Service Adaptation for Voice and Video Applications in WiMax/WiFi Networks

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ABSTRACT: *As wireless access networks are being developed to provide the users with always-on connectivity and better QoS, many papers have addressed the issue of providing service adaptation for the multimedia application in the case of vertical handovers VHO. Thus providing service continuity while roaming among different wireless access networks is one of the most challenging issues of Next Generation Wireless Networks NGWN. Context awareness has showed a significant effect to guarantee services continuity. In this paper, we will study the performance of voice and video applications based on the proposed Context-Aware Management Scheme (CAMS) in terms of different performance parameters such as jitter, packet loss and end-to end delay in the case of vertical handovers VHO from WiFi to WiMax. We will then present the performance of video application for different service adaptation scenarios based on our proposed solution.*

Keywords: Context-aware, Vertical Handover, CAMS, Service Continyuty

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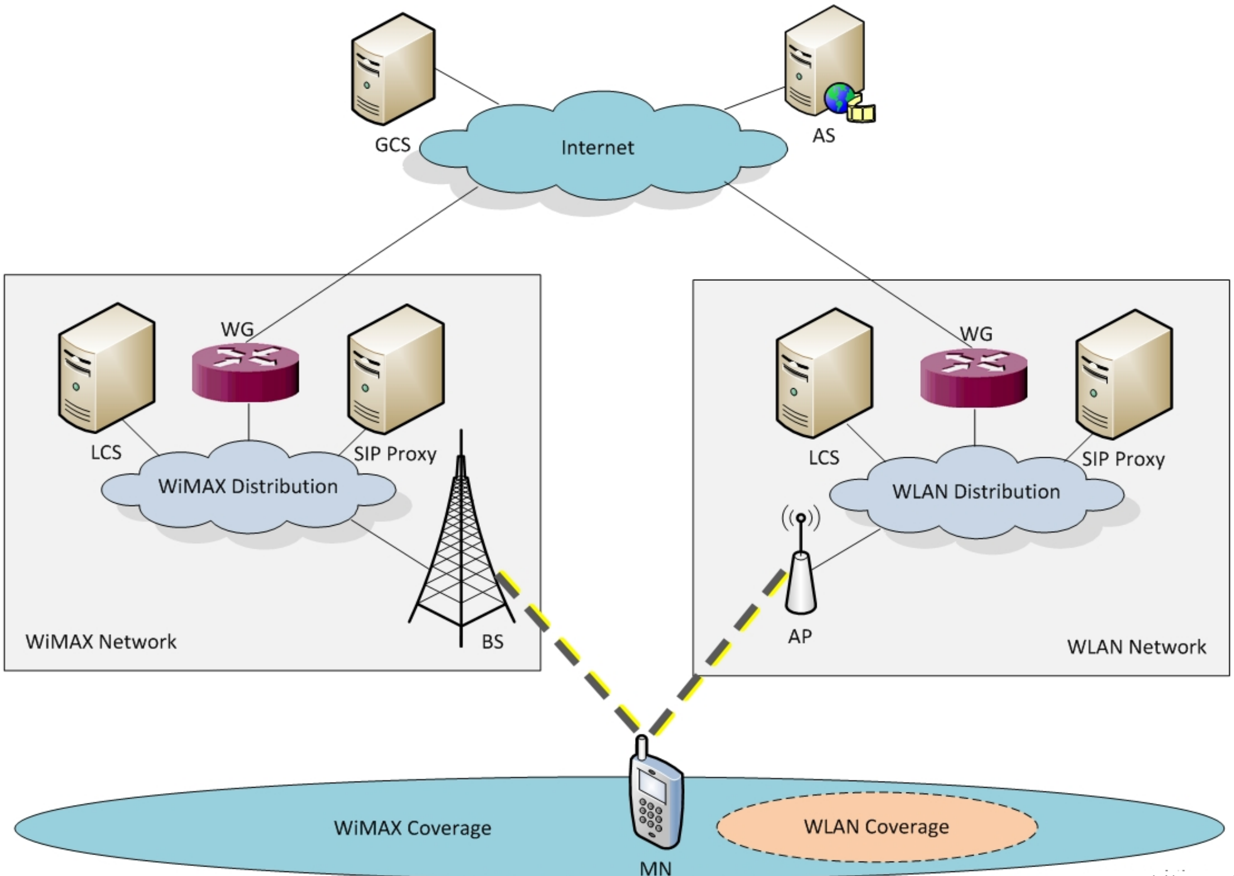
1. Introduction

Next Generation Wireless Networks (NGWN) is a ubiquitous environment that integrates various wireless technologies such as WLAN, 3G, and WiMax. The integration of NGWN brought many issues, the most challenging one is providing consistent and continuous seamless services while considering Quality of Service (QoS) requirements during the mobility between two different access networks which is known as Vertical Handover (VHO).

The ability to maintain service provisioning and avoid service degradation while users are roaming is known as service continuity. However, the heterogeneity of wireless networks makes service continuity a complex task due to bandwidth fluctuations and different access networks connectivity. This calls for the need of context awareness which claims the full visibility of all characteristics describing service execution environments and enables management operations to adapt service provisioning to current system conditions [1]. To satisfy user needs and improve his/her experience, different context information should be considered. Examples of such information include; user preferences (e.g. preferred network), application requirements, and network conditions.

Context awareness handovers have shown a significant effect to guarantee services continuity in multimedia applications.



MN: Mobile Node
BS: Base Station
AP: Access Point
GCS : Global Context Server
LCS : Local Context Server
AS : Application Server
WG : Wireless Gateway

Figure 1. CAMS Architecture

Many papers in the literature have addressed this issue. Starting with some of them, the authors in [2] proved that the use of context information helps to improve the delivered application QoS. The context information is utilized to develop policies for developing connectivity adaptation. They present a conceptual architecture for policy based adaptive decision of channel selection based on application QoS issues. The proposed solution in [3] presents a context-aware profile based middleware to support dynamic service quality management based on the network information in the upper layer, and efficient VHO algorithm with respect to application requirements, user requirements, as well as network information. Different modules are designed, such as the application agent and the vertical handover decision manager module. In [4], the authors present a context-aware framework in which context information is distributed over many context repositories (a user profile repository, a location information server and a network traffic monitor). It also describes an execution platform for the dynamic deployment and execution of context handling components which minimizes the handover decision time. Their work proves that handovers are more efficient when context information is considered. Authors in [5] present loose coupling integration architecture of WLAN/WiMAX access networks. It also describes several interworking scenarios, where WLAN users with ongoing voice, video and data sessions handover to WMAN (WiMAX), study QoS and performance issues and analyze feasibility of seamless session continuity. In addition, the authors propose a new QoS mapping solution related to the continuity of service between WLAN/WMAN networks. Nevertheless, in this solution, the context awareness is not mainly addressed. In [6], the paper proposes a proactive QoS based VHO scheme for integrated WLANs and WiMAX networks. In [7], we presented our proposed Context-Aware Management Scheme (CAMS) which maintains service continuity by taking different context information into consideration in WiMAX/WLAN integrated networks. CAMS adopts a hierarchical approach which includes distributing context information over several components such as mobile nodes and context servers. Since the characteristics of the two access

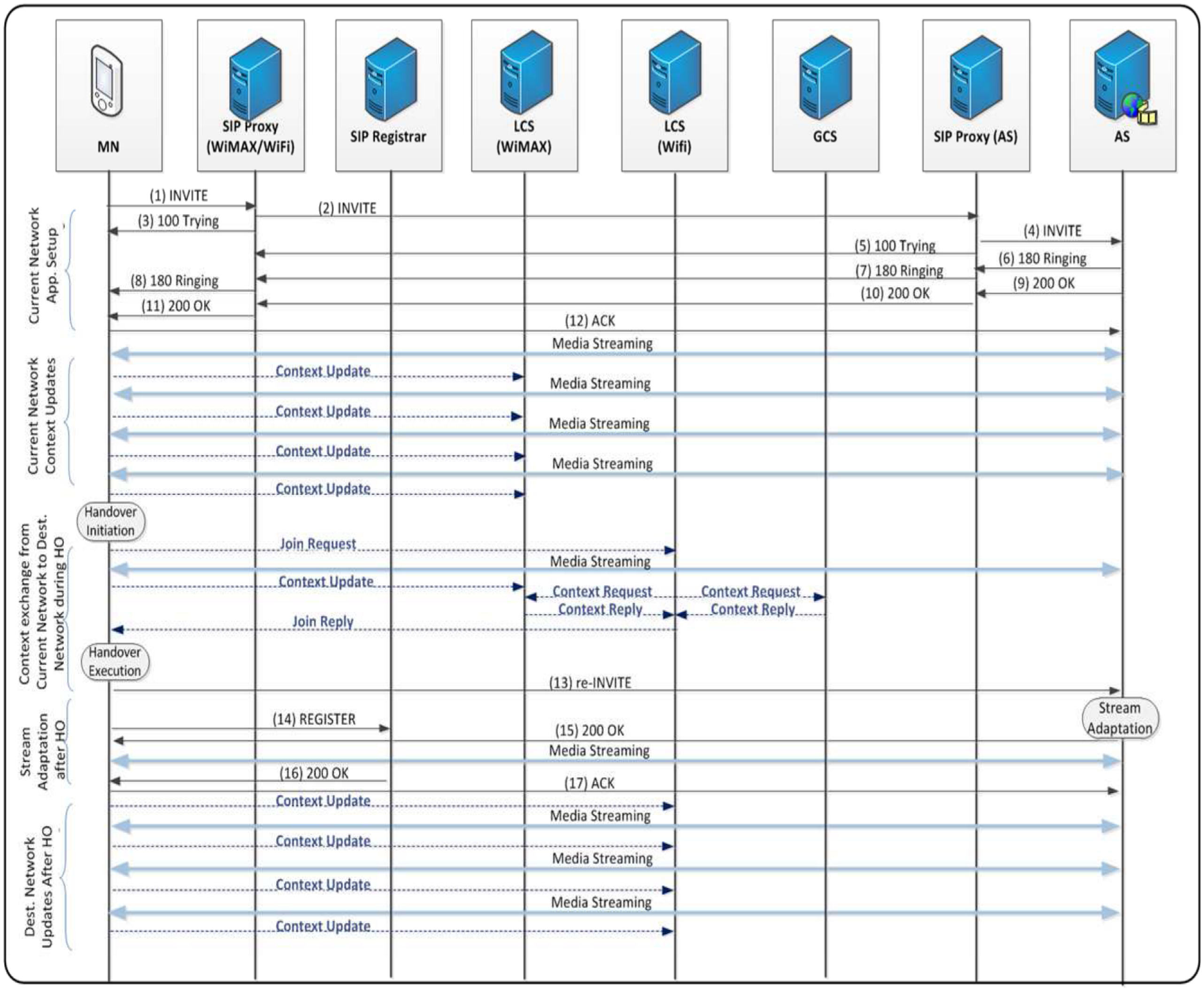


Figure 2. Signaling from WiMax to WLAN

technologies differ significantly in terms of the achievable data rates and QoS, session adaptation is needed. In our scheme, we propose to use SIP protocol along with SDP (Session Description Protocol) [4] for this task. Mobile Node (MN) will modify session parameters to adjust to the new network characteristics by providing the real-time Application Server (AS) with the new parameters. Then, for context messages exchange, we employ UDP (User Datagram Protocol) [5] due to its lightweight messages. The next sections present the architecture, signaling and operation flow of our solution.

This paper aims to evaluate the performance of the proposed CAMS with different context adaptation scenarios for both voice and video applications. The paper is organized as follows: section 2 presents an overview of the proposed CAMS architecture and signaling for vertical handover with context awareness. Section 3 presents the simulation model and the main characteristics of the voice and video applications. In section 4, we will present and evaluate context aware solution for voice and video in terms of delay, jitter and packet loss. In section 5, a performance study was conducted for different adaptation scenarios for both Context-Aware CA and Non- Context aware NCA scenarios in the case of video applications. Section 6 presents the conclusion based on the main results of the performance study.

2. CAMS Architecture and Signaling overview

Our proposed architecture Context-Aware Management Scheme (CAMS) consists of global context server, local context serverand mobile node as shown in Figure 1. Global Context Server (GCS) basically holds the static profiles of users. It acts as static repository and holds information about individual users, their preferences, what the devices they have, including the characteristics and capabilities of the device, and the context history of each user. Local Context Server (LCS) holds the dynamic profile of each user it has been assigned. GCS sends the user's static profile to LCS and it uses this information, plus the information supplied by the Mobile Node (MN), to start the dynamic profile. More components of CAMS architecture related to WiMAX /WLAN networks and SIP protocol are described briefly in the following:

• **Access Point (AP):** AP is WLAN network node, which allows wireless workstations to connect to Internet through a wired network and routers in order to receive the application traffic.

• **Wireless Gateway (WG):** WG is a network node that represents an interface to another network such as Internet. Wireless gateways often provide firewall functions as well.

• **WLAN/WiMAX Distribution:** the distribution is used to connect different network components.

• **Application Server (AS):** AS is server which provides applications with services such as video and voice.

• **SIP Proxy:** Plays the role of request forwarding in aiming to ensure that a request is sent to other proxy servers or directly communicating with a callee list of URLs and forwarding responses back to the caller. Proxy servers used in our model are SIP Proxy1, SIP Proxy2, and SIP Proxy3.

• **SIP Registrar:** A server to maintain user's locations.

• **Base Station (BS):** A station of broadcasting WiMAX signals.

Our solution proposed in [7] consists of two main phases. The first one is context management which is based on hierarchical architecture, consisting of a global context server, a number of local context servers, and the mobile nodes [10]. In this phase, context information exchange is performed between context servers and mobile node to estimate the appropriate parameters of running the application in the new network. The second phase is media streaming adaptation to guarantee service continuity. Session adaptation may include resolutions (e.g., frame rate to provide higher quality), bandwidth limitations that must be taken into account when carrying out session, cost of bandwidth in case of WLAN to WiMAX and changing session type i.e., changing video session to audio.

In our scheme, we propose to use Session Initiation Protocol SIP protocol along with SDP (Session Description Protocol) [4] for this task. Thus, mobile node sends the new session parameters to the real-time application server. Then the server modifies the application parameters to adjust the new network characteristics. For context messages exchange, we employ UDP (User Datagram Protocol) [5] due to its lightweight messages. Details of the proposed solution are described in [7].

Figure 2. shows the signaling which represents the interactions between the components in WLAN to WiMAX scenario. There are two types of messages; SIP messages appear as solid lines and the dashed lines represents the interactions between MN and context servers (UDP messages). The signaling of WLAN to WiMAX scenario follows the same phases. The signaling consists of five phases as shown in Figure 2. The phases of signaling are described in the following:

2.1 Current Network Application Setup

The first phase is the media application session setup between MN and Application Server (AS), using SIP servers to establish the session.

2.2 Current Network Context Updates

The MN updates context such as user location and application requirements periodically to current network LCS using (Context Update) messages. The context is updated as long as streaming is going.

2.3 Context exchange from Current Network to Destination Network during HO

MN can predicate HO by monitoring the performance, location, coverage, QoS degradations, signal strength, application performance and the preferred network. Once a VHO is predicted to new network, the MN sends (Join request) message to destination LCS. Then, destination LCS sends (Context Request) massages concurrently to both GCS and current LCS. Upon receiving context information, the destination network LCS processes dynamic, static profiles and network information to estimate the required parameters. This LCS notifies the MN concerning of HO decision. The notifications may include reducing the quality of service or warning the user of expected disconnection of the service after HO execution.

Voice Quality	Codec	Bandwidth usage (up/down)	Frame size (msec)	Lookahead size (msec)
High	G729	31.2 Kbps	10	5
Medium	G723.1	20.8 Kbps	30	0
Low	GSM	low	20	0

Table 1. Voice codecs

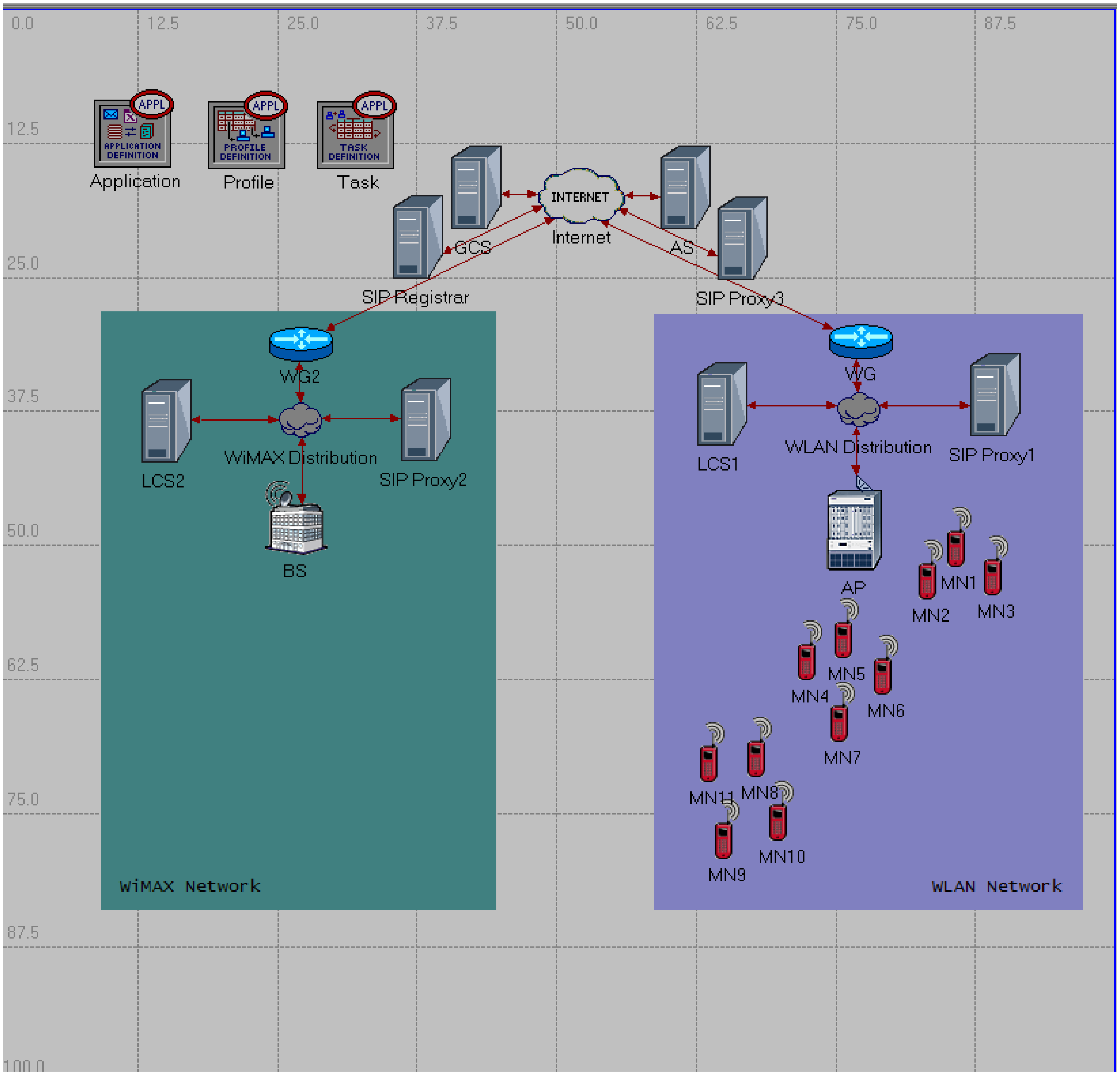


Figure 3. Opnet Sinulation model

2.4 Stream Adaptation after HO

After receiving the reply from the destination network LCS regarding HO, MN either decides to execute HO and update the

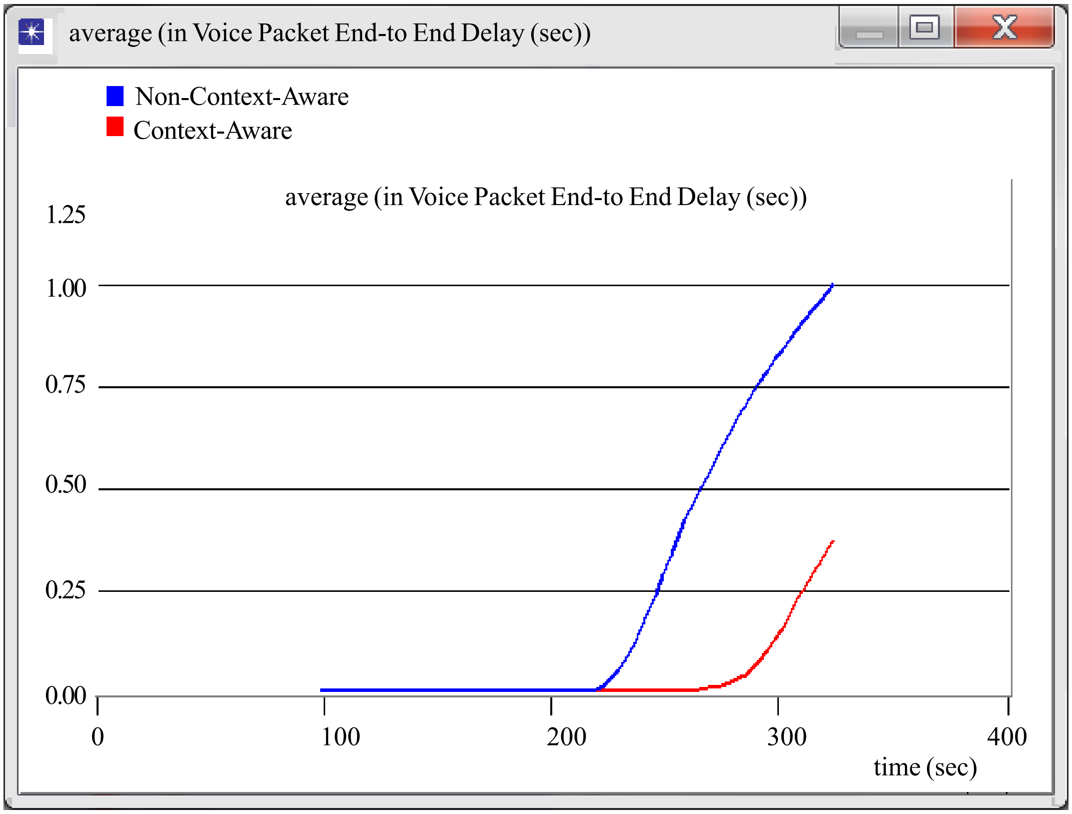


Figure 4. Delay comparison (Video)

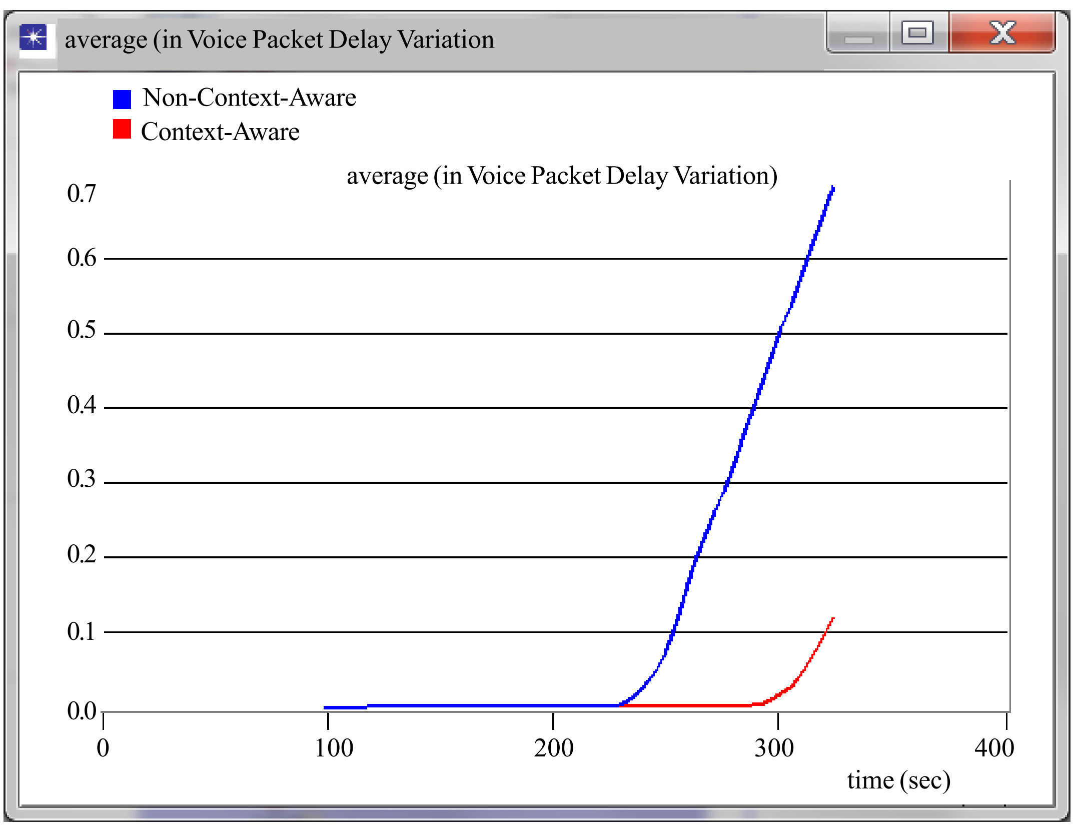


Figure 5. Data loss (Video)

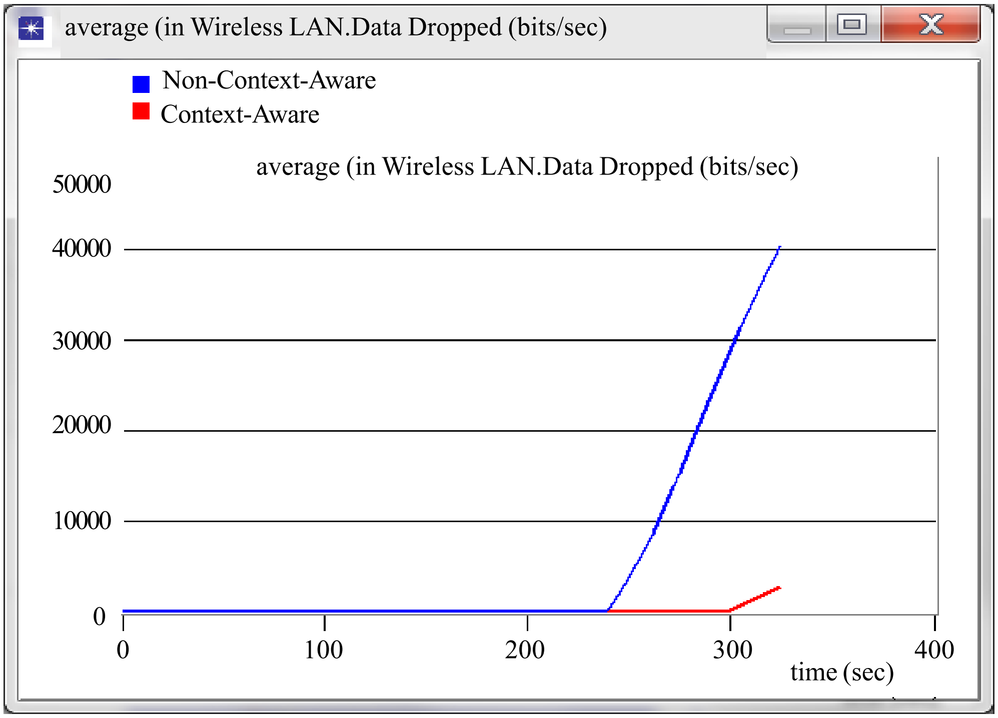


Figure 6. Data Loss

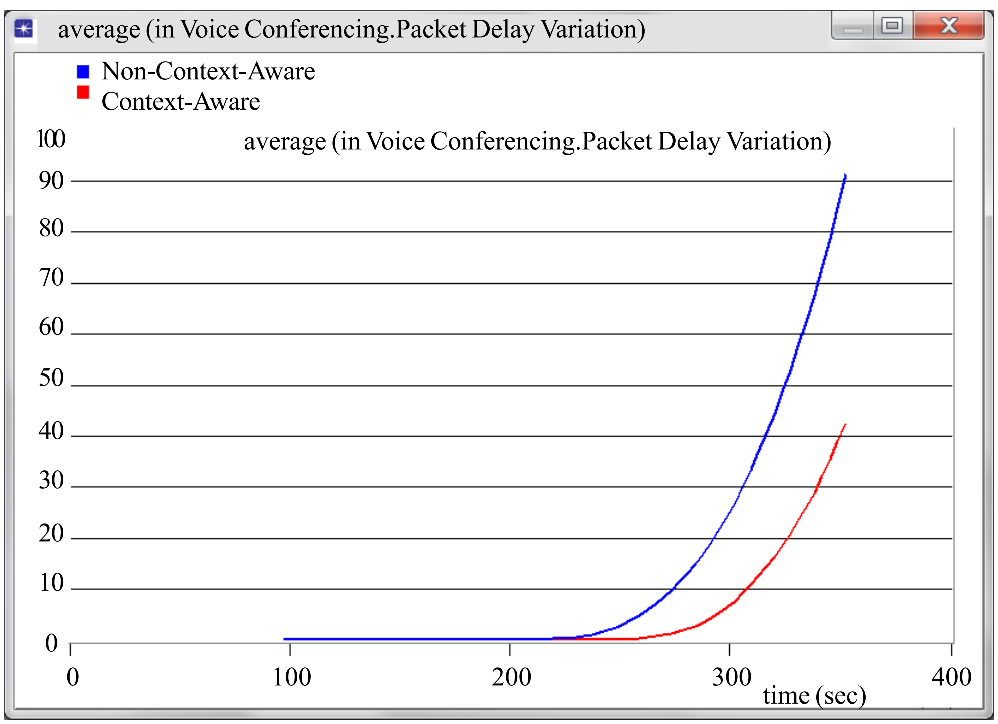


Figure 7. Delay comparision

media streaming or chooses to stay at the current network if possible. Once MN decides to handover to the new network, MN gets a new IP address using DHCP (Dynamic Host Configuration Protocol) and registers its new address to SIP Registrar (by Register message). To update the streaming, the MN uses the parameters suggested by the destination LCS. The adaptation is fulfilled through re-INVITE message with updated SDP parameters such as resolution, frame rate and codec.

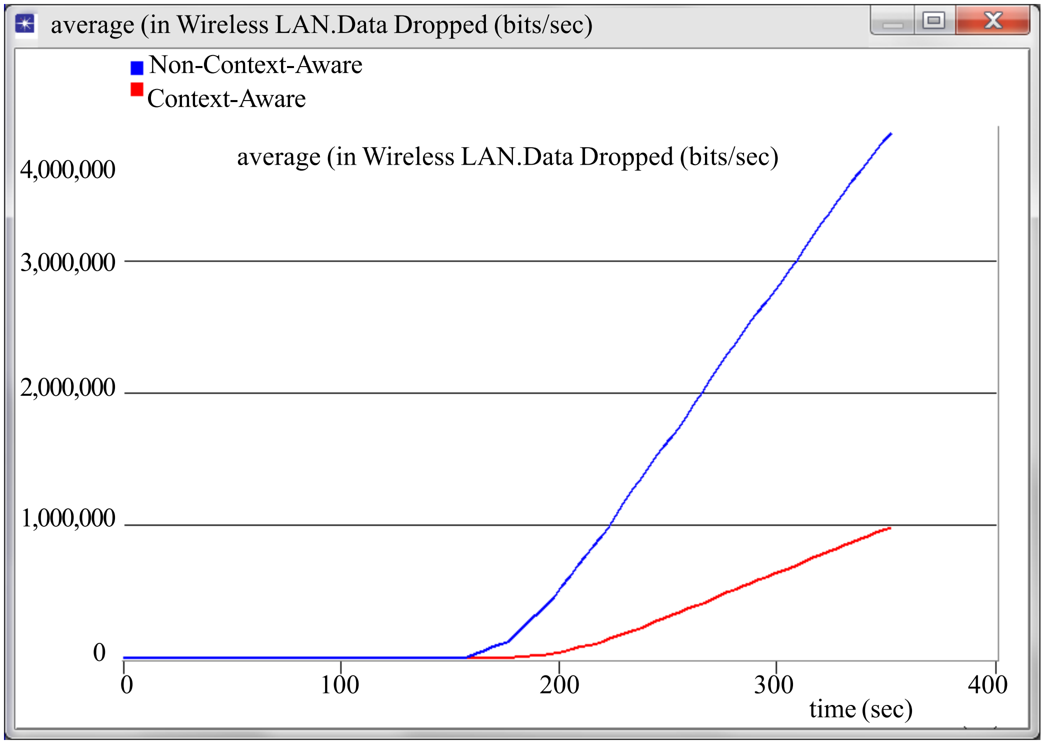


Figure 8. Data Loss

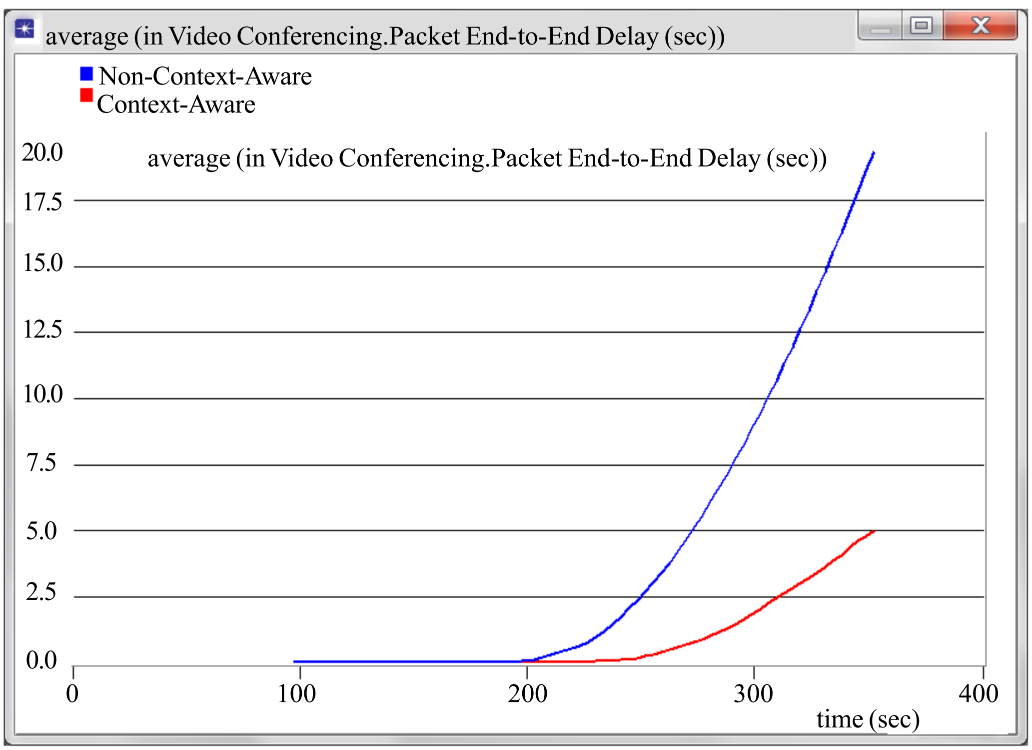


Figure 9. Jitter Comparision

2.5 Destination Network Context Updates After HO

As in phase two, when MN handover to the new network, it starts context updating to the new LCS periodically.

Resolution	Frame size	Frame rate (frames/sec)
High	128*120	15
Medium	120*100	10
Low	96 * 65	10

Table 2. Video Resolution

3. VHO for Voice and Video applications

The purpose of this study is to evaluate voice and video applications performance after VHO execution for both Context-Aware and Non-Context-Aware scenarios in WiMAX/WLAN networks. To achieve this, we used a simulation model built on OPNET simulation tool.

A simulation model is build based on the architecture illustrated in Figure 3. WLAN 802.11 b composed of AP, LCS1 and SIP proxy which connected through WLAN distribution cloud to WG to the Internet. The AS, SIP Proxy 3, GCS, and SIP registrar are connected to Internet too. The AP is connected to Internet through a WLAN Distribution cloud and WG. Application Server (AS) also is connected to Internet to allow real-time applications. This traffic is delivered to mobile workstations (mobile nodes) through AP.

Scenario	Input	Output
Non-Context-Aware	10 MN G.729	9 MN G.729
Context-Aware	10 MN request G.729	5 MNs G.729, 4 G.723.1, 1 GSM

Table 3. Mapping of video codec from VHO from WiMAX to WLAN

In the proposed Opnet simulation model, the following assumptions were made:

• **HO decision:** Every 20 sec a new MN performs VHO to WLAN.

• **Context exchange:** The signaling delay of context exchange is implemented by setting different proprieties of messages such as determining source and destination paths, size, protocol and other specifications by using OPNET components which are custom application and task configuration.

• **HO execution:** At a specific time in each MN profile, the application running is started. In this way, HO execution is assumed to be performed.

• **Service adaptation:** Adapting the resolution of codec of voice and video are as described in Table 1 and 2 respectively. In CA scenario, a number of MNs profiles are set in a certain time to run different combinations of resolutions to accommodate with current network conditions.

Figure 3 shows the Opnet simulation model that is composed of the following components and characteristic:

Scenario	Input	Output
Non-Context-Aware	10 MN request	9 MN high resolution
Context-Aware	10 MN request High reso.	2 High, 3 Mid, 5 low

Table 4. Mapping of video resolutions after VHO from WiMAX to WLAN

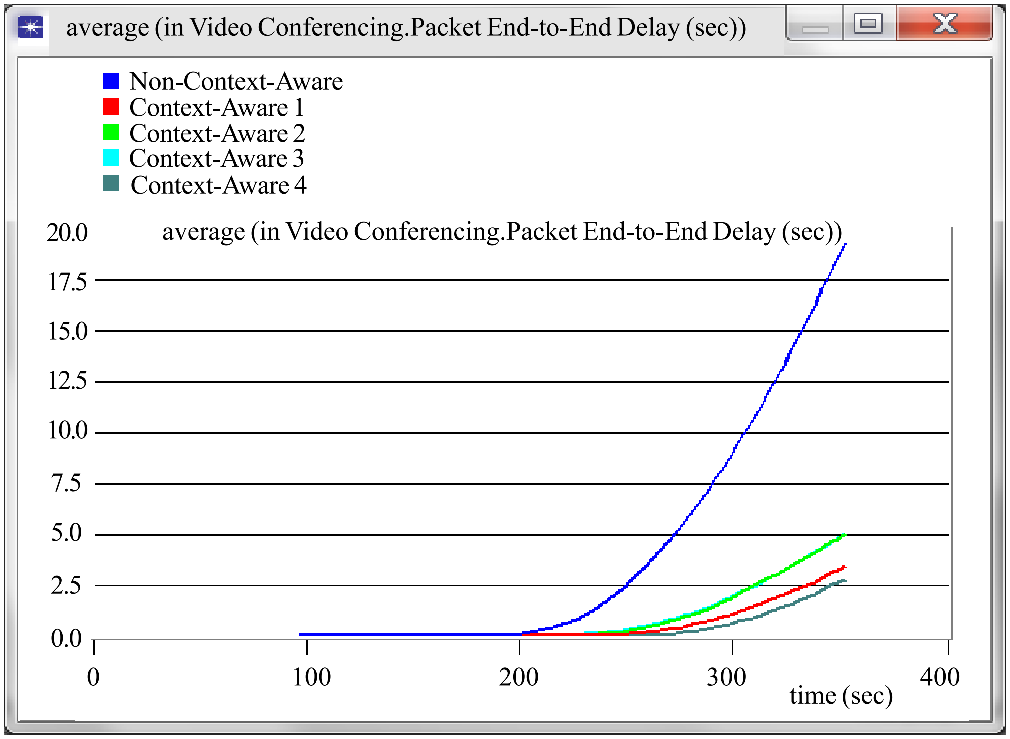


Figure 10. Delay Comparison of different Context-Aware scenarios with Non-Context-Aware scenario

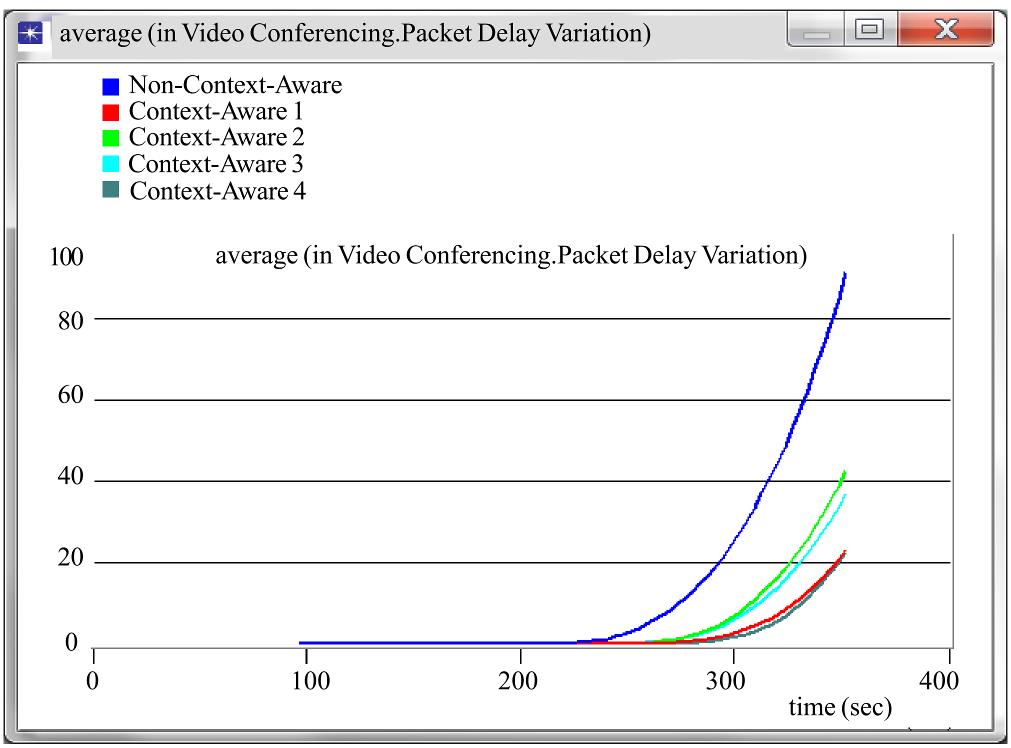


Figure 11. Jitter Comparison of different Context-Aware scenarios with Non-Context-Aware scenario

• MN equipped with two different network interfaces. Namely, the network interfaces in the MN consists of WLAN and WiMAX.

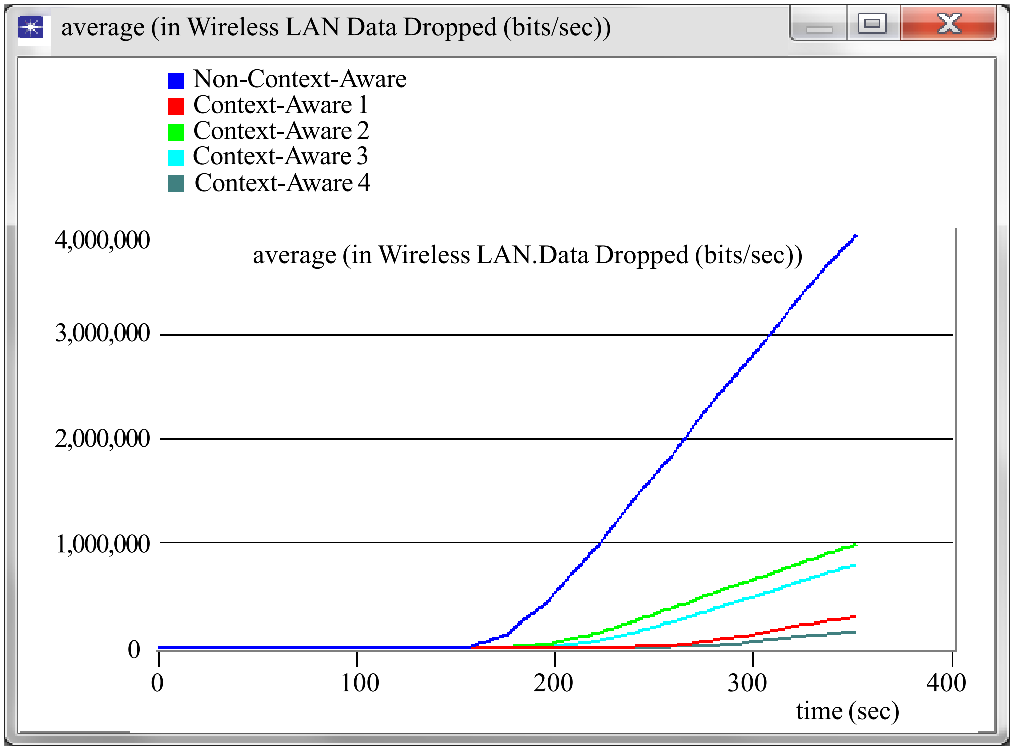


Figure 12. Data Loss Comparison of different Context-Aware scenarios with Non-Context-Aware scenario

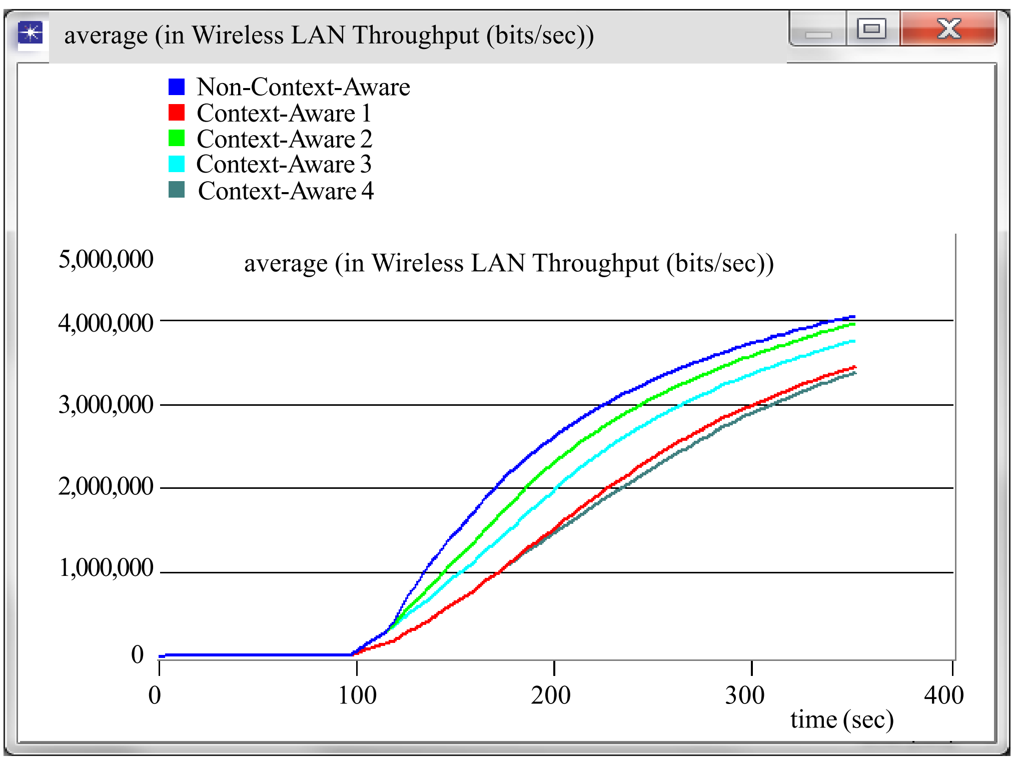


Figure 13. Throughput Comparison of different Context-Aware scenarios with Non-Context-Aware scenario

- WLAN standard is 802.11 b as provided in OPNET (Physical layer technology is DSSS).
- Data rate supported by the AP is 11 Mbps.

• Performance measures consider (ITU G.1010) [11] for video applications.

• **Voice application:** Three different codecs are used for voice application as shown in Table 1.

• **Video application:** Three different video resolutions are provided by the AS as shown in Table 2.

4. Performace evaluation

Our simulation model aims to compare between two scenarios; Non-Context-aware (NCA) and Context-aware (CA) in order to prove the efficiency of our solution. The CA scenario is intended to adapt the application to suite the new network conditions. We assumed that each MN was connected to WiMAX and running high resolution video (video scenario) before performing handover to WLAN. For each scenario, the first 99 seconds is for network preparations. At *time* = 100 sec, MN1 performs VHO to WLAN. Each 20 second a new MN performs VHO to WLAN. The total number of MNs is 10. Once these MNs join WLAN, they keep running their current application until the end of simulation.

For the voice applications, two scenarios were considered:

4.1 Non-Context–Aware (NCA)
After VHO execution, applications request codec G.729. Due to non- context awareness, these requirements may not be satisfied.

4.2 Context–Aware(CA)
To avoid the performance degradation, our solution is applied which allows running high quality voice codec with delay, packet loss and jitter not exceeding the required limits. Thus, the codec is changed to lower codec to meet QoS requirements and avoid the service degradation. Table 3. shows the mapping of running voice application after VHO from WiMAX to WLAN for NCA and CA scenarios.

Scenario	High resoultion	Meduim resoultion	Low resoultion
Context-Aware 1	0	5	5
Context-Aware 2	2	3	5
Context-Aware 3	1	5	4
Context-Aware 4	0	4	6

Table 5. Video adaptation combinations

For video applications, Table 4 shows the mapping of running applications after VHO from WiMAX to WLAN for NCA and CA scenarios.

4.3 Non-Context–Aware
In NCA, applications request high resolution video after performing VHO to WLAN. Due to non- context awareness, these requirements may not be satisfied and the service may be disconnected. MN 10 will be rejected in the network and does not receive traffic.

4.4 Context–Aware Scenario
In this scenario, our proposed solution is applied to avoid the degradation of the performance. It should be noted that the stream adaption is done in cooperation between the MNs and the CA servers as shown in Figure 2.

The simulation model was built based on the following phases:

4.5 HO decision
This step is assumed to be implemented as each 20 sec a new MN performs VHO to WLAN.

4.6 Context exchange
The signaling delay of context exchange is implemented by setting different proprieties of messages such as determining source and destination paths, size, protocol and other specifications by using OPNET custom application and task configuration.

4.7 HO execution

At a specific time in each MN profile, the application running is started. In this way, HO execution is assumed to be performed.

4.8 Service adaptation

We conducted this by testing several scenarios manually by adapting the resolution of video and the codec of voice among other attributes as described in Table 1 and Table 2. In CA scenario, a number of MNs profiles are set in a certain time to run different combinations of resolutions and codecs to accommodate with current network conditions.

4.8.1 Voice Simlulation results

The results of the simulation model using voice applications are shown for both NCA and CA scenarios. For voice application, in NCA, all MNs intend to run G.729 codec. Without considering the current conditions, these MNs will face high delay, high jitter and high packet loss as per Figures 4, 5 and 6. Also different performance measures of CA compared to NCA are shown in these figures.

In Figure 4, the delay started to increase after MN9 (*time* = 240 sec) in CA scenario and delay reached up to 377 ms at the end of the simulation. In NCA scenario, the delay increased to 422 ms after MN8 performed VHO, and to 1 sec at the end of the simulation.

Figure 5 shows jitter as percentage verses simulation time (seconds). In *time* = 220 sec, Jitter stared to increase in NCA when MN7 performed VHO. In CA, the jitter starts to increase after MN9 (*time* = 260). CA scenario has lower jitter values than NCA.

In Figure 6, data loss has *value* = 0 until MN10 (*time* = 280 *sec*) in scenario CA. On the other hand, in the case of NCA scenario, data loss started to increase after MN7 (*time* =220 sec). We can notice that CA scenario has lower data loss values than NCA scenario.

4.8.2 Video Simulation results

For video application, the simulation results are based on handover performance of WiMAX to WLAN. Context-Aware (CA) and Non-Context-Aware (NCA) scenarios for video applications are compared. The performance measures used are the same as the voice application: delay, jitter, and data loss.

Figure 7 shows the delay of NCA and CA scenarios. Both scenarios have the same performance until the handover of MN4 (*time* = 160). In that time, the delay in NCA scenario started to increase and reach to 546 ms and after MN7 it increased to 1.5 sec. In CA, the delay after MN9 increased to 900 ms. At the end of the simulation, NCA delay was 19.36 sec while CA delay was 5 sec.

Figure 8 shows the data loss (bits/sec) verses simulation time (seconds). In NCA, when only 2 MNs were connected to the network. After MN3 (*time* = 140 sec), the data loss begun to arise. In CA scenario, when 4 MNs were connected to WLAN, we can notice that CA scenario has less data loss values than NCA scenario.

Figure 9 shows jitter as percentage verses simulation time (seconds). Jitter stared to increase in (*time* = 200 sec) when MN6 performed VHO NCA has higher jitter values than CA although with not counting the dropped packets in Jitter.

5. Service adaptation scenarios (Video)

This section presents a comparison between Context-Aware and Non-Context-Aware scenarios for different combinations of service adaptation for video applications. Voice applications were also tested in the same way but in this section we will show only the video results (since the video requirements are higher).

The adapted parameters for the video application could be changed due to the application requirements. Although there is a change in video resolution, the performance and the number of users the network can serve in CA is better than NCA scenario.

Table 5 shows the number of MNs of each context-aware scenario according to the used video resolution after joining WLAN. For instance, Context-Aware1 scenario has 10MNs. The first 5 MNs adapted their application stream after VHO to medium resolution and the last 5 MNs adapted the stream to low resolution.

Figure 10 shows Packet End-to-End delay (sec) versus simulation time (sec) to compare the delay in each CA scenario with NCA and show how the used adaptation method could affect the service performance. In NCA, the delay is increased with time and new MNs joining WLAN. All the CA combinations generated less delay values than the NCA. Figure 11 shows jitter verses simulation time to compare different context aware scenarios with NCA. Jitter in NCA scenario has the highest value than the other CAs scenarios. Figure 12 shows the data dropped (bits/sec) versus simulation time (sec). It displays a comparison between NCA with different service adaption combination scenarios. NCA has the highest data dropped then Context-Aware 2, Context-Aware 3, Context-Aware 1 and Context-Aware 4. This is due to the amount of traffic that is more than what the network can handle in NCA. Figure 13 shows throughput (bits/sec) versus simulation time. Context-aware scenarios show efficient usage of throughput even with reduced amount of data.

6. Conclusion

This paper evaluated the proposed service adaptation scheme for voice and video session parameters after Vertical Handover (VHO) from WiMax to WLAN. The adaptation is based on CAMS architecture with described architecture, signaling messages, and service adaptation of the VHO from WiFi to WiMax and vice versa. The proposed CAMS is modeled using OPNET simulator and the performance was analyzed based on the results of both scenarios (CA and NCA) for voice and video applications in terms of different related performance parameters. Studying different service adaptation scenarios, simulation results showed that the proposed scheme increases the number of concurrent users that the network can serve for different service adaptation combinations based on given application requirements or user preferences.

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