

# Mobile Computing – Bluetooth

- It consists of Universal **radio interface** for **ad-hoc wireless connectivity**.
- Interconnecting computer and peripherals, **handheld devices, PDAs, cell phones**
- Embedded in other devices
- Short range (10 m), **low power consumption**, license-free 2.45 GHz
- **Voice and data transmission**, approx. 1 Mbit/s gross data rate



# User Scenarios - Bluetooth

- **Support for ad-hoc networking**
  - Data can be shared on **mobile phone, PDAs**, etc
  - Small devices which might not have WLAN adapters, may have **cheaper bluetooth built in chips**.
- **Bridging of networks**
  - Using the wireless **WPAN** (Personal Area Network) or **piconet** (collection of bluetooth devices), mobile device can be connected to a **PDA/laptop**
    - Through **bluetooth chip**

# Characteristics

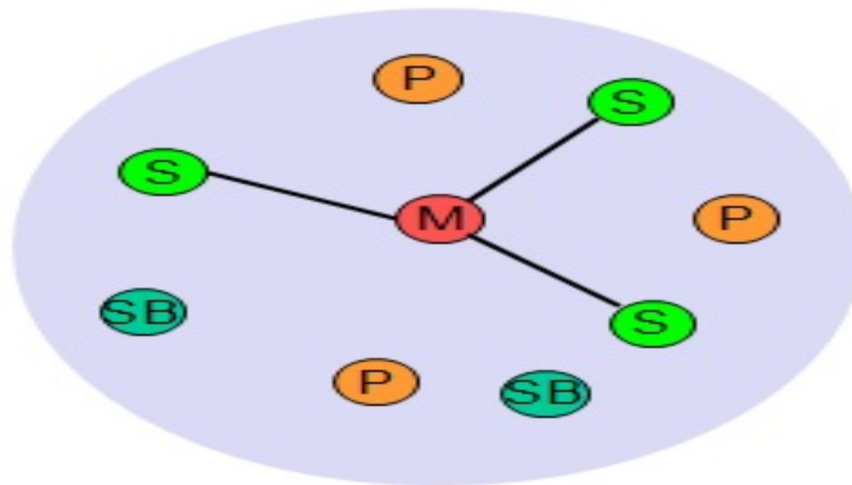
- Bluetooth operates on **2.4GHz band with 1MHz carrier spacing.**
- Each device performs frequency hopping with **1600 hops/s**
- Bluetooth applies **FHSS** (Frequency Hopping Spread Spectrum) for **interference mitigation**
- It also applies **FH-CDMA** for **separation of networks.**

# Architecture - Piconet

- **Piconet: Collection of bluetooth devices which are synchronized to the same hopping sequence**
- **One unit acts as master and the others as slaves for the lifetime of the piconet**
- **Master determines hopping pattern, slaves have to synchronize**
- **Each piconet has a unique hopping pattern**
- **Participation in a piconet = synchronization to hopping sequence**
- **Each piconet has one master and up to 7 simultaneous slaves**

# Piconet

- **Additional devices:**
  - **Parked devices(P): cannot actively participate in the piconet, but are known & can be reactivated.**
    - If a parked device wants to communicate and there are already seven active slaves, **one slave has to switch to park mode to allow the parked device to active mode**
  - **Stand-by (SB) devices: do not participate in the piconet.**

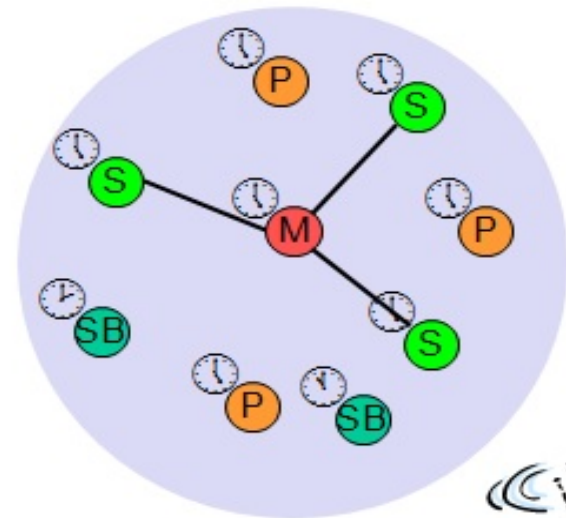
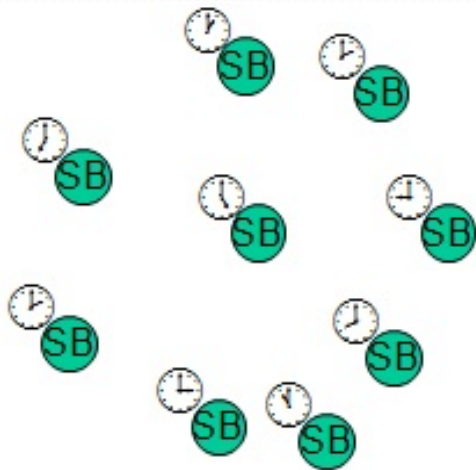


M=Master  
S=Slave

P=Parked  
SB=Standby

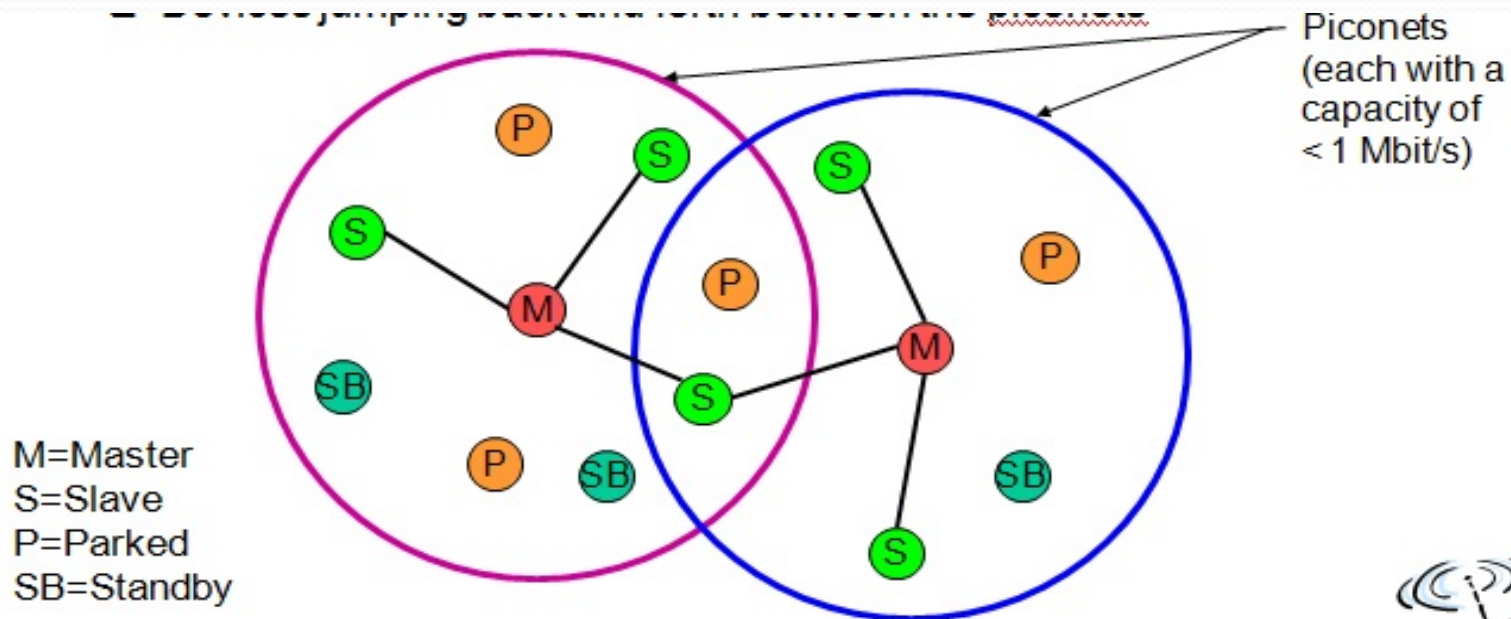
# Forming a piconet – Clock Synchronization

- All devices in a piconet hop together
  - Master gives slaves its **clock and device ID**
    - **Hopping pattern: determined by device ID** (48 bit, unique worldwide)
    - **Phase in hopping pattern determined by clock**
- Addressing
  - Active Member Address (AMA, 3bit)
  - Parked Member Address (PMA, 8 bit)



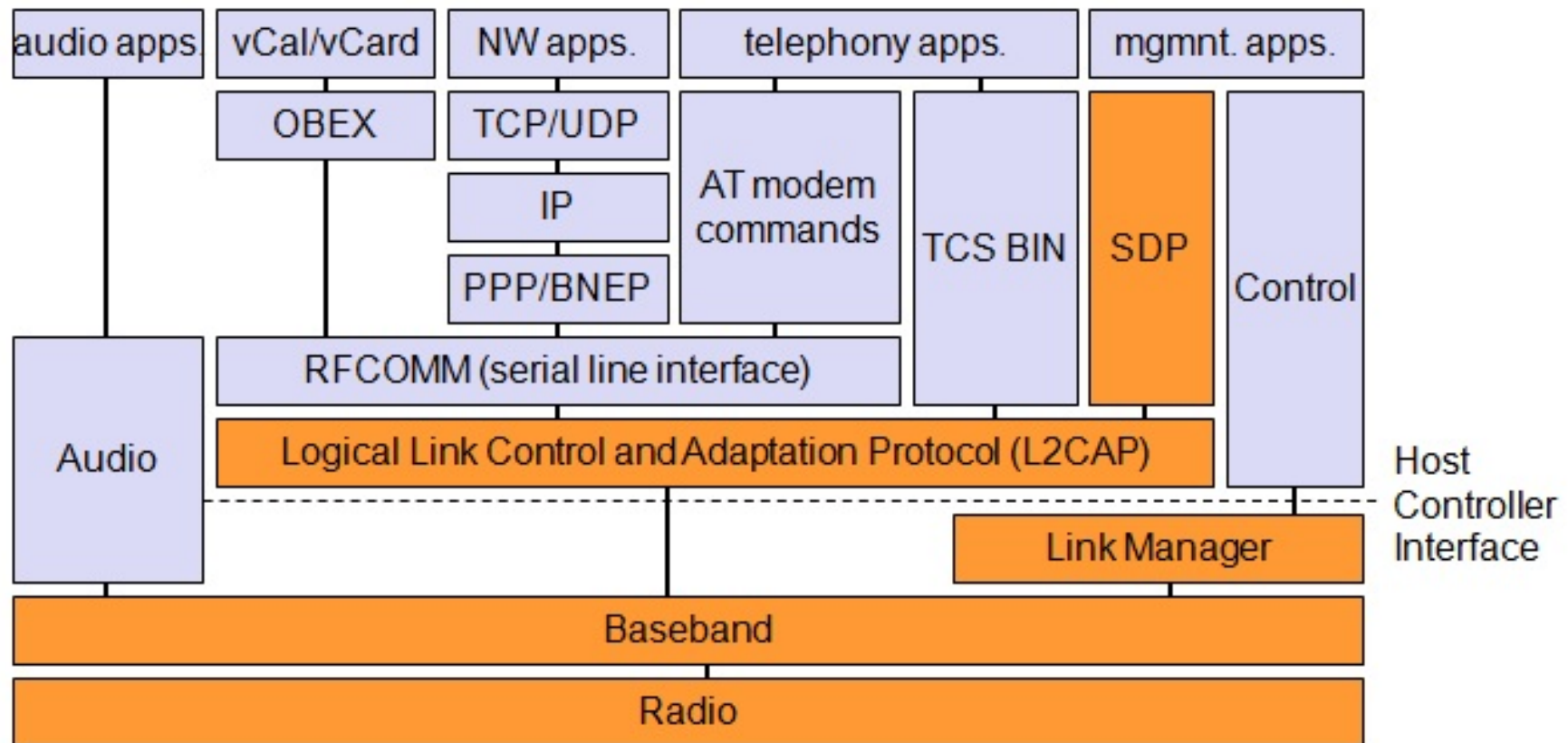
# Scatternet

- **Linking of multiple co-located piconets through the sharing of common master or slave devices**
  - **Devices can be slave in one piconet and master of another**
- **Communication between piconets**
  - **Devices jumping back and forth between the piconets**





# Bluetooth protocol stack



AT: attention sequence  
OBEX: object exchange  
TCS BIN: telephony control protocol specification – binary  
BNEP: Bluetooth network encapsulation protocol

SDP: service discovery protocol  
RFCOMM: radio frequency comm.





# Bluetooth protocol stack

- Protocol stack – divided into two parts
  - **Core specification:**
    - Describes the **protocols from physical layer to the data link control**
    - Consists of **management functions**
  - **Profile specification:**
    - Describes **protocols and functions needed to adapt the wireless bluetooth technology**

# Bluetooth protocol stack – Core Protocols

- **Core protocols:** consists of the following elements:
  - **Radio:** specifies air interface, i.e, frequencies, modulation, transmit power
  - **Baseband:** describes the basic connection establishment, packet formats, timing & QoS parameters.
  - **Link Manager protocol:** manages the devices including security functions and parameter negotiation
  - **Logical Link control and adaptation protocol (L2CAP):** adapts the higher layers to the baseband
  - **Service Discovery protocol:** discovers the device in close proximity

# Bluetooth protocol stack – Additional protocols

- **Cable replacement protocol: (RFCOMM)- Radio Frequency Comm.**
  - Allows for a simple **replacement of serial line cables** and enables many **legacy applications and protocols to run over bluetooth**
- **Telephony control protocol specification-binary: (TCS BIN)**
  - **Bit-oriented protocol** – defines **call control signaling** for the establishment of **voice and data calls between bluetooth devices**.
- **Host controller interface:**
  - Provides a command **interface to the baseband controller and link manager** and access to the **hardware status and control registers**.

# Link Manager Protocol

- **LMP** manages various aspects of the **radio link between a master & a slave**
  - It also manages **current parameter setting of the devices**.
- **Functions of LMP**
  - **Authentication, Pairing & Encryption:** Controls the **exchange of random numbers and signed responses**.
    - Helps in establishing **initial trust relationship between two devices**
  - **Synchronization:** Clock offset is updated each time a packet is received from the master.
    - Devices can exchange **timing information** related to the time differences between two adjacent piconets.
  - **Capability negotiation:** takes care of features such as **multi-slot packets, encryption, SCO links, voice encoding, etc**
  - **Quality service negotiation:** QoS features such as **poll interval, maximum time between transmissions from a master to a particular slave, latency & transfer capacity**.
  - **Power control:** it allows the **bluetooth device to measure the received signal strength**
    - Depending on the signal level, the device can direct the sender of the measured signal to increase or decrease its transmit power.
  - **Link supervision:** controls the activity of a link (failure or success)
  - **State & transmission mode change:** It takes of devices which might **switch the master/slave role, detach themselves from a connection, or change the operating mode**.

# Bluetooth - L2CAP

- **Logical Link control & adaptation protocol (L2CAP):**  
It offers a logical channels between bluetooth devices with QoS properties.
- **L2CAP** provides three different types of logical channels
  - **Connectionless:** unidirectional channels are used for broadcasts from master to its slaves
  - **Connection-oriented:** bi-directional channels & supports QoS flow specifications for each direction.
  - **Signaling:** used to exchange signaling messages between L2CAP entities.

# Bluetooth – Service Discovery Protocol (SDP)

- **SDP:** this module of bluetooth tries to find new services
  - It tries to maintain the **record of new unknown devices and services provided by them.**
  - **Service record:** maintains the **information about a service**
    - Consists of list of **service attributes**
    - **Service attributes:** consists of an attribute ID & an attribute value.
      - **Attribute ID:** identifies the **semantic of the associated attribute value.**
      - **Attribute value:** can be a integer, string, boolean, URL, etc

# Bluetooth – Profiles

- **Profiles:** It is collection of protocols and parameters that is used as a basis for interoperability.
- **Basic profiles:**
  - Generic access
  - Service discovery
  - Cordless telephony
  - Intercom
  - Dial-up networking
  - Fax
- **Additional profiles:**
  - Advanced audio distribution
  - Audio video remote control
- Each profile selects a **set of protocols: e.g RFCOMM, SDP, L2CAP**
- It defines **interoperability requirements, e.g RS232 control signals for RFCOMM or configuration options for L2CAP**