



Routing and Forwarding Protocols in Wireless Multi-hop Ad-hoc Networks in Context of Opportunistic Networks: An Analysis

Chander Prabha¹, Surender Kumar², Ravinder Khanna³

¹Research Scholar, ²Associate Professor (CSE), ³Professor (ECE)

¹MMU, Sadopur, Ambala, Haryana, ²HCTM Kaithal, Ambala, Haryana, ³MMU Sadopur Ambala, Haryana
India

Abstract: Now-a-days the wireless communication is subjected to rapid changes due to its portability, convenience and energy constrained operation. Opportunistic networks are one of the most interesting evolutions of MANETs that is a part of wireless communication. It is an upcoming and promising research field in one of the evolution of wireless multi-hop ad-hoc networks. The design of efficient routing and data forwarding protocol in context of opportunistic network is usually a big challenge due to unpredictable topology. In this paper, we provide a survey of main routing and data forwarding protocols in context of opportunistic networks and then analyze their performance on different parameters. We also emphasize the role of context information in forwarding data in opportunistic networks.

Keywords: Routing, Multi-Hop, Context-aware, Mobility-based, Social-Based

I. Introduction

In recent years opportunistic networks have gained popularity in research and industry. In these networks, nodes come into contact with each other opportunistically and communicate wirelessly. An opportunistic network consists of nodes. These nodes are typically handheld devices carried by people which are equipped with large memory, good sensing capability, high computational power with short-range radio transmission functionality and wirelessly connected to each other [1]. An opportunistic network node can be either mobile or fixed. A mobile node is a mobile device carried by humans with integrated technology such as a Wi-Fi, cameras, Bluetooth etc. A fixed node, working as an access point, is a device set in certain locations to disseminate information to mobile nodes. The transmission range between two connected nodes is usually short. When nodes get into each other's transmission range, contacts will appear opportunistically. That is why the performance of these networks depends on the mobility of nodes. The widespread use of all these computing and communication devices creates a huge number of contact opportunities that are key to opportunistic communication.

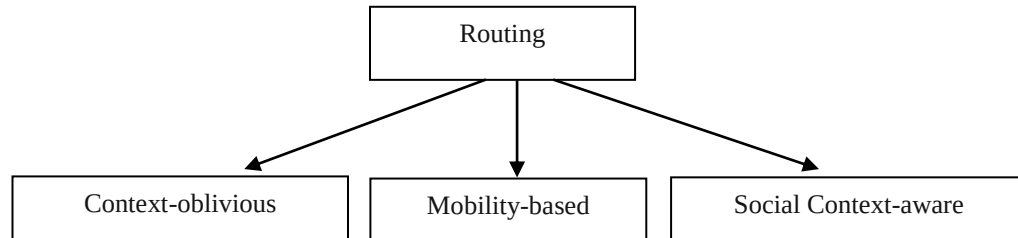
Routing is the most compelling challenge in opportunistic networking. There has been a lot of research in the past on routing in multi-hop ad-hoc networks [2, 3] i.e. in opportunistic networks. Routing algorithms have to cope with the typical limitations of wireless networks: high power consumption, low wireless bandwidth, high error rates. Routing performance improves when more knowledge about the topology of the network can be exploited. But this kind of knowledge is not easily available in opportunistic networks due to unpredictable topology. The network is formed opportunistically based on proximity and network availability, by randomly connecting and disconnecting the networks and devices. In opportunistic network intermittent connectivity is frequent and mobile nodes can communicate with each other even if route connecting them didn't previously exist. The design of efficient routing strategies for opportunistic networks is generally a complicated task due to the absence of knowledge about the topological evolution of the network. In the second section, we provide a brief description of the primary routing approaches in opportunistic networks available in the literature and analyze them on the basis of different parameters.

II. Routing and Forwarding Protocols

A routing scheme in opportunistic network has to provide data with some reliability even when the network connectivity is intermittent or when an end-to-end path is temporally nonexistent. Since "contacts" in an opportunistic network may appear arbitrarily without prior information, the scheduled routing approaches can't be directly applied. In such environment, flooding based routing protocols appeared for some time to be popular design choice [2]. Flooding based approach tends to be very costly in terms of traffic overhead and energy consumption. The performance of routing improves, when knowledge regarding the expected topology, the

behavior of the mobile nodes, and the information about the mobile nodes themselves in the networks can be exploited: that is, the context information of the node [3]. This information plays an important role in routing and forwarding. Context information can cover various aspects, depending on the specific routing protocols. It could be the workplace, home address, profession, email address, the mobility pattern of nodes, or the communities that the nodes belong to, and so on. All information that aids in making decisions to route messages is context information. For example, to identify those hops best suited for communication towards the destination, the home address of a user is a valuable piece of context information.

Figure 1 Classification of routing in opportunistic network



A number of opportunistic routing techniques are there in literature depending upon the category whether it is dissemination based or context based [4]. Dissemination-based approaches essentially are various flooding schemes and differentiate themselves for the policy used to limit flooding. While context-based approaches are non-flooding schemes that use knowledge of the context that nodes are operating in to identify the best next hop at each forwarding step. Figure 1, shows the classification of routing in opportunistic networks. It is classified into Context-Oblivious, Mobility-Based and Social Context-Aware. The routing and forwarding protocols within these categories are discussed one-by-one in subsequent sections.

III. Context Oblivious Routing

The Epidemic routing [5, 6], network coding based routing [7], spray and wait routing are context-oblivious routing approaches and under the category of dissemination based. In Epidemic routing, messages are forwarded randomly each time nodes establish contact in the hope of eventually reaching a receiver node. Epidemic routing exploits all possible space-time paths to deliver a message from its source to its destination. The basic idea of network coding [7] is to make intermediate network nodes intelligently mix several data packets into one coded data packet so that large amounts of transmissions can be saved. Network coding based routing takes an original approach to limit message flooding. In spray & wait routing protocol, a node generates a limited number of copies N to be transmitted for every message originating at the node. The node then forwards the copies to first N distinct encountered nodes. Each of these relay nodes, availing a message copy, are only allowed to directly transmit the message to its final destination.

IV. Mobility-Based Routing

Routing protocols that lie in the mobility-based category [8,9] exploit more context information to make forwarding decisions, such as the mobility information of nodes. The Moby-space routing [9], Probabilistic routing using history of encounters and transitivity (PROPHET) [10], Max Prop routing [11], MV [12], Context-aware routing (CAR) are mobility based routing approaches & are under the category of context-based. PROPHET [10] is proposed as an enhancement to the basic functionality of Epidemic routing in which connectivity/position history of each node can be leveraged to make forwarding decision, thus reducing traffic & increasing throughput with reduced latency. The context information used in PROPHET is the frequency of meeting between nodes. A node uses Max Prop routing to schedule packet transmission to its peers & determines which packets should be deleted when buffer space is full. MV (Meeting & visits) routing protocol also take into account the frequency of meeting between nodes. The nodes remember their path & the other nodes they met on the way. Each node stores variables for all the nodes so far encountered, describing the likelihood of a successfully delivery of this node. The delivery probability relies on recent-past observations of both the meetings between nodes. In MobySpace [9], the mobility pattern is the context information that the source node needed to route the message. It relies on the notion that a node is a good candidate for taking a message if it has a mobility pattern similar to that of the destination. Routing is done by forwarding messages towards node that have mobility pattern similar to that of the destination.

V. Social Context-Based Routing Protocols

The main difference between social context-based protocols and mobility-based protocols is that the context information in the mobility-based protocols is about the mobility patterns of the nodes, the information of the

devices themselves, or the encounter history between nodes. Social context-aware protocols [13] not only exploit such kinds of context information as in the mobility-based protocols, but also take into account the “social aspect” of the nodes as an important parameter to route the messages. This is motivated from the fact that in most cases, the mobility of nodes is decided by the carriers (e.g. human, animals, and vehicles). Hence, the social relationship of the carriers plays an important role in how they encounter each other. Social-aware routing use social-based metrics (e.g. community & centrality) to make opportunistic forwarding decisions. The HiBOP (History based) [14], SimBet [15], Bubble Rap [16], CAOR (Community aware opportunistic routing) [17], Propicman/spatial tempo [18] are social-aware routing approaches. Two key concepts in social network analysis are: Community, which is a group of people with social relations; and centrality, which indicates the social relations between a node and other nodes in a community. Based on the two concepts, algorithms detect the communities & compute the centrality value for each node. The centrality metric is generally used to measure the importance of node during message delivery. A node with a better centrality value means that it has a stronger capability of connecting with other nodes. Messages are delivered via the node with good centralities. Since social relations of mobile users generally have long-term characteristics & are less volatile than node mobility, so social-aware protocols outperform traditional routing protocols [17].

VI. Comparative Analysis

The following table shows mapping of different routing protocols on different parameters. The parameters considered are delivery ratio, message delay, no of messages sent, buffer management, vulnerability to malicious node attack, estimation of link forwarding probability, information exchange and computation.

Protocols	Delivery Ratio	Message Delay	No. of messages sent	Vulnerability to malicious nodes attack	Buffer Management	Estimation of link forwarding probability	Information Exchange	Computation (link state)
Epidemic	High due to flooding	Either high or low	High	High	Infinite	No	No	No
Network Coding	High (But Limited flooding)	Medium	Low	High	Infinite	No	No	No
Spray & Wait	High	Medium	Low	High	Infinite	No	No	No
Moby Space	High	Medium	Low	High	Infinite	Yes, Context info. Used for routing	Yes	Yes
PRoPHET	Better then Epidemic	Low	Medium	High	Infinite	Yes, using delivery predictability vectors	Yes	Yes
MV	Shows improvement	Low	Medium	High	Infinite	Yes, estimating the delivery likelihood	Yes	Yes
CAR	Higher then Epidemic	Low	Low	Very Low	Infinite	Yes, using Kalman Filter	No	Needed
HiBOP	Higher (Exploits social contacts)	Low	Low	Medium	Infinite	Yes, delivery probability evaluated	Yes	Yes
Bubble Rap	Depends on social community	Low	Low	Medium	Infinite	Yes, Exploiting context information	Yes	Yes
Propicman	Higher	Low	Very Low	Very Low	Infinite	Yes, Exploiting context information	Yes	Yes, Computes Delivery probability
CAOR	Much Higher	Very Low	Low	Low	Infinite	Yes, Computation of centrality metric	Yes	Yes

Table: 1 Comparative analysis of different routing protocols on different parameters.

From this table, in terms of delay, it is clear that a flooding based technique is best followed by social context aware protocols, if the network congestion is not an issue. The mobility based routing techniques shows lower

performance. If we consider the network traffic, the flooding based techniques are very costly, as data is flooded to all nodes in the network. Hence the social context aware routing protocols obtain the best performance as only some nodes with certain matching rate of context information are involved in transmission process.

VII. Conclusion & Future Scope

Opportunistic network is an emerging system that is getting growing interest in networking research community. An analysis of various routing protocols is presented in the form of table. The social-aware routing protocols performs better than other traditional routing protocols. Based on the increasing pervasiveness of our world, and on releasing end-to end connectivity constraints, it can better exploit social characteristics via social context awareness, since social relations of mobile users generally have long-term characteristics and are less volatile than node mobility. One can do research in the social based routing protocols as this is an important aspect in social environment.

References

- [1] Anders Lindgren, K.S.Phanse, Tomas Johansson, "Future Direction in Ad hoc Networking Research", IEEE April, 2007.
- [2] Gorgen D.Frey, H.Hutter, "Information Dissemination based on the Communication Pattern", 2005.
- [3] Julien Hailot & Frederic Guidic, "Towards a Use-net like Discussion System for users of MANET", IEEE Computer Society, 2008.
- [5] Jonah P.Tower, Thomas D.C.Little, "A proposed scheme for epidemic routing with active curing in opportunistic networks", IEEE computer society, pp. 1696-1701, 2008.
- [6] Amin Vahdat and David Becker, "Epidemic Routing for Partially-Connected Ad Hoc Networks," Technical Report CS-200006, Duke University, April 2000.
- [7] Qinglong Liu, and Gang Feng, "Mitigating the Impact of Asynchronous ACKs on the Performance of Opportunistic Network Coding", IEEE, Wireless network symposium (Globecom 2012), pp. 5644-5649, 2012.
- [8] A.Chaintreau, P.Hui, J.Crowcroft, et.al, "Impact of human mobility on the design of opportunistic forwarding algorithm", Proceedings of IEEE Infocom, Barcelona, Spain, April 2007.
- [9] J.Leguay, T.Friedman and V. Conan, "Evaluating mobility pattern space routing for DTNs", Proceedings of IEEE Infocom, Barcelona, Spain, April 2009.
- [10] A.Lindgren, A.Doria, et.al, "Probabilistic routing in intermittently connected networks", Mobile Computing & communication review, 7(3), July 2010.
- [11] J.Burgess, B.Gallagher, et.al, "Maxprop: Routing for vehicle-based disruption tolerant networking", Paper presented in the proceedings of IEEE Infocom, Barcelona, April 2008.
- [12] B.Burns, O.Brock & B.N.Levine, "MV Routing and capacity building in disruption tolerant networks", Proceedings of IEEE Infocom, Miami, Mar 2011.
- [13] Mingjun Xiao, Jie We, Liusheng Huang, "Community aware opportunistic routing in mobile social networks", accepted for publication, IEEE Transaction on computers, 2013.
- [14] C. Boldrini, et.al, "HiBOp: A history based routing protocol for opportunistic network", IEEE communication magazine, pp.225-232, Nov 2007.
- [15] V. Erramilli, A.Chaintreau, et.al, "Diversity of forwarding paths in opportunistic networks", ACM Transactions on networking, pp.267-278, Oct 2008.
- [16] Pan Hui, Jon Crowcroft, and Eiko Yoneki, "BUBBLE Rap: Social-based Forwarding in Delay Tolerant networks", IEEE Communication magazine, pp-678-685, Nov 2010.
- [17] Mingjun Xiao, Jie We, Liusheng Huang, "Community aware opportunistic routing in mobile social networks", accepted for publication, IEEE Transaction on computers, 2013.
- [18] Yun Li, Jihong Yu. Et.al, "A Novel Bargaining based Incentive Protocol for Opportunistic Networks", pp. 5285-5289, Globecom 2012: Wireless networking symposium, IEEE 2012.