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Optimal Heterogeneous Network Selection Based on Estimation of Network Quality Factor (NQF)

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Abstract: The paradigm shift from fixed homogeneous network to mobile heterogeneous network for mobile multimedia applications with QoS (Quality of Service) is growing enormously. The main QoS parameters for mobile multimedia application are high bandwidth and low delay. To achieve satisfactory service delivery for mobile multimedia applications in heterogeneous network, the above mentioned QoS parameter is to be met. Provision of such services in heterogeneous environment invites many research issues. One of the main challenge is the selection of optimal network with QoS since current QoS schemes have two drawbacks such as unawareness of the heterogeneous wireless environment and inefficient utilization of the reserved bandwidth. To solve these problems, we present a novel QoS parameter namely Network Quality Factor (NQF) to estimate the network status. NQF is evaluated by estimating the Call blocking probability (Cbp) of heterogeneous network from its 'rch' (recent call history). The estimation of 'rch' parameter and Cbp avoids unnecessary hand-off and enhances the effective bandwidth utilization of a cellular network under heavy load condition. The predicted 'rch' parameter of a network is then mapped in the proposed QoS mapper sub-module present in QoS broker module to select an optimum network. The network with higher NQF is always termed as optimum network as it has low Cbp and it is always selected. A Bayesian Network Model is assumed for Cbp estimation and simulated using Monte-Carlo Method over various heterogeneous environment conditions. The estimated NQF is then mapped with User Satisfaction Factor (USF) to select the most suitable access network for each session. The modeling and simulation results demonstrate that the NQF based optimum network selection can satisfy user's QoS requirement and obtain a more efficient use of the scarce wireless bandwidth during heavy traffic load condition.

Key words: QoS, heterogeneous network, network quality factor, user satisfation factor, call blocking probability and recent call history

INTRODUCTION

The global telecommunications industry faces an imminent crisis in growth of mobile data traffic and its inability to meet growing demand with the industry's present (and planned) infrastructure. Exponential growth of data traffic over cellular networks has led network operators to look at new, alternative approaches to managing congestion because the pace of building out new networks is too slow by itself to keep up with bandwidth demand. Already the incidence of dropped cellular calls has increased markedly. According to a recent survey, in 2010, mobile traffic was about 240,000 Terabytes (TB) per month but by 2015 that is expected to grow to 6.3 million TB per month. At that rate, all the mobile traffic of 2010 will be carried in the first 2 weeks of 2015.

To meet these demands wireless carriers are adjusting their business models, expanding coverage areas, deploying 4G and LTE networks, taking advantage of picocells and femtocells to enhance available bandwidth. Most importantly, they are beginning to offload data traffic onto other networks, primarily WiFi. To quote a few, education and health care are moving more towards mobile data. Increasingly, medical institutions need high-bandwidth connections to run demanding tasks such as e-mailing x-rays, MRI scans and other medical images, sharing databases, transferring medical records and other tasks.

Demand for wireless medical services is anticipated to increase by 50% per year throughout the decade. Including mobile applications, the digital health market is estimated to have been $1.7 billion in 2010, growing to $5.7 billion by 2015. Consumers today have made use of

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>200 million health-related downloads on portable devices with that number growing >100% per year. The benefits to schools and colleges connecting to the Internet by broadband wireless networks are many. Remote learning, virtual classrooms that can be attended by students everywhere without regard to distance, is increasingly used to establish presence of academic institutions throughout the world. At the college/university level, the introduction of campus or building-wide wireless networking options will also act to include research communications and academic data transfer on wireless networks. So, to cope up with increasing demand, selection of optimum network with QoS attracts both operators and users inviting complex research challenges. It is this dire need for greater network capacity, combined with the need for carriers to find bandwidth quickly where available that has presented some unique business opportunities which are highlighted in this study.

The advent of telecommunication has greatly reduced the communication distance between users. However, the emergence of cellular generations from 1G to present 4G has attracted a large number of users to enjoy many value added services like mobile multimedia applications, videoconferencing, on-line classroom besides voice services. The main challenge is to provide seamless and always best connected services to the demanding mobile user in hostile environments as detailed by Marques *et al.* (2003). However, the trade-off between bandwidth and delay of optimum network for bandwidth hungry applications in the vicinity of heterogeneous network is still a research issue. An optimum network is a network which provides Always Best Connectivity (ABC) with high NQF and low Cbp. The significance of high NQF implies the potentiality of a network to provide bandwidth hungry mobile services with USF.

In a wireless network, mobile multimedia users face challenges when the user is handed over to an entirely different wireless network from the recently served network. This is due to the incompatibility of the architectural and technical specification of different networks. For instance, consider a mobile user roaming between networks such as 3G cellular and WLAN during an ongoing video streaming session. Here, the most critical parameters of interest for seamless service to the user are minimum delay, efficient bandwidth utilization factor, low call blocking probability and minimum cost factor.

In any wireless network, minimum delay for real time applications is obtained by using a higher data rate interface, merging of network elements to reduce the hop distance and reserving the resources along the shortest path. However by carefully rearranging the scheduling access of non-real time applications and also by bandwidth upgradation and degradation methods, bandwidth could be efficiently utilized in wireless networks as by Xiao *et al.* (2000). A network can have low call blocking probability by using load balancing concept. Lastly, the cost of the service could be reduced by proper network planning and management process.

In the proposed approach, the behavior of network is predicted based on novel parameter namely NQF measured by estimating recent call history 'rch'. The estimation of 'rch' reflects the call blocking probability of networks. This anticipation of wireless network status is more pronounceable during handover situations besides conventional channel borrowing strategy. So by estimating the 'rch' of a network, the future behavior of the network is predicted and the prediction is utilized for further planning to achieve the performance evaluation parameters of Always Best Connected (ABC) networks. As far as heterogeneous network is concerned, the optimal network selection is itself is a research issue (Sehgal and Agrawal, 2010). Sehgal and Agrawal (2010), Lahby and Adib (2013) and Shen and Zeng (2008) selected the optimal network based on user preference and QoS parameters such as cost, bandwidth, distance and security but, however the network is not studied over long term/average period (Malanchini *et al.*, 2012; Jiang *et al.*, 2013).

In this study, the behavior of networks is studied over some average time instants such as busy/peak hour, business hour and festival hours. Any network is considered as optimum if and only if it has least Call blocking (Cbp) and call dropping probability apart from other QoS parameters. The estimation of Cbp can be best judged by analyzing the behavior of networks in terms of their traffic handling capacity and the type of users and their services. This analysis of networks over some average period of time predict their status and helps in reducing unnecessary handoff of calls, thereby enhancing the system efficiency.

LITERATURE REVIEW

The growing popularity of multimedia based value added services has urged the telecom operators to indulge in some viable solutions to meet the objectives. As by Sehgal and Agrawal (2010) a network is termed as optimum network based on their service for different type of applications. For instance, for real time multimedia applications, the network having high throughput with minimal delay and low call blocking probability is termed as optimum network whereas for applications such as FTP, web browsing like, the network with minimum packet loss, maximum packet delivery ratio and less cost factor is termed as optimum network. So, measures must be devised to select optimum network with high QoS amidst various available networks pertaining to the application request of the user. QoS is a broad term used to describe the Quality of Experience (QoE) a user will receive over a network. Some of the QoS parameters (Xiao *et al*., 2000; Kibria and Jamalipour, 2007) of optimum network are discussed in the following sub-sections.

The popular research work in QoS identified from literature (Verikoukis *et al*., 2005) are European Research Funded Projects, Two IST STREP and 4 MORE-MC-CDMA Multiple-Antenna System on Chip for Radio Enhancements. Its main objective is to emphasize on research, develop, integrate and validate a cost effective low power system on chip solution for multi antenna multi carrier CDMA mobile terminals based on joint optimization of layer 1 and 2. To develop an end to end optimized wireless communication link (Verikoukis *et al*., 2005) proposed PHOENIX, a scheme offering the possibility to let the application world (source coding, ciphering) and the transmission world (channel coding, modulation) talk to each other over an IPV6 protocol stack. Veriksukis *et al*. (2005) also proposed NEWCOM, IST-507325, NEWCOM Project E of IST Network of Excellence on Wireless Communication proposal to identify existing gaps in European knowledge in cross-layer and also investigated the potential benefits of cross-layer in wireless network design in relation to the methodology of separate layer design. It also considered the coupling of higher layers with physical layer and elaborated the information to be exploited from the physical layer to optimize the network performance. However, some possible approaches of QoS Enhancement in Multimedia Mobile Networks identified from literature includes IMS (IP Multimedia Subsystem) to support multimedia traffic with QoS along with Software Defined Radio (SDR) to provide access to network independent services (Chen, 2007) with IPV6 forming common platform for 4G networks. To achieve higher data rate, modification of radio and core network could be done to enable new as well as emerging networks for seamless connectivity to the general framework (Song and Jamalipour, 2005). Cross-layer coordination to enhance QoS parameter among different layers is facilitated through well defined message interfaces such as Application Programming Interface (API), Inter Signaling pipe (ISI) and ICMP. A common control/signaling mechanism could be utilized to assist access network discovery, location management and vertical handoff by periodically computing and broadcasting a list of available Radio Access Network (RANs). List of surrounding BS Ids, their associated AR IDs and network alternatives and their QoS parameters are analyzed by Kibria and Jamalipour (2007). However, the common signaling problem could be resolved using an overlay structure on existing BS/APS as proposed by MIRAI (Kappler *et al*., 2007). For resource management, a distributed Bandwidth Broker (BB) is proposed inside each router domain, along with backup facility where BB includes SLA, SLS, ACS, A and A, PDP (Kappler *et al*., 2007). In 4G heterogeneous networks in order to provide connectivity at anytime along with horizontal hand-off, forced vertical hand-off was also proposed to upgrade the QoS of application against dropped sessions. To be specific, periodical vertical handoff algorithm could also be used. This algorithm can be embedded within terminal architecture for Mobile Terminal controlled against Mobile Terminal assisted handoffs as in 3G (Chen and Yang, 2007). As 4G deals with heterogonous networks, so for access network selection, the proposed method will be Analytic Hierarchy Process (AHP) and Grey Relational Analysis (GRA) taking throughput, delay, jitter, reliability, BER, burst error, average retransmissions, security, cost and power consumption (Ren *et al*., 2002).

The growing popularity of multimedia based value added services with always best connected networks have urged the telecom operators to indulge in some viable solutions in order to meet the objectives. The acronym always best connected network is achieved in terms of various design parameters for heterogeneous applications. For instance, for real time multimedia applications, the network having high throughput with minimal delay and low call blocking probability is termed as best network whereas for applications such as FTP, web browsing like, the network with minimum packet loss, maximum packet delivery ratio and less cost factor is termed as best network.

So, measures must be devised to select always best connected network ad midst various available networks pertaining to the application request of the user. Some of the design parameters of interest are discussed.

QOS PARAMETERS FOR OPTIMAL NETWORK SELECTION

Packet Delivery Ratio (PDR): The ratio of total packets received to that transmitted is termed as packet delivery ratio. Higher the value of PDR, better is the network status. PDR is also a measure of good channel condition and compromising values could be achieved at low load network condition:

$$\text{PDR} = \sum_{i} \frac{\text{Total packets sent}}{\text{Total packets received}} \quad (1)$$

Bandwidth Utilization Factor (BUF): The ratio of utilized bandwidth to that of offered one is measured as bandwidth utilization factor. Higher the value of the BUF, better will be the efficiency of the network. However, effective bandwidth utilization is achieved by rescheduling the non-real time applications followed by bandwidth up gradation/degradation methods (Xiao *et al*., 2000). This adaptive bandwidth scheme also enhances the throughput of the system:

$$\text{BUF} = \sum_{i} \frac{\text{Total bandwidth utilized}}{\text{Total offered bandwidth}} \quad (2)$$

Delay/Latency: The transmission time taken for requested service delivery to recipient is termed as delay. Delay is a very important parameter for real time services like voice communication in which a smaller deviation in its value causes very annoying effect to the users and is defined:

$$\text{Delay} = \sum_{i} (\text{Packet arrival time-Packet start time}) \quad (3)$$

For example, 80 and 150 msec is tolerable delay for voice and video streaming, respectively. Delay is mainly caused due to network congestion and non-availability of channels for traffic communication. However, end to end delay could be minimized by optimal route selection, merging the network elements based on their functionality similar to 3G networks where the RNC radio network controller does the function of BTS and BSC of 2G networks. This merging of network elements along with the functionality reduces the hop distance taken between the network elements.

For instance, as in Fig. 1, a typical 3G network comprising of Node B, RNC-Radio Network Controller, SGSN-Serving GPRS-Support Node, GGSN/NGME and Server/router has a total end to end delay of 180 msec for a multimedia (optional) user. The typical hop time taken between any two network element also vary between

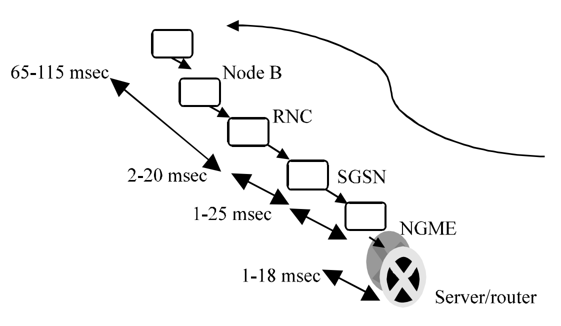

Fig. 1: Schematic diagram of typical 3G network exhibiting network element latency details

2-120 msec. So by merging the network elements the total end to end delay could be minimized from 180-200 msec to a lesser value up to 50 msec based on the network status. The merging of network elements reduces the total end to end delay at the expense of control overhead of the network elements.

Call blocking probability: In wireless networks, the randomly varying channel condition makes difficult for error free reception of applications. The randomly varying channel condition and non-availability of channels causes call blocking probability in networks (Verikoukis *et al*., 2005). However by adapting the allocation of channels based on traffic class such as real time and non-real time, call blocking probability is minimized. Hence, call blocking probability is defined as:

$$\text{Call blocking probability} = \frac{\text{Number of calls serviced}}{\text{Number of calls arrived}} \quad (4)$$

By minimizing call blocking probability, User Satisfaction Factor (USF) is improved. So, an adaptive approach based on recent call history ‘rch’ for the design parameter call blocking probability is proposed to enhance the effective bandwidth utilization of a cellular network under heavy load condition. The novel parameter ‘rch’ estimates status of cellular region over an average period of time from which the call blocking probability of the cellular region is determined. However as by Xiao *et al*. (2000), an adaptive approach is proposed in which available channels are rescheduled based on the traffic class to effectively utilize the available bandwidth thereby minimizing the call blocking probability of the wireless networks.

ESTIMATION OF PROPOSED ‘rch’ PARAMETER FOR CALL BLOCKING PROBABILITY

An optimum network is a network which provides always best connection with desired quality of service. It could be estimated by predicting rch-recent call history parameter of networks. The estimated rch parameter reflects the average call blocking probability of networks measured over average instant of peak/busy, festival and business hour.

A Bayesian Network Model is assumed for estimation of rch is detailed in Fig. 2 in which the status of network N at any time instant depends on previous state of network (whose rch is to be calculated) and the earlier status of all its neighbouring networks. Bayesian network is ideal for combining prior knowledge to predict future events. So, the neighbouring network status is considered

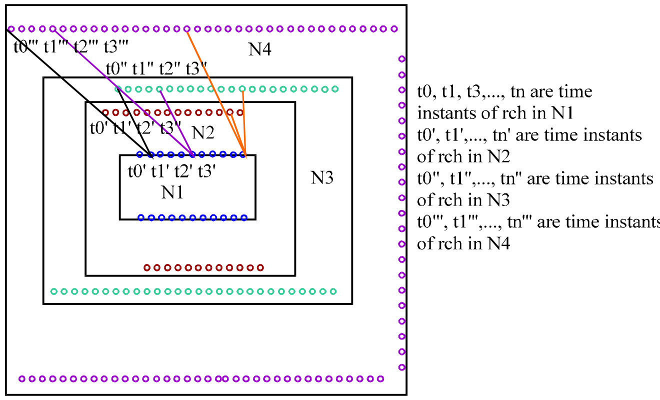

Fig. 2: Bayesian network modeling of heterogeneous network

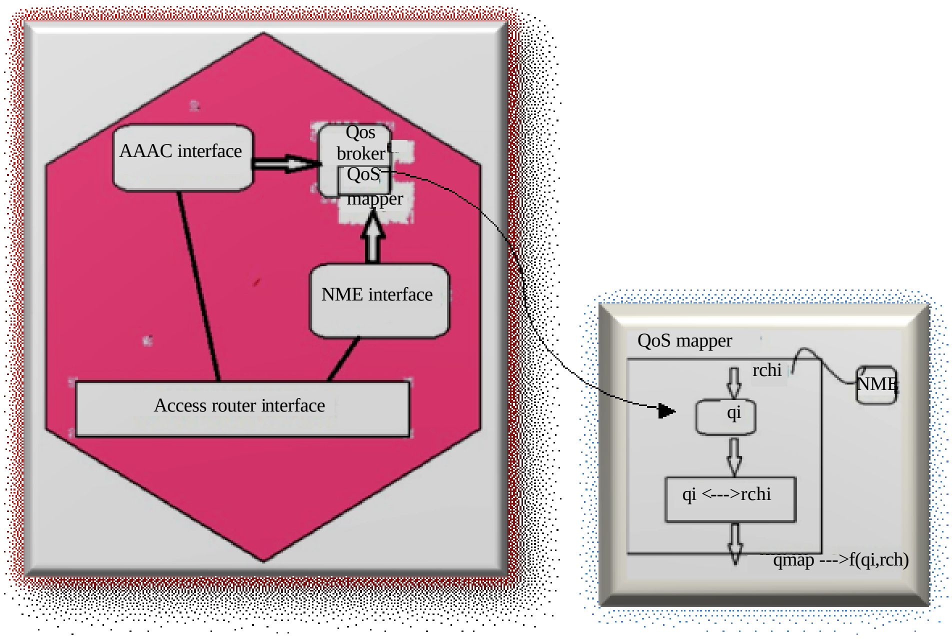

Fig. 3: Schematic diagram of QoS mapper

anticipating handover in those networks. Likewise, the rch of all networks are periodically estimated and updated in the QoS mapper.

The estimated rch is then averaged and the minimum value is always chosen as it reflects the minimal call blocking probability of the network. The status of minimum Cbp is reflected as high NQF for optimal network selection. The architecture considered in the analysis is as by Chen (2007) comprising of a heterogeneous wireless network domain with AAAC server, QoS broker+PDP network element equipped with AP (AR)+PEP to serve the users. The users after authentication by AAAC server are assigned channels based on the available quality of the service from QoS broker of the traffic class.

A QoS mapper module is proposed as shown in Fig. 3 in QoS broker to estimate and map the available channel with QoS and to reschedule the available resources to be distributed for requesting services. From the authentication information of the users, their recent call history-rch over a average period of time is also estimated jointly from AAAC server, QoS broker and QoS mapper. The estimated rch is reflected in terms of Cbp of a network.

The prediction of rch parameter in a network avoids unnecessary handoff by estimation of call blocking probability-Cbp of a network and the prediction selection of optimum network among the available networks thus enhancing the QoS and USF.

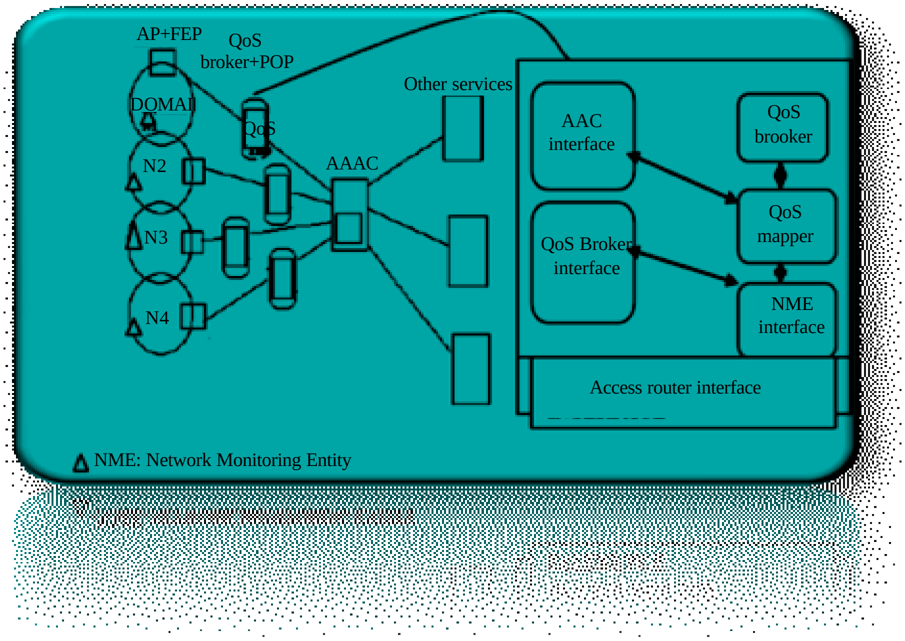

Fig. 4: Proposed heterogeneous network domain

Table 1: Measured network status in and around Tiruchirappalli district over an average period of time

Cell type	Available TCH (Max.)	Busy TCH (Max.)	TCH blocking rate	TCH usage (msec)	Call set up success rate	Drop rate	Outgoing handover success rate	Incoming handover failure rate	Incoming handover success rate	Total traffic (Erlangs)	Utilization (%)	Total data volume DL (kb)	Total data volume UL(kb)
3G	29	38	0.13	841046135	99.14	0.18	97.77	0.08	98.15	233.76	46.294976	41516.31	18378.20
2G (1)	20	19	0.08	255251910	99.46	0.54	97.43	0.18	98.77	70.80	22.379002	17783.69	5334.57
2G (2)	29	10	0.37	137723130	98.86	1.23	96.29	0.27	96.54	38.40	21.039000	3442.58	1105.96
WiFi	11	10	2.28	27760130	98.09	1.89	88.94	0.51	91.09	12.96	9.244201	6764.84	894.63

In a scenario shown in Fig. 4, there are four heterogeneous network domains viz., N1, N2, N3, N4 as 2G(1), 3G, WiFi and 2G(2) networks, respectively with their corresponding BSC/AP along with PEP (Policy Enforcement Point) attached to QoS broker and PDP (Policy Decision Point) (Marques *et al*., 2005). A QoS mapper is proposed in QoS broker to map the traffic class with available quality of service along with the recent call history of the network domain. Of all the available networks, their recent call history is estimated over an average period of time from the information provided by NME network monitoring entity present at various points in a network.

The networks are then arranged along with other design parameters such as cost factor, bandwidth utilization, packet delivery ratio, delay and call blocking probability. The call blocking probability of a network is measured over an average period based on the rch of the available networks. The networks are then ranked based on Cbp in terms of NQF. This estimation improves the performance of always best connected networks pertaining to the various traffic classes.

Let N1, N2, N3, N4 be 2G(1), 3G, WiFi and 2G(2) networks, respectively have users demanding for voice, video, file transfer and interactive sessions. Assume all four networks, i.e., a 3G network, two 2G networks and a WLAN network are available to all users. Now, the optimum selection of always best available networks is not only based on the above mentioned design parameters but mainly depends on the estimation of call blocking probability. The network status of each network is estimated in terms of available TCH (traffic channels), busy TCH, average call blocking rate, call drop rate, call set up success rate and total traffic in each network as detailed in Table 1. The parameters are measured over different time instants at peak hour, festival hour and business hour and their average is taken using Monte-Carlo simulation. The measured parameters as mentioned in Table 1 about various networks corresponds to the measurement taken at various parts of Tiruchirappalli District, Tamilnadu, India. From these measurements three types of case studies are performed to appreciate the effectiveness of rch parameter.

Case study 1 (Selection of optimum network for voice traffic): Consider all four networks as detailed in Table 1 {2G(1), 2G(2), 3G and WiFi} are readily available to a user requesting for voice service. If the user selects

3G network then it causes inefficient resource usage as 3G attracts multimedia users rather than voice users. It is also clearly emphasized in the total traffic generation column of the Table 1. The next option is two 2G networks of which 2G(1) could be selected since it has less call blocking probability and call drop rate compared to 2G(2). But it is interesting and contradictory if available and busy TCH of 2G(1) and 2G(2) are investigated over an average period. 2G(2) network has less busy TCH than 2G(1) at the expense of higher call blocking probability. The geographical terrain, channel conditions and type of frequently handled traffic by the network are studied at various average period such as busy/peak, festival and business hours and their average values are simulated using Monte-Carlo simulation and measured in terms of the rch parameter of that particular network.

The network with lowest 'rch' is always chosen as it reflects least Cbp and high NQF. On the other hand, if WiFi is chosen then it will eventually drop the call during call progress phase as WiFi (from measured average value) has highest call drop rate. So, optimum network for voice traffic is 2G(1). On the other hand, the selection of 2G(2) leads to unnecessary hand-off before the call completion.

Case study 2 (Selection of optimum network for video traffic: The availability feature of networks is best estimated during session initiation which fits to voice and file transfer and e-mail like applications. However, this is not suitable for bandwidth hungry applications as they require adequate channels for session progressing till the entire downloading/streaming process. This is facilitated, only if the network status from recent history is estimated. Even, if all four networks are available, best connected optimum network is selected based on the estimation of the call blocking probability of the network.

Consider α_{ci}, β_{cj}, γ_{ck} be the traffic class of i voice users, j multimedia users and k non-real time applications users with 'c' number of occupied channels, respectively. Let q_{ij} be the quality of channels available in QoS broker module and ai be the authenticity of the ith user from AAAC server. rch(A, t) denotes the recent call history of networks over a period of time where A is the type of network and t is the time period taken for simulation.

The function of QoS mapper sub-module proposed in QoS broker module maps the corresponding allotted channels to the available networks based on the estimated call blocking probability. To calculate the call blocking probability, the novel parameter namely recent call history 'rch' over an average period of time pertaining to networks is estimated. The estimated 'rch' parameter implies the call blocking probability of 3G network is the least of all available network. Based on the status of call blocking probability. Always Best Connected optimum network is predicted and assigned to the users for enhanced performance.

For analysis, consider three networks A, B and C such as WiFi, 3G and 2G wireless networks. Each network has voice services (α), bandwidth hungry services (β) and other non-real time services (γ) with their respective allotted channels. At time period t1, the summation of all services occupation in each network is estimated over allotted channels as follows:

Network A:

$$\text{At t1}: \sum \alpha_{ci}+\beta_{cj} + \gamma_{ck} = \text{At1} \tag{5}$$

$$\text{At t2}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{At2} \tag{6}$$

$$\text{At t3}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{At3} \tag{7}$$

Network B:

$$\text{At t1}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Bt1} \tag{8}$$

$$\text{At t2}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Bt2} \tag{9}$$

$$\text{At t3}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Bt3} \tag{10}$$

Network C:

$$\text{At t1}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Ct1} \tag{11}$$

$$\text{At t2}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Ct2} \tag{12}$$

$$\text{At t3}: \sum \alpha_{ci}+\beta_{cj}+\gamma_{ck} = \text{Ct3} \tag{13}$$

The status of call blocking probability is derived by checking the channel occupancy status of each network over an average period of time instants such as t1, t2, t3 and t4 on a time unit:

$$\text{If At1} > C_A \rightarrow \text{high Cbp} \rightarrow \text{low rch}_A \text{ (least selected network)} \tag{14}$$

$$\text{If At1} < C_A \rightarrow \text{low Cbp} \rightarrow \text{high rch}_A \text{ (most selected network)} \tag{15}$$

$$\text{If At1} = C_A \rightarrow \text{medium Cbp} \rightarrow \text{medium rch}_A \text{ (Optional selected network)} \tag{16}$$

A similar procedure is followed for network B and C. However by bandwidth adaptation, call blocking probability of the network is improved from least selected status to optional selected status thus improving the throughput of the network as presented in Table 2.

Table 2: Weight assignment based on ‘rch’ at instants of time (numerical example)

Time instant	Networks A	B	C	Weights
t1	G	G	M	0.8
t2	G	M	M	0.7
t3	B	M	M	0.4
t4	G	B	G	0.7
Weights	1	0.8	0.9	G: Good (low Cbp), M: Medium (medium Cbp), B: Bad (high Cbp)

Table 3: Selection of network based on ‘rch’ at instants of time

Time instant	Optimum network selection based on NQF A	B	C
t1	✓	✓	×
t2	✓	×	×
t3	×	✓	✓
t4	✓	×	✓
Optimum network selected over average period ‘t’ time units	✓	×	×

Case study 3 (Selection of optimum network for non-real time data traffic): The optimum ABC network for data traffic is WiFi as it provides best resource utilization when compared to other networks. The QoS broker module is responsible for the channel allocation with permissible/available quality of service to the users, admission control, management of network resources and load balancing (Song *et al*., 2007). However, the non-availability of channels is delivered as blocked calls in the network.

The proposed QoS mapper module limits the call blocking probability by predicting the network status in terms of recent call history, ‘rch’ parameter over an average unit time. Thus by adapting the time instants, weight is calculated based on the estimation of recent call history by which the call blocking probability of the networks is predicted. Weights are normalized after 0-1 scale. Higher the weights, lower is the call blocking probability and better is the status of the network. The simulation detail for network selection based on ‘rch’ at various instants of time is given in Table 3.

Experimental results and analysis: For simulation analysis, three regions namely A, B and C are considered to comprise three network domain namely X, Y and Z. Here, X is a WiFi (11 Mbp), Y is a 3G (1.5 Mbp) and Z is a 2G (256 kbp) network. Region A has 5 mobile nodes in additionto 95 stationary nodes, region B is simulated with 4 mobile nodes and 96 immobile nodes, region C with 5 mobile nodes part from 95 other nodes. Various applications like voice, video/multimedia and e-transaction are taken for simulation. The network status is estimated from NME-Network Management Entity present at various points in the network.

QoS broker module estimates the available channel with the requested QoS. The QoS mapper maps the estimated network status which is observed over a average period of time instant as ‘rch’ parameter. The ‘rch’ parameter is utilized for calculating the probability of call blocking. This anticipated network status lowers the unnecessary handovers among the available networks thereby improving the performance of always best connected network. Besides the estimation of distance, cost factor, security issues and bandwidth of the available networks, prediction of ‘rch’ parameter avoids unnecessary handover.

The simulated results clearly exhibit the selection of optimum networks. This estimation shall be useful particularly for multimedia applications. Even though, all the three networks are available, the selection of best/optimum network based on the parameters such as cost, bandwidth, distance and security, shall be effective for low bandwidth applications only (Kibria and Jamalipour, 2007).

However, for bandwidth hungry applications such as multimedia streaming, mere availability of networks does not suffice the progress of the application in the same network except initialization phase. But at the same time, the applications need to face unnecessary handover if the recent call history ‘rch’ parameter of the available networks is not estimated. Therefore by predicting the behavior of the network in terms of ‘rch’ parameter, the performance of always best connected optimum network could be improved.

Selection of optimum network for applications considering ‘rch’ parameter: In real time applications, user can select any type of application like as video calling, voice calling, internet and e-Transaction and so on. An application selection module for setting the specific application with some fixed properties preference is given (Xiao *et al*., 2000; Chen, 2007) in Table 4 and 5.

Table 4: Design parameters for various applications

Applications	Cost	Distance	Security	Bandwidth
Voice	Low	Medium	Low	Low
Video	Medium	Medium	Medium	High
e-Transaction	Low	Low	High	Low

Table 5: Simulation parameters

Parameters	Values
BS range radius (m)	1000
AP range radius (m)	500
Terrain-dimensions (m)	1500,1500
BS-AP distance (m)	1200
Frequency band (GHz)	2.4
Handover RSS trigger	-78.0
Handove RSS margin	3.0
Channel bandwith (MHz)	20
Frame duration (msec)	20
FFT size	2048
MS velocity (m sec^{-1})	20
BS transmit power P_t = [dBm/height] (m)	20/5
AP transmit power P_t = [dBm/height] (m)	20/1.5
MS transmit P_t = [dBm/height] (m)	15/1.5
Somulation time (sec)	25
Traffic	CBR

Table 6: Simulated output results of various wireless networks

Network type	Traffic type	Avg. end to end delay (sec) 30 nodes	Avg. end to end delay (sec) 100 nodes	Throughput (%) 30 nodes	Throughput (%) 100 nodes	Selection of optimal network based on NQF
2G(1)	CBR	0.007090	0.019230	46.60	62.00	Voice applications
	FTP	0.005617	0.003098	24.30	2.00	
2G(2)	CBR	0.003280	0.026300	13.60	21.40	NRT based web transfer applications
	FTP	0.002960	0.003010	20.50	2.13	
3G	CBR	0.017600	0.013030	89.60	47.20	Multimedia streaming
	FTP	0.002980	0.002978	96.70	14.00	

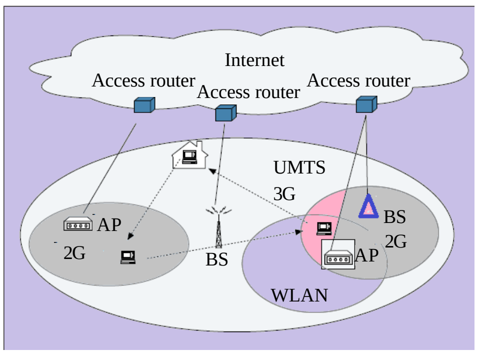

Fig. 5: Simulation scenario

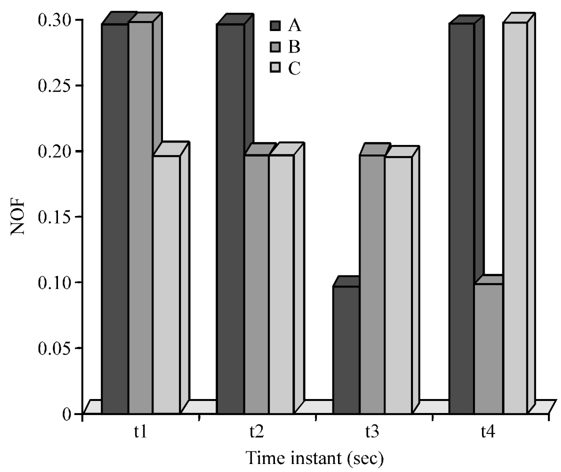

Fig. 6: Simulated results depicting availability of optimum networks in terms of NQF (Y-axis) at various time instants (X-axis)

From the simulated experimental results of Fig. 5, 6 and Table 6 it is very clear that at the time instant t1, of all three available networks, Always Best Connected optimum network is net A/B which has least call blocking probability. Here, time instant is 235 msec and is run periodically to progress to t2, t3 and t4. A buffer size of 80 for a channel capacity of 340 channels are assumed which produces a worst case delay of 235 msec. This assumption of 235 msec is small enough for streaming applications. However, at t2, net A is always best connected network, at t3 either B/C is selected and at t4, net A/C is best network with least call blocking probability. Thus by predicting 'rch' of networks over a period of time instants. Always Best Connected optimum network could be selected among the available best networks with low call blocking probability.

CONCLUSION

The prediction of the proposed 'rch' recent call history parameter in QoS mapper over a time period estimates call blocking probability and lowers unnecessary handoff among the available networks. In existing methods, selection of best network is carried out by estimating distance, cost, security and bandwidth. However, in the existing method, the availability of optimal network is estimated but, in the proposed method, network quality factor based 'rch' parameter prediction of networks translates the network status from best connected to Always Best Connected optimum network thereby enhancing the network performance and user satisfaction.

REFERENCES

Chen, Y. and Y. Yang, 2007. A new 4G architecture providing multimode terminals always best connected services. IEEE Wireless Commun., 14: 36-41.

Chen, Z., 2007. A customizable QoS strategy for convergent heterogeneous wireless communications. IEEE Wireless Commun., 14: 20-27.

Jiang, J., J. Li, R. Hou and X. Liu, 2013. Network selection policy based on effective capacity in heterogeneous wireless communication systems. Sci. China Inform. Sci., 10.1007/s11432-013-4899-1.

Kappler, C., P. Poyhonen, M. Johnsson and S. Schmid, 2007. Dynamic network composition for beyond 3G networks: A 3GPP viewpoint. IEEE Network, 21: 47-52.

Kibria, M.R. and A. Jamalipour, 2007. On designing issues of the next generation mobile network. IEEE Network, 21: 6-13.

Lahby, M. and A. Adib, 2013. Network selection mechanism by using M-AHP/GRA for heterogeneous networks. Proceedings of the 6th Joint IFIP Wireless and Mobile Networking Conference, April 23-25, 2013, Dubai, pp: 1-6.

Malanchini, I., M. Cesana and N. Gatti, 2012. Network selection and resource allocation games for wireless access networks. IEEE Trans. Mobile Comput., 12: 2427-2440.

Marques, V., R.L. Aguiar, C. Garcia, J.I. Moreno, C. Beaujean, E. Melin and M. Liebsch, 2003. An IP-based QoS architecture for 4G operator scenarios. IEEE Wireless Commun., 10: 54-62.

Marques, V., X.P. Costa, R.L. Aguiar, M. Liebsch and A.M.O. Duarte, 2005. Evaluation of a mobile IPv6-based architecture supporting user mobility QoS and AAAC in heterogeneous networks. IEEE J. Selected Areas Commun., 23: 2138-2151.

Ren, T., I. Koutsopoulos and L. Tassiulas, 2002. QoS provisioning for real-time traffic in wireless packet networks. Proceedings of the Global Telecommunications Conference, Volume 2, November 17-21, 2002, Taipai, Taiwan, pp: 1673-1677.

Sehgal, A. and R. Agrawal, 2010. QoS based network selection scheme for 4G systems. IEEE Trans. Consumer Electron., 56: 560-565.

Shen, W. and Q.A. Zeng, 2008. Cost-function-based network selection strategy in integrated wireless and mobile networks. IEEE Trans. Vehicular Technol., 57: 3778-3788.

Song, Q. and A. Jamalipour, 2005. Network selection in an integrated wireless LAN and UMTS environment using mathematical modeling and computing techniques. IEEE Wirel. Commun., 12: 42-42.

Song, W., W. Zhuang and Y. Cheng, 2007. Load balancing for cellular/WLAN integrated networks. IEEE Network, 21: 27-33.

Verikoukis, C., L. Alonso and T. Giamalis, 2005. Cross-layer optimization for wireless systems: An European research key challenge. IEEE Global Commun. Newslett., 47: 2-3.

Xiao, Y., C.L.P. Chen and B. Wang, 2000. Quality of service provisioning framework for multimedia traffic in wireless/mobile networks. Proceedings of the 9th International Conference on Computer Communications and Networks, October 16-18, 2000, Las Vegas, NV., pp: 644-648.