INVESTIGATION OF THE PERFORMANCE OF CONTENT-BASED OPPORTUNISTIC ROUTING PROTOCOL IN DTN: A COMPARATIVE STUDY

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ABSTRACT

Delay Tolerant Network (DTN) is one kind of emerging networks characterized by long delay and intermittent connectivity. Therefore, network environments where the nodes are characterized by opportunistic connectivity are appropriately modeled as Delay-Tolerant Networks (DTN). Traditional ad hoc routing protocols are inapplicable in DTNs because nodes are seldom fully connected. In recent years, many routing protocols are proposed to improve the performance matrix in DTN. In this paper, we have observed the performance of social aware DTN routing protocols, namely Social-aware Content-based Opportunistic Routing Protocol (SCORP), Daily Routine Based (dLife), and Community Based dLife (dLifeComm) in an ICMN scenario. Their performances are analyzed in terms of delivery probability, average latency, and overhead ratio for varying the number of nodes per group, TTL (time to live) and simulation time respectively. Opportunistic Network Environment (ONE) simulator is used as the simulation tool for evaluating these performance metrics. The result of this investigation shows that for the ICMN scenario, SCORP exhibits best performance whereas dLife the worst in terms of all the metrics considered here.

KEYWORDS

Delay-tolerant network (DTN,) intermittently connected mobile network (ICMN), opportunistic network environment (ONE) simulator, SCORP, dLife, dLifeComm, routing, simulation

1. INTRODUCTION AND RELATED WORKS

A delay-tolerant network (DTN) [1] enables communication in such a challenged networks, where there is no direct path from source to destination. There are many real-life networks, which follow this DTN paradigm, for example, satellite communication [2], wildlife tracking sensor networks [3], military networks, vehicular ad hoc networks [4], etc. In this scenario, network topology changes dynamically [5] so that traditional routing protocol is less efficient to circulate the intended proclamation that had evaluated in [6]. Hence, routing in DTN uses store and forward mechanism [7] to enable a successful communication. Various DTN routings apply different techniques to meet the target node based on particular routing metrics [8], such as estimated delivery probability, historical contact frequency, available network resources, or estimated delay [9]. In this modern era, users crave connectivity while on the go with the advent

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of powerful mobile devices [7]. This leads to a networking scenario with heterogeneous, mobile, and power-constraint devices, as well as wireless networks with intermittent connectivity even in urban scenarios [10], due to the presence of wireless shadowing, and the existence of closed access points and expensive Internet services [11]. It has been shown that focusing on the content, rather than on the host, we can improve the performance of challenged networks [12, 13] by allowing an efficient direct communication between producers and consumers of content. In addition, exploiting nodes' social interactions and structure (i.e., communities [14] levels of social interaction [15, 16]) has been shown efficient to increase the performance of opportunistic routings but less than Content-based protocols. Social-aware Content-based Opportunistic Routing Protocol (SCORP) considers users' social interaction and their interests [11] to improve data delivery in urban, dense scenarios. The dLife routing considers the dynamism of user's behavior [17] found in their daily life routines. It takes the trace of social interaction for the further data transmission. The dLifeComm routing protocol is the update version of dLife routing protocol, where it takes also the trace of social interaction and their interest for the better performance than dLife.

In this paper, we have evaluated the performance of the above considered three social aware routings, namely, SCORP, dLife, and dLifeComm. This paper is structured as follows. In Section II, we present SCORP, dLife, and dLifeComm. Section III shows the simulation tool and environmental setup. Section IV presents our evaluation study. In Section V, conclusions and future work are presented.

2. DESCRIPTION OF PROTOCOL UNDER INVESTIGATION

In this section, we briefly discuss the SCORP, dLife, and dLifeComm social aware routing protocols. The social-aware content based opportunistic routing protocol that takes into account the social presence between nodes and the content knowledge that nodes have while taking ongoing decisions. SCORP is based on a utility function that possess the probability of withstanding nodes with a particular interest among the ones that have similar daily social functions. The reason to use social presence with content knowledge is two-fold: first, nodes with same daily habits have larger probability of having similar (content) interest [12]; second, social proximity metrics accommodate a later dissemination of data, taking advantage of the more frequent and longer contacts between closer nodes [11].

With dLife [9, 11, 17] the dynamism of user's behavior found in their daily life routines is calculated to aid routing. The goal is to keep way of the different levels of social interactions that nodes have throughout their daily tasks in order to conclude how well socially connected users are in different periods of the day.

The dLifeComm [17] is community-based version of dLife routing protocol. The dLifeComm social aware routing protocol keeps track the social interest and interaction history for the purpose of gaining the higher performance in the intermittently connected network. It performs the same functionality as dLife social aware routing protocol except community-based activities. It allows the structure of BUBBLE RAP [14] routing protocol.

TABLE 1. Simulation Parameters

Parameters	values
Simulation Time	(3,6,12,24,48)hours
Update Interval	1 seconds
Number of nodes in Group	50,100,150,200,250
Interface	Bluetooth Interface
Interface Type	Simple Broadcast Interface
Transmit Speed	250kbps
Transmit Range	10m
Routing Protocols	SCORP, dLife, dLifeComm
Buffer Size	30M
Message TTL	(50,100,150,200,250)min
Movement model	Shortest Path Map Based
Message Size	500kB-1 MB
Simulation Area size	4500m*3400m

3. SIMULATION METHODOLOGY

Simulations are carried out using Opportunistic Network Environment (ONE) simulator with program version of 1.5.1. This section presents ONE simulator and experimental settings.

3.1. The ONE Simulator

ONE is an agent-based discrete event simulation used for evaluating the performance of DTN routing protocols, which usually focus on mobility modeling, inter node contacts, message handling and visualization. A detailed description of the simulator is available in [18] and the ONE simulator project page [19]. Source code of this simulator are written in Java programming language.

3.2. Simulation Environment Setup

Parameters of simulation setup are specified in TABLE 1. Table 1 shows the simulation configuration for analyzing the simulation time, TTL (Time to live) and number of nodes, respectively. For varying the number of nodes, the simulation time is 1days which is defined in seconds and the TTL is 300 min respectively. When varying the simulation time, the number of nodes is 150 which are distributed equally in three group, and the TTL is remain unchanged which is 300 min. And when varying the TTL then the number of nodes is 150 distributed equally into three group (50 per group), and the simulation time is 1 days (86400s).

3.3. Performance Metrics

We have mainly analyzed three performance metrics of DTN routing protocols: delivery probability, average latency, and overhead ratio.

3.3.1. Delivery Probability

Delivery probability is the ratio of the total number of messages delivered to the destination over the total number of messages created at the source.

$$\text{Delivery Probability} = \frac{Total\ number\ of\ message\ delivered}{Total\ number\ of\ message\ created}$$

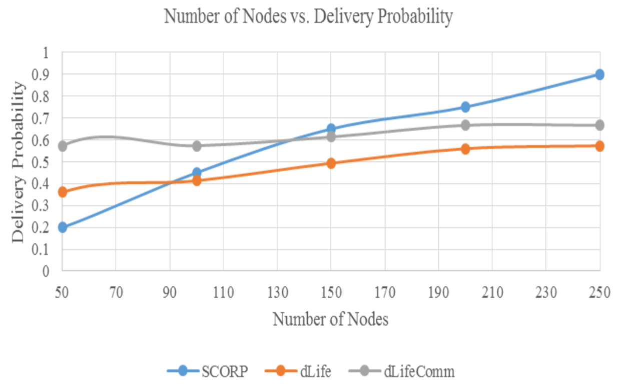

Figure 1. Number of Nodes vs. Delivery Probability

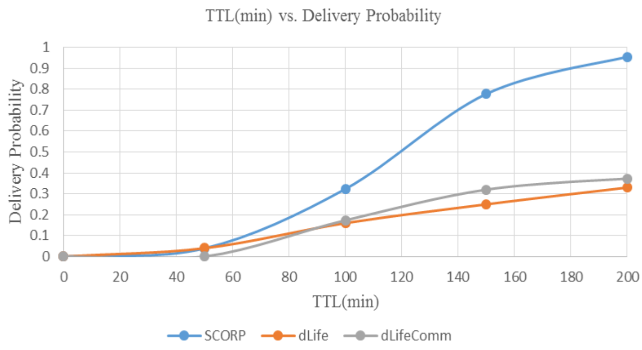

Figure 2. TTL (min) vs. Delivery Probability

From Figure 1, we see that SCORP protocol achieves better performance than dLife and dLifeComm in terms of delivery probability for every number of nodes per group. From Figure 2 and 3, it is clear that the delivery probability of SCORP is much better than both dLife and dLifeComm social aware routing protocols for each setting of TTL and simulation time respectively. In all the cases (varying number of nodes per group, TTL and simulation time), the lowest delivery ratio is provided by dLife routing protocol.

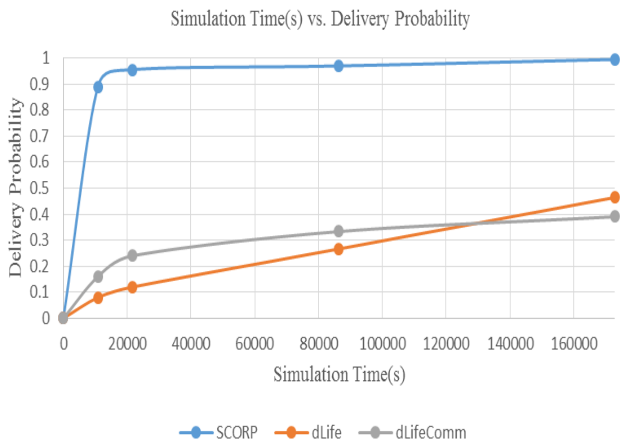

Figure 3. Simulation Time(s) vs. Delivery Probability

3.3.2. Average Latency

It is the measure of average time between messages is generated and when it is received by the destination [6]. We can define the average latency by following equation:

$$\text{Average latency}=\sum_{i=1}^{n}\frac{\textit{Delivery time} - \textit{createt time}}{\textit{Number of delivered message}}$$

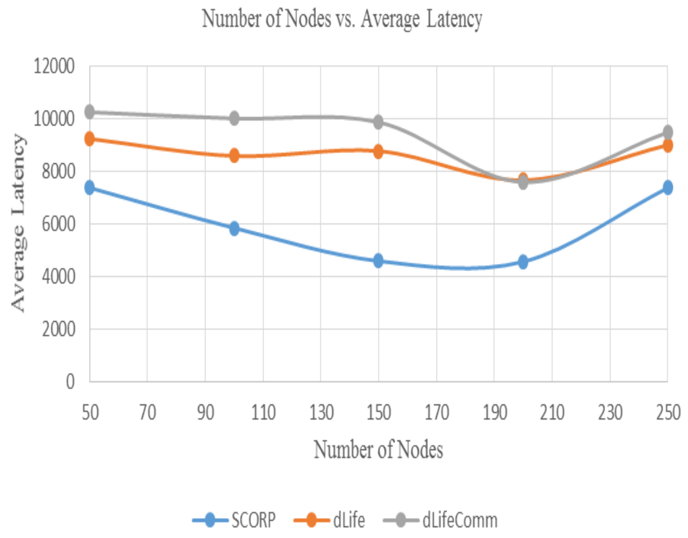

Figure 4. Number of Nodes vs. Average Latency

From Figure 4, we see that average latency of SCORP is less than other two protocols .Varying the number of nodes per group for all protocols in accordance with average latency, the SCORP social aware routing protocol has higher performance than others. While increases the TTL and simulation time respectively in Figure 5 and 6 as shown in Figure 4, the SCORP social aware routing protocol shown better performance than dLife and community based version dLife.

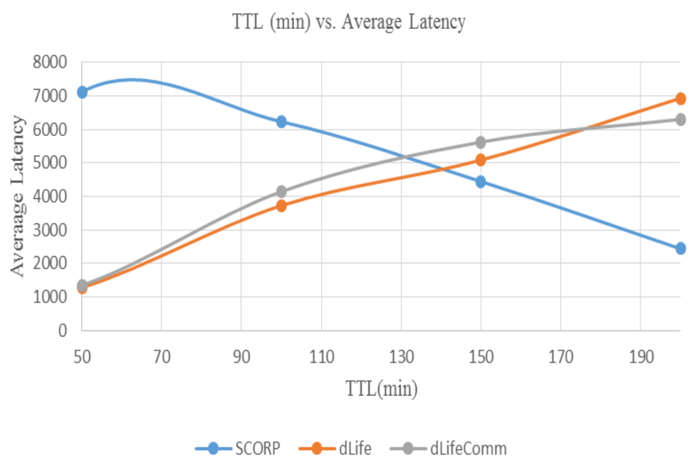

Figure 5. TTL (min) vs. Average Latency

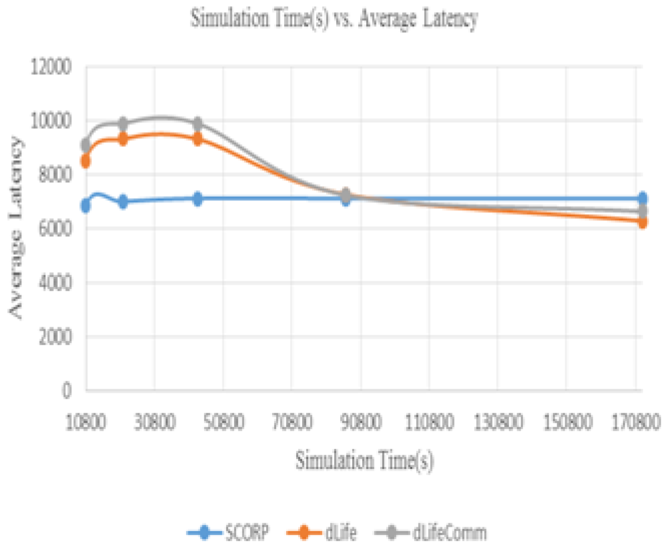

Figure 6. Simulation Time(s) vs. Average Latency

3.3.3. Overhead Ratio

The overhead ratio defines how many redundant packets are relayed to deliver one packet. It simply reflects the cost of transmission in a network.

$$\text{Overhead Ratio} = \frac{R - D}{D}$$

Where R is the number of messages forwarded by relay nodes, and D is the number of messages delivered to their destination.

From Figure 7, 8 and 9 it can be said that the overhead ratio of dLife and dLifeComm are increased with varying the number of nodes per group, TTL and simulation time. Where the SCORP social aware routing protocol shown the better performance than other two social aware routing protocol.

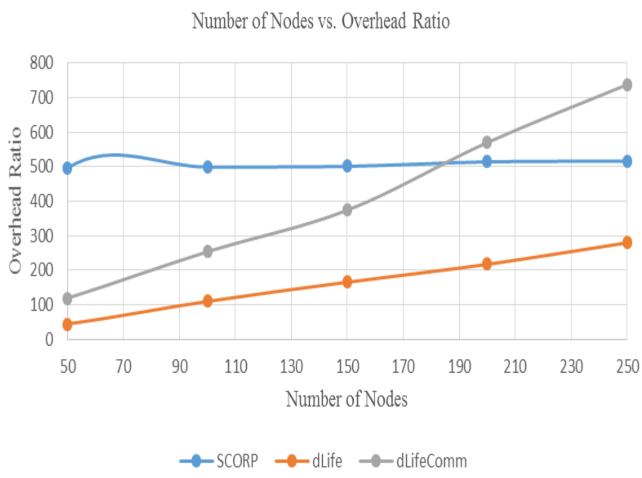

Figure 7. Number of Nodes vs. Overhead Ratio

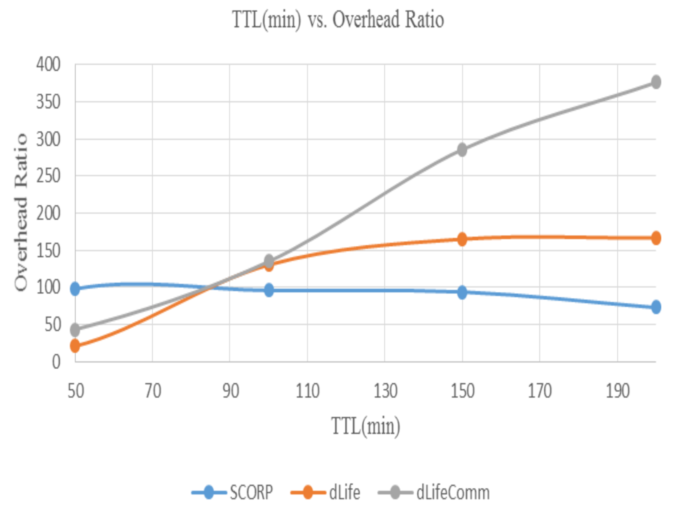

Figure 8. TTL (min) vs. Overhead Ratio

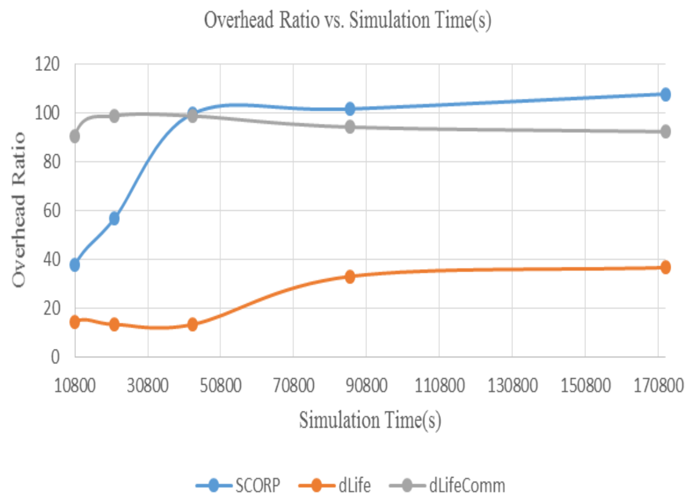

Figure 9. Simulation Time(s) vs. Overhead Ratio

4. CONCLUSION AND FUTURE WORKS

In this paper, we have investigated the performance of DTN social aware routing protocols, i.e., SCORP, dLife, and dLifeComm (Community based version), in intermittently connected mobile networks (ICMNs). Simulation results show the performance comparison of the investigated DTN social aware routing protocols in terms of message delivery probability, average latency and overhead ratio with the variation of number of nodes, TTL, and simulation time respectively. From these results we may conclude that the best candidate of social aware routing protocol for the ICMNs is SCORP. In near future, we will propose a new social aware routing protocol that will exhibit better performance compared to the existing routings.

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