Communicating with Caps:
Managing Usage Caps in Home Networks

Hyojoon Kim
Georgia Tech
joonk@gatech.edu

Srikanth Sundaresan
Georgia Tech
srikanth@gatech.edu

Marshini Chetty
Georgia Tech
marshini@cc.gatech.edu

Nick Feamster
Georgia Tech
feamster@cc.gatech.edu

W. Keith Edwards
Georgia Tech
keith@cc.gatech.edu

ABSTRACT

As Internet service providers increasingly implement and impose "usage caps", consumers need better ways to help them understand and control how devices in the home use up the available network resources or available capacity. Towards this goal, we will demonstrate a system that allows users to monitor and manage their usage caps. The system uses the BISMark firmware running on network gateways to collect usage statistics and report them to a logically centralized controller, which displays usage information. The controller allows users to specify policies about how different people, devices, and applications should consume the usage cap; it implements and enforces these policies via a secure OpenFlow control channel to each gateway device. The demonstration will show various use cases, such as limiting the usage of a particular application, visualizing usage statistics, and allowing users within a single household to "trade" caps with one another.

Categories and Subject Descriptors

C.2.3 [**Computer-Communication Networks**]: Network Operations—*network management, network monitoring*; H.1.2 [**Models and Principles**]: User/Machine Systems—*human factors*

General Terms

Design, Human Factors, Management, Measurement

Keywords

OpenFlow, usage cap, home network

1. MOTIVATION AND SUMMARY

Internet service providers in the United States are beginning to deploy monthly "usage caps", which limit the amount of traffic that any particular subscriber can transfer within a billing cycle. For example, Comcast has deployed a monthly usage cap of 250 gigabytes, and AT&T DSL and U-Verse users are subject to a 150-gigabyte usage cap. Users in other countries already experience much more constrained usage caps [1]. Given the growing diversity of applications, the increasing demands of certain applications (*e.g.*, a high-definition NetFlix movies) and the relative opacity of usage information to individual users [3], consumers need better ways of managing these caps.

Unfortunately, intuitive tools for helping users monitor and manage their usage caps effectively do not exist today. To fill the need

for such a tool, we are developing a system to help consumers perform flexible and fine-grained monitoring and management of their usage caps. Based on our user studies, we have identified that consumers want information to help them manage the usage cap to ensure all household members enjoy good performance for their activities, while also avoiding overage charges or service interruptions if the cap is exceeded [3]. Our demonstration will show a framework that allows users to perform some of the following management functions:

- *Provide visibility about how different activities and applications use network resources.* Users need better interfaces to show them how activities and applications consume their usage caps, both for intentional applications (*e.g.*, Web browsing, streaming video) and for automated or "background" applications like software updates. Better tools can allow users to manage what and who is consuming the most capacity and take actions accordingly.

- *Allocating portions of the usage cap to a specific user, group of users, device, application, or time of day.* Users may wish to restrict particular applications or activities (*e.g.*, ensure that streaming video does not consume more than 50% of the allocated data for the month). Our previous work has shown that a household might wish to allocate portions of the usage cap to each occupant, to ensure that no one occupant uses more than his or her fair share of the usage cap. Users may also wish to limit traffic usage based on time of day or day of the week (*e.g.*, parents may wish to limit or throttle usage in the evening [4]).

- *Allowing users to "swap" micro-caps with one another.* Provisioning allocations from an overall monthly usage cap to individual users in a household might result in inefficiencies where one user has not fully utilized his or her allocation but another user has exhausted his or her allocation. We found that users might want to trade and bargain to ensure the maximum allocation is used, while still allowing each user to carry on activities as needed.

Despite the appeal of a system to help users track and manage data caps, developing such a system has many challenges. First, the desire to allocate data caps to each user within a household requires a system that can *associate traffic flows to specific users*. Typically, traffic flows are associated with individual devices, where a device might be identified by its MAC address. In reality, however, multiple users may share the same device; as such, the system requires a usable captive portal interface to allow users to log in to a device. We have implemented an OpenFlow-based captive portal for associating flows to users, Resonance [5], which we will use for this purpose. Second, the system must support a diverse set
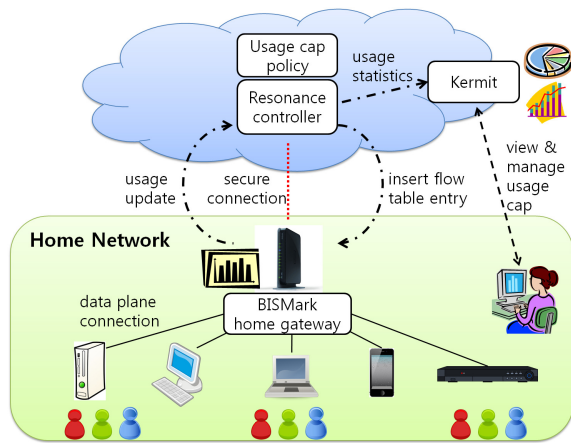
Figure 1: **Proposed demo system.** The demo system comprises a front-end interface (Kermit), OpenFlow controller (Resonance), and a home gateway router (BISMark).

of requirements and policies involving provisioning and enforcing data-cap allocations across users, applications, and devices. To address this challenge, we propose to manage and implement policies regarding usage caps from a network controller "in the cloud" that runs an OpenFlow controller. Third, users may want access to both historical and real-time usage patterns in ways that allow them to understand what is contributing to their usage.

Our demonstration will essentially be a canonical home network, with an access point and several machines and consumer devices connecting to it through wired and wireless interfaces. The setup will have the following components: (1) the BISMark gateway platform and supporting software [6]; (2) a front-end on `networkdashboard.org` that shows traffic utilization over different time intervals, and also help users understand their Internet usage; (3) an interface to help users manage their caps, by performing allocations and setting policies; (4) an OpenFlow-based framework for implementing and enforcing these policies on the BISMark gateway.

2. SYSTEM

We describe the system that we will demonstrate to help users manage data usage caps in their homes. Figure 1 shows the system we plan to demonstrate and how the components fit together.

2.1 Front-end Interface: Kermit

Our front-end system, Kermit [4], will create a user-friendly interface to the underlying networking monitoring and control infrastructure. Kermit will show users three views to help them identify which people, devices, and applications are contributing to the cap in real-time. Kermit will also allow users to track usage over time per each calendar month to see if the cap will run out before the end of the month, if there will be remaining cap, if overage charges may be incurred, or whether additional capacity should be purchased. Kermit will also allow users to easily divide up their usage cap by people, devices or applications at the beginning of the month, and to allow users to trade capacity with each other. In our demonstration, we will showcase this user interface to the functionality described below.

2.2 Network Gateway: BISMark

A cornerstone of our system for managing caps is the *BIS-Mark* custom router firmware, built on top of OpenWRT. BISMark

("Broadband Internet Service BenchMARK") has three separate packages: (1) an active measurement package, which initiates periodic measurement probes to measure properties of the access link; (2) a passive measurement package, which records the traffic flows that pass through the gateway device; (3) a management package, which facilitates remote management, such as software upgrades, as well as pushing traffic logs to a central server. This demonstration will primarily use the latter two packages. BISMark is under active development with many regular contributors and developers [2], and the current version of the firmware is thoroughly tested on the NetGear WNDR 3700v2 router.

2.3 Tracking and Managing Caps: Resonance

Resonance is a network management system that can apply different policies to network traffic flows, depending on the user that originates the traffic flow and that user's state in the system [5]. Resonance uses OpenFlow to centralize management, define policies, make decisions, and enforce policy by installing flow table entries at OpenFlow-enabled switches. Resonance has the following properties that we will use in the demonstration: **(i) *Fine-grained:*** Resonance allows the network to express policies based on a variety of parameters, ranging from a user's identity to the type of application traffic. **(ii) *Event-based:*** Resonance reacts to events (*e.g.*, time of day, cap limit reached, a detected attack) and modifies the flow table according to the specified policy. A cornerstone of Resonance is a central network controller that is coupled with a dynamic *listener* that tracks the state of each user and forwards traffic for the user's flows depending on the the state of the user (*e.g.*, whether the user is capped).

3. DEMONSTRATION

- **Login-based accounting:** To access the Internet, users must login through a Web portal. This login process triggers functionality that associates traffic flows from a device to the user logged in on that device. We will show how the system can enable accounting based on device or application, and how the system can rate-limit or quarantine a user who has exceeded a cap.

- **Exchanging caps:** After showing basic functionality, we will show how users with extra available capacity can swap their cap with a user that has exhausted their allocation.

- **Front-end visualization and management:** We also show how ordinary users interact with the management system to see how different applications are spending their caps. We also demonstrate how an administrator can visualize the network and allocate caps to users.

REFERENCES

[1] Next generation connectivity: A review of broadband internet transitions and policy from around the world, 2010. The Berkman Center for Internet & Society.
[2] Project BISMark (Broadband Internet Service BenchMARK). http://projectbismark.net/.
[3] M. Chetty, R. Banks, A. J. Bernheim Brush, J. Donner, and R. E. Grinter. Under development: While the meter is running: computing in a capped world. *Interactions*, 18:72–75, Mar. 2011.
[4] M. Chetty, D. Haslem, A. Baird, U. Ofoha, B. Sumner, and R. Grinter. Why is my internet slow?: Making network speeds visible. In *CHI*, Vancouver, Canada, 2011.
[5] A. Nayak, A. Reimers, N. Feamster, and R. Clark. Resonance: Dynamic access control in enterprise networks. In *Proc. Workshop: Research on Enterprise Networking*, Barcelona, Spain, Aug. 2009.
[6] S. Sundaresan, W. de Donato, N. Feamster, R. Teixeira, S. Crawford, and A. Pescapè. Broadband internet performance: A view from the gateway. In *Proc. ACM SIGCOMM*, Toronto, Ontario, Canada, Aug. 2011.