Managing the Home Network

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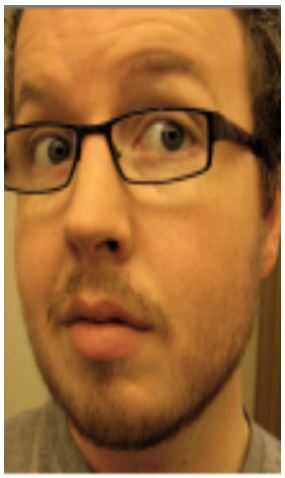

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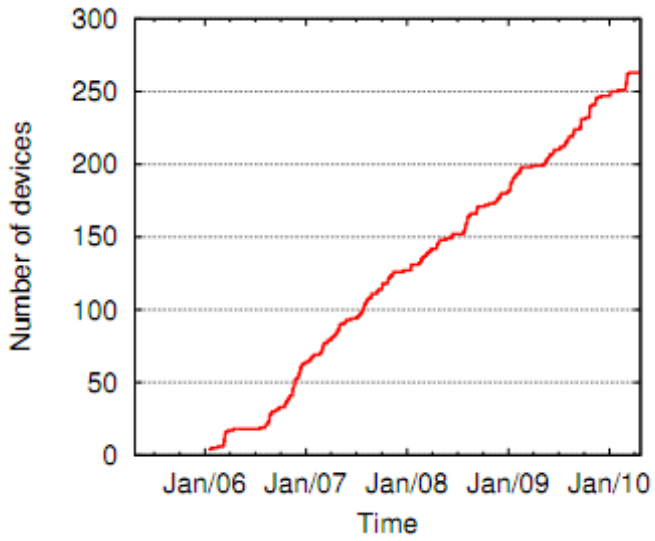
Exploring Networks of the Future

(with Joon Kim, Marshini Chetty, Srikanth Sundaresan, Steve Woodrow, Russ Clark, Abhishek Jain, Alfred Roberts)

NSF

Network Management is Hard!

- Manual, error-prone, complex
- Network configurations change continually
  - Provisioning of new users and devices
  - Adjustments to access control
  - Response to incidents
- Changes result in errors



Morning Reports

Georgia Tech

OIT Office of Information Technology

Friday 10/14/2011

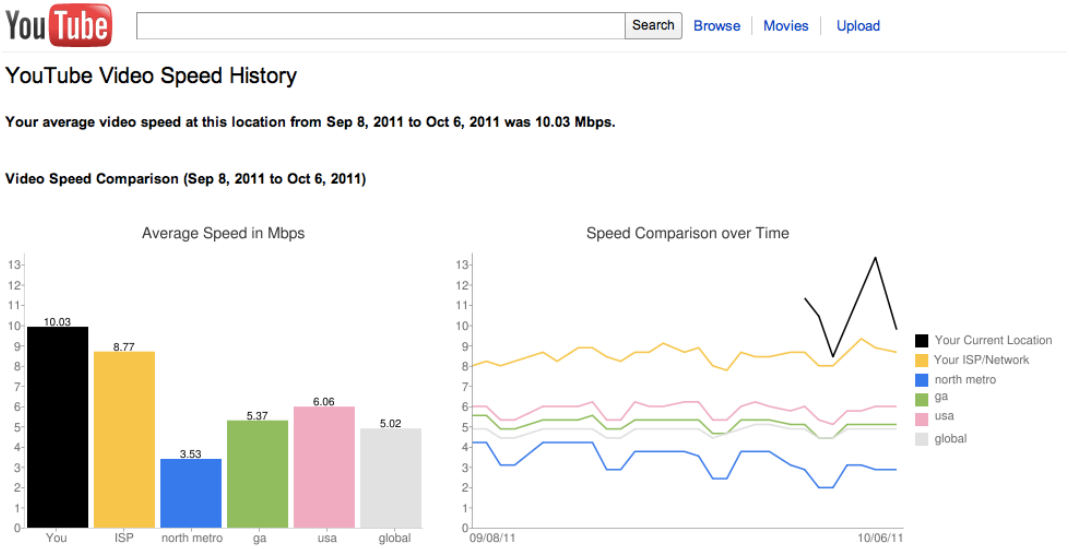
Network

-Fri 0439-0612: Network equipment in O'Keefe down, possibly due to a power outage. Switches came back up on their own.

Systems

-Thu 1305-1320: Network monitoring appliance in BCDC/811 Marietta rebooted, causing users of applications served from BCDC to experience problems. This included MyGatech email, buzzport, HR Psoft, Degreeworks. OIT technicians resolved the problem and all services became available again around 1320.

Home Network Management is Even Harder!



- **Access ISPs**
  - What performance are customers seeing?
  - Can they gain better visibility into downtimes?
  - Can visibility into problems help reduce service calls?
- **Content Providers**
  - How do content routing or traffic engineering decisions affect end user performance
- **Consumers**
- **Regulators**

Home Network Management Tasks

- **Monitoring**
  - Continuous measurements of ISP performance *("Am I getting what I'm paying for?")*
  - Monitoring traffic use inside the home *("Who's hogging the bandwidth?")*
  - Security *("Are devices in the home compromised?")*
- **Control**
  - Traffic prioritization (e.g., ensure file sharing does not clobber critical traffic)
  - Parental controls

Our Vision: Better Home Networks

- **Problem:** Home networks are difficult for the average user to maintain, secure, and optimize.

10 March 2011 Last updated at 03:15 ET

Home wi-fi '30% slower' than fixed broadband

People relying on home wi-fi are getting significantly slower speeds than from their fixed broadband connection, research suggests.

- **Solution:** Open platform/application suite to help the average user **monitor** and **manage** their network

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Why is home network management so hard today?

Too Much Complexity is Exposed

Network State is Dynamic

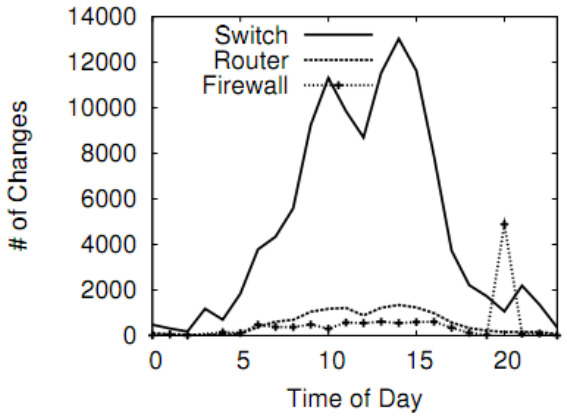
- Network conditions are **dynamic**
  - Hosts coming and leaving, becoming infected, etc.
  - Changing times of day
  - Events may occur (*e.g.*, user exhausts allocation)

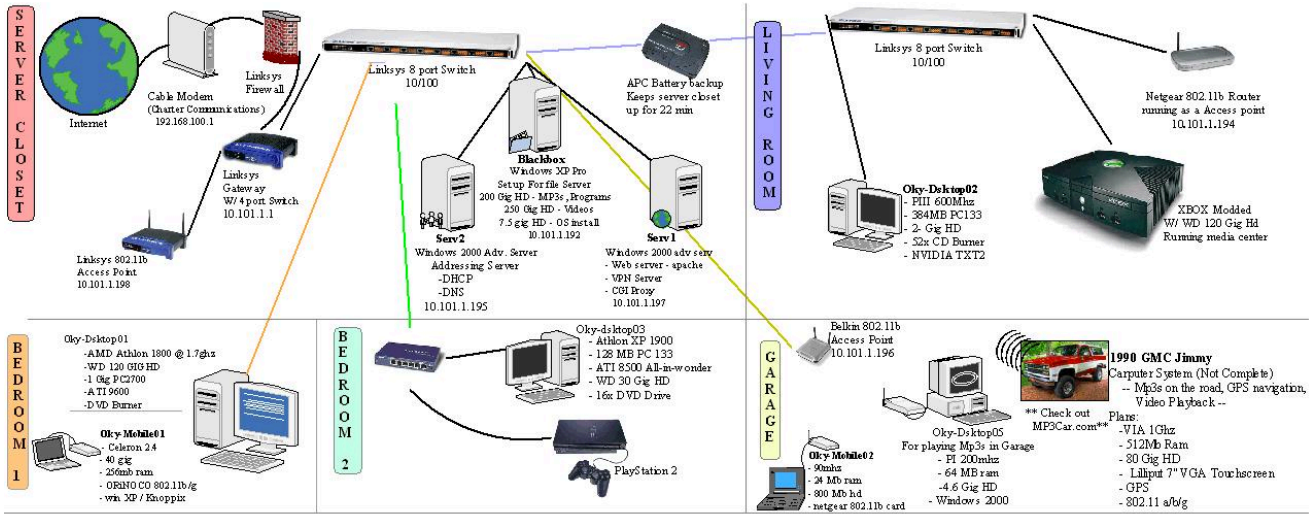
- Today, configuration is **static**, and poorly integrated with the network

- **Instead:** Configuration should incorporate dynamics
  - Track state of each host on the network
  - Update forwarding state of switches per host as these states change

Configuration is Complex, Low-Level

- A campus network may have
  - More than one million lines of configuration
  - Thousands of devices
  - Hundreds of thousands of changes every year
- Home networks are also complex





Network Devices are Heterogeneous

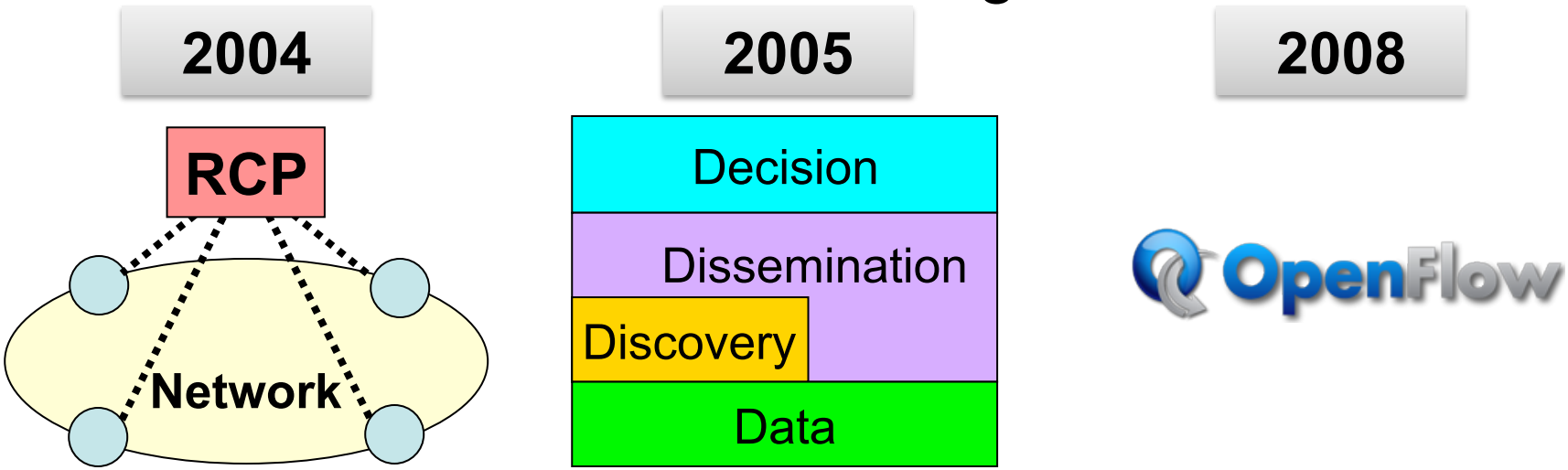
- Many components "bolted on" after the fact
  - **Campus:** Firewalls, VLANs, Web authentication portal, vulnerability scanner
  - **Home:** Set-top boxes, cameras, laptops, desktops, phones

- Separate (and competing) devices for performing different functions
  - Registration (based on MAC addresses)
  - Vulnerability scanning
  - Filtering
  - Rate limiting

How do we solve these problems?

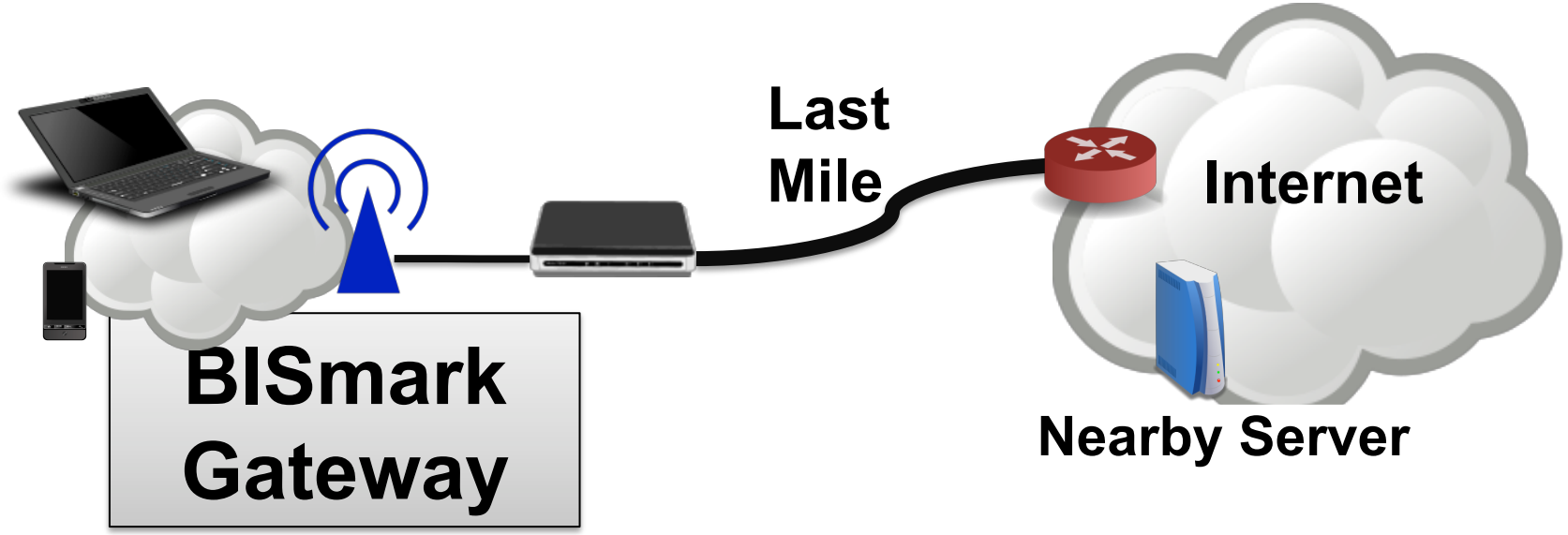
New Philosophy: Software-Defined Networking (SDN)

- ***Monitor* and *control* the network from a logically centralized system**
- Monitoring is simpler, more continuous
- Policies become centralized, high-level



Feamster *et al*. The Case for Separating Routing from Routers. *Proc. SIGCOMM FDNA*, 2004
Caesar *et al.* Design and implementation of a Routing Control Platform. *Proc NSDI*, 2005

BISmark: An SDN Application Platform for the Home Network



- OpenWrt firmware with custom measurement suite
  - Periodic active measurements of access link, home network
  - Metrics: Throughput, latency, jitter
- Current hardware: Netgear 3700v2 router
  - Planned support for other hardware platforms

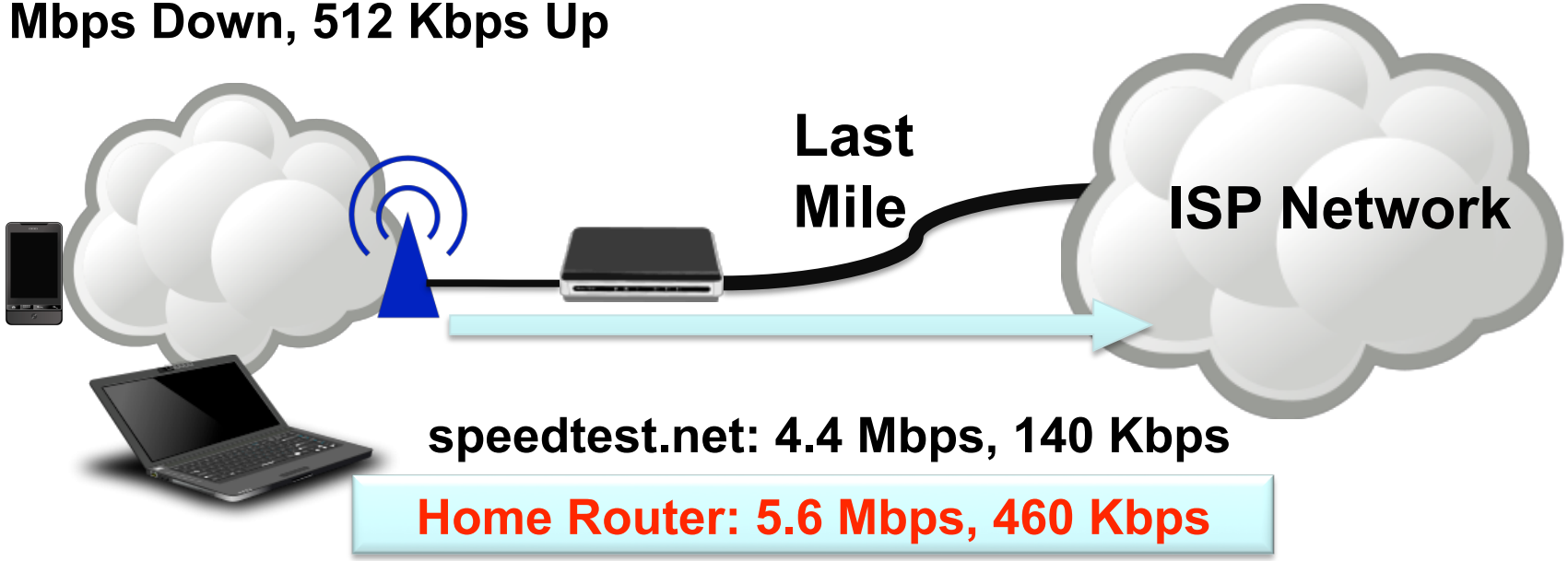
BISmark: Hardware and Software

- Firmware
  - OpenWrt, with luci web interface
  - IPv6-capable

- Netgear 3700v2 router
  - Atheros chipset
  - MIPS processor, 16 MB flash, 64 MB RAM
  - Gigabit ethernet
  - 2.4 GHz *and* 5 GHz radio

Monitoring: Continuous, Direct

Home Network: AT&T DSL
6 Mbps Down, 512 Kbps Up



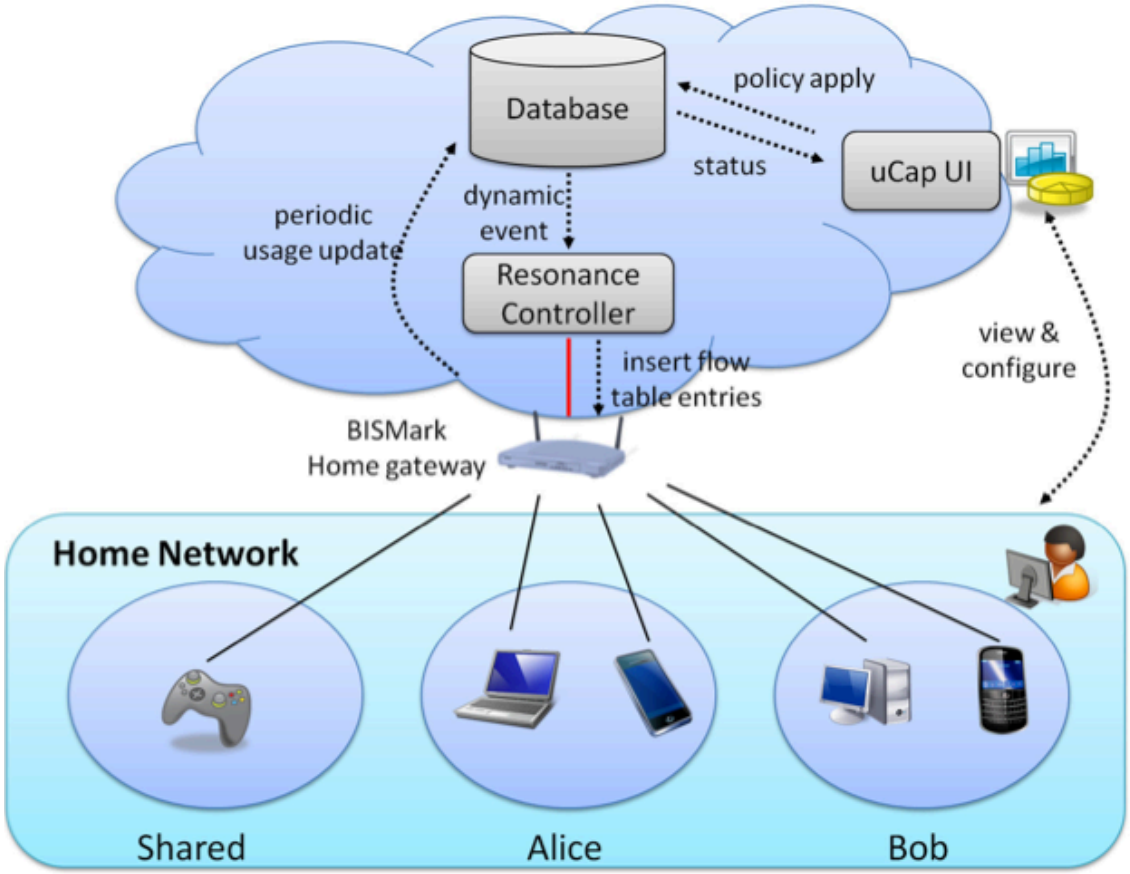
Enables periodic measurements, and can account for confounding factors

Control: Don't Configure the Network, Program It!

- **Today:** Configuring networks with low-level, distributed, vendor-specific configuration

- **With SDN:** Writing network policies and protocols as programs
  - More expressive
  - More predictable
  - More evolvable
  - More usable

Control Framework



- User monitors behavior, sets policies with intuitive user interface
- OpenFlow controller manages policies and router behavior

Better Home Network Management

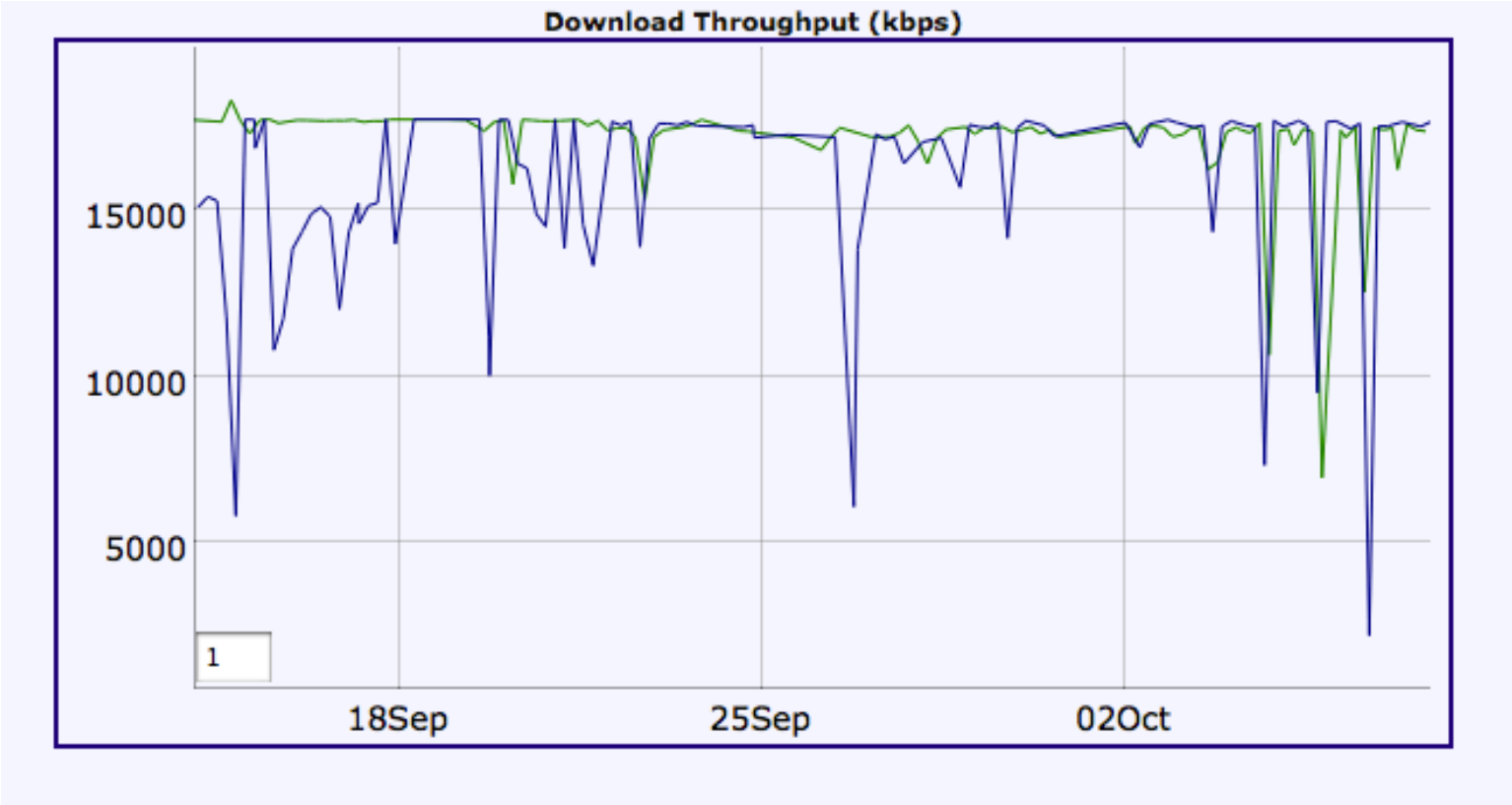
Challenge	Approach
Exposed Complexity	Refactor Complex Functions
Dynamic Conditions & State	Event Listener w/State Machine
Low-Level Configuration	High-Level Policy Language
Heterogeneity	Standard Control Protocols

Refactor Complex Functions

- **Current interfaces:** Decisions only about whether to hide or display complexity
- **Instead:** Changing where function is placed in the system can make the system more usable
- **Principle:** Only expose information if it
  - Improves **situational awareness**
  - Is **actionable**

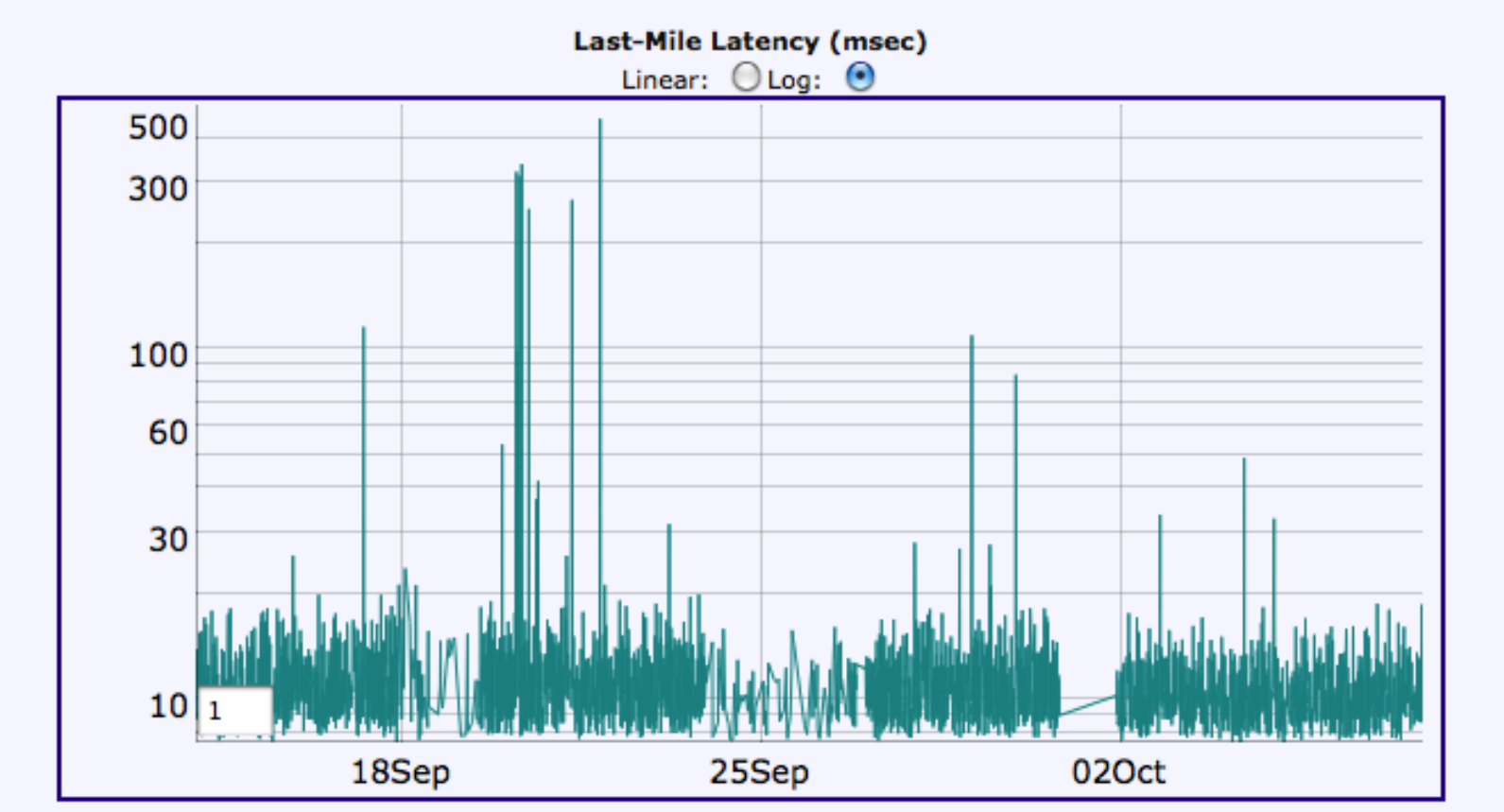
Situational Awareness: Throughput

http://networkdashboard.org



Situational Awareness: Last-Mile Latency

http://networkdashboard.org



Situational Awareness: Latency

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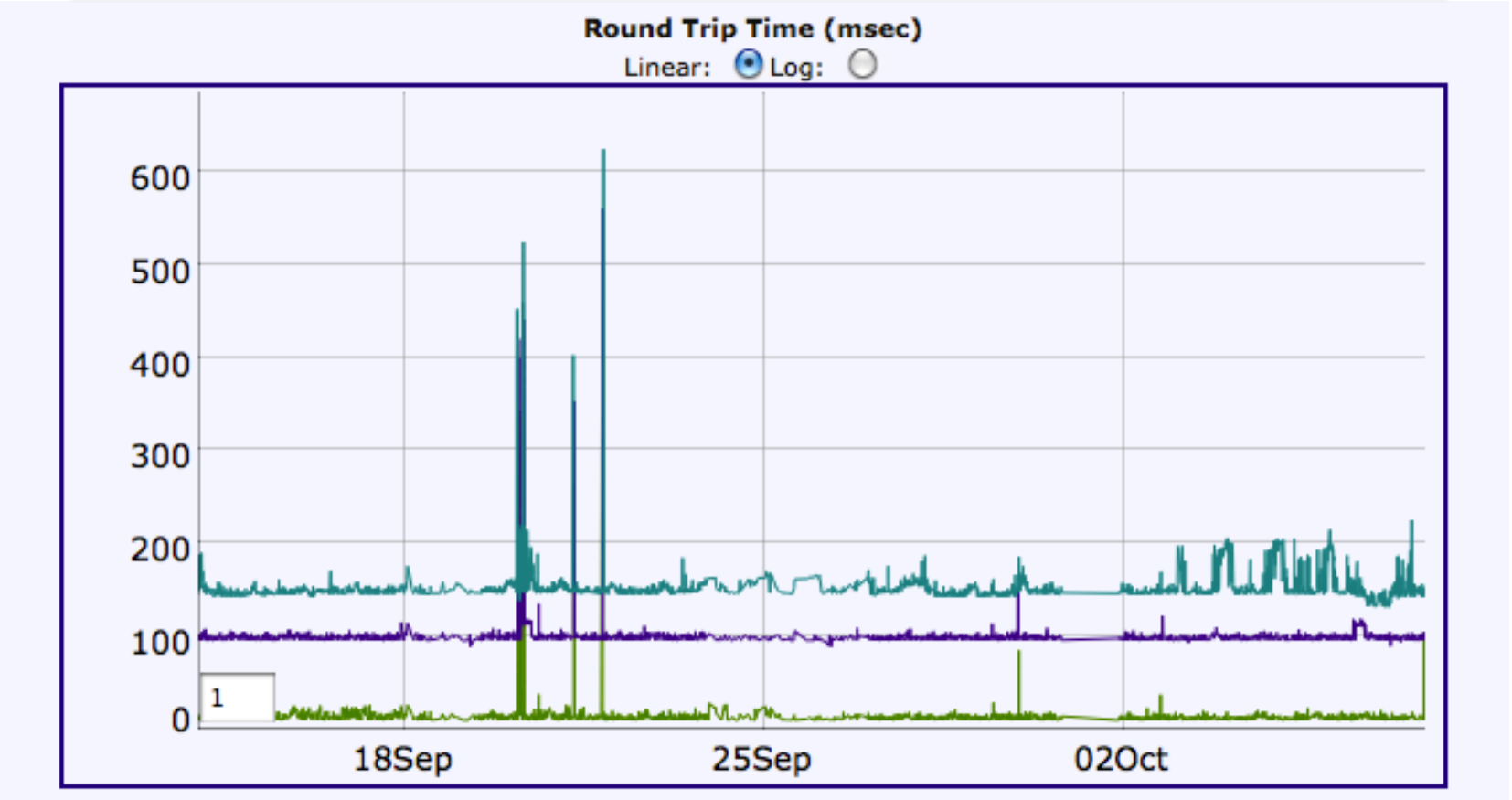
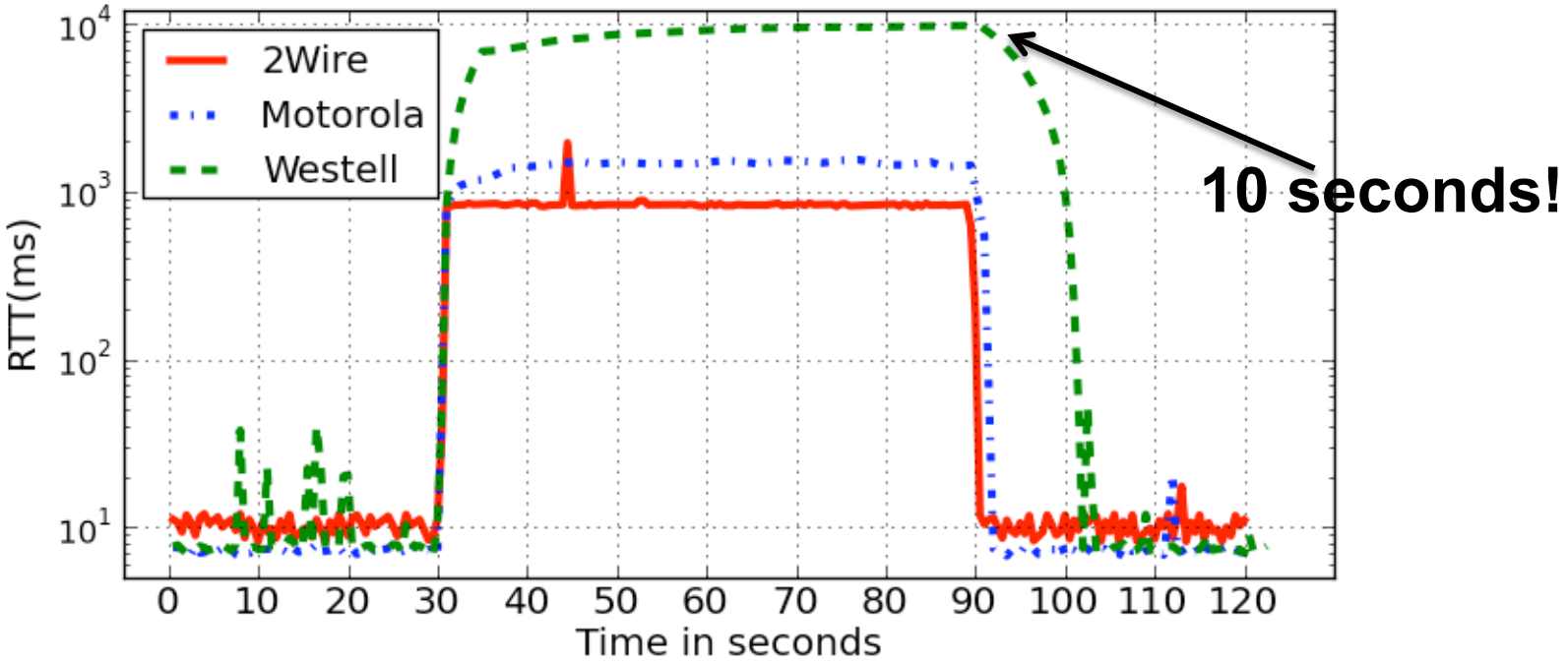
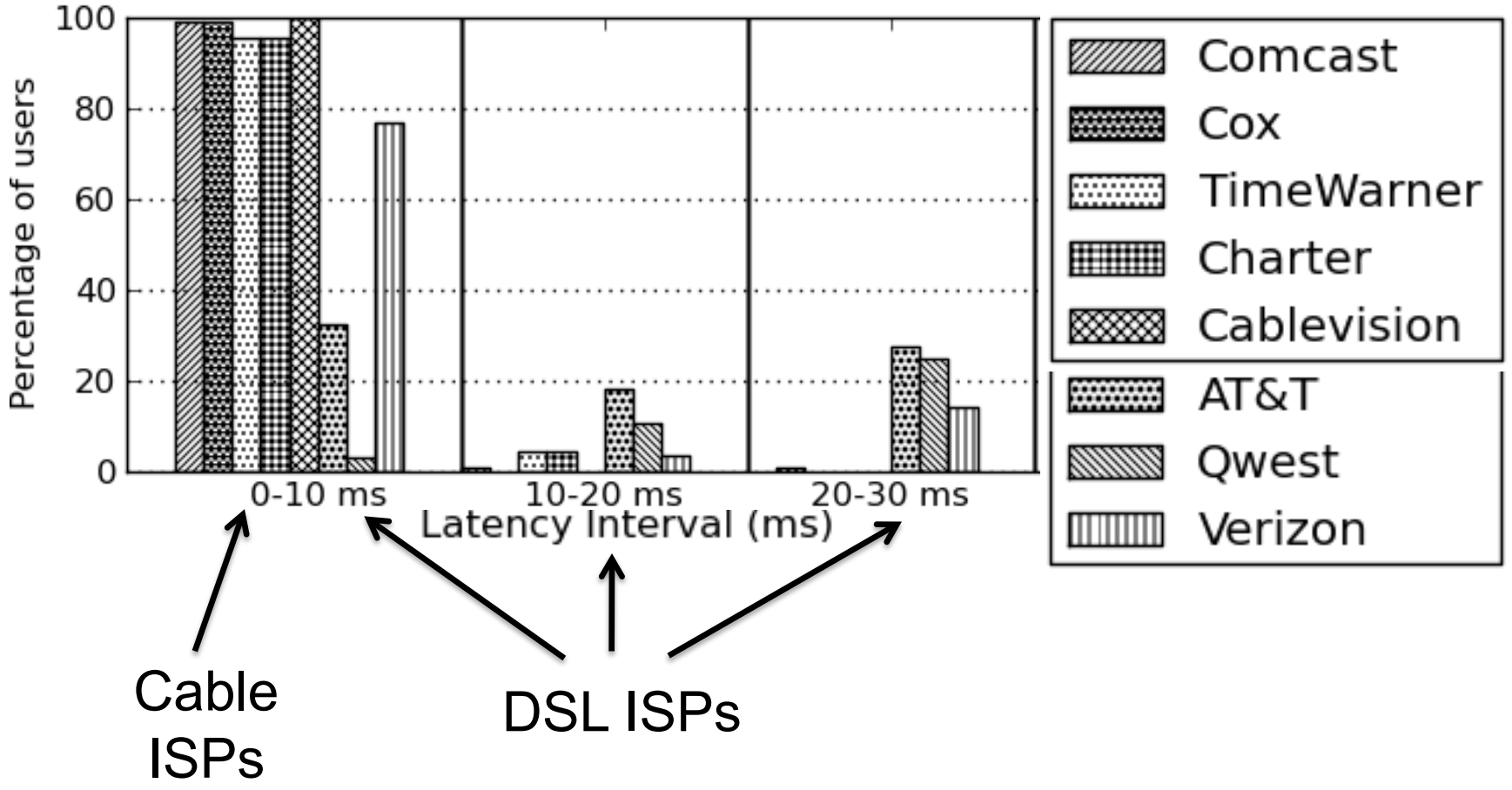


Latency: Not Always the ISP's Fault



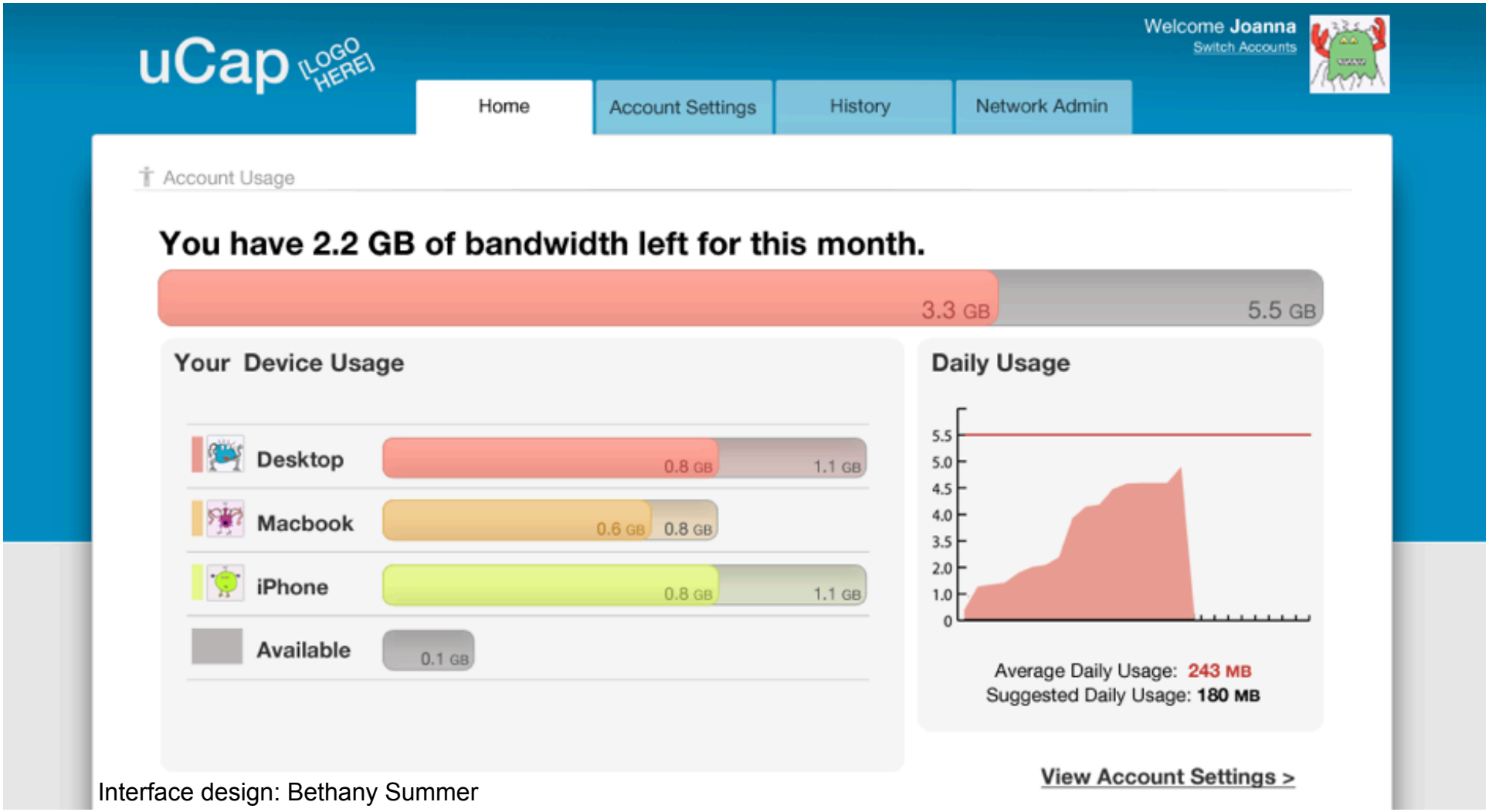
Modem buffers can introduce significant latency

Last-mile Latency Depends on Access Technology



DSL last-mile latencies can be high

Actionable Information



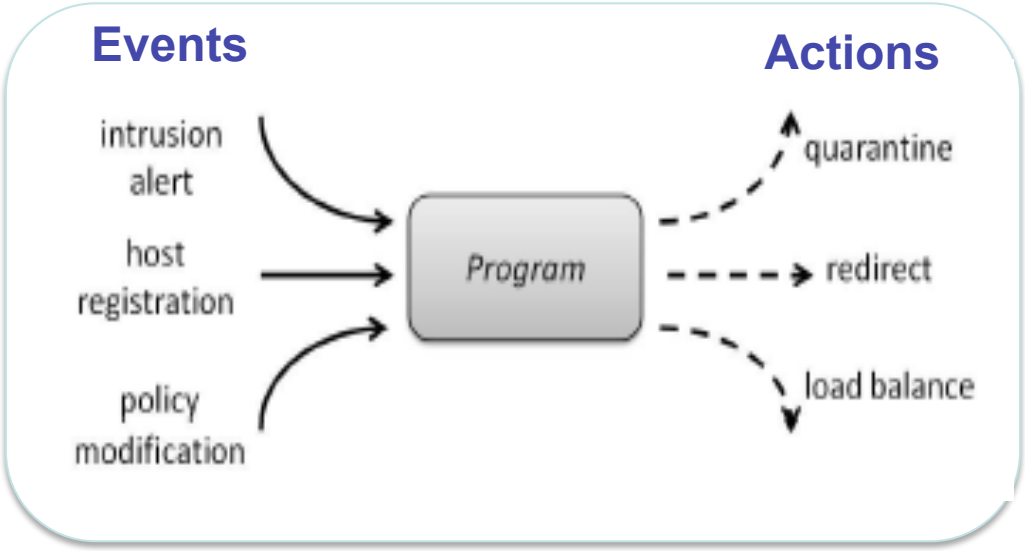
Interface design: Bethany Summer

Better Home Network Management

Challenge	Approach
Exposed Complexity	Refactor Complex Functions
Dynamic Events	Continuous Monitoring, Event Listener w/State Machine
Low-Level Configuration	High-Level Policy Language
Heterogeneity	Standard Control Protocols

Handling Dynamic Events

- **Idea:** Express network policies as event-based programs.



- Policies can be expressed as centralized programs

Configuration as State Machines

- Step 1: Associate each host with generic states and security classes
- Step 2: Specify a state machine for moving machines from one state to the other
- Step 3: Control forwarding state in switches based on the current state of each machine
  - Actions from other network elements, and distributed inference, can affect network state

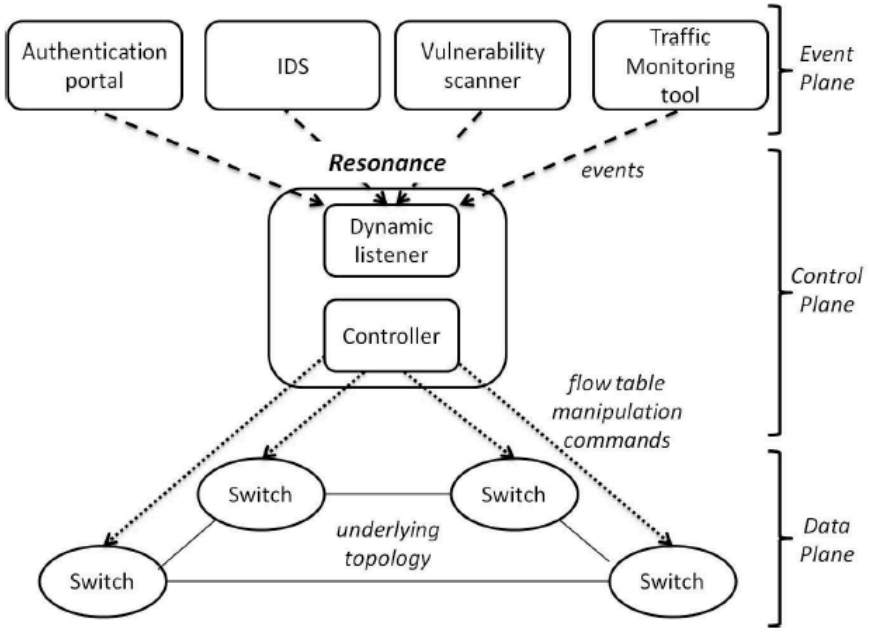
High-Level Policy Language

- Defines states, actions, transitions
- High-level, logically centralized
  - Easier testing and analysis
  - Less complex
- Design is still in-progress

```
if packet-in event occurs:
 - lookup the table by src Ethernet address
 - determine state and security class
switch(state)
   case Registration:
      redirect to web portal: HTTP traffic(to port 80,8080,443)
   case Operation:
      switch(security class)
         case guest:
            if (time is between 12am to 6am)
               block: all
            else
               block: to netws machines
               allow: HTTP traffic
         case gtuser:
            block: to netws machines
            allow: all
         case gtnet:
         case netws:
            allow: all
   case Quarantined:
         block: all
```

Standard Control Protocols

- **Events:** Heterogeneous devices generate standard events that a dynamic listener processes
- **Actions:** OpenFlow channel between controller and switches controls behavior



Demonstration: Usage Control

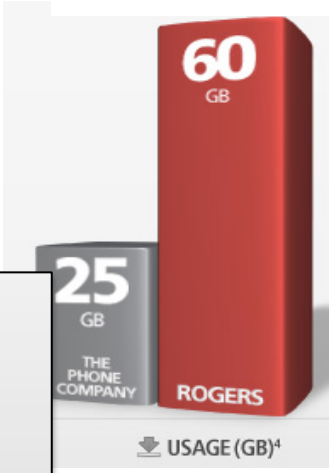
comcast

It's official: Comcast starts 250GB bandwidth caps October 1

at&t

Is AT&T's new 150GB DSL data cap justified?

ROGERS



- One aspect of management: **usage control**
  - Usage cap management
  - Parental control
  - Bandwidth management
- **Idea:** Outsource network management/control
  - Home router runs OpenFlow switch
  - Usage reported to off-site controller
  - Controller adjust behavior of traffic flows

Conclusion

- Problems arise because network monitoring and control is **low-level** and **distributed**

- **Instead:** Monitor and control the network from a logically centralized control point.
  - Refactoring complex functions
  - Continuous monitoring
  - Handling dynamic events, heterogeneity
  - Higher-level language and interfaces

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