

Desktop Underwriter: Fannie Mae's Automated Mortgage Underwriting Expert System

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Abstract

Fannie Mae, the nation's largest source of conventional mortgage funds, has made a commitment to use technology to improve the efficiency of processing a loan by reducing the time, paperwork and cost associated with loan origination. The Desktop Underwriter (DU) system which was developed as a result of this commitment, is an automated underwriting expert system that applies both heuristics and statistics to the problem. The system supports both the wholesale and retail mortgage environments and is built to reason and underwrite loans with incomplete, unverified and conflicting data.

The system generates a credit recommendation based on the loan's conformity to credit standards and an eligibility recommendation based on the loan's conformity to eligibility

requirements. DU is already having a major impact on the mortgage industry. The system helps standardize how the Fannie Mae underwriting guidelines are interpreted, reduces discrimination by removing subjective reasoning from the decision process and reduces the cost of manual underwriting for both lenders and Fannie Mae.

DU was first released into production in June of 1995 and there have been at least two major releases each year. The system's use and importance both to Fannie Mae and the mortgage industry have been growing steadily. DU is well positioned to lead the way in meeting Fannie Mae's goal of reducing the cost of making a mortgage by \$1,000 and reducing the processing time from eight weeks to five days.

Background

In 1938, the U.S. Congress created the Federal National Mortgage Association (currently known as Fannie Mae) in response to the massive upheavals in the housing

finance market during the Great Depression. Fannie Mae's role was to bring stability to the residential mortgage market and to ensure that funds for housing would be available on a continuing basis. With the creation of Fannie Mae the secondary mortgage market was born. This market provides capital support to the primary mortgage lending institutions.

In 1968, Congress split the original Fannie Mae into two separate entities: Fannie Mae, a shareholder-owned Government-sponsored enterprise (GSE); and Ginnie Mae, a government agency within the Department of Housing and Urban Development (HUD). Today, Fannie Mae is the nation's largest corporation in terms of assets as well as the largest source of conventional mortgage funds in the United States.

Fannie Mae purchases residential home loans from the primary market and either retains them for its own portfolio or pools groups of mortgages together as Mortgage Backed Securities (MBS) for sale to investors with a guarantee of timely payment of principle and interest.

The decision whether or not to purchase a loan is based on an analysis that determines if the loan complies with Fannie Mae underwriting guidelines. The task of underwriting a loan is complicated and requires extensive experience in the mortgage business. This manual underwriting process is often dependent upon scarce and expensive resources. Also, because underwriters may interpret Fannie Mae guidelines differently, the process can lead to inconsistent results.

Continuing the Fannie Mae tradition of leadership within the mortgage industry, the corporation has made a commitment to use technology to improve the efficiency of processing a loan by reducing the time, paperwork, and costs associated with loan origination. Fannie Mae developed Desktop Underwriter™ (DU), Desktop Originator™, and several other systems as a result of this commitment.

The Underwriting Problem and Solution

The mortgage underwriting domain consists of myriad business policies that are either general rules or exceptions to these rules. These policies change and evolve because of economic conditions, regulatory changes, and other business objectives.

Underwriting a loan application involves the tedious review of detailed data. A typical loan application may include over 700 data items that share complex interdependencies. The correctness and consistency of this data must be verified before an accurate decision can be rendered.

Borrowers and lenders require underwriting decisions at many different stages of the home buying process. A

broker may want to provide the borrower with a point-of-sale decision based entirely on unverified information which the borrower has entered on the loan application. A loan originator may require an underwriting decision for a loan which the broker has either partially or completely reviewed and then submitted for approval. After all verification documents regarding the case have been gathered together in one file, an underwriter in a lending institution may review the final loan decision as part of a lender's quality control procedures.

The development team identified several overall objectives which directed system design and the technology chosen for implementation.

- Domain knowledge in the system must map to business rules that are documented in published Fannie Mae guidelines.
- The system must provide case-specific feedback for problems and issues with the mortgage application that are detected during underwriting.
- The system must provide case-specific instructions for delivering the loan to Fannie Mae.
- The system must underwrite a case in under a minute.
- The system must handle various levels of documentation to support different modes of operation, such as point of sale decision and underwriting seasoned loans for quality control purposes. The underwriting decision must be tailored to fit the submission scenario.
- The system must be easily maintainable because of constantly evolving mortgage industry standards and practices.
- The system must be designed in a manner that supports the frequent broadening of scope as additional mortgage products become available through DU.

Fannie Mae considered traditional software development languages, but it was evident that these tools did not readily represent business rules and policies. Case Based Reasoning was also considered, but the resulting system would have required a very large case base to support the high number of permutations found in loan applications. The team also thought it would be much more difficult to generate case-specific messages regarding Fannie Mae delivery requirements and specific problems identified in the loan file using a CBR tool.

Fannie Mae initially selected a purely rule-based approach because the business rules that constitute the underwriting domain readily lend themselves to such a representation. Exceptional business policies can also be more easily represented in this paradigm. Rule based systems are easily adaptable to changing business policies. Problem areas in a loan application can be clearly linked

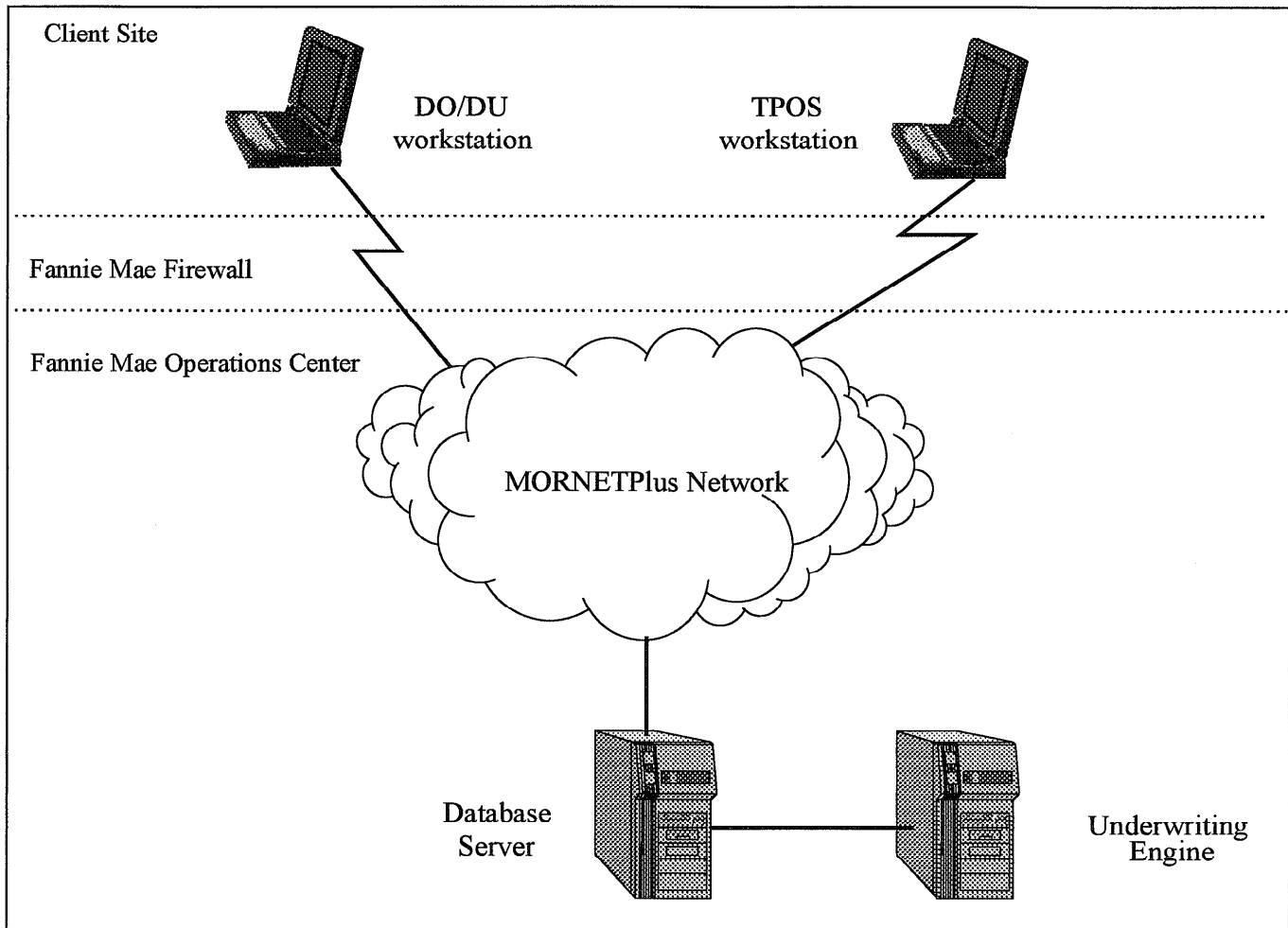


Figure 1: High-Level System Diagram

to policies and procedures which are represented by rules, and the results can be communicated to the user.

One drawback of a policy-based ruleset is that it is not inherently capable of using existing credit data to predict the likelihood of mortgage default. Rules alone do not directly encompass the knowledge inherent in the results of previously underwritten cases, and do not capitalize on the vast amounts of credit data available to Fannie Mae. During the first year of production, ongoing statistical analysis determined that adding a credit scoring algorithm to the existing credit rules would provide an even better measure of expected loan performance and augment the ruleset with a predictive capability.

Project Significance

The mortgage industry has been a rich environment for AI applications. Systems such as the CLUES application from Countrywide first utilized rule-based technology to address the underwriting problem. Desktop Underwriter

distinguishes itself from these earlier systems in several ways:

- The engine uses both a rule-based approach and a sophisticated statistical scoring model to reach a hybrid decision. The rules complement the statistical model to provide the user with a detailed explanation of how a decision was reached.
- Fannie Mae's engine has been deployed in such a way as to make it accessible to loan originators and lenders throughout the industry. Users can access the engine via a proprietary front end, or by integrating their own systems with Fannie Mae's MornetPLUS network.
- The engine provides lenders with a reliable risk assessment tool that will allow them to better manage their own mortgage portfolios. Desktop Underwriter's analysis goes beyond merely approving loans for delivery to Fannie Mae.

- The widespread use of Desktop Underwriter significantly impacts the mortgage industry and will ultimately reduce the cost associated with buying a new home.

Application Description

Customers interact with the underwriting engine using either Fannie Mae's Desktop Originator / Desktop Underwriter (DO/DU) software suite, or any third-party origination system (TPOS) that uses the application programming interface (API) published by Fannie Mae. Once connected to the MORNETPlus network using DO/DU or a TPOS, customers work with the front-end software to populate Fannie Mae's database with the necessary loan data, submit the loan to the underwriting engine, and view the results of the analysis.

Figure 1 depicts the high-level system diagram for the automated underwriting transaction. The sequence of events that occurs during an interaction with the underwriting engine is as follows:

- The lender or originator works with borrower(s) to electronically populate a mortgage application (Form 1003) with the necessary loan data by using one of the front-end applications.
- The loan data is stored in a database server at Fannie Mae.
- The lender or originator submits a request (via the front-end application) to the underwriting engine for the loan to be analyzed. The request is placed in a request queue on the database server.
- The underwriting engine accepts the request from the request queue, reads the case data from the database server, underwrites the case, generates an underwriting recommendation and then publishes its results.
- The lender or originator views and/or prints the results using the front-end application.

The underwriting engine generates a two-part recommendation. The credit portion of the recommendation is based on a loan's conformity to credit standards set by Fannie Mae. Loans can be either approved or referred: approved loans meet Fannie Mae's credit standards, while referred loans either contain insufficient information to complete the risk analysis or contain credit weaknesses for which DU could not compensate. Approved loans require no further review other than the verification of data accuracy and of compliance with documentation requirements spelled out in the findings. A professional underwriter must review all referred loans and make the final underwriting decision. These loans can be delivered to Fannie Mae if

the underwriter attaches sufficient documentation in support of the decision.

The eligibility portion of the engine's recommendation is based on a loan's conformity to eligibility requirements established by Fannie Mae. Loans can be eligible, ineligible, or out of scope. Eligible loans meet Fannie Mae's eligibility requirements; ineligible loans do not meet these requirements; and loans that are out of scope include some characteristic that is not supported by the underwriting engine. Ineligible loans cannot be delivered to Fannie Mae, regardless of the credit recommendation. Lenders must manually underwrite out-of-scope loans.

In addition to the recommendation, the underwriting engine produces five reports which explain the underwriting decision and provide useful loan and credit information to the underwriter.

- The Underwriting Findings report contains messages that explain the underwriting recommendation and the steps necessary to complete the processing of the loan. Users can link directly to Fannie Mae's electronically published guidelines by clicking on the stated reference which accompanies each findings message.
- The Ratings report contains the numeric ratings generated by the underwriting engine for the primary risk factors used to determine a credit recommendation. DU calculates ratings for credit, adequacy of funds, adequacy of reserves, employment stability, payment shock, loan to value ratio, housing expense ratio, and total expense ratio.
- The Credit Summary report contains a summarization of the credit information pooled from the loan application and credit reports associated with the case. This report encompasses payment history, current account balances and monthly payments.
- The Sources of Income report contains the types, sources and amounts of qualified and disqualified income that Desktop Underwriter calculated for each borrower.
- The Underwriting Analysis report contains summary information that is needed to complete the Transmittal Summary Form. This form must accompany any loan that a lender delivers to Fannie Mae.

Underwriting Engine

Desktop Underwriter consists of approximately 1200 domain-specific rules and functions. The system reads data from 73 Sybase tables and invokes 87 stored procedures to retrieve and update data. When necessary, the stored procedures translate code values into symbols used by the DU engine. The engine is deployed on a SUN

UltraSparc server and underwrites a case in under 15 seconds.

The first phase of the underwriting process involves collecting, merging, and verifying data from the loan application. Missing, incomplete, and duplicate data complicates this task. For example, liabilities on the credit report may not match liabilities on the application. Some borrower assets and income may be undocumented or invalid, while others might be verified with multiple types of documentation. The engine is robust enough to handle the unpredictable nature of the data, resolve conflicts, and message uncertainties and assumptions that might require user attention.

The underwriting reasoning process begins once the data has been retrieved, collected, merged and verified. Because the underwriting task can be subdivided into multiple, partially independent subtasks, the team designed a system of autonomous reasoning agents. Reasoning agents within DU perform an eligibility analysis, an analysis of the borrower's ability and willingness to repay, and a collateral (property) assessment. Ability and willingness to repay are based on a borrower's credit history, available funds, and qualified income. The collateral assessment module evaluates the type of loan and the area in which the property is located to determine the type of appraisal required. A C++ mortgage scoring model captures the results of the reasoning agents and determines the statistical credit risk for the loan. A risk assessment agent combines the decisions of both the mortgage scoring model and the other rule-based agents to produce an overall recommendation.

Because of the complicated interdependencies of reasoning agents, the DU team implemented reasoning agents as groups of parent and child modules which can run in series or in parallel under a programmable control facility. The control facility allows developers to specify complex conditions which affect module flow of control. Developers may specify Boolean expressions as start-prerequisites, end-prerequisites, and predecessors for each module. Start-prerequisites are related modules which must complete before the subject module can begin its own processing. Predecessors are parent modules which must have started before the child module can begin. End-prerequisites are child modules which must complete before the parent module can finish. Modules can also register special dependencies with the control facility. This notification system allows modules which cannot begin execution until a specific condition has been fulfilled to register this requirement with the control facility. When the notification conditions are satisfied by another module, the control facility is notified and forwards the information to all dependent modules.

The example below shows a hypothetical Collateral module that depends on the successful completion of the Credit-Recommendation and Eligibility agents, and the start of the Risk-Assessment agent. The Collateral module cannot finish until either the purchase-collateral module or the refi-collateral child module has completed. The Refi-Collateral module cannot start until it has been notified that the case is a refinance and the Collateral parent module has started.

```
(defschema Collateral-Module
  (instance-of module-control)
  (module Collateral-Module)
  (start-prerequisites (AND
    Credit-Recommendation-Agent
    Eligibility-Agent))
  (end-prerequisites (OR
    Purchase-Collateral
    Refi-Collateral))
  (predecessors Risk-Assessment-Agent)
)

(defschema Refi-Collateral-Module
  (instance-of module-control)
  (module Refi-Collateral)
  (predecessors Collateral-Module)
  (request-notification (case-is-a-refinance))
)
```

The independent nature of the reasoning agents necessitated a two-phase approach to the generation of a coherent and relevant set of findings. During the first phase, independent agents generate findings without regard to the decisions or messages generated by other agents. In phase two, the risk assessment agent resolves conflicts between findings and manages the creation of the Findings Report which is presented to the user. A simple example of this technique involves messages that are generated only if the case is referred to a human underwriter.

Application Development

Desktop Underwriter development began in early 1994 after a design phase of nearly six months. Development was done by a staff of roughly twenty to thirty people. The product was developed and delivered on a network of Sun machines running Solaris 2.5 and client PC's running Windows 3.1. The underwriting engine was built using Brightware's ART-IM product, and the front end GUI was written in Microsoft Visual C++. Fannie Mae released a pilot of Desktop Underwriter in October, 1994. The first production release was implemented in June,

1995. Since then, Fannie Mae has met its target of two major Desktop Underwriter releases each year.

Originally one team performed all knowledge engineering and development for Desktop Underwriter. Programmers and analysts worked together to develop the initial knowledgebase from published Fannie Mae guidelines and policies. Fannie Mae's credit policy group reviewed and approved the resulting rules and recruited Fannie Mae underwriters to test the system. As the system grew both in size and importance to the company, the Credit Policy group assumed a greater role in specifying and approving changes to the system. Today, most knowledge acquisition and requirements specifications are written by the Credit Policy group. Developers review these requirements, analyze potential impact to the current knowledgebase, and implement the changes.

A primary goal of the early development effort was to rapidly introduce a basic set of loan products and underwriting features needed by the mortgage industry. Market forces played a significant role in that approach and have wielded significant influence on subsequent development. Although originally implemented as a system for underwriting fixed-rate first mortgages via a proprietary front end, industry competition and customer demands for expanded services have drastically changed Desktop Underwriter in the last two years. The engine now underwrites second homes, adjustable rate mortgages, Community Lending products, and mortgages to multiple, unrelated co-borrowers. Users can access the engine via Fannie Mae's front end or by using front end systems developed by third party software vendors.

To date, the primary development emphasis for DU has been to increase the system's functionality to meet the needs of the mortgage industry. While the addition of new features will remain a priority, the re-implementation of DU in ART*Enterprise™ will be addressed in the near future. ART*Enterprise (A*E) is the successor product to ART-IM and as such is a much fuller development environment. In addition to its rule language, A*E features a strong object-oriented language, a full GUI development facility, and a database integration package. A*E's GUI and database facilities are of interest in terms of creating back-end development and debugging tools for Desktop Underwriter. Although rules are preferable for encoding the majority of DU's underwriting expertise, much of DU involves a series of computations that are performed before any loan recommendation is attempted. Many of these calculations would be better implemented and maintained as methods called within an object hierarchy. The separation of supporting calculations, underwriting judgment rules, and credit scoring

procedures will be better supported by the A*E development environment.

Maintenance

Fannie Mae has placed considerable emphasis on developing a robust, three-tier product support environment that can respond quickly and accurately to customer problems. The first tier and sole point of interface with the customer is the DO/DU Hotline. The hotline resolves customer problems directly or escalates the problem to a production support team. Production support is made up of personnel with long-standing experience in debugging customer problems. All problems that cannot be answered by Production Support are forwarded to Credit Policy for underwriting policy resolutions or to the DU development team for more extensive debugging.

The three tier support architecture is effective because most reported problems are straight-forward and easy to resolve. Most calls to the hotline are the result of data entry errors, which is typical for programs such as DU that have complex data requirements. Because of the volume of simple data errors, Fannie Mae implemented a pre-underwriting checklist to verify the completeness and consistency of the data and inform the user of any obvious problems. More complicated data errors as well as occasional bugs are reviewed and resolved by the development team. This approach to product support stresses fast problem resolution and closure with the customer.

As DO/DU production volume continues to increase, Fannie Mae is looking at new techniques for increasing production support efficiency. One technique with considerable potential is a case-based reasoning help desk application. The concept is to build a case base of problem reports with their associated solutions. New problems can be compared to the case base using CBR-augmented free text retrieval so that the most appropriate solution can be applied to the problem at hand. The primary benefits of such a system include fast problem resolution and the development of a corporate knowledgebase of problem descriptions and solutions.

Insights Gained

As Desktop Underwriter matured, the rule base began to provide a clear and accurate audit trail to specific policies, which in turn provided the customer with unambiguous information as to the decision/recommendation made by the system. Because of these benefits we made an effort to exclusively represent business logic as rules in the knowledgebase. We made a concerted effort to use database stored procedures solely for data retrieval and storage. The team learned that it was important that all

data manipulation, calculations and qualitative interpretation remain within the underwriting engine.

We developed DU in a competitive, market-driven environment, and found it difficult to balance demands for functional enhancements and refinement of policy with a structured development process. Simple changes initially appeared to require only a minor modification of existing rules. As an increasing number of minor changes filtered through the system, regression testing revealed unforeseen side effects. The team learned the importance of maintaining a structured development process and formal change control procedures. We found that an iterative cycle of analysis, development and testing was necessary to refine user requirements and implement a quality product.

Broadening the scope of the application consistently challenged us to maintain a usable collection of test cases. Implementing new functionality necessitated thorough regression testing. A wide variety of well-maintained test data should be considered an essential aspect of development and included in the project plan from the outset. A suite of tools for cloning, manipulating, and moving data between development and test environments is also essential.

Payoff and Usage

In 1994 Fannie Mae announced an unprecedented effort to address the unmet housing needs of American families. The Trillion Dollar Commitment earmarks \$1 trillion to finance eleven initiatives that address every dimension of the housing finance system. One of these initiatives is entitled "Technology to Lower Costs". James Johnson, the Chairman and CEO of Fannie Mae, explains how this initiative is to impact mortgage making in his recent book:

Our goal at Fannie Mae is to cut at least \$1,000 from the cost of making a mortgage and to reduce origination time from eight weeks, or longer, to five days.¹

Desktop Underwriter and the MORNETPlus network are critical technological components in the solutions being developed to meet this and other important goals. Automated underwriting reduces discrimination in the mortgage industry by removing subjective reasoning from the decision process, improves the overall quality of loans sold to Fannie Mae by enforcing uniform standards, and reduces the cost of manual underwriting associated with quality control for both lenders and Fannie Mae. Furthermore, the software encompasses several

underwriting heuristics and exceptions that can be applied specifically to Fannie Mae's Community Lending programs, and is expected to increase mortgage lending to under-served communities of low and moderate income borrowers.

Since its rollout in 1995, the average number of loans analyzed by the underwriting engine has increased tremendously. Figure 2 shows the total number of cases underwritten by the engine each month from March, 1996 to March, 1997. At current volumes, DU is well positioned to reduce the cost and time of loan origination.

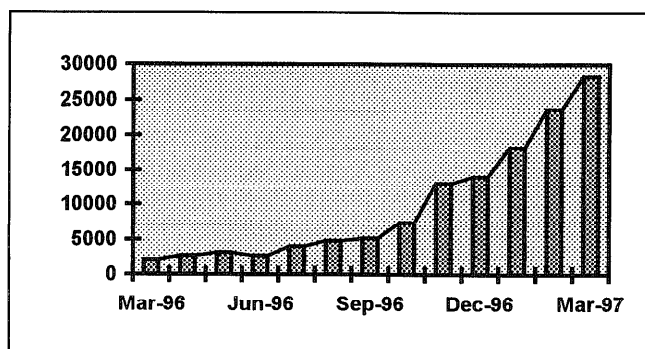


Figure 2: Cases Underwritten per Month

One example of the immediate cost-savings to lenders stems from the streamlined appraisal process available only through DU. The collateral assessment reasoning agent approves the use of several streamlined appraisal forms which reduce the time and expense associated with a property appraisal by 20% to 50%. Further evidence can be found in the many testimonials from lenders who have adopted the technology that Fannie Mae has introduced to the industry. Here are some quotes taken from lenders currently using Desktop Underwriter:

Desktop Underwriter is absolutely fantastic. The streamlined work flow reduces the time we spend by at least 50 percent, if not more. The streamlined appraisal tells us exactly what we need to do; no more guessing. We're getting about a 75 percent approval rate through Desktop Underwriter, and have high confidence in its recommendations. Aside from data entry, there's no room for error. (Sharon LePage, Vice President, Jefferson Bank of Missouri)

Desktop Underwriter is a perfect fit for us; we're very pleased. We're ready to advertise our 20- to 30-minute decisions in the newspaper. And putting our portfolio loans through the system gives us extra confidence that we're doing the right thing. (Paul Peters, Senior Vice President, Hibernia National Bank)

¹ Johnson, James. Showing America a New Way Home: Expanding Opportunities for Home Ownership. Jossey-Bass Inc., San Francisco, CA, 1996.

Overall, the user community reports a notable streamlining of their workflow and a significant reduction in time and effort spent processing each loan. Lenders have been able to reorganize their workforce and improve productivity. With the aid of DU, junior underwriters can increase their caseload. Senior underwriters can focus on the more complex loan applications or be matrixed to provide support for other loan servicing activities.

The trend toward time and cost reduction will continue as production volumes increase and the diversity of loan types supported by the underwriting engine broadens. The success of Fannie Mae's technology efforts is in no small part attributable to the high level of corporate commitment demonstrated by Fannie Mae executives and the influence that Fannie Mae wields in the mortgage industry.

Acknowledgments

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References

Fannie Mae Selling Guide. 1996. Fannie Mae, Washington, DC.

Talebzadeh, H.; Mandutianu, S.; Winner, C.F.; and Crane, L. 1994. Countrywide Loan Underwriting Expert System. In Proceedings of the Sixth Innovative Applications of Artificial Intelligence Conference, 141-152. Menlo Park, Calif: American Association for Artificial Intelligence.

Bynum, S.; Noble, R.; Todd, C.; and Bloom, B. 1995. The GE Compliance Checker: A Generic Tool for Assessing Mortgage Loan Resale Requirements. In Proceedings of the Seventh Innovative Applications of Artificial Intelligence Conference, 29-40. Menlo Park, Calif: American Association for Artificial Intelligence.