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RESEARCH ARTICLE

A MULTIFUNCTIONAL INCENTIVE SCHEME ADAPTIVE TO DIVERSE PERFORMANCE OBJECTIVES FOR DTN ROUTING

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A B S T R A C T

In Delay Tolerant Networks (DTNs), we can exchange packets only when they meet with each other. The routing is usually conducted in a store-carry-forward manner to exploit the scarce communication opportunities. The nodes may be selfish and may not be cooperative on packet forwarding or storage. The current scenario fails encourage nodes to follow a certain packet routing strategy to realize a routing performance objective. Here, we first discuss the routing strategy that can realize different performance objectives when nodes are fully cooperative, i.e., are willing to follow both aspects of cooperation. We then propose Multi cent, a game theoretical incentive scheme that can encourage nodes to follow the two aspects of cooperation even when they are selfish.

INTRODUCTION

With the increasing popularity of mobile devices, Delay-Tolerant Networks (DTNs) comprised of mobile devices, e.g., laptops and smart phones, have attracted considerable research interests recently. In a DTN, nodes move continuously and can only communicate with nearby nodes due to the limited communication range. Therefore, no stable routing path can be assured between any nodes, and only a limited number of packets can be transmitted when two nodes meet. Due to these characteristics, DTN routing algorithms work in a store-carry-forward manner, i.e., a packet is stored on current node until a better forwarder is encountered. Therefore, the forwarding and storage priority of a packet determines its dissemination speed. This provides the possibility to realize different performance objectives for DTN routing. A routing performance objective means to improve a specific routing metric for the most, such as maximal hit rate and minimal average delay. Different routing performance objectives are desired by different application scenarios. For example, in a DTN based monitoring system, the dissemination of control messages usually requires maximal hit rate while the report of collected disaster data needs minimal delay.

Actually, the works in [7], [9] have proposed the routing strategy that can realize different routing performance objectives. In this paper, we define a routing strategy as a set of rules to decide the priority of each packet in forwarding/storage. However, these methods simply assume that nodes are willing to follow the strategy to forward **and** store packets, which may not be true in DTNs. Firstly, nodes may be selfish and do not want to carry or forward packets for others . Further, nodes are not necessarily to follow the priority specified in a routing strategy to forward and store packets. For instance, some nodes may not give priority to important control packets but only give equal importance to all packets. Therefore, an incentive scheme is needed to encourage not only the cooperation on forwarding and storing packets but also the willingness to follow a routing strategy to realize a desired performance objective.

We name the former as the first aspect of cooperation and the latter as the second aspect cooperation. Recently, a number of incentive schemes have been proposed for DTNs. They mainly focus on rewarding packet forwarders so that nodes are encouraged to be cooperative in DTN routing. Most of these schemes build an off-line virtual bank (OVB) for credit clearance. During the packet forwarding, each node imprints its ID into the packet it just forwards. Then, the OVB can determine credit remuneration for forwarders based on their contributions stored in packets.

Though effective, the cooperation in these methods only refers to the receiver, storage, and forwarding of packets. In other words, they cannot encourage nodes to follow a specific routing strategy to store and forward packets to realize a performance objective, i.e., cannot encourage nodes to realize the second aspect of cooperation. In this paper, we propose a game theoretical incentive scheme called Multicent for DTN routing that can encourage nodes to achieve both aspects of cooperation mentioned above. We assume nodes are selfish and rational in nature, i.e., they participate in packet forwarding and storage to maximize their benefits. In this paper, we first summarize the routing strategy that can realize different routing performance objects when nodes are fully cooperative, i.e,. Willing to follow the two aspects of cooperation.

We then design Multicent to encourage nodes to follow the two aspects of cooperation even when they are selfish. In detail, we regard the packet exchange between two nodes as a packet forwarding game. Based on the analysis of the packet forwarding game, we design a payoff function for the game that assigns credits for packet forwarding/storage in proportional to the priorities specified in the corresponding routing strategy. Note that we use payoff function to represent the component in an incentive system that determines credit reward. As a result, when each node follows its interest to choose packets to forward/store in the packet forwarding game, the two aspects of cooperation are simultaneously attained.

Multicent can also adjust the Quality of Service (QoS), i.e., delay and hit rate, for packets with specific sources/destinations or between specific source-destination pairs by adjusting the payoff function for these packets. The contributions of this paper are threefold: _ First, we identify the two aspects of cooperation that are needed to realize a specific performance objective in DTN routing. _ Second, while current methods only encourage the first aspect of cooperation among nodes, we propose a game theoretical incentive scheme that can encourage nodes to realize the two aspects of cooperation in DTN routing simultaneously. _ Third, we propose a way to realize adjustable QoS for packet from, to, and among specific sources, destinations, and source-destination pairs.

Exisisting System

In Delay Tolerant Networks (DTNs), nodes meet opportunistically and exchange packets only when they meet with each other. Therefore, routing is usually conducted in a store-carry-forward manner to exploit the scarce communication opportunities. As a result, different packet routing strategies, i.e., which packet to be forwarded or stored with priority, can lead to different routing performance objectives, such as minimal average delay and maximal hit rate. On the other hand, incentive systems are necessary for DTNs since nodes may be selfish and may not be cooperative on packet forwarding/storage. However, current incentive systems for DTNs mainly focus on encouraging nodes to participate in packet forwarding/storage but fail to further encourage nodes to follow a certain packet routing strategy to realize a routing performance objective. We name the former as the first aspect of cooperation and the latter as the second aspect of cooperation in DTN routing.

Problem

1. Nodes meet opportunistically and exchange packets only when they meet with each other.
2. Routing is usually conducted in a store-carry-forward manner to exploit the scarce communication opportunities.

RESULT

- Different packet routing strategies.
- Selfish nodes.
- Fail to encourage nodes.

Proposed System

We first discuss the routing strategy that can realize different performance objectives when nodes are fully cooperative, i.e., are willing to follow both aspects of cooperation. We then propose Multi cent, a game theoretical incentive scheme that can encourage nodes to follow the two aspects of cooperation even when they are selfish. Basically, Multi cent assigns credits for packet forwarding/storage in proportional to the priorities specified in the routing strategy. Multi cent also supports adjustable Quality of Service (QoS) for packet routing between specific sources and destinations. Extensive trace-driven experimental results verify the effectiveness of Multi cent.

The dissemination of information to users most likely depends upon issue guarantee method where the network disseminates distributed information only to those users who are highly interested to receive. Due to this advantage these services are used only in dynamic environments among the transmitting information. Due to this the performance is greatly improved and overcomes the problems caused by frequent disconnections.Here the best medium of the information transmission is chosen or which its performance and operations are analyzed and validated.

Advantages

1. Routing strategy discussion- realizes different performance objectives when nodes are fully cooperative.
2. Multi cent, a game theoretical incentive scheme that can encourage nodes to follow the two aspects of cooperation even when they are selfish.
3. Multi cent assigns credits for packet forwarding/storage in proportional to the priorities specified in the routing strategy.
4. Supports adjustable Quality of Service (QoS)

Modules

1. Scheduling policies
2. Heterogeneous networks
3. Grouping of cluster member and data transfer
4. Transmission infrastructure

Schedulingpolicies (Sending file)

In this Module, the information about the current and past status of the network, and can schedule any radio transmission in the current and future time slots, similar. We say a packet is successfully delivered if and only if all destinations within the multicast session have received the packet. In each time slot, for each packet p that has not been successfully delivered and each of its unreached destinations, the scheduler needs to perform the following two functions:

Capture

The scheduler needs to decide whether to deliver packet to destination in the current time slot. If yes, the scheduler then needs to choose one relay node (possibly the source node itself) that has a copy of the packet at the beginning of the timeslot, and schedules radio transmissions to forward this packet to destination within the same timeslot, using possibly multi-hop transmissions. When this happens successfully, we say that the chosen relay node has successfully captured the destination of packet. We call this chosen relay node the last mobile relay for packet and destination. And we call the distance between the last mobile relay and the destination as the capture range.

Duplication

For a packet p that has not been successfully delivered, the scheduler needs to decide whether to duplicate packet p to other nodes that does not have the packet at the beginning of the time-slot. The scheduler also needs to decide which nodes to relay from and relay to, and how.

Heterogeneous Networks (Cluster)

In this Module, All transmissions can be carried out either in ad hoc mode or in infrastructure mode. We assume that the base stations have a same transmission bandwidth, denoted for each. The bandwidth for each mobile ad hoc node is denoted. Further, we evenly divide the bandwidth into two parts, one for uplink transmissions and the other for downlink transmissions, so that these different kinds of transmissions will not interfere with each other.

Grouping of Cluster Member And Data Transfer

Clusters are arranged in concentric layers. Cluster members are nodes presented in each node of the cluster network. Data collected from nodes of the same cluster are highly correlated. Data can be fused during the data aggregation process. The fused data will then be transmitted to the base station directly. In such cases, an arrangement, only cluster node is required to transmit data over a long distance. The rest of the nodes will need to do only short-distance transmission.

Transmission Infrastructure (Receiving File)

In this Module, A transmission in infrastructure mode is carried out in the following steps:

1. ***Uplink:*** A mobile node holding packet is selected, and transmits this packet to the nearest base station.
2. ***Infrastructure relay:*** Once a base station receives a packet from a mobile node, all the other base stations share this packet immediately, (i.e., the delay is considered to be zero) since all base stations are connected by wires.
3. ***Downlink:*** Each base station searches for all the packets needed in its own sub region, and transmit all of them to their destined mobile nodes. At this step, every base station will adopt TDMA schemes to delivered different packets for different multicast sessions.

Dtn Routing Algorithms

DTN routing algorithms can be classified into either single-copy methods or multi-copy methods. In single-copy methods, each packet only has one copy. These methods usually rank each node’s probability of encountering the destination node and forward a packet from low rank nodes to high rank nodes so that the packet can gradually reach the destination. In multicopy methods, packers are replicated, rather than forwarded, to the encountered node, thereby leading to better routing reliability.

The works In further discuss the packet routing strategy that can achieve different routing performance objectives, e.g., minimal average delay and maximal hit rate. However, they focus on packet routing and assume all nodes are fully cooperative, which may be true in reality. In this paper, we study how to provide incentives so that even when nodes are selfish, they will still follow the packet routing strategy to realize a routing performance objective.

1. First, we identify the two aspects of cooperation that are needed to realize a specific performance objective in DTN routing.
2. Second, while current methods only encourage the first aspect of cooperation among nodes, we propose a game theoretical incentive scheme that can encourage nodes to realize the two aspects of cooperation in DTN routing simultaneously.
3. Third, we propose a way to realize adjustable QoS for packet from, to, and among specific sources, destinations, and source-destination pairs.

CONCLUSION

In DTNs, communication opportunities between nodes are usually limited, and the packet forwarding or storage priority affects final routing performance. Thus, we first identify the two aspects of cooperation needed to realize different performance objectives in DTN routing: nodes should not only participate in packet forwarding but also forward or store packets as desired by a performance objective (e.g., minimal average delay, maximal hit rate, and minimal maximal delay). To this end, we proposed Multicent, an incentive scheme for DTN routing that can encourage nodes to follow the two aspects of cooperation to realize different performance objectives. It can also realize adjustable QoS for packets of specific sources, destinations, or source-destination pairs. Tracedriven experiments verify the correctness and effectiveness of Multicent in comparison with other schemes. In the future, we plan to investigate how to involve more advanced attacks such as Denial of Service.

Future Work

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

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