# QoS Based Handover Technique for Network Based Network Mobility (N-NEMO)

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**Abstract:** In network based network mobility (N-NEMO), the automatic network selection during the mobility and handover scenarios are very challenging process. Most of the existing works concentrate only on selection of target network during handover execution. Also the user's Quality of Service (QoS) requirements are not taken into consideration. ***Approach:*** In this paper, we propose a QoS based handover technique for network-based network mobility (N-NEMO). The proposed architecture uses tunnel splitting scheme that establishes the global tunnel among local mobility anchor (LMA) and mobile access gateway (MAG) and local tunnel among mobile router (MR) and MAG respectively. Each mobile node estimates the QoS preferences such as bandwidth, battery power, received signal strength and link quality. Based on the estimated value, the priority list of MAG is build so that the best suitable MAG appears first in the list. The generated priority list is sent to the core network along with the handover request. Based on the handover scenario, core network executes either inter-domain or intra-domain handover technique. ***Results****:* By simulation results, we show that the proposed technique is efficient in terms of throughput, bandwidth usage, power conservation and delay.

**Conclusion:** An effective QoS based handover technique is designed for N-NEMO.

**Keywords:** Network Mobility (NEMO), Mobile Access Gateway (MAG), Quality of Service (QoS).

## 1. Introduction

### 1.1 Network Mobility (NEMO)

The mobility of an entire network that alters the sole attachment point to the Internet and transmission of entire data packets to and from the mobile network through one or more selected mobile routers (MR) is termed as network mobility. [1] [6] NEMO basic support protocol (BSP) is an extension of mobile IPv6 for network mobility. The mobile node connections are offered by MR which acts as a gateway for the mobile networks. The mobile network node (MNN) can be either fixed or mobile. The categories of mobile nodes which are supported by the MR are a follows

- **Local Mobile Nodes (LMN):** These nodes are mobile and correspond to the mobile network as its home network. .
- **Local Fixed Nodes (LFN):** These nodes are fixed and connectivity is offered by MR. LFN possess the similar home agent as MR.
- **Visiting Mobile Nodes (VMN):** These nodes connect with mobile network temporarily and do not belong to the mobile network [2].

NEMO BSP protocol facilitates the entire network to wander around different access networks devoid of disturbing current sessions of network nodes and exclusive of necessitating any particular mobility capability in the hosts. [3]

NEMO minimizes the number of handovers of individual hosts and power consumption of mobile host (MH) which is its main advantage. [4].

### 1.2 Preamble

Mobility management has been a significant issue for maintaining seamless communication commencing from cellular networks. The techniques included in mobility management are Location management and handoff management. The tracking and updation of current location of mobile nodes (MN) are performed by location management technique. The process of upholding the active link when the MN changes its attachment point is performed using handoff management scheme. As MN's alter their point of attachment regularly and the network topology gets altered unexpectedly, mobility management is vital for offering high-speed and seamless service for vehicular networks.

The mobility management technique must assure the reachability to correspondent nodes (CN) in the internet in addition to global reachability to mobile nodes. [5]

The process of transmitting the traffic of on-going session(s) from one access point to another is termed as handoff. [1] A mobile network is linked with internet

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through one or more MRs. MNNs behind MR possess transparent movement. The home link includes an entity called Home Agent (HA) through which the mobile router register its care of address (CoA) and prefix. HA interrupts packets on the home link intended to the mobile network and performs encapsulation and tunneling of packets to the MR's registered CoA, though mobile network is far apart from home. MRs obtains network layer access to the global internet from AR through which the transportation of the packets from or to the internet occurs at the foreign link. [7] NEMO's handover procedure does not vary from MIPv6's handover scheme. Hence FMIPv6 and HMIPv6 protocols can be applied for MIPv6 handover progress.
The two process involved in the FMIPv6 are as follows

1) Defining a new CoA: this is done to eliminate the latency owing to new prefix discovery following L2 handover even when MN is present on the previous access routers's (PAR) link.
2) Setting up a tunnel between the previous CoA and the new CoA: This is done to transmit the packet sent to PAR to MN's New AR (NAR) that further minimizes the packet loss.

HMIPv6 minimizes the handover latency by laying a hierarchical network structure and minimizing the signaling overhead. However, HIMPv6 is more adaptable to micro-mobility, and its handover latency does not meet the needs of performance-critical application [7].

### 1.3 Existing Challenges in NEMO

- In NEMO, the load balancing of multi-homing in nested mobile network is not considered widely. The handover delay among MR causes issues in accessing failure recovery scheme. Also there is no real path evaluation metric and algorithm available for selecting best path for load balance. [8]
- As NEMO BSP depends on MIPv6, it takes over the drawbacks of MIPv6 that includes long signaling delay and movement detection time. [9] Additionally some common issues such as sub-optimized routing and high overhead for the packet transmission occurs in the nested NEMO. [10]
- The QoS needs of vehicular applications create more challenges in mobility management design. The safety application possesses higher priority when compared to non-safety applications and this priority should be assured though the handoff is performed. The handoff latency needs to be minimized for multimedia applications. [5]
- The process of using MIPv6 route optimization devoid of enhancement in NEMO generates problems.
    1) Since the CoA of an MNN in NEMO is linked with the home link of the MR, it does not offer the actual geographic location of the MNN. Hence the MNN's CoA cannot be utilized as a destination address in an IP data packet for the sake of route optimization.
    2) When MR's CoA is used by an MNN to perform RO, collapse of binding update occurs since entire MNN's requires updating their binding at HAs and CNs concurrently when an MR alters its CoA. [11]
- When the entire network moves from one visited network to another, ITEF protocol is not appropriate. During this case, Mobile IP protocol provides massive signaling. [7]
- The packet loss and latency occurring in NEMO during handover, when the mobile network travels from previous access router (AR) to its new AR, causes degradation in the on- going session performance. [7]

### 1.4 Problem Statement

From literature survey, it is observed that the selection of network during the mobility of a mobile client plays an important and crucial role in the performance of the network. If the target network does not support the users' QoS requirements such as bandwidth, delay, power level etc. it will result in throughput degradation. Also the association and registration of the mobile client to the new network involve significant delay. Hence it is necessary to proactively predict the client movement and select the suitable network providing required QoS.

Thus our main is:

1) To design an effective movement prediction technique for the mobile clients of NEMO.
2) To develop a suitable network selection algorithm for effective mobility management in NEMO.
3) To consider the QoS requirements of the user while selecting the new target network.

## 2. Literature Survey

Rituparna Chaki and Nandini Guha Niyogi [6] have proposed an innovative scheme for handling the delay due to handover. The proposed scheme aims to free Mobility Anchor Point (MAP) from overload, while guaranteeing low latency due to handoff.
Hai Lin and Houda Labiod [7] have proposed a solution to improve NEMO handover performance for one kind of multi homed NEMO configuration (multiple mobile routers are located in a mobile network). The traffic between access routers and mobile routers is managed by a new control entity which is introduced in order to provide low latency and no packet loss. This entity is also responsible to select the next access point for mobile router when the latter

detects its movement. Using this hybrid approach, mobile router can predict a handover and has the best knowledge regarding its current location and state to initiate the handover. In addition, mobile router based on its current state can perform handover with different strategies, so as to improve handover performance.

Hyo-Beom Lee et al [9] have proposed a Network Mobility supporting scheme, which supports MNs' mobility between PMIPv6 network and mobile network as well as the basic network mobility. The proposed scheme introduces MAG functions to the MR and extends PMIPv6 network to a mobile network. Therefore MN handovers between the mobile network and PMIPv6 network with only IPv6 stack.

### 2.1 Outcome of Literature Survey

In mobility management and handoff situations, automatic network selection plays a crucial role in the functionality of the whole network. Most of the existing works concentrate on the selection of the target network during a handover (HO) execution or the establishment of a new call. Also the user's Quality of Service (QoS) requirements are also not considered in selection of target network. Also, most of the proposed mechanisms do not provide details about how the additional functionality can be integrated into existing network mobility (NEMO) standards.

## 3. Research Methodology

### 3.1 Overview

In this paper, we propose a QoS based handover technique for network-based network mobility (N-NEMO). The proposed network is based on a tunnel splitting scheme that establishes the global tunnel among local mobility anchor (LMA) and mobile access gateway (MAG) and local tunnel among mobile router (MR) and MAG respectively. Each mobile node (MN) estimates the QoS preferences such as bandwidth, battery power, received signal strength and link quality. The priority list of MAG is build which is sorted in descending order of combined values of estimated QoS preferences such that the best suitable MAG appears first in the list. The generated priority list is sent to the core network along with the handover request. Based on the handover requirement, core network executes either inter-domain or intra-domain handover technique.

### 3.2 Architecture of N-NEMO

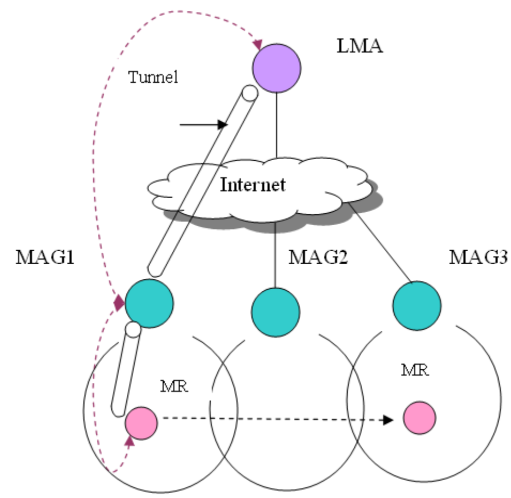


Fig 1 Architecture for N-NEMO

Figure 1 demonstrates the architecture of network based network mobility (NEMO) which is based on tunnel splitting scheme.

The core functional entities in the N-NEMO are the local mobility anchor (LMA) and the mobile access gateway (MAG).

**LMA**: It is responsible for maintaining the MN's reachability state and is the topological anchor point for the MN's Home Network Prefix (HNP)**.**

**MGA**: It is the entity that performs the mobility management on behalf of the MN and it resides on the access link where the MN is anchored. The MAG is responsible for detecting the MN's movement to and from the access link and for initiating binding registrations to the MN's LMA.

There exist two tunnels in the architecture.

**1) Global tunnel**: This is established between local mobility anchor (LMA) and mobile access gateway (MAG).

**2) Local tunnel**: This is established between mobile router (MR) and MAG.

The MR includes mobile network nodes which are categorized into three groups such as local fixed nodes (LFNs), local mobile nodes (LMNs), and visiting mobile nodes (VMNs).

### 3.3 Estimation of QoS Metrics

#### 3.3.1 Estimation of Available Bandwidth (AB)

The available bandwidth (AB) at a link is defined as its unexploited capacity. At any time t, a link can be either idle or transmitted packets at the maximum speed. Hence the definition of AB takes average unexploited bandwidth over time interval T into consideration which is given by following Eq. (3)

$$AB_i(t, T) = \frac{1}{T}\int_{t}^{T+t}(LC_i - \sigma_i(t))dt \quad (3)$$

Where $AB_i$ (t, T) = Available bandwidth at link i at time t,
$LC_i$ = Link's capacity
$\sigma_i$ = Traffic.

The available bandwidth along a path is the minimum available bandwidth of all traversed links. [13]

### 3.3.2 Estimation of Consumed Battery Power ($\Delta$E)

The power consumption in WiMAX networks are as follows. [14]

$$\Delta E = n * P_{wx} * L(1+\alpha) / R_{wr} \quad (4)$$

where $\Delta$E = power degradation or consumed power
n= number of packets.
$P_{wx}$ = transmit power
$R_{wr}$ = received power
L = Length of the packet
$\alpha = R_w / P_{wx}$

### 3.3.3 Estimation of Received Signal Strength (RSS)

The channel condition can be estimated based on the received signal strength (RSS) and signal to noise ratio (SNR) at the receiver. RSS is estimated using Friis equation which is given using Eq: (5) [15]

$$RSS = \frac{P_{tx} * \alpha * \beta * h_{tx} * h_{rx} * \eta^2}{(4 * \eta * d)^2 * \varepsilon} \quad (5)$$

Where
$P_{tx}$ = Transmission power
$\alpha$ = Transmitter gain
$\beta$ = Receiver gain
$h_{tx}$ = Transmitter height
$h_{rx}$ = Receiver height
$\eta$ = Wavelength
d = Distance between the transmitter and receiver.
$\varepsilon$ = System loss

SNR is computed from the received signal power (RSS) using Eq: (6)

$$SNR = \log_{10}(P_{tx}) - \log_{10}(P_{rx}) \text{ dB} \quad (6)$$

Where $P_{rx}$ = Receiver Power

### 3.3.4 Link Quality Estimation (EETTi)

The links holding highest link quality are permitted to transmit more packets when the poor quality links are still waiting to link improvement. This perhaps enhances the link quality. If the link performs normally then the poor quality link could try to communicate. The Exclusive expected transmission time (EETT) metric is utilized to estimate the link quality. It offers a better evaluation of a multi-channel path.

Consider N-hop path with M channels.

For a given link z, its interference set ($\kappa$) is defined as the set of links that has interference with it. A link's interference set also includes the link itself. Then the link z's EETT is defined as:

$$EETT_i = \sum_{linki \in \kappa(z)} ETT_i \quad (7)$$

where $\kappa$(z) is the interference set of link z.

## 3.4 Proposed Algorithm

Each MN considers user's QoS preference like AB and $\Delta$E. (Explained in section 3.3.1 and 3.3.2). Additionally, they also consider RSS and EETT of MAG (Explained in section 3.3.3 and 3.3.4). MN stores the estimated values in its route cache.

MN initially verifies the RSS value of each link and EETT of each MAG for supporting the requested service. The verification is based on the following conditions.

Let $L_i$ represents the link
Let $MAG_i$ represent the existing mobile access gateway. (i=1, 2, 3,…n)

1) If (RSS ($L_i$) =high) && (EETT ($MAG_i$) = high)
   Then
      $MAG_i$ is added in the Priority list (PL) which is built based on respective user's QoS preferences
   Else
      Particular $MAG_i$ is eliminated
   End if
2) Estimate AB and $\Delta$E related with each $L_i$ with respect to each of the available $MAG_i$ in PL.
3) The priority list is then sorted in descending order of combined values of AB and $\Delta$E such that the best suitable MAG appears first in the list.
4) Then, the sorted list is sent to the core network along with Handover request (HOR).

$$MN \xrightarrow{PL(HOR)} \text{Core network}$$

5) If (AB and $\Delta$E) < Th
   Then
      MN finds the combination of connections of $MAG_i$ with max (AB and $\Delta$E).
      MN eliminates the $MAG_i$ with min (EETT)
      MN sorts the remaining $MAG_i$ as per user preference
      Repeat step 4.
   End if

When the battery power level and available bandwidth of current MAG are below the user defined threshold values, the MN determines the combinations of connections of MAG having more battery power level and bandwidth. It then eliminates the entire MAG with inadequate link quality for each connection. The remaining sets are sorted based on the user preferences. The list is then sent to the core network along with HO request.

### 3.5 Handover Execution

There are two possibilities of handover occurrence.

1) **Intra-domain handover:** In this scenario, the movement of MN occurs among the MR's which are located within the same MAG.
2) **Inter-domain handover:** In this scenario, the movement of MN occurs among the MR's which are located under different MAG.

Using Figure 2, handover execution is demonstrated in detail. The mobile network nodes included in $MR_1$ are ($LMN_1$, $LMN_2$), ($LFN_1$, $LFN_2$) and ($VMN_1$, $VMN_2$) Similarly ($LMN_3$, $LMN_4$), ($LFN_3$, $LFN_4$), ($VMN_3$, $VMN_4$) are located within $MR_2$. Both $MR_1$ and $MR_2$ are held within $MAG_1$.
In the same way, ($LMN_5$, $LMN_6$), ($LFN_5$, $LFN_6$) and ($VMN_5$, $VMN_6$) are located within $MR_3$. ($LMN_5$, $LMN_6$), ($LFN_5$, $LFN_6$), ($VMN_5$, $VMN_6$) are located within $MR_4$.
Both $MR_3$ and $MR_4$ are within MAG2.
Let $U_{pb}$ represent the proxy binding update.
Let $U_{lpb}$ represent the localized proxy binding update.

***1) Intra-domain handover***

The steps involved in the intra-domain handover are as follows.

1) When $VMN_1$ moves from $MR_1$ to $MR_2$, both its detachment and attachment are detected by $MR_1$ and $MR_2$ separately.
2) For $MR_1$, $U_{lpb}$ message is sent to the MAG1. Then $MAG_1$ maintains the global tunnel for $VMN_1$ temporarily.

$$MR_1 \xrightarrow{U_{lpb}} MAG1$$

3) For $MR_2$, $U_{lpb}$ message is sent to the MAG1 for the registration of $VMN_1$. Upon receiving $U_{lpb}$ from $MR_2$, $MAG_1$ detects that there exists the state of $VMN_1$ and it sends the acknowledgment (ACK) message to $MR_2$ and another ACK message to $MR_1$ for the deregistration process.

$$MR_2 \xrightarrow{U_{lpb}} MAG1$$

$$MR_2 \xleftarrow{ACK} MAG1$$

$$MR_1 \xleftarrow{ACK} MAG1$$

***2) Inter-domain handover***

The steps involved in the inter-domain handover are as follows.

1) When $VMN_3$ moves from $MR_2$ to $MR_3$, its detachment and attachment are detected by $MR_2$ and $MR_3$.
2) For $MR_2$, $U_{lpb}$ message is sent to MAG1. Then the MAG1 maintains the global tunnel for $MR_2$ temporarily.

$$MR_2 \xrightarrow{U_{lpb}} MAG1$$

3) After time t, the MAG1 sends the $U_{pb}$ message to the LMA for deregistration. LMA then sends ACK message to $VMN_1$ for deregistration.

$$MAG1 \xrightarrow{U_{pb}} LMA$$

$$LMA \xrightarrow{ACK} VMN1$$

4) For $MR_3$, $U_{lpb}$ message is sent to $MAG_2$ for the registration of $MR_2$.

$$MR_3 \xrightarrow{U_{lpb}} MAG_2$$

Upon receiving $U_{lpb}$ message from $MR_3$, MAG2 detects that there is no state of $MR_2$ and transmits $U_{pb}$ message to LMA in order to establish the global tunnel. Then the MAG2 sends the ACK message to $VMN_3$ for local binding acknowledgement.

$$MAG2 \xrightarrow{U_{pb}} LMA$$

$$MAG2 \xrightarrow{ACK} VMN_3$$

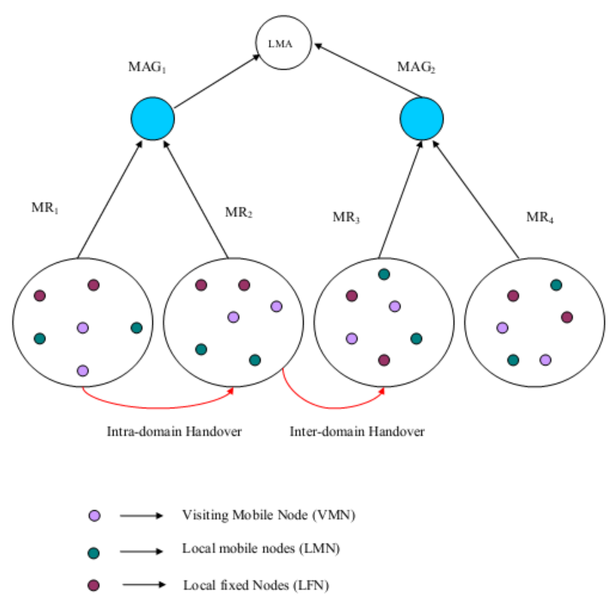


Fig 2 Handover execution in N-NEMO

## 4. Simulation Results

We have used the Network Simulator (NS2) [12] to implement the proposed technique and obtained the results that the proposed technique is efficient in terms of throughput, bandwidth usage, power conservation and delay. Validation of results has been done by comparing the results of our proposed approach with an existing approach by simulating the concept in NS2. By varying different parameters such as the speed of the mobile node, power level and bandwidth in various scenarios of NEMO, we have conducted various experiments. The results have been obtained by mining the simulation trace files using AWK or PERL scripts and graph are plotted using the xgraph utility of NS2.

***Screenshots***

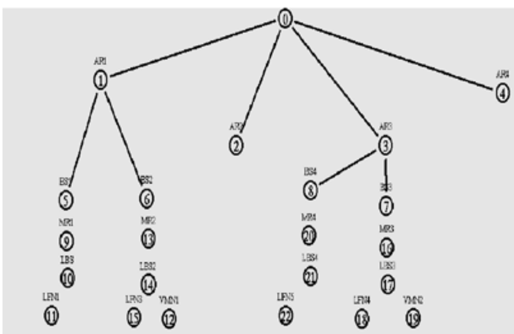

**Fig 3:** Topology

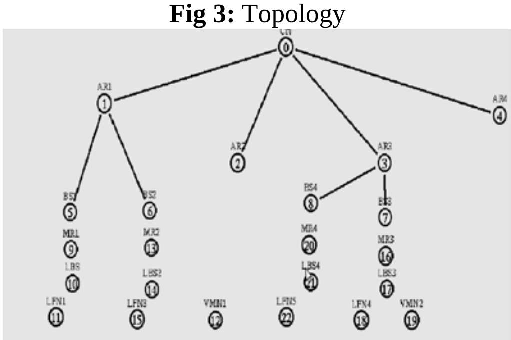

**Fig 4**: Topology

***Scen-1 (TCP)***
***Based on Speed***

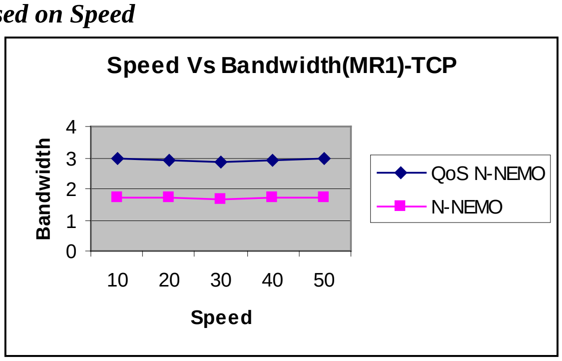


**Fig 5:** Speed Vs Bandwidth

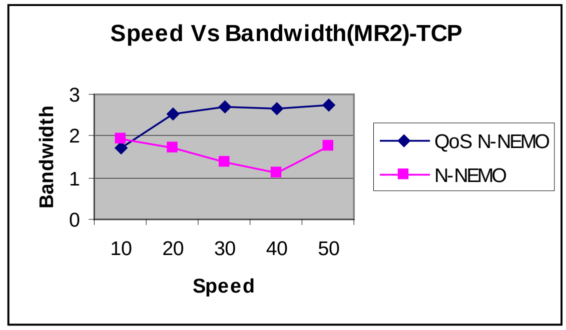


**Fig 6:** Speed Vs Bandwidth

***Based on Time***

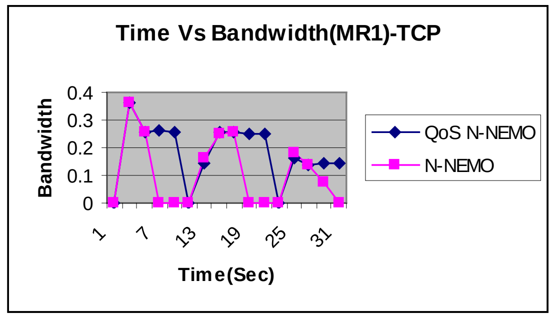


**Fig 7**: Time Vs Bandwidth

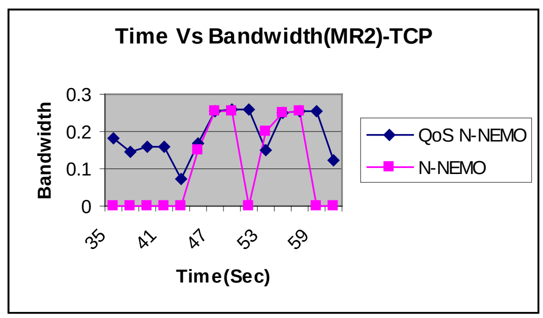


**Fig 8**: Time Vs Bandwidth

***Scen-2 (UDP)***
***Based on Speed***

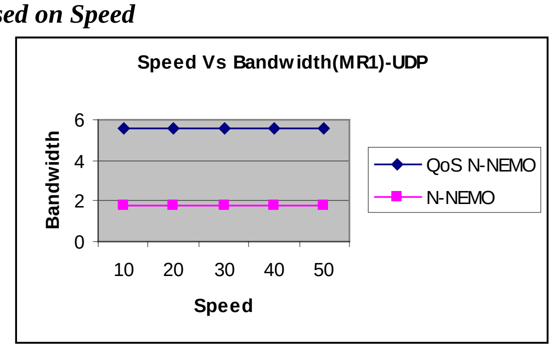


**Fig 9**: Speed Vs Bandwidth

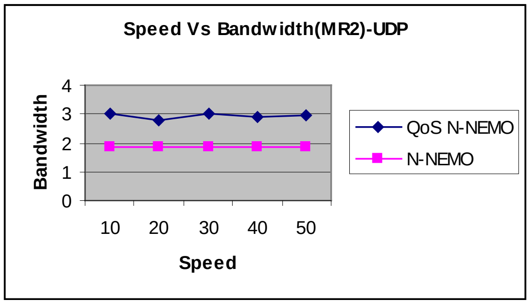


**Fig 10**: Speed Vs Bandwidth

***Based on Time***

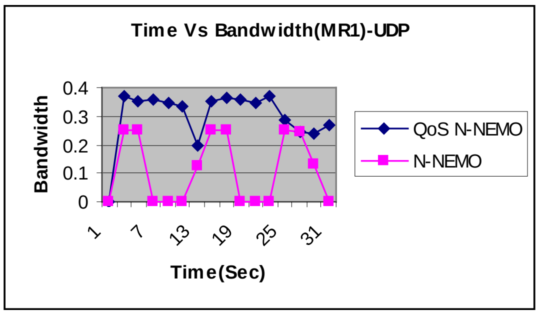


**Fig 11**: Time Vs Bandwidth

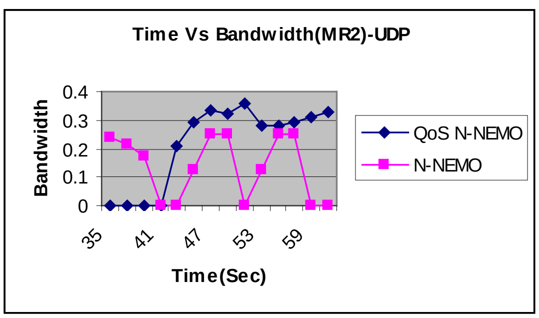


**Fig 12:** Time Vs Bandwidth

## 5. Conclusion

In this paper, we have proposed a QoS based handover technique for network-based network mobility (N-NEMO). The proposed architecture uses tunnel splitting scheme that establishes the global tunnel among local mobility anchor (LMA) and mobile access gateway (MAG) and local tunnel among mobile router (MR) and MAG respectively. Each mobile node estimates the QoS preferences such as bandwidth, battery power, received signal strength and link quality. The priority list of MAG is build which is sorted in descending order of combined values of estimated QoS preferences such that the best suitable MAG appears first in the list. The generated priority list is sent to the core network along with the handover request. Based on the handover scenario, core network executes either inter-domain or intra-domain handover technique. By simulation results, we have shown that the proposed technique is efficient in terms of throughput, bandwidth usage, power conservation and delay.

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