
Generation 11: Wireless Data Moves Outside the Enterprise

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Wireless Arrives

- Within the last 2 or 3 years, wireless data has made the mainstream

Another case of sudden appearance of a technology that has been around in some form for decades!

E.g. Motorola's Ardis, designed for IBM in the early 1980's

- IEEE standards group 802.11 started around 1989 and took years and years...
- But if it had produced a standard promptly, it would probably have gone nowhere: the public really wasn't ready.
- Now we all have cell phones and believe that wireless does work.
- The original 802.11 standard was too slow at 1 or 2 Mbps
- But the next version... 802.11b at 11 Mbps
 - This time the world jumped aboard

The Wireless LAN

- **802.11 was designed to be a commercial LAN**
 - Operated and used by a single enterprise
 - Cost appropriate for commercial equipment
 - Lightweight security: wired-equivalent privacy
 - Mainly for data, but hooks built in for serious real-time priorities
- **Not intended as a home network**
- **Nor as a public network**
- **But its great advantage is being out there first**

The Famous 28% Solution

- Decades ago, Operations Research discovered the 28% learning curve:
 - When cumulative volume doubles, price goes down 28%
 - Applies to high and low tech alike, with only a few percentage points difference in the coefficient “teaspoons to B-29s”
- Therefore the cost advantage goes to the first entrant in the race, other things being at all equal
- 802.11 implementations are moving down the cost curve
 - **The only game in town for enterprise wireless data**

Home Networks

- **Here there is more choice**
 - **Wireless**
 - HomeRF
 - Bluetooth
 - IEEE 802.11
 - **Various technologies using existing wires**
 - Phone line (Home Phoneline Networking Alliance)
 - Power line (Home Plug)
- **The most important property is-- NO NEW WIRES**
 - This rules out Ethernet
 - Phone line and power line networks are OK but have disadvantages
 - Wireless is ideal

HomeRF

- Intended to be an affordable version of 802.11
 - Take 802.11 and cut it back for consumer segment
 - Add a fixed-rate voice channel borrowed from DECT cordless
- Initially 2 Mbps vs. 11 Mbps for 802.11
 - This doesn't compute!
 - Prices are similar: 802.11 has been coming down the curve
- A reprieve:
 - New spectrum allocation from the FCC in Sept. 2000
 - Will permit data rates of 10 Mbps
- But the backers are getting restless
 - Intel's move to 802.11-based home products

Enter Bluetooth

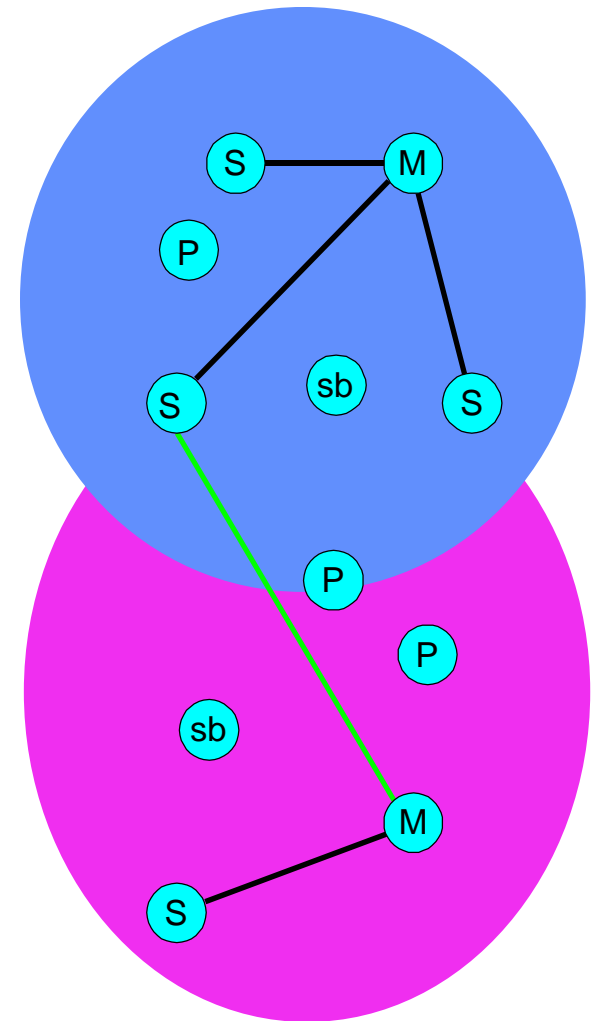
- A short-range wireless technology at 1 Mbps
 - Named for King Harald Bluetooth
 - noted for unifying Denmark and Sweden



- Interconnects a computer and peripherals
 - Clear the snake's nest behind the desk!
- Interconnects various handheld devices
 - Laptop computer, cell phone, palmtop
 - *Preplanning of network is impractical*
- Any short-range application where low cost is essential
 - Goal: \$5 parts cost, not reached yet
- Intended to be embedded in other devices

The Bluetooth network topology

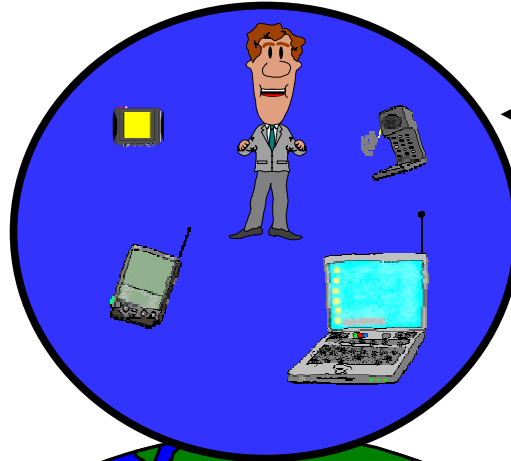
- **Radio designation**
 - Connected radios can be master or slave
 - Radios are symmetric (same radio can be master or slave)
- **Piconet**
 - Master can connect to 7 simultaneous or 200+ inactive (parked) slaves per piconet
 - Each piconet has maximum capacity (1 MSps)
 - Unique hopping pattern/ID
- **Scatternet**
 - Piconets can coexist in time and space



Wireless Positioning

Wireless LAN

On-campus: Office,
School, Airport,
Hotel, Home



Bluetooth

Person Space: Office,
Room, Briefcase, Pocket,
Car

Short Range/Low Power

Voice AND Data

Low-cost

Small form factor

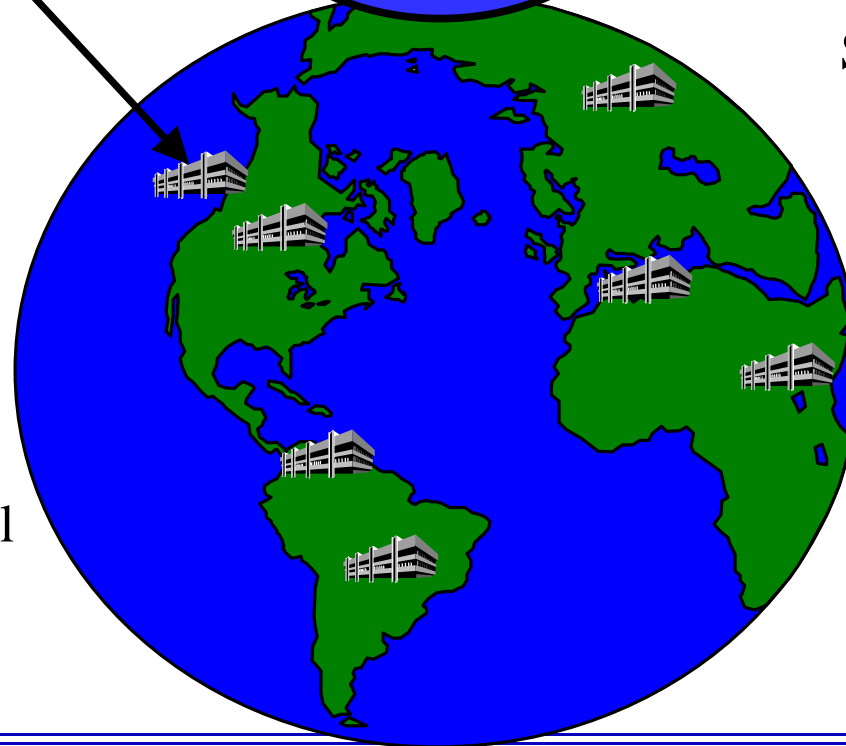
Many Co-located Nets

Universal Bridge

Technical Strategy Associates©

Cellular

Off-Campus Global
Coverage



IEEE 802.11 in the Home

- **Speed requirements**
 - 1 or 2 Mbps “line” speed OK for data
File transfer, info exchange between appliances, MP3 audio
 - 10 or 11 Mbps is better (obviously)
Simultaneous file transfers
Full-rate audio CD
MPEG 2 video is marginal
Need 8 Mbps for action scenes
No statistical multiplexing for 1 or 2 streams
 - 40-50 Mbps will be ideal (IEEE 802.11a)
Like V.90 modems, will not always reach max rate (54 Mbps)
Can support HDTV
Wired technologies (e.g. HPNA) will reach this range also
- **BIG advantage: use the office laptop at home.**
 - Laptops are starting to have built-in 802.11 with antenna in the lid

Home Networking Needs

- Raw data rate is not the only issue
- Need to support voice and video, possibly other real-time apps
 - Dell launches MP3 “radio” on home networks
 - Soon: the flat-panel monitor as portable TV
- Video doesn’t work with best-efforts service
 - Any other network activity renders it unusable
- Solution: use strong priorities
 - Based on deterministic considerations
 - Statistical priorities are insufficient



IEEE 802.11 is Addressing the Problem

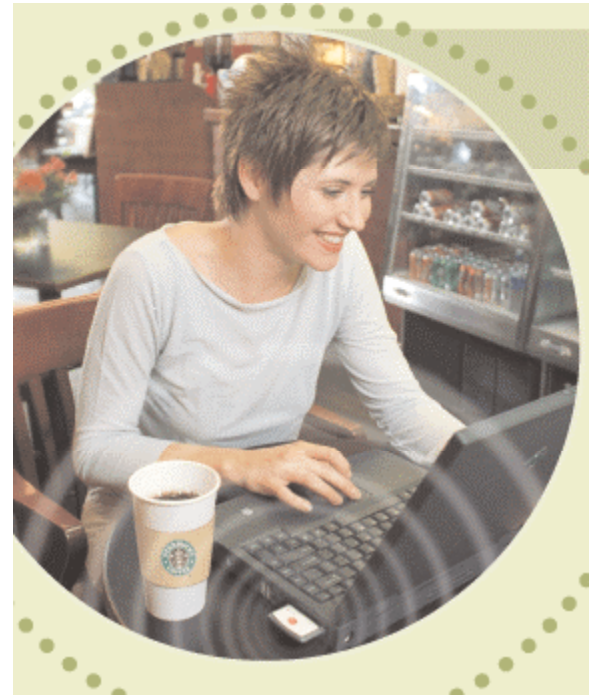
- **Two-fold approach in 802.11e (still under development)**
 - **Enhanced contention mode**
 - Priority traffic backs off less**
 - Collisions still occur, real-time traffic may still lose out**
 - **Point coordination mode**
 - Contention-free period coordinated by access point**
 - Strong priority for real-time traffic**
- **Legacy implementations stay out of contention-free period**
 - **Old and new equipment can co-exist**

Going Out in the World

- Again, several possibilities for wireless access
 - Metropolitan wireless data networks
 - Around for some time: 15 years for Ricochet service
 - Financial troubles: parent company (Metrocom) in chapter 11
 - New-generation cell phones
 - Data rates up to 2 Mbps with Generation 3
 - But a very complex migration scenario
 - Depends on whether carrier is CDMA, GSM, or whatever
 - Bottom line for carriers: a very large deployment expense**
 - Bottom line for users: no single standard**
 - 802.11
 - Coming to an airport near you, not to mention Starbucks

Networks in Public Meeting Places

- **Examples of 802.11 installation**
 - All North American Starbucks will have 802.11b nets
 - Subscription via wireless ISP MobileStar
- **Airports setting up networks also**
 - Logan: AA Admirals Lounge
- **Today: business travelers with laptops**
- **Tomorrow: general public with palmtops**



MobileStar

Transportation Networks

- **Special spectrum allocation at 5.9 GHz for roadside applications**
 - **Wireless LAN in transportation hubs**
 - **Examples: truck stops, weighing stations, toll booths**
 - **Pick up traffic info, whatever ... “telematics”**
- **Modified 802.11a chosen over competitors, August 2001**
 - **Radio section modified for 5.9 GHz**
 - **One gotcha: If the frequency is different can you tune in your laptop?**

Security Concerns

- **The world has discovered:**
 - 802.11 security is easy to crack!**
 - Cracking programs on the Web**
 - A passive attack works -- no transmission necessary**
- **The philosophy of 802.11 (and other wireless networks)**
 - **Wireless is physically insecure**
 - **Put in lightweight security features (wired-equivalent privacy, WEP)**
 - Make wireless as good as cleartext on a wire**
 - **Heavy-duty security should be dictated by the application**
 - Financial, credit cards, confidential corporate material, etc.**
 - **Problem is that most of these applications treat all data the same way -- email programs, file transfer, web surfing**
- **If WEP is too weak, everything is compromised**

Security Issues

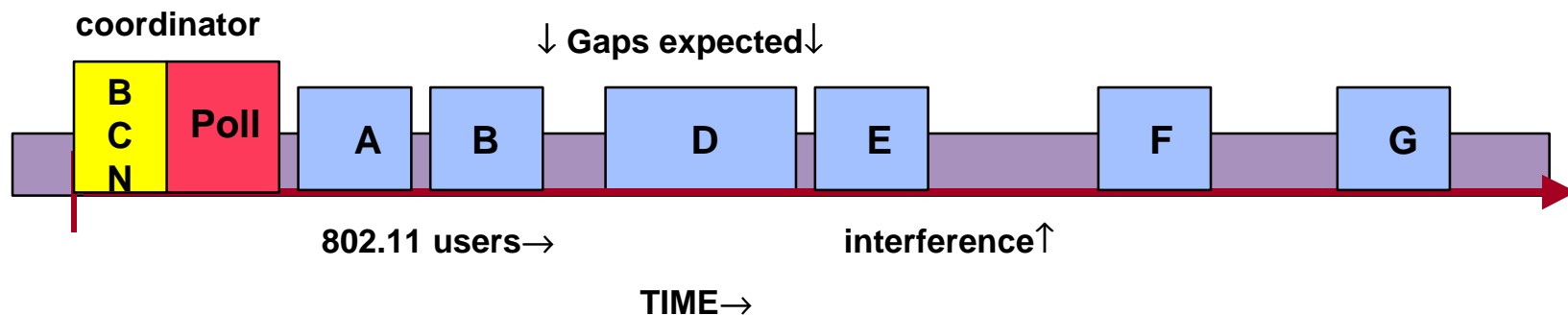
- Goal of the standard: to cover wireless link only
 - Eliminate wireless disadvantage of trivial physical access
- Why not use the existing 802 security standard, 802.10?
 - It sits above the LLC and MAC layers
 - Must be end-to-end as far as bridged LAN is concerned
 - Wireless is typically bridged at access point to Ethernet
 - Use of 802.10 would require it in all wired stations on bridged LAN
- Bottom line: 802.10 is neither air link only, nor end-to-end over TCP/IP
- Why not use full end-to-end security?
 - Fine if the destination has the same security features, e.g. VPN
- Security measures should fit the value of the information
- **But today's minimum (WEP) has proved to be too little**

Restoring Privacy: What to Do?

- **Leave home without it**
 - Just say no to email with your latte, read a book at the airport
- **Redo WEP**
 - Process is starting in 802.11, but products are a long way off
- **Tinker with WEP**
 - RC4 encryption algorithm per se is not the problem
 - Key strategy implemented in firmware not hardware
 - This can probably be improved on a relatively short schedule
- **Move to secure Internet capabilities**
 - IPsec encrypts at layer 3, not 2
 - Easy to add to some applications, not to others
 - Windows XP?
 - Can it be added to email?
 - Need to have it at both ends: mail server and client
 - But not needed at wireline end

Interference Concerns

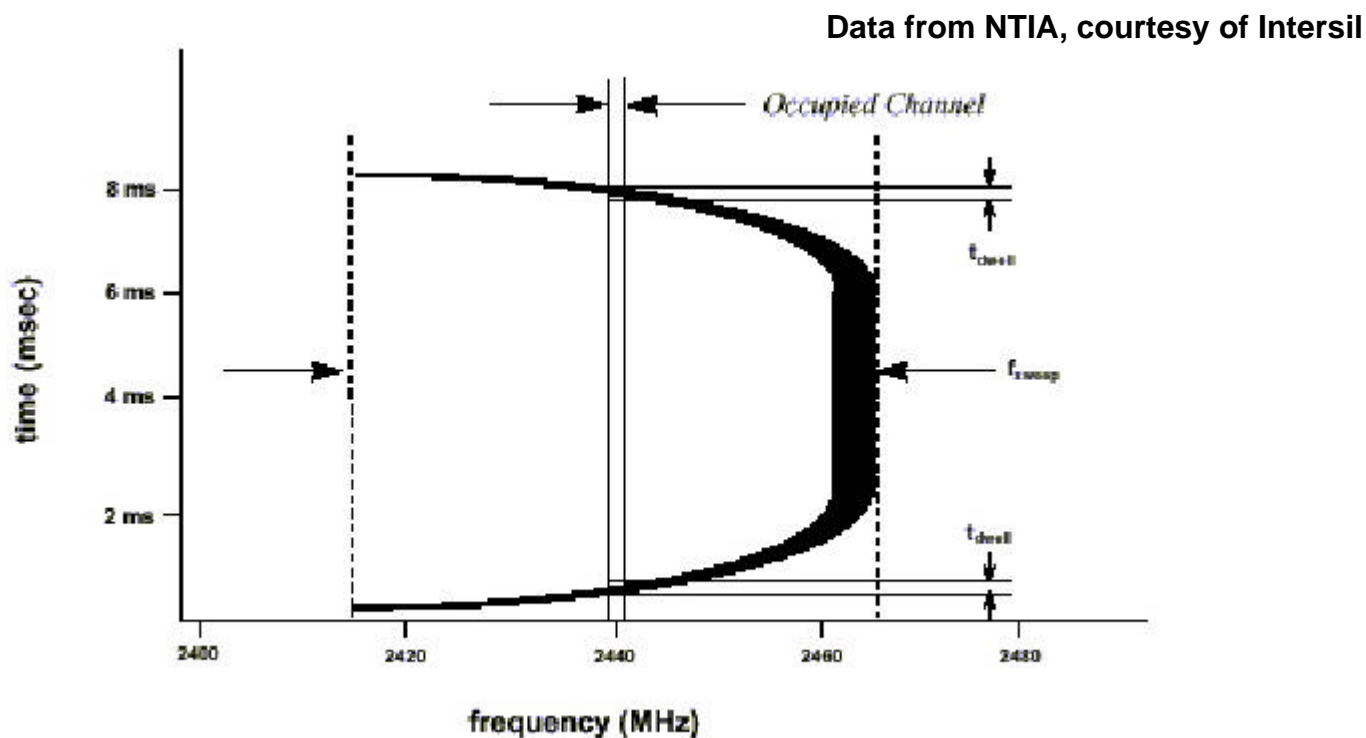
- Two levels of interference
 - Physical layer: interfering signal acts like noise
Spread spectrum technology minimizes this
Interference for a brief interval, then one or both systems move on
Error-correcting code may correct garbled section
 - MAC layer
Interfering signal may look like a rogue member of the network
For example, Bluetooth might confuse 802.11



- Good news: 802.11a at 5 GHz avoids most of these problems

Microwave Ovens

- Use RF induction heating, in the same frequency band as Bluetooth
- Do their own version of spread spectrum, varying the frequency as the AC line voltage rises from zero to peak



Microwave Lighting

- The next big thing in lighting, but RF emissions could be a problem
 - Argon plasma transfers energy to sulfur, which radiates light
- ISM band is legitimate for such applications
- Strong incentives for adopting microwave lighting
 - Most efficient broad-spectrum light known
(6x more than incandescent)
 - Sunlight appearance
 - High output
 - Very compact
- Emission limits established in Europe
- FCC working on the issue



Fusion Lighting, Inc.

Conclusions

- IEEE 802.11 has the lead
- 802.11b turned out to be at the right place at the right time
- May well be the protocol of choice for the home
- Definitely becoming the public access standard
- 802.11a with faster speed will replace 802.11b (gradually)
 - Also, it avoids interference sources at 2.4 GHz
 - Bluetooth
 - Microwave ovens
 - Plasma lighting in the future