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Application of Bluetooth technology to railway systems

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Abstract

We are studying application of Bluetooth™ technology to railway systems. Blluetooth is a short-range wireless telecommunications technology to connect mobile phones, personal computers and their peripheral devices. One application is the CyberNavi system for passenger guidance. In this system, the handy terminal of passengers receives the location data transmitted by fixed Bluetooth stations which are located at appropriate spots at stations such as platforms, and provides location-dependent guidance to the owner of the terminal. Examples of the guidance are navigation for changing trains, and suggesting of alternative routes at accident. Another is a system to support train drivers and collect data of train. This system consists of handy terminals for drivers, host computers at operational offices and on-board devices, all of which have a Bluetooth interface. When a roll call is taken place at the operational office, the duty data for the driver are transferred from the host computer to the handy terminal via Bluetooth. In the train, the handy terminal transmits the timetable to an on-board display and receives the fault history data of the train from an on-board monitoring controller via Bluetooth. If there is a mobile phone with a Bluetooth interface in the cab, the driver can perform hands-free speech communication by using a headset with a Bluetooth interface, and the timetable in the handy terminal can be updated on a real time basis from the operational office. As the diagnostic data stored in the handy terminal are carried to the operational office with the driver, cost reduction for telecommunications and mass data transmission can be achieved. We verified the feasibility of these systems with prototype versions in which we implemented some required functions. We also measured the transmission characteristics of Bluetooth in the vicinity of a locomotive.

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1 Introduction

The Bluetooth technology is a short-range wireless telecommunications technique to interconnect various devices such as personal computers, their peripheral devices, and mobile phones ([1]). It is now embedded in various types of devices, and will become more popular in the near future. Studies for adopting this technology for various railway systems are being promoted. For example, West Japan Railway Company and some other companies tested to deliver digital contents from an on-board server computer to mobile terminals of passengers in Sanyo Shinkansen trains. We are also verifying the adaptability of the Bluetooth technology to railway systems through some trial products and experiments.

In this paper, we introduce application of the technology to railway systems now under discussion. Then we describe the specifications of a prototype system to transfer data between on-board and terrestrial computers with handy terminals. Finally, we report the results of transmission experiments of Bluetooth in the vicinity of a locomotive.

2 Examples of applications of Bluetooth to railway systems

In this chapter, we introduce two examples of the applications to railway systems for business use.

2.1 Application to passenger guidance system

Bluetooth can communicate only within a distance of about several ten meters. This means that if two devices can communicate with each other, they are in the coverage area. As a consequence, we can use Bluetooth as a method for location detection.

We manufactured a trial system called "CyberNavi," which provides passengers with appropriate guidance information about transfer and train delay, for example, according to their location ([2]). In this system, fixed stations of Bluetooth, which provide location data to the handy terminal of passengers, are located at appropriate spots in stations, enabling positioning with high accuracy about 10 meters on the passenger side. The handy terminal also makes access to the train operation database and fare database at the information center by using the Internet access function of mobile phone system. As a result, passengers can receive the service of route discovery to their destination, navigation at the time of transfer, and alternative route suggestion at accident (Figure 1)

2.2 Application to data transfer system

Various types of data are exchanged between on-board devices, drivers, server computers at the operational offices and staffs at train depots. For example, drivers get on the train with duty data, which consist of leg data or a sequence of legs composing the duty and timetables for the legs. As they carry the duty data as a printed medium at present, it requires much labor to generate them. It is

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also hard to cope with the real-time changes of the schedule by the present method. In contrast, operation logging data of the trains such as the fault history data and the diagnostic data that are collected by the on-board monitoring controller, are transferred to the terrestrial servers by floppy disks, IC cards, or wireless telecommunications systems such as the public cellular phone network and train radio systems, and are utilized for maintenance and inspection. Floppy disks or IC cards often fail to record data because of physical damages or degradation. Moreover, drivers are forced to set these media at the devices to write data. When wireless transmission systems are used, on the other hand, it is possible to collect data on a real-time basis at the operational center. However, their transmission rates are generally low and transmission costs are high if the public network is used.

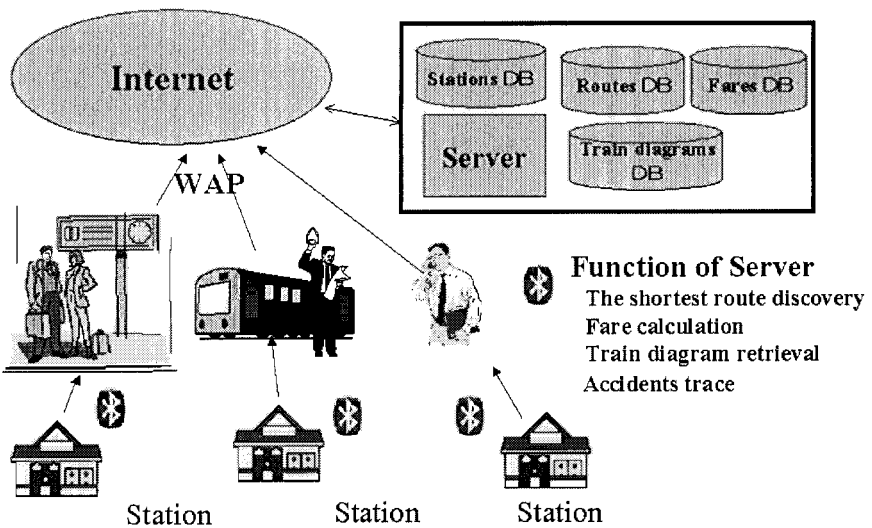

Figure 1: CyberNavi system

We devised a system that comprises handy terminals such as Personal Digital Assistants (PDAs) and Bluetooth technology as local wireless telecommunications media in order to cope with these problems (Figure 2). The basic elements of the system are handy terminals carried by drivers, on-board servers such as on-board monitoring controllers, and terrestrial servers at operational centers to manage duty data and analyze logging data.

Data are transferred between on-board and terrestrial servers basically by handy terminals (Figure 3). If Bluetooth is used as a transmission medium between handy terminals and servers, we can transfer data between them only by setting them close to each other. Handy terminals can record a larger amount of data than floppy disks and IC cards, and also have a human interface such as web browsers. As a consequence, they are useful not only as data carriers but also as an assistant tool for drivers because drivers can refer to timetables and manuals

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while they are being carried. We can also expand this system as explained below.

(1) If access points of Bluetooth are installed at stations, it is possible to notice the latest schedule to drivers after they left their home depots.
(2) It becomes also possible to transfer a small amount of data that should be transmitted on a real-time basis, if handy terminals are equipped with cellular phones. So we can construct a system of the minimum telecommunications cost for data transmission by an appropriate combination with the data transfer by handy terminals. Operation by drivers becomes easier because he/she can perform hands-free speech communication by using a headset with a Bluetooth interface.
(3) It becomes possible to automatically gather status data in trains according to their location and the current time by equipping with GPS receivers.

3 Specification of prototype system

We tentatively determined basic functions of the system described in 2.2 to adopt for locomotives and drivers of freight trains. This system consists of three Personal Computers (PCs) for handy terminal, on-board monitoring controller and terrestrial server at the operational office described in 2.2, to exchange duty data and engine fault data. The target of the trial system is hatched in Figure 2. This chapter describes the specifications of the system.

3.1 System Characteristics

The technologies adopted in this prototype system are as follows.

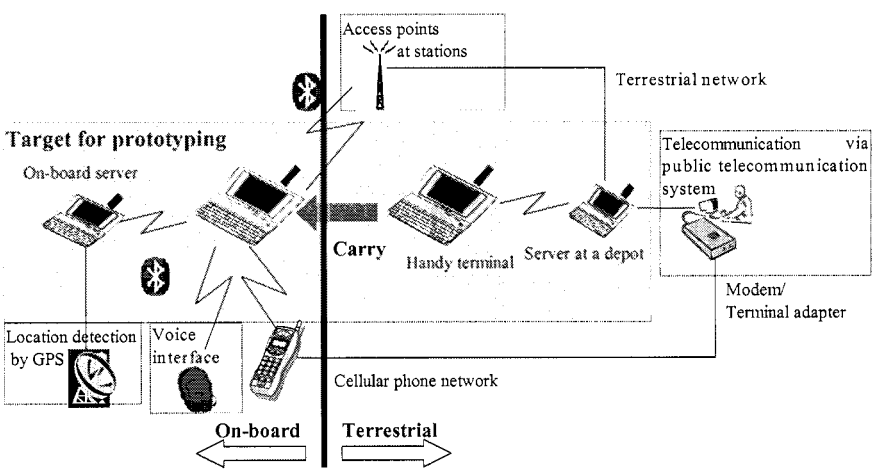

Figure 2: Configuration of data transfer system

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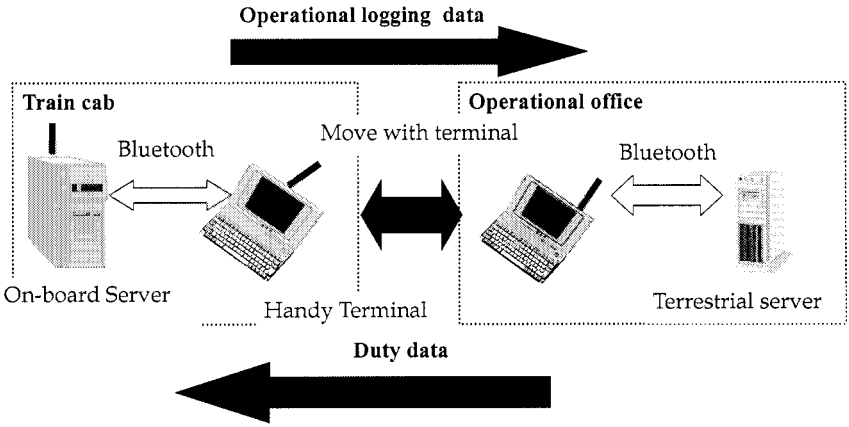

Figure 3: Overview of data transfer between operational offices and the cabs

3.1.1 Transmission by Bluetooth

We adopted Bluetooth as a telecommunications method between handy terminals and on-board and terrestrial servers. We implemented both a manual transfer mode in which users trigger data transfer between the handy terminal and the terrestrial server, and an automatic transfer mode in which data transfer begins automatically between the handy terminal and the on-board server.

3.1.2 Data description by XML

The duty data and the engine diagnostic data are written in the eXtensible Markup Language (XML) format, for future data exchanges with other railway companies and multiple usage of the data.

3.1.3 Web computing

We adopt web browsers as the human interface at terrestrial and on-board servers for easy implementation and flexibility.

3.1.4 Thin clients

We have adopted a design in which not the handy terminals but the servers process the tasks as much as possible because it would be simpler to maintain handy terminals. The handy terminal has no developed programs in this prototype system. Moreover, only the web browsers are required to read the transferred data on the handy terminal if the data are written in the XML format as described in 3.1.1

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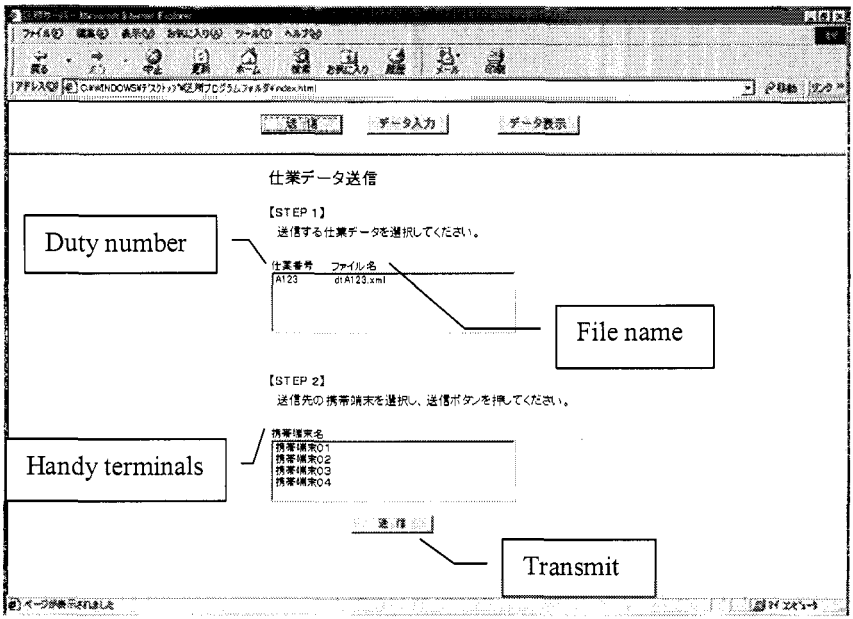

Figure 4: Snapshot for duty data selection and transmission

3.2 Overview of functions

The functions of this prototype system are to transfer data between on-board and terrestrial servers via the handy terminal, and generate the data for transfer.

3.2.1 Duty data transfer from the terrestrial server to the on-board server

When a roll call is taken place at the operational office, the duty data for the driver are transferred from the terrestrial server at the office to the handy terminal via Bluetooth. This process is achieved by selecting the duty data to be sent and the target handy terminal, and clicking the "transmit" button on the server (Figure 4).

The driver carries the handy terminal, gets on the engine, and sets it near the on-board server. Then the duty data is automatically transferred from the handy terminal to the on-board server, and displayed on the screen (Figure 5). So, the driver need not take action for data transfer. When the driver selects a train and click the "timetable display" button, the timetable is displayed (Figure 6).

3.2.2 Fault data transfer from the on-board server to the terrestrial server

The process to transfer fault data from the on-board server to the terrestrial server is almost the same as the above. That is, the driver designates the handy terminal to which the data is transmitted on the on-board server, and activates transfer. When the handy terminal is carried to the neighbor of the terrestrial server and action is taken to receive data on the terrestrial server, the data is

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transferred from the handy terminal to the server. The viewer of the fault data is implemented on the terrestrial server by web browsers (Figure 7).

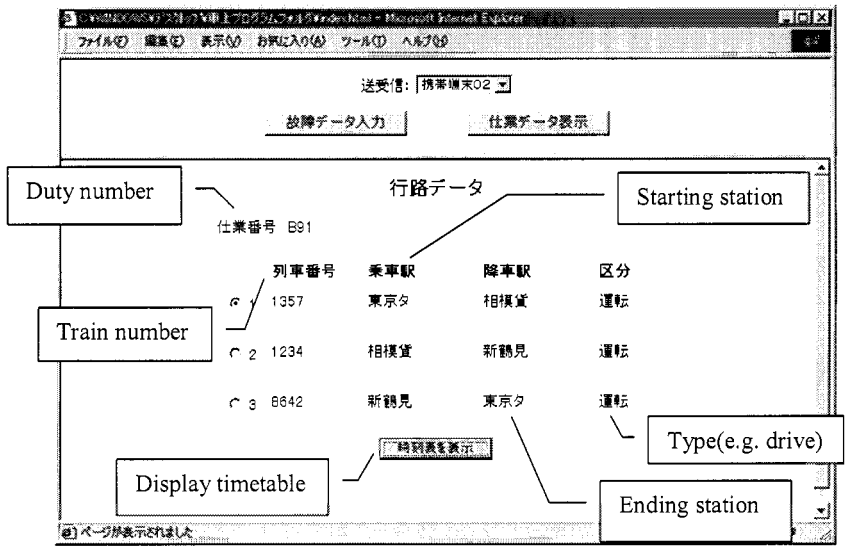

Figure 5: Snapshot for display of duty data

3.2.3 Generating data

The function to generate duty data and fault data to transmit is also implemented on on-board and terrestrial servers, respectively, in the experiments. The input data are recorded in data files in the XML format.

4 Transmission experiments of Bluetooth

Data transmission by Bluetooth seems possible between the handy terminal on the cab and the access point at the side of the railway lines as described in 2.2. We measured transmission characteristics in this environment as one of the experiments to verify whether Bluetooth is usable in railways.

4.1 Conditions for the experiment

We measured the average transmission rate when data files were transferred between two PCs with Bluetooth. One PC was set on the cab inside the locomotive as a fixed terminal, and the other was carried in the neighborhood of the locomotive along and at the right angle to the line (Figure 8). The engine was a diesel locomotive kept at a stop to work as an obstacle for wireless transmission.

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4.2 Results of the experiment

Figure 9 shows the relationship between the distance from the fixed to the mobile terminal and the average transmission rate, when the mobile terminal moves along and at right angle to the line. As the mobile terminal goes far from the locomotive, the transmission rate becomes lower in both cases, but has sufficient characteristics over 180 kbps even if the distance is about 50 meters.

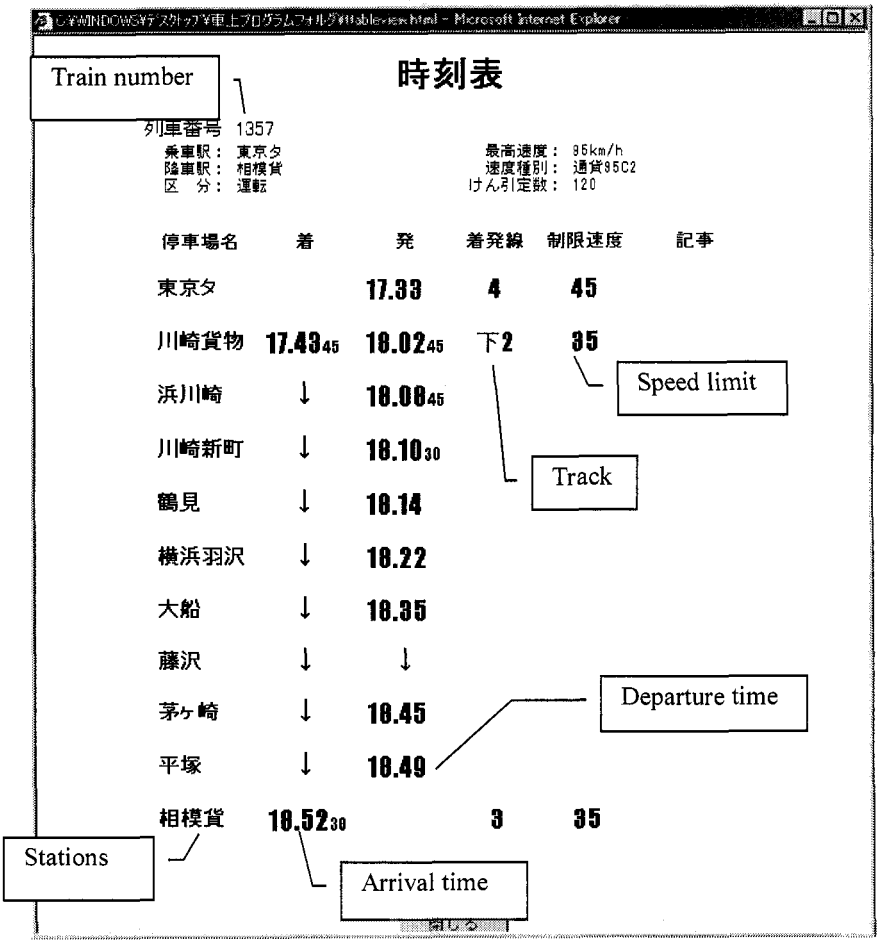

Figure 6: Snapshot for display of timetable

However, there was a case where the link setup failed at this distance. It is thought that the reason for the low transmission rate at a point of 45 meters from the locomotive along the line is that two PCs don't exist on the line of sight with

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each other through the windows of the locomotive. As a result, we can conclude that practical transmission characteristics may be achieved if access points are located at the distance of 30 meters from the cabin.

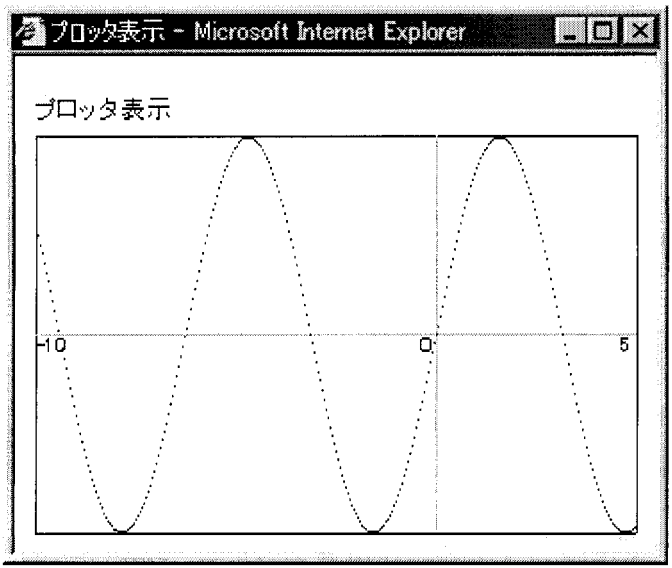

Figure 7: Snapshot for viewing fault data

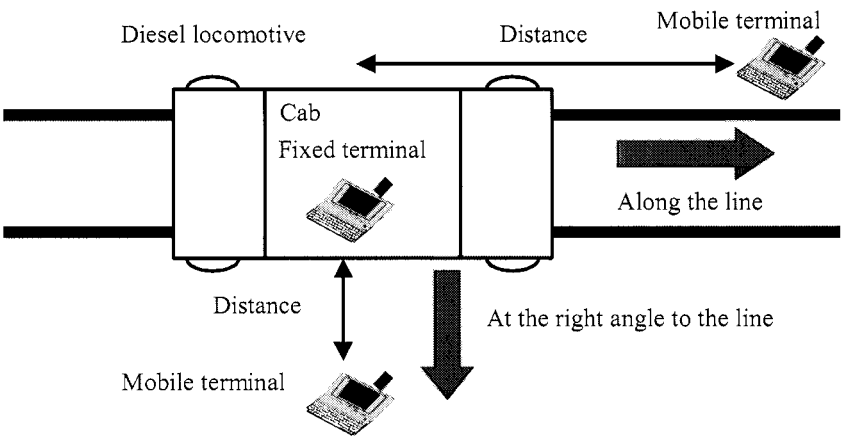

Figure 8: Environment for experiments (bird's eye view)

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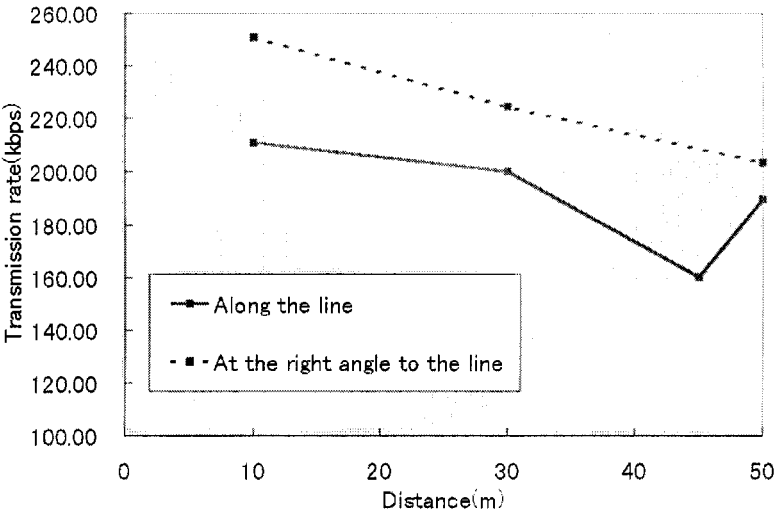

Figure 9: Distance between two Bluetooth devices vs. average transmission rate

5 Conclusion

Bluetooth technology has a possibility to adapt to various aspects of railway systems. We have proposed a data transfer system between trains and operational centers using handy terminals with Bluetooth as an application and constructed a prototype which implemented a part of the whole system. Moreover, we measured the transmission characteristics of Bluetooth in the vicinity of a locomotive, and proved that this technology is highly available.

We will continue to develop the proposed system toward the final configuration shown in Figure 2, experiment under various conditions such as around active engines, and investigate the influence on other wireless systems.

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[1]Bisdikian,C. An overview of the Bluetooth wireless technology, IEEE Communications Magazine, pp.86-94, No.12, 2001.

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