

Hydra

An Open Source Wireless Testbed

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July 23, 2008

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2 Hydra

- Implementation Options
- High-level Overview
- Nitty-gritty details

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Wired network \neq Wireless network

Traditional wired-network assumptions break down in the wireless world.

- The medium is half-duplex broadcast, not full-duplex point-to-point
- Channels vary in time and frequency domains
- Mobility results in rapidly changing link states

What we study

Wireless communication at the PHY, MAC, and routing layers.
Particularly,

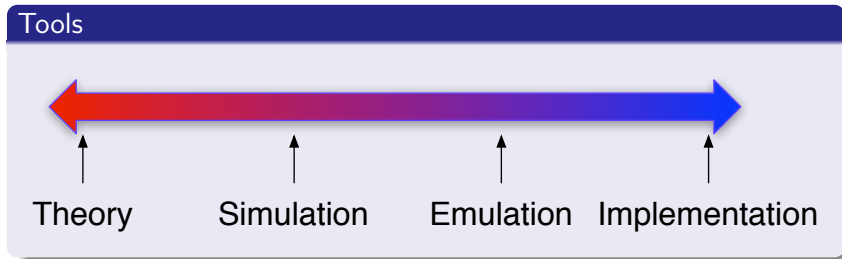
- Cross-layer algorithms (e.g., rate adaptation)
- MIMO (multi-antenna systems)
- Multi-hop networks

Why we study this stuff

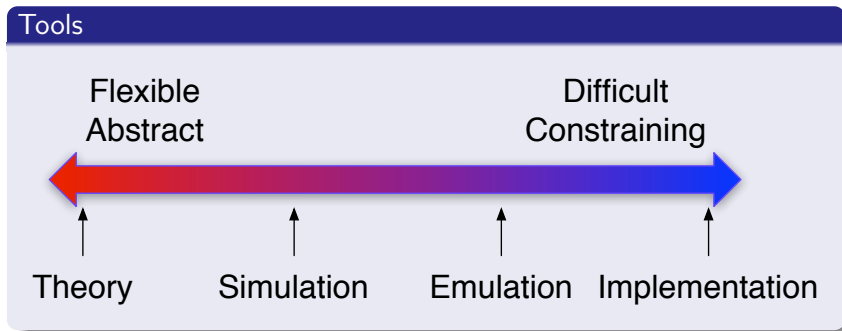
Practical research for the next generation of wireless networking.

- Ad hoc networking can extend network range, help networks scale, and connect places previously unconnected by traditional networks
- MIMO and cross-layer algorithms can help improve network performance

How we study wireless networks



How we study wireless networks



Current Open Source Tools

- Theory - GNU Octave, R
- Simulation - NS2, OMNeT++
- Emulation - Emulab, NS Emulator
- Implementation - GNU Radio, IT++, Click

Weaknesses of Current Open Source Tools

- NS2, OMNeT++ - Difficult to get details of wireless right in simulation
- Emulab, NS Emulator - Built for wired networks, though people are trying to extend them to wireless
- GNU Radio, IT++ - Good tools, but low level. GNU Radio was built for stream processing, not packet processing.

Hydra

Goal

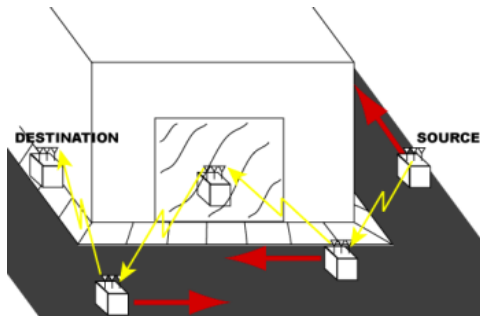
Develop a flexible platform for wireless research and experimentation which uses real channels.

Implementation Options

- Application Specific Integrated Circuit (ASIC)
 - Great performance
 - High cost
 - Difficult to change, revise
- FPGA
 - Easier than ASIC to modify
 - Commodity part = easy to obtain
 - Still requires hardware knowledge to develop
- Software Defined Radio (SDR) Platform
 - Acceptable (but worse) performance
 - Highly customizable
 - Does not require hardware knowledge to program

Hydra

An open-source, flexible testbed for wireless experimentation, almost entirely in software.



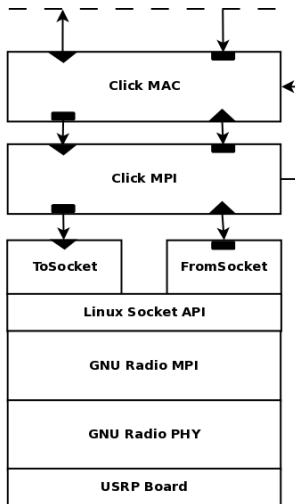
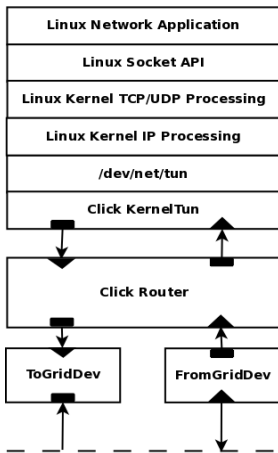
Hydra Node



High Level

- Each node is a general purpose x86 machine
- Upper layers are GNU/Linux
- Link layer and MAC layer are implemented in Click Modular Router
- PHY layer is implemented in C++ and wrapped in GNU Radio
- Hardware is one or more Universal Software Radio Peripheral (USRP) boards, attached via USB

Hydra Block Diagram



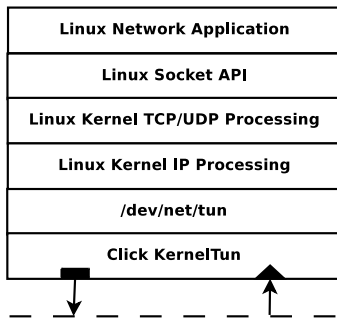
All Open Source Components

- The USRP - all FPGA code and designs are open!
- GNU/Linux operating system
- GNU Radio Software Radio Framework
- Click Modular Router
- IT++ (and its dependencies)
- C++, Python, and SWIG
- GNU Octave (in the works!)

The Upper Layers

Hydra runs standard applications (ping, Firefox, Apache, FTP). Works through the Linux TUN device

- A virtual network device (/dev/net/tun)
- Allows Click to send IP packets from userspace to the Linux kernel's IP processing code
- Allows the kernel to pass IP packets to Click in userspace



Link Layer

Media Access Control: Distributed algorithms for determining transmission priority. i.e., “Who gets to talk when”

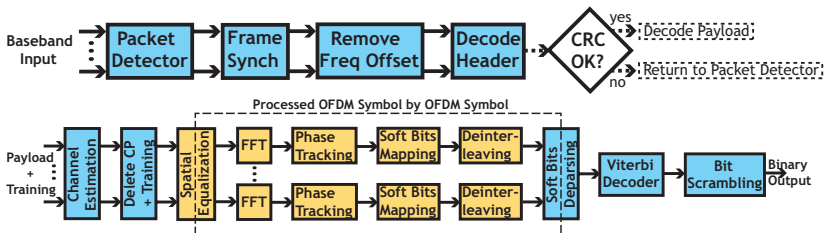
Click Modular Router

- A modular packet router which integrates with Linux.
- Can run in either user or kernel mode.
- Creates an additional network interface which applications can use seamlessly.
- Current MAC implementations: 802.11, plus experimental protocols such as RBAR, OAR and others.
- Using C++, we define “blocks,” and then connect those blocks in a flow graph.

Physical Layer

- 802.11a and 802.11n style physical layers implemented
- Implemented in C++ using the IT++ communications library
- Entire physical layer wrapped in a single GNU Radio Block
- Visualizations written using Matplotlib, wxpython

Physical Layer



Side Project: Octave Integration

- Our current physical layer is written in C++
- Most physical layer researchers are used to MATLAB
- Solution: GNU Octave, an open source version of MATLAB

Octave Integration Structure

Client/Server architecture

- TCP server interface to USRP
- TCP client in GNU Octave
- Physical layer in GNU Octave
 - Functional structure. A series of transformations on data to transmit or receive.
 - Runs in Octave and MATLAB
 - Custom unit-testing framework

Research

Mostly in cross-layer MAC/PHY algorithms

- Physical layer rate control
- MAC frame aggregation
- MIMO
 - Beamforming
 - Limited feedback

Future

- More experiments – Hydra is starting to stabilize as an experimental platform
- More nodes – scale up our test network
- Make easier to use. . .
 - More documentation
 - More visualization
 - More experimental tools
 - Easier network administration
- Release code – backend cleanup!
- Expand Octave integration
- Use in the classroom

Demo Time

BAM

Questions?

Resources

- Hydra: <http://hydra.ece.utexas.edu/>
- GNU Radio: <http://www.gnu.org/software/gnuradio/>

Obligatory Sponsor Info

- National Science Foundation, under grant CNS-626797
- Office of Naval Research (ONR), under grant number N00014-05-1-0169
- DARPA IT-MANET program, under grant W911NF-07-1-0028