

Feasibility of Ad Hoc Cooperative Network

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Abstract

The increase on the reliance of the internet has resulted in the proliferation of internet hot spots in major cities around the globe. However, internet hot spots are usually not for free and are economically inefficient for one who needs internet connection for a short period of time. In recognizing this problem, the idea of an Ad Hoc Cooperative Network is suggested by Jean Gravel from Nortel in which a node with internet connection provides internet access for others who are in the same cooperation using ad hoc approach.

To determine if the technology today can realize such initiative requires thorough investigation on the existing technologies. The objective of this project is to evaluate the feasible Network and Link Layer technologies today for implementation.

Requirement of the Network

The Ad Hoc Cooperative Network must be able to provide experience to users as if it is directly connected to the internet, which suggests for up to 5Mbps broadband speed today. Information transmission must be able to sustain node mobility for up to 3 miles/hour and to enable 30m to 50m transmission distance. Distance between AP to the node requesting internet connection is required to be less than 4 hops.

Network Layer Technologies

The project studied two existing Ad Hoc routing protocols: Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector Routing (AODV). Ad Hoc Cooperative Routing Protocol (AHCR) is proposed by the author in this report and is designed solely for the Ad Hoc Cooperative Network.

AODV and DSR: AODV is a pure on-demand routing protocol in which a node only initiates route discovery and maintenance when communication to another nodes is required. Nodes do not participate in exchanging routing information nor maintain routing information. DSR is a pure source routing protocol in that hop-by-hop information to reach a destination is fully stored in the packet header. DSR differs from AODV in that it aggressively cache route information to different destinations in a local cache through discovery request and promiscuous listening.

Performance Comparison: Performance of the protocols is drawn by studying existing research and simulation results. Observations were made based on the performance of AODV and DSR under same simulation variables including same node density, traffic load, and source/destination pair. All the simulation results studied were performed by assuming 2Mbps IEEE 802.11 interface for the nodes in the simulation environment.

- **End-To-End Delay and Delivery Fraction:** Simulation results demonstrate that AODV and DSR offer same end-to-end delay and delivery fraction when the

fraction of the number of source nodes to the total number nodes in a given area is 0.2 and 0.4. As the fraction increases to 0.6 and 0.8, AODV offers shorter delivery time and more delivery fraction in high node mobility environment (nodes constantly moving) while DSR offers shorter delivery time and higher delivery fraction in low node mobility environment (nodes pause for longer than 300 seconds before moving).

- **Protocol Efficiency**: Simulation shows that DSR transmitted significantly fewer routing packets than AODV independent of source node to total node fraction and the mobility of a node. DSR transmits less routing packets in that routes are aggressively cached in nodes.

Based on these observations, DSR is being selected as the routing protocol for the Ad Hoc Cooperative Network based on the requirement of the network since it offers lower end-to-end delay, higher delivery fraction, and less routing overhead in static network.

Ad Hoc Cooperative Routing Protocol

AHCR is an Ad Hoc routing protocol developed by the author of this report. It is a source routing protocol and takes the advantage of DSR by caching route information. Hop count is introduced in AHCR to limit the distance between membership nodes. A node seeking a member node with internet access broadcasts Node Request Packet (NREQ). NREQ contains source address and nodes the packet has traveled. The source IP address here is randomly selected according to RFC 3330.

A node receives NREQ first consults its local cache to determine if it knows how to reach nodes with internet connection. If an entry is found and the hop count in NREQ is less than 3, the receiving node unicasts the information back to the requesting node using a Node Acknowledgement Packet (NACK). NACK contains information on nodes to be traveled by the packet and information on route to reach a node with internet connection.

Requesting node receiving NACK pass the information to the upper layer application. The application then performs hop-by-hop authentication procedure. Authentication is based on Node ID and access control list. Node ID is the secure hash of a node's public key. Node IDs of members in the same cooperative are stored in access control list. To authenticate each other, nodes consult the access control list before it decides if it is willing to information for the requesting node.

Link Layer Technologies

Three link layer technologies are studied in the project to evaluate the feasibility of implementation including IEEE 802.11, 802.15, and 802.16. Justification on the feasibility of the technology is not only based on the capable performance, but also on the future of where the technology is heading.

- **IEEE 802.11**: Existing simulation results on the 802.11 Ad Hoc Mode show that the actual throughput of TCP traffic in an 802.11 interface is typically three times fewer than the theoretical throughput. For instance, the actual throughput of TCP traffic in an 11Mbps interface is around 0.5Mbps comparing to theoretical throughput of 2.5Mbps. As the interface speed increase to 54Mbps, it is reasonable to suggest an actual throughput of more than 2Mbps. On the other hand, throughput of residential internet connection today is typically less than 1Mbps given the subscribed bandwidth is 5Mbps. Although actual throughput in

the Ad Hoc Mode is three times fewer than the theoretical throughput, the actual throughput of a 54Mbps interface still outperforms a 5Mbps residential broadband subscription. However, 802.11 Ad Hoc Mode suffers from protocol deficiencies including Hidden and Exposed Station Problem and introduces bandwidth unfairness to the involving stations.

- **IEEE 802.15:** From the perspective of bandwidth and coverage, 802.15.1 and 802.15.4 are not suitable for the implementation in the Ad Hoc Cooperative Network. Current 802.15.1 standard offers 2.1Mbps bandwidth and 10m transmission distance. This is in contrary to the requirement of the Ad Hoc Cooperative Network in which the required transmission distance is in between 30 and 50m. 802.15.4 enables transmission distance for up to 30m; however, the achievable data rate is less than 250Kbps. Thus, it is unsuitable for the requirement of the network which requires 5Mbps bandwidth. 802.15.3 offers comparable performance to 802.11g in that enabled bandwidth is 55Mbps in 50m. However, 802.15.3 is considered as unsuitable for the Ad Hoc Cooperative Network in that the technology is moving toward UWB and different PHY implementation by manufactures. UWB enables transmission for up to 2Gbps but reduces the transmission distance below 20m.
- **IEEE 802.16:** IEEE 802.16 is considered as infeasible for the implementation in the Ad Hoc Cooperative Network due to the complicated network entry process and inconsistent frequency band around the globe. Although 802.16 Mesh Mode allows transfer of data in between subscriber stations in a network, it requires all the Ss in the network belong to the same network operator. Hence, it is considered as infeasible for the Ad Hoc Cooperative Network since nodes in a same cooperation need not belong to the same operator. On the other hand, adoption of the operating frequency band is potentially different from country to country. Interoperability in between devices is thus uncertain when an Ad Hoc Cooperative member is traveling to another country. Based on these two factual observations, IEEE 802.16 is thus considered as infeasible for the implementation for the Ad Hoc Cooperative.