

## New Technologies and Old Regulation Are Changes Needed?

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February 27, 2002

## Overview

- Buzzword Technologies
  - Software Defined Radio
  - Ultra wideband
- Non-Buzzword Technologies
  - Multiuser detection
  - Better spatial reuse
  - More Sophisticated Unlicensed Services
- Concluding Thoughts

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## Software Defined Radio

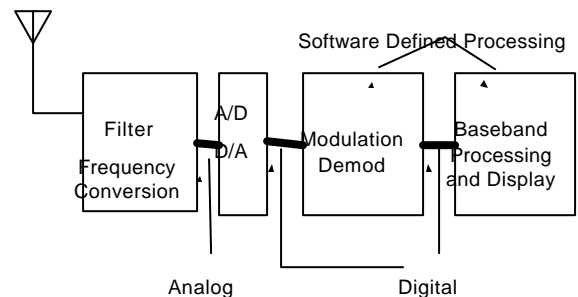
- What do electrical engineers do today?
  - Answer: Write C code.
- If radios are implemented in software, then a change in software can change the way the radio works.
  - One program—implement FM radio
  - Another program—implement TDMA radio
  - Another program — CDMA
  - A big, complicated program—FM, CMDA, and TDMA
- Fundamental architecture has been around for a long time.
- As chips improve, more and more functions of the radio can (and will) be done in software.

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## What is a Software Radio?



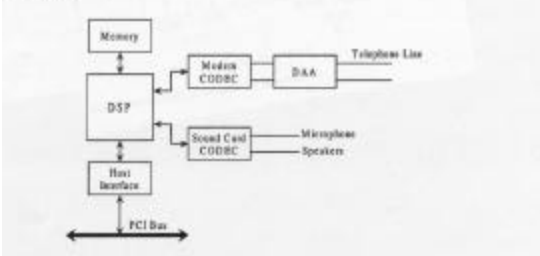
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## Modern Modem

Typical Block Diagram Combining Modem, Sound Card and Telephony Functions



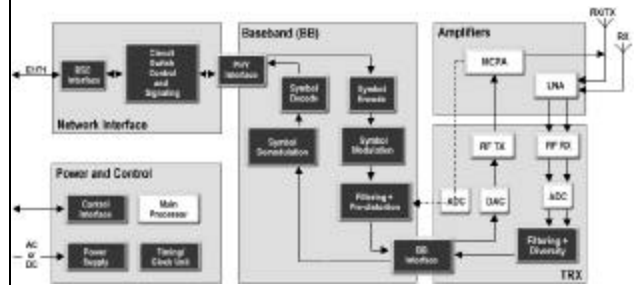
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## Second Generation Base Transceiver Station (TDMA)

- Taken from TI sales literature.



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## Scale of Activity

- Articles in professional journals
- DOD implementation
- Discussion in industry
- FCC Activities
- Google:, about 4000 hits for “software defined radio”
  - versus 2,860 for “Federal Communications Bar Association”
  - 433 hits for “Richard E. Wiley”

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## A Proponent’s View

- Software defined radio (SDR) has tremendous potential in the near term—in the United States to accommodate multiple bands/standards and in Europe (and other GSM countries) to integrate 3G applications. SDR can unite a world of diverse standards, technologies, and frequency bands.

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## Skepticism: Dr. Arthur Ross

- Proponents: well intentioned but misguided.
- Wishing away the limitations of device physics and then talking about all the wonderful things that a fully programmable radio could accomplish.
- It's a bit like assuming the existence of perpetual motion machines and then attempting to market all the wonderful applications of those machines.

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## Forecast and Assessment

- SDR is important for the military
- SDR will creep into commercial products
  - multistandard, for sure (have it already)
  - multiband? (unclear at this time)
- My Assessment
  - Useful but not earthshaking.
  - Will slowly be adopted in more and more radios.

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## UWB

- Very wideband pulses
- Low power at any specific frequency
- Wide variety of applications
  - Radars
  - Communications
- Possible sharing of existing spectrum
  - Feasibility of such sharing is a controversial issue!

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## My Assessment

- Useful
- Ultimate benefits unclear,
- Fun to watch the politics.
- Some proponents have overstated some arguments

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## Multi-user Detection

- Again, not fundamentally a new idea,
  - Recall hum -bucking coils in speakers and dynamic microphones.
- Many communications systems such as cellular and PCS are interference limited.
- Yet, the system (almost) knows what the interfering signal is
  - It detects the signals causing interference

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## Multi-user Detection II

- Multiuser detection (in outline)
  - Calculate the interfering signals
  - Subtract them from the received signal
  - Result is desired signal plus noise
  - Detect the desired signal
  - Loop back to first step (if necessary)
- Takes a lot of processing power

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## My Assessment

- Assessment—substantial increase in capacity of wireless systems
- Regulatory changes are not needed in order for wireless carriers to use this technology.

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## Spatial Reuse

- Again, an idea with a long history
- Directional antennas provide both
  - gain
  - protection against interference/jamming
- Use an array of antennas and the multipath environment to discriminate dynamically among multiple transmitters
- Takes a lot of processing power
- Static is easy (we do it in AM radio!)

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## ArrayComm

- Offers products today
- Focusing on wireless market
  - expanding capacity of base station
- First-generation technology

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## An ArrayComm Configuration

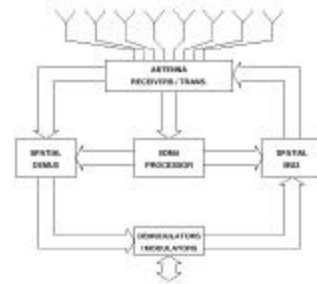


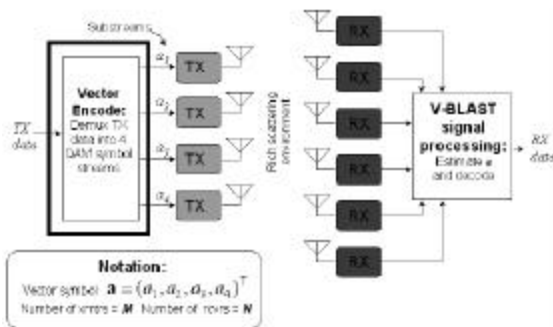
Figure 4. Possible configuration of an SDMA system.

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## Bell Labs Blast



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## Blast Performance

- Authors claim about 30 fold increase in capacity
  - IS-95 twenty users per sector at 9,600 bps
  - Blast 32 users at 154 kbps

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## My Assessment

- Will provide a substantial increase in capacity of wireless systems
- Regulatory changes not needed.

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## More Sophisticated Unlicensed Services

- More efficient operation by unlicensed devices
- Substitute electronics for manual coordination
- Significant economic benefits
- Regulatory changes needed here.

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## Shared Radio Bands

- “Spectrum-sharing rules can bring into play the incentives of equipment manufacturers to optimize the use of spectrum by their devices.”

– Y. Benkler, “Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment,” 11 *Harv. J. Law & Tec* 287 (1998)

- “There are certainly advantages to unlicensed open-access spectrum bands, as well as significant technical problems to be overcome.”

– J. Peha, “Spectrum Management Policy Options,” *IEEE Communications Surveys*, Vol. 1 No. 1 (1998)

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## Critique of Unlicensed Services: “Tragedy of the Commons”

- Famous paper by Garrett Hardin  
– *Science* 162(1968):1243-1248
- “Freedom in a commons brings ruin to all.”
- My wireless LAN works for me (more or less), but it increases the radio noise seen by my neighbors.

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## Key System Design Factors

- Power
  - Maximum power
  - Power in specific conditions
- Modulation
  - Robustness at a given data rate
  - Data Rate
- Antenna Pattern (directionality)
- Channel Selection (etiquette, e.g., listen before talking on a channel)

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## Research or Policy Topics:

- Etiquettes/DCA algorithms
- Coordination algorithms
- Homogeneous vs. heterogeneous systems in a band
- Rules for directional antennas
- Ways to control out-of-building emissions
- Location varying rules (rural vs. urban)
  - Should a 10-watt radio be permitted in rural Montana?

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## My Assessment

- Unlicensed systems—systems that use distributed methods for spectrum management—will become more important.
- A variety of regulatory changes are probably needed.
  - I can't tell you what they are!

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## Fundamental Conclusion

- New and improved technology will provide a substantial expansion of the capacity of radio-based systems.
- The demand for communications lawyers will not decline.

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