Managing Home Routers from the Cloud using Software Defined Networking

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***Abstract*—Software Defined Networking (SDN) is increasingly being applied to the management and orchestration of data center networks, wide-area networks, and enterprise networks. In this work we demonstrate the benefits of cloud-based SDN management of home routers. We install open-source firmware (OpenWRT and OpenVSiwtch) on off-the-shelf gateways, and deliver new services to consumers via our software in the cloud. Our service allows users to see their household devices and respective bandwidth usage in real-time, impose a download quota on a per-device basis, and impose time-based parental controls on specific household devices. By removing control from the home gateway to the cloud, we show that new services can be delivered rapidly via easy-to-use interfaces suitable for technically unsophisticated users.**

I. Problem Statement

Residential networks are becoming increasingly complex [1], with many households having in excess of 10-20 Internet-capable devices, including computers, tablets, smartphones, TVs, and IoT devices (smoke-alarms, webcams, etc.). Further, several household users, using different devices to access different services, share the broadband connection. The subscriber has very limited visibility into what is happening in their own network, such as which device is using how much bandwidth at any point in time, and how much of the monthly quota has been consumed by each device. Further, they have little control over which device is accessing what services, for example whether the kids are accessing inappropriate adult sites or engaging in social-networking during bed-time.

The above problems are solved neither by home router vendors nor by ISPs today. Home routers have proprietary difficult-to-use interfaces that vary from one manufaturer to another, are seldom upgraded to stay current, and lose configuration when replaced. ISPs have to-date preferred not to offer managed services for the home, since the residential market remains a very low-margin business. We believe that SDN offers a new opportunity to tackle this problem, since it decouples the hardware equipment from the software service, using a standardised interface (such as OpenFlow), allowing the software to be resident in the cloud and upgraded/customised on a continuous basis.

II. Our Solution

We have built (and will demonstrate) a system, shown schematically in Fig. 1, comprising the following: (a) A commodity home gateway (from TP-LINK) that will be running open-source software including OpenWRT and OpenVSiwtch (OVS). The latter gives us an OpenFlow agent on the router, using which we can control it remotely to add/remove rule-table entries on-the-fly. (b) An SDN controller, along with an orchestration engine, that will run in the cloud. This entity will monitor traffic flows across the home-gateway, and selectively block flows as needed, such as for a household device that has exceeded its quota, or for a kid's device that is not allowed to access certain sites. (c) A web-based interface through which the user can configure and customise their services as suitable for their household.

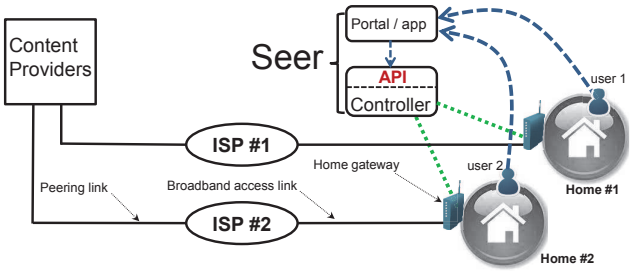
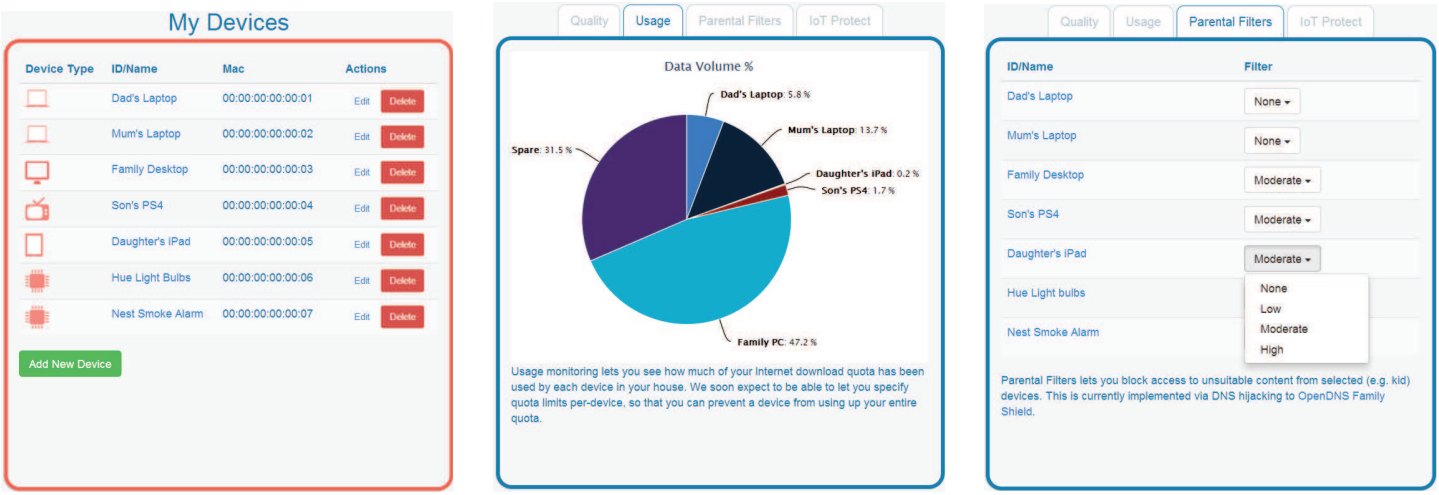


Fig. 1. High level architecture

We will demonstate two services that the user can avail of through our portal: the first is for quota management, so the user can see how much of their monthly quota has been used up by each device in their household, and restrict certain device(s) to a quota limit of their choosing. The second service we will demonstrate is parental blocks, namely being able to restrict, for certain device(s) in their household, the sites that can be accessed (such as Facebook). We believe these services are very cumbersome to realise in houses today, whereas our solution shows that these can be achieved with ease from the cloud. Further, these can work on any commodity home router that supports the OVS SDN agent, without needing to store any configuration local to the home device.

III. Implementation and Evaluation

Fig. 2 shows our web-based user-interface for the consumer, such as their household devices in Fig. 2(a), quota usage by the various household devices in Fig. 2(b), and the parental block controls in Fig. 2(c). User interactions via this interface are communicated via REST API calls to the orchestrator, which instructs the SDN controller to take the appropriate action, such as extracting statistics for a specific device, or redirecting DNS queries from a specific device to the appropriate OpenDNS FamilyShield service.



(a) Home network devices (b) Usage Statistics (c) Parental Filters

Fig. 2. Web interface showing (a) devices, (b) bandwidth, (c) filters, and (d) usage.

Our solution can be deployed either by the ISP (by integrating the user-interface with their customer portal), or over-the-top as a stand-alone service. We have tested the functionality and correctness of the over-the-top approach in a small number of houses [2], and are currently working with an ISP to undertake a trial of these services with their customers. We are also in the process of evaluating several models for pricing these services.

We are not aware of other cloud-managed home routers in the market, though it is very possible that Google's newly released OnHub [3] fits this category – we are in the process of procuring and evaluating the OnHub to understand how its capabilities and services compare to ours.

IV. Conclusions

The growing number of household Internet devices, and diverse needs of household users, necessitate new features for managing home networks, which are lacking in today's offerings from home router manufacturers and ISPs. We are demonstrating a product that leverages the rise of SDN technology (allowing it to be applied to home routers from multiple vendors) and cloud software (that can be upgraded continuously) to offer these services in an easy-to-use and customisable way. Our services can be expanded easily to add new features, without requiring any changes to customer premises equipment, allowing for low-cost scalable self-provisioning by consumers.

V. Demonstration Requirements

For our demonstration we will bring a home router and a few end-user devices (laptop, tablet and smart-phone). We require power connection, and if possible an Ethernet (WAN) connection for our home router (if the Ethernet connection is not possible, we will bring a WiFi to Ethernet converter).

References

[1] A. Sabia and F. Elizalde, "Market Trends: Home Networks Will Drive Success of the Connected Home," Gartner, Report, Mar. 2013.
[2] H. Habibi Gharakheili, L. Exton, V. Sivaraman, J. Matthews and C. Russell, "Third-Party Customization of Residential Internet Sharing using SDN," ITNAC, Nov. 2015.
[3] Google OnHub, https://on.google.com/hub/