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Centralized Media Independent Soft Handover Decision (CMISHD) for Multi-Interface Mobile Node in 4G Heterogeneous Wireless Networks

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Abstract: The next generation mobile communication system called as 4G/NGWN is expected to include heterogeneous wireless networks that will offer high data rate multimedia services to end users at lowest cost. In present Wireless Systems the capability of broader coverage is available but has the limitation of bandwidth and network cost. In addition to the coverage, need to ensure the higher quality of content-delivery at lower cost. This study proposes Centralized Media Independent Soft Handover Decision (CMISHD) which uses Nash-equilibrium based handover for quality oriented content delivery. The primary idea is based upon SASHA which is a Smooth Adaptive Soft Handover Algorithm for wireless networks. The study predominantly focuses on optimizing the ideas that were proposed by SASHA. Simulation based testing for data/video traffic transmissions are presented, depicting the performance of CMISHD in various complex scenarios involving large number of mobile nodes, activities like node movement-velocity have also been simulated which is not addressed in SASHA. The results also show how CMISHD scheme can take content delivery, a step ahead, by its quality calculations and considerations which were optimized from SASHA.

Key words: CMISHD, vertical handover decision, Wi-Fi, WIMAX, LTE-A, velocity, QoS, cost, QoE, QMS

INTRODUCTION

A heterogeneous network is a computer network that combines one or more different types of computers, operating systems and protocols. A wireless network which connects using different access technologies could also be called a heterogeneous network since, it maintains its connections while switching to acellular network.

The importance of seamless mobility is to provide a continuous, intuitive experience for mobile consumers. Seamless mobility allows access to mobile multimedia content with automatic switching between protocols, networks, bands and physical environments. The consumer is continuously connected to relevant content which is automatically synchronized while individual content preferences are predictive and persistent. Seamless mobility is a many-faceted challenge enabling multiple devices to serve up multiple media across multiple access networks and technologies from multiple vendors.

The term handover is used to describe when a mobile terminal changes its attachment point to the Internet. However, the process of performing a handover is referred to as hand-off. One that takes place between same technologies is called as homogeneous handover and that for the different technologies is called heterogeneous handover. There are mainly two types of handovers. They are hard handover is one in which the connection to the source is broken before the connection to the target is made for this reason such handovers are also known asbreak-before-make. Hard handovers are intended to be instantaneous towards the disruption of the call. The soft handover is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken hence this handovers is called make-before-break.

MATERIALS AND METHODS

Vertical handover decision-issues: The study focuses on vertical handover decision on multi-mode terminal using Nash-equilibrium based game theory approach. The decision includes the various QoS parameters for network selection. But this approach has computational complexity as it requires the independent nodes to perform the decision making. Whereas the proposed CMISHD uses server based decision making this reduces the computational complexity (Radhika and Reddy, 2011).

The main objective of this study is to ensure better Quality of Service (QoS) in delivering multimedia content to the user by using the most optimal network available at any given point of time. QoS refers to a broad collection of networking technologies and techniques. Elements of network performance within the scope of QoS often include availability (uptime), bandwidth (throughput),

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latency (delay) and Jitter. Media independent refers to the contents which can be a video or image or streaming video or a file (Ciubotaru and Muntean, 2009).

When deploying large scale of QoS guaranteed IP-TV services over Triple-Play networks, there is a growing demand to access to the live network services, monitor in real time the broadcast chains and acquire the dynamic network parameters to ensure an uninterrupted, high quality service. The real-time monitoring can be deployed in the networks to measure the three ultimate metrics: IP cumulative jitter, packet loss and MPEG TS errors and provide helpful information about the network and service when service failed. Implementation and experimental results show promise of being practical in the real IP-TV trial networks (Luo *et al*., 2009).

The convergence between existing and emerging technologies such as broadband, mobile and broadcast networks is considered as a promising opportunity for existing network operators to increase their services audiences. Performance evaluations using an experimental test-bed are conducted and they show that the proposed cross-layer adaptation gateway reduces considerably packet losses and enhances the perceived quality of the TV service. By independently adapting each individual service, it is possible to address network and terminal heterogeneity and to offer interactive and personalized service to the end users (Djama and Ahmed, 2007).

The Video-on-Demand (VoD) is an essential technology for many multimedia applications. However, it remains challenging to efficiently deliver on-demand streams to a large number of receivers in a heterogeneous network environment. This thesis, proposes a unified approach to heterogeneous VoD broadcasting, called Unified Heterogeneous Broadcasting (UHB). Performance evaluation results indicate that UHB is superior to conventional heterogeneous VoD broadcasting protocols under various network conditions (Ding *et al*., 2008).

It describes the handling of multiple applications simultaneously in a single Mobile Node (MN) with appropriate networks considering handoff based on application (Chang *et al*., 2009). It describes the vertical handoff based on SAW (Simple Additive Weighting) and GRA (Grey Relational Analysis) (Stevens-Navarro *et al*., 2007).

The study describes handover based on QoS metrics with different traffic levels (Kim *et al*., 2007). The study describes handover based on IPv6 based on QoS mapping with bandwidth borrowing (Makaya and Pierre, 2007).

The study describes information, event and command services for handoff (Lampropoulos *et al*., 2008). The describes the LTE Hard-Handover based on Average Received Signal Reference Power (RSRP) (Lin *et al*., 2011).

The study describes the RSS zone based hard handover. It suffers from high dropping of packets (Chang and Chen, 2008). The existing system SASHA formulates a quality function called quality of multimedia streaming which provides a delay of 0.2 sec. This delay will be clearly visible to the naked eye. The network scanner scans the network parameters and sends it to the server. Then, the server calculates the QoS and returns it to the node. The delay is mainly caused because the QoS calculation is done in a centralized server. SASHA is proposed in such a way that it can applied for maximum of 3 nodes. This concept of limited number of nodes is considered as a drawback of the existing system. This system is not applicable for nodes moving at different speeds. It can be applied for maximum of 3 nodes which are moving in a constant speed. The existing system has avoided the concept of Background traffic which is a very important parameter in the QoS calculation.

The proposed system CMISHD will try to reduce the delay <0.2 sec. This delay can be reduced by calculating the QoS in the client side, i.e., in the node itself. Only thing researchers must make sure is that the node has all the configurations to calculate QoS. The proposed system can be applied to any number of nodes. This system will also hold good for the nodes which are moving at a variable speeds. The background traffic and cost are the additional parameters that the proposed system will consider in the QoS calculation.

Cmishd system design: The CMISHD schematic diagram (Fig. 1), depicts two overlapping area of coverage. The area 1 (the coverage cloud on the left) is occupied by Wi-Fi and WLAN access points and a mobile node (in this case a mobile phone).

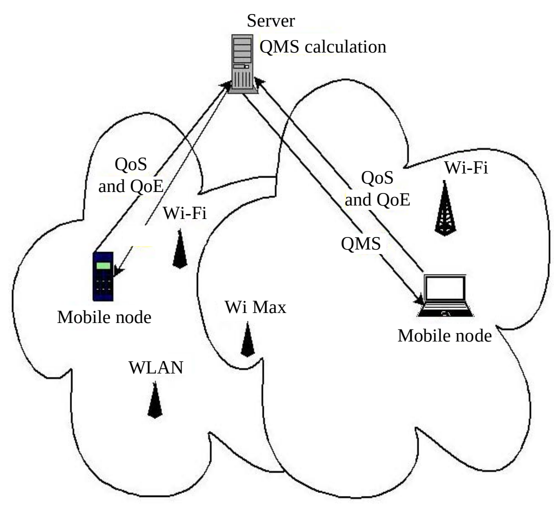

Fig. 1: CMISHD schematic

The area 2 (coverage cloud on the right) is occupied predominantly and by a Wi-Fi and WiMAX access points. Both providing a wide area of coverage to the user, the area also has a mobile node (in this case a laptop).

The picture clearly depicts the way MISH research. The mobile nodes in both the area 1 and 2 have two access points under their coverage but do no know which is optimal and best for a particular type of service, in this case, lets say, it is a video conference. Now, both the mobile nodes will have MISH client side modules which will harvest the QoS and QoE values from the access points. The client module then sends the harvested data to the server side module, a MISH enabled server. The server side module in turn calculates the QMS value and sends it back to the client side module which is also depicted in the schematic diagram.

CMISHD architecture: Figure 2 depicts the skeletal block diagram of MISH approach. The intricate details are all discussed in the diagram itself and it is almost self explanatory. The network scanner, scans for various access points available in the coverage area. It then calculates the QoS and QoE parameters using the parameter analyzer and QoE harvester modules. The values are then sent via the feedback controller module to the QMS calculator in the server side MISH module.

The Fig. 3 depicts the overall layered architecture diagram of CMISHD approach. From the Fig. 3,

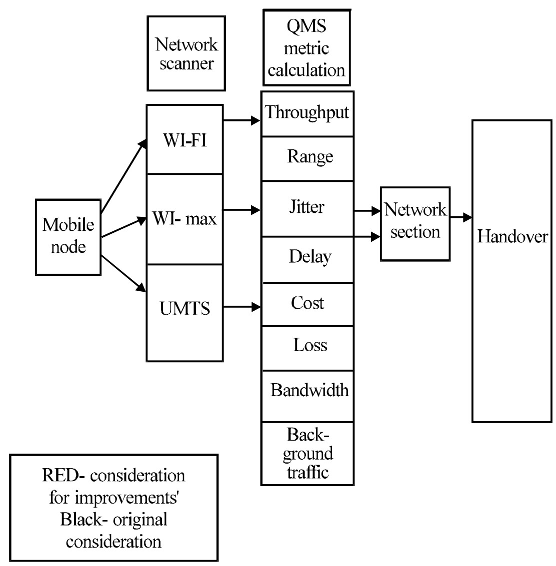

Fig. 2: CMISHD architecture

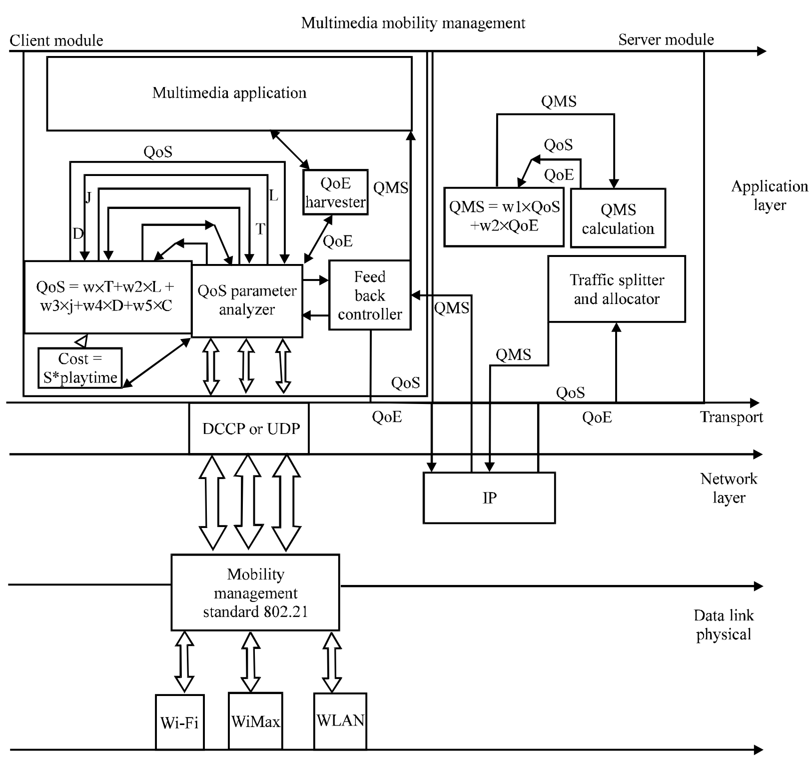

Fig. 3: CMISHD layered architecture

researchers can clearly see that both the client and server side MISH modules, research in the application layer. Protocols like DCCP (Datagram Congestion Control Protocol) and UDP (User Datagram Protocol) are predominantly used in the transport layer. IP protocol is used in the network layer. IEEE 802.21 or MIHF (Media Independent Handover Function) is used to interface the network and physical layers.

CMISHD algorithm: The CMISHD algorithm operation is explained as flow diagram in Fig. 4:

- Configure the n/w driver. This triggers another message sequence that sets thresholds for the link quality
- WIMAX is ready to begin a handover as soon as the provided QoS is below threshold
- WIMAX based on PoA (Point of Attachment) location, to be informed about neighboring PoA and their characteristics
- WIMAX examines the available resources in Target. Make the decision about the target PoA
- Wireless connection establishment by Mobile IP registration/binding update

CMISHD implementation: The implementation of MISH consists of two main modules, the first being the client module and the other being the server module. The two modules perform unique set of activities that are an optimization from the idea proposed by SAHSA.

Client module: The client module consists of all the components that are necessary to scan and list various network parameters pertaining to any particular access point. To satisfy this purpose the client module consists of:

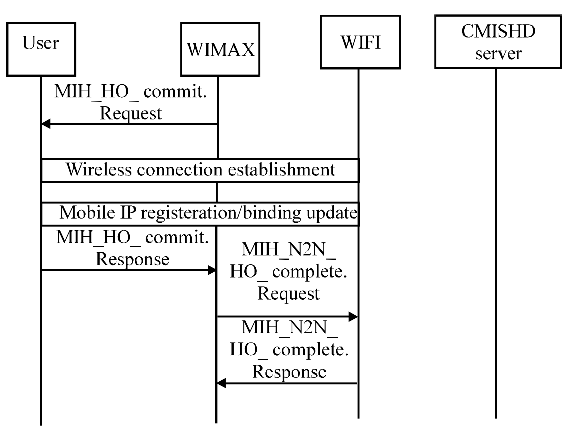

Fig. 4: CMISHD flow diagram

- QoS parameter analyzer
- QoE harvester
- Feedback controller

Qos parameter analyzer: The QoS parameter analyzer (Fig. 5) performs the main job of collecting parameters from various networks available. The parameter analyzer is a part of the client side module that operates in the application layer of the OSI. Critical network parameters that influence the quality of service being offered are collected. These parameters include throughput, loss, jitters, delay and cost. One main improvement from SASHA is that the cost is calculated in the client side module itself rather than the server side as done in SAHSA. This will improve the speed of service and will give more weight to cost in calculation of the QoS. The parameter analyzer collects the critical network parameters as listed above and will send it to a QoS calculation module. The QoS calculation module calculates the QoS as given by the below equation:

$$QoS = w1\times Throughput+w2\times Loss+w3\times Jitters+w4\times Delay+w5\times Cost$$

where, w1-w5 are weights, the weights are given on a scale ranging from 1-3. The 1 denotes minimal importance and 3 will indicate a maximum importance. An avarage importance will be denoted by weight of 2. The weights depends mainly on the type of service that particular network is going to be utilized for. For example, if an access point is going to be utilized for video call then high importance has to be given to delay because a delay in the video will disrupt the quality of the service being provided. Whereas in case of services like web browsing, delay can be given minimal importance because it does not cause much of an impact in the quality being produced.

QoE harvester: The QoE harvester performs the main job of getting a quality of experience parameter from the

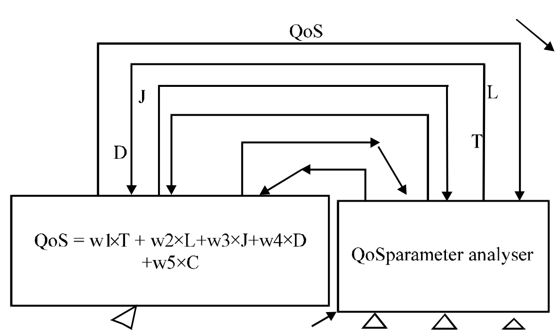

Fig. 5: QoS parameter analyzer

multimedia application. The harvester asks the user to give feedback about the feel of usage of a particular service on a particular access point. Proper weight will be provided to the QoE metric as it is very much necessary for user perceived quality.

The working of the QoE harvester (Fig. 6), the double headed arrow, ealier the module depicts the interaction between the QoE harvester and the multimedia application. The calculated QoE is communicated to the QoS parameter analyzer for further analysis which will be discussed in the subsequent studies.

Feedback controller: The MISH feedback controller (Fig. 7) works much similar to the one that was proposed by SASHA. The main aim of the feedback controller is to synchronize data between the client and the server modules. The QoS value received from the QoS parameter analyzer and the QoE value obtained from the QoE harvester are forwarded to the server side module for QMS calculations. Communication between the two modules takes place using the IP protocol.

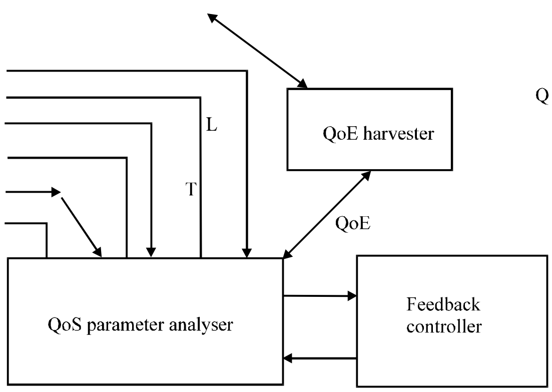

Fig. 6: QoS harvester

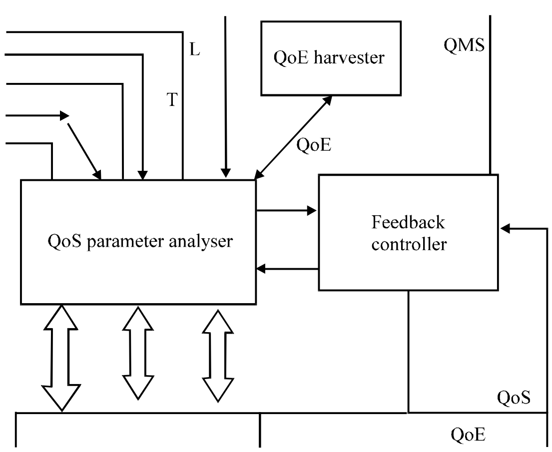

Fig. 7: Feedback controller

The working of the feedback controller is shown in (Fig. 7) of CMISHD client side module. The QoS and QoE are collected from their corresponding modules and at the lower right corner of the image, it can be seen that the QoS and QoE are sent to the server module for further calculations from the feedback controller.

Server module: The MISH server module consists of two main elements, they are the traffic spiltter and QMS calculation module. The research of each of the modules is discussed briefly in the following studies.

Traffic splitter: The traffic splitter performs the job of segregating the incoming traffic to the server side module of the MISH architecture. The QMS and QoE values come from not one MISH enabled client side module but many MISH enabled client side modules throughout the region of coverage. The work of the splitter is to analyze and segregate the traffic into various channels and to obtain the QoS and QoE values without any overlapping or conflicts between any two access points. The traffic splitter may or may not be a part of the QMS calculation module of the MISH server side module. It can act as either an independent module functioning and moderating traffic to ease of the overload from the QMS calculation module or can be a part of the QMS calculation module. In both cases the research of this component is the same but a slight increase in functionality can be seen in the latter alignment than the former alignment of this module.

The exact working of traffic splitter is shown in Fig. 8. It gets the QoS and QoE value from individual client side MISH enabled modules via the IP protocol. The collected values o f the various access points are then sent to the QMS calculation module for further calculations necessary towards providing a quality oriented multimedia content delivery.

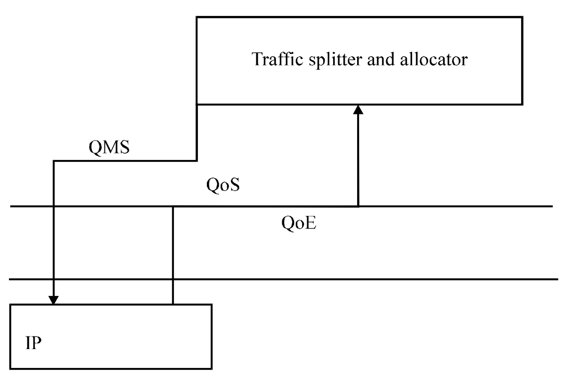

Fig. 8: Traffic splitter

QMS calculation module: The QMS calculation module (Fig. 9) is the heart of the quality oriented approach proposed by the MISH architectural framework. It takes as input the QoS and QoE values from the individual access points segregated by the traffic splitter module as discussed earlier. From the obtained values of QoS and QoE, an effective QMS value is calculated this value is then communicated to the client side module for further analysis and selection of the most optimal access point for a particular type of service:

$$QMS = w1 \times QoS + w2 \times QoE$$

The above equation is used by the MISH server side module in order to calculate the QMS value. The w1 and w2 are weighted values that are given to the QoS and QoE, respectively. Unlike the client side module a varying weight to w1 and w2 is not provided in the QMS calculation rather an equal weight is assigned to both the values in order to ensure an efficient QMS output that relies equally on both the QoS and QoE parameters obtained from the client side module.

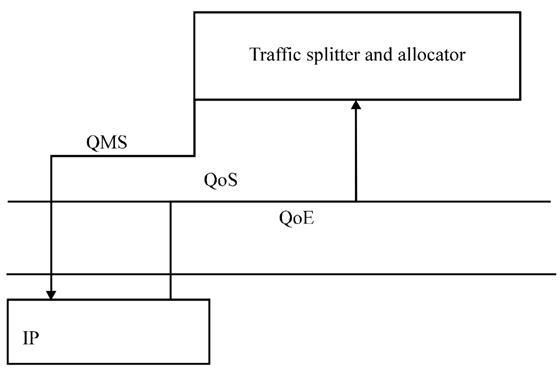

Fig. 9: QMS calculator

The working (Fig. 9) of the QMS calculation module. The QoS and QoE values are given as input and a QMS value is obtained as the output. The obtained QMS value is then sent back to the access point from which the QoS and QoE values were obtained through the IP protocol.

RESULTS AND DISCUSSION

The results shown in Fig. 10 depicts that the packet loss for MISH based handover decision is low when compared with SASHA approach. The packet loss recorded by MN's in each of the mobility scenarios with a networking overlap area determined by a 200 m distance between AP's.

The evaluation of QMS grades (Fig. 11) for each communication channel when the mobile node is crossing the overlapping area using both the techniques MISH and SASHA. It can be clearly seen that the QMS values of the MISH are far better than SASHA.

It can be clearly (Fig. 12) seen that for the distance of 160 m between the AP's the throughput is almost

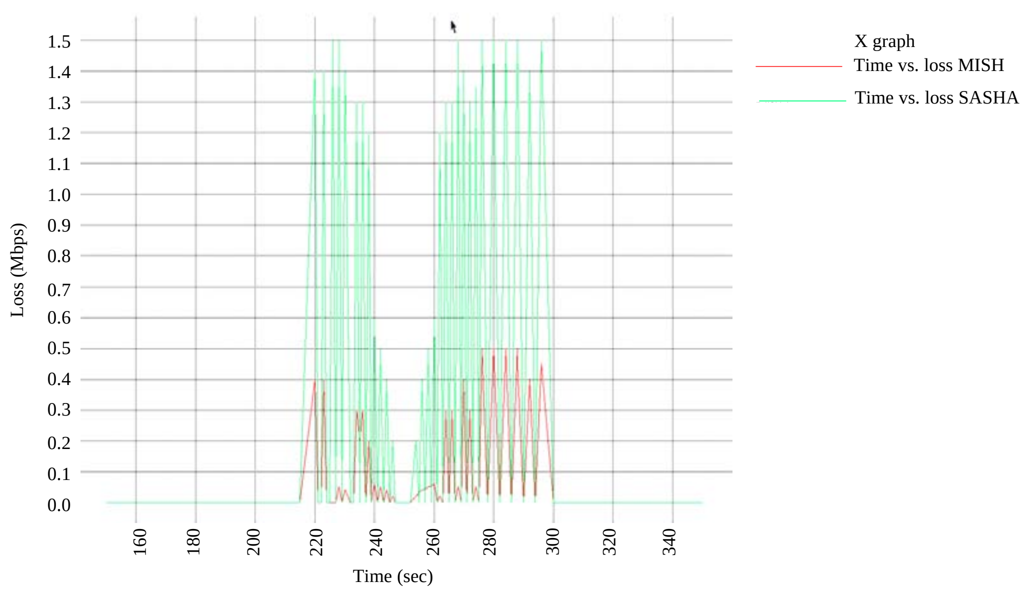

Fig. 10: Packet loss-CMISHD vs. SASHA

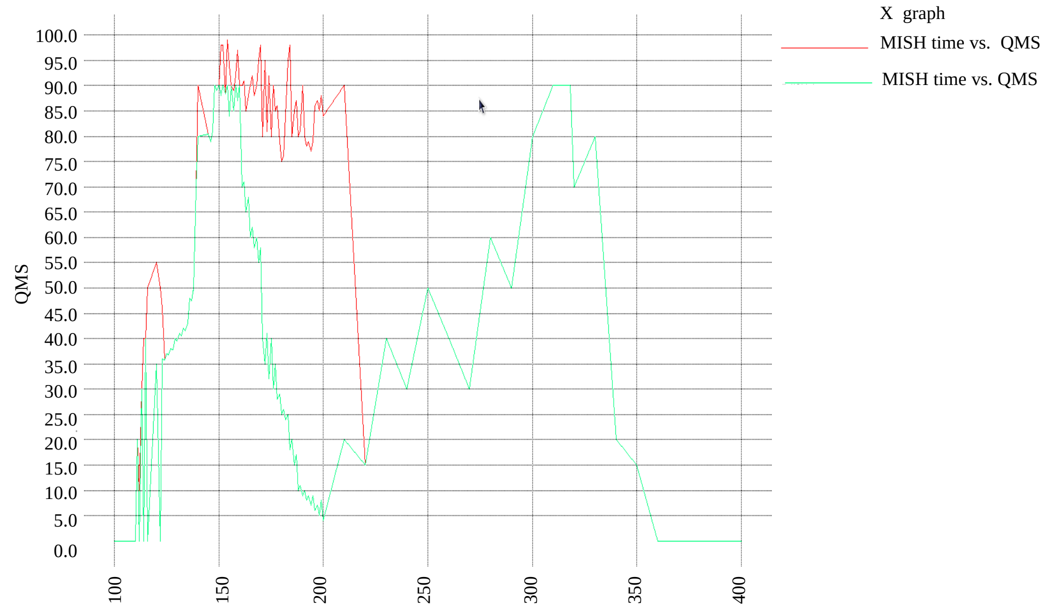

Fig. 11: QMS CMISH vs. SASHA

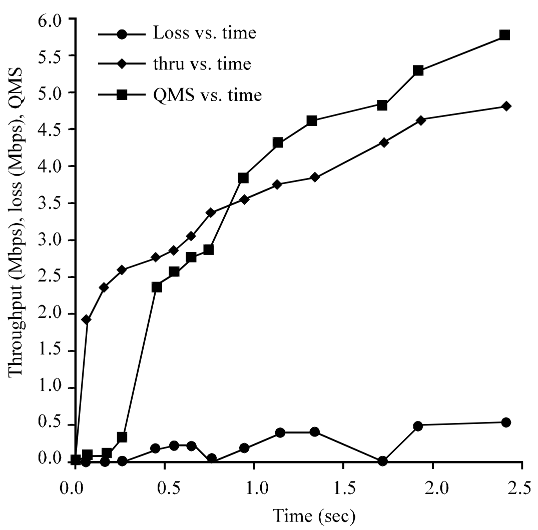

Fig. 12: Throughput-CMISHD vs. SASHA

continuous. A small gap appears when the distance is increased to 160 m, leading to a significant gap when gap is increased to 170 m. The line graph (Fig. 13) shows significant values of the three graphs in a combined way.

The main idea of this study is to provide a quality oriented service to the users of the mobile networks although, very primitive in state, the MISH will have many future advancements in terms of quality calculations as well as the architecture. The study proposed above is only a start for the decades of quality oriented optimization's that are to follow.

Video data experiments and evaluation: The sample video consists of 2001 frames. The analysis of video sent from the router and the video received by the user is shown in Table 1.

The analysis result over the video sent from the router and the video received by the user is shown in Table 2. The same video is transmitted from the router to a mobile user in the same heterogeneous n/w environment (Fig. 14) while the user moves across different network base stations.

The video frames that are received by the mobile user with and without CMISHD based handover mechanism are shown in the Table 2 and 3, respectively. Since, the quality of a video is completely depends on the number of I-frames lost, the video in Table 2 seems with less quality when compared to that of in Table 3.

Video traffic in heterogeneous network: This is because in the scenario the mobile user starts to receive video frames from the wimax base station and then it starts to move away from the wimax base station. At a certain distance the user will detect a wifi network. The analysis result over the video sent from the router and the video received by the user is shown in Table 3.

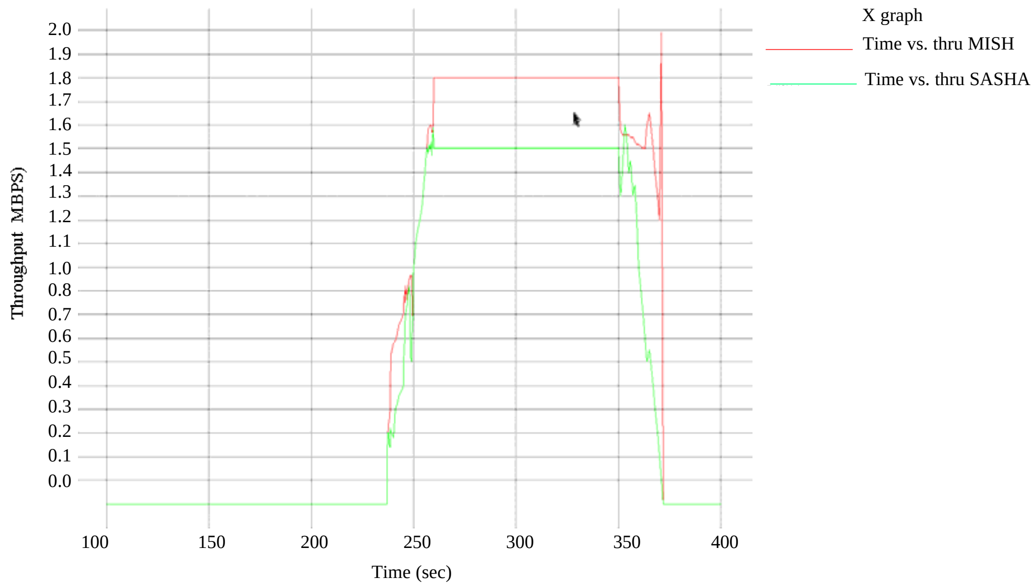

Fig. 13: Loss, QMS and throughput-CMISHD vs. SASHA

Table 1: Frame loss in homogeneous network

Specification	I-frame	P-frame	B-frame	Total
No. of packet sent from the router	1215	924	2467	4607
No. of packet lost during transmission	0	0	0	0
No. of frames sent from the router	223	445	1332	2001
Frame lost during transmission	0	0	0	0

Table 2: Frame loss in heterogeneous networks without CMISHD

Specification	I-frame	P-frame	B-frame	Total
No. of packet sent from the router	1215	924	2467	4607
No. of packet lost during transmission	77	26	43	147
No. of frames sent from the router	223	445	1332	2001
Frame lost during transmission	33	21	35	90

Table 3: Frame loss in heterogeneous networks with CMISHD

Specification	I-frame	P-frame	B-frame	Total
No. of packet sent from the router	1215	924	2467	4607
No. of packet lost during transmission	5	4	8	17
No. of frames sent from the router	223	445	1332	2001
Frame lost during transmission	1	2	5	8

If there is no application oriented hand over installed, the user will continue to receive data through the WiMAX base station. In this case, the p and b frames of the video are transmitted without any packet loss. Whereas the loss of i-frame packets will increase as the user moves away from base station since, the QoS required for I-frame transmission is not enough.

Fig. 14: Video frames received by the mobile user with Application based handover decision mechanism (CMISHD)

But in the case of application oriented handover mechanism, the MIH agent in the User's Mobile System will have the knowledge about the handover decision with respect to the video transmission. So, when the user moves away from the WiMAX base station, after it detects the WiFi network, the handover decision mechanism commands the user's MIH agent to get connected to the WiFi base station due to which the total i-frame loss will get minimized. Hence, the user will receive the video with better quality.

CONCLUSION

In the next generation wireless networks, overlaid multiple wireless access systems with significantly different capabilities coexist. In such network environments, mobiles devices equipped with multiple air interfaces may execute diverse applications simultaneously. In this project, concept leveraging end-to-end mobility management and cross-layer technique is implemented in order to accomplish the following objectives: Enabling the effective multi-layer triggering for handover decisions. Enabling per-application handover decision and network selection. Enabling transport and/or application specific control and adjustment when handover occurs.

RECOMMENDATIONS

The future direction can be:

- The proposed MISH based handover decision mechanism is designed based on handling only a single application type which can be extended to handle multiple applications simultaneously with different network accessing in a mobile node
- There are various other QoS to be considered like missed beacons and number of packets received with error. In the simulations researchers have considered only the number of dropped packets and the RSSI as the QoS parameters
- Also, the authentication and the other security aspects when a mobile node registers with a base station can be considered

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