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Performance analysis of Bluetooth asynchronous connection-less service

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ABSTRACT

In recent years Bluetooth has been a growing technology for ad-hoc wireless communication between embedded devices, in a range of 10 m. Such a network is called a piconet, in which a master employs round-robin mechanism to poll and serve the slaves. Many new products have become Bluetooth enabled recently, which may cause a complex mix of traffic. Two types of connection are being offered in this network: the Synchronous Connection-Oriented (SCO), and the Asynchronous Connection-Less (ACL). ACL is proper for best-effort service as in IP networks, which has gained more importance as now a day's most of the applications have moved to IP, and may carry bursty traffic. In this paper, to analyze the Bluetooth ACL, a general model for complex mix of traffic, which is the superposition of many ON–OFF mini-sources, is considered. Moreover, due to unreliable nature of wireless media, a Channel Failure Rate (CFR) has been assumed. This system has been investigated analytically and its performance has been evaluated. The effects of channel failure and packet size on the mean delay and waiting time have been studied by simulations as well.

1. Introduction

Bluetooth is an evolving technology for the Wireless Personal Area Networks (WPAN). Recently many products such as PDAs, mobile PCs, computer equipments, mobile phones, headsets, office equipments, audio and visuals, and house appliances are Bluetooth enabled. The technology performs low-cost, short range (up to 10 m, or 100 m with a power boost) wireless connections between various voice and data communication devices. It operates in 2.402–2.483 GHz frequency band with 79 frequency hopping channels of 1 MHz bandwidth (Misic and Misic, 2006).

Up to eight devices within range, communicating on the same channel can setup an ad-hoc network called a "piconet". One unit in a piconet operates as master and the others are slaves, which employ Time Division Multiplexing (TDM) to communicate over GFSK modulation with 1 Mbps data rate. The channel is divided into 625 μs time slots, in which the master and the slaves communicate. Two types of connection are defined between a master and a slave: the Synchronous Connection-Oriented (SCO) and the Asynchronous Connection-Less (ACL). The SCO link is a symmetric point-to-point connection, which carries 64 Kbps of voice traffic. In ACL mode, the master controls the access to the channel using a round-robin (polling) scheme where master and slave transmissions alternate consecutively. The ACL link is an asymmetric connection with Automatic Repeat Request (ARQ) procedure in case of packet errors. All the slaves listen to downlink transmissions from the master and may reply with an uplink transmission immediately after being polled by the master. The master takes even-numbered slots, whilst slaves' packets are odd-numbered. Both master and slaves are allowed to send packets with 1, 3, or 5 consecutive slots length (Fig. 1). A downlink packet and the subsequent uplink packet are referred to as a frame. So, the Bluetooth ACL service, which is a Pure Round Robin (PRR) with variable length packets, replicates the basic model for the polling system, consisting of multiple queues and a single server that serves those queues one at a time (Bary and Sturman, 2000).

Fig. 2 illustrates the structure of an ACL packet. The overhead plus the blank space between two consecutive packets is about 60% of one time slot (380 μs).

As the number of products working with Bluetooth rises, the ACL traffic generated in a piconet turns out to be more heterogeneous. Moreover, due to unreliability of wireless media, channel failure in this system is unavoidable and should be taken into consideration. In this paper we analyze Bluetooth ACL service against the conditions, which happen in many of the practical situations, but have been disregarded in previous analytical works, namely the service failures. Furthermore, the focus of this research is evaluation of Bluetooth network for a mix of bursty traffic, which happens in multimedia transmission over IP. Previous studies have emphasized that in spite of its nice simplicity and theoretical properties, Poisson process is not a good model for bursty traffic. The main theoretical justification for this claim is that the Poisson counting process is based on having memory-less, exponentially

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