. IMS guarantees QoS which is a keyword in the world of networks. In the NGN VoIP will replace the traditional Circuit-Switched (CS) voice since all the services will be brought over IP. For studying the effects of the interworking between UMTS and WLAN based on IMS, a simulation is performed using OPNET version 11.5. The interworking scenario is implemented and VoIP service is defined. The simulation is strictly for VoIP as the most important multimedia service. Results show that VoIP has been successfully deployed in the new interworking technique.

Keywords: *IMS, Interworking, UMTS, WLAN, VoIP, OPNET.*

1. INTRODUCTION

The next step in the communication networks is the interworking between UMTS and WLAN. The UMTS and WLAN interworking refers to combining the two networks. The resultant network is a unified IP Core-Network (CN) that can be easily integrated with other IP networks. The idea of interworking transforms the traditional networks into access networks. It's expected that both networks WLAN and UMTS will complement each other in the advantages and eliminate their disadvantages. One can simply say that interworking is gaining best of two worlds. The comparison between the two networks characteristics in Table 1 is the proof of this motivation.

The difference in technologies employed in UMTS and WLAN bring many challenges to the interworking. These challenges are called the interworking challenges. The interworking challenges are expressed in three terms:

- Quality of Service (QoS)
- Mobility Management
- Security Support

The QoS is an important issue in the networks, since without providing an acceptable level for the QoS there is no possibility to apply the interworking. The QoS must be guaranteed by the interworking mechanism. The mobility management refers to location management and handoff management. The interworking introduces a new type of handoff; it's the vertical handoff which occurs between heterogonous networks. The interworking mechanism must provide smooth mobility for users. The security support in networks can be defined by AAA (Authentication, Authorization and Accounting) which are necessary to provide secure access to the networks. Also the introduced interworking mechanism must support the security for both networks strongly.

Many interworking scenarios where proposed such as loose-coupling and tight-coupling but all of them suffer from shortages in introducing a complete solution for the interworking challenges. The IP Multimedia Subsystem is one of the best solutions for the interworking challenges as it will be discussed later.

The enhanced multimedia services are one of the reasons why an interworking between the UMTS and the WLAN is proposed. But on the other hand to reach the convergence in services, all the services must come over IP. This affects the most important service provided by the cellular network which is the voice. The traditional voice provided by the UMTS is a circuit-switched service. To deliver this service as a packet-switch it must be replaced by Voice over IP (VoIP). This work focuses on the VoIP to discuss the UMTS and WLAN interworking based on IMS. VoIP like other PS services suffers from unguaranteed QoS, so the bet is to prove

Table 1: UMTS vs. WLAN characteristics

Characteristics	WLAN	UMTS
Bandwidth	low bandwidth	High bandwidth
Mobility	Low, local	High, global
Coverage	Small areas	Wide areas
Speed	11 Mbps to 54 Mbps	384 Kbps to 2 Mbps
Deployment costs	Cheap	Expensive

that VoIP can replace the CS voice with an acceptable QoS. It is noted that the other interworking challenges: mobility management and security support are tightly related with the QoS. For example the handoff and authentication latencies are QoS parameters.

2. IP MULTIMEDIA SUBSYSTEM (IMS)

The IMS is the proposed solution for the interworking between the UMTS and the WLAN. The IMS is global, access-independent and standard-based IP connectivity and service control architecture that enables various types of multimedia services to end-users using common internet-based protocols [5]. IMS is a mediator between networks that accepts all their technologies and provides convergence between them. IMS is a multimedia supporter which is the new vision of services. The IMS is basically SIP servers which provide several functions in a cooperative fashion. The Call/Session Control Function (CSCF) processes the SIP signalling in the IMS. This essential node contains the P-CSCF, S-CSCF and the I-CSCF. Also the IMS includes databases like the SLF and HSS for storing subscribers' information. Figure 1 illustrates an interworking architecture based on IMS with the main components. The signalling in IMS is based on SIP protocol. Session Initiation Protocol or SIP is a signalling protocol for initiating, managing and terminating voice and video sessions across packet networks. SIP is a text-encoded protocol borrowed its characteristics from the ordinary internet protocols such as HTTP and SMTP.

3. SIMULATION, RESULTS AND DISCUSSION

For studying the UMTS and WLAN interworking based on IMS, the VoIP is selected to represent the multimedia services. A simulation is performed using the OPNET (Version 11.5) and it will be discussed next with the results. The interworking model is designed using the OPNET from the available components in the library. The IMS model is implemented as SIP servers and databases that provide registration for users. The VoIP application is defined in the model with SIP signaling protocol configured with the IMS. The vertical handoff is defined in this model to complete the vision of the interworking. The IMS model shown in Figure 2 illustrates the network layer for the IMS consisting of UMTS, WLAN, IP network and IMS networks from the OPNET screen. The IP network represents the internet.

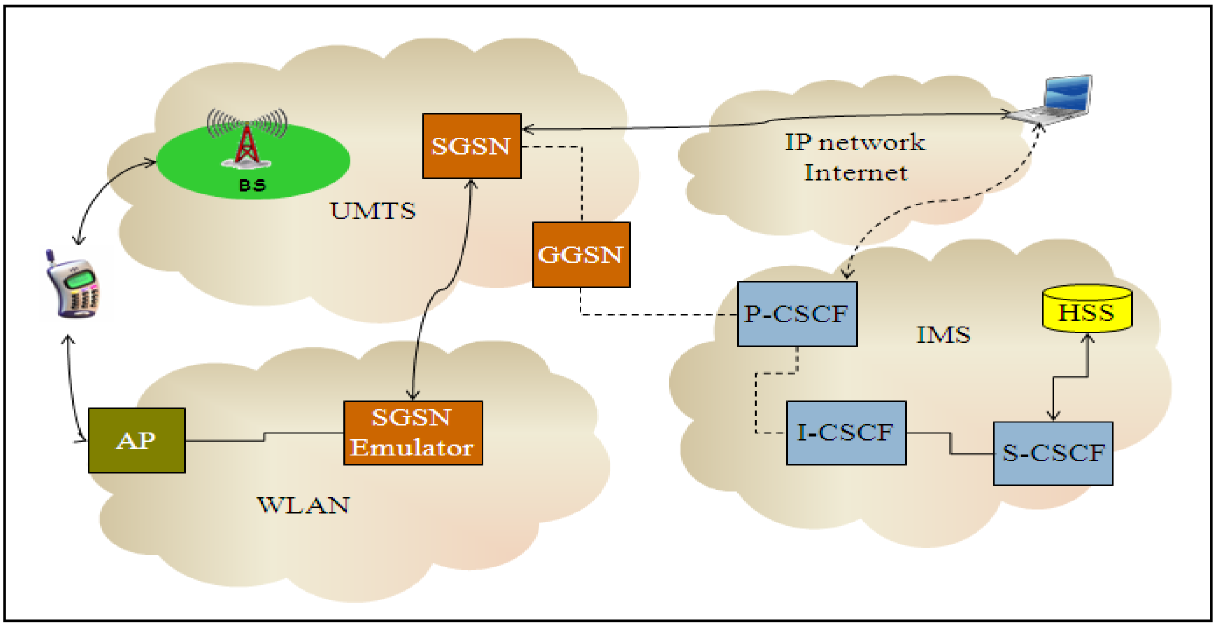

Figure 1: IMS-based Interworking Architecture

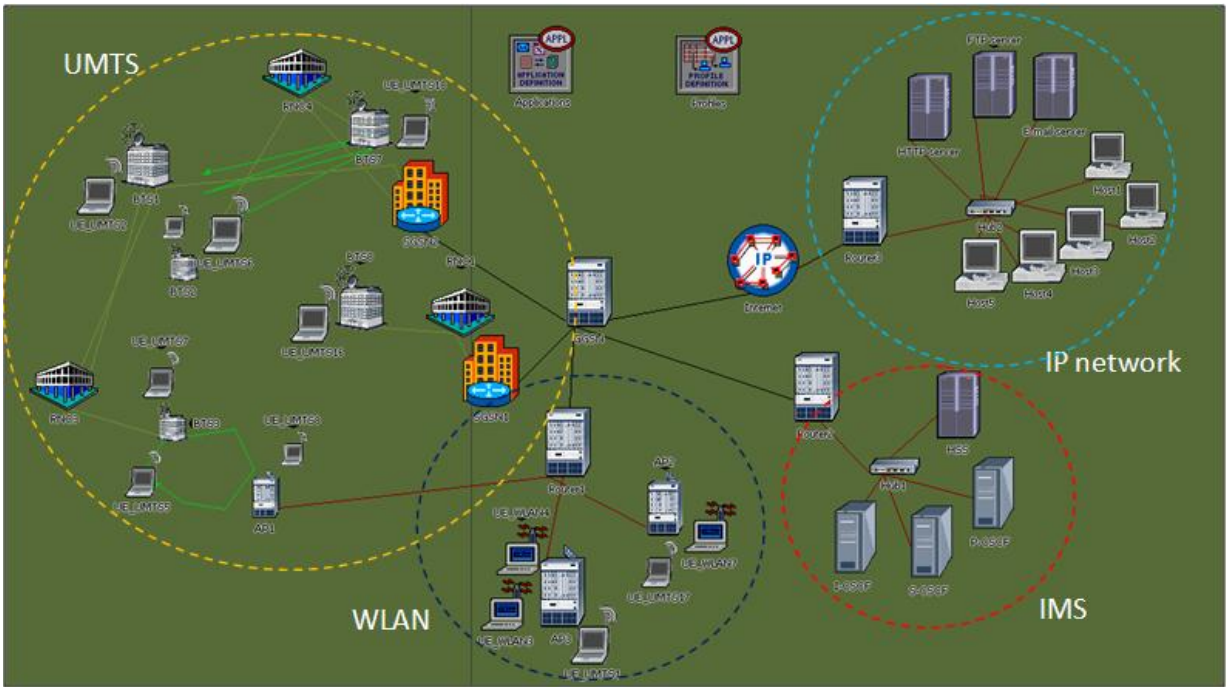

Figure 2: IMS Model Architecture

3.1 Results Selection Criteria

The purpose of this simulation is to study the performance of the UMTS and WLAN interworking using the IMS with VoIP, so results have been selected the to measure the effect of the interworking on VoIP. These effects were mentioned previously in the interworking challenges: Mobility management, Quality of service and Security support. Therefore the results were grouped to illustrate the interworking challenges and their effects on the VoIP.

3.2 Quality of Service (QoS)

Quality of Service will be discussed for VoIP by: packet loss ratio, packet end-to-end delay and Jitter. The key idea is that when the CS voice of the UMTS is replaced with the PS voice which is VoIP, attention to the QoS should paid. The introduction of the IMS brings all the services

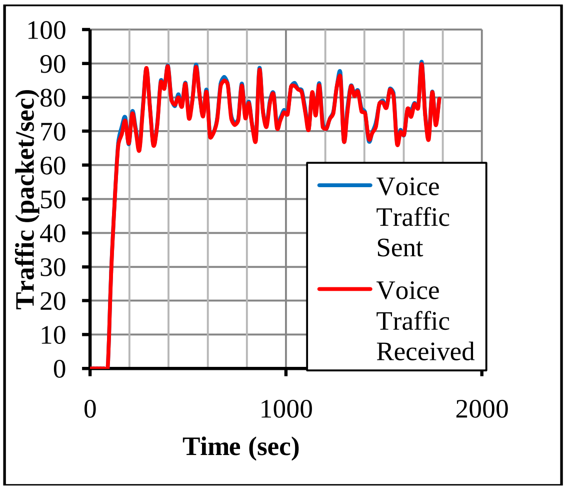

Figure 3: VoIP traffic sent/received

over IP as mentioned previously, so this is the reason of defining VoIP instead of CS voice.

3.2.1 Packet Loss

Figure 3 shows the overall VoIP traffic sent/received by all the users running VoIP as an application. The curves are almost identical.

The packet loss is equal to 0.657% and remains almost constant in the graph. The acceptable VoIP packet loss is less than 1%.

3.2.2 Packet End-to-End Delay

The overall VoIP end-to-end delay is shown in Figure 4. The average value of the curve is about 136 msec. The VoIP maximum delay is recommended to be 150 msec.

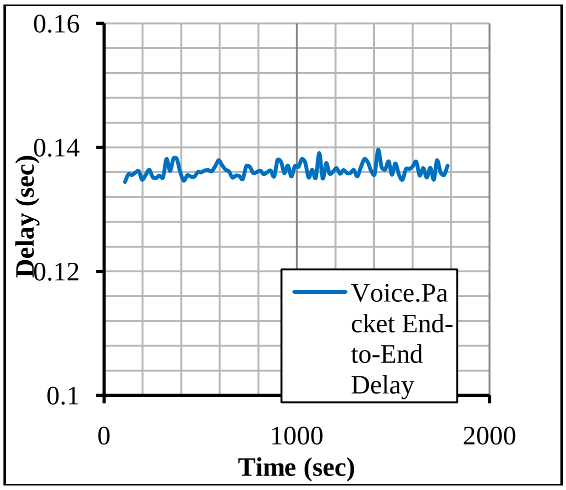

Figure 4: VoIP end-to-end delay

3.2.3 Jitter

The VoIP Jitter is shown in Figure 5. The maximum values of the Jitter are below 3.5 msec. The recommendation is that the Jitter between the starting and final point of the communication should be less than 10 ms.

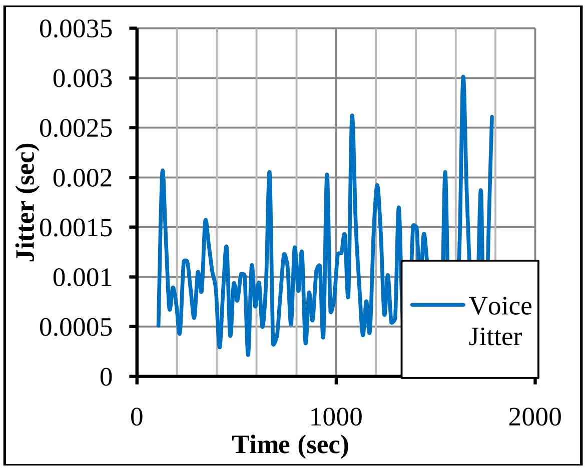

Figure 5: VoIP Jitter

3.3 Mobility Management

Mobility management will be discussed by: vertical handoff and horizontal handoff.

3.3.1 Vertical Handoff

Figure 6 illustrates the energy to noise ratio (E_c/N_o) in dB for the UE_UMTS5 with the BTS3. Note that UE_UMTS is a mobile user which moves in the green path illustrated in Figure 7 starting from the UMTS BTS3 to WLAN AP1 and finally returns to the UMTS BTS3. This motion brings the concept of the vertical handoff from the UMTS to the WLAN and vice versa. Also note that UE_UMTS5 is having a VoIP session as defined in the design.

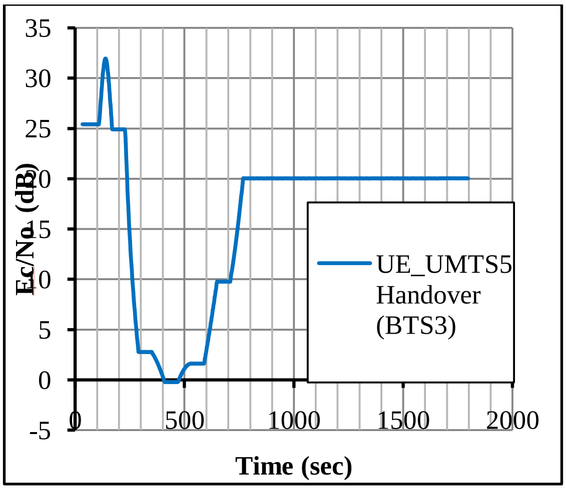

Figure 6: UE_UMTS Handover with BTS3

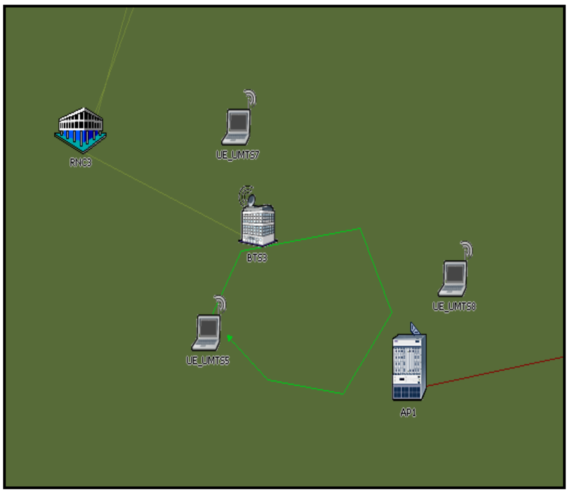

Figure 7: UE_UMTS5 trajectory

Figure 6 shows clearly the E_c/N_o decreased in the time interval between 300 sec and 600 sec under 0 dB. This means that the UE_UMTS5 has lost the connectivity with BTS3 since the minimum E_c/N_o to establish a VoIP session through a UMTS is 5 dB and the cutoff is 0 dB. At this time interval the user is still having service not from the UMTS but through the WLAN. Figure 8 shows the VoIP traffic sent/received in packet per second for UE_UMTS5 during the simulation time. It can be clearly said that UE_UMTS5 traffic is normal and doesn't suffer any cutoffs.

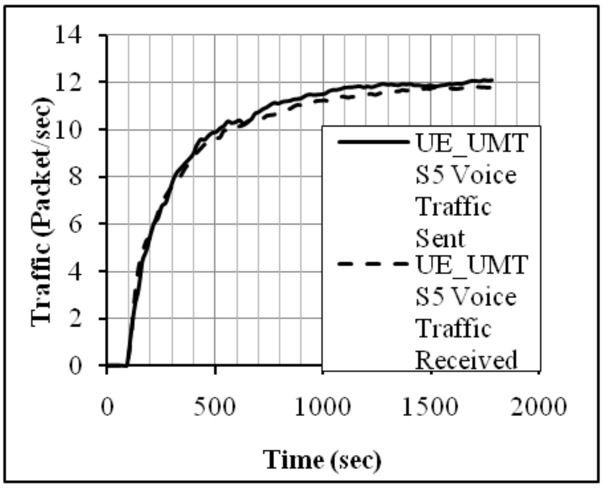

Figure 8: UE_UMTS5 traffic sent/received

3.3.2 Horizontal Handoff

The horizontal handoff can be shown inside the UMTS network. Figure 9 illustrates the E_c/N_o in both BTS2 and BTS7. UE_UMTS6 is a mobile user inside the UMTS which has a trajectory as shown in Figure 10 between BTS2 and BTS7. The solid and dashed curves are alternating oppositely around 8 dB reaching values up to 50 dB and minimum to -17 dB. This scheme is relative to the user zigzag path which results in multiple handoffs. Note that UE_UMTS6 is having a VoIP session.

Figure 11 demonstrates the sent/received traffic of UE_UMTS6. Back to Figure 9 the horizontal HOs occurs in the time interval 80 sec and 330 sec comparing with Figure 11 which shows that the traffic is seamless and doesn't suffer any cutoffs.

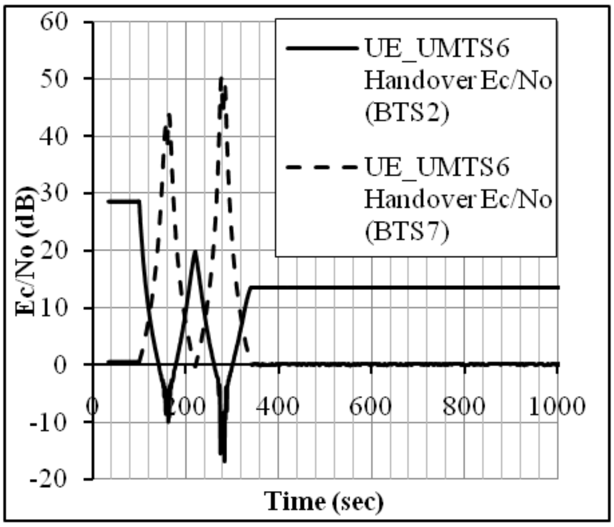

Figure 9: UE_UMTS6 HO between BTS3 & BTS7

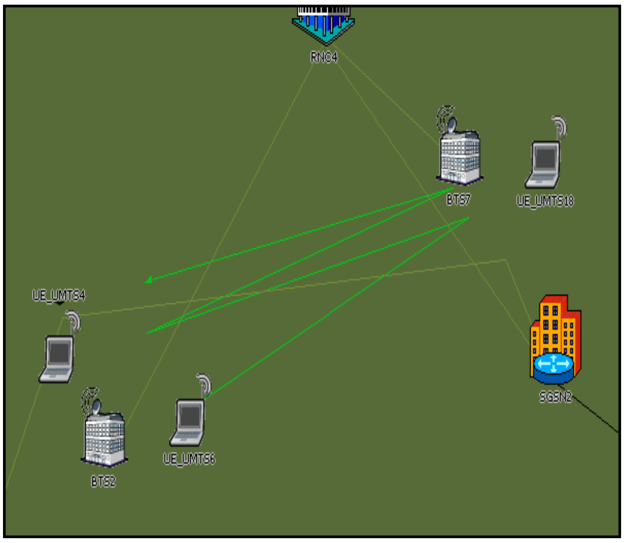

Figure 10: UE_UMTS6 trajectory

3.3 Security

The security support is an important topic in interworking. To measure the security level in the simulation it is a hard task since an attack scenario must be defined to check the security weaknesses. Instead the authentication of users is chosen in the IMS to illustrate the security support. Figure 12 shows the number of calls registered in the IMS P-CSCF. The authentications were performed successfully according to the requests.

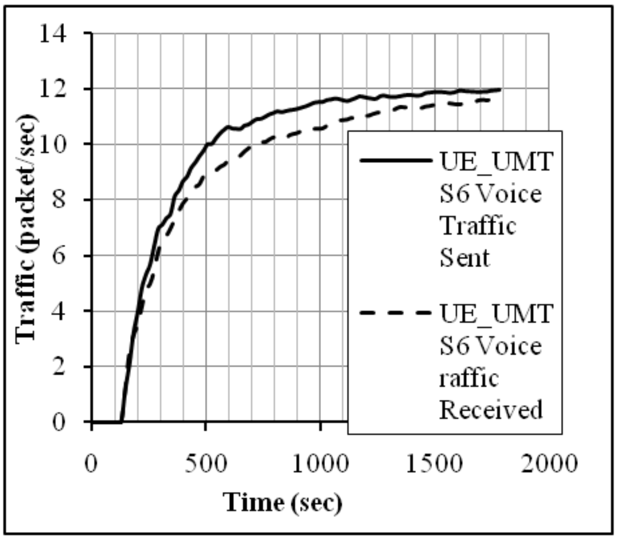

Figure 11: UE_UMTS6 traffic sent/received

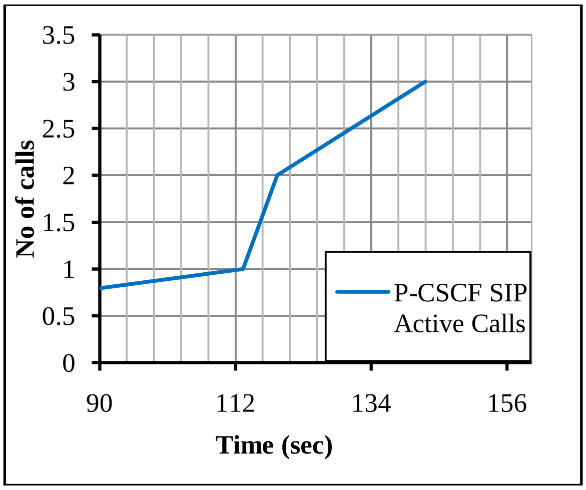

Figure 12: P-CSCF No. of calls

4. CONCLUSION AND RECOMMENDATIONS

By the end of this study, the IMS-based UMTS and WLAN interworking has been acheived through simulation. From simulation it have been found that the IMS is able to introduce interworking with guaranteed QoS, accurate security support and complete mobility management

From simulation results and analysis the IMS-based interworking between UMTS and WLAN has proved its capability to integrate these netwroks perfectly and solving all the interworking challenges. It can be concluded saying that IMS has provided:

- Guaranteed QoS:

  The IMS has supported the multimedia services represnted by the VoIP in an acceptable quality of service as discussed in the results.

- Mobility management:

  The vertical and horizontal handoffs were performed succesfully without any interruption in the services as discussed in the result.

- Security support:

  The IMS has implemented the authentication in the P-CSCF which will provide with the UMTS network the required accounting and authorization.

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