An Agent based Framework to Support Multimedia Communication in Ad Hoc Wireless Networks

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Abstract
Mobile Ad Hoc Networks (MANET) have emerged as one of the most significant areas of research in the field of mobile computing. However, the dynamics of mobile, wireless ad hoc networks as a consequence of mobility and disconnection of mobile hosts pose a number of problems in designing proper routing schemes for effective communication between any source and destination. The protocols proposed so far in this context and mechanisms for data communication have failed to ensure a stable QoS in such an infrastructure primarily due to two main reasons. First, due to the dynamism of the ad hoc architecture, uninterrupted multimedia (or any other data) communication has to rely heavily on the changing link stability. And, second, on link failures, resuming communication requires the entire route-establishment process to be redone. This generates intolerable overhead and delay. In this paper, we address the problem of maintaining a stable route in a resource limited, dynamic architecture like MANET, proposing an agent-based protocol that guarantees uninterrupted message transfer against the backdrop of minimal congestion and delay.

1 Agent Based Framework

Mobile agents or messengers that hop around in the network are a novel solution to the problem of topology discovery in a dynamic network such as ad hoc networks [1,2]. In the first part of this work, we have developed an agent based information exchange and navigation protocol in order to make each node in the network aware of the positions of other nodes. Our primary aim is to collect position-related information from each node in the network and distribute them periodically (as updates) to other nodes through mobile agents. The notion of stigmergic communication [3] has been used through the implementation of a shared information cache in each node. We have used the GPS (Global Positioning System) support at each node for the extraction of geographical co-ordinates, velocity and direction of movement of each node. We have also incorporated a predictive mechanism, which helps each node to predict the instantaneous positions of other nodes, based on the information that agents had fetched in the near past. We have evaluated the performance of our protocol in support of the agent-based system, which proves to be effective, especially to the capacity of generating minimal congestion in the network.

2 Ensuring Uninterrupted Communication

In the second part of this work, we analyze the relevance of topology awareness in maintaining a stable link for multimedia data communication. Each of the nodes has a local view of the network topology and the mobile multi-agent framework proactively replenishes the information cache of each node with fresh topology updates. This leads to a scenario where conventional route discovery is no longer necessary. More explicitly, the nodes can now determine the best route locally (i.e. by invoking routing algorithms on the local information matrix) and initiate the sending of data packets through it. After a point of time, if the source node finds that the chosen route has attained a low stability [4] (indicating that it would soon cease to exist), the node computes a new better stable route from the local information cache and redirects data packets through the later. This adaptive route selection facilitates continuous communication through multiple paths. The route discovery delay is minimal. Thus we can envision that as long as two nodes remain connected, they will always be able to get at least one route through which communication can continue. In the case of multi-route availability, the best route can always be selected. Quite perceivably, the adaptive selection of best routes guarantees an uninterrupted communication session between two nodes thus ensuring multimedia data transfer to occur.

3 Topology Discovery

An agent visits a particular node and mutually exchanges the more recent information. In other words, the agent updates the information cache of its host node with only those information that is more recent in comparison. The node may also have more recent information regarding certain parts of the topology that the agent had visited a long time back (this is understandable because the node gets multiple agents who traverse various parts of the network). The agent copies these more recent information into its own data structures. Agents also interact between themselves similarly. After mutual updation, the agent selects a neighbor of its host node, which has not been recently visited, and migrates to it to continue the same set of operations. At each node, the agent is made to wait for a pre-specified amount of time (TtM) in order to prevent the network getting flooded with agents. A major aspect underlying the infiltration of topology information into mobile nodes is that the information carried must be recognized with a degree of correctness. Since the agent navigation is asynchronous and there is an obvious time gap between the procurement of information by an agent from one node and its delivery by the same agent to another node, it becomes imperative to introduce a concept of recency of information. For example, let us assume two agents A_1 and A_2 arrive at node n, both of them carrying information about node m which is multi-hop away from node n. In order to update the topology information at node n about node m, there has to be a mechanism to find out who carries the most recent information about node m; agent A_1 or agent A_2 ? To implement that, every node in the network has a counter that is initialized to 0. When an agent leaves a node after completing all its tasks at the node, it increments that counter by one. We term this counter as recency token [2]. At any point of time, the magnitude of the recency token of any node represents the number of times that node was visited by agents since the commencement of the network. This also implies that if two agents have a set of data concerning the same node, say node m, then the agent carrying the higher recency token value of node m has more current information about it .

4 Supporting Multimedia Communication

In order to support real time/multimedia communication, the two most momentous factors are uninterrupted communication and delay minimization. In our protocol, the source node executes a modified version of the link state algorithm on the local topology information that it is regularly updating through agents. On selection of the best route, the source node initiates switching data packets through it. From then on, the source node executes the same algorithm at regular intervals and checks whether there exists a better stable route between itself and the destination node. In the event of finding a better stable path, the data packets are redirected through this newly selected route. This indicates that as long as the source and the destination remain connected, the execution of the local algorithm would always yield a path. This in turn implies that, unless the network gets partitioned or an intermediate node participating in a communication suddenly switches itself off, two nodes can maintain an uninterrupted session between themselves for an indefinite span of time. Conclusively, what seems to be a free flowing stream of continuous data packets, is actually an outcome of zero-latency and periodic route computation, performed locally and almost parallely with message transfer. We have used link stability and number of hops as parameters that define the quality of a route. Additionally, in our protocol, a source node always selects the best route available to it at any point of time. This means that a route that might be sufficiently stable, would get discarded in the event of a better-route discovery. The advantage in doing this is that no resource of the network is held for a very long time. Now, the consideration of the link load as one of the contributing parameters to decide upon the best route would result in to an automatic load balanced network. In other words, links that are less stable would no more be discarded by source nodes as because they would in most cases be less loaded as well. Presently, we are working towards developing a cost function that would quantify the best route in terms of the relative importance of these three parameters.

5 Performance Evaluation

In figure 1, we have shown the path availability between any two arbitrary node 3 and 17. The result shows that in a connected network, a better path for data communication between source and destination can always be found out.

The performance of the agent-based protocol would be best quantified by the deviation (or error) between the actual network topology and the network topology perceived by the individual nodes. This is shown in figure 2. We have defined a metric: *average topology deviation***.** As a concise definition for this metric, we could say that if the average topology deviation for a particular system is x meters, it signifies that, on an average, each node can conclusively pinpoint a circular region of x meters within which a desired node would be located. Another metric, which we have used to capture the celerity with which topology change information get infiltrated into the system, is percolation. Percolation is defined as the time required, for all the nodes in the system, to learn about the entry of a new node in the network. This is also a measure of the scalability of the system.

6 Conclusion

We have used our own simulator for the entire work and the performance analysis has been presented in support of our agent-based approach. Results show successful and uninterrupted data communication from any source to any destination without degrading path stability.

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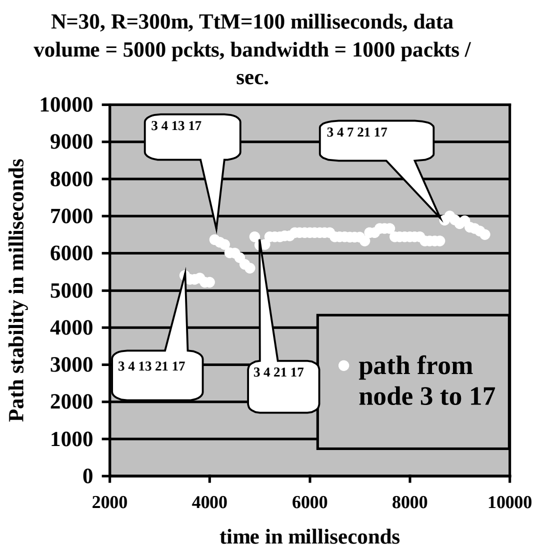

Fig. 1 Uninterrupted path between two nodes

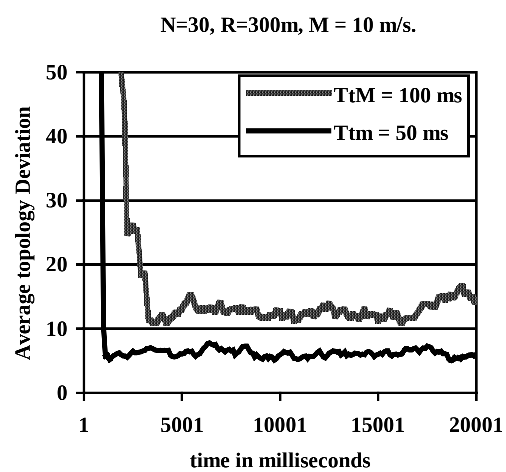

Fig 2. Average Topology Deviation at different TtM