Multipath Support for Name-based Information Dissemination in Fragmented Networks

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ABSTRACT

In the aftermath of natural disasters (e.g., earthquakes and hurricanes), networks are fragmented, and communication is intermittent and disruption-prone. In this paper, we propose a multipath support for publish/subscribe name-based information dissemination in such fragmented networks. Our solution helps to reduce unnecessary replication and transmission in disaster scenarios.

Categories and Subject Descriptors

C.2 [**Computer-Communication Networks**]: Network Architecture and Design, Network Protocols

Keywords

Information-Centric Networking (ICN); Content-Centric Networking (CCN); Publish/Subscribe; Safety Confirmation

1. INTRODUCTION

In the aftermath of natural disasters, existing mobile network infrastructure is damaged and isolated due to base stations and backhaul network failures. We therefore study how to improve the dissemination of information from and to these isolated networks. Hereafter, we refer to these isolated networks as *fragmented networks*.

Figure 1 shows a reference network that includes fragmented networks, a non-fragmented network, and a data mule, such as an ambulance, a fire engine, a patrol car, or a special drone. We assume a Wi-Fi access point and an ICN [1] router are installed at each fragmented network (i.e., shelter) for refugees to enable communication with others in the same fragmented network. Data mules, on the other hand, have a communication method with access points and can transfer and receive messages from/to a fragmented network and a non-fragmented network.

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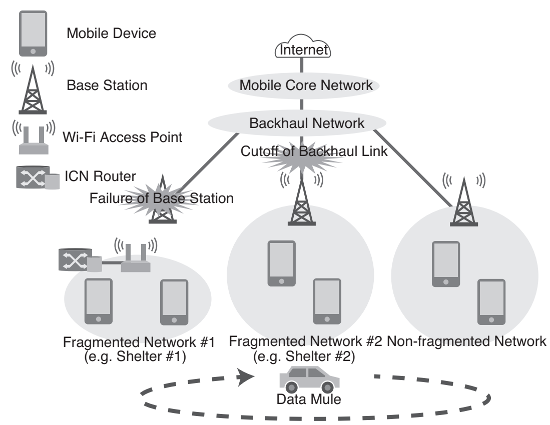

Figure 1: Hypothetical examples of fragmented networks in a disaster scenario

A rendezvous point-based publish/subscribe mechanism to support information dissemination in fragmented networks has been proposed in [6]. The basic idea is to construct a disruption tolerant logical topology over fragmented networks and build a subscription table (ST) exploiting this logical topology. The logical interfaces of a node is viewed as distinct from its physical interface. The association of a physical interface to a logical interface is established when the physical connectivity is established. The advantage is a reduction in the unnecessary transmission of messages, since messages are forwarded on the basis of a managed routing table. However, rendezvous point-based solutions could lead to a substantial increase in the length of information dissemination paths since each published message is forwarded to the subscribers via the corresponding rendezvous point. This paper proposes an extend version of our solution with multipath support in order to achieve more reduction in unnecessary message replication and transmission.

2. RELATED WORK

Delay-/Disruption-Tolerant Networking (DTN) is a promising ad-hoc communication method that provides network services continuously with a network that has no specific infrastructure. More recent studies on the interface between ICN and DTN have shown that name-based communication is superior to IP-based mobile communication [7]. Most of the work to bring information centricity on DTN, mobile ad-hoc networking, or vehicular networking is still in the early stage [8]. Recently, the authors of [5] proposed NREP, which enables named-based message dissemination based on priority. NREP is suitable for disseminating messages, such as warnings and availability of shelters and food, but not suitable for services, such as safety confirmation, since NREP does not take the specific interests of users into account.

3. DESIGN

3.1 Overview

To deal with the problem described in Sec. 1, we introduce *weighted logical topology* to support multipath forwarding in fragmented networks. Our multipath support enables the intermediate routers, i.e., ICN routers, data mules, and of course the rendezvous point, to select suitable next hops to deliver subscribe/publish messages for efficiency in the fragmented networks. The key idea is that a weight is assigned to a logical face dynamically and asymmetrically. We use two kinds of routing tables for publish/subscribe messages to construct the optimal tree with a breadcrumb model. Intermediate routers can decide which data mule is the fastest to disseminate messages to users. In that sense, multipath support helps to reduce unnecessary replication, transmission, and delay of messages in fragmented networks.

Figure 2(a) shows an example map, where there are five sites, i.e., the rendezvous point (RP) and 4 shelters. In this map, three data mules a, b, and c go around sites and have planned routes R_a = { RP, 1, 2 }, R_b = { RP, 4, 3, 1 }, and R_c = { RP, 3, 4 }, respectively. A logical link is established based on the order of a planned route. When planned route R_a of data mule a has Shelter#1, for example data mule a and Shelter#1 are connected by a logical link. Figure 2(b) shows the weighted logical topologies, whose roots are RP and Shelter#4, respectively. The weight on a link between two nodes is the transit time between the two nodes. For example, if RP sends a message to Shelter#4, there are two routes from RP to Shelter#4, i.e., RP → b → 4 and RP → c → 4. The sums of weights over the routes are 67 (57 + 10) and 74 (42 + 32), respectively. Thus, RP chooses data mule b as the next hop because data mule b is likely to reach Shelter#4 faster compared with data mule c. Similarly, Shelter#4 selects data mule c as the next hop for a message to RP.

3.2 Two Forwarding Planes

Since the weighted logical link is asymmetric, the least-cost route is determined by the direction. This asymmetry is excellent potential for breadcrumb forwarding, like PIT and ST (defined by NDN [4]/CCN [3], and COPSS [2], respectively). Publish/subscribe communication model has multiple data packets, i.e., subscriptions and publications. The total of message delay is the sum of the delay from the publisher to the rendezvous point and the delay from the rendezvous point to the subscriber. A delay from a subscriber to the rendezvous point is not so important from the viewpoint of QoS. We, therefore, build two forwarding planes. One plane routes publish messages from a publisher to the rendezvous point, and the other plane routes subscribe messages to construct ST, which is the least-cost tree rooted by the rendezvous point.

To construct two forwarding planes on top of ICN, the rendezvous point advertises two names, i.e., `/pub/rp/` and `/sub/rp/`. Each edge router calculates cost, i.e. transit time, according to the destination's prefix and advertises the cost to neighbor routers.

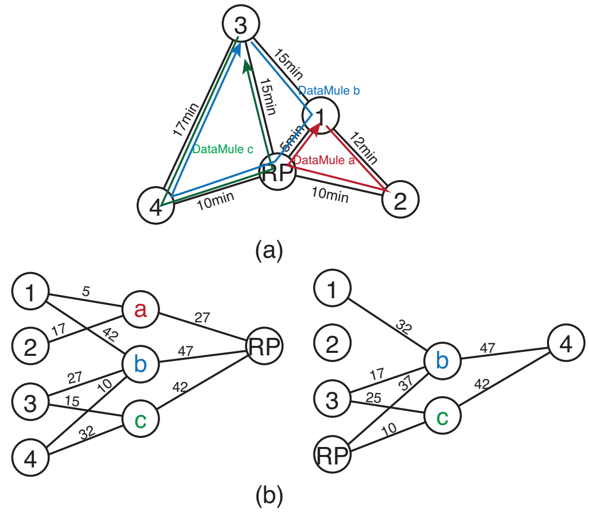

Figure 2: (a) A map with routes of data mules and transit time between sites (b) Weighted logical topologies, whose roots are RP and Shelter#4, respectively

4. CONCLUSION

In this paper, we presented a multipath support built on top of a publish/subscribe architecture, for information dissemination in fragmented networks. As future work, we need to evaluate the effectiveness of our multipath support by simulation experiments.

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