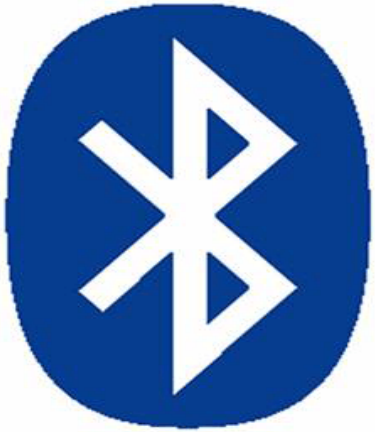


BLUETOOTH TECHNOLOGY

Prasan Kumar Sahoo

Outline of the talk

- Introduction
- Applications and Usages
- Bluetooth Network
- Technical Specifications
- Bluetooth Protocol Stack
- Research issues
- Our Routing Protocols
- Summary

Introduction to Bluetooth

Naming

Why its name is Bluetooth?

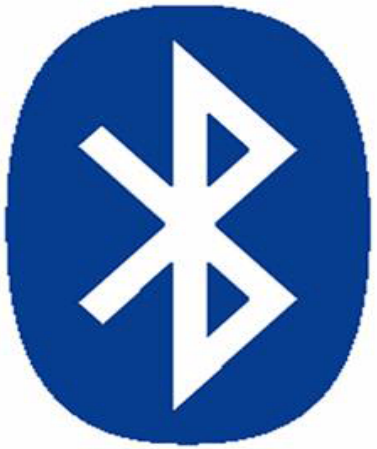
- In 10th Century, there was a Danish King:

  Harald Blatand

- He has united all the Scandinavian Countries

Naming

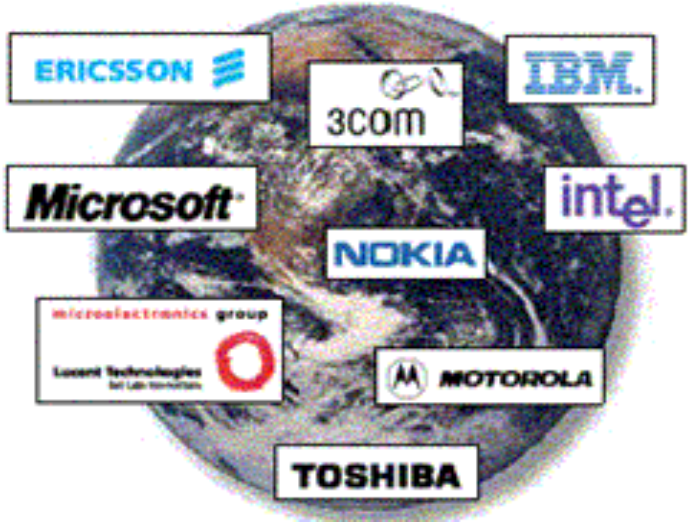
- Founders used the King’s name for the globalization of their technology
- Bluetooth logo, created by a Scandinavian company, is composed from the characters **"H"** and **"B"** which are Danish king's name initials.



History

- **1994:** ***Ericsson started the idea***
- **1998:** ***Special Interest Group (SIG) is formed with 5 companies***
- ***Founder Group:*** ***Ericsson, Nokia, Intel, Toshiba, IBM***
- **1999:** Another 5 Major Companies joined.
- ***Promoter Group:*** ***Lucent, 3 Com, Motorola, Microsoft***
- **2002:** SIG became an Independent group with more than 3000 companies. Office: Kansas, USA

History



- SIG released first Spec in 1999 (Spec 1.0)
- Latest Spec in 2005 (Spec 2.0)
- First retail product found in market: 2001

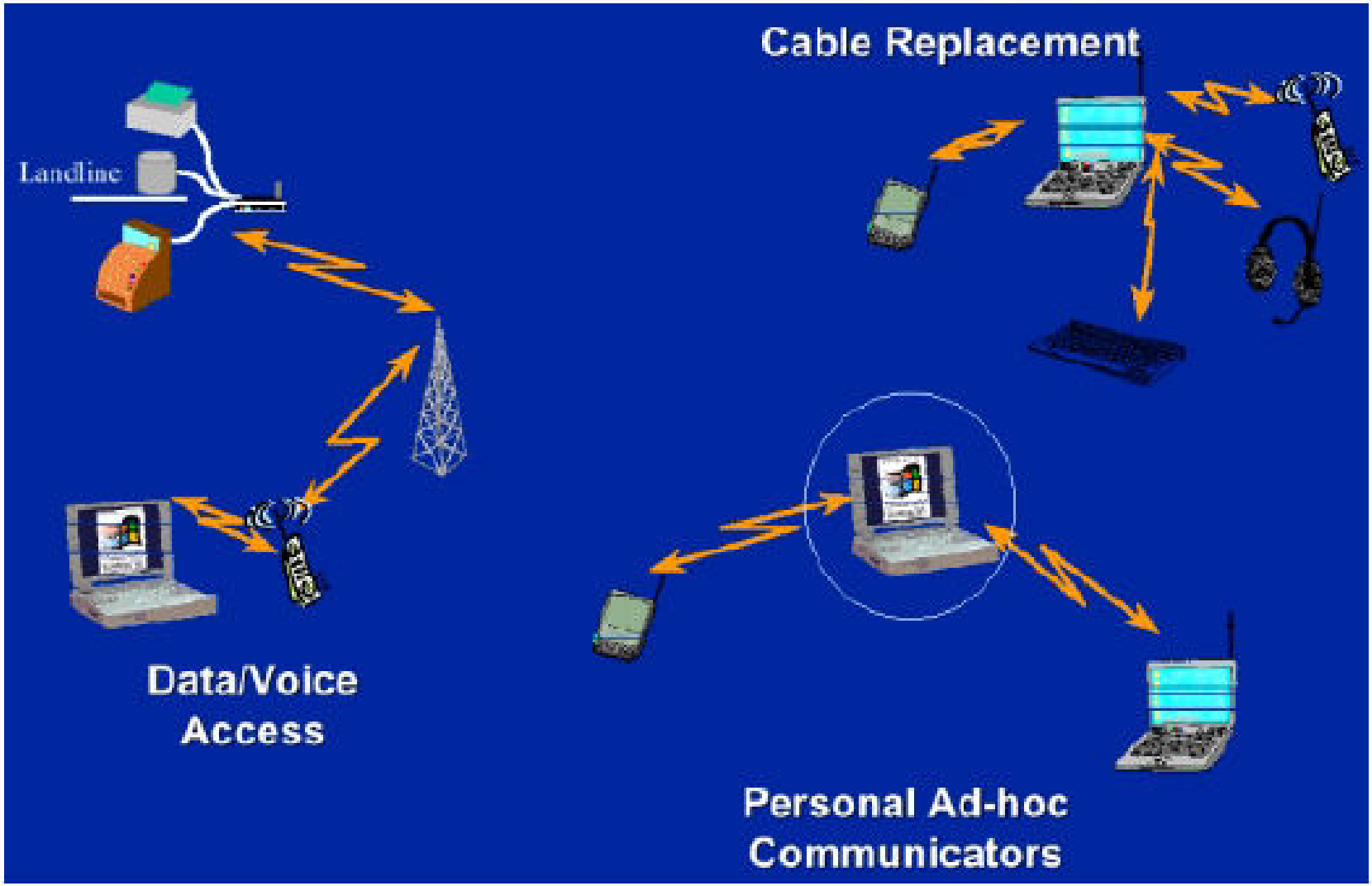
What is Bluetooth?

- It is a wireless, short range communication technology.
- Designed as a low cost, low power technology for all types of mobile devices.
- Used as a cable replacement among devices located within same area.
- Supports high data rate, voice and video transmission.

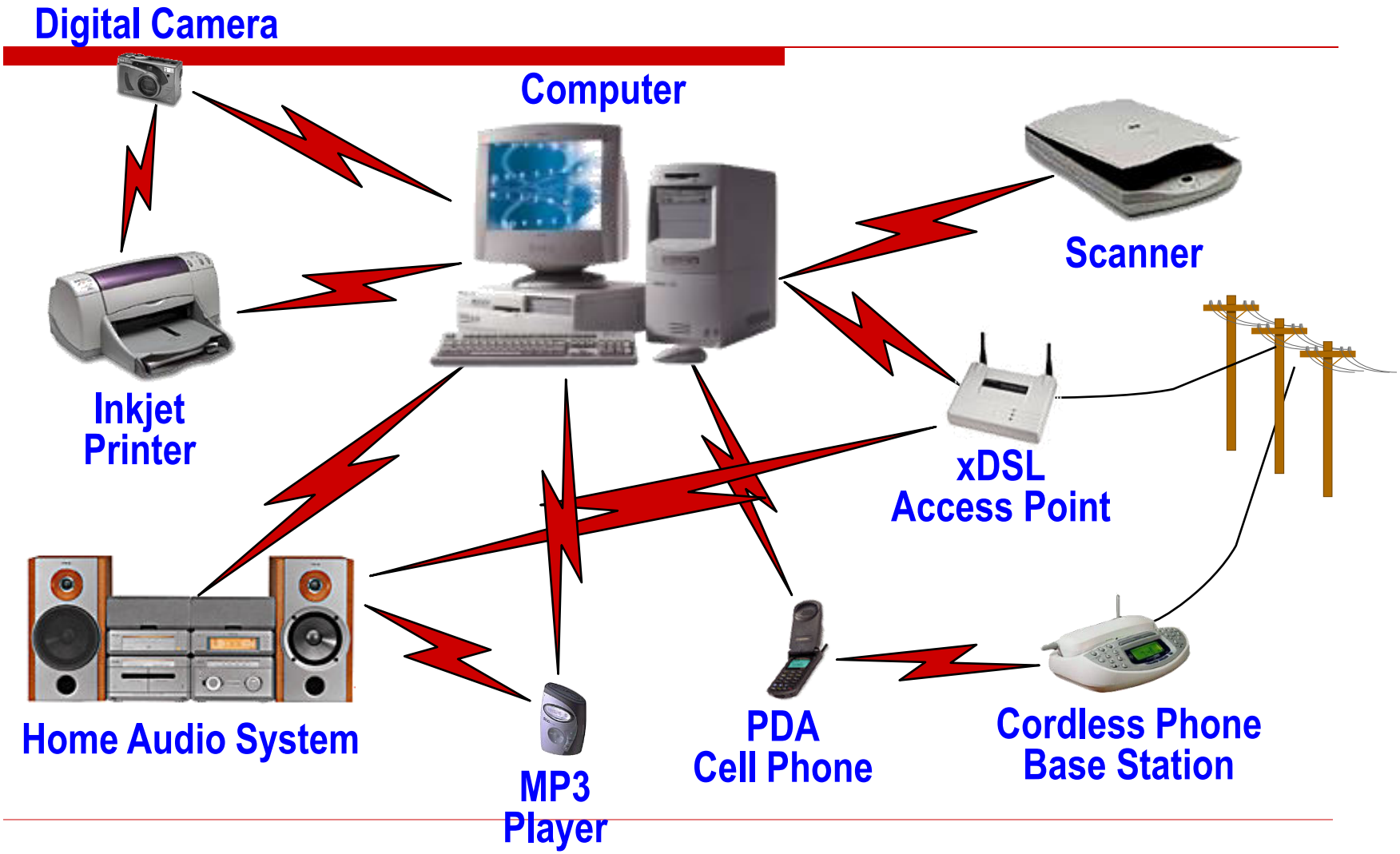
Applications and Usages

- **A cable replacement technology**
- **Range 10+ meters**

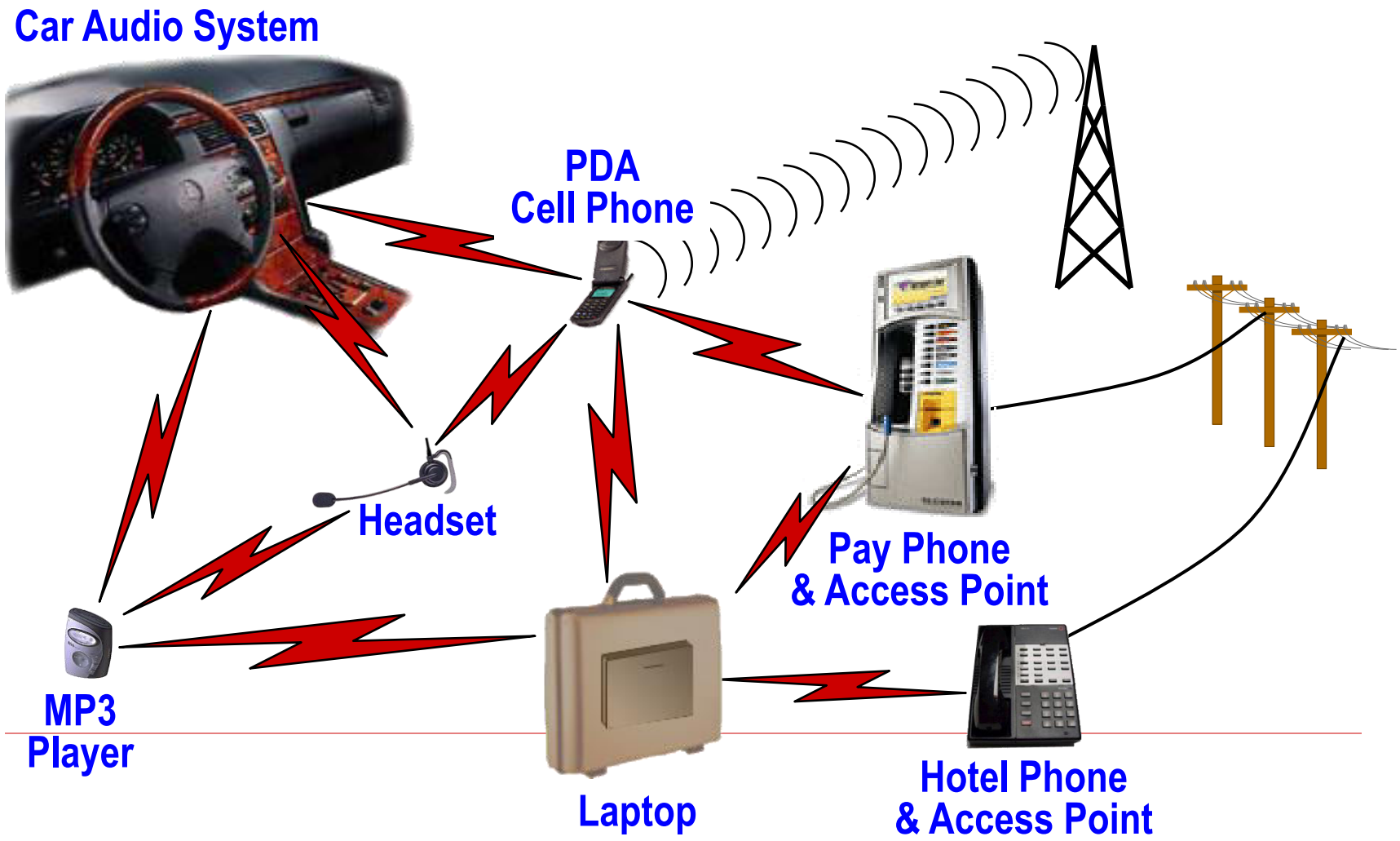
Bluetooth Concept



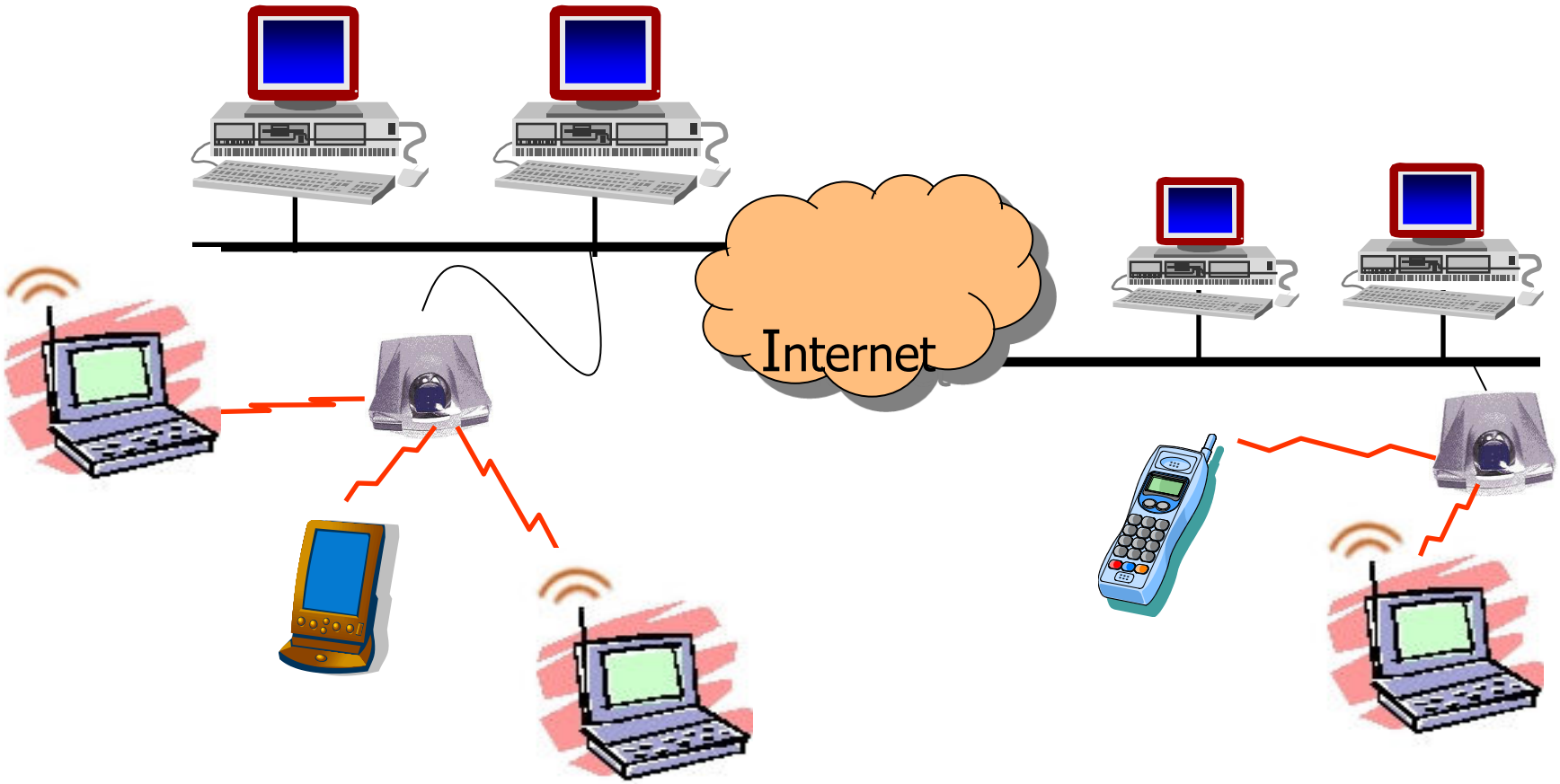
Home Network



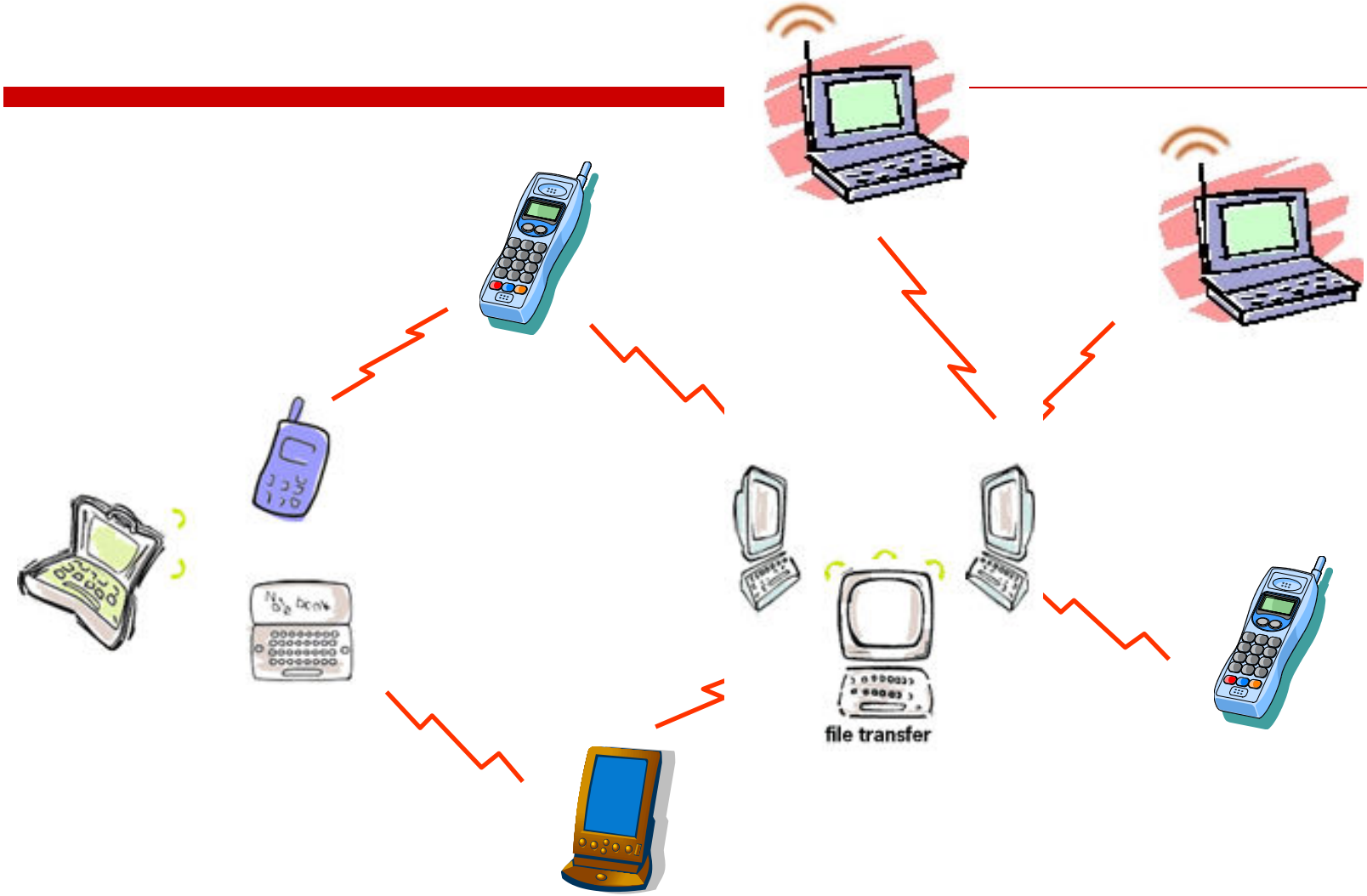
Car & Hotel Network



LAN Access Point



Ad-Hoc Network



Usage Models (1)

- Internet Bridge
  - Mobile browsing in the sofa, on the go, in the office, in the car

Usage Models (2)

- Instant Postcard
  - Send instant postcards and videoclips

Usage Models (3)

- Ultimate Headset
  - Keep your hands free

Usage Models (4)

- Briefcase Trick
  - Laptop in briefcase

    E-mail alert through phone, browse E-mails in phone
  - Phone off

    Answer mail on laptop and send mail from phone or laptop at arrival

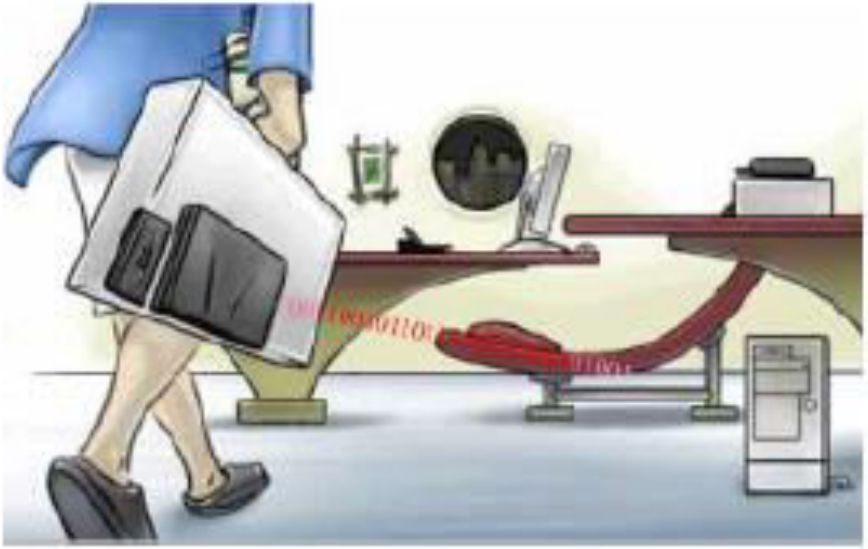
Usage Models (5)

- Synchronizer
  - Background synchronization

    PDAs

    Cellular phones

    Notebooks



Usage Models (6)

- Wireless Workspace
  - Wirelessly connected computer peripherals

Usage Models (7)

- Conference Table
  - Share and exchange data in the meeting room

Usage Models (8)

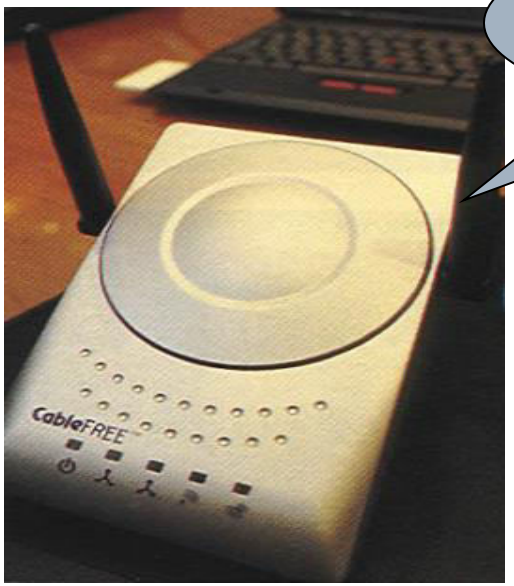
- Three in One Phone
  - One phone three functions
    - Intercom
    - Cordless
    - Cellular

Bluetooth Products

- Blue-Dongle
- Blue-Connect
- BluePort
- Bluetooth printer
- Bluetooth Modem

Current Products

Access point (AP)



Line connects to Internet

Mobile Device

Current Products

Blue-Dongle

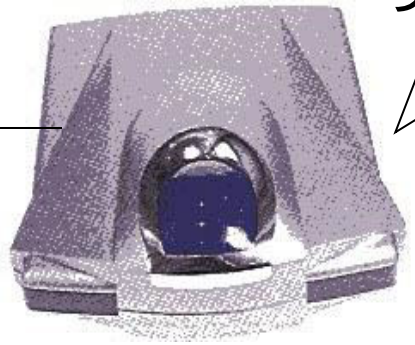
藍芽連接卡<Blue-Connect>

Current Products

電話線、乙太網
路
寬頻網路、ADSL

藍芽上網家

<BluePort>



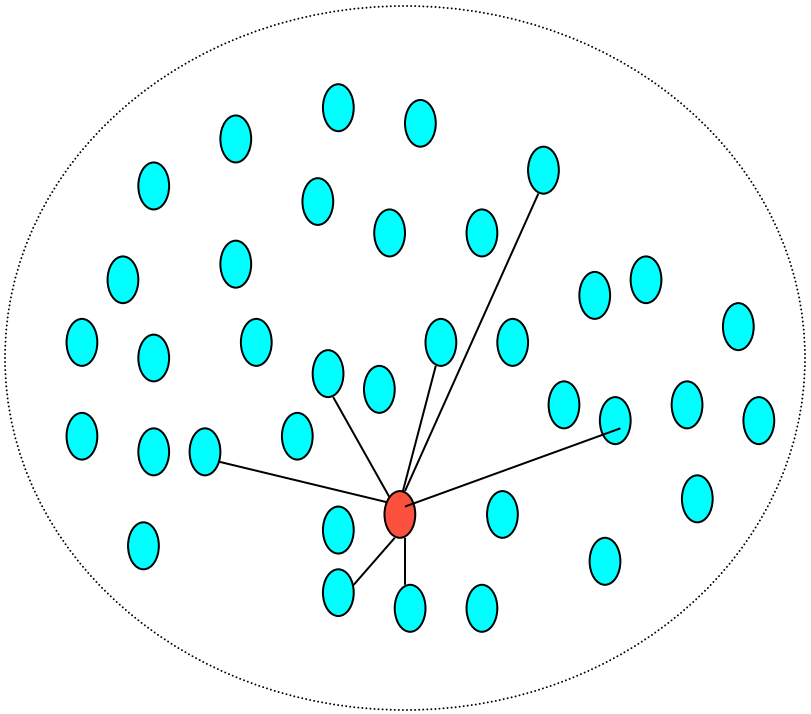
Bluetooth Network

- Two parts: **Piconet** & **Scatternet**
- Piconet: 1 Master can connect to 7 active slaves simultaneously.
- 7 active slaves
- 256 parked slaves [power saving mode].
- Master controls the slaves in the piconet.

Master-Slave

- **Who is a Master in Bluetooth?**
  - **Any node who starts the Connection Procedure is the Master**
  - **Master goes to Inquiry State**
- **Who is a Slave in Bluetooth?**
  - **Any node who responds to the Master is a Slave**
  - **Slave goes to Inquiry Scan State**

A Piconet



Up to **256** slaves/piconet
Max **7** slaves with active state/piconet

Communication in a piconet

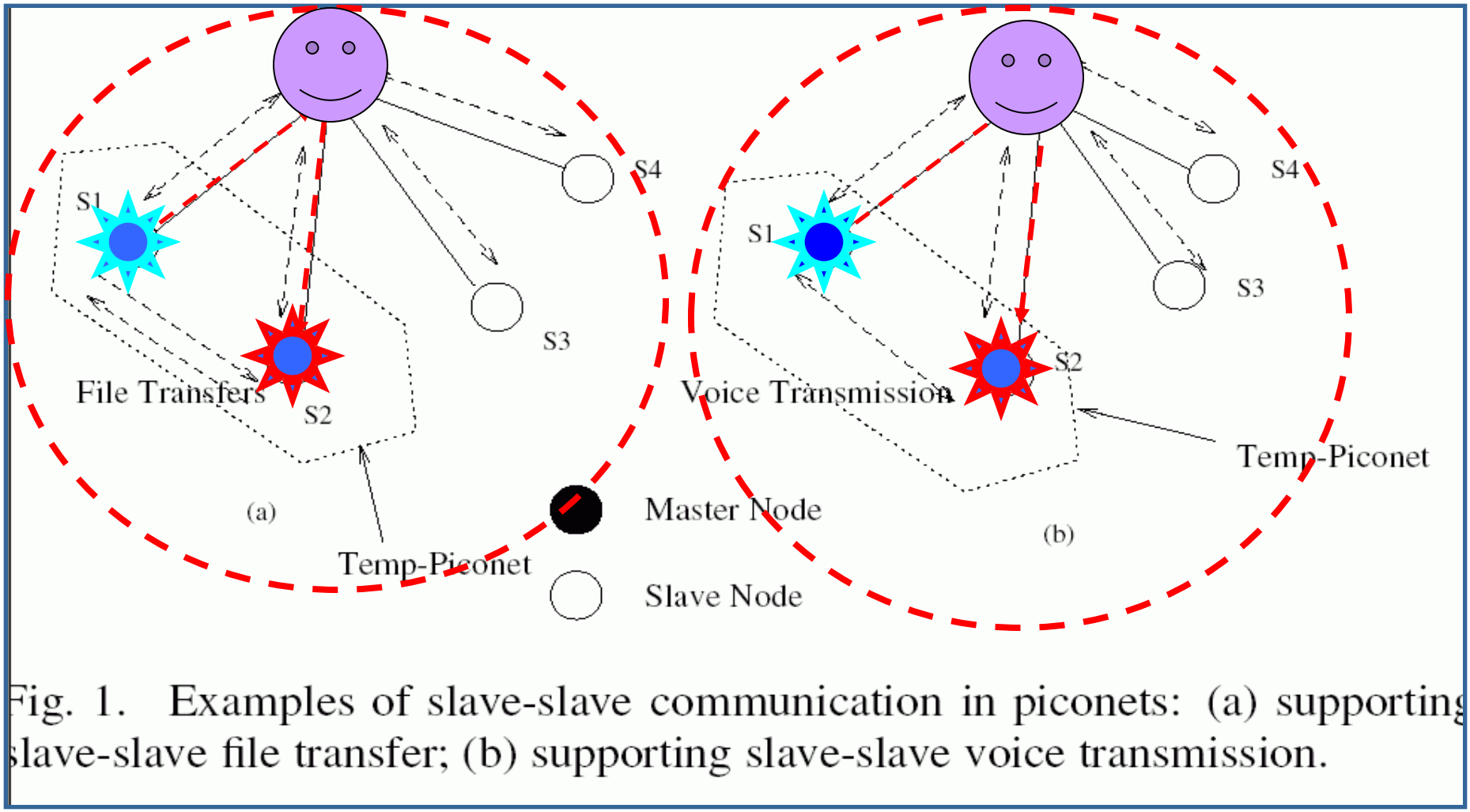
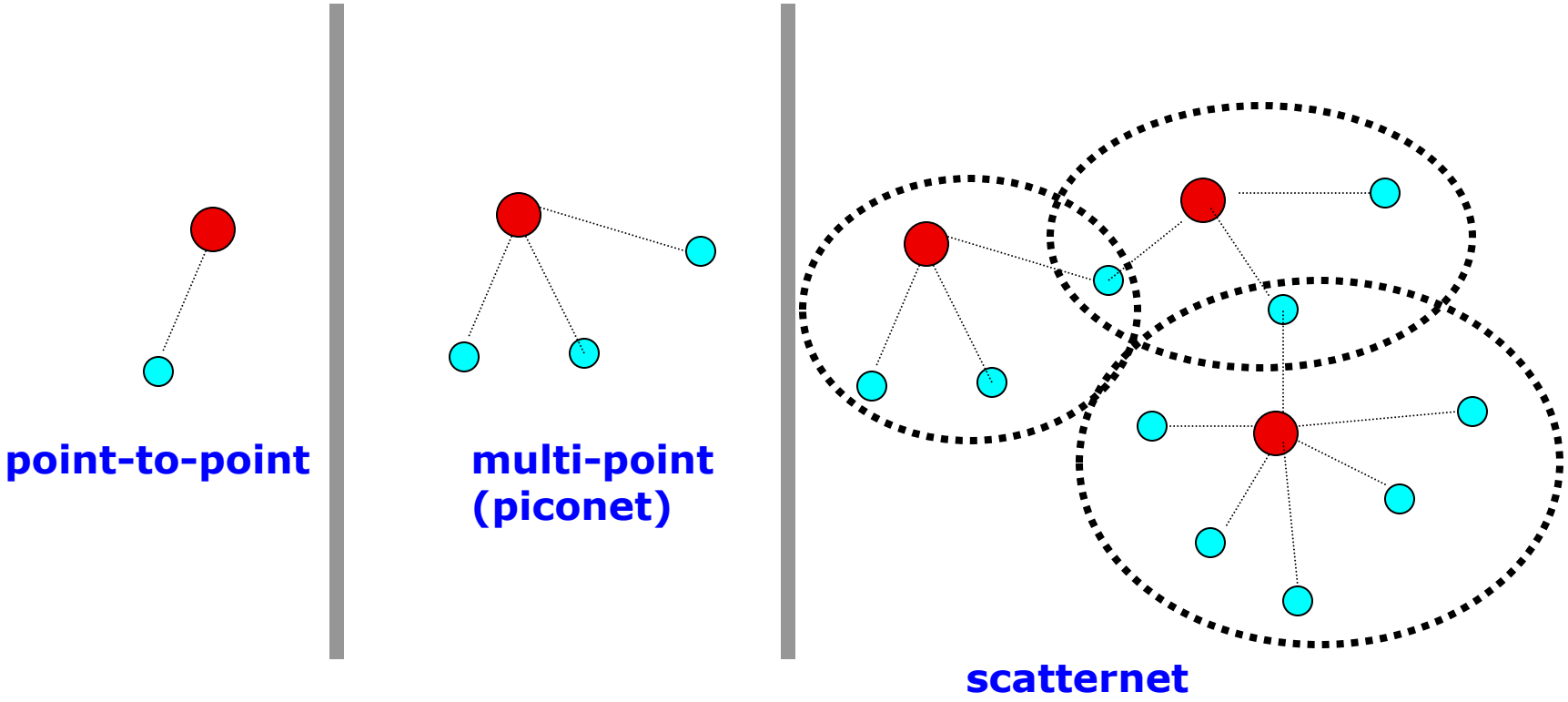


Fig. 1. Examples of slave-slave communication in piconets: (a) supporting slave-slave file transfer; (b) supporting slave-slave voice transmission.

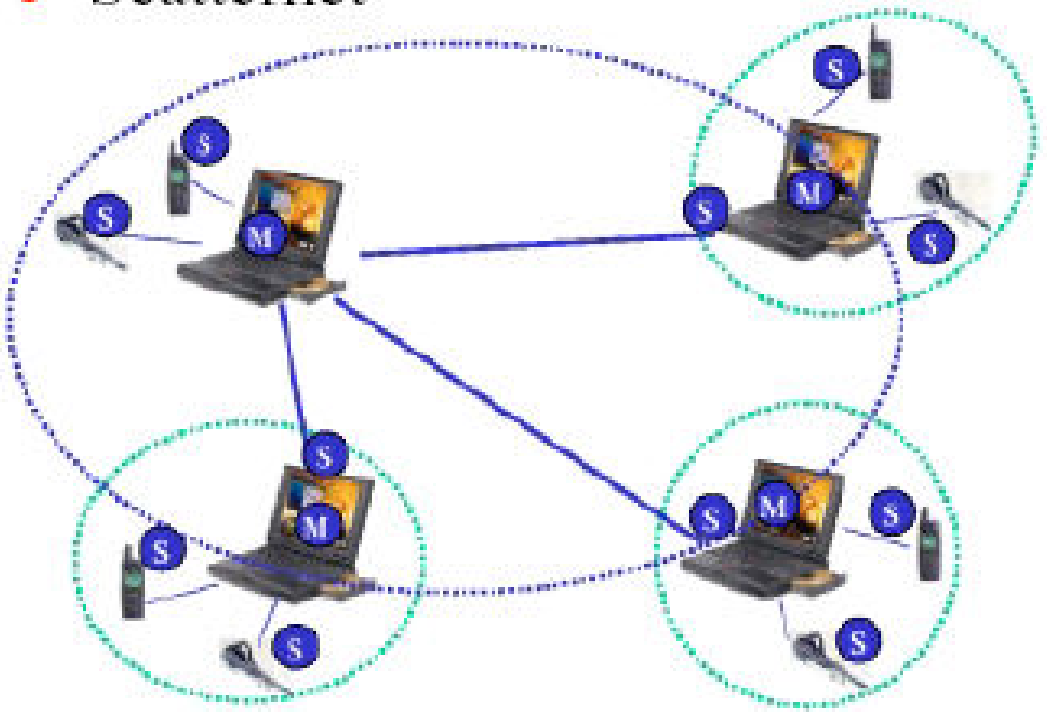
A Scatternet

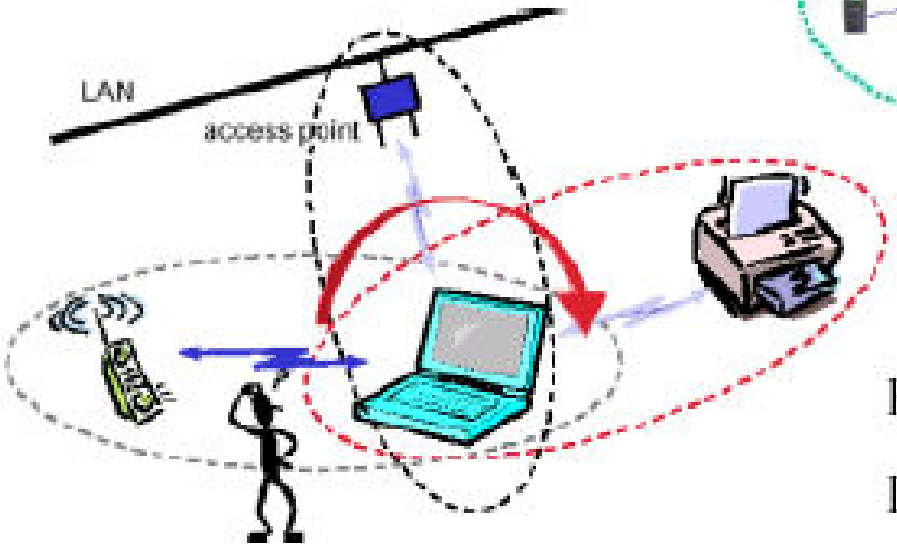


Bluetooth Network

- Piconet

- Scatternet





How to jump efficiently between piconets?

Delay sensitive applications?

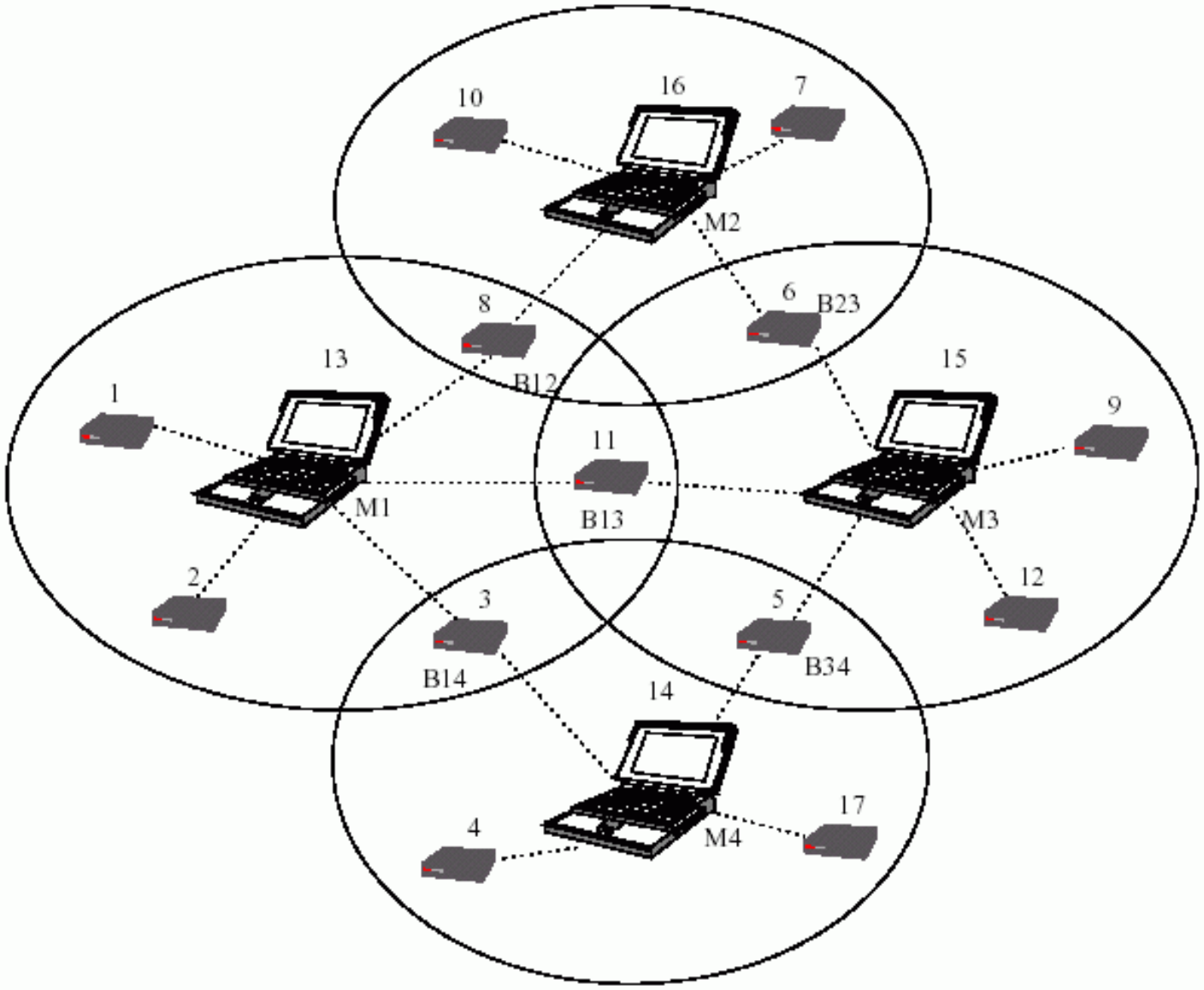


Fig. 1. An example of a Bluetooth scatternet with four piconets.

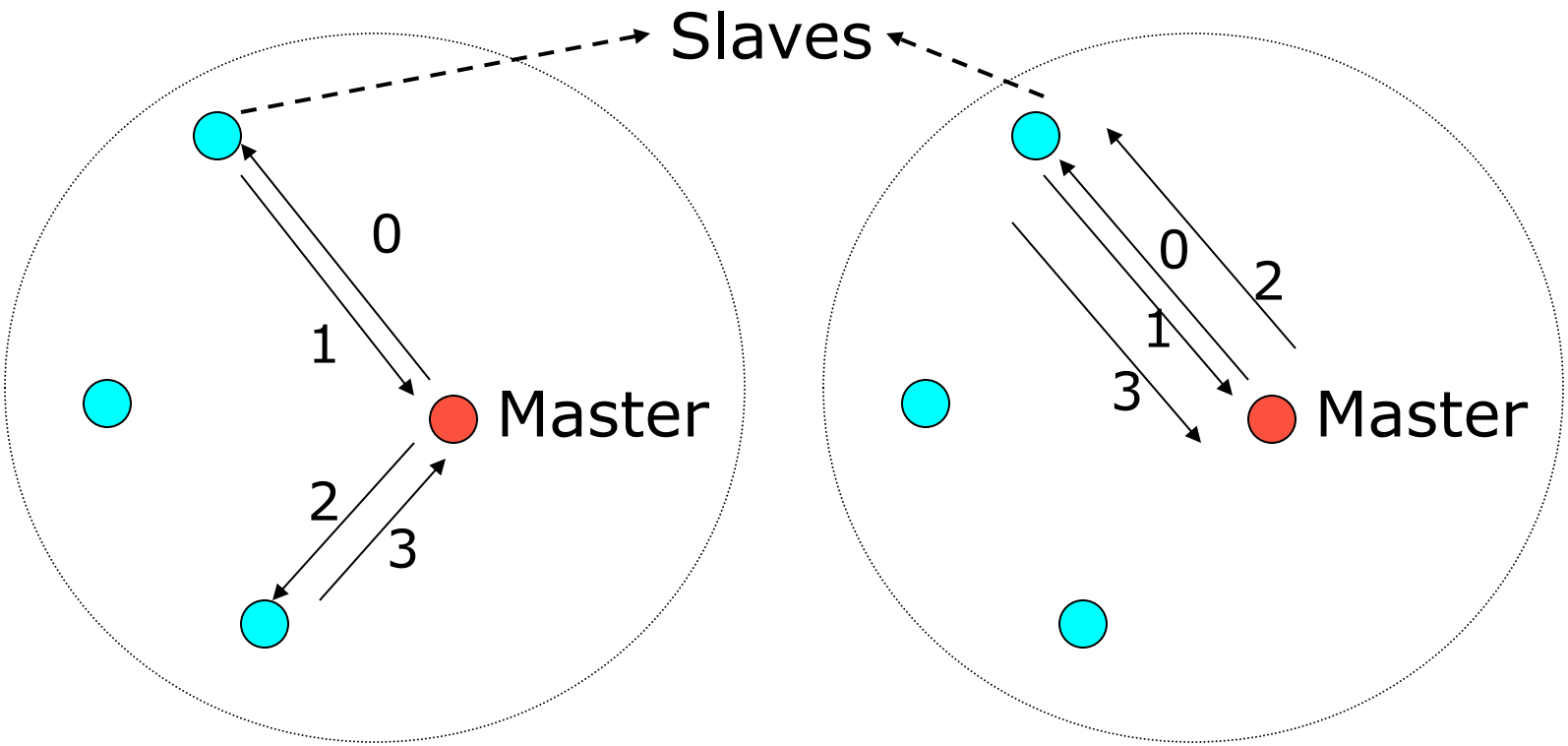
Technical Specifications

- Uses **2.4Ghz ISM unlicensed band** for communication.
- Uses **79 channels** to hop.
- Each device hops **1600 times/sec**
- Hop Rate = 0.000625 sec = **625µsec**
- This duration is called **ONE SLOT**.
- Packets are **1, 3 or 5 slots** long
- Frame consists of **two** packets
- Uses **Spread Spectrum Frequency Hopping (FHSS)** radio

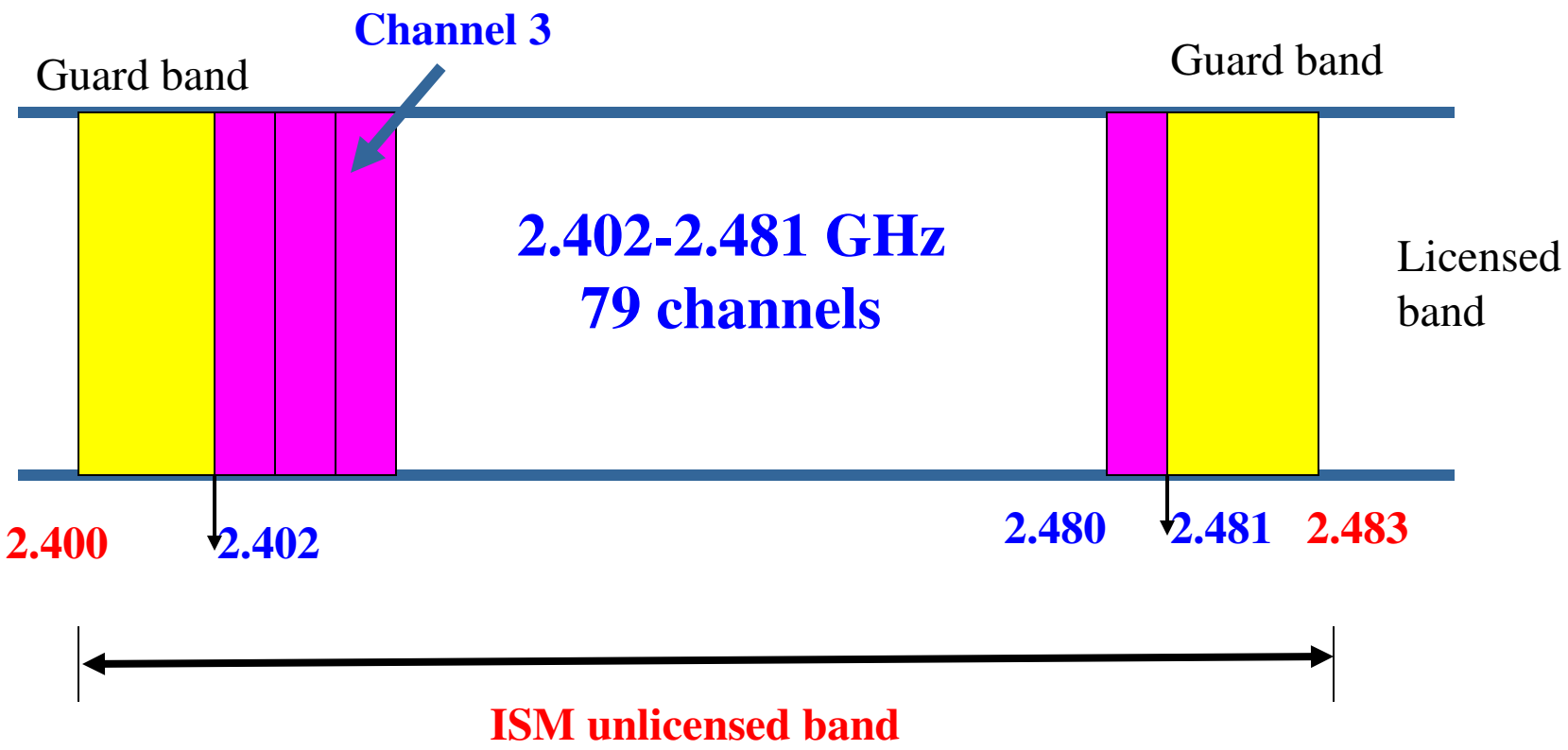
Technical Specifications

- Data rate: 1Mhz
  - Symbol rate: 1M bps
  - Data rate: 721Kbps excluding header [Data]
- Uses Time Division Duplex **(TDD)** technique.
  - Time is divided into 625ms(1 time slot)
  - Master sends packet to its slaves in the **Even** time slot
  - Slave sends packet to its Master in **ODD** time slot
- Uses 3 Power classes.
- **Communication Range: 10 m, can be extended to 100 m.**

Master/slave Communication

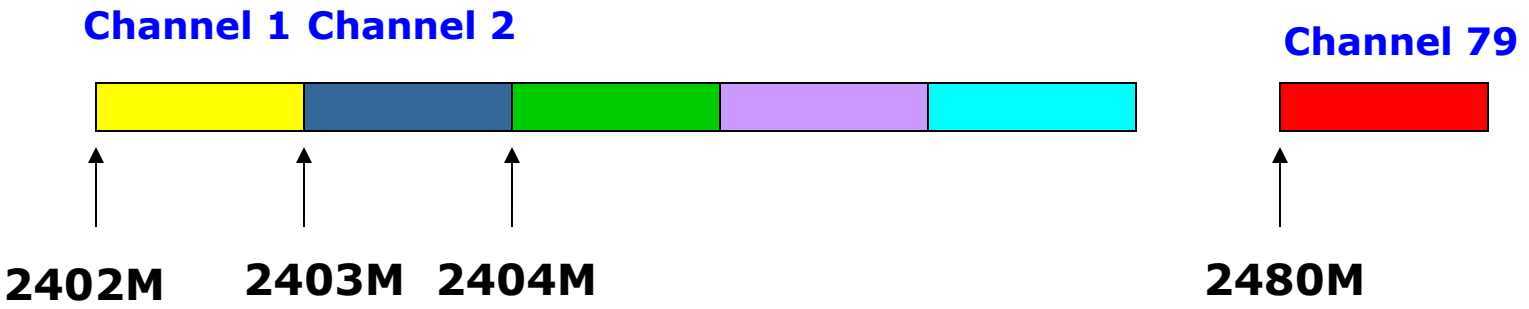


Bandwidth Management



Bandwidth Management

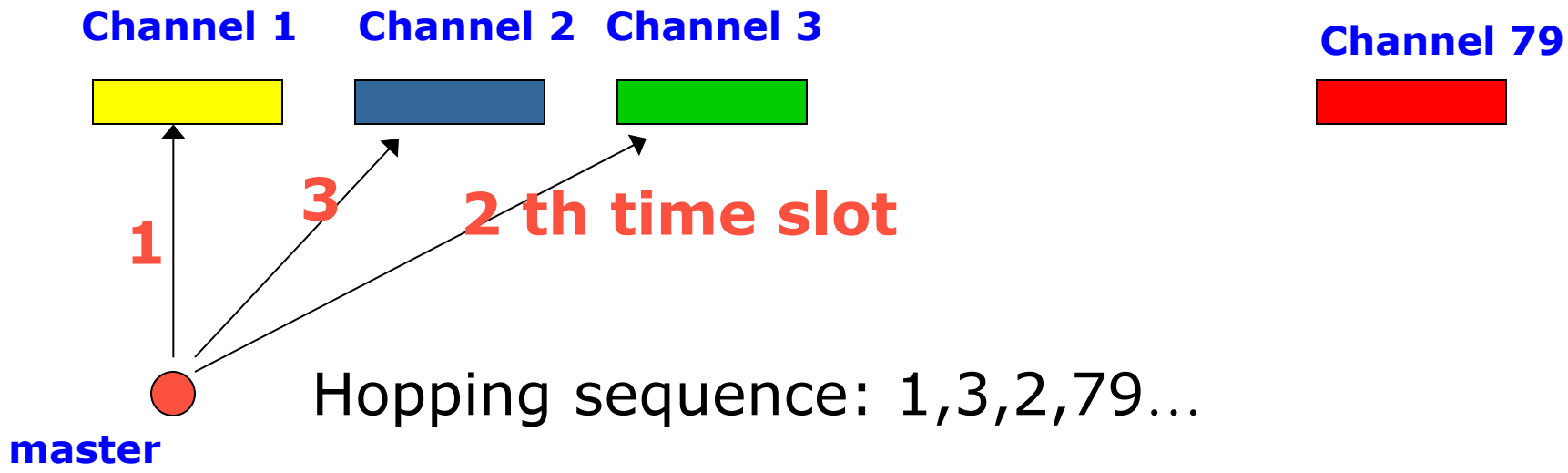
- 2.4GHz ISM band
  - **2402-2483 M Hz**
  - **In total, 79 channels are scheduled**
  - **Each channel occupies 1M Hz**
  - **Bandwidth: 1M bps**



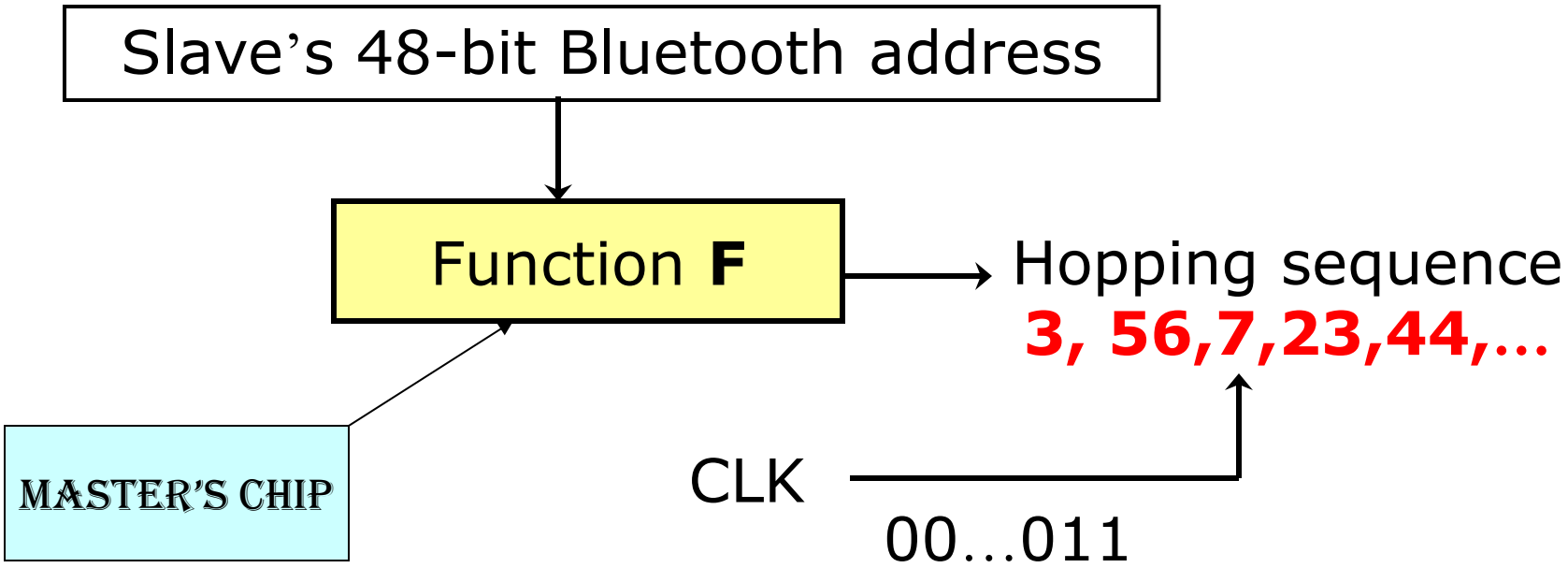
2.4G ISM band

Frequency hopping

- Master hops 1600/s➔ 0.625ms/hop
- Master hops to another channel according to its hopping sequence



Hopping Sequence Generation



Master-Slave Connection

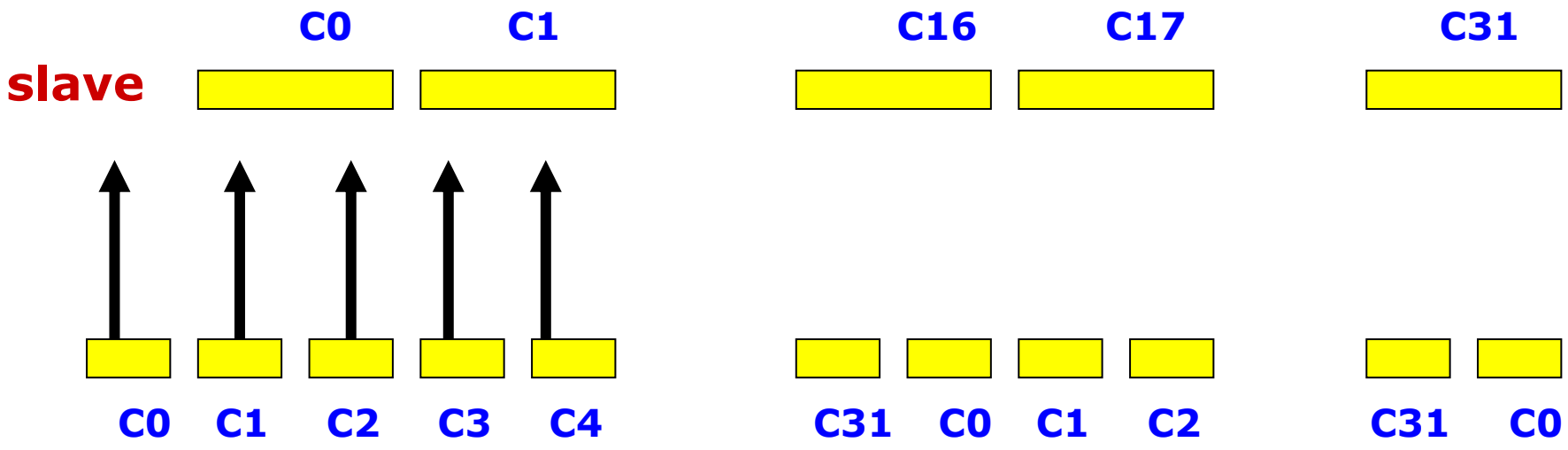
- **How connection is established between the master and slaves?**
- **Two phases:**
  - Before Connection
  - After Connection
- **Before Connection:**
  - **Inquiry/Inquiry Scan state**
  - **Page/Page Scan state**
- **After Connection:**
  - **Active mode**
  - **Hold mode**
  - **Sniff mode**
  - **Park mode**

Master-Slave Connection

- Before connection between Master and Slave:
- Master uses 32 channels to hop.
  - Master hops in each **312.5 µsec**.
  - It hops 2 times within a single slot in the same channel.
- Slave also uses 32 channels to hop.
  - Slave hops in each 625 µsec.
  - It hops 1 time within a single slot in the same channel.

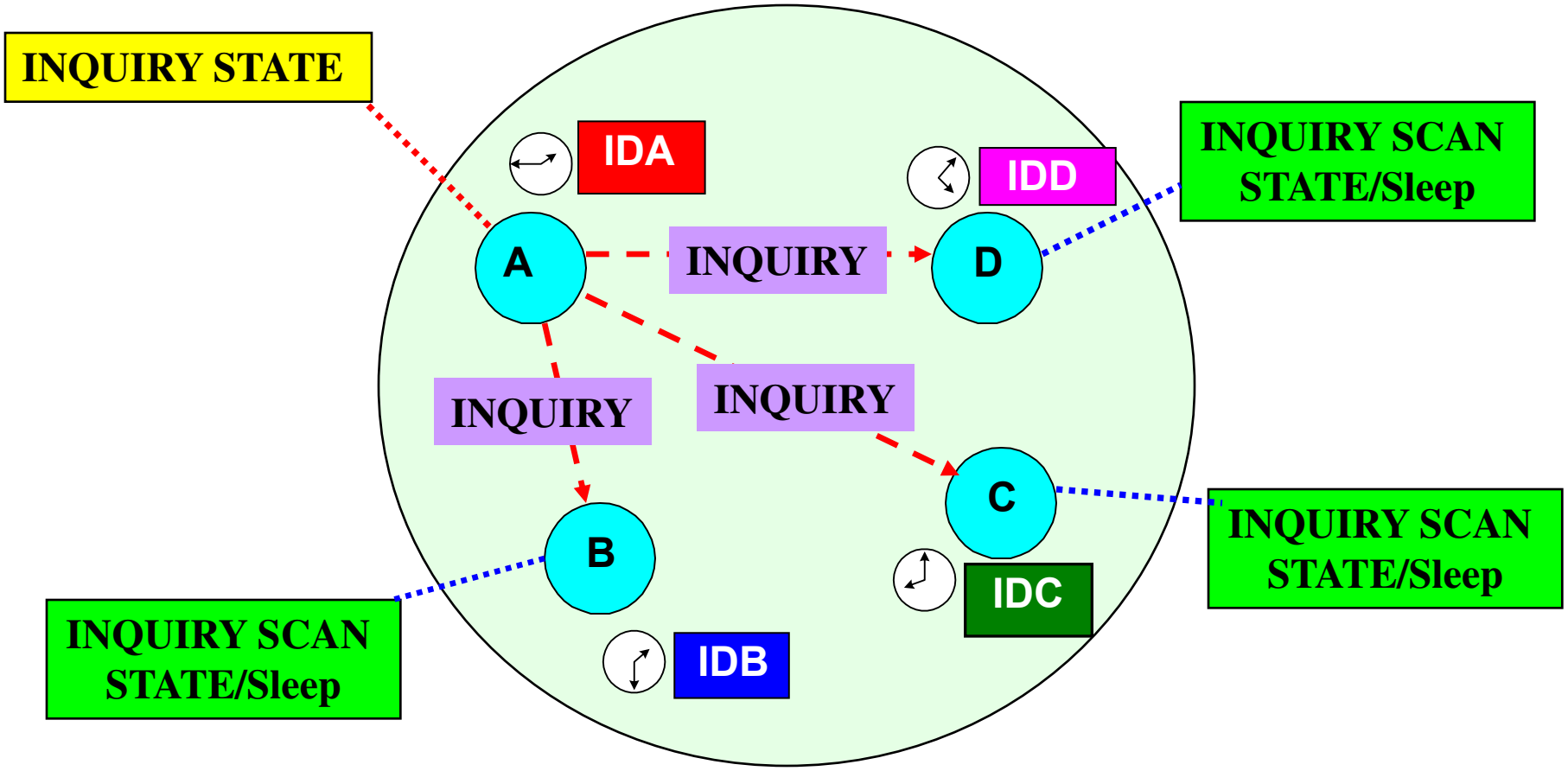
Master-Slave Connection

Inquiry scan mode



master Inquiry mode

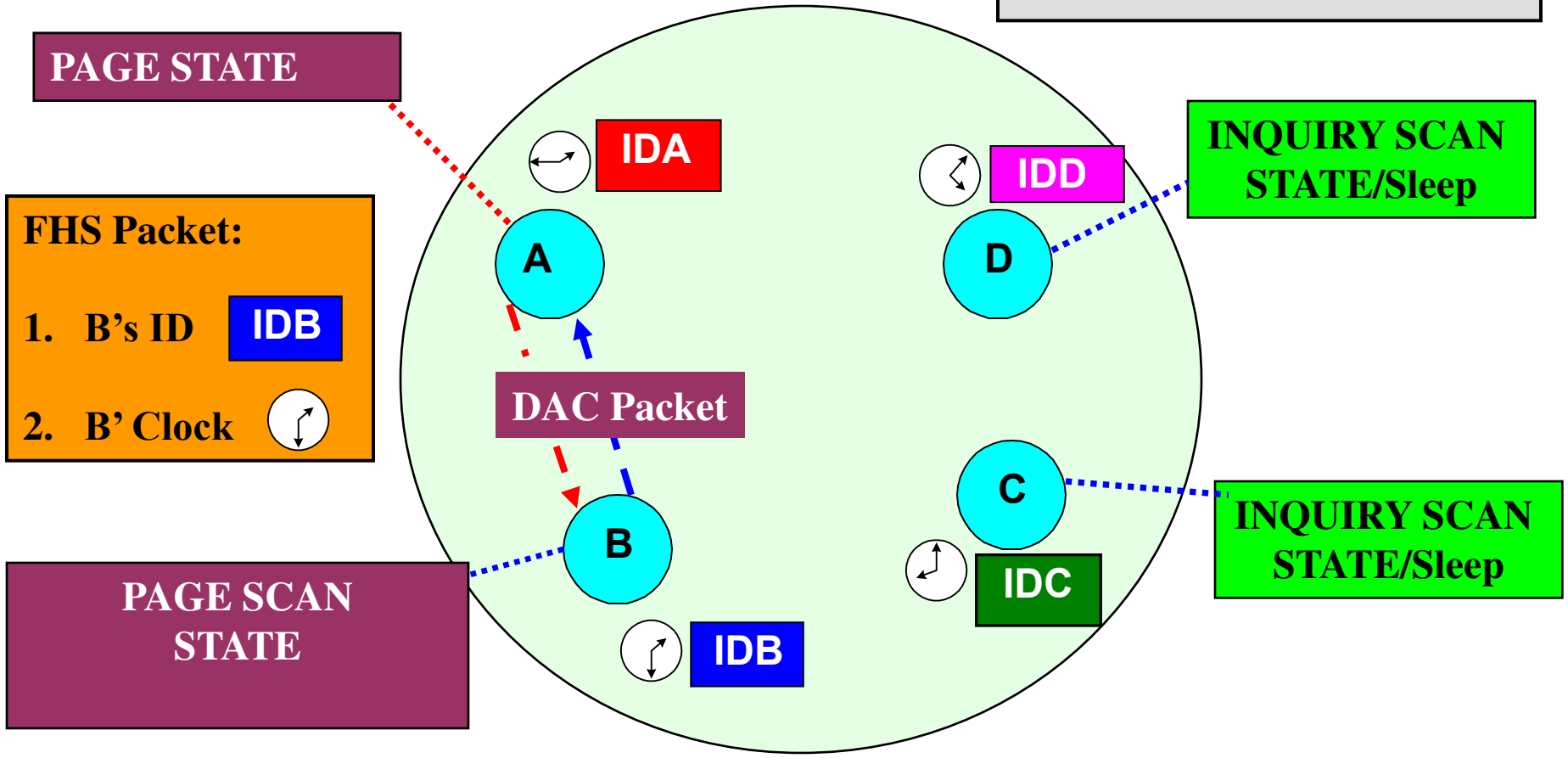
Master-Slave Connection



Master-Slave Connection

DAC Packet:

1. A's ID — IDA
2. A' Clock
3. Active Member Address

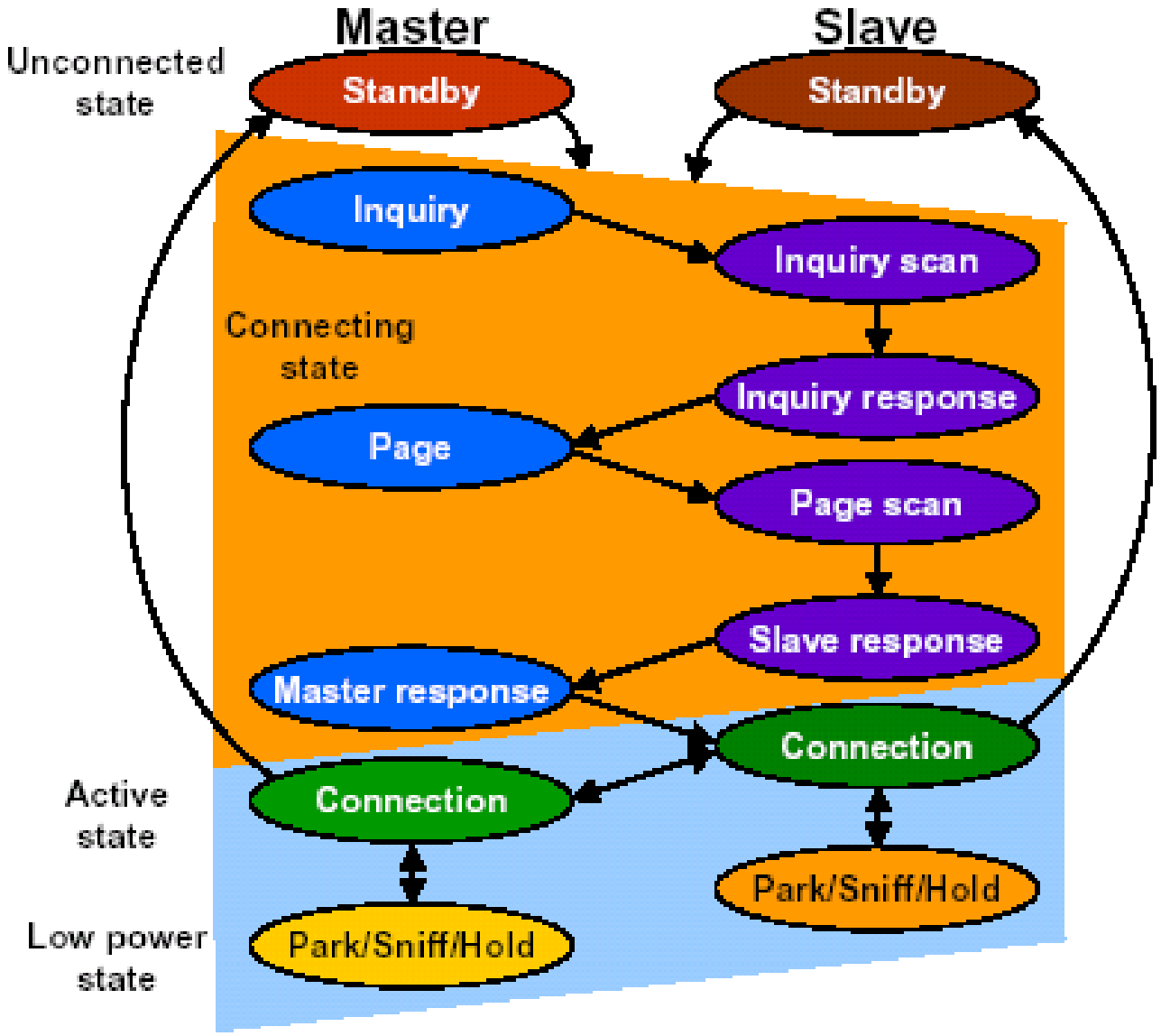


Addressing

- ***What is ACTIVE MEMBER ADDRESS:***
- It is 3-bit address given by a Master to each slave
- AMA address: 000 for broadcasting use
- 001-111 for 7 active slaves
- ***What is ID here:***
- ID is the Bluetooth Device Address
- It is always 48-bit

Slave
001
Slave
101
Slave
011
Slave
110
Broadcast
000
Slave
010
Slave
100
Slave
111
Active Member Address

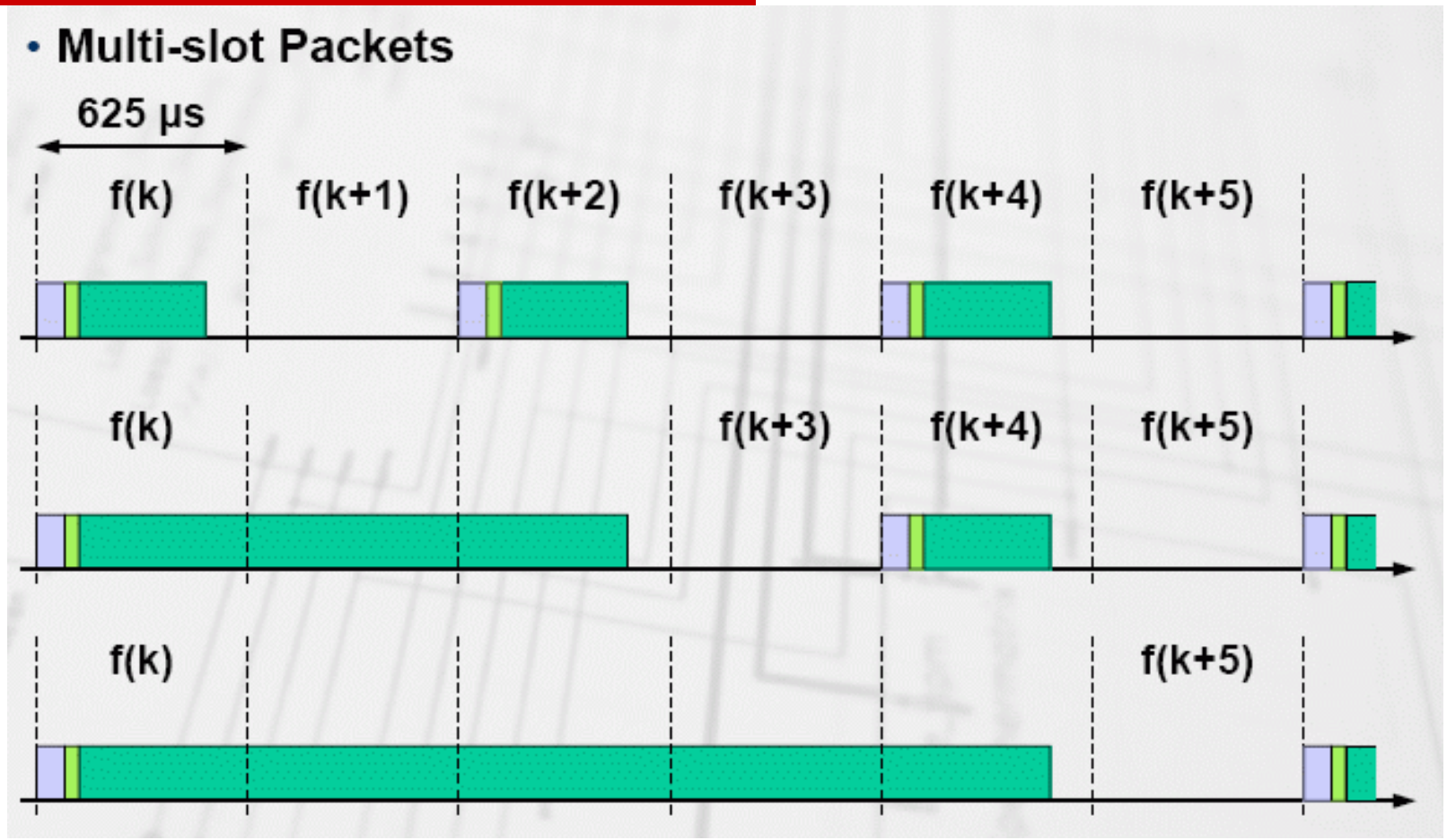
Connection Procedure (2)



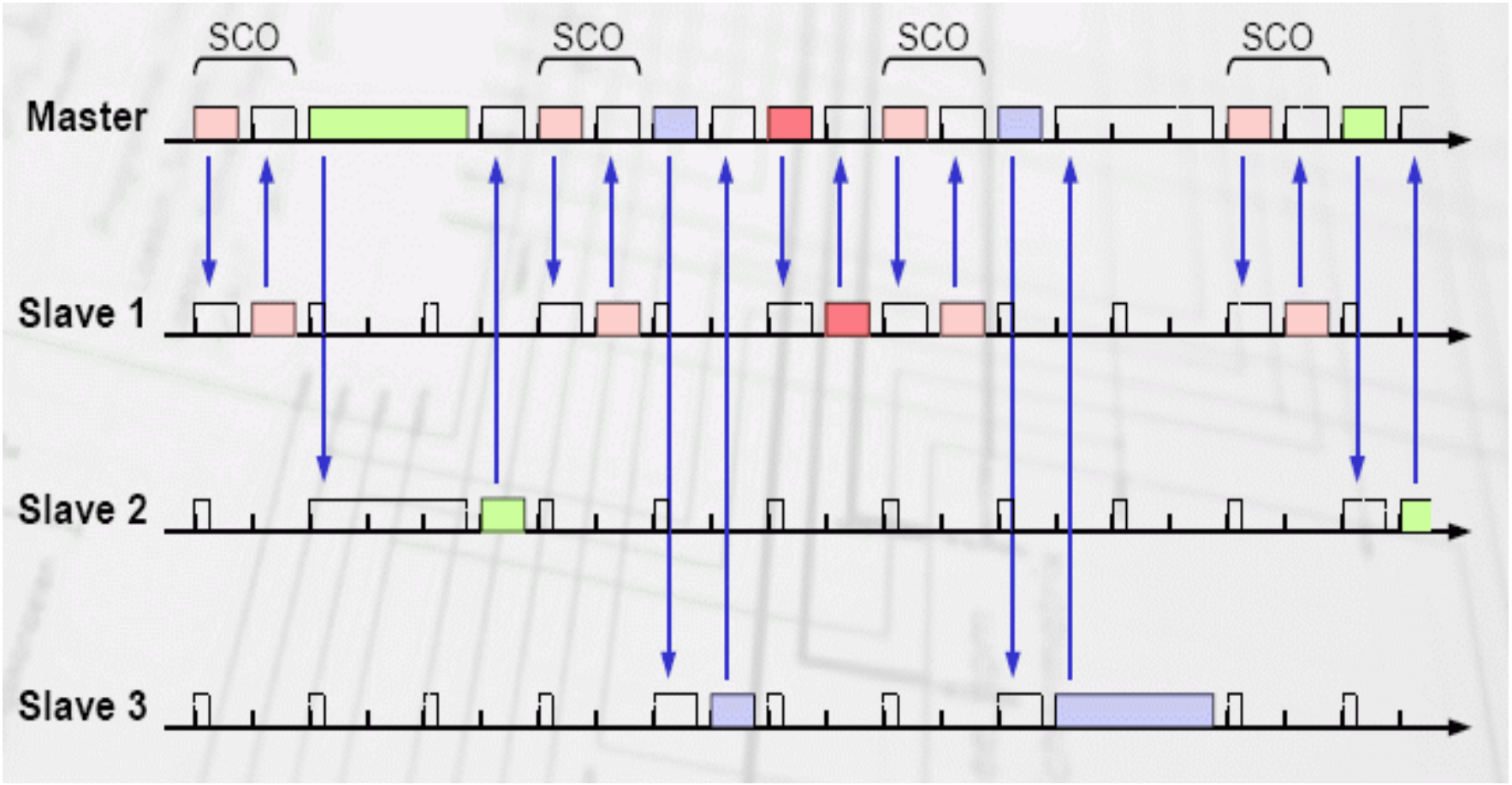
Post Connection Phase

- After connection of master and slave:
  - Piconet is constructed
  - All slaves follow the master's hopping sequence
  - Supports both **voice (SCO)** and **data (ACL)** transmission.
  - Three possible power saving modes for each slaves:
    - **Hold mode**
    - **Sniff mode**
    - **Park mode**

Multi-slot Packets

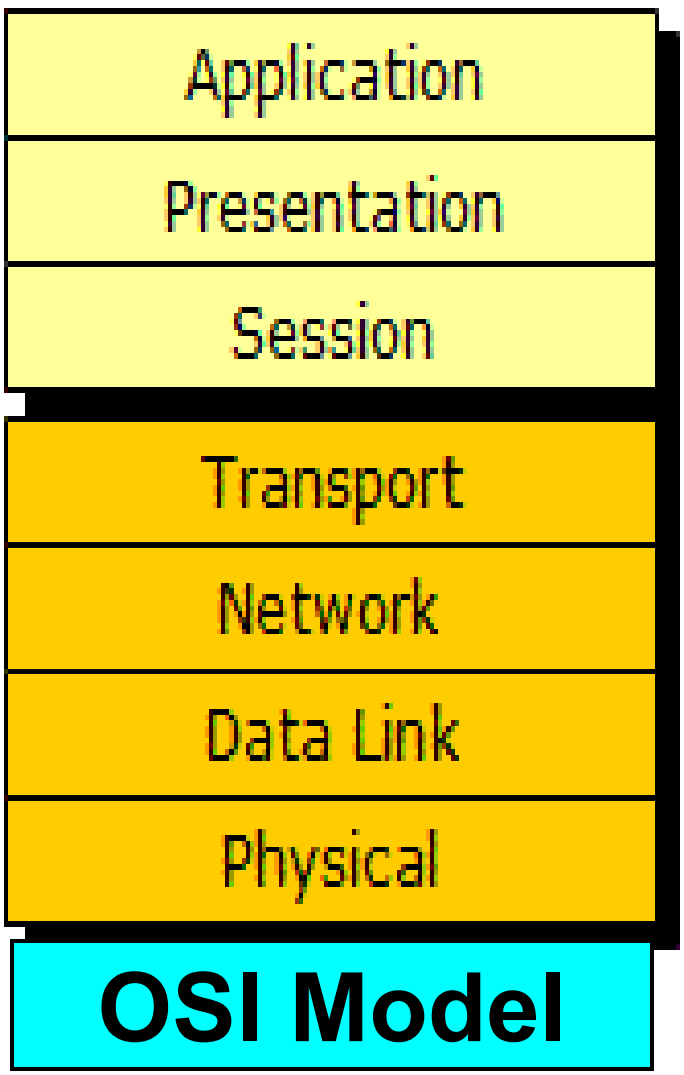


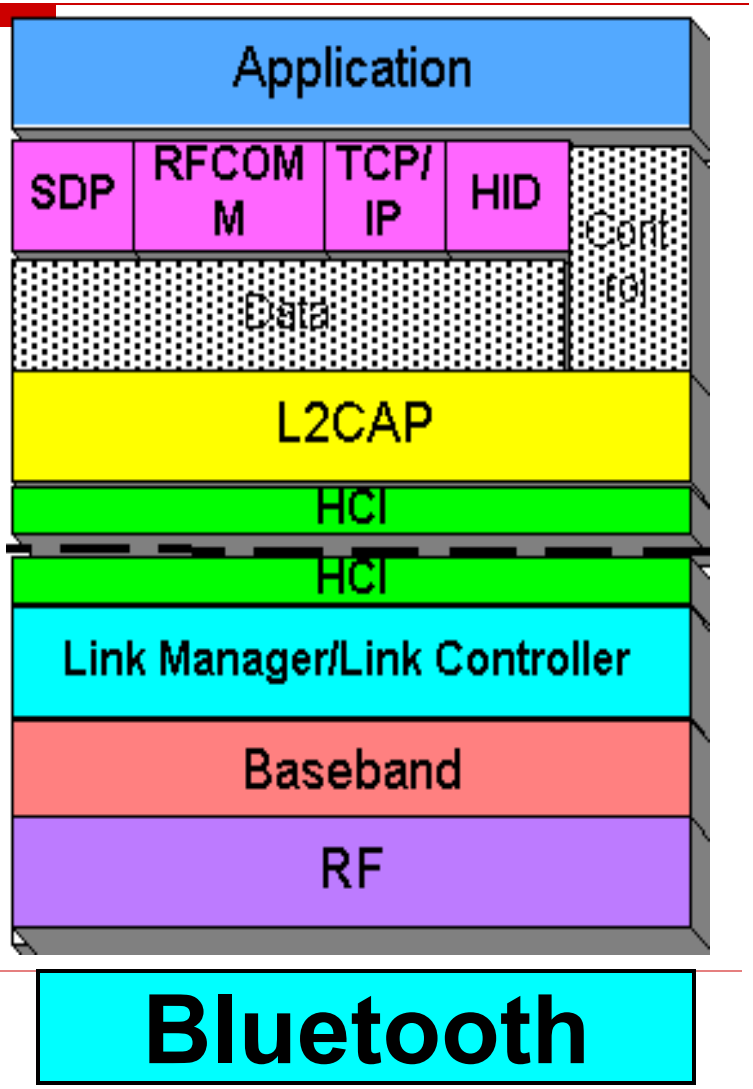
Master-Slave Communication



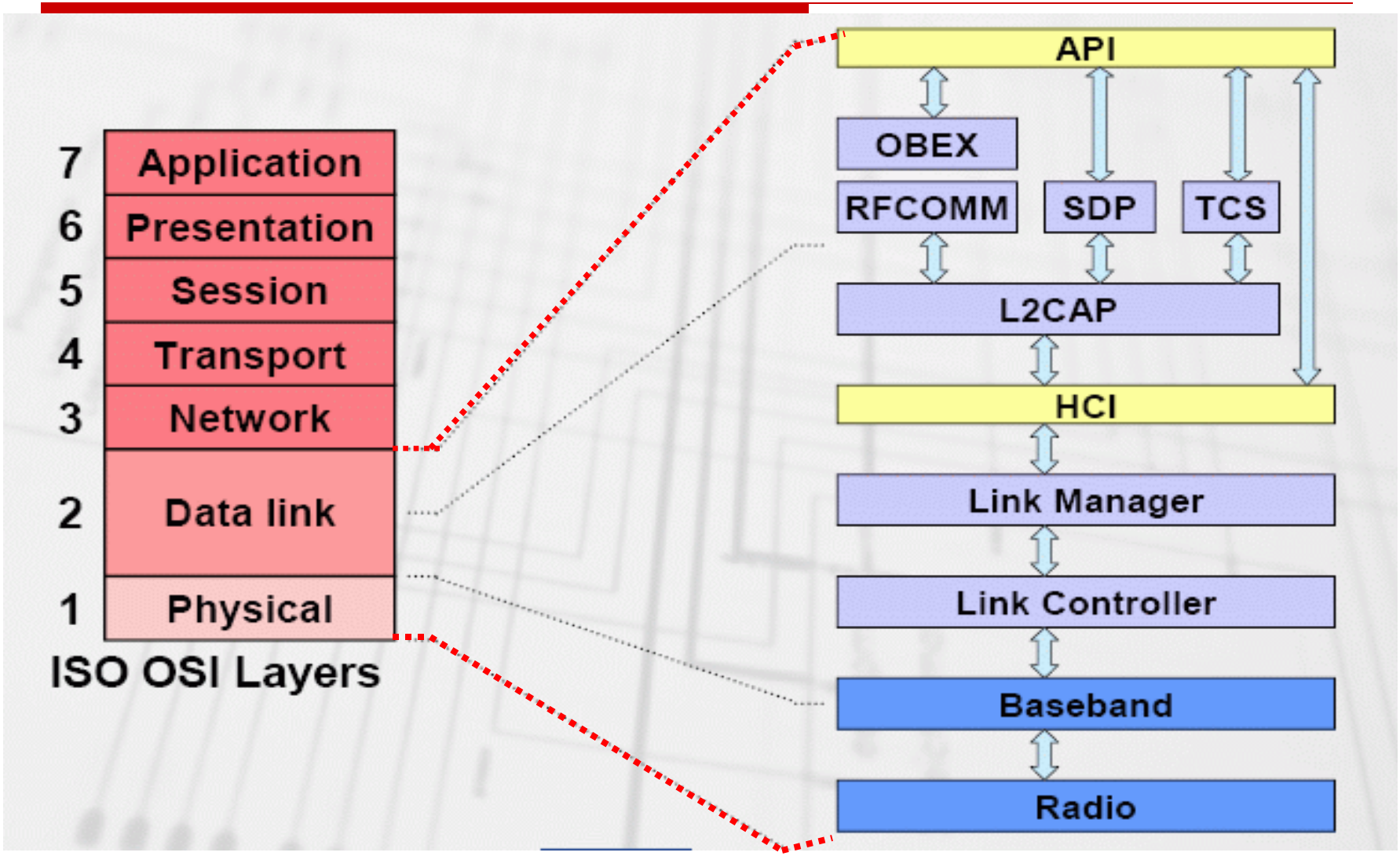
SCO-1 **SCO-2** **SCO-3**

Bluetooth Protocol Stack

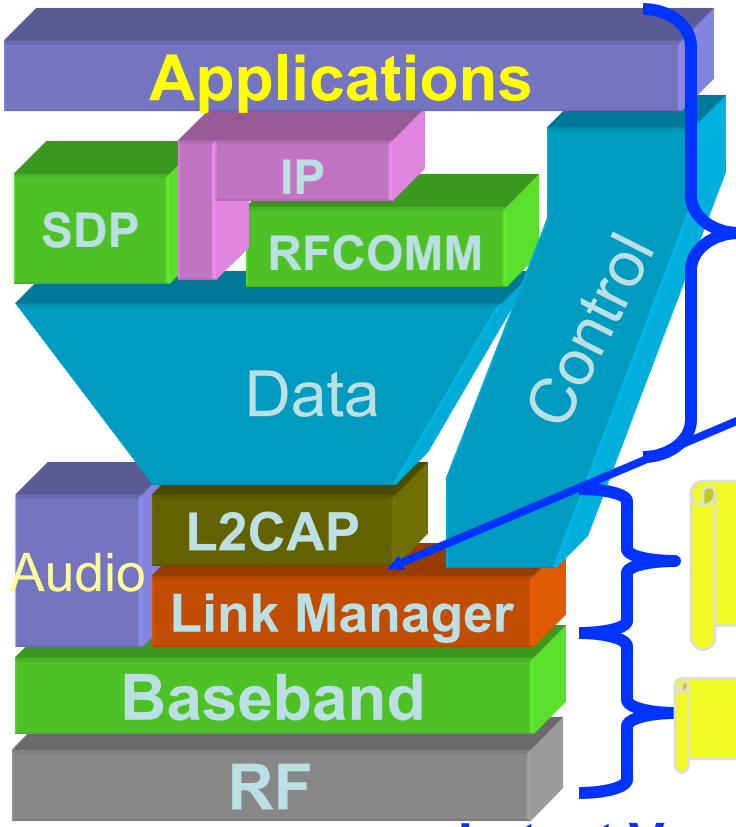




OSI vs Bluetooth Protocol Stack



Protocol Stack



Application Framework and Support

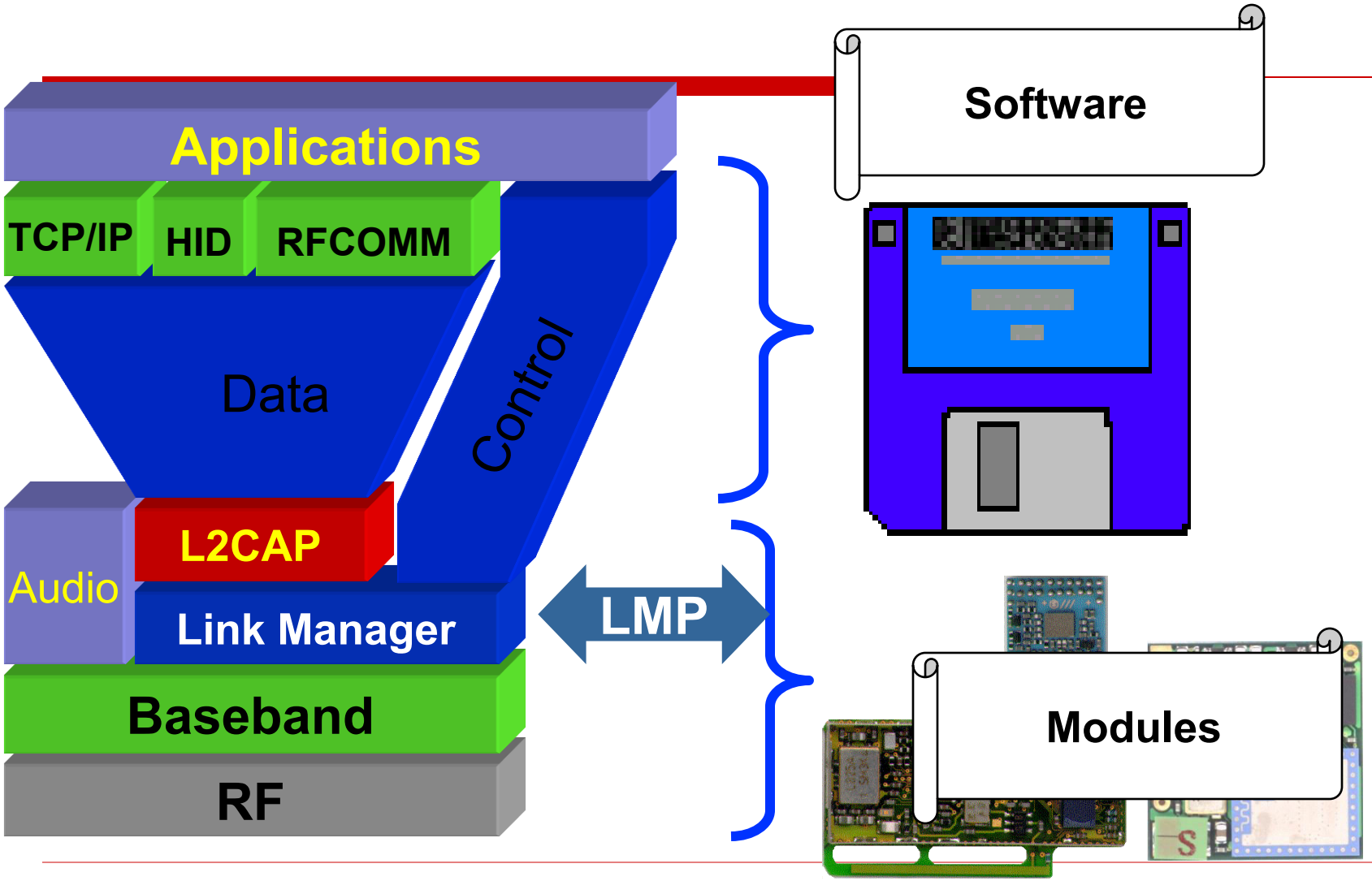
Host Controller Interface

Link Manager and L2CAP

Radio & Baseband

Latest Version on Bluetooth Website: www.Bluetooth.com

Protocol Stack



Research Issues

- Most of the research issues lie in Scatternet.
- Research Areas:
- Topology Construction
- Scheduling
- Routing
- Energy consumption
- QoS
- Security

Research Issues

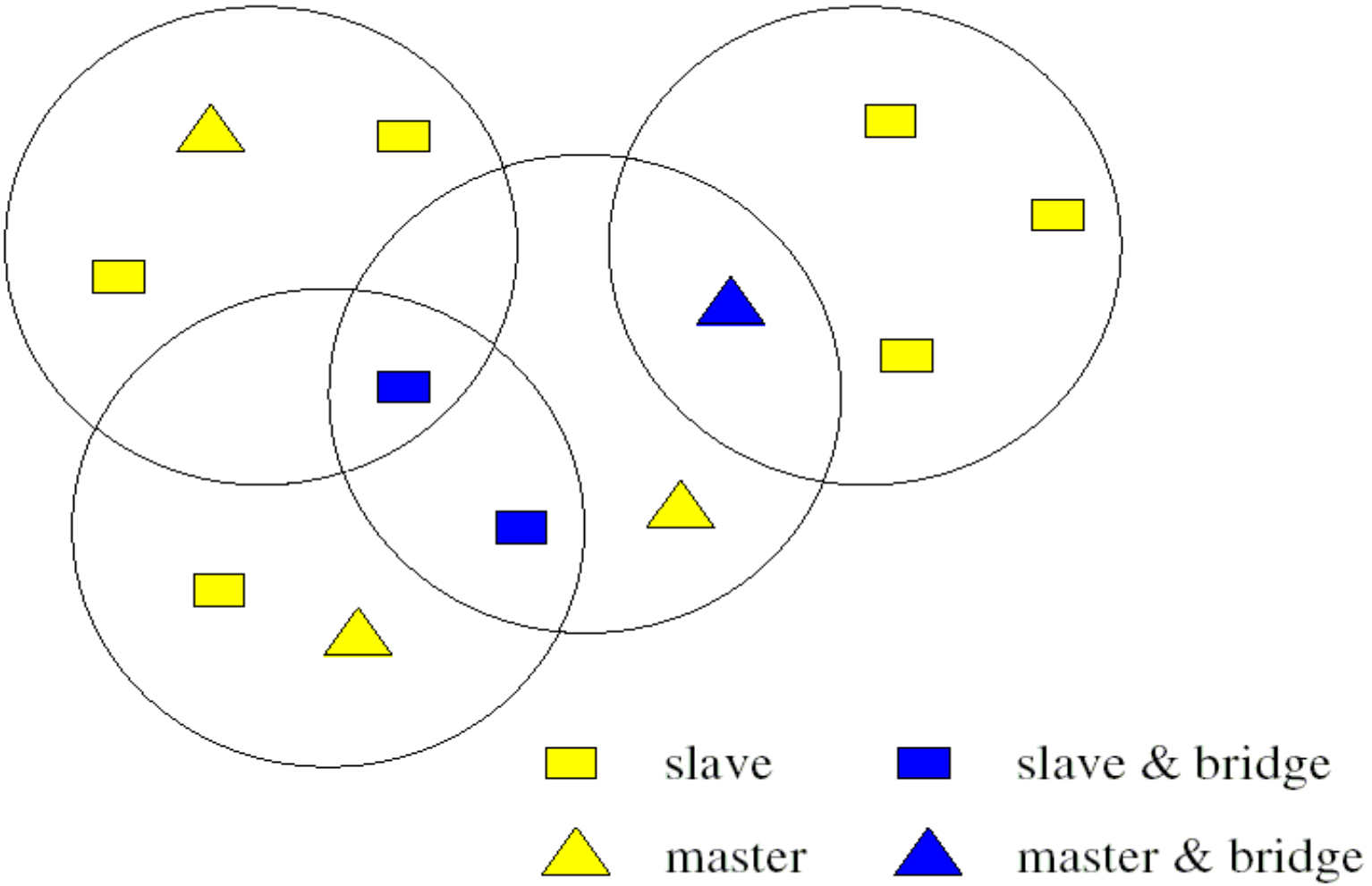
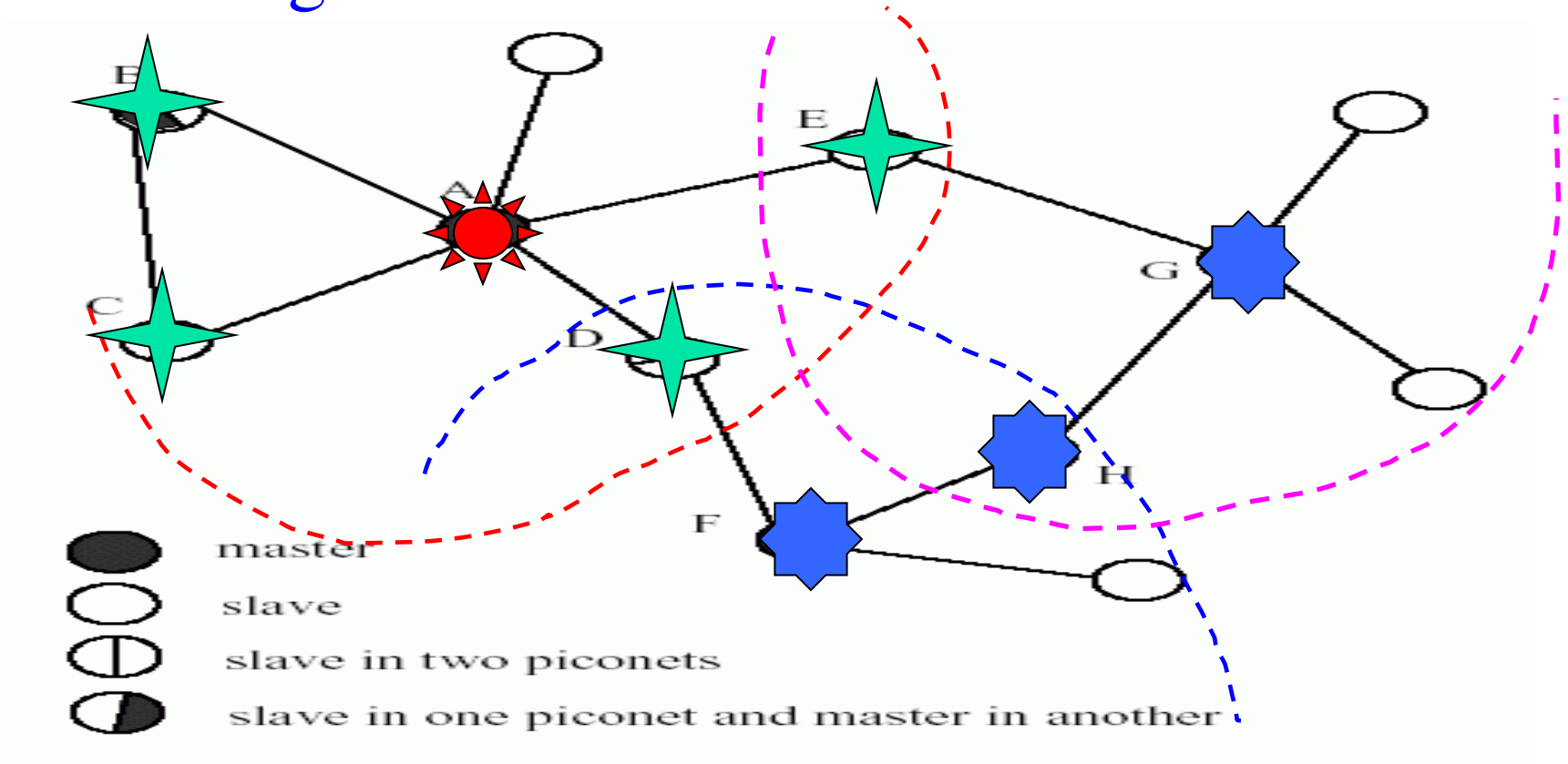


Fig. 1. BT-WPAN topology.

Bluetooth: A Wireless PAN

Bluetooth: Scatternet

- A node with multiple BT links may be a Master or Bridge or both.



An Integrated Scenario

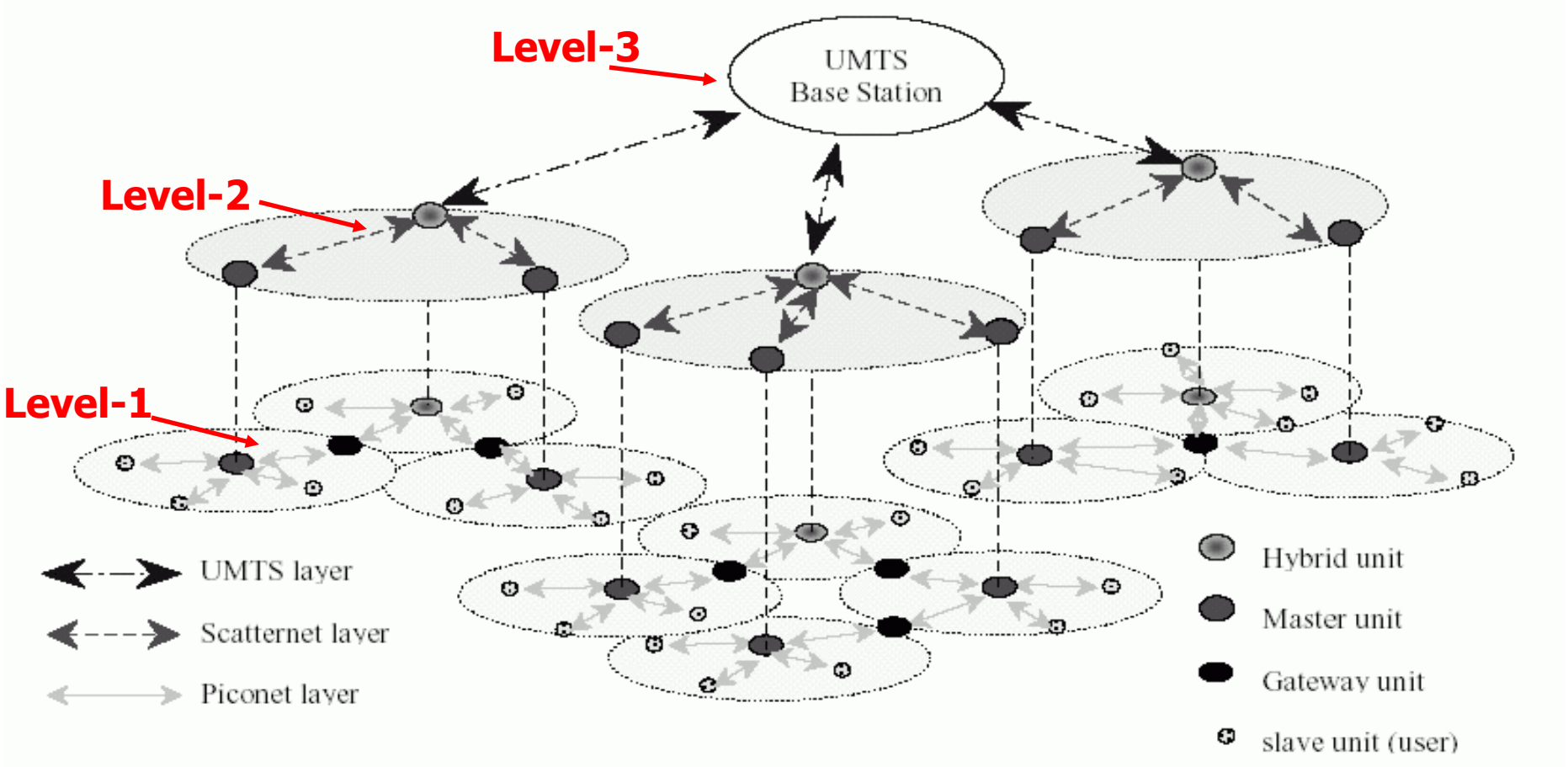
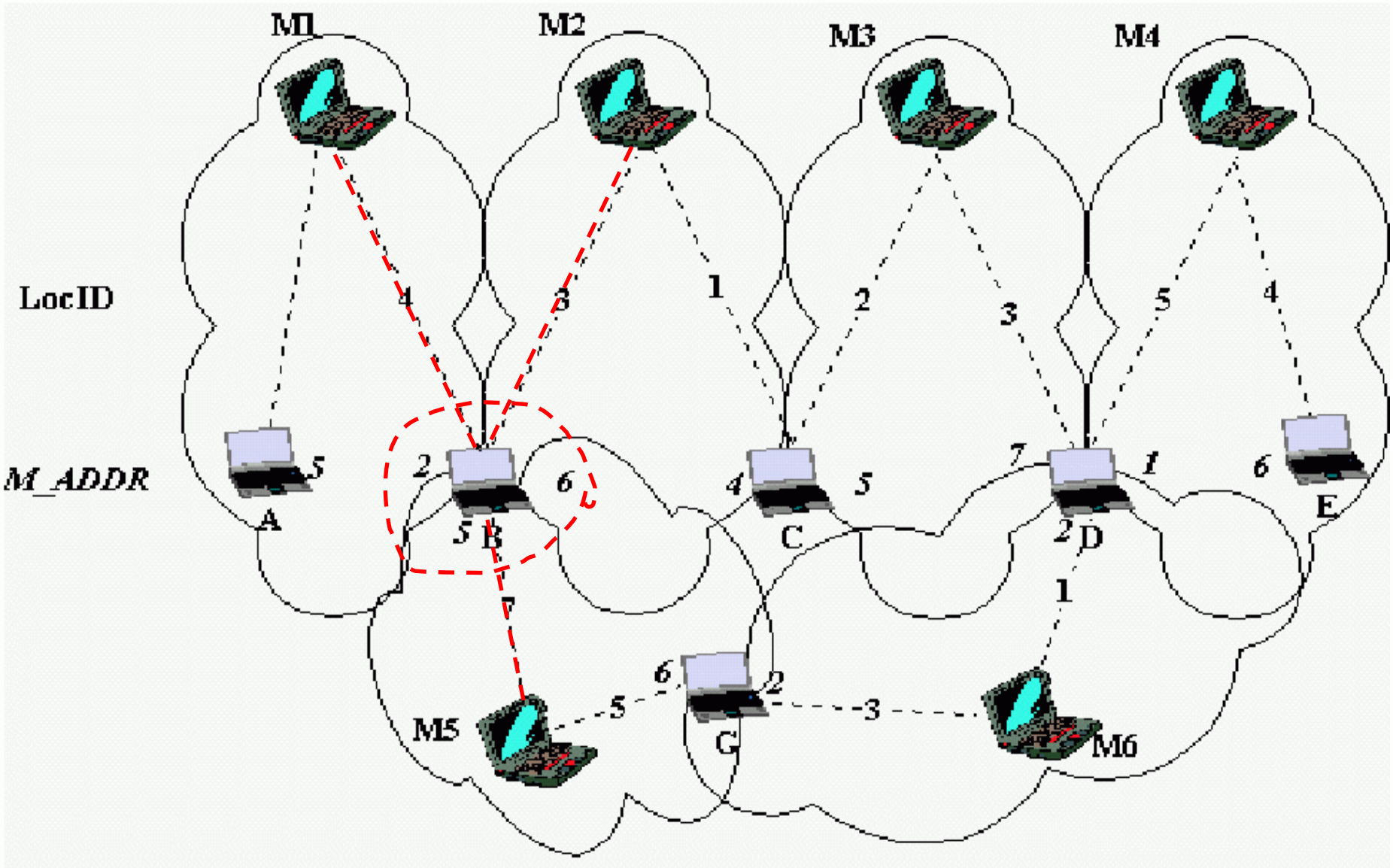


Fig. 1. "Centralized Wireless LAN Architecture" (CWLAN) using Bluetooth and UMTS

Routing Vector Method (RVM)

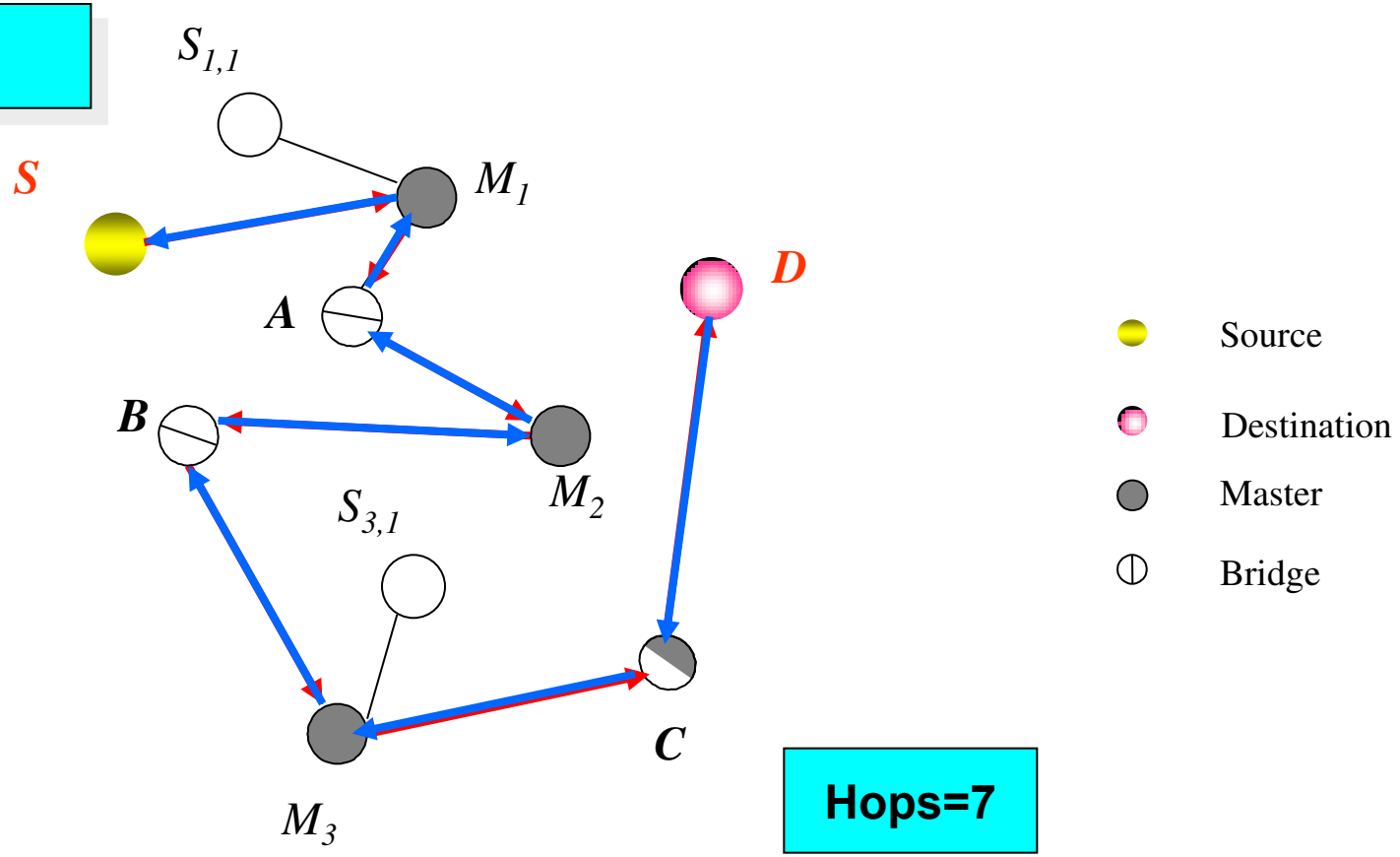


Our Routing Protocol

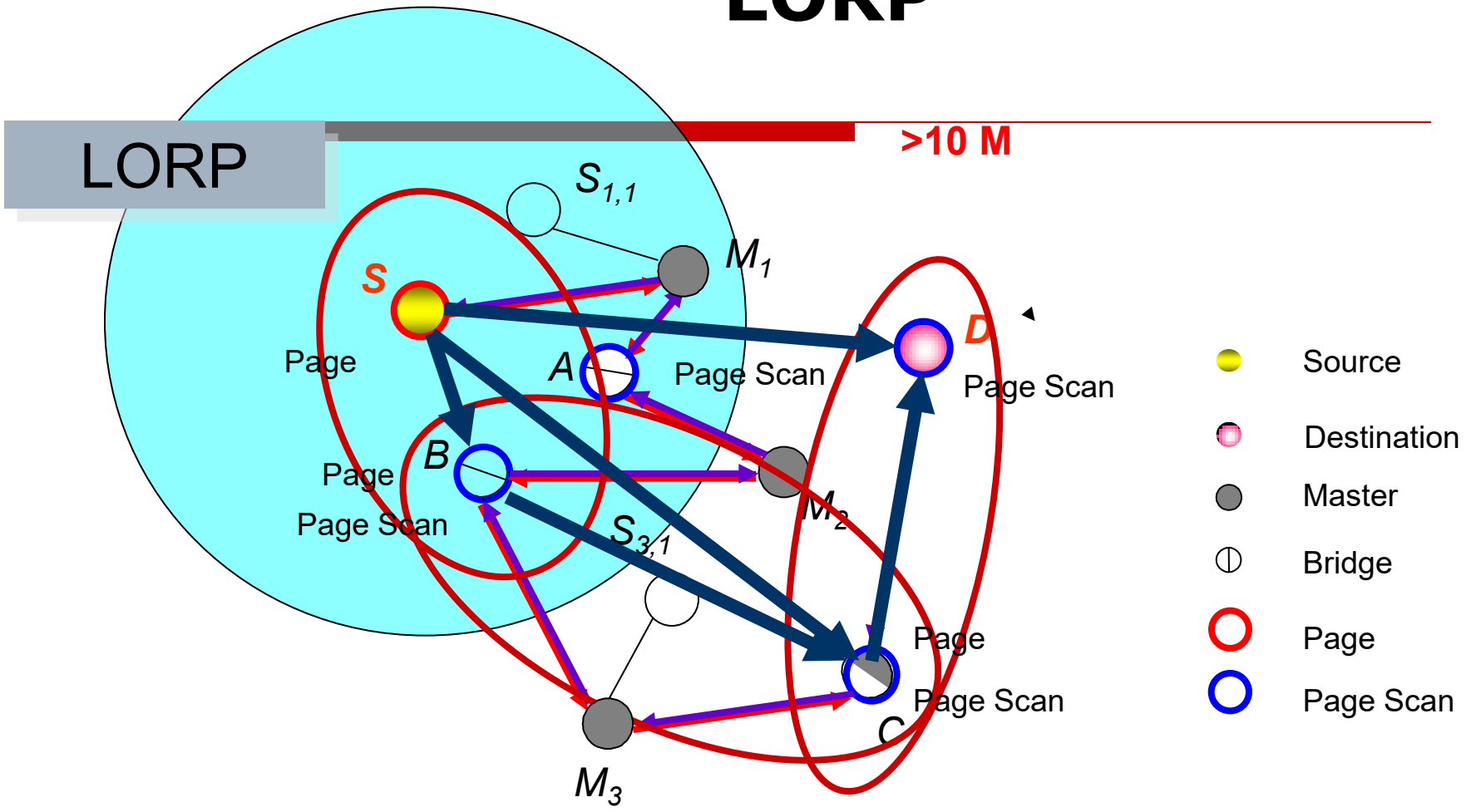
- **Paper Title:**
- **LARP: A Novel Routing Protocol for the Bluetooth Scatternet**
- **Published:**
- **In the Proc. of IEEE, WOCN, Dubai, March, 2005.**
- **Authors:**
- **Chih-Yung Chang, Prasan Kumar Sahoo, Shih-Chieh Lee**

LARP: A Novel Routing Protocol for the Bluetooth Scatternet

RVM



LORP



Reply Packet — S → A → B → C → D — **Hops=3**

Drawbacks

- **Drawbacks of these work:**
  - **Longer routing path length**
  - **Long transmission delay time**
  - **High bandwidth consumption**
  - **High power consumption**

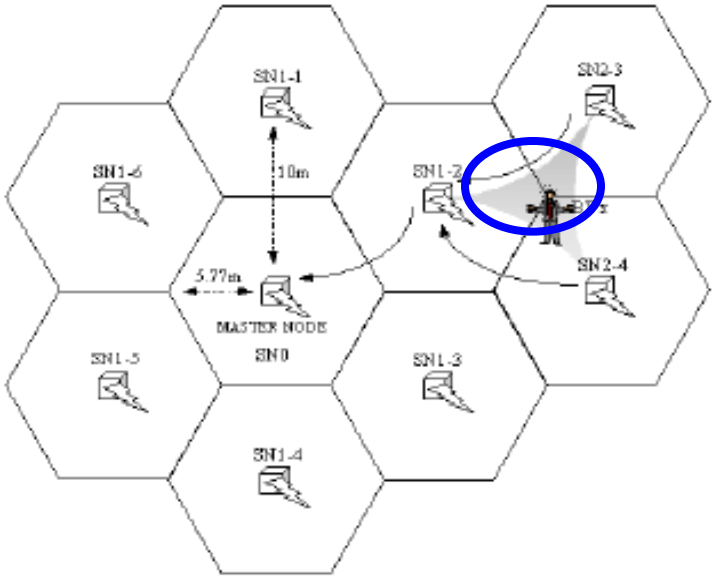
LARP: Location Aware Routing Protocol

Assumptions:

- Scatternet is connected
- Each device has it's location information
- A source intends to communicate with destination whose ID is known and location is unknown
- All device have the neighbor information
  - *ID, Location* and *Clock_offse*t
- Low Mobility
  - Mall, supermarket

Environment

- Bluetooth device gets it's location information:
  - Outdoor —By GPS
  - Indoor— RFID

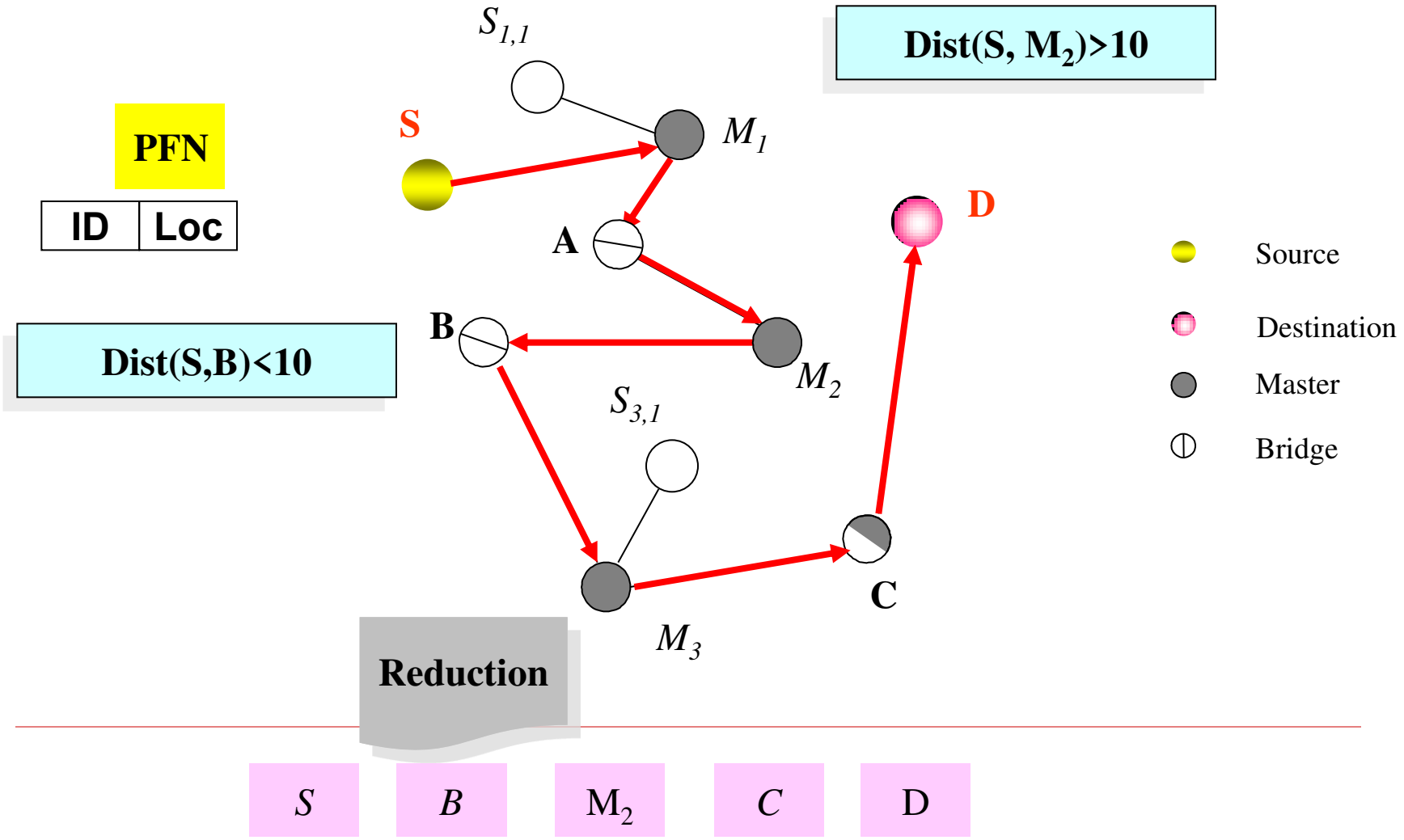


- **BLN**
  - "Bluetooth Location Networks," Globecom '02

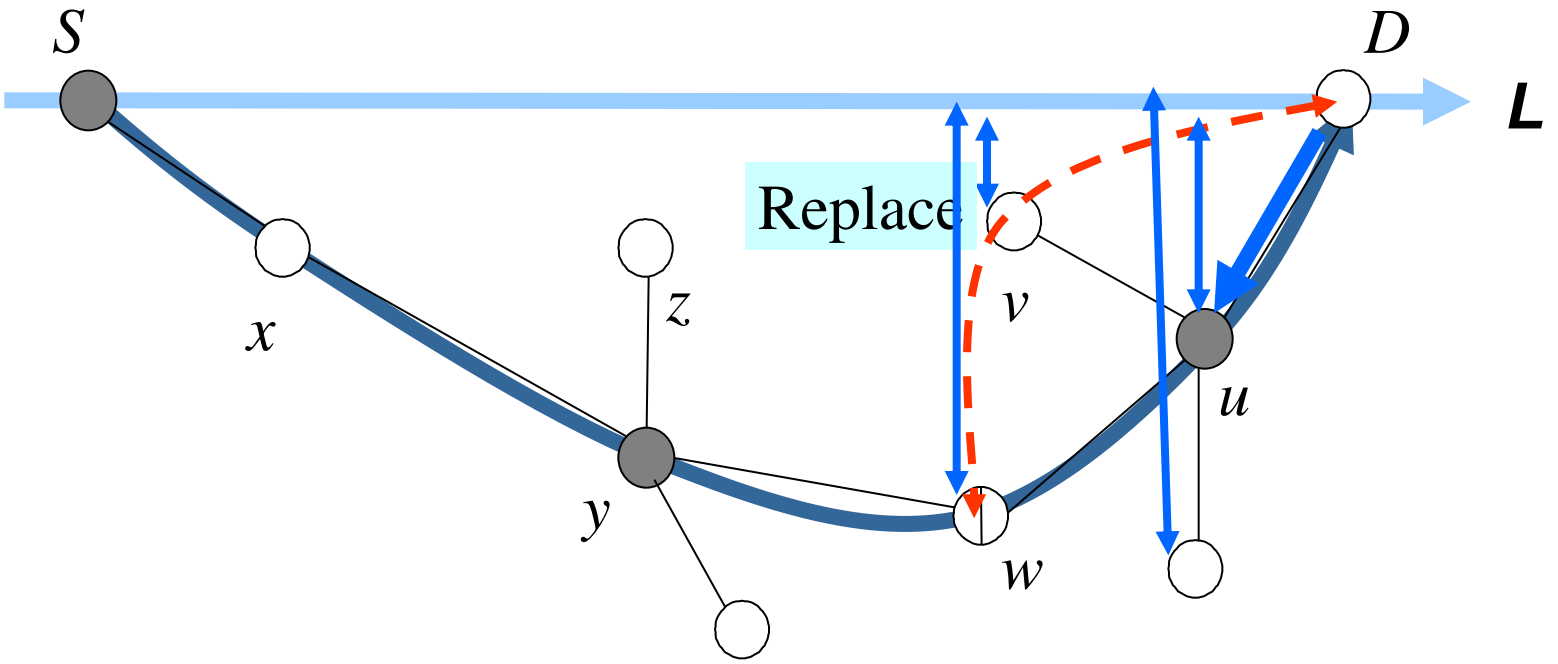
LARP: Location Aware Routing Protocol

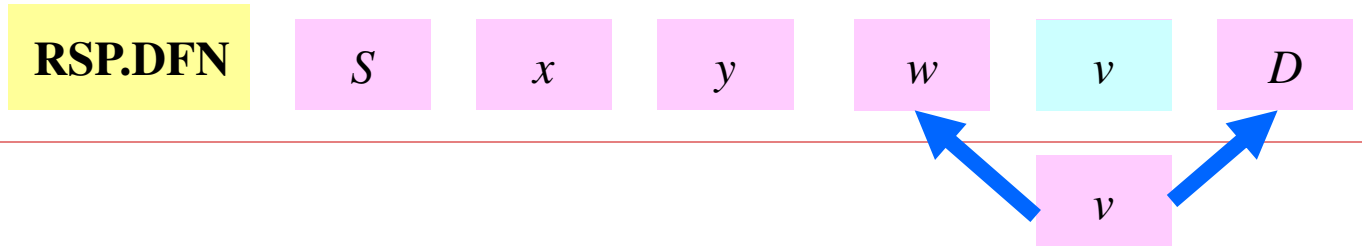
- Route Search Phase
  - Rule 1 : Flooding
  - Rule 2 : Appending
  - Rule 3 : Reduction
- Route Reply Phase
- Route Connection Phase

Route Search Phase

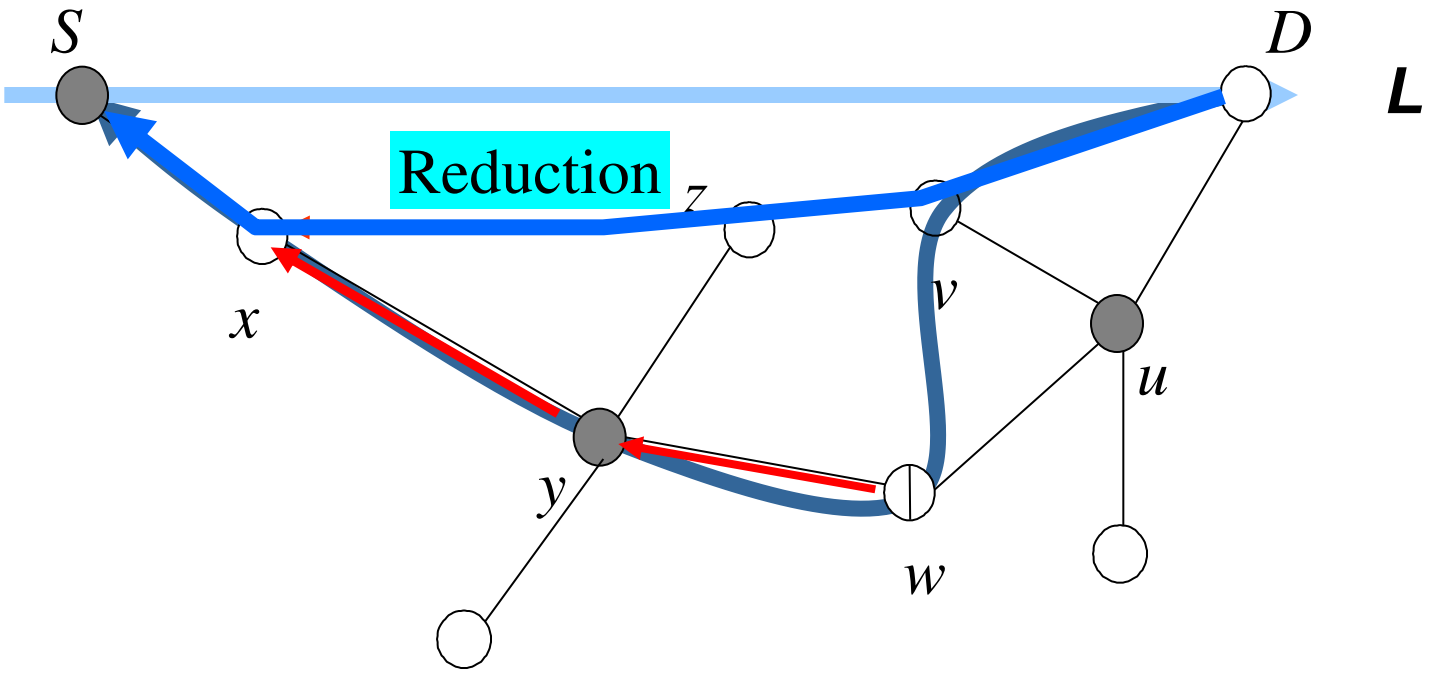


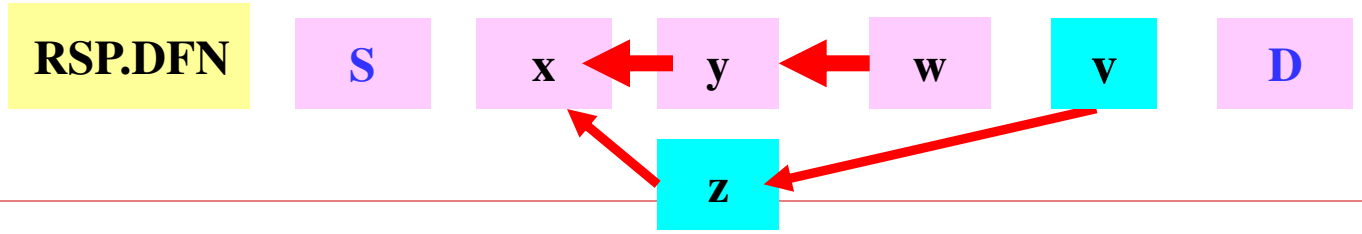
Rule: Reduction due to Replacement



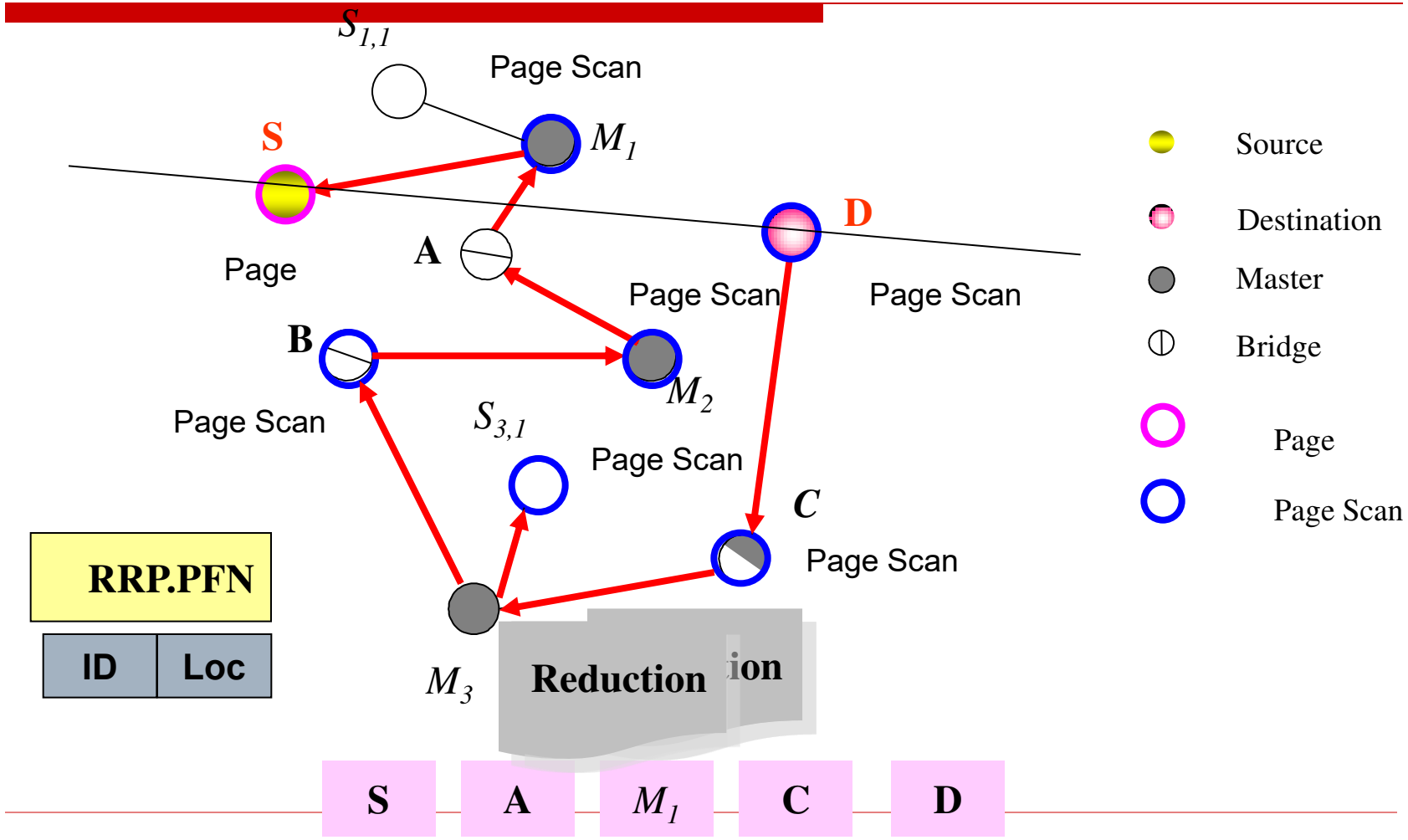


Reduction

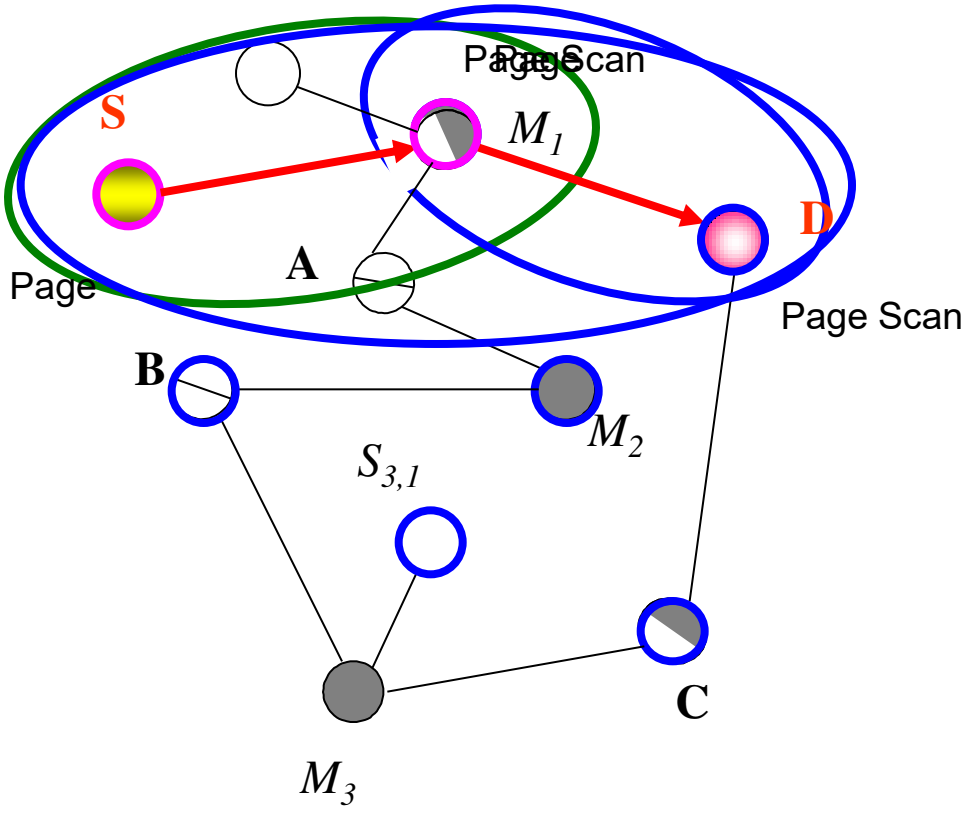


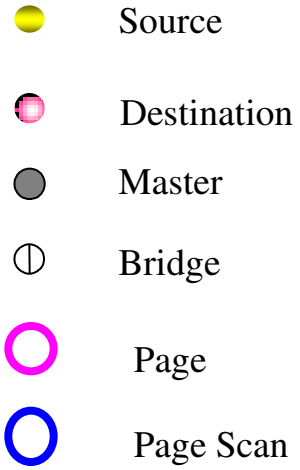


Route Reply Phase

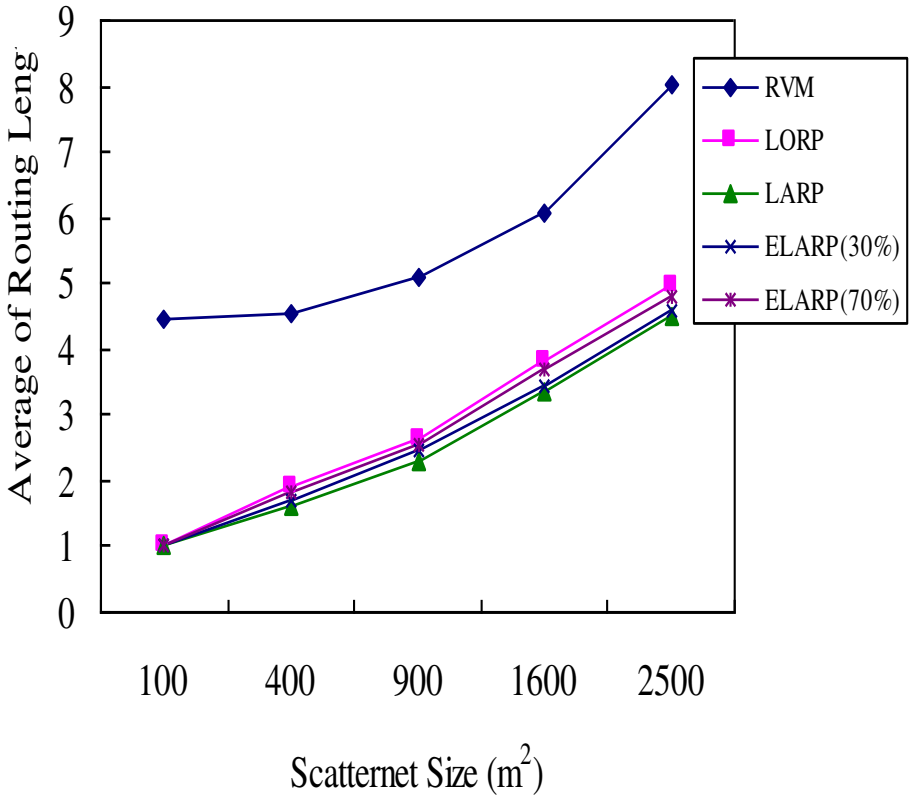


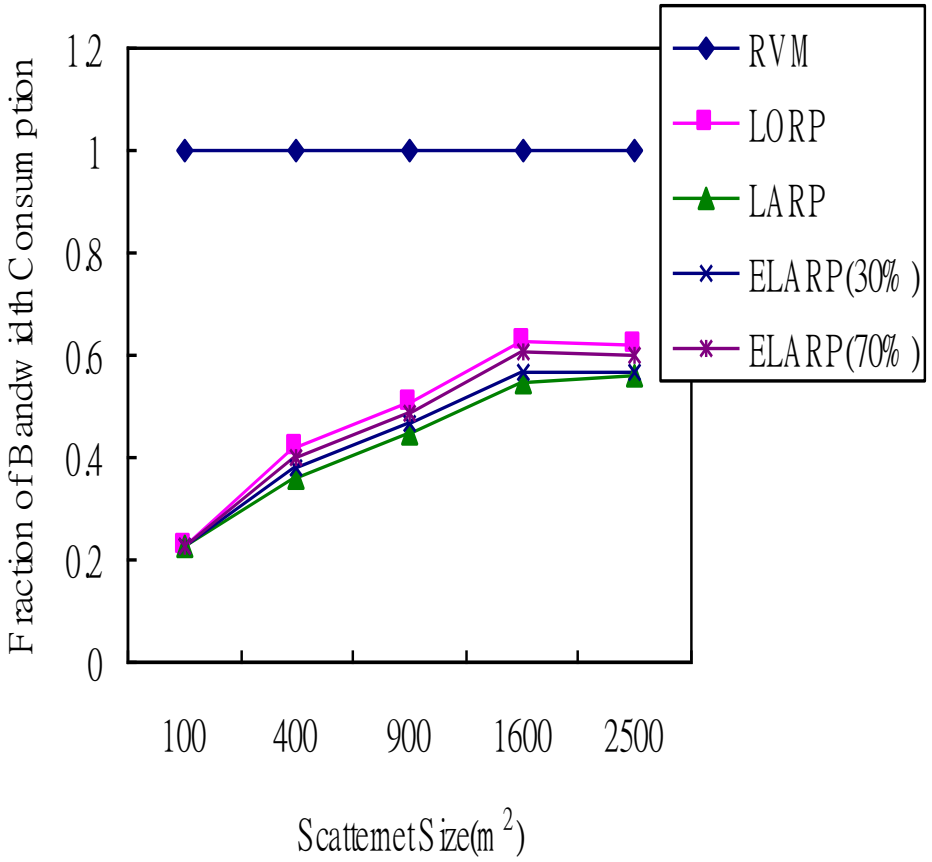
Route Construction Phase

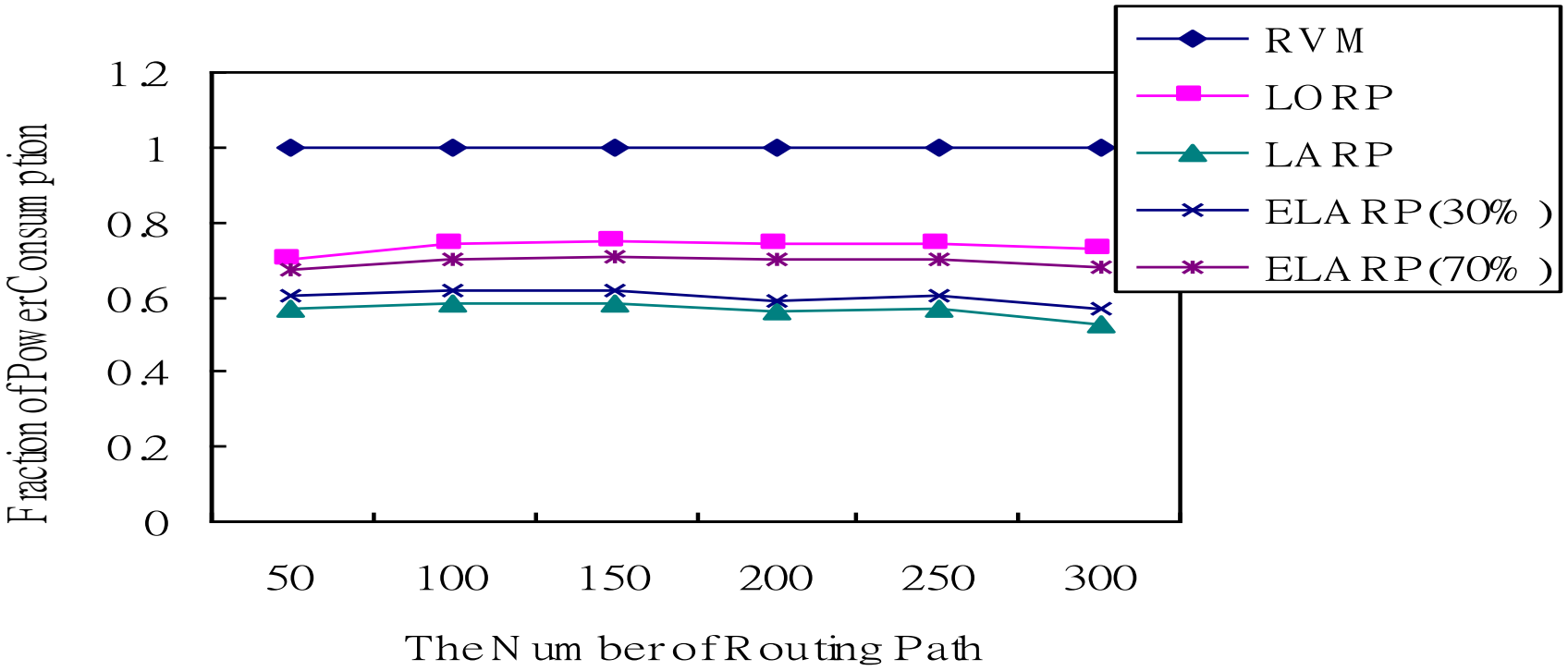




Simulation Results







Protocols	Route Length	Transmission delay	Power and Bandwidth consumption	Control Packet
RVM	Long	Long	High	Few
LORP	Short	Short	Low	Many
LARP	Very Short	Very Short	Very Low	Many

Summary

- Bluetooth Technology is designed to replace wires.
- It is one up from IrDA and one down from Wi-Fi WLAN.
- IrDa and Bluetooth can coexist.
- Bluetooth does not need the device to be in line of sight.
- It's communications speed and distance are much worse than available with Wi-Fi.
- It supports 'ad-hoc networking‘.

Thank Q
to
All !!!