Demand-based Bluetooth Scheduling

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Bluetooth

Bluetooth is an open specification for technology to allow short range wireless communication of voice and data anywhere in the world.

It operates in the noisy unregulated/unlicenced ISM band at 2.4 GHz.

In this band, 79 (or 23) consecutive 1 Mbps channels are available for use by Bluetooth devices.

Each cluster of Bluetooth devices (called a “piconet”) has net effective bandwidth usage of 1 Mpbs.

System Architecture

The range of operation of Bluetooth devices is 10m to 100m, typically closer to 10m; this range determines the physical radius of a piconet.

Bluetooth employs Time Division Duplex (TDD) for communication between devices (within a piconet): two consecutive 625 microsecond time-slots per exchange.

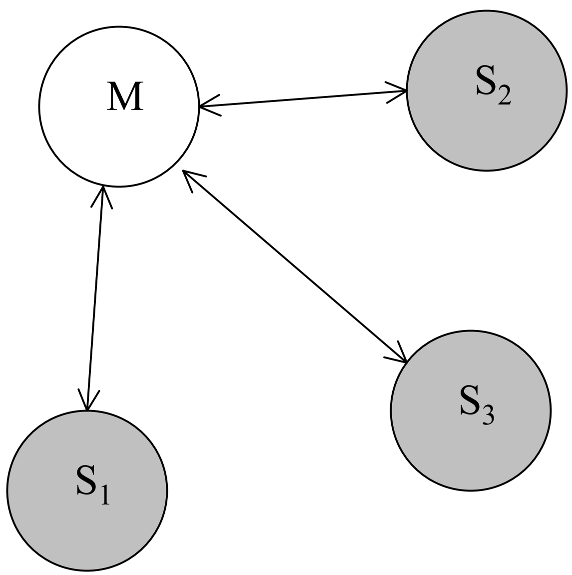
Each piconet uses a different pseudorandom frequency hopping strategy so that every 625us slot uses a different 1 Mbps band among the 79 (or 23) available.

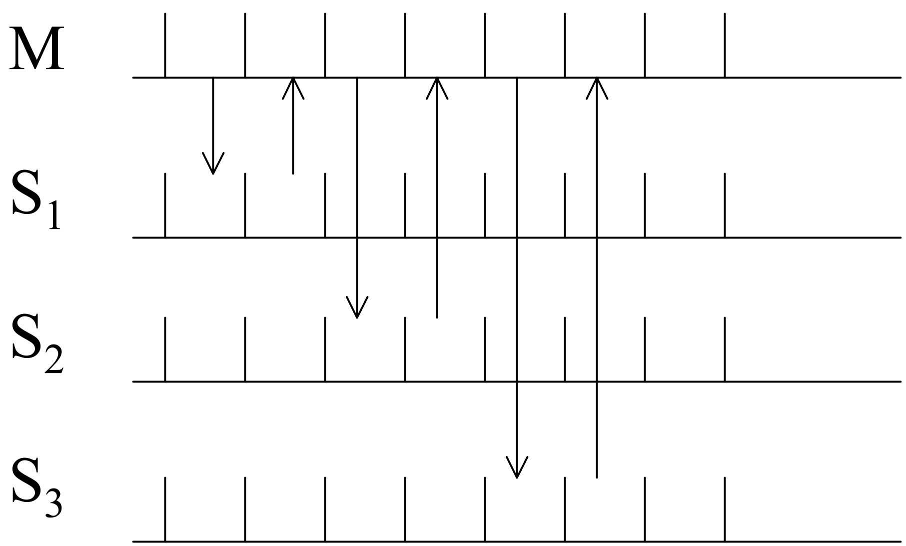
Frequency hopping improves noise immunity and allows for multiple access of ISM band by adjacent piconets.

The Piconet

A piconet can consist of one master and up to 7 slaves; each slave is synchronized to the master's freq. hopping sequence. A piconet is identified by the Master Bluetooth Address and clock.

The slaves communicate only with the master using TDD.

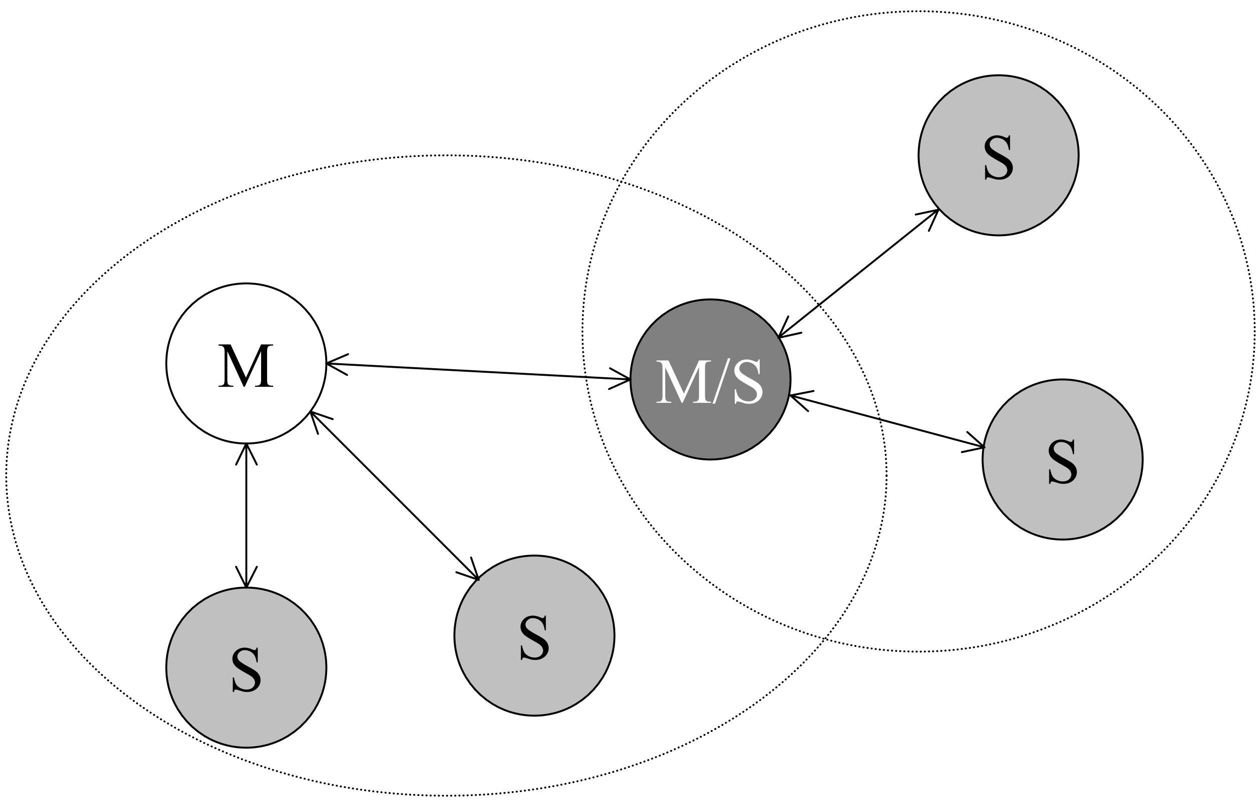




Scatternets

Bluetooth devices can belong to more than one piconet.

A group of interconnected piconets is called a “scatternet.”



Bluetooth "Channels"

There are two types of communication channels:

- Synchronous (Voice communication)
- Asynchronous (Data communication)

A synchronous channel needs to be set-up and is given priority over Asynchronous channel. A synchronous slave is periodically polled (two slots) at least once every 7x1.25 ms.

An asynchronous channel employs strict round-robin polling (in which a master simply polls each slave in turn).

For Efficient Bandwidth/Power Usage:

An inactive slave can enter a dormant state for reduced power consumption; Bluetooth supports three such states: *sniff*, *hold* and *park*. We consider only the *park* state for simplicity and note that a bluetooth device can communicate only in the *active* state.

The use of multi-slot packet formats (1:1), (1:3), (3:1), (1:5), (5:1). Multislot packet formats improve throughput in situations where the master-slave connection has information flowing primarily in one direction, i.e., an asymmetric TDD connection.

Scatternet Scheduling

- Identify shared (including bridge) slaves.
- Determine piconet schedules so that shared slaves are not simultaneously polled by different masters.
- We assume here that the polling slots of the shared slaves are decided and no shared slave communicates with more than one piconet simultaneously.

Demand-based Piconet Scheduling

- Polling positions of synchronous and shared slaves are fixed
- Asynchronous, dedicated slaves can be polled "on demand" in remaining slots
- Example of 4-slave piconet : 3 is synch., 1 is shared, 0 and 2 are asynchronous, dedicated (ADS)

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Slave polled	0	1	2	3	0	1	2	0	1	2	3	0	1	2	0
ADS slots	x		x		x		x	x		x		x		x	x

Demand-based Piconet Scheduling

- Each, ADS has a current polling period, n, and time-stamp t.
- In an "ADS slot" (x), the ADS with smallest time-stamp is polled by the master.
- Initially, each ADS polling period is set to n=D. Where D is the number of ADS slaves.

Demand-based Piconet Scheduling

- The polling period is updated based on the traffic of the master or slave.
- If the master and/or slave have packet(s) to transmit in the allotted slot the polling period is set to D.
- If the master or slave have no packet to transmit, the polling period is updated, n=n+m.
- Thus polling period takes values
  $n = D \leq N_1 \leq N_2 \leq \ldots . \leq N_{K-1} \leq N_K$

Demand-based Piconet Scheduling

- Park rule: if the polling period of an ADS reaches a certain level, $n=N_K$, the master will park the slave.
- Parking the slave saves bandwidth and power consumption of the bluetooth piconet.

Advantages and Disadvantages

- The Demand-based piconet scheduling increases the throughput of the piconet.
- Parking of slaves reduces the power consumption of the piconet. Also it gives a rule “when” to park the slave.
- The Demand-based piconet scheduling increases the “access latency” of the slaves. Access latency is defined as the delay experienced by the first packet of data burst.
- The increase in access latency can cause packet lose. This can be remedied if we alter the step-size based on the traffic load. A. Das *et al* have also proposed Adaptive Flow Based Polling in their paper at INFOCOMM 2000.

Simulation

The simulation for Demand-based scheduling considers only the ADS slaves. We assume the synchronous and shared slaves are periodically polled and polling period are fixed.

The traffic profiles considered for ADS are CBR. This is not a comprehensive simulation of an actual piconet but is detailed enough to show the affect of Demand-based scheduling.

The simulations showed that the Demand-based scheduling has the same result as Strict round-robin scheduling when all the slaves have same traffic profiles.

It has better throughput when the slaves have unequal traffic load.

Plot of Step size Vs Throughtput, Access Latency and Frames Lost.