Case-Based Reasoning for General Electric Appliance Customer Support

William Cheetham

General Electric Global Research, One Research Circle, Niskayuna, NY 12309
cheetham@research.ge.com
(Deployed Application)

Abstract

A case-based reasoning system was created to support customers who purchased appliances from General Electric. When a customer calls General Electric for help, a call-taker uses the system to diagnose the problem and step the customer through its solution. The system has been in use by 300 call-takers since 1999. It has resulted in a 20 percent increase in the probability the customer's problem can be solved over the phone. This has greatly improved customer satisfaction and saved GE $44.5 million between 2000 and 2005 from reduced cost of visits of field service technician to customer's homes.[1]

Introduction

General Electric (GE) Consumer & Industrial's Appliances Division manufactures and sells a wide range of home appliances. GE has the largest manufacturer's service organization in the appliances industry and employs a nation-wide fleet of vans to provide prompt, quality service. GE's subsidiary, Advanced Services Inc. (ASI), provides customer service call centers that help solve customer issues over the phone and schedule field service visits when needed. In 1999 ASI and GE began creation of a case-based reasoning (CBR) (Aamodt and Plaza 1994) tool to help call-takers support the customer in solving these issues. That tool has been in constant use since 1999 and has greatly increased the percentage of customer issues that are solved over the phone. This has improved customer satisfaction with our service and reduced GE's costs for providing that service.

Call Center Problem

Call centers provide help to customers who have questions, problems, complaints, or need assistance. The quality of this help is often a major factor in a customer's opinion of the company, so the highest possible quality is desired. The cost of the help is an added cost to the product that is being supported by the call center, so the cost of this help needs to be reduced as much as possible. These goals are often in opposition to each other.

GE provides a variety of customer support services over the phone and on the web. These services included separate groups for talking with a technician and scheduling a time for a field service technician to visit the customer. When this project started GE had over 300 field service call-takers whose primary job was to schedule field service personnel to visit customers' homes. These call-takers would also try and solve the customer's problem over the phone, but that was difficult so in 1999 they were only successful on 3.9% of the calls. Field service representatives reported that about 20% of the time they visited a home and all that was needed was to educate the customer. This education could usually have been done over the phone saving time for the customer and field service representative. However, the field service call takers were not fully able to diagnose and explain issues over the phone. Most previous efforts to improve the success rate involved making paper copies of information available to the call takers. They would use their training, personal experience, paper manuals, frequently asked question lists, and weekly paper flyers with updates of new issues. However, correctly diagnosing all problems was difficult because of the following issues:

- The growing complexity of products
- The diagnosis can be confusing
- Extended warranties can be complicated
- There is a limited supply of qualified people
- Off-line training is expensive
- Low pay / high turnover (60% per year)
- There needs to be consistency among call takers
- Little or no feedback on failures

The "Support The Customer" (STC) project was initiated to create an automated assistant for the call-takers that will help them satisfy our customers.

Related Work

CBR has been used to automate customer support help-desks by many companies such as Compaq (Acorn and Walden 1992) and Broderbund (Watson 1997). Using CBR for customer support (Simoudis 1992) has become of interest to many other companies with help desks. The paper by Helen Thomas, Richard Foil, and Jim Dacus on Thompson Consumer Electronic's help desk automation (Thomas, Foil, and Dacus 1997) was especially useful because we were able to contact the authors and they were kind enough to invite our development team to visit their site and get a first-hand look at their successful effort to use CBR to support their customers.

Application Description

The STC system is just one part of the call-taking process. The full process is shown in Figure 1. In this process, the customer calls a 1-800 number provided for scheduling home visits of field service technicians. A custom call-taking system receives the call, accesses a customer database to retrieve information, such as the customer's address and registered products, then displays this information to the call-taker who answers the phone. Before STC was developed the call-taker would answer the questions to the best of their ability then type in some information about the call, which would be saved in the call record database. After STC was developed the call-taking system also sends data about the customer to STC. Then, STC uses a case base to assist the call-taker in helping the customer. After the call is completed STC writes information about the diagnostic process to the call record database. Each case includes a description of a problem and solution to that problem and a series of questions to diagnose the problem. The cases can have attachments including diagrams. The STC system also has rules to automatically answer questions.

Figure 1: Customer Support Process

The current interface for STC is shown in Figure 2. The Critical Information Tab at the top has the Product Line and Model Number, which are both passed in from the call-taking system. It also has the Problem Description, which is typed in by the call-taker. The Model Group can be determined by a rule that uses the Model Number. The Symptom is a keyword phrase that is selected by the call-taker. The Questions tab has a set of questions the call-taker can ask the customer to diagnose the problem. The Results tab has a set of solutions. Selecting the correct result is the goal of the process.

A typical call would involve the STC system answering as many of the questions as possible using the information passed in from the call-taking system. The STC user interface would be displayed to the call-taker, who would talk with the customer. The call-taker would select the correct answer to the questions by either asking the question directly to the customer or by listening to the customer and selecting any answers they give in any order they give them. After each answer is selected the lists of potential questions and results are updated. The most important question is at the top of the list of questions. This will continue until only one result is left in the Results tab or the result is obvious to the call-taker. If the customer accepts the result the action for that result is taken and the call ends. If the customer does not accept the result then the answers can be reviewed and changed, providing different results. Finally, the action suggested after diagnosis is completed and can be automated. The call-taker could step the user through a pre-created repair process, or email / fax the process to the user. If parts are required, one click of the solution can place an order for the parts to be sent to the address of the customer. If a service technician is required, the time for that visit can be scheduled and description of the problem (called and Intercept) automatically sent to the technician for their review.

STC was created using a CBR tool from Inference Corporation called k-commerce. Since deployment, Inference has been acquired by eGain Communications Corporation and the tool is now called KnowledgeAgent. The knowledge for each case is stored in this tool. It runs on a dedicated personal computer at ASI.

Figure 2: Call-taker's User Interface

Use of AI Technology

STC is a mixed-initiative conversational CBR system that acts as an intelligent assistant for the call-taker. The call-takers are good at the natural language processing that is needed to interact with the customers, but it is difficult for them to store and correctly retrieve the large amount of technical information that is needed to help the customer. Luckily, STC is very good at storing and retrieving this information even though it cannot do any natural language processing. Together, STC and the call-taker form a team where each provides a needed strength where the other has weakness.

The flow of control of the mixed-initiative system (Allen 1999) is shown in Figure 3. When a new call is received the STC system, represented by the Agent, searches for any questions that are needed for the diagnosis, automatically answers as many of these questions as possible, then passes initiative back to the user. The user can now take action to

answer as many questions as needed. After each question is answered the agent can update the list of questions, automatically answer new questions, or do nothing. The call-taker is not forced to answer any questions and can jump to a competed diagnosis at any time during the question answer process. We try and have the agent do as much of the work as possible, so the process is as quick as possible.

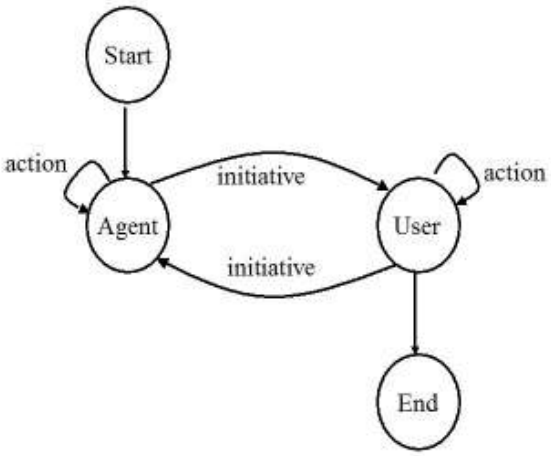

Figure 3: Mixed-Initiative Flow

Conversational CBR (Aha, Breslow, & Muñoz-Avila 2001) is a problem solving technique that is used when all the information needed to solve a problem may not be available at the beginning of the problem solving process. The CBR system solves the problem to the best of its ability with the given information, but also suggests information that can be gathered (i.e., questions that can be asked) to improve the accuracy of the solution. This approach is very useful in a call-taking domain. The information that is available at the start of the decision making process includes:

- Phone number of caller
- Registered products at that phone number
- Previous calls from that phone number
- Information entered at phone prompts (i.e., type of appliance)
- Registered products that match phone prompts
- Model number of that product
- Common issues for that model number

All other information needs to be gathered in a conversation between the customer and call-taker.

All of the knowledge needed by the STC system is stored in the case base. Collecting and maintaining this knowledge is the most time consuming portion of this project. Most CBR systems store cases that are historical problem / solution pairs that represent actual problems that took place in the past. This CBR system has cases that are abstractions of a class of problem that may have taken place many times in the past and hypothetical cases of problems that may take place in the future. Each case has a title, description, set of questions, and solution. A case may have an attachment, such as a diagram or web link. The collection and organization of these cases is a time-consuming knowledge acquisition problem. The decision of when to add a new case or split an existing case into multiple cases can be complicated. In order to ease the effort of case collection and maintenance we use diagrams to visualize the cases and questions. Figure 4 shows one of the original Visio® diagrams that was created for the refrigerator case base. This diagram acts as a decision tree that starts in the top left corner. The rectangles are questions, trapezoids are possible answers, ovals are cases, and circles are links to other diagrams.

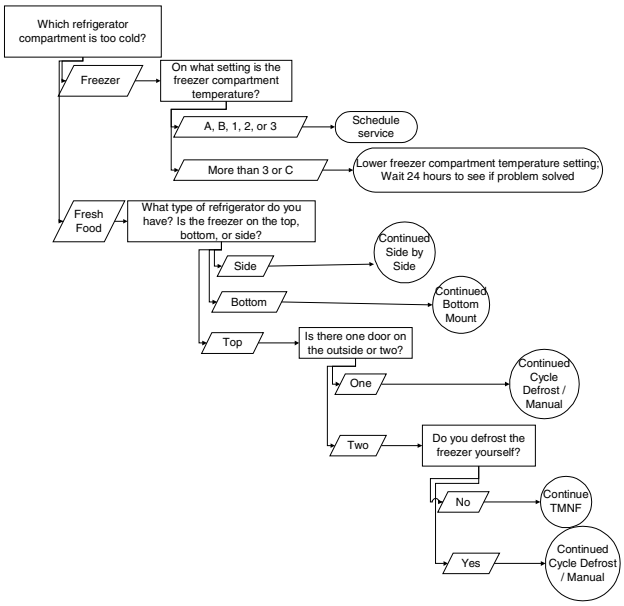

Figure 4: Visualization of Case Base

The k-commerce tool was selected from a set of tools that were evaluated. The other tools we looked at were Servicesoft, Serviceware, Clarify, and Spotlight. The attributes on which we evaluated the tools were

- Integration (working with current systems, input attribute value pairs and text description, output multiple top possible solutions, output summary of usage to database for reporting, custom reporting)
- Case base management (authoring tool exists, ease of initial creation, maintenance difficulty, multiple authors possible, automated testing of case base)
- User interface (web-based, easy to use, graphical attachments, customizable)
- Cost (initial development, professional consultation, ongoing maintenance)

Each of the attributes was rated from 1 to 9 on its importance to the project. Then each tool was rated from 0 to 5 on how well it satisfied that attribute. The importance was multiplied by the satisfaction value to produce a score for that tools attribute. The sum of these values for each tool was the score for the tool. The tool with the highest value was k-commerce.

Application Use and Payoff

STC has been in constant use since the end of 1999. Over 300 call-takers at multiple locations in the United States use the system. The percentage of calls that are correctly answered over the phone has increased each year. Figure 5 shows the success rate for each year. Frequent customer surveys show customer satisfaction is higher with cases that are answered using STC than with call that are not.

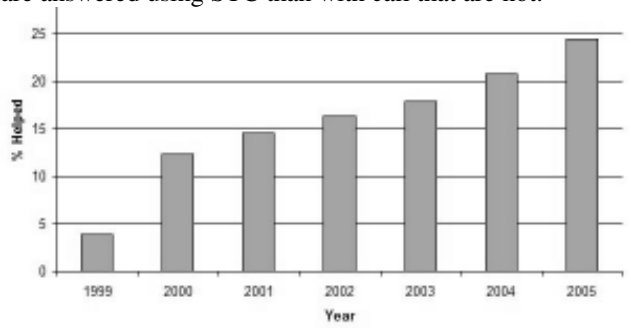

Figure 5: STC Success Rate

This system has also been a financial success for GE. The initial development in 1999 cost $1 Million for the software tool, Inference Corporation professional services, two person years of effort by GE personnel, and the cost of hardware to deploy the system. The maintenance in each of the next six years has averaged $0.5 Million for ongoing maintenance of the cases and a major upgrade to a new version of the eGain software in 2004. The benefit of not sending a field service technician to a customer's home when the product is in warranty is $50 for GE. The dollar savings for GE can be calculated by the following formula

Savings = increase in success rate * call volume * $50

Figure 5 shows the call volume per year. The sum of the savings for each year from 2000 to 2005 is $44.5 Million. This is a project that can both provide better service for customers and reduce the cost of this service.

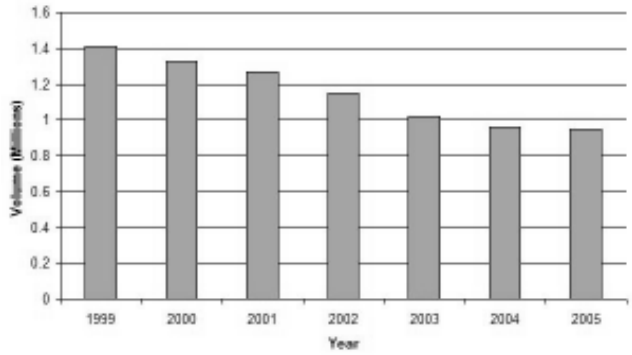

Figure 6: Call Volume

Other benefits include:

- Higher first call success rate. This increases customer satisfaction and decreases the number of calls GE needs to handle.
- Early identification of new types of customer problems. This feedback can be sent to design teams who can fix the problem in future releases, and reduces future customer problems.
- We can enforce policies such as "If the model is sold by Sears then ask if it was purchased at Sears." Sears pays for this service and we often forgot to ask and paid for it ourselves.
- Increased ability to mail parts out with instructions and avoid a service call for items that cannot be fixed over the phone but are an easy fix and the customer wants to do it themselves.
- STC identifies parts needed when a field service technician is sent to the home so more fixes can be made on the first trip, saving time for the customer and field technician. This is the Intercept shown on the cases in Figure 2.
- The increased consistency of call-takers has reduced repeat calls from customers "fishing" for different advice than they obtained on their first call.

Application Development and Deployment

The development of the STC system was a five-step process. These same five steps can be followed for deploying other applications of artificial intelligence.

- Standardize the process and knowledge
- Digitize the inputs and outputs
- Automate the process as much as possible
- Control the quality of the system
- Leverage the system and knowledge for improved impact

Standardizing the call-taking process involved identifying all cases that can and cannot be solved on the phone, determining the correct questions to ask, and the correct order to ask these questions. Much of this knowledge was tacit knowledge (i.e., personal experience of the call-takers and engineers). Since different call-takers would ask different questions to diagnose the same problem we formed teams of call-takers and engineers to determine what should be the correct cases, questions, and order of questions. The visualizations of the case base, Figure 4, were very useful with the standardization and optimization of the knowledge. The knowledge was only entered into the case base after the engineers and call-takers created these visualizations and safety, legal, quality, and consumer service personnel validated them.

Digitizing the inputs and outputs of the STC system was the next step. The call-taking system was modified to start up the STC system and send relevant data (e.x., model number) for every phone call. K-commerce was modified slightly so that it could accept the data. The call record

database, from Figure 1, was modified to accept a large amount of data from the STC system in addition to the data it was receiving from the call-taker. The STC data was captured every time the case base was used to answer a call. The data included start time, end time, customer phone number, call-taker ID, type of appliance, short text description of issue, all questions asked by CBR, all answers given to these questions, the case suggested, and if this answer was accepted by the customer.

Automating the entire phone conversation was not possible with the state of natural language processing technology, but a team of a call-taker working with the STC system can effectively automate the application of the standardized and optimized process. An attempt was made to automate the application as a web-based customer self-service tool. This is discussed in (Cheetham 2003).

Controlling the quality of the system after it was created was more expensive than the initial creation but also continued to improve the success rate, Figure 5. Initially, each week a case author would analyze the data in the call record database for every call that was taken for the week using standardized database queries. The author was looking for any trends and especially any times a caller would not be satisfied by a suggestion. Any trends or outstanding items would be discussed in a weekly feedback meeting with the call takers. The result of the feedback meetings would be a few changes in the case base. These changes would be made immediately and reviewed in the next weeks meeting. The frequency of these reviews decreased as the case base stabilized.

Leveraging the STC system, knowledge in the case base, and data in the call record database provided additional benefits that were not all foreseen when the first version of STC was created. Most of the other benefits listed in the "Application Use and Payoff" section were only realized by follow on projects in the years after the initial development. An example of this leverage that was not listed in "other benefits" is use of the STC tool by a group of customer support personnel who do not answer calls. They call the customers themselves. Customers can schedule their own field service visits on GE's web site, http://www.geappliances.com/service_and_support/service/schedule_service.htm. The web site asks the customer to enter the type of product, nature of problem, and a brief description. The type of product and nature of problem are the first two questions asked by the STC system. The support personnel use the STC system when they call the customer to try and solve the problem over the phone. We keep track of the success rate for each product/ nature-of-problem combination so we know the predicted chance of solving the problem over the phone. If the customer does not answer the phone at our first attempt we can repeatedly try to contact customers with a high chance of success.

Maintenance

As was stated above, controlling the quality of the system after the initial development was very important. There is one full time case author who makes all the changes to the case base. Forty technical experts, who only work when a change is needed from their specialty, support her. Regular updates are now released monthly. Special updates from new products or important updates to existing products take place at needed intervals, but these are less frequent than the regular updates.

A major update to a new version of the eGain software took place in 2004. This included a new user interface, new standardized templates for the cases, rewrites of many existing cases, a new effectiveness measure for cases, and improved, unambiguous, answers to top-level questions (e.x., What is the nature of your problem?).

Conclusion

STC is an example of an artificial intelligence system that has been successfully deployed for many years. It has provided many benefits for the customer and General Electric. The general manager in charge of this work was interviewed for his comments on this project and he said, "STC is the best thing to ever happen at GE Appliances."

Acknowledgements

I would like to thank Cynthia Bonner, who is the current case author, and Greg Crite, who has lead the leverage of the system and the update in 2004.

References

Aamodt, A., Plaza, E., 1994. Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches, AICOM, Vol. 7, No. 1.

Acorn, T., Walden, S., 1992. SMART: Support Management Cultivated Reasoning Technology for Compaq Customer Service, In IAAI 4, Cambridge, MA. AAAI Press / MIT Press.

Aha, D., Breslow, L., & Muñoz-Avila, H., 2001. Conversational Case-based Reasoning. Applied Intelligence, vol. 14, pp. 9-32.

Allen, J. (1999). Mixed-initiative interaction. IEEE Intelligent Systems, 6, 14-16.

Cheetham, W (2003). Lessons Learned using CBR for Customer Support, The Sixteenth International FLAIRS Conference, St. Augustine, Florida.

Thomas, H., Foil, R., Dacus, J., 1997. New Technology Bliss and Pain in a Large Customer Service Center. Lecture Notes in Computer Science, Vol. 1266. Springer-Verlag, Berlin Heidelberg New York. pp. 166-177.

Simoudis, E., 1992. Using Case-Based Reasoning for Customer Technical Support. IEEE Expert 7(5), pp. 7-13.

Watson, I., 1997. Applying Case-Based Reasoning: Techniques for Enterprise Systems. San Francisco, Cal. Morgan Kaufmann.