Unicast Communication based on Context-aware Adaptive Routing in delay Tolerant Mobile Adhoc Network

[1]E.P. Prakash, [2]R. Senthil Kumar
[1,2]Assistant Professor
[1,2]Department of CSE, SNS College of Engineering, Coimbatore, India

Abstract: **Applications of decentralized mobile systems are often characterized by network partitions. As a consequence delay tolerant networking research has received considerable attention in the recent years as a means to obviate to the gap between ad hoc network research and real applications. In this paper we present the design, implementation and evaluation of the Context-aware Adaptive Routing (CAR) protocol for delay tolerant unicast communication in intermittently connected mobile ad hoc networks. The protocol is based on the idea of exploiting nodes as carriers of messages among network partitions to achieve delivery. The choice of the best carrier is made using Kalman filter based prediction techniques.**

***Index terms*—context-aware adaptive routing, Kalman filter, MANET.(*Key words*)**

I. INTRODUCTION:

Delay tolerant networking (DTN) has received considerable attention from the research community in recent years as a means of addressing exactly the issue of routing messages in partitioned networks.DTNs span very challenging application scenarios where nodes (e.g., people, wild animals) move around in environments where infrastructures cannot be installed (e.g., emergency operations,military grounds, protected environments). Some solutions to routing have been presented also for these cases, starting from the basic epidemic routing where messages are blindly stored and forwarded to all neighbouring nodes generating a flood of messages. The drawback of epidemic dissemination lies in the very high number of messages which are needed to obtain successful delivery to the right recipient. Other solutions have been proposed to tackle the problem of routing in (possibly mobile) delay tolerant networks, based on the previous knowledge of the routes of the potential carriers or on probabilistic approaches.

In this paper we present the Context-aware Adaptive Routing (CAR) protocol, an approach to delay tolerant mobile ad hoc network routing which uses prediction to allow the efficient routing of messages to the recipient. A host willing to send a message to a recipient, or any host in the multi hop path to it, uses a Kalman Filter prediction and multi-criteria decision theory to choose the best next hop (or carrier) for the message. The decision is based on the mobility of the host (a highly mobile host is a good carrier as it meets many hosts) and its past collocation with the recipient (we implicitly assume that past collocation indicates that the host will meet the recipient again in the future). CAR does not assume any previous knowledge of the routes of the hosts like other approaches, such as the Message Ferrying project , that rely on the a priori knowledge of the routes of the special hosts carrying the information. Moreover, our protocol is based on a single copy of the message in the system, instead of having multiple replicas. Other solutions are predicated on semiepidemic algorithms like PRoPHET, where the probability of replication is proportional to the time of the last encounters and their frequency. Finally, we do not exploit any geographical information such as GPS coordinates. Our approach can be considered the first one exploiting forecasting techniques for carrier selection founded on analytical prediction models.

II. DESIGN OF THE CAR PROTOCOL:

Overview

Firstly, we describe the general steps of the protocol. Secondly, we analyse the prediction theory and its foundation algorithms. Thirdly, we discuss the protocol implementation, focussing on the management of routing information for synchronous and asynchronous delivery.

The design goal of CAR is to support communication in intermittently connected mobile ad hoc networks. The key problem solved by the protocol is the selection of the carrier. Our solution is based on the application of forecasting techniques and utility theory for the evaluation of different aspects of the system that are relevant for taking routing decisions.Let us now consider the key aspects of the protocol. CAR is able to deliver messages synchronously (i.e., without storing them in buffers of intermediate nodes when there are no network partitions between sender and receiver) and asynchronously (i.e.,by means of a store-and-forward mechanism when there are partitions). The delivery process depends on whether or not the recipient is present in the same connected region of the network (cloud) as the sender. If both are currently in the same connected portion of the network, the message is delivered using an underlying synchronous routing protocol to determine a forwarding path. If a message cannot be delivered synchronously1, the best carriers for a message are those that have the highest chance of successful delivery, i.e., the highest delivery probabilities.The message is sent to the host with the highest one using the underlying synchronous protocol.In order to understand the operation of the CAR protocol,consider the following scenario in which two groups of nodes are connected as in Figure 1(a). As in our implementation,let us assume that Dynamic Destination-Sequenced Distance-Vector (DSDV) [12] is used to support synchronous routing.Host H1 wishes to send a message to H8. This cannot be done synchronously, because there is no connected path between the two. Suppose the delivery probabilities for H8 are as shown in Figure 1(a). In this case, the host possessing the best delivery probability to host H8 is H4. Consequently, the message is sent to H4, which stores it. After a

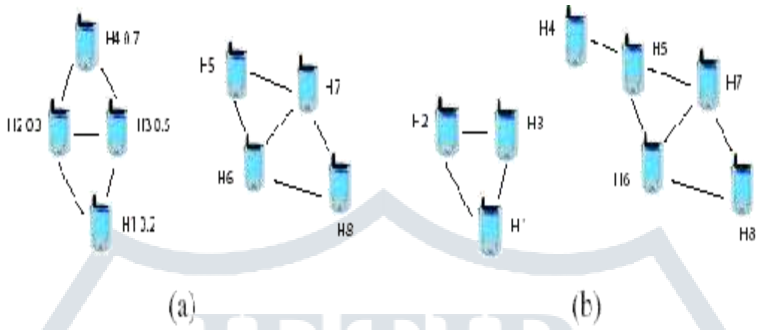

Fig. 1. Two connected clouds, with associated delivery probabilities for message transmission between H1 and H8 (Fig. a). Then, H4, carrying the message, joins the second cloud (Fig.b).

certain period of time, H4 moves to the other cloud (as in Figure 1(b)). Since a connected path between H4 and H8 now exists, the message is delivered to its intended recipient. Using DSDV, for example, H4 is able to send the message shortly after joining the cloud, since this is when it will receive the routing information relating to H8.Delivery probabilities are synthesised locally from context information. We define context as the set of attributes that describe the aspects of the system that can be used to drive the process of message delivery. An example of context information can be the change rate of connectivity, i.e., the number of connections and disconnections that a host experienced over the last T seconds.

This parameter measures relative mobility and, consequently, the probability that a host will encounter other hosts. Since we assume a proactive routing protocol, every host periodically sends both the information related to the underlying synchronous routing (in DSDV this is the routing tables with distances, next hop host identifier, etc.), and a list containing its delivery probabilities for the other hosts. When a host receives this information, it updates its routing tables. With respect to the table for asynchronous routing, each host maintains a list of entries, each of which is a tuple that includes thefields(destination,bestHost,delivery Probability).We choose to explore the scenario in which each message is placed with only a single carrier rather than with a set, with the consequence that there is only a single list entry for each destination.When a host is selected as a carrier and receives the message,it inserts it into a buffer. The size of this buffer is fundamental, and represents a trade-off between storage overhead and likely performance. If the buffer overflows, messages will be lost, since we assume the existence of a single replica.What we have described is the basic model behind the CAR protocol. In the following sections we will describe the details of the algorithm, in particular the techniques exploited for the calculation of the delivery probabilities.

Prediction and Evaluation of Context Information

CAR is optimised by using predicted future values of the context attributes for making routing decisions, instead of using the available current context information as it is, so to have a more accurate estimation of the trend of the time series associated to each context dimension. For example, in the case of patterns of colocation, a host HA currently not colocated with a host HB may be considered of scarce utility for acting as a carrier for HB if we evaluate only this instant of time. However, HA may have been colocated with HB for the past three hours and, therefore,its likelihood of being colocated again, given the assumptions of our model, are high and should be represented accordingly. The process of prediction and evaluation of the context information can be summarised as follows.

Each host calculates its delivery probability for a given set of hosts.This process is based on the calculation of utilities for each attribute describing the context.Then the future values of these utilities are predicted and composed using multi-criteria decision theory in order to estimate the overall delivery probability. The calculated delivery probability are periodically sent to other host that are connected cloud as part of routing information.

Each host maintains a logical forwading table of tuples describing the next logical hop,and its associated delivery probability,for all known destinations.

Each host uses local predictions of delivery probabilities between updates of information. The prediction is used during temporary disconnections and is carried out until a certain accuracy can be guaranteed.

Message Delivery
Synchronous Delivery:

When a message has to be sent, if the recipient is reachable synchronously (i.e. an entry with the field TargetHostId exists in the routing table and the associated distance is less than 16), the message is forwarded to the next hop indicated by nextHopId. This forwarding mechanism is the typical one of distance vector protocols.It may happen that the path to a certain host is broken, but,at the same time, the routing table has not yet been updated with the information related to this change, given the propagation delay of routing tables. In this case, the message is forwarded until it reaches the host that has been already notified about the disconnections. This host will then check if the message can be sent using the asynchronous delivery mechanism (i.e., an entry for the selection of the best carrier exists in its routing table). If not, the host stores the message in its buffer and tries to resend it periodically.

Asynchronous Delivery

If a connected path to the recipient does not exist (i.e., the value of distance is equal or greater than 16), the message is forwarded to the host with the highest value of delivery probability (expressed by delivery Prob).In order to reach the carrier, DSDV is used. In other words, the entry having the value of the key targetHostId equal to bestHopHostId is used to forward the message. As the network is dynamic, it may happen that the carrier is unreachable, since, in the meanwhile, it has left the connected cloud. In this case, if the information about the disconnection has reached the sender, the entry related to the best carrier is removed (set to an invalid state designated by 0). In order to avoid the propagation of stale routes, we use sequence numbers for the routing tables like in DSDV. If this information has not been propagated yet to the sender, the intermediate host aware of the topology change will try to resend the message.

Prediction of the Context Information Attributes using Kalman Filter Techniques

Kalman filter prediction techniques were originally developed in automatic control systems theory. These are essentially a method of discrete signal processing that provides optimal estimates of the current state of a dynamic system described by a state vector. The state is updated using periodic observations of the system, if available, using a set of prediction recursive equations5. Kalman filter theory is used in CAR both to achieve a more realistic prediction of the evolution of the context of a host and to optimise the bandwidth usage. As discussed above, the exchange of context information that allows the calculation of delivery probabilities is a potentially expensive process, and unnecessarily so where such information is relatively predictable. If it is possible to predict future values of the attributes describing the context, we update the delivery probabilities stored in the routing tables, even if fresh information is unavailable. Fortunately, this prediction problem can be expressed in the form of a state space model. Starting from a time series of observed values that represent context information, we derive a prediction model based on an inner state that is represented by a set of vectors, and to add to this both trend and seasonal components.One of the main advantages of the Kalman filter is that it does not require the storage of the entire past history of the system, making it suitable for a mobile setting in which memory resources may potentially be very limited. In the addendum of this paper, we give a general introduction to state space models and then we present how we have applied these concepts to the analysis and the prediction of context information, discussing three cases according to the different behaviour of the time series. We also discuss how the Kalman filter model that we use in CAR can be recast and studied using alternative theoretical frameworks, namely EWMA, ARMA and Bayesian forecasting models.

III. RELATED WORK:

A number of approaches have been proposed to enable asynchronous communication in intermittently connected mobile ad hoc networks. The seminal paper analysing the problem and containing a first solution to it is.The authors propose an approach that guarantees message transmission in minimal time. However, the proposed algorithm relies on the fact that mobile hosts actively modify their trajectories to transmit messages. CAR has inspired the design of other protocols based on the study of mobility patterns , where different metrics forth evaluation of host co-location are taken into the consideration for the selection of the best carriers, and where machine learning techniques are applied to extract social patterns among the individuals carrying the devices.

IV. CONCLUSION:

We have presented the design, the evaluation and the implementation of the Context-aware Adaptive Routing protocol which supports communication in delay tolerant mobile ad hoc networks. We have shown that prediction techniques can be used to design store-and-forward mechanisms to deliver messages in intermittently connected mobile ad hoc networks, where a connected path between the sender and receiver may not exist. We have designed a generic framework for the evaluation of multiple dimensions of the mobile context in order to select the best message carrier. We have demonstrated that Kalman filter based forecasting techniques can be applied effectively to support intelligent message forwarding.

REFERENCES:

[1] C. E. Perkins, Ad Hoc Networking. Addison- Wesley, 2001.
[2]K. Fall, “A delay-tolerant network architecture for challenged internets,” in Proceedings of SIGCOMM’03, August 2003.
[3] A. Vahdat and D. Becker, “Epidemic Routing for Partially Connected Ad Hoc Networks,” Department of Computer Science, Duke University, Tech. Rep. CS-2000-06, 2000.
[4] S. Jain, K. Fall, and R. Patra, “Routing in a delay tolerant network,” in Proceedings of SIGCOMM’04, August 2004.
[5] V. Zhao, M. Ammar, and E. Zegura, “A message ferrying approach for data delivery in sparse mobile ad hoc networks,” in Proceedings of MobiHoc’04, May 2004.
[6] M. P. N. Sarafijanovic-Djukic and M. Grossglauser, “Island Hopping:Efficient Mobility Assisted Forwarding in Partitioned Networks,” in Proceedings of IEEE SECON’06, September 2006.
[7] A. Lindgren, A. Doria, and O. Schelen, “Probabilistic routing in intermittently connected networks,” Mobile Computing and Communications Review, vol. 7, no. 3, July 2003.
[8] T. Spyropoulos, K. Psounis, and C. S. Raghavendra, “Spray and wait: anefficient routing scheme for intermittently connected mobile networks,” in Proceeding of WDTN’05. New York, NY, USA: ACM Press, 2005, pp. 252–259.
[9] R. L. Keeney and H. Raiffa, Decisions with Multiple Objectives: Preference and Value Tradeoffs, ser. Wiley Series in Probability and Mathematical Statistics. John Wiley and Sons, 1976.
[10] M. Musolesi, S. Hailes, and C. Mascolo, “Adaptive routing for intermittently connected mobile ad hoc networks,” in Proceedings of WoWMoM’05. Taormina, Italy. IEEE press, June 2005.
[11] M. Musolesi and C. Mascolo, “Designing mobility models based on social network theory,” ACM SIGMOBILE Mobile Computing and Communications Review, vol. 11, no. 3, 2007.
[12] C. E. Perkins and P. Bhagwat, “Highly dynamic Destination-Sequenced Distance-Vector routing (DSDV) for mobile computers,” in Proceedings of SIGCOMM’94, August 1994.