New Directions in Transaction Terminal Interfaces

Richard L. Henneman

David M. Rubini

As market demands have led to increased functionality of transaction processing systems, such as those used by cashiers, bank tellers, and users of automatic teller machines (ATMs), limitations and complexities in the underlying technologies have created challenges in user interface (UI) design. This paper discusses NCR's work with new UI technologies that are having a significant impact on the ease of use of transaction terminals. These technologies include touch screens, pen computing, and the use of video and graphics. This paper also describes some of the tools and methods that support UI design for transaction terminal systems.

Introduction

What is transaction processing? A *transaction* is simply the exchange or sale of goods or information between two or more parties. The *processing* of transactions is, therefore, the processing of agreements. These agreements may be about the exchange of money for goods, such as in a retail transaction, but they could just as well be about the processing of information, such as the request for an account balance from a bank. As with any processing task, issues of speed, accuracy, and efficiency are critical.

Technology has driven improvements in these areas. For example, in a retail environment, the machines used to record sales and collect money are no longer known as cash registers, but as point-of-sale (POS) terminals. Completing a banking transaction no longer necessarily means going to a bank, thanks to the high popularity and acceptance of ATMs. In both instances, the role and use of technology has evolved from a behind-the-scenes application (mainframes, specialized teller terminals, and other equipment) often hidden from the customer, to include extensive end-user interaction at the point of transaction. In fact, without technology, most of the transactions conducted today would not be possible.

In transaction-processing tasks, users have well-defined goals (for example, placing an item on layaway, or withdrawing $20.00 from an ATM), and must recall and implement the appropriate, well-defined method to achieve that goal. User tasks are deterministic, in that all task sequences are predefined or predetermined. There is no need for creative problem solving by a user to develop a way to perform a task.

Perhaps due to time and resource limitations, a lack of focus on usability, or an assumption that the UI is inherently simple, some system developers have ignored the user. As a result, UIs to transaction processing systems are often needlessly difficult to learn and use.

These problems have brought new importance to the role of human/machine interaction in transaction processing. This paper discusses NCR's current efforts to find ways to apply new UI technologies, methods, and tools to improve the usability of transaction-processing systems. It goes on to describe current problems in transaction processing, particularly as they relate to retail environments, and new NCR technological solutions to these problems. The paper concludes with new directions in UIs to transaction-processing terminals and systems.

Current Problems In Transaction Processing

Transaction-processing tasks may be classified in terms of the people who perform them. One category typically uses the

product to perform a specific job, such as a cashier or a bank teller. Another category, such as an ATM customer, has a choice whether to use the product or not.

Human-factors issues, such as training time and end-user efficiency, are important design considerations for operators of POS terminals. Systems in which use is optional (ATM machines) must also address subjective factors, including the need for a user to perceive some advantage of one system over other available options (such as choosing between an ATM or bank teller).

In the set of transaction-processing tasks known as *point-of-sale tasks*, the transaction being completed can be organized into several distinct phases. These phases include:

- Itemization—Information about items being purchased is in some way recorded by the system.
- Finalization—Payment for the items is collected and change is returned.
- Modification—The characteristic of a transaction, group of items, or single item is changed.
- Error Correction—Improperly entered or incorrect information is fixed.

Itemization and finalization occur in all typical POS transactions; not all transactions require modification or error correction. Opportunities for increased productivity at the POS terminal should address improving error-free performance of one or more of the above phases.

Common POS-terminal interfaces consist of a display and a keyboard. The display ranges in configuration from an 8-character light-emitting diode (LED) readout to a 9" monochromatic color graphics adapter (CGA) monitor. The keyboard may include from 22 to 100 dedicated function keys, with a numeric key pad, to a full alphanumeric key pad with up to 23 dedicated function keys (see Figure 1). POS terminal interfaces traditionally have been designed incrementally, function by function, and have been subject to problems common to many incrementally designed interfaces, including a lack of internal consistency in the interface design. As a result, most of today's retail POS systems unintentionally accentuate the potential for human error. Some of these problems were identified by observing a number of retail POS systems as shown in Table I.[1]

In addition, POS interface problems are exacerbated by a number of other characteristics of the task, the user, and the environment. A retail environment is both time-constrained and interrupt-driven. For example, a cashier may be pressured by long waiting lines during a holiday season, or may be interrupted in the middle of a transaction by another customer or by a telephone call. The tasks cashiers perform are either highly practiced, as with a normal sale, or rare events, as with a layaway. The rare events lead to long task times and increased errors. Many retailers instruct their cashiers to ask a supervisor to handle these rare events, rather than training cashiers to complete tasks that might delay a transaction.

Retailers attempt to combat interface limitations through training sessions that can take as long as three days for new employees. Additional training is done "on the floor." Training costs are high because many cashiers have limited skills and experience working with advanced technology, and frequently change jobs. Current estimates for employee turnover among general merchandise retailers range from 100- to 300-percent per year.

The high and increasing costs associated with training and lost productivity are pressuring retailers to find new UI design solutions. Hardware and software vendors are starting to offer retailers new input and display technologies, including touch screen, voice recognition, and graphical interfaces. In fact, the transaction-processing market seems primed to make significant advances in human/machine interaction—changes similar to those seen in the early 1980s in the office environment. Such advances can be hastened, in order to make appropriate use of the new technology, by a thorough understanding of a users' tasks.

User-Centered Design

The breadth of the problems described above suggests that a unified, user-centered approach is required to avoid the piecemeal solutions of the past, which have only compounded usability problems. To be successful, new UI technologies require careful consideration of who the end-users are, the tasks they perform, and the environment of use. NCR cognitive engineers are working to develop and promote a user-centered design process, which can be applied to the development of any product that has end-users. Tools and methods to support user-centered design are also being developed and applied within NCR, including the use of usability and

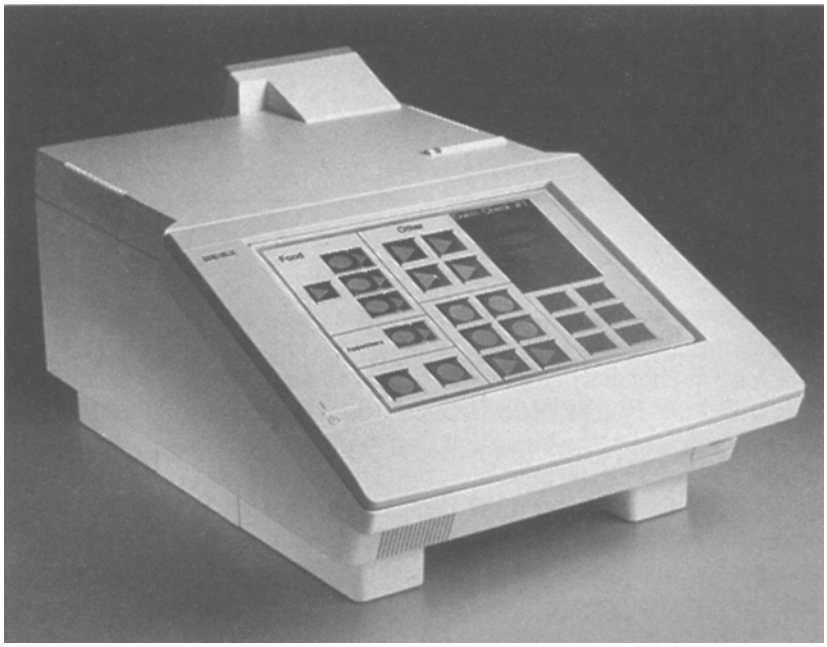

Figure 1. NCR 7054 ITS Work Station operates with the NICE Touch library of building blocks to simplify touch-screen transaction processing.

field testing, quality-function deployment, focus groups, and ethnographic observation. A major emphasis is being placed on educating management and developers about the importance of designing products that meet end-users' needs.

Field observation and research provide valuable feedback to user-centered design processes for transaction processing. NCR uses field research extensively in retail-industry segments, where virtually all retailers are focused on improving the perceived levels of customer service. Customer service must be defined and measured for each retailer. For a grocery chain, it may be defined as the amount of time a customer spends in line, while a department store may measure it in terms of eye contact and communication between the clerk and the customer. NCR uses a variety of techniques, including video transaction analysis, in-store interviews, and observation to help retailers define and quantify their current level of customer service, identify areas of improvement, and accurately measure results of new procedures, tools, and technologies.

New Technologies

The implementation of new technologies in the use of transaction terminals has been driven both by purchasers and by end-users of the systems. Rightly or wrongly, purchasers perceive new technologies as a way to achieve greater efficiencies in transaction processing, employee training, and overall customer service. End-users of transaction terminals have come to expect improvements in the system with which they interact. This "pull" from the market has forced producers of transaction terminals, including NCR, to turn to new technologies as a staple for survival, as opposed to merely a source of differentiation or enhanced image. The following sections discuss a few of the new technologies that are rapidly finding their way into transaction terminals.

Touch Input

Although touch screens provide a number of advantages for end-users, they also present a number of design challenges for developers. Design issues include:

- Desirable size and spacing of touch-sensitive areas
- Desirable feedback for touch-sensitive input
- Best location for input areas on the display
- Effect of viewing position on data-entry accuracy.

The application of touch-activated UIs in a retail environment was explored by an NCR advanced development group that engineered a customer-activated terminal (CAT). The CAT allowed customers to place orders in a quick-service restaurant. This terminal was designed and implemented by using a user-centered process.[2] The development process culminated in a two-month, in-store evaluation. It showed that customers would use such a self-service device if they perceived there were significant advantages, such as decreased waiting time, over dealing with a human cashier. The CAT development effort also demonstrated the sometimes subtle interplay between design considerations that arise when developing touch-activated UIs. For example, it was necessary to sacrifice some functionality in the system to achieve simplicity in the interface.

NICE™ Touch

The CAT project demonstrated that there is nothing intrinsically easy about using a touch-activated UI. Its success depends on the way in which the end-user application is developed. NCR has traditionally sold hardware platforms, with third-party software companies responsible for developing end-user applications. Due to

Table I. Common problems with retail POS terminal interfaces

Problem	Example
Commands with arbitrary syntax	To discount an item, a cashier enters the discount percentage followed by the item. However, to change the price of an item, a cashier enters the item followed by the new price.
Commands with multiple meanings	At different points in a transaction, pressing the CLEAR key will either clear a numeric entry, cancel the function currently being performed, or signal that a slip has been placed in the printer.
Limited on-line help	It is still very common to see a user's manual or paper help chart at a work station to aid a cashier.
Arbitrary rules of operation	A cashier performs a check transaction differently based on the amount of the check due to store policy/security reasons.
Outdated and cryptic retail terminology	"No Sale" causes the cash drawer to open. "Void" is used to remove an item that has been entered.
Command-based interfaces; that is, no selection mechanism from a list of choices	To discount an item, a cashier enters the discount percentage or amount instead of selecting the type of discount; that is, employee discount, senior citizen discount, etc.
Displays that do not reflect current system state	Many POS systems require a cashier to indicate the type of transaction (cash sale, charge return, layaway) to be performed before any items can be entered. This information is often not indicated to a cashier, and a mistake remains unnoticed until after all the items have been entered.
Many keys that create the potential for error	A cashier cannot VOID an item if no items have been entered. However, the VOID key is always physically present on the keyboard and will elicit an error if it is pressed.
Key presses that provide little to no feedback	A "Tax Mod" key is used to change (or modify) the tax calculation for the next item entered. When pressed, there is no feedback that the next item entered will be charged a different tax rate than normal.
Command sequences that place great demands on long-term memory	A cashier in a department store must remember at least 25 different key sequences to enter or modify items and finalize a transaction.
Cryptic error messages	"W003" and "Invalid Input" are common error messages.

time pressures and resource limitations, these interface developers may have to trade off ease-of-use for meeting deadlines. The NCR E&M Atlanta facility developed the Natural Interface for Computing Environments (NICE) to address this problem and the emerging use of touch screens in computing, especially in transaction processing.

NICE Touch is an application building block library, designed specifically for the NCR 7054, Release 2.0, Integrated Touch Screen (ITS) work station. It includes a set of interface controls, an icon library, access libraries for retail-specific peripherals, and a UI design guide.

NICE Controls. NICE Touch controls are similar to those found in Microsoft Windows. (Microsoft is a registered trademark, and Windows is a trademark of Microsoft Corporation.) They provide the application developer with a set of objects to create the UI for a touch-screen application. A touch is physically different from a mouse click. Therefore, different control characteristics are required for the user to be able to interact successfully with the system. Radio buttons, check boxes, and scroll bars—although quite successfully used with a mouse—are much more difficult to manipulate by

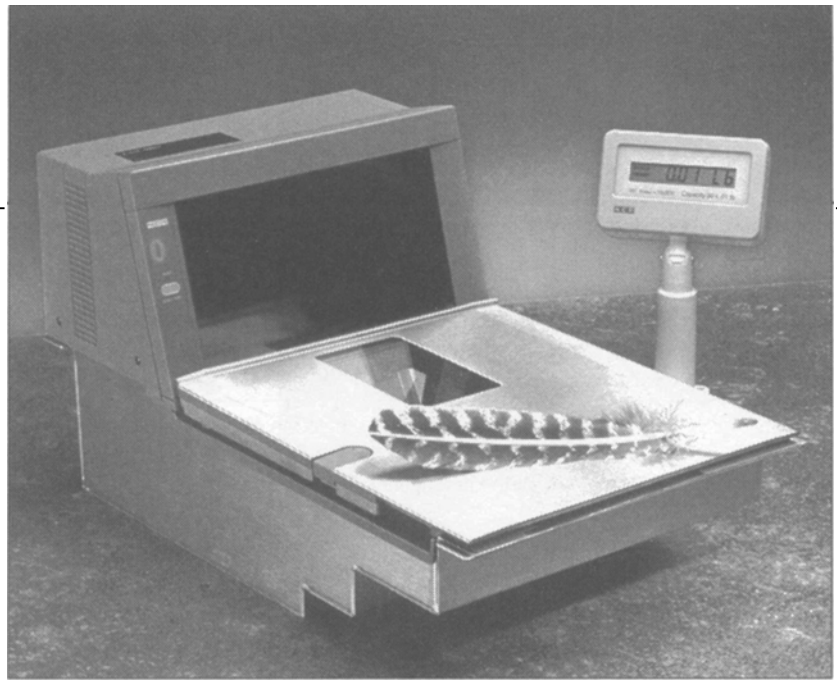

Figure 2. The NCR 7870 Scanner, featuring a bi-optic, two-window scan zone, reduces the necessity to reorient items for bar-code registering.

the touch of a finger. NICE Touch controls provide touch-screen analogs and additions, with special emphasis on the type of tasks being performed in an order-entry controlled environment.

NICE Design Guide. The NICE Touch User-Interface Design Guide was produced to help application developers using the NICE Touch library build better touch-screen UIs for order-entry environments. It helps developers make UI design decisions based on an understanding of the end-users, the tasks they need to accomplish, and the environment in which they work.

NICE Icon Library. Included in the NICE Icon Library is a predefined set of interface display and control elements; for example, food items and transaction-processing functions. A sample application, with limited functionality, is also included. This application demonstrates the recommended usage of the UI objects based on basic UI principles.

Pen Input

The NICE product program is currently exploring the expansion of NICE controls to the pen-computing environment. Pen computing has been lauded by many in the computer industry as the next important evolution in the way people interact with computers. If this is the case, it will be greatly influenced by how well developers of hardware and software recognize that the users of pen computers want to complete their tasks quickly, efficiently, and with little training. In the design of transaction-processing equipment, pen computing is particularly challenging, because the range of users is so wide. Moreover, the pen can perform a wide variety of functions.

Like a finger, mouse, or track ball, a pen stylus can function as a pointer. It can be used to select items from lists, push buttons, and activate controls. This is a very powerful approach, when combined with the proper software, and offers a particularly effective way to interact with a computer. This approach has many advantages in the design of transaction-processing systems, and as a result requires little or no training.

A second way the pen stylus can function in pen computing is as a command-input device. Gestures, the set of coded commands written with the stylus, initiate an action when recognized. Unlike a pointing device, however, the user must know the commands and their meanings to communicate with the machine. This presents interesting challenges to the world of transaction processing. Speed and efficiency offered by gestures must be balanced with training requirements, naturalness of operation, and use of the interface by non-computer-literate users. Current approaches to character recognition are limited in some respects.[3]

A third way the pen stylus functions is as a device for depositing electronic "ink." Although a conventional ball-point pen emits liquid ink that adheres to paper, the pen stylus emits "electronic ink" in the form of activated pixels on a display. Drawing pictures and words is a widely accepted method of communicating between people, but has only recently been possible between computers and people. In transaction processing, the ability to replace conventional writing with an electronic equivalent shows great promise in many areas.

From order entry in restaurants, to signature capture and recognition in banking transactions, pen computing offers many opportunities. This approach, while conceptually appealing, offers the most challenge in terms of having user perceptions and expectations meet the reality of the technology. Capturing written

Table II. Two POS-system data-entry methods

	Keyboard Method	Potential SR Method
Coupons		
Department entry	<170> + MEAT key	"One - point - seven - zero - meat"
Item lookup	Look up on paper sheets	"Tomatoes"
Finalization	TOTAL key	"Total"
Entering the tender amount	<500> CASH key	"Five - cash"
Error correction		
Item void	VOID key - scan item	"Void" - scan item

input, and recognizing it for computer processing, tend to be lumped together by end- users in their perceptions of pen computing. The reality is that write capture currently offers much more, in terms of system reliability and speed, than does write recognition, in terms of meeting user expectations.

Scanners

NCR has aggressively explored new interface developments in bar-code scanning technology.[4] The recently released NCR 7870 Scanner, featuring a bi-optic, two-window scan zone, effectively increases first-time bar-code registration without physical reorientation of the item (see Figure 2).

Reductions in the physical manipulation of products to orient them for scanning have major implications for scanning efficiency and cashier training.

Multimedia

The challenge of effectively integrating new technologies into transaction-processing systems is readily apparent in the technologies of sight and sound—collectively termed *multimedia*. The integration of high-resolution images into transaction terminals appeals to many NCR customers. However, the potential to decrease employee training time and increase its effectiveness, and the visual marketing of products and services, are tempered by the current cost sensitivity of most retailers and bankers. The NCR Transaction Terminal and Retail Systems Division has experimented with images and text as a way to teach simple hardware maintenance tasks, such as changing the paper in a printer. Trends suggest an increasing demand for on-line training and advertising.

Speech Recognition

Speech recognition (SR) technology offers several opportunities for increasing efficiency in transaction processing. If there is a significant reduction in the amount of time required to enter information via a voice command rather than as a keyed input, then efficiencies can be realized.

In a scanning POS environment, SR technology has been explored in a joint project between NCR and AT&T Bell Laboratories. SR is especially attractive when it can be used to replace keyboard functions that normally require an operator to stop scanning and enter information. For example, when multiple quantities of the same item need to be entered, an operator must shift attention away from scanning, look at the keyboard, and enter the quantity before or after having scanned the item. Typically, this takes about one to three seconds, depending on the location of the keyboard and the expertise of the operator.

With SR technology, this task could be shortened by not requiring the operator to change position relative to the scanner. Instead, the operator could speak a command to modify the quantity, scan the item, and then move all similar items to the take-away area. The operator might say "quantity 7", scan the item to be modified, and then move the other six items to the take-away area. The benefits of this approach include:

- Operator focus stays at scanner
- Reduction in scan time by eliminating switching

between scanner and keyboard
- Less potential for operator stress due to reduced twisting and shifting
- Greater potential for increased productivity because operator can now use two hands to move and scan items, rather than keeping one hand on the keyboard
- Greater potential for increased efficiency by allowing operator to complete some tasks in parallel rather than serially.

The same rationale could be applied to other tasks in the POS environment, including payment tasks and product look-up.

In environments that do not use scanners—such as kitchen-display systems in fast-food environments, baggage handling, and process control—the opportunities for SR technology are most apparent when an operator has both hands occupied and would otherwise need to stop a task to enter information via a keyboard.

User Assistants

Another set of interface technologies, *user assistants*, is being developed by the NCR Human Interface Technology Center in Atlanta. User assistants are on-line "intelligent advisors" that monitor an operator's actions while using a device. A user assistant, by relying on "knowledge" of specific tasks, will recommend alternative courses of action when a user makes a mistake. The user assistant's "advice" will adapt to varying levels of user expertise. User-assistant technology has been applied to an NCR retail POS system. This resulted in a working prototype that reduced training time, accelerated performance, and decreased user errors. A number of key issues has been explored in evaluating such adaptive systems.

Conclusion

The future of transaction processing, or the processing of agreements, will rely heavily on the role of new technologies for incremental improvements in efficiency and productivity. Implicit in this reliance is the requirement that new systems be easy to learn and easy to use. This is due to the varying levels of skill and technology acceptance by end-users, and the financial realities of operating a transaction-processing business with great speed and efficiency. NCR seeks to implement new technologies in products through a process that is based on a thorough understanding of users, the tasks users must perform, and the environment in which users must function. The user-centered design approach is being driven into NCR's existing hardware and software development processes via the projects discussed. NCR cognitive engineers are also informing NCR stakeholders about the substantial benefits that can be realized from this approach.

References

1. R. L. Henneman, M. Inderrieden, and C. Benson, "Model-Based Interface Design for Transaction-Processing Tasks", *Proceedings of the 35th Annual Meeting of the Human Factors Society*, September 1991, San Francisco, California, pp. 421-424.
2. R. L. Henneman et al., "Evolutionary Design of a Customer-Activated Terminal: A Case Study", *Proceedings of the 34th Annual Meeting of the Human Factors Society*, October 1990, Orlando, Florida, pp. 300-304.
3. P. J. Santos et al., "On Handwriting Recognition System Performance: Some Experimental Results", *Proceedings of the 36th Annual Meeting of the Human Factors Society*, October 1992, Atlanta, Georgia, pp. 283-287.
4. Mark Hoffman, "Challenges of Providing Ergonomic Solutions for Users in the Retail Scanning Environment", *NCR Journal*, Vol. 5, No. 2, December 1991, pp. 2-12.

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Richard L. Henneman *is manager of cognitive engineering in the Cognitive Engineering/Technology and Development Division at the NCR Human-Interface Technology Center in Atlanta, Georgia. He manages a core group of cognitive engineers that focuses on achieving ease of use of all NCR products. Mr. Henneman received a B.S. and M.S. in industrial engineering at the University of Illinois, Urbana-Champaign, and a Ph.D. in industrial and systems engineering, human-machine systems, at Georgia Institute of Technology, Atlanta. He joined NCR in 1989.*

David M. Rubini *is a senior human-factors engineer in the Cognitive Engineering/Technology and Development Division at the NCR Human-Interface Technology Center in Atlanta, Georgia. He focuses on developing NCR's cognitive engineering infrastructure, and on establishing the business validity of user-centered design processes. Mr. Rubini received a B.S. in human-factors engineering from Tufts University, Medford, Massachusetts, and an M.B.A. from Columbia Business School in New York City. He joined NCR in 1990.*