Distributed computing--an application for a small business
by David Charles Marshall

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science
Montana State University

Abstract:
Distributed computing systems are growing rapidly in their use in business applications. Geographically dispersed businesses have a need for distributed computing ability with interprocessor communication. Yellowstone Park Service Stations is a remote, geographically dispersed business with the special problem of operating with a six month business season. This thesis discusses the possible application of distributed computer systems to Yellowstone Park Service Stations.

A feasibility and background study of the company and its current situation was done. This was followed by a discussion of current design criteria for distributed systems. It includes interconnect schemes, routing and software protocol level tradeoffs. Special attention was paid to the tradeoffs involved with each of the design choices. The tradeoffs were then analyzed to find the best fit for the application. It was recommended that a network of microcomputers, interconnected through the telecommunications system, is the best choice for the company. Finally, particular systems are recommended for the application.

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Nov 30 1982
Date

Michael A Lassner
Chairperson, Graduate Committee

Approved for the Major Department

Nov. 30, 1982
Date

Wesley Faulkner for D.A. Pierre
Head, Major Department

Approved for the College of Graduate Studies

12-6-82
Date

Michael P. Malone
Graduate Dean

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ABSTRACT

Distributed computing systems are growing rapidly in their use in business applications. Geographically dispersed businesses have a need for distributed computing ability with interprocessor communication. Yellowstone Park Service Stations is a remote, geographically dispersed business with the special problem of operating with a six month business season. This thesis discusses the possible application of distributed computer systems to Yellowstone Park Service Stations.

A feasibility and background study of the company and its current situation was done. This was followed by a discussion of current design criteria for distributed systems. It includes interconnect schemes, routing and software protocol level tradeoffs. Special attention was paid to the tradeoffs involved with each of the design choices. The tradeoffs were then analyzed to find the best fit for the application. It was recommended that a network of microcomputers, interconnected through the telecommunications system, is the best choice for the company. Finally, particular systems are recommended for the application.

CHAPTER ONE

INTRODUCTION

The purpose of this thesis is to explore potential computer opportunities for a unique business situation. The Yellowstone Park Service Stations (hereafter known as YPSS), is a small business located in a national park. It is highly diverse in location and somewhat remote. This situation gives it unique problems in effectively computerizing its accounting, inventory, payroll, and budget functions. The primary emphasis of the thesis, therefore, will be to find a system that can solve the communication problems cost effectively.

Poor communication lines, caused by the remoteness, focused the research on computer networks, since they can handle retransmission and prolonged broken communication while remote terminals cannot. The paper is divided into three major chapters. Chapter Two is a description of the current practices of the company. This includes their inherent problems as well as a list of priorities for improvement.

The third chapter is a survey of various types of networks. It contains a discussion of network performance and evaluation criteria.

The fourth chapter deals with a search of potential business systems for the most effective system for YPSS's application. This includes some practical and theoretical design criteria as well as an evaluation of currently available products.

CHAPTER TWO

FEASIBILITY STUDY

Yellowstone Park Service Stations' primary business is operating nine full service gas stations and four auto repair services in Yellowstone National Park.

The business is highly seasonal. Almost all of the business occurs in June, July, and August. A small amount of business begins in May and remains in September and October. Business is virtually nonexistent in November, December, and April, while during January through March a small amount of snowmobile gas is sold. Consequently, the summer finds 150 to 175 employees at 15 locations. In the spring and fall seasons there are approximately 30 to 60 employees at 4 to 8 locations. In the winter, 3 to 8 employees are at 1 to 3 locations.

The business is also geographically dispersed over 90 highway miles in two states. A round trip, from the office to all the stations and back, is about 170 miles and takes about six hours due to traffic. From November 1 to April 30 no road travel is allowed, with the exception of snowmobiles. This leads to communication problems, especially since the telephone service is notoriously poor.

The facilities themselves vary greatly. Built between 1910 and 1970, they range from corrugated metal and wood sheds to modern, large scale (heated) service facilities. Inside temperatures in many locations vary from 0 F to 100 F in the summer and from -60 F to 40 F in the winter. They are located at altitudes of between 5000 and 8000 feet above sea level.

The employees, due to the seasonal nature of the jobs, are primarily college students. Most of them work for only one or two summers (a total of three to six months). Even

seasonal management and office help seldom work more than five or six seasons (two to three years). There are only three permanent employees (see Figure 2), so there is a massive training problem each spring.

At the present time all accounting and business functions are done manually in ledgers. The exceptions are the general ledger, the financial reports based on it, and the payroll. These are sent (individually) for outside data processing in Helena, Montana. The cost is approximately $6,000 per year.

The accounting, inventory, and payroll processes all begin at the various locations each night. The station personnel collect all the raw data needed to summarize the day's business. This includes delivery and transfer tickets, payroll information, pump readings, cash, credit and charge tickets, labor tickets, a list of all accessories (non-fuel items) sold that day, an inventory of all oil and several other products, and the cash register tape. Depending on the location, this may take from one half hour to one and one-half hours of management's time. The next day the reports are picked up by a vehicle circling the Park and delivered to the main office in Gardiner.

During the two to four days following the data collection, a clerk in the office rechecks figures, and calculates total sales in all categories, totals receipts, and an over/short figure. (See report form in Appendix B). Sometime during the fourth through seventh days the report is returned to the station. This means that it can be up to a week before the management at a station knows the day's results. On a twelve to fourteen week "season," this is a long wait. The delay also eliminates any opportunity to catch errors, so they are usually allowed to "bounce" from day to day resulting in erratic and unreliable daily reports.

In the office, this one week delay introduces a delay in generating financial reports. The "current data" is four days old before it is usable. An even further delay, however, is introduced by having the payroll and general ledger done by mail in Helena. The general ledger is thus only updated once a month at a very significant expense. Also, the payroll

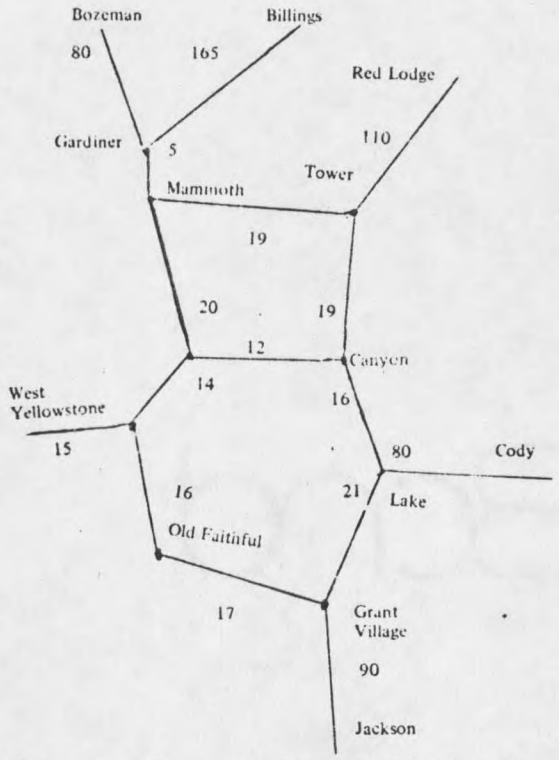

Figure 1. Diagram of YPSS facility locations.

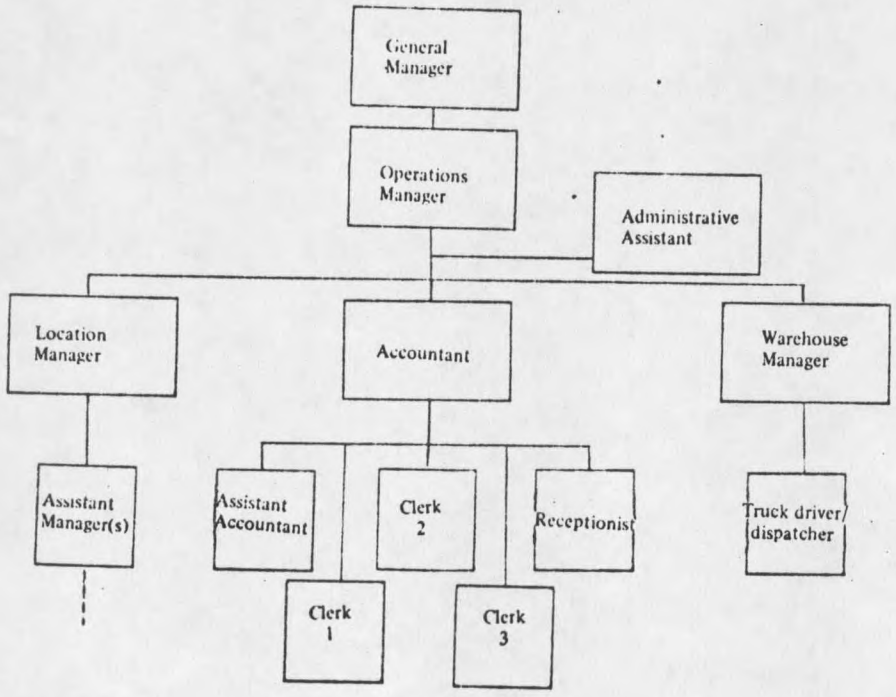

Figure 2. YPSS management structure.

must be complete for the month before the general ledger is sent in to be updated. A delay of approximately one week on the payroll, plus another delay of almost a week on the ledger, means all financial reports are two weeks behind. In a business with a three month operating season, the year is one half over by the time the first financial report is seen. This practice eliminates any flexibility that management has in making decisions based on financial reports during the summer. The reports only can summarize the results after the summer is over.

The primary cost of the outside report and payroll processing, the key punch personnel time,[1] is to redo what has already been done at YPSS. They simply type the data that YPSS sends to them. Thus, not only is there the risk of introducing new errors, but the company pays for the duplication of effort.

The payroll is also sent for outside processing. Verification of time cards and the quantification of hours, meals, etc., is one of the most time consuming processes for the staff. Although this preparation time cannot be reasonably reduced, virtually all delay incurred after that could be eliminated. Currently, it takes about two days to prepare the payroll information, then five to six days for processing (including mailing time), and, finally, an additional two to three days for distribution. This is a total of ten to eleven days. Without the mail time and duplicated effort, certainly four to five days would be an attainable goal for the entire process. In addition to saving duplication of effort, the reduced delay would increase employee good will. Cash advance requests are available to employees who need money before their paycheck arrives. These requests should be reduced substantially by a more timely payroll process, which would save the office staff time. The reduction from eight or nine days down to three days for producing the payroll would make all of the general ledger reports approximately one week more current.

Several activities in addition to those mentioned above also deserve to be considered for computerization. Accounts receivable and accounts payable, for example, would bene-

fit from computerization. The volume of accounts payable is very small, perhaps twenty to thirty accounts over the course of a year. The company's bills are nearly always paid as received so there is little activity. However, they still must be posted to the general ledger. Accounts receivable is different. About 250 accounts are current and perhaps 100 charges per day are posted during the summer. Bills are then produced manually. Automatic bill generation would speed this process substantially.

The annual budget is another function which is currently sent out for processing. This takes virtually no "computing power" to accomplish. In that sense it is wasted money on an outside service. Again, the primary limitation of this process is timing. It takes at least one week, and up to two weeks, to see a budget comparison with the year-to-date situation. Some decisions could benefit by more current knowledge of the situation (expenses or sales) versus the budget estimates.[2]

Other areas that could benefit from computerization are the warehouse and station inventories. Currently, the stations are inventoried completely at the end of the year and daily on about ten items. Tires and batteries are inventoried early in the summer and, occasionally, again later in the summer. One office employee makes an effort to keep the tire and battery inventories up-to-date for all locations. They are usually close to correct, but rarely exact enough for ordering or locating critical items. During the months from June to September, a quick, accurate source of the location of items (especially tires and batteries) is important to station personnel trying to make a sale. Inventory is kept low (very low in September). Locating the required product quickly and accurately may mean making the sale. Often the customer will not wait for nine to ten locations to be called, have their inventory checked, and return an answer.

Sales could be increased with one accurate and easily available inventory by allowing timely updating of inventories in the spring. Each fall (from mid-August on) inventory quantities are allowed to drop on all items. Little or no reordering is done. Business is low

from mid-September until the end of the year so missed sales are minimal. May is not a critical month either, since business is still relatively slow. It would be beneficial to moderately rebuild inventories at this time, however.

In June, sales increase dramatically, often before management rebuilds the inventory levels. Sales reach peak summer levels by July 1. Any low inventories during this period can cause enough lost sales to significantly affect a station's profit for the summer. After managers arrive (about June 1-10), their first priorities are cleaning and fixing the station for the summer and training employees. Ordering inventory is based primarily on the manager's wishes and is often not done until late in the month. This is especially true for new management personnel, who often make up a substantial percentage of the total number of managers. They frequently are unfamiliar with the items that particular station can sell or has sold in the past. By late June, they have begun to realize what sales are being missed, but by early July when the items arrive, many sales have been lost. This could amount to as much as one-third of the summer's sales of a product at that location.

An easily available list of all current inventories, with the last one or two years' sales, could eliminate much of the problem. It would allow the office staff to establish an approximate inventory level for each location in May, based on previous sales and current (exact) inventory levels. Yet it would not require taking a physical inventory at that time. It also would allow new management to order quickly and accurately when they arrive. They would not need to guess at previous sales levels or spend time taking inventory to find out what present levels are.

Warehouse inventory is currently maintained on index cards. While accurate, this is a tedious job and often falls behind by a few days. Automatic updates based on invoices and shipments would be desirable. Also, retrieval by office staff of the quantity of an item currently on hand would be improved. No automatic mechanism is currently present to alert management to low inventory levels. To check all current levels each file must be syste-

matically pulled. A short, quick summary would save time and allow more frequent evaluation of inventory levels.

Another central office function of interest is the dispatching of wreckers and service trucks to disabled vehicles. All service calls in the Park must be authorized and dispatched by a central communications center. During the day, this center is the YPSS office. At night, it is the National Park Service. Each request is logged (see the wrecker dispatch form in Appendix B). While this process would not be readily improved by automation, it would be of significant interest and value to be able to compile statistics on these calls. Questions such as: How many calls? Where to? At what time?, etc., would provide valuable information. The road service business is not very profitable largely because 10 to 20% of the calls are "dry runs" (no vehicle there). The ability to easily compile statistics on these calls should make them easier to reduce, thus limiting wasted money and time. For example, wreckers might be more optimally located than they are. Certain types or locations of calls might be prone to being "dry runs." Perhaps a better way to verify these calls might then be able to be used.

The final area of possible improvement is in the office paperwork. Currently, memory typewriters and copy machines are used. While these perform adequately, a memory typewriter does not have the speed or editing capabilities of a text editor. This is not a major problem, but a computer certainly could decrease the time spent on outgoing communications while increasing their quality. Copies with very minor changes can be produced more easily. It also would allow display of the text before a printed copy is generated.

A list of the reports required for the various functions mentioned above is found in Appendix A. In general, these reports follow current accounting practices and standards. Some reports are completely unique to YPSS, however. These include the location reports, the year-to-year comparison reports, the gas delivery ledger, and the wrecker dispatch log. Several of these forms are found in Appendix B.

YPSS management has discussed several priorities for improvement that would be helped by automation. There are other improvements which could be made that as yet have not been defined as problems. The management's priorities are to:

1. Reduce office staff to save money.
2. Eliminate outside processing.
3. Increase error checking abilities.
4. Reduce computational errors.
5. Reduce time spent on reports by station personnel.
6. Provide more up-to-date inventory (especially on tires).

Other areas where the computer could improve operations are to:

7. Obtain more current data on financial reports for decision making.
8. Obtain a complete, current inventory with sales information, resulting in more timely ordering capabilities.
9. Compensate (both at the station and in the office) for untrained personnel by using faster and simpler procedures. (This could include things like being able to correct report "bounces" from bad data immediately and having less office paper-work forms).
10. Obtain ability to query for answers from the wrecker dispatch log, reducing dry runs.
11. Obtain faster and neater text editing capability.
12. Allow the generation of new reports and summaries in the future from present information with little or no office overhead.

The present system appears to work quite adequately for the company at this time. However, there are problems that could restrict growth. This system offers almost no chance of being flexible enough to reduce the time, effort, or expense involved in process-

ing the accounting functions at a future date. In fact, an additional report requires a significant addition to the office staff's workload, whether it requires new data or not.

The primary areas of a computer's expertise are in speed, extra computing ability (i.e., summarizing and calculating ability), and in reduction of errors. All of these could be achieved to a greater degree than they are with the present manual system. These improvements would help to reduce or eliminate the problems mentioned above.

YPSS's need for computer service can be divided into four basic levels of development. Although they may be done all at once, or separately, any system which implements less than the total should be expandable to include the entire system.

The first step is to get a small office system with editor, ledger, payroll, inventory, and budget functions (inside dashed line on data flow chart in Appendix A). This would be a microcomputer, hard disk, CRT, printer, and possibly a tape backup. All software would be purchased.

The second step would be to expand this to a total main office system. This would not include any extra hardware, but would include all of the software on the data flow chart. The additional software would probably need to be custom written.

Step three would be to locate microcomputers at the remote locations. Communications hardware and software would be needed to relay the data collected at the remote locations to the main office system. This would enhance station access to data. It would also eliminate the data duplication from the location report to the computer because station personnel would enter data directly. Feedback on errors could increase greatly because station personnel would receive instantaneous results from their data.

Step four would be to incorporate point-of-sale cash registers and automatically read pumps into the location microcomputers. This would reduce both data gathering time and the errors associated with it. This step would also greatly reduce the time that station personnel spend on paperwork.

Several factors suggest it would be prudent to implement this plan slowly. First, YPSS management traditionally has been fiscally quite conservative. They prefer to stay with a trusted procedure rather than to commit to a capital expenditure that might produce future headaches. A huge investment would be a large commitment to something very unfamiliar. This is an important consideration since without active management support any system is likely to be unsuccessful.[3] YPSS would tend to agree with Robert Townsend that, "I've never known a company seriously hurt by automating too slowly, but there are some classical cases of companies bankrupted by computerizing prematurely".[4]

A second reason for slow implementation is that few employees remain for the winter. All training must be done during the busy summer season. This would be more easily accomplished if only one new section of the system had to be implemented and taught to personnel each summer.

A third reason will be seen from the cost benefit analysis. The local office system has the shortest payback period. Adding remote data collection has the largest capital investment. This is especially true if the cost of point-of-sale registers, electronic pumps, and heated offices is included. Eventually all locations will probably have new buildings with electronic pumps. However, this is still in the future for many of them. The size of the investment for the remote locations makes pausing after complete office automation logical. The office would be essentially computerized but nothing would be committed elsewhere. To have the payback period be reasonable, the computerizing of the remote locations needs to wait until point-of-sale registers are bought and the locations are upgraded. This could be five to ten years away. Although step three could be accomplished separately (just remote microcomputers), its payback period would be relatively long if point-of-sale data collection did not occur within the next several years. These two divisions—office automation and remote data gathering—correspond to the two major data gathering options described by Birkle and Yearsley in *Computer Applications in Management* (p. 63).

Cost-Benefit Analysis

The primary needs of the company with regard to a system to purchase are listed below in approximate priority order:

1. Low cost. This is vital to purchase approval.
2. Short term payback period. This is needed since present accounting costs are not high.
3. Ease of use. Since it will be used by primarily short term, untrained personnel, anything requiring a knowledge of computers or learning extensive command sets will be prohibitive.
4. Serviceability. This is most vital in the summer. It would be most desirable to have a contract for the summer with fast (one day) service on both hardware and software. In the winter it could be cheaper, slower service since needs are not as pressing.
5. Audit ability. It must meet accepted accounting standards for document traceability.
6. Ability to be networked with other computers and cash registers.
7. Ease of programming. This is important since all program maintenance and modifications done at YPSS must be done by non-programming personnel and since custom programming costs must be kept to a minimum.
8. Ability to expand memory and peripherals. This would be needed if the business expanded substantially in the next ten years or if more processing requirements were introduced.

As in any business venture, price and justifiability (payback period) are preeminent. This means justifying purchase price, and training and operating costs, in terms of reduced costs in the problem areas listed above.

Both major system divisions, office computerization and remote data collection, were analyzed for costs and benefits for a five year period. This is the generally accepted life of an information system.[5] The life at YPSS should be much longer (at least ten years), with only minor changes, since the business is not in a fast growth situation and has limited needs for most of the year.

Benefit Analysis

The Benefit Analysis was made for two overall system types. First, it was done for buying a standard pre-packaged accounting system. In the third year, modules would be added to do location reports and automatic ledger updating, as well as "peripheral" reports such as gas inventory, wrecker dispatching, and year-to-year sales comparisons.

Table 1. Local Office System Benefits

	Year				
	1	2	3	4	5
Sales increase	0	600	1,500	2,000	2,500
Outside process saving	0	6000	6,000	6,000	6,000
Office staff reduction	0	2400	4,800	4,800	4,800
Totals	0	9000	12,300	12,800	13,800
Cumulative totals	0	9000	21,300	35,100	48,900

The sales increase is an estimate based on two factors. One is the speed and accuracy of looking up a request for an item for a customer. The other factor is more timely ordering by both the warehouse and the stations based on their known inventory and past sales. By year five, this is estimated to be 100 tires over the course of the year, or about one every other day someplace in the Park. I believe this is a reasonable estimate of the number of missed sales on batteries and tires due to problems caused by distributing these items. The figure would run even higher if the improvement in inventory causes personnel to be more confident and aggressive in pursuing sales.

The benefit resulting from outside processing reduction is the elimination of the need for that service. Primarily this savings is in eliminating the extra person involved in translating that data. No benefits were estimated for year 1 assuming that a year might be spent testing results against current practice. If not, benefits would begin immediately.

Office staff reduction is based on the elimination of some location report work (specifically report calculations, elimination of the sales journal, and some hand calculations on gas reports and the year to year comparison report). Also, inventory cards for the warehouse would be eliminated. The reduction was calculated from an estimated cost for a report clerk at $7.00 per hour for 16 weeks, or $4800 per year.

Not quantified for either this or the following benefit analysis are those benefits received by more current financial information, reduction of errors and station "bounces," or benefits gained from improved knowledge about wrecker dispatches.

The second benefit analysis is for a complete system. This would include point-of-sale cash registers, pumps tied to the computer, and all data entry at the time of sale by the cash register (propane, charges, credit, etc.).

Table 2. Point-of-Sale System Benefits

	Year				
	1	2	3	4	5
Sales increase	0	1,000	2,000	2,500	3,000
Outside process saving	0	6,000	6,000	6,000	6,000
Station staff reduction	0	1,000	1,500	1,500	1,500
Office staff reduction	0	4,800	9,600	12,000	12,000
Totals	0	12,800	19,100	22,000	22,500
Cumulative totals	0	12,800	31,900	53,900	76,100

Sales increase is as before, with a minor addition due to a more current knowledge of all products stocked at the stations, not just tires and batteries. Current information on how all products are selling around the Park would be available.