AdjudiPro® 2.0

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Abstract

AdjudiPro, version 2.0, is the latest incarnation of United HealthCare's patented physician claims adjudication expert system (US patent # 5,359,509). Its core is an embedded expert system that contains the logic for processing 55% of all physician claim situations reviewed on United HealthCare's managed care system. Certain physician services are reviewed as part of the claims adjudication process to ensure that submitted charges meet contractual, and other guidelines. In 1995, nearly $20 million in gross savings was realized through use of this system. Since its initial deployment in 1991-1992, there has been a steep increase in AdjudiPro's processing volume. This increased demand created a number of issues that had to be addressed to ensure AdjudiPro's continued viability and growth. As a result, much of the past three years was spent rearchitecting AdjudiPro to meet the increasing load placed on it, while achieving acceptable throughput. AdjudiPro is now an essentially real-time application, processing claims twenty-four hours a day, seven days a week. This paper describes the current AdjudiPro application, and the key issues faced during the past three years.

Introduction

United HealthCare is a national leader in health care management, serving purchasers, consumers, managers, and providers of health care since 1974. The company serves over 40 million individuals through a broad continuum of health care products and services, including HMOs, point of service, preferred provider organizations (PPOs), and managed indemnity programs. United HealthCare also provides managed mental health and substance abuse services, utilization management, workers compensation and disability management services, specialized provider networks, third-party administration (TPA) services, employee assistance services, Medicare and managed care programs for the aged, managed Medicaid services, managed pharmacy, health care evaluation services, information systems, and administrative services.

This paper describes AdjudiPro®, a patented expert system (US patent #5,359,509, issued 10/94) developed at United HealthCare that is used in the physician claims adjudication process by many of United HealthCare's health plans. The initial production version of this application was described in a paper presented at IAAI in 1992. Although this paper describes the new version of this application, one of the goals of this paper is to describe major issues and challenges that arose as a result of the significant growth in AdjudiPro's impact to United HealthCare's business. Most of the major issues faced resulted from the overall design of the application, not from the expert system components themselves. Nevertheless, we feel that understanding and overcoming these issues were key to the ongoing success and growth of this application's use.

System Background

United HealthCare offers advanced health care management capabilities and contracting approaches layered upon a core claims administration process. Many of these capabilities are supported by United HealthCare's mainframe managed care system called COSMOS. This system supports the majority of the processes necessary for operating an HMO in today's marketplace. It is currently used to manage geographically dispersed HMOs with membership of more than 3 million.

COSMOS core claims administration is used to enter, adjudicate, pay, and store physician and hospital (facility) claims. Traditionally, United HealthCare increased COSMOS' capabilities through direct modification of COSMOS. However, in recent years many new features have been added by integrating other systems with COSMOS, both systems developed within United HealthCare and systems developed externally. AdjudiPro is one such application. Its design commenced in 1990, with implementation of the automatic claims update feature in mid-1992. Its goal was and is to improve

United HealthCare's claims adjudication process (i.e., determination of proper payment). In many cases, proper payment involves complex decision making that requires detailed knowledge of provider contracts, members' benefits, federal and state government regulations, and established billing practices. This decision process often requires the application of logic not easily programmed using a traditional, procedural approach. Traditionally, these types of payment decisions have been handled manually by expert personnel. It was for this reason that a knowledge based systems approach was selected for development of this automated adjudication process. In order to understand what AdjudiPro does, it is important to understand United HealthCare's overall claims adjudication process.

When a claim is received by COSMOS, a complex set of adjudication logic is applied. This process results in the claim being assigned one of two states -- payable (not necessarily as billed) or pended. A claim may be in a pended state for multiple reasons. Each of these reasons is called a review. Reviews are set whenever the claim, together with its associated historical claims and/or other factors, matches the criteria for the review. Associated with each review is a set of logic ("rules") and a priority. Application of the review's logic can alter the amount payable for the claim.

Reviews are processed in the order determined by the priorities of the reviews that match a claim. Reviews that have not yet been performed are termed open reviews, while processed reviews are closed reviews. The highest priority open review is called the next open review. In general, review priorities are grouped according to the "group" responsible for clearing the review. This is to simplify workflow issues and allow for timely payment of claims. Currently, review priorities are generally grouped as follows: 1) claims processor reviews, 2) AI reviews, and 3) medical analyst reviews. Claims processors are responsible for administrative types of reviews, such as verification of pre-authorization or referral. Medical analysts are RNs. This group is responsible for reviews that require clinical training and experience. Reviews processed by this group include determination of whether or not a submitted service is cosmetic or experimental. A review is considered an AI review when the majority of claims that pend to the review are automatically processed by AdjudiPro.

Once all reviews for a claim have been processed, the status of the claim is set to payable. Payable claims are paid periodically by a COSMOS checkwriting process, at which point the state of these claims is set to paid.

AdjudiPro's goal is to enhance the manual process described above, through full and partial automation of reviews. This applies both to existing fully manual reviews, as well as new reviews developed and implemented directly with AdjudiPro. Presently, AdjudiPro contains the logic to automatically resolve, fully or partially, nine existing reviews. AdjudiPro also contains the logic of 14 reviews that were implemented directly with AdjudiPro. As a result of this logic, AdjudiPro automatically resolves nearly 60% of all situations that pend for physician claims within the COSMOS system.

In most cases, logic for new reviews is sufficiently complete to allow near full automation of the review (i.e., > 99%). Overall, AdjudiPro resolves more than one million reviews per month, which is more than 97% of all the reviews it attempts to resolve. Any attempted review not automatically resolved is handled by a manual process similar to the one described above. However, in many of these cases, AdjudiPro is able to provide the claims processor or medical analyst with information (e.g., relevant claims history) that they would have otherwise been required to research manually.

Much of the success of AdjudiPro can be attributed to its close alignment with the business objectives of the organization. All systems developed at United HealthCare are required to meet one or more of the following four tenets -- the more that are applicable, the better. The systems must:

- Reduce the Medical Loss Ratio
- Reduce Selling, General and Administrative Expense
- Improve quality of medical care to our constituents, and
- Improve "time to market" for products

With the exception of a fair number of the reviews previously stated, the above description was the task accomplished and presented at the 1992 IAAI conference (Figure 1). However, since that time there have been several things that needed to be improved or implemented for this system to survive and prosper.

Problem Description

In September of 1992, three new reviews were added to AdjudiPro as part of the migration of an HMO, acquired by United HealthCare, from their existing managed care system to COSMOS. The addition of these reviews not only resulted in a dramatic rise in AdjudiPro cost savings, it demonstrated to United HealthCare business personnel that knowledge based systems approaches were viable. Moreover, it could be depended on as a tool to help meet key business objectives. The rapid completion of these three reviews, in a time span of just a few months, convinced many doubters of this technology.

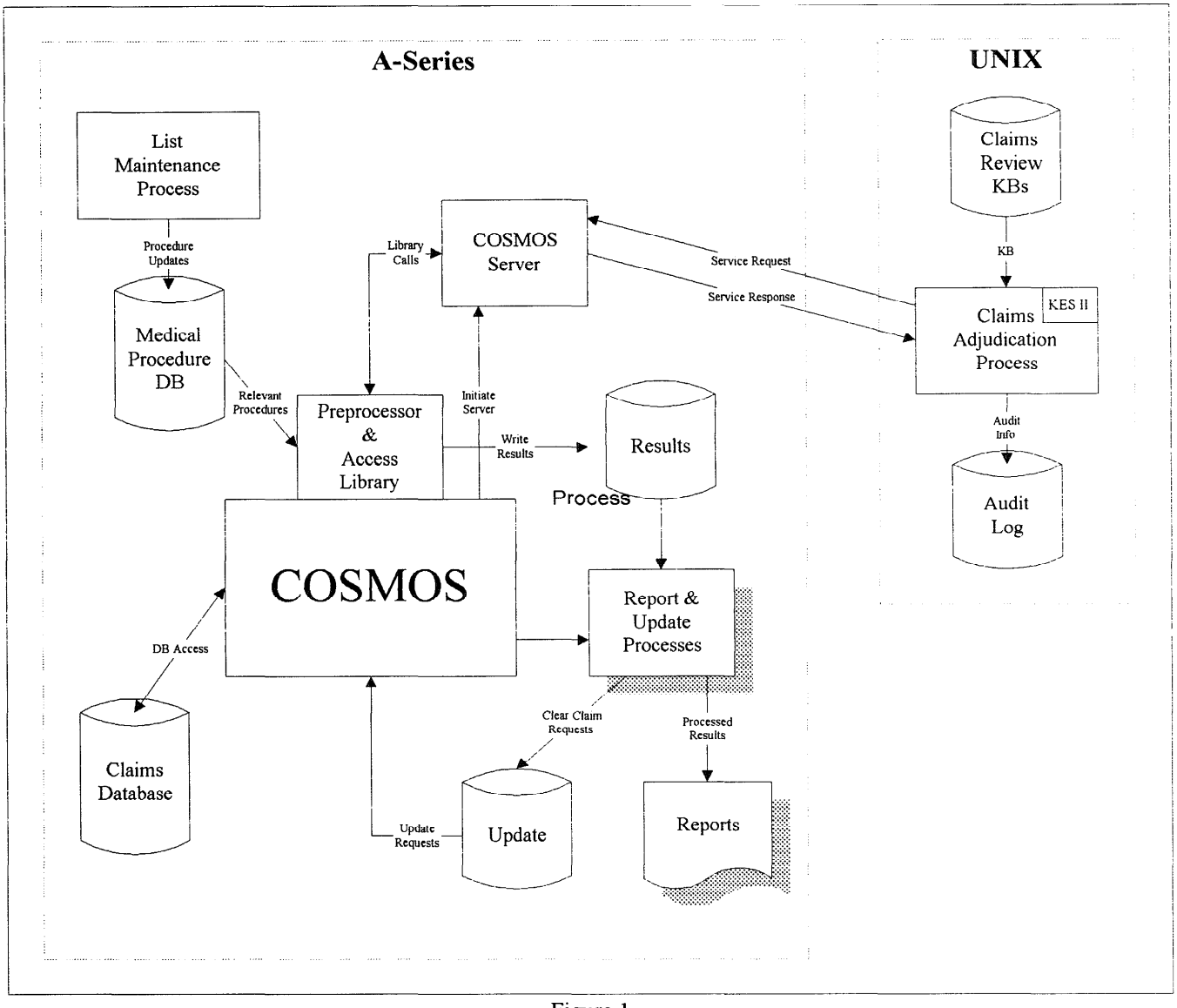

Figure 1

Following successful incorporation of these reviews, AdjudiPro entered a rapid growth phase in terms of both volume and return on investment (savings). From October of 1992 to October of 1993, review volume grew from 70,000/month to 450,000/month, while gross savings grew from $75,000/month to $900,000/month. It was around this time (October 1993) that some major issues arose. Although the business was generally convinced in the ability of AI technology to solve this problem, and was also increasingly impressed by the savings this application generated, business people were also increasingly concerned with the AdjudiPro's impact on claims throughput.

The original AdjudiPro system was a batch application that ran each review once a day. Reviews generally were run between midnight and 6 a.m., one job for each review for each health plan for each day. This created a problem with claims throughput, since reviews are required to be performed in a specific order and the way jobs were scheduled did not always allow every AdjudiPro review to be cleared in one night. In many cases, two to three days were required for all AdjudiPro processing of the claim to be completed. Since many of the reviews processed by AdjudiPro are reviews that were added to the overall adjudication process, this noticeably increased the average time to pay claims. There are often substantial financial penalties involved when the average time to pay claims is

too long -- that is, when they exceed the performance guarantees specified in United HealthCare's contracts or in government regulations. Thus, this decrease in throughput was a key business concern. It was critical that AdjudiPro be redesigned to minimize its impact on claims throughput.

In the short run, increased throughput was achieved through careful scheduling of the time at which each review was run. In some cases, the frequency of execution of a review was also increased. In addition, the priority order for review processing was altered to simplify the scheduling effort. After several months work, AdjudiPro operations were tuned so that in most cases, AdjudiPro performed all its required processing for a claim within one day. However, the result of this rescheduling and increase in frequency of AdjudiPro jobs placed an increasing load on United HealthCare's Computer Operations Department. For each run of each review (for each of the twenty or so health plans using COSMOS), a job had to be scheduled on the mainframe and report distribution setup was required for each report recipient for each job. In other words, there were literally hundreds of AdjudiPro jobs scheduled daily on the mainframe. Each of these jobs required operational monitoring and support --a very undesirable situation.

Another issue that factored into the redesign of AdjudiPro was that the original design was beginning to have difficulty "keeping up" with the increasing claim volume. Finally, at about the same time (4Q93), United HealthCare made the decision to purchase Health Payment Review's Patterns of Treatment Plus™ software and incorporate it as a review within AdjudiPro. It was decided that this should not be done without a redesign of AdjudiPro to meet the claims department throughput needs. It was thus paramount to AdjudiPro's continued growth and perhaps survival that it be significantly redesigned.

Keep in mind that AdjudiPro was United HealthCare's first experience with knowledge bases systems technology. As a result, for the first three years the AdjudiPro development team focused on proving the viability of the technology. At United HealthCare, this meant using the technology to build an application that had a demonstrable return on investment. This led to sometimes choosing expediency in development over perfection in design. Had the initial development languished in analysis and design, funding for the system might have been cut.

In any case, the decision was made to focus resources on a major redesign in 1994. The goals of the redesign were twofold -- minimize the time for which a claim pends for AdjudiPro processing and minimize the impact of this application on Computer Operations. Since this was to be a major effort and the knowledge engineering staff had become aware of several shortcomings in the design of portions of the expert system core, it was also decided to incorporate modifications to the design of the expert system component (i.e., the knowledge base) as part of this project. Changes to AdjudiPro's overall architecture were largely completed by the end of 1994, at which time Patterns of Treatment Plus was incorporated in production, integrated with AdjudiPro. In 1995, further enhancements were completed and existing AdjudiPro reviews were converted to the new architecture, one by one, with the project completed in third quarter of 1995.

One of the major changes to the knowledge base was to redesign its class structure -- to more accurately reflect the underlying information, to facilitate maintenance of the existing rules, and to ease the addition of logic for the many new reviews scheduled for implementation. More extensive use of class inheritance was also incorporated at this time to simplify future maintenance by more clearly sharing elements of classes that were common to more than one review. Another goal was to modify the classes so that they not only mirrored United HealthCare's proprietary COSMOS environment, but so that they would be flexible enough to be used with other claims systems.

The other major enhancement to the knowledge base (KB) was the reorganization of its rules. AdjudiPro rules are actually contained in many separate sets of rules, or knowledge bases, with one knowledge base for each review. Until not that long ago, the knowledge base for a new review was created by copying and modifying the knowledge base of an existing review. As the number of reviews grew, this created a maintenance headache. Some KBs contained rules that were not applicable to that review, and many rules were duplicated across all of the KBs. As part of the redesign, all obsolete elements were removed from each KB. In addition, elements common to each KB were extracted and placed in files that could be shared. For example, rules common to multiple reviews were placed in files with .rul file extensions. Each KB that requires an element, references the common item where it belongs within the KB via a #include construct. Common elements are pulled into each KB prior to parsing the KB. One unexpected benefit of separating the common information into separate files was that it facilitated the use of AdjudiPro's data model, rules, and other elements by other applications.

Application Description

As noted above, AdjudiPro is a client/server, knowledge based system (i.e., expert system) that operates in tandem with COSMOS, United HealthCare's proprietary COBOL managed care system. AdjudiPro is primarily a UNIX application, but it includes several components that

execute on the Unisys mainframe. The UNIX components execute on an IBM RS/6000 and the Unisys components execute on Unisys A-series mainframes.

AdjudiPro, version 2.0, transformed the application into a UNIX based client-server application. AdjudiPro only uses the Unisys mainframe as a data warehouse and a report distribution engine. All job and process management functions, plus creation of the report images, were migrated to UNIX. A Motif interface was also built to control and monitor AdjudiPro. This replaces the mainframe job scheduling described above. The application is now a data-driven, essentially real-time application. It is more flexible, tunable, and scaleable. A diagram of the system is shown in Figure 2. An overview of the AdjudiPro process is provided below, followed by a detailed description of the knowledge base component of the system.

AdjudiPro executes as a collection of Distributed Computing Environment (DCE) servers passing remote procedure calls (RPCs) amongst themselves and yet all functioning independently. These servers are constructed using a set of tools, Entera, supplied by Open Environment Corporation (OEC). One of the tools supplied by OEC is a production environment monitoring utility that verifies all servers are running, automatically restarting any servers that fail. Periodic UNIX cron jobs are executed to refresh the data upon which AdjudiPro is driven.

AdjudiPro consists of the following major components:

- UtoA Router: Provide access to Unisys data and services.
- COMS: Execute RPC's on Unisys.
- Claim Server: Obtain claim and process reviews.
- Knowledge Server: Execute adjudication logic on claim.
- Reviewable Claim Server: Provide access to reviewable claim list.

A detailed description of the AdjudiPro system flow of control is contained in the sections that follow but the basic steps include:

- Claim Server obtains next reviewable claim from Reviewable Claim Server.
- Claim Server obtains claim from COSMOS.
- Claim Server sends claim to Knowledge Server for adjudication.
- Claim Server sends request to modify COSMOS claim.
- Claim Server sends adjudication results to Report Server.

AdjudiPro's Unisys components are developed and maintained in XGEN, a fourth-generation language that generates COBOL. AdjudiPro's UNIX components (except for the KBs) are written in C. In addition, the client-server development relies heavily on the Entera tool set produced OEC. The Entera tools produce DCE compliant servers. Finally, the knowledge bases are built using SNAP's Object Modeler, version 6. SNAP is a development environment from Template Software. This Object Modeler component of SNAP is used for construction of AdjudiPro's embedded expert systems. Before describing each of AdjudiPro's components, as well as the relevant existing services used, a process (control) flow of the application will be provided.

AdjudiPro essentially operates in a continuous loop. Two basic functions are performed during each loop. The first is creation of the list of claims for which the next open review is a review processed by AdjudiPro. This list is known as the Reviewable Claims List (RCL) and its creation is controlled by the Reviewable Claims Server (RCS) described below. The RCL is stored in Sybase and is the list from which by the Claim Servers (CSs) operate.

The second step in each loop is the resolution of as many of the open reviews as possible, for all claims in the RCL. Each CS running extracts the highest priority claim in the list that has not been processed. The CS then attempts to resolve the claim's open, contiguous AdjudiPro reviews. (To be contiguous, two reviews must be next to each other in terms of priority.) This is done by a call to the appropriate Review Servers (RSs), each of which contains the full or partial logic for handling a single review. If the RS is unable to completely determine how to resolve a review, no further processing of this claim is done. The CS merely adds a record for the claim to the report file indicating that manual intervention is required. The CS then proceeds to the next claim in the RCL. If the Review Server fully resolves the review, the Claim Server checks if the next review on the claim is also an AdjudiPro review. If so, it continues processing of this claim as noted above. Otherwise, processing moves to the next available claim. Once all claims in the RCL have been processed, AdjudiPro rebuilds the RCL and begins anew.

Once a day, the logs and report information are copied from the working files to archive files. At this time, the report system is initiated. It is a collection of COBOL programs that generates reports for various user groups, including internal audit groups, claims processor groups and medical analyst groups. These last two groups use a "manual" report that lists claims reviewed by AdjudiPro that were not automatically cleared. The reports are distributed electronically to the Unisys system, allowing AdjudiPro to utilize the standard distribution system,

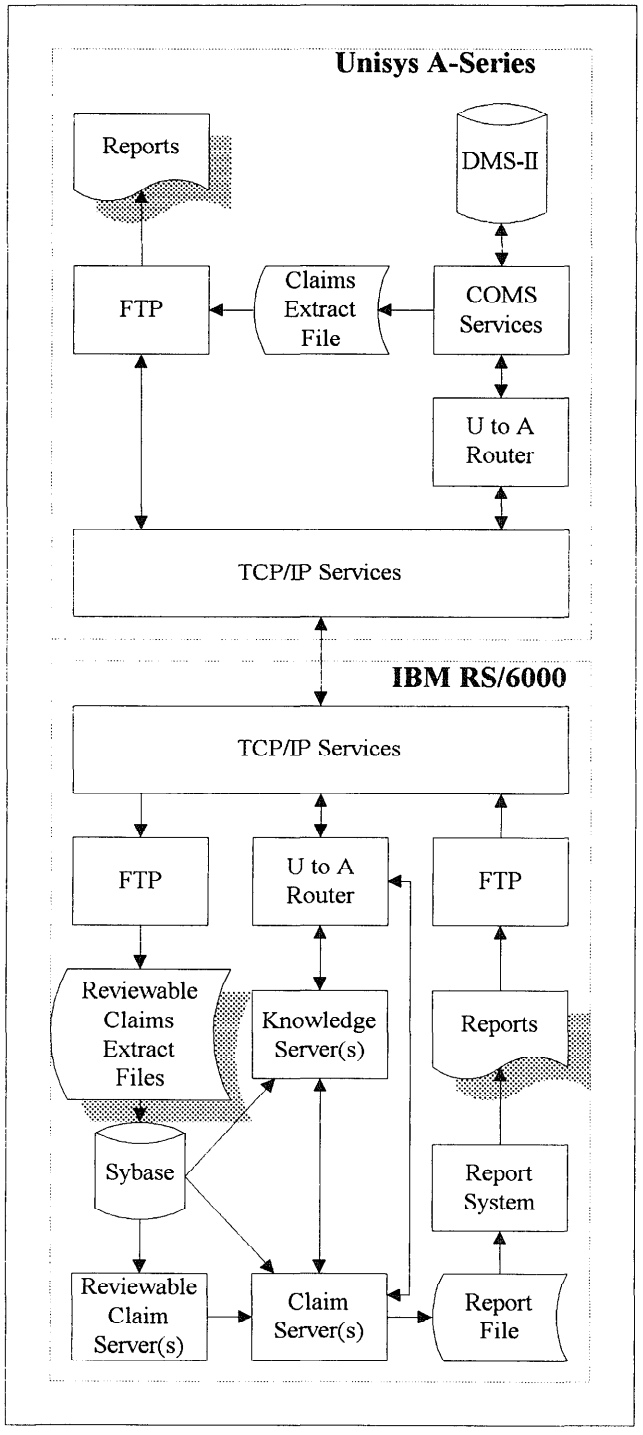

Figure 2

when appropriate. Reports are also moved electronically to some user groups, through United HealthCare's wide area network (WAN) and local area networks (LANs), to ease access to this information.

Unisys Components

As indicated in figure 2, a number of key systems and COSMOS services are utilized by AdjudiPro. The Unisys COSMOS system components used may be grouped into three categories - database services (DMS-II), transaction services (COMS), and communication services (TCP/IP, FTP, and the UtoA Router). The UtoA (UNIX to A-series) Router was developed to provide AdjudiPro and several other client-server applications access to COSMOS data. The UtoA Router provides access to COMS from remote hosts via standard TCP/IP sockets.

Reviewable Claim Server

The Reviewable Claim Server provides access to the reviewable claims Sybase table. The reviewable claims table contains all claims with an open AdjudiPro review. It is called by claim servers to get a claim to process.

Knowledge Server

The Knowledge Server is responsible for review adjudication. There are currently 23 AdjudiPro reviews. The logic for each review is in a SNAP knowledge base. Each Knowledge Server is a C program with an embedded SNAP component. The Knowledge Server initiates evaluation by the embedded KB by asserting the claim information and requesting payment advice. This results in a backward chaining process. This process proceeds until advice is determined or a situation is encountered for which the knowledge base has no internal knowledge source. In this situation, an external call is made to the Knowledge Server to retrieve the necessary information.

An example of how AdjudiPro can utilize other software applications is the Patterns review. Patterns of Treatment Plus is software tool used in the evaluation of the appropriateness of care. A DCE server, the Patterns Server, was developed that essentially included Patterns of Treatment Plus software as an embedded component. Claims that are put on review for appropriateness checking are then processed by having a knowledge server send the claims to the Patterns Server to obtain the Patterns of Treatment advice. In all other aspects, this review is handled by the knowledge server like all other reviews.

Specific information retrieved during the evaluation of a claim includes service authorization information, referral information, Sybase lookups, date computations, and claim history lookups. The claim history lookup is the most widely used lookup. Most AdjudiPro reviews attempt to reduce or deny payment of a claim. Most often this requires information about other procedures the member has had. The history lookup extracts all member claims

for a specified period of time that match certain criteria. The period of time and criteria vary by review.

Knowledge Bases

The knowledge bases currently share 26 classes and 9 demons. The largest knowledge base is the one that contains the logic for processing the multiple surgical review. This review is performed whenever multiple surgical episodes are performed on the same patient in a single day. This KB currently contains 607 rules, as compared to 168 rules just three years ago. The total number of rules contained in the knowledge bases for AdjudiPro's 23 reviews is 2275. This is significantly more than the 461 rules that existed three years ago.

Within the knowledge bases, substantial class development has occurred since 1992. In order to accurately mirror COSMOS data model and to simplify maintenance and enhancement of AdjudiPro, a new set of classes that utilized inheritance was developed. In COSMOS, physician claims are stored with header information, plus up to four lines. Each of these lines details one service performed by a physician on a day. In addition, each claim has may have an infinite number of history claims to which it is related. However, the structure of the a claim and each of its related history claims is the same. This information was used to redefine AdjudiPro's data model. The initial version of AdjudiPro had four classes -- a claim class, a line class, a history claim class, and a history line class. Much of the information in the claim and line classes was identical.

For AdjudiPro 2.0, a tree structure was used for defining both the line and the claims classes. At the highest level there is a generic line class and a generic claim class. This is the first (root) level of the tree structure. These classes contain attributes that are common in all reviews for these data elements, for both historical and pending claims. The second level in the tree structure contains the review line class and the review claim class, which inherit the generic line class and the generic claim class, respectively. This second level is used to attach attributes to claims and lines that are specific to a review. Finally, at the third level of the tree structure contains the line class, the history line class, the claim class and the history claim class. The first two classes inherit the review line class, while the second two inherit the review claim class. This structure has provided a number of advantages, including the elimination of separate identical rules that existed in the previous version, one rule which processed lines and another which processed history lines. This is now accomplished by having a single rule that utilizes the review line class elements. Moreover, this structure maintains the capability for looping on only the lines of the claim pending payment, or looping on its history lines.

Claim Server

The Claim Server is responsible for overall AdjudiPro control. At activation, each Claim Server is provided a set of review criteria identifying for which claims the server is responsible. The Claim Server begins by requesting a reviewable claim from the Reviewable Claim Server. If a reviewable claim is found, the claim is obtained from COSMOS and passed to the appropriate Knowledge Servers. The Knowledge Servers to which the claim must be sent are determined based on the open reviews.

Each claim may have up to ten reviews, which must be cleared according to the priority order defined by COSMOS. As noted above, the next review to clear is referred to as the next open review. The Claim Server attempts to clear all contiguous AdjudiPro reviews. The processing of a claim stops when either all reviews are cleared, the open review is not cleared by the Knowledge Server, or the next open review is a non-AdjudiPro review.

Reports

The AdjudiPro reports are the only deliverable produced by the system. The necessity for reports is a concept inherited from COSMOS. Since AdjudiPro reports are intended for the same audience as COSMOS reports, AdjudiPro is designed to distribute reports via the mainframe. The reports are generated on UNIX and transferred to Unisys via FTP.

Application Payoff

AdjudiPro was initially developed in 1990, with initial production (non-update) in 1991. Automatic update of claims was added in 1992. Return-on-investment from AdjudiPro has exceeded all expectations. Overall, the project has a positive net present value ($4.1M), and an internal rate of return equaling 178%. AdjudiPro is currently used by all United HealthCare health plans (HMOs) that operate on the COSMOS system. Together these health plans provide managed care services to more than 2 million enrollees. AdjudiPro is used twenty-four hours a day, seven days a week to assist with COSMOS physician claims adjudication. Processing statistics and savings for AdjudiPro, since automatic update are shown below.

Year	Savings(Gross $)	Reviews Cleared
1992	500,000	250,000
1993	7,250,000	3,750,000
1994	11,750,000	8,000,000
1995	19,500,000	12,500,000

Application Development

AdjudiPro is currently supported and enhanced by a development staff of thirteen, including management, knowledge engineering, system development, customer support, and testing personnel. In addition, there are two key individuals on the business side of the house responsible for the ongoing maintenance and enhancement of this application. One of these users, the "AdjudiPro Specialist", resides in the group responsible for overall claims administration. The other user resides in the department responsible for development of medical policies that impact claims payment.

The actual redesign of AdjudiPro from version 1.0 to version 2.0 required approximately eighteen months to complete. The cost of this effort is approximately four full-time staff for 12 months. Ongoing enhancement and maintenance of this system is coordinated by the development staff and the AdjudiPro Specialist. This AdjudiPro Specialist is responsible for communication with internal business personnel impacted by AdjudiPro, scheduling of enhancements, training of users, communication with the health plans, etc. The development of new reviews typically involves discussions between the staff knowledge engineers and various business experts, including the AdjudiPro Specialist. The length of time for development of new reviews varies from a day or two to several months. Reviews and enhancements to the system go through a business priority setting process. Except for system errors and required enhancements, enhancements are prioritized according to their potential return on investment.

Maintenance

AdjudiPro is fully maintained, from a code perspective, by the development staff noted above. No interface has been built to allow users the ability to add, delete, or modify rules. Currently, thirty percent of staff hours are budgeted for maintenance of the application. However, as the system continues to grow, so does maintenance. Full-time staff are now budgeted for AdjudiPro maintenance activities.

There are two major sources of maintenance. The first is a yearly review and update of the logic to ensure the reviews take into account the yearly updates to CPT-4 (i.e., *Physicians' Current Procedural Terminology*, Fourth Edition). CPT-4 codes are the standard used within the United States for submitting claims for physician services. It is published by the American Medical Association and revised annually.

Generally, changes to established polices that result from the annual CPT-4 updates are not large. However, there have been a couple of instances where reviews needed to be rewritten from scratch. The reason for the major change has been a fundamental redefinition of an entire set of CPT-4 codes. Maintenance of CPT-4 code issues has been simplified by storing much of this information in lists external from the knowledge base. Updates to some of these lists are automatically generated using an electronic version of CPT-4. The second main source of maintenance is when reevaluation of existing policies occurs as the result of other regulatory changes, or a review of the policies following acquisition of another HMO.

Along with the previously stated maintenance, the AdjudiPro team is constantly receiving requests for enhancements. All enhancement requests are quantified in terms of a return and prioritized for inclusion in future releases of the system. All requests pass through the AdjudiPro Specialist, and are fully tracked and documented. In addition, they are annotated with information as development occurs, as acceptance testing is performed, and when the request is implemented. Management of this process and documentation is done by the AdjudiPro Quality Assurance and Customer Support staff that are part of the overall AdjudiPro development team.

Conclusion

AdjudiPro has proven the viability of the expert systems and AI technologies at United HealthCare. The completion of this new version of the system has resulted in an increasing demand for use of AdjudiPro by groups within United HealthCare. The environment has gone from one of caution and skepticism, to full support. As a result, funding for AdjudiPro and similar projects has increased dramatically.

Acknowledgments

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