Efficient Formation of Dynamic Bluetooth Scatternet via Mobile Agent Processing

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Abstract. During recent years, there has been an increasing interest in the research and development of Wireless Personal Area Networks (WPANs). In particular, Bluetooth has been widely acknowledged as a suitable solution to enable small electronic devices with wireless connectivity. However, a number of issues remain to be solved before Bluetooth-equipped devices can provide users with full ad-hoc networking capabilities. This paper explores and discusses the applicability of mobile agent technology to address a specific issue in Bluetooth networks: the scatternet formation problem. It is argued that mobile agent technology can be efficiently employed to solve this particular problem in Bluetooth WPANs, overcoming restrictions seen in existing schemes. Simulations results demonstrate the effectiveness of using mobile processing to solve the scatternet formation problem.

Keywords: Mobile agents, mobile processing, Bluetooth, scatternet formation, ad-hoc networks, and wireless personal area networks.

1 Introduction

Providing small computing devices with wireless connectivity is one of the key steps toward enabling mobile users with ubiquitous computing capability. To this effect, Bluetooth technology has been widely adopted as an alternative solution to other wireless technologies. Its simplified radio circuitry is specifically tailored to meet the requirements of small electronic gadgets, such as cellular phones and personal digital assistants. Its current specification provides wireless connectivity of up to 10 metres, and a maximum data rate of 721 Kbps [1]. Wider coverage areas are also possible, e.g. up to 100 metres, while additional specifications are being developed to reach data rates as high as 55 Mbps [2]. Given these features, and a target price of a few dollars, Bluetooth is widely considered a promising technology to enable WPANs [3], [4]. However, before this possibility becomes a reality, a number of issues inherent to the Bluetooth wireless architecture must be addressed. One particular problem is the need for efficient solutions to configure scatternets, a term coined to Bluetooth-enabled ad-hoc networks. Scatternets possess unique characteristics that are inherent

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to the Bluetooth technology, which adds extra complexity to scatternet formation protocols. This paper presents a novel solution, in which mobile (agent) processing is employed to dynamically configure scatternets. To our knowledge, there has been no existing work reported in the literature, that applies agents technology and mobile processing to the problem of dynamic Bluetooth scatternet formation. Not including this introduction section, this paper is organized into 6 sections as follows. Section 2 reviews the basics of Bluetooth technology to give a foundation for the rest of the paper. Section 3 gives a brief description of the mobile-processing paradigm and its applicability to ad-hoc networking. Section 4 elaborates on the proposed method to solve the scatternet formation problem using mobile processing. Simulation results are presented in Section 5 to demonstrate the effectiveness of the proposed method. Finally, in Section 6 we offers concluding remarks and suggestions for future work.

2 Introduction to Bluetooth WPANs

In comparison to the wireless LAN technology, establishing a communication link between two Bluetooth enabled devices is a somewhat more intricate process. This can be primarily attributed to the mechanism used in the Bluetooth architecture for devices to gain access to the wireless channel. Such mechanism is known as Frequency-Hopping Spread Spectrum (FH-SS), which is widely acknowledged to provide high bandwidth utilization and improved noise immunity. Bluetooth devices (BDs) establish a communications link by synchronizing the pseudo-random sequence with which they sequentially access different channels in the available bandwidth according to the FH-SS mechanism [1]. To accomplish this, BDs must first become aware of their mutual existence. This is the primary objective during the first stage of the discovery procedure, known as the inquiry process. Once two BDs have become aware of their mutual existence, both devices are able to complete the synchronization procedure by entering the page state. This second stage enables one device to transfer hardware-specific data to the other, leading to the desired synchronization that precedes the connected state. A drawback to this scheme is that the delay incurred during the inquiry process can be as long as 10 seconds [1].

According to the current architecture of the Bluetooth technology, after a wireless link has been created between two BDs, one of the devices assumes the role of a master, while the other assumes the role of a slave. More than two BDs can connect to create a piconet. In a piconet, there can be only one master, and up to seven active slaves. Dual master-slave roles in a BD are also possible, but are rather avoided due to further role-swapping delays. A master BD has the task of controlling the data flow among the members of its piconet that inherently has a star topology centred at the master BD. A piconet can accommodate additional slaves as long as they assume a parking (inactive) role. A scheduling scheme can then be enforced to control the way in which slaves swap between connected or parking states to enable data transfer as required. In addition, a slave BD may belong to more than one piconet by assuming an active role in one of them and a parking role on the others in a rotating fashion. Such a BD, referred as a bridge, can then be used to relay data among piconets, resulting in the scatternet concept shown in Figure 1.