Enterprise Productivity:
Comparative Economic Analysis of VoIP Conversion Strategies

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Executive Summary:

The operational efficiencies that Voice over Internet Protocol (VoIP) telephony brings to a converged network infrastructure have encouraged many large enterprises to evaluate migration of their existing digital PBX networks. One such case is that of Constellation Energy Group (stock symbol: CEG)[1]. CEG has an existing Nortel Meridian[2] infrastructure consisting of more than 30 PBX installations serving close to 9,000 seats within the firm. While the Meridian system has been very reliable (greater than 99.999% availability), CEG is interested in the operational cost efficiencies of managing a converged voice/data network.

Those advantages include the following, which any VoIP solution would provide:

- lower cost of moves, additions and changes
- toll bypass (not necessarily the same between vendors)
- lower physical infrastructure maintenance (one drop to each work seat)

CEG has the option of upgrading the existing Nortel infrastructure for VoIP, or to selectively replace digital seats with a Cisco Call Manager VoIP solution[3]. CEG has decided that, due to the low cost of maintaining the Nortel system and certain regulatory requirements surrounding key energy plants, the implementation is to be a hybrid deployment where the Nortel PBXs will not be retired. Digital lines will not be completely eliminated, and any VoIP solution must integrate with the existing Nortel PBX solution.

We performed an economic analysis on the total cost of operation for both a Nortel PBX/VoiP hybrid system and the competing Nortel PBX/Cisco Call

[1] All information pertaining to public companies were acquired through sources within the public domain
[2] All references to Nortel Networks copyrights and trademarks remain solely the property of Nortel Networks
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Manager system. A combination of conversion process analysis and expected reliability calculations were performed for both cases.

The primary finding was that, due to differential productivity costs in ongoing operations and outages due to conversion, the Nortel PBX/VoIP hybrid bore the lowest costs when evaluated over a five year period. Furthermore, the Nortel solution was more capable in terms of feature set reliability and flexibility.

The costs break down as follows.

TCO (5 years)	Nortel VoIP	Cisco Call Manager
Labor and Maintenance Cost	$6,871	$545,558
Cost of Lost Productivity	$96,349	$16,976,029
Total:	$103,220	$17,521,587

CEG is a high productivity company, meaning that revenue-per-employee metrics are more than $1 million per employee-year. Even small network outages are very significant with such a company.

The industry group to which CEG belongs (Utility-Electric Power), is a low growth business. Seldom does revenue growth exceed a 5% annual rate. The key element, then, is to drive operational efficiencies to the point that each dollar saved drops directly to the bottom line, and once optimized to protect the performance.

Any changes to CEG's network or infrastructure should be analyzed against potential impact to productivity, and clearly the cost of a provider hybrid NT-PBX/Cisco Call Manager network significantly exceeds that of a NT-PBX/VoIP system. The reliability issues alone are significant enough to warrant closer investigation.

Detail:

Analysis was performed upon the scenario provided which includes the following assumptions.

- CEG to retain the existing NT-PBX network and deploy VoIP as an overlay
- CEG owns and maintains connectivity links between sites on their fiber optic network
- Cisco solution requires retirement (without migration) of existing voicemail system
- Cisco solution requires existing network upgrades to accommodate Cisco AVVID
  - upgrade 6500s with analog cards, PRI cards, universal trunk cards
  - additional PRI cards for Meridians to interface with Cisco dial plan
  - implementation of QoS in existing data network to support Cisco solution
- CEG doesn't require Cisco to integrate with existing voicemail, call center applications or 3rd party applications

Total cost of ownership includes not only the direct cost of equipment, installation, and software licenses, but also the cost impact to ongoing operations as well as any operational efficiencies recognized as a result of the project. In this particular scenario, both Nortel and Cisco offer similar standard advantages for VoIP with some small variations. For the purposes of this economic analysis, we are concentrating on vendor-to-vendor differentiation thus will focus on ease of migration and operational reliability.

Process Analysis:

Nortel's process for migrating digital lines to VoIP is shown below in Figure 1. As stated, existing users suffer no downtime of telephone service, existing

applications such as voicemail are not affected, and the primary cost will be equipment and licensing. Little impact to enterprise productivity is experienced.

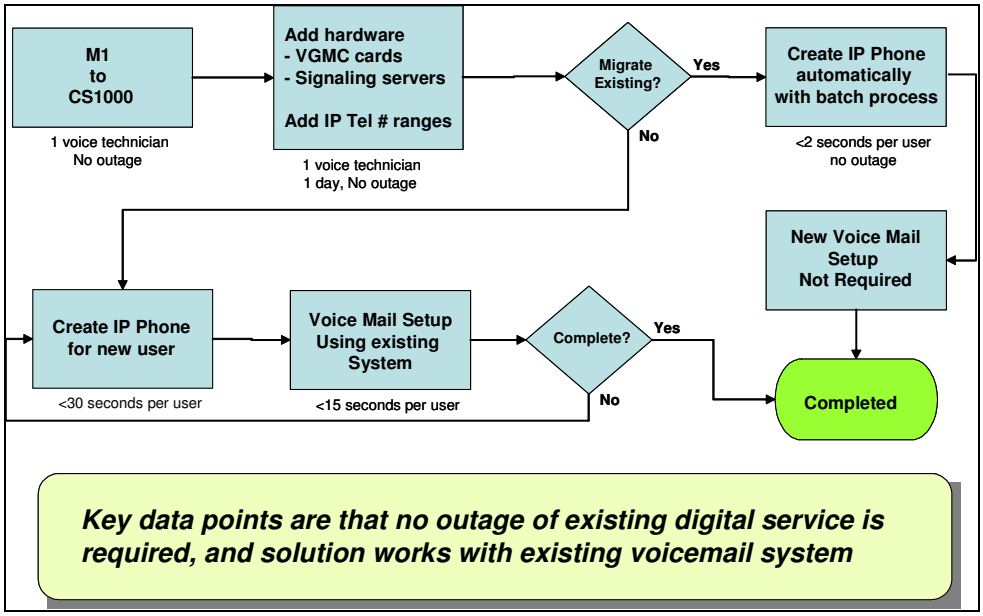

Figure 1: Nortel Process for Migration of Digital Lines to VoIP

Cisco's process is necessarily more complex, as their system needs several levels of activity to implement. First, the existing data network must be upgraded to support an overlay of the VoIP solution as well as making provisions to integrate with the existing Nortel PBX system.

Figure 2 details an estimation of the IT labor cost involved with performing the upgrade.

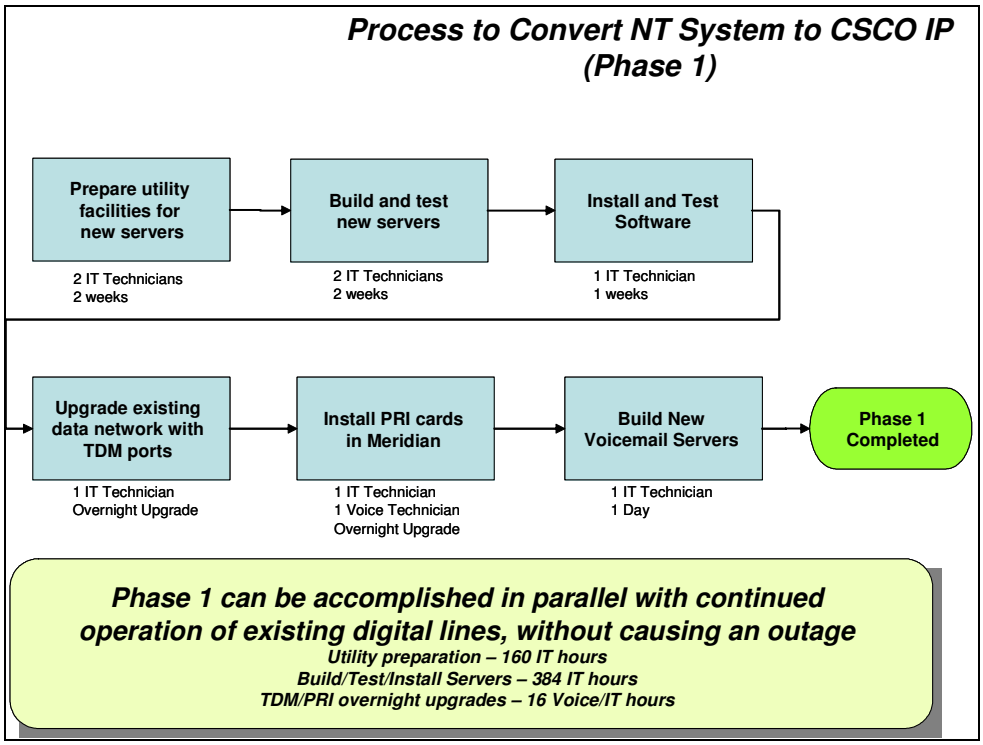

Figure 2: Cisco Data Network Upgrade Phase

The assumptions within the economic analysis incorporate the above metrics. Actual experience is likely to exceed this estimate, as this is conservatively framed with a "no-fault" installation/upgrade experience. IT data system engineers will attest that "no-fault" installs are the exception rather than the rule. Note that the economic model provided allows for the user to modify these assumptions at will.

The next phase in the Cisco migration is characterized by Figure 3. This process is heavily manual, with access to multiple management platforms, and cannot be automatically batch processed.

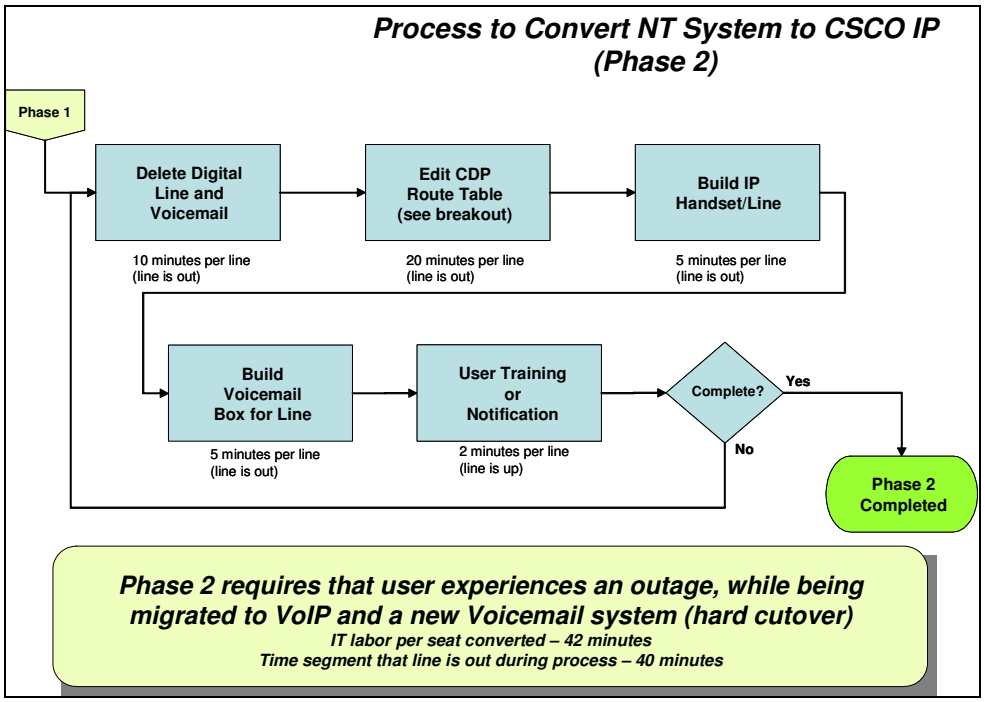

Figure 3: Cisco Process Detail for Converting One Digital to VoIP line

There are two cost elements to consider with this process. First the manual effort which is captured in IT-manpower hours, and second the productivity costs associated with the outage of the user during the process. So in this case, there is 42 minutes of IT effort for each migration seat as well as 40 minutes of line outage to the user.

The casual reader may object at this point that the duration of several process components seem overly long, so the most intensive element (Edit CDP Route Table) is broken out further within Figure 4.

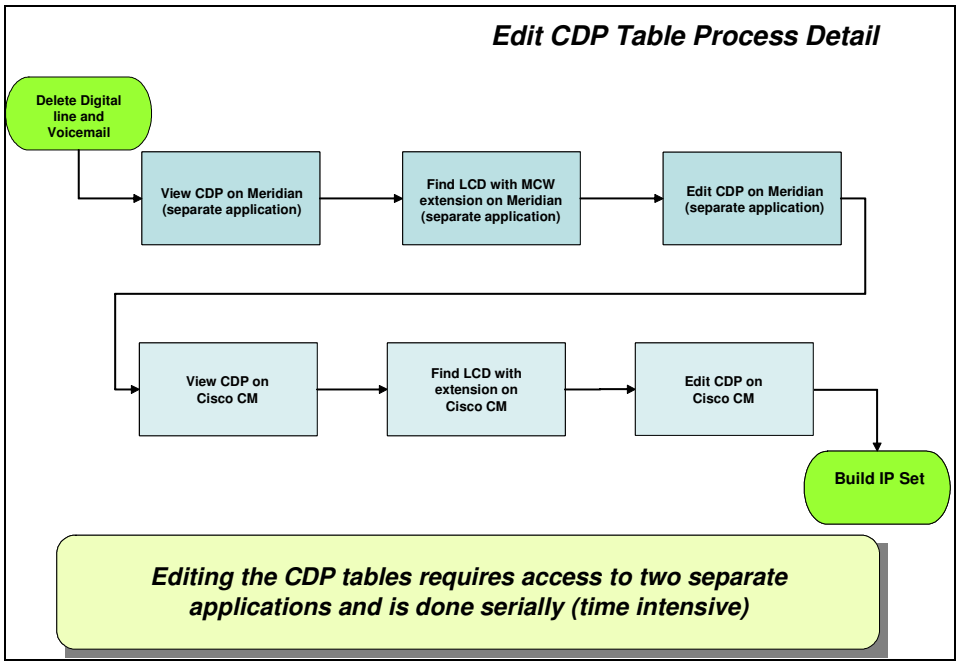

Figure 4: Cisco Edit CDP Table Process

Note that the technician must utilize two different platforms, perform manual analysis, and make sure that key data is passed correctly between the systems. Performing thousands of manual migrations will result in transcription errors, which have not been assessed within the model.

While it is possible to plan conversions on a maintenance window, the sheer volume of seats to be migrated will work against that approach. Given the above assumptions, the total IT manpower-hours necessary to support a migration of 9000 seats is in excess of 6,300 (more than 3 man-years). By necessity, user outages will occur and enterprise productivity will be impacted.

Reliability Analysis:

In this particular comparison, we have two manufacturers who come at the issue of VoIP from different directions. Nortel has an extensive history of providing reliable (in excess of 99.999% availability) voice telecommunications systems. Cisco has an extensive history of providing IP data networking systems where the standard for reliability is somewhat less.

Nortel's design approach:

- 99.999% as a minimum system design standard for voice telecommunications
  - Regular PBX reboots not required (memory leakage not endemic)
  - Hardware upgrades/replacement are hot-plug redundant within the box (no dependence on network connectivity to provide redundancy)
  - Patches are hot-plug to single processor, and can be rolled back to previous state easily
  - No degradation of services during upgrades/patches, fully functional
  - Very secure, history of very few security exploits
- VoIP solution coexists within the PBX platform management system for ease of operation and use of existing applications

Cisco's design approach:

- Depends on IP networking to drive reliability (via clustering)
  - Regular Call Manager server reboots required (underlying system Windows OS)
  - Hardware upgrades/replacements require taking a cluster node offline
  - Patches are not simple to roll-back, requires re-image in most cases
  - When nodes are offline, cluster services are affected with latency or unavailable
  - Multiple security issues on a yearly basis (both Cisco IOS and Windows OS)
- VoIP solution requires use of both the Nortel PBX management platform as well as the Cisco Call Manager

Both providers will commit to 99.999% reliability, so how can we drive to a more rational comparison? Since both systems will be subject to the same data network access, we will ignore the access component for the moment.

Nortel has more than 30 PBXs installed currently at CEG, and actual reliability statistics can be input into the model. For the purposes of economic analysis, reliability data is captured as outage minutes per year. Given history and design, Nortel's metric is credibly less than 5 minutes of outage per year, yielding a very low impact to enterprise productivity.

Cisco's underlying reliability requires a more bottoms-up analysis. Given their design philosophy, Cisco requires the network to provide redundancy. For ease of analysis, we'll make the following (very optimistic) assumptions.

- Node failure switchovers have zero latency
- All patches are successful and do not require roll-back
- No hardware failures are experienced

Figure 5 details an outage calculation model for a cluster based on individual server node reliability.

Per Node Calculations (including Win-OS updates)	
730.00	hrs/mo
8.00	Cisco hours/patch
32.00	Cisco patches/year
2.67	Patches/mo
21.33	Patch hours/mo
2.00	MS-Win OS patches/mo
0.50	Hours/Win-OS patch
1.00	Win-OS patch hours/mo
22.33	Total patch-hours/mo
96.941%	Actual server reliability

Figure 5: Model Reliability Inputs by Server

In this case, the highlighted fields indicate user inputs for the model. The inputs shown were based on publicly available information on the number of patches issued in 2004, with estimated hours per patch. Note that critical Cisco patches often involve a re-image of the underlying server and cannot be easily be rolled back to a previous state. MS-Win issued many more patches, however we have assumed only 2 per month as being critical. All servers require rebooting at least

once per month as well due to memory leakage issues, but that is considered to be included within the above calculation.

Given the resulting server reliability figure, the minimum cluster configuration is illustrated by Figure 6. Note that the expected reliability of the cluster, given the above assumptions, is between 99.9% and 99.99%, a far cry from 99.999%. In order to achieve credible 99.999% performance, significantly more server nodes are required, with attendant patching IT-labor cost. In fact, fulltime resources would be needed simply to maintain the cluster.

Cisco		96.941%
Outage Minutes per Year	**# of Servers in cluster**	**Cluster Reliability**
0.01	5	99.9999973%
0.46	4	99.9999124%
15.05	3	99.9971365%
491.95	2	99.9064031%
16,080.00	1	96.9406393%

Figure 6: Calculated Reliability of Server Cluster

Let's re-examine the optimistic assumptions above to understand why this analysis is conservative.

First assumption, that node switchovers have zero latency. IP networks do not easily re-route around failed nodes and some path switching latency is involved. 99.999% reliability means that combined outages are less than 26 seconds per month. Note that the standard Ethernet spanning tree reconfiguration will take longer than 30 seconds for a single node switchover. Other faster approaches exist, but some measurable latency of switchover will occur and the transition will be noticeable as minutes of outage. IP networks, are designed to cope with mini-outages, and experience many on a daily basis. Dropped packets represent a mini-outage, and are significant when discussing a 99.999% design standard. Often, the IT technician is not even aware of outages which are intermittent, since most enterprises do not have real-time data network monitoring.

Second, all patches are successful and do not require rollback. Anyone with real-world IT experience will acknowledge that all patches are not successful and some do require rollback. This is true for Cisco IOS as well as MS-Win. Rollback is painful, in terms of time required, for the Cisco Call Manager cluster.

Finally, no hardware failures are experienced. Again, anyone with real-world experience will acknowledge that power supplies, NIC ports, cabling, and chipsets fail on occasion. When they fail, the server system tries to resolve the issue, and if unsuccessful will switch to an active node or simply stop responding. The latency involved when trying to resolve an error state within a server is significant and is not included in the model.

Based on these facts, we consider the reliability calculations to be conservative and optimistic in relation to Cisco's actual system performance.

Productivity:

Economic productivity, when talking about enterprises, is typically captured using yearly enterprise revenue per employee. When reviewing companies within industry groups, it is a means to identify well-managed and efficient operational use of company resources.

Constellation Energy Group (CEG) is a member of the Utility – Electric Power industry group. Other members of that group include Alleghany Power (AYE), American Electric Power (AEP), and Duke Energy (DUK). Figure 7 below, shows the relative performance of all four companies for the years 2002, 2003, and 2004.

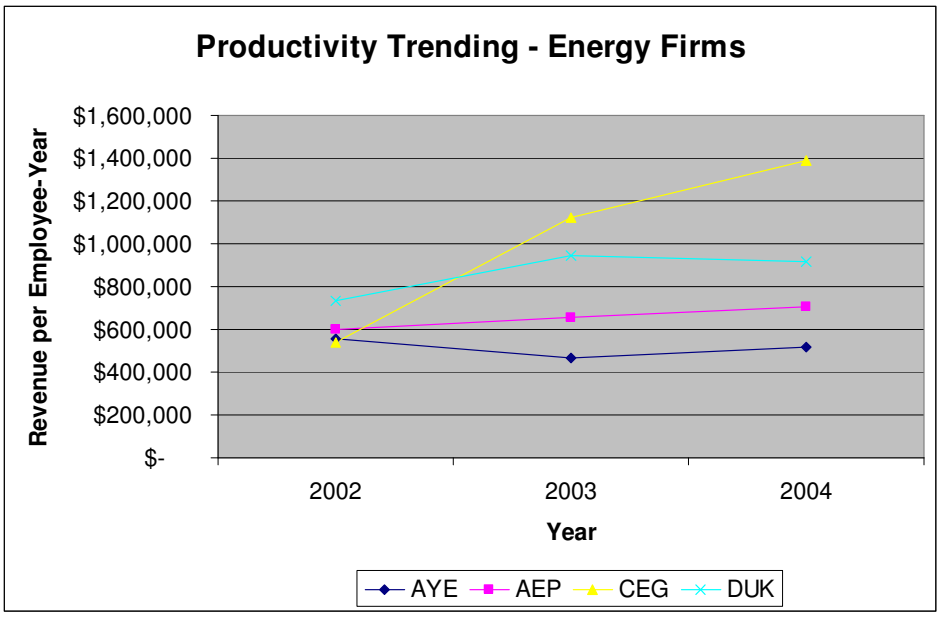

Figure 7: Productivity per Employee by Year

Note that CEG experienced a tremendous improvement from 2002-2004, as they went from the worst in the group to the best in class. Note that in order to maintain their standing, anything that impacts productivity is significant.

Breaking it down by employee-minute is also useful, for reasons that will become clear. Figure 8 shows the same chart recast in terms of employee-minute. Outages impact the enterprise's ability to generate revenue through the introduction of operational inefficiency. Companies with high productivity have more at stake during network outages than companies with lower productivity.

Using the below example, suppose CEG and AYE both experience a system-wide outage of voice services for 10 minutes. Plus, let's assume that users are 70% productive without telephones (efficiency coefficient). The relative impact, regardless of what efficiency coefficient is applied, is much worse for CEG (lost productivity of $314,229 vs. $70,135).

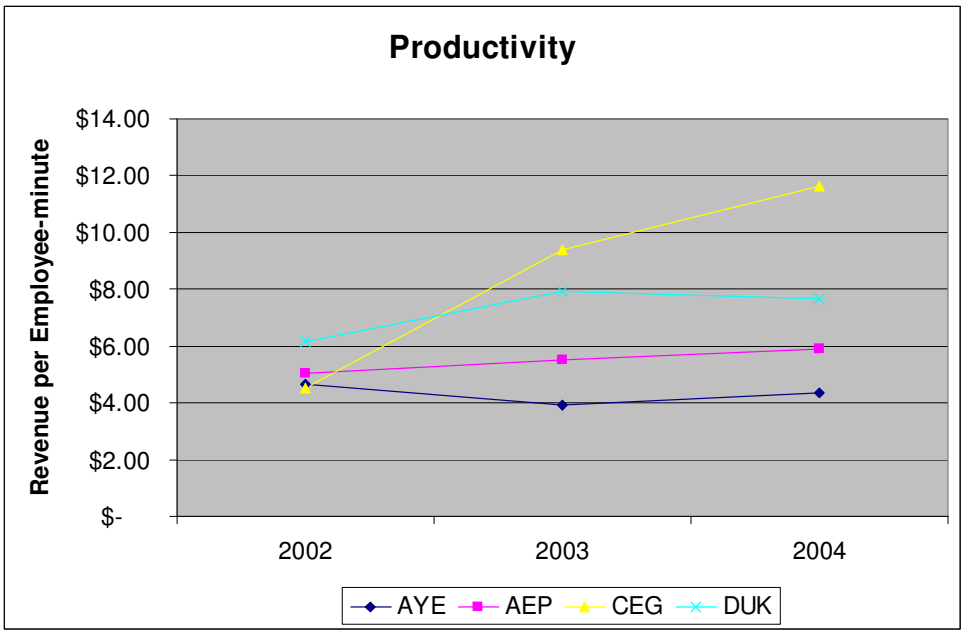

Figure 8: Productivity per Employee by Minute

This study is focused on an aggregate overview of these issues. It is obvious, hopefully, that some functional work categories within the enterprise experience more (or less) impact from outages. Actual functional economic impacts can be determined, but are beyond the scope of this analysis. The key, in this context, is to understand the relative impact when making enterprise infrastructure decisions.

Productivity Costs:

Clearly, any analysis of total cost of ownership needs to include an estimation of the expected productivity costs for each solution over time. From the earlier discussion of the Cisco Call Manager cluster, conservative expected cluster reliability is somewhere between 99.9% and 99.99%. Figure 9 depicts the annual cost of outages for various configurations, given CEG's productivity.

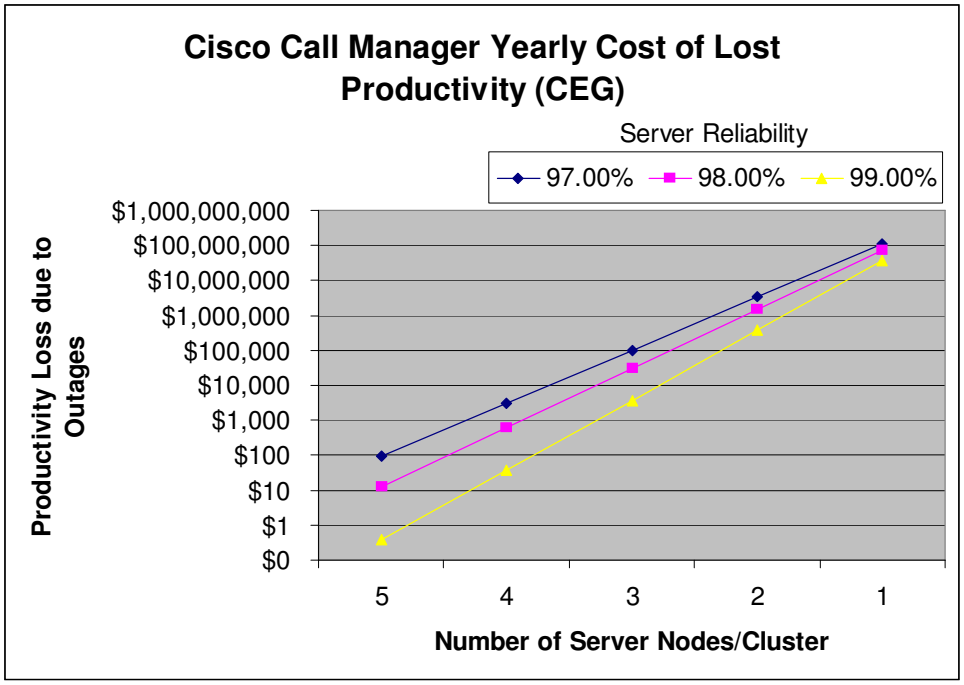

Figure 9: Cost of Lost Productivity by Cluster Design

Note that earlier, we determined that the Cisco server reliability was very likely to be less than 97%, meaning that the actual experienced cost will exceed the 97% trend line. Note that these are yearly totals, and over 5 years will continue to impact the enterprise operational costs. The actual calculations are also adjusted by the user efficiency coefficient to render productivity costs attributable to the outages.

Results:

The following model results are based upon the assumption set shown in the Appendix. Modification of inputs will yield different results, but the core effects will hold.

Labor and Maintenance Costs		Year 1	Year 2	Year 3	Year 4	Year 5
Installation of server utilities		7,200	-	-	-	-
Build/Test/Installl New Servers (labor)		17,280	-	-	-	-
Upgrade existing data network for TDM/PRI (labor)		920	-	-	-	-
Convert Digital to IP lines (labor)		283,500	-	-	-	-
Patching manpower costs		23,040	24,192	25,402	26,672	28,005
Yearly Maintenance Contract		50,000	50,000	50,000	50,000	50,000
	Total	381,940	74,192	75,402	76,672	78,005
	NPV	$ 597,415				

Figure 10: Cisco Call Manager Labor and Maintenance Costs

Productivity Losses Due to Outages		Year 1	Year 2	Year 3	Year 4	Year 5
Productivity Loss Attributable to Conversion Outage		1,291,322	-	-	-	-
System Outage Costs/Year		3,503,139	3,678,296	3,862,211	4,055,322	4,258,088
	Total	4,794,462	3,678,296	3,862,211	4,055,322	4,258,088
	NPV	$16,976,029				

Figure 11: Cisco Call Manager Productivity Costs Due to Outages

Labor and Maintenance Costs		Year 1	Year 2	Year 3	Year 4	Year 5
Installation of server utilities		-	-	-	-	-
Build/Test/Installl New Servers (labor)		-	-	-	-	-
Upgrade existing data network for TDM/PRI (labor)		-	-	-	-	-
Convert Digital to IP lines (labor)		7,050	-	-	-	-
Patching manpower costs		63	66	69	73	76
Yearly Maintenance Contract		-	-	-	-	-
	Total	7,113	66	69	73	76
	NPV	6,871				

Figure 12: Nortel Meridian VoIP Labor and Maintenance Costs

Productivity Losses Due to Outages		Year 1	Year 2	Year 3	Year 4	Year 5
Productivity Loss Attributable to Conversion Outage		-	-	-	-	-
System Outage Costs/Year		21,404	22,474	23,598	24,778	26,017
	Total	21,404	22,474	23,598	24,778	26,017
	NPV	96,349				

Figure 13: Nortel VoIP Productivity Costs Due to Outages

Conclusion:

The key differentiator, when considering this scenario, will be related to CEG's high productivity metrics. Normally, other considerations would come into play such as WAN connectivity and clients' normal reluctance to consider a non-integrated PBX-VoIP hybrid solution. It is, however, very common for firms to maintain integrated hybrids, due to interoperability and maintenance efficiencies.

This particular scenario doesn't require extensive analysis to determine the highest operational cost or which approach is the most reliable. Nortel PBX/VoiP solution offers the lowest overall operations cost. CEG will recognize higher operations costs if implementing the non-integrated hybrid solution, i.e. Nortel PBX/Cisco Call Manager.

Depending on how CEG is functionally organized, it may not be readily apparent that CEG will recognize higher costs at the IT department level. Therefore, we

recommend communication of this data to a functional audience which includes operations finance, so that CEG can make technology decisions which support their position as the industry productivity leader.

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*Dan Kalin is Principal Consultant, for **Arbitor, Inc.** He brings over 25 years of operations management, technology consulting and engineering experience in the telecommunications, IT, aerospace and energy industries from organizations such as Dresser Industries, Lockheed Martin, WorldSpace, XO Communications, and Intersections, Inc. Dan can be contacted at dkalin@arbitor.com*

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APPENDIX:

Assumption Baseline	
Full Time Employees	9,000
Part Time Employees	-
Contractors	-
Yearly Revenue	$ 12,500,000,000
Estimated annual enterprise growth %	5%
Enterprise Productivity/min	$ 23,782.34
Productivity (Rev/employee/year)	$ 1,388,889
Productivity/hour	$ 717.40
Employee Hours per year	1,936
Productivity % without phone	70%
Corporate Cost of Funds (%)	7%
IT-Head fully loaded labor cost/hour	$ 45.00
Telephony Head fully loaded labor cost/hour	$ 47.00
Yearly Headcost increase estimate %	5%
Number of employees to be migrated	9,000
CISCO Server Reboots Required per year	12
CISCO Time Required per Reboot, minutes	10
IT Hours to prepare facilities for new Cisco Servers	160
IT Hours to build/test/install new Cisco servers	384
Overnight shift premium %	25.00%
Upgrade existing data network for TDM/PRI (labor hours)	16
CISCO Outage minutes per year	491
NT Outage minutes per year	3
CISCO Digital-to-IP conversion minutes/seat	42
NT Digital-to-IP conversion minutes/seat	1
CISCO Digital-to-IP conversion outage minutes/seat	40
NT Digital-to-IP conversion Outage minutes/seat	-
Cisco (Windows OS patches per year)	25
Cisco Average patch time per server (MS-Win patches)	10.0
NT yearly patch updates (zero downtime)	8
NT patch installation/test time per patch (zero downtime)	10.0
Cisco CallManager Patches per year	32
Cisco CallManager patch installation/test time per patch	480.0
Cisco Number of Server nodes in Call Manager Cluster	2

Note: Model inputs are indicated by shaded fields