SDR Platforms for Research on Programmable Wireless Networks

John Chapin
jchapin@vanu.com

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Outline

SDR components / terminology

Example SDR systems

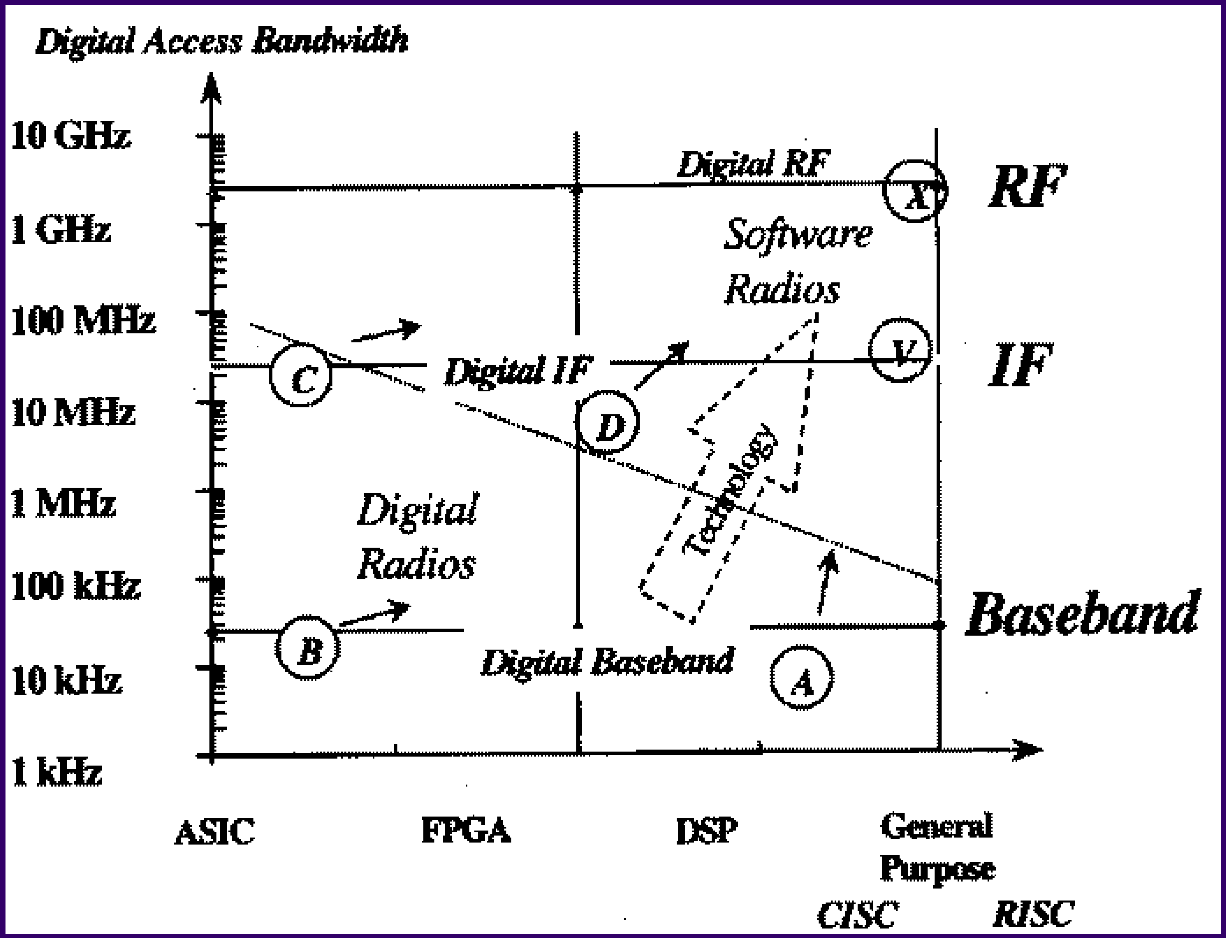
Limitations and opportunities

Opportunities

SDR Components / Terminology

Components	Signal Format Between Components
Host	
normal computer	
	user data bits
Signal Processing Subsystem	
high speed software, DSP, FPGA	
	digital samples
Transceiver	
A/D, D/A, digital filters	
	analog at IF (eg 70 MHz)
RF Front End	
frequency up/down converters	
power amplification	
RF filters	
	analog at RF carrier freq
Antenna	

One view of the SDR design space



A: HF STR-2000
B: COTS Handset
C: SWR Cell Site
D: SPEAKeasy II
V: Vanu, Inc.
X: Ideal SDR

Warning: old graph

Source: Mitola, Joseph. “Software Radio Architecture: A Mathematical Perspective”, *IEEE JSAC*, April 1999.

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“Normal” SDR

Host

- VME or CPCI

SPS

- Low-volume card with DSPs, FPGAs
- custom high-speed digital connection to transceiver
- digital access bandwidth in the 10s of MHz

Transceiver, FE

- Low-volume cards or external units

Issues

- expensive
- hard to program
  - languages, tools, partitioning, debugging
- resulting code not reusable

GnuRadio

Host

- Linux desktop

SPS

- normal C application on desktop CPU

Transceiver

- sound card, 30-40 kHz max DAB today

Front end

- external unit
- today: receive only, limited tunability

Issues

- cheap! great for student projects
- not yet capable enough for networking research
- watch for developments

Vanu laptop

Host 2 GHz x86 laptop

SPS C/C++ code on x86

Transceiver
6 MHz DAB (2 MHz practical)

RF FE
receive only
tunes from 20 MHz to 3.0 GHz

Waveforms today
FM broadcast, FM LMR,
APCO Project25
IS-91 AMPS, IS-136 TDMA,
GSM, IS-95 CDMA

Issues
Receive only
Expensive
- low-volume RF FE

Vanu handheld

Host HP iPaq

SPS C/C++ code on Xscale

Transceiver
- custom card
- 30 kHz DAB

RF FE
- tunes from 100 to 500 MHz

Waveforms
- FM LMR
- APCO Project25

Issues
- Hand built, no more being made

What the software is like

On handheld system

206 MHz StrongARM

APCO Project 25 waveform

24 percent of CPU at peak

27,000 lines of source code

260 kB

FM LMR waveform

30 percent of CPU at peak

3,900 lines of source code

495 kB (includes middleware library not counted in SLOC)

Vanu server

Host — normal rackmount server
dual 2.8GHz x86

SPS — C/C++ code on x86

Transceiver, RF FE
PCI card + external unit
25 MHz wide analog (8 MHz DAB)
fixed to cell/PCS frequencies

Waveforms
cellular infrastructure for GSM,
other standards

Issues
need spectrum license to use it
can’t talk to itself

Vanu laboratory system

Host

- high-end desktop running Linux

SPS

- C/C++ on main processor
- simplified source code so students can work with the SPS

Transceiver

- PCI card, 40 MHz wide analog (8 MHz DAB)

RF FE

- PCI card, 902 - 928 MHz ISM band only

First users

- NSF NRT testbed
- Stevens Institute, University of Colorado

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Mobile units

What you want

battery powered handheld

What you will get

wall-powered or large-battery device

laptop or small-box PC

- if goal of research is power reduction, must extrapolate

Why

integration engineering too costly

mass-market systems are TOO integrated

- can't reuse their subsystems in experimental platforms

High-speed WLANs

What you want

- 802.11b, 802.11a, bluetooth all in software where you can modify it

What you will get

- no 802.11a
- 802.11b or bluetooth only if developed specifically for this research community (e.g. $$)

Why

- WLAN boards are so cheap, no commercial reason to invest in SDR software or discrete RF front end hardware
- 802.11a digital access bandwidth is too high

Frequency flexibility

What you want

SDR that can operate over any band

What you will get

SDR that operates in a few bands

Why

Basic research needed on RF front end technology, antennas

- high-Q tunable filters
- linear wideband power amplifiers

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What research would you do if you could...

Experiment easily with new physical layers

Modify MAC and MAC/phy interactions

- cross layer optimization using information from network and app

Create dynamic physical layers

- control frequency, modulation, symbol rate, power, coding
  - on a packet-by-packet basis

Get much better telemetry/feedback

- observe bit error rate, noise level, collision info from inside phy

The bottom line

NeTS is seeking to stimulate a leap forward in wireless networking research

A software radio is necessary but not sufficient

- affordable platform?
- sufficient digital access bandwidth and frequency agility?
- easy to program and modify?
- resulting code reusable across platforms?

Vanu, Inc. is moving to address these needs

- what capability should be added to support your research?