ABSTRACT

Mobile Ad-hoc networks (MANETs) are an emerging dimension in wireless networks. MANET enables wireless nodes to communicate without any support of fixed and centralized network as it does not follow any fixed network infrastructure and all nodes are free to move from one place to another. Routing protocols play an important role during exchange of information between nodes. Routing is a challenging task as topology is not fixed in MANET. Any node may move from one place to another at any point of time, and hence to predict the movement of any mobile node at an instance is difficult. Due to this dynamic change in topology the route establishment and its maintenance become complicated. As MANETs are not currently deployed on a large scale; hence most of the research in this area is being conducted by using simulation. Among various simulation parameters, mobility of nodes plays an important role in the assessment of routing protocols’ performance in MANET. Overall, the performance of routing protocols is significantly affected by the mobility. Thus, it is essential to study and analyze the performance of routing protocols with mobility and to investigate the impact of mobility on MANET routing protocols.

Choosing a routing protocol for a designed network scenario has become very critical issue and the same is required to be considered before its actual deployment. In present thesis an attempt has been made to investigate the impact of mobility by evaluating the performance of different routing protocols under different mobility models. Detailed simulations were carried out, using QualNet simulator with varying node density and speed. In simulation studies, the Random Waypoint Mobility, Group Mobility and File Mobility models were considered. It if plausibly considered that the aspect of mobility may affect the performance of routing protocols in MANETs. Conversely, it has clearly been observed from the simulation results that the node mobility has an adverse effect
on the performance of routing protocols in diverse networks scenario in MANETs. Simulation results also illustrate that the performance of routing protocols are significantly affected by the mobility models, data traffic pattern and node density. The entire work has been presented in six chapters. The chapter wise summary of the thesis is as follows:

**Chapter 1** is introductory and provides an overview of the state of the area of study including MANET characteristics, advantages and applications. This chapter also covers the routing protocols with their desirable properties and types. Different routing protocols have also been discussed; which were considered for the performance evaluation and simulation.

In **Chapter 2**, a review of the literature in the related field carried out. There have been several works in the literature that simulated, evaluated and compared the performance metrics of several routing protocols. The past studies related to the various routing protocols namely AODV, DSR, RIP, STAR, LANMAR, DYMO, FISHEYE, and ZRP, etc. are presented here.

**Chapter 3** presents information about the research methodology adopted in the study. The statement of the problem, objectives of the research work, scope of the study, limitations, tools and techniques used in the study have been elucidated in this section.

In **Chapter 4**, Simulation design and implementation is presented. The selected routing protocols chosen for the study is given along with the introductory part related to the simulator. The chapter also underlines the details about the network simulation and scenario design with the parameters used in performance evaluation of the routing protocols including mobility and traffic models.

**Chapter 5** contains the detailed analysis and interpretation of data. This chapter presents the simulation results obtained from the various simulations conducted
in QualNet for the performance metrics namely Average Jitter (s), Average End-to-End Delay (s), and Average Throughput (bits/s). The analysis part has been summarized in four different sections in this chapter.

In the first section, the impact of mobility on MANET routing protocols using OLSR and STAR routing protocols using Random Waypoint mobility model has been investigated. It is observed that the OLSR routing protocol gives a better performance than gives a STAR routing protocol. In absence of mobility, the STAR routing protocol gives a better performance than OLSR. Under the subsection of first section; the effects of varying mobility speeds on DSR and DYMO routing protocols have been presented. It is observed that the DSR routing protocol outperformed the DYMO routing protocol in case of throughput while the DYMO has the least delay and jitter as compared to the DSR routing protocol.

In the second section, the impact of mobility on MANET routing protocols under different traffic patterns has been investigated. The performance of AODV and DSR routing protocols using CBR and FTP traffic patterns under random waypoint mobility model has been presented. The interpretation of results indicates that the AODV routing protocol gives a better performance in comparison to the DSR routing protocol for both types of traffic patterns. It has also been observed that mobility has an adverse affect on the performance of AODV and DSR.

Summarized results of the DSR, DYMO and FSR routing protocols with CBR and FTP traffic patterns have been presented in a subsection. It has been observed that the performance of FSR, DSR, and DYMO routing protocols is decreased under the CBR traffic pattern. However, the DYMO routing protocol gives quite satisfactory results for average end-to-end delay and jitter as compared to those of DSR and FSR. Therefore, it can be concluded that traffic patterns have the significant effects on the performance of routing protocols.
The subsection of second section contains the performance comparisons of AODV, DSR and DYMO routing protocols for varying node density and speed under different traffic patterns. It has been observed that the AODV routing protocol gives the best performance overall for both CBR and FTP traffics as compared to those of DYMO and DSR routing protocols. However, DYMO has a higher throughput in case of FTP traffic than that of DSR, while the DSR outperform DYMO in case of CBR traffic.

The third section embodies the outcomes related to the impact of mobility on MANET routing protocols using Group, Random Waypoint and File mobility models with CBR traffic. The performance of nine routing protocols namely: Bellman Ford, FISHEYE, LANMAR, RIP, STAR, AODV, DSR, DYMO, and ZRP using varying node densities under Group mobility model has been investigated. It has been observed that the group mobility has significant impact on the performance of all the routing protocols. Simulation results shows that varying densities in groups and their mobility have a significant impact on the network performance which has not been documented previously.

However, choosing an efficient routing protocol is a critical task for studying the operations and performance of MANETs. It has clearly been indicated that reactive routing protocols AODV, DSR and DYMO are best suited for high dense networks with group mobility. While proactive routing protocols Bellman Ford, Fisheye, LANMAR, RIP, and STAR have underperformed in similar conditions due to increase in routing overheads. In highly dense networks with large groups; the reactive routing protocols give quite satisfactory results than the proactive routing protocols. It has been observed that the hybrid routing protocol ZRP is not suited for MANET with large groups as its overall performance is not satisfactory.

A subsection of this section summarises the performance of five proactive (FISHEYE, LANMAR, Bellman ford, RIP and STAR), three reactive (AODV, DSR,
and DYMO) and one hybrid routing protocol (ZRP) under the Random Waypoint mobility model. Simulation results are presented for performance metrics. It has been observed that the performance of these routing protocols degraded with the increasing mobility speed. This may be due to frequent routing failures under high mobility conditions which further lead to downfall in the packet delivery; during the process of communication.

The next section covers the performance comparison under File mobility model. It is observed that the performance of AODV reactive protocol is consistently showing better result with varying node density in case of all performance metrics.

The last section presents the discussion related to the impact of mobility models on MANET routing protocols. It is observed that the overall performance of various routing protocols is highly affected in terms of average end-to-end delay under File mobility model. On the contrary, the Random Waypoint mobility and Group mobility models show quite improved results for average end-to-end delay. The Random Waypoint mobility model is depicted the best performance efficiency as regards to end-to-end delay.

In general the reactive AODV, and RIP routing protocols performed better in comparison to all other routing protocols under all three mobility models in terms of average jitter.

In case of average throughput, the performance of DSR routing protocol is satisfactory under file model in case of low node density. Similarly, the DSR outperforms all other routing protocols in the case of high node density under Group mobility. In case of Random Waypoint model, the performance of DSR routing protocol is highly degraded and it underperforms for both high and low node density situations as compared to all other routing protocols.

In general, the throughput of AODV routing protocol improves with the increasing node density and it outperforms all other routing protocols in high node density
under File and Random Waypoint mobility. While the DSR shows better results in case of Group mobility model.

The DYMO routing protocol shows better results for high node density vis-à-vis between node density in File and Random Waypoint mobility models. However, the result is reversed in case of Group mobility model.

From File mobility model performance outcomes, it is concluded that the AODV, DSR, DYMO, RIP, ZRP and Bellman Ford perform satisfactorily in terms of throughput. While the performance of STAR and ZRP is poor.

From Random Waypoint mobility model outcomes, it has been found that the performance of Bellman Ford, RIP, STAR and ZRP is not satisfactory when compared to other protocols having low node density. In Group mobility model it has been observed that the AODV, DSR, Bellman Ford, RIP, STAR, and FISHEYE routing protocols indicated better throughput with increasing node density. On the other hand, the DYMO, LANMAR and ZRP routing protocols indicate moderate downfall in terms of throughput performance with increasing node density.

**Keywords:** Mobile Ad-hoc Network, Routing Protocols, Mobility Models and QualNet.