

# An Efficient Opportunistic Routing Protocol for ICN

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## ABSTRACT

Opportunistic routing protocols, such as delay tolerant networks (DTN), can be used to enable information centric networking (ICN) in disaster environments. Existing approaches using DTN for ICN suffers from message overhead due to the mobility of sparsely populated mobile nodes and overall performance degradation. We therefore propose an efficient opportunistic routing protocol for ICN to reduce message overhead and improve delivery probability, too. Performance evaluation results thorough simulation show that the proposed protocol has better delivery probability and overhead ratio than conventional protocol.

## CCS CONCEPTS

• Networks → Network protocols; Network performance evaluation;

## KEYWORDS

Information-centric networking, Delay-tolerant networking, Opportunistic protocol

## 1 INTRODUCTION

In information centric networking (ICN), consumers request contents and these requests are replied by original producers or intermediate nodes caching the contents [1]. To this end, Content store (CS), pending interest table (PIT), and forwarding information base (FIB) were proposed in ICN. In disaster environment, connectivity between nodes is not guaranteed due to the failure of network infrastructure and ICN should be deployed with the help of opportunistic routing protocols such as delay tolerant networks (DTN) [2]. Applying DTN for ICN, however, is not simple, since Data cannot be routed using the reverse path of Interest, i.e., breadcrumb, due to the mobility of sparsely populated nodes.

Some approaches have been proposed to apply DTN for ICN [3]-[5]. In [3], fragmented networks with gateways are assumed and DTN is used to deliver ICN messages between gateways. In [4], data mule was proposed to communicate between users located in fragmented networks after disaster. In [5], a routing

protocol to deliver ICN messages between nodes has been proposed by adapting probabilistic routing protocol using history of encounters and transitivity (PRoPHET) protocol [6]. In [5], the information of different requesters is merged in Interest messages. In [7], pending requester information on the interest packet (PRIT) table was proposed in DTN environment, where pending requester information in Interest is stored in PRIT table.

Due to the intrinsic nature of mobility of sparsely connected nodes, the previous opportunistic protocols for ICN suffer from message overhead, since Interest and Data messages are still disseminated even after Interest and Data are successfully delivered. We therefore propose an efficient opportunistic routing protocol to reduce message overhead and improve delivery probability.

## 2 PROPOSED PROTOCOL

In the proposed protocol, we assume that requester information is shared between nodes whenever they contact each other and delivery predictability defined in PRoPHET protocol is used to decide forwarding of Interest and Data, similar to the work in [5]. To reduce message overhead, we propose an approach to remove already delivered Interest and Data by sharing delivery information of Interest and Data between nodes. This approach is similar to the anti-packet approach of the work in [8], where anti-packet is generated for already delivered message and redundant messages are removed if a node contacts an another node with anti-packet for the message. However, the work in [8] was intended for unicast communication in DTN and thus, cannot be directly applied to opportunistic protocols for ICN, where multiple requesters and multiple caching nodes exist.

In the proposed protocol, each node manages pending anti-interest and data table (PAID), which includes Data ID, requester ID, and satisfaction flag. The proposed PAID is similar to PRIT table in [7] which also manages requester information but it is different from PRIT table by additionally managing more information such as satisfaction flag. Each node manages buffer which stores Data and Interest with requester ID. In PAID, requester IDs are managed for each requested Data ID. Also, if a Data is successfully delivered to a requester, satisfaction flag for the requester for the considered Data is set to 1. PAID is exchanged between nodes whenever any two nodes contact each other, and requester ID and satisfaction flag are also shared. If a satisfaction flag for a requester ID for a Data is satisfied, Interest for the requester is removed from buffer. If all the satisfaction flags for a Data are 1, the corresponding Data is also removed from buffer. By doing this, dissemination of successfully delivered

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Interest and Data can be controlled locally, although each node does not have global information of requesters in a whole network.

Figure 1 shows example scenarios of the proposed protocol. When a node  $R_1$  contacts a node  $N_1$ , they exchange PAID. Then, requester ID  $R_2$  for Data  $d_1$  and requester ID  $R_3$  for Data  $d_2$  are shared. Data  $d_1$  is forwarded from  $N_1$  to  $R_1$  and Interest  $i_1$  is removed from the buffer of  $R_1$ . Also, Data  $d_2$  is removed from the buffer of Node  $R_1$  since all satisfaction flag for Data  $d_2$  are 1 in Node  $R_1$ .

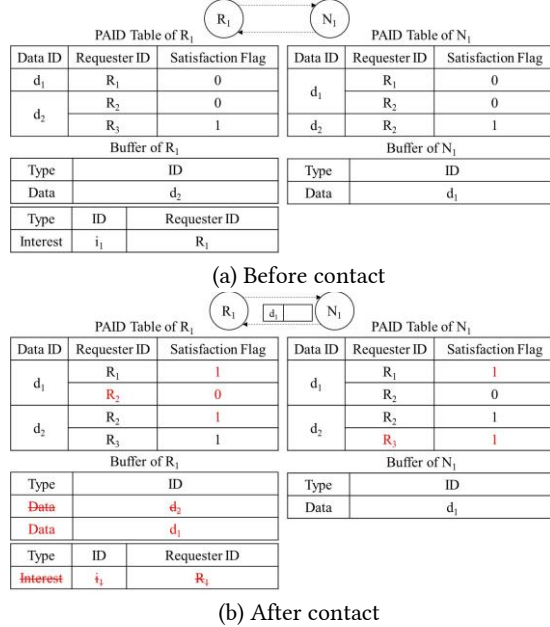


Figure 1: Example scenarios of the proposed protocol

### 3 PERFORMANCE EVALUATION

In this paper, the performance of the proposed protocol was evaluated through simulation by modifying opportunistic network environment (ONE) simulator [9]. The parameters assumed in the simulation are shown in Table 1. Figure 2 shows that the proposed protocol has smaller overhead ratio and higher delivery probability than conventional protocol proposed in [5] by efficiently controlling the dissemination of Interest and Data using PAID table.

Table 1: Simulation parameters

| Parameter                  | Value                                 |
|----------------------------|---------------------------------------|
| Area size(m <sup>2</sup> ) | 4,500×3,400                           |
| Simulation time(s)         | 43,200                                |
| Transmission range(m)      | 10                                    |
| Movement model             | Shortest path map based movement      |
| Number of nodes            | 400                                   |
| Velocity of nodes          | U[0.0, 0.5], U[0.5, 1.0], U[0.0, 1.0] |
| Buffer size(Mbytes)        | 10, 20, 30, 40, 50, 60                |
| Message size(Mbytes)       | Data: U[0.5, 1.0], Interest: 0.001    |
| Number of Message          | Data: 100, Interest: 1,000            |

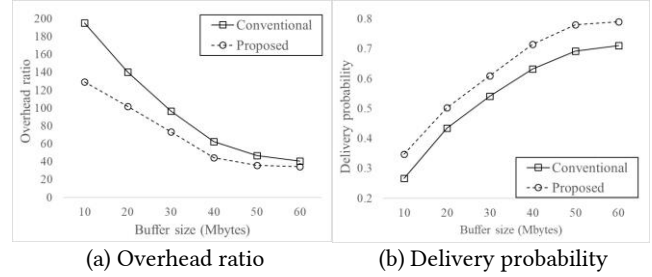


Figure 2: Performance evaluation

### 4 CONCLUSION

In this paper we proposed an efficient opportunistic routing protocol for ICN and showed that the proposed protocol has better overhead ratio and delivery probability.

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### REFERENCES

- [1] G. Xylomenos, C. N. Ververdis, V. A. Siris, N. Fotiou, C. Tsilopoulos, X. Vasilakos, K. V. Katsaros, and G. C. Polyzos. 2013. A Survey of Information-Centric Networking Research. *IEEE Communications Surveys & Tutorials*, 16(2), 1024-1049.
- [2] Z. Zhang. 2006. Routing in intermittently connected mobile ad hoc networks and delay tolerant networks: overview and challenges. *IEEE Communications Survey and Tutorial*, 8(1), 24-37.
- [3] J. Seedorf, A. Tagami, M. Arumathurai, Y. Koizumi, N. Blefari Melazzi, T. Asami, K.K. Ramakrishnan, T. Yagyu and I. Psaras. 2015. The Benefit of Information Centric Networking for Enabling Communications in Disaster Scenarios. In *Proceedings of IEEE Globecom Workshops (GC Wkshps)*, San Diego, CA, USA.
- [4] H. Islam, A. Lukyanenko, S. Tarkoma, and A. Y. Jaaski. 2015. Towards disruption tolerant ICN. In *Proceedings of IEEE Symposium on Computers and Communication (ISCC)*, Larnaca, Cyprus.
- [5] M. W. Kang and Y. W. Chung. 2018. Performance Analysis of a Novel DTN Routing Protocol for ICN in Disaster Environments. In *Proceedings of International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju, South Korea.
- [6] A. Lindgren, A. Doria, E. Davies, and S. Grasic. 2012. *Probabilistic routing protocol for intermittently connected networks*. IETF RFC 6693.
- [7] H. M. A. Islam, D. Lagutin, A. Lukyanenko, A. Gurtov, and A. Ylä-Jääski. 2017. CIDOR: Content Distribution and Retrieval in Disaster Networks for Public Protection. In *Proceedings of IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)*, Rome, Italy.
- [8] Z. J. Haas and T. Small. 2006. A new networking model for biological applications of ad hoc sensor networks. *IEEE/ACM Transactions on Networking (TON)*, 14(1), 27-40.
- [9] The Opportunistic Network Environment simulator. <https://www.netlab.tkk.fi/tutkimus/dtn/theone>.