Bluetooth: Short-Range RF Communication

✿ Brief overview
✿ Scenario with the personal server
✿ Issues

Overview

✿ Universal short-range wireless capability
✿ Uses 2.4-GHz (ISM) band
✿ Available globally for unlicensed users
✿ Devices within 10m can share up to 720 kbps of capacity
Bluetooth Application Areas

- Data and voice access points
  - Real-time voice and data transmissions
  - Cordless headsets
  - Three-in-one phones: cell, cordless, walkie-talkie
- Cable replacement
  - Eliminates need for numerous cable attachments for connection
  - Automatic synchronization when devices within range
- Ad hoc networking
  - Device with Bluetooth radio can establish connection with another when in range
  - Devices can “imprint” on each other so that authentication is not required in each instance
  - Meeting support for file/business card transfers

Bluetooth Standards Documents

- Core specifications
  - Details of various layers of Bluetooth protocol architecture
- Profile specifications
  - Use of Bluetooth technology to support various applications
Protocol Architecture

- Bluetooth is a layered protocol architecture
  - Core protocols
    - Radio
    - Baseband
    - Link manager protocol (LMP)
    - Logical link control and adaptation protocol (L2CAP)
    - Service discovery protocol (SDP)
  - Cable replacement and telephony control protocols
  - Adopted protocols

Bluetooth Stack Overview
Protocol Architecture

- Cable replacement protocol
  - RFCOMM
- Telephony control protocol
  - Telephony control specification – binary (TCS BIN)
- Adopted protocols
  - PPP
  - TCP/UDP/IP
  - OBEX
  - WAE/WAP
- Profiles – vertical slide through the protocol stack
  - Basis of interoperability
  - Each device supports at least one profile
  - Defined based on usage models (e.g., headset, camera, personal server, etc.)

Piconets and Scatternets

- Piconet
  - Basic unit of Bluetooth networking
  - Master and one to seven slave devices
  - Master determines channel and phase
- Scatternet
  - Device in one piconet may exist as master or slave in another piconet
  - Allows many devices to share same area
  - Makes efficient use of bandwidth
Wireless Network Configurations

Radio Specification

◆ Classes of transmitters
  ■ Class 1: Outputs 100 mW for maximum range
    ✷ Power control mandatory
    ✷ Provides greatest distance
  ■ Class 2: Outputs 2.4 mW at maximum
    ✷ Power control optional
  ■ Class 3: Nominal output is 1 mW
    ✷ Lowest power
Frequency Hopping in Bluetooth

- Provides resistance to interference and multipath effects
- Provides a form of multiple access among co-located devices in different piconets

Frequency Hopping

- Total bandwidth divided into 1MHz physical channels
- FH occurs by jumping from one channel to another in pseudo-random sequence
- Hopping sequence shared with all devices on piconet
Physical Links between Master - Slave

- **Synchronous connection oriented (SCO)**
  - Allocates fixed bandwidth between point-to-point connection of master and slave
  - Master maintains link using reserved slots
  - Master can support three simultaneous links

- **Asynchronous connectionless (ACL)**
  - Point-to-multipoint link between master and all slaves
  - Only single ACL link can exist

Bluetooth Packet Fields

- **Access code** – used for timing synchronization, offset compensation, paging, and inquiry
- **Header** – used to identify packet type and carry protocol control information
- **Payload** – contains user voice or data and payload header, if present
Channel Control

 States of operation of a piconet during link establishment and maintenance

 Major states
 - Standby – default state
 - Connection – device connected

 Interim substates for adding new slaves
 - Page – device issued a page (used by master)
 - Page scan – device is listening for a page
 - Master response – master receives a page response from slave
 - Slave response – slave responds to a page from master
 - Inquiry – device has issued an inquiry for identity of devices within range
 - Inquiry scan – device is listening for an inquiry
 - Inquiry response – device receives an inquiry response
L2CAP Logical Channels

- **Connectionless**
  - Supports connectionless service
  - Each channel is unidirectional
  - Used from master to multiple slaves

- **Connection-oriented**
  - Supports connection-oriented service
  - Each channel is bidirectional

- **Signaling**
  - Provides for exchange of signaling messages between L2CAP entities
Personal Server Scenario

Scenario steps

- Master device (PC) pages for nearby devices
- Slave device (personal server) responds to page when in range
- L2CAP establishes Bluetooth connection assigning paging device to be master
- Devices exchange profiles they both support
- Agree upon PAN + TCP/IP as the vertical slice
- Fixed IP addresses exchanged (could have used DHCP)
- Devices can now send messages to each other
Stack

- App + TCP/IP + PAN + L2CAP + Bluetooth
- App packets are encapsulated into IP
- IP packets are broken down into Bluetooth segments for reassembly on the other device
- Keep-alive packets used to maintain connections
- Connections dropped if keep-alive packets are not acknowledged

Issues

- How are multiple personal servers viewed by the master paging them?
- How does the application know they are there?
- What if there are two masters within range of each other?