



CAMPUS NETWORK REPORT

ACADEMIC YEAR 2010-2011

JULY 19, 2011

Table of Contents

| | |
|---|----|
| 1. Executive Summary for the Campus Network Report – AY1011 | 3 |
| 1.1. Points of Interest | 3 |
| 1.2. New Investments | 3 |
| 1.3. New Requirements | 3 |
| 2. Scope of the Campus Network | 4 |
| 3. Service Levels | 5 |
| 4. The Campus Network | 6 |
| 4.1. Campus Network Backbone | 6 |
| 4.2. External Connectivity | 9 |
| 4.3. Network Population | 14 |
| 4.4. Departmental Networks | 16 |
| 4.5. Wireless Networks (Public) | 18 |
| 4.6. DNS (Domain Name System) | 20 |
| 4.7. DHCP (Dynamic Host Configuration Protocol) | 21 |
| 4.8. VPN (Virtual Private Network) | 22 |

Executive Summary for the Campus Network Report – AY1011

This report provides a brief look at metrics describing the size and performance of the campus computer network. Included are overall reliability statistics, traffic rates, network size statistics, data on the growth of the systems and services, and related commentary.

The key points of interest from this year's network report are categorized by points of interest, new investments, and new requirements. Questions may be sent to networking@its.utexas.edu.

1.1. Points of Interest

- There were no campus-wide backbone outages YTD, and only 39 minutes of downtime for the commodity Internet.
- Building networks across campus received an average grade of 82 (B).
- There were 145 routers, 3,113 switches, and 4,820 wireless access points comprising the network.
- Approximately 159,000 individual devices are in use on the network.
- Inbound commodity traffic increased by 43% from spring 2010, and all hosts are consuming more bandwidth.
- Total wireless connection hours increased 56% to 21 million hours for spring 2011.

1.2. New Investments

ITS made and is making the following investments in the campus network:

- A new network architecture was brought into production at the new data center. This architecture, which uses Cisco Nexus 7010 and Nexus 5020, provides enhanced resiliency features.
- The campus network core is being replaced during summer 2011 – fall 2012. The new core is based on the same new architecture as the data center (Cisco Nexus 7010) and allows us to prepare for 40Gbps and 100Gbps connectivity.
- The wireless core is being replaced during summer 2011. This will enable the network to handle increasing loads and maintain vendor support.

1.3. New Requirements

The Network Operations Manual [<http://www.utexas.edu/cio/policies/>] was endorsed by IT governance Strategic IT Accountability Board (SITAB) and brings new recommendations and requirements to the campus network.

2. Scope of the Campus Network

The University of Texas at Austin has an enrollment of approximately 50,000 students as well as 12,000 full time and 13,000 part time faculty and staff. The university budget for fiscal year 2010-2011 was \$2,238 million, with annual research contract and grant funding that exceeds \$644 million across more than 100 research units. There are 17 colleges and schools, as well as over 90 research units, 7 museums and 17 libraries. The main campus and the Pickle Research Campus (PRC) include several hundred buildings with a network point of presence. There are also external sites located around the city of Austin. All told, the campus network serves roughly 200 buildings and sites, covering over 20 million gross square feet indoors.

The campus network is funded and operated in a federated model. Central staffing and operations are provided by Information Technology Services (ITS), which had an AY1011 networking budget of approximately \$5 million. University departments provide distributed funding, operations, and staffing. While support and funding is distributed, ITS-Networking co-manages 90% of the wired networks on campus and all of the wireless networks. Current replacement cost of the campus network is estimated at \$60-\$65 million.

3. Service Levels

All service level goals were exceeded for AY1011:

| Metrics | Achieved | Goal |
|--------------------------------------|----------|----------|
| Campus Network Backbone Availability | 100% | >99.950% |
| Building POP Availability Average | 99.995% | >99.900% |
| Wireless Core Availability | 99.996% | >99.900% |
| Commodity Internet Availability | 99.993% | >99.750% |
| Commodity Internet Utilization | 80% | <95% |
| Average Building Network Grade | 82 | >80 |
| DNS Availability | 100% | >99.980% |
| DHCP Availability | 100% | >99.950% |

A departmental network Technical Support Contact (TSC) satisfaction survey was taken in March of 2011 and yielded the results in **Figure 1**. 184 responses were received (ranks: 1=Very Unsatisfied, 2=Unsatisfied, 4=Satisfied, 5=Very Satisfied).

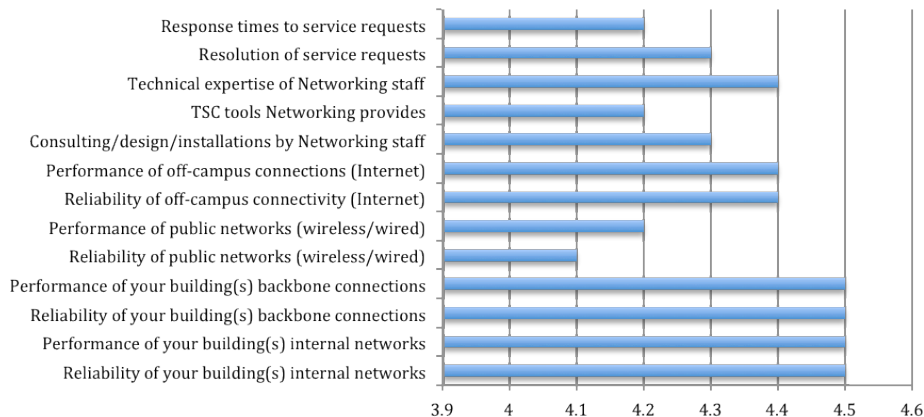


Figure 1: TSC Satisfaction

ITS is taking action to address the categories which had the lowest satisfaction:

- **Reliability of public networks (wired/wireless)** – Further examination of the survey results shows that departments with dense wireless coverage are generally more satisfied. Therefore, to improve with network reliability, departments will need to invest to increase the density of wireless coverage.
- **TSC tools Networking provides:** The TSC tools system is being re-written this summer/fall with focus group feedback.
- **Response time to service requests:** Networking is assigning dedicated staff to ensure requests are being assigned and responded to promptly, publishing a project wiki for TSCs to track the project progress, and deploying a telephone auto-attendant to route critical outage calls for immediate response.

4. The Campus Network

4.1. Campus Network Backbone

There have been no campus-wide backbone outages year-to-date, which exceeds the SLA of 99.95% uptime. Core devices on redundant sides did fail, but this did not affect network service because of the dual connectivity built into the core network. These failures and their lack of impact emphasize the need for individual campus buildings to dual connect. This requirement is now part of the minimum standards in the Network Operations Manual.

All traffic between buildings and to the Internet passes through the core. There was only a 9% increase in core traffic (**Figure 2**) in the last year, as compared to a 76% increase the previous year. Consolidation of services within the new data center may have reduced core traffic growth.

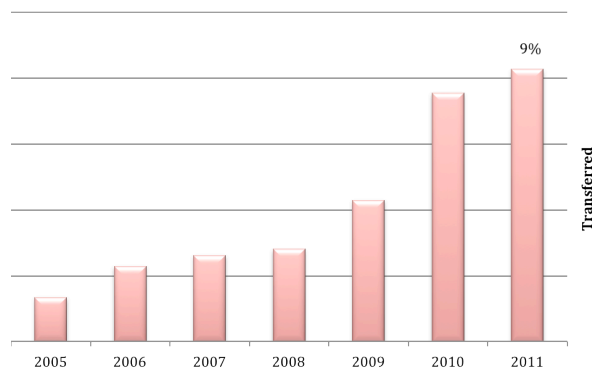


Figure 2: Core Traffic

The number of subnets carried by the network increased 8% to 3,149.

In 2010 an additional network border with external connectivity was added to the secondary Network Operations Center (NOCB) to increase the reliability of external access (**Figure 3**).

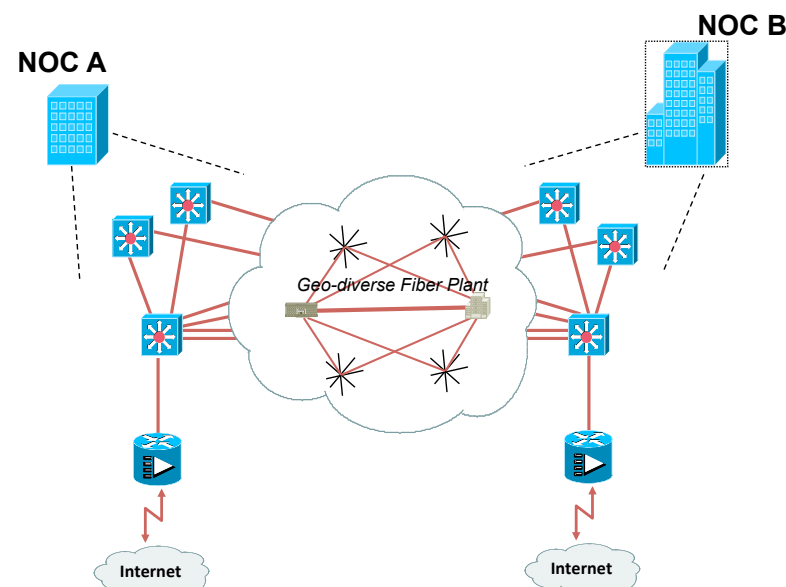


Figure 3: Network Diagram

During the summer and fall 2011, Networking will be replacing the seven-year-old core with a new architecture based on the Cisco Nexus 7000 product line (**Figure 4**). This product was deployed last year at the new data center and has been tested extensively. The new core architecture is expected to support the campus network for the next five years if judiciously managed and upgraded. It has a much higher capacity (1.4Tbps backplane), new capabilities and prepares the backbone to accept 40Gbps and 100Gbps connections from departments in the future.

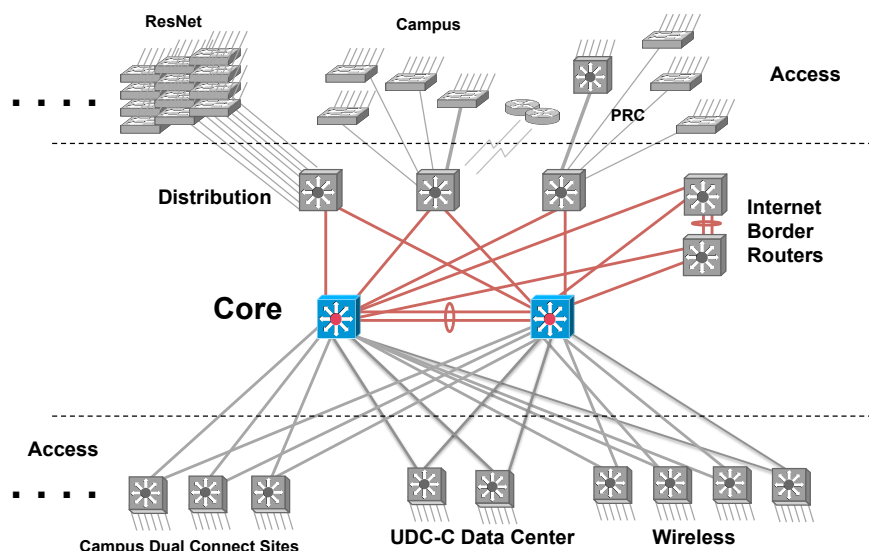


Figure 4: Campus Routed Subnets

Due to the growth of wireless devices, campus is facing increased pressure on its IPv4 address pools (see section 4.5). Additional net blocks will be deployed as a temporary measure, and departments will need to update their filters and firewalls appropriately when the blocks are announced. However, either Network Address Translation (NAT) or re-addressing and consolidation of campus address spaces for wireless will likely be necessary within the next 2 years. Departmental IPv4 address pools are still sufficient.

The IT governance Architecture and Infrastructure Committee has formed a task force to investigate the addition of IPv6 to the campus network. That effort is expected to take 1-2 years. The majority of work and complications are expected to occur with servers and clients. Most network layer devices will support IPv6. Higher layer devices (firewalls, load balancers, IDS, etc.) may require upgrades.

The average availability across all Points of Presence (POP) connecting a building to the campus network was 99.995% (99.9% is the service goal for individual buildings). Excluding remote sites, where UT does not operate the remote uplinks, overall availability was 99.998%. TSCs may view individual building scores in the network tools.

Minimum Network Standards from the Network Operations Manual call for all POPs on the main campuses to be dually connected and routed, with at least one connection for medium and larger sites being 10Gbps (illustrated in **Figure 5**). A majority sites on campus have at least gigabit uplinks, are dually connected and routed, with 10 gigabit beginning to make a significant penetration (**Figures 6-8**). Sites not meeting network standards tend to be smaller buildings or departments without adequate funding, as well as locations on the PRC campus.

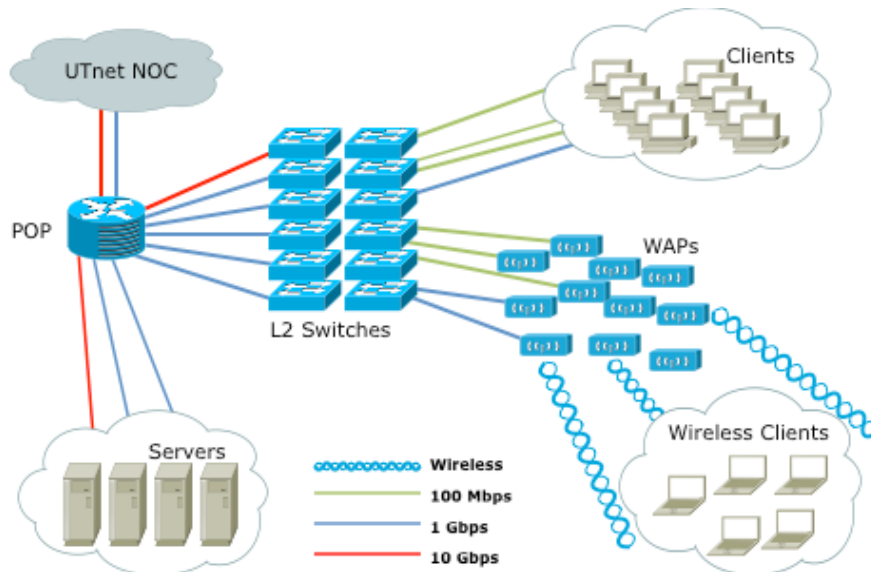


Figure 5: Recommended Building Network Design

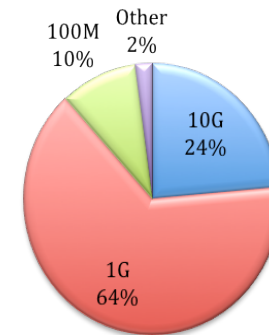


Figure 6: Building Connection Speeds

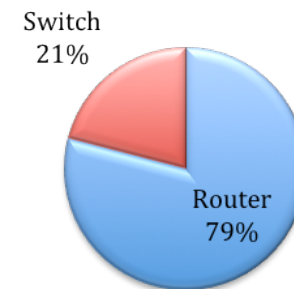


Figure 7: Router vs. Switch

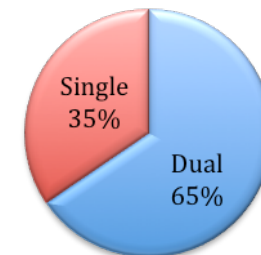


Figure 8: POP: Dual vs. Single Attach

4.2. External Connectivity

Commodity Internet availability was 99.993% (39 minutes of downtime) year-to-date, which exceeds the SLA of 99.95% uptime. The SLA metric was increased from 99.75% to 99.95% due to the addition of the second network border, which was utilized on several occasions during outages involving the first border and its external communications provider.

Busy hour peak-day inbound commodity traffic increased by 57% from Spring 2010 and was at 98% of our allocation, with excursions beyond our allocation (Figures 9 and 10).

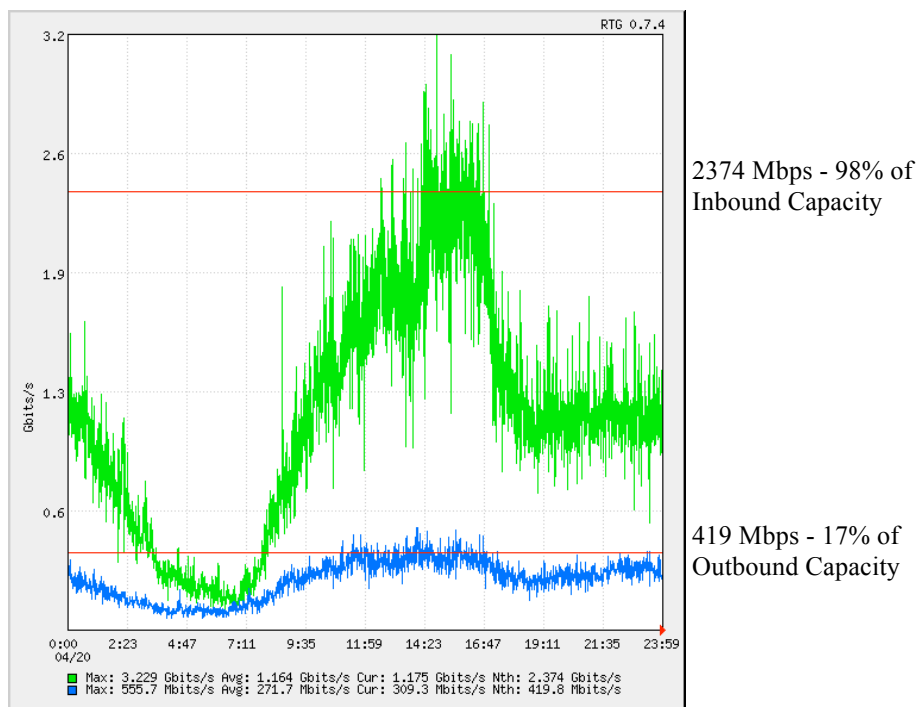


Figure 9: Busy Day Commodity Bandwidth (4-20-2011)

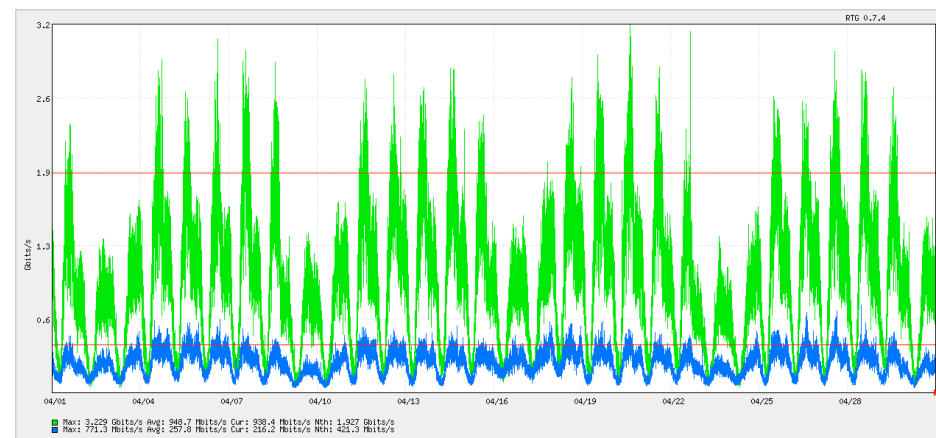


Figure 10: Busy Month Commodity Bandwidth (4-2011)

For FY1112 our ISP will be utilizing a monthly method for calculating the 95th percentile consumption, instead of the previous 72-hour method. Using a monthly method, our 95th percentile peak would have been 80% of our allocation and 43% growth from last year's monthly 95th percentile. This new method more closely matches our volumetric increases and will result in lower bandwidth costs to campus.

The 43% increase is close to industry ISP growth rates of 47% for North America, as reported by Cisco. While Cisco predicts a reduction in the rate of increase in North American to 33% for 2012, the same growth rate of 43% is projected for campus to due to increases in new classes of use detailed below.

Commodity consumption maintained a healthy ratio of outbound to inbound traffic which, along with the diurnal usage pattern, indicates a mainly consumer network.

Per host, volumetric mean, median and standard deviation for consumption of commodity bandwidth increased from spring 2010 (Figure 11). All hosts continue to consume more commodity bandwidth, and the difference between the amounts of bandwidth consumed by various devices continues to grow.

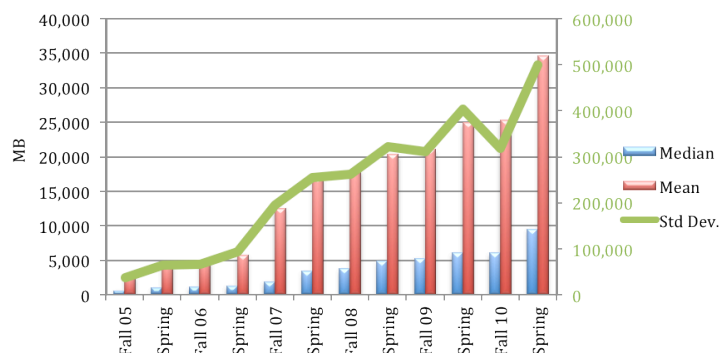


Figure 11: Per Host Growth of Commodity Bandwidth Consumption

By class, departmental wired networks still dominate long-term volumetric commodity consumption (Figure 12).

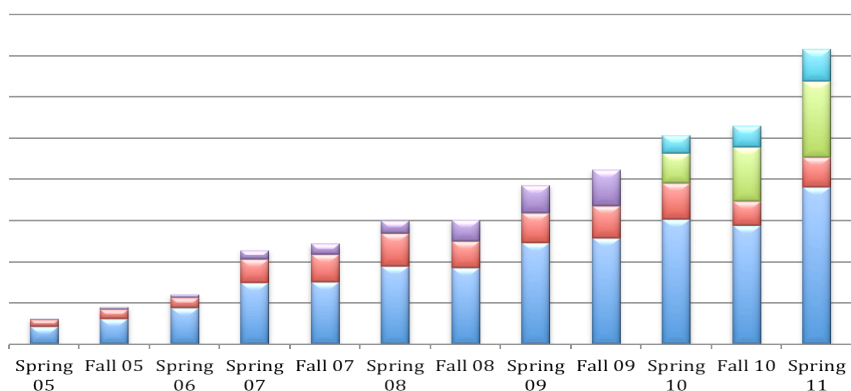


Figure 12: Volumetric Growth

However, if we look at the short-term peak times, the public wireless and residential wired and wireless networks consume more bandwidth (Figure 13).

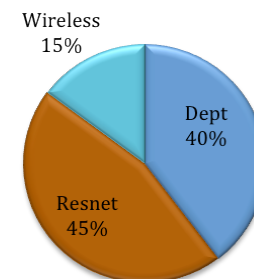


Figure 13: Burst Bandwidth by Class

Wireless volumetric consumption continues to grow rapidly (Figure 14), fueled by the shift in residential use (Resnet) from wired to wireless since full wireless coverage was completed in the dorms in 2010. Additional wireless bandwidth consumption is coming from new mobile phones and tablets from non-Resnet students and faculty/staff. Department network consumption, while still growing, is decreasing proportionally to these other classes of use.

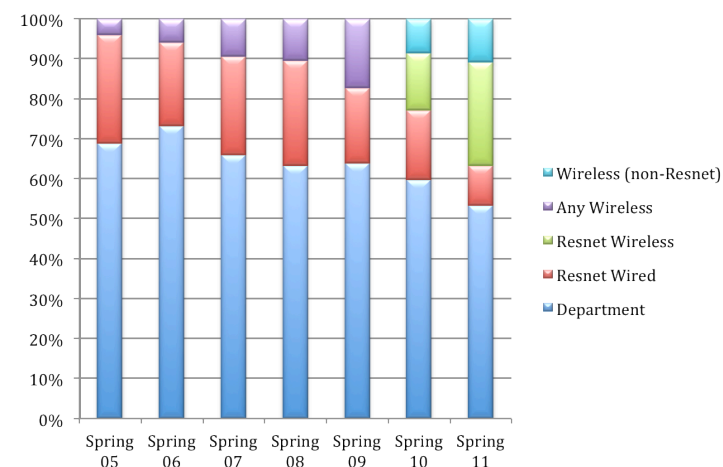


Figure 14: Volumetric Proportions by Class

Wireless and wired Resnet consumption increased 35% from spring 2010. However, because Resnet is self-funded with user fees, no central funding was used to pay for Resnet's consumption increase. Departments and Resnet benefit from each other's bandwidth consumption through combined higher volume purchases at lower costs. In addition, Resnet users consume more bandwidth during the evening and departments consume more bandwidth during business hours, leading each to have more available bandwidth in their time of need. Resnet users are individually metered for bandwidth consumption and subscribe to tiers of service for a fee. These allocations apply to Resnet wired and wireless networks and Public wireless networks across campus.

Median non-Resnet wireless bandwidth consumption continued its growth trend, increasing by 47% (**Figure 15**) from spring 2010. It now accounts for 15% of all bandwidth consumption. Traffic samples of this fast-growing category indicate a large portion of the bandwidth is not related to the university's mission. Bandwidth accounting has been applied to the wireless network, as with Resnet, to fund this increasing consumption. Students may purchase tiers of service beyond their default allocation.

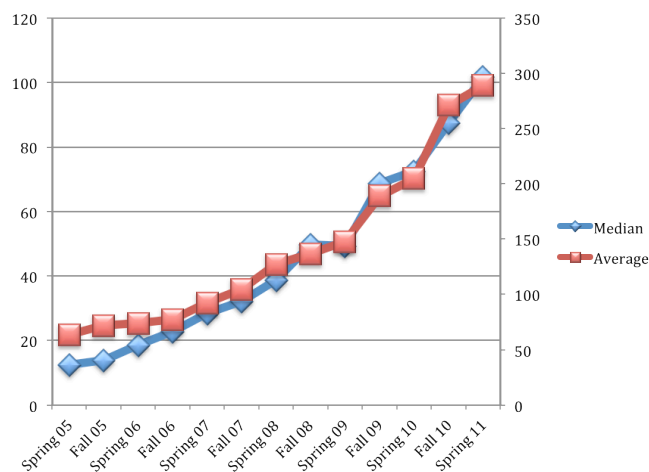


Figure 15: Weekly Avg. Wireless Bandwidth (non-Resnet)

Bandwidth consumption over and above the default student bandwidth allocation (500MB/week) continues to increase. Over half (50%) of the students with a default allocation exceeded their bandwidth allotment and were second classed at least once during the academic year (being second classed reduces off-campus network access to dial-up speeds until the weekly reset). 17% of students with the default allocation were second classed five or more times during the academic year. On average 8% of all students with default allocations were second classed on any given week.

Due to the low bandwidth costs for tiered services, increasing consumption rates, and an unclear connection to mission, the default allocation is unlikely to increase. For AY1011, an additional 5GB/week could be purchased for \$12 for the academic year (rates change yearly based on overall cost and measured consumption). However, despite the prevalence of students exceeding default bandwidth allocations, only 1,700 non-Resnet students purchased additional bandwidth. This is a small proportion of those who exceeded their default allocation and indicates that additional outreach is needed.

Figure 16 is one indicator that student wireless and Resnet users are primarily consumers, and are not engaged in rampant unauthorized sharing of intellectual property. Most methods of unauthorized exchange require a user to send as much traffic as they receive. Students' high receive to send ratios (7:1 and 8:1) indicate that such activity does not dominate their use. Indeed, when compared to studies of typical broadband networks where users have a receive to send ratio of 4:1, university students engage in far less of those activities. The university's bandwidth accounting, notification and education programs are designed to reduce unauthorized exchange of copyrighted materials.

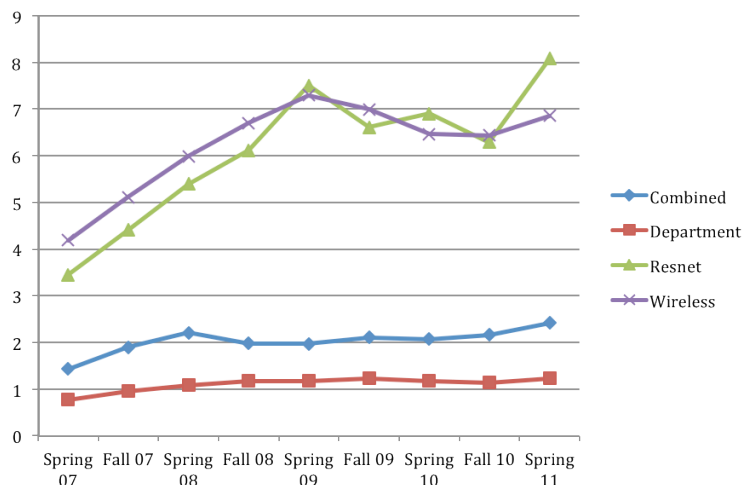


Figure 16: Receive to Send Ratio

Bandwidth demand for next year has been projected assuming the same growth rate as AY1011 (**Figure 17**). *Twenty-eight hundred megabits per second (or 2.8Gbps)* of commodity Internet bandwidth at the 95th percentile is being acquired for AY1112. The cost is slightly reduced, made possible by:

- A reduction in rates negotiated with the ISP.
- A change in how the 95th percentile is calculated.

- Augmentation of the budget by public network purchases.

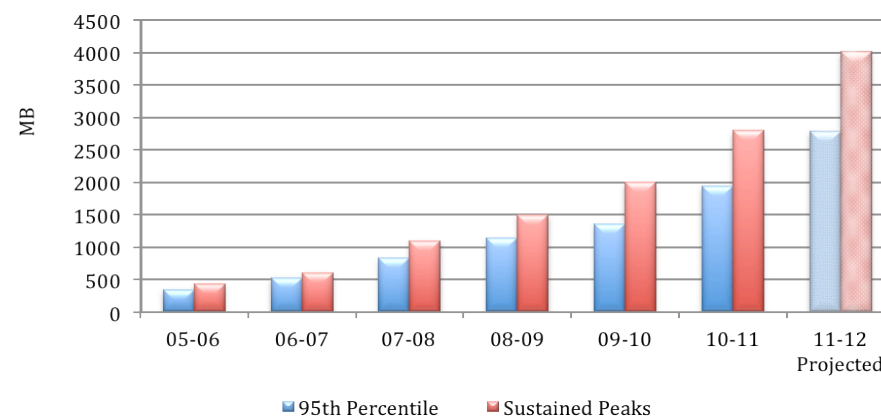


Figure 17: Historical Commodity Internet Usage

Research Networks: The campus network is connected to a number of research networks. Nationally it connects with both Internet2 (I2) and National Lambda Rail (NLR). Regionally it connects with the Lone Star Education and Research Network (LEARN), and the Texas Higher Education Network (THEnet). I2, NLR, LEARN, and THEnet are all reached through a 10Gbps connection campus has to THEnet. LEARN maintains the regional connections to the national research networks I2, which was increased recently to two 10Gbps circuits, and NLR, which is 10Gbps. Next year the university plans to connect to the new UT System Research Network (10Gbps).

Campus usage (except for Texas Advanced Computer Center) of I2 and NLR networks is modest, and configured to prefer NLR paths. Representative I2 and NLR hourly consumption patterns are shown in **Figure 18** and **Figure 19**.

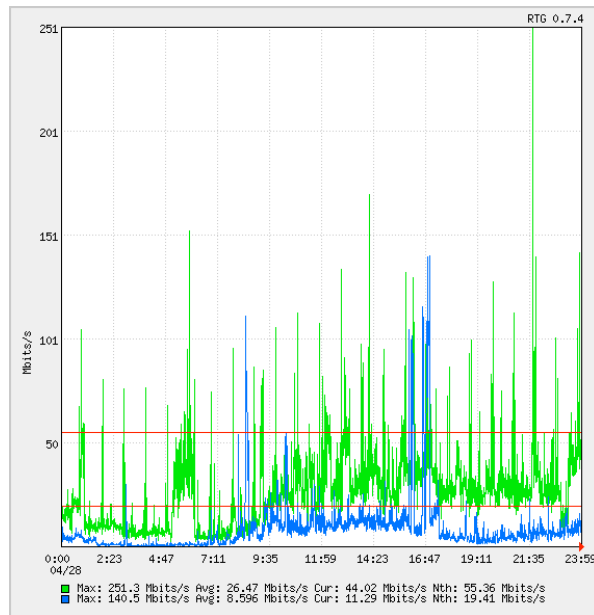


Figure 18: Hourly Internet2 (I2) consumption

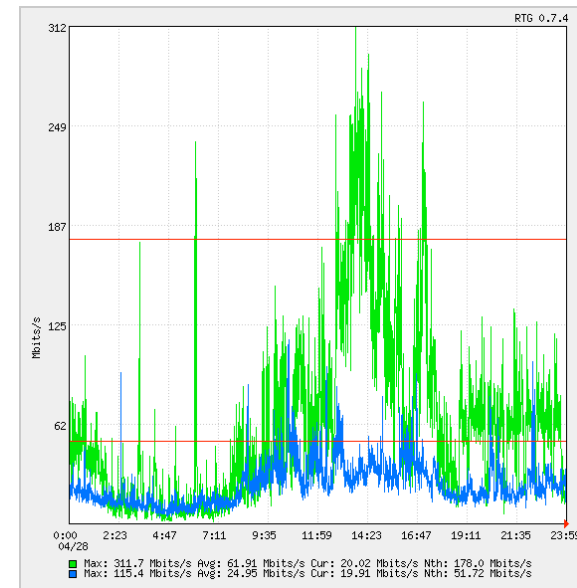


Figure 19: Hourly NLR consumption

4.3. Network Population

Based on collected statistics, there are an estimated 159,000 devices utilizing the campus network (**Figure 20**).

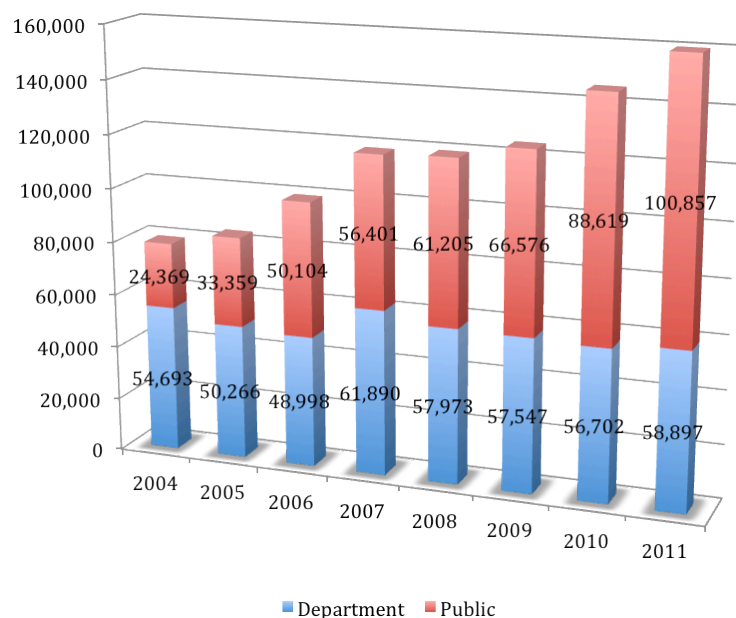


Figure 20: Devices on the campus network

Wireless device count on the public networks continues to increase, even though the number of unique users is growing slowly. Between fall 2010 and spring 2011 the number of users with multiple wireless devices nearly doubled (**Figure 21**). Mobile devices now account for 22% of all devices on the network (wired and wireless) and are expected to grow to become the dominant device type on the network. Currently, only one third of the campus population is utilizing mobile devices on wireless leaving room for dramatic growth.

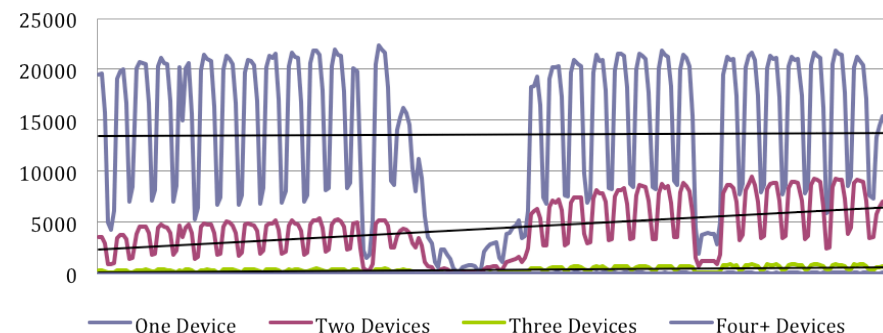


Figure 21: Devices Per User on Wireless AY1011

The number of wired devices connecting to departmental networks appears steady. Even though some users are moving to exclusively wireless connections, new wired devices continue to be added to the network.

To estimate the percentages of different operating systems in use on campus, we analyze the network signatures as these devices communicate off campus. Understanding the OS population assists with planning for technical support.

For department wired networks, Microsoft operating systems dominate (**Figure 22**). The ratio of Microsoft versus Apple devices is relatively unchanged from the last survey point, after correcting for unknowns. There has been an increase in Linux devices.

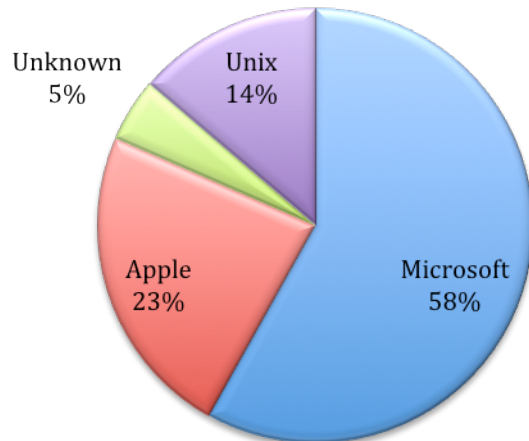


Figure 22: OS for Department Wired Devices

Wireless networks are different: Apple operating systems are the majority for traditional devices (ex: laptops) (**Figure 24**), and dominate mobile devices (ex: phones) with over 85% share. However, Android's share of mobile devices is growing rapidly, doubling from fall 2010 to spring 2011 (**Figure 23**).

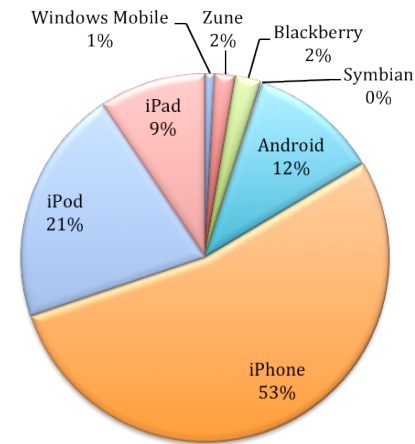


Figure 23: OS for Mobile Devices

Resnet wired networks were more similar to department wired networks, with the majority of devices running Microsoft operating systems. However, wired use represents only 1/3 of total Resnet use, most of which has moved to wireless where Apple dominates.

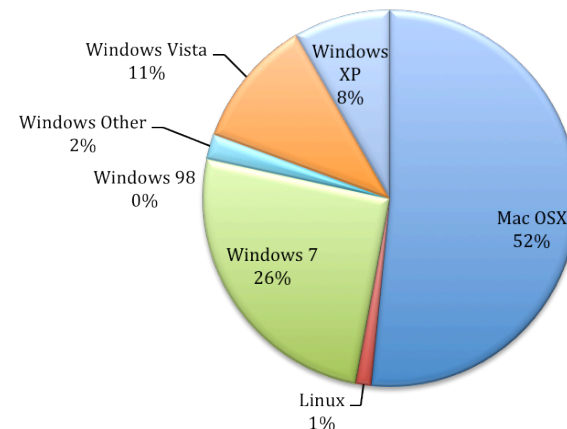


Figure 24: OS for Traditional Wireless Devices

4.4. Departmental Networks

The average grade for departmental building networks, as determined by the Building Report Card application available to TSCs as part of their network tools, was an 82 (B). Isolating medium and large buildings, the average grade was 86 (B). Distribution of grades is seen in **Figure 25** (note that buildings can get “bonus points” so it is possible to get a score higher than 100). Smaller buildings, such as those located on the PRC campus, typically received lower grades. The reporting tool automatically collects information about the age of building network equipment and how it is interconnected. The current grading tool will be updated this fall to evaluate buildings based on criteria from Network Operations Manual’s Minimum Network Standards. The first report using the updated grading tool is due to the Operational IT governance committee (OIT) in January of 2012.

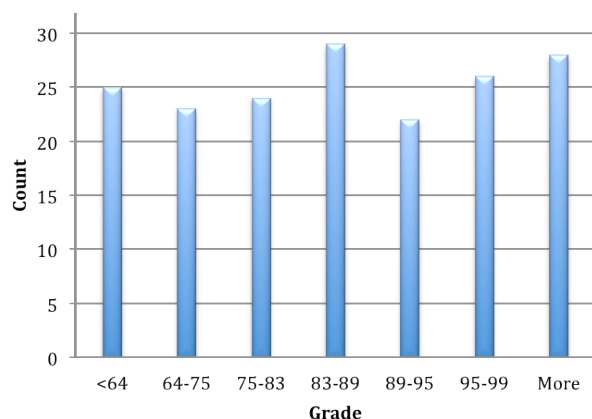


Figure 25: Building Report Card Grades

Most departmental networks are co-managed with ITS Networking, which provides complete International Standards Organization network management, FCAPS (Fault, Configuration Management, Accounting, Performance and Security), as required for all networks in

the Network Operations Manual. Networking supports 3,113 switches, 145 routers and 4,820 wireless access points. Lifecycle expenses for ITS Networking managed departmental equipment are estimated at \$4M/year, and will continue to increase with network growth, especially wireless costs.

There were over 135,000 wired Ethernet ports on campus (inclusive of infrastructure ports, like those used to connect to WAPs). Over the past 6 months, active Ethernet port utilization was monitored at 46%, down 9% from AY0910. This indicates a need to improve port allocation efficiency-- 65% utilization is the goal.

Yearly wired ports deployed by Networking are shown in **Figure 26**. Port growth is most influenced by new construction, and in AY1011 a number of new or remodeled building sections have come online including: CRB, DPRI, FAC, NHB, SAC and UTA. Wireless services have not caused a noticeable decline in port counts, although that is to be expected at some point.

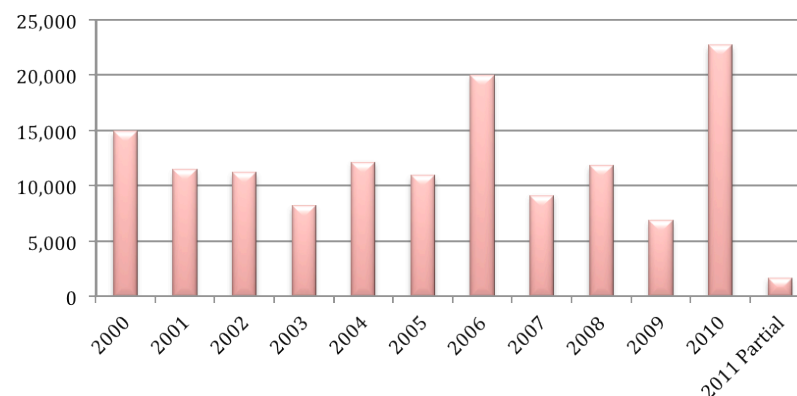


Figure 26: Number of Wired Ports Deployed by ITS Networking

The minimum standard port speed for edge switches is 10/100Mbps, with 1Gbps required for all new switches purchases. **Figure 27** shows current percentages for port speeds on campus.

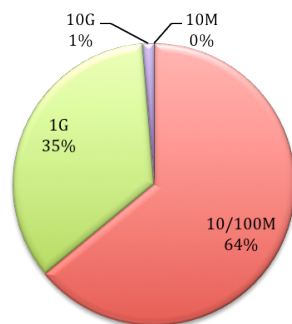


Figure 27: Speeds for Wired Ports deployed by ITS Networking

4.5. Wireless Networks (Public)

Core Wireless availability was 99.996%, which exceeded the SLA goal of 99.9% availability. Impressive growth of the 802.11 wireless network continues. The number of unique users has leveled out to around 60,000, but the number of wireless devices (114,000) and the bandwidth consumed by them is increasing. Connect time increased 56% from spring 2010 to over 21 million hours. Simultaneous connections increased 67% to over 20,000 users. Growth is expected to continue as:

- Individuals use the wireless network more frequently.
- Users connect with multiple wireless devices, such as tablets and phones, the use of which has doubled in the past 9 months.
- Faculty and staff migrate from traditionally wired connections to wireless. (Figures 26-27).

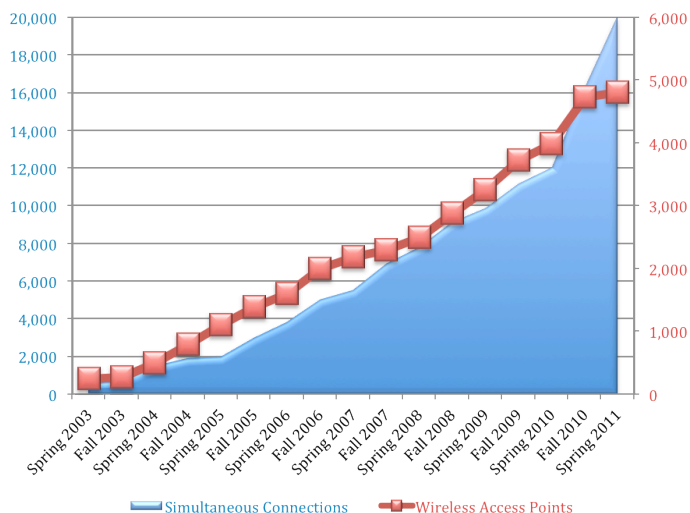


Figure 26: Wireless APs and Connections

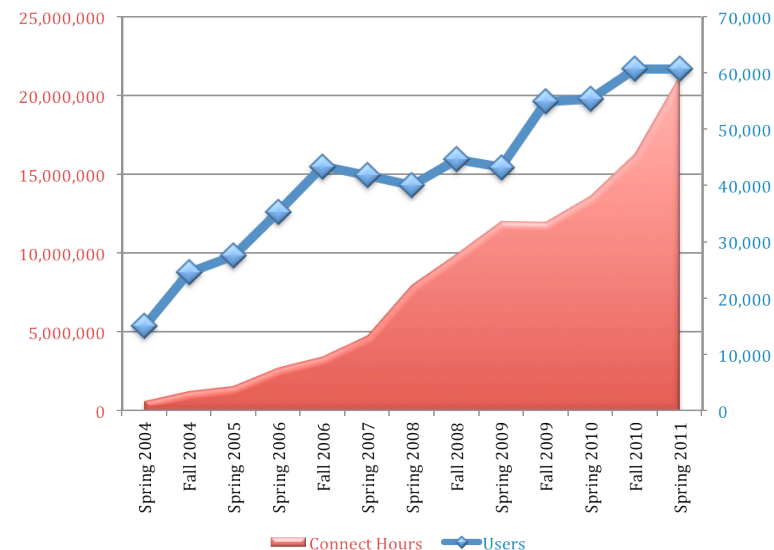


Figure 27: Wireless Users and Connect Time

The existing wireless network core, based on Cisco WiSM1 controllers, is five years old, has exceeded its lifecycle expectations, and is approaching the end of available software updates. Therefore, Networking will be upgrading the wireless core during summer 2011 to Cisco WiSM2 controllers. In addition, the chassis supporting the controllers are being upgraded for increased resilience and higher speed interconnections to the network core. Note that the wireless core is not survivable in the event of loss of an entire chassis or NOC, unlike the network core. The Network Operations Manual does not call for high availability levels for wireless services.

The 2.4GHz wireless radio spectrum is becoming congested in high use areas. Therefore, there is an urgent need to move devices to the 5 GHz range where more than four times the capacity is available and

there is less interference. **Figure 28** illustrates bandwidth consumption between the two ranges in Spring 2011— only 25% of the bandwidth was consumed in the 5GHz range.

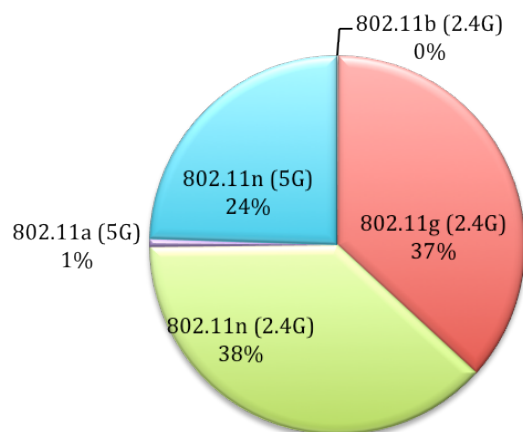


Figure 28: Square Footage by Frequency

To increase the efficiency of 2.4GHz use, in Spring of 2011, Networking eliminated 802.11b and lower signaling speeds for 802.11g. This summer the wireless system will be configured to

encourage capable clients to move to 5GHz. However, continuing bandwidth consumption and growth in 2.4GHz-only devices, such as mobile phones, will soon exceed available capacity in high use areas leading to congestion and collapse.

Ultimately, departments will need to invest in additional Wireless Access Points (WAPs) to ensure that dense 5GHz coverage is provided. Currently, 4,820 WAPs are installed on campus, but we project that over 8,000 will be needed to ensure good coverage.

The high use problem is most acute in large auditoriums (ex: 400 seats). At present none of UT's auditoriums can support usage of that density. Departments that need wireless coverage for large auditoriums should consult with Networking to obtain estimates for improving wireless coverage.

Networking is negotiating with a commercial provider for guest wireless access. Once a contract has been signed, a new SSID specifically for guest users will appear on campus.

4.6. DNS (Domain Name System)

Networking maintains highly resilient DNS servers that provide both primary and secondary hosting and caching. There have been no DNS outages year to date, which exceeds the SLA of 99.98% availability. Over 222,000 IP addresses are registered on these DNS servers. Queries for the service peak at over 3,500 per second on busy days (Figures 29 and 30).

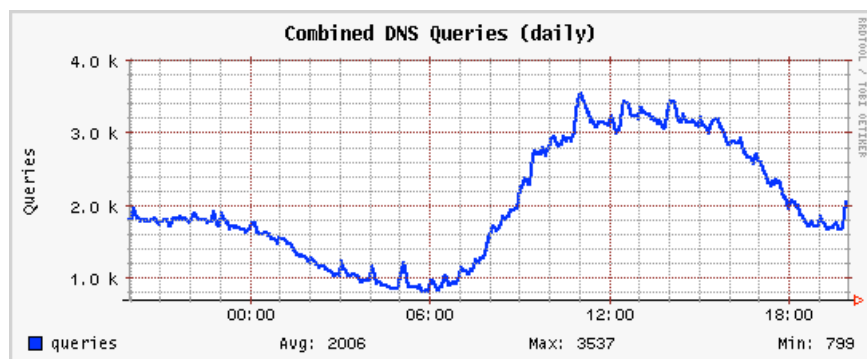


Figure 29: Daily DNS Service Queries

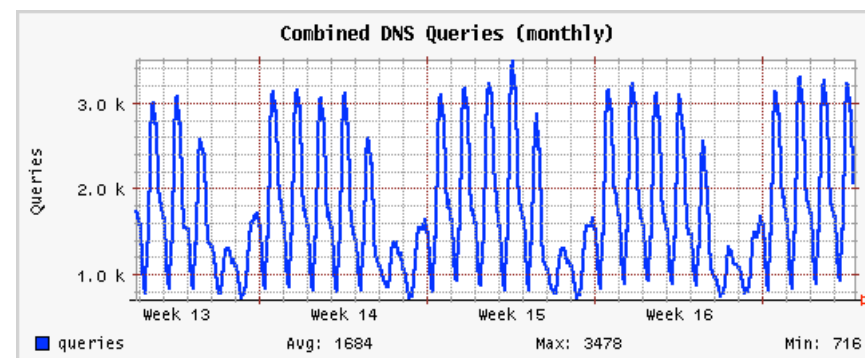


Figure 30: Monthly DNS Service Queries

The DNS caches are being upgraded this summer from djbdns to BIND in order add support for IPv6.

Some departments elect to provide their own local DNS services. There are valid reasons to do so, including vendor requirements. Use of a local DNS service deprives departmental users of centrally engineered resiliency/redundancy. The Network Operations Manual requires all DNS caches to be configured to resolve through the campus caching/resolver system.

4.7. DHCP (Dynamic Host Configuration Protocol)

Networking maintains resilient clusters of DHCP servers to provide IP addresses to devices on campus. There have been no DHCP outages year to date, exceeding the SLA goal of 99.95% availability. Over 121,000 IP addresses are configured in Networking's DHCP servers for allocation. **Figures 31 and 32** shows lease holdings. The saw-toothed swings come from the wireless network, where the average hour-long usage profile coincides with classes. However, this trend is less pronounced than in previous years as mobile devices, which constantly access the network, are becoming more prevalent.

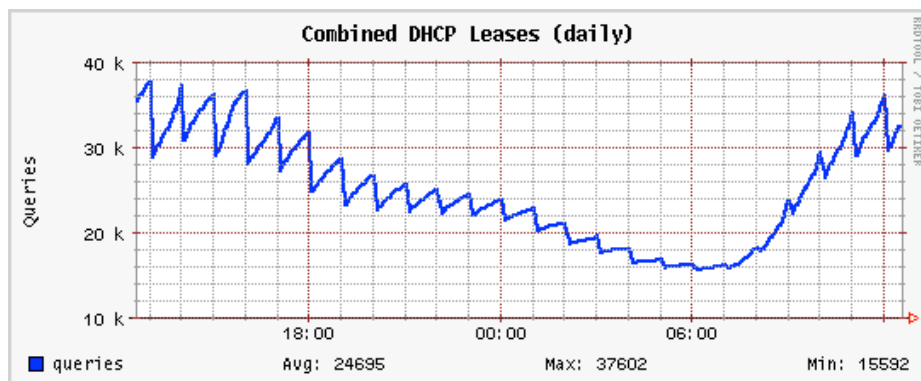


Figure 31: Daily DHCP Leases

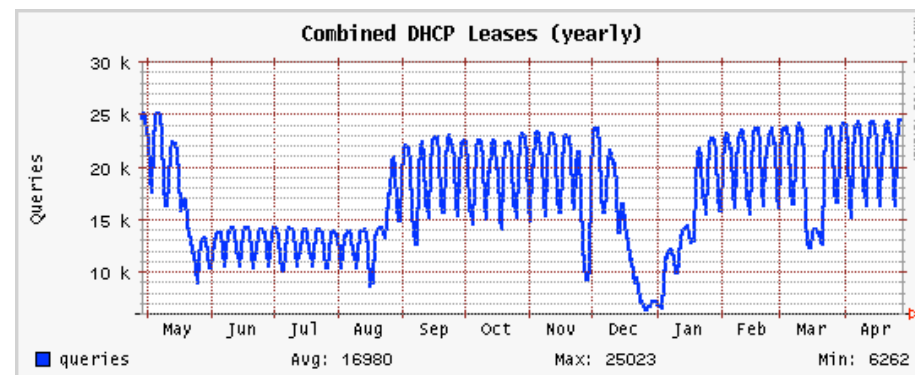


Figure 32: Yearly DHCP Leases

Some departments use their own DHCP servers, which are not included in these statistics. There are valid reasons to do so, including support for special DHCP options not offered by Networking's service. Use of local DHCP servers deprives departmental users of centrally engineered resiliency/redundancy.

4.8. VPN (Virtual Private Network)

The central VPN service is lightly loaded. Utilization peaked at 378 users during the AY1011 (**Figure 33**). The service is designed to support either 5,000 simultaneous IPsec clients or up to 2,500 SSL VPN clients. The high design load is for business continuity purposes.

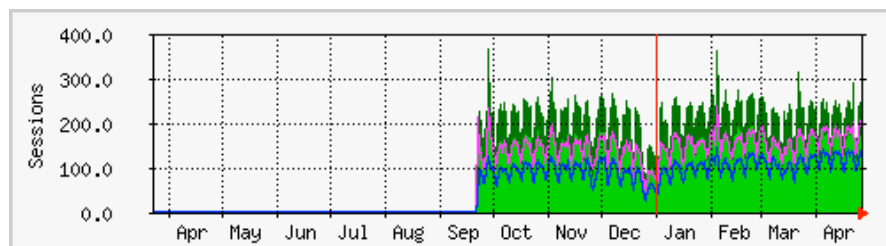


Figure 33: VPN Utilization

The SSL VPN client is recommended over the IPsec client. SSL users experience more reliable connections than IPsec, and studies show “buffer bloat” across the Internet is contributing to failure of IPsec VPN clients. IT staff should be cautious about requiring VPN use to access their applications, due both to resource limits inherent in any centralized VPN service and impositions on users and the networks they access from caused by VPN software problems/constraints.