

# Multicast over the Delay Tolerant Networks Prophet Protocol

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Delay and Disruption Tolerant Networking is a new networking paradigm that deals with the establishment of new communication protocols to improve the network communication in case the connectivity is intermittent and/or subject to disruptions. Delay means the end-to-end latency of the data transmission. Disruption refers to factors that are in the origin of connections to break down or even of not being established. Delay Tolerant Networks (DTNs) are networks in which no stable infrastructure exists that can guarantee permanent link connectivity. Examples of these situations are: military communications in the battlefield, deep space communications, vehicular Ad Hoc networks and rescue actions in catastrophe hit areas.

The Internet protocols are not useful for DTNs because link disruptions are not properly handled, causing protocols to timeout and abort. The DTN Research Group (DTNRG), which was chartered as part of the Internet Research Task Force (IRTF), has proposed an architecture and a communication protocol (the Bundle Protocol) for DTNs.

In DTNs, a message-oriented overlay layer called "Bundle Layer" is added. The Bundle Layer exists above the transport (or other) layers of the networks it interconnects. Application data units are transformed by the Bundle Layer into one or more protocol data units called "bundles", which are forwarded by DTN nodes according to the Bundle Protocol. To help routing and scheduling decisions, bundles contain an originating timestamp, useful life indicator, a class of service designator and a length indicator. The Bundle Protocol includes a hop-by-hop transfer of reliable delivery responsibility, called bundle custody transfer, and an optional end-to-end acknowledgement. Persistent storage may be used in DTN nodes to help combat network interruption.

The Bundle Protocol does not include a bundle routing protocol nor mechanisms for populating the routing or forwarding information bases of DTN nodes. These functions are left for protocol extensions or for other protocols. One of the important routing protocols in DTNs is Epidemic Routing, which works by flooding the network with the messages. Although it provides a good solution for DTNs as regards the delivery ratio and latency, it is very wasteful of resources.

The PROPHET (Probabilistic Routing Protocol using History of Encounters and Transitivity) protocol is a routing protocol

for unicast communication in DTNs. The DTN PROPHET Protocol (DTN-PP) uses the history of encounters between nodes and transitivity to estimate the probability of nodes meeting and exploits the mobility of some nodes to bring messages closer to their destination. The DTN-PP is an alternative to Epidemic Routing with lower demands on buffer space and bandwidth, with equal or better performance in cases where those resources are limited and without loss of generality for scenarios where it is applicable.

Multicast communications are used when data is to be sent efficiently and simultaneously to a group of destinations, creating copies of the data not in the source, but only as required by the paths to the destinations. No multicast routing strategies are yet defined, just the basic mechanisms for supporting multicast.

In this presentation we give an overview of DTNs, of the PROPHET protocol and present our Multicast over DTN-PROPHET Protocol (MoDTN-PP) [1] as an extension to DTN-PP for non-custodial multicast. Non-custodial, by itself, means that the protocol will do its best effort to deliver messages. No node assumes custody for bundles being transmitted to the destination, so no special actions will be done to assure success. The probabilistic model from DTN-PP for estimating probability of node contacts was kept in MoDTN-PP. A pseudo-multicast tree mechanism was added to manage multicast groups. A heuristic based on the estimated probability of contacts between nodes and indications of the location and direction of movement of the nodes was introduced in MoDTN-PP to help forming a pseudo multicast tree.

We show that DTNs can benefit with multicast communications when certain requirements are respected. We demonstrate that if there are a minimum number of contacts between nodes, the pseudo-multicast tree will exist, multicast works efficiently, minimizing the number of message replications done in the network.

- [1] José Santiago, Augusto Casaca, Paulo Rogério Pereira. Multicast in Delay Tolerant Networks using Probabilities and Mobility Information. *Ad Hoc & Sensor Wireless Networks, An International Journal*, vol. 7, number 1-2, pp. 51-68, 2009.