



Are the Tools the Rules?: The Future of the Digital Commons

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Magic and Technology and Mistakes

- Arthur C. Clarke's Third Law
“Any sufficiently advanced technology is indistinguishable from magic”
- Esther Dyson
“Always make new mistakes!”



Agenda

- Follow-on to Larry Lessig's book 'Future of Ideas'
- Developed from the two chapters on wireless issues
- Part of the 'Open Spectrum' movement
 - <http://www.reed.com>, click on 'Open Spectrum'



Kennard's Statement - 3/2000

- “All of the new technologies -- mobile phones, faxed, wireless computers -- are consuming spectrum faster than we can make it available, and we are in danger of a spectrum drought. We need to find spectrum to build the web of wireless applications that will continue to fuel our economic growth. The demand for spectrum is simply outstripping supply.”



Kennard's Proposals

- Establish as a goal that spectrum become like any other commodity that flows fluidly in the marketplace.
- Look to technology to provide better spectrum management tools, for example, ultra-wideband and software-defined radios (SDR).
- Promote greater spectrum efficiency



Powell Statement - 10/2001

- “Our nation’s approach to spectrum allocation is seriously fractured.”



Powell's Proposals

- DEREGULATE EVERYTHING
- House aide comment 4/19/02
“The FCC has no (3G) plan in place, they have no (HDTV) plan in place and most importantly, they have no spectrum management plan in place.”



Regulatory Precursors

- SS NOI in '81
- Introduced notion of wideband technologies (aka spread spectrum)
- Introduced 'spectrum overlay' as part of spectrum management toolkit
- NPRM in '84
- R&O in '85



Unlicensed Radio History

- FCC Part 15 in 1985
- WLAN products
- WMAN products
- Data-PCS at 1.9 GHz in '94
- Data-PCS at 2.9 GHz in '96
- U-NII Band in '97



FCC Roadblock

- Created back when radios were dumb and simple
- 20 years before Shannon created Information Theory, before RADAR, before digital electronics and distributed computing
- We've had 50 years to get it right, but rules still based upon 1934 technologies



Does spectrum have a capacity?

$$C = W \log\left(1 + \frac{P}{N_0 W}\right)$$

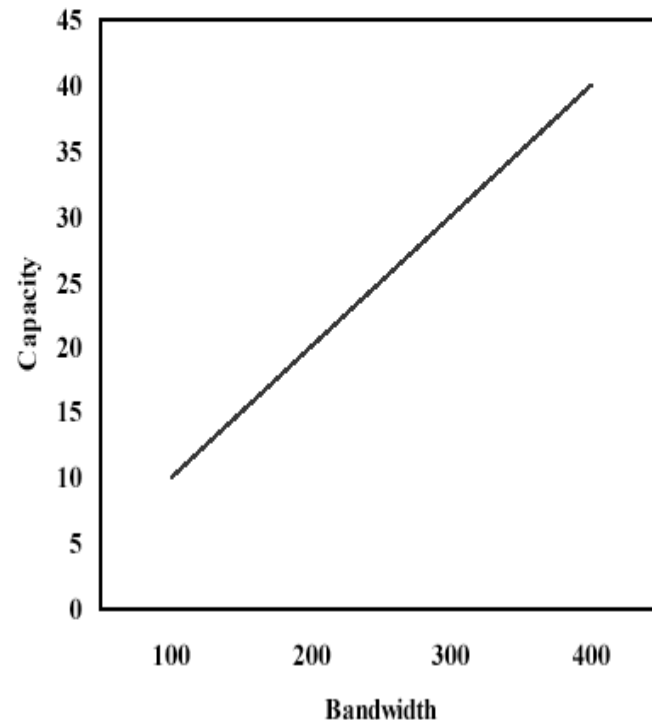
C = capacity, bits/sec.

W = bandwidth, Hz.

P = power, watts

N_0 = noise power, watts.

Channel capacity is roughly
proportional to bandwidth.





What Is a Software Defined Radio?

Software Radio (SW)

The ultimate device, where the antenna is connected directly to an A-D/D-A converter and all signal processing is done digitally using fully programmable high speed DSPs. All functions, modes, applications, etc. can be reconfigured by software.



Benefits of SDR

- Flexible
- Reduced Obsolescence
- Enhances Experimentation
- Brings Analog and Digital World Together

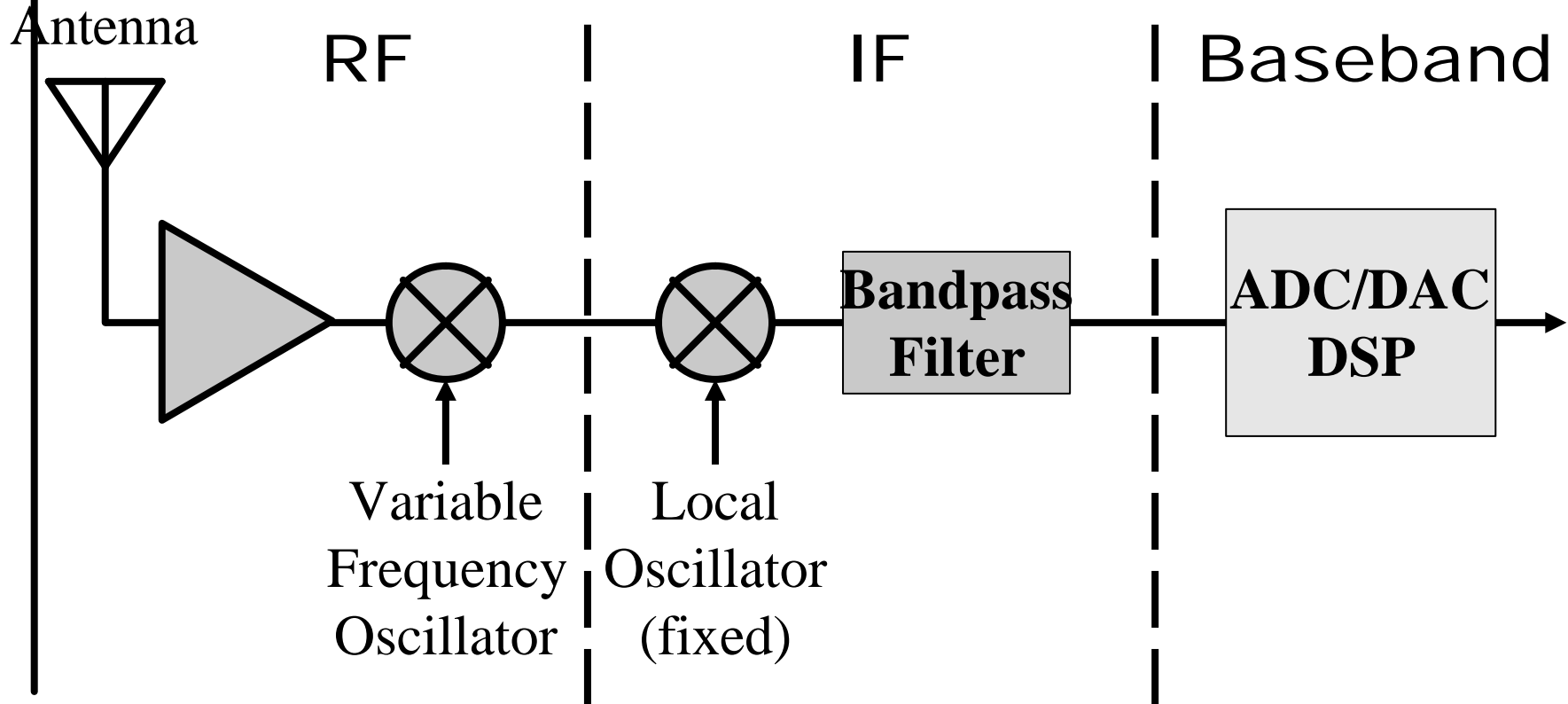


New Breed of Radio

- Reprogrammable
- Multiband/Multimode
- Networkable
- Simultaneous voice, data, and video
- Full convergence of digital networks and radio science.

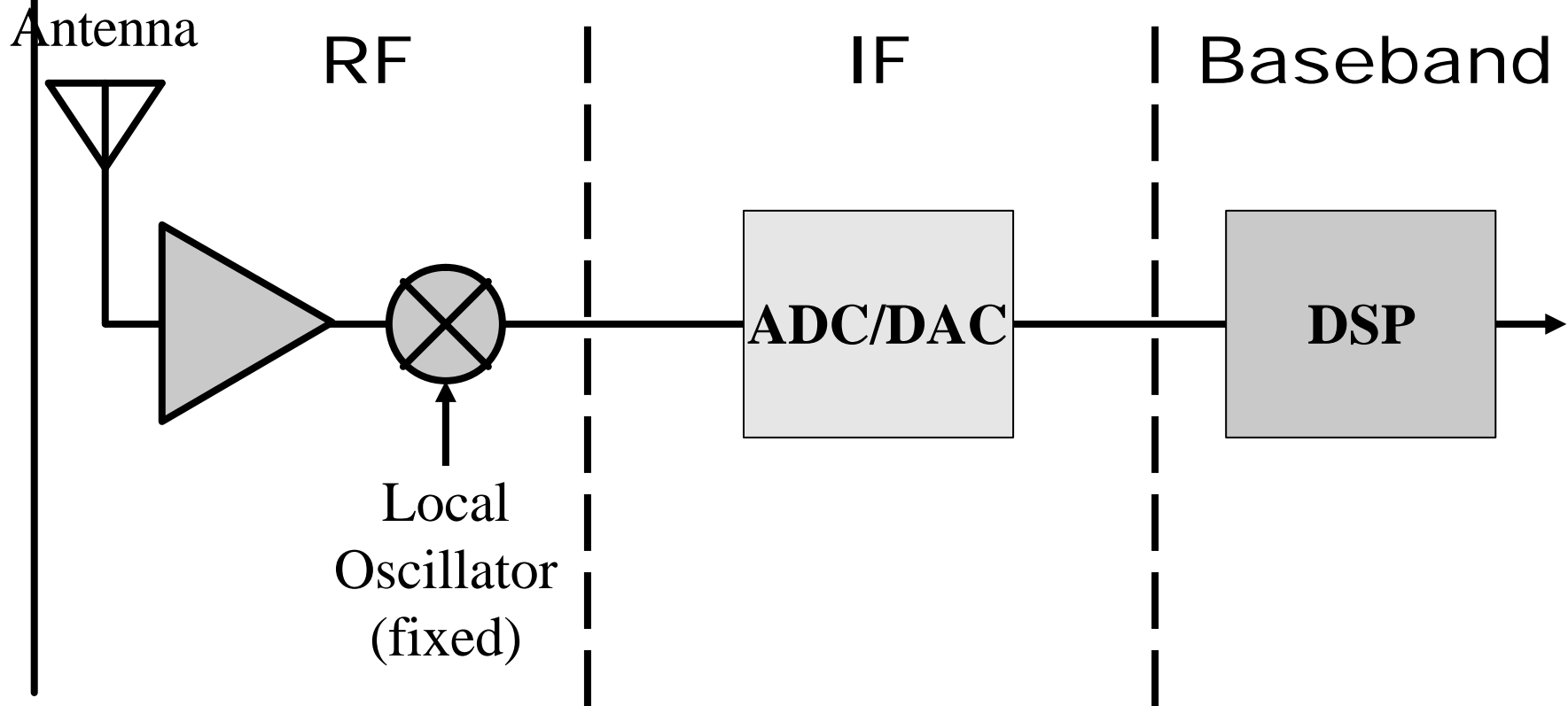


Block Diagram Software Defined Radio



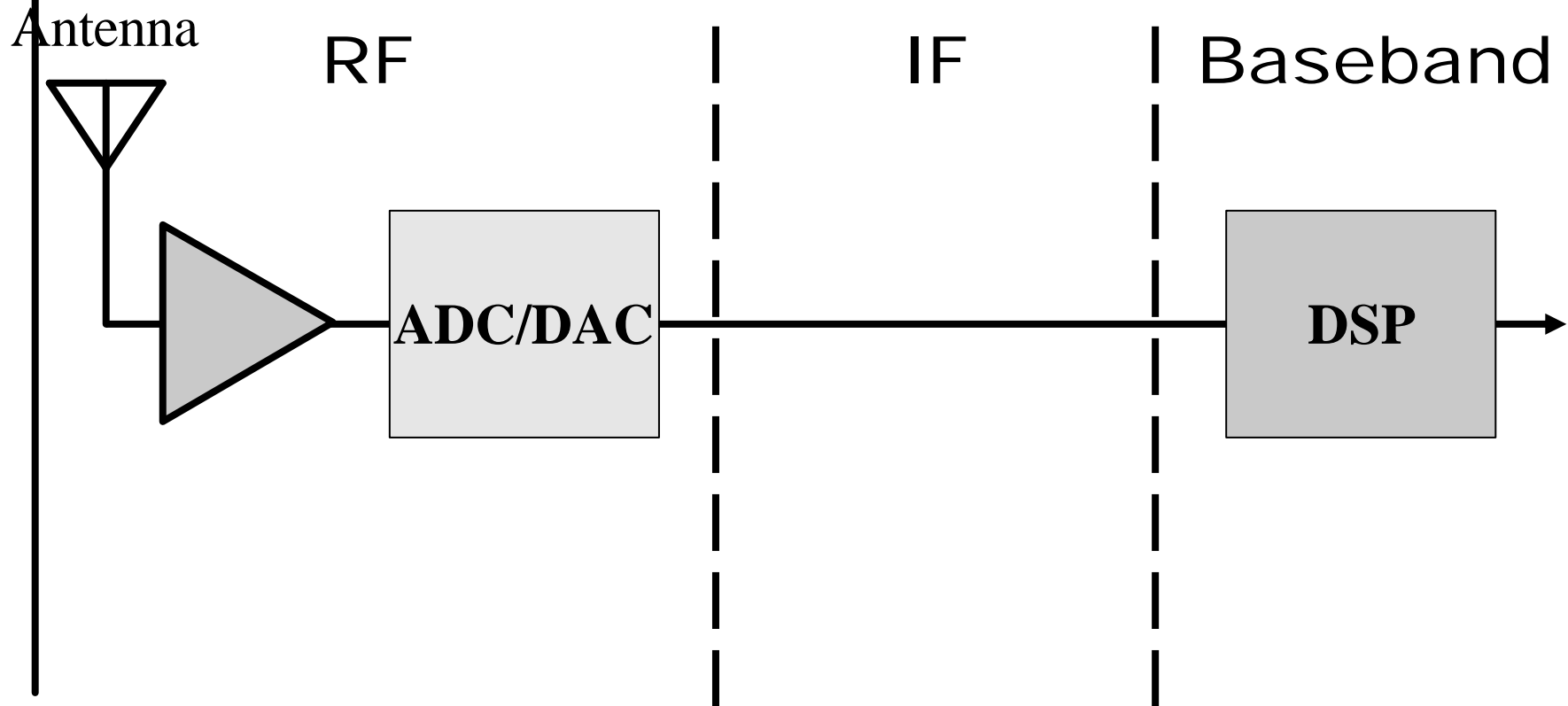


Block Diagram Software Defined Radio





Block Diagram Software Radio





Smart Radios

The positive control over the transmitter's use of the spectrum has traditionally been the purview of the radio operators, who were guided and trained to follow the rules of engagement carefully crafted during the course of decades to prevent harmful interference to other users.

The control of radio functions by software algorithms embedded into the future "smart" communications device will directly affect the manner in which that device uses the spectrum.



Smart Radio

- When combined with the software radio's ability to monitor the RF environment and precisely sense its location, the software radio opens the possibility of sharing spectrum among vastly different users.



What Is a Software Defined Radio?

Cognitive Radio (CR)

As radios embed increasingly complex and realistic models of their environments, users, and networks, they begin to approach what an outside observer might call rational, or common-sense behavior.



Regulatory effects of a Cognitive Radio

Frequency channels are no longer important
Capacity, Architecture and Scaling are important

Spectrum should no longer be treated as a scarce resource

Control not only the transmitter but also the receiver



CR 'Rules of the Road'

- Rule #1. Keep away from the big bullies in the playground. (Avoid the strongest signals.)
- Rule #2. Share your toys. (Minimize your transmitted power. Use the shortest hop distances feasible. Minimize average power density per Hertz.)
- Rule #3. If you have nothing to say, keep quiet.



CR 'Rules of the Road' (2)

- Rule #4. Don't pick on the big kids. (Don't step on strong signals. You're going to get clobbered.)
- Rule #5. Don't get too close to your neighbor. Even the weakest signals are very strong when they are shouted in your ear.



CR 'Rules of the Road' (3)

- Rule #6. If you feel you absolutely must beat up somebody, be sure to pick someone smaller than yourself. (Now this is a less obvious one, as weak signals represent far away transmissions; so your signals will likely be attenuated the same amount in the reverse direction and probably not cause significant interference.)



CR 'Rules of the Road' (4)

- Rule #7. Lastly, don't be a cry baby. (If you insist on using obsolete technology that is highly sensitive to interfering signals, don't expect much sympathy when you complain about interfering signals in a shared band.)



Wireless Bandwidth Trends

- 802.11 standards are forcing prices down for bandwidth
 - Now in steep slope of 'S' curve
- Cost for 45 Mbps will go from \$12K/link today to \$2K in one year; will approach \$500/link in two.
- Cost/bit/distance will strongly favor wireless over wired alternatives in rural areas where there currently are no wires



Regulatory Approach

- Develop/Evolve FCC & Congress strategy
- Start with simple exceptions
 - Power & EIRP
 - Frequency
- New Technologies
 - Real Spread Spectrum
 - UWB
- Explore use of SDRs



Summary

- Wireless is the 'wildcard'!
- Trends indicate that options and prices for broadband wireless are becoming more favorable
- More technology available than we know what to do with!
- Need to find a place where wireless regulatory issues are absent!!
 - Henry Goldberg (GGWW) Protocol - 1996
- Need to spread the word about what is needed and what is possible to industry and policy makers