Supporting Novel Home Network Management Interfaces with Openflow and NOX

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ABSTRACT

In the Homework project[1] we have been examining the redesign of existing home network infrastructures to better support the needs and requirements of actual home users. Integrating results from several extensive ethnographic studies, we have designed and built a home networking platform providing detailed per-flow measurement and management capabilities in support of several novel management interfaces. This demo demonstrates these new capabilities specifically, and explores the broader benefits available by taking an integrated view of the networking infrastructure from top to bottom, ranging from ethnographically determined user requirements to detailed protocol behaviours.

1. DEMO

The demo involves running our home network wireless Ethernet access point, with wired uplink if available, with several connected client devices. We will demonstrate several of the novel user interfaces for network visualisation and control we have built (§2) using our router's augmented measurement and control APIs (§3). Viewers may connect their own devices and interact with the user interfaces if they wish.

2. USER INTERFACES

The first two interfaces are both for visualization, and make use of the *hwdb* streaming database. The first runs on an iPhone/iTouch device and simply displays the per-device per-protocol bandwidth consumption, as shown in Figure 1. This allows users to focus on how their devices and, to the extent permitted by the imperfect application–protocol mapping, their applications are using the network.

The second, depicted in Figure 2, is a custom hardware interface based on the Arduino hardware platform.[2] It enables awareness of the *network as a whole* rather than specific devices, displaying one of (*i*) wire-

Figure 1: Per-device bandwidth consumption.

Figure 2: Network artefact as physical interface.

[1] `http://www.homenetworks.ac.uk/`
[2] `http://www.arduino.cc/`

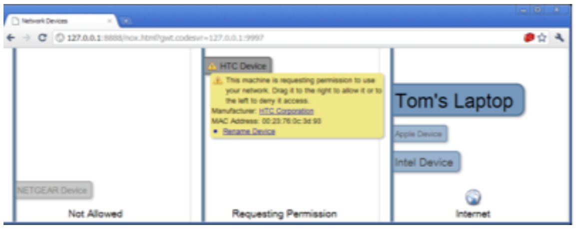

Figure 3: Simple control interface.

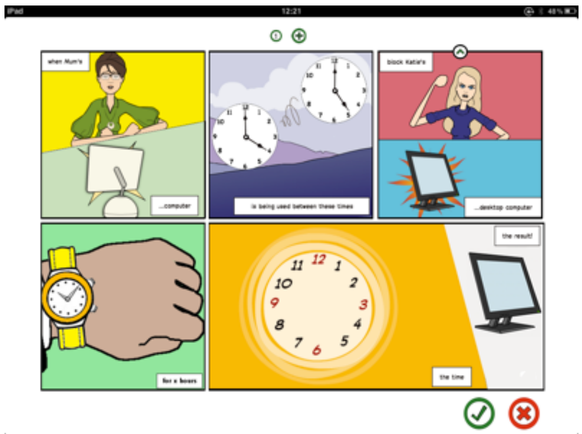

Figure 4: Novel interactive policy interface.

less signal strength (RSSI) based on number of LEDs lit; (*ii*) current total bandwidth use mapped to the speed of animation of LEDs across the device; and (*iii*) DHCP lease grant and revocation activity indicated by the colour of flashing LEDs.

The next two interfaces both demonstrate different control mechanisms available through our platform. The first, shown in Figure 3, is a simple control interface that exercises the control API to manage DHCP allocations. It is accessed via a situated display in the home. This allows non-expert users to detect, interrogate and supply metadata for devices requesting access, and to control the DHCP server on a case-by-case basis by dragging each into the appropriate permitted/denied category.

The second demonstrates physical mediation of control: the user simply plugs a USB storage device with appropriate file-system layout into the router, which then enables specific devices to connect to the network, possibly also limiting access to web-hosted services such as Facebook. The final interface, shown in Figure 4, integrates the above into a simple visual policy language. By selecting appropriate options for each panel in the cartoon, the non-expert user can implement simple policies such as "the kids can only access Facebook on weekday evenings after they've finished their homework." This is mapped to per-device network and DNS access restrictions which are only lifted once a suitably responsible adult has inserted the appropriate USB storage key.

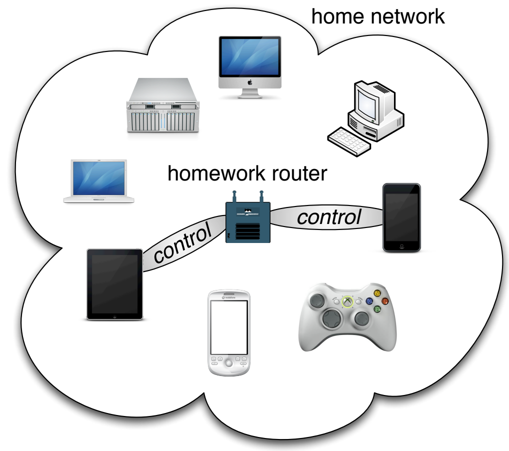

Figure 5: Overview of the Homework home networking platform.

3. TECHNICAL DETAILS

In more detail, our home networking platform takes the form of a small form-factor PC running our software, acting as the home router, and exposing various APIs that are used by several satellite interrogation and control devices, as depicted in Figure 5. Within this, our software sits atop a standard Linux Ubuntu distribution running Open vSwitch[3] and NOX,[4] and provides our measurement and control infrastructure. Figure 6 shows the software architecture of the router, with our code shown as the shaded components.

Measurement support is provided by *hwdb*, the Homework Database. This is an active ephemeral stream database which stores ephemeral events into a fixed size memory buffer. It links events into tables and supports queries via a CQL [1] variant that can express temporal and relational operations on data items. The database supports a simple UDP-based RPC interface that enables applications to subscribe to query results, persisting output as required. Currently used tables include *Flows*, periodically observed flow five-tuples; *Links*, link-layer information including MAC address and received signal strength (RSSI); and *Leases*, giving MAC address to DHCP allocated IP address.

Control is via the *control API* NOX module which provides a simple RESTful web interface to the router. This is invoked to exercise control over connected devices: by the Linux *udev* subsystem when a suitably formatted USB storage device is inserted; and directly by the various graphical control interfaces. In turn, the

[3] `http://openvswitch.org/`
[4] `http://noxrepo.org/`

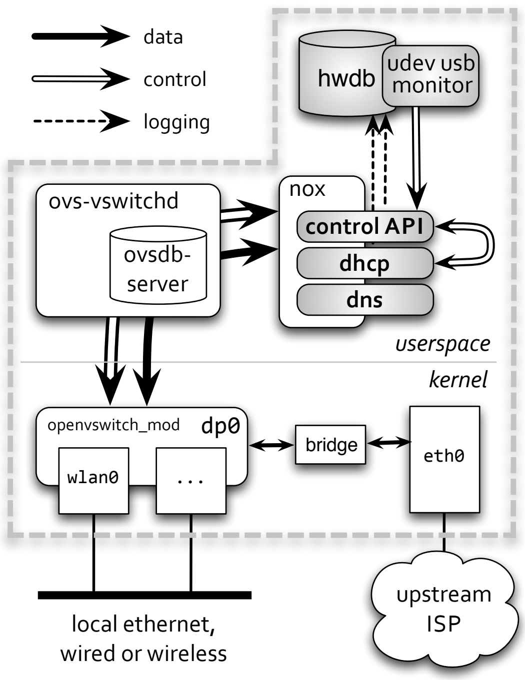

Figure 6: Software architecture of the Homework home router.

control API configures the behaviour of our NOX modules, implementing a DHCP server and a DNS proxy. The DHCP server manages DHCP allocations to ensure that *all* traffic flows are visible to software running on the router, avoiding direct Ethernet-layer communication between devices. The DNS proxy ensures that upstream communication is only allowed between permitted devices and sites, by intercepting outgoing DNS requests as well as performing reverse lookups on flows that do not match a previously requested site.

4. REFERENCES

Aspects of the work to be demonstrated have been published: the Homework Database in Internet Management (IM) 2011 [3] and implications of the ethnographic results are to appear at the SIGCOMM W-MUST workshop 2011 [2]. Separate, more detailed expositions of the interface elements, and the system performance and implications, are currently under submission at other venues. A pre-alpha code release is already available at `https://github.com/homework/` and we anticipate a public beta release in August/September 2011.

5. RESOURCE REQUIREMENTS

We will provide all routers and interface devices. Demo setup should not take more than 30 minutes.

Required.

- Up to 8 standard US power sockets (e.g., two sockets each with a 4-way extension cable).
- Desk/table space to accommodate the demo, estimated at 3–4 m^2.

Desired, but not required.

- UK adaptors for each power socket.
- One standard computer display screen (e.g., LCD panel) with VGA input.
- Two wired Ethernet connections to provide “upstream” links for each router.
- Display space for a descriptive poster providing background information.

ACKNOWLEDGEMENTS

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6. REFERENCES

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