Motivation to Teach Network Hardware

- **Research and Education**
  - Students Today
    - Build network systems mostly with software
  - Students Tomorrow
    - Can quickly learn to also build system components in hardware

- **Interesting Topics for Networking Hardware**
  - Switching and Routing
    - Gigabit-rate networking
  - Network Security
    - Intrusion Detection and Prevention Systems (IDS, IPS)
  - New Protocols
    - Wire-speed Content Routing and Clean-slate designs
Networking Hardware Education

- **CS344 Course @ Stanford**
  - Build an Internet router in 8 weeks
  - Hardware forwards packets
  - Software implements pw-OSPF

- **CSE565, CSE566 Courses @ WU**
  - Accelerate Networking algorithms in hardware
    - TCP/IP Flow processing
  - Build a Reconfigurable Networking System-on-Chip
    - Intrusion Detection and Prevention Systems
cs344: Build an Internet Router in 8 weeks

- Stanford class offered Spring ‘03, ‘05, ‘07
  - Laboratory utilizes NetFPGA hardware

- Organized as student teams working on projects
  - One hardware developer + one-two software developers

- Results
  - Students start with baseline
    - Two port learning Ethernet switch
    - pw-OSPF software
  - Students build
    - Four-port Gigabit-speed Internet Router
    - Hardware performs MAC address learning & IP forwarding
    - Software performs OSPF distributed routing

NetFPGA Platform

- **Function:**
  - 4 Gigabit Ethernet ports

- **Fully programmable**
  - Entire datapath in FPGA

- **Low cost**
  - Widely deployable platform

- **Open-source FPGA hardware**
  - Routing hardware base in Verilog

- **Embedded Software**
  - Host PC,
  - Embedded PowerPC, and/or
  - Soft-core LEON or Microblaze
Details of the NetFPGA (ver 2.1)

- Fits into Standard PCI Host Interface
- Provides 4 Gigabit Ethernet Interfaces
- Enables hardware-accelerated processing of content using Field Programmable Gate Array (FPGA) logic & attached memory
  - Virtex-2 Pro FPGA
  - 4MB ZBT SRAM
  - 64MB DDR2 DRAM
NetFPGA Reference Development System

- **Chassis**
  - Open-window case
  - Thermal sensor on FPGA

- **NetFPGA**
  - Standard PCI Interface
  - Four Gigabit Ethernet Ports

- **Host NIC (optional)**
  - Two Gigabit Host Ports
  - PCI-Express bus

- **Processor**
  - Dual-Core Athlon-64
  - 2 Gigabytes DRAM

- **Operating System**
  - Linux CentOS 4.4
  (or Fedora Core, RedHat .. )

Internet2 Machines - Tested fine with the NetFPGA

NetFPGA properly recognized in PCI-X slot

Dell 2950
with PCI-X and PCI-Express Slots
Streaming Video through the NetFPGA

- **Video server**
  - NetFPGA Router
  - Apache Web server

- **Video client**
  - Windows Media Player
  - Linux `mplayer`

- **Video traffic**
  - MPEG2 HDTV (35 Mbps)
  - MPEG2 TV (9 Mbps)
  - DVI (3 Mbps)
  - WMF (1.7 Mbps)
Explore Router Architecture with GUI

GUI Configuration
• Router Quickstart configuration

Reference details
• simple
• modular
• pipeline

Project Homepage: [http://NetFPGA.org](http://NetFPGA.org)
Request Hardware: http://NetFPGA.org

Upcoming NetFPGA Tutorials

- **SIGMetrics**:  
  - Half-day Tutorial  
  - June 12, 2007  
  - San Diego, California  
  [http://www.cs.cmu.edu/~sigm07/workshops.html#TUTORIAL_2](http://www.cs.cmu.edu/~sigm07/workshops.html#TUTORIAL_2)

- **Hot Interconnects**:  
  - Full-day Tutorial  
  - August 24, 2007  
  - Stanford, California  
  [http://www.hoti.org](http://www.hoti.org)

- **NetFPGA Homepage**  
  [http://NetFPGA.org](http://NetFPGA.org)