Cost Benefit Analysis for Network Edge and Infrastructure Upgrade

October 2000

CORNELL UNIVERSITY

HIGHER EDUCATION
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Scope of the Effort

- The university is about to embark on a major upgrade of the existing edge and cable infrastructure environment. To ensure that the funds of the University are properly spent, KPMG has been asked to review the current environment, requirements (current and future), and industry trends to develop a roadmap for the upgrade, cost analysis, and high level schedule.
Components of the Upgrade

- **Edge Electronics Upgrade** – The current equipment is based on a shared 10Mbs standard. The University is evaluating replacing this equipment with a switched 10/100 Mbs environment.

- **Wiring Infrastructure Upgrade** – The current environment consists of about 95% Cat 3 cable and about 5% Cat 5. There is a small amount of installed fiber connection in some of the most recently renovated buildings but it is almost exclusively ‘dark’ except for intra-building runs (e.g. to servers).
Edge Electronics Upgrade
There are about 600 network segments served by shared devices

Shared 10Mbs Equipment

- Each segment supports about 50 users
- There are about 20 (2%) trouble calls involving these devices per month (207 since 1/1/00)
  - Each trouble call takes about four hours to resolve
- The equipment is a mix of David Systems and Asante
  - The equipment ranges from 0-15 years old
  - About 55% is David Systems, 45% Asante
- Based on University statistics about 320 (53%) of the segments show degraded performance
  - About 100 (18%) show seriously degraded performance
  - 15,000 (faculty, students, staff) could be affected every day – (50 users per segment, 320 show degraded performance)
Edge – Upgrade Equipment

- Estimated to upgrade the edge equipment is
  - $9M (Includes hardware, labor, and related expenses
  - Will provide a Level 3 (for QoS) edge environment
  - Equipment has about three year life-span to remain current with technology

- The university is gradually replacing the Shared devices with switches
  - There are about 300 switches installed on the campus today
  - There have been 18 (about two/month- 1%) trouble tickets for problems with these devices since 1/1/00
  - Each problem takes about 2.5 hours to resolve

- No significant performance problems are experienced on those 300 switched segments
  - Bandwidth problems are virtually non-existent
  - CPU utilization problems are small in number (2%) and minor in severity
Edge – Cost Assessment

Factors to Consider:

- Maintenance costs
- Lost productivity costs
- Intangibles
  - Faculty/Student dissatisfaction
  - Lost research
  - Damage to reputation
Edge – Maintenance Costs

Based on statistics provided by CIT

- # repairs: 17/month for Hubs, 6/month for switches (normalized)
- Avg. time for repairs
- Avg. labor rates ($40)

Network Statistics indicate average repair time for hubs is 4 hrs., for switches 2.5 hours.
17 hub failures/month @ 4 hrs./failure @ $40/hr (labor) = $32,000/year
If switches installed, estimate 6 switch failures @ 2.5 hrs/failure @$40/hr (labor)= $7,200/year
Average savings = $25,000/year for switched environment
Edge – Lost Productivity

- Based on CIT provided information
- 15,000 shared ports show degraded service levels daily
  - 300 segments (50 users/segment)
  - 11,000 ports in academic/support buildings
  - 4,500 in residence halls
- Assume 75% of faculty and academic staff is impacted, 33% of staff
- Assume $40/hour for faculty, $25/hour for staff
Impacts to productivity can range from slow response to email, problems with application performance, to complete segment failure (overload or maintenance).

- Assume that an average user is impacted for 3 hours per month the productivity costs would be:
  - Faculty/Academic: 1950 @$40/hour for 3 hours (each person)/month = $234,000
  - Staff: 2200 @ $25/hour for 3 hours (each person)/month = $165,000
- Total productivity impact/month: $400,000
Edge – Ability to support future requirements

**Video/ distance learning**
- Already seeing initiatives at Universities
- Shared 10 and majority of existing switches will not be able to support this reliably. Need Level 3 aware equipment for QoS.
  - Without QoS – cannot guarantee delivery, critical for video and voice transmissions
  - Contention with other users on the network segment (shared) will cause overloading of segment and loss of service

**Increased demand and utilization**
- University network traffic is significantly increasing
  - Peaks are 50% higher than last year
  - Average traffic has increased approximately over last year
Edge – Core Router Traffic

Traffic across core router during the specified time frame. Note significant increase in traffic levels between April/May of 2000 and September/October 2000. This validates that Cornell is experiencing the increased use of the internet shown in industry reports and campus surveys.

Blue - Inbound
Green – Outbound
Dark Green – Outbound peak
Pink – Inbound peak
Edge – Ability to support future requirements

- Internet use (worldwide per person) is up significantly since August 1999 - Nielsen

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<td>Current universe</td>
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<td>147.7M</td>
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</table>

- Recent Greenfield Pulse-finder on-campus survey
  - 31% of college students describe themselves as Internet dependent
  - 81% of students make on-line purchases
  - 92% of students own a computer
  - 90% go on-line at least once a day
  - 92% percent use email regularly
  - 72% ‘surf’ the web
  - 60% use instant messaging
Edge – Intangibles

- On a daily basis 4500 residential ports receive degraded service
  - Can’t relate lost productivity to cost but relates to overall satisfaction

- Recent survey of ‘competitor Universities’ (1998)
  - About 50% (1998) were on or moving to switched 10Mbs or 100Mbs
  - Think that this doesn’t matter?
    - Requests are being received today for upgrades but are unable to be satisfied. Network is being maintained but not upgraded
      - No University statistics are kept on this
  - The potential exists for an impact on grant funding if the University computing infrastructure can not support the technology needs (e.g. Medicine, engineering, super computing)
Students in high schools are increasing relying on the Internet for classroom activities. Cornell students will expect equal or better access (U Cal – Irvine study)

- 98% of high school students have internet access (45% with high speed access (T1 or greater))
- 41% of high school students regularly conduct research on the internet

Security – In a shared environment the data can not be protected from other members of the LAN. Information is vulnerable to anyone who gains access to the workgroup. Potential for significant loss and liability (e.g. credit cards, health records, financial information)
Edge – Benefits to a Switched 10/100

- Majority of network performance problems will be eliminated
  - Compare shared segments today to switched segments
    - 50% - degraded performance on shared
    - <5% - on University switched network
- Current shared 10 equipment is failing and must be replaced
  - Reliability is greatly improved (NOC statistics)
  - Spent $2M to upgrade portions of the network due to poor service levels
- More in-line with other University systems
- Greater data protection
Edge – Recommendations

- Begin the campus-wide upgrade of Edge equipment to Level 3 aware devices
  - Will provide a network that will improve service to 15,000 data ports who regularly receive degraded service
  - Repair costs will be significantly reduced
  - Will position Cornell with other ‘competitive’ Universities
  - Will limit vulnerabilities to unauthorized users viewing sensitive data
  - Internet use in the University and the world shows that problem will only get worse
Edge – Recommendations (cont’d)

- Strongly consider the purchase of 10/100 switches, little difference in initial cost (Alcatel) but will provide better positioning for future upgrades (The requirements for the edge procurement should be carefully considered and proposals evaluated to ‘future-proof’ your investment)
  - Even though current requirements are not there for 100Mbs to the desktop, useable life of the equipment will be expanded by several years (high probability) with little additional investment
  - As part of evaluation of vendors consider: full life cycle costs, interoperability, and expandability
  - Ensure that QoS is supported in a way that can be utilized in the environment. Be especially careful with interoperability between various vendor equipment
  - Prepare to negotiate extensively with the vendor to ensure the best price. With a large procurement discounts of 40% (60% possible) or more should be expected
Wiring Infrastructure Upgrade
Wiring – Current State

- About 95% of the University is Cat 3 based cable, 5% is Cat 5
  - Cat 3 will only support 10Mbs connections
- Every year several hundred thousand is spent on new wiring and connectors
  - Purchases are approaching 50% ($250K) in 2000 for Cat 5
- Wiring failures are not common, new wire is being run to support additional requirements
- About 20% of the existing Cat 3 cable plant is ‘out of spec’ because of run-length
  - Using repeaters if required to boost signal strength
  - Not a significant source of performance or reliability problems
- The majority of cable-ways will not support Cat 5 (or higher) installation
  - No space
  - Out of spec (run length, bend radius, etc.)
Wiring – Current Requirements

There are few applications today that require 100Mbs to the desktop

- Validated by Gartner, Meta & Cornell experience
- University has installed Cat 5 and Fiber cable to some areas
  - Johnson school has Cat 5 and ‘dark’ fiber to desktop
    - No current requirements for 100Mbs to the desktop
    - Fiber is left dark, can be illuminated if the need arises
  - Computer Science department has Cat 5 to the desktop
    - No current requirements for 100Mbs to the desktop
    - Has installed 10/100Mbs switches
- Server rooms and other locations where traffic is high use Cat 5, or Fiber to support higher data rates
Wiring – Building Infrastructure Upgrade

- Recent cost estimate from Western Telecom estimates costs up to $90M for campus wiring upgrade
- RFP for pilot project involving five buildings is about to be sent to prospective vendors
  - Will refine cost model
- Recent standards for wiring will ensure proper consideration during building renovations

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Wiring – Options for Consideration

- Cat 5 – Minimum standard for new wiring construction
- Cat 5e – Upgrade of Cat 5, permits better support to Gigabit Ethernet
- Cat 6 – Pre-standard, wiring costs very similar to Cat 5e. Risk with connectors because of no standard, connector costs are significantly higher than Cat 5e
- Cat 7 – Very new, opinion is that it is too bulky, costly, and offer little advantage over Cat 6 or fiber
- Fiber – Expensive, connectors are expensive and require care

<table>
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<th>Wire Type</th>
<th>Relative Cost</th>
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<th>Comments</th>
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<td>Cat 5</td>
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<td>Minimum standard for new wiring infrastructure. Will be new ANSI/TIA/EIA 568-B.1 standard as minimum requirement for new buildings</td>
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<td>Cat 5e</td>
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<td>Yes</td>
<td>Improved version of Cat 5, provides better ACR, support to Gigabit Ethernet</td>
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<tr>
<td>Cat 6</td>
<td>1.31</td>
<td>Pre</td>
<td>Better cable, better Gigabit support, intermateability</td>
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<tr>
<td>Cat 7</td>
<td>N/A</td>
<td>No</td>
<td>Not expected to be widely deployed</td>
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<tr>
<td>Fiber</td>
<td>2.1</td>
<td>No</td>
<td>Greater bandwidth capability, requires care in installation, fragile connectors</td>
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</table>

Source: Gartner, Meta reports
Wiring – Type Recommendations

- Install minimum of Cat 5e in all new installations
- Consider Cat 6 cable with Cat 5e connectors (cost difference of <20%)
  - Upgrade connectors after standardized and as needed

The price differential between Cat 5e and Cat 6 will continue to narrow. Given the duration of the Cornell wiring upgrade project Cat 6 represents a better long-term investment due to better performance and little cost difference.
Wiring – Cost Assessment

Factors to Consider:

- Maintenance Costs
- Lost productivity costs
- Future Opportunity Costs
- Intangibles
  - Faculty/ Student/ Staff Dissatisfaction
  - Lost Research
  - Damage to Reputation
  - Wireless impact
  - Delay to meet installed need
- Phone closet is insecure
Wiring – Maintenance Costs

- University does not experience substantial maintenance costs related to the existing wire plant
- Majority of wiring efforts are to support new requirements
- Copper maintenance costs are the same for Cat 3, Cat 5, Cat 5e, and Cat 6
  - Differences are in installation and the connectors

*Result:* Little benefit in maintenance costs from new infrastructure over current cable plant.
Wiring – Lost Productivity Costs

- Users are not experiencing degraded service because of current Cat 3 cable plant
- Edge Electronics are the cause of the impact
- Cat 5 cable to the desktop is not required to support current operations
  - Data points:
    - Johnson school
    - Computer Science department
- Cat 5 or Fiber is required for server or other high data traffic areas of the network, this is installed as required

**Result:** Little productivity impact caused by current cable-plant
Wiring – Future Opportunity Costs

- A number of applications could require the use of 100Mbs connections (or higher) to the desktop
  - Video (high resolution)
  - Voice over IP – increase network demands
  - Tele-medicine applications (virtual surgery, tele-radiology, etc.)
  - Time sensitive movement of large data files (maps, photos, etc.) between users or users and the server to support research or system back-up

- Benefits are mostly intra-campus, connections to outside are limited by Internet congestion

- Result: Future proofing the network is prudent to support high bandwidth applications such as video, voice, large data intensive computing (e.g. genetic mapping, search for intelligent life)
Wiring – Intangibles

- Faculty/Staff/Students dissatisfaction – Is impacted by Edge electronics and not the infrastructure
  - Basis: Johnson school, CS department, and existing loading of switched 10Mbs LANs

- Lost Research – Specific programs may require enhanced connectivity. To date, no immediate requirements have been identified

- Damage to Reputation – Peers are either on or migrating to Cat 5 infrastructure
  - Assessment: Will not seriously impact faculty/staff/students in the near term
    - No current requirements
Wiring – Intangibles (cont.)

- Impact of wireless – the wild card
  - Has the potential to impact future use of the network in a variety of unexpected ways
  - Competing standards
  - Expensive, limited market penetration
  - Low data rates today (could be 45Mbs in future – Gartner)
  - Industry analysts believe that wireless will play a role of increasing importance in the future
    - Supplement to existing cable plant
    - Could compensate for varying work habits (e.g. group interaction, virtual research)

- New initiatives could impact use and bandwidth requirements
  - ‘Virtual’ University
  - Distributed research (computer pooling)

- Delay between realized needs and wiring upgrade
  - Will require 5-8 years after need identified to rewire entire campus
  - Ability to satisfy customer needs will be impacted
Wiring – Future Trends (Best time to Invest)

■ Distributed learning (DL) will become increasingly important in the next five years and represents the most likely (known today) new learning initiative that will impact bandwidth requirements
  – Gartner estimates that 70% of higher education institutions will implement Distributed learning programs by 2004 (.8 probability)
  – Gartner also states that by 2005 an estimated 80% of educational content and programs will be delivered on-line (.7 probability)
  – Most connections to the homes of faculty, students will continue to be analog modems for next five years
    – Design of DL systems should support all connection types (design for the low-end so that all users can benefit)

■ Assessment: In spite of increasing use of distributed learning in the near term (5 years) bandwidth limitations of end users will continue to be well below that which would require a full Cat 5 (or greater) infrastructure
Wiring – Recommendations

- Continue an opportunistic approach to rewiring the campus
  - No compelling business case exists for immediate wholesale upgrade
  - Concentrate on those building that are being renovated
  - Solve ‘trouble spots’ on an ad-hoc basis
  - Evaluate yearly to ensure needs are being met and expenditures are prudent

- Continued strategic planning is crucial to understand what all stakeholders (faculty, administration, students) envision as their future requirements, this will help to shape the infrastructure needs
  - IT is the enabler for many new efforts and research activities

- Carefully study the work habits of your constituents: how they connect, when, where, and what they do. This could affect the scope of this effort and how you provide connectivity in the future
Wiring – Recommendations

- Keep aware of new technologies such as wireless, they may shape the campus LAN of the future and affect the replacement of the campus infrastructure

- When performing upgrades use a minimum of Cat 5e cable
  - Consider Cat 6 with Cat 5 connectors until prices drop and standardization occurs with Cat 6 components
  - Ensure that enough cable space exists for future media upgrades (more cable, different types, etc.)
    - Marginally more expensive, saves effort and money later
  - Ensure at least three connections to every desktop for future expansion
## Summary – Cost/Benefit Scenario

Chart is based on University data and industry estimates of current/future trends.

<table>
<thead>
<tr>
<th>Edge Upgrade</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<td><strong>Option 1: Do Nothing</strong></td>
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<td><strong>Option 2: Complete Upgrade</strong></td>
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<tr>
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