Sporadic Communication Protocol for Mobile Clusters *

4G－05

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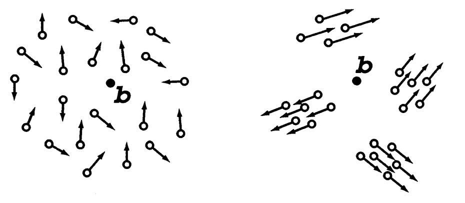
1 Introduction

Recently, mobile computers such as laptop, handheld and parmtop personal computers (PCs), personal data assistants (PDAs) and computers in automobiles consisting of ITS (Intelligent Transport Systems) have become widely available. In order to exchange messages between mobile computers, infrared wireless communication is widely used. For configuring a LAN to which mobile computers are connected by using wireless communication devices, wireless LAN protocols such as IEEE802.11 [1] and HIPERLAN [2] have been developed and standardized. By using such protocols, mobile computers exchange messages with the Internet through a base station while the mobile computers are in a wireless signal transmission range of the base station.

According to the characteristics of mobility, there are two mobile computer network models:

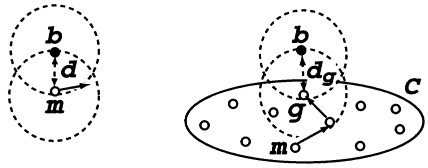
- *Autonomous mobile computer networks*: Each computer changes its location autonomously (Figure 1(a)).
- *Ad-hoc clustered mobile computer networks*: A mobile computer network is composed of multiple clusters of mobile computers. Each cluster consists of multiple mobile computers that move with almost the same velocity. (Figure 1(b)).



(a) (b)

Figure 1: Mobile computer network models.

As in Figure 2(a), a mobile computer m communicates with a base station b directly only if $d < l$ where l is a wireless signal transmission range of the mobile computers and d is the distance between m and b. On the other hand, as in Figure 2(b), suppose a that mobile computer m included in a cluster C. Let a mobile computer g be a gateway for communication between C and b satisfying $dg < l$ where dg is the distance between g and b. If there exists such a gateway g, m and b communicate with each other even though $d > l$.



(a) (b)

Figure 2: Communication between mobile computers and a base station.

2 Sporadic Communication Protocol

In order to support sporadic communication between a cluster and a base station, this section proposes protocols for switching a gateway of a cluster as its movement. Here, a cluster is defined as follows:

[Cluster] Let $\vec{v_i}$ and $\vec{v_j}$ be velocities of mobile computers m_i and m_j, respectively. A set C of mobile computers is a *cluster* where $\forall m_i, m_j \in C$, $|\vec{v_i} - \vec{v_j}| < \delta$ and m_i and m_j communicate with each other by exchanging messages in multi-hop message transmission within C. □

In this paper, protocols for supporting sporadic communication between a cluster and a base station connected to a wired network and whose location is fixed. These protocols are applied to support communication between a set of mobile computers in automobiles and base stations in a freeway in order to realize a kind of ITS services. In such a system, if multiple mobile computers in a cluster independently and autonomously communicate with the base station, there occur many contentions and collisions in a wireless LAN protocol such as IEEE802.11. Thus, our protocols are designed to satisfy the following condition:

[Gateway] A gateway g in a cluster C is a mobile computer that exchanges messages directly with a base station. At most one mobile computer serves the role of a gateway in a cluster. □

Here, the followings are assumed:

[Assumptions]

- The velocity $\vec{v_i}$ of a mobile computer m_i does not change rapidly. That is, $|d\vec{v_i}/dt| < \delta$.
- No mobile computer enters into and removes from a cluster.
- A base station b periodically transmits keep alive messages to its wireless signal transmission range.

*間欠的に通信可能なモバイルコンピュータ群のための無線通信プロトコル

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2.1 Start of cluster–base station communication

(1) By receiving a keep alive message from a base station b, a mobile computer g_1 in a cluster C finds that C becomes able to communicate with b.

(2) g_1 updates its routing table as that all the messages destined to out of C are forwarded to b. In addition, g_1 floods $Gateway(g_1)$ to all the mobile computers m within a C.

(3) On receipt of $Gateway(g_1)$, b updates its routing table as that all the messages destined to mobile stations in C are forwarded to g_1. □

2.2 Gateway switching

Suppose a mobile computer $g_k \in C$ is a gateway. Here, all the messages from a mobile station $m_s \in C$ destined to out of C is routed to g_k and forwarded to b. Furthermore, all the messages from out of C and destined to a mobile computer $m_r \in C$ is forwarded to g_k by b. According to the movement of C, a gateway for a base station b is switched from g_k to another one g_{k+1}.

(1) By receiving a keep alive message from b, g_{k+1} broadcasts $Gateway(g_{k+1})$ to all the mobile computers and a base station within a wireless signal transmission range of g_{k+1} in order to inform them that g_{k+1} becomes a next gateway.

(2) On first receipt of $Gateway(g_{k+1})$ transmitted from a mobile computer m_s, a mobile computer m_r updates its routing table as that all the messages destined to out of C are forwarded to m_s.

If the routing table of m_r is modified, m_r broadcasts $Gateway(g_{k+1})$ to all the mobile computers m within a wireless signal transmission range of m_r. Otherwise, m_r discards the control message. If m_r receives multiple $Gateway(g_{k+1})$, m_r discards them. According to this steps, in order to route all the messages destined to out of C not to g_k but to g_{k+1}, necessary and sufficient routing tables in C are updated by flooding $Gateway(g_{k+1})$ only within a subset of C.

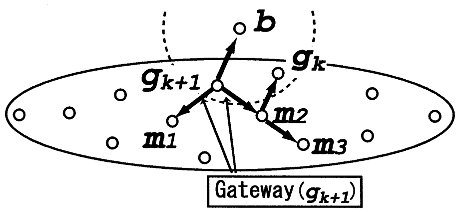

Figure 3: Update of routing tables within a cluster.

(3) On receipt of $Gateway(g_{k+1})$ from g_{k+1}, b updates its routing table as that messages destined to C are forwarded to g_{k+1} instead of g_k.

(4) On first receipt of $Gateway(g_{k+1})$ from a mobile computer $m_s \in C$, g_k updates its routing table as that messages destined to out of C are forwarded to m_s. Then, g_k broadcasts $Gateway(g_{k+1})$ to all the mobile computers m within a wireless signal transmission range of g_k. If g_k receives multiple $Gateway(g_{k+1})$, g_k discards them.

(5) If there are any messages destined to out of C in a message buffer in g_k, g_k forwards them directly to b until the message buffer becomes empty or g_k moves out of the wireless signal transmission range of b. Then, g_k transmits $Switch(g_1, g_{k+1})$ to g_{k+1}.

(6) On receipt of $Switch(g_1, g_{k+1})$, g_{k+1} becomes a gateway in C.

(7) In step (5), if g_k moves out of the wireless signal transmission range of b before the message buffer in g_k becomes empty, all the buffered messages are transmitted to b through g_{k+1}. □

2.3 End of cluster–base station communication

If the current gateway g_n in a cluster C moves out of a wireless signal transmission range of a base station b without switching the role of a gateway to another mobile computer , C and b become unable to communicate with each other. Until one of the mobile computers moves into a wireless signal transmission range of another base station b', all the messages destined to out of C are routed to the current gateway that is now unable to communicate with any base stations. Since the mobile computers in C move with almost the same velocity and the network topology in C is almost stable, it is most probable that g_1 becomes the first gateway for b'. Hence, it is preferable that the role of a gateway is switched from g_n to g_1 in advance and the messages destined to out of C are buffered in g_1 not g_n in order to reduce the required time duration since g_1 detects that it moves into a wireless signal transmission range of b' until the routing tables in the mobile computers in C are updated and the buffered messages are forwarded to g_1. Even if another mobile computer g'_1 becomes the first gateway for b' instead of g_1, less time duration is spent for updating the routing tables in C, and for forwarding the buffered messages to g'_1. Here, g_n gets an address of g_1 due to piggying back the address to control messages $Switch(g_1, g_k)$ where $k = 2, \ldots, n$.

3 Concluding Remarks

This paper has proposed a routing protocol for supporting sporadic communication between a mobile cluster and a base station. Here, a protocol for gateway switching to keep communication in spite of movement of the cluster. In addition, a routing protocol to update routing tables in a cluster to route the messages exchanged between mobile computers in the cluster and computers out of the cluster to the current gateway. In future work, the performance of the proposed protocol will be evaluated in ITS.

References

[1] "Wireless LAN Medium Access control (MAC) and Physical Layer (PHY) Specifications," Standard IEEE 802.11 (1997).

[2] "Radio Equipment and Systems (RES); HIPERLAN," ETSI Functional Specifications (1995).