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Supporting Novel Home Network Management Interfaces with Openflow and NOX

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ABSTRACT

The Homework project¹ has examined redesign of existing home network infrastructures to better support the needs and requirements of actual home users. Integrating results from several ethnographic studies, we have designed and built a home networking platform providing detailed per-flow measurement and management capabilities supporting several novel management interfaces. This demo specifically shows these new visualization and control interfaces (§1), and describes the broader benefits of taking an integrated view of the networking infrastructure, realised through our router's augmented measurement and control APIs (§2).

Aspects of this work 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 system performance and implications are currently under submission at other venues. A partial code release is already available² and we anticipate fuller public beta release by Q4 2011.

Categories and Subject Descriptors:

C.2.6 [Computer-Communication Networks]: Routers

General Terms:

Management, Design, Security, Human Factors

Keywords: Home networks; Network management; DHCP; NOX; OpenFlow

1. USER INTERFACES

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

The second, Figure 2, is a custom hardware interface based on the Arduino platform³ enabling awareness of the *network as a whole* rather than specific devices. Via its LEDs, It



Figure 1: Per-device bandwidth consumption.



Figure 2: Network artefact as physical interface.

displays one of (i) wireless signal strength (RSSI) based on number lit; (ii) current total bandwidth use mapped to the speed of animation across the device; and (iii) DHCP lease grant activity indicated by the colour of flashes.

The next two interfaces demonstrate two control mechanisms available in our platform. The first, Figure 3, is a simple control interface that exercises the control API to manage DHCP allocations, 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 the device's tab into the appropriate permitted/denied category.

The final interface, Figure 4, integrates physical mediation of control into a simple visual policy language. When the user plugs a USB storage device with appropriate file-system layout into the router, it enables specific devices to

¹<http://www.homenetworks.ac.uk/>

²<https://github.com/homework/>

³<http://www.arduino.cc/>

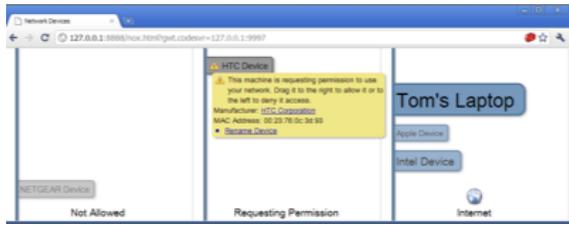


Figure 3: Simple control interface.

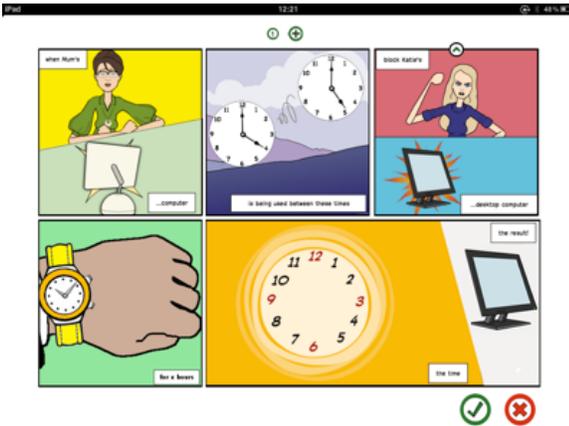


Figure 4: Novel interactive policy interface.

connect to the network as well as limiting access to specified web-hosted services, e.g., Facebook. By selecting appropriate options for each panel in the cartoon, non-expert users can implement simple policies such as “the kids can only use Facebook on weekdays 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 inserts the appropriate USB storage key.

2. TECHNICAL DETAILS

Our platform takes the form of a small form-factor PC acting as the home router, exposing various APIs used by satellite interrogation and control devices. Providing those APIs, our software sits atop a standard Linux Ubuntu distribution running Open vSwitch⁴ and NOX,⁵ depicted in Figure 5 with our code shown as the shaded components.

The Homework Database, *hwdb*, provides measurement support as 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 able to express temporal and relational operations on data. The database supports a simple UDP-based RPC interface enabling applications to subscribe to query results, persisting output as desired. Tables used are *Flows*, periodically observed active five-tuples; *Links*, link-layer information, e.g., MAC address and received signal strength (RSSI); and *Leases*, mapping Ethernet to IP address.

The *control API* NOX module provides a simple RESTful web interface to the router, 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. The con-

⁴<http://openvswitch.org/>

⁵<http://noxrepo.org/>

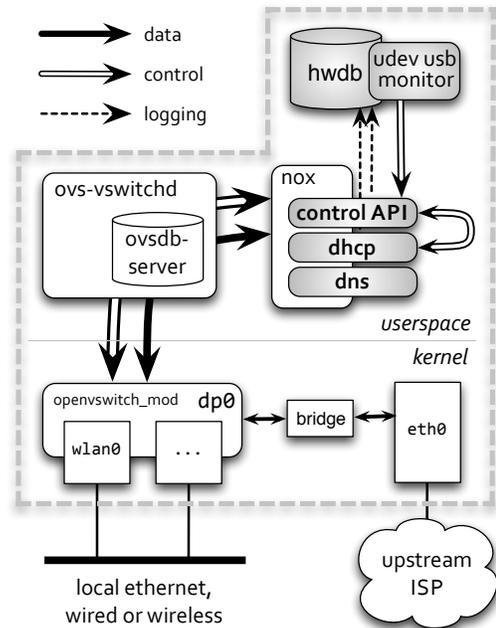


Figure 5: Software architecture of the Homework home router.

trol API configures the behaviour of our DHCP server and DNS proxy NOX modules. The first 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 second intercepts outgoing DNS requests, performing reverse lookups on flows not matching previously requested names, to ensure that upstream communication is only allowed between permitted devices and sites.

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3. REFERENCES

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