Sample Company

Business Technology Assessment

May 15, 2004

Prepared by:

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Project Background

Scope & Purpose

The *Sample* 2004 business plan lays out a comprehensive five year plan, addressing the competitive and operational issues facing the company. *Sample* management is comfortable addressing the business issues; however, they are less comfortable addressing those issues related to the technological infrastructure and technology applications.

BEST was engaged to review and evaluate the current technological infrastructure, projects, plans, and effectiveness. Several critical questions were posed to the BEST team, defining the scope of the project:

- ✓ Is the overall effort in regard to strategies, business functions, and technologies heading in the right direction?
- ✓ Is *Sample* Industries spending too much or too little? How, where, and why are the funds being expended?
- ✓ How long can *Sample* prosper given the current information base infrastructure?
- ✓ How can *Sample* identify what new technologies make sense for the business?
- ✓ Is *Sample* staffed and trained properly to manage tomorrow's technology?
- ✓ Is *Sample* adequately controlling and securing the information systems function?
- ✓ Are the current applications right for the company over the next five years?

Work Performed

The project was initiated with a full day data collection activity at the *Location* office. *Assigned Consultants* of BEST visited the headquarters to discuss the project and to conduct interviews. Representatives from the various functional areas in Operations, Finance, and Information Systems were interviewed to gain an understanding of the current operations and systems and to identify any potential opportunities. Follow-up visits were made over the next few days to collect additional data and conduct additional interviews. These follow up visits also included meetings and plant tours at the company's other facilities.

During these on-site visits, the following individuals were interviewed:

Location Interviewee	Functions Discussed
John Doe	Overall project Background information Finance/Payroll issues
Jane Doe	Accounting
Fred Mertz	Finance
Bob Johnson, Joe Smith	Computer Systems & Applications Network Infrastructure
Tom Wright	ERP System
Bob Mann	Quality Assurance Routing Instructions
Barry Shoppe	Production Scheduling
Janice Operman	Customer Service/Order Entry
Sarah Smith, Vinnie Boombah	Procurement Materials Planning
Larry Johnson	Tool Room Operations
Paul Jones, Jim Knight	Shop Management Requirements
Dick Jefferson	Sales and Marketing
Patricia Bennett	Shipping & Traffic Management
Brendan Fraser	Purchasing

Site 1 Interviewee	Functions Discussed
Brian Thompson, John Wilson	Purchasing Maintenance
Mary Wagner, Marvin Hagler	Scheduling
Lance Corporal	Routings Quality Assurance
Steve Preston	Tooling & Engineering
Susan Smith	Materials Management

Site 2 Interviewee	Functions Discussed
Jeff Bridges	Computer Systems Operations Overview
Robin Williams	Purchasing
Jack Daniels, Ernest Gallo	Quality Assurance
Jerry Jones, Art Model	Customer Service Order Entry Production Scheduling

These interviews provided the detailed data necessary to prepare the recommendations presented in this report.

Technological Infrastructure

Current Situation

LAN Topology

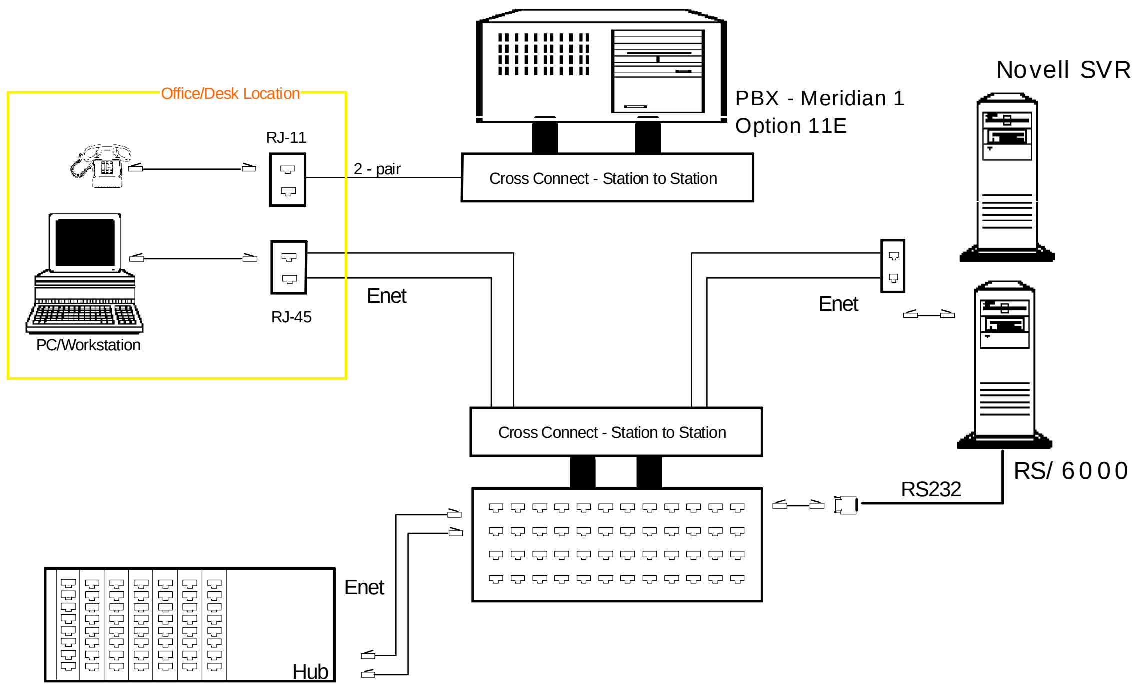
Sample Complex

The Local Area Network (LAN) topology of the network at the *Sample* facility is a centralized hub complex design for data connectivity using RJ45 patching and terminations with Category-5 certified cable. This cabling is used to support 10baseT ethernet standards used to support the workstations access to the Novell File Servers and the RS/6000 systems. The office data jack is connected to a central patch panel and then connected to the Ethernet hubs using Cat-5 patch cables. Asynchronous cabling used to support plant floor access to the RS/6000 system is provided with Cat-5 cabling using the same interconnection patch panel with patch cabling to an RS232 termination. Different patch cable colors are used to differentiate the type of interconnection patch cabling to ease support. This cabling infrastructure design should be considered very appropriate for today's needs as well as future needs for data.

Voice connections are provided via RJ-11 jacks at the workstation/office location with telephone cabling to an interconnection point in the PBX room. The office termination panel is cross connected to Telco 66 blocks of the Nortel Meridian 1 Option. This is a normal manner to provide voice connectivity between the office location and the PBX.

Figure 1 provides a diagram of the cabling used within the *Sample* complex or both voice and data cabling.

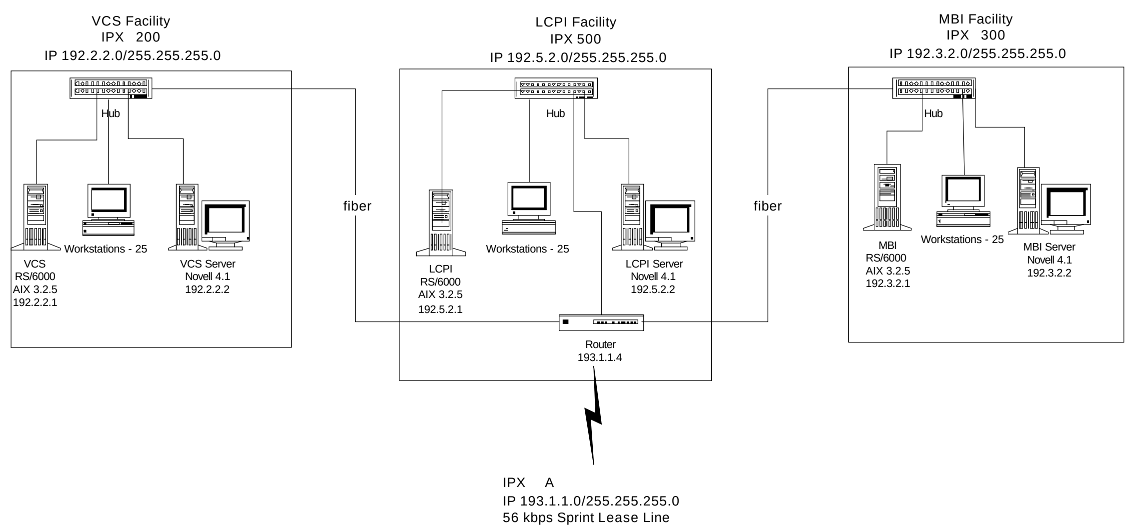
Figure 1: Wiring Diagram - Voice & Data



Site 1 Complex

The cabling and connections for the three locations in the *Site 1* complex are based upon the same wiring design as provided in the diagram above. The linkage between the locations within the complex is provided by fiber interconnection from the main facility to the other two plants. Figure 2 provides the details associated with the WAN/LAN interconnection at *Site 1*.

Figure 2: Site 1 Plant Inter-Wiring Diagram



Site 2

Cabling and wiring infrastructure at the Site 2 location is similar to that detailed in the Figure 1 diagram.

Philadelphia (Proposed)

The Philadelphia plant is designed to be 100baseT wire plant compliant. The design will implement 100 Mb ethernet instead of the normal 10 Mb ethernet using 100baseT hub equipment coupled with the same Cat-5 wiring infrastructure as used within the other plants. This design and infrastructure investment will provide a solid foundation for both today and future network implementation and plans. The implementation details follow the same basic design as presented in Figure 1, except that the hub and other equipment with be certified for 100 baseT ethernet. The reasoning for the 100 Mb network bandwidth is to take advantage of the similar price point associated with 10baseT designs. This allows for an improved bandwidth for the new facility for a similar cost.

The PBX system will be provided by the Nortel Meridian 1 Option 11E with similar voice wiring as detailed in Figure 1.

WAN

Interconnection

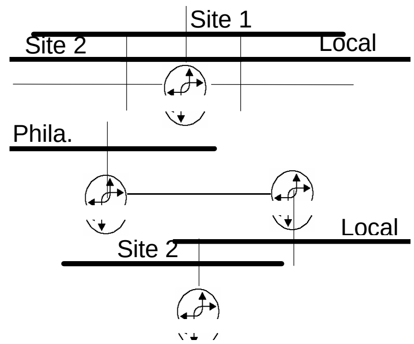
The *Sample* Industries remote locations are connected using multiple point to point lease circuit starred topology as provided in Figure 2. The inter-exchange carrier for the data circuits is Sprint. Provided in Table 1 are a list of the WAN circuits and their approximate monthly costs.

Table 1: Circuits Costs (Estimated)

Circuit to:	Approximate Cost
Philadelphia	1052.00
Site 1	836.00
Site 2	836.00

The *Sample* voice traffic is provided by MCI from the *Sample* location. The Site 1 facilities use Sprint as the IXC for voice due to a local facilities contract at that industrial complex. No specific investigation was performed on the voice technology for either the *Sample* location or the remote locations.

Figure 2: WAN Overview



Router/Addressing

Internal addressing for the IP and IPX networks is presented in Table 2. The IP addressing was not acquired from the Internet Address Network Administration (IANA) and is therefore not IANA address compliant. The impact is that a connection to the Internet would not support routing to this address space. To implement IANA IP addressing, changes will need to be made and addresses acquired. The current IP address implementation uses Class C addressing with appropriate subnet masking. This current addressing performs well for the IP intranet used within SI. The internet connection could be engineered with a limited number of IANA address compliant addresses and will be required to utilize the Internet for commerce and communications.

Table 2: IP & IPX Addressing

Location	IP Address	IPX Address
Sample	192.1.2.0/255.255.255.0	100
VCS	192.2.2.0/255.255.255.0	200
SITE 1	192.3.2.0/255.255.255.0	300
SSI	192.4.2.0/255.255.255.0	400
LCPI	192.5.2.0/255.255.255.0	500
Philadelphia	192.6.2.0/255.255.255.0	600
Sample-LCPI Link	193.1.1.0/255.255.255.0	A
Sample-SSI Link	193.1.2.0/255.255.255.0	F
Sample-	193.1.3.0/255.255.255.0	B

Figure 3 : WAN Details

Layout omitted.

Workstation

Desktop PC

Workstations for the most part within the company are 486 processors and better. Current acquisition are Pentium IV's based upon the acquisition standard which is based upon the pricing of the specifically configured PCs. This pricing is set at approximately the $2,000.00 price point for the workstation hardware. While this allows different hardware to be brought in during a period of time, it does provide for increasing the price performance relative to a unit cost for hardware over that period of time. Use of a limited number of hardware vendors also ensures an increasing performance point at the same price during the acquisition period. The current process limits the number of vendors to a maximum of three. Some deviation to the approved vendors has developed within some of the remote plants for equipment.

The current operating system standard is Windows XP Professional. The workstations are configured to support both IP and IPX protocols to access the Novell system and the RS/6000 systems. The standard for office computing is Lotus SmartSuite (AmiPro, Lotus 123, Approach and Freelance), with support still provided to remaining WordPerfect 6.1 users.

Laptop/Portable PCs

Several IBM ThinkPad laptops have been acquired for the Sales Support Staff. These units are being used to provide remote computing support to the dispersed marketing and sales group. Their usage is limited presently to sales forecasting, weekly sales activity reports and electronic mail via individual Yahoo accounts. The Department is still developing an overall plan for the use of these machines.

Solaris Workstations

The Sun Microsystems Sparcstations are Solaris operating system based and are separated from the rest of the *Sample* Industries network by utilizing a Sun workstations as a router. This workstation separates the CAD LAN and the *Sample* LAN. This effectively allows the Sun workstations to share information among themselves with little or no impact to the *Sample* LAN. Continued use of the workstation is encouraged since CAD documents can significantly degrade network performance.

Server Systems

Novell 4.1 Server

The network operating systems (NOS) used within *Sample* Industries is the Novell NOS Release 4.1. This is an old Novell NOS release level and provides for print, file sharing and other LAN services. A Novell Connect 2.0 2-user license is implemented on the LAN, which allows remote access and outbound modem sharing. This facility is used very little outside the technical support group presently, but could provide remote access for a variety of business purposes. The WAN is used in a limited manner to support the dispersed Novell network environment, since each facility has its own local Novell file server to support the internal computing environment.

The Novell Directory System (NDS) employed at *Sample* is a well designed, practical and simple. The systems allow the technical group effective management the LAN and WAN resources associated with the Novell inter-network environment. The current Novell system allows for both intra and inter-facility sharing of resources, but is not effectively used to support data and information movement. This is not the result of the design or the systems, but more a result of the user training and knowledge.

RS/6000 AIX Systems

Table 3 summarizes the RS-6000 AIX systems used within SI to provide the plant operations support. These systems provide the operating systems for the operation and control of the plants and are linked loosely with the WAN network. Support for the systems is provided by *Location* technical support personnel.

Table 3 : Unix Systems Configurations

Location	Name	Model	Serial #	Op Sys	RAM	Disk
Main	STD6000*	7013-J30	2651186	4.1.4	256 MB	2 - 2.2 GB 3 - 4.5 GB
	STDDEV	7012-340	2636111	4.1.4	80 MB	2 - 400 MB 2 - 1.0 GB
Location 1	LCP6000	7012-340	2639879	3.2.5	96 MB	1 - 400 MB 2 - 1.0 GB 1 - 2.0 GB
	SITE 16000	7013-530	2625652	3.2.5	192 MB	1 - 400 MB 2 - 1.0 GB 1 - 2.0 GB 1 - 2.8 GB RAID5
	VCS6000	7012-340	2637405	3.2.5	96 MB	1- 400 MB 1 - 670 MB 1 - 1.0 GB 1 - 2.0 GB
Location 2*	SSI6000	7009-C10	08197	3.2.5	256 MB	3 - 2.0 GB
Philadelphia	SMI6000	7013-550	2625688	3.2.5	192 MB	2 - 400 MB 4 - 2.0 GB

* Owned Equipment

Intranet Applications

The use of consistent business programs across the corporation is limited to those of the standards -- Lotus Smart Suite. A serious disruption and support issue is being undertaken at Site 1 locations with the adoption and development of electronic mail system using Pegasys. Pegasys is free-ware system that can be used to support local electronic mail, but is not a system to base a growing corporation upon, since this is an enabling and necessary technology for the future at *Sample*. This issue can develop to the point where important synergy within the *Sample* Intranet can be lost due to divergent and different electronic mail standards being used within *Sample*. Because of the need to improve communications among and between plants, a corporate wide decision should be made on the appropriate technology to employ to solve this critical business application for the corporation.

Operations Review

Manufacturing Systems

CAMS

CAMS is an integrated software package from XYZ Corp., purchased approximately four years ago to replace an NCR tag management system. CAMS was purchased specifically for the machining operations. It does not apply to the finishing side of the business. This software is the basis package around which related manufacturing systems have been developed. CAMS is a character based system developed in Thoroughbred BASIC. Thoroughbred's Query 4 freelance query tool is available, but only to the DP staff. It is not sufficiently user friendly to release to the workforce. The source code and fourth generation programming tools are available to assist with system maintenance, and the base software has been heavily modified in-house (roughly 50% of current product is custom developed). The base software has never been upgraded with XYZ's software upgrades due to the heavy degree of customization. The software was written in the early 80's, and is still representative of software of that era.

Much of the original NCR tag management system has been incorporated into CAMS to manage inventory from receiving through shipping. Tag management is the basis for all of the shop floor data collection currently in place. *Sample* is making effective use of shop floor data collection through this system, but the system needs to be expanded to include labor and represents a significant opportunity for further automation. Tag management is the one common link between the machining operations and the finishing operations.

There are a number of tools available through the CAMS package that are not in use at any facility. The flattened bill of materials and simplified routing structure of *Sample's* parts makes a full blown MRP implementation somewhat of an overkill; however, significant time could be saved in the scheduling and purchasing arena if the system were permitted to generate material requirements and general scheduling. All shop scheduling functions are done off line, either on a spreadsheet or in a rudimentary word processor attached to the CAMS system. *Location* is utilizing much more of the system than is Site 1. Site 1 has chosen to develop personal computer based applications to supplement basic CAMS functionality. This is due in part to the nature of their customer mix, and in part to a lack of training or understanding of the available functionality. Some rather nice, custom developed Paradox applications have provided Site 1 with some nice tools, but they take "snapshots" of the CAMS information at whatever time the interface program is run, and do not reflect the current state of requirements. This situation creates a very manually intensive operation.

Maintenance is being handled on a PC(LAN) based package called MPS. This software is also in varying stages of use at the different facilities. Maintenance inventory is maintained separate from the CAMS inventory. Preventive maintenance is being monitored, and maintenance work orders are being released through the software.

PlantData

The steel processing side of the business is run on software purchased from PlantData, a Calgary based company with offices in Philadelphia, PA and in the U.K. All development is done in the Calgary office, and North American sales are coordinated out of the Philadelphia office. The software was designed for use in the finishing industry.

The PlantData software in general, is named PD-PLAN, and consists of two separate entities: PD-PROC and PD-CHEM. Although the two systems fall under the PD-PLAN umbrella, they are completely separate. The databases are separate and their data cannot be combined or shared. Menu structures, database structures, database keys, production paperwork, and screen functions are all different between the two packages. *Sample* selected the package based on its selection at ABC, at the time, Site 2's largest customer. The package is also in use at EFG, HIJ, and KLM.

Both packages are EDI compatible; although, they do not share common format compatibility. EDI is fully implemented with ABC. The last ABC invoice was sent over one and a half years ago. They pay directly from the Bill of Lading, and funds are electronically transferred from ABC's bank to Site 1's. Their current largest customer, NOP, is moving to EDI, but are planning a piecewise implementation.

The ACU-COBOL source code has not been purchased for either PD package. PlantData's maintenance system offers new versions either downloaded via modem or on tape. Updates are received roughly monthly. If updates are received via tape, there is a 30 day limit within which, the new software must be installed, and the tape returned to PlantData. Passing the thirty day window breaks the maintenance contract. PlantData has been slow to respond to the smaller clients, being more keyed into the chemical giants. The June release is scheduled to offer some features at the request of the smaller clients.

PD-PLAN was identified as doing a nice job with inventory; although, toll inventory is separate from purchased inventory, and maintenance inventory is maintained in another package altogether (MPS).

The PlantData accounting subsystem is not very powerful. Detailed transactions are maintained, and trial balances may be generated, but the systems do not generate financial reports. Macola PC based software was purchased to enhance the accounting software applications. The PD general ledger can be downloaded as a flat file to a PC, and through a conversion routine written by Ben Rose & Associates, be converted and imported into Macola. Financial statements are generated in Macola; although, final reports are rekeyed into a Lotus 1-2-3 spreadsheet for presentation to corporate. Macola was installed in the first quarter of last year.

Site 1 scheduling is currently handled manually from photocopies of customer orders. Schedules are created on PC spreadsheets in the Scheduling office. Customer Service/Order Entry is located across the plant from Scheduling, and cannot see schedules in system. Although the scheduling system is sufficiently elaborate for the size of the operation, the lack of visibility to that schedule is problematic.

Customer Service is required to provide status reports to customers and salespeople on a daily or weekly basis. The data necessary to complete these status reports is compiled manually and entered into Lotus spreadsheets. Separate spreadsheets are maintained for each customer, listing the applicable material, quantity on hand, quantity in process, quantity on order, and summary shipments for the year. Order and inventory quantities are currently maintained via purchase order and shipping records. Nothing is extracted from the PD systems. A database application (Approach) is being developed to automate this activity. Implementation will be stepwise, with a download of purchasing data first, followed by a download of sales data once the first interface is debugged.

Production tags are physically collected from the shop floor, along with the production sheets. Schedulers manually reconcile the two data sources. Bar coded tags are not in use in the finishing operations, but the machining tag system applies. There is another level of product marking that is in use on the finishing side. Gummed labels are pre-printed when the customer/shop order is printed. Customer service carries the labels with photocopies of the production work order to the scheduling department, and the labels are applied to the pallets following processing.

Financial Systems

For the scope of this review, the financial systems included the accounts receivable, accounts payable, and financial reporting systems for *Sample* Industries; However, due to the anticipated sale of Site 2, the systems for that company were not specifically reviewed.

Overall, except for the consolidation of *Sample* financial statements, the company's financial systems are operated on a decentralized basis, with information being passed between locations via fax, mail, and/or Lotus 1-2-3 spreadsheets. The systems are characterized by a high level of manual entry and re-entry into locally accepted formats to serve specific purposes, such as monthly financial reporting and reporting packages for the Board of Directors meetings. Although not within the scope of this review, it appears that consolidation of the accounting functions being conducted at the plants should be evaluated, particularly cash application, collection follow-up, and check preparation.

Accounts Receivable

Billing is performed at the plants and the customer's account is automatically updated but only on a local basis. Corporate personnel, or any other entity that has an interest in the customer's account, cannot view the account on a consolidated basis. On a monthly basis, accounts receivable information is sent to central accounting for review. This information is entered into Lotus spreadsheets at the plant using their existing systems as a source. The spreadsheets are then mailed or faxed to central accounting for review. In cases where a payment problem exists, the General Sales Manager is notified, and subsequently the salesperson is instructed to contact the customer directly. These contacts are all made via written communication or the telephone. Accounts receivable are currently at approximately 45 days sales in A/R. Tooling billing is done manually, sometimes involving progress billing with final bills being prepared on completion of the jobs.

Cash application is also performed on a decentralized basis. The Company uses the lock box facilities at Keybank for each plant, which are then 'swept' into a common *Sample* account. Remittance detail is forwarded from the bank via the mail to each plant for application the customer account. Actual posting to the account is done during batch processing in a rudimentary approach. Collection follow-up is done at the plant level with the only centralized reporting being the 90- day accounts mentioned above. The Company does not currently have a Credit Manager and credit applications are not used per *Location* personnel. The scope of this review did not include interviewing financial personnel at the plants. Credit hold decisions are made at the plant with the involvement of the Plant Manager. The lack of consolidated data does not permit an overall view of any customer who deals with more than 1 plant simultaneously.

Accounts Payable

Forging purchases dominate the dollar volume of Accounts Payable and although forging purchasing is done centrally, invoices are entered at the plants where the receiving is performed. Otherwise, accounts payable is decentralized, with checks being created and issued at the plant level. Central accounting is notified of the amount of each check run from the various plants via fax or telephone. This notification is done after the fact, which nearly eliminates any possibility of doing adequate cash forecasting. With the significant level of capital expansion currently in process within the company, improved cash forecasting would take on more importance. Keybank bank "sweeps' the checking account on a nightly basis to pay all checks which clear that day. (Overall, communication between the plants and central accounting is very similar to the process just described in the Accounts Receivable section.). At the end of the month, the plants create a listing of open receipts and send it to central accounting to book the inventory accrual. Again, the lack of integrated data requires a significant amount of entry, re-entry, and redundant work to achieve the desired results.

Freight verification of inbound material is difficult to accomplish because no reference is available to confirm the accuracy of the charge and the volume prevents an accurate manual approach. Consideration should be given to review this area in more detail to determine the overall impact of possible overcharges.

Financial Reporting

Each plant processes and closes its own financials each month. The plant level information is entered onto Lotus spreadsheets and faxed or mailed to central accounting for consolidation. At central accounting it is re-entered into reformatted Lotus spreadsheets for final financial statement preparation. The general ledger system does not provide year to date comparisons nor does it provide comparison to budget. These comparisons are entered manually through a series of Lotus spreadsheets for management review. One major difficulty in working with plant level data is that the chart of accounts is not consistent between plants, even though an attempt to make them consistent has been underway for some time. In addition, it is possible that the same account number may be used for different accounts by different plants, which adds to the difficulty in working with the plant data. The system does interface with accounts receivable and accounts payable, but does not interface with inventory. The excessive manual effort to compile financial data obviously lessons the available time to analyze the data once it is in a reviewable format.

The system does not provide exception reporting for any level of user. Key data is typically summarized manually or taken selectively from a number of existing reports and entered into Lotus spreadsheets.

Information Systems Organization

The Information Systems department consists of 14 individuals. The responsibilities are distributed in a conventional manner, allowing for and IS Manager, who's direct reports are an Applications Manager and a Technical Manager.

The Applications Manager has 6 direct reports, including a part time consultant who assists on specific projects. These people have been employed by the company for an average of 10 years each, although the EDI support person has not been employed very long. One analyst/programmer works second shift to accommodate her personal schedule.

The current technical staffing within *Sample* Industries is provided by 7 people. The distribution of the technical resources is provided as follows:

Sample	2
Site 1	4
Site 2	1

The group functions well for the most part, but suffer from reporting responsibilities and associated matrix management problems. The Sample (Location) group provides support for the Novell and RS/6000 systems and the remote technical group provides support for the local workstations and other support needs. The current organization is budgeted by Location IS, but the reporting is through the plant management structure. This organization structure is not effective in maintaining an overall strategy for MIS within *Sample* and has caused significant issues with technology related acquisitions which can not participate within the *Sample* WAN due to cost based acquisitions. The structure needs to be designed to integrate the various individuals into a collective group with stronger reporting and responsibilities to the corporate group to maintain company wide technology consistency. Additionally, this will allow the corporation to leverage the group with cross plant support and working knowledge. Consideration should be given to locate all systems personnel in Location, and dispatch support personnel to the plants when needed. The exception to this approach may be the Philadelphia location because of the travel distance and start-up considerations for the plant.

Currently, the *Location* technical support group is under-staffed for the work performed and systems supported with *Location* and the other locations. Only two (2) technical staff support the following:

7	AIX/6000 Systems
	NCR Tower System
6	Novell Files Servers & NDS
50+	Workstations
	Shop floor terminals
	Wire Plant @ Location
3	WAN Links between Plants
	Voice systems
	Development activities
	Equipment acquisition, repair
	Hardware and Software Evaluations
	EDI communications with • CommerceNET • GEIS • Direct connection via Dial-up customer • Other connections for EDI
	Helpline Referral group for technical questions

It is likely that additional support personnel should be added to the group to ensure that continued support for new initiative are effectively handled and managed. The environment is rapidly becoming more complex and the current ability of the group is being outstripped with the new technology and complexity. An additional support person with appropriate technical skill and knowledge is required to move into some of the technologies being identified within this document. Without the additional staff, *Sample* could potentially find the situation where its high priority systems needs are not being satisfied.

The IS Department has developed a plan but it has not been fully embraced by the user community. At this time, no member of the IS staff sits on a user committee so the visibility and input of the department is minimized.

The current investment in the IS department is approximately $1,000,000 annually, which includes salaries, software licenses, maintenance, and other expenses. This amount represents approximately .4% of sales. Our experience indicates that most companies, particularly during development periods, spend between 1.5 and 4 % of sales on new technology.

Significant Issues

Multiple Systems

Three separate computer systems are in place to provide Sample Industries with basic manufacturing functionality. A heavily modified CAMS package is utilized in varying degrees at various stamping and blanking facilities, and two separate PD-PLAN systems are utilized in the steel processing operations.

While there is no real reason for the CAMS and PD-PLAN packages to cross communicate at this time, the likelihood that future facilities will coSite 1ne stamping, blanking, and steel processing makes this lack of communications a stumbling block to the organization’s expansion. A more current difficulty stems from the fact that the two PD-PLAN packages (PD-PROC and PD-CHEM) do not communicate with each other. The two databases and systems are utilized within a single facility to manage the same pieces of information, separated only by a difference in material accounting philosophies. Further, the two packages have significantly different formats. The database keys do not match, the menu and screen layouts are not similar, and the report formats are different (including shop documentation).

None of these packages have adequate financial packages, forcing the use of PC based CAMS to assist with these functions. Site 1 and Site 2 utilize Macola accounting software and Lotus 1-2-3; whereas, the CAMS based plants utilize Lotus 1-2-3 spreadsheets.

No PlantData Source Code or Productivity CAMS

The PlantData system (PD-PLAN)was purchased without the source code. Sample is paying $100,000 annually for a maintenance contract for PlantData to provide periodic software upgrades. PD-PLAN was written primarily for chemical processing companies, and the smaller processing centers have had difficulty in getting PlantData to respond to their special system requirements. Given the value received in upgrades since the purchase date, the maintenance fee does not seem worthwhile.

Redundant and Wasted Effort

There is redundant and wasted effort in almost every area of the operation. The most significant areas are:

- Accounts Receivable
- Financial Closing
- Electronic Data Interchange (EDI) re-entry
- Scheduling
- Bulk Reporting

The accounts receivable and financial closing areas were discussed previously in the Operations Review section. These areas were characterized by a very high degree of 'entry/ re-entry' of data into Lotus spreadsheets.

Orders are received from major customers via electronic data interchange (EDI). These customers forward purchase orders directly from their operating computers to *Sample* computers. The information should be placed directly into the order database and into the scheduling system; however, in this particular application, EDI orders are printed and re-keyed into the order entry and scheduling systems. Several days are consumed every week in manual re-entry of Site 1 orders alone.

The scheduling activities are all done off-line, and manually. Open orders for sixty to eighty part numbers are shuffled daily at the Location facility. Orders are manually keyed into a 1-2-3 spreadsheet from the CAMS customer order recap report. Individual machines are then scheduled four or five setups deep and re-keyed into a "word processor" which was added to the CAMS system. Site 1 keys customer orders into CAMS, and downloads them into a Paradox application which is used to maintain and print the machine schedules. In all cases, the schedules are no better than a snapshot in time, which may or may not represent current requirements. Changes may note be seen by other parties within the facility, and there is no forward capacity picture available to sales/order entry

Except in cases where "fill-in" PC applications have been developed, the operation is running on batch reports. A number of bulk reports are utilized throughout the operation to plan and conduct day-to-day operations. An organization needs to run on information, not just data. Bulk reporting presents a mass of data without a means of selecting the subset that responds to specific business needs. A more responsive system is needed.

Short Term

Support Helpline Operations

The support and operation of the technical environment is provided utilizing a central response center staffed with one person to handle the issues, problems, etc. associated with all Sample computing. The actual specific call handling is based upon complexity and a referral based system routing to the best support person following the initial Helpline call. The system has just been implemented and some time will be required to determine the relative value of the referral system and the ability to reduce the number of referral calls routed to the technical support at Location by handling them with the initial Helpline support person.

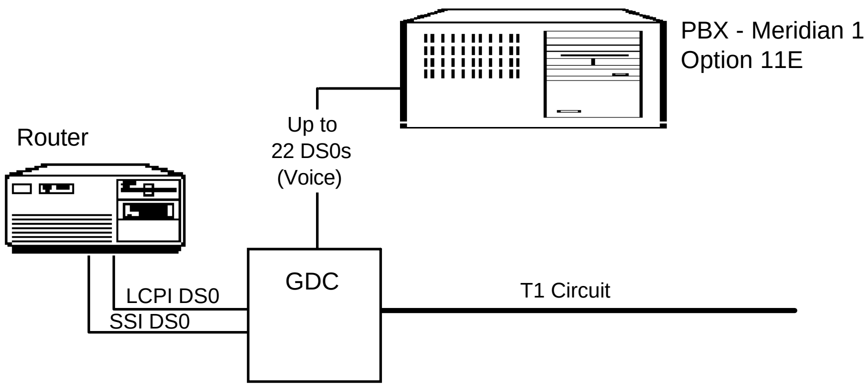
The use of this organizational structure requires that first line support be technically proficient and this normally requires time to acquire sufficient skills to reduce the workload of the referral group. Additional training and on-the-job learning should create a more productive and responsive support group.

Infrastructure Issues with Newbridge 3624

The Newbridge 3624 T1 Termination Unit is capable of providing all voice and data circuit terminations at the Location complex. The issue appears to be the inability for the GTE engineers to utilize the Newbridge 3624 as the T1 termination device. With the present unit, a General Data Comm (GDC), a replacement for the T1 DSU/CSU will be required to provide the additional circuit termination for the planned Philadelphia data circuit. Presented in the Appendix A is the specification for the Newbridge

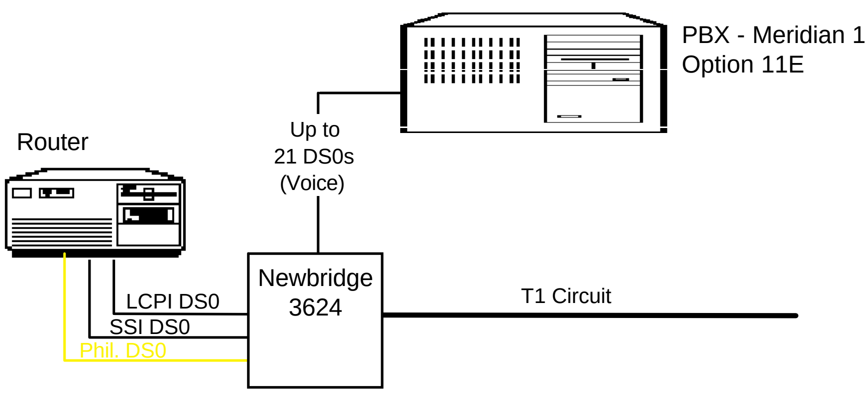
3624, which clearly indicates the ability of this unit to provide the T1 termination and support the three (3) data terminations as well as support the remaining DS0 as voice circuits. Figure 5 provides the current details associated with the T1 termination at Location.

Figure 4 : Sample Termination Design - Philadelphia



Provided in Figure 5 is the design for the use of the NB 3624 Termination unit. This unit will be able to drop off 3 - 56 kbps circuits from the T1 at the Sample complex and provide the remaining 21 DS0 (56 kbps circuit) or less to the Location PBX for voice circuits usage. By utilizing the Newbridge 3624, the current GDC unit can be relocated to Philadelphia and used to provide the termination unit for the Philadelphia complex when it come into operations.

Figure 5 : Sample Termination Design - Philadelphia



Internal EMAIL Communication Architecture

The use of internal enabling technologies needs to be examined to determine the benefits of this type of technology within *Sample*. The examination should be pursued to determine if improvements for internal communications between and among plants can facilitate better scheduling and knowledge about capacity issues associated with production scheduling. This infrastructure or intranet can provide a basis for distributing information using the internal electronic mail network. Other communications can also utilize this infrastructure whine implemented enterprise wide. The current wide area network between plants can be utilized to provide enterprise electronic mail, bulletin boards and other internal communication from HR, Safety, Plant Management, etc. as well as other business related communications.

The proposed intranet utilizes the current computing environment as well as expanding the current limited Lotus Notes infrastructure currently being beta tested by the technical group. The initial design of the *Sample* intranet is to utilize appropriate technologies for the different groups and communities of interest within *Sample*, but maintain the appropriate interaction between the groups. Figure 6 presents a conceptual design for the intranet communication architecture. The intranet electronic mail architecture will facilitate better and faster communications within and between Sample plants. The communications would be used to support better production planning and scheduling updates and other operational information to improve utilization at the plants as well as providing timely management information as required. Work will need to be performed to identify the best areas to pursue initially with the deployment and implementation of the intranet messaging

The development of a multi-technology based infrastructure is to reduce the per seat cost of its technology acquisition and implementation. SMTP services are available on all the RS/6000 Unix processors used at all the plants and could provide approximately $45.00 per electronic mail seat and information browsing capabilities. Additionally, even 'dumb' terminals can use the SMTP mail facilities with simple to use terminal GUIs. Lotus Notes costs in excess of $ 125.00 per seat, but does provide increased functionality for Sales Force Automation, financial and management communications. Both of these technologies can co-exist and work well together. The ability to utilize communication effectively can provide better information, informed decision making, and reduced effort within *Sample* for a reasonable investment and development effort.

Figure 6 : Initial Intranet Conceptual Design - Electronic MAIL

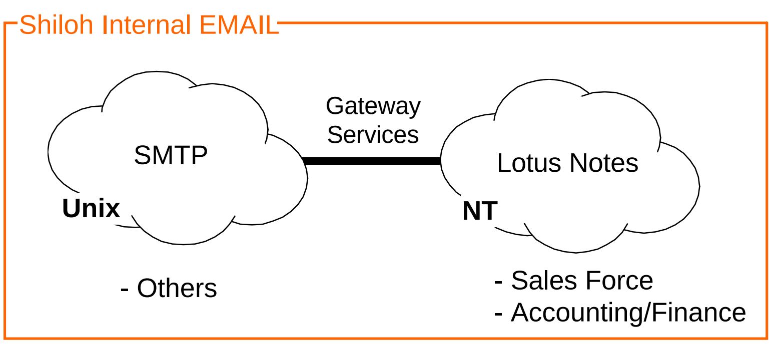
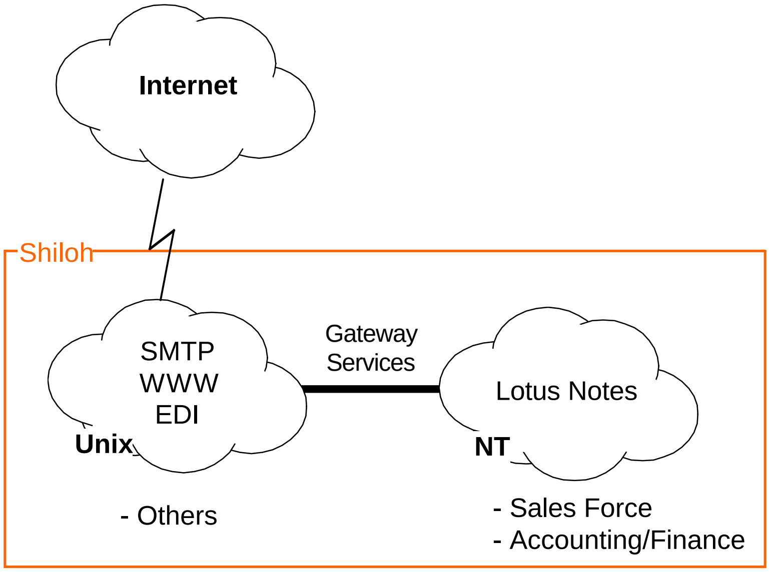


Figure 7 provides a longer term intra and inter network design. With this strategy, *Sample* would begin leveraging the Internet for outside electronic mail, Internet EDI and World Wide Web information exchange. Publishing information on the WWW will soon be the norm and potentially required since the Thomas Register is beginning to develop their resources and product in electronic form. This avenue will open up new marketing and sales avenues and potential competition should they not be available from *Sample*.

Figure 7 : Internet Usage/Connection



Sales Force Automation/Remote Access

Providing remote access for the non-office based workers and the sales force allows those workers to share in updated information the same as those in the office facilities. This ability provides timely information flows, order processing and other business related communications to and from the field workers and facilitates improved communications between the field sales and support team and the operations and production facilities. The remote access infrastructure to support remote access computing is currently in place and could be easily supported and expanded. The previously proposed electronic messaging would be required to effectively integrate these processes within the daily *Sample* processing and operational environments.

Automated Quoting System

The procedure for developing customer quotes is currently very manually intensive. Automation of this function outside of a new major application system would provide significant productivity improvements, enable Sample Industries employees to benefit from electronic messaging, as described above, and share the necessary resources.

Spreadsheet Scheduling Visibility

The off-line nature of Sample's scheduling makes it difficult to share this critical information within a single plant, or within the organization as a whole. Taking further advantage of the previously proposed electronic messaging, Sample could provide visibility to these schedules without significant changes to the procedures currently in use at any facility. The off-line methods in use today could simply be loaded into the messaging application and made available to all users, making up-to-date information available at all times.

Longer Term

Security

Both the Novell and the RS/6000 environment need to be evaluated for security related exposures. The IP environment with either remote access or an internet connection should be thoroughly reviewed against potential threats. The ability to limit intruders as a first line of effective defense should also be examined in light of any exposures. There are a number of issues related to security, but it should be noted that the SEC will hold management responsible for any loss of competitive or financial disclosure from inadequate controls when using the internet.

IANA Addressing & Internet Connection

The use of non IANA acquired addressing for the Sample Industries environment should be completely revised and addressing should be IANA approved and registered. The ability to provide an internet connection should be viewed as a strategic business development project. The Internet provides many benefits to a company such as *Sample*. The Internet connection allows an outsiders view to the firm, its products and other related marketing information, but also provides an environment to conduct business, using both electronic mail communications and internal access to network available resources by human resources, information systems, purchasing, and others that need outside information to perform their jobs more effectively. Other reasons for the connection revolve around the ability to maintain a competitive stance with both customers and suppliers in this rapidly changing network environment.

Reasons for developing an Internet connection for *Sample* are:

- Business integration with the Internet services and information
- Electronic communication to/from customers and suppliers in a timely manner
- Aid in the conducting business from within *Sample*
- Basis for Internet commerce and Internet EDI to be investigated and developed
- Alternative access to marketing information about *Sample*
- Simplified means of obtaining critical business benchmarking information
- Potential to be involved in corroborative engineering with customers, gaining competitive advantages
- Potential to leverage this communications infrastructure and reduce intranet communication costs
- Global participation with customers with transportation being the only impediment of commerce within the global economy

A project to select an Internet Service Provider (ISP) is required to begin this process with the formulation of cost associated with developing an Internet connection. The internet connection to the ISP needs to be engineered with a limited number of IANA address compliant addresses that either the ISP can acquire or *Sample* can acquire through IANA. The addressing design should employ the Internet Engineering Task Force (IETF) RFC 1918. With this design, only a very limited number of IANA is required to satisfy the needs of SAMPLE INDUSTRIES. RFC 1918 is presented in Appendix A.

The review of the interconnection and the security of the link also need to be reviewed and engineered to prevent security breaches. A benefit of the RFC 1918 addressing design is that they are effectively "hidden" and more secure than the normal IANA addresses. The design of the addressing and security should be undertaken in parallel to effectively design the IP address environment for *Sample*.

Voice Review & Long Distance/Calling Study

A long distance voice study and review for the total company is required to understand the voice calling and operations within the corporation. The ability to leverage the voice across the corporation should be undertaken since significant cost savings can be taken by consolidating all voice traffic to a specific inter-exchange carrier.

Video Conferencing

With the startup of the new Philadelphia facility, travel time and expenses will increase for employee moving between the centrally located Ohio facilities and the Philadelphia facility. An opportunity exists to reduce the time and expenses through the use of video conferencing, while maintaining and improving the communications. Coupled with the other intranet communication projects, video conferencing can be used to hold regular meeting for operational and management meeting without incurring the loss time for travel or the expenses associated with the travel.

While video-conferencing can not replace all travel, it can provide an alternative in various business circumstances that can be very cost effective manner to conduct remote business. A study to investigate the opportunities to utilize this technology needs to be examined in response to the opening of the Philadelphia facility.

Single Minute Exchange of Dies (SMED)

The Sample 2004 plan mentions improved setup procedures several times. The Location operation has a series of “Green Books” and Site 1 utilizes individual sheets printed with the production orders both containing setup instructions for the presses and parts. These documents are maintained manually, and are available for the production operators to browse when preparing a new job for production. The nature of this type of information makes it difficult for production operators to make effective use of the information presented therein. CAMS exist within the intranet environment described previously to assist with the goal of SMED. Multimedia presentation of this information may be accomplished at the press. Video, voice, still photo, and support textual information may be combined to present an effective tool to the press operator. This more user friendly presentation of setup and operational information, coupled with effective focused team activities can further reduce the job changeover time at all presses.

Automated Shop Floor Data Collection

The blanking and stamping operations are currently making good use of shop floor data entry. Production completions and quality data are being entered by production operators right at the press. The next step in this process is to incorporate labor data collection, and to automate the whole process further. With the requirement to replace the existing application software, a new structure for shop floor documentation will be developed. By incorporating bar codes on the shop work orders and adding wand readers at the press, the data collection effort can be reduced significantly, while maintaining the close point of entry.

Automated Press Monitoring

A further step in automating the shop floor data collection would be the incorporation of press monitoring instrumentation. Monitoring such things as bearing temperatures, vibration, strokes, flywheel energy dissipation, etc. will close the loop on production data collection, and provide a tool for automating the preventive maintenance system.

Hardware and Software Standards

Although an attempt has been made to implement hardware standards, and consideration has been made to create software standards also. Although some standards exist on an informal or ‘accepted’ basis, a specific set of standards should be developed and enforced so that the company’s support effort can be as efficient and effective as possible.

Recommendations

A variety of areas and issues have been discussed in the course of this report. Many of the issues overlap, or cannot be addressed without considering a number of related issues. Without a specific plan of action, it will be difficult to make progress in a given area, or to convince user's to 'buy in' to a development effort. As a result, it is now necessary to develop a comprehensive systems plan which will provide for steel processing and stamping in the same location, address the technical issues presented in this report, and identify short-term improvements (less than 6 months) which can be accomplished during the more extensive development period.

The Next Step

The next step consists of:

1. Identifying the detailed requirements that will be used to differentiate between the capabilities of various software packages.
2. Identifying the vendors and packages that have a potential fit for *Sample*.
3. Evaluating these packages relative to the requirements identified above.
4. Viewing demonstrations of the high potential packages.
5. Meeting with the management of the software vendor and viewing their facilities.
6. Selecting and purchasing the "best fit" package
7. Identifying the hardware requirements to support the selected system and the operational needs of the business.
8. Developing a detailed implementation plan and carrying out the installation
9. Provide extensive training to all impacted personnel and user of the new system

These steps are grouped into logical headings and discussed in greater detail in the following three sections.

Requirements Definition (Step 1)

The requirements definition step begins with "Management Awareness". There must be a consensus for change within the Sample senior management group. Senior and middle management's agreement and awareness of the strategy (to replace the existing software portfolios and hardware) and the process being employed to execute such an endeavor must be communicated at the outset. This communication step is best delivered by the CEO, indicating the strategic importance of the project, that the organization is committed and that each functional group's input and cooperation is critical to its success. Completing this portion of the project successfully will minimize "road blocks" throughout the process. This will also begin the formulation of the education program required to successfully implement the new software.

The actual definition of the company's requirements focuses on a top-down assessment of each functional area of the business, isolating the Critical Success Factors that must be managed to assure that area's success. BEST's System Requirements Definition Methodology includes the following key activities:

- **Gather and Analyze Background Information -** To support the overall definition process, background data must be gathered to gain a clear understanding of the requirements as a whole including senior management's assessment of the Critical Success Factors of the business. This includes an orientation as to the company's products, strategies, functional areas, and system support. For the most part, this task has been accomplished as a part of the current analysis. The Critical Success Factors which will become the project's measuring stick must be identified.

- **Prepare For and Conduct Interviews -** Interviews with key personnel, driven by the previously defined critical success factors as they apply to each functional area of the business, provide the basis for the requirements document. In all cases, the interviews target existing and new functionality that will better serve the needs of the organization.

- **Evaluate Critical Existing Application Systems and Manual Procedures -** All critical application software and manual procedures must be analyzed to gain insight to the information that is currently available, deficiencies in that information, how the information is used and the overall impact on the business. This step has been fundamentally accomplished through the current project; however, all personnel interviewed will be asked to prepare, in advance, a detailed sample of all critical information and reports being used. This step will help the interviewees to picture the current operation from a different perspective, and open the communications along a more productive vein.

- **Catalog and Analyze General Casting's Information Requirements -** Once initial requirements have been defined through the interviews, they are communicated back to the functional organizations for further refinement and prioritization. A measure of the value of each feature based on its contribution to toward achieving the business Critical Success Factors must be established. These measures may appear differently to each facility, and the differences must be highlighted to identify areas where flexibility is critical. A requirements "checklist" is the result of this effort. This checklist is a publication of the prioritized requirements that will form the basis for a formal request for proposal from software vendors.

Vendor Evaluation (Steps 2 through 6)

The Vendor Evaluation process is a multi-step procedure which begins with identifying potential vendors and ends with the selection of the "best fit" package. Software alternatives are objectively evaluated and final candidates are chosen for further consideration. The final tasks in this procedure deal primarily with establishing relationships with the final vendors and becoming comfortable with their package's ability to meet Sample Industries' business requirements.

A variety of resources are tapped to identify those software packages with a wide potential fit. Technical societies, published evaluations or rankings, BEST's internal library, and knowledge gained through previous requirements definition and software selection projects will identify a listing of vendors who may have a solution for Sample. Preliminary evaluation of these vendors based on the Critical Success Factors and detailed requirements will reduce this list to a manageable size for RFP distribution.

The requirements checklist forms the structure for a request for proposal document that is submitted to all candidate vendors. The resulting vendor proposals can be objectively analyzed and quantitatively measured against the original checklist as a means of weighing the strengths and weaknesses of each package. From the RFP responses, a list of three to five vendors are selected to proceed to the demonstration phase of the project.

Initial vendor presentations and demonstrations with vendor supplied equipment or via modem are typically limited to one half day per vendor. This preliminary look at the company and the software package will be used to reduce the vendor population to the two with the best fit based on both function and personality. Two day follow-up demonstrations are then conducted with Sample data and tailored to address very specific features and functionality required by the business. It is vital that the ownership of the process shifts to the user community during the demonstrations. A degree of subjectivity begins to enter the evaluation in terms of comfort with the vendor's staff, ease-of-use of the software, documentation, facilities, professionalism, etc. The internal project team chartered with the final software selection takes an integral role in this and subsequent tasks in the evaluation process.

All vendors will be requested to provide references. These references, as well as others which may be identified, will be checked via telephone or visits if feasible. Vendor reliability, support, product performance, and functionality are the focus of the reference checks. Peer-to-peer discussions (manager to manager) are very productive to determine functional fit.

It is recommended that the internal project team visit the vendor's headquarters as a part of the evaluation of the top two vendors. A meeting with the vendor's management team and a tour of their facilities will provide comfort that the potential supplier is one which is viable today and will be in the future, and that they are committed to Sample as a customer.

Finally, the negotiation of a contract with the selected vendor is conducted with the second choice vendor still in the "game". The willingness of the vendor to negotiate in the face of strong competition is always greater than after the "game" has been won.

Implementation Planning (Steps 7 through 9)

A high level implementation plan is developed soon after a vendor has been selected. This plan covers the tasks of purchasing and installing hardware, converting the existing data for use in the new system, procedural changes necessary to operate in the new environment, and the sequence of modules to be implemented. A much more thorough plan is formulated in conjunction with the selected vendor, but high level planning should be done in preparation for this effort.

Vendor representatives are the best resource for implementation assistance. If the vendor offers such services, they will likely have a format for their detailed implementation plan. This plan should provide a schedule for all tasks necessary to take Sample Industries "live" on their package. The tasks identified in the preliminary plan will be detailed with names, places, and hours.

Central to this detailed plan, and to the success of the implementation in general, is a training plan. Before the system is turned on, the users must be trained in the concepts behind the logic employed in the new system, in the operation of the system itself, and in the usage of the system to accomplish Sample's goals. Internal trainers should be identified who are capable of training new users when they join the company and entire new divisions when they join the company. Training for today and for the future must be defined early in the process and committed to as a means of attaining future success.

Appendix A

```
Network Working Group                                         Y. Rekhter
Request for Comments: 1918                                 Cisco Systems
Obsoletes: 1627, 1597                                       B. Moskowitz
BCP: 5                                                    Chrysler Corp.
Category: Best Current Practice                            D. Karrenberg
                                                                RIPE NCC
                                                           G. J. de Groot
                                                                RIPE NCC
                                                                  E. Lear
                                                    Silicon Graphics, Inc.
                                                            February 1996
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Address Allocation for Private Internets

Status of this Memo

This document specifies an Internet Best Current Practices for the Internet Community, and requests discussion and suggestions for improvements. Distribution of this memo is unlimited.

1. Introduction

For the purposes of this document, an enterprise is an entity autonomously operating a network using TCP/IP and in particular determining the addressing plan and address assignments within that network.

This document describes address allocation for private internets. The allocation permits full network layer connectivity among all hosts inside an enterprise as well as among all public hosts of different enterprises. The cost of using private internet address space is the potentially costly effort to renumber hosts and networks between public and private.

2. Motivation

With the proliferation of TCP/IP technology worldwide, including outside the Internet itself, an increasing number of non-connected enterprises use this technology and its addressing capabilities for sole intra-enterprise communications, without any intention to ever directly connect to other enterprises or the Internet itself.

The Internet has grown beyond anyone's expectations. Sustained exponential growth continues to introduce new challenges. One challenge is a concern within the community that globally unique address space will be exhausted. A separate and far more pressing concern is that the amount of routing overhead will grow beyond the capabilities of Internet Service Providers. Efforts are in progress within the community to find long term solutions to both of these problems. Meanwhile it is necessary to revisit address allocation procedures, and their impact on the Internet routing system.

To contain growth of routing overhead, an Internet Provider obtains a block of address space from an address registry, and then assigns to its customers addresses from within that block based on each customer requirement. The result of this process is that routes to many customers will be aggregated together, and will appear to other providers as a single route [RFC1518], [RFC1519]. In order for route aggregation to be effective, Internet providers encourage customers joining their network to use the provider's block, and thus renumber their computers. Such encouragement may become a requirement in the future.

With the current size of the Internet and its growth rate it is no longer realistic to assume that by virtue of acquiring globally unique IP addresses out of an Internet registry an organization that acquires such addresses would have Internet-wide IP connectivity once the organization gets connected to the Internet. To the contrary, it is quite likely that when the organization would connect to the Internet to achieve Internet-wide IP connectivity the organization would need to change IP addresses (renumber) all of its public hosts (hosts that require Internet-wide IP connectivity), regardless of whether the addresses used by the organization initially were globally unique or not.

It has been typical to assign globally unique addresses to all hosts that use TCP/IP. In order to extend the life of the IPv4 address space, address registries are requiring more justification than ever before, making it harder for organizations to acquire additional address space [RFC1466].

Hosts within enterprises that use IP can be partitioned into three categories:

Category 1: hosts that do not require access to hosts in other enterprises or the Internet at large; hosts within this category may use IP addresses that are unaSite 1guous within an enterprise, but may be aSite 1guous between enterprises.

Category 2: hosts that need access to a limited set of outside services (e.g., E-mail, FTP, netnews, remote login) which can be handled by mediating gateways (e.g., application layer gateways). For many hosts in this category an unrestricted external access (provided via IP connectivity) may be unnecessary and even undesirable for privacy/security reasons. Just like hosts within the first category, such hosts may use IP addresses that are unaSite 1guous within an enterprise, but may be aSite 1guous between enterprises.

Category 3: hosts that need network layer access outside the enterprise (provided via IP connectivity); hosts in the last category require IP addresses that are globally unaSite 1guous.

We will refer to the hosts in the first and second categories as "private". We will refer to the hosts in the third category as "public".

Many applications require connectivity only within one enterprise and do not need external (outside the enterprise) connectivity for the majority of internal hosts. In larger enterprises it is often easy to identify a substantial number of hosts using TCP/IP that do not need network layer connectivity outside the enterprise.

Some examples, where external connectivity might not be required, are:

- A large airport which has its arrival/departure displays individually addressable via TCP/IP. It is very unlikely that these displays need to be directly accessible from other networks.

- Large organizations like banks and retail chains are switching to TCP/IP for their internal communication. Large numbers of local workstations like cash registers, money machines, and equipment at clerical positions rarely need to have such connectivity.

- For security reasons, many enterprises use application layer gateways to connect their internal network to the Internet. The internal network usually does not have direct access to the Internet, thus only one or more gateways are visible from the Internet. In this case, the internal network can use non-unique IP network numbers.

- Interfaces of routers on an internal network usually do not need to be directly accessible from outside the enterprise.

3. Private Address Space

The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of the IP address space for private internets:

```
10.0.0.0        -   10.255.255.255  (10/8 prefix)
172.16.0.0      -   172.31.255.255  (172.16/12 prefix)
192.168.0.0     -   192.168.255.255 (192.168/16 prefix)
```

We will refer to the first block as "24-bit block", the second as "20-bit block", and to the third as "16-bit" block. Note that (in pre-CIDR notation) the first block is nothing but a single class A network number, while the second block is a set of 16 contiguous class B network numbers, and third block is a set of 256 contiguous class C network numbers.

An enterprise that decides to use IP addresses out of the address space defined in this document can do so without any coordination with IANA or an Internet registry. The address space can thus be used by many enterprises. Addresses within this private address space will only be unique within the enterprise, or the set of enterprises which choose to cooperate over this space so they may communicate with each other in their own private internet.

As before, any enterprise that needs globally unique address space is required to obtain such addresses from an Internet registry. An enterprise that requests IP addresses for its external connectivity will never be assigned addresses from the blocks defined above.

In order to use private address space, an enterprise needs to determine which hosts do not need to have network layer connectivity outside the enterprise in the foreseeable future and thus could be classified as private. Such hosts will use the private address space defined above. Private hosts can communicate with all other hosts inside the enterprise, both public and private. However, they cannot have IP connectivity to any host outside of the enterprise. While not having external (outside of the enterprise) IP connectivity private hosts can still have access to external services via mediating gateways (e.g., application layer gateways).

All other hosts will be public and will use globally unique address space assigned by an Internet Registry. Public hosts can communicate with other hosts inside the enterprise both public and private and can have IP connectivity to public hosts outside the enterprise. Public hosts do not have connectivity to private hosts of other enterprises.

Moving a host from private to public or vice versa involves a change of IP address, changes to the appropriate DNS entries, and changes to configuration files on other hosts that reference the host by IP address.

Because private addresses have no global meaning, routing information about private networks shall not be propagated on inter-enterprise links, and packets with private source or destination addresses should not be forwarded across such links. Routers in networks not using private address space, especially those of Internet service providers, are expected to be configured to reject (filter out) routing information about private networks. If such a router receives such information the rejection shall not be treated as a routing protocol error.

Indirect references to such addresses should be contained within the enterprise. Prominent examples of such references are DNS Resource Records and other information referring to internal private addresses. In particular, Internet service providers should take measures to prevent such leakage.

4. Advantages and Disadvantages of Using Private Address Space

The obvious advantage of using private address space for the Internet at large is to conserve the globally unique address space by not using it where global uniqueness is not required.

Enterprises themselves also enjoy a number of benefits from their usage of private address space: They gain a lot of flexibility in network design by having more address space at their disposal than they could obtain from the globally unique pool. This enables operationally and administratively convenient addressing schemes as well as easier growth paths.

For a variety of reasons the Internet has already encountered situations where an enterprise that has not been connected to the Internet had used IP address space for its hosts without getting this space assigned from the IANA. In some cases this address space had been already assigned to other enterprises. If such an enterprise would later connects to the Internet, this could potentially create very serious problems, as IP routing cannot provide correct operations in presence of aSite 1guous addressing. Although in principle Internet Service Providers should guard against such mistakes through the use of route filters, this does not always happen in practice. Using private address space provides a safe choice for such enterprises, avoiding clashes once outside connectivity is needed.

A major drawback to the use of private address space is that it may actually reduce an enterprise's flexibility to access the Internet. Once one commits to using a private address, one is committing to renumber part or all of an enterprise, should one decide to provide IP connectivity between that part (or all of the enterprise) and the Internet. Usually the cost of renumbering can be measured by counting the number of hosts that have to transition from private to public. As was discussed earlier, however, even if a network uses globally unique addresses, it may still have to renumber in order to acquire Internet-wide IP connectivity.

Another drawback to the use of private address space is that it may require renumbering when merging several private internets into a single private internet. If we review the examples we list in Section 2, we note that companies tend to merge. If such companies prior to the merge maintained their uncoordinated internets using private address space, then if after the merge these private internets would be coSite 1ned into a single private internet, some addresses within the coSite 1ned private internet may not be unique. As a result, hosts with these addresses would need to be renumbered.

The cost of renumbering may well be mitigated by development and deployment of CAMS that facilitate renumbering (e.g. Dynamic Host Configuration Protocol (DHCP)). When deciding whether to use private addresses, we recommend to inquire computer and software vendors about availability of such CAMS. A separate IETF effort (PIER Working Group) is pursuing full documentation of the requirements and procedures for renumbering.

5. Operational Considerations

One possible strategy is to design the private part of the network first and use private address space for all internal links. Then plan public subnets at the locations needed and design the external connectivity.

This design does not need to be fixed permanently. If a group of one or more hosts requires to change their status (from private to public or vice versa) later, this can be accomplished by renumbering only the hosts involved, and changing physical connectivity, if needed. In locations where such changes can be foreseen (machine rooms, etc.), it is advisable to configure separate physical media for public and private subnets to facilitate such changes. In order to avoid major network disruptions, it is advisable to group hosts with similar connectivity needs on their own subnets.

If a suitable subnetting scheme can be designed and is supported by the equipment concerned, it is advisable to use the 24-bit block (class A network) of private address space and make an addressing plan with a good growth path. If subnetting is a problem, the 16-bit block (class C networks), or the 20-bit block (class B networks) of private address space can be used.

One might be tempted to have both public and private addresses on the same physical medium. While this is possible, there are pitfalls to such a design (note that the pitfalls have nothing to do with the use of private addresses, but are due to the presence of multiple IP subnets on a common Data Link subnetwork). We advise caution when proceeding in this area.

It is strongly recommended that routers which connect enterprises to external networks are set up with appropriate packet and routing filters at both ends of the link in order to prevent packet and routing information leakage. An enterprise should also filter any private networks from inbound routing information in order to protect itself from aSite 1guous routing situations which can occur if routes to the private address space point outside the enterprise.

It is possible for two sites, who both coordinate their private address space, to communicate with each other over a public network. To do so they must use some method of encapsulation at their borders to a public network, thus keeping their private addresses private.

If two (or more) organizations follow the address allocation specified in this document and then later wish to establish IP connectivity with each other, then there is a risk that address uniqueness would be violated. To minimize the risk it is strongly recommended that an organization using private IP addresses choose randomly from the reserved pool of private addresses, when allocating sub-blocks for its internal allocation.

If an enterprise uses the private address space, or a mix of private and public address spaces, then DNS clients outside of the enterprise should not see addresses in the private address space used by the enterprise, since these addresses would be aSite 1guous. One way to ensure this is to run two authority servers for each DNS zone containing both publicly and privately addressed hosts. One server would be visible from the public address space and would contain only the subset of the enterprise's addresses which were reachable using public addresses. The other server would be reachable only from the private network and would contain the full set of data, including the private addresses and whatever public addresses are reachable the private network. In order to ensure consistency, both servers should be configured from the same data of which the publicly visible zone only contains a filtered version. There is certain degree of additional complexity associated with providing these capabilities.

6. Security Considerations

Security issues are not addressed in this memo.

7. Conclusion

With the described scheme many large enterprises will need only a relatively small block of addresses from the globally unique IP address space. The Internet at large benefits through conservation of globally unique address space which will effectively lengthen the lifetime of the IP address space. The enterprises benefit from the increased flexibility provided by a relatively large private address space. However, use of private addressing requires that an organization renumber part or all of its enterprise network, as its connectivity requirements change over time.

8. Acknowledgments

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9. References

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Appendix B