

Laboratory Hardware Infrastructure: The Flux Research Group at the University of Utah develops and maintains the Emulab network testbed software and the Utah Emulab cluster itself. The current Utah Emulab cluster is composed of 178 Pentium-class PCs serving both as routers and as traffic shaping nodes. Each machine has 5 or more 100 and 1000Mb Ethernet interfaces; one is for a dedicated control and data acquisition network; the others are for arbitrary use by experiments.

In addition to standard PCs, the cluster includes 10 Intel IXP network processor boards and 2 Cisco GSR 12000 routers (on loan from Internet2) packed with a variety of fiber and copper based interconnects. These provide experimenters with “real” network devices that can be seamlessly integrated with the PCs via the Emulab software.

We have recently added 9 prototype wireless nodes—PCs with wireless interfaces—spread around two floors of our building. 21 3.0 Ghz Pentium-IV PCs have arrived and are about to be installed as additional wireless testbed nodes, for a total of 30.

All nodes are connected using five Cisco Catalyst 6500 series switches. Four function as a “programmable backplane,” connecting the experimental links in potentially arbitrary configurations, through VLANs. These switches contain a total of 1152 100Mbps and 160 1000Mbps Ethernet ports, providing for both current and short-term future needs. The four emulation switches each contain a dedicated 16-port Gigabit Ethernet module to provide inter-switch connectivity via trunked Gigabit Ethernet links, to accommodate experiments that are too large to fit completely on a single switch. The final 6509 functions as the core router for the testbed, connecting the node control interfaces, the testbed server machines, the SNMP-managed power controllers, and a link to the outside world. Additionally, this switch provides firewalling between all of the links.

The Emulab testbed is connected via a gigabit connection directly to the University’s campus backbone which is in turn connected to Internet2 and the commodity Internet.

Remote Laboratory Resources: In collaboration with the MIT RON project, Emulab software controls and provides seamless access to over 50 remote PCs around the world. In collaboration with the Planetlab Consortium, the software presents an Emulab-like interface to the Planetlab distributed testbed, allowing access to over 350 additional geographically distributed nodes. Finally, we enjoy access to a number of the other Emulab sites, including the University of Kentucky, Georgia Tech University, and the University of Wisconsin, enabling use of more than a hundred additional PCs and Cisco routers.

Infrastructure Computing: Computing infrastructure for the project is largely provided by the Emulab cluster and distributed resources, but also includes 50 single- and dual-processor PCs running FreeBSD, Linux, or Windows 2000/XP on the desks of all researchers as well as a number of shared servers providing file system and other centralized services including daily file backup.

General Department Facilities: The School of Computing, of which the Flux Research Group is a part, provides additional research facilities. This facility is a heterogeneous mix of over 300 machines, including PC’s, SGI, and Sun-based hardware. The research computing facility includes major laboratories devoted to computer- aided design and graphics, computer systems, asynchronous digital systems and VLSI, robotics and vision, scientific computing and imaging, and information retrieval and natural language processing. These research laboratories contain a wide array of specialized equipment, including: several large SGI Origin machines; a multi-source nonlinear video editing environment; a real-time signal processing lab; an image analysis lab; equipment for various types of custom hardware design; a Sarcos Dextrous Arm, Utah/MIT Dextrous Hand, and PUMA 560 robots; and a Sarcos Treadport locomotion interface, several SensAble Phantom haptic interfaces, Fakespace Responsive Workbench, nVision Datavisor HiRes, and a variety of position trackers.