HUMAN FACTORS INVOLVEMENT IN BRINGING THE POWER OF AI TO A HETEROGENEOUS USER POPULATION

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ABSTRACT

This paper describes the Human Factors involvement in developing COMPAQ QuickSolve, an electronic problem-solving and information system for Compaq's line of networked printers. Empowering customers with expert system technology so they could solve advanced network printer problems on their own was a major goal in designing this system. This process would minimize customer down-time, reduce the number of phone calls to the Compaq Customer Support Center, improve customer satisfaction and, most importantly, differentiate Compaq printers in the marketplace by providing the best, and most technologically advanced, customer support.

This 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 more quickly and correctly answer customer questions and problems. QuickSolve is a second generation system in that customer support is put directly in the hands of the consumers (an example of "knowledge publishing"). As a result, the design of QuickSolve presented a number of 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 required while designing and implementing the system. Research that shaped the organization and design of the expert system component as well.

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1.0 INTRODUCTION

Human Factors involvement and the iterative usability test and design process were key to the development of a utility called QuickSolve - an electronic problem-solving and information system for Compaq's line of networked printers. QuickSolve includes a case-based reasoning module that helps troubleshoot network printer problems and is a second-generation customer support system based on Compaq's SMART system (Acorn & Walden, 1992).

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 1-800 hotline number. With the success of SMART, Compaq looked for additional ways to use case-based reasoning technology to improve 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 issues on their own and to use Compaq's help desk as a backup facility.

1.2 Background

Compaq Customer Support representatives must provide technical support on a wide range of topics, from simple product information requests to complex questions about networked environments. Catalogued questions pertain not only to Compaq hardware, but to third-party hardware and software compatibility 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.

A key point is that 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, Compaq servers, and third-party software and peripherals. QuickSolve, which has a new case base 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 end users as well. Therefore, the target audience for QuickSolve was dramatically more heterogeneous than that for SMART[2]. This was a challenge for the knowledge engineers and developers working on the system, 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 our Customer Support Center, and 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, which can be easily provided using CBR (Gordon, 1991).

2.0 QUICKSOLVE DESCRIPTION

QuickSolve was developed as a Microsoft Windows®[3] application with an intelligent search engine that targets three groups of users: printer customers, service providers, and the Compaq Customer Support Center. SMART, the tool on which QuickSolve was based, was developed with Inference's CBR Express ®[4]. SMART and QuickSolve recently switched to another Inference tool called CasePoint[5] for their run-

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[2]SMART was designed to be used by several hundred trained customer support representatives, whereas QuickSource needed to be designed for thousands of general printer customers.
[3]Microsoft Windows is a product of Microsoft Corporation, Redmond, WA
[4]CBR Express is a product of Inference Corporation, El Segundo, CA

time search engines. CasePoint was selected primarily because of its memory requirements (less than 40KB). Other reasons included its ability to invoke other Windows applications via Dynamic Data Exchange(DDE), performance, natural language capability, and fuzzy search capability.

2.1 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®[6] database format, located on the corporate Banyan Vines®[7] network. The structure for entering cases was leveraged from earlier work on the SMART system (Acorn & Walden, 1992). This structure divided the case base into several partitions: hardware problems, software problems, networking problems, and general information. Using 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 panel that allowed users to select answers to questions about their problem from a list.

QuickSolve's interface has a description field which allows the user to describe the printer problem encountered. This description field is accompanied by a weight used to indicate the field's importance in determining the closeness of a match by the system. Similarly, a weight is assigned to each "honing" question presented to the user by the system, to specify the importance of the answer. The overall matching score is defined by the combination of these weights during the search process.

One problem observed during Human Factors testing 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 answers to disallow any input error from dominating the overall matching score.

During the design process, the Human Factors Engineer worked with the knowledge engineers to develop a simpler case structure for software and network cases. This was necessary because the information obtained from our printer experts was 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.

Users begin a search for a problem solution by invoking the QuickSolve panel. This allows them to answer a set of predefined questions and to access the underlying search engine (CasePoint). In testing, users found this search engine to perform extremely well, resulting in a list of potential solutions within one second (based on a 386 microprocessor). (Our field research has shown that electronic documentation users judge the value of the documentation by the power of its search engine). Misspellings when entering problem symptoms are handled gracefully by the search engine, and confirmation questions 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 meet 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 on end user task and needs analysis (interviews with users of the SMART system, as well as printer specialists in the field), and iterative usability testing.

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[5]CasePoint is a product of Inference Corporation, El Segundo, CA
[6]Raima Data Manager is a product of Raima Corporation, Bellview, WA
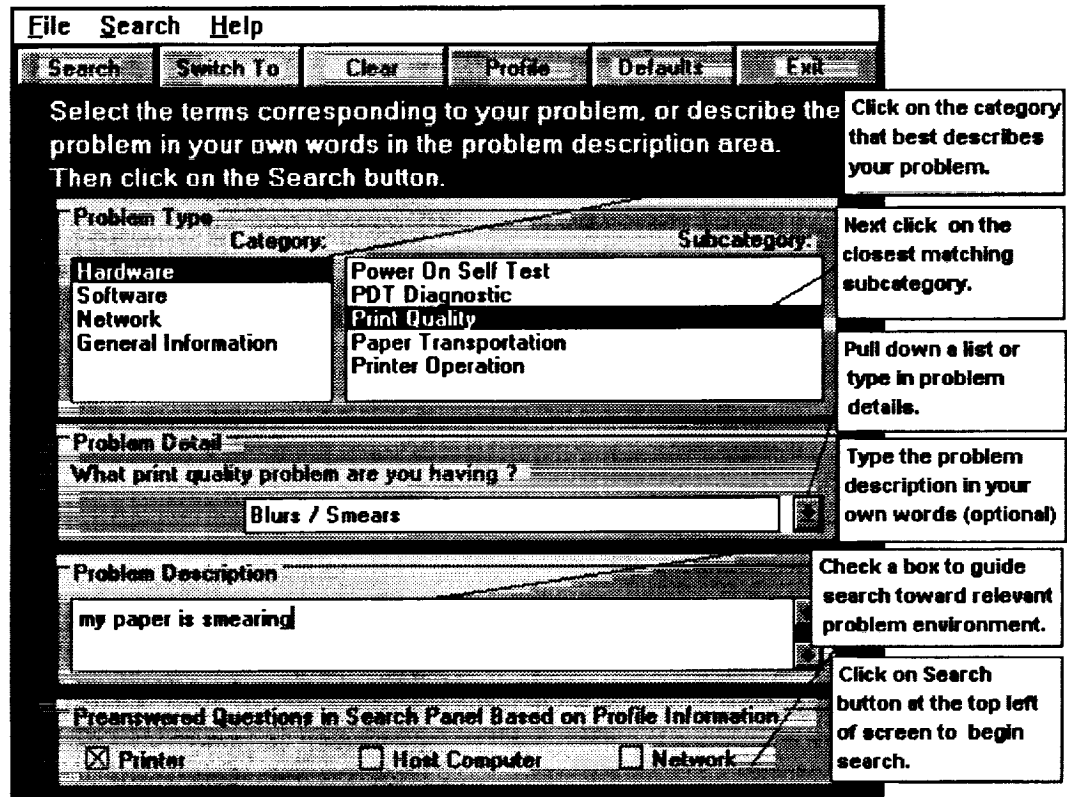[7]Vines is a product of Banyan Inc., Westboro, MA

Figure 1. Screen Example from QuickSolve panel

2.2 Example Using QuickSolve

To understand the use of QuickSolve, consider the following: A common printer print quality problem - "Blurs/Smears" - has been detected and the user is asked to correct the problem. When QuickSolve is invoked the first time the user is presented with a QuickSolve menu screen. This initial panel allows users to select symptoms from pre-designated sets of questions, which are presented in a logical and dynamic structure 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 can also type more specific symptom information in the problem description box (see Figure 1).

QuickSolve has the added capability over the predecessor SMART system of providing answers to some questions based on information previously stored in the printer profile file. Usability testing demonstrated this added functionality to be key if users were to accept and use the system. The printer profile information is saved during the installation process and includes printer configuration, host computer configuration, and network environment information. Users may keep multiple printer environment profile files.

Figure 2 shows an example search panel where six questions have been answered by the system. The first three questions were answered from the profile, while the next three questions were answered from the initial QuickSolve panel (Figure 1).

Rule-based reasoning pre-answers as many questions as possible based on the user's problem description. Rules also can answer questions based on previously answered questions. This ability to pre-answer questions, coupled with the CBR search engine, resolved another major usability challenge observed during earlier Human Factors testing.
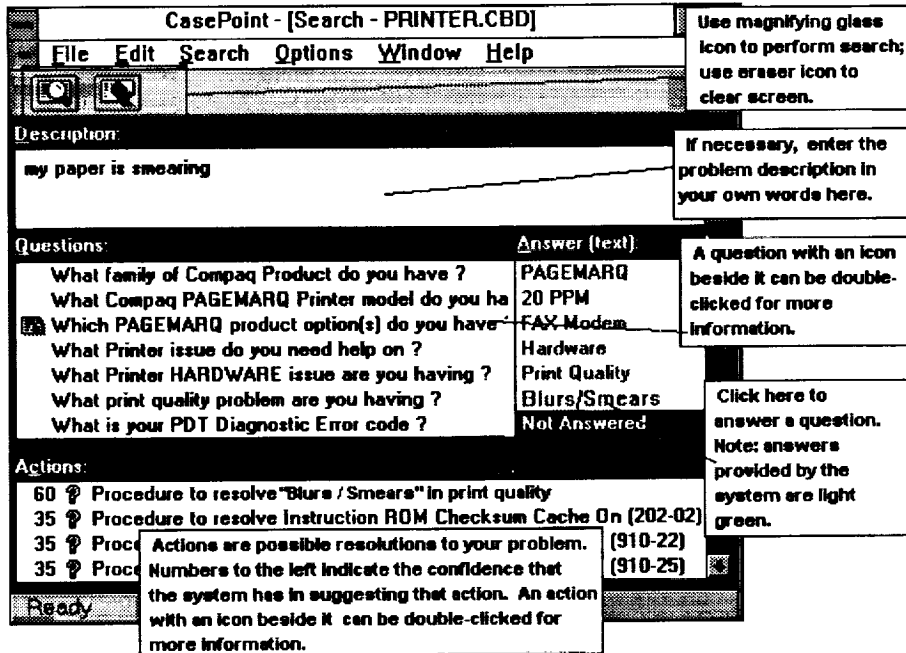
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┌──────────────────────────────────────────────────┐  ┌──────────────────────┐
│        CasePoint - [Search - PRINTER.CBD]          │  │ Use magnifying glass │
│   File  Edit  Search  Options  Window  Help        │  │ icon to perform search;│
│   ┌──┐┌──┐                                          │  │ use eraser icon to   │
│   │  ││  │                                          │  │ clear screen.        │
│   └──┘└──┘                                          │  └──────────────────────┘
├──────────────────────────────────────────────────┤
│ Description:                                       │  ┌──────────────────────┐
│                                                    │  │ If necessary, enter the│
│  my paper is smearing ───────────────────────────────│ problem description in │
│                                                    │  │ your own words here.  │
├──────────────────────────────────────────────────┤  └──────────────────────┘
│ Questions:                      Answer (text):     │  ┌──────────────────────┐
│   What family of Compaq Product do you have ?  PAGEMARQ │ A question with an icon│
│   What Compaq PAGEMARQ Printer model do you ha 20 PPM  │ beside it can be double-│
│ 🖼 Which PAGEMARQ product option(s) do you have FAX Modem│ clicked for more       │
│   What Printer issue do you need help on ?     Hardware │ information.            │
│   What Printer HARDWARE issue are you having ? Print Quality└──────────────────────┘
│   What print quality problem are you having ?  Blurs/Smears ┌──────────────────┐
│   What is your PDT Diagnostic Error code ?     Not Answered │ Click here to    │
├──────────────────────────────────────────────────┤       │ answer a question.│
│ Actions:                                           │       │ Note: answers    │
│   60 🖼 Procedure to resolve"Blurs / Smears" in print quality│ provided by the  │
│   35 🖼 Procedure to resolve Instruction ROM Checksum Cache On (202-02)│ system are light│
│   35 🖼 Proc┌──────────────────────────────────┐ (910-22)│ green.          │
│   35 🖼 Proc│ Actions are possible resolutions to your problem.│(910-25)└──────────────┘
│            │ Numbers to the left indicate the confidence that │
│ Ready      │ the system has in suggesting that action. An action│
│            │ with an icon beside it can be double-clicked for │
│            │ more information.                                │
│            └──────────────────────────────────┘
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Figure 2. Example of Search Panel with Pre-Answered Questions

Once QuickSolve finds an appropriate solution, the user may double-click on the solution topic in the Actions area of the search panel and a detailed solution appears. Figure 3 shows a detailed solution retrieved from the QuickHelp module. To further explore this solution, users can access related procedures/glossary information through hypertext links.
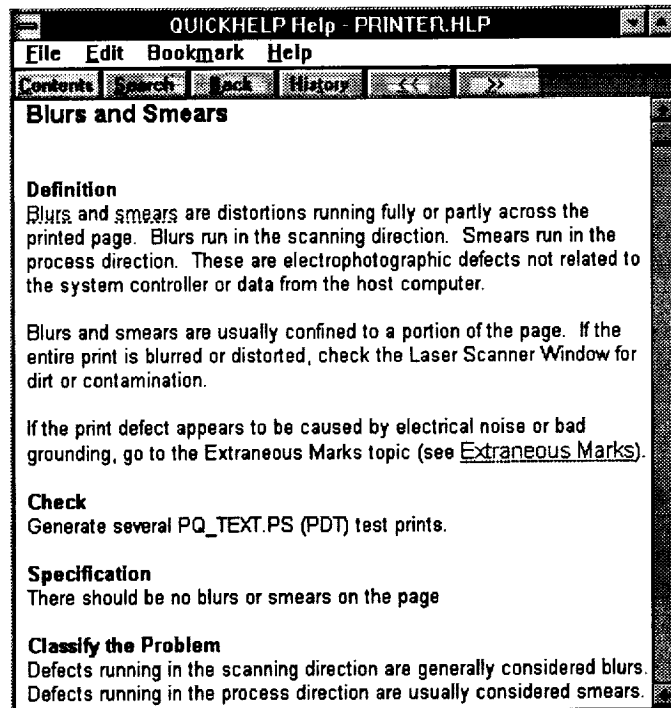
```
┌──────────────────────────────────────────────────┐
│        QUICKHELP Help - PRINTER.HLP                │
│   File  Edit  Bookmark  Help                       │
│  ┌────────┐┌──────┐┌──────┐┌───────┐┌────┐┌────┐  │
│  │Contents││Search││Back  ││History││ << ││ >> │  │
│  └────────┘└──────┘└──────┘└───────┘└────┘└────┘  │
│  Blurs and Smears                                  │
│                                                    │
│  Definition                                        │
│  Blurs and smears are distortions running fully or partly across the│
│  printed page. Blurs run in the scanning direction. Smears run in the│
│  process direction. These are electrophotographic defects not related to│
│  the system controller or data from the host computer.│
│                                                    │
│  Blurs and smears are usually confined to a portion of the page. If the│
│  entire print is blurred or distorted, check the Laser Scanner Window for│
│  dirt or contamination.                            │
│                                                    │
│  If the print defect appears to be caused by electrical noise or bad│
│  grounding, go to the Extraneous Marks topic (see Extraneous Marks).│
│                                                    │
│  Check                                             │
│  Generate several PQ_TEXT.PS (PDT) test prints.    │
│                                                    │
│  Specification                                     │
│  There should be no blurs or smears on the page    │
│                                                    │
│  Classify the Problem                              │
│  Defects running in the scanning direction are generally considered blurs.│
│  Defects running in the process direction are usually considered smears.│
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Figure 3. Example of Blurs/Smears Solution Available in QuickHelp

2.3 Designing QuickSolve Based on Human Factors Research

QuickSolve and its complementary problem-solving modules have gone through nine iterations of usability testing 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 with prototype testing of the SMART system with Customer Support representatives. Usability issues were noted and passed on to developers via reports 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 determine if they were, or were not, using SMART and why. Problems and issues with SMART were presented in a report for management. At that time, QuickSolve was in the conceptual stage of design and the developers called on Human Factors to begin testing prototypes of the QuickSolve system, especially the QuickSolve module.

We had noted that with the SMART system, users were often frustrated with the flow of questions and answers. Specifically, users were frustrated when forced to answer questions that were redundant or to which they had already input into the description field. This problem was attacked from two perspectives: internally through the use of rules and profiles, and externally through a new user interface panel. 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 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 panel that allowed them to answer relevant questions in a flexible manner. This panel (shown in Figure 1), 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 with these users. Novice users could also use the natural language capability of the front panel to describe their problem. The problem description field of the panel 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 panel use.

Case Base Issues. With the SMART system, there were usability issues with respect to the case base. For the design of the QuickSolve system, it was decided that 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 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 technical support experts for networked printers.

When entering cases, the knowledge engineer followed this structure strictly in building the case using a pre-designated pool of questions with which to query the user about problem symptoms. To further promote system usability, 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 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 rule-based reasoning. With this implementation, a user types in a problem description using natural language and 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.

2.3 Future Enhancements

Further enhancements to QuickSolve have been, and will continue to be, identified through usability testing. These enhancements are already being tested in the Human Factors laboratory. 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 panel 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 investigated 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.

3.0 CONCLUSION

QuickSolve represents Compaq's first use of "knowledge publishing". Compaq intends to further develop this technology, and Human Factors involvement is crucial to its success. Unless the power of artificial intelligence is presented to the end user in an easy to use, non-intimidating user interface, it will never afford the benefits so often espoused by its proponents. For this reason, Human Factors continues to follow our users into the field, watching how they use intelligent tools and asking how they can be better designed to support problem-solving styles and information needs.

ACKNOWLEDGMENTS

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