RE-ENGINEERING: A FRAMEWORK FOR ANALYSIS AND CASE STUDY OF AN IMAGING SYSTEM

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ABSTRACT

Re-engineering or business process redesign has become very popular. This paper presents a clear description of re-engineering and contrasts it with incremental change in systems. The paper also develops a framework for comparing two related systems. The framework is applied to a case study of the re-engineering of the Merrill Lynch Securities Processing System. This system features image processing, character recognition and extensive process redesign. The re-engineering effort has had a substantial impact on the firm.

INTRODUCTION

One of the latest trends in the information systems field is re-engineering. What is re-engineering? Hammer (1990) described the spirit of re-engineering as "obliterating" rather than automating. He argues that systems developers have too often simply automated existing processes without thinking about the need for radical change. While there probably are situations where eliminating the old system is advisable, it may not always be possible to do away with a business process. Instead, designers will re-engineer or redesign the process (Davenport, 1993).

Is re-engineering anything more than "radical" systems analysis and design? Texts on systems design have always advocated a careful analysis of the existing system before thinking about the design of a new one (Lucas, 1992). What is different in re-engineering?

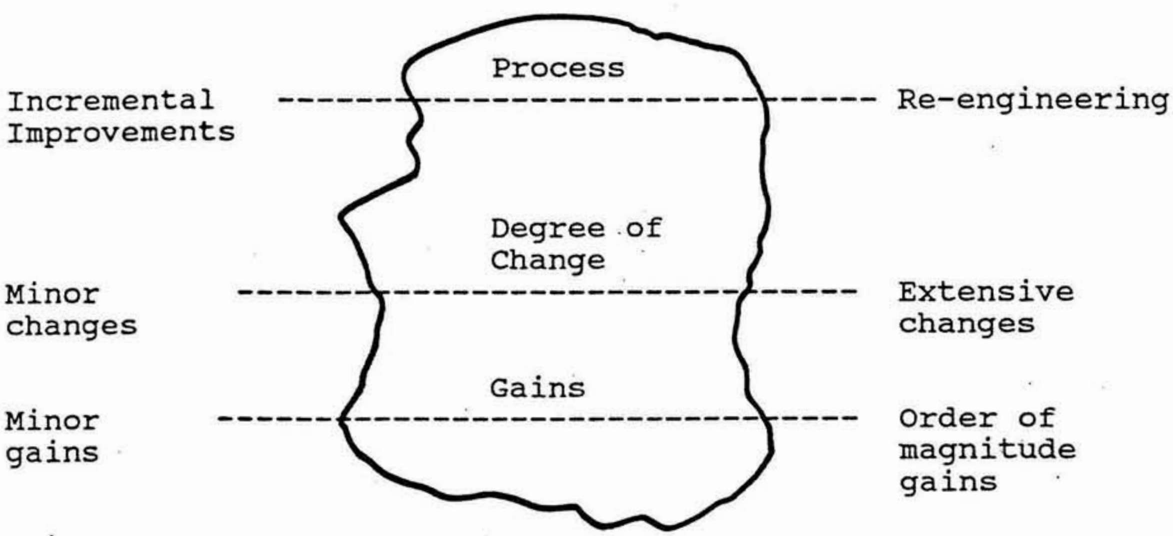
The purpose of this paper is to present a clear description of re-engineering and to contrast it with other types of changes to systems. Second, the paper proposes an approach to comparing two different systems. This approach is used to present a case study of re-engineering. The case describes the significant gains that an organization can obtain from a re-engineering effort; it also illustrates the use of a new technology, image processing, in a re-engineering effort.

RE-ENGINEERING VERSUS THE ALTERNATIVES

Table 1 and Figure 1 offer insights into the differences between incremental improvements and re-

Incremental Improvements vs	Re-engineering
Accept current process	Ask if process is necessary
Look for ways to tune processes	Look for radically different models
Try to modify components of system	Try to make changes that are dramatic, e.g. cut labor 50%
Avoid radical change and disruption	Seek radical change in hopes of making significant improvements

Incremental Improvements Compared
With Re-engineering
Table 1



Avoid the Middle Ground
Figure 1

engineering. Incremental improvements described in Table 1 are constantly made in systems through the maintenance and enhancement process. Designers tune systems for improved performance or to add new functions. The approach stresses minimal disruption; designers try to improve different modules and functions without affecting the other parts of the system. This on-going task of improvements is difficult and important; it is often cited as a strength of Japanese firms.

Re-engineering asks the question of whether or not whole processes are necessary; can the firm "obliterate" a process? When designing a system for accounts payables, the analyst would first ask if the firm even needs an accounts payable function. The idea is to look for radically different models and to make changes that have a high multiplier. Incremental improvements might bring about a 5% increase in functionality for a system while re-engineering would look for order of magnitude changes like a 50% reduction in cost. The objective of re-engineering is to bring about radical change while the incremental improvement process seeks to avoid radical change.

Figure 1 presents a continuum contrasting incremental improvements with re-engineering. The figure emphasizes the need to avoid the middle ground. In the area marked by the jagged lines the organization obtains the least in terms of gains for the effort expended and the risks taken. The real contribution of re-engineering is to call management's attention to the fact that designers should either concentrate on incremental improvements or the radical redesign of processes; working in the middle ground often results in high expenditures to automate an existing, inefficient process.

If re-engineering creates such dramatic gains why would the organization ever be satisified with incremental improvements? Working on the re-engineering side of the continuum is risky. Changes of great magnitude may even appear to some as doing violence to the organization. When management selects re-engineering over incremental improvement, it is taking greater risks in the hope of obtaining greater benefits. In fact, if one takes a more historical view, the evolution of applications systems can be characterized by on-going incremental improvements punctuated by major re-engineering efforts.

COMPARING SYSTEMS

The next section of the paper presents a case study of a re-engineering project. In order to assess the impact of a re-engineering effort, it is necessary to compare a new system with the old, existing process in some detail. In conducting the study, the research team found that it was very difficult to rigorously compare two information systems. A literature search found examples of individual systems, but few comparisons of two systems.

This section proposes a framework for comparing and contrasting two systems. The framework has two parts, qualitative information and quantitative data. The comparison framework follows:

Qualitative Information

- Changes in organization structure
- Major changes in work flows and functions performed
- Interface changes
- Major changes in technology
- Impact on the organization

Quantitative Data

- Comparison of Dataflow Diagrams
- Comparisons of resources required
- Investment
- Return on investment

Most of the items in the framework are obvious and have been used to describe systems in the past. They will be illustrated in the case which is presented in the next section. The quantitative comparison of DFDs is new and is described below.

Comparing DFDs

This paper presents the first use of a technique for comparing Dataflow Diagrams proposed by Berndt (1993). Problems comparing DFDs arise because the identification of a DFD element or function is a subjective process. Two analysts are likely to develop two different DFD representations of the same system. In order to compare two systems at the level of DFDs, it is necessary to avoid the bias that is created by the uncoordinated development of DFDs for the systems involved.

In Berndt's approach, the DFDs for two or more systems need to be developed in tandem. Of course, this strategy is most feasible for comparing two similar systems, such as an old system and one that has replaced it. (It is not clear, however, why one would want to compare totally dissimilar systems.)

The first step in the process is to develop a "core" DFD representing overlap between the two systems. The analyst encodes alternative DFDs when developing the core system. He or she also attempts to develop lower level DFDs at the same level of detail. (This process will be illustrated in the case study which follows.) This effort is intended to be supported by an appropriate computer-aided development tool.

Berndt (1993) proposes four metrics derived from the DFDs for comparison; two of these are appropriate for the case which follows: control points and level of automation.

Information systems contain a number of control points which are critical to their success. For example, a system which prepares payables has a control point that compares a purchase order and a receiving document. Without this kind of control, the system would have no way of validating payments and would quickly cause serious damage to the organization.

The comparison technique looks at control roots and control points. A control root is an object that produces information utilized at some later points for verification. A control point is a function or process that consumes information and performs a verification function.

The analyst constructs a matrix of control points consisting of two rows for each system being compared. For each system, the analyst lists control roots and points. He or she may also want to categorize the control points into manual, computer-aided or automated controls.

The level of automation achieved is an important measure of the effective use of technology and re-engineering. Level of automation can be further broken down into three components: stability, obsolescence and newness

	Manual functions	Computer-aided functions	Automated functions	Totals
Stable:				
Old system	s_1	s_2	s_3	s_t
New system	s'_1	s'_2	s'_3	
Obsolete functions	o_1	o_2	o_3	o_t
New functions	n_1	n_2	n_3	n_t

SON Matrix
Table 2

(SON). Berndt's technique involves constructing an SON matrix as shown in Table 2. The purpose of this table is not to replace the observer's intuition; it is designed to help the analyst focus on the most important areas of change.

Stable functions exist in both the old and new systems; they may shift among automation categories (the columns in Table 2). Obsolete functions are functions that exist in the old system, but have been eliminated in the new system. New functions represent change between the old and new system; this category contains functions that exist in the new system but not in the old.

By computing various ratios, the analyst derives a numerical characterization of the extent of automation, the number of obsolete objects, and a measure of system change. The stability factor is intended to capture the extent to which two alternative systems overlap and can be thought of as a measure of "radicalness." (The less stable, the more radical the change.)

$$\text{Stability} = s_t/(s_t + o_t + n_t)$$

Obsolescence is the percentage of obsolete functions:

$$\text{Obsolescence} = o_t/\ (s_t + o_t + n_t)$$

Newness is the percentage of changed functions

$$\text{Newness} = n_t/\ (s_t + o_t + n_t)$$

Comparing the changes in automation categories within the stable functions captures a measure of the extent of automation with the expectation there will be more automation in the new system:

$$\text{Automation} = (s_2 + s_3)/s_t < (s'_2 + s'_3)/s_t$$

Finally, it is possible to compute a measure of system-wide change. This ratio should capture the addition of new functions, the nature of the shift of stable functions to more automated categories and the extent to which functions have become obsolete. A measure of change is:

$$\text{System-wide change} = (n_t+\text{Sum}(|s_i - s'_i|/2)+n_t)\ /\ (s_t + o_t + n_t)$$

The summation in the numerator captures the change between the old and new systems in each automation category, computer-aided and automated (halved to correct for double counting).

The case study in the next section will illustrate the comparison of DFDs using both control points and levels of automation.

SECURITIES PROCESSING AT MERRILL LYNCH

Merrill Lynch is the largest brokerage and financial services firm in the United States with over 400 branch offices. While there has been much publicity about "book entry" shares of stocks, there still are a large number of physical shares of stocks and bonds in circulation.

On a typical day, Merrill Lynch offices around the US receive some 3500 securities which need processing of some kind. What are some of the reasons for customers bringing securities to a branch office?

1. The customer has sold the stock and must surrender it so that shares can be issued to the buyer.

2. A person has inherited stock and must have the shares registered in his or her name.

3. A company has reorganized and has called its old stock to issue new shares.

4. A bond has been called by the issuer.

5. A customer wants Merrill to hold his or her securities.

The customer brings the security plus other supporting documents to the branch office cashier. The cashier provides a receipt and batches all of the securities together to be sent for processing. Before the development of a new system, the branch would send these documents to one of two securities processing centers, either Philadelphia or Chicago.

The objective of securities processing at the centers was to credit the customer's account as soon as possible, certainly within the 24 hours suggested by the Securities and Exchange Commission. Because of exceptions and the possible need to contact the customer again, sometimes it was not possible to achieve this goal.

A good example of problems is in the area of legal transfers when someone inherits stock. There are requirements for supporting documents like a death certificate. If the customer does not bring the documents and the branch does not catch the fact that a necessary piece of paper is missing, the securities processing center must contact the branch and ask them to contact the customer.

Because many of the securities are negotiable, the SPCs must be extremely careful in processing. Merrill Lynch is required to keep an accurate audit trail whenever it moves a security. This requirement led to frequent, repeated microfilming of securities as they moved around a center.

To the Merrill Lynch Financial Consultant (FC) or broker, the securities processing task seemed to require an inordinate amount of time and lead to numerous problems. (There are some 10,000 FCs and 4000 administrative assistants at Merrill.) The branch operations staff had to continually monitor accounts to see if securities had been credited properly. FCs were forced to contact clients to obtain additional documents. There was a great deal of friction between the sales side of the business and securities processing department.

All of these reasons plus the labor intensive nature of processing led to a desire to improve securities processing. After suggestions by the operations staff and extensive research, the systems group at Merrill proposed a new system using image processing to capture an image of the security certificate and related documents that accompany a transaction. The focus of the project was on workflow redesign, not just the use of image processing. Workflow redesign involved the closing of the two processing centers described above and the development of a securities processing department at a single site in New York (now New Jersey).

The Old System

Appendix 1 contains selected Dataflow Diagrams for the original securities processing system. In the old system, customers brought securities and supporting documents to a branch office or sent them to Merrill through the mail. This set of documents will be referred to as a "certificate," the terminology used at Merrill. After receiving the certificates, the branch conducted a manual review for negotiability. If this preliminary review verified that the security was negotiable, a clerk typed a receipt for the customer. If the certificates appeared not to be negotiable, the clerk told the customer what additional information was necessary to complete the transaction.

During the day, several branch clerks accepted certificates and accumulated them. At the end of the day a courier took all certificates to one of two securities processing centers (SPC) in Philadelphia or Chicago. The clerks attached a manually-prepared manifest to the package summarizing its contents.

Normally the package arrived at the SPC the next day. Upon arrival, an SPC clerk inspected the package and checked that its contents balanced to the manifest. The clerk contacted the branch office to resolve any discrepancies. (Typically a discrepancy involved the inclusion of a certificate that was not recorded on the manifest.) All certificates that matched the manifest continued to the next stage in processing.

The first step after bursting packages was to microfilm all certificates. Next, clerks conducted a second negotiability review which is contingent on the type of transaction: legal or non-legal. An example of a legal transaction is a stock transfer because the customer had inherited the security. Regulations require that certain documents accompany the security, for example, a death certificate for the person in whose name the security is currently registered. Legal negotiability review is more complex than non-legal, though some of the steps are the same.

An important step in negotiability was verifying the CUSIP number (an industry-wide, unique identifier for each security). If the CUSIP number did not exist in Merrill's internal CUSIP database, then the staff held the transaction until the CUSIP number was located and added to the internal database.

If further review showed the certificate was not negotiable, it was segregated. A clerk logged this status into a Merrill Lynch securities control system known as MICS. This nonnegotiable status triggered MICS to generate instructions to resolve negotiability through a Document Request Form (DRF) which went to the branch office that accepted the certificate in the first place. The branch tried to resolve negotiability, usually by contacting the customer to obtain missing documents. Once classified as negotiable, the certificate moved to a final holding area for distribution.

The SPCs sent 80 to 90% of the certificates directly to depositories. The remaining certificates were distributed to specialty departments in New York for further processing, for example, a department handles exchanges of stock necessitated by a stock split. Upon arrival at a depository or at a Merrill specialty department, the certificates were again microfilmed and staff members updated their status in MICS. Certificates were microfilmed yet again before consignment to their final holding area.

Why did this process entail so much microfilming? Merrill must carefully control securities and credit them to a customer's account as soon as possible. Given the volumes of paper involved, microfilming became an integral part of the control process. Merrill must also pass audits by the SEC which checks the controls on securities processing.

The New System

Appendix 2 presents DFDs for the re-engineered securities system. As in the old system, customers bring securities to a branch office or mail them to Merrill. The branch cashier conducts a preliminary negotiability review supported by an expert system called CERTS. This system helps the cashier determine negotiability status; it also prints a customer receipt and generates a document control ticket (DCT). CERTS posts a record of the certificate to the Anticipated Receive File (ARF), including a unique identifier known as the ARF number which is represented by a reference bar code on the DCT.

At the end of the day, clerks package all certificates and their DCTs to be taken by courier to the single Securities Processing Center in New Jersey. The system generates a manifest sheet for the package and updates a manifest file so that it contains information on the shipment.

At the SPC the staff wands the bar code on the package to verify receipt. Clerks check the package against the manifest; if there is a discrepancy they update the ARF and manifest files and notify the branch. Branch personnel have access to these files so they can check the status of processing of any security at any time. The staff bursts completed and balanced packages for individual certificate processing.

Negotiability must be verified in the new system, both for legal and non-legal documents. However, the presence of the expert system in the branches reduced the number of certificates arriving without the documents needed for negotiability by 50% for legals and 75% for non-legals. As before, clerks must validate the CUSIP number. If the CUSIP number is missing from the DCT, a procedure identifies a new number and enters it into the CUSIP database. The ARF reflects the status of a certificate held pending assignment of the CUSIP number.

The staff separates the certificates for scanning into scanable and oversized groups. If the certificate transaction is non-negotiable, the system records a "9L" status in the ARF. Such a status in the ARF triggers branch notification through a system called ASAP. The branch is responsible for clearing up the nonnegotiable status by obtaining the required legal documents from the customer. Documents associated with the 9L transaction proceed en route with other negotiable certificates.

Oversized certificates will not fit through the current scanners and must be microfilmed. Scanable certificates proceed to the imaging operation. The scanning system recognizes the ARF reference number via the bar code on the DCT. The system uses the ARF reference number to access the ARF record which shows the scanner operator the certificates included in the transaction. Following the DCT, the operator scans the certificates and any legal documents. At this point the images and physical certificates diverge.

The scanned certificate image undergoes a character recognition procedure using a proprietary algorithm contained in firmware in the imaging computer. This recognition process converts three important fields from image to ASCII format: the CUSIP number, denomination of the security and security number. These three numbers are already recorded in the ARF; recognition of the imaged fields is to establish rigorous control and provide assurance that the right documents have been scanned.

The recognition task is complicated by the fact that there are no standard formats for securities; the three fields may exist any place on the security. The recognition algorithm needs to know where to look for the fields it is trying to convert. This information comes from a template database which contains x, y coordinates for the three fields on the security. Merrill has developed a template for each CUSIP and date of issue combination. The scanning computer routes any certificate whose template is not in the database yet to a workstation operator. The operator uses a mouse to draw a box around each field and the system records this information in a new template for the security.

The system performs the image-to-character conversion by referencing the image, overlaying the template, and executing the algorithm. If the converted ASCII fields match the same fields in the ARF, the system updates the ARF to show that scanning has been completed and stores the images for this transaction permanently to optical disk. If there is a mismatch between the converted characters and the ARF or other non-recognition, the system refers the transaction to key edit. There, operators examine the image and input data to unrecognized fields.

The staff takes the physical certificates for distribution to their final location. The system executes a procedure to provide routing orders for each certificate; it specifies a destination box for the certificate. On a periodic basis couriers collect certificates from the boxes and take them to their final destinations.

When a user needs access to security information, he or she can retrieve the image of the security on a graphics workstation. There is no need to access the physical security, or to hunt through microfilm records, a process that could take as long as three days in the old system.

COMPARISON OF THE OLD AND NEW SYSTEMS

Qualitative Information

Qualitative information provides an overall comparison of the changes created in developing the new system. Table 3 lists the major changes from the Merrill Lynch SPC system. The re-engineering effort resulted in the elimination of two process centers and the creation of a securities processing department at a central site. The system supports major changes in tasks and workflow, beginning with the receipt of securities at a branch office. The interface to the system for all groups having contact with it has also been changed.

Technology changes include the expert system for the branch office input, scanners, a template library, character recognition from images and optical disk storage. There have been significant increases in the level of customer service and the quality of support securities processing provides to the branches. There is much less handling of physical securities and retrieval time for a certificate image is nearly instantaneous. The time to research a security has been dramatically reduced; from up to three days in the old system to virtually instantaneously in the new.

Quantitative Comparison

Comparison of DFDs. Table 4 presents the results of an analysis of control points following Berndt's method which was described earlier. One of the major enhancements in the new system is additional control roots and points. For example, the on-line document collection system in the branch offices is a major new control as is the branch office expert system. The optical store of securities images is another control as is the character recognition of fields on the digitized image.

In Table 4 the new system exceeds the old system on counts of control roots by 4 to 2 and control points by 5 to 3. More importantly, there are more computer-aided and automated controls. In these categories there are 4 control roots in the new system versus 0 in the old and 4 control points versus 1 in the old system.

Changes in organization structure

The major organizational change was the elimination of two securities processing centers and the consolidation of all securities processing in a central site.

Changes in workflows and functions performed

There are many such changes in the DFDs:

- Branch office input changes
- Branch office customer receipt
- Anticipated receipt information
- Package receipt and bar coding
- Elimination of most microfilming
- Legal negotiability workflow changes
- Imaging operation; scanning and key edit
- Retrieval of image rather than physical security

Interface changes

- Branch office interface
- Customer interface
- Worker interface with scanning equipment
- User interface retrieving images

Major changes in technology

- Expert system to assist branch cashier receiving certificates
- Incorporation of scanning to replace most microfilm and provide better control, including:
    - Scanners
    - Template definition
    - Key Edit
    - Computer facility with optical disk jukebox
    - Retrieval of scanned documents
    - Modifications to existing control system

Impact

- Improvements in customer service
    - Better customer receipt
    - More information captured at point of contact
    - Broker can query system for status of processing
    - Better control
- Certificate level control
- High quality images compared to spotty microfilm
- Reduction in up to 3 day searches for microfilm to instantaneous retrieval
- Significant cost reduction as detailed in the next section.
- Reduction in research time

Qualitative Evaluation of the SPC System
Table 3

Control category	Manual controls	Computer-aided controls	Automated controls	Totals
Old Control				
Roots	2	0	0	2
Points	2	0	1	3
New Control				
Roots	0	1	3	4
Points	1	1	3	5

Merrill Lynch Securities Processing System
Control Points
Table 4

Function category	Manual functions	Computer-aided functions	Automated functions	Totals
Stable				
Old system	10	2	3	15
New system	3	7	5	15
Obsolete functions	3	0	0	3
New functions	0	0	4	4

Merrill Lynch Securities Processing System
SON Matrix
Table 5

Stability	15/22 = .68
Obsolescence	3/22 = 0.14
Change	4/22 = 0.18
Extent of automation	5/15 = 0.33 < 12/15 = 0.8
System-wide change	14/22 = 0.64

Merrill Lynch Securities Processing System
Summary SON Metrics
Table 6

Table 5 contains a SON matrix for the two DFDs in the appendix. Table 6 is an analysis of the data in Table 5 using the ratios defined earlier. The results are difficult to interpret as absolute numbers in the absence of a database of other projects for comparison purposes. Since the maximum for each of the ratios is 1, the results can be carefully viewed as gross measures of percentage change. One would expect that low scores on automation and system-wide change would put a project in the incremental improvement part of Figure 1 while high scores would indicate a re-engineering effort.

The new Merrill Lynch system has a number of functions that are common with its predecessor yielding a stability index of.68. The system did not eliminate securities processing. However, looking at the extent of automation and the system-wide change score of.64, it is clear that the new system is much more highly automated than before. Combined with the analysis of control points, this quantitative comparison suggests that the re-engineering project resulted in much greater system control along with extensive automation.

Comparison of Resources Required. The new securities processing system has had a dramatic impact on resources:

Reduction of occupancy from two locations to one
Reduction in depository fees
Interest savings on receivables
Reduction of microfilm costs
Savings in security services
Reduction in staff of 168 positions leaving a current total of 165 including temporary staff

Investment. The new system required an investment of approximately $3 million.

ROI. The return on the investment was calculated as a payback period of less than two years which translates to a savings of around $1.5 million a year.

CONCLUSIONS

The evidence presented above suggests that the securities processing system project at Merrill Lynch represents a successful example of process re-engineering. The system has created a major change in the processing of securities; the changes have had a positive impact on customers and on Merrill operations staff members who need access to the certificates. Image processing is an important technological component of the re-engineering, but there is far more to the system than scanning. The entire workflow had to be redesigned taking into account the capabilities of the technology.

The changes go far beyond an incremental improvement in an existing system. The degree of redesign and the changes involved are on the radical side of the continuum in Figure 1. This case illustrates what is meant by "re-engineering" as opposed to incremental improvement. Merrill managed to avoid the "middle ground" in Figure 1 and obtain the benefits of a radical redesign of a system which incorporates new technology and workflow changes.

DISCUSSION

The tone of this report has generally been positive. Based on extensive interviews in Merrill, the system is certainly viewed as a success in the company. Of course, there are few projects in which everything goes well. What were the critical steps and problems with the securities processing system?

Because the firm was not convinced that image processing would work, the design team insisted on a very thorough demonstration on a large sample of documents before it signed a contract with the image subsystem vendor. This pilot test helped reduce uncertainty.

The project, as is often the case, ran late. Part of the problem was the image vendor who was providing an integrated system. Merrill employees ended up closely monitoring the vendor after it became apparent that it would not meet the schedule.

There were problems assigning sufficient programmers to the team so that some functions were not ready when the system was implemented. In addition, various departments had included anticipated savings in their budgets the year the system was scheduled for installation. Delays that year in the cutover meant that these managers would be over budget. This problem generated intense pressure to install the new system resulting in a conversion that was premature.

Currently, recognition rates are below what was anticipated. However, the number of individuals in key edit who correct mis-scanned fields is fewer than planned in the original system. Part of the problem lies in the measurement; if a single character of a field is not correctly scanned, the operations staff considers scanning to be a failure at the document level. The fact that 95% of the characters in the three fields being recognized are correct does not matter. Currently the method of measuring errors is being changed to reflect the scanning and recognizing task more realistically.

IMPLICATIONS

The purpose of this paper is to provide a framework for re-engineering and to illustrate it with a case study. The paper also suggests an approach for comparing two systems. While the comparison here is of two versions of the same system after the implementation of a new design, the technique should be equally applicable to two or more competing proposals for a new system.

One conclusion from this study is that re-engineering can be described as simply radical systems design. However, by assuming that there is nothing new here, the designer may forget to ask critical questions and end up in the high effort, low payoff middle ground of Figure 1. The designer's "mind set" approaching the development of a new system should produce questions like "is this process necessary" and "is there an entirely different way of looking at this problem" Thinking about re-engineering during design should allow information technology to make the kind of dramatic difference in the organization that has eluded many projects.

The important consideration is whether one is able to use the technology to make significant changes in the organization, to transform tasks, functions and organizational structures. When designers can say that their systems accomplish this kind of change, they will have finally achieved the potential of information technology.

REFERENCES

Berndt, D. "Techniques for the Comparative Analysis of Data Flow Diagrams", Stern School of Business Working Paper no., 1993

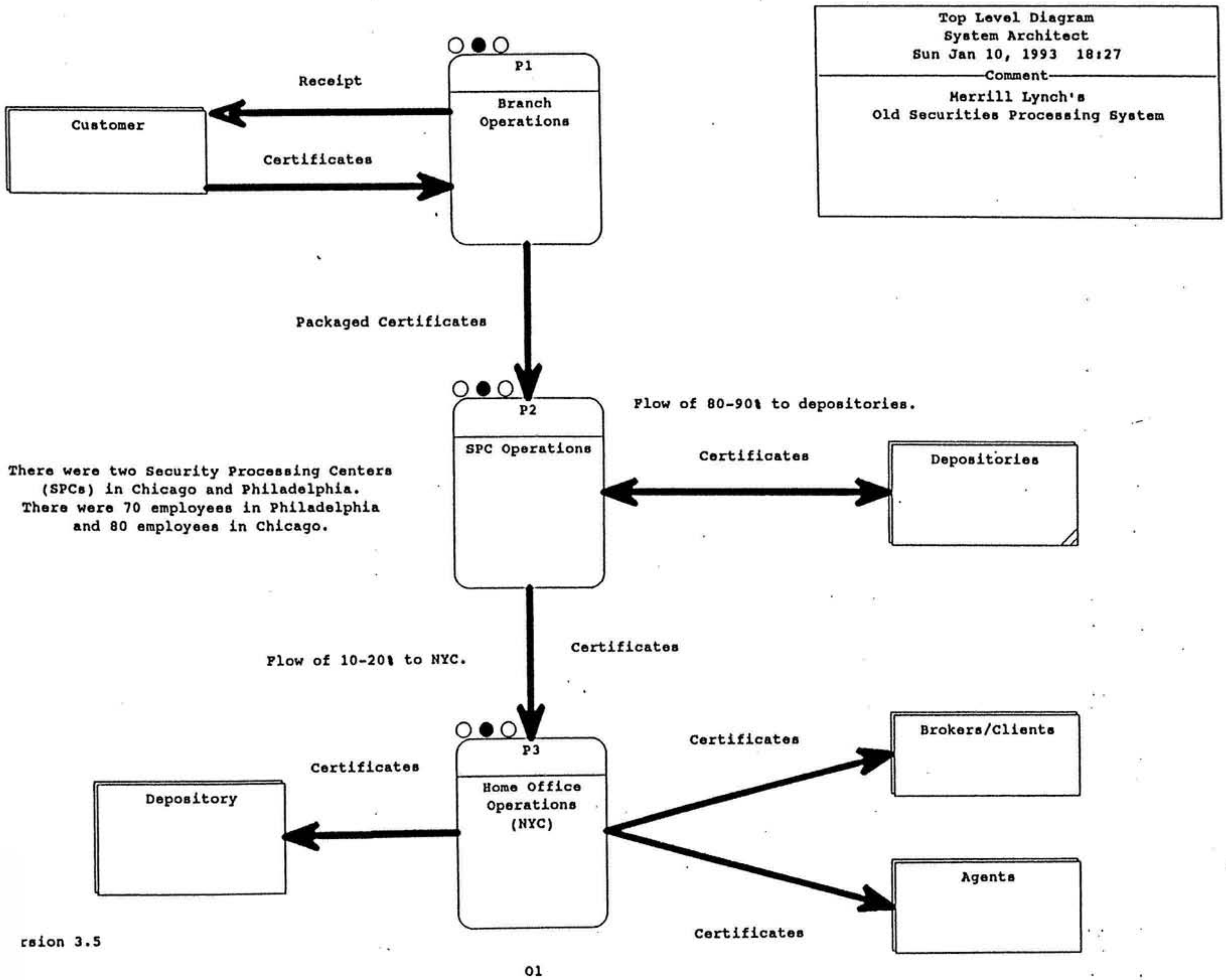
Davenport, T., Process Innovation: Re-engineering Work Through Information Technology, Boston: Harvard Business School, 1993.

Hammer, M. "Reengineering Work: Don't Automate, Obliterate," Harvard Business Review, (July-August), 1990, pp. 104-112.

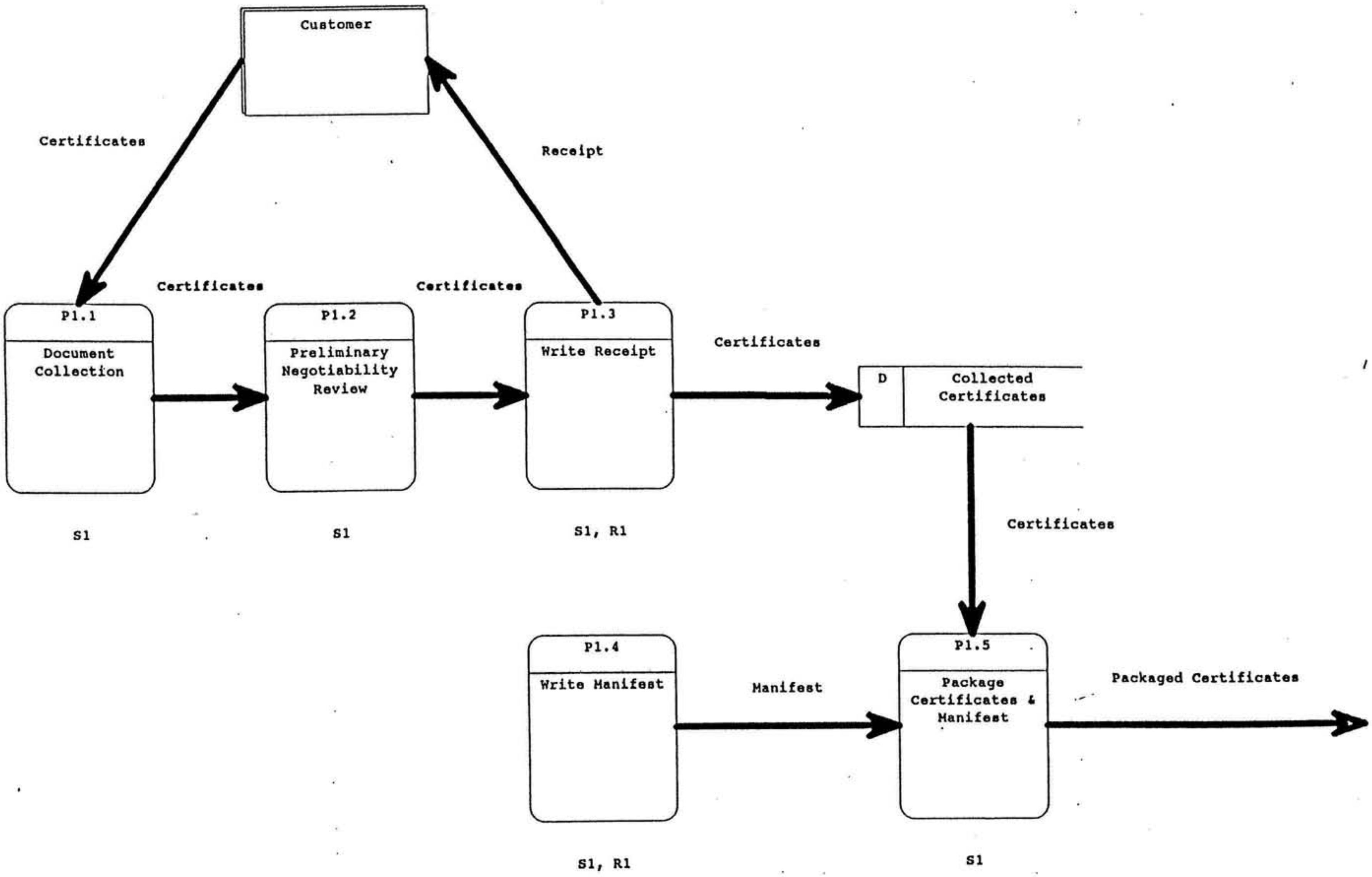
Lucas, Henry C., Jr. The Analysis, Design and Implementation of Information Systems, 4th edition, New York, McGraw-Hill, 1992.

Appendix 1

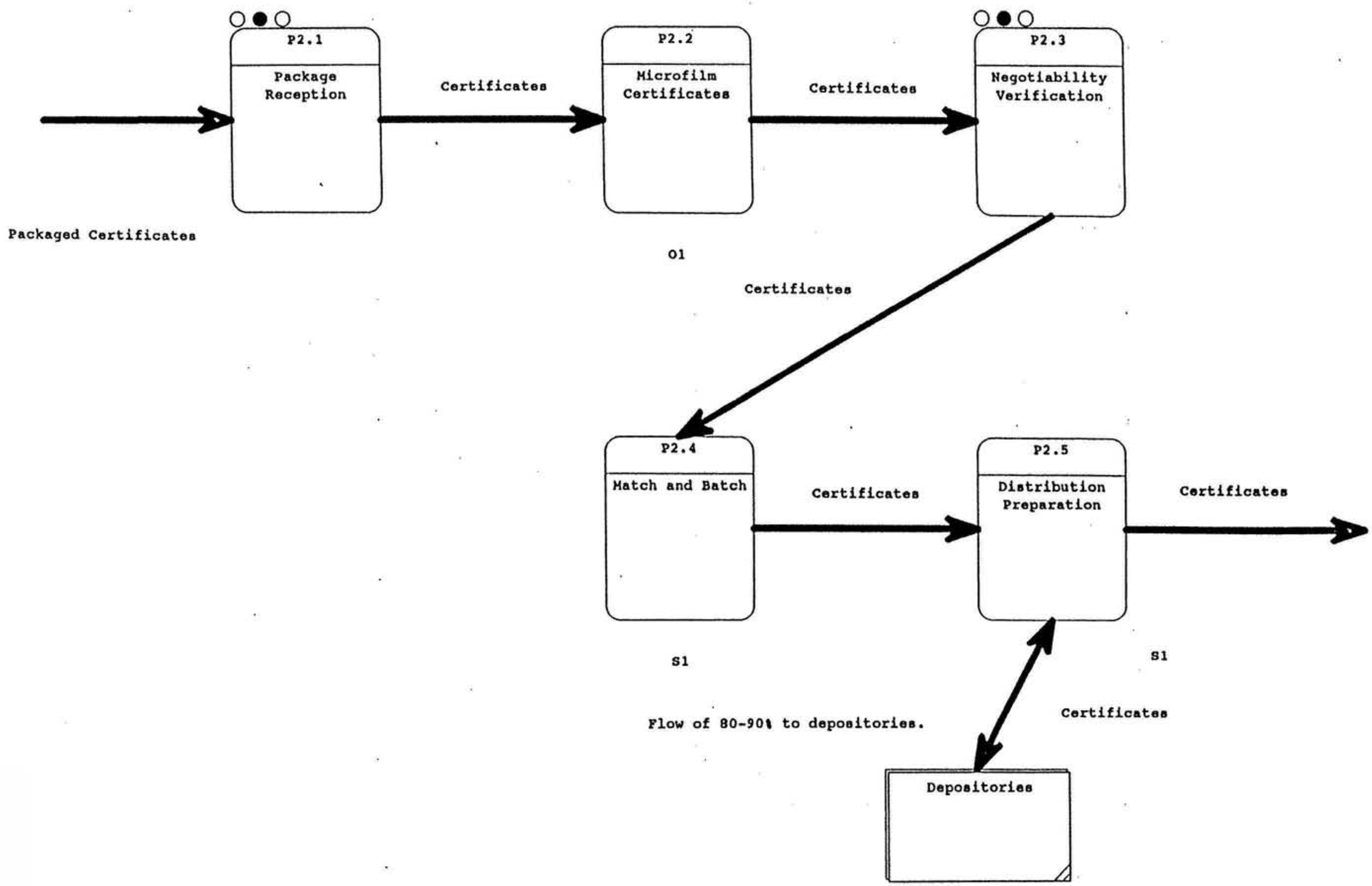
Original Merrill Lynch Securities Processing System


Top Level Diagram
System Architect
Sun Jan 10, 1993 18:27
Comment
Merrill Lynch's
Old Securities Processing System
Customer
Receipt
Certificates
P1
Branch Operations
Packaged Certificates
P2
SPC Operations
Flow of 80-90% to depositories.
Certificates
Depositories
There were two Security Processing Centers (SPCs) in Chicago and Philadelphia.
There were 70 employees in Philadelphia and 80 employees in Chicago.
Flow of 10-20% to NYC.
Certificates
P3
Home Office Operations (NYC)
Certificates
Depository
Certificates
Brokers/Clients
Certificates
Agents
rsion 3.5
01

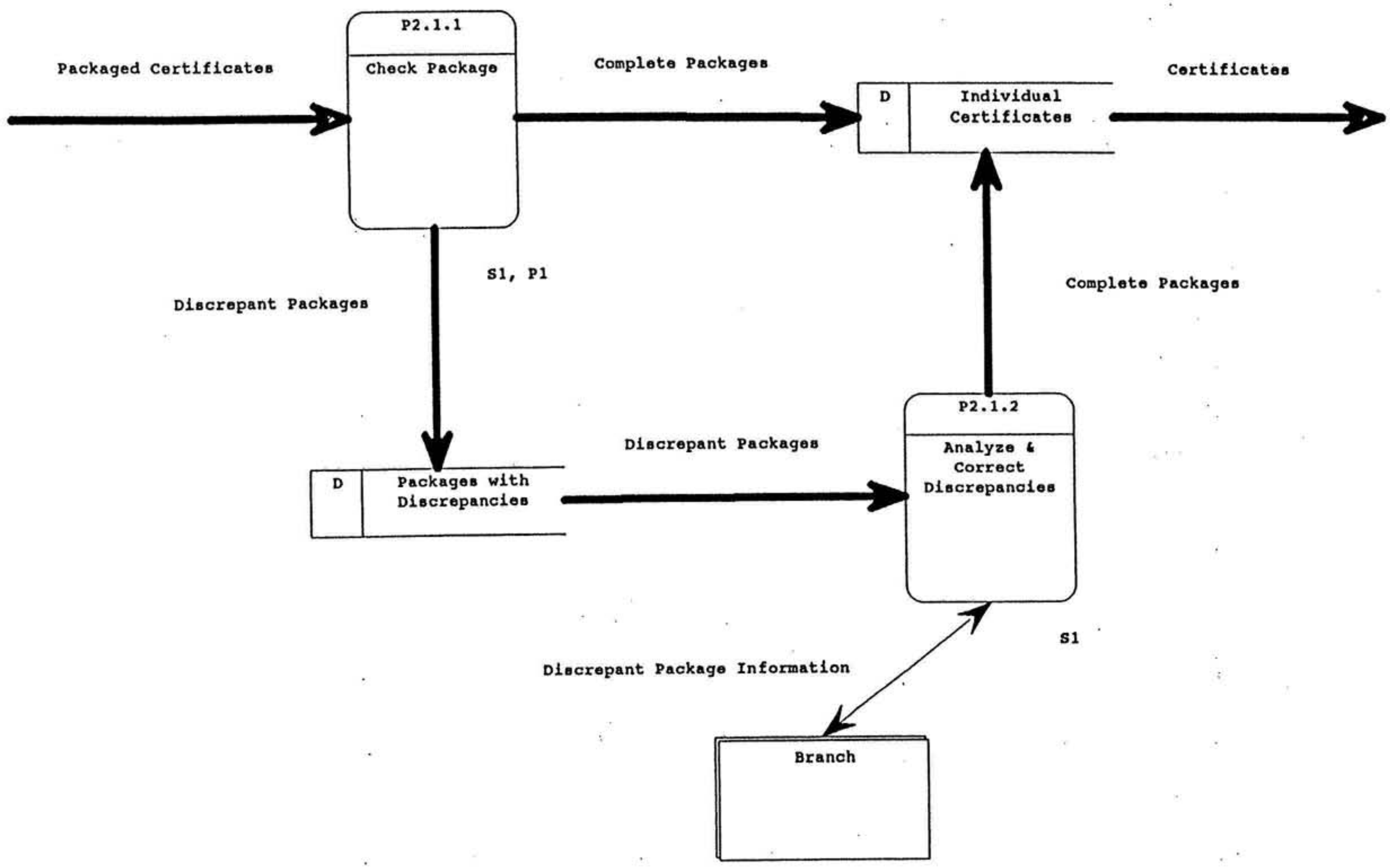
Branch Operations



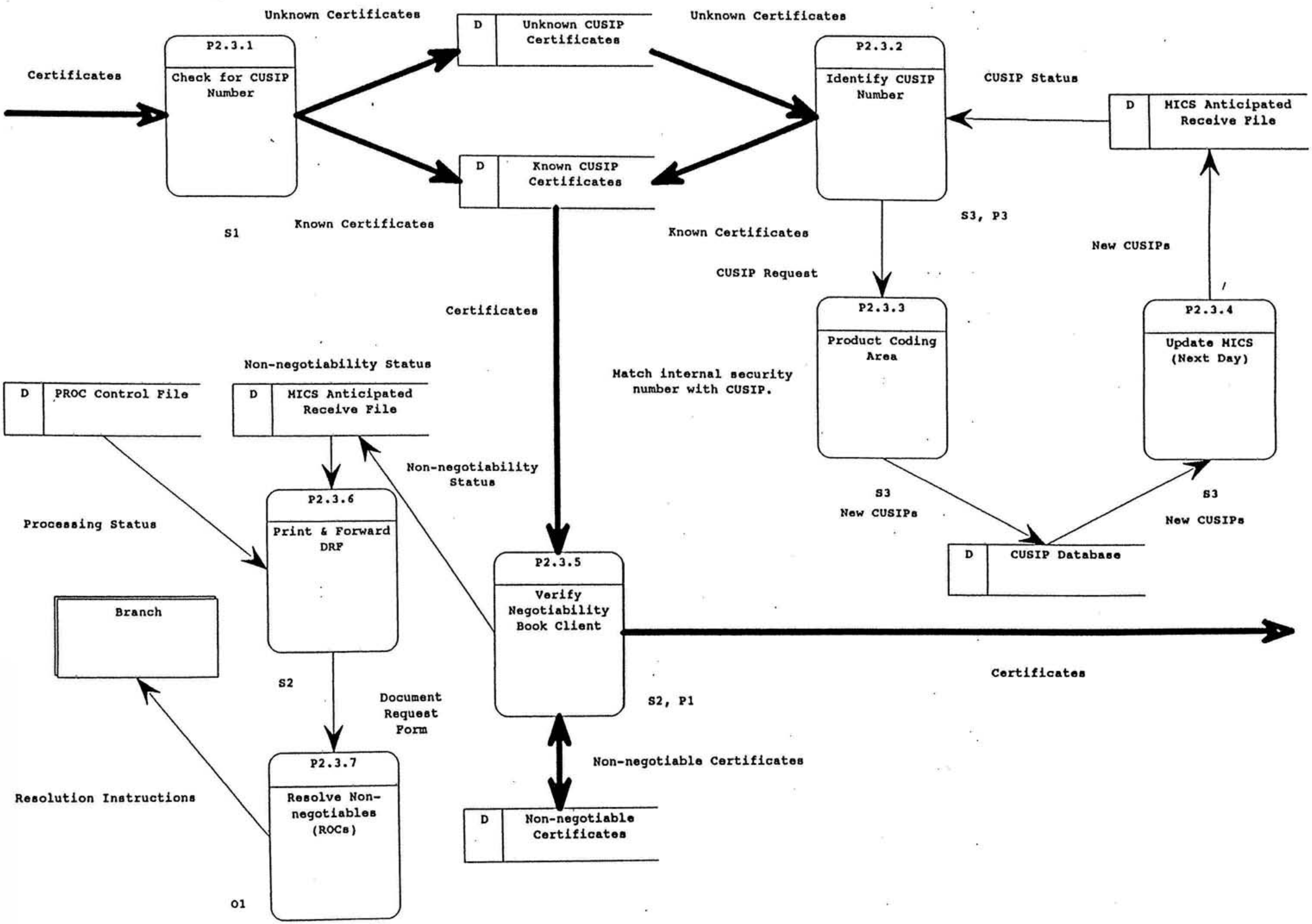
SPC Operations



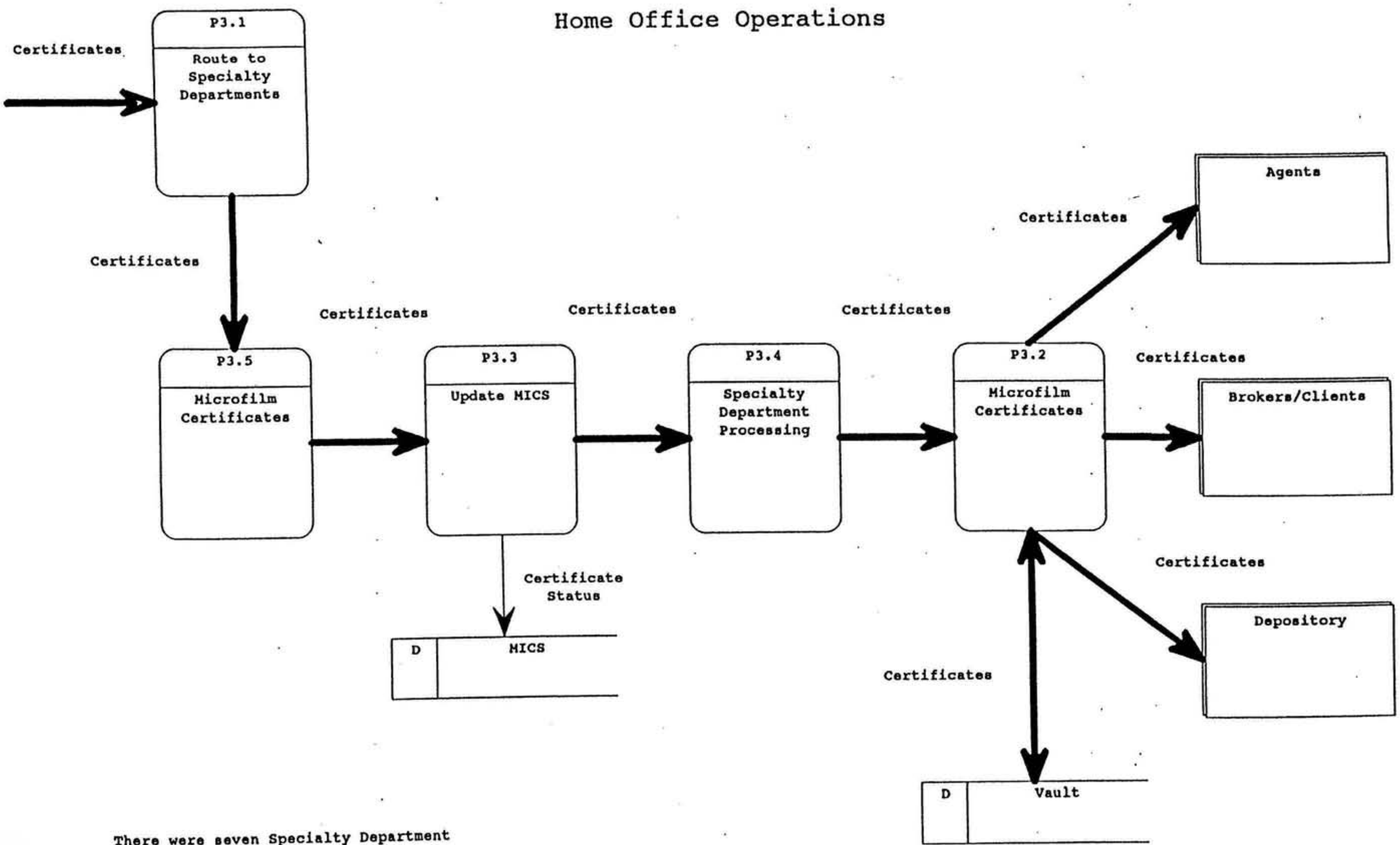
Package Reception



Negotiability Verification



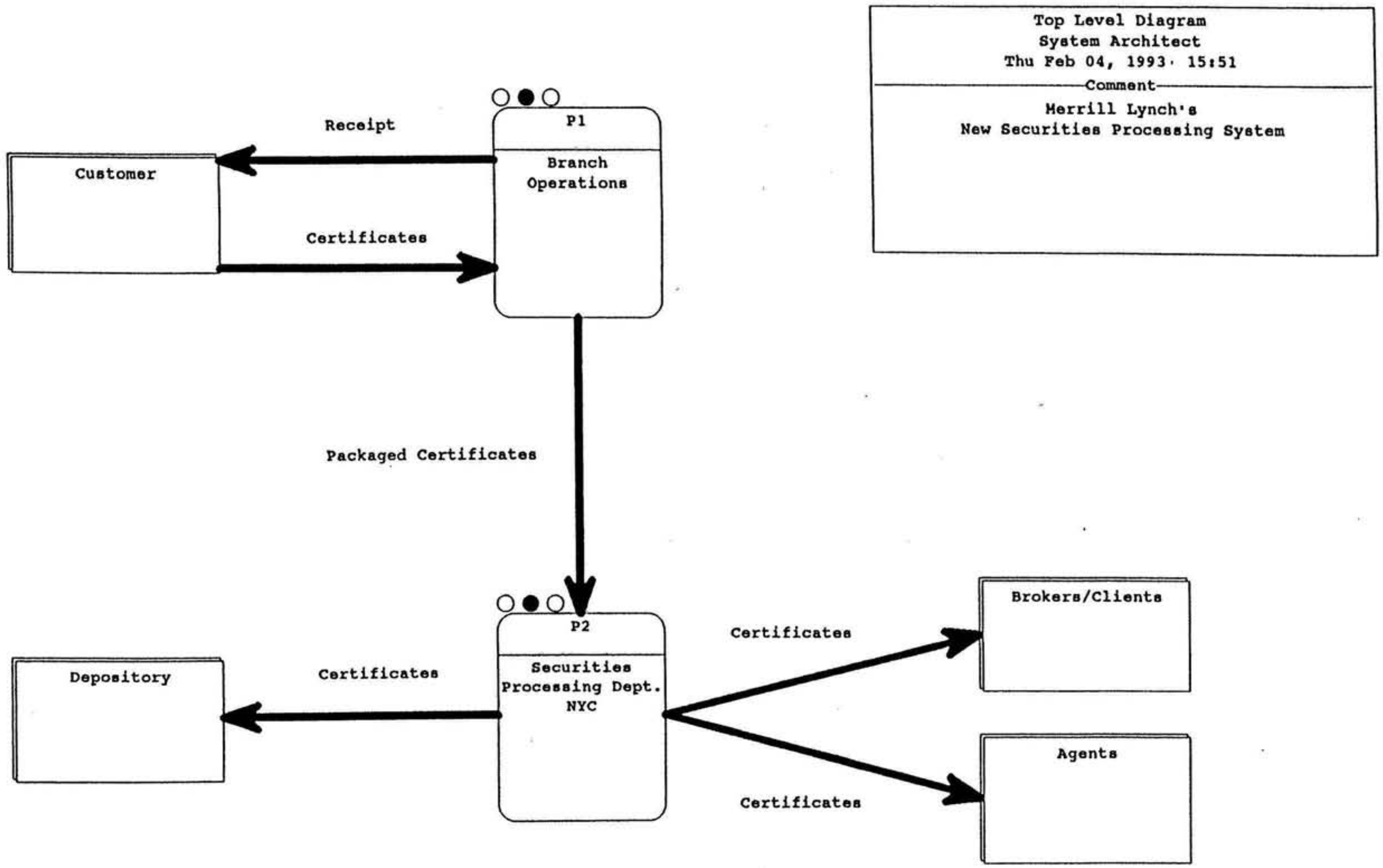
Home Office Operations



There were seven Specialty Department destinations. The three external sites included Cashiers OLP, GMMD OLP, and Somerset NJ. The internal sites included Transfer Services, Legal Transfer, Exchange, and Expiration. Each of these departments microfilmed and processed certificates before routing to final destinations.

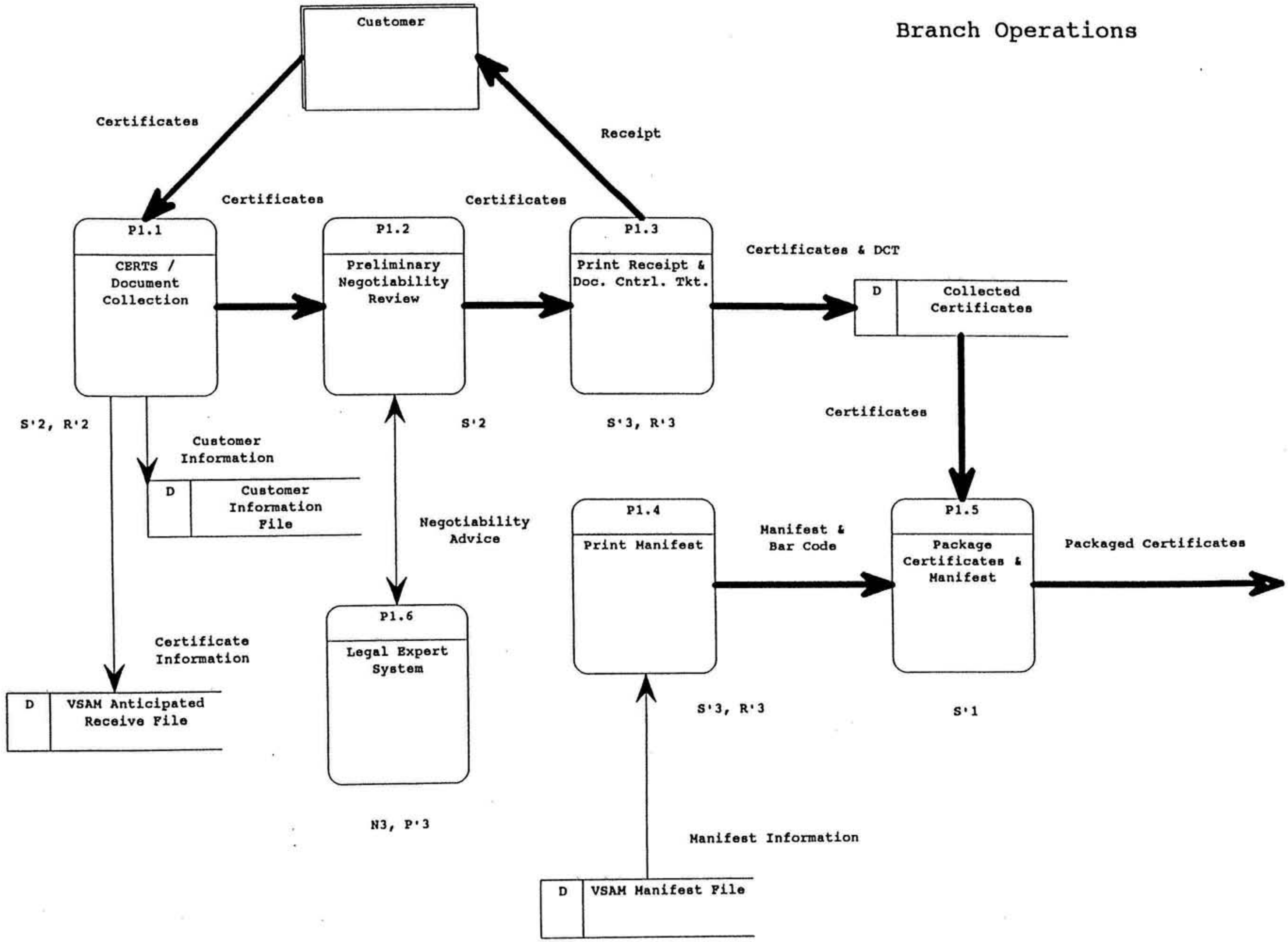
Appendix 2

Re-engineered Merrill Lynch Securities Processing System

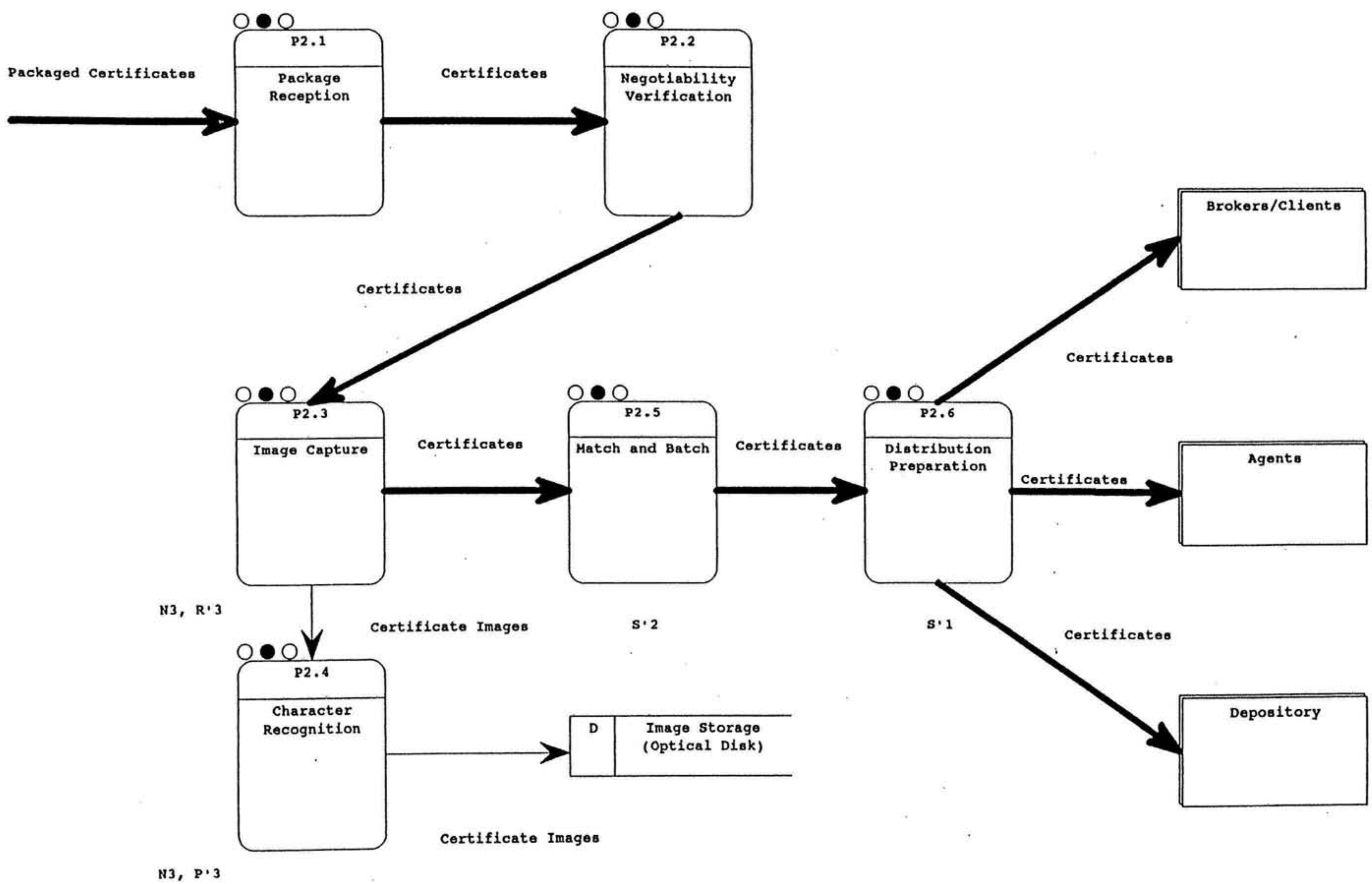

Top Level Diagram
System Architect
Thu Feb 04, 1993 15:51
Comment
Merrill Lynch's
New Securities Processing System
P1
Branch
Operations
Receipt
Customer
Certificates
Packaged Certificates
P2
Securities
Processing Dept.
NYC
Depository
Certificates
Certificates
Brokers/Clients
Certificates
Agents

Version 3.5

Branch Operations



Securities Processing Department



Package Reception