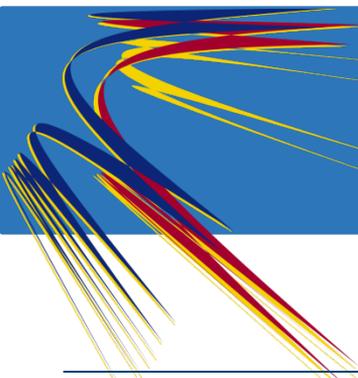


Control and Understanding: Owning Your Home Network

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School of Computer Science
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Home Networking is Mundane

- Another channel through which everyday life happens
 - 300 million people worldwide have broadband connections to the Internet
 - 51% of UK households now have a broadband connection
- Yet, the most returned consumer electronics item (25%)
 - Consumers cite technical complexity as the largest barrier to home networking
- The (software) technology has not made the leap!
 - Still managed in terms of protocols and services
 - Shopping, not the web, not HTTP

So What's the Problem?

- Most, if not all, the technology has been appropriated
 - Networks have moved out of corporate and managed environments to the home virtually unchanged
 - Internet protocols and tools designed in the '70s for trained system administrators
 - Disinterested householders have become reluctant network administrators
- Must enable top-to-bottom connections to be made
 - Making the network **intelligible** (not intelligent)

Future Visions vs. Lived Reality

xDSL Access Point

- Multiplayer gaming
- Video on demand
- Home security
- Digital audio

DSL Internet Access

Wired PC

- Streaming video
- Print/file sharing

Wireless Laptop

- Distance learning
- Video calls
- MP3 downloads

IP Phone

- Internet access
- Multiple voice lines
- Wireless printing
- Wireless IP phone

Wireless Gaming

Home Networking

At the heart of the digital home sits the xDSL access point distributing a host of enhanced content and services throughout the home

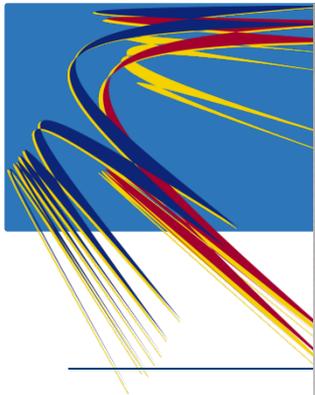




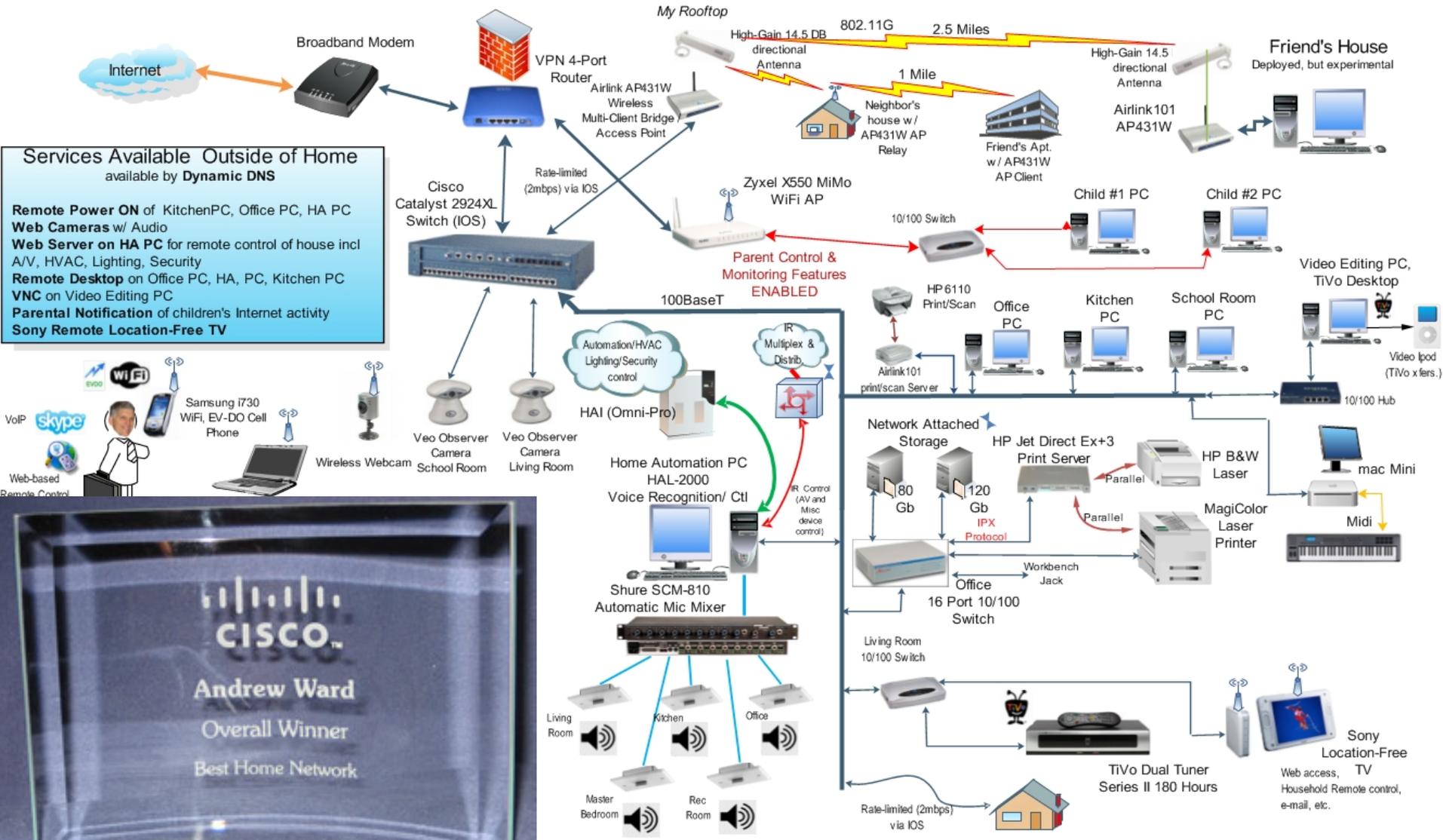






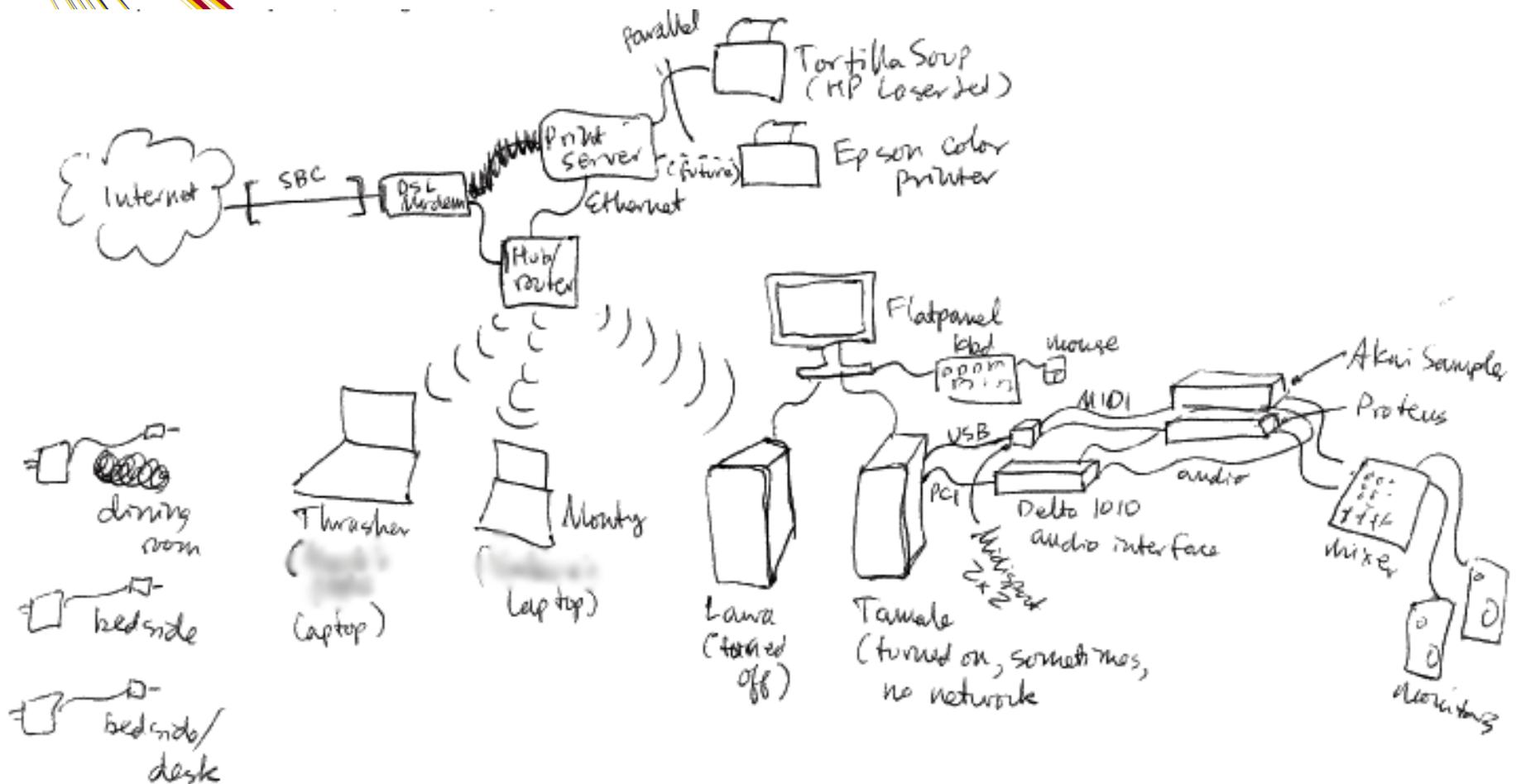


Conceptions of the Network

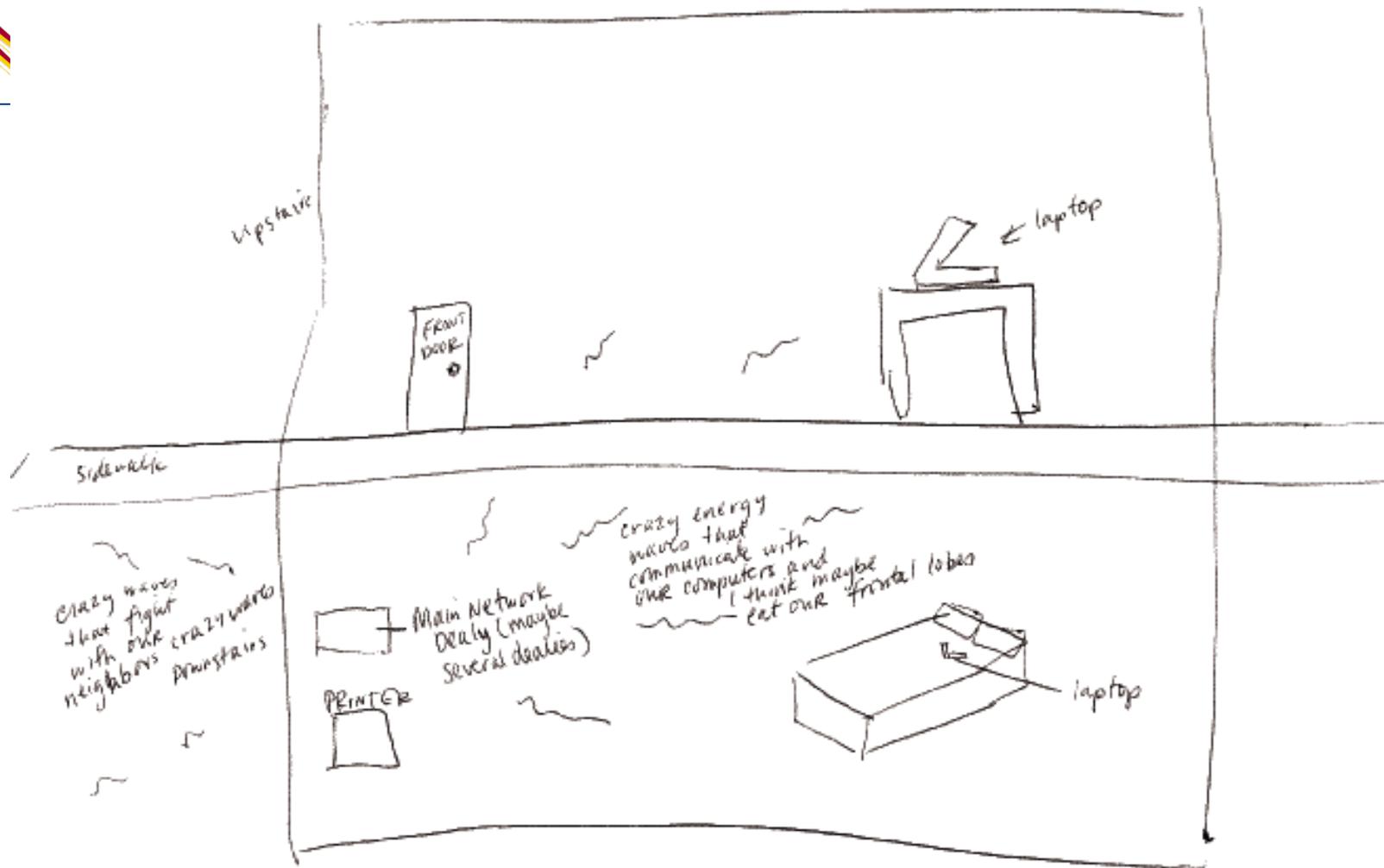


CISCO
Andrew Ward
Overall Winner
Best Home Network

Inhabitants' Perspective (1)



Inhabitants' Perspective (2)



BBC NEWS | linksys properties

File Edit View

Getting Started

Association Authentication Connection

350 Series Properties - [Test profile]

System Parameters RF Network Advanced (Infrastructure) Network Security

Network Security Type: WEP

No WEP

http://192.168.1.1/ - Internet Explorer provided by @Home Network - Versi...

File Edit View Favorites Tools Help

Address http://192.168.1.1

LINKSYS SETUP

Setup Password Status Log Help Advanced

This screen contains all of the AP's basic setup functions. Most users will be able to use the AP's default settings without making any changes. If you require help during configuration, please see the user guide.

Firmware Version: 1.009

AP Name: YourAP

LAN IP Address: (MAC Address: 00-06-25-53-BC-E6)

Obtain an IP Address Automatically

Specify an IP Address

192 . 168 . 69 . 69

Subnet Mask: 255 . 255 . 255 . 0

Gateway: 192 . 168 . 1 . 1

key for the following:

Shared

WEP

Wireless Network C

General Wireless Network

Use Windows to config

Available networks:

To connect to an availa

CompLit960

complit930

LINKSYS SETUP

Setup Password Status DHCP Help Advanced

This screen contains all of the router's basic setup functions. Most users will be able to use the router's default settings without making any changes. If you require help during configuration, please see the user guide.

Router Name: C579739-A (Required by some ISPs)

Domain Name: @home (Required by some ISPs)

Firmware Version: 1.12, Jan 17 2000

LAN IP Address: (MAC Address: 00-20-78-C5-5D-24)

192 . 168 . 1 . 1 (Device IP Address)

255.255.255.0 (Subnet Mask)

VAN IP Address: (MAC Address: 00-20-78-C5-5D-25)

Obtain an IP Address Automatically

Specify an IP Address

24 . 15 . 217 . 106

Subnet Mask: 255 . 255 . 255 . 0

Default Gateway Address: 24 . 15 . 217 . 1

DNS(Required): 24 . 1 . 4 . 12

Apply Cancel Help

Options

WEP key sizes

64-bit 152-bit

128-bit 256-bit

Session settings

10000 packets needed to start a new session

180 session start timeout (mins)

Packets needed to start key recovery

64-bit key 400000 152-bit key 1000000

128-bit key 800000 256-bit key 1800000

11333 port to listen on Send decrypted packets back to the application

OK Cancel

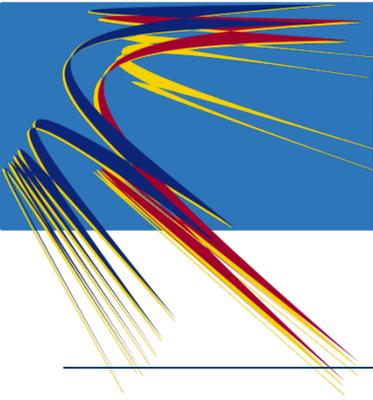
those different devices to work together and swap data via a home network.

While connecting computers with ethernet cables is

FSA sees credit squeeze on banks

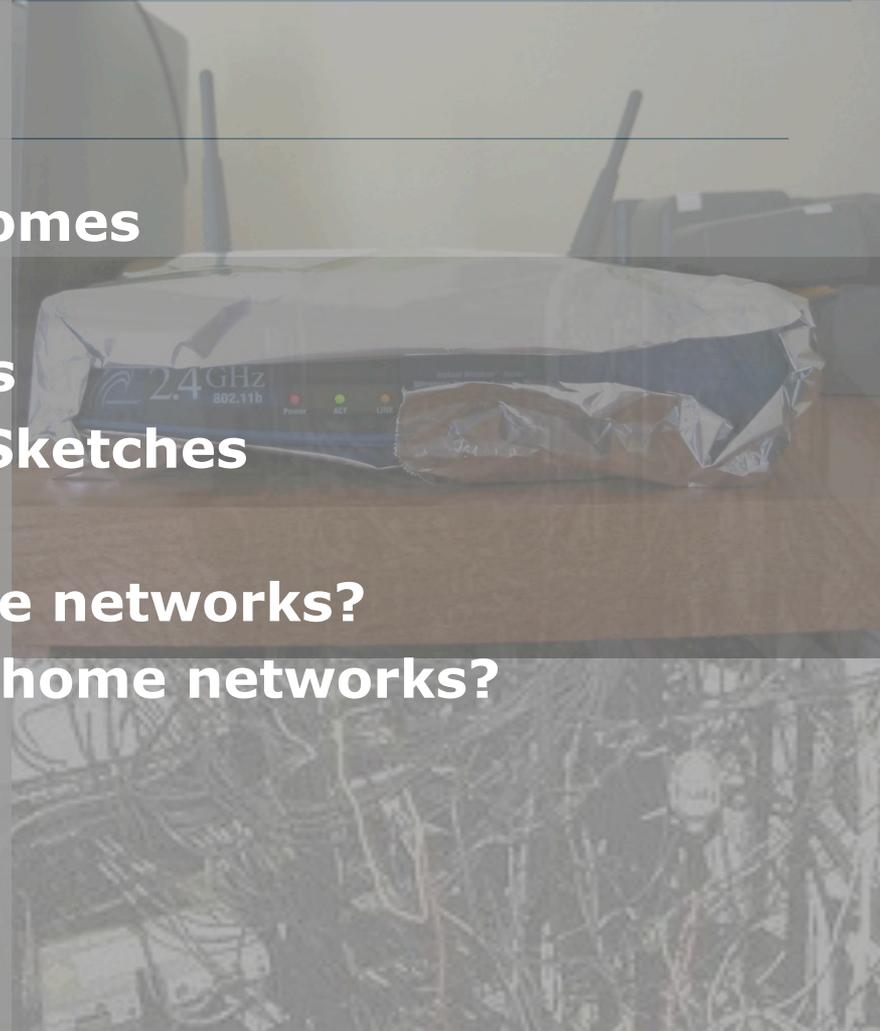
Most popular now, in detail

Done



Understanding Home Networks

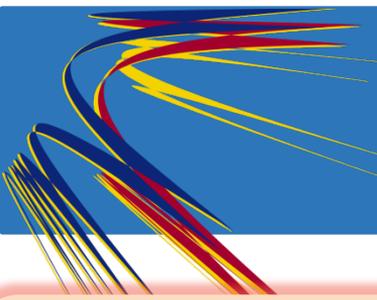
- **Ethnographic studies of 24 homes**
 - **Technology tours**
 - **Semi structured interviews**
 - **War Stories and Network Sketches**
- **How do people use their home networks?**
- **How do people manage their home networks?**





Heterogeneous, Fluid, Mundane

- Heterogeneous collection of devices
 - 5–15 devices in most homes
 - UK average is 4.6
 - PCs, Laptops, Mobiles, Games consoles, Media Streaming, Cameras, Radios
- Device ownership and access rights are very fluid
- Digital “housework” is an **unremarkable** feature of everyday life



Four Key Challenges

“I would like to see an accumulative/historical record of bandwidth usage. The current month/week/day so I can see patterns of use of time... This is important to me because we keep exceeding the Internet allowance. It has gone up 5 fold because we have an international student living with us. I don't think she believes it's her who's eaten up all of the allowance! “

“I see myself as using the Internet to bring in income, so I can justify that pretty well everything that I do takes priority.”

M: ... we have had big rows about T stealing the Internet. E said to him “You've stolen the Internet!” coz he's uploading to YouTube and the whole thing just like grinds to a halt for everybody else. We have had a “You put it on overnight T when nobody else needs it”.

One thing that I try to do is to schedule my work around them.. if they are watching TV on their machine or using Skype I tend to back off from the network for a while and let them do that. it tends to be an all or nothing sort of thing.. they can do anything on the network or nothing...

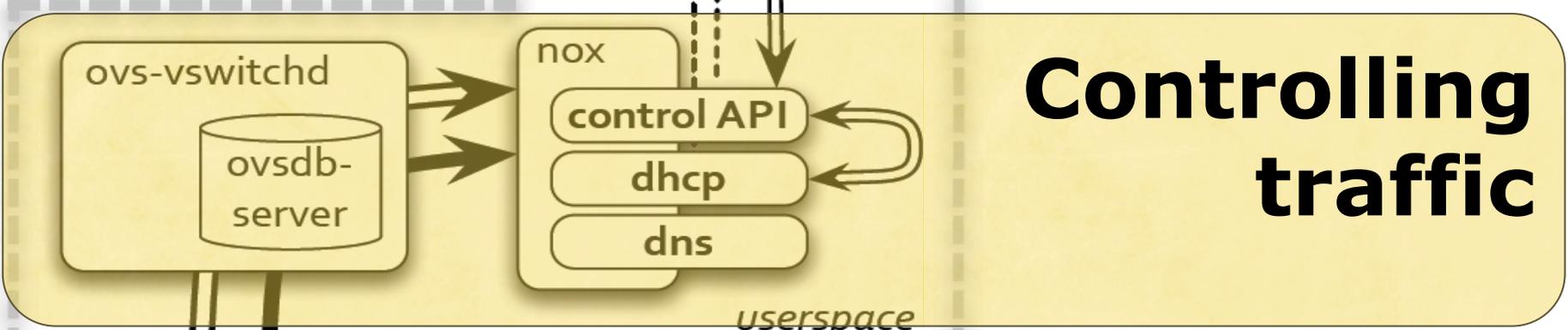
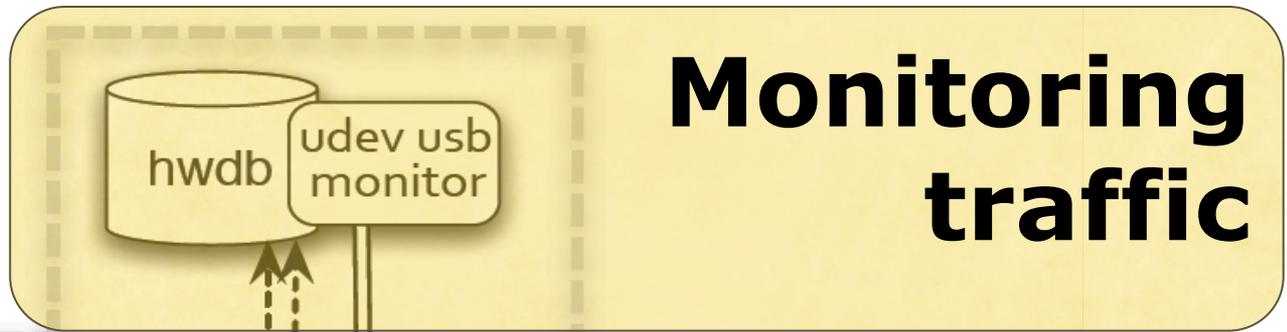
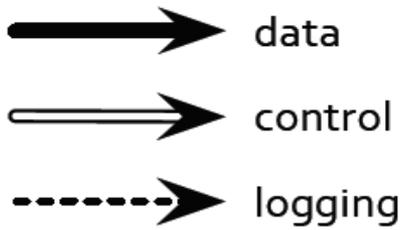
D: ... Joe's mum doesn't like given out the password.. Joe doesn't know it ... and his Dad uses the Internet for work ...”

N: Joe's mum is worried that ... she doesn't like giving the password out ... I don't care cause the kids only really use it. ... I was wondering about getting one of those 3G things to let him get on the network to play that World of Warcraft without worrying Joe's mum

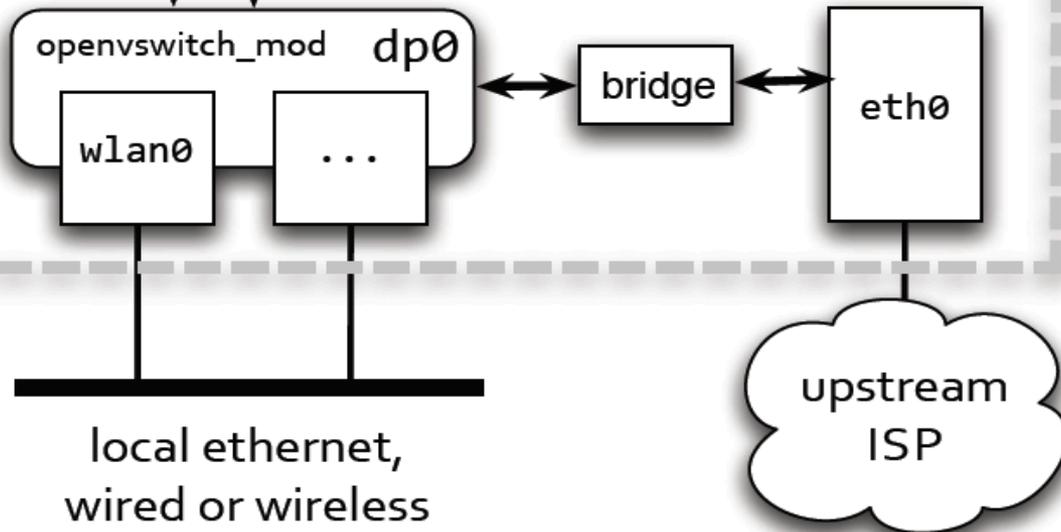
Technology Platform

- Exploit the gateway role of the home router
- Designed and built a novel home router infrastructure
 - eeePCs running Linux & hostapd
- Enabling direct interaction with the infrastructure
 - APIs to support a range of UIs: phones, tablets, browsers
 - Custom pub-sub system (HWDB)
 - Control via OpenFlow/NOX
 - Policy management engine





userspace
kernel



Simple API

- Web API exposes mechanisms to application developers
- Allows exploration of alternative models and approaches

Method

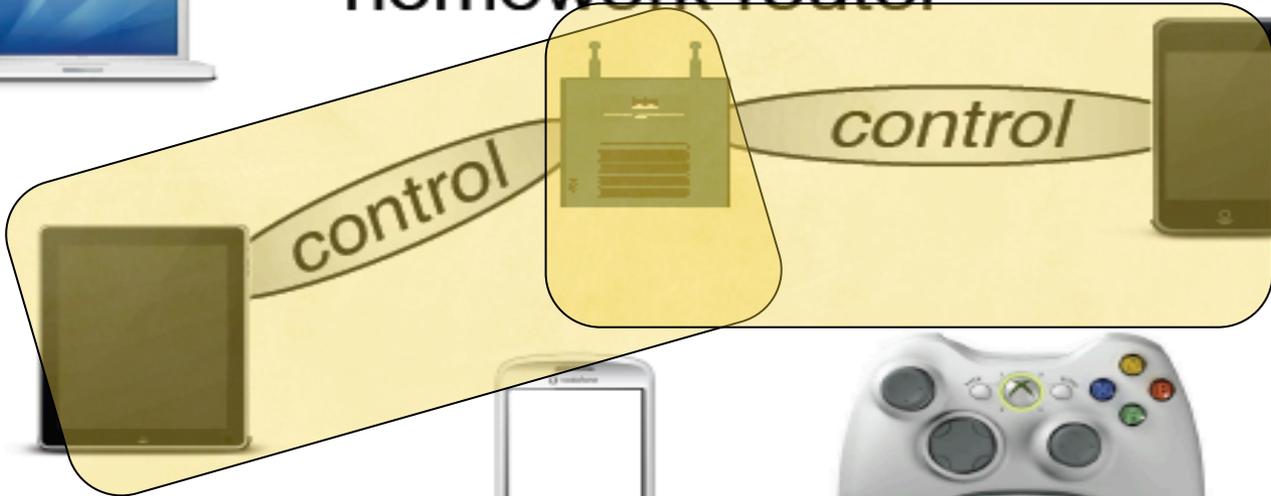
Function

/permit: <eaddr>	Permit access by specified client
/deny: <eaddr>	Deny access by specified client
/status: [eaddr]	Retrieve currently permitted clients, or status of specified client
/dhcp-status/	Retrieve current MAC—IP mappings
/whitelist: <eaddr>	Accept associations from client
/blacklist: <eaddr>	Deny association to client
/blacklist-status/	Retrieve currently blacklisted clients
/permit-dns: <eaddr> <domain>	Permit the device access to given domain
/deny-dns: <eaddr> <domain>	Deny access to the given domain by the specified device

home network



homework router



Measurement/Interaction

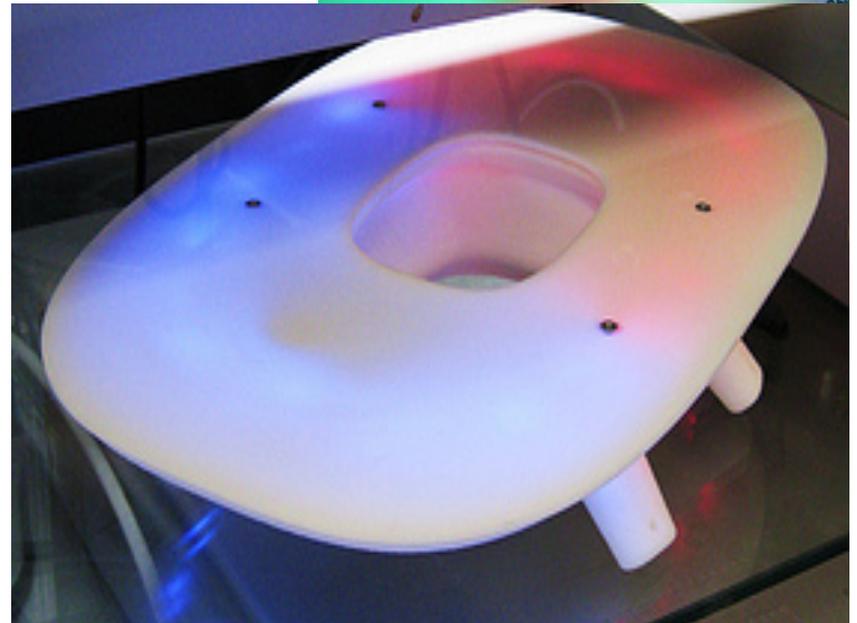
- Time series database capturing traffic in real time
- User actions can be captured alongside network traffic
- Notification service to allow users to be informed about traffic

"with [] it was really unclear what she was doing on the network.. it was good to be able to show her it was her machine using the bandwidth"



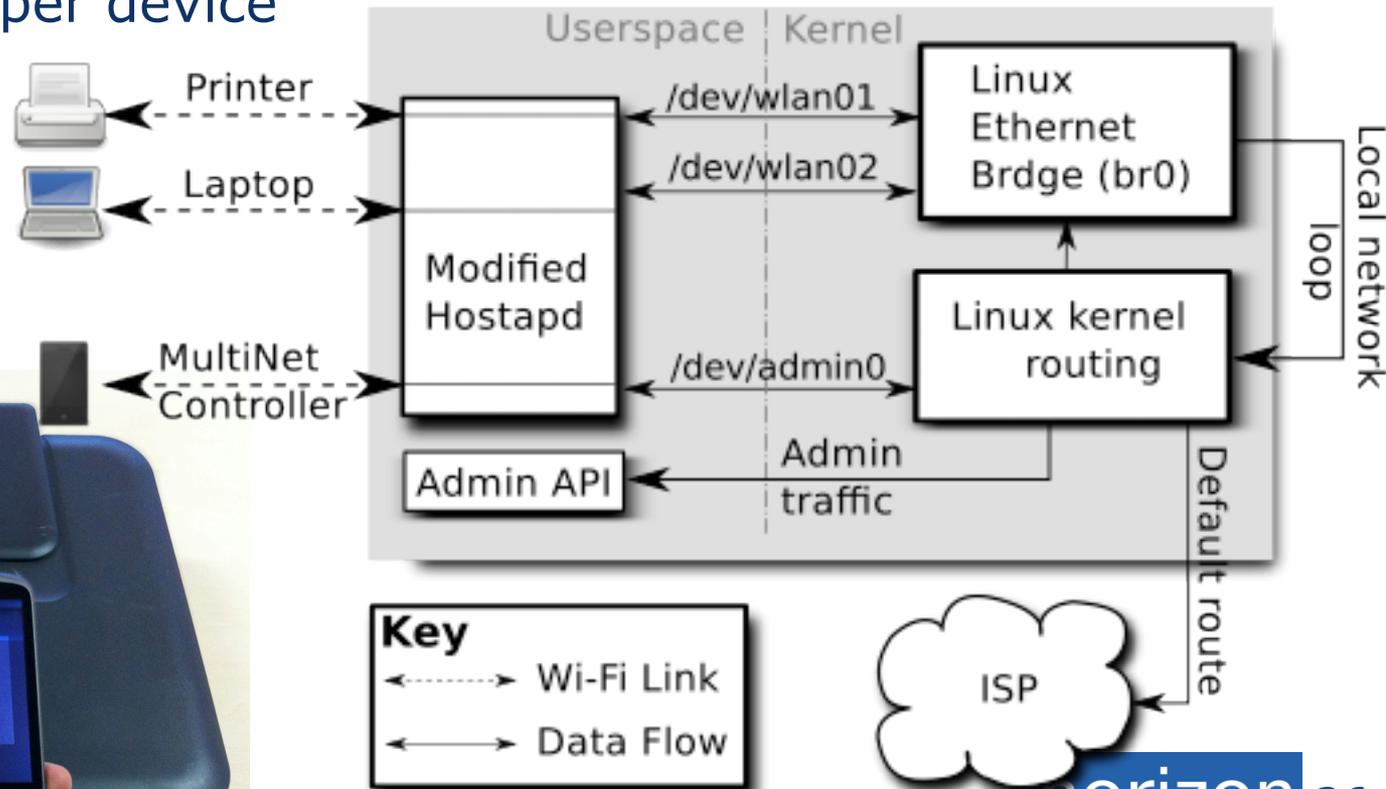
Physical Nature of the Home

- Physical access control is the norm
 - “The bag of keys” is a virtue
- USB Keys and Physical Markers used for security
- Physical Devices provide ambient awareness



MultiNet: Easy, Secure Association

- Use a controller to associate devices to the network
- Create a VAP per device



MultiNet Usability



- Users asked to construct a network consisting of three consumer devices:
 - HP Deskjet 3050A e-All-in-One Printer
 - Logitech Squeezebox Radio
 - Samsung laptop running Windows 7
- Compare connecting devices using WPS Direct and MultiNet



User Study

- 16 participants, ten male and six female
 - Ten were the home network admin
 - Twelve had never used WPS before
 - Six had never used QR Codes
- Home networks ranged from 3 devices to 15 (mean 5.6)

Connecting the HP DeskJet 350A Using

1.  To start the process p

2.  Select 2. Wireless set

3.  Select 2. Wi-Fi Protected Set Up (WPS)

4.  Select OK

5.  Select "Push Button" and follow the onscreen instructions.

The device is connected when the blue Wi-Fi light stops flashing

Connecting the HP DeskJet 350A Multinet

1.  Locate the device QR-code

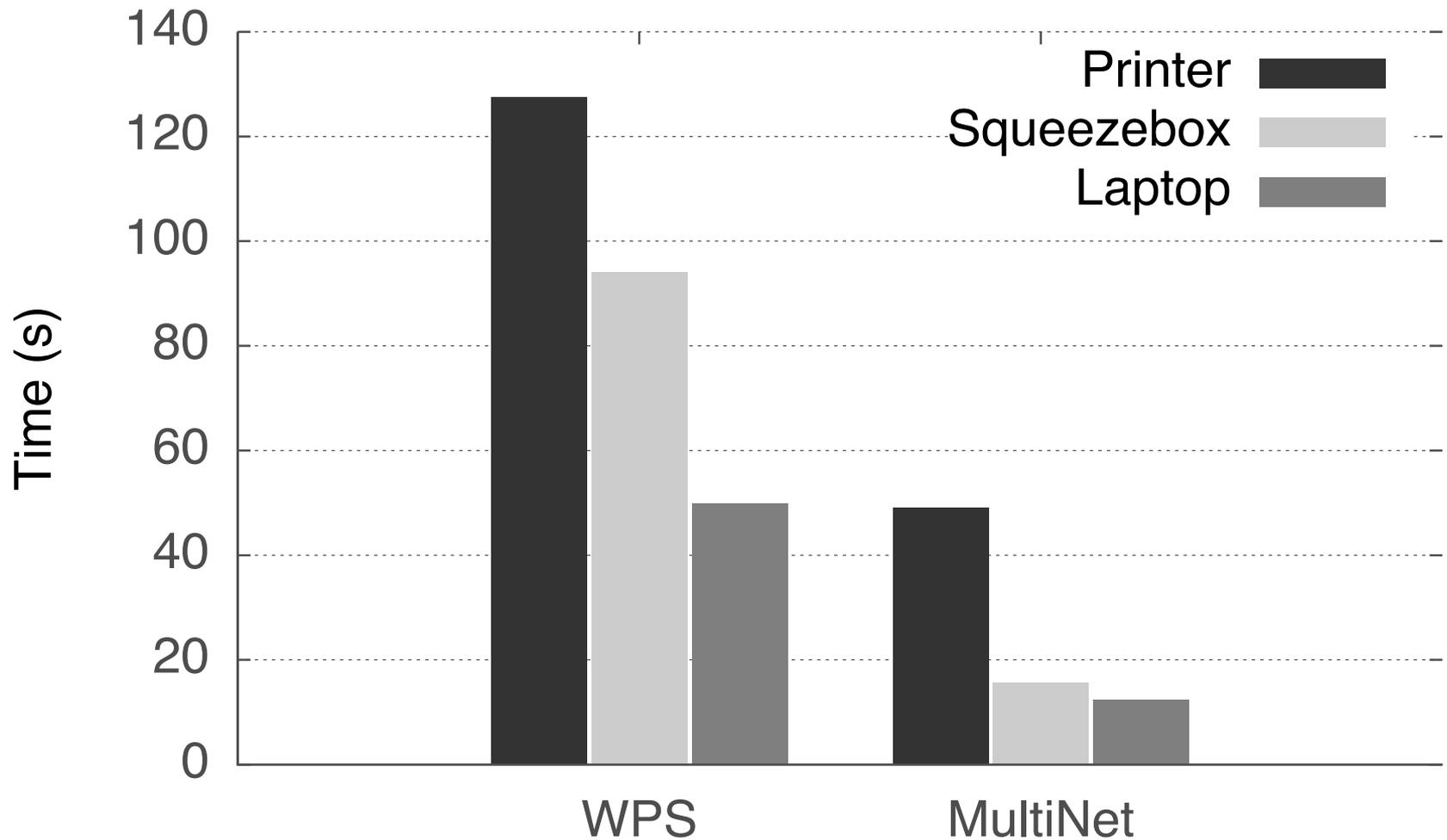
2.  On the satellite controller select "add new device"

3.  a) Align the QR-Code in the centre of the screen
b) Hold the satellite controller still for a few seconds.
c) A beep will sound and you will be returned to the main screen

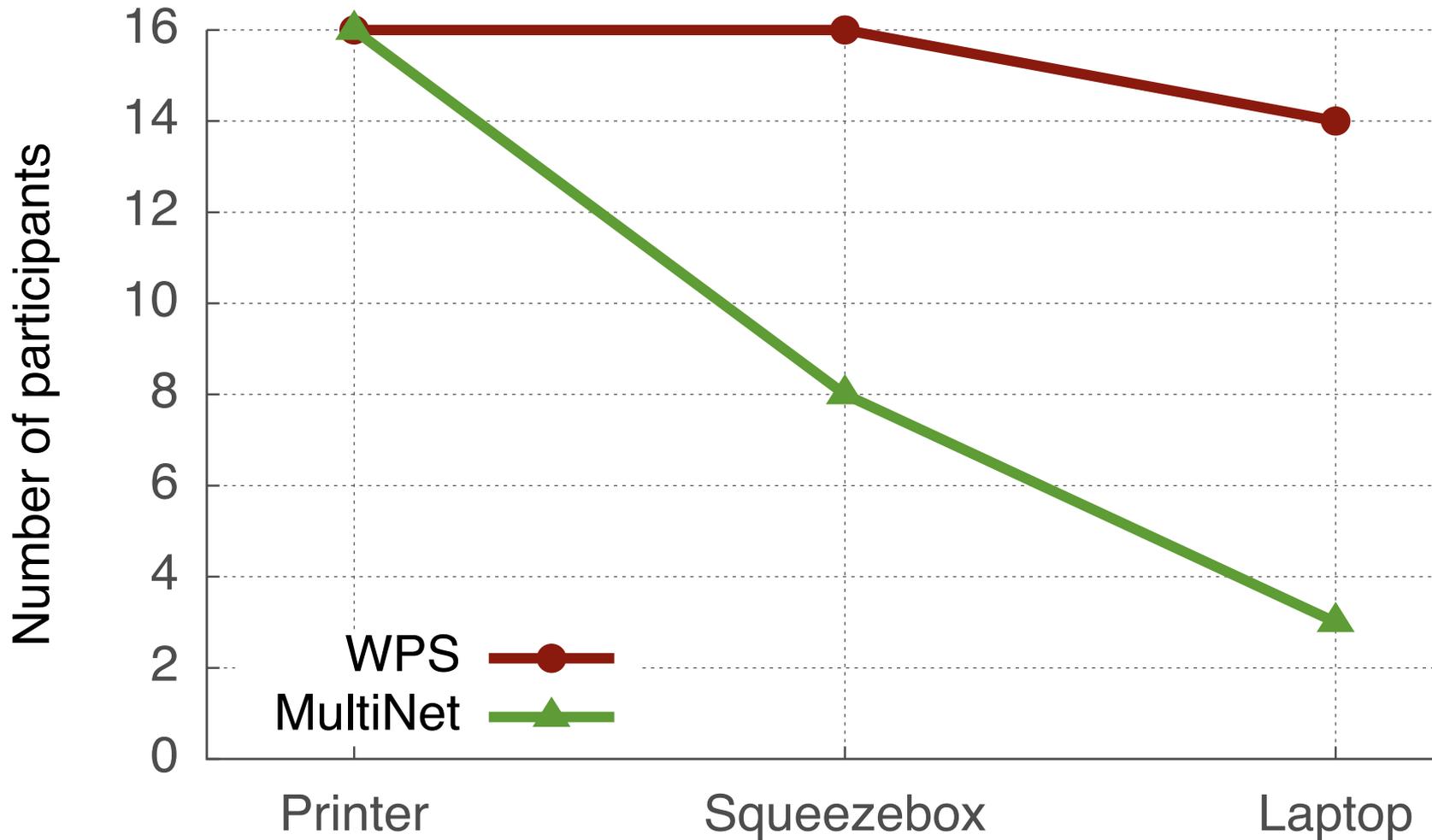
4.  Turn the printer on using the power button 

5. The device is connected when the blue Wi-Fi light stops flashing

Configuration Times

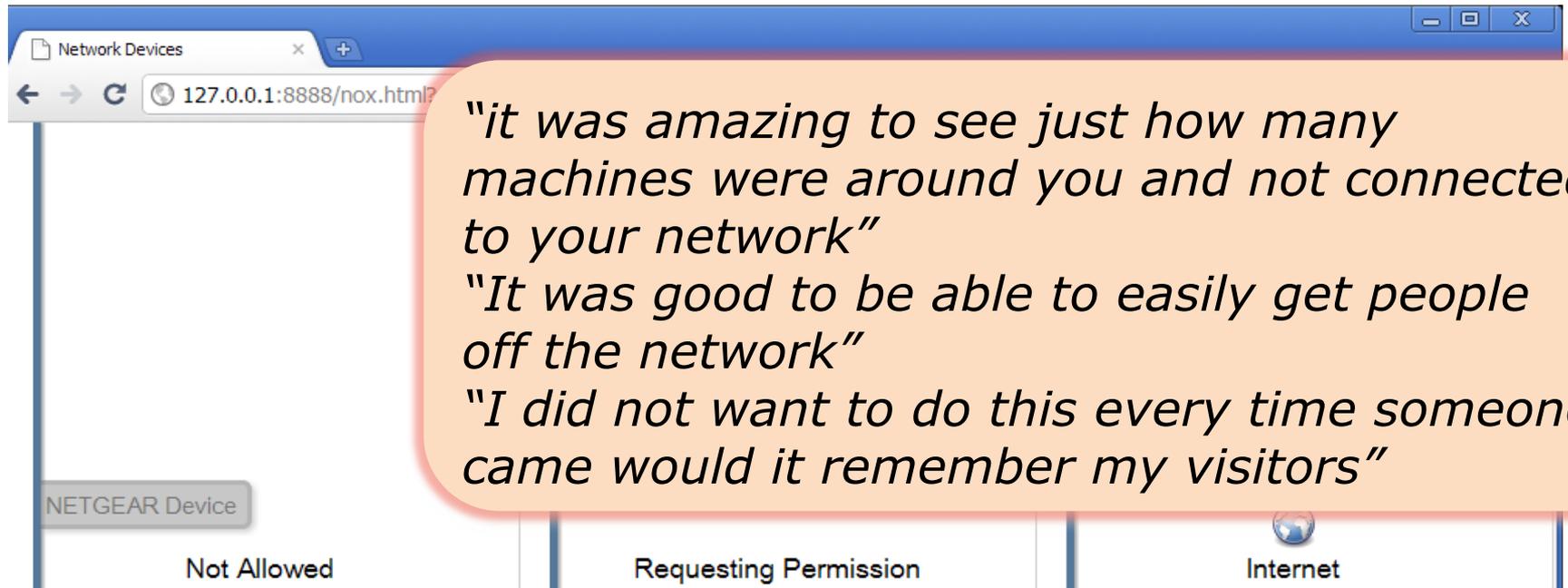


Use of Instructions



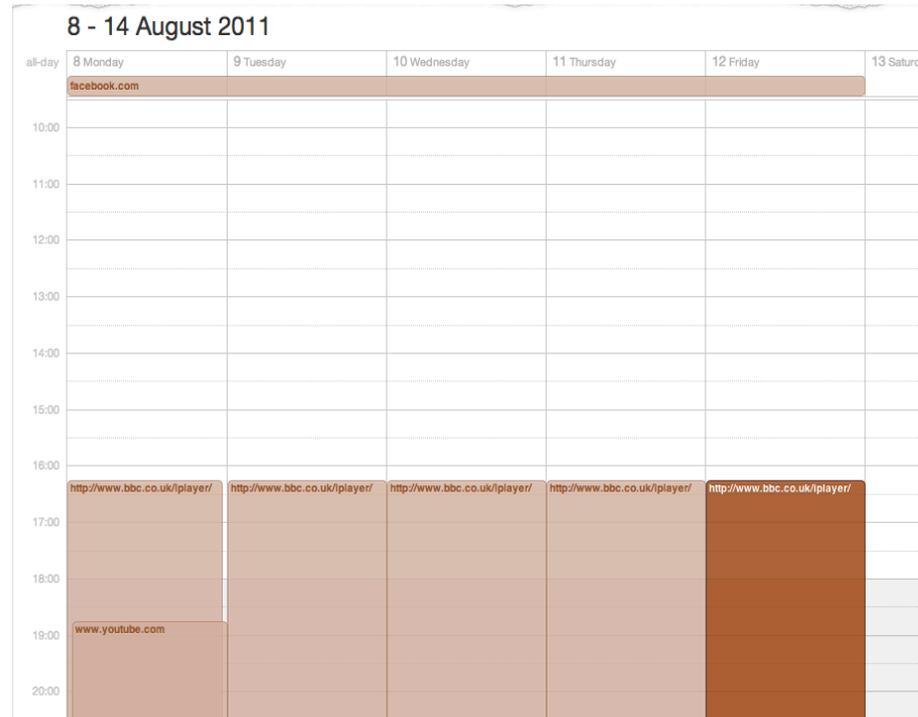
Putting People in the Protocol

- Amended DHCP to allow user involvement
 - User's permission requested via the DHCP service
 - Situated display where people drag and drop to permit



Exploiting Localised Services

- Locally determined name resolution
 - Users can police Internet access
 - Can set up dynamically resolved rules for connectivity
- Can link DNS to other services
 - Notification when a site is accessed sent to others

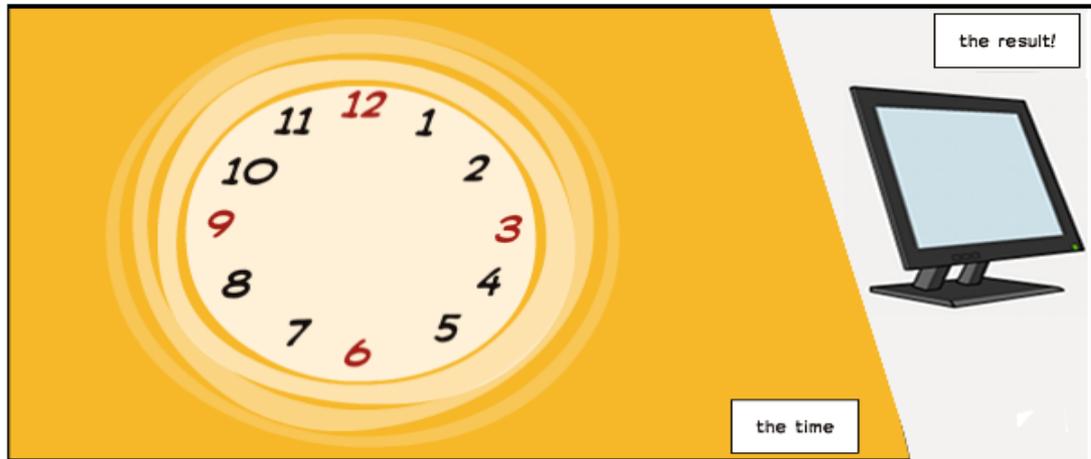
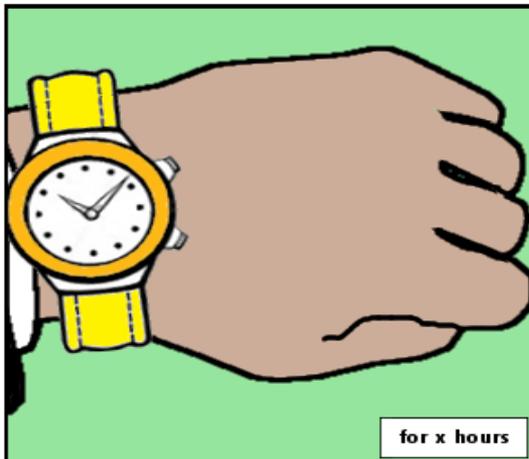
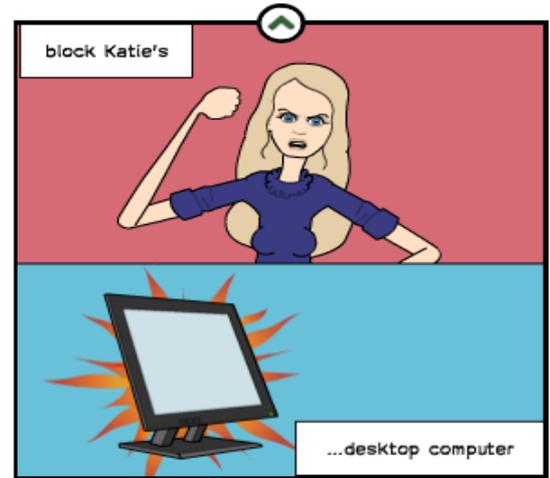
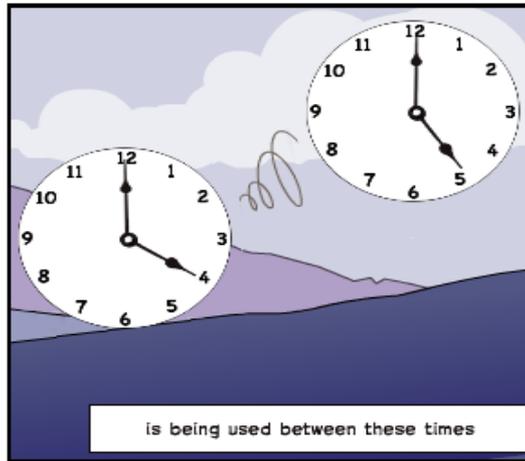
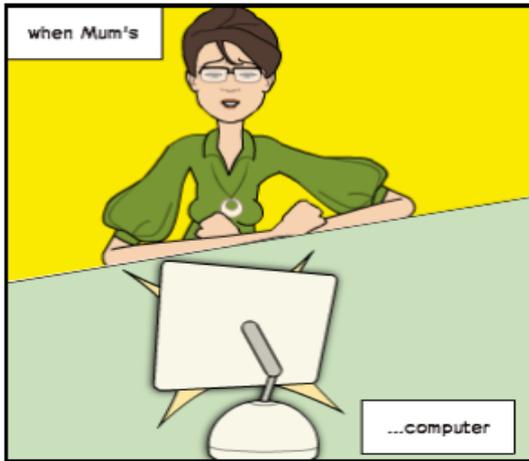


Policies

iPad

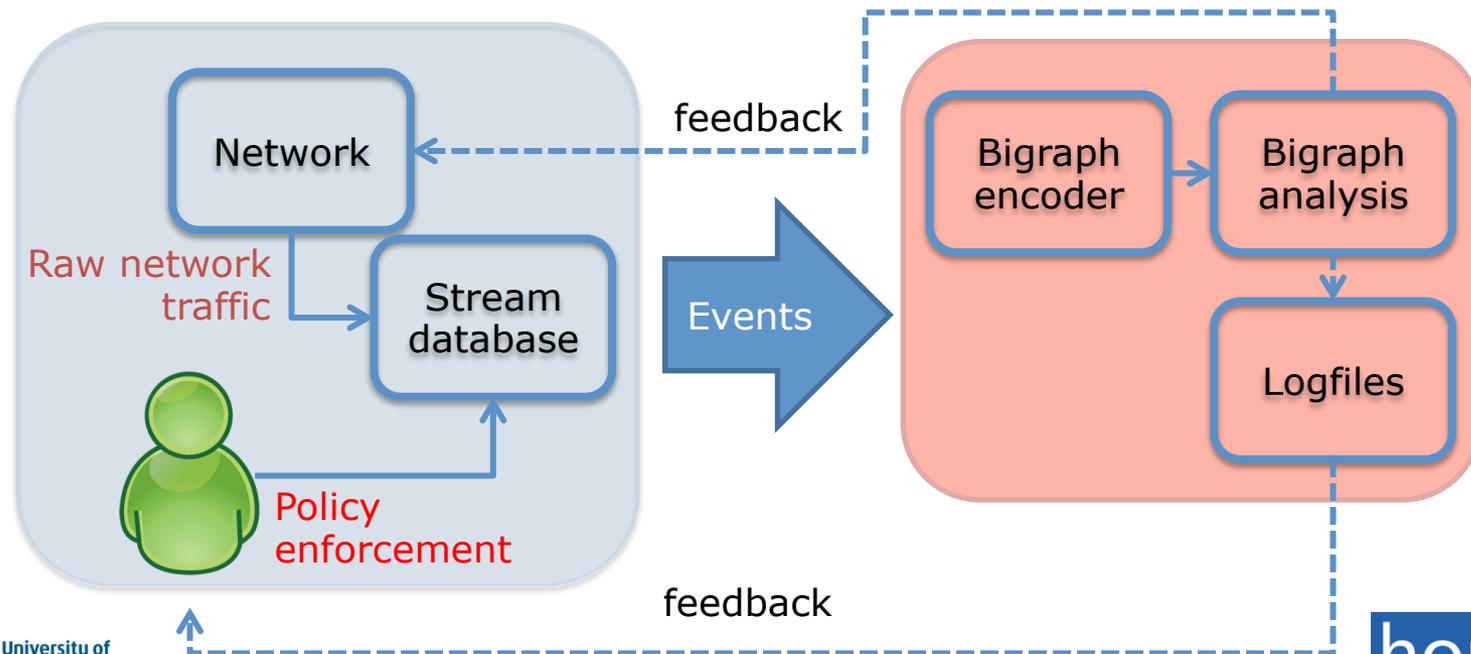
12:21

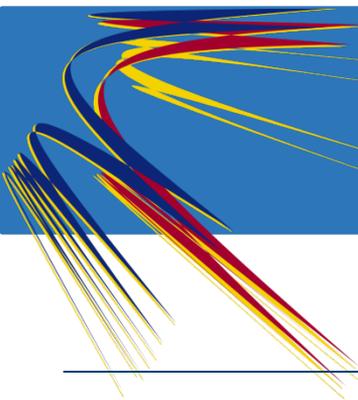
48%



Bigraphs: Formal Modelling

- A formal modelling approach proposed by Robin Milner
 - Locality, connectivity and composition as core concepts
 - Equivalent visual and algebraic representations
- A flexible model of behaviour in terms of “reactions”





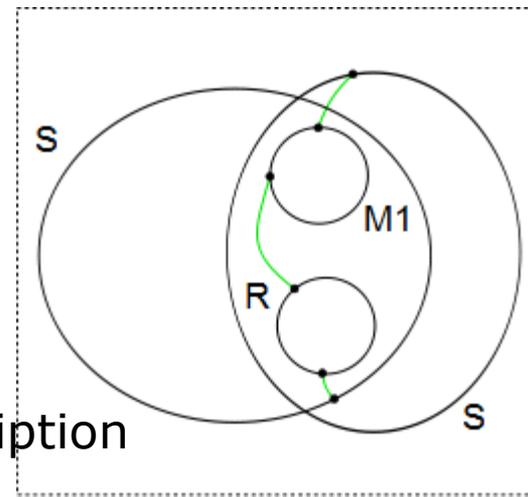
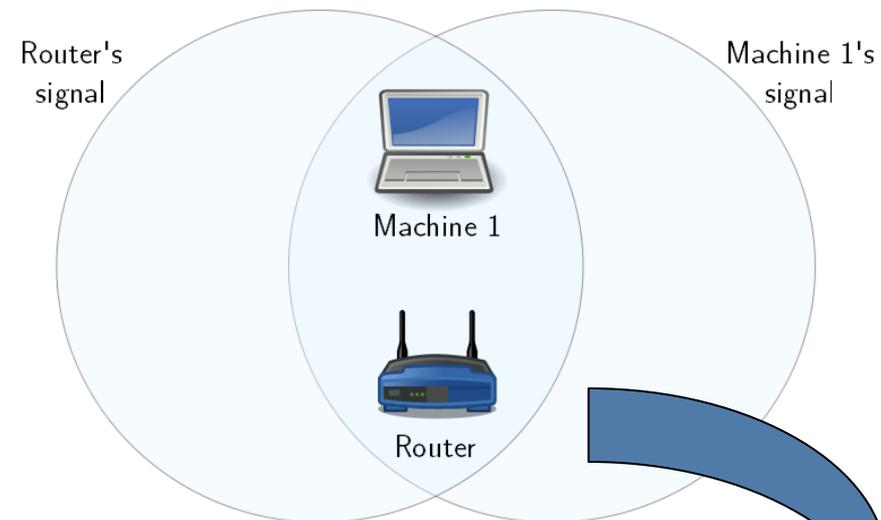
Interplay: Policy vs. Events

- Network and policy events occur in any order in the system
- Interpret policies as properties the system must always satisfy
- Network events can invalidate this, e.g.,
 - All machines are blocked
 - A new machine is added
 - New machine is not blocked
- Active policies are enforced after a network event
- Full prototype of live modelling and analysis is implemented
- Results indicate models can be generated/analysed every 2s

Example: Static WLAN

- Encode Machine 1 and Router by nodes R and M1
- Overlapping wireless signals are represented by S-nodes
- R and M1 are linked to their signals
- Router can sense Machine 1 signal and vice versa
 - Intersection of signals
- R and M1 linked as they are part of the WLAN

Informal Description



Formal Description

Deployments

- Router and interface deployments for 4—6 months
- Traffic displays are like home energy displays
 - Novelty Effect followed by no engagement
- Surfacing traffic introduces domestic discord
 - Networks are intertwined with the home's moral ordering
 - Surfacing traffic is far from neutral
- Privacy in the network
 - Records and history need to be carefully managed
- Managing the network **is** managing the household
 - Users desire involvement



Summing Up

- Home networks have become mundane
 - Another channel through which everyday life happens
 - Really no longer special
- Digital Economy is predicated on effective home networks
 - The delivery of services built on the Internet and delivered to people's homes

Work Still To Do

- But the (software) technology has not made this leap!
 - Still managed in terms of protocols and services
 - **Shopping**, not browsing the web, not using HTTP
 - The user doesn't draw a distinction between service (name resolution) and the network (IP forwarding)
- To do better we need the enabling technologies to allow these top-to-bottom connections to be made
 - Making the network **intelligible** (not *intelligent*)
 - Support “interaction within the infrastructure”
 - To complement HCI emphasis on interactive technologies

Broader Lessons Learned?

- Designing to meet these challenges needs multiple skillsets
 - Ethnography, HCI, Systems, Networking, Theory, ...
- This requires greater dialogue between communities
 - **Within computer science**
 - Just throwing results over the fence doesn't work
 - Engineers need to know about ethnography
 - Ethnographers need to know about technology
- Else we will continue to make useless things
 - By imposing ridiculous demands on technology, or
 - By implementing unusable/inappropriate technology

Questions?

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