Introduction

Over the last 5 years the UMass Lowell has incrementally upgraded its network to make it more reliable, stable and secure. Since the original network was designed and implemented in the late 1980's many of the components are outdated and becoming problematic. Rather than continue with incremental enhancements senior management concluded that a network assessment was needed to fully understand the University's network needs over the next 3 to 5 years. UMass Lowell (UML) engaged Sullivan and McLaughlin Co. (SullyMac) in a "Next Generation Network: Infrastructure Planning Process" to assess the network infrastructure, conduct critical review sessions to gather user requirements, and develop a long term network infrastructure plan for UML's Next Generation Network. This was performed from March – June 2006.

Concurrent teams were deployed to ascertain the current health and substance of the physical infrastructure of the UMass Lowell network cabling plant. In parallel to the physical assessment, another team reviewed and assessed the logical network and current status of active network equipment as well as collected user requirements from cross-functional representation of UML community in facilitated critical review sessions and in smaller meetings with key stakeholders.

All this information will allow UMass Lowell representatives to prioritize the physical network upgrade plans ensuring a better coordinated effort between departments who share a long term vision to upgrade the technology and infrastructure.

This document summarizes the findings, requirements, and recommendations which are broken down into subsections:

- The physical infrastructure findings section summarizes current state of UML fiber plant, closets, manholes and utility poles.
- The user requirements section is a summary of information collected during the facilitated review sessions and small group meetings.
- Based on the physical and logical infrastructure findings, user requirements, and best practices, the last two sections summarize recommendations for UML broken down into Physical Plant Recommendations and key Network Recommendations.

Physical Inventory Findings

The majority of manholes were in good working condition. However, the fill ratio for the majority of manholes was at or greater than 75% capacity, with several closer to the 90-95%.

The utility pole survey included poles on public roads and on the UML campus. One hundred eighty nine (189) poles were assessed.

Overall the poles surveyed appear to be in good condition. They all had a three-hole hardware system which is more than adequate, and will be able to support the weight of future cable to be installed. Not only was the hardware found to be more than adequate, the strand and strand attachments were found to in good condition and able to support future cable as well.

The physical condition of the cable was found to be in acceptable condition; cable was not under stress at any point in the survey. The splice enclosures surveyed were found to be in extremely poor condition; in the five (5) splices observed each one had bare fiber exposed. In each case the physical enclosure was in good condition however the covers had not been secured properly. Some of the slack loops were found to be tied up with rope and other unacceptable means. When the survey team encountered a transitional utility pole (arial to underground) some of the U-Guard that was observed was in less than acceptable

condition. All utility poles in the survey had enough room for expansion for mounting new hardware. Most of the utility poles surveyed were found to be owned by Mass Electric, and they, Mass Electric used metal tags to identify the utility poles.

UML User Requirement Findings

Nearly thirty small user group sessions were conducted with various departments and groups across all areas of the university to get a comprehensive understanding of tactical and strategic directions. In these small sessions, current and future network and application requirements were discussed. Additionally, six facilitated critical review requirements sessions were held on the University. Approximately 250 representatives of UML were invited and 88 individuals attended those sessions to discuss network requirements in general or as they relate to: teaching, research, administration, community service and outreach, and student life.

A derived requirement is one which was not explicitly stated in one of the facilitated discussions, but which is required as a prerequisite for one or more of the explicitly stated requirements.

Reliability/Increased Bandwidth/Higher Availability/Redundancy
Availability is made up of reliability and redundancy. Today UML only has reliability (equipment reliability), but little redundancy (except for EAPS ring). UML needs to increase the use of redundancy in the internet connection and the core network to best support the availability requirements of their mission critical applications and to support future user requirements:

A plan will be developed to address the requirements and below is an update to the user requirements brought forward in the campus-wide sessions.

General

- Increased usage of collaboration tools and collaboration in general
  - ✓ *Planning for use of MS collaboration tools. UITS uses Sharepoint and we are looking into using it or "live" meeting. We are using Horizon Wimba and a number of free ware tools but not campus-wide.*
- Centralized and supported backups, storage, and help/support
  - ✓ *Faculty server expanded and backed up. Administrative share folders available to those using the Active Directory domain. We continue to convert offices to the this. Latest has been Research Administration. CSCE is next. Student Services, Career Services, Advancement and Library already converted.*
- Ubiquitous internet access
  - ✓ *We continue to expand access to the internet through wired and wireless connections and will be a part of the NGN upgrade.*
- Remote access from anywhere there is Internet access.
  - ✓ *Virtual Private Network solution in-place and being rolled out to campus. However we are working to minimize the dial-in (modem pool) given usage is going down and hardware is off maintenance.*
- Faster speeds for desktop applications and internet access.
  - ✓ *This will be part of the Next Generation Network (NGN). Additional Internet bandwidth is in planning. We continue to replace older wiring with newer to allow for higher speeds. Residence Halls will be completed and have all category 6 (high speed) wiring in place by this summer.*

Teaching

- Virtual office hours

- ✓ *Currently being explored with the use of WebCt with online courses. Needs further discussion as to how this can be addressed sufficiently.*

- Increased usage of online video/audio teaching
  - ✓ *Audio and Video podcasting available. A campus-wide license purchased for podcasting and we are subscribing to iTunesU which is an Apple podcasting tool.*
- Online streaming of video for classes, Athletics, and other events/centers.
  - ✓ *Upgrade of Video streaming services completed. Multicasting video across the UML network still in planning and part of the NGN.*
- Increase demand of internet access in the dorms and to desktops
  - ✓ *Internet access at 100mb from all residence halls available this summer. Desktop access speeds dependent on wiring upgrades which continue as funding allows and will be a component of the NGN.*
- Internet in the classroom
  - ✓ *As of Fall 2006 an inventory was completed. There are 73 technology classrooms with projection equipment and network access*
    - *43 classrooms on North and 30 on South*
    - *9 classrooms have 2-way video*
    - *27 have wireless access*
    - *51 have document projectors*
    - *7 classrooms have Smartboards*
    - *6 classroom have capture systems (3 with video capability)*
  - ✓ *Classroom controls standardization for instructors in place*
  - ✓ *This Spring another 14 more technology classrooms added.*
  - ✓ *Need to work with colleges and department on planning for increased technology rooms to reach 80% over the next 3 years.*

Research

- Real-time online access requirements
  - ✓ *A workgroup has been formed to identify the requirements for high performance computing to assist research on campus. Input has been received from a number of departments on campus.*
  - ✓ *Grant proposal submitted to President's Office for a system-wide approach to High Performance Computing.*
  - ✓ *Online access somewhat dependent on Internet 2 access with a quality of service installed.*
- Access and transfer of large research data sets
  - ✓ *Currently available. Will become better with Internet 2 access (as above).*

Administration

- Increased access and use of e*mpac, ISIS, and reporting. (An increased growth of users of those applications; approximately double the # of users are projected).
  - ✓ *Reporting improving. Current reporting requests under control. Need to start to address management reporting. ISIS and e*mpac stable. Finance upgrade to version 8.9 (Web access) with grants processing included. Planning for upgrades to ISIS and HR to start in the Spring.*
- Increased student life applications (such as a Ruckus server for music and video downloading)
  - ✓ *Music downloading installed and available to students in residence halls. The university is looking into existing Internet software for us on campus (i.e. Myspace, Facebook, etc.)*

Increased Security for embedded network devices

This is based on the following user requirements:

- 24x7 access to classrooms and labs
- Increased usage of card access and surveillance cameras
- Increased usage of campus debit card
- Accessing and monitoring environmental management systems (such as HVAC)
- Increased student life applications that could impact network such as but not limited to shuttle bus updates and washing machine availability.
  - ✓ *Several items in the planning stages. One area is security in general and a consultant was hired to review current security and will be making recommendations this spring. We continue to install devices on the network that will allow us to use our Prox cards to access buildings and doors. We will finish with the installed in FY09. At that point all buildings will have the capability. During that time we continue to install keyless access doors in strategic locations based on need. The keyless access will allow for a greater level of security and less work on key maintenance.*

Improved Wireless Access

This is based on request for:

- Ubiquitous wireless access
- Wireless in the classrooms
- PDA access to the wireless network
- Wireless access for sensors, robots, and experiments
  - ✓ *Over 150 wireless access points installed on North, South and East campus in key locations. There is about 60 to 70% coverage. PDA access available. We continue to add wireless to classrooms through the expansion of the wireless network. Currently we are replacing all access points with newer technology for better reliability and support.*

Additional Space for Servers

The following requests were made:

- Space for research and computing systems
  - ✓ *Space in Olsen CC available. Planning the expansion of space as systems are turned down. This next fiscal year the Vax Cluster and CSCE will be turned down.*
- Community outreach and hosting
  - ✓ *Discussions with Paul Marion underway on how this can be best supported.*
- Distributed clusters
  - ✓ *This will likely be a tiered approach for the system. Some department based, campus based and system based cluster for specified research will be available. System is in the planning stages. A grant request submitted to President's Office to provide for this planning.*

Other

During the critical review sessions all input was captured. Additionally, several items are beyond the scope of the network but will benefit from other network changes. They are as follows:

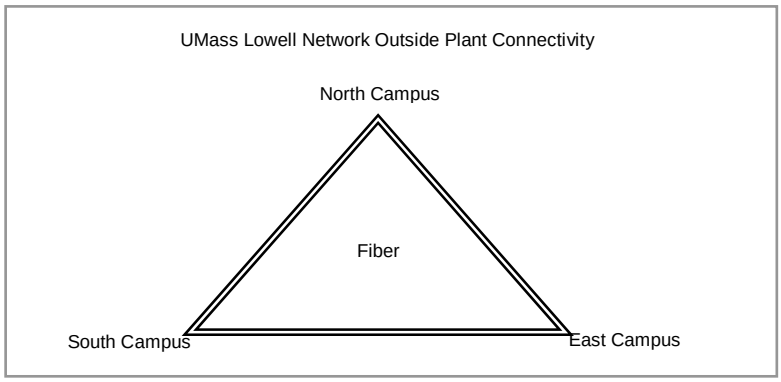
- Increased usage of active directory and simplifying logging into multiple systems
  - ✓ *Besides converting departments to UML Active Directory a system-wide initiative is underway to provide of a higher level of access throughout the system (Id Mgmt).*
- Training
  - ✓ *We continue to expand training. We are conducting a survey on how faculty would like to be trained and what of tools they want to be trained on.*
- Electronic Portfolios
  - ✓ *UMass Online currently experimenting with WebCt ePortfolio. Need a campus wide plan on how to implement this once a software solution is in place.*

- Student/Parent Interaction
  - ✓ *Increased functionality on the web for admissions. A pilot underway for online tutoring in the Centers for Learning. More planning needed in this area.*
- Expanded computer resources centers
  - ✓ *This is being explored and looking at all the possibilities.*

Physical Plant Recommendations*

Fiber

A fundamental physical change of the core network topology is needed to provide physical redundancy and therefore avoid a "single point of failure" that could cripple large portions of the UML network. The current core network nodes reside at Cumnock Hall (North Campus), Dugan Hall (South Campus), and Fox Hall (East Campus),



The current physical infrastructure is laid out such that any damage at any of these sites to the core cabling, or equipment, could cause potential long term network outages to vast portions of the UML campus. UMass Lowell must create a true physical ring by installing new OSP Fiber Optic Infrastructure connecting the Primary Core Sites noted above to Secondary Core sites (to be introduced during future construction) on each campus. This would greatly minimize the potential for a major network outage.

The upgrades of the lateral cabling from each of the core sites would be a Tertiary concern after establishing the Secondary Core Sites, and building the Core Fiber Optic Cabling Ring between the Primary and Secondary Core sites as described above. Each lateral could be built in parallel with existing network infrastructure, and could be integrated into the network with little or no downtime.

Closets

The closets are the primary connections from the UML network backbone to individual desktops. In general to improve network reliability and security and to increase capacity a number of short term activities need to be addressed. Approximately thirty-five percent (35%) of closets have more than one type of cabling. Nearly thirty percent (30%) of the closets have CAT3 and/or POTS cabling; just over fifty percent (50%) of the closets have CAT5 and/or CAT5E cabling; and, forty percent (40%) of the closets have CAT6 and/or CAT6HD cabling. Closets with CAT5 and/or CAT5E cabling or lower should be replaced with CAT6 cabling to run apps at gigibit speed. The highest priority needs to be those closets with CAT3 cable since this will severely limit bandwidth to desktops.

Additionally approximately ten percent (10%) of closets that have switches have zero free outlets and

* The Physical Assessment and Recommendations document provides more details.

nearly twenty-five percent (25%) of the closets with switches have only one free outlet; this population represents potential power capacity issues.

Utility Poles

All cable owned by UMASS Lowell should be identified with a tag and a telephone number in case of damage to the utility pole. The fiber splice's that were surveyed should be replaced before an interruption in service occurs. Perhaps a good time for this would be when there are not students on campus. The U-Guard on some of the poles needs to be replaced to protect the contents from vandalism and accidents that may occur. Slack loops should also be properly supported with the correct media, any tree's that hang over the cable span should be trimmed back to prevent damage to the cable, and possible outage in service.

Manholes

- Improve support of the cable so there is less stress of the cable as it enters or exits the conduit.
- Label all cable that UMASS Lowell is using in the manhole.
- Label all manhole covers and develop accurate and maintainable schematic of the manhole system.
- Identify all non-communication cable to see if it is abandoned; if so, remove it to make space for future installation of communication cable.
- Rod and rope any empty conduits for future work .

Key User Network Recommendations*

Based on the requirements along with a detailed assessment of the logical layer of the network infrastructure, Recommendations that support best practices and will define an infrastructure plan for UML that focuses on network reliability and growth to meet future needs. Below is a summary of the key Recommendations for the Network both short-term and long-term goals.

Short Term – 6 months to 1 year (short term recommendations could largely be implemented by Fall 2007 with some by Fall of 2006)

To improve reliability and address areas of network congestion

- Increase Internet Bandwidth based on user requirements, new applications, and increased growth. The Current internet connection is 76Mbps split between the Campus and Administrative networks. The new Internet connection will include 100Mbps for General Internet access and 150Mbps for connectivity to Internet2. This will bring the total for both connections to approximately 300Mbps for Internet and Internet2 access across the 2 links.
- Increase the Bandwidth across the Campus Core from 1 gigabit to 2 gigabit to increase resiliency and ensure the core network won't be the bottleneck related to internet bandwidth.
- Increase the Bandwidth between the Core and Distributions Layers as building upgrades to higher bandwidths occur. (For example, upgrade dorms to 100MB and upgrade high-speed faculty areas.)
- Add a Second Independent Internet Connection (Redundant connections to the internet)
- Simplify current connectivity at Internet edge to better utilize infrastructure and bandwidth.

* The Network Assessment and Recommendations document provides more details.

- Implement Quality Of Service (QOS) Marking and Policing at Edge of Network. Currently student and administrative access to the Internet bandwidth is only shaped of policies on the traffic shapers as the traffic exist to the Internet. The Extreme Network switches that connect to the users of the network also have the ability do so some of this policing as well. Policing at the edge of the network will give more specific control and help to take some of the load off of the network from virus and other malware traffic.

Long Term 2 to 3 years (long term recommendation could be in the starting stages by Fall 2007)

To build on the current network infrastructure and to meet future needs and requirements

- Upgrade Core Network and Key technology buildings to 10GB Ethernet
- Build second data center for to provide backup and redundancy for critical services
- Support for Gigabit Ethernet, where needed, to the desktop of faculty and in research Labs
- Build a segmented overlay network for video surveillance, access control applications and debit card transactions

Cost vs. Impact

Ideally implementing solutions that are considered low cost and high impact are good short-term items to focus on. This will demonstrate to the community progress and that their concerns and requests were heard. Then, strategically over time, UML should plan to implement solutions that are high impact but costs are higher. Items that fall into low cost & low impact or high cost & low impact quadrants aren't recommended. Additionally some of the lower cost items that have high impact are pre-requisites or interim benefits to the longer term solutions and as such there is value in implementing them sooner. The figure below depicts some of the key recommendations in a cost vs. impact graphical display.

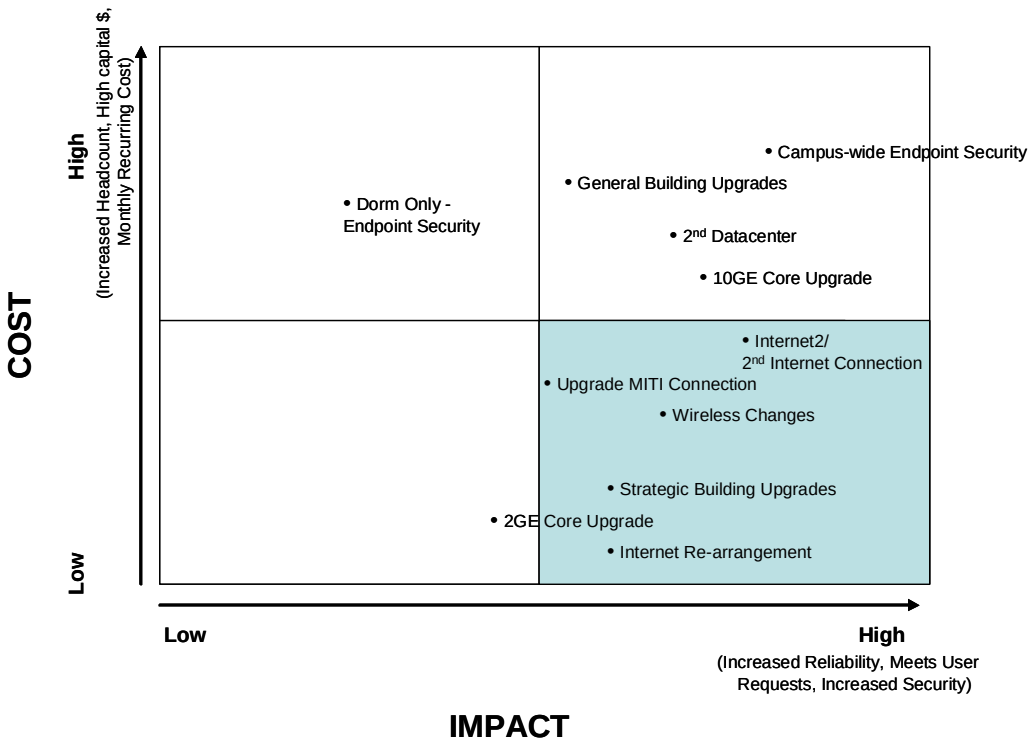


Figure 1: Cost vs Impact

Below is a summary of cost estimates for items recommended. The costs listed are not quotes for services or equipment. They are included for budgeting and prioritization purposes only.

			Est CapEx Over 3 Year Period			OpEx
Ref #	Item	Total Capital Expense (CapEx) Est	Year 1	Year 2	Year 3	Monthly Recurring Cost (MRC) Est
1	Core Fiber Upgrade to Secondary Sites	$625,000	$625,000			$0
2	Lateral Upgrades from each of the core	$465,000		$220,000	$245,000	$0
3	Closet Cabling Upgrades to CAT6	$4,170,000	$1,390,000	$1,390,000	$1,390,000	$0
4	Increase bandwidth across core from 1 gigabit to 2 gigabit	$10,000	$10,000			$0
5	Increase bandwidth between Core & distribution layers	$250,000	$50,000	$100,000	$100,000	$0
6	Add Second Independent Internet Connection/Internet 2/Increased BW	$96,500	$96,500			$11,412
7	Upgrade Core Network 10GB Ethernet	$1,079,100		$1,079,100		$5,175
		$6,695,600	$2,171,500	$2,789,100	$1,735,000	$16,587

Figure 2: Budgeting Estimates

Revised

			Est CapEx Over 3 Year Period				OpEx
Ref #	Item	Total Capital Expense (CapEx) Est	Year 1	Year 2	Year 3	Year 4	Monthly Recurring Cost (MRC) Est
1	Core Fiber Upgrade to Secondary Sites	$625,000	$625,000				$0
2	Lateral Upgrades from each of the core	$465,000			$220,000	$245,000	$0
3	Closet Cabling Upgrades to CAT6	$4,170,000		$1,390,000	$1,390,000	$1,390,000	$0
4	Increase bandwidth across core from 1 gigabit to 2 gigabit	$10,000	$10,000				$0
5	Increase bandwidth between Core & distribution layers	$250,000		$50,000	$100,000	$100,000	$0
6	Add Second Independent Internet Connection/Internet 2/Increased BW	$96,500	$96,500				$11,412
7	Upgrade Core Network 10GB Ethernet	$1,079,100			$1,079,100		$5,175
		$6,695,600	$731,500	$1,440,000	$2,789,100	$1,735,000	$16,587