The Stanford Virtual Router

A teaching tool and network simulator

Martin Casado	Vikram Vijayaraghavan	Guido Appenzeller	Nick McKeown
casado@stanford.edu	vvikram@cs.stanford.edu	appenz@cs.stanford.edu	nickm@stanford.edu

Department of Computer Science, Stanford University
Contact: appenz@cs.stanford.edu   650-723-1414

The virtual router project is an effort to develop a platform to facilitate research and teaching of network routing. It allows to set up a virtual topology of routers and network links and to run user-space programs on the simulated hardware. Unlike existing network simulators such as ns2, the system operates with real IP packets in real time. This makes it possible for students or researchers to generate traffic with real, standard clients and servers and evaluate performance over the simulated topology.

In virtually all modern operating systems, routing is implemented within kernel space. Providing a good kernel debugging environment and assuming a basic knowledge of kernel level development may be restrictive requirements for a project focused on routing. Take for example an undergraduate research course, not only would the previous two requirements have to be met, but students could only work one to a computer. For these reasons, routing typically has been taught either from a theoretical perspective or through the use of a software simulator such as ns2. The virtual router project provides full access to actual network traffic, but bypasses the trouble of having to work within the kernel.

Some experiments such (e.g. routing protocols such as RIP) require more than a single router. The virtual router makes it possible to simulate large number of routers on one physical host and enforce a virtual network topology between them. This simulated topology can be connected to real networks. Packets can travel from a physical network (e.g. the internet) through the simulated topology and back to the physical network.

The Virtual Router system can be broken down into two components, the virtual router server, and a number virtual router clients. The virtual router server is an application or set of applications running on a physical server that have access to link layer traffic. The virtual router client is a program created by users of a VR system. In a typical session, a user will use a VR client to connect to the server via a TCP socket, and a decision is made about what packets the server will send to the client. The user may then run a network application, such as FTP, whose traffic can be seen by the server. The server, on capturing traffic, will based on the simulated topology decide whether or not a particular client can see the packet. If this is the case it is forwarded to the client who can then manipulate the packet (e.g. decrement the TTL field). The client may then send the packet back to the server with instructions to send it out of a particular interface on the network, thus potentially routing the packet. With its relationship with the server, the VR client has full capability to manipulate and route traffic flows from user space.

The virtual router has successfully been used to teach students basic functionality of routers. Students had to implement virtual router clients that make routing decisions, use the ARP protocol to communicate with other routers and route actual web traffic from their desktop computers. However the scalability of the virtual router (up to several hundred simulated routers) makes it attractive as a research tool. Currently there are efforts under way to investigate the behavior of routing protocols using the virtual router as an experimental platform.