CHAPTER 7

CONCLUSION AND FUTURE ENHANCEMENTS

7.1 CONCLUSION

This research has focused on designing a clustering protocol and a service discovery with trust for a mobile ad hoc network (CST-MANET) to provide services to trusted nodes. In this work, a mechanism to offer services to the requester, such as the AETCP cluster constructor and the trust-based service discovery, is developed. The AETCP cluster constructor is used to select the cluster-head nodes to form clusters and maintain them. The trust-based service discovery contains the Semantic service discovery component and the DSmT-based Trust management system. The Semantic service discovery component including the DBF-based registration system and the semantic service matchmaker, are used to discover services, semantically, in the clustered ad hoc networks. The Trust management system, based on DSmT, is used to provide services to only the trusted nodes.

The AETCP cluster constructor is designed and developed for ad hoc networks. The AETCP considers metrics like mobility, residual energy, connectivity degree and distance to neighbors. This algorithm considers the combination of three techniques, namely, the AHP, Entropy and TOPSIS, for cluster head election. These integrated techniques are used to calculate both
the subjective and objective weights, followed by the ranking of the mobile nodes. Therefore, it reduces the mean number of clusters, reaffiliation rate and reelection rate, resulting in stable cluster heads and low energy consumption. It also reduces the delay and increases the throughput ratio during the cluster head selection process. The load balancing factor and overall energy consumption of the cluster head nodes are also improved.

The semantic service discovery component for the AETCP, based on the Dynamic Bloom Filter (DBF), is implemented. The semantic knowledge is acquired by designing a domain ontology and a service ontology for the civil unrest scenario. In the service directories, the DBFs, dynamic in size, are used to summarize the concepts and related terminologies of the service operation names. The DBF is integrated with the semantic service discovery approach, by making use of the hybrid service matchmaking algorithm. The effect of SSD-DBF on the AETCP does not cause a significant overhead on the network. The scalability of the DBF is better than that of the SBF, once the size of the service operation names exceeds the capacity of one SBF. Irrespective of the various number of nodes, the DBF takes less amount of time, in the service discovery process. When the number of SSD-DBF requests is increased, the average service discovery success ratios for the intra-cluster discovery and the inter-cluster service discovery are improved.

The DSmT-based Trust management system evaluates the direct and indirect trust computations of the service requester nodes. The trust transitivity rules are applied for the recommendation of trust computation. The mobile nodes may provide different opinions about the target service requester nodes, leading to paradoxical information. Using the DSmT rule of combination, legitimate decisions about these nodes can be taken, from the fusion of this paradoxical information. The direct trust values of the service
requester nodes are investigated in the presence of on-off attacks. The adaptive
time factor is used in the DSmT, to improve the service discovery success
ratio and the packet delivery ratio in the presence of on-off attacks. Thus, this
system provides services to trusted nodes.

7.2 JUSTIFICATION FOR THIS STUDY

One of the main factors in a MANET is to deal with a high service
request frequency. To address this issue, the clustering protocol is designed
using the AHP, Entropy and TOPSIS, which could be more efficient. The
conflicting criteria such as mobility, energy, distance and node degree are
considered in the cluster-head nodes’ selection problem. In the existing
approaches, more importance is given to one criterion, and less importance to
the other criteria. This relative importance or priority assigned to each
criterion may be contrary, due to differences in opinion. To overcome these
contradictory opinions, the designed system considers the relative importance
of the criteria, that can be computed using the AHP to handle multiple criteria
simultaneously.

Still, the level of uncertainty and diversification of information
contained in each criterion exists in the system. This can be estimated using
the Entropy method. For every criterion, an ideal solution exists among the set
of candidate mobile nodes. A candidate mobile node that is relatively close to
the ideal solution (i.e. rankings of mobile nodes) is thus identified, using the
TOPSIS method. The comprehensive assessment weight is obtained by
combining the weights that are evaluated from the AHP and Entropy methods.
Thus, the combined methods avoid improper selection of the clusterheads.
Then the TOPSIS method ranks the mobile nodes and selects the highest
weighted node as the cluster-head node.
Since the mobile nodes in MANETs can exchange and share each other’s services, there is a need for a service discovery protocol. Thus, the SSD-DBF is designed to address this issue. The services and service requests are described very expressively rather than conforming in a syntactic manner. The OWL-DL, based on description logics, allows a great expressiveness keeping computational completeness and decidability. In addition, a thesaurus is included to relate the concepts’ names with other terms using terminological relationships.

When one or more services are advertised or withdrawn at any point of time, from the ad hoc network, the cardinality of the set of services cannot be approximated. To address these issues, the DBF is a feasible option. The DBF supports interoperability between nodes and uses a suitable amount of memory (to avoid unnecessary waste and transmission overhead) by increasing its capacity in an incremental way, according to the set cardinality. The DBF is used to summarize the service operation names, and support probabilistic querying with a small probability of false positives. During the discovery process, the matching algorithm must consider partial matches, in addition to, complete matches between the service requests and the offered services. Thus, the FC-Match algorithm is considered to evaluate the similarity degree.

Since MANETs are deployed in uncontrolled environments and the nodes communicate with other nodes, their behavior changes with time and environmental conditions. Thus, trust is important for computing the nodes’ behavior. Since, trust is an individual’s belief; the set of mobile nodes can independently provide the behavioral information of another node. The combination of this behavioral information may lead to uncertain, highly
conflicting sources of evidence. The DSmT is able to solve this fusion problem in a dynamic manner.

7.3 CONTRIBUTIONS OF THIS RESEARCH

A system of a clustering protocol and a semantic service discovery with trust model (CST-MANET) has been designed and developed.

The performance of the CST-MANET is evaluated and compared with that of the existing approaches. The modules of the CST-MANET are the AETCP, SSD-DBF, and DSmT-based trust. The performance metrics are evaluated using the modified random way point mobility model and by varying the number of nodes from 60 to 100, the transmission range from 200 m to 350m and the maximum speed from 11 m/s to 15 m/s with the minimum speed of 1 m/s. Using these parameters, the following results of CST-MANET are achieved:

- The mean number of clusters of AETCP is reduced by 14% and 21% compared to that of the AHPCP and WCA.
- The reaffiliation rate of AETCP is decreased by 16% and 34% compared to that of the AHPCP and WCA.
- The reelection rate of AETCP is reduced by 18% and 35% compared to that of the AHPCP and WCA.
- During the cluster formation process, the overall energy consumed by the whole network in the AETCP is increased by 18% and 25%, compared to that of the AHPCP and WCA.
• On the contrary, the average energy consumption of the cluster head nodes in the AETCP is decreased by 2% and 4% compared to that of the AHPCP and WCA.

• The throughput ratio of AETCP is improved by 2% and 3% compared to that of the AHPCP and WCA.

• The average delay of AETCP during the cluster-head selection process is minimized by 14% and 27% compared to that of the AHPCP and WCA.

• During intra-cluster service discovery, the average service discovery success ratio of the SSD-DBF is 59%.

• During inter-cluster service discovery, the average service discovery success ratio of the SSD-DBF is 36%.

• Compared to the GSD, the service discovery success ratio of the SSD-DBF is increased by 4%.

• Compared to the existing approach, the service discovery success ratio of the DSmT-based trust model is improved by 3% in the presence of on-off attacks.

• Compared to the existing approach, the packet delivery ratio of the DSmT-based trust model is improved by 9% in the presence of on-off attacks.
7.4 FUTURE ENHANCEMENTS

The AETCP cluster constructor may include a directory-less architecture to form a hybrid architecture. This architecture may be investigated to discover services. The DSmT-based trust management system can be improved by evaluating the trusts of the service provider nodes. The DSmT-based trust management system may include cryptography techniques, to provide services to trusted nodes. The other types of attacks may be investigated in this trust management system. The notion of false recommendations and attacks that deal with false recommendations may be investigated in this trust model. The optimization technique may be used to enhance the overall system.