5ZA-8 Sporadic Communication Protocol between Clusters of Mobile Computers *

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1 Background and Objective

A mobile ad hoc network with only mobile computers is going to play an important role for achieving a ubiquitous computing environment. Mobile ad hoc networks are classified into the following two according to characteristics of mobility; autonomous mobile computer networks and clustered ones.

Until now, many kinds of routing protocols for supporting autonomous mobile computer networks have been proposed. Here, mobile computers are assumed to be uniformly distributed and to move with low speed. In short, they can always communicate with each other even if transmission routes are changed. However, in a clustered mobile computer network, density of clusters of mobile computers is low. Consequently, a mobile computer communicates sporadically with mobile computers in different clusters, i.e. only when distance between those computers is shorter than the wireless signal transmission range of a mobile computer. Hence, bandwidth gets lower if mobile computers communicate independently of clustered structure. In this paper, we propose a novel routing protocol CC-WSCP(Cluster-Cluster Wireless Sporadic Communication Protocol), for supporting sporadic communication. For achieving higher bandwidth even though the clusters move with high speed, we propose protocols for switching gateways in the clusters according to the movement.

2 CC-WSCP

Two mobile computers m_i and m_j communicate with each other directly only while m_i is in a message transmission range of m_j and vice versa. On the other hand, if m_i and m_j are included in clusters C_i and C_j of mobile computers, respectively, more messages are exchanged between m_i and m_j while there is a message transmission route between m_i and m_j, i.e. at least one pair of mobile computers in C_i and in C_j directly exchange messages. Here, in each cluster of mobile computers, there is one gateway mobile computer to transmit messages from a mobile computer in the cluster to another mobile computer in a neighbor cluster. In [1], a routing protocol CB-WSCP(Cluster-to-Base Station Wireless Sporadic Communication Protocol) for supporting communication between a cluster and a base station. On the other hand, CC-WSCP supports communication between clusters. Two gateway mobile computers are required in each cluster; a transmission gateway and a receipt one. This paper proposes a method to switch the gateways to keep message transmission routes between the clusters available even with mobility of the clusters. CC-WSCP consists of five protocols. Here, only protocols for switching a receipt gateway and a transmission one are explained. For each mobile computer m_i, tgw_cand_i and rgw_cand_i represent that m_i is a candidate for a transmission gateway and a receipt gateway, respectively.

2.1 Switch of Receipt Gateway

Due to mobility of clusters A and B of mobile computers, a current receipt gateway b_i^r in B for message transmission from A to B moves out of a message transmission range of an initial transmission gateway a_0^t in A. Hence, in order to achieve continuous communication between A and B, b_i^r delegates another mobile computer b_{i+1}^r in B, i.e. b_{i+1}^r serves a receipt gateway, when b_{i+1}^r moves into a message transmission range of a_0^t.

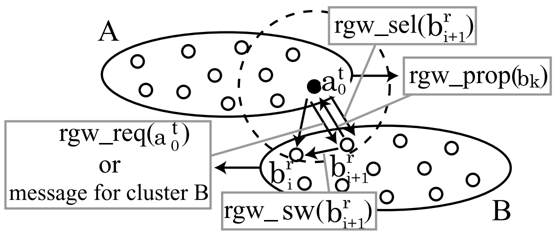

Figure 1: Switch of Receipt Gateway.

(0) In order to realize switch of a receipt gateway in B, a current transmission gateway a_i^t broadcasts $rgw\_req(a_i^t)$ to all mobile computers in a message transmission range of a_i^t if a_i^t does not forward a message destined to a mobile computer out of A for an interval τ_c.

(1) A mobile computer b_k in B detects that b_k moves into a message transmission range of an initial transmission gateway a_0^t in A due to receipt of an application message transmitted from a_0^t to a current receipt gateway b_i^r in B and/or receipt of $rgw\_req(a_0^t)$ broadcasted with an interval τ_c by a_0^t.

(2) If $rgw\_cand = true$ in b_k, b_k sends a receipt gateway proposal message $rgw\_prop(b_k)$ to a_0^t for informing of a_0^t that b_k is a candidate for a next receipt gateway in B for message transmission from A to B. In addition, $rgw\_cand := false$ in b_k.

(3) Multiple mobile computers b_k in B might receive the $rgw\_req(a_0^t)$ simultaneously and send back $rgw\_prop(b_k)$ to a_0^t. In order to support such a case, after transmission of $rgw\_req(a_0^t)$, a_0^t waits for $rgw\_prop(b_k)$ for an interval $\delta(< \tau_c)$. If a_0^t receives multiple $rgw\_prop(b_k)$, a_0^t selects a mobile computer b_{i+1}^r from the mobile computers in B

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which send $rgw\_prop(b_k)$ as a next receipt gateway in B. a_0^t broadcasts a receipt gateway select message $rgw\_sel(b_{i+1}^r)$ to all mobile computers within a message transmission range of a_0^t. A routing table in a_0^t is modified as to forward messages destined to a mobile computer out of A to b_{i+1}^r.

(4) On receipt of $rgw\_sel(b_{i+1}^r)$, b_k serves a next receipt gateway in B for message transmission from A to B if $b_{i+1}^r = b_k$. $b_k(= b_{i+1}^r)$ sends a receipt gateway switch message $rgw\_sw(b_{i+1}^r)$ to the current receipt gateway b_i^r in B in order to inform of b_i^r that b_k becomes a next receipt gateway. Here, b_{i+1}^r achieves an address of b_i^r by receipt of an application message transmitted from a_0^t to a current receipt gateway b_i^r in B and/or receipt of $rgw\_req(a_0^t)$ broadcasted by a_0^t in step (1). Otherwise, i.e. $b_{i+1}^r \neq b_k$, b_k does not serve a receipt gateway for communication between A and B.

2.2 Switch of Transmission Gateway

According to the protocol in 2.1, a receipt gateway in B is switched and message transmission from A to B is continued even though mobility of clusters A and B of mobile computers. If no mobile computer in B is in a message transmission range of an initial transmission gateway a_0^t in A, i.e. a current receipt gateway b_n^r in B is the last mobile computer included in a message transmission range of a_0^t, it is impossible to continue message transmission from A to B by switch of a receipt gateway in B. However, by introducing a protocol for switch of a transmission gateway in A, it might be still possible to continue message transmission from A to B. Since it is assumed that each mobile computer does not get its relative location in a cluster, b_n^r detects to be a last receipt gateway in B by using receipt power of a message from a transmission gateway a_i^t(initially a_0^t) in A.

(1) If receipt power of a message from a current transmission gateway a_i^t, i.e. an application message from A to B and $rgw\_req(a_0^t)$, gets lower than a threshold value rpw_{th} without receipt of a receipt gateway switch message $rgw\_sw(b_{n+1}^r)$ from a next receipt gateway b_{n+1}^r in B, b_n^r broadcasts a transmission gateway request message $rgw\_req(b_n^r)$ to all mobile computers in a message transmission range of b_n^r.

(2) On receipt of $tgw\_req(b_n^r)$, a mobile computer a_k in A sends a transmission gateway proposal message $tgw\_prop(a_k)$ to b_n^r for informing of b_n^r that a_k is a candidate for a next transmission gateway for message transmission from A to B if $tgw\_cand = true$ in a_k. In addition, $tgw\_cand := false$ in a_k.

(3) Same as 2.1(3), one of the candidates is selected as a next transmission router.

(4) On receipt of $tgw\_sel(a_{i+1}^t)$, a_k serves a next transmission gateway for message transmission from A to B if $a_{i+1}^t = a_k$. $a_k(= a_{i+1}^t)$ broadcasts a transmission gateway switch message $tgw\_sw(a_{i+1}^t)$ to all mobile computers in a message transmission range of a_k. Otherwise, i.e. $a_{i+1}^t \neq a_k$, a_k does not serve a transmission gateway for communication between A and B.

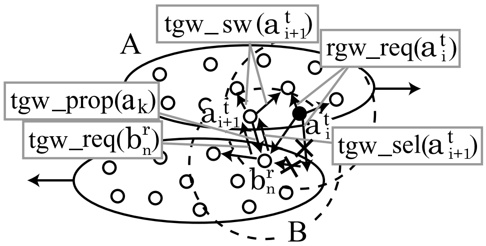

Figure 2: Switch of Transmission Gateway.

3 Evaluation

This section evaluates performance of CC-WSCP by bandwidth between two mobile computers in different clusters C_i and C_j of mobile computers comparing with direct communication. There are 50 mobile computers in both clusters C_i and C_j where distance between two neighbor mobile computers is in accordance with normal distribution.

Figure 3 shows an evaluation result. A solid line and a dotted one represent bandwidth between mobile computers in CC-WSCP and a conventional ad hoc protocol. Totally, in CC-WSCP, 2.85 times more messages are transmitted. However, Figure 3 also shows more messages can be transmitted by modification of switch timing of clusters.

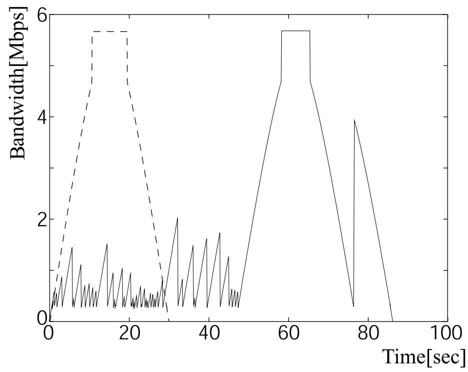

Figure 3: Bandwidth Comparison.

4 Concluding Remarks

This paper proposed a novel routing protocol CC-WSCP for supporting mobile computers which communicate with wireless LAN protocols and change their locations based on clustered mobility. In addition, by evaluation of the protocol, it becomes clear that CC-WSCP achieves higher bandwidth modification of timing control of gateway switching is needed.

References

[1] Kato, C., Harada, S. and Higaki, H., "Wireless Sporadic Communication Protocol for Supporting Cluster-to-Base Station Communication," Proceedings of the IASTED International Conference on Communications and Computer Networks, pp.311–316 (2002).

[2] Harada, S. and Higaki, H., "Sporadic Communication Protocol between Clusters of Mobile Computers," IPSJ Technical Report, Vol.2003, No.30, pp.53–38 (2003).