

# COMPAQ QuickSource: Providing the Consumer with the Power of Artificial Intelligence

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## **Abstract**

This paper 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 to allow them to solve advanced network printer problems entirely on their own. This process minimizes customer down-time, reduces the number of phone calls to the Compaq Customer Support Center (resulting in monetary savings), improved 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 re-engineering 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, the design of QuickSource 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 to help design and implement the system. The analysis also dictated certain decisions on the organization and design of the expert system component. Since September 1992, Compaq has shipped more than 3,000 copies of QuickSource.

## **Introduction**

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

problems. QuickSolve is a second-generation customer support system based on experience with the Compaq SMART system (Acorn & Walden, 1991). SMART was developed for Compaq's help desk operation. It used case-based reasoning to provide expert-level knowledge and experience to Compaq's Customer Support Center to help representatives answer customer calls via the customer service hotline. With the success of SMART, Compaq looked for new opportunities to use case-based reasoning technology to provide even higher levels of customer service. This analysis resulted in a re-engineering 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 issues 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 to allow users 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 Artificial Intelligence 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. Catalogued questions not only pertain to Compaq hardware, but to third-party hardware and software compatibility with our systems, as well. With an expanding product line, 24-hour technical support, and a three-year product warranty, the need for support tools was high. For these, and many other reasons, the SMART system was designed.

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SMART was designed only for use in Compaq's Customer Support department. The case base for SMART was intended to cover all of Compaq's personal computers, servers, third-party software, and peripherals. QuickSolve, which has a new case base that is specific to networked printer products, was also envisioned to be used by our Customer Support Center. But 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<sup>2</sup>. This was seen as a challenge for the knowledge engineers and developers working on the system. If successful, the design would be quite innovative, as designing expert systems for heterogeneous user populations is known to be a difficult problem (Gordon, 1991).

Based on Compaq's experience with SMART, case-based reasoning (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 because both novices and experts would need explanations of proposed printer solutions (Gordon, 1991). This paper describes the innovative design engineering that resulted in QuickSource, and the intelligent trouble-shooting module, QuickSolve.

### QuickSource Description

QuickSource was developed as a Microsoft Windows<sup>®3</sup> application with an intelligent search engine that targets three different groups of users: printer customers, service providers, and the Compaq Customer Support Center. SMART, the tool on which QuickSource was based, was developed with Inference's CBR Express<sup>®4</sup>. SMART and QuickSource have recently switched over to another Inference tool called CasePoint<sup>5</sup> for their run-time search engines. CasePoint was selected for use with QuickSource primarily because of its memory requirements (less than 40KB). Other reasons for its selection included its ability to invoke other Windows applications via Dynamic Data Exchange (DDE), its performance, its natural language capability, and its fuzzy search capability.

<sup>3</sup> Microsoft Windows is a product of Microsoft Corp., Redmond, WA

<sup>4</sup> CBR Express is a product of Inference Corp., El Segundo, CA

<sup>5</sup> CasePoint is a product of Inference Corp., El Segundo, CA

<sup>6</sup> Microsoft Visual Basic is a product of Microsoft Corp., Redmond, WA

<sup>7</sup> Microsoft C is a product of Microsoft Corp., Redmond., WA

Since QuickSource's main objective was to find the right answers to printer issues quickly, it was designed to operate in a highly inter-related, 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<sup>®6</sup>, 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 (see Figure 10).

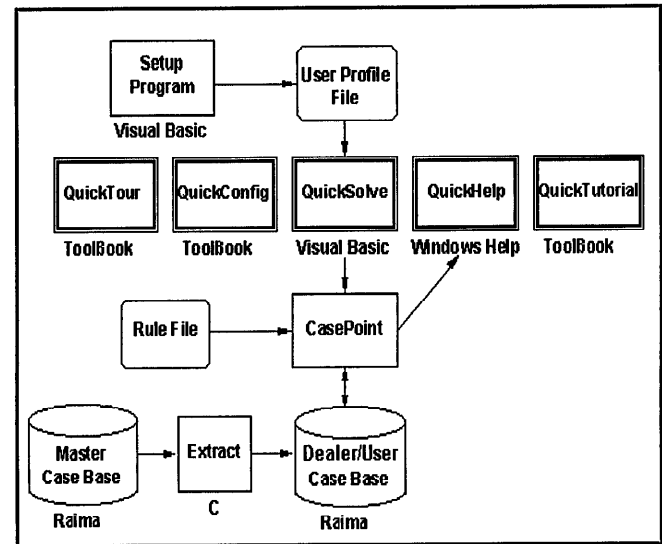


Figure 1. QuickSource System Architecture

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 support provider/dealer version, which is in turn a subset of the Compaq version. The main difference between the three versions is in 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 Providers/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<sup>®7</sup> programming language.

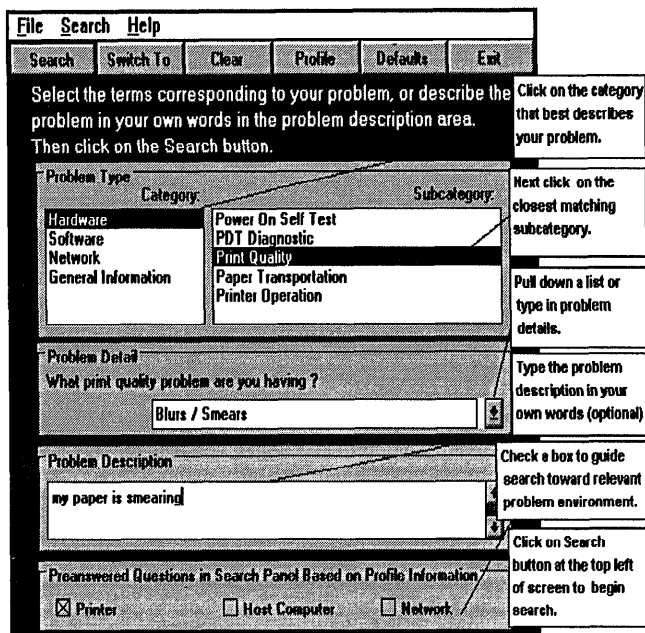


Figure 9. Screen Example from QuickSolve

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, has been designed to be saved during the installation process and includes the printer configuration, the host computer configuration, and the network environment. Users may keep multiple profile files based on their printer environment(s).

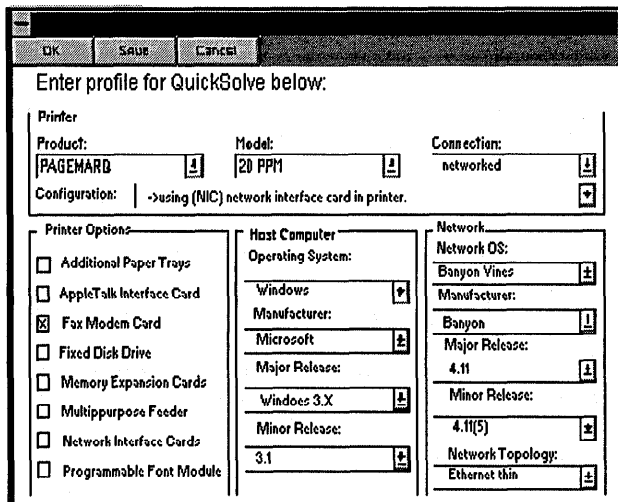


Figure 10. Profile Panel of QuickSolve

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), while the next three questions are answered from the initial QuickSolve screen (Figure 9).

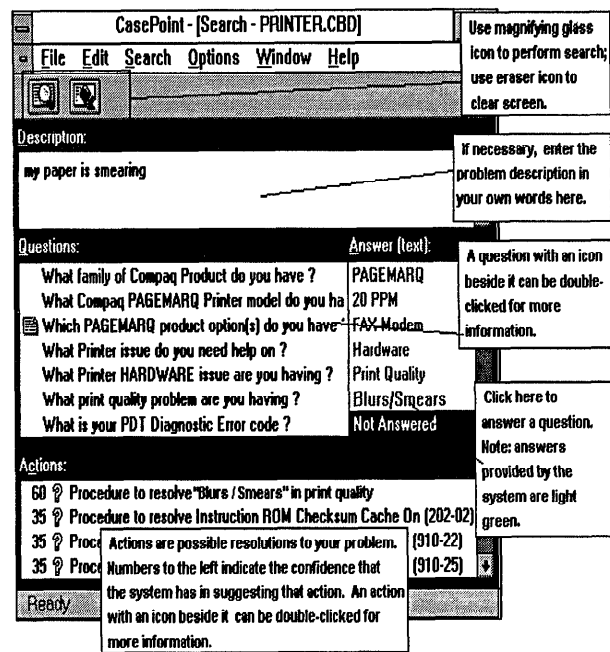


Figure 11. Example of Search Screen with Pre-answered Questions

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

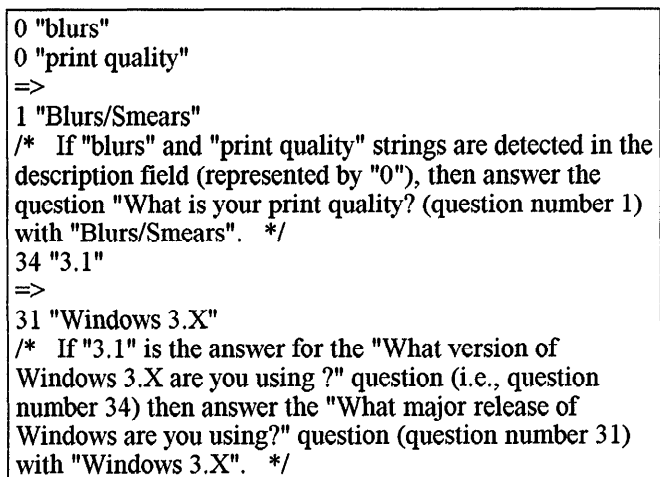


Figure 12. Examples of Rules Used by QuickSolve to Pre-answer Questions

## 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.

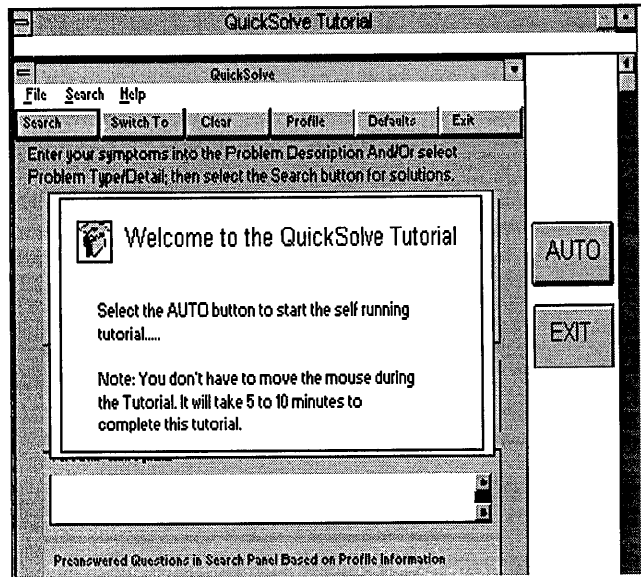


Figure 5. Screen Example from QuickTutorial

## 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. Since QuickSolve is the module that contains expert system technology, it is described at length throughout the rest of the paper.

## QuickSolve Architecture

The QuickSolve case base was developed by two printer specialists and one knowledge engineer. This development team designed cases and stored them in Raima®<sup>9</sup> database format, located on the corporate Banyan Vines®<sup>10</sup> network. The structure for entering cases was leveraged from earlier knowledge engineering work performed on the SMART system (Acorn & Walden, 1991). This structure consisted of dividing the case base into several partitions: hardware problems, software problems, networking problems, and general information (see 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

<sup>9</sup> Raima Data Manager is a product of Raims Corp., Bellview, WA

<sup>10</sup>Vines is a product of Banyan, Inc., Westboro, MA

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, insuring that the structure of the cases was usable and consistent.

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

Figure 6. Case Base Organization

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. This was because software and network cases were highly unstructured. Thus, more information content was anticipated in the description field than from 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.

<p><b>TITLE:</b> Win, MS Word - Fonts not updated correctly</p> <p><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.</p> <p><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></p> <p><b>ACTIONS</b>  Click on Word for Windows Printer Setup to update the Font selection</p> <p><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.</p>
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Figure 7. Example of a Software Case from the QuickSolve Case Base

<p><b>TITLE -</b> Print Quality - <i>Blurs/Smears</i></p> <p><b>DESCRIPTION</b>  <b>SYMPTOMS</b> - Print quality has blurs/smears problem on the printed page.</p> <p><b>QUESTIONS</b>  What Printer issue do you need help on? -  <i>Hardware</i>  What Printer hardware issue are you having? -  <i>Print Quality</i>  What print quality problem are you having? -  <i>Blurs/Smears</i></p> <p><b>ACTIONS</b>  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

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 one 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 step users toward the solution.

Solutions were developed in both text and graphical formats in a highly inter-related Microsoft Windows Help® environment. Complicated printer fault isolation techniques often required referencing many printer repair and replacement procedures. To achieve our ease of use goal, these textual and graphical solutions were developed with an emphasis on the hypertext capability of Windows Help. This 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. 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 is a hardware problem, a problem of print quality and that 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 (see Figure 9).

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 on-line support for printer installation and configuration.
- QuickHelp provides on-line documentation on maintenance procedures and general information.
- QuickSolve provides intelligent troubleshooting analysis and advice.
- QuickTutorial provides an on-line tutorial on how to use QuickSolve.

Example screens of these modules are provided below.

### QuickTour

QuickTour was developed to be a proprietary, on-line, 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 by the use of text and graphics. QuickTour was developed with Asymetrix ToolBook®<sup>8</sup>. This module required no documentation for its successful use, as determined via Human Factors testing, and has been distributed as a pre-sales tool.

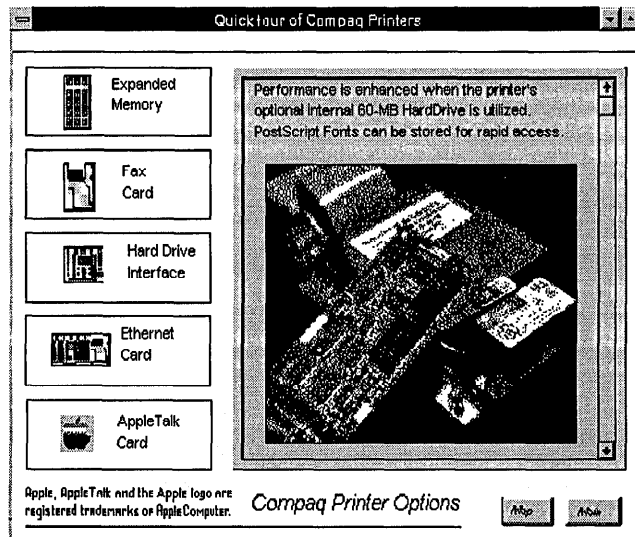


Figure 2. Screen Example from QuickTour

### QuickConfig

QuickConfig was developed to provide product configuration and installation information. End users have used QuickConfig when they were in need of information about installing or reconfiguring a printer for different

environments. This graphical tool, also developed with ToolBook®, provides end users with installation and configuration guidelines. QuickConfig has been used effectively without accessing documentation.

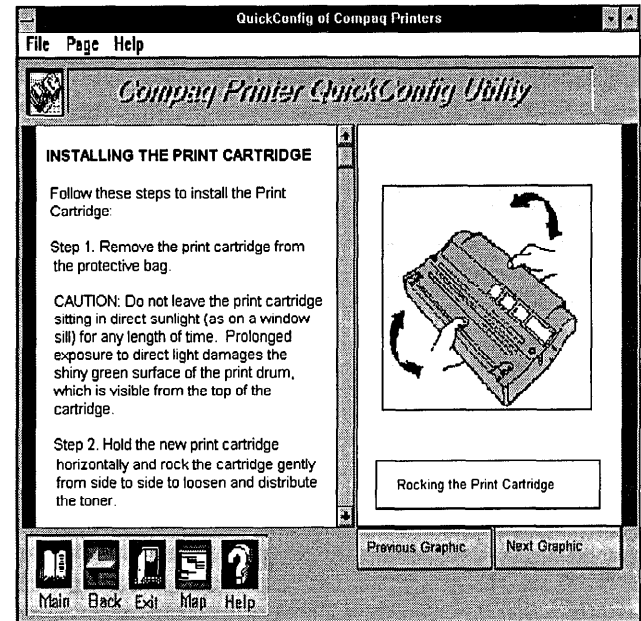


Figure 3. Screen Example from QuickConfig

### 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 other common printer problems. This module, developed with Microsoft Windows Help®, can be accessed directly or from within the QuickTour, QuickConfig, or QuickSolve modules.

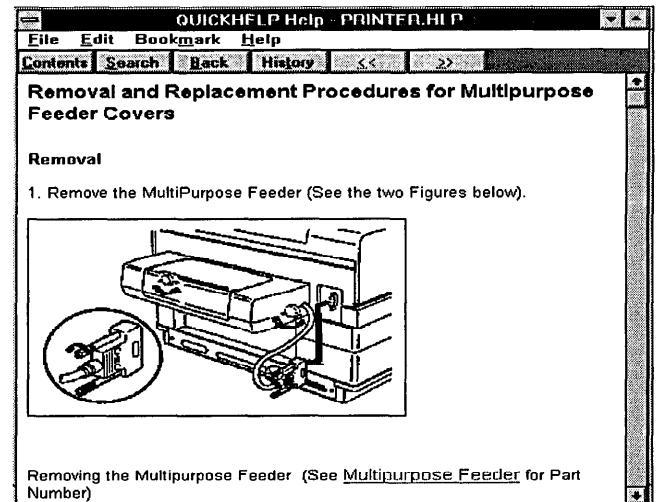


Figure 4. Screen Example from QuickHelp

<sup>8</sup> ToolBook is a product of Asymetrix Corp., Bellview, WA

Once QuickSolve finds an appropriate solution, the user may 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/glossary information through hypertext links.

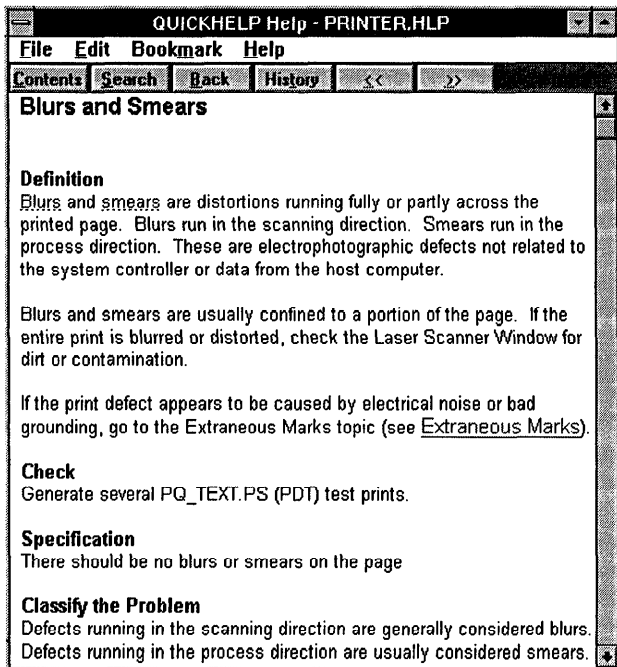


Figure 13. Example of Blurs/Smears Solution Available in QuickHelp

## Designing QuickSource Based on Human Factors Research

QuickSource has gone through nine iterations of usability testing performed by Compaq's Human Factors Department during all phases of the development 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 via 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, in order to compare solution times and error rates. Finally, after the SMART system was fully implemented and on the network, Human Factors performed interviews with Customer Support representatives (both novice and experienced) to see whether or not 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 Human Factors 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 which the user had already input information into the description field of the screen. 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 pre-answer redundant, confirmation questions. Also, a profile was built for each user's environment during installation of QuickSolve that pre-answered several basic questions that the system needed to guide its search. Multiple profiles could be stored, so that different questions would be pre-answered by the system, depending on the user's chosen environment (e.g., 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 that problem space. Usability testing showed this technique to be very effective in determining a problem category. Novice users could also use the natural language capability of the front screen to describe their problem. The problem description field of the screen allows for typographical errors and common naming conventions (e.g., "winword" for Microsoft Word for Windows) and essentially performs a fuzzy search based on the entries in that 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. In order 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 for asking the user questions about the problem was devised. 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 the networked printers technical support experts.

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 usability of the system 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 (i.e., a question that the user can answer by choosing from a list). This more often insures that the user provides the system with the correct symptomatic input.

### **Tuning the Casebase**

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 in some rule-based reasoning. With this implementation, when a user types in a problem description using natural language, the character strings are used to pre-answer some of the questions used for searching the case base. Rules are also used to pre-answer certain focusing questions based on previous answers. This was 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 Compaq Customer Support Center's Call Tracking System and with feedback from Compaq printer engineering. The plan is to update the case base on a quarterly basis via 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 very flexible. Automation of the knowledge base updates has been implemented so that printer problem resolutions, available through the Compaq engineering trouble report system, can be automatically 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 of 1992, exactly six months from its first conceptual design, Compaq has shipped more than 3,000 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.

In order to quantify the benefits of QuickSource we compared the new PAGEMARQ network printer to a new Compaq PC server product (a product without QuickSource). The two products have many features in common and several features that differentiate them. However, we felt that, due to 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. Following is a breakdown of the similarities and differences between the two products.

#### **Similarities:**

- The server product and PAGEMARQ were both announced and shipped in the same time frame.
- The server product and PAGEMARQ are both used in networked environments.
- The number of shipped units for the server product and PAGEMARQ are comparable.

#### **Differences:**

- The server product does not have a QuickSource-like tool.
- The server product is derived from the well-established Compaq system product line.
- The server product consists of only electronic complexity.
- Compaq's Customer Service organization has developed a solid network servicing strategy for the system products.
- The server product is sold mostly to the PC network market.
- The server product uses the Intel-based microprocessor technology.
- PAGEMARQ is shipped with QuickSource.
- PAGEMARQ is a completely new and complex network printer - a new product line for Compaq.
- The PAGEMARQ printer consists of electronic, mechanical, and laser printing complexity.
- Compaq's Customer Service organization was relatively unfamiliar with printer and laser technology.
- PAGEMARQ is sold in both the PC and Apple network markets.
- PAGEMARQ is based on the RISC based (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 phone calls recorded by the Compaq Customer Service Center during a one week time period.



During this data collection period, we were able to access call information on the PAGEMARQ and the server product. In order to compare this data, we must account for four important factors: product complexity, amount of time since shipment, number of units sold and the error margin (for comparing two separate product lines).

Compaq experts in both printer and network technology have agreed, based on the differences listed above, 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 at +/- 5%.

Due to the confidential nature of this data in the highly competitive PC market, we cannot release the exact figures of our study. However, after analyzing this important data, we have concluded that PAGEMARQ has roughly 20% fewer calls. This is a conservative number. We extrapolate the 20% over a one year period to compute the total saving. We could safely estimate that with QuickSource Compaq may save 10 to 20 million dollars per year in customer service operations alone. Additional savings due to marketing and training benefits are not factored into this bottom line.

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

1. *Customer satisfaction.* The feedback has been extremely favorable. QuickSource has generated enthusiastic reviews, not only among Compaq's customers, but among internal Compaq users. Human Factors usability testing provided suggestions for improvements to the user interface, performance, and functionality. 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.
2. *Minimize customer down time.* From the server product vs PAGEMARQ study above, we see that roughly 20% of all PAGEMARQ issues are now handled directly by customers thus eliminating the need and the time required to call in an inquiry and obtain a resolution.
3. *Provide training for Customer Support personnel and for the 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% of the printer calls coming in to the Product Information group.

4. *Reduce the number of calls into Compaq's Customer Support Center.* Analyses provided above show that there is a 20% reduction of calls because of QuickSource.
5. *Provide Compaq with a market differentiator.* QuickSource has been an extremely effective competitive tool, both in market advertising and in direct selling. QuickSource is distributed free of charge to buyers of the new printers.
6. *Reduce operational cost for Compaq.* Analyses provided above demonstrates the multi-million 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 functionality. Specifically, the rule-based reasoning component is being further optimized to pre-answer even more of the focusing questions. Also underway 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 & 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 (i.e., multimedia) accompanying the textual and graphical solutions.
- Enhance QuickSource graphics with 256 color bitmaps.
- 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 widely distributed directly to Compaq's printer user community. These users are now empowered with Artificial Intelligence 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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