Multi-region Aadaptive Geocast Enabling Two-way Communication

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Abstract -Recently, there have been many researches on ad hoc networks that can be constructed without relying on existing communication infrastructures. Since mobile terminals perform routing functions in an autonomous distributed manner in MANETs (mobile ad hoc networks) using wireless communication, MANETs are expected to be applied to areas where it is difficult to construct communication infrastructure such as disaster areas or at the sea for example. Global positioning systems (GPSs) have been deployed in almost all mobile terminals.

If a disaster occurs, we must obtain the IP addresses of the terminals in the stricken area to communicate with the terminals. In this case, we have to use the flooding method to search for the IP addresses of the destination terminals. However, this method is inefficient because it can cause a lot of traffic in the network. Therefore, a communication method called "geocast" that corresponds with the destination terminals in such a situation is proposed.

Geocast is a casting technique using geographical information. Geocast can transmit data to all terminals existing in the area that we set by specifying the latitude and longitude. Recently, there have been many researches on routing protocols and algorithms for geocast. However, those researches focus mainly on one-way communication. This means that the source can only transmit data to the destination area by geocast. If we take into consideration two-way communication using geocast, we can transmit data from the source to the destination area and transmit the response data from the destination terminals to the source by a different communication technique. We propose a new geocast protocol by using two-way communication to solve the aforementioned problem.

Keywords**:** ad hoc networks, geocast, GGP, DSR

1 INTRODUCTION

The conventional geocast protocols [1] are basically one-way communication protocol as its purpose is to transmit a packet to an existing terminal in the specific area that we set. However, this method is not as efficient as two-way communication protocol because finding a second path is necessary for the return journey. We did not have any problems with one-way communication by advertisement delivery. However, two-way communication is necessary when we communicate with terminals in disaster areas.

When we communicate in an area where the infrastructure has collapsed, we realize two-way communication using geocast. In particular, we can use geocast in stricken areas to communicate with victims by, for example, issuing evacuation advisories. In addition, it is necessary to have many transmission areas to allow geocast to transmit a message to plural areas in actual use.

If we transmit a packet to plural areas using geocast, the network traffic becomes large when we use flooding, thus rendering the transmission ineffective. Therefore, a geometry-driven geocasting protocol (GGP) algorithm is proposed [2].

The GGP can transmit a packet to plural areas using geocast.

In this paper, we propose a multi-region adaptive geocast protocol considering for two-way communication based on the GGP and source routing protocol. And at the same time, we will show how to obtain the performance evaluation results by simulation.

2 RELATED WORKS

2.1 Geocast

Geocast is a communication scheme proposed by Julio. C. Navas in 1997. The expected acquisition of the GPS location tool facilitated the future of Navas as this tool was devised as a geocast protocol for position dependency. Geocast has the ability to transmit data to all terminals existing in an area that we set by specifying the latitude and longitude by utilizing geographical information obtained through casting techniques.

2.2 Reliability of Geocast

Recent researches on geocast have been studied to demonstrate how proposals for routing protocols and algorithms efficiency are being conducted and implemented. In addition, the application of geocast to such communication and disaster information has also been proposed. However, these researches mainly focus on one-way communication rather than taking in-to account two-way communication. These researches consider one-way communication. This means that because these researches consider one-way communication only, the source terminals cannot determine whether or not the packet was received at the destination terminal. In contrast, there is reseach that has reliable geocast communication by returning an ACK to the source terminal when the destination terminal area receives a packet [3]. However, in this research, communications will end once the ACK is returned, thus proving that the method is unable to perform continued communications thereafter. In reality, if we wish to communicate with terminals in stricken areas, reviving and using two-way communication will be necessary. Furthermore, the transmission destination is not limited to only one area as we are considering transmission via geocast to multiple areas.

2.3 ROUTING ALGORITHM OF GEOCAST

(1) Routing scheme of geocast

There are three types of routing scheme that are typical of geocast: flooding, no flooding, and directed flooding. In particular, directed flooding is a method of communication that uses position information. It is therefore often utilized in geocast researches. We have decided to use this method as a base protocol of our proposal.

(2) Overview of directed flooding method

In the directed flooding method, each terminal is in possession of the position information, and the method using a forwarding zone demonstrates how it controls the communication with position information. Generally, there are three types of algorithms: static zone scheme [4], adaptive zone scheme [5], and adaptive distance scheme (ADS) [5]. We have to select the scheme in the actual use of this method.

When source terminal transmits a packet to several areas using geocast, the network traffic becomes large especially if the terminal uses flooding. This basically makes the system ineffective. Therefore, a geometry-driven geocasting protocol (GGP) algorithm is proposed as the GGP can transmit a packet to several areas using geocast. This routing algorithm is Greedy forwarding [6]. The communication model is shown in Figure 1.

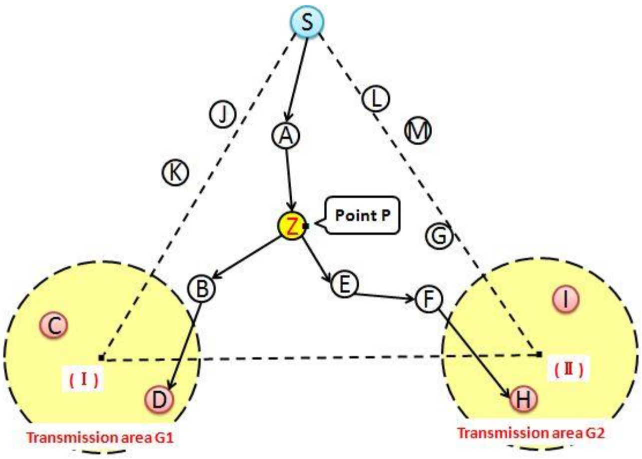

Fig. 1 GGP

In Figure 1, I (G1) and Ⅱ (G2) are the point of the destination areas. Source terminal (S) is connected to two other transmission area points Ⅰ (G1) and Ⅱ (G2) thus creating a triangular center of gravity with middle point P. When the terminal (A) receives the packet, the terminal (A) sends packet to the point P. Source terminal (S) then transmits a packet towards P. When the terminal of point P receives a packet, the terminal transmits the other packet to two transmission areas. As a result, the communication path will become two from the terminal (Z). Through this way, the communication until the terminal (Z) is one path. The communication until the terminal in the destination areas is two paths. As a result, we can create an efficient network.

2.4 DSR Protocol

The DSR (dynamic source routing) protocol consists of two functionalities: route maintenance and route discovery [7] [8]. In addition, each terminal pathway that leads to any terminal is recognized and stored in the route cache. This route cache is updated each time a route to any terminal is discovered. In the beginning, route discovery automatically checks whether a route to the destination exists. If the route exists, we then use it. If the route does not exist, the terminal flooding route request packet (RREQ) captures its own IP address. The terminal that receives the RREQ checks whether the route to the destination exists in the route cache by itself. If the path exists in the route cache, the destination terminal notifies the sender of the route via routing reply (RREP). If the path does not exist in the route cache, the terminal transmits to the destination in the RREQ to achieve flooding and to capture its own IP address in the packet. If the RREQ reaches the destination, the destination terminal then transmits an RREP to the source terminal using a path that is described in the packet. DSR protocol is for performing construction on the pathway. The basic DSR protocol is shown in Figure 2.

When the source terminal captures its own position information in the packet header, the two-way communication geocast can be recognized by the IP address that is captured at the same time.

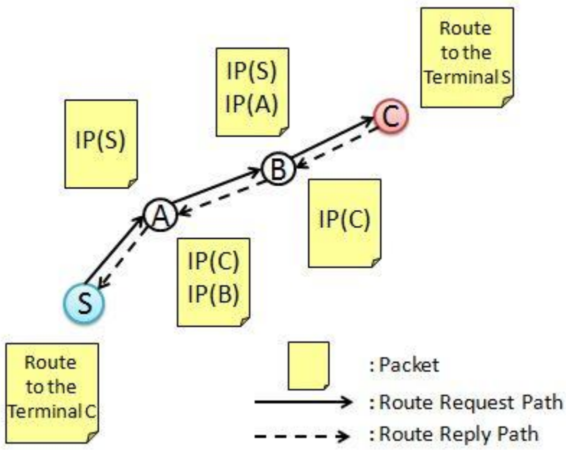

Fig. 2 DSR

3 PROPOSAL OF MULTI-REGION ADAPTIVE GEOCAST

(1) Basic concept

Conventional geocast communications use a different routing protocol in the forward path and the backward path. However, this method requires route searching again. Therefore, it is very inefficient because a delay occurs. To solve this problem, we propose an addition to the GGP algorithm to create the geocast DSR that fuses the DSR and source routing geocast.

(2) Selection of directed flooding scheme

We have evaluated and compared the number of packets that are sent over the network and the complexity of each terminal [9]. The terminal that receives the packet only determines the sending terminal itself that exists in the transmission area so the amount of calculation in the terminal is usually small. However, this approach always communicates using the flooded method. Thus, the number of packets in the network increases. The terminal that receives the packet determines the sending terminal itself existing in the transmission area. Then, we rebuild the forwarding zone, which involves calculating the one hop flooding. Therefore, the amount of calculation is higher than that of the static zone scheme. In addition, the number of packets in the network will be less due to some rebuilding of the forwarding zone. The terminal receiving the packet determines whether approaching the center of the transmission area is necessary to calculate the distance to the center. In addition, we examine the terminal just before forwarding to determine whether a destination area exists. This technique has high computational complexity because it requires determining its own override position information before forwarding. However, the number of packets in the network is reduced by transfer control of the distance between the center coordinates. There is not much difference in the number of calculation algorithms used by the three routing schemes as significant performance improvement of the mobile terminal was achieved. Therefore, in the proposed method, we used the ADS, which seems to operate with the lowest number of packets in the network.

(3)Two-way communication in real environment

Performing two-way communication using geocast when the communication infrastructure has collapsed is considered. It is possible to communicate with the victims using geocast when there is an evacuation and substantial damage to buildings. In addition, we performed geocast communication in a number of areas.

The purpose of the conventional geocast protocol is to transmit a packet to a terminal that is in the destination area. Accordingly, it is a one-way communication protocol. If we realize two-way communication using geocast, we transmit data from the source to the destination area and transmit the response data from the destination terminal to the source by a different communication technique. This method requires route searching for the return again. Accordingly, two-way communication with this approach is inefficient. We did not have any problems with one-way communication by advertisement delivery, but two-way communication is necessary when we communicate with terminals in stricken areas. We proposed a two-way communication geocast technique using source routing and GGP. However, the packet would be concentrated in the Fermat point terminal. In this method, we have not obtained a result that is higher than expected. In addition, when there is more than one destination area, packet loss due to redundant paths occurs.

In this paper, we propose a multi-region adaptive geocast protocol for two-way communication based on the GGP and source routing protocol.

4 IMPLEMENTATION OF TWO-WAY COMMUNICATION

4.1 One-to-one communication

If the destination area and the source terminal are in one-to-one communication, we create the route using the DSR and ADS.

There is a pattern for the three communication phases: first forward path, first return path, and round-trip path after the first path.

Phase 1: First forward path

The basic first forward path is shown in Figure 3.

First, the source terminal S decides the transmission area. Second, the source terminal S transmits a route request (RReq) packet to the transmission area. Third, terminals A and E, which have received the (RReq) packet, decide whether to forward it. This is the ADS algorithm. All terminals which received the packet perform this determination. In this case, terminal A is closer to the transmission area than source terminal S. Therefore, terminals A and E encapsulate the IP address and location information in the packet. Then, terminals A and E transmit the RReq packet to the nearest terminal. When terminal F receives an RReq packet, it determines whether to send an RReq packet it. However, terminal F is one more step away from the transmission area than terminal E. Therefore, terminal F discards the RReq packet. When terminal C (which is within the transmission destination area) receives the RReq packet, terminals C and D will receive the route information to source terminal S.

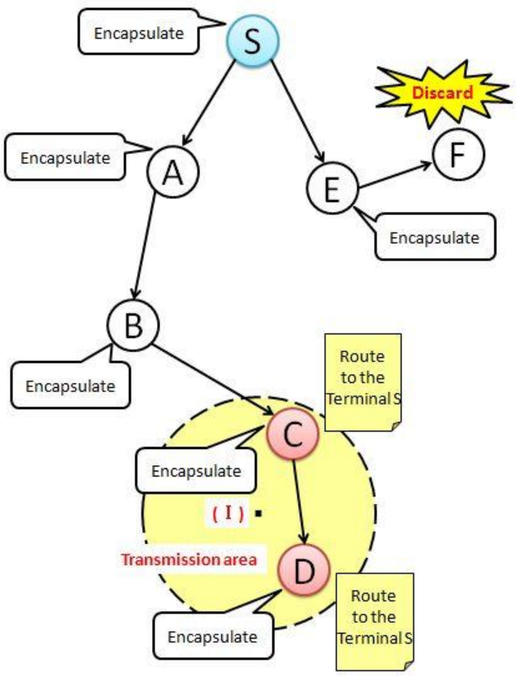

Fig. 3 First forward path

Phase 2: First return path

The basic first return path is shown in Figure 4.

Terminal D (which has received the RReq packet) knows route to source terminal S. Therefore, terminal D sends the route reply (RRep) packet to source terminal S. Terminal S (which has received the RRep packet) has the route to terminal D. Therefore, the destination terminal may not have to search for a route. As a result, the proposed method can suppress the delay.

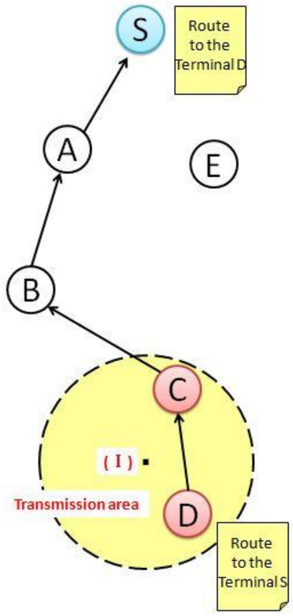

Fig. 4 First return path

Phase 3: Round-trip path after the first return path

The basic round-trip path after the first return path is shown in Figure 5.

When the first forward communication and the first backward communication are completed, the creation of the route by DSR is completed. Therefore, terminals D and S have a route to each other. Two-way communication with this route is possible.

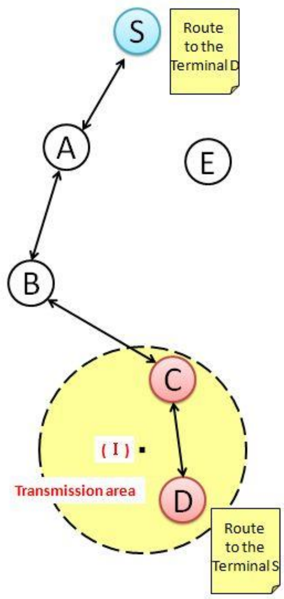

Fig. 5 Round-trip path after first return path

4.2 Basic one-to-n (n≧2) communication

The basic one-to-n communication is shown in Figure 6. First, source terminal S decides two destination areas. Second, terminal S decides the Fermat point P. At this time, we find out the Fermat point to determine the radius of a circle for any point P. And the terminal in this range is the Fermat point terminal. Third, we draw a tangent from terminal S towards the Fermat circle. We called this area the forwarding zone. Terminal S sends the RReq packet encapsulating the information towards the Fermat circle. When terminal A receives the RReq packet, it sends the RReq packet encapsulating its own information to terminal Z. Fermat point Terminal Z sends the RReq packet to the destination area of the two specified RReq packets that encapsulate its own information. At this time, the RReq packet that terminal G received is discarded by the ADS. Each terminal encapsulates its own information so that a destination terminal area knows the route to Terminal S. A destination terminal transmits the RRep packet to the source terminal using this pathway. There is only one route for each terminal in Figure 6, and the terminal flooded the forwarding zone. Thus, various routes are constructed in practice. We communicated by selecting the most efficient route. However, we considered the situation when a route cannot be used due to any failure. At that time, the terminal rebuilt the route by DSR and continued to communicate.

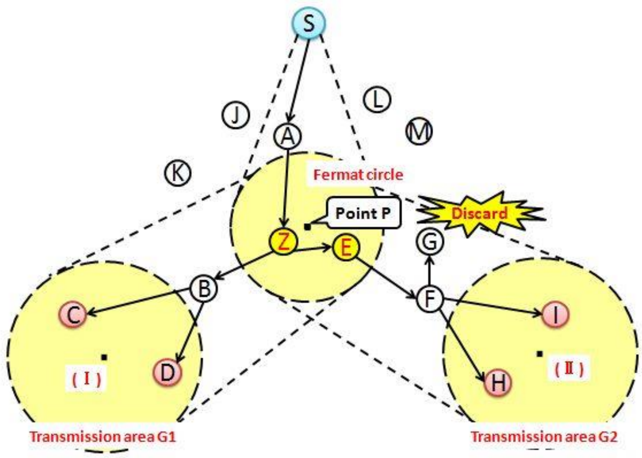

Fig. 6 One-to-n communication

4.3 Advanced one-to-n(n≧2) communication

The advanced one-to-n(n≧2) communication is shown in Figure 7.

First, the source terminal decides a destination area and divides it into three separate areas for every 120 degrees of the network area. Second, the source terminal does this to all the destination areas and chooses the most efficient way of dividing them. In Figure 7, the source terminal wants to set areas 1 and 2 and we communicate 1 to 2 in the network area. The source terminal communicates 1 to 1 in area 3.

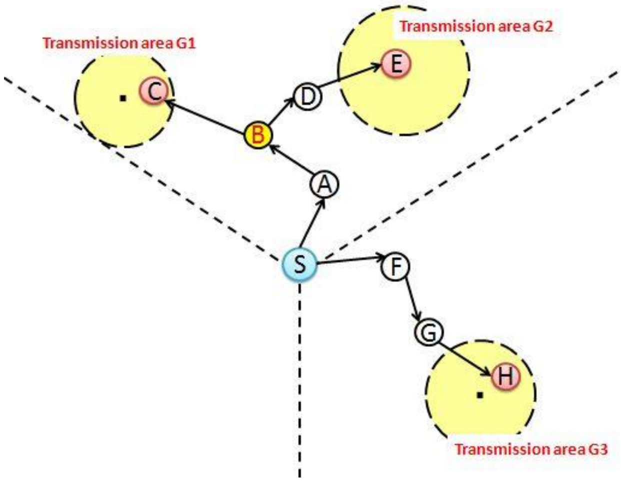

Fig. 7 Multi-directional transmission algorithm

The basic communication without the use of multi-directional transmission algorithm is shown in Figure 8.

The source terminal transmits one at a time toward the three transmission areas. Therefore, the path will become longer. As a result, congestion and packet loss occurs and the packet arrival rate will be lower.

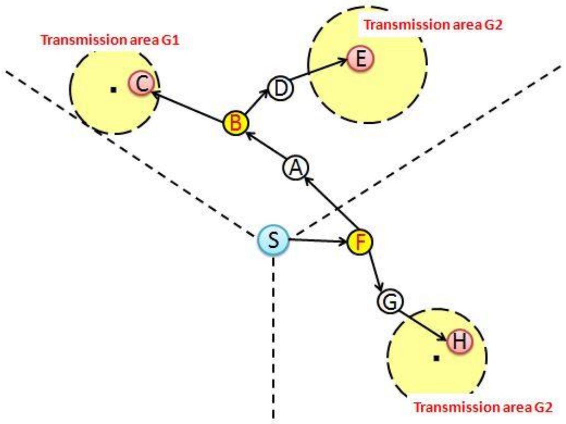

Fig. 8 Communication without the use multi-directional transmission algorithm

5 EVALUATION

5.1 Simulation

In this paper, we aim to send packets to more than one area by using geocast DSR. Also, we aim to further improve efficiency by adding the GGP function.

In this paper, we evaluate the proposed method by using the Qualnet network simulator.

We have compared the proposed method with the traditional geocast method.

We examined the number of RReq packets sent over the network and verified the effectiveness of the utilization efficiency of the network. The basic simulation model is shown in table 1.

Table 1 Simulation environment

Simulator	Qualnet 5.2
Area range	1000m×1000m
Coverage area	300m (max)
Total number of terminal	30, 60, 100
Number of the source terminal	1
Moving speed of the terminal	2.0m/s
Number of the destination terminal	5
Number of the destination area	3
Radius of geocast	100m
Radius of fermat circle	100m
The packet transmission interval	1packet/sec
Size of data packet	512kbyte

We have measured the packet arrival rate in the above environment. The packet arrival rate is the probability that the packet reaches the destination terminal from the source terminal. The situation set-up of the network is the same as that in Figure 7.

5.2 Results and discussion

The experimental results are shown in Figure 9 and 10.

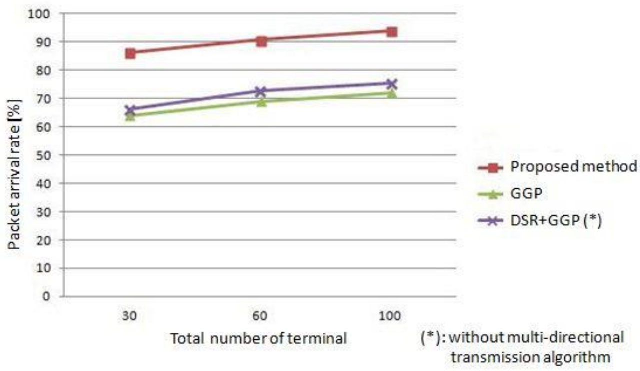

Fig. 9 Packet arrival rate

The packet arrival rate increases as the number of terminals increases in all methods. However, DSR+GGP and GGP send packets towards the multi-directional area. Therefore, the packet arrival rate is lower. The proposed method has a separate transmission to each network for each area. Therefore, the proposed method can construct an efficient route. In addition, the proposed method can perform route packet reassembly after multiple packet collisions caused by multiple algorithms at the Fermat point terminal. Therefore, the proposed method maintains a high packet delivery ratio.

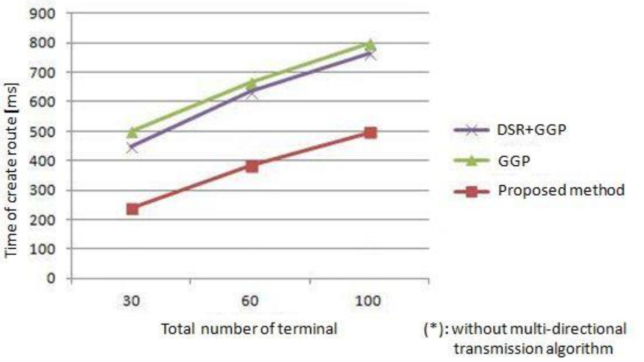

Fig. 10 Time of create the route

Then, we measured the amount of time to create the route. The proposed method uses a multi-directional transmission algorithm. This method has two paths, which increases the time to create the route. However, DSR+GGP and GGP does not use multi-directional transmission algorithm. This means that these methods have one path thus elongating the path of these methods causing a decrease in time of creating the route.

6 CONCLUSION

In this paper, we evaluated a geocast routing algorithm. In addition, we selected an algorithm with a good network utilization efficiency.

We examined the problems associated with the traditional geocast. These problems occur when two-way communication is difficult. And we propose a multi-region adaptive geocast protocol while considering the two-way communication. In addition, we had many Fermat point terminals. As a result, we determined the reconstruction path when the route failure occurred. We conducted experiments to compare the conventional method and the proposed method and discussed these experiments on the basis of the results. We found that the proposed method is superior to geocast DSR. Therefore, the proposed method can control avoiding wasteful packets when performing two-way communication using the geocast in the affected areas. Furthermore, we can realize flexible two-way communication with the terminal in the affected areas.

We now have some problems to tackle for the future. The first problem is a network area determination algorithm. The proposed method selects the network area. We must then be able to perform this process automatically. The second problem is a path reconstruction algorithm. When reconstructing the route, the proposed method uses another route stored in the route cache. In this case, we must consider the algorithm for selecting the optimum route. The third problem is when there are obstacles on the network. The proposed method does not simulate while simultaneously considering obstacles. When using the proposed method in the disaster area, there are obstacles in the disaster area. Therefore, we must propose a routing algorithm that considers the obstacles.

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