Hybrid PRoPHET-Epidemic Routing Protocol for Optimizing Possibility of Sending Messages in Remote Fishermen Residential Area

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Hybrid PRoPHET-Epidemic Routing Protocol for Optimizing Possibility of Sending Messages in Remote Fishermen Residential Area

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***Abstract*—Limitations of communications facilities and infrastructure in the residential areas of the fishermen create problems of information difficulty. Lack of signal availability from the nearest Base Transceiver Station (BTS) that can reach the fishermen's residential area. A solution is needed that allows the communication path from the residential area of the fishermen to the area available for communication facilities and infrastructure. From this issue, there are several methods that can be used to overcome this problem. One of the methods that are used as a solution is Delay or Disruption Tolerant Network (DTN) network architecture, and another method utilize Crowdsource Mobile Access (CrowdMAC) to send message data packets to the destination device. In this paper, we carried out the integration of PRoPHET and Epidemic routing protocols to increase the level of the possibility of sending packets via multiple nodes with crowdsourcing.**

***Index Terms*—Crowdsource; Disruption Tolerant Network; Epidemic; PRoPHET.**

I. Introduction

Vehicular Ad Hoc Network (VANET) communication system characteristics are high connectivity and Ad Hoc network coverage with close node density so that the success rate of message delivery to the destination is also high. However, if the density of the node decreases and the range of limited communications will result in unstable and often interrupted connections resulting in increased information delivery delay. This communication system is called DTN [1]. Message delivery on DTN applies store-carry-forward paradigm. The method of sending messages on the DTN is based on the chance of a peer node with other nodes. If not have a chance, then the message will be stored in storage media owned by each node. [2].

The problem with TCP / IP utilization in areas with an end to end connectivity has a very high delay and disturbance is the beginning of the DTN concept. According to the research [3] that designed the DTN network scalability by applying the protocol epidemic routing algorithm as well as the removal mechanism independently. In principle, the delivery rate of the epidemic algorithm is good but less good for the use of network resources.

Various types of communication tools circulating in Indonesia such as smartphones have not been widely used to access information to increase fishermen income. Most of its use still depends on the means of communication available in urban areas only. Fishing villages in the coastal area have no adequate communication facilities. In this paper, propose the incorporation of DTN routing protocols Epidemic and PRoPHET in order to improve the success of message delivery.

II. Related Work

Challenges for the provision of means of communication in emergencies have been done by [4], using the MANET method of sending message data. However, MANET method is highly dependent on supporting infrastructure already available. Through the DTN routing protocol is expected to expand the range of data transmission messages without the support of the availability of means of communication.

In research [5], proposed a DTN routing replication algorithm called Epidemic. In principle, messages are sent to all node randomly like Epidemic outbreaks. This method is done to increase the chances of successful delivery of the message to the destination. But this will lead to an increase in the amount of energy consumption in the network and increase overhead. The random message delivery process using the Epidemic algorithm is fixed by the PRoPHET routing algorithm where messages are sent only to multiple nodes that have a chance to meet with the destination node.

Crowdsourcing method is needed especially for isolated areas or areas lacking support facilities to be able to communicate. Utilizing existing features on a smartphone such as Wi-Fi Direct to be able to connect between devices by way of smartphone relay.

In reference [6] has also approached Crowd MAC communications network architecture consisting of mobile devices, mobile hotspots (AP), and mobile infrastructure using the Lyapunov algorithm [7], but data packets transmitted in the form of data files. In other words, process context is performed in the form of file sharing. Unfortunately, most of them have a false assumption in the fact that smartphone users will participate in the crowdsourcing voluntarily [8].

According to [9] research, Wi-Fi selection can be recommended as a more suitable protocol for communication between smartphones. These devices are capable of searching nearest connection in 1 second compared to Bluetooth which takes almost 10 seconds search time. Nevertheless, Wi-Fi point is assumed immobile therefore only one device is actively scanning for a reachable peer. Therefore, in infrastructure conditions which lacking Wi-Fi point is not yet suitable to be implemented.

Considering limited communication support facilities, especially the availability of signals in remote areas, a short

message service solution for fishermen living in coastal settlements is not supported by communication signals availability. Utilizing communities or crowds of fishermen settlements using smartphone devices to relay data messages and supported by proxies as devices aiding message data packets relay. The combination of DTN network architecture and Crowdsource Mobile Access (CrowdMAC) method is expected to be an alternative communications line solution for relaying message data packets to intended device, and it was developed in this research.

Crowdsourcing mobile access has been discussed since last 5 years [10]. In last 2 years, it sparked a number of research discuss it. Associated with CrowdMAC, it started with the architectural styles and approaches related to hardware and software support.

Further research studies the opportunities and challenges surrounding mobile crowdsourcing [11]. According to [12] who conducted research on device-to-device communications protocols on Wi-Fi direct stated that although Wi-Fi Direct protocol is useful, it is not free of security issues. It should be addressed before the method is accepted and implemented. However, since Wi-Fi access is open nature, Wi-Fi Direct still has an opportunity for attacks.

DTN network architecture and CrowdMAC method could become a communication path solution to forward message data packets up to destination device. Crowdsourcing as a method that utilizes many people who have devices that can function as a carrier of data packets on a chain (hop to hop).

With the support of the Data Dissemination process for short message delivery to smartphone devices, it can help speed up message relays. In Data Dissemination process, there are methods of message queue and copy mode capable of speeding up the execution of message data packets from the sender.

Topologies selection on the DTN protocol that combines Probabilistic Routing Protocols using History of Encounters and Transitivity (PRoPHET) and Epidemic is expected to produce a new method of delivering faster and more accurate message data packets. That method required an application that serves to make the process of sending messages between smartphone devices by utilizing another smartphone (CrowdMAC-DTN Data Dissemination) where each smartphone can perform message queue and copy mode functions via Wi-Fi Direct connection.

An opportunistic network routing scheme designed to minimize delay and maximize the success rate of message packet delivery. By using a weighted function that can calculate deliverability considering the buffer size, power, location, popularity, as well as the predictability value of PRoPHET. However, this study also still uses the simulation and has not produced a definite value of better performance.

III. Crowdsourcing Method

Crowdsourcing is a complex problem-solving method through a distributed model that exploits the crowd [13]. Crowdsourcing can generally be defined as a process of obtaining certain services, ideas, or content by soliciting the help of others in mass or specifically in a particular area. Viewed from its meaning, crowdsourcing can be interpreted as an effort to obtain a goal by utilizing the participation of many people.

Based on crowdsourcing definition, it is known that crowdsourcing method is how to take advantage of the role of society or a group of people to achieve a goal. If connected with the business world, understanding crowdsourcing actually still very close with the presence of people in it.

According to [14], crowdsourcing is an approach to exploit the potential of crowds (many people) open to other groups to join the system. On the other hand, crowdsourcing is a phenomenon studied in many fields, and research mostly focuses on its utilization in isolated areas. In addition, there are still few references that speak of the integrated design of crowdsourcing itself.

In general, a crowdsourcing application is more widely used in activities or fundraising programs that are social by nature. By utilizing the community as an object that will provide input to the process, crowdsourcing method is more focused on the role or utilized the wider community in a positive sense to achieve a certain goal.

A. Crowdsourcing Mobile Access (CrowdMAC)

CrowdMAC mechanism allows for crowdsourcing mobile access connected to the internet where an Access Point (AP) with direct access can connect to mobile devices (smartphones) easily with the use of proxies as intermediate interconnecting CrowdMAC network and internet.

B. CrowdMAC-DTN

This research describes one aspect of DTN which utilizes Crowdsource Mobile Access method to send messages between smartphone devices. According to [15], the topic on Delay Tolerant Networks is divided into 2 parts according to the type of communication: Interface Communication and Ad-hoc Communication.

There are two basic parts based on smartphone communication method. Those are Interface Communication and Ad-hoc Communication. In its implementation, the DTN and Overlay section utilize Copy Mode and Message Queue methods to communicate between smartphones via the Hybrid DTN and Hybrid Overlay protocols.

Based on its principle, DTN protocol routing is store-carry-forward where message queue will be stored on a smartphone device. The hybrid routing approach resulted in the use of additional usage on the smartphone device to store the message data queue which is then sent to other smartphones via direct connection facility.

DTN routing can be interpreted as a single duplication process (single) and multiple (multi). In hybrid routing, it will be divided into three parts of routing process which is analogous to messages given different protocol states. Those are described as follows: (1) State routing protocol from DTN sources; (2) State routing protocol on communications system infrastructure; (3) State routing protocol in destination DTN.

Each protocol states could be configured to perform single-copy or multi-copy routing to produce 4 (four) copy conditions of messages:

i. Single-copy or multi-copy on DTN sources
ii. Single-copy or multi-copy at the time of message transfer from DTN source to the intermediate system.
iii. Single-copy or multi-copy at the time of message transfer from intermediate system to destination DTN.
iv. Single-copy or multi-copy on DTN purposes.

There are 16 combinations of copy-mode on hybrid DTN depending on the quality of information in protocol states.

This research contributes by combining (hybrid) method of data dissemination protocol in the form of message queue and

copy mode by utilizing other devices as an intermediary (carrier) message to be relayed to the destination device.

IV. PROPHET - EPIDEMIC HYBRID

A. PRoPHET

In principle, the PRoPHET protocol routing aims to increase the message delivery rate by maintaining the use of buffers and overhead communication between nodes. The movable node behavior is assumed to be predicted to transfer data at another node when the Delivery Predictability Value is higher [16].

PRoPHET mechanism consists of two parts of Information Exchange Phase (IEP) when a communication between the smartphone devices starts. The first part of the condition involves an encountered node will communicate which results as a vector. The information exchange takes place after both authentications are successful. It would then analyze the information related to possible routing to the destination. The second part is sending the message data packets from the sender to the intermediary.

B. Epidemic

In general, epidemic routing protocol works in a way that each node encountered will be sent message packet data. Therefore, it will be possibly delivered optimally because each time peer will be sent as well. But this protocol is very good for nodes that have an unlimited storage capacity (buffer) only. However, the Epidemic routing protocol also limits resources to the number of hops.

C. Hybrid PRoPHET-Epidemic

PRoPHET routing protocols have a weakness when node connection conditions fail, and there is no chance of connecting. In addition, if the contact duration with another node has a short time, then the message sending will fail. Another possibility is that the message packet will be delayed because the carrier node does not often visit the destination node location.

Based on the weakness of PRoPHET and advantages of Epidemic, in this research propose to combine two DTN routing protocol is Epidemic and PRoPHET. It is expected to get better the success rate of delivery messages that utilize the crowd via Wi-Fi direct connection on some package carrier conditions. The concept is as shown in Figure 1.

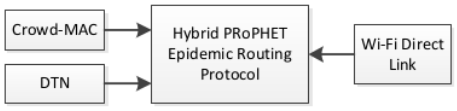

Figure 1: Basic concept Hybrid PRoPHET Epidemic

Crowdsourcing using smartphones [17] addresses the issue in the design of intensive mechanism used to motivate users to participate in the crowd. However, they only focus on designing a rational, profitable and efficient computational model of the crowd, not the design of data exchange between smartphones.

In the study [18] sending a message with many copies of messages that can decrease the delay in message delivery and also can increase the acceptance ratio. Delivery of multiple copy messages through multiple nodes by adding a DTN routing protocol functionality using Message Delivery Predictability (MDP). However, the results of study still a simulation not real testing.

V. IMPLEMENTATION

A. Study Area

Geographically, the fisherman's residential area of Peh Pulo Beach is about 50 km away from Blitar regency as shown in Figure 2. It is located in the mountains with a wide coverage area of forestry and the access is very dangerous during the raining conditions.

Figure 2: Fishermen's residential area

Availability of communication signals is very limited since the distance between the last Base Transceiver Station (BTS) and the fisherman's residential area about 9 kilometers so that the signal reception quality is very low because it blocked by the mountains. Peh Pulo Beach area, there are 43 where 35 people work as fishermen and others work as farmers.

B. ParameterTesting

As an implementation, there is three methods of routing protocol that will be tested. The parameter value that is used as model for testing is shown in Table 1.

Table 1
Parameter Testing

Parameter	Value
Standard Interface	Wi-Fi Direct 802.11 b
Transmit/relay speed	9 Mbps
Transmit range	100 m (LoS)
Testing area	10000 m^2
Number of source node	15
Number of carrier node	15
Number of receiving node	15
Average test time	180 minutes

Based on the parameter values specified in Table 1, we tested 3 times for each protocol routing, i.e. Epidemic, PRoPHET, and Hybrid PRoPHET-Epidemic. It is expected that by conducting repetitive testing can result in obtaining a maximum value.

C. Testing Method

As an example, in Figure 3, B will send message data packets through D, or E, or F if B perform peer connection with the intermediate device. Furthermore, after message data

packet is received by an intermediary, it will be sent should the intermediary peer with the receiver. Peer in this context is able to make communication (connection) via Wi-Fi direct.

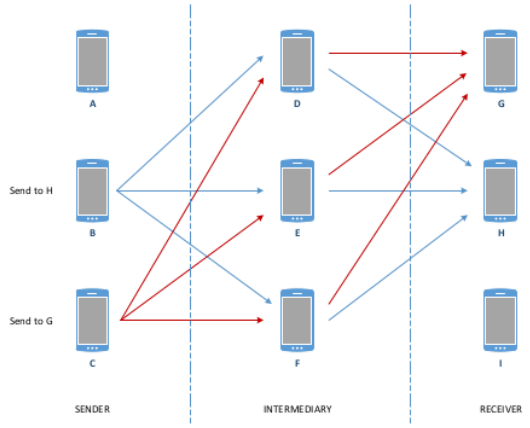

Figure 3: Model link peer to peer (via Wi-Fi direct connection)

To determine the recipient status whether they have received the message data packet or not, the application on recipient side will automatically replay (send back) information in the form of status sent to the sender through intermediaries (there is a possibility it will not go through the same intermediary as the previous relay).

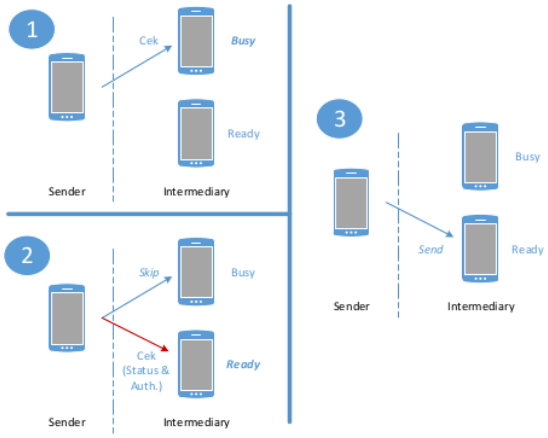

Figure 4: Stages of message relay from sender to intermediary device

Stages of message relay from sender to intermediary sequences are depicted in Figure 4. There are 3 stages of the process of message data relay which are described as follows:

1. Peer-link check
   Transmitting device will emit a signal periodically (3 seconds) to search peers within a range of direct Wi-Fi. If there is a response from other devices, then next step taken is checking the intermediate device whether it is in ready or busy condition. If it is busy then sending device will remain on standby as an initial condition (idle). Execution process will be ignored (skip).
2. Status and Authentication Check
   Should intermediate devices are ready, and the next stage involved checking MAC address of intermediate devices. In addition, it will also check peer routing recipient log history. This stage is done to obtain the possibility (probability aspect on PRoPHET) the message will be received by the receiver. If the intermediary does not have a peer routing log history to get to the recipient, then the sender will not send the message data to an intermediary.
3. Message delivery
   If the intermediate device has a history log peer routing to get to the recipient, then the intermediate will receive the message data.

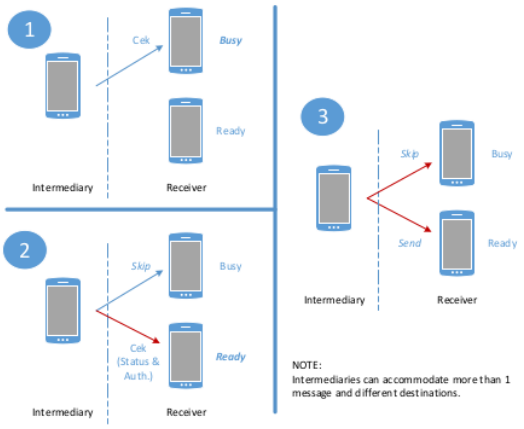

Figure 5: Stages of message relay from an intermediary device to a recipient

Stages of message relay from an intermediary to the recipient sequence are depicted in Figure 5. There are 3 stages of the process of message data relay which are described as follows:

1. Peer-link check
   Transmitting device will emit a signal periodically (3 seconds) to search peers within the range of direct Wi-Fi. If there is a response from other devices, then next step taken is checking the intermediate device whether it is in ready or busy condition. If it is busy then sending device will remain on standby as an initial condition (idle). Execution process will be ignored (skip).
2. Check and Authentication Status
   If intermediary obtains other intermediate devices status or the receiver is ready, then it will check the MAC address of other intermediate devices or recipients. In addition, should it obtain another intermediary it will be checked through recipient's peer routing recipient log history. If other intermediaries do not have routing recipient log history to get to other intermediaries, then the previous intermediaries will not send message data to other intermediaries.
3. Message delivery
   If in the end the intermediate device finds the destination peer and message data packet will be sent to the recipient.

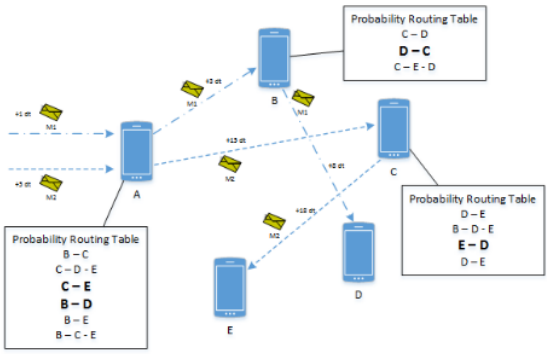

Figure 6: Message relay vector using Hybrid PRoPHET-EPIDEMIC

PRoPHET is capable of relaying data packets based on the probability of each *node to node* process to the destination. The mechanism and calculation of node chances for relaying messages were also conducted by PRoPHET. The message data packets are only sent to nodes that are likely to peer to the destination device. The calculation of the message may be acceptable to destination node called Delivery Predictability.

On the other hand, Epidemic is a routing algorithm on DTN that duplicates message data packets to all nodes connected (peer). By using Epidemic algorithm, it is expected to increase the success rate of message data packets received until it reaches the destination device. But more message data packets duplicates that exist on devices and networks will create new problems, both in buffering and network traffic density itself.

Based on the weaknesses and advantages of PRoPHET and Epidemic it is expected that the combination of PRoPHET - Epidemic algorithms can complement each other and result in better performance.

The DTN Message application is built to implement the DTN topology selection using the PRoPHET-Epidemic Hybrid is presented. In the DTN Message application, there is a menu interface that corresponds to its. The functions of each are explained as follows:

1. Contact: Input MAC address of the smartphone peer device included in the intermediate and recipient membership.
2. Send: Input messages to be sent to recipients via intermediaries. The selection of recipients based on the MAC address already in the list.
3. Receive: The status list of messages has been received by the recipient
4. Sent: The status list of messages that have been sent but still waiting for the sending process until received by the recipient.
5. Peer History: The list of MAC addresses ever peer routing gets to the receiver.
6. Carrying Message: List of messages that are still stored (buffered) by an intermediary.
7. Info: MAC address information of smartphone device that has been installed DTN message application.

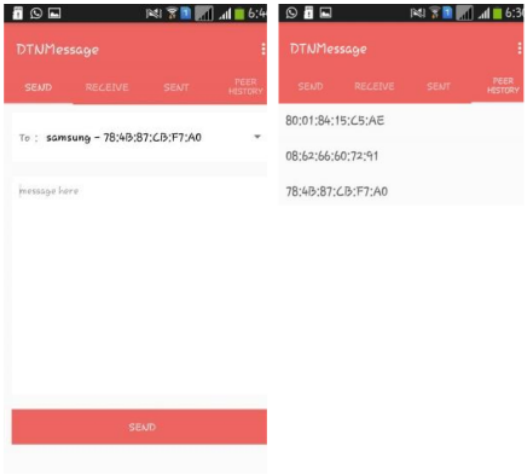

Figure 7: DTN message software feature

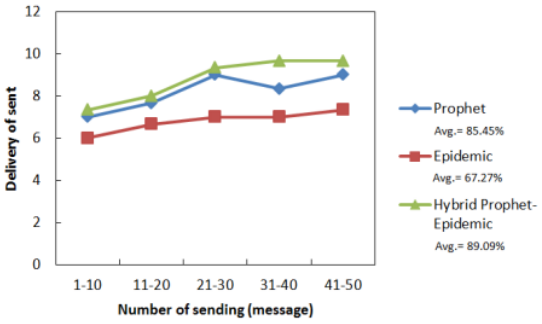

Figure 8: Comparison of success rate sending messages

As shown in Figure 8, the success rate of delivery of each protocol routing are divided into 5 shipping periods ranging from 1 to 10, 11 to 20, 21 to 30, 31 to 40, and 41 to 50 message times.

VI. Conclusion

The results evaluated by using Hybrid of PRoPHET-EPIDEMIC routing protocol have a success rate of sending message data packets is greater than that of PRoPHET and EPIDEMIC individually. EPIDEMIC and PRoPHET have a success rate of about 67.27% and 85.45% respectively, while Hybrid PRoPHET-EPIDEMIC has success rate about 89.09%.

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