What is Bluetooth? 1/2

• A wireless LAN technology designed to connect devices of different functions such as telephones, notebooks, computers, ... offering a short-range connectivity solution (cable replacement)
  ➢ Eliminates line of sight requirements
• A Bluetooth LAN is an ad hoc network (devices find each other and make a network called a piconet)
• A Bluetooth LAN can be connected to the Internet if one of the devices has this capability
• Applications
  ➢ Peripheral devices of a computer can connect with the computer through this technology (wireless mouse or keyboard)
  ➢ Monitoring devices can communicate with sensor devices in a small health care center

What is Bluetooth? 2/2

• Originally started as a project by Ericsson
• Named for Harald Blaatand, King of Denmark (940-981) who united Denmark and Norway (Blaatand translates to Bluetooth in English)
  ➢ Bluetooth aims at uniting personal computing devices
• Currently, Bluetooth is an implementation of a protocol defined by 802.15 standard
  ➢ Wireless personal-area network (PAN) operable in an area the size of a room or a hall
Bluetooth Architecture 1/7

- A Bluetooth network is called a piconet (small net)
- Up to eight stations, one of which is the master (only one master), while the rest are slaves (The master is usually the station initiating the connection)
- Master slave communication is one-to-one or one-to-many (no slave to slave communication)
- Additional eight slaves can be in parked state (in synch with master)
- Devices not associated with any piconet are in standby mode
- Piconets can be combined to form a scatternet (a slave can become a master in another piconet)
  - Receives messages from master in first piconet, and acting as a master deliver it to slaves in second piconet

Bluetooth Architecture 3/7

- Receives messages from master in first piconet, and acting as a master deliver it to slaves in second piconet

Bluetooth Architecture 4/7

- Receives messages from master in first piconet, and acting as a master deliver it to slaves in second piconet
Bluetooth Devices

- A Bluetooth device has a built-in short-range (around 10m) radio transmitter
- Data rate is 1 Mbps with a 2.4 GHz bandwidth
  - Possibility of interference between 802.11b LANs and Bluetooth LANs
Radio Layer

- Roughly equivalent to physical layer of Internet model
- Devices are low-power and have a range of 10 m
- Uses a frequency-hopping spread spectrum (FHSS) to avoid interference from other devices or networks
  - Sender sends on one carrier frequency for a short amount of time, then hops to another carrier frequency for the same amount of time, and so on
  - Sender and receiver agree on sequence of allocated bands
  - Amount of time spent at each subband is called the dwell time
- Bluetooth hops 1600 times per second (a device uses a frequency for only 625 microseconds – dwell time is 625 microseconds)
- Communications channel in piconet defined as the sequence of frequency hops followed by members in a synchronized manner

Baseband layer 1/5

- Roughly equivalent to MAC sublayer in LANs
- Access method is TDMA (time slots)
- A form of TDMA called TDD-TDMA (time-division duplexing TDMA)
  - Half-duplex communication
  - Communication for each direction uses different hops
- Single-slave communication (one slave in piconet)
  - Time divided into slots of 625 microseconds
  - Master uses even-numbered slots, slaves use odd-numbered slots
  - Slot 0: master sends and slave receives (half-duplex)
Baseband layer 2/5

Single-slave communication

Baseband layer 3/5

- multiple-slave communication (more than one slave in piconet)
  - Master uses even-numbered slots
  - Slave sends in the next odd-numbered slot if the packet in the previous slot was addressed to it. If the slave has no frame to send, the channel is silent
  - All slaves listen on even-numbered slots
- Each baseband transmission resides fully within boundaries of a slot
- Multi-slot packets occupying three of five slots are allowed (during transmission of multi-slot packet, frequency does not change)
- Time synchronization between master and slaves utilizes the master’s clock
- Master’s Bluetooth clock identifies particular frequency to be used at a given slot (for scatternet, a device can be a master for only one piconet)

Baseband layer 4/5

Baseband layer 5/5

- Two types of links
  - SCO links (synchronous connection-oriented)
    - Used when avoiding delay is more important than integrity
    - If a packet is damaged, it is never retransmitted
    - A physical link is created by reserving specific slots at regular intervals (basic unit is 2 slots, one for each direction)
  - ACL links (asynchronous connectionless)
    - Used when data integrity is more important than avoiding latency
    - If a payload is corrupted, the packet is retransmitted
    - A slave returns an ACL frame in the available odd-numbered slot if the previous slot has been addressed to it
    - Can use one, three, or more slots
    - Achieves data rate up to 721 Kbps
L2CAP layer

- Logical Link Control and Adaptation Protocol (L2 is LL)
- Roughly equivalent to LLC sublayer in LANs
- Link-oriented
- Used for data exchange on an ACL link
  - SCO links do not use L2CAP
- Duties
  - Multiplexing
  - Segmentation and Reassembly
  - QoS
  - Group Management (similar to multicasting)

Profiles

- Bluetooth specifications comprises communications protocols and applications
- Specifications for building interoperable applications are called profiles
- Some basic profiles
  - Generic access, service discovery, cordless telephony, and generic object exchange
- Additional profiles
  - Audio video remote control, basic printing, and basic imaging
- Each profile selects a set of protocols

Packet Forwarding in a Scatternet

- Packet forwarding becomes necessary when packets must traverse multiple hops between source and destination
- Routing over scatternet not handled by IP layer
  - IP addresses allocation protocols rely on link layer connectivity, hence won't work over scatternet
  - For efficiency, routing function should be joined with function of forming scatternets (IP needs to interact with Bluetooth layer)
  - Non-IP based applications may use scatternet functionality provided by Bluetooth networking layer
- Bluetooth Network Encapsulation Protocol (BNEP) provides a broadcast segment across a scatternet
Packet Forwarding in a Scatternet

Figure 8. Location of BNEP in the Bluetooth IP stack.