CHAPTER 9

CONCLUSION AND FUTURE WORK

9.1 CONCLUSION

The soft handover in 4G or next generation networks is the critical issue considered and solved in this thesis work. Seamless vertical handover decision was implemented based on game-theoretic Nash-equilibrium and the weighted-ranking approaches. Also the centralized media independent soft handover decision (CMISHD) framework based on quality metric score (QMS) was implemented. The speed based vertical handover with EEBEL braking was incorporated. The result showed that the network selection was based on maximal QoS of the network with minimal cost.

In next generation wireless networks, overlaid multiple wireless access systems with significantly different capabilities coexist. In such network environments, mobiles devices equipped with multiple air interfaces may execute diverse applications simultaneously. In this thesis, concept leveraging end-to-end mobility management and cross-layer technique is implemented in order to accomplish the following objectives:

1. Enabling the effective multi-layer triggering for handover decisions.
2. Enabling per-application handover decision and network selection.
3. Enabling transport and/or application specific control and adjustment when handover occurs.

The various seamless vertical handover decision schemes for 4G heterogeneous networks and VANETs are implemented. The implemented results exhibit that the seamless handover decisions are realistic with very less latency during handover in heterogeneous networks.

9.1.1 Seamless Vertical Handover Decision in 4G Networks

The implemented SMIVH shows that the total frames lost by transmitting the video without SMIVH algorithm is more than that of the transmission with Seamless Media Independent Vertical Handover algorithm. The seamless media independent vertical handover (SMIVH) algorithm was implemented in heterogeneous environments to accomplish the following tasks:

1. Reduction in packet drop during handover
2. Reduced delay
3. Increased throughput.

SMIVH algorithm considers the values of QoS and RSSI to perform handover decision in order to make efficient handover decisions and to avoid unnecessary handover, thus reducing the number of packet drops which in turn increases the throughput of the system. The mobile user is thus best connected to a network. Thereby, the user is able to achieve good communication even in remote areas.

Vertical handoff between WiFi, WiMAX and LTE networks was simulated based on RSS, combined QoS metrics and cost of real time multimedia data. To evaluate handover performance according to the users’ mobility, random walk mobility model along with pause time was adopted. MNs execute handover only if candidate WLAN can provide better data rates.
than currently attached eNB of LTE network. Thus inefficient handovers are prevented.

Table 9.1 Summary of Vertical Handover Decision in 4G Networks

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Implemented Solution</th>
<th>Featured Modules</th>
<th>Performances</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>Adaptive Bandwidth Allocation (ABA) &amp; Call Admission Control (CAC)</td>
<td>CAC, Maximum Bandwidth Utilization, NS-2.29 simulator</td>
<td>New call blocking probability (NCBP) and Handoff call dropping probability (HCDP): NCBP – decreased to 0 (based on traffic type) HCDP – decreased to 0 (based on traffic type) Bandwidth Utilization ((\gamma)) – Maximizing to Unity</td>
</tr>
<tr>
<td>3</td>
<td>Congestion-aware Vertical Handover Decision</td>
<td>Congestion Estimator, Erlang Loss function based congestion computation, MATLAB 2012a</td>
<td>Handover decision based on RSS and congestion factor: LTE to WiMAX handover WiMAX to LTE handover No Handover (Based on necessity)</td>
</tr>
</tbody>
</table>
| 4     | Policy based Vertical Handover Decision | Cross-layered Policy Engine, Tracegraph tool | Increased throughput (average 20%) Decreased packet loss (average 12%), end-to-end delay and jitter.
Congestion aware vertical handover decision algorithm was simulated. The performance of each handover was analyzed and compared. This thesis concentrated on the integration of LTE and WiMAX networks. The vertical handover between the heterogeneous networks was simulated using MATLAB. Based on the received signal strength and the congestion factor the state of the mobile node is the criterion for network selection.

The summary of obtained performance improvements of vertical handover decision for 4G networks against the existing works are discussed and tabulated in Table 9.1.

9.1.2 Seamless Vertical Handover Decision in VANETs

In vehicular networks, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications were done using Wi-Fi, WiMAX and UMTS / LTE heterogeneous networks. The horizontal and vertical handover decisions were made effectively using Game-Theoretic and MDP approaches. Also the crash was managed by calculating the safe distance using Intelligent Driver Model (IDM). The communication between the nodes was done using EEBL.

This thesis describes the minimal gateway selection mechanism and the speed based vertical handover algorithm. To guarantee acceptable Quality-of-Service and to support seamless connectivity, vertical handovers
avoidance. The system allocates a special lane for the emergency vehicles i.e. the emergency lane out of the multiple lanes. In normal situations all the vehicles can travel through this emergency lane. But when an emergency vehicle arrives, the vehicles in the emergency lane will move to some other lane making it free for the emergency vehicle.

**Table 9.2 Summary of Vertical Handover Decision in VANETs**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Implemented Solution</th>
<th>Featured Modules</th>
<th>Performances</th>
</tr>
</thead>
</table>
| 1      | VANETs Real-time Mobility Framework | • Nash-Equilibrium with EMD  
• NS-3.10 with SUMO  
• Merkaartor Road map | • Prioritize the Vehicles in the Lanes  
• Network utility ratio is high (packet delivery ratio) (i.e.,) Average increase of 55%  
• Collision messages  
• EEBL messages |
| 2      | Extended Constrained MDP with Emergency Braking | • NS-2.31 simulator  
• IDM model | • Speed limits and safe distance indication  
• Speed based Handover  
• Emergency Braking |
| 3      | Speed Based Vertical Handover | • Cluster and Gateway selection  
• NS-2.31 simulator | • Gateway node identified by cluster head selection  
• Increased packet delivery ratio  
• Call blocking and dropping probabilities are decreased |

The current system is inefficient under critical situations and slows down emergency vehicles. The warning is often recognized too late and drivers are confused about the position and direction of the emergency vehicle. This often leads to inappropriate reactions. To avoid this, combined
emergency lights and sirens warning system has been proposed and implemented that disseminates warning messages in a geographic region just ahead of the vehicle through the vehicular network. In addition to this collision avoidance system was also implemented. A minimum safe distance between two moving vehicles is fixed. When this rule is violated, warning messages are sent to the respective vehicles about it and thus collision is avoided.

Without using a realistic mobility model, performance results obtained from simulations of mobile ad hoc networks may not correlate well with performance in a real deployment. A realistic mobility model based on topological maps must include a traffic generation model and must take into account the preferential movements or destinations. So mobility model should be realistic as well as it should take all real world parameters in order to simulate the vehicular ad-hoc network protocols for which intelligent transportation was implemented.

The summary of obtained performance improvements of vertical handover decision with real-time mobility model for vehicular networks against the existing works are discussed and tabulated in Table 9.2.

9.2 DIRECTIONS FOR FUTURE WORK

The proposed application based handover decision mechanism was designed based on handling only for two kinds of data such as text and video which can be extended to handle other types of data like voice etc. In this simulation, RSSI and only few QoS parameters are considered. Other QoS parameters such as missed beacons and number of packets received with error can also be considered. Also, the authentication and the other security aspects when a mobile node registers with a base station can be considered.
The future direction can be:

1. The proposed MISH based handover decision mechanism is designed based on handling only a single application type which can be extended to handle realistic multiple applications simultaneously with different networks accessing in a mobile node.

2. There are various other QoS to be considered like missed beacons and number of packets received with error. But the implemented work considers only the number of dropped packets and the RSSI as the QoS parameters.

3. Also, the authentication and the other security aspects when a mobile node registers with a base station can be considered.

4. Enhanced handling of content delivery by incorporating powerful encryption methods while transferring data can be modelled.

5. Inclusion of new network parameters other than the traditional ones can be considered.

6. The implemented framework can be upgraded to accommodate their own family of networks or even other networks like opportunistic networks, body area networks, etc.

In future, VANETs with more real-time constraints like congestion-free mobility in the narrow roads or high density roads for implementing Vehicular mobility models can be considered. Safety and emergency reporting messages must be delivered on time with higher priority. This thesis work can further be extended to design a framework for designing VANET application protocol such as priority for emergency vehicles and delay
tolerance file sharing over VANETs protocol. The framework can also include the designing of new routing protocol based on predictive location. The designing of new mobility model and its performance evaluation by this framework will give better performances like highly sensitivity to delay and throughput.

In future, the fuzzy logic and neural networks trained input and mobility prediction approaches can to be incorporated for making the vertical handover decision. This thesis work can be extended to work on neural networks and can be combined with the proposed Game-theoretic solution approach by adding feed formula of the neural system. The decision can be faster when the logic is extended to a neural network’s soft computing strategies. The neural approach takes the data set consisting of bandwidth parameters of WiFi, WiMAX and LTE networks as input and the network id of the target network as the output.

The system can be allowed to get trained on the specific data set and the decision can be taken based on it. The network can be trained with Levenberg-Marquardt back propagation algorithm for 1000 iterations as per the data set and the performance can be measured using Mean Squared Errors (MSE). By properly selecting the learning rate and the acceptable error value, the system will be able to find the best available network successfully. The future work can also include trained genetic datasets for building seamless vertical handover decision framework which selects the best optimal network.