Outline

- Wireless networks
  - 802.11
  - Infra-red Irda
  - Bluetooth

Wireless LANs

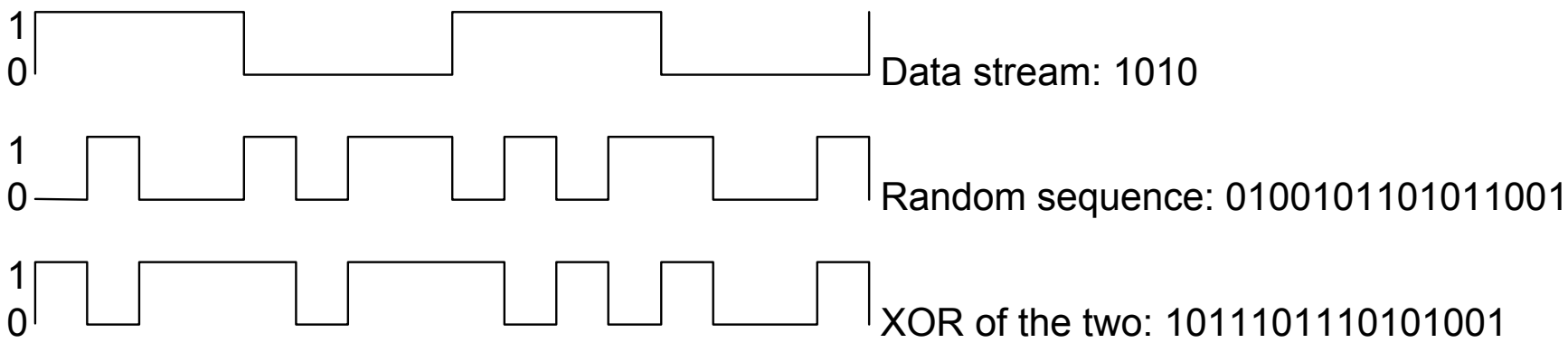
- IEEE 802.11
- Bandwidth: 1 or 2 Mbps
- Physical Media
  - spread spectrum radio (2.4GHz)
  - diffused infrared (10m)

Spread Spectrum

- Idea
  - spread signal over wider frequency band than required
  - originally designed to thwart jamming
- Frequency Hopping
  - transmit over random sequence of frequencies
  - sender and receiver share…
    - pseudorandom number generator
    - seed
  - 802.11 uses 79 x 1MHz-wide frequency bands

Spread Spectrum (cont)

- Direct Sequence
  - for each bit, send XOR of that bit and n random bits
  - random sequence known to both sender and receiver
  - called n-bit chipping code
  - 802.11 defines an 11-bit chipping code

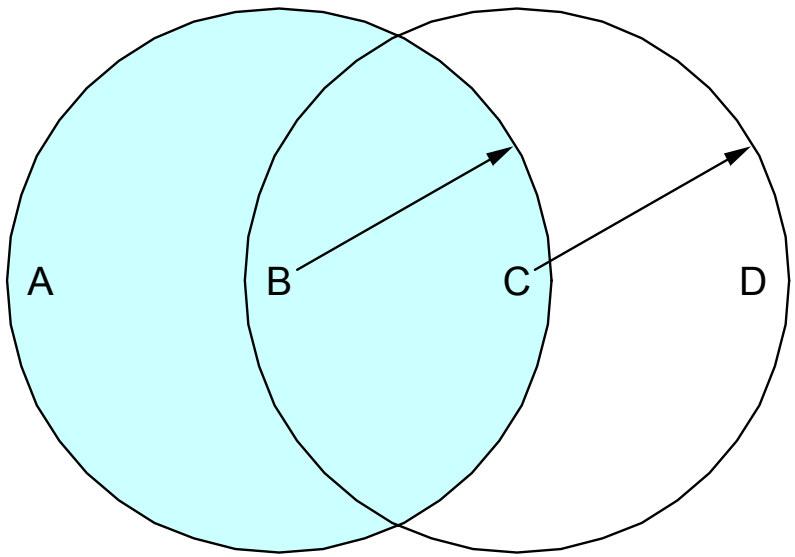


Challenges

- Limited wireless transmission range
- Broadcast nature of the wireless medium
  - Hidden terminal problem
- Packet losses due to transmission errors
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints
- Potentially frequent network partitions
- Ease of snooping on wireless transmissions (security hazard)

Collisions Avoidance

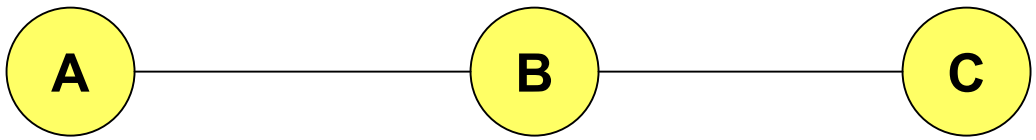
- Similar to Ethernet
- Problem: hidden and exposed nodes



Hidden Terminal Problem

- Node B can communicate with A and C both
- A and C cannot hear each other

- When A transmits to B, C cannot detect the transmission using the *carrier sense* mechanism
- If C transmits, collision will occur at node B



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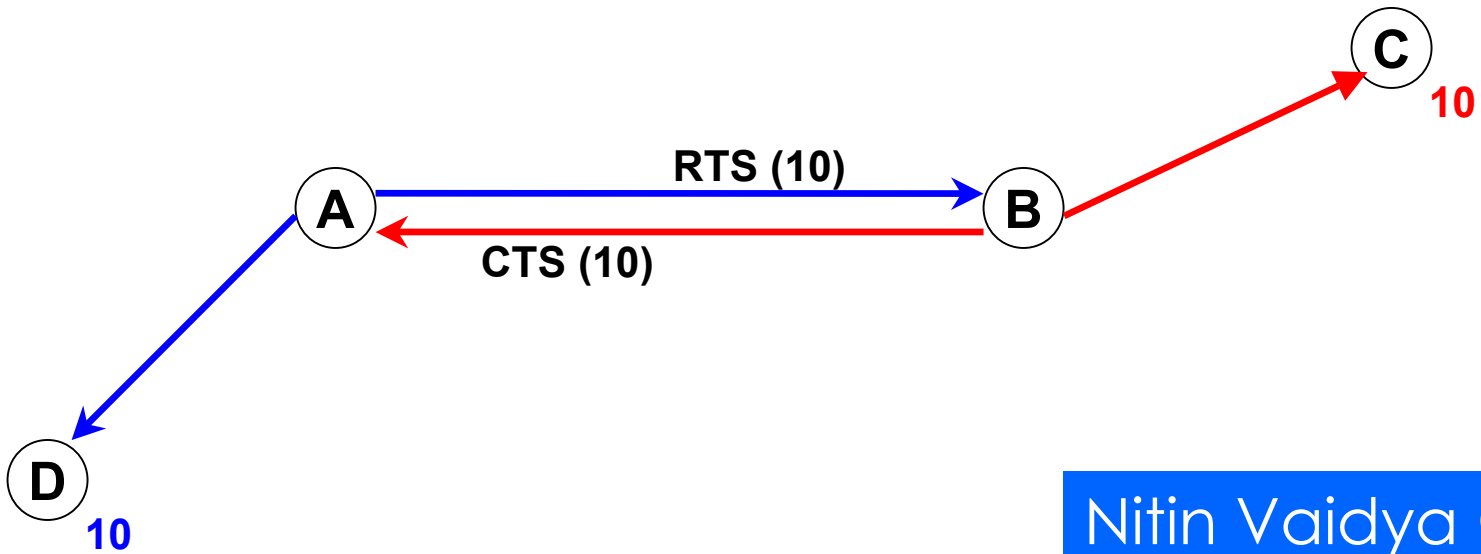
RTS/CTS Handshake

- Sender sends Ready-to-Send (RTS)
- Receiver responds with Clear-to-Send (CTS)
- RTS and CTS announce the duration of the transfer
- Nodes overhearing RTS/CTS keep quiet for that duration
- RTS/CTS used in IEEE 802.11



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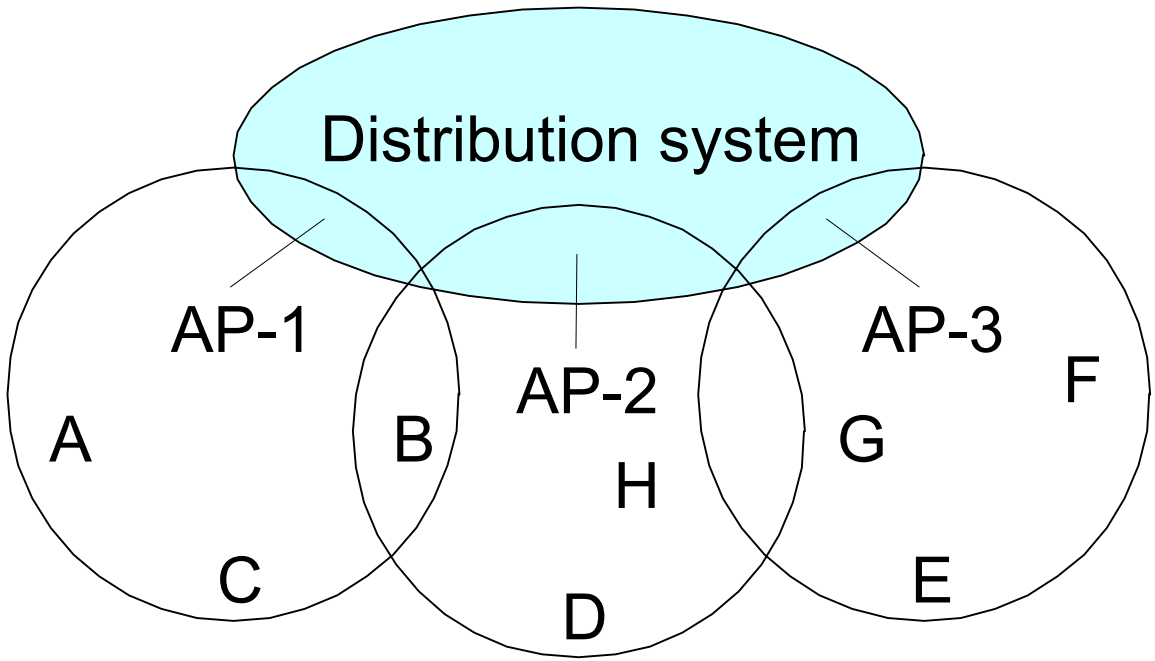
Multiple Access Collision Avoidance – Wireless (MACAW)

- Sender transmits RequestToSend (RTS) frame
- Receiver replies with ClearToSend (CTS) frame
- Neighbors…
  - see CTS: keep quiet
  - see RTS but not CTS: ok to transmit
- Receive sends ACK when has frame
  - neighbors silent until see ACK
- Collisions
  - no collisions detection
  - known when don't receive CTS
  - exponential backoff

Supporting Mobility

- Case 1: ad hoc net working
- Case 2: access points (AP)
  - tethered
  - each mobile node associates with an AP



Mobility (cont)

- Scanning (selecting an AP)
  - node sends Probe frame
  - all AP's w/in reach reply with ProbeResponse frame
  - node selects one AP; sends it AssociateRequest frame
  - AP replies with AssociationResponse frame
  - new AP informs old AP via tethered network
- When
  - active: when join or move
  - passive: AP periodically sends Beacon frame

irda

- Infrared Data Association – Point and Shoot Profile

irda

- Founded in 1993
- Short range, point-to-point, low cost infra-red based
- Speeds from 9600b to 16Mb
- Great non-cable device
  - Ubiquitous deployment
  - 4 Mbps irda can talk to 9600 irda
- Protocols for point and shoot, exchange mp3, images, vcards, wrist watch ….

Point and shoot model

- Point to the device. If both device understand object begin shared then transparent access
- Push server – the device that provides an object exchange server. Waits passively for the client to initiate an operation
- Push client – the client that pushes the object to the push server. Push client initiates operation
- Security not an issue because of range

Discussion

- Available in PDA's, laptops, printers, projectors, digital cameras, wrist watches, pagers, ……

- wanted – "killer app!!"

Bluetooth

- *Bluetooth: Vision, Goals, and Architecture*, Jaap Haartsen, Mahmoud Naghshineh, Jon Inouye, Olaf J. Joeresson, and Warren Allen, ACM Mobile Computing and Communications Review, Volume 2, Number 4, October 1998.

Bluetooth

Pravin Bhagwat
@ AT&T Labs

- A cable replacement technology
- 1 Mb/s symbol rate
- Range 10+ meters
- Single chip radio + baseband
  - at low power & low price point

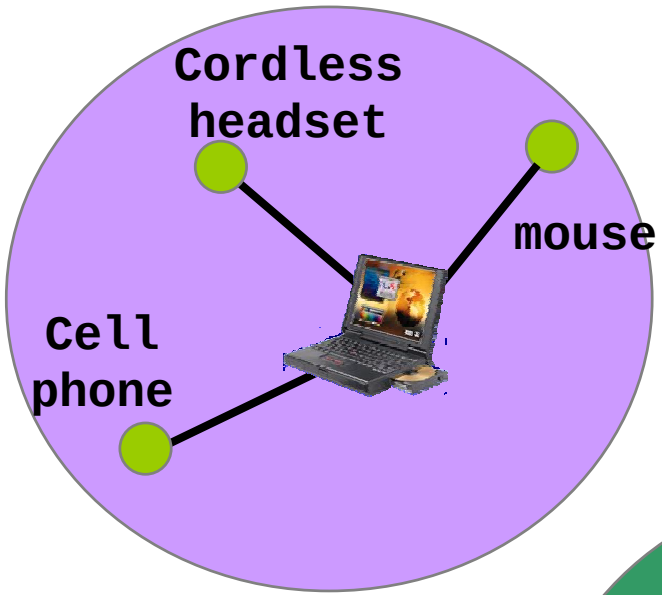
Why not use Wireless LANs?
- power
- cost

Bluetooth

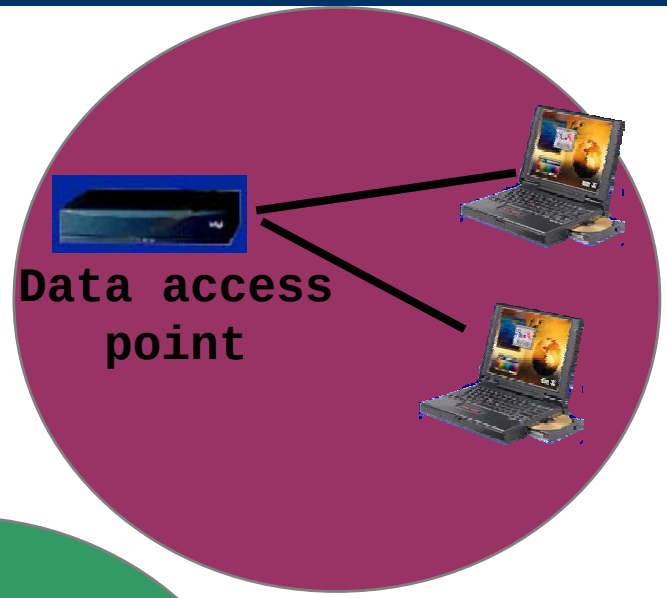
- Low cost, low-power radio-based cable replacement

- Related technologies
  - IrDA – Uses Infrared
    - Pros: Less governmental restrictions, lower cost, lower standby power, higher bandwidth
    - Cons: Line of sight
  - IEEE 802.11 – Same wireless band
    - Wireless LAN capability for a larger range
  - HomeRF – Wireless for data and voice
    - Data similar to 802.11, voice ADPCM

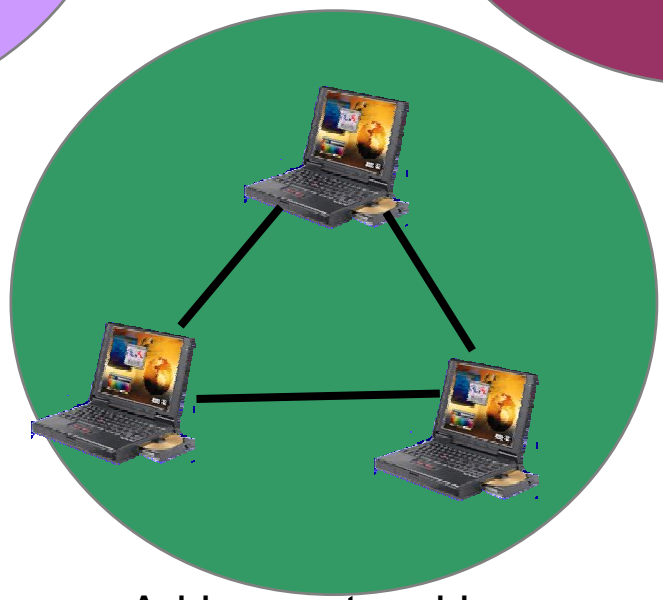
Value proposition of Bluetooth



Cable replacement



Internet access



Ad hoc networking

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Bluetooth working group history

- February 1998: The Bluetooth SIG is formed
  - promoter company group: Ericsson, IBM, Intel, Nokia, Toshiba
- May 1998: Public announcement of the Bluetooth SIG
- July 1999: 1.0A spec (>1,500 pages) is published
- December 1999: ver. 1.0B is released
- December 1999: The promoter group increases to 9
  - 3Com, Lucent, Microsoft, Motorola
- February 2000: There are 1,800+ adopters

New applications enabled by Bluetooth

Synchronization

- User benefits
- Automatic synchronization of calendars, address books, business cards
- Push button synchronization
- Proximity operation

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Cordless Headset

- User benefits
- Multiple device access
- Cordless phone benefits
- Hands free operation

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Three-in-one phone

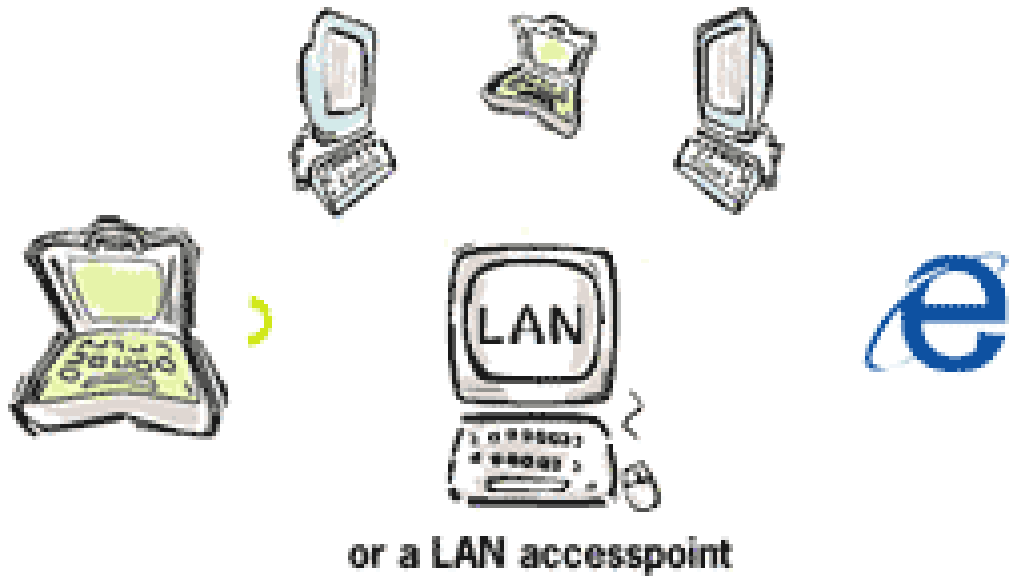
- At home, your phone functions as a portable phone (fixed line charge). When you're on the move, it functions as a mobile phone (cellular charge). And when your phone comes within range of another mobile phone with built-in Bluetooth wireless technology it functions as a walkie talkie (no telephony charge).
- Source: bluetooth.com

mobile phone

The Internet Bridge

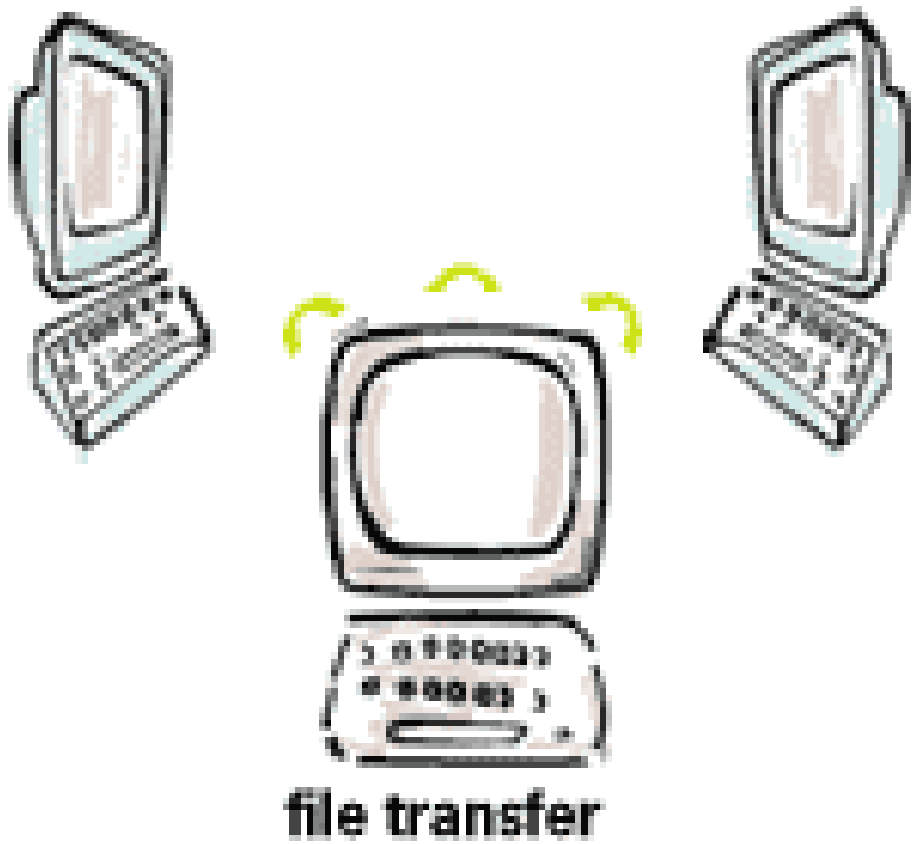
- Use your mobile computer to surf the Internet wherever your are, and regardless if you're cordlessly connected through a mobile phone (cellular) or through a wire-bound connection (e.g. PSTN, ISDN, LAN, xDSL).

- Source: bluetooth.com



The Interactive Conference

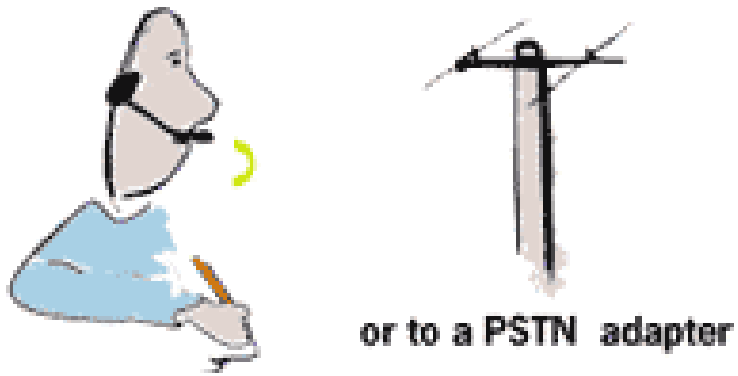
- In meetings and conferences you can transfer selected documents instantly with selected participants, and exchange electronic business cards automatically, without any wired connections
- Source: bluetooth.com



The Ultimate Headset

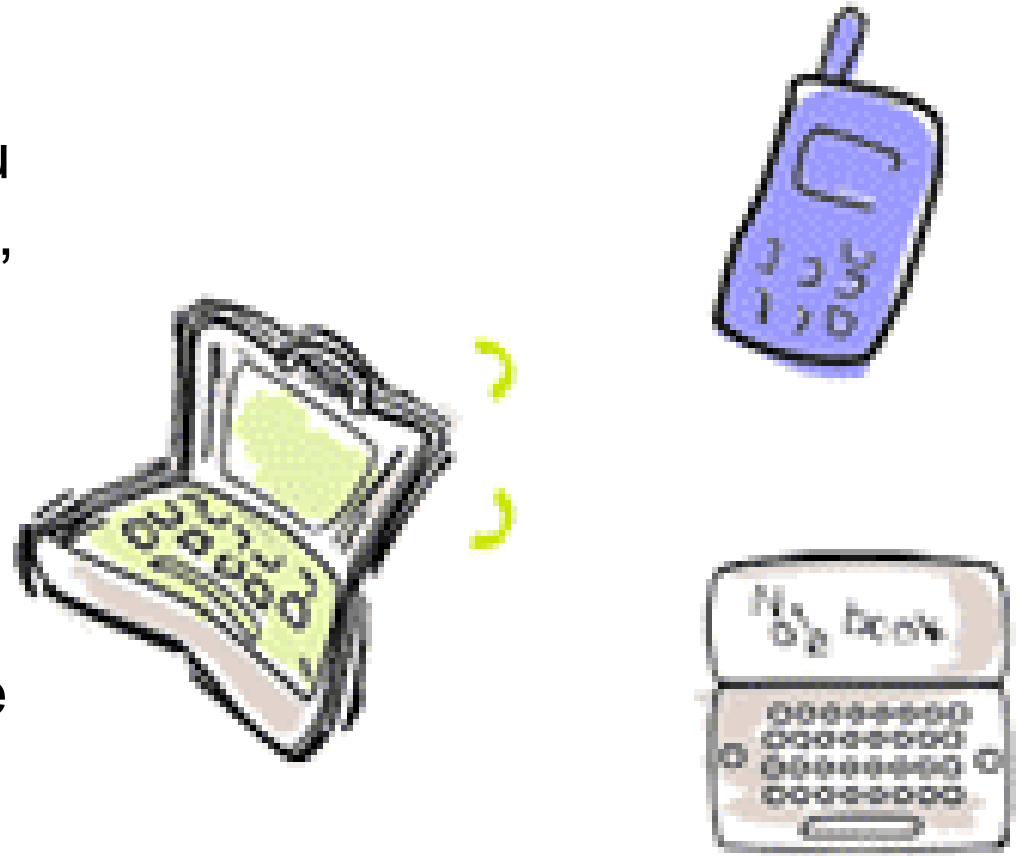
- Connect your wireless headset to your mobile phone, mobile computer or any wired connection to keep your hands free for more important tasks when you're at the office or in your car

- Source: bluetooth.com



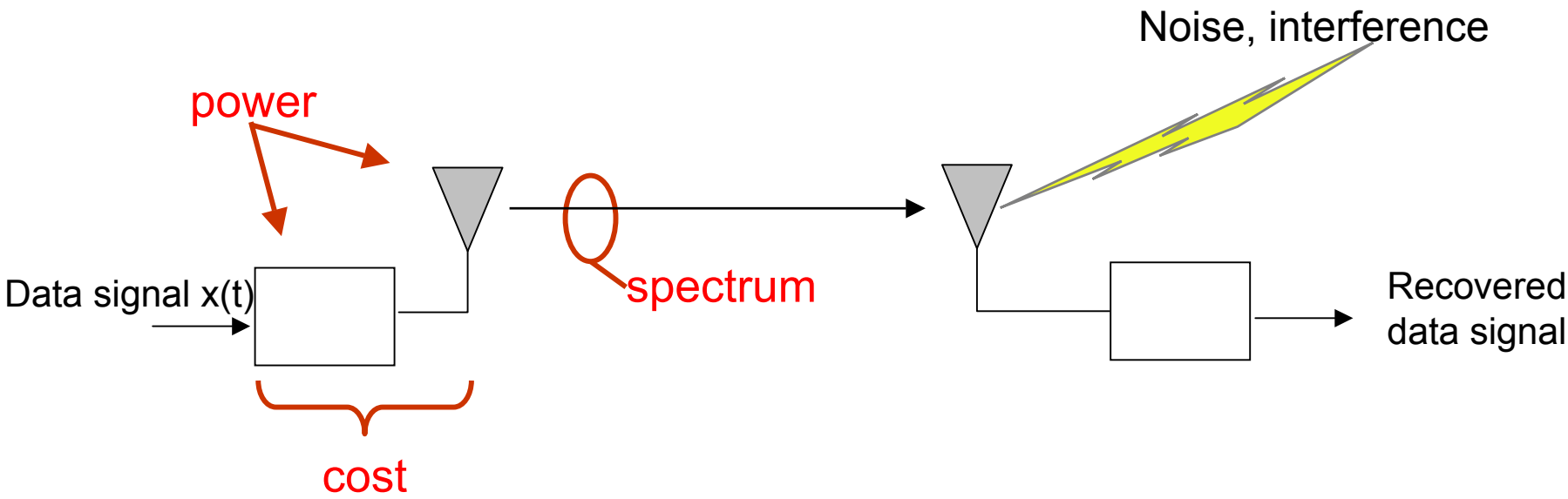
The Automatic Synchronizer

- Automatic synchronization of your desktop, mobile computer, notebook (PC-PDA and PC-HPC) and you mobile phone. For instance, as soon as you enter your office the address list and calendar in your notebook will automatically be updated to agree with the one in your desktop, or vice versa.



- Source: bluetooth.com

Design considerations



Goal

- high bandwidth
- conserve battery power
- cost < $10

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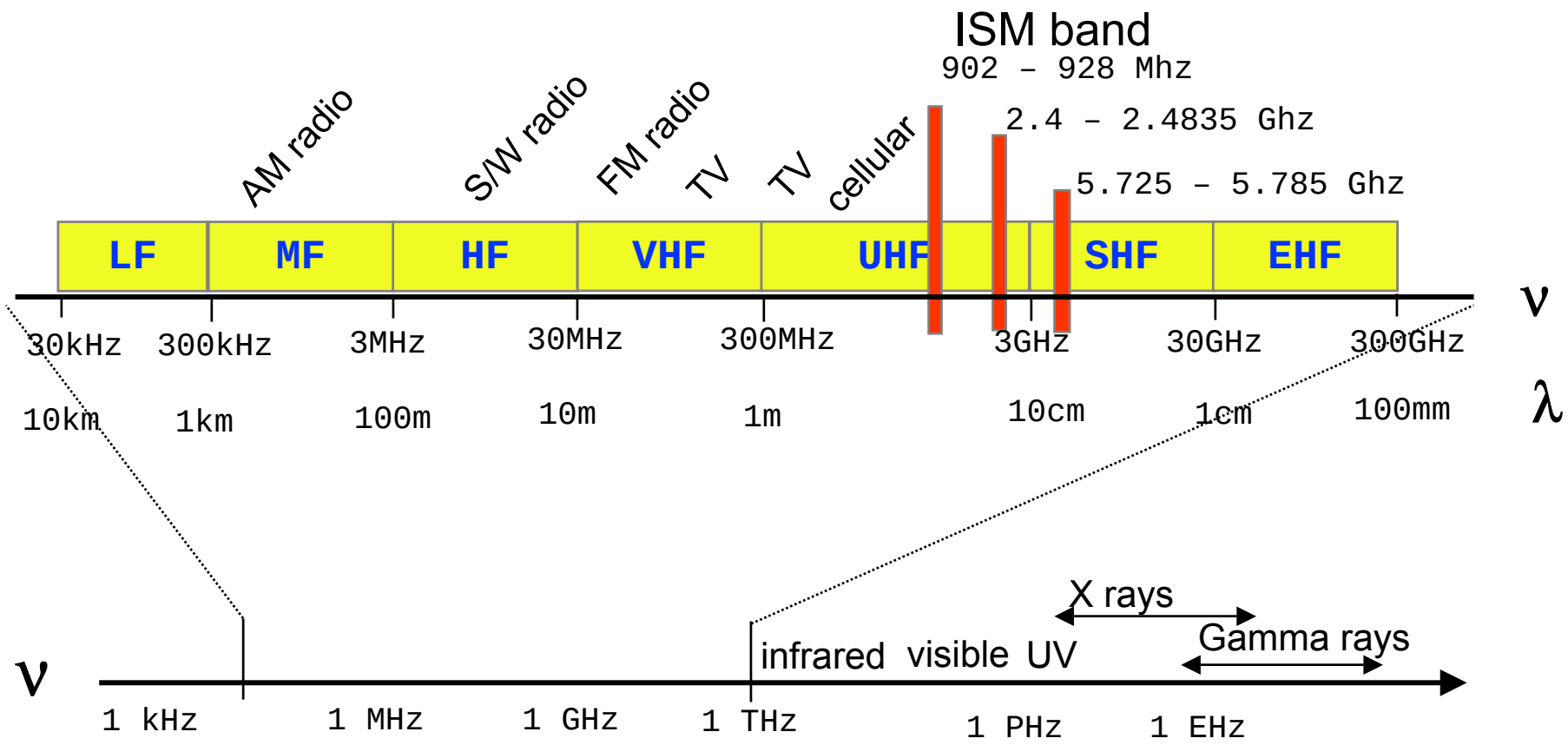
EM Spectrum



Propagation characteristics are different in each frequency band

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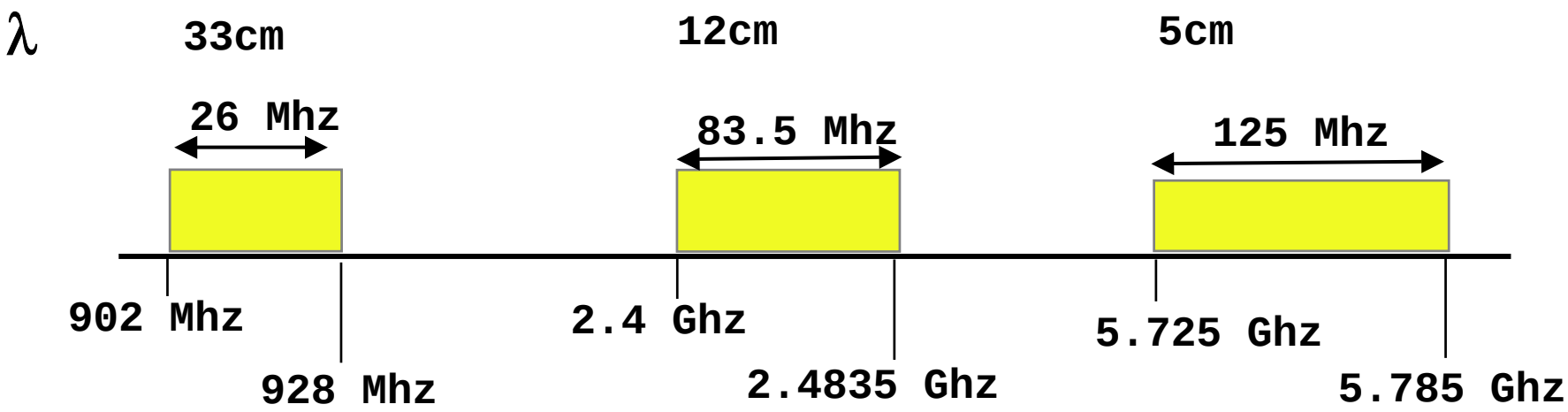
Unlicensed Radio Spectrum



cordless phones	802.11	unused
baby monitors	Bluetooth	
Wireless LANs	Microwave oven	

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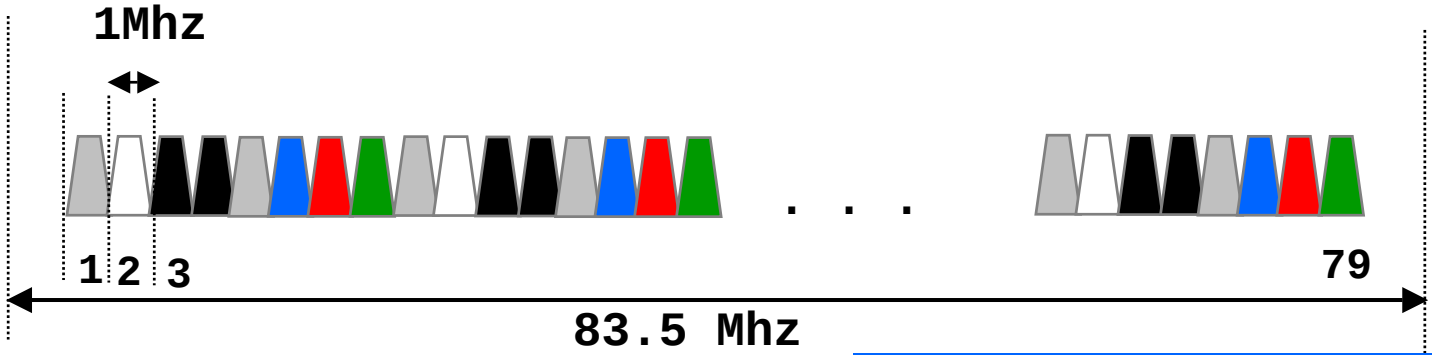
Bluetooth radio link

- frequency hopping spread spectrum
  - 2.402 GHz + k MHz, k=0, …, 78
  - 1,600 hops per second
- GFSK modulation
  - 1 Mb/s symbol rate
- transmit power
  - 0 dbm (up to 20dbm with power control)



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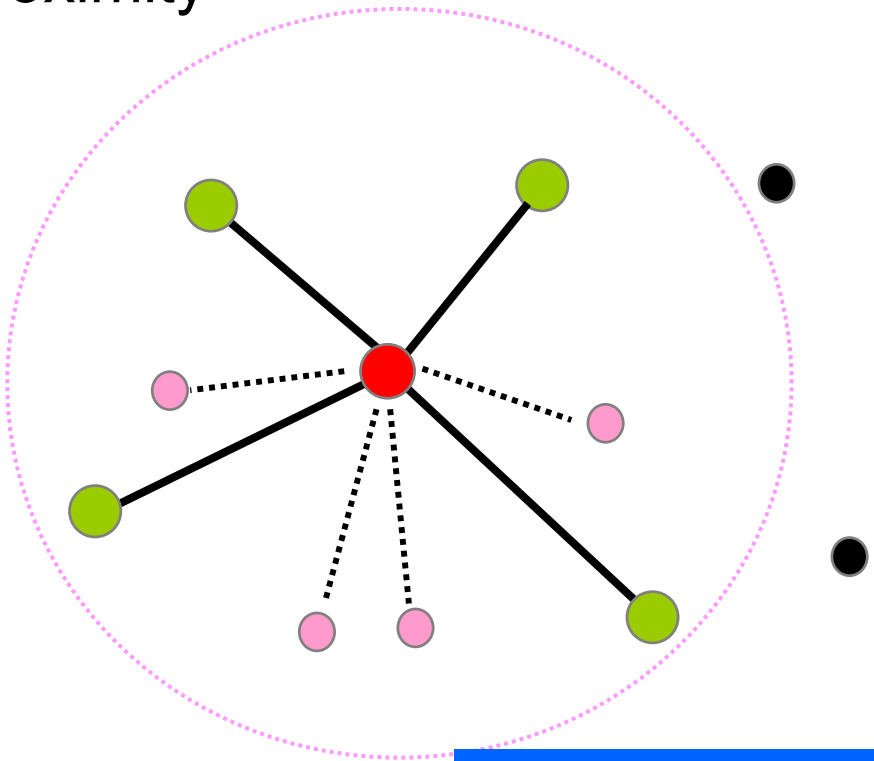
Piconet formation

- Page - scan protocol
  - to establish links with nodes in proximity



Master

Active Slave

Parked Slave

Standby

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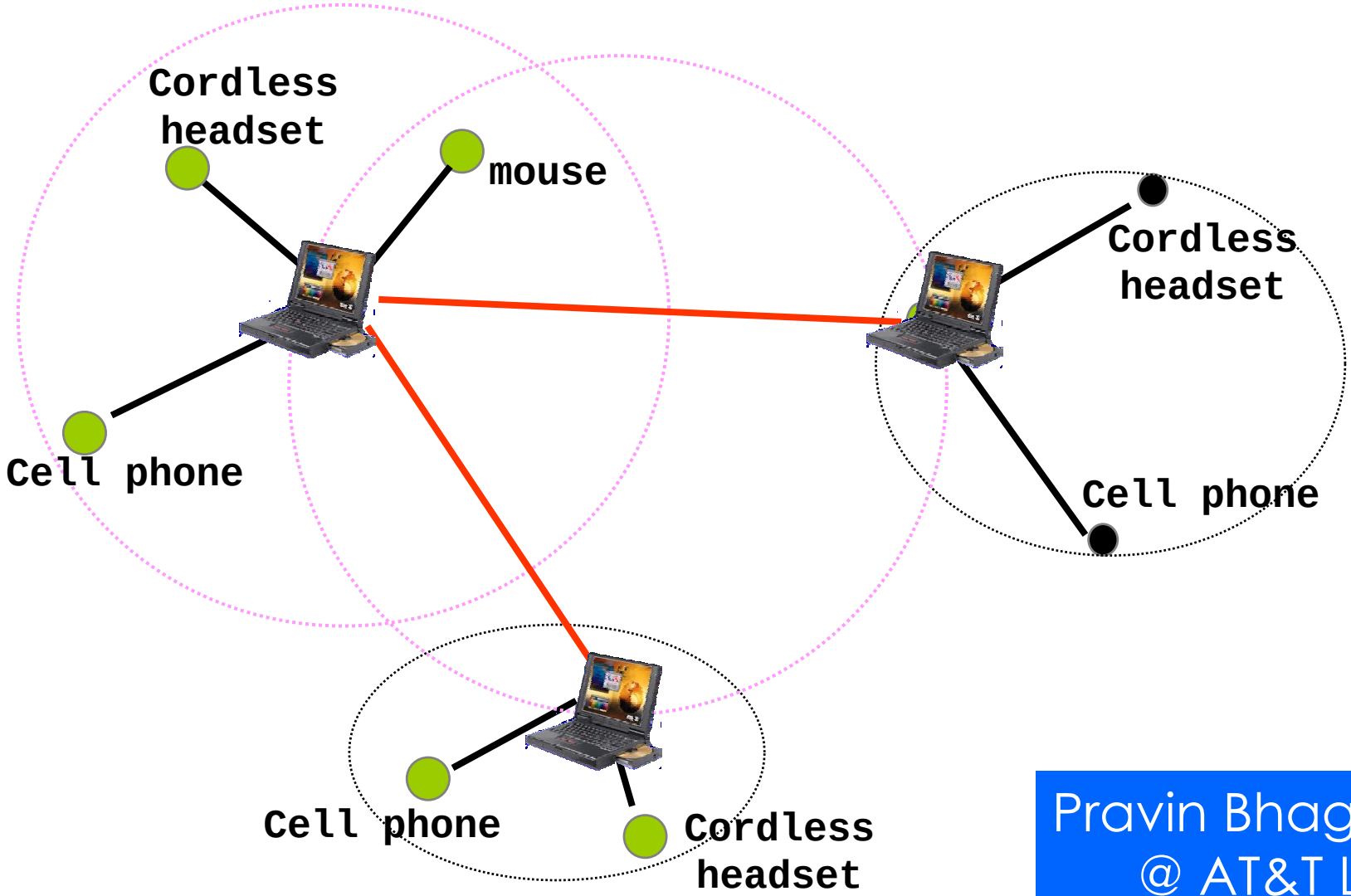
Inter piconet communication



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Discussion

- Wanted – killer app!!