Lec32

Saturday, April 4, 2020 3:11 PM

Bluetooth - 15min

Monday, January 21, 2008 3:15 PM

- 802.15.1
- one of the IEEE 802.15 family of standards
  - WPAN: Wireless Personal-Area Network

- 1Mbps

- Connectivity within a small area.
  - 10 meters
  - e.g. headset ⇔ cell phone

- Other 802.15 standards
  - 802.15.3 higher data rate
    up to 100Mbps
    UWB, WiMedia

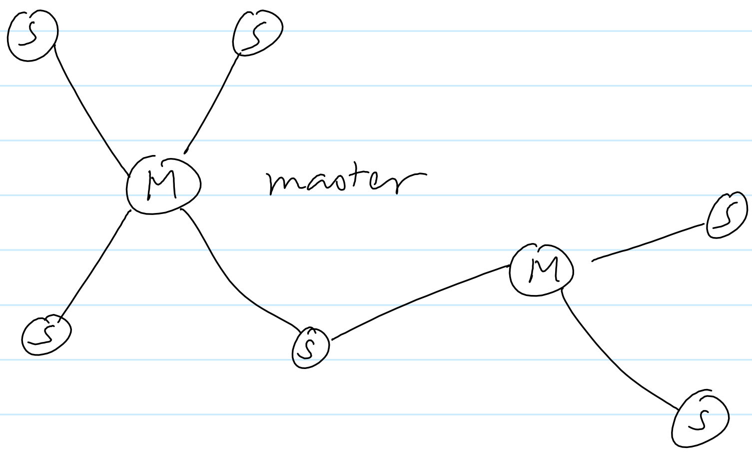
  - 802.15.4 low data rate
    20 ~ 250 kbps
    Zigbee

Bluetooth also uses 2.4GHz unlicensed band (2402 ~ 2480 MHz).

- Frequency-hopping at 1600 Hops/sec within 79 equally spaced 1MHz channel.

- 1Mbps data rate.

Devices within the coverage range of 10m organize themselves into piconets



- up to 8 devices (1 master + 7 slaves) can coexist in a piconet.

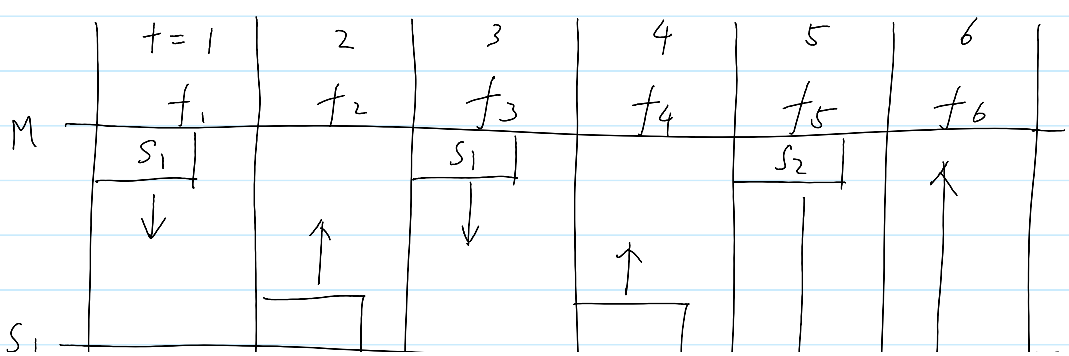
- the master sets the freq. hopping sequence of the piconet, and slaves sync to the master

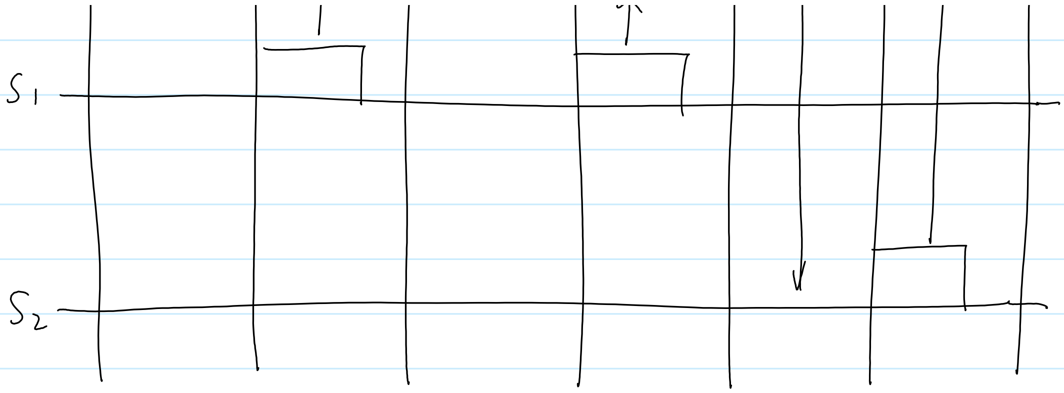
- A device can join multiple piconets, thus forming a scatternet.

  (A device can only be master in one piconet).

Data Transmission by Polling

- every time-slot (625 μsec) the master polls a slave





Two modes:

- Synchronous connection-oriented (SCO) link:
  - master polls slave at constant intervals
  - good for voice
- Asynchronous connectionless (ACL) link:
  - master polls slave on demand (in between SCO)
  - good for best-effort data traffic.

Summary:

Interference relationship in Bluetooth

- A master can only speak to one slave at each time-slot
- A slave can sync to one master at each time-slot

⇒ Any two links that share a common node can not be used at one time-slot.

— Primary interference constraint

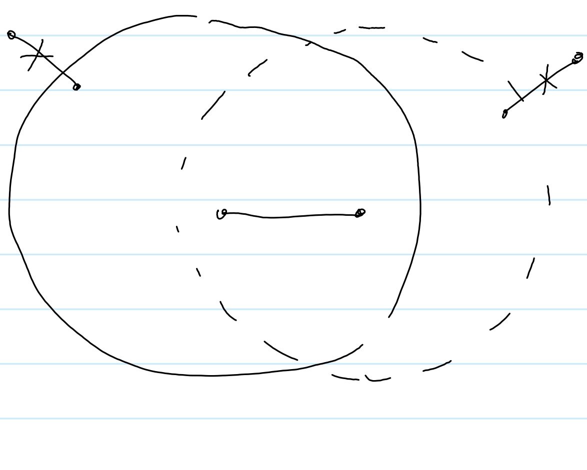
Otherwise, the two links can transmit at the same time since they use near-orthogonal hopping sequences.

— Node-exclusive interference model

(45) — one-hop interference model

- In contrast, WLAN is more like a 2-hop interference model

Each link interferes with links in a two-hop neighborhood.



Random Access

Sunday, April 5, 2020 10:11 AM

- In the following, we will discuss several models for understanding the performance of random access.
- This is not only useful for WLAN, but also for massive IoT connectivity in 5G
    - Due to the small payload of IoT devices, the type of overhead in BS scheduling may be too excessive.
    - If we want IoT devices to transmit without BS scheduling. One possible setting will be random access
    - However, the # of devices will likely be much larger than WLAN
        - spectrum efficiency will again be important.

- Unfortunately, random access systems are quite difficult to analyze.
    - The retransmissions usually depends on the history
      $\rightarrow$ need to account for "state"
    - The states of multiple devices are coupled

together due to collision

- For tractability, it is typical to invoke some simplifying assumptions.

- Some models assume a fixed # of devices

  → Main metric of interest are throughput, delay, fairness, etc.

- Some models tackel dynamic arrivals of devices

  → stability also becomes important.

Slotted Aloha

Sunday, April 5, 2020 10:11 AM

- We will assume a time-slotted model throughout
  - ok when devices can sense each other, and therefore their transmission attempts are naturally synchronized.
  - refered to as slotted-Aloha.

- The simplest model is perhaps to assume that each device transmits with a probability p in each time-slot, independently of others
  - The details of backoff are abstracted out

- Assume n devices. The probability that a successful transmission occurs is

$$np(1-p)^{n-1}$$

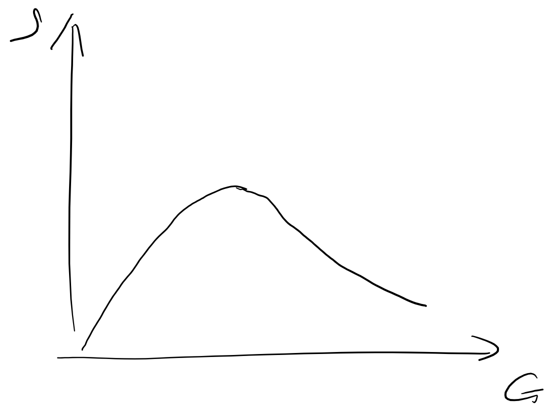
- Let $G = np$ denote the total rate of transmissions.

  Let S be the rate of successful transmissions

  We get

$$S = np(1-p)^{n-1}$$
$$= G\left(1-\frac{G}{n}\right)^{n-1}$$

- We can see that, as G increases, S first increase, and then decrease (due to collision)



- There is a value of G such that S is maximized.

- When G is fixed and n is large,

$$\left(1-\frac{G}{n}\right)^{n-1} \approx \left(1-\frac{G}{n}\right)^{n} \approx e^{-G}$$

- We then get

$$S = Ge^{-G}$$

- To solve the maximum S

$$\frac{dS}{dG} = e^{-G} - Ge^{-G} = 0$$
$$\Rightarrow \quad G^* = 1$$
$$S^* = e^{-1} \approx 0.36$$

- In summary, the maximum throughput of slotted Aloha is $\frac{1}{e}$
  - It is attained when each device transmits with probability $p = \frac{G^*}{n} = \frac{1}{n}$

- Finally, although this analysis assumes all slots are the same, it can also be used when slots are of variable length, depending on whether the slot is idle, collision, or success.
  - Useful for model CSMA/CA in WLAN, as we will see shortly.