Impact of Protocol Switching Strategy in Delay Tolerant Networks

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Abstract : Delay-Tolerant Networks (DTNs) are sparse dynamic wireless networks in which a complete end-to-end path from the source to the destination does not exist. In this context, conventional mobile ad-hoc routing schemes would fail, because they try to establish complete end-to-end paths, before any data sent. DTNs lack continuous connectivity among their nodes because of node mobility, limited data storage space and constraint in power source. DTN nodes store and carry the data packets until they come into communication range of each other. In recent years several routing protocols have been developed for DTNs. In these protocols there is always a trade-off between different performance metrics. In this paper we have proposed a protocol switching strategy for DTNs that is a combination of two routing protocols each from flooding-based and forwarding-based family namely Epidemic and Probabilistic routing. The performance is discussed using Opportunistic Network Environment tool.

Keywords: Delay Tolerant Networks, Protocol switching, ONE simulator.

I. INTRODUCTION

Delay Tolerant Networks (DTNs)are categorized by frequent disconnections and long delays of links among devices due to mobility, sparse deployment of devices, noises and attacks etc. The main feature of DTNs is disruption or delay which is mainly because of limited wireless radio range of mobile nodes, limited energy resources, interference and attacks etc. Hence routing in these networks is a challenging task and also is an active research area. The lack of instantaneous path connections in DTNs result in high latency of packet delivery, overall low data rates, long delays and limited longevity of individual nodes.

Some significant applications of DTNs are: deep space communications [1], internet access in rural areas [2], vehicular communications [3], habitant monitoring [4]andmilitary battlefields [5]. As there are diverse applications of DTNs, the design of a DTN depends on its application scenario. Fig. 1 gives the various design parameters for a DTN. Contact schedules of nodes and waiting times affect the DTNs design. The available storage capacity on contacts also affects the design of DTNs by determining the forwarding capabilities of intermediate nodes. Bandwidth and radio coverage range which depends on the radio technology being used also affects the design. Finally, available energy supply determines the lifetime of the communicating devices in the DTN.

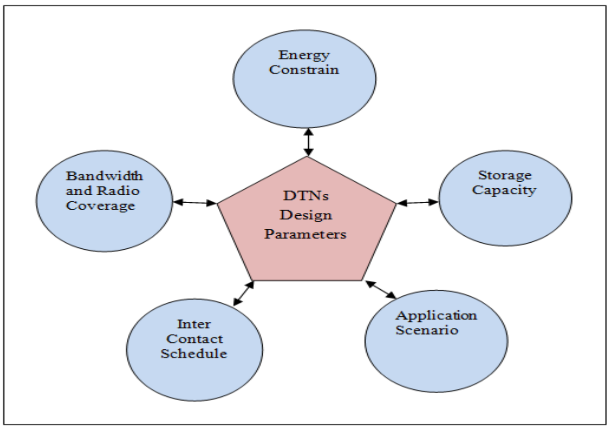

Figure 1: DTNs design parameter

The organization of this paper is as follow: Section I gives a brief introduction about DTNs. Section II describes the related work by various authors in this field. Section III is focused on routing approaches used in DTNs and Section IV is about the simulation and results analysis of the work done.

II. REALATED WORK

As compared to traditional routing strategies DTN design parameters make a different set of choices in the architectural design of its routing protocols : messages vs. packets, hop-by-hop reliability and security vs. end-to-end, name based routing vs. address based routing, and a routing abstraction of partially-connected rather than fully-connected network graph making the TCP/IP protocols useless in this scenario [6].

Epidemic protocol [7] in DTNs is a complete flooding approach for message transmission. In this area, Ram Ramanathan et al. [8] have extended their work to get Prioritized Epidemic which uses expiry time information and topology awareness to decide which bundles to delete or hold back when faced with a resource crunch. On the other hand are forwarding protocols like MaxProp [9] and Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET) [10] which make use of mobility patterns for routing decisions.

Applications of DTNs are significantly recognized in various scenarios till now [11]. The Disaster Response system in [12] and Mobile AdhocNETworks (MANETs) are among these application areas which need DTNs.

Ari Keranen et al. [13] have given a detailed description about the Opportunistic Networks Environment (ONE) simulator tool which is a Java-based simulator for the evaluation of routing strategies in DTNs. It offers a wide variety of tools to create complex mobility scenarios that come closer to reality than any other mobility models.

III. ROUTINGPROTOCOLS

Routing is an important issue in DTNs. They use a store-carry-and-forward mechanism to route messages in the network. This mechanism stores data while next hop is not available for forwarding message. It carries the message while moving and forwards it to the node which has better opportunity to transmit message to the destination.

Epidemic Routing:Epidemic routing belongs to the protocols of flooding family. Vahdat and Becker applied this routing algorithm to forward data in a DTN [10]. It works as follows: when a message is sent for a destination, it is first saved in a local storage and tagged with a unique ID. When two nodes come in each other's contact range they exchange the list of all message IDs they have in their local storage and exchange those messages they don't have in their local storage. In the end of this exchange both the nodes will have same messages. This process continues till all nodes have all messages in their storage. In epidemic routing, messages can be delivered with a high probability. However, the network resources are consumed heavily [24].

Probabilistic Routing:*Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET):* PRoPHET [17] is a forwarding family protocol. PRoPHETforwards data from one node to another usinga probabilistic metric called *delivery predictability*. This metric indicates the likelihood of a source node to deliver a message to the destination. The operation of PROPHET can be described with the help of Figure 2 which is self explanatory. When two nodes meet, they exchange information which in PRoPHET also contains the delivery predictability information stored at the nodes. This information is used to update the internal delivery predictability [17] and then the information in the information message is used to decide which messages to request from the other node based on the forwarding strategy used.

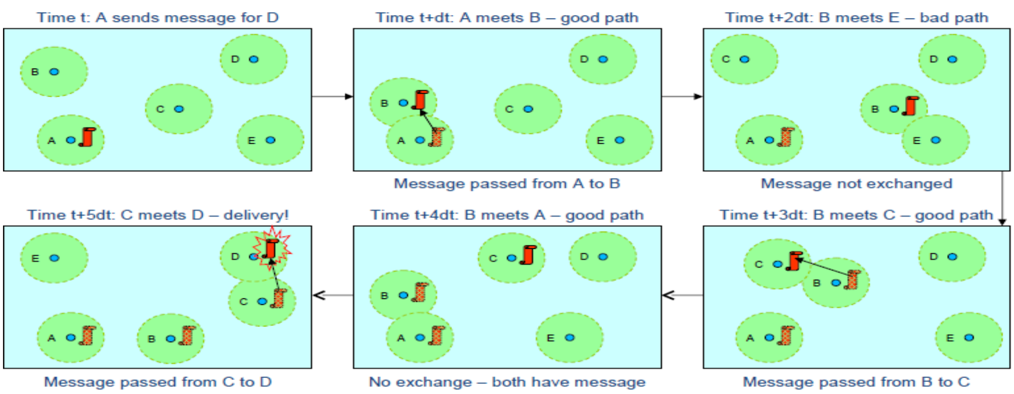

Figure 2 Probabilistic Routing in DTN

IV. PROTOCOL SWITCHING STRATEGY

In this section we present a protocol switching strategy using two protocols namely Epidemic and PRoPHET. Firstly, we describe the application scenario in which this strategy is used because design of a DTN protocol is application specific. The simulation is carried out in ONE simulator tool. Next we give our protocol switching strategy to make use of advantages of both switching protocols.

Application Scenario:There are various scenarios where DTN nodes have limited energy supplies either because they are mobile, or because they are in a location that cannot easily be connected to the power grid. Our application scenario considers 60 DTN nodes (pedestrians having mobile nodes for communication) moving along shortest path in predefined trajectories in Helsinki city map (provided in ONE simulator).

In this scenario, DTN nodes have no source for recharging the battery powers and all nodes have same amount of initial energy. Figure 3 shows our example scenario in which 60 nodes are there communicating with each other in a battery constraint environment.

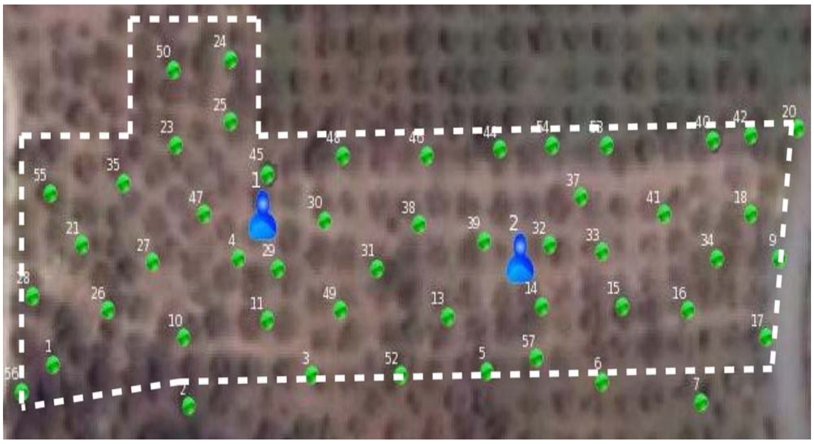

Figure 3 A field with DTN nodes

Protocols Switching Strategy:Our hybrid approach exploits the advantages of two protocols: Epidemic (flooding family protocol) and PRoPHET (forwarding family protocol). Epidemic protocol ensures message delivery by sending each message over all the paths in the network (but at the cost of high resource consumption). Next PRoPHET is a battery saving protocol as it only sends a single copy of the message through the best possible path in the network. Our switching strategy is a kind of power saving strategy in which initially all nodes have epidemic router but when the remaining energy level comes down to a threshold point it switches to the PRoPHET. This strategy is designed to sense the remaining battery capacity which keeps a reserve for emergency communications which in our case is the 40% of the initial energy power. This energy threshold value is decided by user and can be changed depending on the application scenario.

V. SIMULATION AND RESULTS

Simulation Tool:We used ONE simulator tool to evaluate our hybrid routing strategy on the parameter of remaining energy level. It is a powerful simulator used to implement realistic DTN scenarios. It is a Java-based tool offering a broad set of DTN protocol simulation capabilities in a single framework [13]. In our scenario the settings of the simulation contains following parameters: Simulation time: 2 hours, Number of nodes: 60, buffer size: 50MB, initial nodes energy: 5000, movement model: shortest-path-map-based movement.

Results: As shown in Figure 4 by using the switching routing strategy the energy is utilized efficiently. Epidemic routing is expensive in terms of resource consumption. In our switching strategy all routers initially utilize epidemic as initially resources are not consumed at all. At a point where energy conserves are below a threshold level and a need for low energy consuming protocol is needed this strategy switches to power saving PRoPHETprotocol. Our simulation results have shown that this protocol switching strategy can save around 15% of energy in situations where battery power is critical.

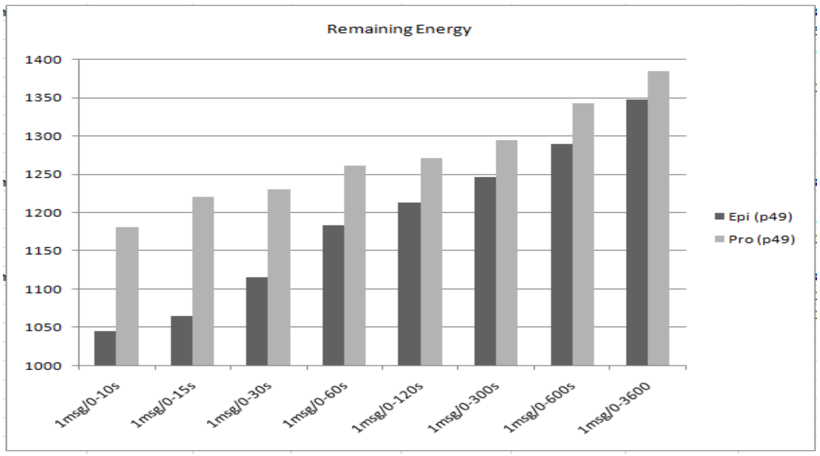

Figure 4 Remaining Energy Level

VI. CONCLUSION AND FUTURE WORK

In delay tolerant networking different routing protocols have tried to minimize the delays, which are unavoidable and there is always a trade-off between high resource consumption and high delivery ratio of a routing protocol. In this paper we have proposed a protocol switching strategy for DTNs that is a combination of two routing protocols each from flooding-based and forwarding-based family namely Epidemic and PRoPHET.

Future work in this scenario could be to analyze this combination on different other performance metrics also. Switching can also be performed on other protocols to improve the efficiency and performance of the resulting protocol. DTN protocols are still at their infancy stage as compared to the traditional TCP/IP. An efficient routing protocol should integrate the replication, knowledge and better buffer management mechanisms to obtain the best performance [14].

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