A Knowledge-Based System within a Cooperative Processing Environment

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CADS (consumer appliance diagnostic system) is a diagnostic and advisory knowledge-based system that provides advice through call-taking representatives to consumers calling the Whirlpool Consumer Assistance Center (CAC). Even though this application is not an original AI application, valuable lessons can be learned from the process that was followed during its development and integration into a revolutionary support system for a customer service operation (the Consumer Assistance Center System [CACS]). Whirlpool CACS was developed and implemented over a 3-year period with a financial investment of over $20 million. Whirlpool recognized the necessity of pursuing an advanced technological solution to the problem of handling an ever-growing number of customer calls. Over 250 call-taking representatives are currently handling as many as 1.7 million calls annually, which is projected to grow to approximately 9 million calls by 1995. This chapter focuses on CADS and how it will strengthen Whirlpool's ability to respond to customer requests as well as create a front-line source for quality information on Whirlpool products. CADS plays a synergistic role in CACS by either accessing other components to enhance its decision-making

Taking a Call from a Consumer and Consulting the CACS.

ability or providing it with additional information from which to efficiently support the consumer.

CADS is intended to support the call-taking representative when he/she responds to a variety of calls being taken through a toll-free telephone line. A call usually takes one of the following forms: asking for help with an appliance that seems to be malfunctioning, soliciting advice on using or installing an appliance, asking for information on an appliance, or requesting a technician to service the appliance. Two levels of representatives are dedicated to supporting these calls. The initial call takers, or *front-end representatives*, can respond to general calls about appliance information, schedule a service call for the consumer, order replacement or additional parts on request, or screen the consumer before transferring him/her to a more technically adept representative. The *technical representative* is on hand to guide the consumer through a diagnostic procedure that leads to a successful resolution to the consumer's problem.

The Need for CADS

One of the most important roles of CADS is to bridge the knowledge chasm that exists between the two levels of representatives. The front-end representative is usually a person who recently joined Whirlpool and has little knowledge or experience with Whirlpool products. The representative is hired into this position based on the ability to communicate over the telephone with a confident, yet compassionate attitude. Training consists of an elementary introduction to Whirlpool products with emphasis on how to expeditiously access sources of detailed information. The technical representative is an extension of the front-end representative with at least five years of experience (usually from the field) in handling appliance problems. Unfortunately, there are insufficient technical representatives to support the growing number of technical calls, with limited prospects for adding more because of the reluctance of experienced technicians to take desk jobs and the disparity of the skills required of the technicians who take this position.

CADS also presents more tangible benefits to the company by helping to eliminate unnecessary service calls. Before CADS, the call-taking representative would condense the consumer's problem to a one-line description when calling to schedule a service. The technician responding to the request for assistance would travel to the consumer's home and diagnose the problem. The technician would then do one of the following: inform the consumer of the incorrect use of the appliance, replace a malfunctioning part in the appliance, readjust a consumer's unsuccessful attempt at fixing the problem, or reschedule a return to the consumer's home to replace a previously unavailable part. The consumer is inconvenienced by the additional call, and Whirlpool incurs the expense of additional service calls, especially when the appliance is under warranty.

The following is an analysis of the anticipated savings that were mapped out as a justification for developing CADS: It was conservatively estimated that 15 percent of repeat calls would be eliminated with the effective use of CADS. If the cost for a call remained static over the next five-year period, and the number of calls requesting service increased by about 10 percent annually, the approximate savings obtained during this period would be $1.5 million for in-warranty calls and $2.5 million for out-of-warranty calls. This figure excludes the approximately $2 million that would be saved by eliminating in-warranty calls that occur because of incorrect use or installation of the appliance.

Further intangible benefits were anticipated and are now being realized. These benefits are discussed in Current Status of CADS.

Functional Overview of CADS

CADS was implemented as a standard graphic user interface with the capability of coexisting as a component of the larger application, CACS. The user selects a response from a list of answers to a question displayed in a question window. Each question is offered to the caller in a paraphrased form by the user. The customer responds with an interpretation of what can be observed about the problem with the appliance. The answers are not necessarily mutually exclusive but often overlap to provide the user with the confidence of not misguiding the system by entering an inappropriate answer. The knowledge base is structured so that qualifying questions are offered if the response is not specific enough.Different entry points in the knowledge base address the problem created by the system of having to support many levels of technical competency among consumers. For example, one consumer might suggest a problem with dishes not coming out clean after completing a dishwasher cycle, but another consumer might have already performed some simple tests to determine that the dishes are dirty because the dishwasher dispenser is not opening at certain points in the cycle. Both situations might lead to the same diagnosis, but the first consumer will be asked more questions and go into a greater amount of detail than the second consumer.

The questions used by CADS are designed to prevent the consumer from performing any mechanical or electrical testing of the appliance. The consumer is asked to report on what is observed either during the initial running of the appliance when the problem was first observed or after running certain tests. The consumer might realize the answer by seeing, hearing, feeling, or smelling the problem.

CADS then suggests one of three scenarios after diagnosing the probable cause of the malfunctioning appliance: The system might explain to the user how to resolve the problem that occurred because of incorrect use of the appliance (consumer instruct), the system might recognize that the problem was caused as a result of a bad installation or electric problems in the home and have the consumer first call the installer or electrician or plumber to resolve the problem, or the system might identify a part or list of parts that could have caused the problem and suggest servicing the unit. In the last case, suggested part names and corresponding part numbers are placed on the technician's service work order, and control is transferred to a scheduling system to schedule the service call.

Certain utilities were added to CADS to improve the accuracy of the diagnosis and offer subsequent advice to encourage consistent use of the system.

Receiving Context-Sensitive Help

At any stage during a consultation, the user can request more information about a question or how to interpret an answer if it does not match one of the responses provided. When the help button is depressed, the system displays text directly related to the question and its effect on the reasoning of the system. This technique has been beneficial when using the system with live calls and adds a level of credibility to the reasoning process. It also acts as a supplemental training tool.

Accessing an Image System

A second level of help is provided by one of the cooperative systems within CACS, an image system. Technical and user documentation on all models of appliances is provided directly to the users through an image-retrieval system that contains over 175,000 scanned pages stored on a CD-ROM. The image-retrieval system allows users to acquire information directly through a menu-driven interface or indirectly through an application such as CADS.

CADS was built to diagnose problems for over 12 appliance types at a level at which the consumer would be able to provide diagnostic input. It became apparent that it would not be feasible either functionally or financially to have model-specific diagnoses for over 20,000 appliance models. Precision is compromised by the generality of the rules, with the lowest level of questions discriminating between brands (Whirlpool owns the three brands Whirlpool, KitchenAid, and Roper) and major functional differences between the appliances, such as side-by-side versus top-mount or bottom-mount refrigerators.

This problem of gaining specificity existed at both the question and advisory levels. For example, the consumer might be asked whether the refrigerator thermostat is set to the middle setting. The consumer might respond that he/she is not familiar with what the middle setting of his/her particular model of refrigerator is. The call-taker will access, the system accesses the literature on the specific model through an image button associated with the CADS question, which will display the location of the thermostat and what the middle setting should be. Direct access to image is also especially beneficial when a diagnosis refers to use and care instructions. These model-specific instructions are found by selecting an image button from the resolution screen.

Having a Familiarity with a Model's Features and Components

CADS has access to a database arranged by model number that consists of all the features and some of the components contained within every appliance. This database eliminates the need to ask questions about features or components that do not apply for the appliance model being diagnosed. Thus, CADS will not ask a question specific to top-mount refrigerators if the refrigerator model is a side by side, or suggest a defrost timer as a part that might have failed if the refrigerator is not frost free.

Rules about features that certain types of appliances will or will not have are also contained in the knowledge base (see later discussion). Once the system recognizes that it is not dealing with a KitchenAid trash compactor, for example, then all questions associated with charcoal air filters (specific only to KitchenAid) are avoided.

Suspending a Diagnostic Session

Certain situations require that the consumer be able to call back to resume a suspended consultation. A CADS session might be suspended because the telephone line was disconnected, the consumer could not answer a question because he/she was calling at a location remote from the appliance, or the consumer had to run a test and call back with the results. The architecture of CACS is defined around a series of local area networks (LANs) that are connected over multiple locations to form a wide-area network (WAN). The return call is directed to any one of 250 representatives at a site in either Knoxville, Tennessee, or Benton Harbor, Michigan, that is transparent to the consumer.

When the consumer suspends a CADS session, the session is stored in a mainframe database associated with the consumer's current profile. CACS detects the origin of the call through an automatic telephone number identification facility and alerts the representative that the consumer might be calling back to resume a previously suspended session. Once confirmed, the session is automatically reloaded onto the representative's machine, and the CADS session is restored without loss of context.

Rescinding a Selection

CADS allows a user to back up to a previous question if he/she wants to change an answer. This change might result from an incorrect user selection or a change of heart by the consumer. The system then pursues an alternative path of reasoning based on the new answer. All previously asserted answers that were system implications are undone to maintain the validity of the consultation.

This facility has the additional benefit of allowing a trainee to learn about hypothetical cases and what the answer would have been if an alternative selection had been made.

Handling Uncertainty

If the consumer is unsure of an answer, the user selects "don't know." Currently, the system is set up to follow a path that leads to the most general solution in the current context. This approach is being modified to force the system to traverse all the alternative paths and either lead to a conclusion that contains more than one suggested solution or lead to a solution that was not contradicted by subsequent questions.

More Precise Scheduling of Service Calls

Once the solution has been determined and a list of probable faulty parts identified, CADS searches a central database for the part numbers that correspond to the replacement parts. The consumer is informed that a service call might be necessary to correct the problem and is immediately transferred within CAC to a scheduling system to plan the call. The scheduling system identifies the most appropriate technician to run the call and checks the inventory of parts that the technician has in stock. One of the factors influencing when the technician is available to run the call is the availability of parts suggested by CADS. Ideally, the technician makes the call once he/she has all the parts that CADS suggested as necessary to successfully complete the call.

The parts suggested by CADS are usually high-turnover parts, and if not used on this particular call, they will most probably be used on a future call. This process establishes a store of inventory for each technician and location that contains the parts with the highest turnover, thereby creating a customized and more manageable inventory system.

Prioritizing the List of Parts

The user decides whether to schedule the service call if only a subset of parts is available to the technician. CADS helps by prioritizing the list of parts according to the rate of failure for each part for the model number or model group.

For example, CADS might suggest the following three parts as possibly causing the consumer's problem: defrost heater, defrost timer, and thermostat. CADS lists these parts in descending order of failure rate for the specific model number. Suppose that for this model, the defrost timer contributes 50 percent of all part failures, the defrost heater contributes 20 percent, and the thermostat contributes 5 percent. If the user is informed that the technician does not have the correct thermostat in stock but does have the other two parts, then the chances are that the user will proceed with scheduling the service call. However, this case might not be so if the defrost timer is the unavailable part.

These failure rates are specific to the model number and might show completely different results for a different appliance model. The part failure rates are accessed from a central database that is continually being updated. Therefore, this heuristic is dependent on current failure rates that reflect a snapshot of the pattern of part failures corresponding to particular models at any point in time.

Creating a Diagnostic Trace for the Technician

The diagnostic system generates and stores a trace of the consultation, including the resolution, the correct procedure to follow (including service pointers), and a list of suggested parts and corresponding part numbers. As soon as a technician is scheduled to service the appliance, these results are linked to the corresponding service work order that is available to the technician in the field through a hand-held computer.

Once the service call is completed, a failure code and the parts that were replaced are resubmitted to the system database through a modem from the hand-held computer. This procedure acts as a validation check of the knowledge base and an assessment of the part failure rates.

Development Details

All texts on successful knowledge-based system deployment (Prerau 1990; Irgon et al. 1990; Bahill, Harris, and Senn 1988) emphasize the need for management sponsorship and the assessment of management and user expectations. Early sponsorship was easily obtained because of the insights that upper management brought to the early specifications. The original project was conceived by upper management, which established a solid ground on which to proceed. It was the responsibility of the CADS development team to sustain this positive attitude. This task was achieved by decomposing the project into manageable tasks that would produce demonstrable results.

We chose a rapid application-development approach by proceeding through successive cycles of modeling a problem, implementing the resultant model, and then testing it. Prototypes were developed and tested for every new product type added to the knowledge base.

The CADS architecture and coding were developed by two knowledge engineers and a system programmer. The tasks of knowledge acquisition and representation were separated from that of implementation to develop a sound knowledge model that was not reliant on the characteristics of the expert system shell.

A knowledge engineer worked with the experts and users to extract the relevant information and formalize the knowledge into a decision tree–like structure that could be encoded into the expert system shell. An expert in the ADS development tool dealt with the nuances of the shell and translated the acquired knowledge into a supportive representation (discussed later). He was also responsible for manipulating the shell to address the needs suggested by the system (trace and backing up) and domain requirements (forward chaining on model features). The system programmer was responsible for creating the interfaces from CADS to the other components of the larger system and ensuring that accurate data were being transmitted to and from the applications and databases. He was also responsible for developing the user interface in PRESENTATION MANAGER that was to interact with the underlying ADS tool.

Fundamental expertise for the system was supplied by a 25-year veteran technician whose skills spanned Whirlpool brands and products as well as the delivery of technical advice over the telephone. In conformance with advice and insights provided by Prerau (1990), this technician was appointed lead expert. He was selected because of his knowledge and experience, his demonstrated ability to communicate, his vision of the benefits that could be realized through such a system, his willingness to work on the project, and the respect afforded him by his peers. His most valuable trait that had the greatest bearing on the outcome of the project was his modesty, which allowed him to recognize weaknesses in his knowledge. This trait was surmounted by his research of other knowledge sources to supplement his own. It is doubtful that the system would have succeeded without his outstanding contribution.

We were fortunate in acquiring the assistance and commitment of three other experts: a second field technician, a technical representative, and a front-end representative. The field technician was used to verify the knowledge in the system to ensure soundness and completeness. He accomplished this task by generating hundreds of hypothetical and bona fide cases and testing them against the system. The technical and front-end representatives were instrumental in periodically authenticating and refining the wording of the questions. Questions were disambiguated and customized to address the subtle differences in the wide range of callers that are Whirlpool consumers. Proposed users were involved in prototyping the iterative design of the user interface.

CADS development spanned approximately 11 months from its inception to the first phase of deployment.

Knowledge Maintenance and Problem Detection

An infrastructure was created to address the future maintenance needs of the knowledge. As with any manufacturing company, products are frequently introduced, and new problems surface with these and existing products. Therefore, *knowledge maintenance* was defined as "maintaining knowledge integrity, adding depth and breadth to the knowledge, and removing irrelevant or obsolete knowledge."

The user community appointed respective users to coordinate with a knowledge engineer to manage these tasks. This user ownership was critical to supporting the creation of a communication channel between the manufacturing and servicing segments of the business. Thus, the flow of knowledge about new appliances and problems to CADS was achieved.

The integrity of the knowledge base is divided into two sections: ensuring that correct parts and advice are provided within a problem context and ensuring that the appropriate sequence and wording of questions are maintained. For every service call, the technician records the failure and the parts that are replaced. These reports are submitted directly to the central database, which is checked against the suggested diagnosis from CADS. A CADS failure to suggest the correct parts and diagnosis might result from incomplete or inaccurate knowledge or from an invalid consumer response to a question. As a check, selected technicians transmit a comparison of the appliance status against the trace of the CADS consultation to ascertain where the problem occurred. If this check produces incongruous results, then the questions are reviewed for ambiguities; otherwise, the knowledge base itself is updated.

CACS Environment

CADS is a subcomponent of a large cooperative processing application, CACS, operating over various networks and at remote sites. We are concentrating on CADS as a subprocess within the overall CAC system, noting which services are supplied by CACS and those that are supplied

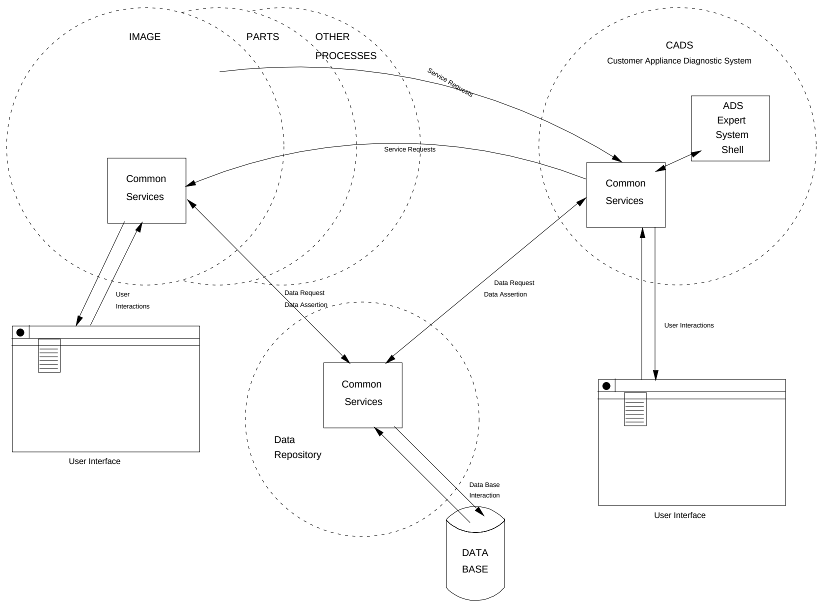

Figure 1. CACS Distributed Environment.

from within CADS.

Figure 1 illustrates the configuration of CADS and CACS within the cooperative environment, demonstrating that each has independent and dependent functions to facilitate communication between other processes and the user.

CACS Architecture

The user interfaces to CACS consist of two main forms: the hand-held field unit and the workstation. CADS is not intended to operate on the hand-held device, which is a DOS-based machine using a cellular modem to communicate with mainframe databases. The workstations are PS/2s running OS/2 CICS and operating off token ring networks. The LANs are linked by mainframe-based WANs. Database services are provided from a number of locations and are intended to be transparent from the view of the workstation (although, in practice, the location of the database is considered because of communication time constraints). The CACS user interacts with CACS through a standard CUA graphic interface. Functions are provided in logical units encapsulated as screens. Screens can operate independently of each other and are constrained by the interdependence of the specific business function being provided.

An incoming telephone call is routed to a workstation where a front-end representative, the user, interacts with CACS and the consumer to resolve the problem. If a consumer requests servicing of an appliance, the user is (optionally) routed through CADS to help determine what the problem is. Basic information, such as the make and model number of the appliance, is gathered from the consumer, if it does not already exist within CACS databases, before invoking CADS. This information is made available to CADS on invocation (CADS requests additional information directly from the user). After a diagnosis is derived, CADS places it into a data repository. The data repository resides on the workstation and is responsible for routing data to and from appropriate CACS databases. Data in the repository are immediately available to all processes residing on the workstation. If CADS recommends that a service call be scheduled, the recommended repair parts are accessed directly by the CACS scheduling subsystem.

CADS Architecture

CADS is divided into two asynchronous components: a front end implemented in C and a back end implemented in Aion's expert system shell ADS. The C-based front end provides the means by which the ADS back end communicates with the rest of the world. The front end consists of components that deliver the following functions: PRESENTATION MANAGER windowing user interface, file handling, imaging interface, backup, diagnostic tracing, suspension and restoration of a diagnostic session, and database interfacing.

Figure 2 presents the Ptolemaic view of CADS within CACS. The primary components of CACS that CADS interacts with are image, consumer services, service work orders (SWOs), and parts.

The ADS back end is the expert system shell that the diagnostic rules are implemented in. ADS was chosen from the shells that run under OS/2 because it supplies a rich set of required capabilities, including object-oriented programming; forward and backward chaining; extendibility through a C interface; the ability to run under DOS, OS/2, and several mainframe environments; and support of direct interfaces to various database formats.

The ADS object-oriented properties were used to implement CADS. A hierarchy of question, answer, and solution objects incorporates common methods and data. The expert's diagnostic knowledge is represented as standard production rules (if-then rules), where each rule

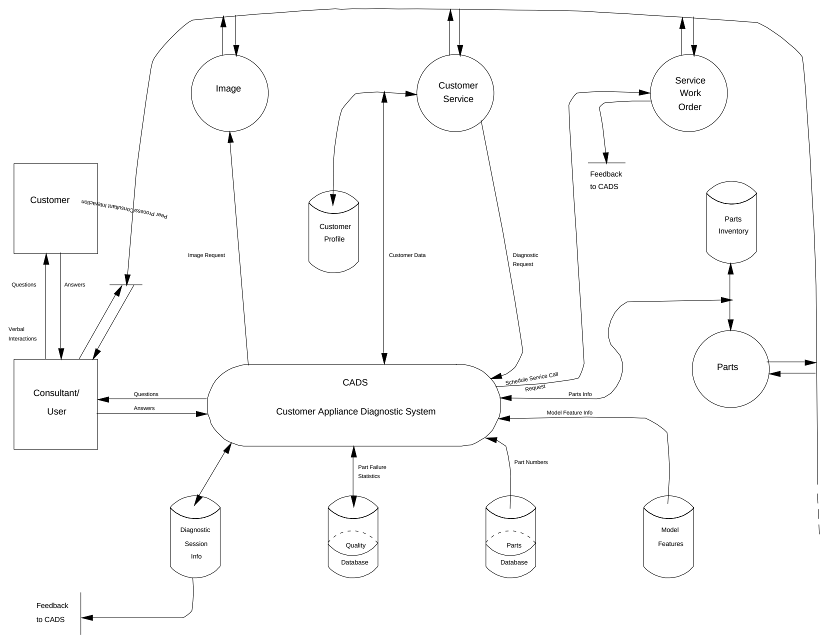

Figure 2. Ptolemeic View of CADS *and* CACS*.*

corresponds to a specific diagnosis. Rules are classified into a hierarchy of rule classes or states, each state containing related rules.

The *solution object* is the superclass for diagnostic solutions within CADS. It consists of a method to fire the rule and slots containing the attributes of the particular solution, including the solution ID, the diagnostic result text, recommendations about whether to schedule service or do it yourself, a recommended parts list, and a reference to any corresponding image indexes. Descendant classes of instances for specific appliance types are created primarily for efficiency and ease of maintenance, such as "air conditioner" and "refrigerator" classes. Question and answer object classes are similarly constructed. See figure 3.

CADS Reasoning

CADS uses a mix of forward and backward chaining to arrive at a diagnosis. When firing a rule, all the question-response pairs (conditions) of the rule (the if part) must be confirmed. CADS forward chains when a question is flagged as having an implies relationship. The implies relationship defines the interdependence of question-response pairs. For example, after recognizing that the refrigerator is frost free, CADS up-

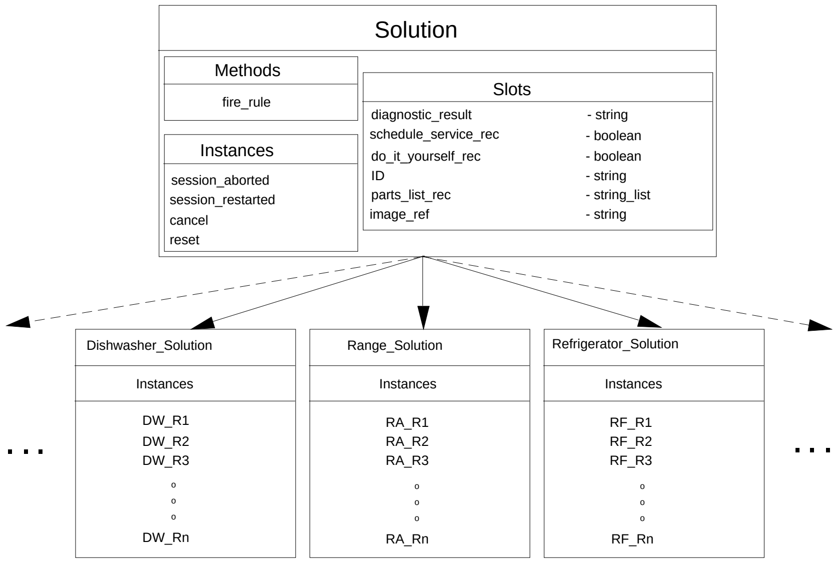

Figure 3. Solution Class Hierarchy.

dates the working memory by asserting facts common to all frost-free refrigerators, such as that they only contain compact model ice makers. These implications can be compounded such that a combination of facts leads to further assertions of facts. When a response to a question is flagged as implying further information, it fires an attached ADS demon method to resolve the implied relationship. This method forward chains across a state containing rules that represent the implied relationships. A chain reaction of new fact assertions can propagate across the implies rule set because one assertion can imply new assertions.

The rule body (the then part) constitutes either a call to a subclass of rules (more specific diagnosis) or instantiates a resolution to terminate the reasoning. A method attached to the corresponding solution instance is responsible for instantiating all resultant values (see later discussion) when a final resolution is found. The qualifying subclass of rules is invoked by backward chaining over a newly established goal that is more specific than the prior one.

When the user is prompted for an answer, the ADS back end passes the identification of the question object to the front end, which contains the following attributes: the text of the question, the set of possible response texts, the type of the question, an indicator of whether the question is a model feature (system driven), a help reference, and an image reference. The front end populates a window with the relevant details and displays it. If the user selects one of the responses to the question, the question is pushed onto a stack of question-response values, and the response is passed to the ADS back end. If another action is selected, such as a request for help or image, the front end services these requests and then returns to the original question to await a response.

If the user requests backing up to a previous question, the ADS back end is sent a message indicating the user's intention. The session is restarted, and the front end pops the questions off the stack until the requested question is reached. All question-response pairs and implications made after the selected question are retracted and present a state consistent with the new selections. (A similar method is used for suspended sessions that are being restored.)

Current Status of CADS

At the time this chapter was written, CADS had been deployed for 11 months. During this period, Whirlpool was shifting the operation of scheduling service calls from the field branches to CAC. Thus, CADS was initially used in stand-alone mode in the field and as a support tool for the call-taking representatives and was slowly phased in to CACS. A tracking system was installed to compute the frequency of use of CADS during this transition phase and was found to be used by about 150 representatives approximately 4000 times each month, with the greatest concentration of calls being advice to consumers on incorrect use of their appliances. During this period, an estimated savings of over half a million dollars was realized.

CADS has been fully integrated in CACS for two months, with data being transferred directly between CADS and the other business systems. The technicians are currently using the data to assist them when running service calls and ordering parts. The feedback from the technicians is still manual because their use of the hand-held systems has not been implemented.

The following is a list of benefits (based on formal and informal surveys) that we have realized from running CADS both as a stand-alone and an integrated system:

Consumer satisfaction has improved because we have demonstrated that we are sincerely willing to help consumers eliminate unnecessary service calls and, therefore, save them time and money. When a service call was warranted, the consumer revealed to us that the information provided over the telephone boosted their confidence when conversing with the technician, who they then felt would not deceive them.

Reasoning about appliance problems has been standardized. Consumers are confident in our ability to help them because they hear consistent approaches to resolving their problems when speaking to multiple representatives.

CADS contains the most detailed assemblage of formalized information about diagnosing appliance problems that exist at Whirlpool. The knowledge has been extracted from the most experienced technicians at Whirlpool and has been made available not only to the call-taking representatives but also to other groups within the organization. These groups apply CADS in stand-alone mode to help with consumer mail correspondence, training, and engineering.

The first line representatives are gaining greater confidence in dealing with consumers who call about problems with their appliances. The representatives have never had immediate access to this level of detailed support and relish the independence they are being afforded when working with consumers. The representatives are also learning more about the functioning of appliances and reasoning about defects.

Results generated by CADS will be used as a resource for quality control with appliances and user documentation. The database fed by CADS is constructed to associate rule firings with model numbers, failure history, appliance location, serial numbers (containing manufacturing and engineering details), and subsequent technician support. Therefore, the potential exists for querying the database about patterns of recurring product defects. These patterns might appear in common geographic locations with similar climates; products manufactured at the same facility and, possibly, along the same manufacturing line; products with a similar history of failures; certain working environments; and more. CADS is playing a significant role in closing the loop between engineering, manufacturing, and servicing operations at Whirlpool. We will also be able to detect weaknesses in consumer use and care documentation for each model number or product type. This is becoming evident now with the online database that is concurrently being updated.

Limitations and Potential Enhancements to CADS

The greatest limitation of CADS is the unreliability of the responses provided by consumers. The knowledge base might be considered sound, but it will never be complete until we can preclude inaccurate diagnoses from being generated because of bad input. Therefore, the knowledge base needs to be updated to compensate for this weakness by adding rules to verify consumer responses.

An underlying assumption when developing CADS was that we would not expect the consumer to perform any mechanical or electric analysis of the appliance. This shallow depth of knowledge often leads to a more general diagnosis. A planned enhancement is to qualify the consumer and follow a path of reasoning that most reflects his/her level of competency with handling appliances, thus allowing mechanical and electric analyses for those consumers who are qualified and willing to perform them.

CADS is currently designed to follow a reasoning path that closely matches a problem with an appliance. This path is generated in a stepwise fashion, with each new question being proposed based on the developing context of the problem—a typical backward-chaining approach. The users, however, are complaining that the consumer volunteers much of the information at the front end that causes breaks in the conversation while the user proceeds through the system. We are planning to address this problem with a more hybrid approach to the reasoning (integrating forward and backward chaining) by emphasizing forward chaining early in the consultation. A constrained natural language interface might also be considered.

User acceptance of the system is critical to its success. CADS is not intended to replace expertise that currently exists but rather augment what is already known. The users have been educated to understand the distinction so that it will not appear threatening to them. The users' productivity has always been assessed on the rate of taking calls. Because of quality initiatives that Whirlpool is implementing, call rate is less important than quality of call. CADS is helping to adjust this mindset by measuring the frequency of its use.

The plan is to demonstrate to the representatives that the additional time spent using CADS will generate greater payback to Whirlpool and is directly attributable to them.

Management also has to be convinced that using CADS will not adversely affect the ability of the users to take an acceptable number of calls each hour. This result could be achieved by using the utility provided by CACS that monitors the number and frequency of incoming calls. CADS could be customized to control the depth of the decision trees such that it is inversely proportional to the size of the queue of incoming calls being placed on hold. This approach would speed the use of CADS during busier periods, with a sacrifice in the reduction in specificity of the results. The capability exists for CADS to report on its effectiveness through feedback about its use and the accuracy of its results. Management can monitor these results and devise a threshold that corresponds to the knowledge level at which the marginal returns are optimal.

Concluding Remarks

These and other enhancements will be considered and prioritized by the users once they have had the opportunity to investigate the system more fully. They will also recognize the benefits that are being gained from using the system and those places where they could potentially add to these benefits. As soon as the users start benefiting directly from using CADS, they will realize that their ownership of the system allows them greater control over its evolution. They will be motivated to discover areas where CADS could be improved to enhance their ability to earn Whirlpool (and themselves) greater revenues. CADS has provided Whirlpool with a genuine opportunity for making inroads into the AI and expert system arena after years of tentative investigation into the virtues and pitfalls of the technology for business. We have successfully demonstrated that AI can be rewarding if applied effectively. CACS and CADS, in particular, have been receiving much exposure throughout the company, and with positive results starting to emerge, other departments within Whirlpool are inquiring about using the technology. Certain areas have been identified for expert system development and are currently being explored and developed. We have managed to leverage the momentum gained from the development of CADS at Whirlpool and establish AI as a viable technology in the hands of users, management, and analysts.

Acknowledgments

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