Future Trends and Directions in Wireless

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What's Driving Wireless?

- Broadband
  - More throughput
  - Time-bounded communications
  - Bandwidth on demand
- Mobility
  - Form factors, environmental concerns
  - Power consumption
- Broadband and mobility *together* are a major challenge…
- *Ultimately:* eliminate the differences between wired and wireless

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Why Wireless *(sometimes)* Doesn't Work

- Multipath
- Fading
- Power limitations
- Interference and noise
- Antenna type and orientation
- Coverage
- Congestion (capacity limitations)

General Approaches

- More aggressive modulation
  - More bits/symbol, more symbols/Hz.
- Improved channel coding
  - Reliability – ECC
  - Efficiency
- Better electronics (analog -> digital)
- Being clever…

What Can Be Done?

- Wideband CDMA (W-CDMA)
- Orthogonal Frequency-Division Multiplexing (OFDM)
- Smart Antennas
- Self-Organizing Mesh (SOM) Networks
- Software-defined radios (SDRs/software radios)

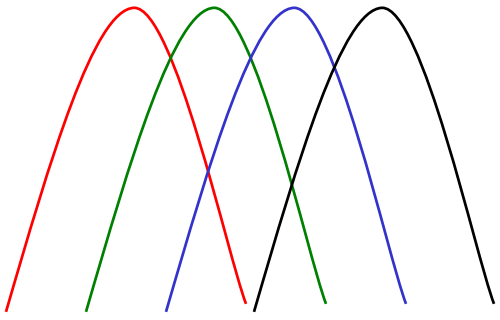
W-CDMA

- Essentially, CDMA using 5+ MHz. channels in place of IS-95's 1.25 MHz.
  - More bandwidth => more throughput
  - Design points are 144 Kbps, 384 Kbps, and 2 Mbps
  - Could be used just for more voice capacity
- No single standard
  - Most 3G systems will use W-CDMA in some form
  - The two key directions are UMTS/UTRA (4.096 Mcps) and CDMA2000 (1XRTT/3XRTT; *n* x 1.2288 Mcps)
- 1.25 MHz. channels remain important…

OFDM

- Essentially, an inverse multiplexing technique
  - Divide a single high-speed channel into multiple, parallel, lower-speed, non-overlapping channels
  - Very similar to DWDM
- Applying appropriate channel codes and interleaving can result in excellent throughput and reliability
- Used in IEEE 802.11a (WLANs)
- Others (e.g., Flarion)

OFDM Carriers



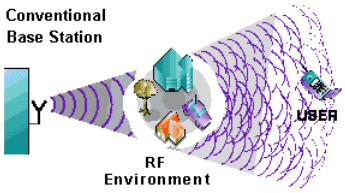
Four (in this case) non-overlapping, *interleaved* carriers

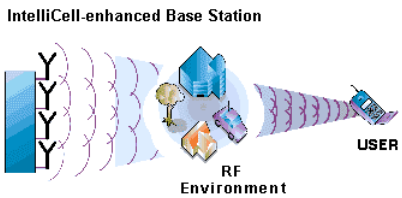
Source: Farpoint Group

Smart Antennas

- Based on *phased-array* technology developed by the military
- Directional
- Involve significant processing
- Steerable beams
  - Tracking and focusing
- Other related technologies: superconducting filters

Smart Antennas: IntelliCell



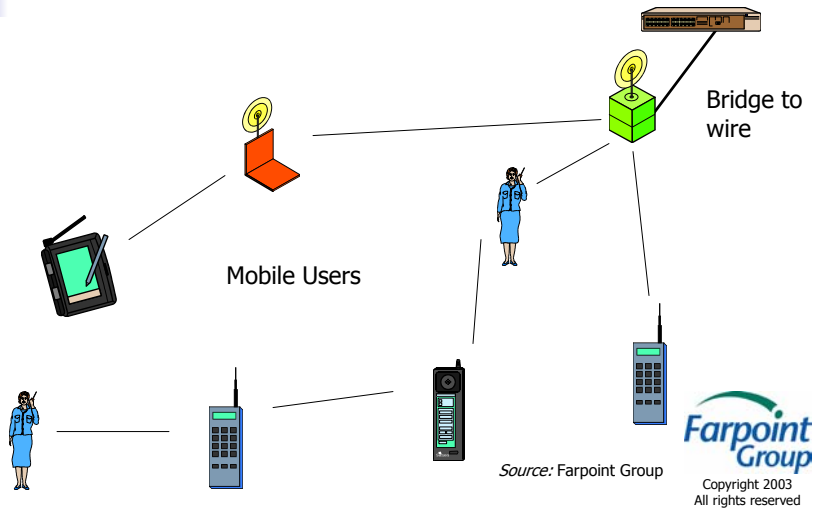


Source: Arraycomm

Self-Organizing Meshes

- Essentially, a cellular network but without the cells
- Each node can be (must be?) a router
- Bridges to wire still required (the more, the better…)
- Lots of issues – coverage, loading, battery life, security, …

Self-Organizing Meshes

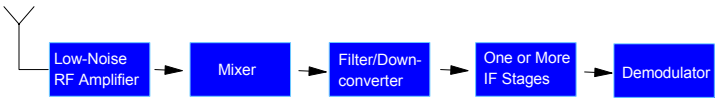


Source: Farpoint Group

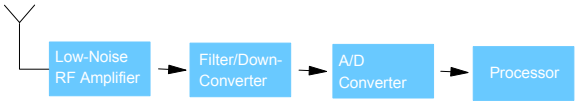
Software-Defined Radios

- Replace analog circuitry with digital
  - Thermal stability
  - Reprogrammability – multi-mission, bug fixes, value-added features, etc.
  - Improved performance and battery life
- Will be used extensively in 3G designs
  - Base stations initially, then handsets
  - Support for multiple RTTs
  - An end to "forklift upgrades"?

SDR – Conceptual Model



Conventional Radio



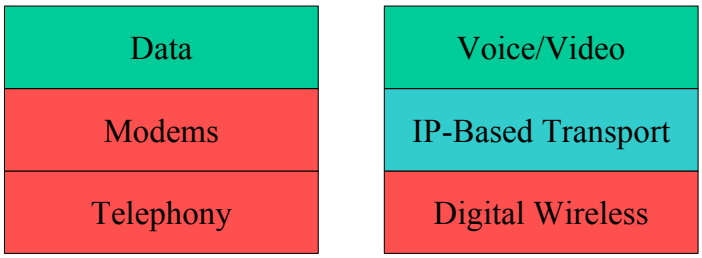
Software-Defined Radio

Source: Farpoint Group

Where Are We Going?

- Short answer: *4G*
- What is 4G wireless? Two schools of thought:
  - Ever higher throughput (e.g., 100 Mbps)
    - NTT has demonstrated this in the wide area
    - But: the throughput/distance tradeoff
  - "Inverted" wireless networks
    - Full support for time-bounded IP-based communications – not separate voice/data
    - Essentially, what the Internet was meant to be…
- The key is support for *native* IP transport

The Inversion



The Old Way

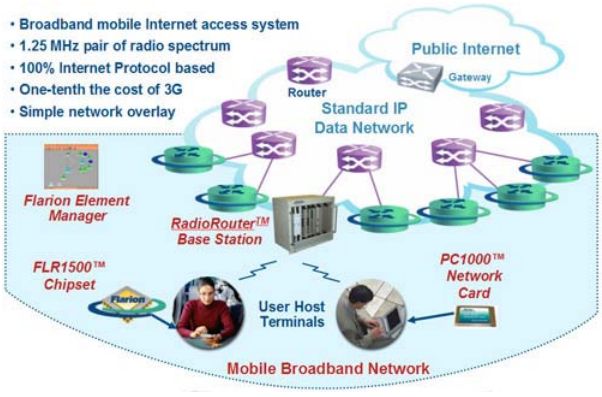
The New Way

Source: Farpoint Group

4G: Some Examples

- Flarion – Flash OFDM – to 3 Mbps
  - IEEE 802 Mobile Broadband Wireless Access Study Group
- Tantivy – I-CDMA – to 1 Mbps
- Qualcomm – 1xEV-DO and 1xEV-DV – 2.4 Mbps
  - DO now being deployed in Korea and Duluth (!)
- Mitsubishi - SwiftCOMM

4G System



Source: Flarion

Summary – and Conclusion

- We have the technologies – *today* – that will allow wireless to achieve parity with wireline
  - The big challenges may be financial and subscriber unit-related
  - Issues relating to time-boundedness can be addressed
- Wireless broadband will be here in less than 10 years
  - But: cost, cost, cost…

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