

# Network Processing in Reconfigurable Hardware

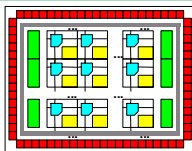
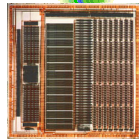
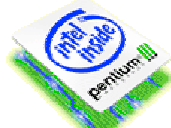
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## Technology Options for Network Processing



- **Microprocessors**

- ✓ Fully Reprogrammable
- ⊗ Optimized for general purpose computing
- ⊗ Sequential Processing

- **Custom Packet Processing Hardware**

- Highly concurrent processing
- ✓ Optimized for specific networking application
- ⊗ Static Functionality

- **Network Processors**

- ✓ Fully Reprogrammable
- Some concurrent processing (8-32 cores)
- ✓ Some hardware optimized for applications

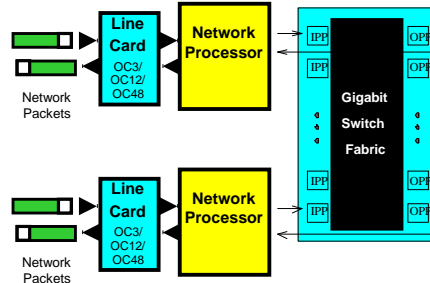
- **Reconfigurable Hardware**

- ✓ Fully Programmable
- ✓ Highly concurrent processing
- ✓ Hardware optimized for specific application

## Properties of Ideal Network Processor

- **High Performance**

- Fast Network Interfaces
  - OC48 (2.4 Gbps) and better
- Hardware Accelerated
  - 10 Million packets/second +



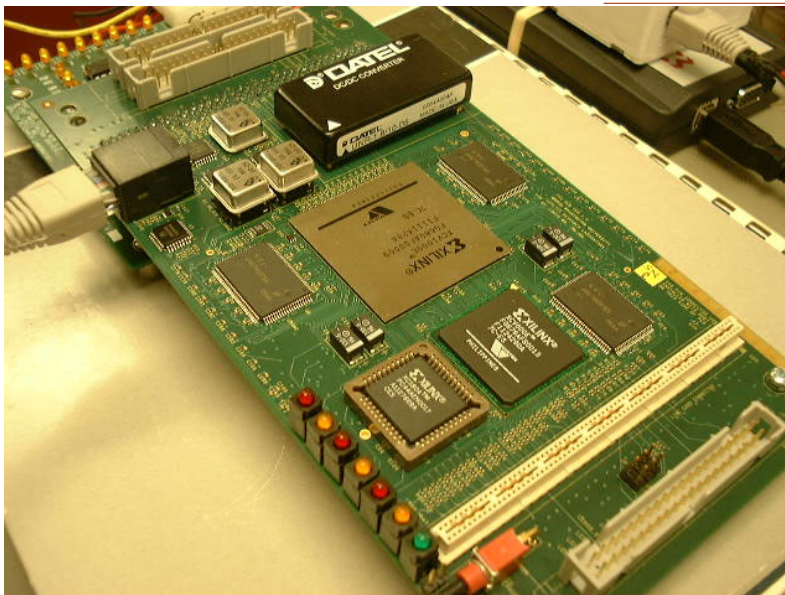
- **Fully Extensible**

- Fully Programmable
- Modular Plugins

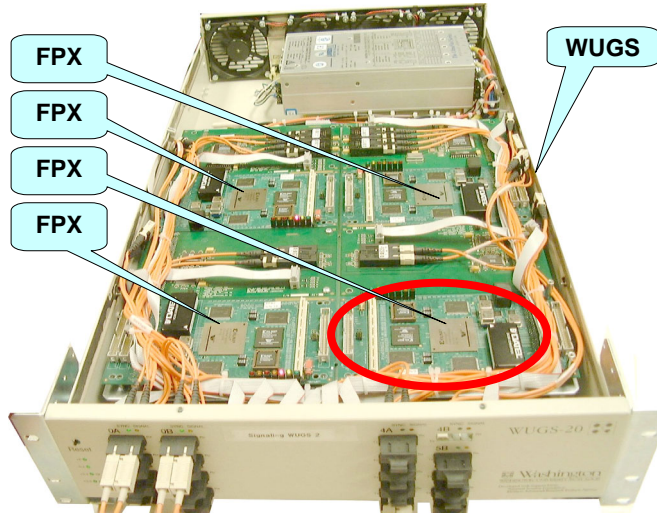
- **Open Interfaces**

- Open switch interface
  - Device fits into existing switch and firewall
- Open hardware interface
  - FPGA modules can be added and combined
- Open software and signaling interfaces

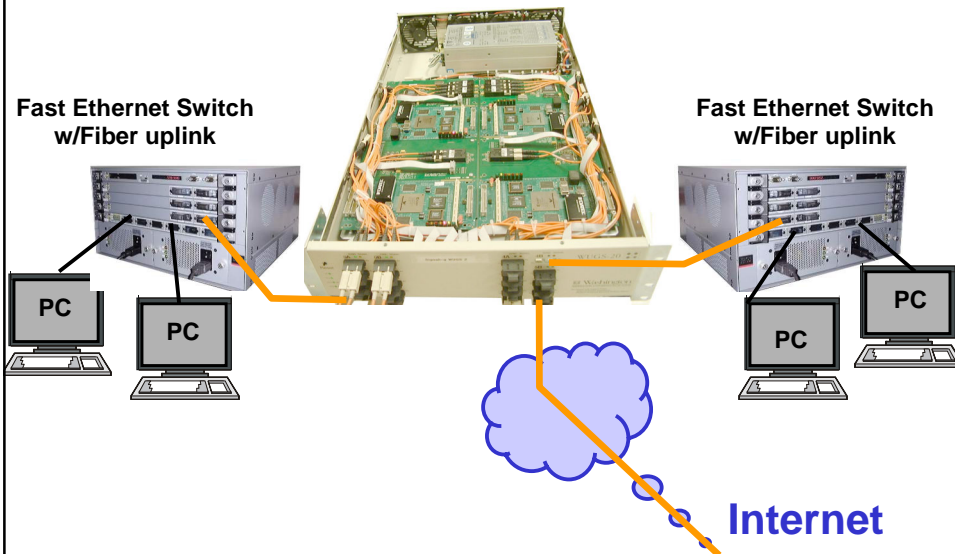
## Field Programmable Port Extender (FPX)



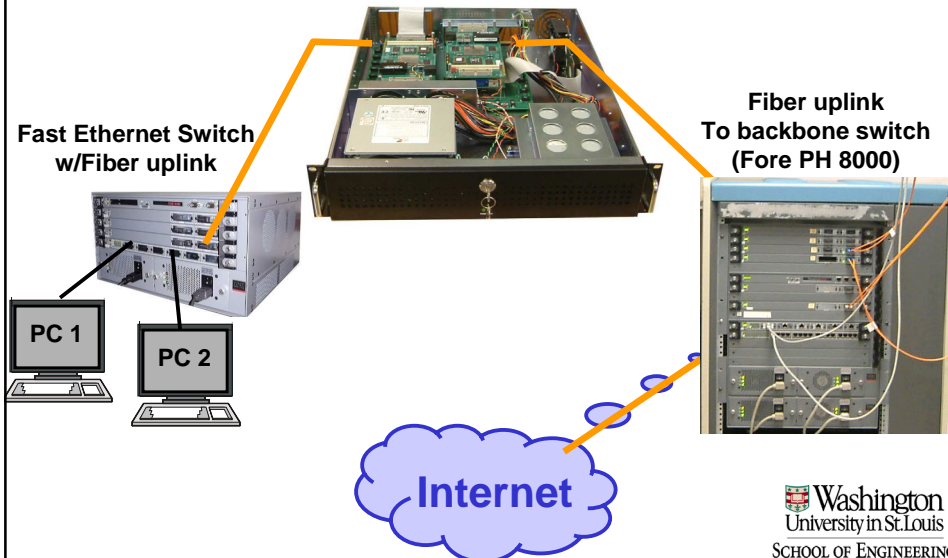
## FPX in Washington University Gigabit Switch



## Using FPX & WUGS Process and Route Packets



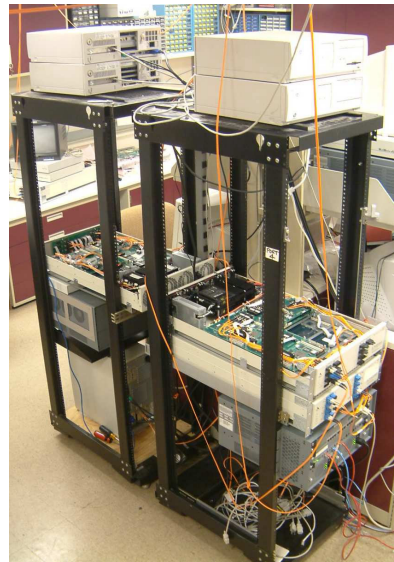
## FPX “in a box” Firewall Configuration



## FPX Platform platform developed



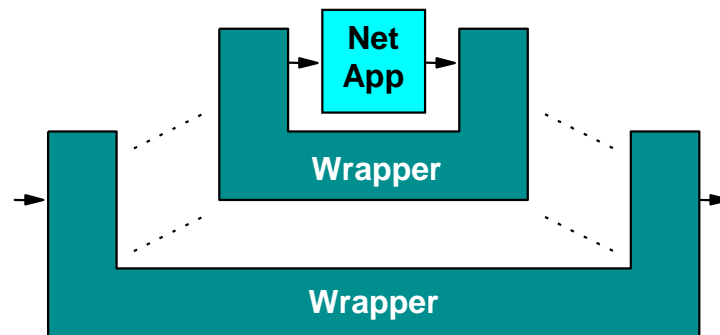
**FPX combined with WUGS to route and process Internet packets**



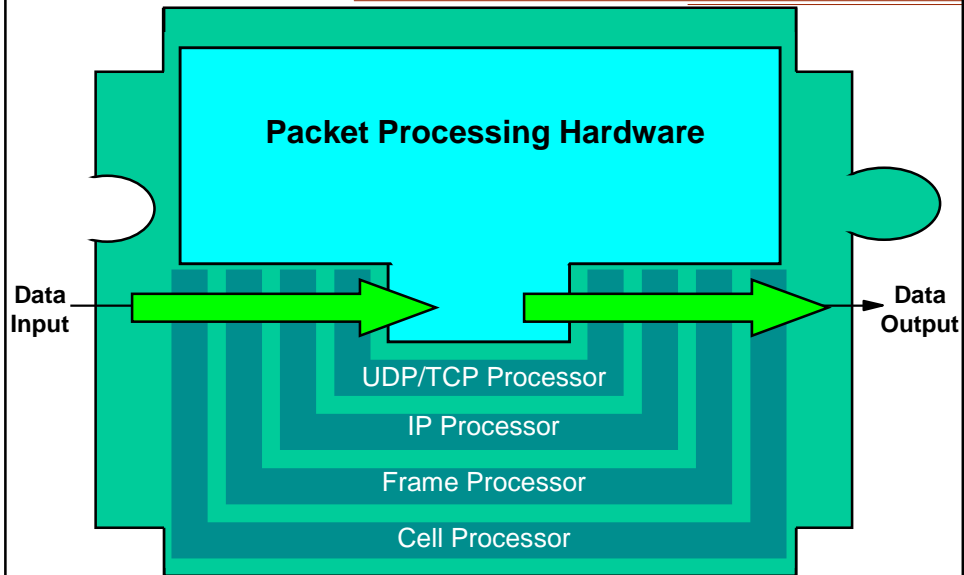
## Properties of a Module

## Payload Processing Environment

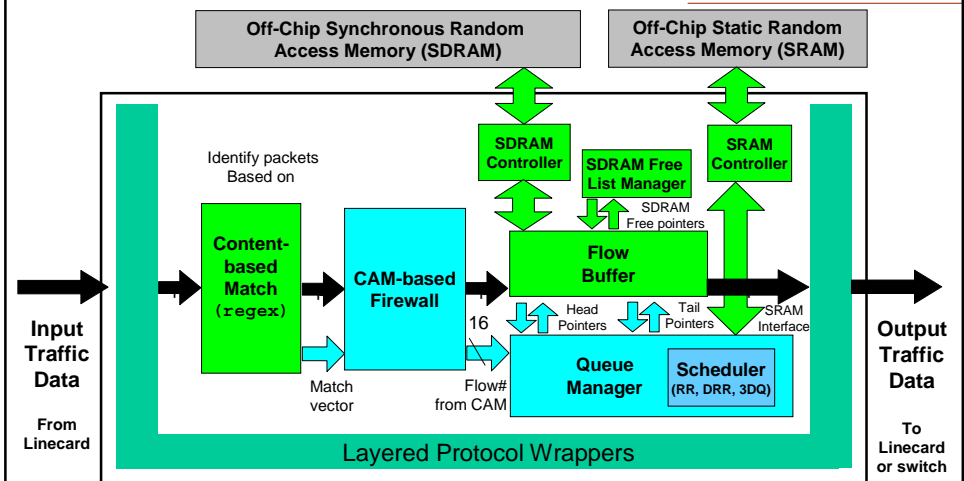
- Network applications benefit from higher-level data abstractions
- Protocol Wrapper Framework provides a simple interface to multiple layers of a Network



## Layout of typical FPX Hardware Module

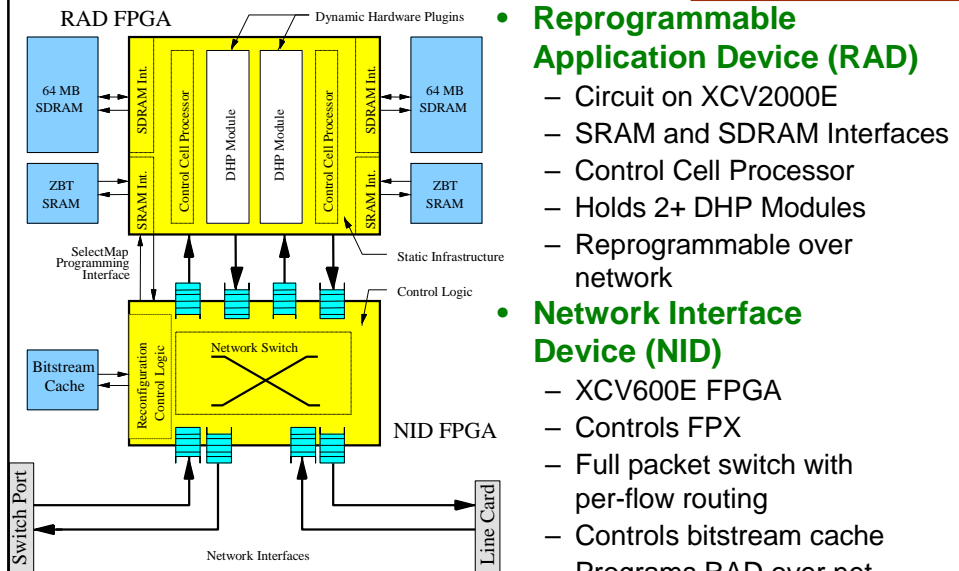


## Content-Aware Firewall on a Chip

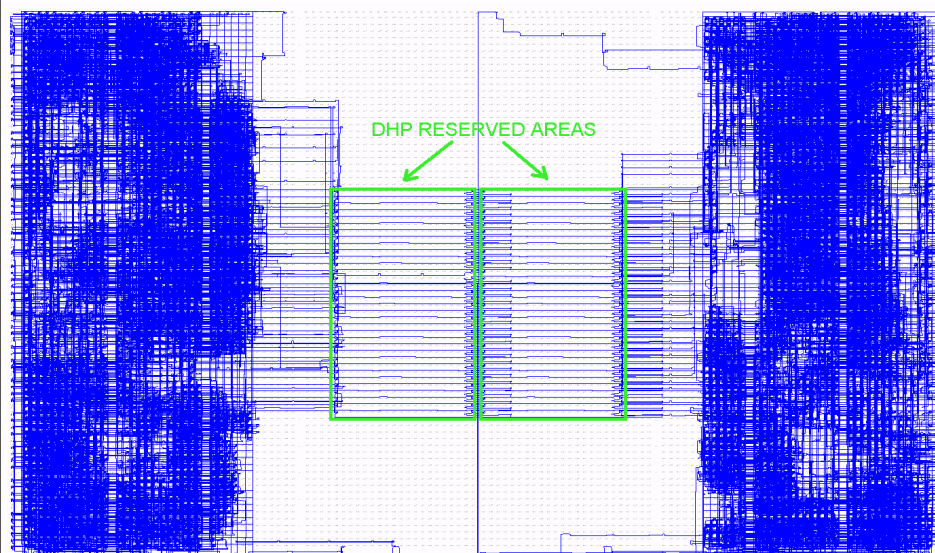


( Implemented on the RAD on the FPX, using a VirtexE 2000 FPGA )

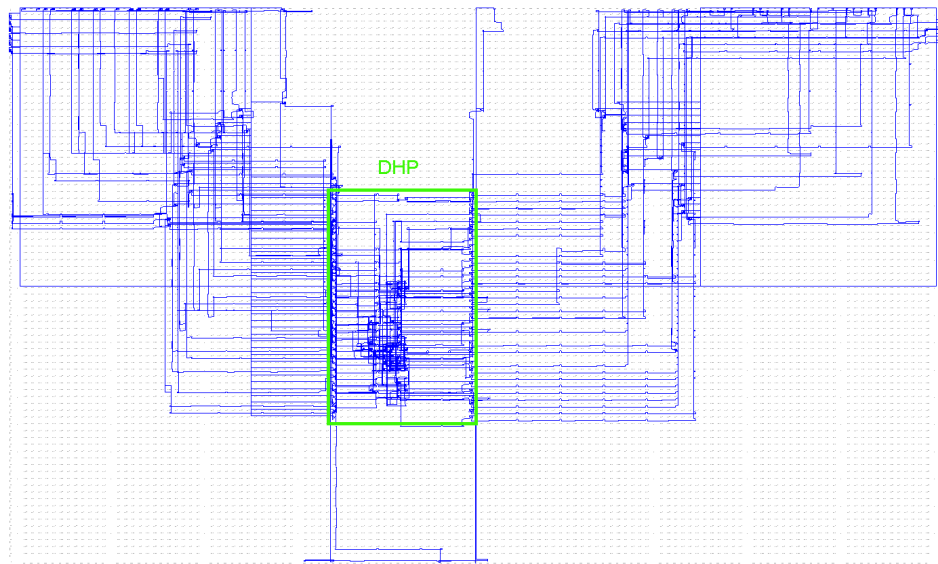
## DHP Implementation on the FPX



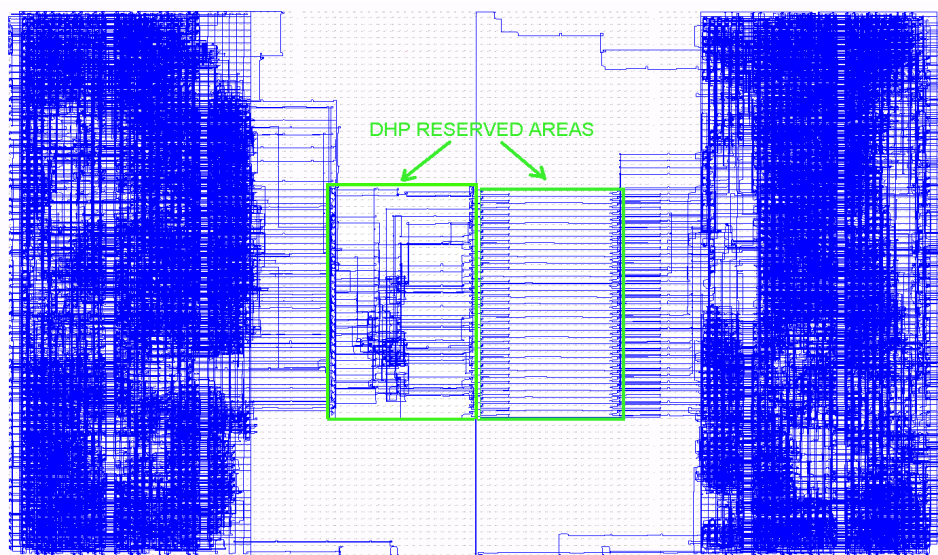
## Floorplanning - Sample Infrastructure



## Floorplannings - DHP



## Floorplannings - INFRA

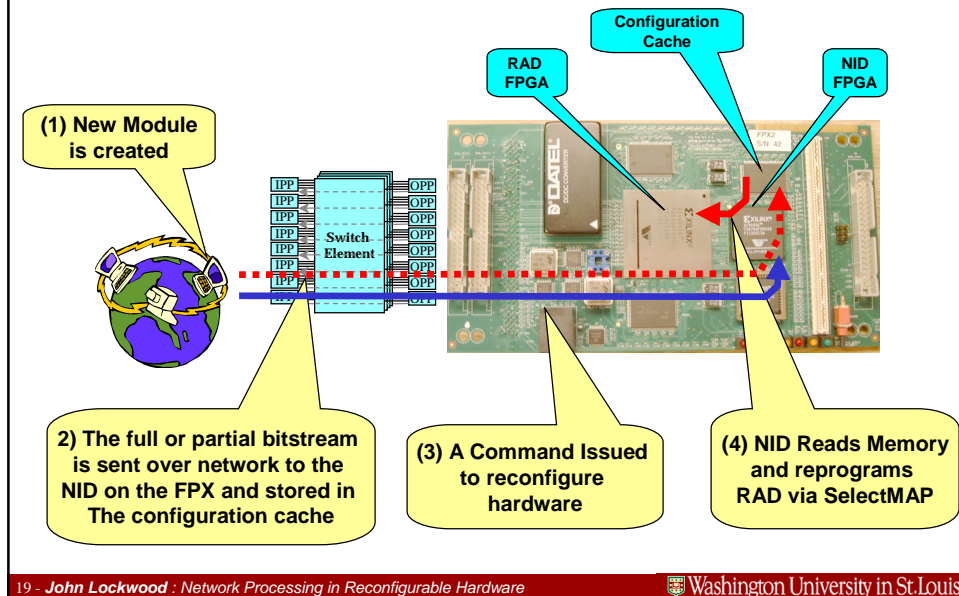


## Other Modules Implemented

- **IPv6 Tunneling Module**
  - Tunnels IPv6 over IPv4
- **Statistics Module**
  - Event counter
- **Traffic Generator**
  - Per-flow mixing
- **Video Recoder**
  - Motion JPEG
- **Embedded Processor**
  - KCPSM
- **IPv4 CAM Filter**
  - 104 Bit header matching
- **Fast IP Lookup (FIPL)**
  - Longest Prefix Match
  - MAE-West at 10M pkts/second
- **Packet Content Scanner**
  - Reg. Expression Search
- **Data Queueing**
  - Per-flow queue in SDRAM

## Control and Reconfiguration

## Reprogramming the FPX

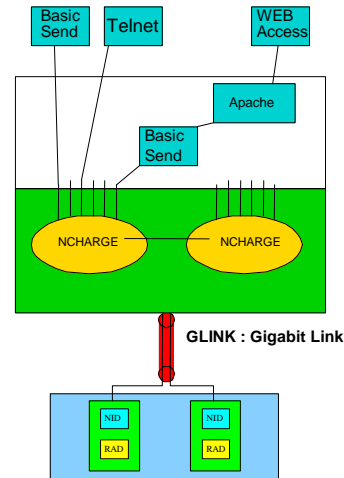


## Reconfiguration Times

- **Million-Gate Reconfiguration (XCV2000E)**
  - Configuration Size: 1.25 Mbytes = 10 Mbits
  - Network Transfer: 10 Mbit / 1 Gbps = 10ms
  - Configuration Time: 1.25 Mbyte / 50 MHz = 25ms
- **Hardware Plug-in Module Reconfiguration**
  - Configuration Size: 200 Kbytes = 1.6 Mbits
  - Network Transfer: 1.6 Mbit / 1 Gbps = 1.6 ms
  - Configuration Time: 200 Kbytes / 50 MHz = 4ms

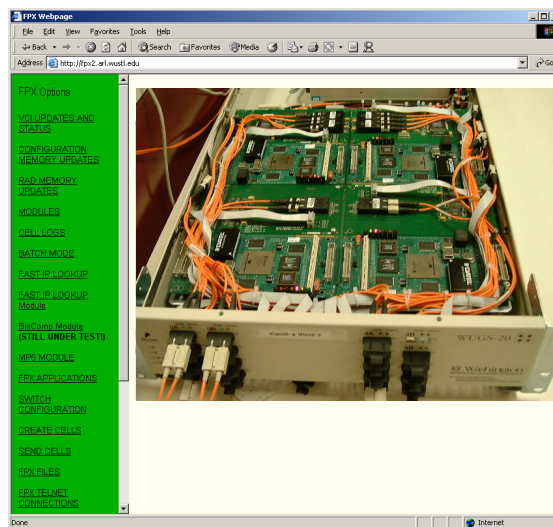
## Control and Configuration Services

- Allows communication to FPX hardware over the Internet using the Web, TCP/IP Sockets, or other signalling packages.
- Provides API to controls and configures the FPX
- Provides reliable transport mechanism with retransmission to communicate with hardware
- Allows multiple control devices to remotely connect and control common FPX resources



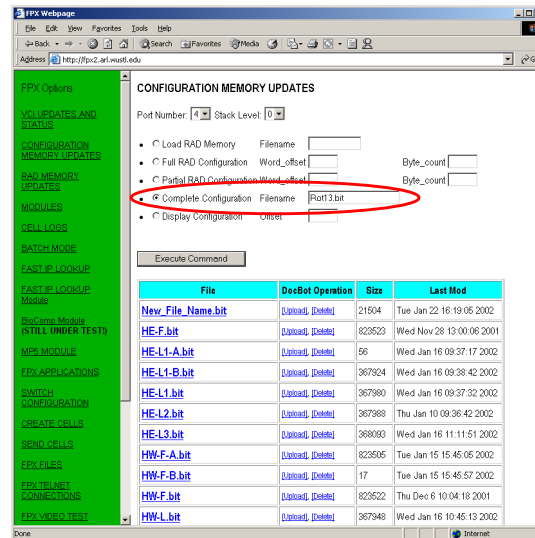
## Control and Configuration GUI

- **Web interface to communicate with the FPX**
- **Menu Functions**
  - Route traffic flows
  - Reprogram hardware
  - Upload bitfiles
  - Read & write on-chip Memory
  - Create test cells



## Installation of New Hardware Module

- Allows uploading and downloading of full or partial bitfiles
- Allows user to select a bitfile for programming
- FPGA reconfigures when user presses 'Execute Command'



## Summary

- **Reconfigurable Hardware performs Network Processing**
  - Provides high degree of configurability
    - Literally, every gate of a module can be reprogrammed
  - Provides high performance
    - OC48 (2.4 Gbps) performance achieved using Xilinx XCV2000E-6
- **Field Programmable Port Extender (FPX) Platform Developed**
  - 85 FPX devices built
  - Over 20 Hardware modules have been developed
- **Layered Internet Protocol wrappers**
  - Enable processing Internet packets at Gigabit rates
- **Control and Reconfiguration Mechanisms**
  - Hardware Modules dynamically reconfigure over the network
  - Control software provides extendable socket interfaces
  - Web interface simplifies FPX control and configuration
  - Chained TCP/IP channel simultaneously programs multiple FPX devices