

G 364: Mobile and Wireless Networking

CLASS 15, Mon. Mar. 8 2004

Stefano Basagni

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M-W, 11:40am-1:20pm, 109 Rob

Bluetooth Technology (BT): Enabling Ad Hoc Networks

- ◆ Wireless technology in the 2.4GHz, globally available, license free ISM (Industrial, Scientific and Medical) band, originally introduced for cable replacement → **must be low cost, reliable**
- ◆ 1MHz spaced channels, GFSK modulation → 1Mb/s
- ◆ Frequency Hopping Spread Spectrum
 - Devices follow a FHSS sequence
 - Frequency used for transmission changes for every packet → low interference, security

BT: Enabling Ad Hoc Networks

- ◆ Time divided in slots (1 slot = 625 μ s)
- ◆ Packet size: 1, 3 or 5 slots
- ◆ Short range communication
- ◆ Power class nodes: Class 1 (100 meters tx range), class 2 (20 meters tx range), class 3 (10 meters tx range)
- ◆ Power control (mandatory for class 1)

Why Should I Care About It?

◆ Up and coming

- In billions of devices by 2005 (*Business Week*, 18 September 2000)

◆ "Cool"

- Cordless desktop
- Briefcase e-mail
- Wire-free headphones

◆ Cheap (expected)

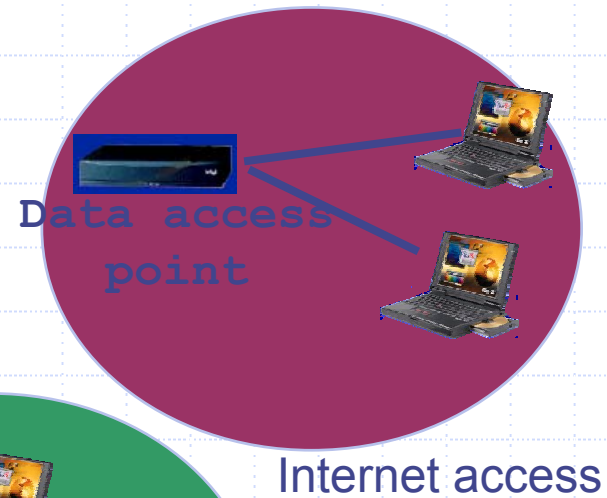
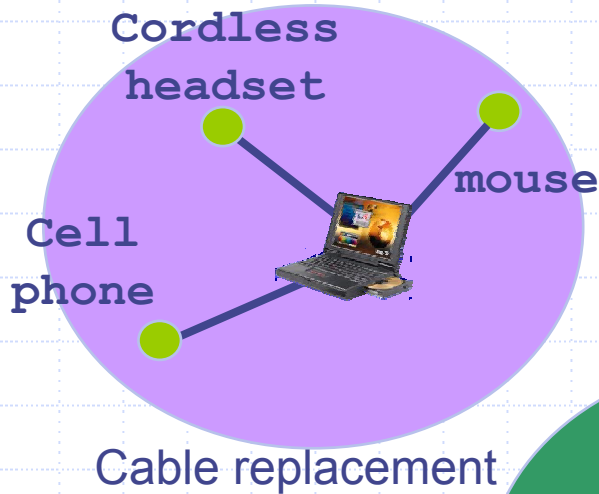
- As little as 29¢
- 80K transistors

Bluetooth History

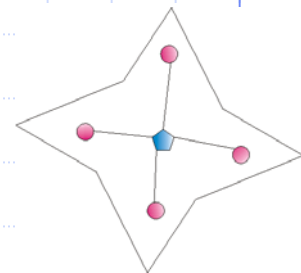


- Named after a Danish Viking King who unified and controlled Denmark and Norway
 - ➔ BT aims at unifying telecom. and computing industries
- First standard release in 1999 (v 1.0)
- BT Special Interest Group counts over 1800 members, including Ericsson, Nokia, IBM, Intel, Toshiba, Microsoft, Lucent, 3Com, Motorola...
- All BT SIG members agree to provide key technologies for development, have BT license and BT brand for free

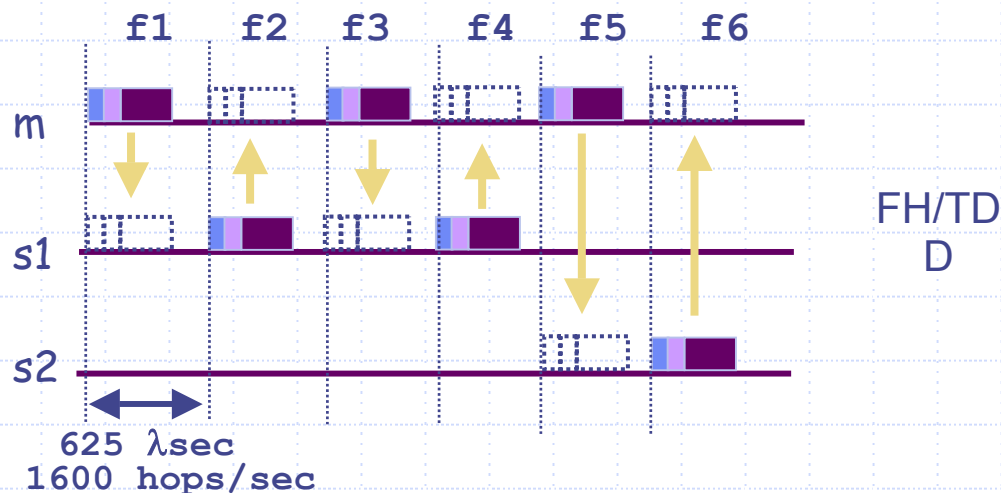
Bluetooth Application Scenarios



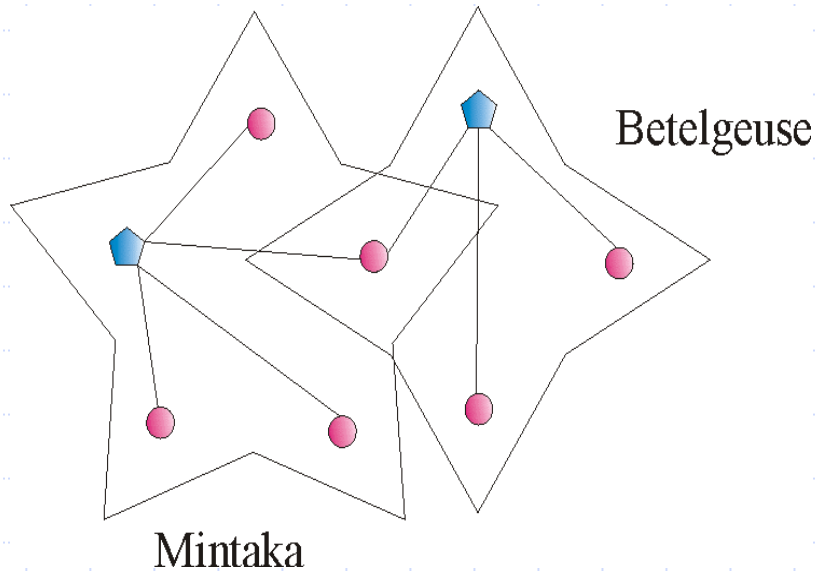
Bluetooth: Piconets



- ◆ **BT devices are organized in *piconets*, clusters of :**
 - One master
 - Multiple slaves, no more than 7 actively communicating
- ◆ **Synchronization based on master ID and clock**
 - Based on the master ID and clock a frequency hopping: all devices in a piconet use the same sequence
- ◆ **Master (M) – Slave (S) communication**

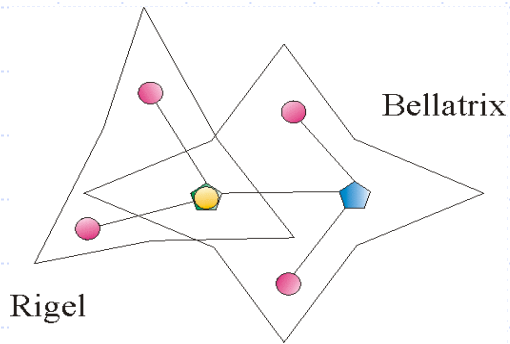


Bluetooth: Scatternets

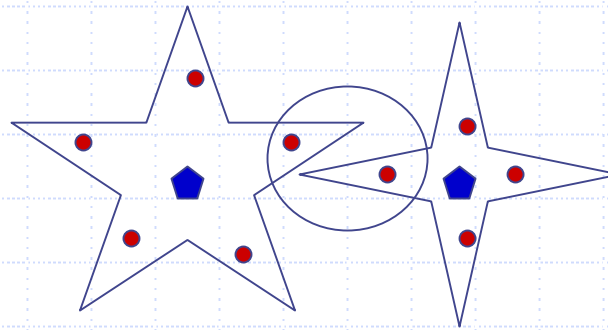


- ◆ Nodes can have multiple roles
- ◆ Nodes with multiple roles timeshare between multiple piconets
- ◆ A **scatternet** enables multi-hop communication

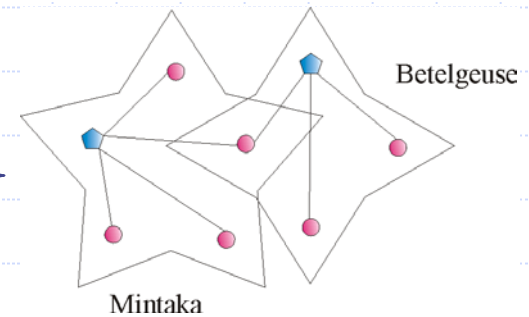
Piconets Interconnection



master/slave



additional piconet
interconnecting
neighbor slaves



common slave


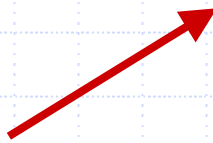


Efficiency

Scatternet Formation

- ◆ Forming connected ad hoc networks of Bluetooth device

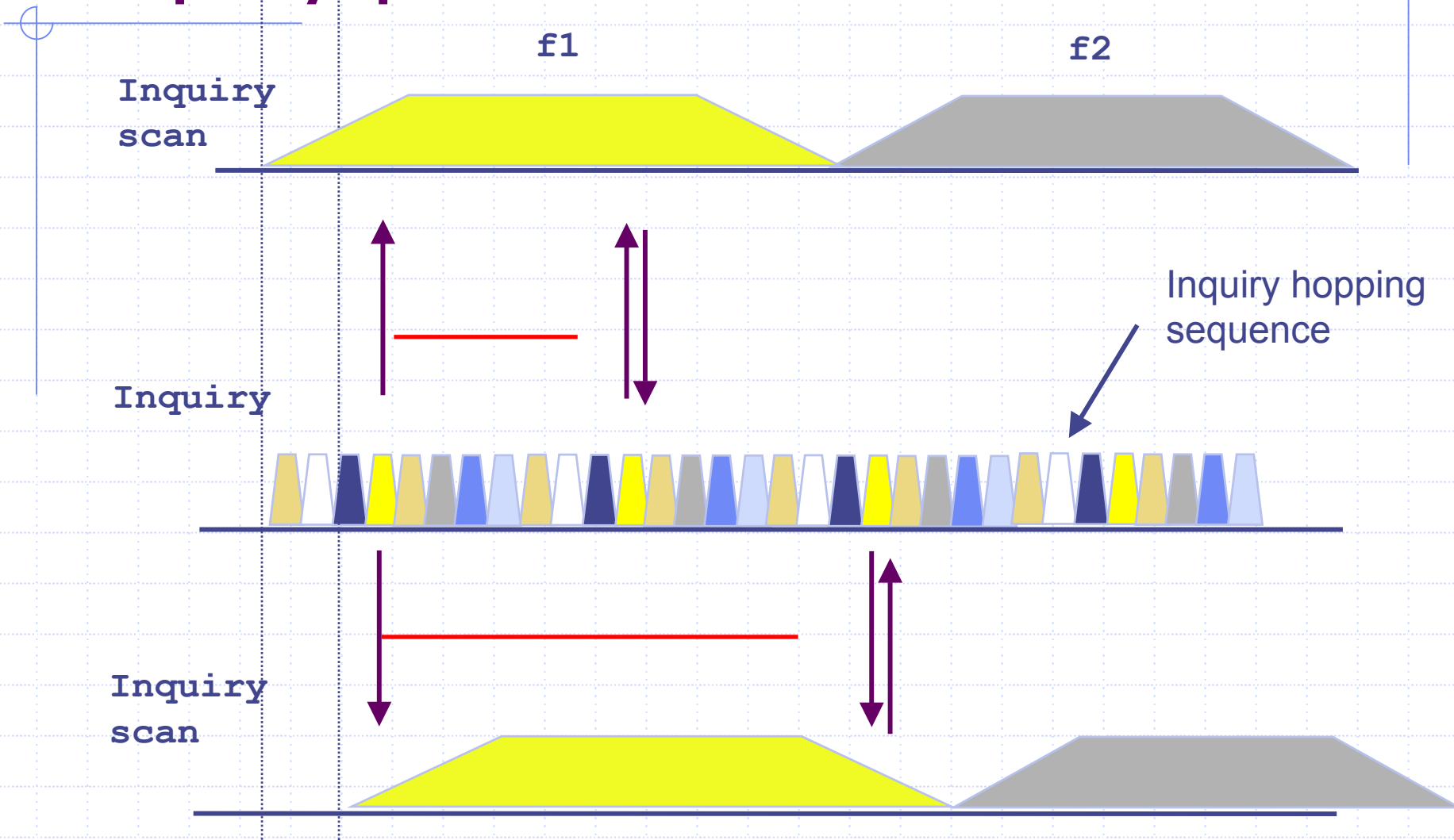
- ◆ Three major problems:

- Device discovery  use BT standard inquiry and paging procedures
- Piconet formation 
- Piconet interconnection

Device Discovery in BT

- Requires neighbor nodes to be in opposite modes (inquiry/inquiry scan)
- Leads to asymmetric neighbor discovery
 - The inquirer gather information on the neighbor BT clock and address, not vice versa

Inquiry procedure



Symmetric Device Discovery

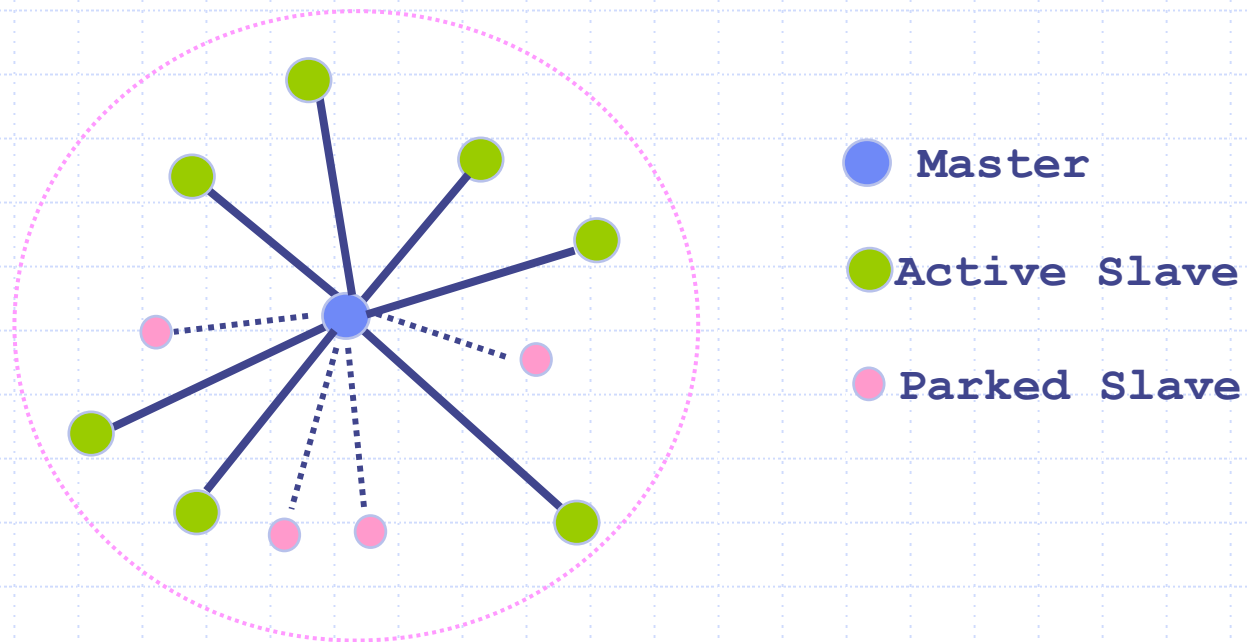
First proposed by Salonidis, Tassiulas, Baghwat, INFOCOM 2001



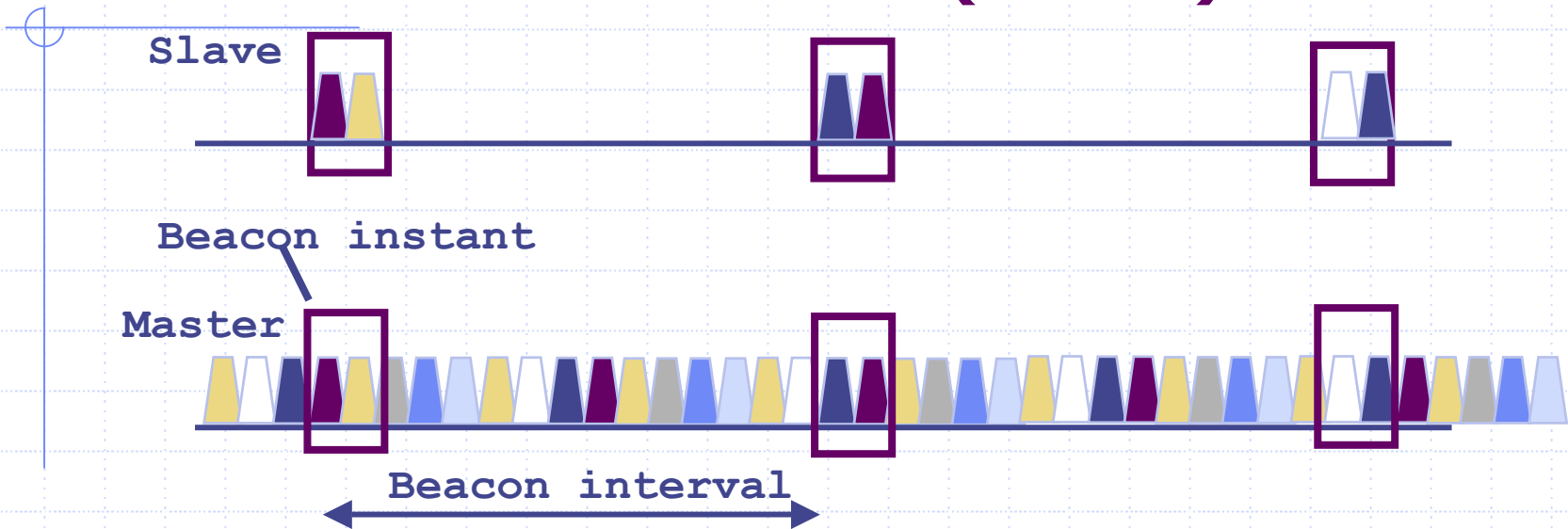
- Nodes alternate between inquiry and inquiry scan mode
- Random residence times in a mode
- Nodes perform standard inquiry (inquiry scan) procedures when in inquiry (inquiry scan) mode
- Idea: “two nodes discover each other when they are in opposite mode for sufficiently long time”

Piconet Formation

- ◆ Page/page scan protocol
 - To establish links with nodes in proximity



Low Power mode (Park)



- ◆ Power saving + keep more than 7 slaves in a piconet
- ◆ Give up active member address, yet maintain synchronization
- ◆ Communication via broadcast LMP messages

Assignments

- ◆ Read the survey on Bluetooth
- ◆ Updated information on the class web page:

www.ece.neu.edu/courses/eceg364/2004sp