Ham Radio: The Best 1,000 Hobbies you can Undertake

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Outline

• What is Ham Radio?
  • Can anyone really answer that question?
  • Why do you want to be a ham?

• Life Long Learning (and Technology)
  • What technologies do we use in Ham Radio?
    • Silicon, Firmware, Software, Maker, SDR, Internet, Cloud
  • Where are (some of them) headed?
  • How will it impact you? Our hobby?

• Ham Radio is a big playground.
  • Get your hands dirty
Wise Garbage Man,
Tell me why PowerPoint slides are so boring.
What is Ham Radio?

• Depends on your perspective.
  • Public Service.
  • Field Day, Contesting, DXing.
  • CW, SSB, Rag Chewing.
  • Antique Radios.
  • The list could go on forever.

• It’s 1,000 hobbies rolled into one.

• For many folks in this room:
  • It’s probably about technology.
    • Equipment, Software, Antennas, Physics, Science.
  • It’s about learning, knowledge, and teaching.

• Let’s look forward a bit.
Key Technologies

• Our future amateur operational & experimental capability is dependent on three key technologies:
  • Silicon
    • The foundation of modern electronics.
  • Computation
    • The ability to process information.
  • Data Networking
    • The ability to move (and store) information.
AS REQUESTED, I FIT MY PRESENTATION ON ONE POWERPOINT SLIDE.

I HAD TO USE ALL OF THE WHITE SPACE, BUT I THINK IT WAS WORTH IT TO FIT EVERYTHING ON ONE PAGE.

IT'S ACTUALLY ONLY ONE BULLET POINT, BUT IT'S A LONG ONE.
Silicon

• Many recent advances dependent on Silicon.
  • Especially: CPU, GPU, FPGA, RAM, FLASH, Ethernet

• Reduction in Silicon geometry:
  • Reduces Cost per transistor.
  • Reduces Power dissipation per transistor.
    • Power-per-unit-area still increasing
  • Increases Switching speed of a transistor.
  • Permits system-on-chip (SOC) due to phenomemal transistor count per die.

• However:
  • Features are smaller than optical wavelength.
    • Photo-lithography: Ultra-Violet, phase-masks, Extreme Ultra-Violet.
    • 7 & 10 nm devices may need 90 masks, ~$15m mask set.
      • High fixed-cost. Concern for low- & medium- production volume devices.
  • It’s getting difficult to turn off a transistor.
    • The channel is short, electric field can’t pinch off.
      • High-dielectric constant gate insulator, Fin-FET, Gate-All-Around FET
    • Gate oxide approaching 5 atoms thickness.
      • Quantum tunneling of gate charge into the channel.
  • CPU clock rate Power-Dissipation-limited last ~10 years.
New CMOS Silicon

• Integrated RF/Mixer + LO synthesizer chips becoming available.
  • Analog Devices, Lime Micro, Mirics to name a few.

• Provide range of input frequencies.
  • Mirics: 150 KHz – 2 GHz. [used in SDRPlay]
  • Analog Devices: 100 MHz – 6 GHz [used in Ettus SDR radios]
  • Lime Micro: up to 12 GHz (multi chip solution).

• Some paired with dual ADC + DSP + Host interface chip (USB typical).
• Some provide AGC, typically not for SSB.
Analog Devices AD9361

- Single Chip 70 MHz – 6 GHz.
- 2 Rx + 2 Tx (2x2 MIMO)
- 12-bit ADCs and DACs
- Channel BW: 200 KHz to 56 MHz
- Includes LNAs, LO Synthesizer, and RF AGC.
60+ GHz SDR Chipsets

- Growing interest in millimeter wave for 5G. Chipsets for 60-80 GHz available.
- Open source Gnuradio / Hittite drivers: Per Zetterberg.

HMC6001 Rx  
HMC6000 Tx  
60 GHz Transmitter board.
I found some numbers that support your strategic plan.

I had to take the square root of a negative number to do it.

The timeline is on this Möbius strip.

Good work.
Computer System Enhancements

- As experimenters, we need faster computer systems.
  - Can no longer get there via CPU speed.
  - Computer gamers driving Consumer bleeding-edge.

- Alternate approaches:
  - Speed up memory access
    - Larger on-die cache. 15 Mb on some devices.
    - Massive DRAM: servers now up to 1.5 TB
    - PCIe SSD replace mechanical hard drive (AHCI → NVME).
  - Parallel computing
    - 2017: Consumer CPUs increasing to ~10 cores / 20 threads.
    - Xeon / Epyc devices in 20~36 core range.
    - 2-4 Xeon devices per server.
  - GPU computation: 10,000 cores now feasible.
  - FPGA co-processing: Customized to the problem.

- I/O electrical signals soon becoming a bottleneck.
  - Multi-level signaling, active pre- and post- equalization
    - NRZ → PAM4: 25 Gsym/sec = 50 Gb/s per lane.
  - The reach is a couple inches on PC board.
  - 400GE = 25G PAM4 x 8 for 2~3 meter reach on twin-axial cable.
What is a Data Center?

• Cluster of 50,000~80,000 server blades.
  • Standardized HW, SW Virtualization.
• Makes networked parallelism affordable on an on-demand basis.
  • $0.015 ~ $2.00 per CPU hour depending on resources.
• CPU (increasingly also GPU) does almost any function
  • Datacom processing (NFV)
  • Application functions and services
  • Data analysis, search, filter/map/reduce, etc.
  • Signal processing.
• Massively interconnected Ethernet
  • High speed Ethernet switching, low cost copper and fiber.
  • 10 GE now leaking into high-end Consumer products.
• Computer System technology is driven by the data center.
  • Technology leaks into consumer products after several years.
YOU'RE PRETTY NEW TO CLOUD STORAGE, AREN'T YOU?
Software Defined Radio

• For many, it’s simply a different implementation of the same old radio.
  • Some new features enabled: adaptive pre-distortion, wideband noise mitigation, etc.

• What could SDR otherwise do?
• Form the basis of growing low-cost test equipment implementations.
  • Spectrum Analyzer, Network Analyzer.
  • Change FPGA image → Oscilloscope, Bode Analyzer.
  • RFI Test Set and signature analysis. Networked coherent localization.

• Capture wide spectral bands, transient capture.
  • Save to disk, or make available on the internet.
    • Post-contest sponsor verification.
    • Web-based SDR reception.

• Emergent silicon → Low-cost all-mode VHF, UHF, Microwave radios.
  • High performance point-to-point data links.
  • Radar-like applications with increasing resolution, excellent sensitivity.

• Citizen Science
  • Eclipse analysis, ionospheric sounding, sensor fusion.
Evolution of Mobile Radio

Downconverter
Analog Signal Processing

Downconverter
Fixed Digital Signal Processing

Block Downconverter
Programmable Digital Signal Processing

Block Downconverter
Radio Remote Head (RRH)

Base Band Unit (BBU)

Virtualized BBU (Data Center)

Gen

CRAN – Centralized Radio Access Network (Dedicated HW/FW/SW Processing Unit)

Cloud RAN – Cloud Radio Access Network (General Purpose Virtualized Processing)

* Common Public Radio Interface
Lessons from Mobile Evolution

- FPGAs made programmable DSP (and thus SDR) initially possible.
- Separation of the processing from the radio head makes the RF small, lower power, remotable.
- Virtualization of baseband processing uses general purpose CPU and GPU in a data center.
  - Eliminating dedicated hardware.
  - Supporting massive number of radio channels and antennas.
  - Providing flexibility, easy to change.
  - Chaining functions, coupling to the internet.
Ham Radio example of the Evolution

- FPGA makes the second generation of SDR much more performant.
- Local general purpose CPU (and GPU) can process baseband information.
  - **New capability**: advanced signal processing
  - **New capability**: wideband spectral recording and analysis.
- Condensation and chaining of information onto the web (e.g. WSPR spots).
  - **New capability**: propagation analysis.
Error 404: Road not Found
Connections (James Burke, BBC)

• 1978 (UK) 1979 (USA) TV Series.
• Self-motivated ($) individuals invent (seemingly) unrelated technologies.
• These form a web of interconnected technologies that lead to new inventions that no one anticipates.

Conjecture:
Consumer Computing and Networking advances +
Open-source HW, FW, and SW make discovery and sharing vastly easier.
= Much more rapid solutions that can’t be easily anticipated.
“If you don’t read the newspaper, you’re uninformed. If you read the newspaper, you’re mis-informed”

-- Mark Twain

- Your personal experience, experiments, projects, and measurements are more valuable to true understanding.
- Build, Experiment, Publish.

- Invent Ham Radio hobby # 1001
THAT CONCLUDES MY TWO-HOUR PRESENTATION. ANY QUESTIONS?

DID YOU INTEND THE PRESENTATION TO BE INCOMPREHENSIBLE, OR DO YOU HAVE SOME SORT OF RARE "POWER-POINT" DISABILITY?

ARE THERE ANY QUESTIONS ABOUT THE CONTENT?

THERE WAS CONTENT?