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THE DESIGN OF A STAND-ALONE MINICOMPUTER SYSTEM FOR A SAVINGS AND LOAN ASSOCIATION

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee

James R. White

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ABSTRACT

This thesis analyzes a savings and loan association's requirements for computer support. A comparison between support by a service organization and an in-house system is made, an in-house system is designed and a vendor is selected. The applications software package is discussed and communications and maintenance requirements are analyzed.

This investigation was conducted during the spring of 1975 for an actual savings and loan association. At this writing the system is being installed as designed herein.

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CHAPTER I

INTRODUCTION

I. THE ASSOCIATION

The savings and loan association in this investigation is located in the greater Washington, D.C. area and is close to the median in size of the 4,600 plus associations in the United States (1).[1] Its assets total about 50 million dollars and it has some 12,000 savings accounts and holds just over 2,000 loans. The association presently has one main office and one branch and has made application to open a second branch. All locations are within a three mile radius. The association, which presently employs 27 persons, underwent a change in management in the spring of 1975. The new president immediately embarked on a course to minimize the cost of servicing each account in a manner consistent with high quality service. A lawyer by trade, this president had had significant exposure to electronic data processing (EDP), having helped set up an automated judicial administration system for the state of Alaska. This experience undoubtedly made him more aware of the capabilities of automation than most top managers.

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[1] Numbers in parentheses refer to similarly numbered references in the bibliography

II. CURRENT EDP SUPPORT

At the time this investigation began, the association had four teller terminals on-line to a service organization in Pittsburgh, Pennsylvania. Only savings accounts were being handled on-line. Loans and general ledger accounts were being handled in-house using an IBM magnetic ledger card unit and the payroll was being processed by a service organization in Washington, D.C. Reports on the savings accounts were generated in Pittsburgh and mailed to the association. For these services the association was paying approximately $4,000 per month. The breakdown of expenses is shown in Table I. Further, this cost was to increase significantly within the next few months as the association was paying only 4.75 cents service charge per savings account per month under an old contract. This cost was to increase to 9 cents per account per month as soon as the old contract expired. This would increase the monthly cost by about $500.

The association had an immediate requirement for upgraded computer support. First, automated service for loans was required. Second, the president wanted access to management information to aid in decision making. It was also realized that the association could handle its own general ledger accounts and payroll at little or no extra cost if the best solution to their primary problems proved to be an in-house computer. In addition, the association

TABLE I

MONTHLY COMPUTER SERVICE COSTS AS OF THE BEGINNING OF INVESTIGATION

Service Charges	$653
Leased Phone Lines	273
Modem Rental	921
Terminals	1,335
IBM 6400	298
Maintenance (IBM 6400)	198
Maintenance (Terminals)	284
Payroll	100
Total	$4,062

wanted a system which would permit expansion. Lastly, it was realized that the association was probably paying too much for the EDP service it was getting.

The service organization which was providing the association its EDP service was unable to provide the additional service required. Therefore, the problem was to find another service organization or to install an in-house computer system.

III. SCOPE AND ORGANIZATION

This study deals with the computer system which was designed to meet the needs of the savings and loan association. In Chapter II, a comparison between service organization support and in-house support is made. The design of an in-house system is discussed in Chapter III and the method by which a computer vendor was chosen is described in Chapter IV. Chapter V is concerned with the applications software package and Chapters VI and VII consider the communications equipment and systems' maintenance. The research is summarized in Chapter VIII.

CHAPTER II

IN-HOUSE SYSTEM OR SERVICE ORGANIZATION

I. FACTORS TO BE CONSIDERED

When the need to upgrade the quality of computer support came under consideration, a wide range of options presented itself. These included service by other service organizations or the purchase or rental of an in-house system. The first order of business, therefore, was to determine which was the better course of action--to switch to another service organization or to install an in-house system. This decision could not be made, of course, without simultaneously making a tentative choice of an in-house system for comparison with the service organization. First, however, the factors which were to be considered were isolated.

The first and most obvious factor was cost. Care had to be exercised in measuring costs since it was impossible to get a simple one-for-one comparison of services. Both alternatives involved buying or renting terminals and interface modems and communications costs. In addition, the service organizations charged for each service provided on a per account basis. The in-house alternative involved hardware and software costs on a rental or purchase basis.

Closely related to cost was the quality of service which each alternative could provide. Three factors were considered. These were timeliness, flexibility and reliability. Consideration was also given to security and future operations.

The management aspects of the problem were thoroughly considered. On the one hand, the in-house system would offer management the opportunity to gather almost any sort of information desired, while the service organization would provide only standard types of information of the same type as that available to competing organizations. On the other hand, an in-house system would impose a greater demand on management for implementation and maintenance than would a service organization. The service organization with its EDP staff and its EDP maturity could be expected to take most of the EDP burden off the savings and loan association and leave their management free to concentrate on the savings and loan business.

II. SERVICE ORGANIZATION: ADVANTAGES AND DISADVANTAGES

Several service organizations were considered. Two, in addition to the one then providing the service, were explored in detail. One was a large nationwide organization specializing in data processing for the thrift industry. This organization will hereinafter be referred to as Organization X. The second was a savings and loan organization

hereinafter called Organization Y, which was located in the local area and offered service from its large computer to other associations. The closest service center of Organization X was located in New York and they proposed service from that site. Organization X appeared to be well staffed and highly competent in their field. One of their customer associations was interviewed at some length and was quite happy with the service being received. This customer association was quite large (some 400,000 accounts) and had previously had its own in-house system but had switched to the service organization because, to quote one of its officers:

> It just never seemed to work properly. The solution to all our problems always seemed to be to buy more equipment. Soon we had a large EDP installation with its own staff which was difficult to manage properly. We knew the technology was changing and we (the bank's management) just couldn't keep up with it. Now we are getting good service and are very happy to have this management burden taken from us.

Organization X used an IBM 360 computer. Monthly costs for service by Organization X were estimated as shown in Table II. This estimate was predicated upon using a controller (actually a mini-computer) at the savings and loan association as a data collector and interface mechanism between the local terminals and the central computer. This was not mandatory but was the most economical approach since the alternative was to lease separate communications lines for each terminal. With this approach in mind, the equipment and other one-time costs were computed (Table III).

TABLE II

ESTIMATED MONTHLY COSTS FOR SERVICE BY ORGANIZATION X

Service Charge	
.10 per savings account (12,000 accounts)	$1,200
.20 per loan (2,000 loans)	400
Management information package	700
Other miscellaneous accounts (general ledger, etc.)	224
Communications Cost	
One long distance line, three locals, including modems	677
Total	$3,201

TABLE III

ESTIMATED ONE-TIME COSTS FOR SERVICE BY ORGANIZATION X

1 Controller	$17,025
6 Teller Terminals	46,845
1 CRT	3,350
2 Administrative Keyboards	2,410
1 Thermal Printer	2,900
Conversion Charge	3,000
Total	$75,530

Service by Organization X could be expected to be excellent. New technology would be introduced when appropriate, and changing requirements, due to Federal Law, would be promptly implemented. Some information on accounts could be obtained on-line via CRT and thermal printer. The lengthy written reports, however, would be printed at the service center and sent by air to County Federal. Overnight delivery service could be expected.

Organization Y, which was in the local area, had the obvious advantage of reduced communications cost. Although its EDP staff was much smaller, it did have considerable maturity in on-line service and was handling several other savings and loan associations' data processing in addition to its own. Its computer was an IBM 360 model 40 with 128K (128,000) words of core and some 225 megabytes of disk storage. The configuration was similar to the one proposed by Organization X except that a data converter (DC 140), on a rental basis, was proposed for the interface rather than the controller. Cost estimates for service by Organization Y are given in Tables IV and V.

No printer was provided since the service center was in the local area and printed material could be obtained by courier within two hours. The teller terminals envisioned in this estimate were of a different (less expensive) type than those envisioned by Organization X. Teller terminals are discussed in detail in Chapter III.

TABLE IV

ESTIMATED MONTHLY COSTS FOR SERVICE BY ORGANIZATION Y

Service Charge	
.10 per savings account (12,000 accounts)	$1,200
.16 per loan	320
Other accounts, notices, reports and history file	755
Communications Cost (Including Modems)	285
DC 140	400
Total Monthly Costs	$2,960

TABLE V

ESTIMATED ONE-TIME COSTS FOR SERVICE BY ORGANIZATION Y

6 Teller Terminals	$24,000
1 CRT	3,350
2 Administrative Keyboards	2,410
Total	$29,760

The major advantages of service by a service organization were concluded to be:

1. Low risk. Both service organizations were operational and in the business of servicing savings and loan associations at the time of the investigation. They both had qualified EDP staffs and maturity in operating on-line systems. Obviously, both hardware and software were tested and working.
2. Management. Although considerable effort would be required to convert to a new service organization, the problems would be mostly details and the association's management would be freed of the necessity of making EDP type decisions regarding either hardware or software.
3. Back-up. Both service organizations had some form of back-up for their computer system, both to protect the data files and to provide alternate methods of data processing in event of long duration major equipment failures. Communications outages would disrupt service to some extent but even this problem was not unsolvable with Organization Y located in the same general area.

The major disadvantages of service organizations were the following:

1. Cost. It became apparent very early that in-house costs would be considerably lower than those charged by a service organization.
2. Timeliness. Some time delays would be experienced in obtaining printed information. This delay would range from two hours in the case of Organization Y to overnight in the case of Organization X.
3. Flexibility. A service organization could never be expected to be as flexible as in-house service. True, the service organization would have an EDP staff and would be better capable of keeping current with both technology and changing banking requirements and would have a ready pool of programmers to implement changes. However, the service organization would have to use standard programs to support all their customers, whereas, an association with its own in-house system could develop and implement its own innovations and hope to gain a competitive edge on other similar organizations.

III. IN-HOUSE SYSTEM: ADVANTAGES AND DISADVANTAGES

The advantages of an in-house system are, to a certain degree, the disadvantages of a service organization.

1. Cost. The in-house system was more economical for several reasons. First, communications costs would be reduced, since leased long distance lines would be eliminated and only short local lines from the main office to the branches would be required. Courier service could be greatly curtailed. Secondly, hardware costs would be reduced. Both service organizations had large expensive installations which contributed to higher service charges. Since most of the charges were on a per account basis, any increase in the number of accounts would mean an increase in the cost of EDP support while with an in-house system, a considerable increase in accounts could be supported at no additional cost. This aspect of the cost analysis was graphed and the results are presented in Figures 1 and 2. Equipment purchase costs are amortized over five years. For the in-house system, the cost drops to the amortized rates for the added disk after the first five years. Maintenance costs are ignored. The data shown in the figures assume that no additional branches are to be opened. Figure 1 assumes no additional hardware, while Figure 2 assumes only an increase in disk capacity. These assumptions are likely fallacious since, to grow to 70,000

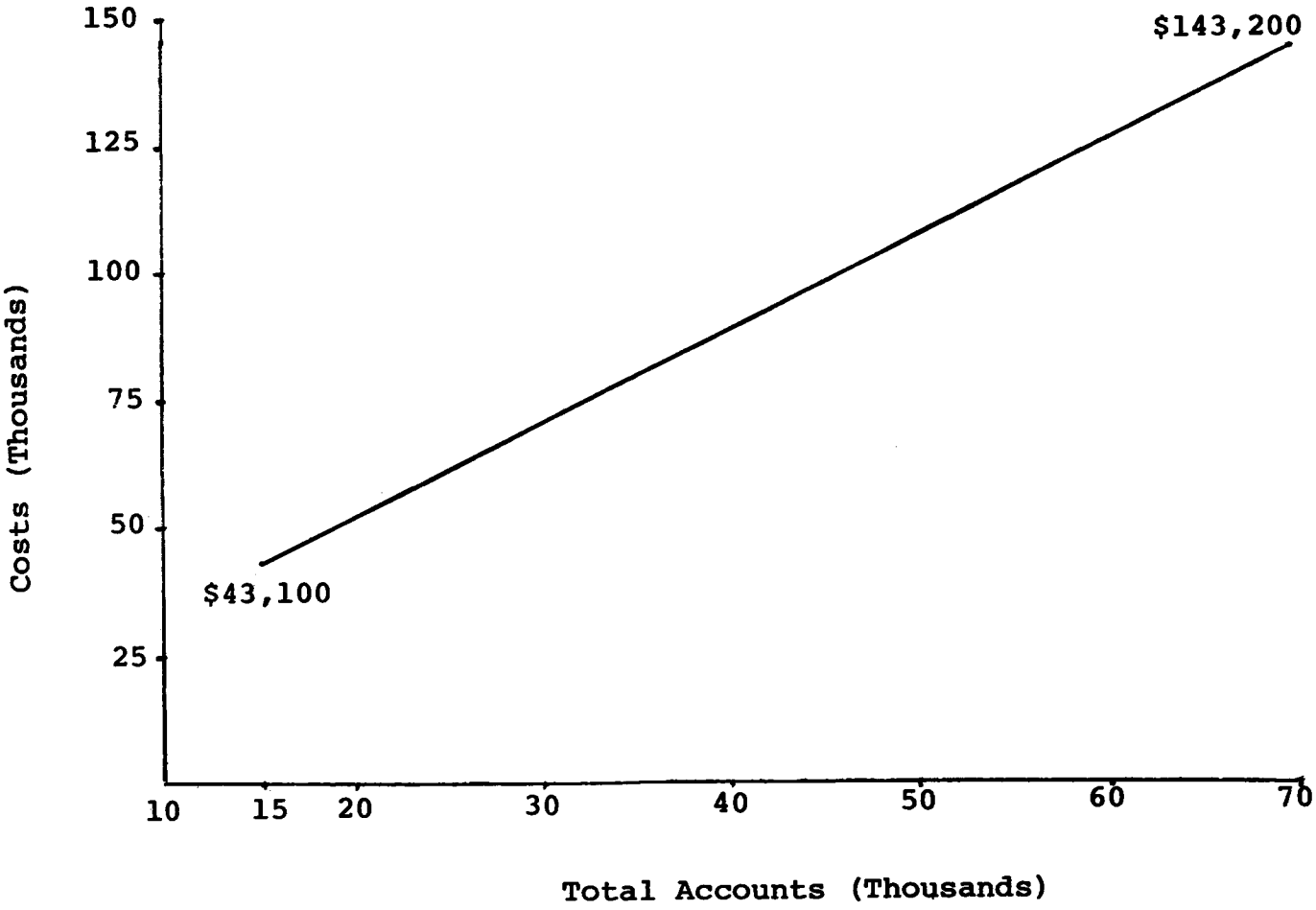


Figure 1. Annual cost of service by Organization Y for varying numbers of accounts (total).

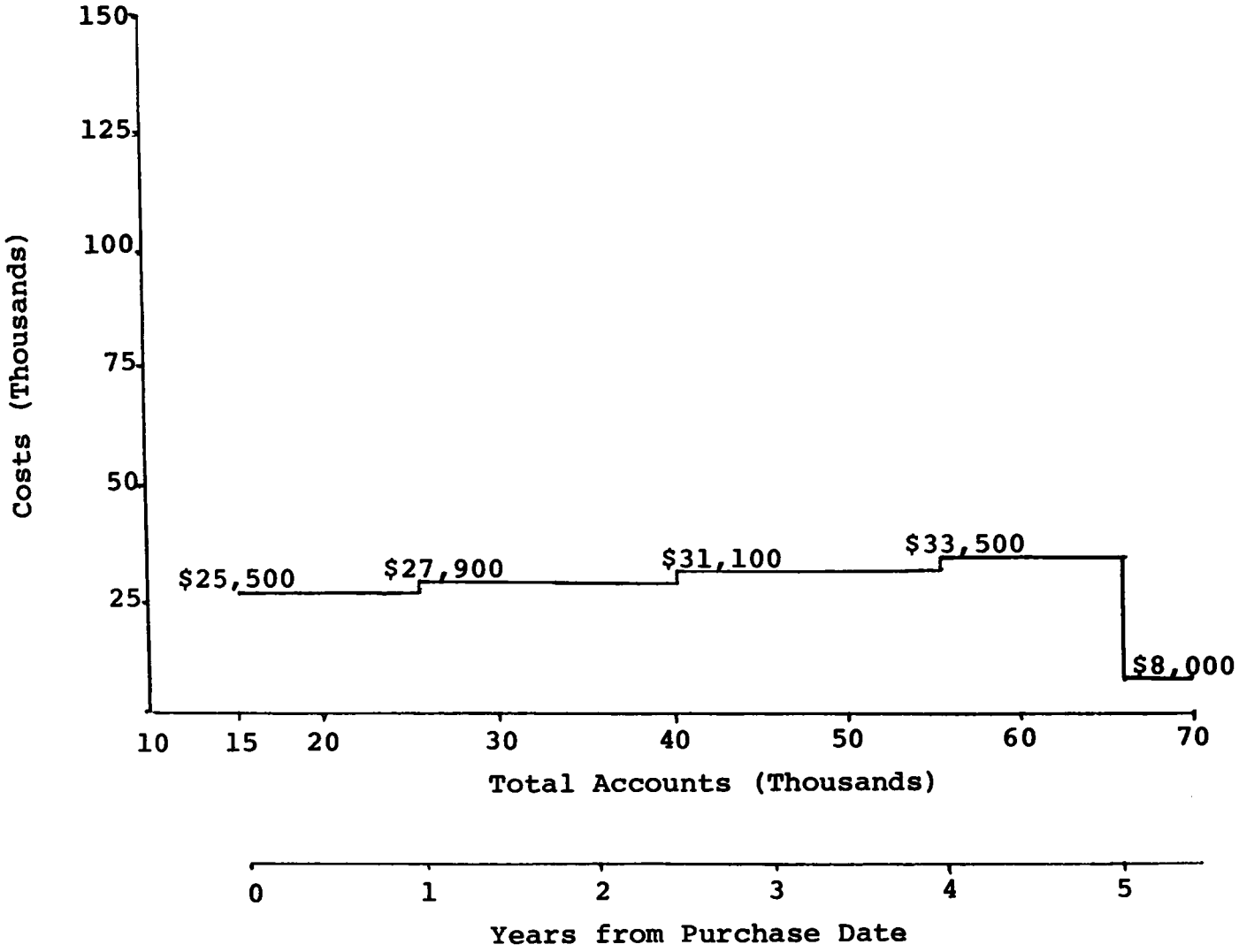


Figure 2. Annual cost for in-house system for varying numbers of accounts.

accounts, some new branches would probably be opened thus necessitating additional terminals, modems and telephone lines. However, the comparative costs should be valid since the additional hardware costs would be approximately the same for either alternative.

2. Timeliness. The in-house system would provide faster response than a service organization.
3. Flexibility. The in-house system could be as flexible as desired. Changes or additions to service could be implemented as desired. Minor changes could be programmed in-house. Programming support could be hired for any major changes. A common criticism of computer systems has been that they are not asked to do enough (2). The in-house system would be limited only by the imagination of the management.

The disadvantages of an in-house system were likewise the other side of the service organizations' advantages.

1. Risk. Implementing an in-house system certainly entailed more risk than buying service. First, the system must be designed. The design, obviously, should be as economical as possible yet must give good performance. A vendor had to be chosen. This would be a difficult process, sorting among the claims and counter claims presented by the competing vendors. An adequate

applications package must be written. True, a systems house could be hired to design the system, choose the vendor and develop the applications package. This, however, would add significantly to the cost of an in-house system without completely eliminating the risk factor.

2. Management. In addition to the management problems inherent in the design and implementation of an in-house system, it was planned that the system, once installed, would be operated entirely by the existing work force. Indeed, if only one dedicated EDP professional were required, the monthly costs of the in-house system would be roughly comparable to that for service organization support at the current level of accounts.

3. Reliability. The in-house system could be expected to be somewhat less reliable than that provided by a service organization. Data files could be protected by periodic off-line storage. However, equipment break-downs would disrupt service unless costly back-up systems were provided. One vendor offered the somewhat extreme proposal of a back-up mainframe. Another suggested an arrangement for on call back-up from a similar installation in the area via communications line.

IV. THE DECISION

After weighing the factors carefully, it was decided to install an in-house system. The overwhelming factor was cost. The analysis indicated that the in-house system would cost only approximately one half that of service from a service organization. Further, as the number of accounts increased, the cost savings became even greater. In addition, the in-house system would be paid for in five years causing in-house costs to approach zero. The quality of service from an in-house system could be expected to be at least as good as that provided by a service organization and probably would be better as the users grew more familiar with the system and developed better ways to use its capability. The employees were somewhat familiar with the EDP environment from their work with the service organization and, with some training, could operate the in-house system. The advantages of an in-house system therefore heavily outweighed the disadvantages.

CHAPTER III

SYSTEM DESIGN

I. PRELIMINARY

It was recognized at the outset that the in-house system requirements could be fully satisfied by a so-called "minicomputer" (3). The design of the system was determined by examining the specific requirements of this particular association and by research into other savings and loan associations' computer support. Next, five prospective minicomputer vendors were selected along with one systems house. Detailed discussions were held with each of these vendors to solicit their advice on a suitable installation. Although their views were somewhat divergent, a reasonably clear picture of the requirement began to emerge. A preliminary design was developed as outlined in the following paragraphs.

II. THE CENTRAL PROCESSING UNIT (CPU)

A 16 bit CPU with 32 K words of core storage was selected. The 16 bit design was common to all the machines which were investigated. This was acceptable using double or quadruple words to represent the larger numbers which could not be accurately represented by 16 bits. The 32 K primary storage requirement was the consensus of opinion.

One vendor recommended 64 K and the systems house, at one point, even recommended 128 K. However, with the simple operating system which was envisioned and with the secondary storage which was chosen, the other four vendors and finally the investigators were convinced that 32 K was sufficient. Since a savings and loan association's rate of transactions is relatively low, and since only six teller terminals were contemplated for the initial configuration, speed was not considered a significant factor and one microsecond cycle time was deemed fully adequate.

III. SECONDARY STORAGE

A disk system was required to supplement primary storage with fast access data files. Required storage capacity was determined by counting the bytes of data that should be immediately accessible for each savings account and each loan and multiplying by the number of each. This estimate was checked by comparing it with other savings and loan associations. One such installation used a 149 byte record for each savings account and a 147 byte record for each loan account on fixed disk and supplemented these records with name and address files, control files, transaction files and temporary data files on removable disk. The total disk capacity used by this association (which was almost identical in size to the association for which the system was being designed) was 10 million bytes on fixed disk and 5 million on removable disk. Punched cards were

used for input and no magnetic tape was used. Another association used only two files for savings accounts, one a master file of 190 bytes and another a trailer file of 45 bytes. Only one file (302 bytes) was used for standard mortgage loans. This appeared to be a far more satisfactory arrangement and it was resolved to use as few files per account as possible to cut down on storage requirements, as well as to simplify access. It was estimated that 300 bytes of information per savings account would be adequate and that 400 bytes per loan would suffice. With 12,000 savings accounts and 2,000 loans, this would require 4.4 million bytes. However, since the exact organization of the files could not be accurately predicted and to allow room for the additional accounts expected, 10 megabytes was settled upon as the minimum requirement.

Back-up storage was deemed a necessity. It was realized that equipment malfunctions can sometimes cause data to be inadvertently erased from disk. In addition, there was a requirement to keep some historical data almost indefinitely. Although historical data could be stored on the removable disk, this would have been somewhat more expensive than tape (4) and it would have been operationally more cumbersome to provide the required back-up. For these reasons, a magnetic tape unit was selected to augment the disk storage. A nine track, 800 bit per inch version was selected. This would provide another 10 or 11 megabytes of information on each tape.

IV. THE CASE AGAINST CARDS

Initially, it was thought that a card reader/card punch was absolutely essential. Almost every installation investigated included a card unit. Cards are in particularly wide use in loan applications. Payment cards could be pre-punched under machine control and mailed to the customer. The card could serve as a payment reminder and mailed in with the customer's payment. When the bank received the payment, the amount of the check could be visually compared with the amount printed on the card. The cards could be collected and fed into the reader in the batch mode with no further human action required. In spite of these attributes, however, the need for cards in this particular application was re-examined. A card unit would add significantly to the cost of the system and could serve only limited functions. Cards would make a very poor secondary or auxiliary storage media since they are bulky and subject to damage or loss. Only a limited amount of information could be placed on one card, yet other input/output devices could substitute for cards. Paper forms could be sent to the customer at reduced cost and could contain more information than cards. However, operator action would be required to post the transaction when the payment was received. If all the data had to be keyed in, this would represent an unacceptable work load and would be a source of error. After some investigation, it was concluded that the amount of operator keying could be

reduced to that amount necessary to identify the account, i.e., the account number. The applications software could be designed such that if the customer's payment matched that specified, the entry could be made by a single action, such as depressing a specified action key. If any but a standard transaction were processed, i.e., if the amounts did not agree or if the payment were late, the card would lose its value in any event and the transaction could be handled at least as efficiently with the alternative input/output device as with the card unit. The alternative device could be a Cathode Ray Tube (CRT) terminal or a teletype terminal. These type units would be required for on-line input/output with or without a card unit. It was decided, therefore, that a card unit could not be justified and would not be a part of the system.

V. THE TELLER TERMINALS

The choice of teller terminals was the most perplexing part of the system design and, at this writing, is still not fully solved. It should be pointed out that the choice of teller terminals was virtually independent of the type of system which provided the EDP service. The same types of terminals could be used by either the service organization or by the in-house system. There were a wide variety of choices. The association was currently using four large teller terminals produced by one of the major manufacturers of business machines. These terminals had

many special action keys designed specifically for the banking application. They were capable of printing on both a ledger roll and in a passbook. The terminals were performing satisfactorily but were large and cumbersome and, more significantly, bore a $13,000 purchase price or $256 per month rental charge. This seemed prohibitively high when compared to standard general purpose terminals which sell for $3,000-$4,000 each. The only special feature actually required was the capability to print in a passbook. Some consideration was given to discontinuing the passbook. Many savings institutions have gone to statement accounts and do not use a passbook primarily because of the difficulty in adapting EDP systems to the passbook. However, it was decided to continue use of the passbook in this case because of customer satisfaction with the passbook system. The passbook gives customers a ready understandable record of their savings account and switching from the passbook system might cause a loss of customers. So the problem became one of finding a reasonably priced terminal which would accommodate a passbook. Of course, a passbook can be inserted into almost any typewriter carriage. However, the printer had to accommodate other paper at the same time so that the teller could call up the account and type the transaction on journal paper for visual verification before it was entered on the passbook. Also, the association needed a hard copy record of transactions for accounting purposes. Therefore, a split or dual platen terminal was required

which would allow regular written output as well as provision for passbook entries. As stated above, several such terminals were on the market. However, all of them had many other built-in features which greatly increased their price. Typically, they used some sort of front end processor (basically a minicomputer) at a price of $10,000-$12,000 in addition to the terminal. The terminals themselves ranged in cost from $8,000 up. The search for an inexpensive general purpose terminal with a split platen was intensified. A terminal meeting most of the requirements was eventually discovered and was priced at $3,100 each.

Although not specifically designed for a passbook, it did provide for front end feeding of forms and, therefore, could handle the passbook adequately. In addition, blank checks could be inserted from the front, a particularly attractive feature. However, this was not designed to be used as a remote terminal but as part of a business system configuration and, as a consequence, presented some serious interfacing problems. First, the terminal handled data characters in a parallel rather than in a serial format. The binary bits which represented characters were produced simultaneously and presented in parallel by the keyboard and the printer accepted its information in the same format. This is the normal method of transmitting data within a computer system (such as between the central console and the central processor) because of the increased speed of transmission. Parallel transmission of data becomes very

expensive, however, when considerable distances are involved because, essentially, one wire must be provided for each data bit in a character. Serial (or bit by bit) transmission is the normal mode over telephone lines (5).

The terminal also used a special code for character representation which was a cross between the BCD (binary coded decimal) code and the Hollerith code. See Table VI. The computers under consideration used the standard ASCII (American National Standard Code for Information Interchange). Table VII shows a representation of the ASCII code (6). In view of the interface problems, it initially was decided to use the terminals already in use until a more satisfactory solution could be found. This was, at best, a temporary solution since the terminals currently in use were completely over-designed for the system envisioned.

It was soon realized that the interim solution was even worse than initially thought, since this solution presented interface problems of its own. The terminals then in use each contained 256 words of memory and normally transmitted and received information in bursts; whereas, the systems under consideration used simple terminals which received and transmitted information character by character with little or no local buffering. Considerable programming effort would be required to make these terminals operate in the manner required by a minicomputer system. A re-examination of the general purpose terminal alternative indicated that the interface could possibly be built cheaply

TABLE VI

CODING CHART FOR THE GENERAL PURPOSE TERMINAL

				Graphics & Controls				Tabulate Positions			
			b7	0				1			
			b6	0		1		0		1	
			b5	0	1	0	1	0	1	0	1
b4	b3	b2	b1								
0	0	0	0	Space	Ø	-◇	&	1	49	97	145
0	0	0	1	1	/	J	A	4	52	100	148
0	0	1	0	2	S	K	B	7	55	103	151
0	0	1	1	3	T	L	C	10	58	106	154
0	1	0	0	4	U	M	D	13	61	109	157
0	1	0	1	5	V	N	E	16	64	112	160
0	1	1	0	6	W	O	F	19	67	115	163
0	1	1	1	7	X	P	G	22	70	118	166
1	0	0	0	8	Y	Q	H	25	73	121	169
1	0	0	1	9	Z	R	I	28	76	124	172
1	0	1	0	@	*	%	◇	31	79	127	175
1	0	1	1	PO#	,	$	o	34	82	130	178
1	1	0	0	P1	I	Index	Red	37	85	133	181
1	1	0	1	P2	II	Index (R)	Index (L)	40	88	136	184
1	1	1	0	P3	III	Black	Bk. Space	43	91	139	187
1	1	1	1	P4	IV	Form	Open / Close	46	94	142	190

TABLE VII

CODING CHART, ASCII CODE

			b7	0				1			
			b6	0		1		0		1	
			b5	0	1	0	1	0	1	0	1
b4	b3	b2	b1								
0	0	0	0	NUL	DLE	SP	ø	@	P	`	p
0	0	0	1	SOH	DC1	!	1	A	Q	a	g
0	0	1	0	STX	DC2	"	2	B	R	b	k
0	0	1	1	ETX	DC3	#	3	C	S	c	s
0	1	0	0	EOT	DC4	$	4	D	T	d	t
0	1	0	1	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	ACK	SYN	&	6	F	V	f	v
0	1	1	1	BEL	ETB	'	7	G	W	g	w
1	0	0	0	BS	CAN	(	8	H	X	h	x
1	0	0	1	HT	EM	)	9	I	Y	i	y
1	0	1	0	LF	SUB	*	:	J	Z	j	z
1	0	1	1	VT	ESC	+	;	K	[	k	{
1	1	0	0	FF	FS	,	<	L		ℓ	|
1	1	0	1	CR	GS	-	=	M	]	m	}
1	1	1	0	SO	RS	.	>	N	↑	n	~
1	1	1	1	SI	US	/	?	O	←	o	DEL

enough to keep the overall cost of the modified terminal cost competitive. The cost of the types of hardware required to make the interface had been dropping steadily for several years (7). A thorough analysis reinforced this supposition. Therefore, the terminal interface is being developed and the modified general purpose terminal will be used in the system.

CHAPTER IV

WHICH MINI?

I. A COMPARISON OF BRANDS

The choice of a vendor was made concurrently with the decision to go in-house. However, for clarity of presentation, this chapter will address the analysis which led to the selection. To protect the identity of those companies who were considered but not chosen, all companies will be referred to by letters. As indicated earlier, five hardware manufacturers were considered along with one systems house. After preliminary discussions had produced a reasonably clear picture of the desired system, each prospective vendor was asked for a price quote on a system with the following components:

Central Processing Unit, 32 K, 16 bit words

10 megabytes of disk storage

One magnetic tape drive

One line printer (200 lines per minute)

One CRT terminal

Six teletype terminals

Communications controller capable of handling at least 16 ports (terminals)

A price quote on a maintenance package and a bid on a complete turn-key package to include applications software was also requested.

There was some evolution of the terminal requirements before all the bids were in. The teller terminals were discussed in the preceding chapter. At the time the requests were made, teletype terminals were envisioned and the requirement was stated at six. Subsequent discussion resulted in a requirement for three CRT terminals and four teller terminals. To facilitate a brand-by-brand comparison, the bids/proposals were modified by deleting the teletype terminals entirely and by increasing the CRT requirement to three with a corresponding increase in cost. With these modifications, the hardware portions of the proposals were as follows. Brand A did not submit a proposal.

Brand B proposed as follows:	
CPU (32 K)	$20,820
4.8 megabytes of disk storage	16,100
4.8 megabytes of additional disk storage	10,200
Magnetic tape system	11,500
Line printer (60 LPM)	6,200
Three CRT terminals (12 lines)	3,750
Multiplexor (16 ports)	7,700
Systems software	6,500
Miscellaneous software	970
Total	$83,740

Brand C proposed as follows:	
CPU (32 K)	$15,350
10 megabytes of disk storage	12,900

Magnetic tape system	9,900
Line printer (200 LPM)	6,525
Three CRT terminals (24 lines)	7,371
Multiplexor (16 ports)	6,000
Miscellaneous interface equipment	2,450
Total	$60,496

Brand D proposed as follows:

CPU (32 K)	
10 megabytes of disk storage	
Magnetic tape system	
Line printer (200 LPM)	
Three CRT terminals (24 lines)	
Multiplexor	
Miscellaneous equipment	
Total cost (not itemized)	$78,600

Brand E proposed as follows:

CPU (32 K)	$20,950
23.4 megabytes of disk storage	16,400
Magnetic tape system	9,900
Line printer (300 LPM)	9,900
Three CRT terminals (24 lines)	8,550
Multiplexor (16 ports)	2,750
Systems software	2,100
Miscellaneous interface equipment	5,000
Total	$75,550

The systems house proposed the following:

CPU (32 K)	
W/Multiplexor (16 ports) and 36 megabytes of disk storage	$63,900
Additional 36 megabytes of disk storage	15,500
Three video screen terminals	5,400
Remote terminal communications equipment	3,700
Total purchase price	$88,500
Line printer (rental)	$140 per month

The obvious competitive advantage of Brand C is partly explained by two facts. First, the CPU proposed was the slowest of the lot. The proposed CPU had a cycle time of 1 microsecond while the others were considerably faster (800 nanoseconds down to 600 nanoseconds). Secondly, the system configuration requested was to have 10 megabytes of disk storage. Brand C had a 10 megabyte unit as a standard product. Most of the other companies either had to combine several smaller units or overbid by going to a larger size unit.

An additional factor which contributed to Brand C's lower bid was the operating system software. Brand C proposed a fairly simple operating system and the use of extended BASIC as the programming language for the time-sharing portions of the applications package. Some of the other vendors offered more sophisticated operating systems with increased flexibility and, in all probability, faster throughout.

II. THE DECISION

With the significantly lower cost proposal offered by Brand C, the decision on which vendor to choose appeared to resolve itself into a single question, "Is the system proposed by Brand C adequate to do the job?" Stated another way, "Can any of Brand C's competitors offer any increased utility in this application for the marginal dollars they are asking us to spend?" If any increased utility were to be realized it must come in one or both of two areas, i.e., a valuable increase in speed of operation or a reduction in the level of effort required to develop the applications package. A "valuable increase in the speed of operations" is intended to mean a noticeable or usable increase in speed. For instance, the difference between 600 nanoseconds and 1 microsecond is not usable or even perceptible to a human user in a single operation; whereas, a search of 12,000 savings account files to find a particular one or reading each of 12,000 files to compile a report might well cause a 600 nanosecond machine to perform noticeably and usably better than a 1 microsecond machine. An examination of the types of operations the system would have to perform indicated that the 1 microsecond time would be fully acceptable.

In the area of applications programming, Brand C recommended multi-user extended BASIC for the on-line time sharing programs and FORTRAN for the batch operations.

These languages and their operating system could be made to handle the job in an efficient manner. Finally, Brand C appeared to be adequate and better suited, in some respects, to the task at hand than its more expensive competitors. Therefore, the decision became a simple one--Brand C.

CHAPTER V

THE APPLICATIONS PACKAGE

I. TURN-KEY SYSTEM OR IN-HOUSE DEVELOPMENT

It was recognized at the outset that applications programming would be a major factor in determining whether and how well the system would perform. In the requests to the minicomputer vendors, proposals for complete turn-key systems to include applications programs were sought. None of the manufacturers sold applications software directly but all had some sort of arrangement with a systems house which could offer applications packages. Typically, the systems house would buy the hardware from the manufacturer and then sell the complete hardware/software (turn-key) system to the user. In addition to asking the manufacturers to arrange for a proposal including applications software, several software companies were contacted directly for software estimates. The estimates/bids varied widely. The cheapest bid was $11,000 for the savings accounts and loan applications only. However, this bid was contained in a total package which also contained hardware priced considerably higher than that offered by Brand C. The next lowest bid was $18,000 but this too was part of a package which seemed to hide part of the software cost in hardware mark-up. The lowest bid for applications software which was not packaged

with a hardware proposal was $30,000 and this proposal was so vaguely stated that it was deemed almost certain to go higher before the work was finished.

In the meantime, another alternative was being considered. The applications software could be done using the association's employees to do as much of the actual code writing and documentation as possible. This approach seemed to have considerable merit for several reasons. First, the entire concept of an in-house minicomputer envisioned that there would be no electronic data processing staff. Secondly, one of the biggest criticisms leveled against computers and computer personnel has been that they have tended to isolate themselves in a cocoon away from the mainstream of their business objectives (8). Having bankers actually program and operate the system would alleviate this problem. Training and documentation would be simplified and could be performed concurrently with program development. Software maintenance and future modifications could be performed entirely in-house. This is the alternative which was chosen.

II. SOFTWARE DEVELOPMENT

Applications software development began soon after the purchase decision was made. The hardware manufacturer made a computer available for intermittent use until the association's hardware could be delivered. A number of innovations have been implemented to date. To understand

the significance of these, some basic facts about the programming language must be presented.

Extended BASIC, as used in the chosen system, uses one byte (8 bits) of storage space for each character in a literal string plus one additional (null) byte at the end of each string. Therefore, to store a literal string of one character, two bytes are required; for two characters, three bytes, etc. Real numbers up to six digits in length are stored in four bytes of space without a null. If a number larger than 999999 is to be represented it must be handled either as a double precision (8 bytes) number or as a string literal. The language does not permit the use of double precision and single precision numbers in the same program. However, it does provide for string arithmetic with up to 18 digits of accuracy.

An early decision was to use single precision numbers as the general rule since most of the numbers would contain less than six significant digits. For the larger numbers ($10,000 and up for dollar amounts), string variables and string arithmetic would be used.

Earlier chapters have described how disk storage requirements were estimated. It now became imperative to make the most efficient use of the storage space available not only to delay the time when more disk capacity would be required but also to speed up access time. One technique which was used to conserve spaee was packing the string variables. Six strings of information were to be placed in

each savings account disk file. These were name, social security number (SSAN), current balance, available balance, passbook balance and dividend distribution code (DD). To have placed them in the file as six variables would have used six null bytes. However, if the strings were placed adjacent to one another as one string and addressed by array locations within this string, only one null would be used.

The string portion of the savings account disk file was thus stored as shown in Figure 3.

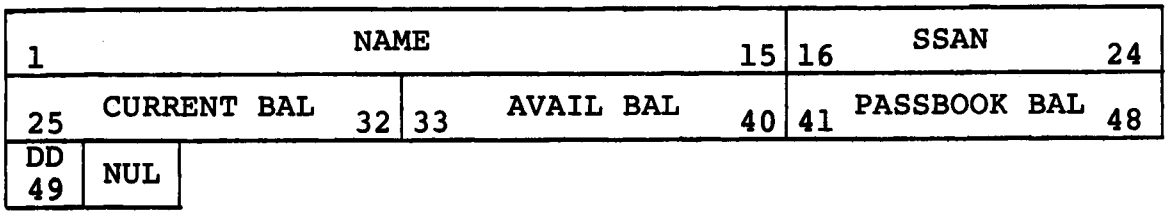


Figure 3. The string literal portion of the savings account disk file.

The variable was read into and out of the disk file by a single variable name (U$) which could be addressed as follows:

```
U$ (1,15) = NAME
U$ (16,24) = SSAN
U$ (25,32) = CURRENT BALANCE
U$ (33,40) = AVAILABLE BALANCE
U$ (41,48) = PASSBOOK BALANCE
U$ (49,49) = DIVIDEND DISTRIBUTION
```

Another technique used to save disk storage space involved the transaction history file for savings accounts. It was desirable to keep as much history on disk as possible so as to answer as many customer inquiries as possible in an immediate manner without having to go to the slower tape file or to the manually accessible microfiche file. Transactions required a minimum of 14 bytes each. At first, it was planned to allow space for 10 transactions per account to be appended directly to the account file. This would have required 1.68 million bytes of space for the 12,000 accounts. The remainder of the savings disk file required about 74 bytes per account for another 0.888 million bytes or about 2.5 million bytes total. This was not a good solution, however, since the transaction rate varies widely from account to account. Some certificate accounts, for example, may have only one transaction per year while some passbook accounts may average more than one transaction per week. A better solution was a separate transaction file with a pointer from the primary disk file to the most recent transaction and a pointer from that transaction to the next most recent, etc. (9). This added one number (4 bytes) to the disk file and 4 bytes to each transaction record but proved to be more economical overall. The average transaction rate for all 12,000 accounts was only 3,600 per month. The transaction rate permits at least three months transactions to be kept on disk with no fear of overflow. Transaction files would then be placed on microfiche.

Another technique used to save space and speed up access time was to store the loan accounts as records with record numbers which correspond to the account numbers. This can be done since the loan accounts are numbered consecutively with few gaps or skips. Using this technique, it is not necessary to store the account number at all and the account can be found immediately with one access. This technique was not feasible with the savings accounts since they are not numbered consecutively but have been allocated in small blocks over the entire range between 1 and 1 million. Some thought was given to renumbering the accounts but it was felt this would cause some customer dissatisfaction and give an impression that the computer was the master rather than the slave. The next best solution was to arrange the savings accounts in ascending account number sequence so that a binary search algorithm could be used to find any given account record (10).

With this technique, it will be possible to find any savings account in 14 accesses or less since two to the 14th power is 16,384 which is greater than 12,000 (the number of account records in the file).

CHAPTER VI

COMMUNICATIONS

I. DATA TRANSMISSION RATES

To maintain flexibility in the mix of terminal types, a custom multiplexor was chosen that allows selectable rates of data handling from 110 baud to 9,600 baud.[2] Each of the 16 ports can be set to its data handling rate independently by simply turning a selector. It was decided to use 1,200 baud rates to the CRT terminals. This was a compromise between delay time and the cost of modems. The maximum time to completely fill the CRT screen can be calculated by multiplying the number of bits per character (7 information bits, 1 parity bit, 1 start bit and 2 stop bits for a total of 11) times the number of characters which the screen will hold (24 lines of 80 characters each or 1,920 characters) and dividing the product (21,120) by the baud rate (1,200) and is equal to 17.6 seconds. This would be intolerable. However, an examination of the displays normally used indicated that a normal or average display would use only about 12 lines of 30 or less characters each which would make the transmission time equal 3.3 seconds. Mostly, the information exchange would be one line or less and, thus, the

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[2]One baud = one bit per second.

transmission time would be less than one second. This delay would hardly be perceptible to the operator. From the cost standpoint, 1,200 baud modems cost about one third as much ($475) as the 2,400 baud modems ($1,150 and up). Two modems are required for each remote terminal--one at the computer site and one at the terminal site. For this cost differential 1,200 baud was deemed sufficient.

The teller terminals are only capable of operating at speeds up to 30 characters per second (300 baud). This set the data transmission rate for those lines since data would be lost if it were transmitted any faster. Although modems can be rented from the telephone company, it is not economical to do. A 1,200 baud modem, for example, rents for $48.50 per month as compared to the $475.00 purchase price. The total purchase price would, therefore, be paid in 10 months' rental fees.

II. DIAL-UP VERSUS DEDICATED LINES

An analysis was also made of the costs of dedicated telephone lines versus dial-up lines. Facts pertinent to this analysis are as follows:

1. Either dedicated lines or dial-up lines were satisfactory for the data handling speeds contemplated.
2. Installation costs were $30 per phone for dial-up phones or $60 per line for dedicated lines.

3. Dial-up phones cost $8.25 each per month with no penalty for length of local call.
4. Dedicated lines cost $1.20 per quarter mile per month.
5. The system would have three remote terminals in the existing branch which was 2.5 miles away and would have another two terminals in the new branch which would be 1.5 miles away.
6. Dial-up phones which do not use telephone company modems must have a data coupler provided by the telephone company at $6.00 per month.

With these data, cost readily could be determined. One time costs (installation costs) were exactly equal for dedicated lines and dial-up lines. Five dedicated lines would be required at $60 per line for a total of $300. Ten dial-up lines would be required at $30 each for an identical total of $300. Monthly costs clearly favored dedicated lines. A total of 10.5 miles of line would be required (1.5 × 2 + 2.5 × 3). This would cost only $50.40 per month ($1.20 × 4 × 10.5), whereas, the 10 dial-up lines would cost $142.50 per month ($8.25 × 10 + $6.00 × 10). It was decided, therefore, to use dedicated lines, but to install one dial-up phone at the computer site on an unused port to the multiplexor to permit interface with the outside world via data link in the event this was ever required.

CHAPTER VII

MAINTENANCE

Each vendor was asked to provide a bid for a maintenance contract. There was a remarkable similarity in the maintenance proposals. The most responsive and most expensive plans all cost about one percent of the purchase price per month and guaranteed response within four hours and covered all expenses including parts and labor. Maintenance was also available on a per call basis by paying an hourly rate for labor, a mileage charge, and total purchase price for any parts required. Service was guaranteed within 24 hours under this arrangement. Brand C charged $35.00 per hour for labor and 12¢ per mile (about 50 miles round trip from the service center). Unless some costly component should require replacement, the second course would be the least expensive. The 24 hour delay would not pose an insurmountable problem since the association had often experienced failures of this length from their service organization with only minor problems. Transactions could be handled manually during periods of down-time and manually entered in the system once it was running again.

The key factor necessary to make an intelligent choice of maintenance options was equipment reliability. No hard data was available. However, indications were, from other users, that the equipment was very reliable. One user

of similar equipment stated that he had no equipment failures in two years of operation. With these indications as a guide, no maintenance contract is contemplated. A 90 day warranty will cover all parts and labor for that period. If, at the end of that time, no failures have occurred, it is likely that no maintenance contract will be signed and maintenance assistance will be obtained on a per call basis. If, however, the equipment failure rate ever looks sufficiently high to warrant the contract, such an agreement can be entered into at that time.

CHAPTER VIII

SUMMARY

The concept of a stand alone minicomputer for a savings and loan association is very attractive from several points of view. First is the simple economics involved. The exact costs of the complete in-house systems are not yet known. However, the total package seems certain to cost less than $100,000 including terminals, modems and applications software. If these costs are spread over a five year period at current interest rates the monthly cost will be approximately $2,000. This is almost exactly half the price which was being paid for computer service before the decision to go in-house. But the quality of service is being up-graded by a factor which is difficult to estimate. Every computer service needed by the association can and will be implemented at minimum additional cost. This will include loan processing, general ledger, payroll and any type of management information desired by the officers of the association. The programming language is simple enough that most of these functions can be programmed by the association's officers and employees themselves. It is true that this will take some effort by the association's work force, but this effort will be more than compensated by the harnessing of the computer's power to meet the needs of the association.

If this is such an attractive concept one might well ask why every savings and loan association does not have a stand alone minicomputer or why would any association continue to pay the high prices associated with large computers when an in-house mini can do the job better and more economically. The answer is not clear. Part of the reason undoubtedly is that the banking industry, having perhaps the most straightforward application in the business world, started using computers early when there were no minicomputers. Then, with large capital investments in big machines and exotic software, they have been slow to change (11).

As hardware costs continue to drop, as businessmen become less wary of managing computer systems, and as programming languages become easier for the layman to understand, a trend toward in-house minicomputer systems seems likely.

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VITA

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