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CONTENT

MOBILE AD-HOC NETWORK OF VEHICLES BY WIRELESS DISTRIBUTION SYSTEM

Krisztián Medgyes[1], Tamás Kovács

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ABSTRACT

This work examines the possibilities of maintaining a mobile ad-hoc network (MANET) by a Wireless Distribution System. We introduce and treat the performance limitations of this system regarding a MANET. In our case the MANET is considered to be a communication system of randomly moving vehicles, robot swarm or a group of people carrying mobile phones. A computer simulation study on the reliability of the wireless connection between a base station and the vehicles (or robot swarm) is given here. We measured the average broadcast time of a message from the base station while the vehicles are moving enclosed in a square shaped area. It was obtained that the average broadcast time is increasing dramatically when the linear size of the area exceeds the triple of the radius of the radio coverage.

KEYWORDS:
wireless networking, access point, WDS, MANET

1. INTRODUCTION

Wireless communication plays an important role in numerous swarm intelligence applications solved by mobile robots or autonomous distributed traffic controlling problems. Due to the considerable development in the field of swarm intelligence and multi-robot cooperation there are a wide variety of problems that can be solved efficiently by a group of autonomous robots or vehicles. In swarm robotics, for example, the most investigated tasks are the exploration of an unknown area [1,2,3] and the realization of some collective movement patterns such as gathering or chain formation [4]. In most of the cases the vehicles at hand are equipped with Wi-Fi (IEEE 802.11), Zig-Bee (IEEE 802.15.4) or Bluetooth (IEEE 802.15.1) radio systems, since they render cheap and yet satisfactory solutions for the communication between the autonomous agents. The Bluetooth system is economic and cheap but the most serious limitation of a Bluetooth network is that it is not scalable, since a Bluetooth piconet can consist of a master and at most seven slaves, and its radius of coverage is limited to ten meters [5,6]. If we have robots or vehicles big enough to supply a Wi-Fi Access Point (AP), the networking possibilities are better, since the Wi-Fi has a radius of coverage of 100 meters and is much more scalable than a Bluetooth network. In the following we examine theoretically the connectedness problems in a MANET of randomly moving vehicles with a fixed base station.

2. WIRELESS DISTRIBUTION SYSTEM

Connecting two or more wireless (distribution) systems can have several practical reasons. Wireless systems can most easily be created from Bluetooth or Wi-Fi networks. From previous publications [6] it is seen that the Bluetooth technology cannot provide coverage of suitable range, although it has low energy-consumption, which is important when implementing it on robots.

Due to the significance of range, the answer to the problem can be the Wi-Fi standard with a greater and higher quality range than of a Bluetooth solution – though with a bigger consumption of energy.

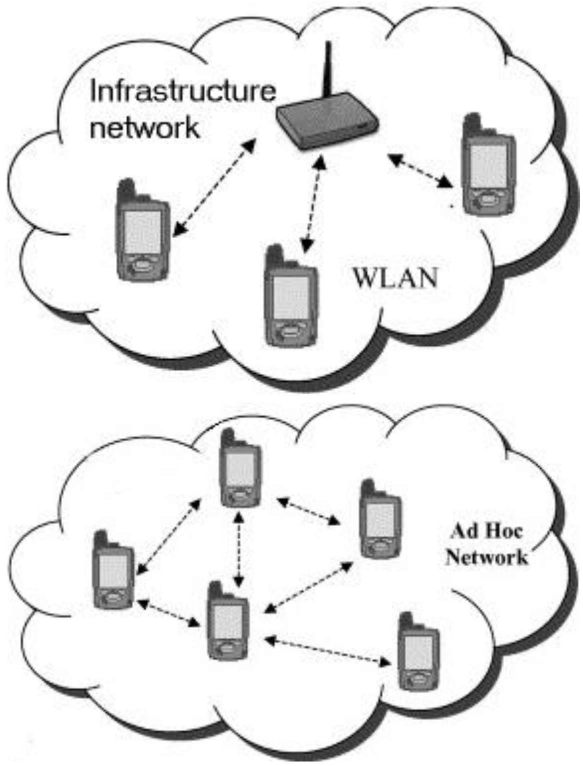

Figure 1. The Infrasctructure and the Ad-hoc network.

Network connections can be classified into two categories based on the type of connection (Figure 1.). One is the Ad-Hoc connection, where two devices connect to each other directly (without an AP). The other is, when more clients connect via an AP, the connection is called an infrastructure mode in a wireless network.

There are 3 well-known wireless network modes which enable clients and APs to connect to one sub-network. First, the Wireless Client Bridge mode, which, however, disables clients to connect directly to a wireless network and makes connection possible for a client only through a wired link to an AP. The second is the Wireless Repeater Bridge mode, where incompatibility problems (potential ARP problems) with certain programs or protocols (dependent on the MAC address) may occur due to the translation of the MAC address (Proxy ARP). The third is the WDS mode, which has the advantage of the WDS-method, that it is easy to create a continuous and long-range wireless network. The equipment on the vehicles (robots) (APs) not only connects to the Base Station in an infrastructure mode, but also transmits its signals to the other APs connected (SSID Broadcast) as a WDS Client. Thus, networks of arbitrary graphs can be formed without using any repeater.

To be more exact, any number of links (both wired and wireless) can connect to the points of the wireless backbone-network. For the installation of the WDS mode, all access points/devices to connect to the WDS master have to support the WDS client connection option.

Setting the WDS master:

- Select the WDS master mode in the menu of the wireless router.
- Set individual SSID network in the required field.
- Select an available radio channel.
- Note the MAC address of the WDS Master AP – it will be necessary during the setting of the clients.

Setting a WDS client:

- Select WDS client mode in the menu of the wireless router.
- Give the preset SSID in the required field.
- Give the preset channels of the WDS master.
- Give the MAC identification of the WDS master in the BSSID field.

From the encryption standards supported by the WDS, one can use the WEP and the WPA(1) standards. But irrespectively, one can use a MAC address filter, both for the connection points and the clients connecting to them. One should also consider the fact that in terms of WDS connections, the connection speed for communicating between two access points can only be the half of the connection speed of the access point at maximum.

Since the vehicles or mobile robots use little data exchange for communicating between each other, their requirements are profusely met by the wireless Wi-Fi.

3. COMPUTER SIMULATION AND RESULTS

With the help of a (MATLAB) computer simulation we evaluated the performance of the WDS regarding the connectedness in a MANET. The simulation consisted of ten APs, one WDS master and nine slaves. The master is considered to be a fixed base in the center of the simulated area. The other nine APs performed a random Brownian motion independently from each other but enclosed in the area. The magnitude of their speeds was constant and equal to each other in the linear parts of the Brownian motion.

We measured the broadcast time, while a message was spread in the network completely i.e. all of the nine mobile stations obtained the message. The delivery time was taken to be zero inside the ad-hoc wireless network connected momentarily to the base station. Obviously, not all of the APs will get the message at once; if the area is large enough, it can be a long time while an AP far from the base station is reachable. An explanation of the simulation environment can be seen in Figure 2.

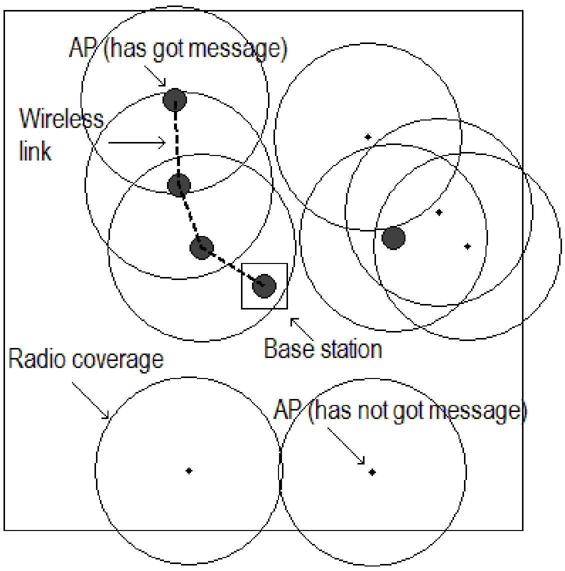

Figure 2. The MATLAB simulation of the MANET.

One hundred broadcast times were measured for each of the area sizes from 1.5 up to 5.5, where the area size was measured in the units of the radius of the radio coverage. The average broadcast times and their standard deviations were plotted as a function of the linear size of the area (Figure 3).

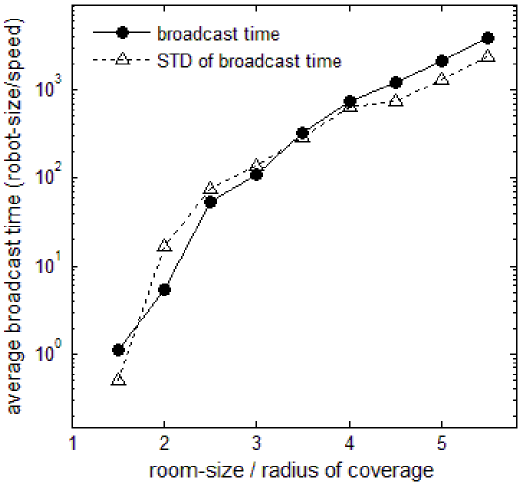

Figure 3. The average broadcast times and their standard deviation in a log scale as a function of the linear size of the area.

It can be seen that the broadcast time increases dramatically with the size of the area. When this size is comparable to the radius of the coverage, in most of the cases the APs form a complete connected network, so the broadcast time is close to zero. However, when the size of the area is raised to several times the radius of coverage, the total broadcast time increases to thousands of seconds (supposing one meter robot size and one meter/second constant wandering speed).

4. CONCLUSION

It can be concluded that if the working area is in the order of magnitude of the radius of wireless coverage, it is not necessary to apply additional algorithms to ensure connectivity. However when the area is bigger than 3-4 times this radius, then the application of such an algorithm ([7,8]) is essential.

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