

SWIN
BUR
NE

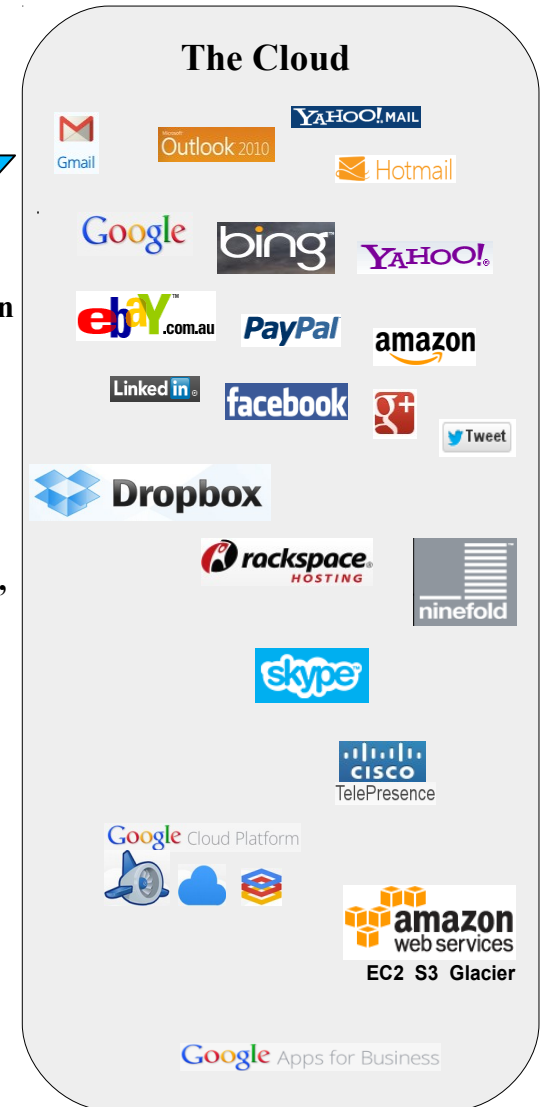
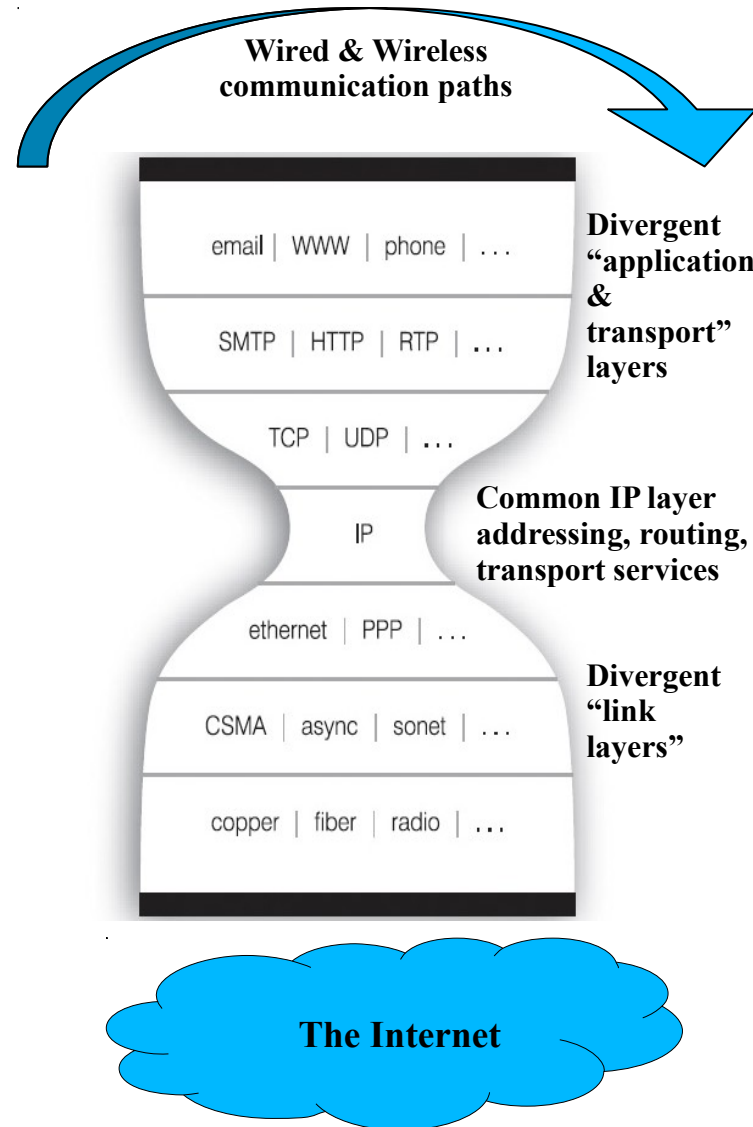
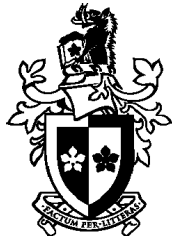
SWINBURNE
UNIVERSITY OF
TECHNOLOGY

Consumer Internet of Things: Networking challenges

Grenville Armitage



“Smart Worlds” / “Internet of Things”





The communications perspective

Telecommunications is an *enabler*

- Telemetry *from* smart devices/things
- Control signals *to* smart devices/things
- Data *between* storage, computation, visualisation and control devices

Convergence: “Internet” protocols:

- {TCP,UDP}/IP, HTTP, dynamic routing
- Diverse links: Wireless (WLAN, WiMAX, 3G/4G, Zigbee, Z-Wave...), Fixed (copper, optics, p2p microwave, ...)

Communications challenges

- Timeliness, reliability, robustness, efficiency
- ...while *things* are mobile & links intermittent
- ...while *environments* are insecure or hostile

The main visualization is a large, complex network graph. It features a dense, multi-colored structure with nodes and edges. The colors range from blue to yellow. A prominent star-like structure is visible in the upper right. An inset in the bottom right corner shows a zoomed-in view of a specific cluster of nodes and edges, with labels for various nodes.

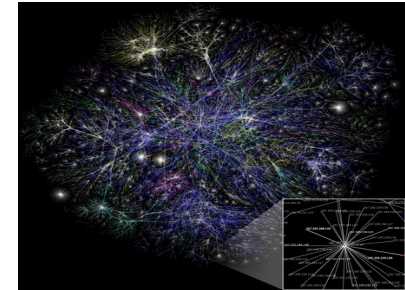
The inset shows a detailed view of a cluster of nodes and edges. The nodes are labeled with IDs such as 207.205.230.110, 207.205.230.128, 207.205.230.105, 207.205.230.123, 207.205.230.117, 207.205.230.174, 207.205.230.188, 207.205.230.126, 207.205.230.158, 207.205.230.139, 207.205.230.170, 207.205.230.155, 207.205.230.120, 207.205.230.118, 207.205.230.116, 207.205.230.114, 207.205.230.112, 207.205.230.110, 207.205.230.108, 207.205.230.106, 207.205.230.104, 207.205.230.102, 207.205.230.100, 207.205.230.098, 207.205.230.096, 207.205.230.094, 207.205.230.092, 207.205.230.090, 207.205.230.088, 207.205.230.086, 207.205.230.084, 207.205.230.082, 207.205.230.080, 207.205.230.078, 207.205.230.076, 207.205.230.074, 207.205.230.072, 207.205.230.070, 207.205.230.068, 207.205.230.066, 207.205.230.064, 207.205.230.062, 207.205.230.060, 207.205.230.058, 207.205.230.056, 207.205.230.054, 207.205.230.052, 207.205.230.050, 207.205.230.048, 207.205.230.046, 207.205.230.044, 207.205.230.042, 207.205.230.040, 207.205.230.038, 207.205.230.036, 207.205.230.034, 207.205.230.032, 207.205.230.030, 207.205.230.028, 207.205.230.026, 207.205.230.024, 207.205.230.022, 207.205.230.020, 207.205.230.018, 207.205.230.016, 207.205.230.014, 207.205.230.012, 207.205.230.010, 207.205.230.008, 207.205.230.006, 207.205.230.004, 207.205.230.002, 207.205.230.000.



SWINBURNE
UNIVERSITY OF
TECHNOLOGY

Happily chattering away....

Many, many millions(+) of loosely co-operating, mostly de-coupled devices....



All trying to locally optimise for their preferred mix of speed,

responsiveness,

consistency,

'quality'

price....



http://ny.racked.com/uploads/2011_11_Macys-Black-Friday-Crowd.png

Enjoying regular traffic jams....

Many, many millions(+) of loosely co-operating, mostly de-coupled devices....

All trying to locally optimise for their preferred mix of speed,

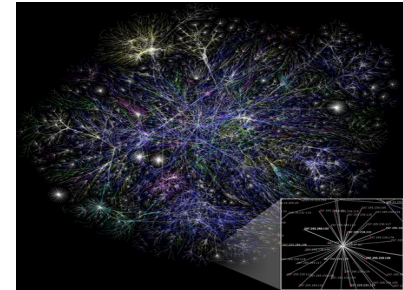
responsiveness,

consistency,

'quality'....

price....

What could possibly go wrong?



http://izismile.com/2009/12/22/how_traffic_jams_start_6_pics-5.html

More “things” for the home...



Philips Hue: <http://www.meethue.com>



GE Appliances' “Wifi Connect”



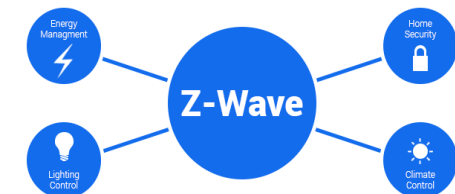
Belkin's WeMo home automation



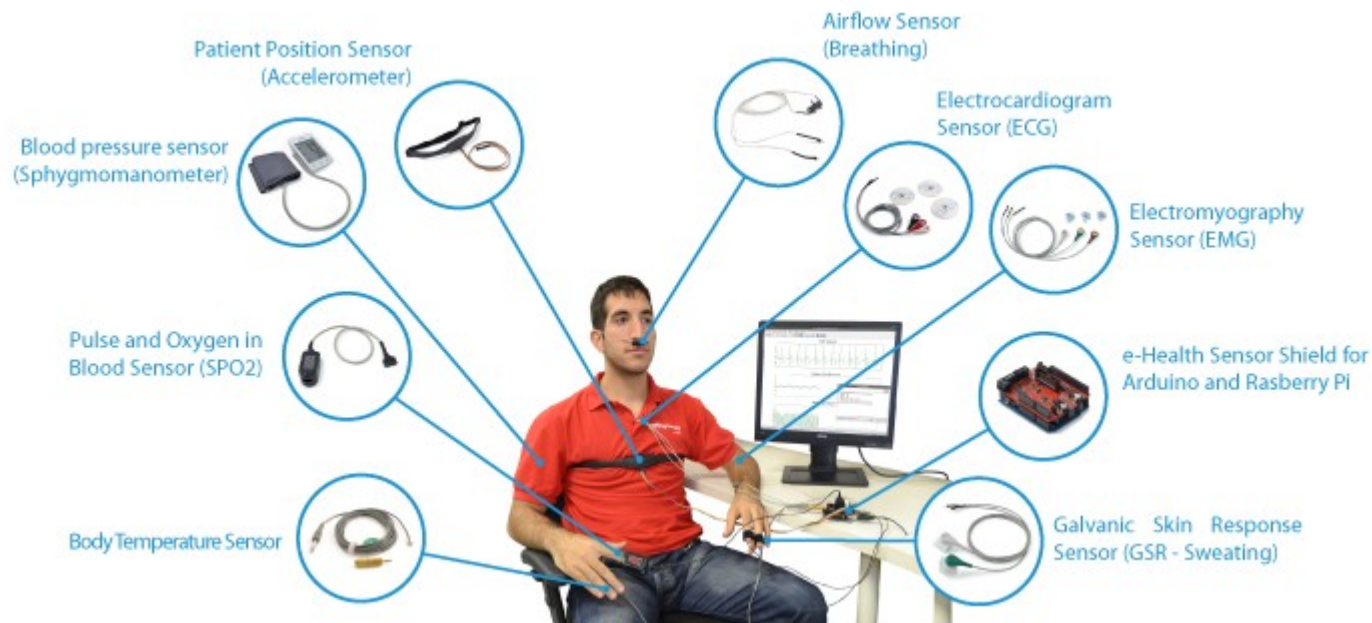
FitBit Surge



Connected Hydration Bottle with Smart Lid



More “things” for the home... #2



<https://www.cooking-hacks.com/documentation/tutorials/ehealth-biometric-sensor-platform-arduino-raspberry-pi-medical>

(I ran out of time to find more diverse images for tele-health. Sorry.)

Lifestyle automation...

openHAB

“...software for integrating different home automation systems and technologies into one single solution that allows over-arching automation rules and that offers uniform user interfaces.”

Addressing the needs of
“...home automation solutions and Internet-of-Things (IoT) gadgets..”

An “..Intranet of Things..”



The screenshot shows the openHAB website homepage. At the top is a navigation bar with links: Home (highlighted in orange), Features, Downloads, Community, Github, Wiki, and my.openHAB. The main content area has an orange background. On the left is a large logo consisting of a grey circle with a red house shape inside, and three small red squares at the bottom. To the right of the logo, the text 'openHAB' is displayed in white. Below it is a list of features with orange arrow icons: 'Developed in Java', 'Pluggable OSGI architecture', 'Absolutely vendor-neutral', 'Hardware/protocol-agnostic', 'Fully open source', and 'Passionate and growing community'. A 'Read More' button is located below the list. At the bottom of the page, a grey banner contains the text: 'Welcome to openHAB - a vendor and technology agnostic open source automation software for your home. Build your smart home in no time!'.

<http://www.openhab.org>



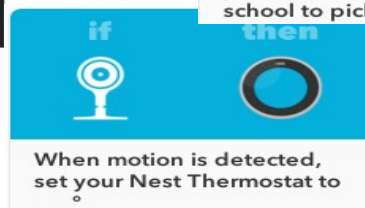
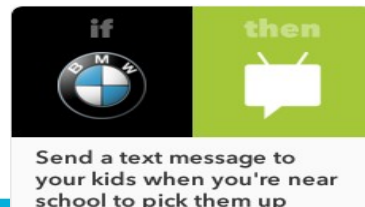
More lifestyle automation...

“If This Then That” (IFTTT)

Consumer-friendly
“programs” trigger actions
based on events

Events: environment sensors,
social media activity, ...

Actions may control
household devices, ...



Internet of Things – Home Networking

Connect Your Home

From smart thermostats to wireless light bulbs, here are 6 ways to improve your home's IQ.



Light up your house at sunset

No need to reach for the switch when it gets dark. Let IFTTT light up the room for you.

[Learn More](#)



Come home to a warm hello

Keep your home cozy and warm. IFTTT can detect when you're leaving work and flip on the heater.

[Learn More](#)



Wake up to coffee in the morning

Brew a fresh pot of coffee from bed each morning to get your day started.

[Learn More](#)



Print at Grandma's with your camera phone

Setup an internet connected printer so you can share beautiful photos from anywhere.

[Learn More](#)



Never forget to arm your alarm

All you have to do is leave home to arm your smart alarm.

[Learn More](#)

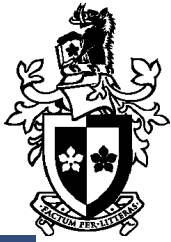


Don't overwater

Save water while keeping your lawn refreshed and healthy.

[Learn More](#)

<https://ifttt.com/categories/connect-your-home>



Even more lifestyle automation...

Apple HomeKit

Consumer-friendly, iOS-based, integrated control of household devices, ...

Simple triggers (you control)

Environmental triggers (rules)

Integrated with Siri: *“Turn on the TV...”, “Movie night...”*

HomeKit

Securely control your home.
From the palm of your hand.

You use your iPhone every day — to stay in touch with people, stay organised and help manage your health and fitness. With HomeKit, now you can also use your iOS device to connect the products you use in your home — so you can privately and securely control them and make them work together.

Lighting Locks Heating + Cooling Sensors Plugs + Switches Blinds

<http://www.apple.com/au/ios/homekit>



Reliance on offsite 3rd parties

Some of these are cloud-based services

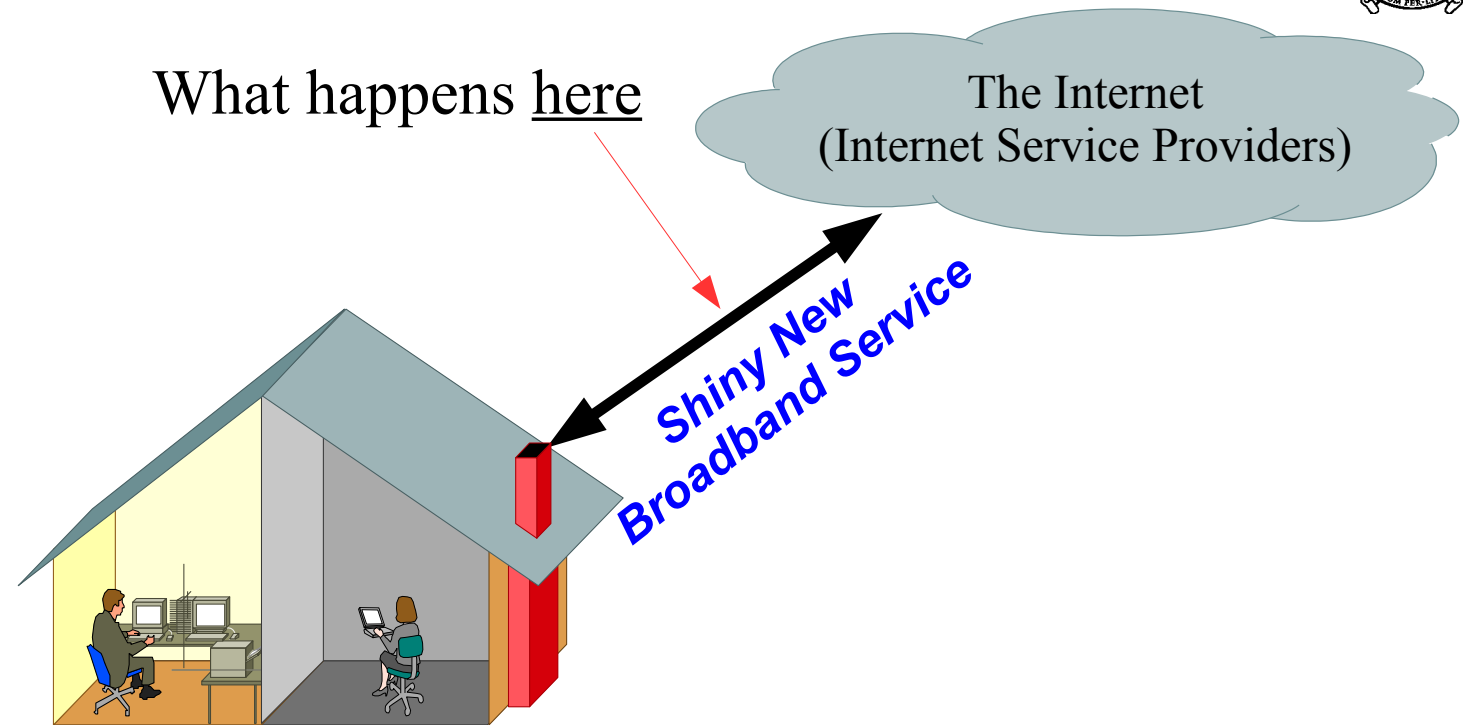
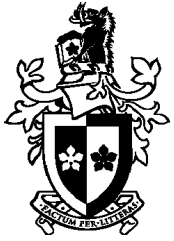
- Offsite servers link devices & user controls (phone, etc)
- Offsite servers instantiate stand-alone 'smart' rules
- Responsiveness and reliability constrained by your wired or 3G/4G Internet access

(And *someone* knows what your house is doing...)



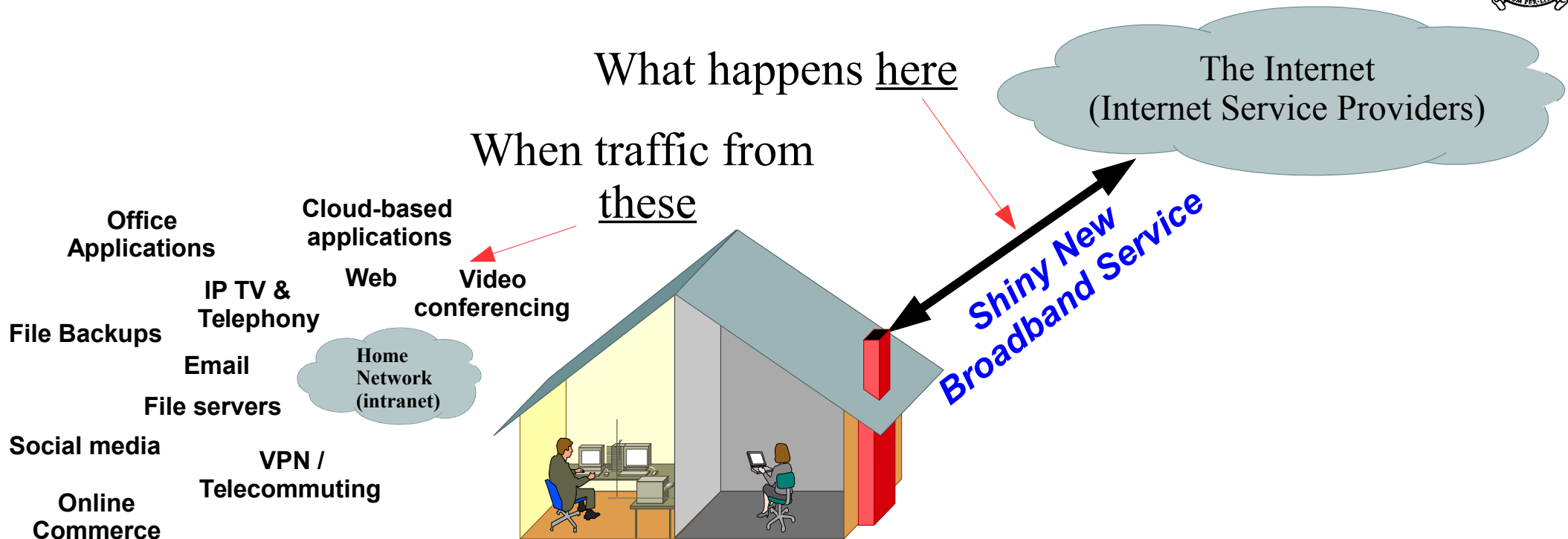
So what?

A weak point: the internet plumbing...



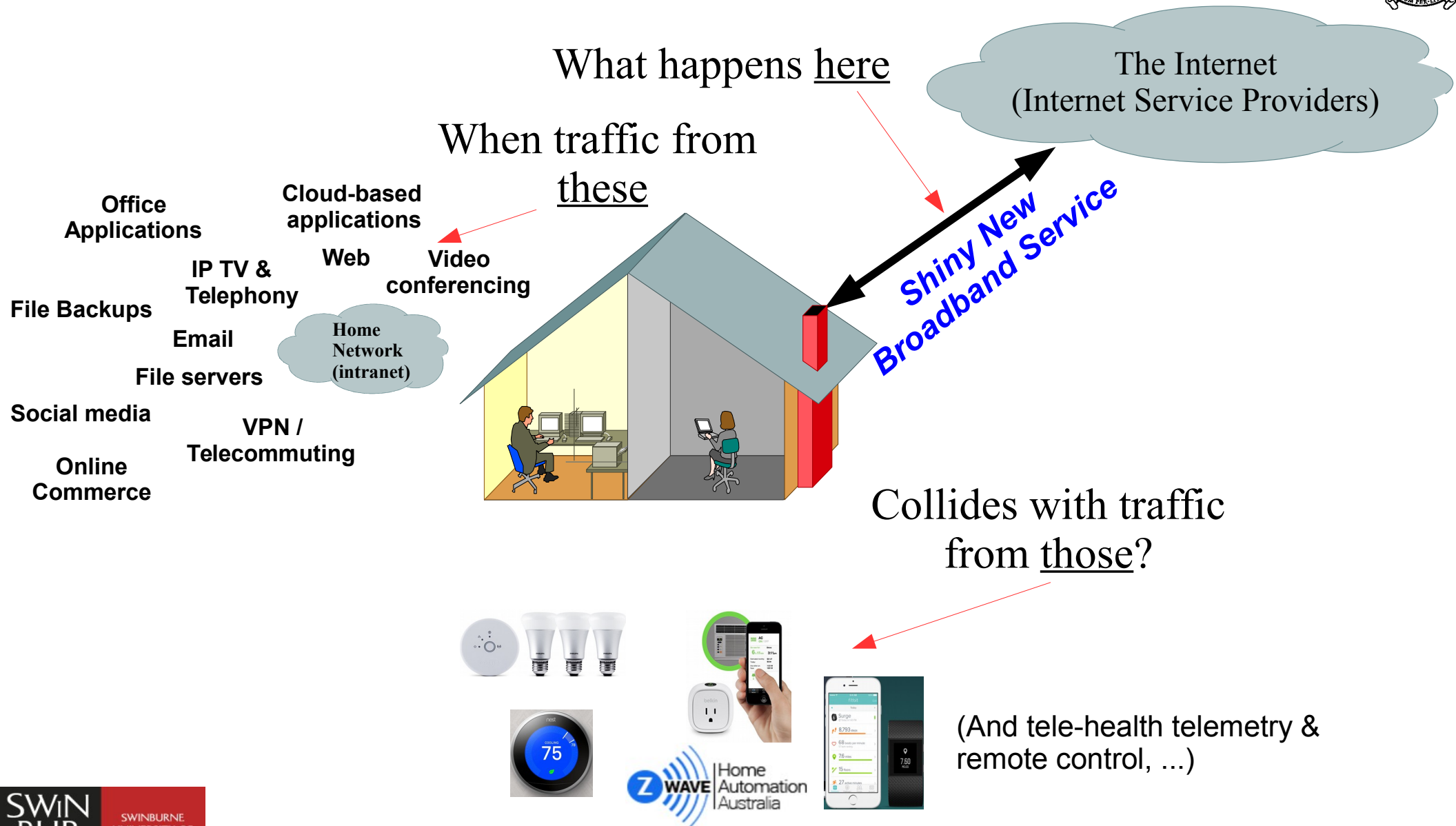


A weak point: the internet plumbing...





A weak point: the internet plumbing...

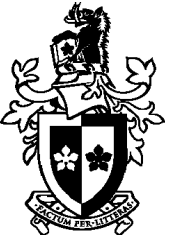




Consumer internet is... challenging

- Link layer sync issues
 - ADSL & DOCSIS come and go at inopportune times
 - No-one promises 5-nines service anyway...
- “Bufferbloat”
 - Long-lived/bulk TCP data flows fill traditional buffers, so all traffic sees large RTT spikes (gateways, Wifi APs, ...)
 - Responsiveness declines for all offsite services

(Oh, and *curious* security practices by device vendors....)



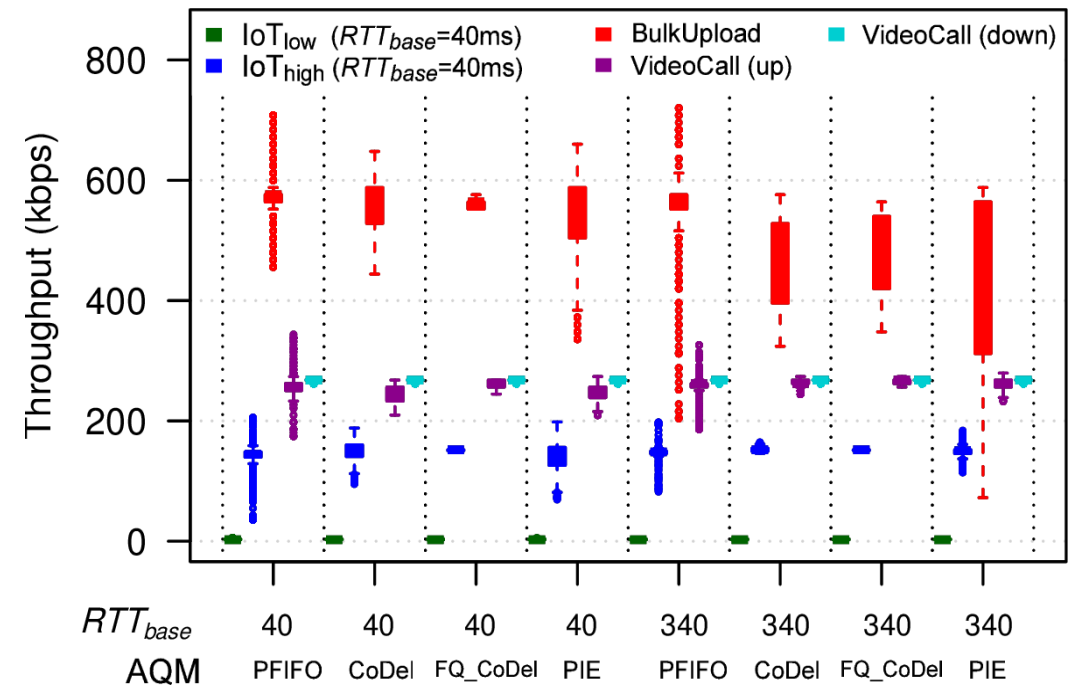
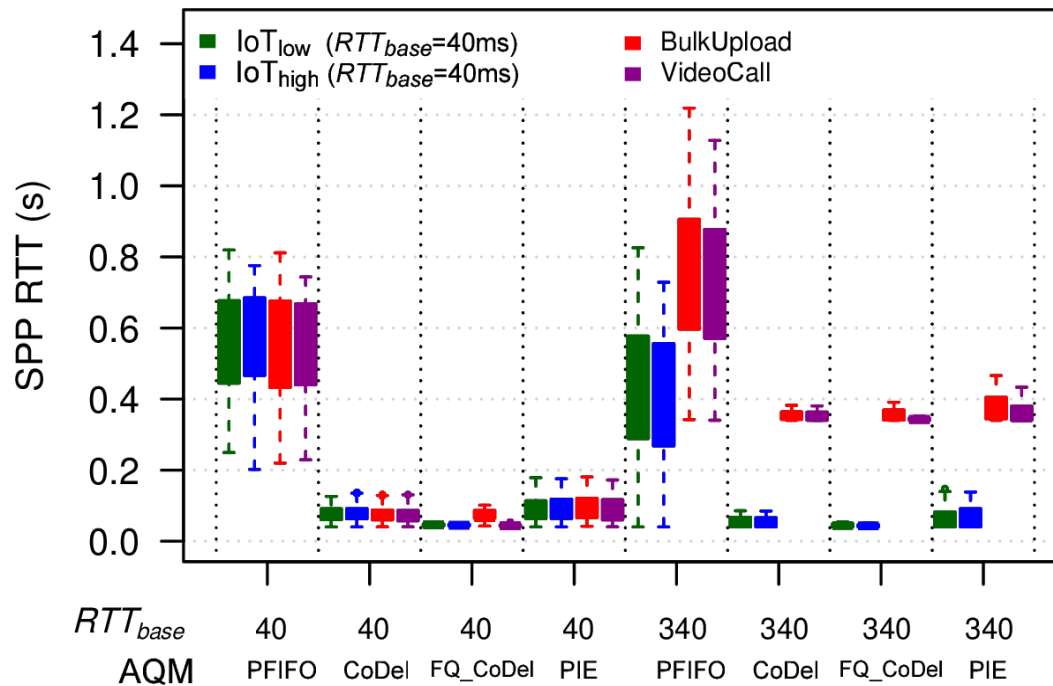
An open topic: Peaceful coexistence

(or: *sharing the home Internet access link*)

- Interactions with consumer entertainment traffic
 - Modeling the impact network of streaming TV, etc...
- Enhanced transport protocols?
 - multi-path TCP, delay-sensitive TCP, scavenger TCP, ...
- Better queue/buffer management?
 - Active Queue Management (CoDel, PIE)
 - Dynamic flow isolation (FQ-CoDel, FQ-PIE)



AQM helps reduce RTT



Throughput and RTT of four flows at 12/1Mbps (Base RTT={40,340}ms for non-IoT flows)

(PFIFO is prevalent gateway queue management. CoDel, FQ_CoDel and PIE are new AQM algorithms.)



Some overlapping CAIA work

- Cisco-funded (and jointly with SISR)

"An integrated social and technical evaluation of household broadband service requirements for educational innovation and the Internet of Things"
- Comcast-funded

"Independent implementation of modern Active Queue Management in FreeBSD"
- Netflix-funded

"Support for a PhD program in high performance IP-based content delivery"
- Cisco / FreeBSD Foundation funded

"FreeBSD implementation of Multi-path TCP", "New TCP congestion control protocols"