

# Compaq QUICKSOURCE

## Providing the Consumer with the Power of AI

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■ This article describes Compaq QUICKSOURCE, an electronic problem-solving and information system for Compaq's line of networked printers. A major goal in designing this system was to empower Compaq's customers with expert system technology, allowing them to solve advanced network printer problems entirely on their own. This process minimizes customer down time; reduces the number of telephone calls to the Compaq Customer-Support Center (resulting in monetary savings); improves customer satisfaction; and, perhaps most importantly, differentiates Compaq printers in the marketplace by providing the best and most technologically advanced customer-support facility. This approach also represents a reengineering of Compaq's customer-support strategy and implementation. In its first-generation system, SMART, the objective was to provide expert knowledge to Compaq's help-desk operation to better and more quickly answer customer calls and problems. QUICKSOURCE is a second-generation system in that the customer-support function is put directly in the hands of the consumers (an example of knowledge publishing). As a result, its design presented a number of different and challenging issues. Because the product would be used by a diverse and heterogeneous set of users, a significant amount of human factors research and analysis was performed as part of system design and implementation. The analysis also dictated certain decisions about the organization and design of the expert system component. Since September 1992, Compaq has shipped more than 3000 copies of QUICKSOURCE.

QUICKSOURCE is an electronic problem-solving and information system for Compaq's line of networked printers. It includes a case-based reasoning module, QUICKSOLVE, that is used to troubleshoot network printer problems. QUICKSOLVE is a sec-

ond-generation customer-support system based on experience with the Compaq SMART system (Acorn and Walden 1992). SMART was developed for Compaq's help-desk operation. It used case-based reasoning (CBR) to provide expert-level knowledge and experience to Compaq's Customer-Support Center, helping representatives with customer calls on the customer-service hotline. With the success of SMART, Compaq looked for new opportunities to use CBR technology to provide even higher levels of customer service. This analysis resulted in a reengineering of Compaq's customer-support strategy. The decision was made to package and deliver the troubleshooting knowledge and expertise directly with the product, allowing consumers to solve most of their problems entirely on their own and to use Compaq's help desk as a backup facility.

QUICKSOURCE is one of the first examples of *knowledge publishing*: The idea is to deliver intelligence and human expertise directly with the product. The benefit is that users are able to access this intelligence directly to help them solve their problems. We view knowledge publishing as the most effective way of delivering the power of AI to the general consumer population.

### Background

Compaq customer-support representatives were hired to provide technical support on a wide range of topics, from simple product-information requests to questions about complex, networked environments. Cataloged questions not only pertain to Compaq hardware but also to third-party hardware and

software compatibility with Compaq systems. With an expanding product line, 24-hour technical support, and a 3-year product warranty, the need for support tools was high. For these and many other reasons, the SMART system was designed.

SMART was designed only for use in Compaq's customer-support department. The case base for SMART was intended to cover all Compaq personal computers, servers, third-party software, and peripherals. QUICKSOURCE, which has a new case base that is specific to networked printer products, was also envisioned to be used by our Customer-Support Center. However, Compaq recognized an opportunity to provide QUICKSOURCE to dealers, service providers, and home users as well. Therefore, the target audience for QUICKSOLVE was dramatically more heterogeneous than that for SMART. The development of QUICKSOURCE was seen as a challenge for the knowledge engineers and developers working on the system. If successful, the design would be quite innovative because designing expert systems for heterogeneous user populations is known to be a difficult problem (Gordon 1991).

Based on Compaq's experience with SMART, CBR was known to be an effective technology for the Customer-Support Center. It was decided that the same expert system technology could be used successfully by a wider audience. One of the nice features of CBR is that it can be fine tuned to work with user groups of different levels of expertise. CBR was also used because the stimulus environment (networked printers) was continuously changing, and both novices and experts would need explanations of proposed printer solutions (Gordon 1991). This article describes the innovative design engineering that resulted in QUICKSOURCE and the intelligent troubleshooting module QUICKSOLVE.

## QUICKSOURCE Description

QUICKSOURCE was developed as a Microsoft WINDOWS application with an intelligent search engine that targets three different groups of users: printer customers, service providers, and the members of the Compaq Customer-Support Center. SMART, the tool on which QUICKSOURCE was based, was developed with Inference's CBR EXPRESS. SMART and QUICKSOURCE recently switched to another Inference tool called CASEPOINT for their run-time search engines. CASEPOINT was selected for use with QUICKSOURCE primarily because of its memory requirements (less than 40 kilobytes [KB]).

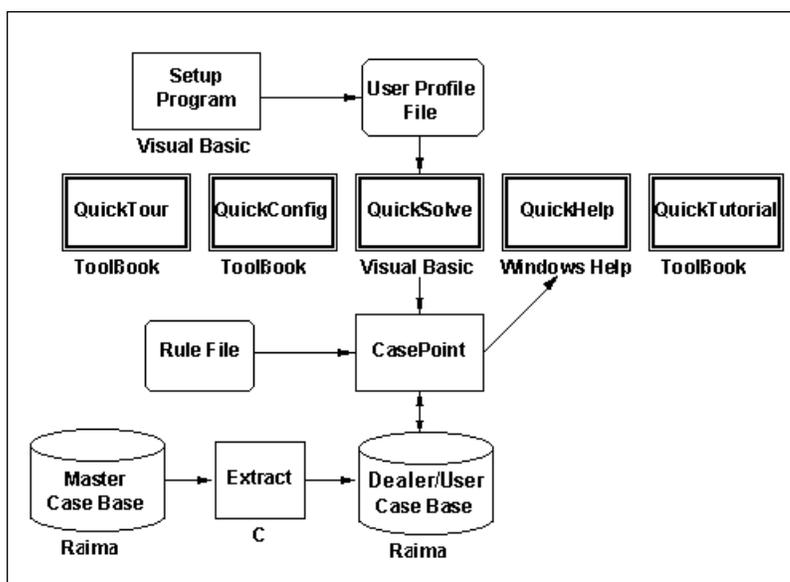


Figure 1. QUICKSOURCE System Architecture.

*CBR was known to be an effective technology ... one of the nice features of CBR is that it can be fine tuned to work with user groups of different levels of expertise...*

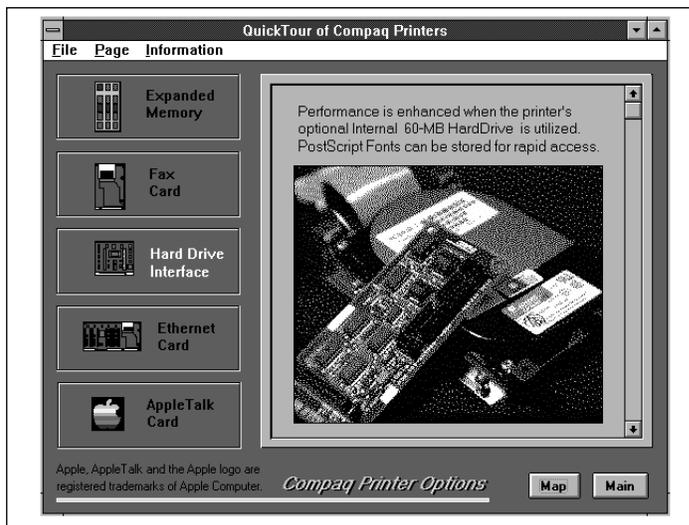


Figure 2. Screen Example from QUICKTOUR.

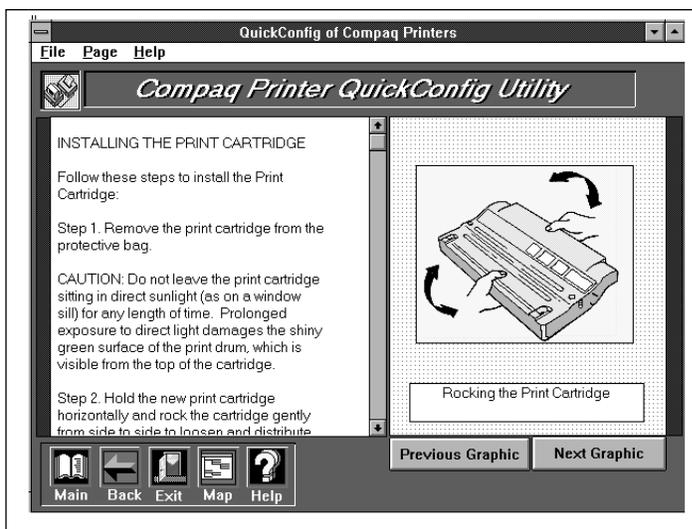


Figure 3. Screen Example from QUICKCONFIG.

Other reasons for its selection included its ability to invoke other WINDOWS applications through dynamic data exchange (DDE), its performance, its natural language capability, and its fuzzy search capability.

Because QUICKSOURCE's main objective was to find the right answers to printer issues quickly, it was designed to operate in a highly interrelated, integrated environment. Its modules were designed to communicate with and reference one another. The system architecture, defined in figure 1, was designed to include the five main modules (QUICKTOUR, QUICKCONFIG, QUICKSOLVE, QUICKHELP, and QUICKTUTORIAL), a setup utility, and the different case bases.

The setup utility, developed with Microsoft VISUAL BASIC, was designed to provide an easy-to-use installation procedure. It was programmed to query users for printer hardware, host computer, and network information that is saved in a profile information file in ASCII text format (as shown in figure 10).

The master case base was designed for three versions of QUICKSOURCE: an internal Compaq version, a service provider-dealer version, and an end user (printer customer) version. The end user version is a subset of the service provider-dealer version, which is in turn a subset of the Compaq version. The main difference between the three versions is the level of detail provided within a solution. End users are provided with sufficient detail to assist them with most immediate printer problems. In those cases where printer technicians are required, users are requested to contact authorized Compaq service provider-dealers for additional help. Printer solutions in the service provider-dealer version include more detail, such as printer and printer component repair procedures. The internal Compaq version also includes option, distribution, and logistical information in its solutions. Each of the versions is extracted by a utility named EXTRACT that was developed in the Microsoft C programming language.

Each of the five main modules of QUICKSOURCE was developed as a stand-alone program: QUICKTOUR provides a guided tour of printer capabilities and features. QUICKCONFIG provides online support for printer installation and configuration. QUICKHELP provides online documentation on maintenance procedures and general information. QUICKSOLVE provides intelligent troubleshooting analysis and advice. QUICKTUTORIAL provides an online tutorial on how to use QUICKSOLVE. Example screens of these modules are shown in figures 2 through 5.

## QUICKTOUR

QUICKTOUR was developed to be a proprietary, online printer-information utility. End users have used it to find answers to questions about printer features, options, and support programs. This module was written to function as an electronic product brochure enhanced with text and graphics. QUICKTOUR was developed with Asymetrix TOOLBOOK. This module required no documentation for its successful use, as determined by human factors testing, and has been distributed as a presale tool.

## QUICKCONFIG

QUICKCONFIG was developed to provide product-configuration and product-installation information. End users have used QUICKCONFIG when they were in need of information about installing or reconfiguring a printer for different environments. This graphic tool, also developed with TOOLBOOK, provides end users with installation and configuration guidelines. QUICKCONFIG has been used effectively without accessing documentation.

## QUICKHELP

QUICKHELP was designed to be a help utility that contains printer specifications, repair procedures, an illustrated parts catalog, solutions to printer error messages, and answers to common printer problems. This module, developed with Microsoft WINDOWS HELP, can be accessed directly or from within the QUICKTOUR, QUICKCONFIG, or QUICKSOLVE modules.

## QUICKTUTORIAL

QUICKTUTORIAL provides a brief, animated lesson on how to use QUICKSOLVE. This self-running tutorial, developed with TOOLBOOK, simulates a path through the QUICKSOLVE search process with animation and instructional guides.

## QUICKSOLVE

QUICKSOLVE was developed to provide Compaq-recommended solutions to printer problems. These solutions are either well-structured procedural information stored in QUICKHELP or complex software-network solutions that are stored locally in the QUICKSOLVE cases. Because QUICKSOLVE is the module that contains expert system technology, it is described at length in the remainder of this article.

## QUICKSOLVE Architecture

The QUICKSOLVE case base was developed by two printer specialists and one knowledge engineer. This development team designed

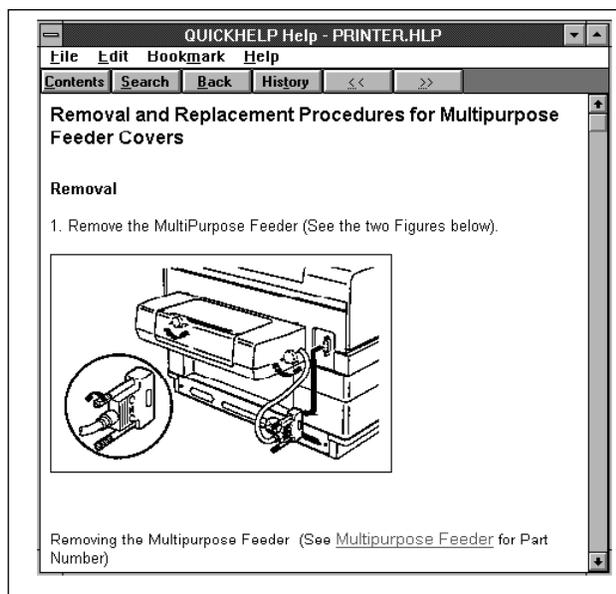


Figure 4. Screen Example from QUICKHELP.

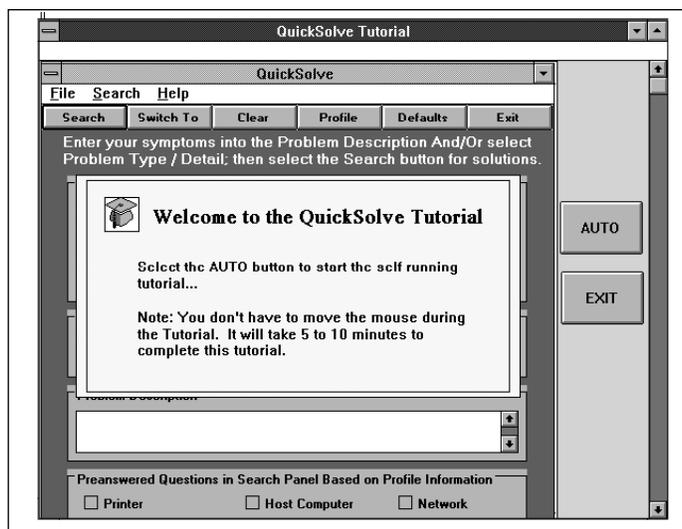


Figure 5. Screen Example from QUICKTUTORIAL.

<b>Hardware</b> Power-On Self-Test PDT Diagnostic Print Quality Paper Transportation Printer Operation	<b>Software</b> Application Software Compaq Printer Utility Print-Enhancement Utility Operating Environment
<b>Network</b> Installation Configuration Performance Communications-Problems	<b>General Information</b> Printer Care & Maintenance Procedure Printer Configuration Printer Consumables Printer Customer Support Printer Glossary Printer Illustrated Parts Guide ....

Figure 6. Case Base Organization.

<b>Title:</b> Win, MS Word - Fonts not updated correctly
<b>Description:</b> H/W - N/A HOST - PC OPERATING ENVIRONMENT - Windows 3.x APPLICATION S/W - MS Word for Windows 1.1a SYMPTOMS - The fonts just added in ATM are not available in the Microsoft Word Font menu.
<b>Questions</b> What printer issue do you need help on? <i>Software</i> What printer software issue? (pick the first that applies) <i>Application software</i> What operating environment are you using? <i>Windows</i> What major release of Windows are you running? <i>Windows 3.X</i> What is the name of the software you are having an issue with? <i>Microsoft Word for Windows</i> What revision of this software are you using? <i>1.1a</i>
<b>Actions</b> Click on Word for Windows Printer Setup to update the Font selection.
<b>Action Text</b> Whenever you add or remove fonts from the ATM control screen, and you are using Word for Windows, you will need to perform the following procedures the next time you use the Word for Windows program: Pull down the File pop-down menu and select Printer Setup. Once the Printer Setup dialogue box appears, simply click on the OK button. Doing this forces Word for Windows to scan all available fonts and to associate them with the active printer driver.

Figure 7. Example of a Software Case from the QUICKSOLVE Case Base.

cases and stored them in RAIMA database format, located on the corporate Banyan VINES network. The structure for entering cases was leveraged from earlier knowledge engineering work performed on the SMART system (Acorn and Walden 1992). This structure consisted of dividing the case base into several partitions: hardware problems, software problems, networking problems, and general information (figure 6). This structure allowed the team to define a limited set of questions that needed to be answered for a unique solution to be retrieved from the case base. The team also used the case entry structure to design the front-end QUICKSOLVE screen, so users could select answers to questions about their problem from a list.

One benefit of this structure was that this limited set of questions was used to define all existing and future cases as the system evolved, allowing new cases to be added to the case base with ease. Another benefit was that users noticed a drastic improvement in the logical presentation of questions during the search process. Dividing the case base into various domain partitions enabled the knowledge engineers to know what areas needed a concentration of effort and led to a well-organized QUICKHELP, which used the same structure as the case base. Cases were built and tested concurrently, ensuring that the structure of the cases was usable and consistent.

The case base was developed using Inference's CBR EXPRESS tool. The roughly 500 cases were audited by a knowledge engineer to ensure adherence to the Compaq-defined style guide and accuracy of content. Also, references to relevant documentation (such as application notes, operation guides, and printer maintenance and service guides) were provided to the knowledge engineer for quick and easy case building. A subset of problem solutions was organized as a hypertext document in the Microsoft WINDOWS HELP file format and presented as the QUICKHELP module.

Each case consists of the following information: a title, a description field that describes a case's symptoms in natural language, a question area, and a solution section. See figures 7 and 8 for examples of the case structure.

The description field is accompanied by a weight used to indicate its importance in determining the closeness of a match. Similarly, a weight is assigned to each question that specifies the importance of a question's answer. The overall matching score is defined by the combination of these weights during

the search process.

One problem with this weighting scheme was that if an important question or description was input incorrectly by users, it could dominate, and the correct matching solution might not be found. Therefore, the case base was fine tuned for fault tolerance by dropping the weight assigned to the description field and the first few questions that the end user can answer. This scheme disallowed any input error from dominating the overall matching score.

During the design process, the development team learned that software and network cases required a simpler case structure because software and network cases were highly unstructured. Thus, more information content was anticipated in the description field than in answers to questions. Therefore, the number of questions for network and software cases was reduced, resulting in shallow cases. This approach allowed the development team to overcome the problem associated with having both well-structured and loosely structured information.

Users begin a search for a problem solution by invoking the QUICKSOLVE screen (figure 9), which allows them to answer a set of predefined questions, such as problem category, problem subcategory, and problem detail, and to access the underlying search engine (CASEPOINT). This search engine performs extremely well, resulting in a list of potential solutions within 1 second (based on a 386 microprocessor). Users can also enter problem symptoms with misspellings that can be handled gracefully by the search engine. The system was developed to provide confirmation questions to move users toward the solution.

Solutions were developed in both text and graphic formats in a highly interrelated Microsoft WINDOWS HELP environment. Complicated printer fault isolation techniques often required referencing many printer repair and replacement procedures. To achieve the ease-of-use goal, these textual and graphic solutions were developed with an emphasis on the hypertext capability of WINDOWS HELP. This approach enabled the development team to support end users with varying degrees of network printer experience. The user interface was developed based on end user task and needs analysis as well as repeated usability testing.

To understand the use of QUICKSOLVE, let us consider the following example: A common printer print-quality problem—blurs-smears—has been detected, and the user is asked to correct the problem using QUICKSOLVE.

<p><b>Title:</b> Print Quality - Blurs-Smears</p> <p><b>Description</b></p> <p><b>Symptoms:</b> Print quality has blurs-smears problem on the printed page.</p> <p><b>Questions</b></p> <p>What printer issue do you need help on? Hardware</p> <p>What printer hardware issue are you having? Print Quality</p> <p>What print-quality problem are you having? Blurs-Smears</p> <p><b>Actions</b></p> <p>Procedure to resolve blurs-smears in print quality</p>
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Figure 8. Example of a Hardware Case from the QUICKSOURCE Case Base.

The screenshot shows the QUICKSOLVE search interface. At the top is a menu bar with 'File', 'Search', and 'Help'. Below it are buttons for 'Search', 'Switch To', 'Clear', 'Profile', 'Defaults', and 'Exit'. The main area is divided into several sections:

- Problem Type:** A table with 'Category' and 'Subcategory' columns. 'Hardware' is selected in the category list, and 'Print Quality' is selected in the subcategory list.
- Problem Detail:** A text input field containing 'Blurs / Smears'.
- Problem Description:** A text input field containing 'my paper is smearing'.
- Preanswered Questions in Search Panel Based on Profile Information:** A section with three checkboxes: 'Printer' (checked), 'Host Computer', and 'Network'.

Callouts on the right side of the screen provide instructions: 'Click on the category that best describes your problem.', 'Next click on the closest matching subcategory.', 'Pull down a list or type in problem details.', 'Type the problem description in your own words (optional)', 'Check a box to guide search toward relevant problem environment.', and 'Click on Search button at the top left of screen to begin search.'

Figure 9. Screen Example from QUICKSOLVE.

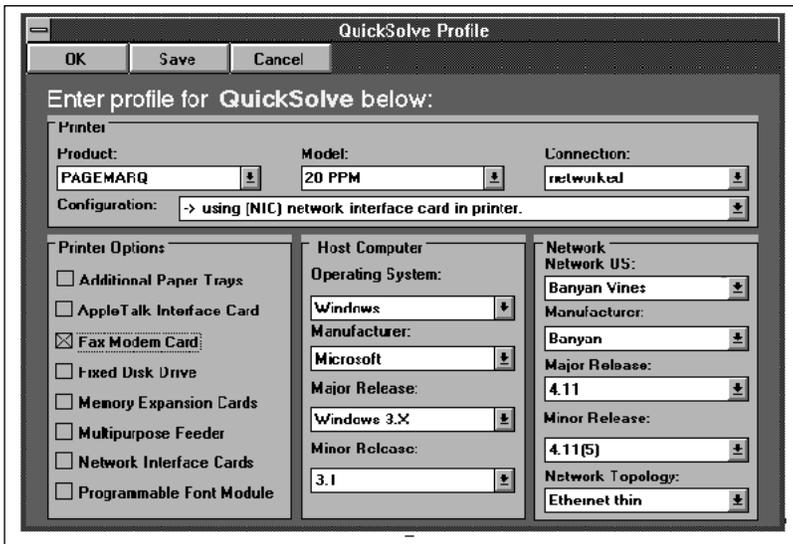


Figure 10. Profile Panel of QUICKSOLVE.

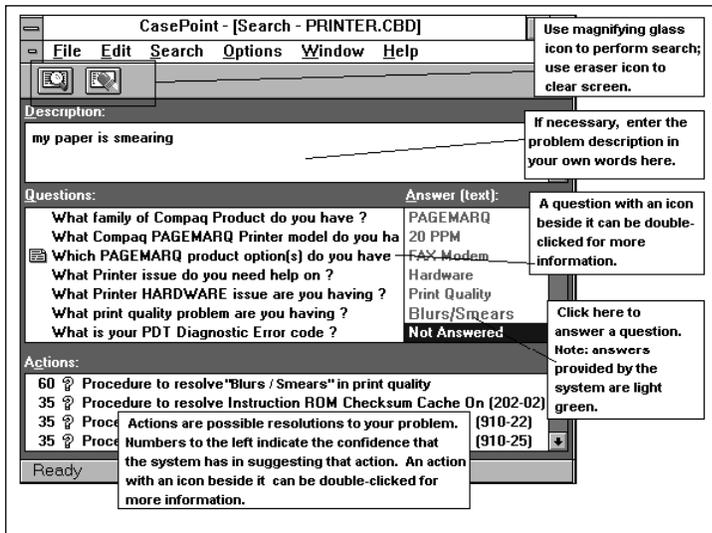


Figure 11. Example of Search Screen with Preanswered Questions.

When QUICKSOLVE is invoked the first time, the user is presented with a QUICKSOLVE menu screen. This initial screen allows users to select symptoms from a predesignated set of questions. These questions are presented in a logical and dynamic structure that is similar to the previously defined case base structure. For this example, the user should answer that this problem is hardware related—a problem of print quality—and the symptom is blurs-smears. The user also has an option to type more specific symptom information in the problem-description box of this screen (figure 9).

QUICKSOLVE was designed to have the added capability over the predecessor SMART system of providing answers to some questions based on information previously stored in the printer-profile file. This printer-profile information, shown in figure 10, was designed to be saved during the installation process and includes the printer configuration, the host computer configuration, and the network environment. Users can keep multiple profile files based on their printer environment(s).

Figure 11 provides an example search screen where six questions have been answered directly by the system. The first three questions are answered from the profile (figure 10), but the next three questions are answered from the initial QUICKSOLVE screen (figure 9).

Rule-based reasoning is used to preanswer as many questions as possible based on the user's problem description. Rules can also answer questions based on previously answered questions. See figure 12 for some examples of QUICKSOLVE's use of rules. This ability to preanswer questions through the use of rule-based reasoning coupled with the CBR search engine resolved one of the major usability challenges observed during the earlier human factors testing.

Once QUICKSOLVE finds an appropriate solution, the user can double-click on the solution topic in the actions area of the search screen, and a detailed solution appears. Figure 13 shows an example of a detailed solution that is retrieved from the QUICKHELP module. To further explore this solution, users can access related procedures and glossary information through hypertext links.

## Designing QUICKSOURCE Based on Human Factors Research

QUICKSOURCE went through nine iterations of usability testing by Compaq's Human Factors Department during all phases of the develop-

ment cycle. This section discusses the human factors research that helped us overcome usability issues.

The human factors analysis started out with prototype testing of the SMART system with customer-support representatives. Usability issues were noted for the prototype and passed on to developers through a report and videotapes of users performing tasks with the system. Later, human factors professionals analyzed customer-support representatives performing the same tasks without the SMART system to compare solution times and error rates. Finally, after the SMART system was fully implemented and on the network, human factors personnel interviewed customer-support representatives (both novice and experienced) to see whether they were using SMART and why. Problems and issues with SMART were written up in a report for management. At that time, QUICKSOURCE was in the conceptual stage of design, and the developers called on the Human Factors Department to begin testing prototypes of the QUICKSOURCE system, especially the QUICKSOLVE module.

We noted that with the SMART system, users were often frustrated with the flow of the user interface's question-and-answer style. Specifically, users were frustrated when forced to answer questions that were redundant or to again have to input information into the description field that had already been supplied. This problem was attacked from two perspectives: internally through the use of rules and profiles and externally through a new user interface screen. Rules were built in to preanswer redundant confirmation questions. Also, a profile was built for each user's environment during the installation of QUICKSOLVE that preanswered several basic questions that the system needed to guide its search. Multiple profiles could be stored so that different questions would be preanswered by the system, depending on the user's chosen environment (for example, networked or not).

Novice users were provided with a front-end screen that allowed them to focus on answering the relevant questions for search in a flexible manner. This screen (shown in figure 9) uses drop-down lists based on particular selections to provide the user with information about a problem area. In essence, the drop-down lists give novice users information about a problem domain prior to their committing to this problem space. Usability testing showed this technique to be effective in determining a problem category. Novice users could also use the natural lan-

```
0 "blurs"
0 "print quality"
=>
1 "Blurs-Smears"
/* If "blurs" and "print quality" strings are detected in the description
field (represented by "0"), then answer the question "What is your print
quality? (question number 1) with "Blurs/Smears". */
34 "3.1"
=>
31 "Windows 3.X"
/* If "3.1" is the answer for the "What version of Windows 3.X are you
using?" question (i.e., question number 34) then answer the "What
major release of Windows are you using?" question (question number
31) with "Windows 3.X". */
```

Figure 12. Examples of Rules Used by QUICKSOLVE to Preanswer Questions.

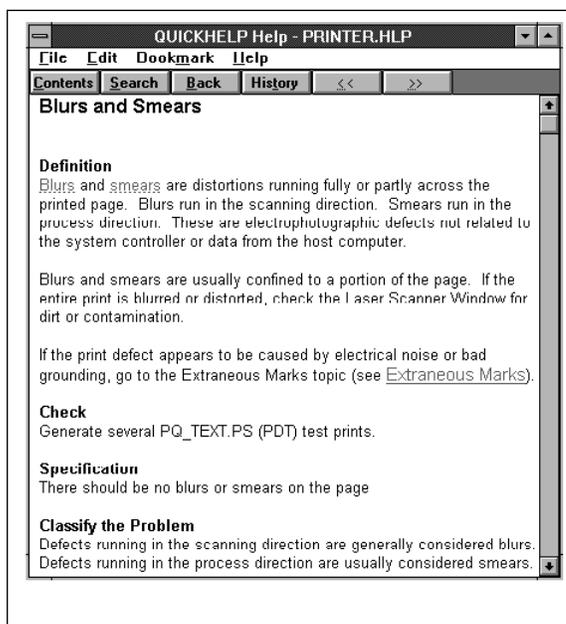


Figure 13. Example of Blurs-Smears Solution Available in QUICKHELP.

guage capability of the front-end screen to describe their problem. The problem-description field of the screen allows for typographic errors and common naming conventions (for example, *winword* for Microsoft WORD for WINDOWS) and essentially performs a fuzzy search based on the entries in the field. A tutorial was developed to instruct the end user on how the screen is used.

### Case Base Issues

With the SMART system, there were usability issues with respect to the case base. For the design of the QUICKSOLVE system, these issues were resolved in several ways. To build a consistent structure for entering and retrieving cases, the case base had to become uniform. To institute this uniformity, the knowledge base was divided into four separate problem domains: hardware, software, networking, and general information. For each domain, a distinct structure was devised for asking the user questions about the problem. For the hardware and general information domains, this structure was gleaned from existing documentation. For the software and networking domains, this structure was engineered by interviewing technical support experts for the networked printers.

The knowledge engineer strictly followed this structure in building cases, using a pre-designated pool of questions with which to query the user about problem symptoms. To promote system usability even further, the knowledge engineer has been vigilant in reusing questions from this pool whenever possible (as opposed to making up new questions). In doing so, the system retrieves cases that match a user's symptoms more cleanly. Whenever possible, QUICKSOLVE prompts the user with a *list question* (that is, a question that the user can answer by choosing from a list), helping to ensure that the user provides the system with the correct symptomatic input.

### Tuning the Case Base

It was determined during customer-support interviews that the questions coming back from the SMART system were sometimes not well tuned or clearly relevant to the problem description. To address this usability issue, weights indicating a question's importance were adjusted to achieve fault-tolerant system behavior. A user could answer one or more questions incorrectly and still find the appropriate answer to the problem.

### Rule-Based Implementation

To further enhance performance of the expert

system's problem-solving abilities, a decision was made to add some rule-based reasoning. With this implementation, when a user types in a problem description using natural language, the character strings are utilized to preanswer some of the questions used for searching the case base. Rules are also utilized to preanswer certain focusing questions based on previous answers. This approach was chosen once again in response to a human factors issue observed during usability testing of the SMART system.

## Maintenance Process

The development team will continue to enhance QUICKSOURCE with information from the Compaq Customer-Support Center call-tracking system and feedback from Compaq printer engineering. The plan is to update the case base on a quarterly basis through electronic bulletin boards such as CompuServe and floppy diskettes. As described earlier, with a well-designed system architecture and a well-organized case base, the QUICKSOURCE maintenance process will be flexible. Automation of the knowledge base updates has been implemented so that printer-problem resolutions, available through the Compaq engineering trouble-report system, can automatically be translated into case format. However, manual testing and fine tuning of these cases by a knowledge engineer is still required to ensure that there is no degradation in system performance.

## Benefits of QUICKSOURCE

Since its release in September 1992, exactly 6 months from its first conceptual design, Compaq has shipped more than 3000 copies of QUICKSOURCE. Each copy consists of three floppy diskettes and a three-page instructional guide. Positive feedback on QUICKSOURCE has been received from many users.

To quantify the benefits of QUICKSOURCE, we compared the new PAGEMARQ network printer to a new Compaq personal computer (PC) server product (a product without QUICKSOURCE). The two products have many features in common and several features to differentiate them. However, we felt that because of their simultaneous ship dates, using this server product as a benchmark for the PAGEMARQ-QUICKSOURCE combination in terms of possible dollar amount saved was justified. The following paragraphs give a breakdown of the similarities and differences between the two products.

*After analyzing these important data, we concluded that PAGEMARQ had roughly 20 percent fewer service calls.*

There are three product similarities: (1) The server product and PAGEMARQ were both announced and shipped in the same time frame. (2) The server product and PAGEMARQ are both used in networked environments. (3) The number of shipped units for the server product and PAGEMARQ is comparable.

The number of differences was much greater: (1) The server product does not have a QUICKSOURCE-like tool. (2) The server product is derived from the well-established Compaq system product line. (3) The server product consists of only electronic complexity. (4) Compaq's customer-service organization has developed a solid network servicing strategy for the system products. (5) The server product is sold mostly to the PC network market. (6) The server product uses the Intel-based microprocessor technology. (7) PAGEMARQ is shipped with QUICKSOURCE. (8) PAGEMARQ is a completely new and complex network printer, a new product line for Compaq. (9) The PAGEMARQ printer consists of electronic, mechanical, and laser printing complexity. (10) Compaq's customer-service organization was relatively unfamiliar with printer and laser technology. (11) PAGEMARQ is sold in both the PC and Apple network markets. (12) PAGEMARQ is based on the reduced instruction set chip (AMD 29K) microprocessor technology.

To get an idea of the kind of monetary impact QUICKSOURCE has provided for Compaq, we collected a sample of all the telephone calls recorded by the Compaq Customer-Service Center during one week. During this data-collection period, we were able to access call information on the PAGEMARQ and the server product. To compare these data, we must account for four important factors: product complexity, amount of time since shipment, number of units sold, and error margin (for comparing two separate product lines).

Compaq experts in both printer and network technology have agreed, based on the differences listed earlier, that a network printer is at least twice as complex as a network server. As we mentioned earlier, both products in our comparison were shipped in the same time frame in approximately the same quantities. The error margin is estimated to be +/- 5 percent.

Because of the confidential nature of these data in the highly competitive PC market, we cannot release the exact figures of our study. However, after analyzing these important data, we concluded that PAGEMARQ had roughly 20 percent fewer service calls. This number is a conservative estimate. We extrapolate the 20 percent over a 1-year period to compute

the total savings. We can safely estimate that with QUICKSOURCE, Compaq might save \$10 to \$20 million dollars a year in customer-service operations alone. Additional savings because of marketing and training benefits are not factored into this figure.

To explore QUICKSOURCE benefits further, let us evaluate benefits in relation to the main objectives Compaq originally set for QUICKSOURCE:

**Achieve customer satisfaction:** The feedback has been extremely favorable. QUICKSOURCE has generated enthusiastic reviews, not only among Compaq's customers but among internal Compaq users as well. Human factors usability testing provided suggestions for improvements to the user interface, performance, and functions. As a result, QUICKSOURCE has been optimized and streamlined to get the correct information to the user as quickly as possible. Enhancements will continue to be identified and implemented in the future.

**Minimize customer down time:** From the server product versus PAGEMARQ study, we see that roughly 20 percent of all PAGEMARQ issues are now handled directly by customers, eliminating the need and the time required to call in an inquiry and obtain a resolution.

**Provide training for customer-support personnel and international support staff:** QUICKSOURCE has been an effective training tool and memory bank for the Customer-Support Center and sales personnel. QUICKSOURCE has been used to resolve approximately 80 percent of the printer calls coming in to the Product-Information Group.

**Reduce the number of calls into Compaq's Customer-Support Center:** Analyses provided here show that there is a 20-percent reduction in calls because of QUICKSOURCE.

**Provide Compaq with a market differentiator:** QUICKSOURCE has been an extremely effective competitive tool in both market advertising and direct selling. QUICKSOURCE is distributed free of charge to buyers of the new printers.

**Reduce operational cost for Compaq:** Analyses provided here demonstrate the multimillion dollar savings resulting from the distribution of QUICKSOURCE.

## Future Enhancements

Further enhancements to QUICKSOLVE have been and will continue to be identified through usability testing. These enhancements will be released in future versions of QUICKSOLVE. Some enhancements are already being addressed to further improve QUICKSOLVE's user interface, performance, and

functions. Specifically, the rule-based reasoning component is being further optimized to preanswer even more of the focusing questions. Also under way are performance enhancements to the integration of the QUICKSOLVE initial search screen and the search engine. Finally, various knowledge elicitation techniques, such as concept mapping (Gowin and Novak 1984; McFarren 1987) and repertory grid analysis (Boose 1986), are being used to better understand and differentiate the problem-solving techniques of expert and novice users. The objective is for QUICKSOLVE to further exploit an expert user's problem-solving capabilities and tailor the system's operation to the knowledge level of the user.

There are a number of other enhancements to QUICKSOURCE currently being considered. These include full motion and sound (that is, multimedia) accompanying the textual and graphic solutions, enhanced QUICKSOURCE graphics with 256-color bit maps, and integration with other existing printer utilities to remotely configure and test printers.

## Conclusion

QUICKSOURCE represents Compaq's first use of knowledge publishing. Through QUICKSOURCE, human expertise and knowledge have been distributed widely direct to Compaq's printer-user community. These users are now empowered with AI techniques to help them solve printer problems entirely on their own. Experience with QUICKSOURCE has reinforced Compaq's service strategy of supporting users through knowledge publishing. QUICKSOURCE is viewed by Compaq as an evolutionary product that will form the basis for other products in the future.

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