Link Stability based Handoff for QoS Provisioning In 4G Network

Gurumurthy G D\textsuperscript{1}, Dr K B Shivakumar\textsuperscript{2}, Srinidhi G A\textsuperscript{3} Dr H S Shivaram\textsuperscript{4}

\textsuperscript{1}Research Scholar, Mewar University, India

\textsuperscript{2}\&\textsuperscript{3}Department of TCE, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India

\textsuperscript{4}Visiting Professor, Mewar University, Chittorgarh, Rajasthan, India

Abstract

Future generation 4G network is considered to bring most seamless data and internet access across different devices and networks. 3G network architecture incorporates several mechanisms for continues connectivity. 4G networks abstracts the communication as any form of digital data including but not limited to voice and video calls, media streaming, content sharing, cloud computing and distributed services. 4G network offers a seamless collaboration between core 3G data network, local WiMax networks, GSM networks and so on. Every core network follows it’s own architecture and protocols. Therefore switching from one network to another requires techniques that ensures optimum performance and quick switching. However as every switching is performed by set of command exchange between current, bridging and new network, ensuring least frequent switching is as important an issue as determining the best network itself. Once a user opts for a specific network, data exchange within the network and through any other core networks needs QoS provisioning. Most existing protocols focuses on choosing the best network at specific time instance which never ensures either longevity of the connection or quality of it.

A Link Quality is an estimation of the nature of all inbound and outbound links of a node that takes into account of power, bandwidth, jitter and latency. Therefore in this work we propose a Link Quality based routing and handoff for 4G network. Considering link quality in routing decisions rather than hops ensures that the obtained routes are optimum in terms of packet delivery and lifetime of the path.

Keywords: 4G, QoS, Vertical Handoff, Bandwidth, Signal Strength, Link Quality

1. INTRODUCTION

Connectivity among multiple Wireless networks is becoming an increasingly important and popular way for providing seamless connectivity to the mobile users. Current technologies vary widely in their bandwidths, latencies, frequencies, and media access methods. In simple words there are several wireless networks in place and in use with different architecture, MAC protocol, services, Bandwidth, Cost and accessibility. Unfortunately, no technology in and of itself makes possible the best available network at all times. For example a WLAN may be better at internet connectivity over GSM cellular network, but when it comes to voice calls, the second clearly outperforms the first. No single network technology provides a low-latency, high-bandwidth and wide-area connection for all the services over the whole access time to a huge number of users. Therefore 4G networks are built around the idea of making the best network available to an end user.

In the other conventional networks, for example 2G and 3G horizontal handoff system, a handoff or passing the services from one to another peer was designed to support the mobility and the handoff is generally a designed phenomenon between two base stations such that when a mobile device leaves a cell, the current base station hands off the connection to the base station of the cell that the mobile device is currently on. But in the 4G network, at a same time several connections may be available to a particular node for a particular service. The end user or the network node is initiated Vertical Handover, that is supported by the designed protocols. Few studies said that opting for a handover depending upon the access cost. Such as for connectivity of internet, a Cellular Gateway and a WLAN gateway are available to the end user. When the end user needs high speed connectivity, it can use WLAN which will cost more and when he requires a low speed low cost connection, he can switch back to cellular gateway.

Competition is increasing among the wireless service providers and the infrastructure cost coming down, cost becomes a secondary metric to the quality in connections.

Therefore in this work we focus on designing a system for measuring and quantifying the Quality of Service at the end node and selecting an appropriate network based on the best QOS available from a network. We estimate the quality of service by calculating the bandwidth between links from available gateways to the end node and by measuring the received signal power. Even though Handoff is easy for theoretical claims, it passes on several challenges which include detection of handoff need and initiating the handoff process.
2. LITERATURE REVIEW:

Pedro et al. [1] proposes two different procedures in the handover preparation phase in IEEE 802.11, candidate access technologies discover and resources availability check, can be performed only in one procedure, optimizing the handover process.

Inwhee Joe et al. [2] propose a mobility-based prediction algorithm with dynamic LGD (Link Going Down) triggering for vertical handover by applying the IS (information server) of IEEE 802.21 MIH (media independent handover). The proposed algorithm predicts a possible moving area (PMA) of the mobile terminal based on mobility information (the velocity, coordinate values, position, movement detection, etc) in IS. Since the PMA indicates a next target cell for handover, it can advance the LGD trigger point dynamically to prepare for handover beforehand.

Khan [3] proposes an approach build on IEEE 802.21 standard for service negotiation. SIP and IPv6 based flow management approaches are discussed, the later approach is implemented using OPNET modeller simulator. The performance of our approach is compared with Long-term contractual approach in terms of users throughput, users’ cost, operators’ revenue and call blocking probability.

In [4] Ferrus et al. develop a comprehensive framework to categorize interworking solutions by defining a generic set of interworking levels and its related key interworking mechanisms. The proposed framework is used to analyze some of the most relevant interworking solutions being considered in different standardization bodies. More specifically, I-WLAN and GAN approaches for WLAN and cellular integration, solutions for WiMAX and 3GPP LTE/SAE interworking, and the forthcoming IEEE 802.21 standard are discussed from the common point of view provided by the elaborated framework.

Lampropoulos [5] discusses enhanced handover functionality is described for integrated Wi-Fi/WiMAX networks, based on the recently established IEEE 802.21 standard that serves to glue together heterogeneous wireless access technologies. Moreover, alternative implementation choices are introduced with an emphasis on the mapping of primitives between the IEEE 802.21 standard and the various underlying access network technologies. As a result, optimized media-independent handover operations are provided alongside highlighted possible improvements to the related standards.

Shin-Jer Yang and Sao-Uen Chen [6] proposed IQDE (Improved QDE) to mitigate service interruption and improve the performance via following new features: (1) Adding IEEE 802.21 MIH parameters; (2) Adopting IQDE to shorten the QoS path reestablishment time for improving service continuity problems on the MIPv6. The simulation results indicate that PFMIPv6 with IQDE can provide stable Packet Transfer Delay (PTD), obtain higher Throughput (TH), and lower Packet Delay Variance (i.e., Jitter) than other two handover protocols, FMIPv6 and PFMIPv6.

Buiati et al. [7] Proposes a new Media Independent Handover (MIH) standard. Using the IEEE 802.21; this letter proposes a new neighbor network discovery mechanism, considering a hierarchical view of the network information.


Guang Lu [9] presents a solution using IEEE 802.21 to enable seamless mobility for data and video streaming sessions. The solution was implemented and evaluated using commercial wireless networks and mobile devices. Lab and field trial results show minimal handover delay and improved user experience.

V. Kumar [10] presents a novel vertical handover scheme applicable for IEEE 802.11 (WLAN) and Universal Mobile Telecommunication System (UMTS) based on IEEE 802.21. UMTS is a 3GPP (Third Generation Partnership Project) technology, which is being used in cellular networks. WLAN is a LAN technology which supports smaller coverage area than the cellular networks. Vertical handover between these two is needed because they have different RAT.

Jiann-Liang Chen [11] develops a novel IEEE 802.21 MIH (Media Independent Handover) mechanism for next generation vehicular multimedia network. An adaptive QoS management mechanism is also proposed. By obtaining received signal strength parameters, the proposed MIH framework can determine the best available network. The adaptive QoS mechanism substantially improves the performance of real-time multimedia applications. The simulation results show that average handover time is slower than both UMTS and WiMAX when the MIH mechanism is used in vehicular network. However, the simulation results confirm that using the IEEE 802.21 MIH mechanism can increase overall throughput. Increased throughput is satisfactory compensation for increased handover time.

Jun Yuan et al. [12] proposes a novel scheme using IEEE 802.21 MIH services to improve packet loss performance by utilizing the active links to maintain the data flow. The MIH services, Link_Action and MIH_Link_Action, are extended and an MIH event named Link_PDU_Receive_Status is added. A complete message exchange in handover procedure is provided. Numerical analysis shows that the proposed scheme performs better in terms of packet loss comparing with the traditional independent FMIPv6 scheme.

Obreja [13] presents a solution for mobility management in heterogeneous networks which is based on the MIH framework. It is presented the architecture and the simulation testbed used for system validation. QualNet simulator was chose to implement the proposed solution.

Vaca Ramírez, Ramos [14] present extensive numerical simulations of a novel vertical handover mechanism, which is compared with well known mechanisms: one based on the RSS (received signal strength) and the other one based on the traditional AHP (Analytic Hierarchical Process) method. The proposed scheme considers that a mobile node carries
more than one traffic class; it also integrates an MIH (Media Independent Handover) QoS Model, the AHP method, and cost functions to a fuzzy MADM (Multiple Attribute Decision Making) handover decision algorithm. We show that our proposed scheme outperforms the other two schemes.

Andrei, Valentin [15] provides a view on the developing process of the Media Independent Information Service, later referred as MIIS, described in the IEEE 802.21 standard, which has the main functionality of providing the mobile terminal information about all access points in its coverage area. Our approach is towards the management of the entire mechanism of delivering data to the device, that is realized at a central location.

3. PROBLEM DEFINITION:

Handoff is one of the most important aspects of 4G network's seamless connectivity. It is one of the most important feature of the protocol that determines the method and measures to be followed when a client switches from one network to another network without having to wait long for the switching or dropping packets for switching process. Handoff process can be seen as having two stages: (1) Handoff Initiation, and (2) Handoff execution. Handoff initiation includes need for handoff and possible network detection followed by network discovery and handoff decision. Which kind of handoff metrics should be used and how to apply them to make the handoff decision are the main problems in handoff detection. In handoff execution, the mobility management plays an important role. To achieve seamless and fast handoff, these two stages should be paid attention. The time when the handoff decision is made can affect the overall performance of the handoff process such as packet loss. A heavy signaling overhead in handoff management leads to large handoff latency. Hence following notions must be taken care off while designing a Handoff.

- Handoff process must not be frequent
- Handoff must be initiated only when a handoff guarantees much better service than the existing one.
- Handoff must not adopt heavy signaling that might introduce unnecessary Latency.
- Handoff should occur without disturbing or dropping the existing connection.

4. PROBLEM DEFINITION:

4.1: Architecture

In proposed architecture, we are using dynamic database at network which maintain the network condition such as present network available bandwidth, network load etc. In UMTS network database is connected to 3GPP server and When MN attached to AP at WLAN needs to switch to UMTS, it sends the request to WAG, it forwards the request to SGSN of UMTS were mobile node need to switched, SGSN checks all the RNC connected to it gets the network conditions of all RNC connected from 3GPP server were database is connected and sends it back to WAG and finally to MN through AP. MN gets all condition and finally executes handoff. When mobile node attached RNC of UMTS network need to switch to WLAN it send request to SGSN and then to WAG and collect network condition from server were database is connected and sends back the information to MN through RNC and finally handoff initiated at MN.

![Figure 1 Proposed Model](image1)

![Figure 2: Handoff between WLAN and UMTS](image2)
When RSS at MN falls below threshold it sends REQ request message for UMTS network condition which is integrated with WLAN, through WAP to SGSN gets the network condition from 3GPP server were database maintained which has condition of network (bandwidth availability) which is dynamically updated. SGSN send back the detail network condition of all RNC which are attached to SGSN with network details back to MN through WAP and AP. Now at mobile node after receiving the network condition it select the best network among them and send the handoff request to SGSN. SGSN accept the request and forward to particular RNC for handoff, RNC send ACK (acknowledgment) back to MN through SGSN to MN. then MN establishes connection to new UMTS network after receiving the ACK and release the old connection from WLAN.

When RSS at MN attached to UMTS falls below threshold it sends request message for network condition REQ for network condition of WLAN which is integrated with UMTS through SGSN TO WAP and checks the network condition network (bandwidth availability) from 3GPP server which is dynamically updated regularly. Servers send back the details network condition to MN through SGSN and RNC. Now at mobile node after receiving the network condition it select the best network among them and send the handoff request to WAP through SGSN. WAP accept the request and forward to particular AP for handoff AP send ACK (acknowledgment) back to MN through WAP, SGSN and RNC. then finally MN establishes connection to new WLAN network after receiving the ACK and release the old connection from UMTS.

4.2: Link Quality Assessment

4.2.1 Signal to Noise Ratio: SNR is a good measure of the link quality and it ensures higher packet delivery ratio. In a signal level measurement, calculation of SNR is typically complex and needs model like kalman filter and so on. It is also calculated from the power spectrum of the received signal. But in this work we propose a packet level estimation of SNR which can be directly derived from the bit error rate.

SNR or signal to noise ratio is typically given by:

\[
\frac{E_b}{N_0} = \frac{P_{Rj}/D}{N_0 + P_{Ij}/W},
\]

(1)

where \(D\) is the data rate in bits per second, \(W\) is the system bandwidth in hertz, \(N_0\) is the power spectral density of the thermal noise, \(P_{Ij}\) is the power of the interference at node j due to all nodes excluding node i, and \(P_{Rj}\) is the received power at node j due to node i.

It is quite difficult to form a model which can appropriately give the estimation of interference level and the power spectral density of the Gaussian noise present in the channel. We use the theoretical limit table for estimating SNR from BER.

Where simulation [16] has shown that the results obtained are very closer to the theoretical values. Erroneous bits are calculated using parity check of the received packet. Now a node stores the number of packets it has received and the current measure of bit error rate. As the simulation is using 20 packets to 50 packets per second as the data transmission rate, maximum error rate that can be observed per second is \(e^{-7}\).
Table 1: Relationship between Signal to Noise Ratio and BER

<table>
<thead>
<tr>
<th>SNR(dB)</th>
<th>BPSK&amp;QPSK</th>
<th>CCK5.5(5.5Mbps)</th>
<th>CCK11(11Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>9e-2</td>
<td>1.7e-2</td>
<td>4e-2</td>
</tr>
<tr>
<td>5</td>
<td>9e-2</td>
<td>3.5e-3</td>
<td>8e-3</td>
</tr>
<tr>
<td>6</td>
<td>3e-2</td>
<td>6.2e-4</td>
<td>1.2e-3</td>
</tr>
<tr>
<td>7</td>
<td>4.1e-3</td>
<td>7e-5</td>
<td>1.2e-4</td>
</tr>
<tr>
<td>8</td>
<td>1.01e-3</td>
<td>5e-6</td>
<td>1.01e-5</td>
</tr>
<tr>
<td>9</td>
<td>2e-4</td>
<td>2e-7</td>
<td>3.9e-7</td>
</tr>
<tr>
<td>10</td>
<td>2.02e-5</td>
<td>4e-9</td>
<td>7e-9</td>
</tr>
<tr>
<td>11</td>
<td>1.8e-6</td>
<td>7e-11</td>
<td>2e-10</td>
</tr>
<tr>
<td>12</td>
<td>5.9e-8</td>
<td>7e-11</td>
<td>2e-10</td>
</tr>
<tr>
<td>13</td>
<td>1.4e-9</td>
<td>7e-11</td>
<td>2e-10</td>
</tr>
</tbody>
</table>

Thus any value over it may be considered as infinitely low BER and infinitely high SNR. Further an argument can be easily put forward about selecting SNR as the performance measurement criteria instead of BER where it is derived directly from the table. Error rate are more instantaneous values. We assume the trend of the ratio is universal, though the table represents the Signal to Noise ratio for 802.11 channels. Exact value of SNR may vary from network to network but Link Quality measurement is similar in terms of BER and SNR.

It is also understandable from the table that Bit error rate can not be measured for small data or burst of small data. In a 4G network if an end user is using certain connection, then it can measure the BER and hence SNR in that connection. But the proposed technique needs the SNR of the other available connections to also be known.

Therefore we propose a unique proactive technique for Signal to Noise Ratio calculation which is used for measuring the bandwidth. We assume that the neighboring node broadcast a periodic advertisement signal called HELLO packets with it’s ID. When a gateway receives Hello packet from a node, it calculates the SNR and Bandwidth available between it and the end node (as explained in the next section) and notifies to SGSN which passes the value to 3GPP server which in turn save the value in the database. At wireless gateway’s every signal estimation updates the value in the database.

4.2.2 Bandwidth Estimation:
Bandwidth is calculated as inverse function of latency between two nodes and is essentially the link bandwidth here.
Every Hello packet is time stamped at the sender side. When a node receives the hello packet, it calculates the total delay from the sender by subtracting the sending time from current time. Let the delay be T.

Then bandwidth between two nodes is given by:

\[ BW = \frac{K \times \text{Packet Size}}{T} \]  

(3)

Where K is the proportionality constant and are consistent for a specific network. Adaptation of this bandwidth function in a heterogeneous network can be well argued as different links belongs to different network. Not let us assume that in any arbitrary link an ideal bandwidth is 200Kbps. then if 100 bits are received in 10 milliseconds, effective transmission rate or bandwidth is 1kbps. An actual link speed cannot be measured through this technique because hello packets are short. Now assume that there are congestion in the network. Then the same packet may take 50 milliseconds to arrive which results in calculation of effective bandwidth being .02kbps. Instead of Hello packet, if a data frame were transmitted then also delays would have been the same as in a given slot a node may transmit minimum one frame of payload. As the measurement occurs at the gateway, the gateway replaces K with the frame size of the network it represents and measures the bandwidth.

Thus equation 3 can be simplified as (4) which is also the mean link bandwidth measured over a period N.

Whenever multiple metrics are used in any network, it is essential to device a relationship between them such a single cost can represent the entire link quality. In any multi-metric decision, cost can be calculated as

\[ \text{Link Cost} = x \cdot \alpha + y \cdot (1-\alpha) \]  

(6)

where x and ye are the metrics. \( \alpha \) is network dependent and here it is assumed as .5. Hence (5) can be simplified as (6) by considering our metrics.

Here (6) defines the link cost. Link quality is defined as inverse link cost which determines the suitability of a link.

5. Methodology
1. Measure Cost at NIC and at Wireless Gateway, when Cost falls below threshold then generate a signal to request SGSN for all available connections
2. SGSN checks if any other connection or network has better QOS than the current one. If available, it notifies the mobile node with available QOS and networks
3. Node selects the best Cost Network and Request for a handoff to its connected gateway.
4. The gateway passes on the request to the requested Network’s Gateway.
5. The connection is passed to the other gateway, upon Receiving the Handoff acknowledgement.

Threshold is selected as the 30% of the cost of the connection at the time of connection establishment. Therefore when the current cost is below 30% of the cost at the time of connection setup, the handoff process is initiated.

\[
\text{Cost} = \alpha \left( \sum \left( \frac{1}{1+x} \right) + (1-\alpha) \left( \sum \left( 1- \frac{1}{1+y} \right) \right) \right) \quad (6)
\]

\[
\text{Cost} = .5(1+\text{SNR}) + .5(1-1/(1+\text{BW})) \quad (7)
\]

6. Simulation and Results

Proposed system is simulated with Omnet3.3, an event based simulator. Proposed technique is compared with current standard Hop based method where node opts for a handoff to a network with least possible hops. This technique is also known as DSDV based horizontal handoff where the connecting network is automatically selected. Call drop probability and Call block probabilities are calculated as given in [17]. The results are verified for proposed system and conventional system that performs handoff based on mobility (i.e. handoff is performed only when a mobile moves away from it’s current gateway).

![Network Topology as Seen in Simulation run time](image)

**Figure 4:** Network Topology as Seen in Simulation run time

![Call Drop Probability](image)

**Figure 5:** Number of calls per second v/s Call Drop Probability

![Call Block](image)

**Figure 6:** Number of Call Block Probability
Clearly we can see that PDR for proposed technique is much better than the PDR for Hop based handoff. As Node speed increases the mobility increases. Due to the increased mobility PDR decreases. So the graph initially with constant rate decreases suddenly.

As the network load increases the PDR initially from lower values increases to some constant value. As the proposed technique relies on link quality based handoff where link quality is measured through both bandwidth and link power and bandwidth is the measure of load, proposed technique incorporates load of all possible nodes to the network to connect and therefore the handoff achieved by the proposed technique ensures better QoS for network.

As number of nodes increases the PDR varies from lower to higher values as observed in the graph. We can say that PDR optimized at some points is better than the non-optimized run.

7. Conclusion and Future work:
Assuring quality of service to the links and especially to the end nodes in heterogeneous 4G network is a major challenge due to different signaling, inherent quality and services provided by different interconnected network. Besides being difficult to quantify and provide an optimized framework for handoff, it is quite difficult to propose and formulate a suitable structure for the same. Conventional mobility and connectivity based approach for handoff may are not suitable as seen from results (figure 6,7). It is clear from the result that with increase in network load (i.e. number of calls per second) the drop and block probability increases in the conventional technique. In case of proposed solution, the need of the handoff is determined way before the quality of a link enforces a handoff. It is also proved through the result which
clearly shows the improved performance, especially in block probability. This technique can be further modified by incorporating other network resources as QOS parameters like Jitter, Number of Flows in the nodes and so on.

References
[1] Neves, Pedro; Soares, Joao; Sargento, Susan, Dynamic media independent information server , IEEE Symposium on Computers and Communications (ISCC), 2010
[2] Inwhee Joe; MinChul Shin;, A Mobility-Based Prediction Algorithm with Dynamic LGD Triggering for Vertical Handover , IEEE 7th Consumer Communications and Networking Conference (CCNC), 2010
[5] Lampropoulos, G.; Skianis, C.; Neves, P. Optimized fusion of heterogeneous wireless networks based on media-independent handover operations [Accepted from Open Call], IEEE Wireless Communications, Volume: 17 , Issue: 4, IEEE 2010
[9] Lu, Guang; Enable multimedia mobility with IEEE 802.21 , IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM) 2010
[10] Kumar, V.; Tyagi, N.; Media independent handover for seamless mobility in IEEE 802.11 and UMTS based on IEEE 802.21, 3rd IEEE International Conference on Computer Science and Information Technology (ICCSIT), 2010
[11] Jiann-Liang Chen; Yi-Wei Ma; Yueh-Min Huang; Qing-Tai Yang; An Adaptive QoS mechanism for multimedia applications over next generation vehicular network, 2010 5th International ICST Conference on Communications and Networking in China (CHINACOM), 2010
[13] Obreja, S.G.; Fratu, O.; Vulpe, A.; A simulation testbed for a MIH enabled system, 2010 8th International Conference on Communications (COMM), IEEE 2010
[16] Wu Xiuchao, SOC, NUS, Simulate 802.11b Channel within NS2
[17] Sreenath Ramanath, Veeraruna Kavitha, Eitan Altman, Impact of mobility on call block, call drops and optimal cell size in small cell network

AUTHOR

Gurumurthy G D obtained his BE in Electrical & Electronics Engg., In the year 1990 from Mysore University University & M Tech in Digital Electronics and Communication Systems in the year 1995 From Mysore University. He is pursuing his PhD in Electronics and Communication Engg in Mewar University, Rajasthan. He has 20 years of teaching experience and presently he is working as Assistant Professor, Dept. of E&C, Kalpataru Institute of Technology, Tiptur, Karnataka. His research area is Wireless Networks.

Dr K B ShivaKumar received the BE degree in Electronics & Communication Engineering, ME degree in Electronics, MBA Degree from Bangalore University, Bangalore and M Phil Degree from Dravidian University Kuppam. He obtained Ph.D. in Information and Communication Technology from Fakir Mohan University, Balasore, Orissa. He has got 30 years of teaching experience and has over 60 research publications in National
and International conferences and journals. Currently he is working as Professor, Dept. of Telecommunication Engineering, Engineering, Sri Siddhartha Institute of Technology, Tumkur. His research interests include Signal processing, image processing, Multi rate systems and filter banks, and Steganography.

Srinidhi G A received the BE degree in Telecommunication Engineering, from Visveswaraya Technological University, Belgaum, Karnataka, MTech degree in Sensor Systems Technology from VIT University Vellore, Tamilnadu. He has over 10 research publications in National and International conferences and journals. Currently he is working as Asst Professor, Dept. of Telecommunication Engineering, Sri Siddhartha Institute of Technology, Tumkur. His research interests include Signal processing, image processing, Automotive Sensor systems, MEMS and Steganography.

Dr.H.S.Shivaram procured BE in Electrical Engineering, University of Mysore, 1967, M Tech in Electron Devices Technology, Indian Institute of Technology, Bombay, 1974 & PhD in Electronics /Instrumentation, Indian Institute of Science, Bangalore, 1983. He has more than 43 years of teaching experience & currently he is working as a Research supervisor and Visiting Professor at Mewar University Chittorgarh, Rajasthan, India. He has published 4 International Journals and presented research papers in 5 national conferences. His area of interest being communication Engineering and Networking.