



Stanford Clean Slate Program

<http://cleanslate.stanford.edu>

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Stanford Clean Slate Program

Two questions:

1. With what we know today, if we started over with a clean slate how would we design the Internet?
2. How will the Internet be in 15 years?

Clean slate is a research approach,
not a deployment strategy

Our Approach

Build “Platforms for Innovation”

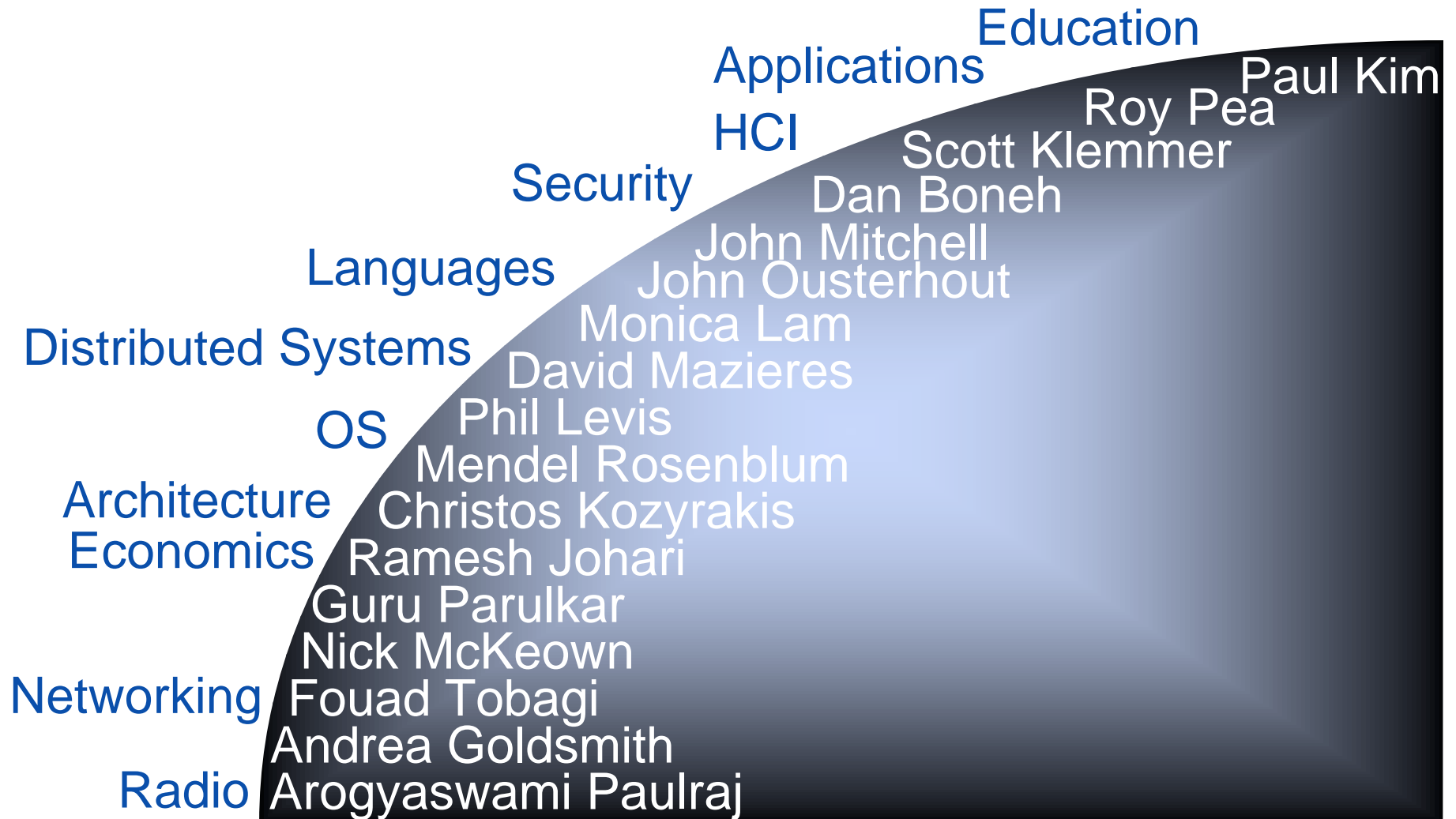
Enable a large community to bring about
change from the ground up

Team: 15 faculty, 40 graduate students

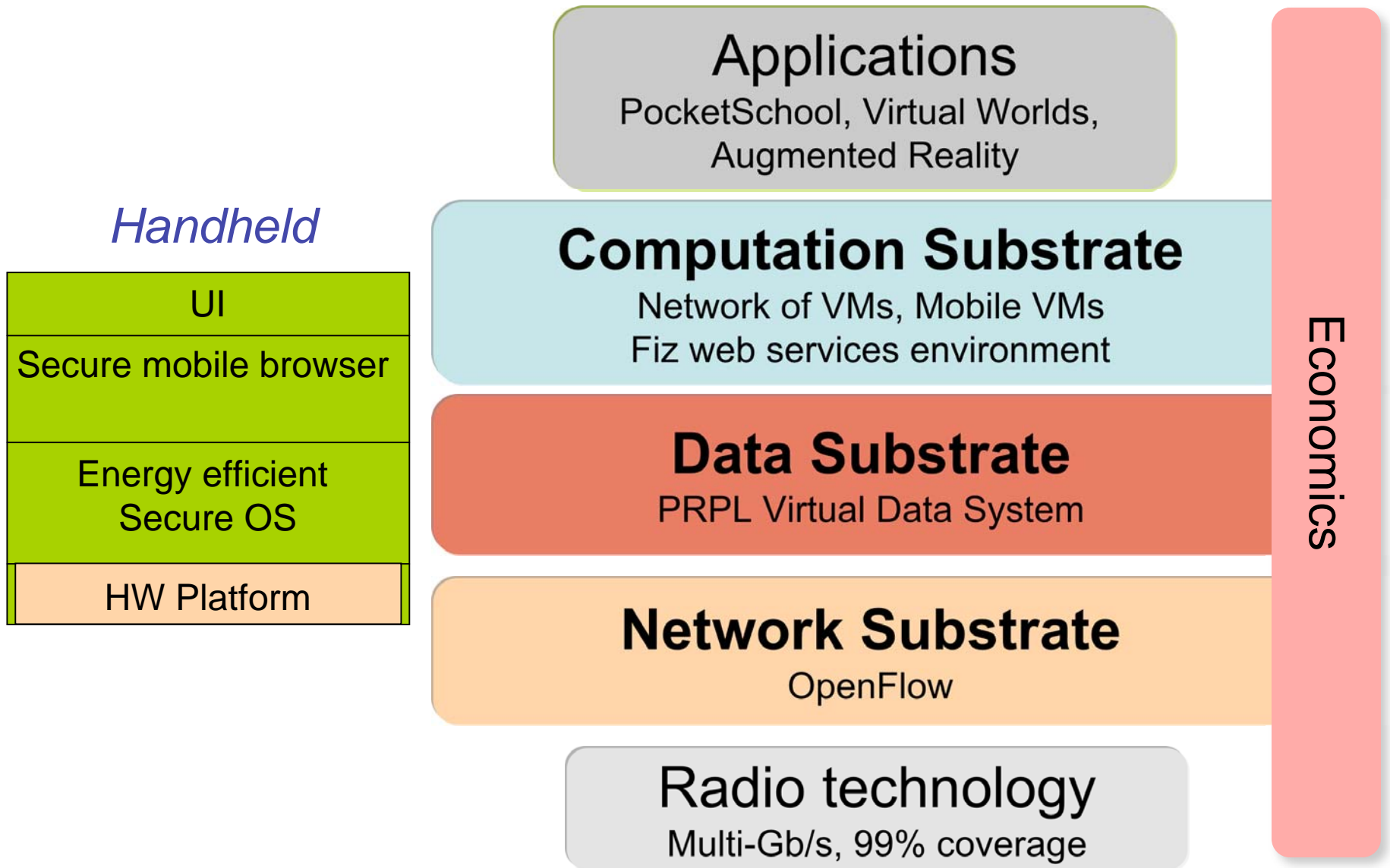
Clean Slate Lab: Guido Appenzeller + team of 6 engineers

Sponsors: NSF, NEC, DT, Cisco, DoCoMo, Ericsson, Xilinx

Stanford Clean Slate Team

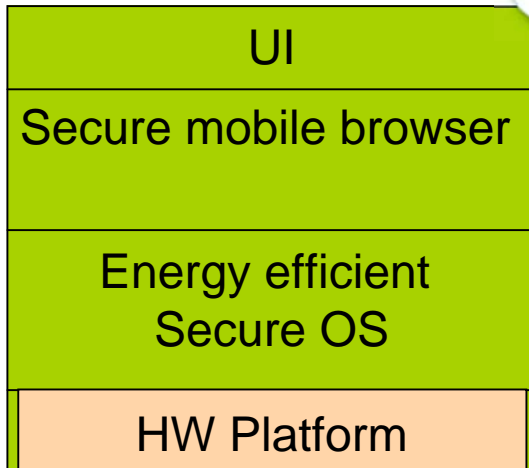


The POMI Expedition Picture



The Big Picture

Handheld



Learn more

Nick McKeown

Guru Parulkar

<http://OpenFlowSwitch.org>



Network of VMs Mobile VMs

OpenFlow

- Continued innovation by users, owners and operators
- Easy to experiment with mobility, security and mgmt

PRPL Virtual Data System

Network Substrate

OpenFlow

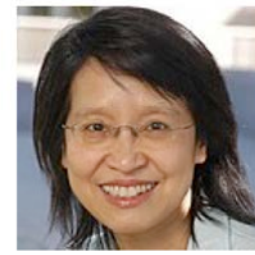
Radio technology

Multi-Gb/s, 99% coverage

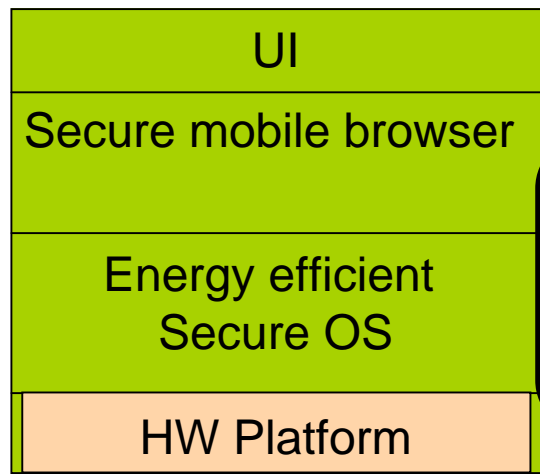
Economics

T

Learn more
Monica Lam



Handheld



PRPL Platform

- Allow users to control who can access and mine their data
- PRPL protocol allows services to be separated from data
- We can choose where our data resides

Data Substrate
PRPL Virtual Data System

Network Substrate
OpenFlow

Radio technology
Multi-Gb/s, 99% coverage

Economics

Th

VM as granularity of computing

- Large services built from 100s or 1000s of VMs
- VMs stay seamlessly connected, tracking users
- Made possible by OpenFlow

Handheld

UI

Secure mobile browser

Computation Substrate

Network of VMs, Mobile VMs
Fiz web services environment

Economic

Network of VMs
Mendel Rosenblum



Fiz environment
John Ousterhout



Radio technology

Multi-Gb/s, 99% coverage

The Big Picture

Applications

PocketSchool, Virtual Worlds,
Augmented Reality

OS

- Make users aware of how they use energy
- Energy management per thread
- Integrate with Information Flow Control
- “Capacitors”

Information Substrate

Cloud of VMs, Mobile VMs
Services environment

Econ

Energy efficient
Secure OS

HW Platform

Learn more

Phil Levis
David Mazieres



OpenFlow

Radio technology

Multi-Gb/s, 99% coverage

The Big Picture

Applications

PocketSchool, Virtual Worlds,
Augmented Reality

Secure Mobile Browser

- Build on hugely successful work
- Exploit the move from desktop to mobile browsers

Application Substrate

Stack of VMs, Mobile VMs

Secure mobile browser

Energy efficient
Secure OS

HW Platform

Learn more

Dan Boneh
John Mitchell



Network Substrate

OpenFlow

Radio technology

Multi-Gb/s, 99% coverage

The Big Picture

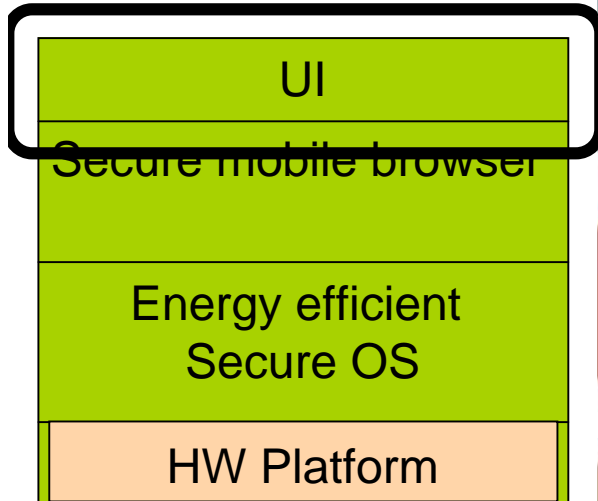
User Interface

- New populations of users
- Need to quickly repurpose and test new Uis
- Today's technology is rudimentary
- Decouple UI from application

Applications

School, Virtual Worlds,
Augmented Reality

Handheld



Learn more
Scott Klemmer



PRPL Virtual Data System

Network Substrate

OpenFlow

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Multi-Gb/s, 99% coverage

Economics

OpenFlow

Our Approach

1. Define the substrate
 - ✓ Define the **OpenFlow** feature
 - ✓ Add to commercial switches, routers, APs and basestations
2. Deploy on college campuses
3. Deploy in national networks
4. Deploy in enterprise networks



OpenFlow...

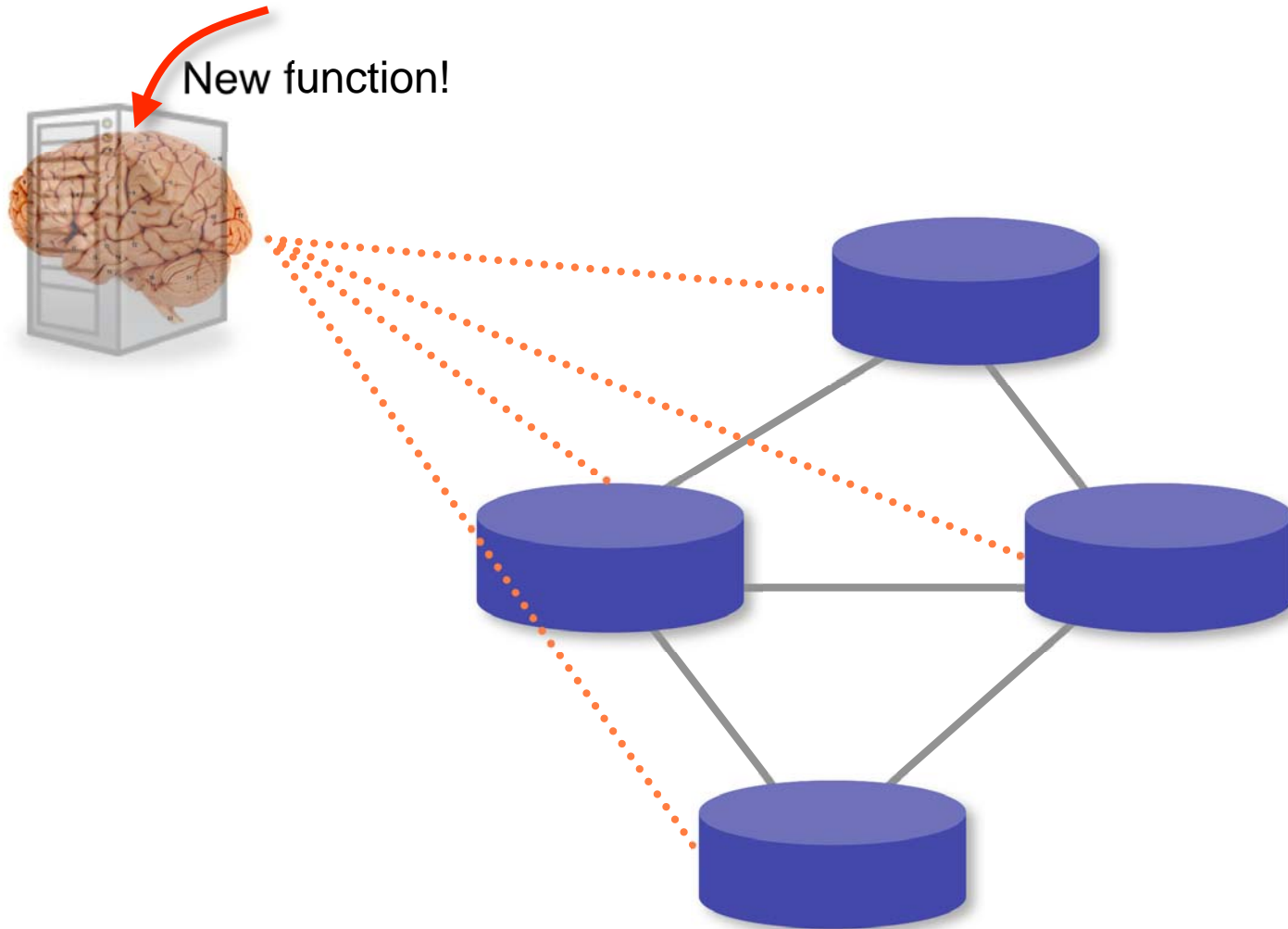
- ✓ Puts control into the hands of **users**, **owners** and **applications**
- ✓ Allows continued **evolution** of the network



Step 1:

Remove all intelligence from datapath

Operators, users, 3rd party developers, researchers, ...



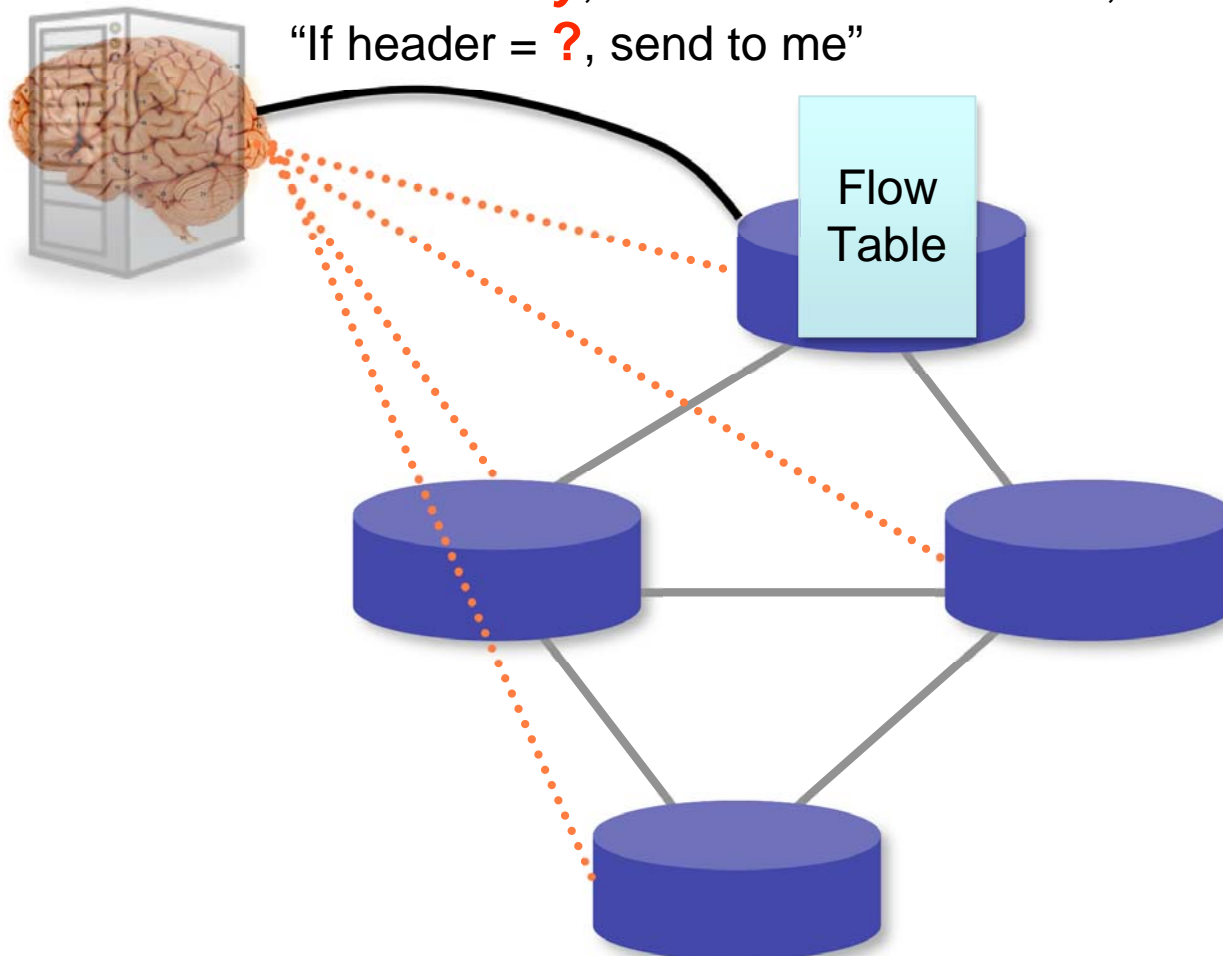
Step 2:

Cache decisions in dumb datapath

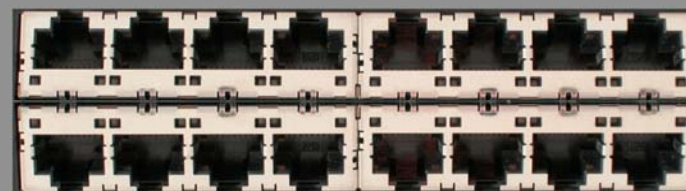
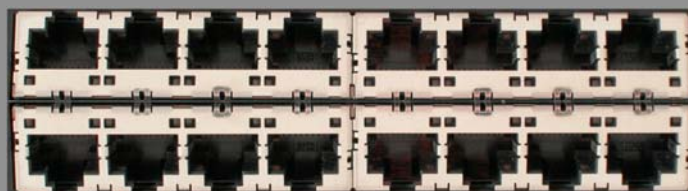
“If header = **x**, send to port 4”

“If header = **y**, overwrite header with **z**, send to ports 5,6”

“If header = **?**, send to me”



Ethernet Switch



Control Path (Software)

Data Path (Hardware)

OpenFlow Controller

OpenFlow Protocol (SSL)

Control Path

OpenFlow

Data Path (Hardware)

OpenFlow Deployments

Clean Slate Laboratory

Stanford Deployments

- ▶ Wired: CS Gates building, EE CIS building, EE Packard building (soon)
- ▶ WiFi: 100 OpenFlow APs across SoE
- ▶ WiMAX: OpenFlow service in SoE

Other deployments

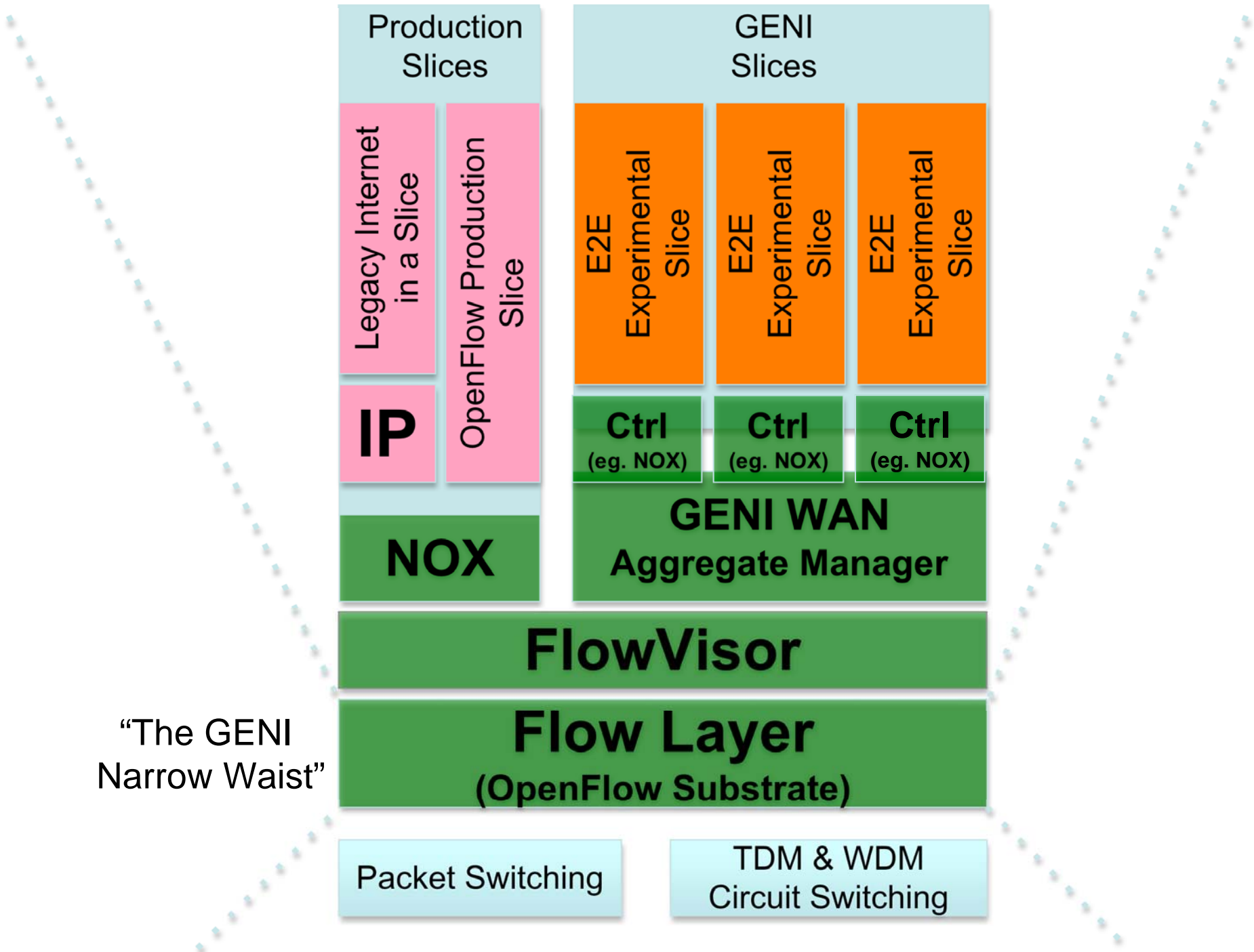
- ▶ Internet2 (NetFPGA switches)
- ▶ JGN2plus, Japan (NEC switches)
- ▶ 10-15 research groups have switches

Trombone: A national substrate

Proposed

Goal: Create national OpenFlow Substrate for research community

- ▶ Internet2/NLR and 6 regional networks
- ▶ Extend into 30 college campuses
- ▶ Based on commercial switches/routers running OpenFlow (Juniper, Cisco, HP, NEC)



“The GENI Narrow Waist”

Thanks!

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