White Paper

Cost Benefits of
High Density Dial Access Products

Economic advantages of high density reliable solutions in comparison to lower density dial access products.

by Andrea Benoit and Bruce Ford

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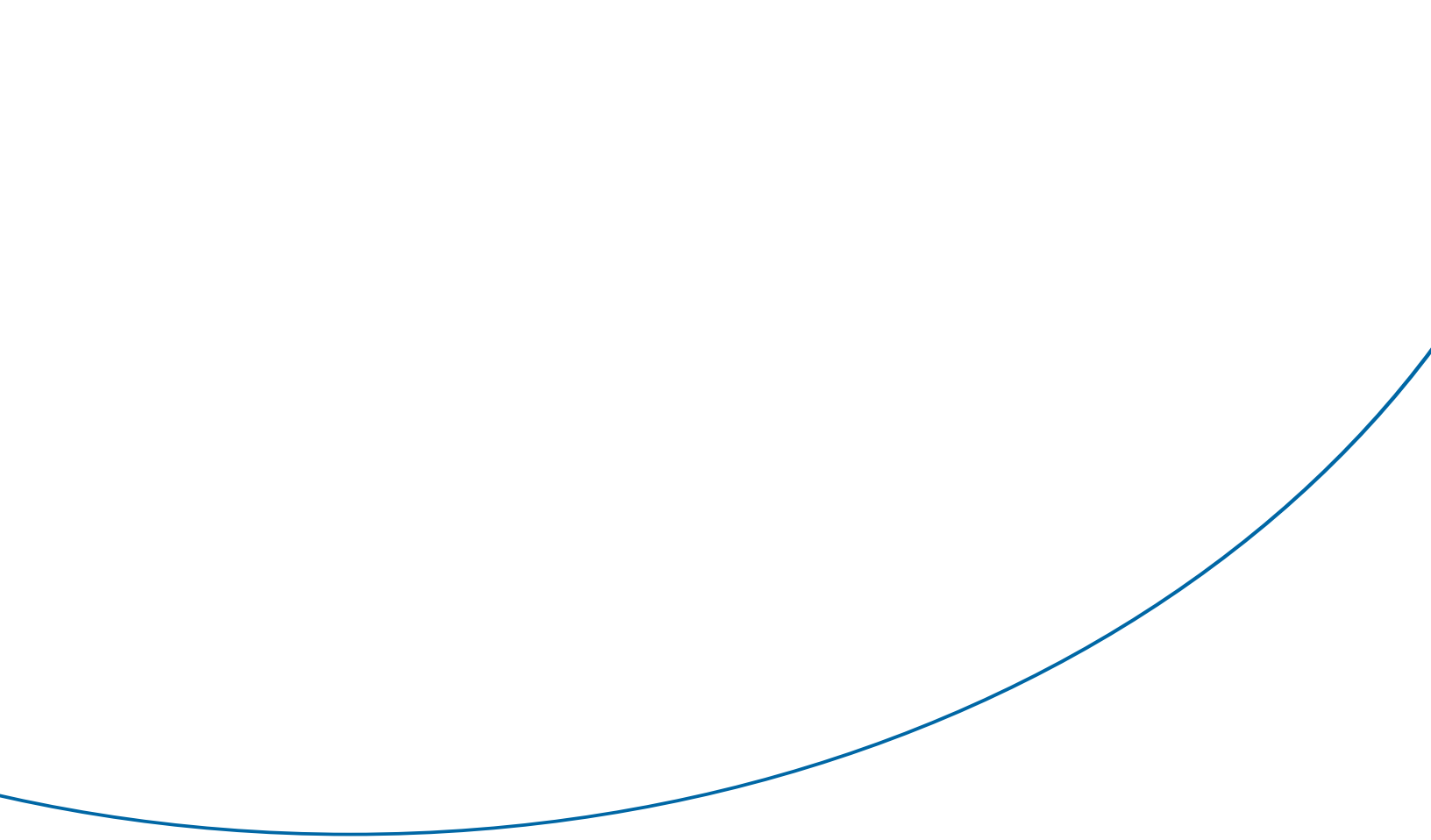


Introduction

The rapid growth of the Internet has created many opportunities for ISPs, CLECs, and ILECs alike. The Internet market is developing at an unprecedented rate in comparison to any other telecommunications market ever [1], resulting in a demand and market share that are being aggressively sought after by a growing number of competitors in this segment. As the competition increases, so does the need for service providers to offer competitive pricing. To survive, service providers must become increasingly cost conscious in selecting dial access solutions, taking into consideration not only the product purchase cost but also ongoing maintenance and operations costs. One such way for service providers to reduce costs is to purchase next generation high density dial access products. These products offer many cost savings over their lower density alternatives, including initial installation, ongoing monthly operations, software upgrades, and network extensions.

While high density dial access products can provide cost savings, these savings can be quickly eroded if the dial access platform is unstable, resulting in high impact service outages that affect many end users. Such service outages can be costly not only from a maintenance and repair aspect, but also for the potential loss of clients to competitors. Quality of Service (QoS) is becoming increasingly important to end users as market sophistication grows and as competitors offer quality of service as a differentiator. Carrier class, NEBS certified, dial access products can minimize such service outages by offering high reliability (e.g. redundant hardware) for components such as CPUs, trunk interfaces, modem pools, and, finally, power supplies. Additional information regarding NEBS electromagnetic and physical compatibility as well as criteria levels can be found in Telcordia Technologies (formerly Bellcore) documents [5].

There are dial access products available on the market today which offer the best of both worlds: carrier class reliability and the benefits of high density. Service providers in the market for dial access products should seek out products that offer high reliability, density, and performance. High performance implies that an end user dialing into the shelf will receive the same throughput whether they are allocated the first or last port available on the box. The benefits of high performance are not analyzed in detail in this white paper; however, an example of throughput performance for a 1,514 byte packet size is shown in Figure 1, where the maximum bi-directional throughput is around 12Kbytes/sec or 96Kbits/sec. LANQuest Labs, an independent third party, conducted this testing. For more information, please refer to the Competitive RAS Benchmark Comparison of Nortel's High Capacity Remote Access Switch [2].

The benefits of high density and high reliability are described in greater detail in the following sections of this white paper. In particular, a cost savings analysis is conducted for a two-year period, which clearly demonstrates the economic advantage of high density, reliable solutions, in comparison to lower density dial access products. Please see Table 1 on the next page for a savings summary. The analysis does not represent all costs that are incurred for the installation and operation of the dial access network, but only those costs that are expected to vary depending on the port density.

This white paper describes in detail how these cost savings are achieved.

Figure 1: Throughput for 1,514 Byte Packets

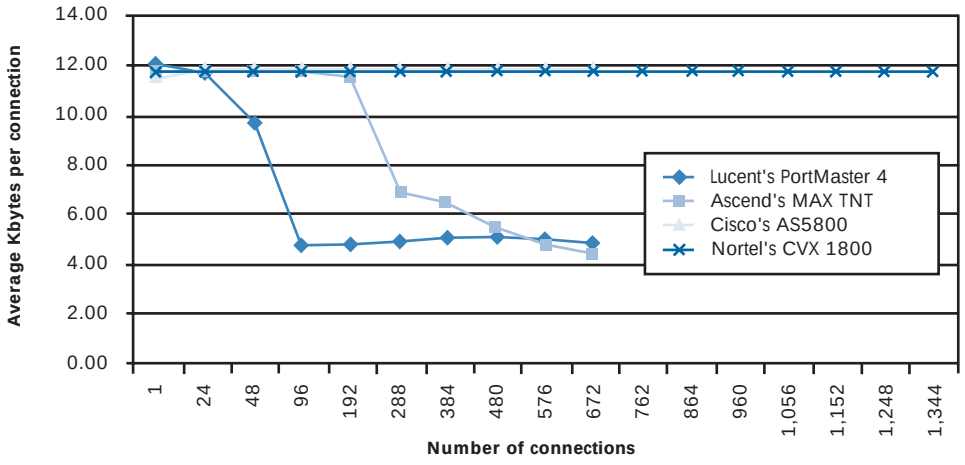


Table 1: Two-Year Aggregate Savings Summary (US$)

	Year 1: 50,000 ports				Year 2: 60,000 ports			
	96 Port	**672 Port**	**1,344 Port**	**2,688 Port**	**96 Port**	**672 Port**	**1,344 Port**	**2,688 Port**
Cost Summary	1,736,289	621,743	459,913	248,546	524,670	207,280	154,737	77,486
Savings over 96 Port		64% 1,114,545	71% 1,240,375	86% 1,487,742		60% 317,390	71% 369,933	85% 447,184

Benefits of High Density and High Reliability

To enable a more specific analysis of the benefits of high density and high reliability dial access products, a detailed cost comparison is made between a 96 port, a 672 port, a 1,344 port, and a 2,688 port solution, with multiple DS1 and/or multiple DS3 access interfaces. The analysis will cover various aspects of dial access service startup and ongoing network management, including initial installation, ongoing monthly expenses, software upgrades, network growth, and product reliability. For the purpose of this analysis, only costs that are expected to vary depending on the density of the dial access platform have been selected. As a result, costs not evaluated include service provisioning, ongoing network performance, accounting and security management, customer service, and SG&A. Calculations herein are based upon a network deployment of 50,000 ports; please see Table 2 for details.

Initial Installation

The initial installation of a dial access product consists of one time costs that are required for the initial setup and ongoing operation of the product. The following costs are expected to vary depending on the density of the platform and have therefore been included for analysis: physical installation, power and cabling, configuration of the platform's software, multiplexers, and battery/generator back-up. A summary of these costs is available in Table 3. As shown, dramatic cost advantages can be achieved with the higher density dial access platforms, in the order of 65%, 72% and 86% for the 672, 1,344 and 2,688 port solutions respectively, in comparison to the 96 port dial access platform. This translates to initial installation savings in the range of US$1.0 to US$1.3 million.

Table 2: Number of Ports Used for Analysis

	96 Port	**672 Port**	**1,344 Port**	**2,688 Port**
Number of DSIs	4	28	48-56	96-112
Equivalent number of DS3s	0	1	2	4
Maximum Ports/Shelf	96	672	1,344	2,688
Shelves/7' Rack (Telco Standard *)	10	5	4	4
Maximum Ports/Rack	960	3,360	5,376	10,752
Shelves Req'd for 50,000 Ports	521	75	38	19
Telco Racks Req'd for 50,000 Ports	52	15	10	5

**Seven feet is the Telco standard for an equipment rack, any other rack size is non-standard.*

Table 3: Summary of Initial Installation Costs for 50,000 Ports (US$)

	96 Port	**672 Port**	**1,344 Port**	**2,688 Port**
Physical Installation	105,239	20,632	11,421	6,300
Base Software Configuration	85,740	18,373	12,249	6,124
DS3 to DS1 Multiplexer	595,238	-	-	-
Battery and Generator Backup	781,250	502,232	418,527	209,263
Total Cost	1,567,467	541,237	442,197	221,687
Savings over 96 Port		65% 1,026,230	72% 1,125,270	86% 1,345,780

Assumptions:

- Loaded Labor Rate (LLR) for installation technician is US$125,000, for network engineer is US$160,000 [3].
- Time required to install a telco rack is 2 hours, time to install the 3 highest density dial access shelves in the rack is 45 minutes, and time for the 96 port shelf is 30 minutes [3, 4].
- Setup of power is 1.5 hours per shelf, for cabling runs of 50 feet or less [3, 4].
- Time for the rest of the Ethernet/FR and DS1/DS3 cabling is 45 minutes for the 96 port, 1.25 hours for the 672 port, 1.5 hours for the 1,344 port and 2 hours for the 2,688 port solutions. It is assumed that the 672, 1,344 and 2,688 port solutions are using DS3s. Cabling runs are 50 feet or less and have standard RJ45 type connectors [3, 4].
- Time required to perform software configuration on the 96 port shelf is 2 hours, on the 672 port is 3 hours, and on the 1,344 or 2,688 port shelf is 4 hours. This includes sanity testing after the software is configured [3, 4].
- An M13 DS3-DS1 multiplexer is costed at US$8,000 per single DS3 unit [4]. These multiplexers are only needed when leasing DS3 transport facilities for equipment with only DS1 interfaces.
- Battery and Generator backup is costed at US$7.5 per Watt [4, 6]. The 96 port solution requires 200W per shelf, the 672 port requires 900W per shelf, and the 1,344 and 2,688 port solutions

require 1500W per shelf. On a per rack basis, this translates to 2000W per rack for the 96 port, 4500W per rack for the 672 port, and 6000W per rack for the 1,344 and 2,688 port solutions.

Physical Installation

The cost of the physical installation of the dial access platform is based primarily on the cost of labour for the technician to install both the standard telco racks and the dial access shelves. There is also a capital cost associated with each rack, which can vary from US$150 for a basic rack to US$1,500 for a NEBs compliant version. The figures shown in Table 3 are based on the US$150 rack. Note that wire wrapping cables to cross connect panels and any equipment moves/setup are not included. As the density per rack increases, resulting in less time to physically install the same number of ports, the cost savings increase substantially.

Base Software Configuration

The cost of the base software configuration is comprised of the cost of labour for the network engineer to install the software, configure the network and the dial access product for a single Point of Presence (POP) with basic management/data routing and services, and finally to perform a sanity test to ensure proper operation. Since these activities are performed on a per shelf basis, the fewer number of shelves required to meet 50,000 ports, the less costly the activities, as clearly demonstrated in Table 3. The 1,344 and 2,688 port solutions offer the greatest savings, in the order of 86% and 92% respectively over the 96 port solution.

Multiplexer

For Service Providers that lease DS3 transport facilities from their network provider, M13 DS3 to DS1 multiplexer equipment is required to convert the DS3 leased line to a DS1 if their dial access product only supports DS1 interface cards. This adds a substantial cost to the dial access solution, namely US$595,238 to the overall installation. This cost can be completely eliminated through the use of a dial access platform that supports DS3 interfaces, as is typical with the high density products.

Battery and Generator Backup

Battery and generator backup is a typical requirement for large telco environments, but may also be a desirable configuration for smaller ISPs/CLECs seeking to offer a differentiated, more reliable service than their competitors. The higher density products studied have a lower power rating per modem and are thus more efficient in their power consumption in comparison to the lower density 96 port solution. At a cost of US$7.5/Watt for the purchase of battery and generator backup, great savings can be achieved with the higher density products, as the power per port required to operate the server decreases as density increases. This results in savings around US$570,000 for the 2,688 port dial access product, as shown in Table 3.

It should also be noted that depending on the real estate arrangements for the dial access equipment, there might be additional costs associated with the footprint space usage of the battery and generator equipment. These costs have not been included in this analysis; however, they would decrease as the power requirement per modem decreases and would thus be less for higher density products.

Ongoing Monthly Operations Expenses

Some of the ongoing monthly expenses included for this analysis are the real estate lease associated with the dial access equipment's footprint, the electrical power consumption of the equipment, and finally the air conditioning cost for cooling the room in which the equipment is located. A summary of these costs is shown in Table 4. Total monthly expense savings add up to 67% and 83% for the 1,344 and 2,688 port solutions respectively, in comparison to the 96 port product. Labour costs associated with service provisioning, billing, and customer service are not included as it is assumed these costs will be dependent on the total number of ports and/or subscribers rather than the 'ports per shelf' of the dial access equipment. Product reliability and maintenance will be discussed in the Product Reliability section on page 5.

Assumptions:

- Real Estate costs are based on a typical co-location lease of US$7.88/square foot/month [7].
- A standard 7 foot telco rack requires a footprint of 10 square feet.
- Power rate is 6.5 cents per kWh [8, 9].
- Air conditioning equipment is already on premise and has free capacity to be used up for the new dial access equipment, using a 'rule of thumb' of 10,000 BTUs per ton at a cost of US$3 per ton per day [9].
- The heat dissipation of the 96 port solution is 680 BTU/Hr, for the 672 port is 2,730 BTU/Hr, and for the 1,344 and 2,688 port solutions is 2,100 BTU/Hr.

Real Estate

Real estate costs can vary widely depending on the region, location within a region (city core versus suburb), and even the nature of the leased space, such as ILEC co-location, carrier hotel, or simple office/warehouse space lease. Finding a space adequate for dial access equipment

Table 4: Summary of Ongoing Monthly Operations for 50,000 ports (US$/Mth)

	96 Port	672 Port	1,344 Port	2,688 Port
Real Estate Cost	4,104	1,173	733	366
Power Consumption Cost	4,943	3,177	2,648	1,324
Air Conditioning Cost	3,232	1,854	713	356
Total Cost	12,279	6,204	4,094	2,046
Savings over 96 Port		49% 6,075	67% 8,185	83% 10,233

(structure, ventilation, cooling, power feeds, cabling, etc.) can be a challenging and frustrating task, especially when future growth considerations must be factored into the size of the required space. These circumstances contribute to the growing importance of the footprint size of dial access equipment, which is based on the square footage required by a telco rack. As a result, not only is the port density per dial access shelf important, but more so the port density per rack. As shown in Table 2, the 2,688 port solution has the greatest port density per rack, followed by the 1,344 port, 672 port, and 96 port solutions respectively. This translates into monthly real estate savings as illustrated in Table 4.

Power Consumption

The higher density dial access products require about 50% less Watts per modem in comparison to the 96 port product and therefore consume less electric power. Not only does this result in monthly cost savings as shown in Table 4, but it also reduces the total amount of power required to operate the equipment. Some service providers may have limitations on their power plant, or restrictions on the amount of power they can obtain from an incumbent, which should be taken into consideration when selecting dial access equipment.

Air Conditioning

The two lower density dial access products studied have more than double the heat dissipation per modem than do the 1,344 and 2,688 port solutions, which translates into increased monthly costs for the 96 and 672 port dial access products. It should also be noted that this analysis assumes the air conditioning equipment is already purchased and can support the new dial access equipment. Should a capital purchase be required for air conditioning, the reduced heat dissipation of the higher density dial access platforms will result in a lower capital purchase cost.

Software Upgrades

Software upgrades may be required when configuration changes are made or when new/maintenance software releases are available for the dial access equipment. The software upgrade cost is based on the time required for the network engineer to perform the upgrade, which is largely dependent on the time the platform takes to reboot or re-initialize itself.

Assumptions:

- The 2,688 and 1,344 port dial access platforms require 30 minutes for complete software upgrade, including pre checks and post testing [4]. The 672 port product is allocated 20 minutes for the same activities. The 96 port solution requires 20 minutes for the same activities; however, simultaneous upgrades may be done due to the smaller size of the server. As a result, 10 minutes was allocated for this activity.
- LLR for network engineer is US$160,000 [3].

Since the software upgrades are performed on a per shelf basis, a network wide configuration change or software upgrade could take a substantial amount of time, resulting in a costly activity. As illustrated in Table 5, the lower the port density, the higher the cost to upgrade or change the dial access software. With new software versions appearing at least quarterly and network configuration changes that could arise due to growth, it's anticipated that software upgrades will be required at least once per quarter. The higher density platforms offer savings in the order of 72% to 89% over the 96 port dial access platform. For the 2,688 port solution, this represents savings as high as US$6,400 per software upgrade of the 50,000 port dial access network.

Network Growth

With the explosive growth of the Internet, it is foreseeable that a service provider will need to expand their network to accommodate a growing number of subscribers. In fact, an IDC report indicates that dial access port shipments is expected to grow by 33.9% in year 2000 and 26% in 2001 [10]. In this white paper, a 20% port extension was assumed, thus resulting in 10,000 additional ports in the network. The costs analyzed for the port extension include the physical installation and the base software configuration of the new dial access switches, as described previously in the Initial Installation section. In addition, battery and generator backup as well as multiplexers may be required for the new servers. The same assumptions apply as in the previous sections.

As shown in Table 6, in comparison to the 96 port product, a savings of around US$205,000 to US$267,000 can be achieved for the higher density solutions. Assuming a port extension will occur

Table 5: Cost of a Single Software Upgrade for 50,000 ports (US$)

	96 Port	672 Port	1,344 Port	2,688 Port
Cost of a Software Upgrade	7,159	2,021	1,531	766
Savings over 96 Port		72% 5,138	78% 5,628	89% 6,393

Table 6: Summary of Initial Installation Costs for 10,000 Port Extension (US$)

	96 Port	672 Port	1,344 Port	2,688 Port
Physical Installation	21,048	4,126	2,284	1,260
Base Software Configuration	17,148	3,675	2,449	1,225
DS3 to DS1 Multiplexer	119,048	-	-	-
Battery and Generator Backup	156,250	100,446	83,705	41,853
Total Cost	313,494	108,247	88,438	44,338
Savings over 96 Port		65% 205,247	72% 225,056	86% 267,504

every year, these installation costs will quickly add up. In addition, time to market will be a very important factor in capturing new subscribers or new ISPs (if wholesaling is applicable), and the added delay in getting the port extension into service for the 96 port solution (515 person hours) may be costly in terms of lost business opportunity. For the 96 port product, it would take two installation technicians over 6 weeks (assuming 8-hour days, 5-day weeks) to complete the port extension installation and configuration activities. These same activities would be complete in 4 days or 2 days for the 1,344 and 2,688 port solutions respectively, under the same assumptions.

Product Reliability

Product reliability is a critical factor in a dial access network, both for controlling maintenance and operations costs and for ensuring quality of service. With today's competitive ISP market, controlling costs is necessary to enable aggressive pricing. A high availability, carrier class product will reduce the Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR), resulting in lower costs. 'NEBS certification' is the standard used by telcos to ensure the quality and reliability of carrier grade equipment. While many products claim to be NEBS compliant, very few have undergone the rigorous testing conducted by credited NEBS labs, such as Telcordia Technologies (formerly Bellcore), to prove certification. Nortel's CVX™ 1800 is an example of a product that has achieved 'NEBS certification' [12].

Reliability becomes an even more important issue with high density dial access products as a single failure can impact many more end users than the 96 port solution. Quality of Service is a key differentiator in today's cutthroat market and reducing end user service outages is an important component. The 1,344 and 2,688 port solutions studied offer the best of both worlds, with high density as well as carrier class availability in all of their system components.

CPU

The higher density 1,344 and 2,688 port dial access platforms analyzed have a primary and redundant CPU card. This redundancy is estimated to offer a 70% reduction in downtime [11], for in the case of failure on the primary card, the redundant CPU takes control for reduced outage time. Not only does this improve quality of service, but it also reduces maintenance and operations costs. Although the failed CPU card will eventually need to be serviced, there is no requirement for immediate repair at the POP location. This can save on labour costs as repairs can be grouped and performed with less frequent site visits and during regular business hours, rather than random times throughout the day and night, which will add additional overtime charges. Assuming a 3-hour travel and repair time for a CPU failure, the cost for a technician to make the repairs is up to US$300 if overtime is applicable. If a redundant CPU is available as with the 1,344 and 2,688 port solutions, the system downtime is only around 2 minutes while the system fails over to the backup card, and the repairs can be performed at a convenient time for the service provider.

Trunk Interface

Redundant interface cards are another feature of carrier class dial access products. While not typically available for DS1 interfaces, the 1,344 and 2,688 port solutions both offer redundant DS3 interface card configurations. Given the high density of the shelf, this ensures that a large number of end users will not be out-of-service should a DS3 card failure occur. In addition, the 1,344 and 2,688 port high density products utilize a mid-plane design that allows hot swap of cards. Hot swappable cards allow continuity of service, even during card replacement, and also provide the ability to change a card without impacting the associated cabling, which is time consuming and can reduce the reliability of the cables. The hot swappable feature also applies to the CPU and modem cards.

Modem Pool

Effective modem pool architecture is one that allows any DS0 time slot to be associated with any modem on any card. This type of modem pool sharing offers the greatest flexibility and highest availability in case of an individual modem or a card failure. The two higher density port solutions studied offer this availability in addition to the hot swap feature mentioned above. In contrast, if a DS1 interface is mapped directly to a specific set of modems, failure of those modems will leave the end users out-of-service until a technician can arrive on site to perform the repairs.

Power Supply

Traditional power architecture is to provide redundant power supplies that are shared by the entire dial access shelf (if this is the case, ensure that these power supplies are easily field replaceable). However, a more reliable power architecture is Point of Use Power (PUP), which offers a MTBF of 8 million hours in comparison to traditional power supplies, which offer an MTBF of only 20,000 hours. The reason for the higher reliability is that each card within the shelf has a PUP; therefore, if a PUP fails, it only impacts the card that it's on, not the rest of the shelf. The 1,344 and 2,688 port dial access platforms studied utilize PUP architecture.

Two-Year Aggregate Cost Summary

Many different costs have been examined thus far and the intent of this section is to bring them all together over a two year period and assess the overall impact of a low density versus a high density dial access solution. A summary is shown in Table 7.

Assumptions:

- Software upgrades occur once per quarter; therefore 3 times in the first year and 4 times in the second year.
- A 20% port extension (10,000 ports) is required at the beginning of Year 2 for network growth.

Table 7: Two-Year Aggregate Cost Summary (US$)

	Year 1: 50,000 ports				Year 2: 60,000 ports			
	96 Port	**672 Port**	**1,344 Port**	**2,688 Port**	**96 Port**	**672 Port**	**1,344 Port**	**2,688 Port**
Physical Installation	105,239	20,632	11,421	6,300	21,048	4,126	2,284	1,260
Base SW Configuration	85,740	18,373	12,249	6,124	17,148	3,675	2,449	1,225
Battery / Generator	781,250	502,232	418,527	209,263	156,250	100,446	83,705	41,853
Multiplexers	595,238	-	-	-	119,048	-	-	-
Software Upgrade	21,478	6,063	4,593	2,297	34,364	9,701	7,349	3,675
Power Consumption	59,313	38,129	31,775	15,887	71,175	45,755	38,129	19,065
Air Cooling	38,781	22,242	8,555	4,277	46,538	26,691	10,266	5,133
Real Estate Lease	49,250	14,071	8,795	4,397	59,100	16,886	10,554	5,277
Total Cost	1,736,289	621,743	495,913	248,546	524,670	207,280	154,737	77,486
Savings over 96 Port		64% 1,114,545	71% 1,240,375	86% 1,487,742		60% 317,390	71% 369,993	85% 447,184

- This table does not represent all costs that are incurred for the installation and operation of the dial access network, but only those costs that are expected to vary depending on the density of the dial access solution.

As seen in Table 7, huge savings can be achieved using the higher density dial access solutions. Savings for Year 1 in comparison to the 96 port shelf are 64% (US$1.1 million) for the 672 port, 71% (US$1.2 million) for the 1,344 port, and jump as high as 86% (US$1.5 million) for the 2,688 port solution. While a large amount of these dollar savings are from the backup battery/generator and the DS3 to DS1 multiplexers, a service provider not utilizing these items will still save 78% and 89% with the 1,344 and 2,688 port solutions respectively.

In year 2, a 20% port extension has been included to meet growth demands. To support this extension, additional backup power and multiplexers are required, as well as incremental monthly expenses for power consumption, air conditioning, and real estate. The savings achieved with the 2,688 port high density dial access switch are in the order of US$450,000 dollars in comparison to the 96 port product. A summary of the cost savings is illustrated in Figures 2 and 3.

Figure 2: High Density Cost Savings for 50,000 Ports

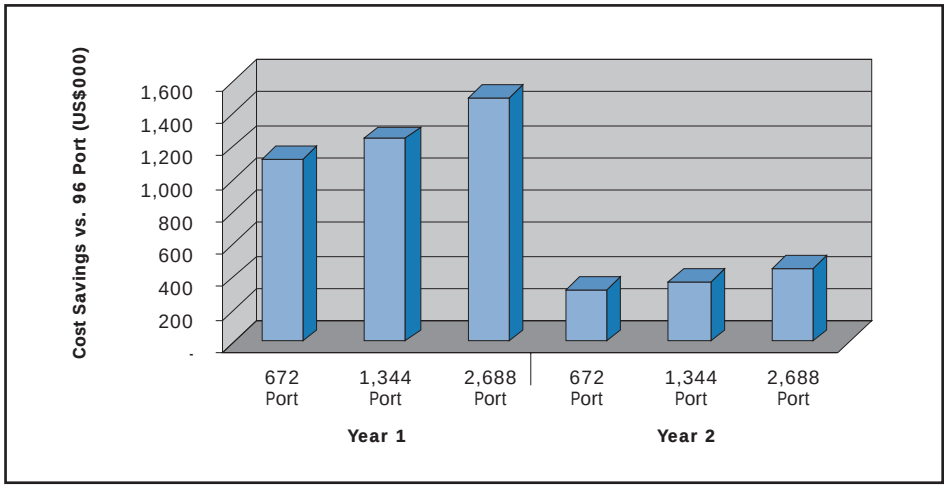
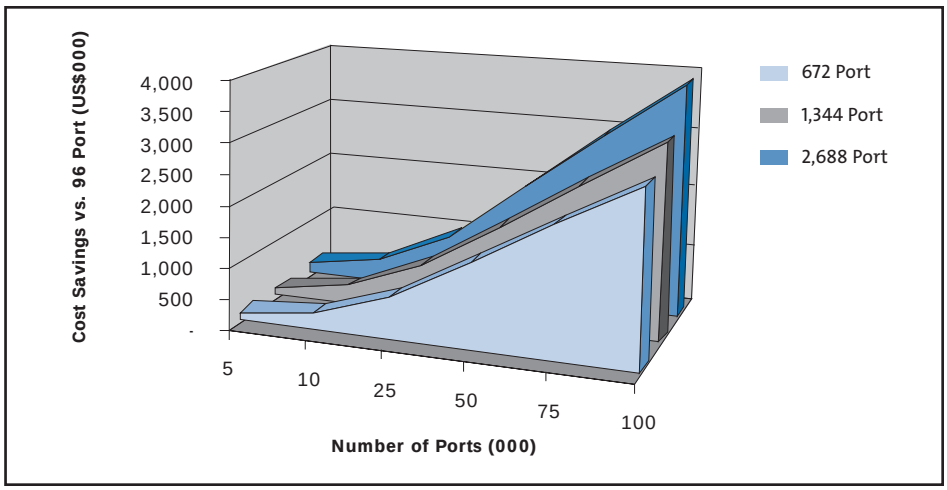


Figure 3: Two Year Cost Savings vs. Network Size



Conclusions

To be successful in today's Internet market, ISPs, CLECs, and ILECs must compete on the price and quality of their service. Deployment of a high density, NEBS certified dial access solution can facilitate the achievement of these goals, as was demonstrated in this white paper. The 1,344 and 2,688 port dial access technologies analyzed herein are examples of high density and high reliability products available to service providers.

This white paper shows that the higher the port density of the dial access switch, the lower the overall costs for initial installation and for ongoing monthly expenses. Over a two year period, the 1,344 and 2,688 port dial access solutions offer overall cost savings of 70% up to 85% in comparison to the lower density 96 port product; while the 672 port switch offers lesser savings of 60% in comparison to the 96 port product. These savings can be passed on to end users through lower pricing, thus making the service offering more attractive and competitive.

With regards to QoS and NEBS certification, the carrier class 1,344 and 2,688 port solutions achieve better MTBF and MTTR times than the 96 port density product. This is achieved through the use of highly reliable and available components, such as redundant CPU and trunk interface cards, modem pool sharing, hot swappable cards, and PUP power architecture. Not only does this reduce maintenance and operation costs, but it also ensures less frequent and less lengthy outages for end users, increasing the overall quality of service.

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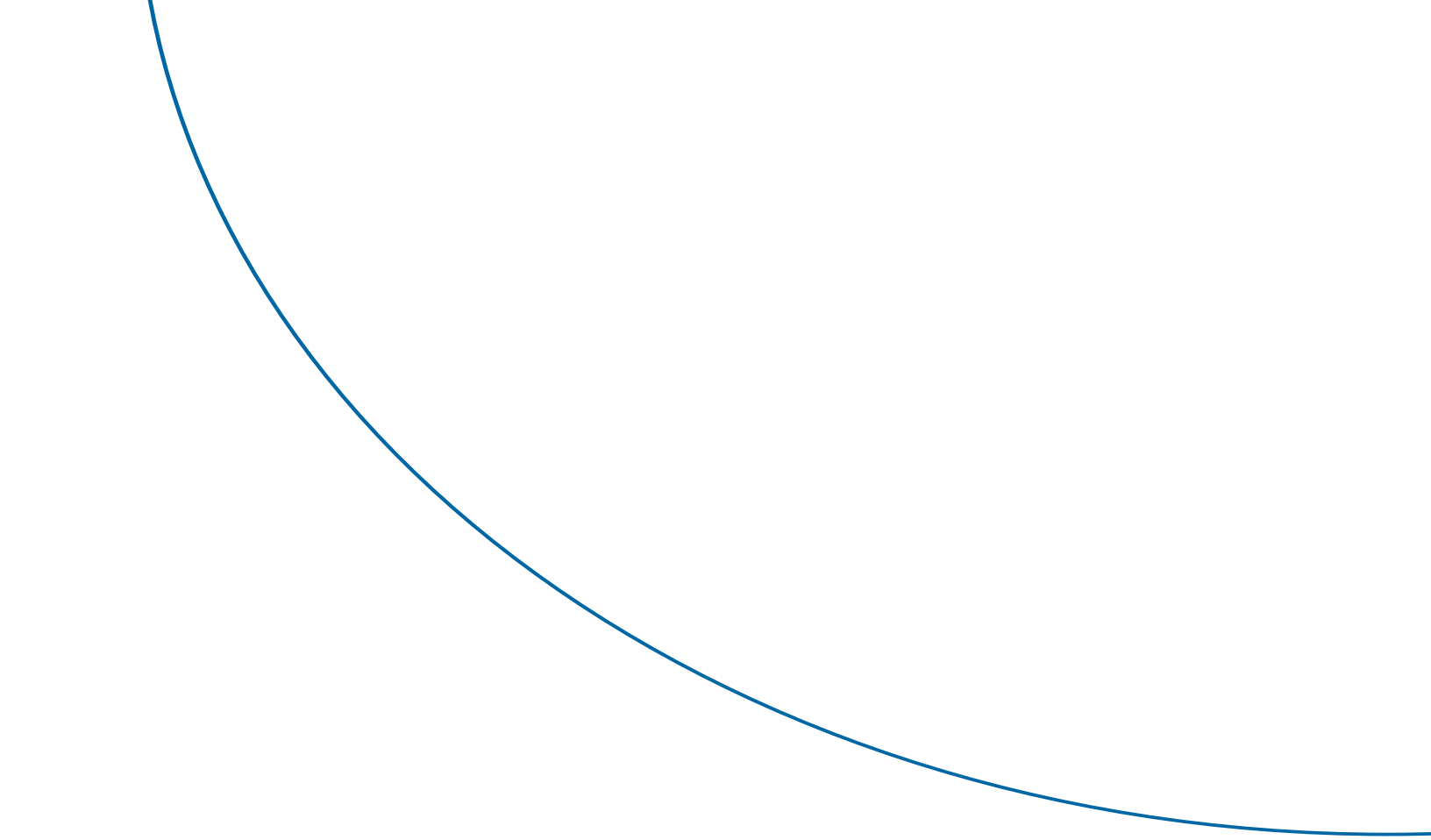
Notes



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80006.25/06-99 Printed in USA — July 1999