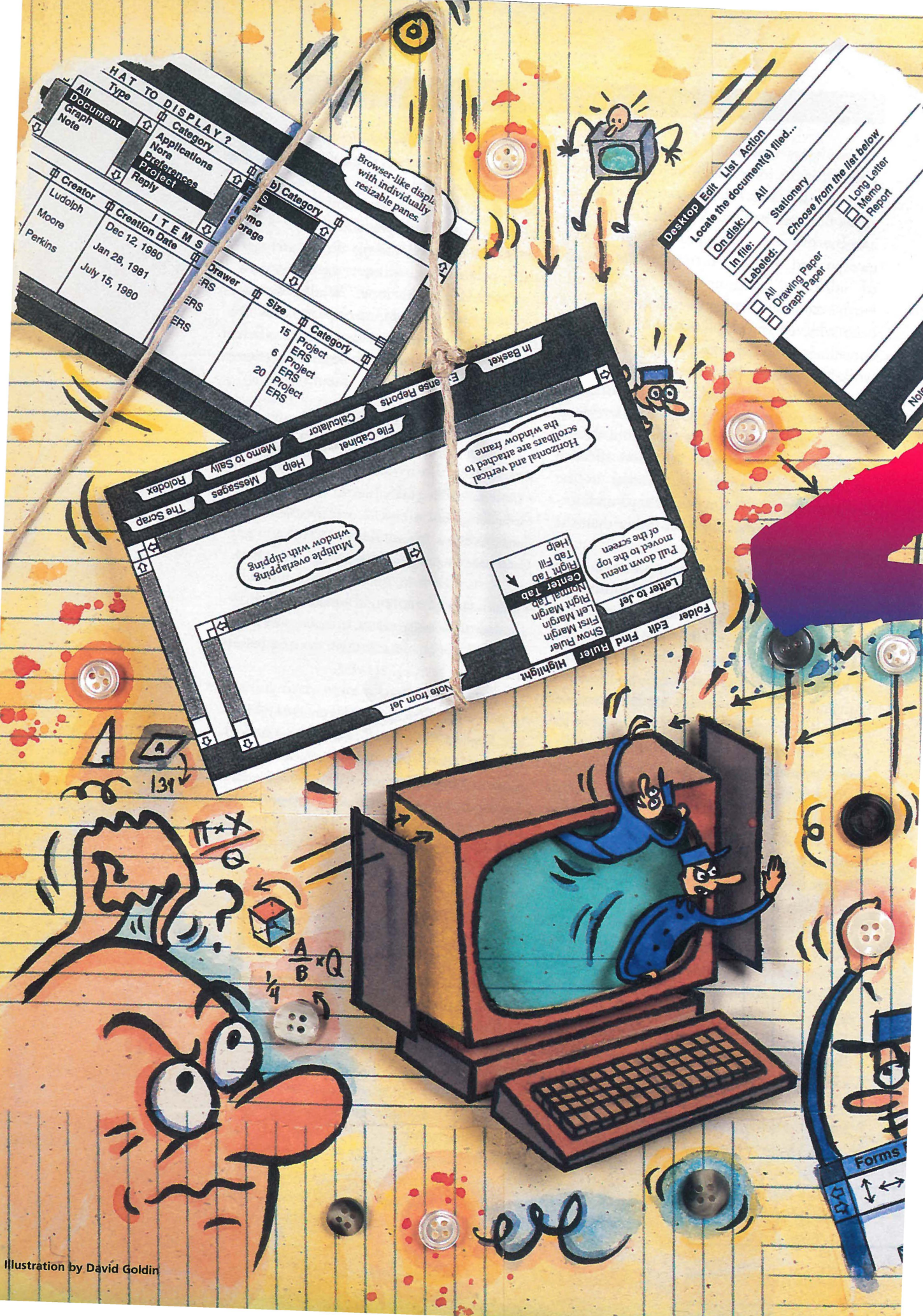


Illustration by David Goldin

Roderick Perkins
Dan Smith Keller
Frank Ludolph

INVENTING THE Lisa USER INTERFACE

Today's familiar Macintosh user interface is a direct descendant of the interface first developed and used on Apple's Lisa computer. Instead of a text-based system that presented the user with a blank screen and blinking cursor, the Lisa displayed an electronic desktop, a picture that the user manipulated directly to tell the computer what to do. The electronic desktop, with its windows, menu bar, and icons was not part of the original design; rather, it was the result of a 4-year-long process of refining goals and developing, testing, and synthesizing many alternative ideas. In fact, the iconic desktop was first tried in 1980 and discarded! The final result (Figure 1) not only made computers easier to use, it made them fun.

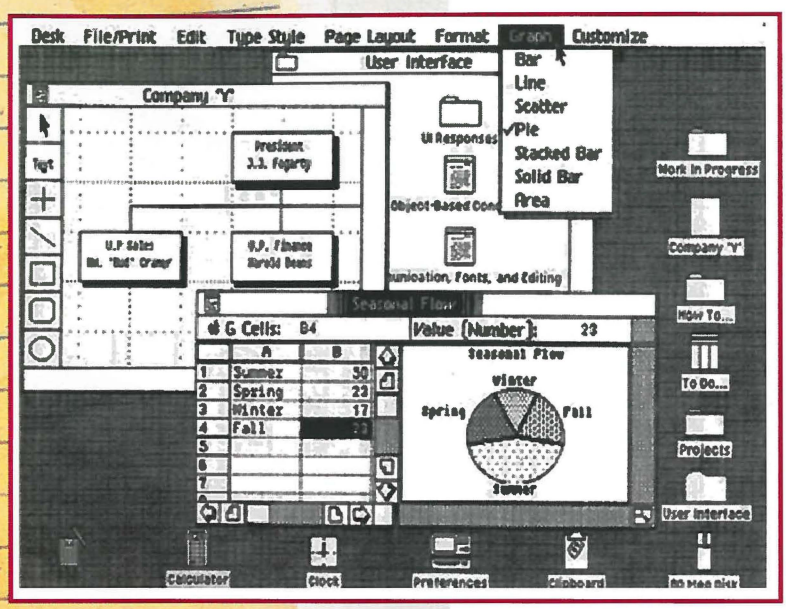


Figure 1
The Lisa Desktop (January 1983)

The authors were members of the software team that designed and implemented Lisa's system software and applications. Rod Perkins joined the team in early 1979, shortly after the start of the project, to work on applications and prototypes of the early ideas about the appearance and workings of windows, dialogue boxes, and menus. Dan Keller and Frank Ludolph began working on Lisa in late 1980 and were responsible for what eventually became the Desktop Manager with folders and icons.

Goals and Guiding Principles

The new machine, first proposed in late 1978, was to be designed for general office use—a high-quality, easy-to-use computer for secretaries, managers, and professionals that would give the individual more independence performing multiple tasks without disrupting the office. The ease-of-use goal evolved during 1979 as the software team tried many ideas. Requirements, developed jointly by marketing and engineering, enumerated the following goals [4].

Lisa must be fun to use. It will not be a system that is used by someone "because it is part of the job" or "because the boss told them to." For this reason, special attention must be paid to the friendliness of the user interaction and the subtleties that make using Lisa rewarding and job enriching.

Lisa will be designed to require extremely minimal user training and "hand holding."

The system will provide one standard method of interacting with a user in handling text, numbers, and graphics...

The system will adhere to the concept of "gradual learning"... A user must be able to do some important tasks easily and with minimal instruction or preparation... The more sophisticated features will be unobtrusive until they are needed.

Errors will be handled consistently in as friendly a manner as possible, and the user will be protected from obvious errors...

... A "Set-up" program will allow the user to customize several system attributes in order to "personalize" interaction with the system... in order to make the system uniquely personal for the user without interfering with the interface standards...

(It should allow) a user to put whatever he/she is doing on "hold" in order to answer the phone, look up an address, or respond to an asynchronous interrupt (time for a meeting, mail received on the network, etc.)...

In addition, the use of graphics in general user interaction will set Lisa apart from its competitors and will go a long way toward making the system friendly, easy and enjoyable to use. "Intuitive icons" can be designed to indicate certain messages to the user...

During the same period the engineering team developed several principles that would be used to achieve these goals. The interface would be "intuitive," modeled on documents and other office-based objects instead of traditional and unfamiliar computer concepts. Like the office, this electronic desktop would not be limited to showing only one thing at a time. Commands would be visible on the screen, consistent across applications, and modeless. When possible, commands would be replaced by direct actions using the mouse. Data were to be moved easily between documents and displayed on the screen in a style known as WYSIWYG ("what you see is what you get")—that is, the screen and printed output should look the same.

Some of these ideas came from team members with strongly held convictions, some came from other projects within Apple, and other ideas originated outside the company.

Whatever the source, it took time for these goals and principles to develop and be assimilated by the Lisa team.

Beginnings of the Lisa

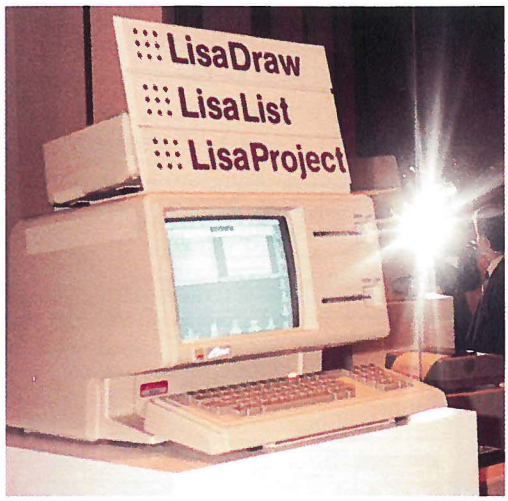
When the Lisa project was started in late 1978 the goal was to build a computer that would propel Apple into the business market of the 1980s. The original plan was to build a custom microprocessor that would be more powerful than the established Apple II computer and could provide greater flexibility for future machines. The Lisa hardware would have an Apple II–style bitmap screen and graphics support for creating simple line drawings using Logo™-style instructions. The hardware would also scroll the screen one line at a time to give a smooth scrolling effect. "Soft" function keys (soft keys) and cursor keys appeared on the keyboard to be used by the applications. The Lisa hardware was to be competitive with the specialized business equipment that existed in 1978, but with the added distinction of being a general-purpose computer.

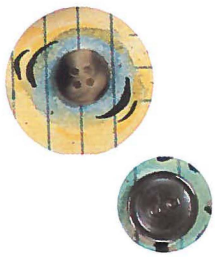
The early hardware limited the user interface that the Lisa applications would have. The video capabilities of the hardware could not display high-resolution graphics. Fortunately, it was envisioned that word processing and databases would be the first applications, neither of which would rely heavily on graphics. Each application was to be distinctive in its use of the soft keys and cursor keys, thereby providing an easier interface to the user. Early prototypes of the Lisa applications were written on the Apple II until the new hardware could be used.

Early User Interface

The first Lisa application, a data Forms Editor, was started during Summer 1979. Forms Editor created the data entry forms for the database engine that would drive the Lisa software. Additionally, the Forms Editor could create simple line drawings such as a business organization chart. Even in this early application, the following familiar Lisa user interface concepts could be seen (Figure 2):

- **Easy to Manipulate.** The user could create text, lines, boxes, and data fields; move them on the screen; and go back and edit them, all by using the cursor keys and a special selection key. The user would constantly receive visual feedback as things were drawn, which we felt would increase their feeling of control.
- **Intuitive.** The soft keys displayed the options currently available. The user simply pointed to the option desired instead of typing a command. There was no need for the user to remember complicated command sequences. Likewise, there were no hidden commands because all choices were clearly displayed on the screen. An arrow displayed what cursor movements were appropriate at a given moment. This display was useful for drawing and while filling in a form.
- **Friendly.** The Lisa would prompt with messages instead of just waiting for a command to be typed. The prompts could be





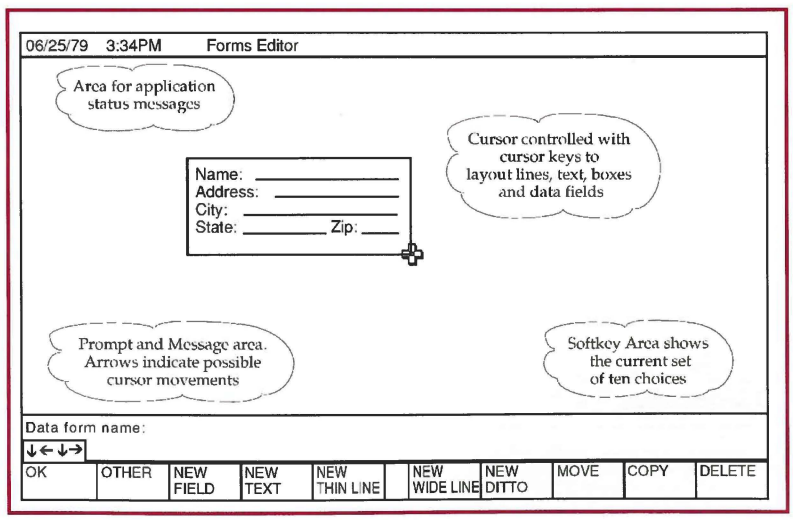


Figure 2
The Lisa display as seen on an Apple II screen (July 1979)

Figure 3a
The Lisa display with a simple window, as seen on Lisa prototype hardware (February 1980)

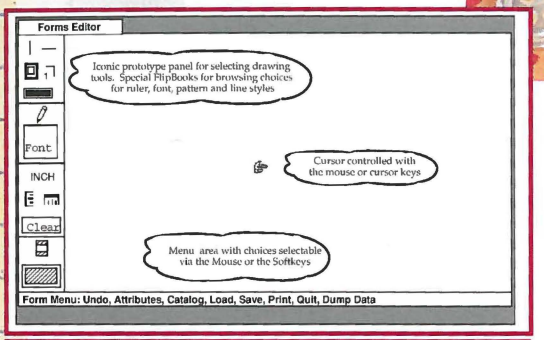


Figure 3b
The Lisa display with a simple window and dialogue box (March 1980)

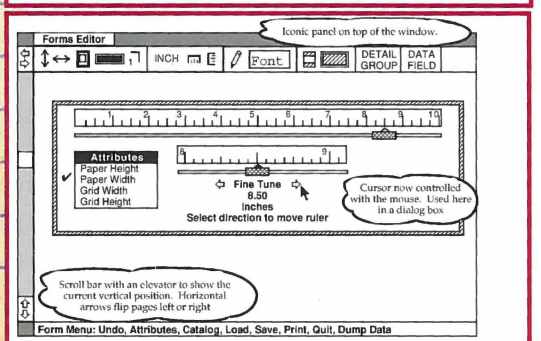


Figure 3b. The Lisa display with a simple window and dialog box (3/80).

answered by typing in a special message area or by selecting from the choices listed in the soft key display. Errors would be reported in a status panel or in the message area using clear, friendly English, not computer jargon. Users were prevented from making common errors by visibly indicating inappropriate commands.

Although the first Lisa interface was consistent with the appearance of business equipment of 1979, it was not very exciting to use. It showed that Apple was serious about being businesslike, but the Lisa interface did not generate the same enthusiasm created by the emerging, highly graphic-oriented video game industry and programs found on the Apple II platform. The progress on the first interface established the correct goals, but left most of us dissatisfied with our hardware and soft key approach. Many people shared feelings that Apple could get better leverage from the Lisa hardware, especially from its bitmap display.

Outside Influences

In late 1979, two major events occurred that helped to change the thinking behind the design of the Lisa hardware and software: the announcement of the release of the Motorola 68000 microprocessor and visits by a small group of Apple engineers to Xerox Corporation's Palo Alto Research Center (PARC).

The Motorola 68000 microprocessor had the performance to support both a higher resolution bitmap display and a highly interactive user interface. This made the 68000 a natural replacement for the custom microprocessor designed for the Lisa and broadened the vision of what people thought possible with Lisa hardware. Lisa software could make use of this powerful new platform to expand on its user interface concepts. The team thought that with this processor the Lisa would be so fast that it would be waiting on the user most of the time! The idle time could then be used to drive a more elaborate user interface.

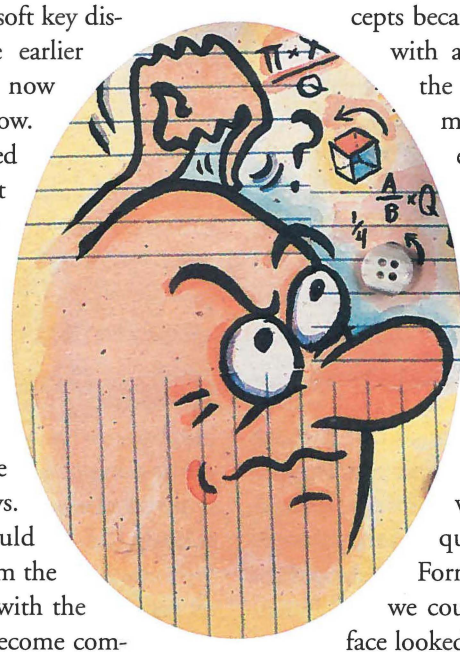
In the summer of 1979, Apple was still a private company and sought additional venture capital through a private offering of stock [14]. Xerox Corporation bought 100,000 shares and agreed not to buy more than 5 percent of Apple. According to Mike Scott, the president of Apple at the time, the deal helped Apple gain access to Xerox's research laboratory while limiting their access to Apple's advance products.

The visits to Xerox were prompted after a number of people at Apple read papers published by Xerox about their Smalltalk™ environment [3]. Smalltalk made extensive use of a mouse rather than a keyboard to control the cursor. A high-resolution bitmapped display allowed Smalltalk to prominently use graphics to enhance what the user viewed on the screen. It was a friendly yet powerful environment that used the concept of modeless commands, which were reported to be less confusing for the user.

The Apple group made two visits to Xerox. The purpose of the first visit, in December 1979, was originally to see demonstrations of programs under development at Xerox—but not Smalltalk specifically. However, during that trip, the Apple group was given an impromptu Smalltalk demonstration. During the second visit there were additional demonstrations and another look at Smalltalk. The Apple team was very excited by the Xerox visits and sought to make the Lisa as exciting. Enthusiasm from that visit caused us to further rethink the Lisa's user interface.

A Shift in Thinking

After the Xerox visits, the user interface became more dynamic as our new hardware became available. We began experimenting with the mouse and changed our interface to include windows (Figures 3a and 3b) similar to those we saw in Smalltalk. The soft key display was kept from the earlier interface, but it was now attached to the window. Using the soft keys retained the keyboard control that was thought to be important for a business-oriented machine. The mouse was introduced into the interface as an alternative to using the keyboard. We began to allow things to be drawn with either the mouse or the cursor keys. Likewise, the user could select an option either from the keyboard or by pointing with the mouse. The decision to become completely mouse oriented was still hotly debated. A number of us felt that radical changes could not be made to the user interface because the Lisa was scheduled to be announced later in the year at the National Computer Conference of 1980.



The interface was moving toward a standard that was called the Lisa "look and feel." All the applications would be similar in their appearance and use commands that would be common to each of them. This consistency reinforced our previously defined interface concepts because the user would interact with all the Lisa applications in the same manner. This also made writing the applications easier because the software to create the user interface could be shared by all the applications.

The first Lisa hardware using the 68000 began to appear in Spring 1980. Numerous software prototypes of our user interface ideas were written and subsequently incorporated into Forms Editor. For the first time we could see how the user interface looked as well as how it felt.

Desktop Metaphor

We had developed a model to describe the typical Lisa user. This user was a business person whose day was constantly interrupted with immediate requests to do other things.

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Dan Smith Keller is a vice president for product development at PowerAgent, Inc. P.O. Box 507 Cupertino, CA 95015 dan@keller.org

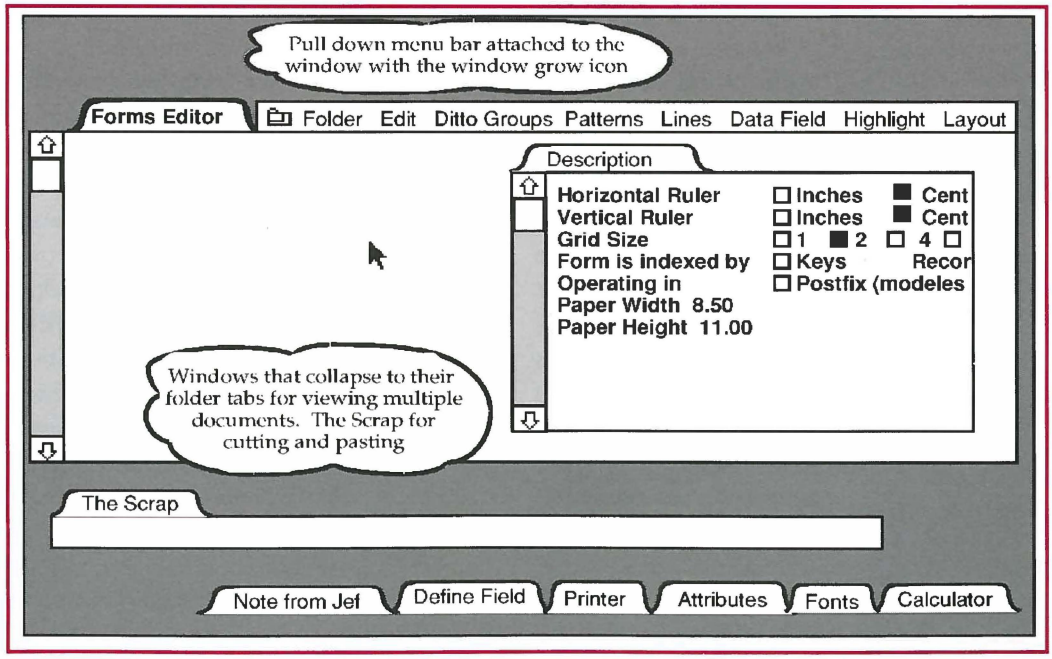
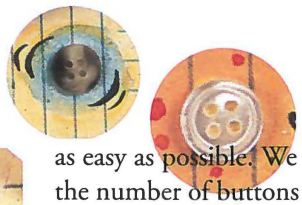
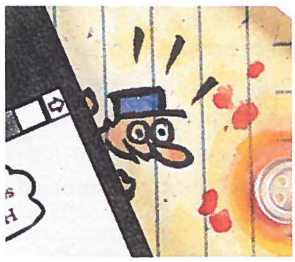


Figure 4
The Lisa display with dialogue box (August 1980)



From that user model it was decided that the Lisa had to offer an environment that safely allowed several applications to be used simultaneously and would permit any of the user's work to be put on hold. The job of the user interface was to portray this multitasked environment in a manner that would make sense to the user (Figure 4).



After numerous experiments, a new interface was developed that became known as the Lisa desktop metaphor. The interface had multiple windows on the screen to display the different types of work conducted by the user. We called he work performed within the windows "documents"—to use a concept already familiar to the user. We decided that the user should not have to worry about which application went with which document. Instead, users would select the document they wanted and the Lisa would determine which application was needed. Switching between different documents was as obvious as pointing at the window containing the desired work. The window appearance was spruced up to look more like a file folder as we sought to create an electronic equivalent of the user's real desktop. The Lisa desktop would have objects already familiar from a real desktop such as documents, folders, calculator, and other handy tools; everything short of an electronic paperclip to mangle.

Role of User Testing

Controversy surrounded a number of decisions that were made on the user interface, the introduction of the mouse being a good example. We were concerned that our target users would not accept using the mouse. We had investigated alternatives, such as the soft keys and even a light pen, but none proved to be as efficient. Our own experience with the mouse agreed with the research conducted by Douglas Engelbart [2], who created the mouse while at SRI International, and with that by Xerox [1], which discussed the virtues of the mouse. We knew that users would benefit by using the mouse, but we had to make using it as easy as possible. We felt that the number of buttons affected how easy it was to use. Factions developed to promote their choice for the "correct" number of mouse buttons. What ensued became known as the "button wars"—one of many wars that developed over interface issues.

Normally, the user interface wars would end in a stalemate of opinions. We found it best during these times to test our opinions on the users for which we were designing. We would use as test subjects new Apple employees who had no previous computer experience. The first tests were conducted during Summer 1980 by Larry Tesler, the applications software manager, and were observed by psychologists as well as ourselves. Many of the observations were recorded for later review and served as a form of détente between the warring factions.

Some of the engineers resisted taking time to make improvements derived from the user testing or from recommendations made by users themselves. A system was established whereby a troika, led by Larry Tesler with representatives from engineering and marketing groups, ruled on controversial issues.

User testing continued throughout the Lisa's development for each application, the desktop manager, and new Lisa concepts such as pull-down menus, the location of scroll bars, and alert boxes. More than a year before first shipment, a special room was built to give a sneak preview of the Lisa to potential corporate customers. These "sneaks," as they were called, generated positive feedback when participants were challenged to learn the user interface and be productive within 30 minutes of use.

Recommendations from the sneaks helped generate changes that fine-tuned the interface design. In some cases, the recommendations were misguided and were either rolled back or, more often, led to some other approach being taken. Many of the high priority changes were made before the final product shipped. The team felt this was an innovative approach for the personal computer industry because the user interface was being designed from the user's perspective using their direct feedback.

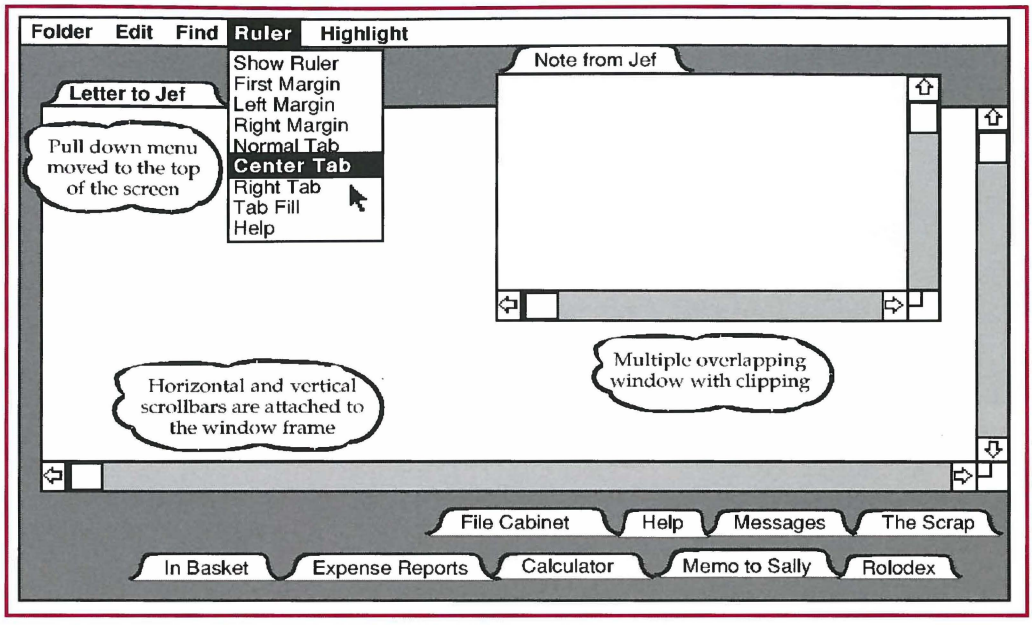


Figure 5
The Lisa display as seen in the Lisa User Interface Standards Document (October 1980)

In the case of the mouse button, it was discovered that with our user interface the three-button mouse used in Smalltalk had a slight, but not significant, advantage for the experienced users. Similar results were observed for the two-button mouse. For beginners, the extra buttons were confusing as the users sought to remember which button to press. The extra buttons also hindered learning the Lisa user interface quickly. The one button mouse was chosen to make the user interface easier for the first-time user.

Arriving at an Interface

By the end of Summer 1980 the design of the Lisa user interface culminated in the release of the Lisa User Interface Standards document [5]. The document served as a guideline for what should and should not be done in the user interface. The document also began to involve the hardware as part of the overall user interface.

The scope of the user interface now included items such as the keyboard layout, how the machine was turned on and off, how the machine would be serviced—even whether there should be a door on the disk drive. These issues became part of shaping users' perceptions of the entire machine and defining what would entice them to use it.

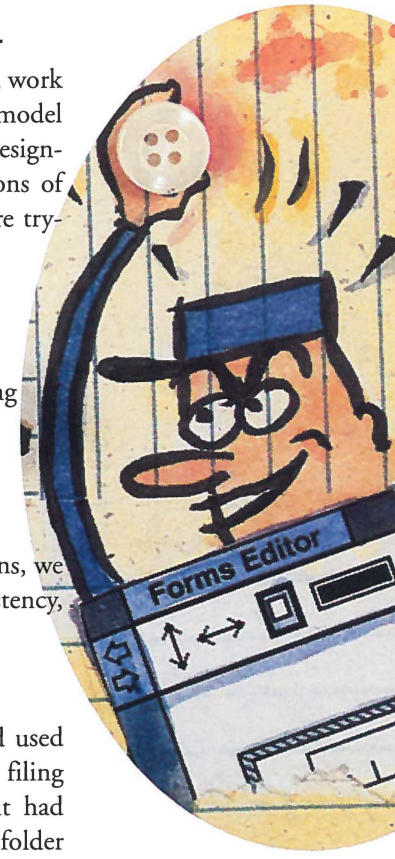
The interface would continue to evolve, but the release of this document signaled the birth of what eventually became the Lisa and Macintosh user interfaces (Figure 5). Only after the user interface standards were resolved did serious work begin on the applications. Work on Forms Editor and other prototypes became the basis for the other Lisa applications.

Early Days of the Desktop Manager

With the basics of the interface defined, work began on filling out the rest of the user model of the system. In late 1980, we began designing the interface for the filing functions of the Lisa system. The questions we were trying to answer included

- How are documents created or destroyed?
- How are they located?
- How are they returned to their filing homes?
- How should their attributes be displayed?

In considering each of these questions, we were guided by the desire for consistency, ease of use, and efficiency.



Desktop Icons Rejected!

One of the first models we considered used desktop icons for performing the basic filing functions. Our interface to this point had only folder title tabs as document and folder

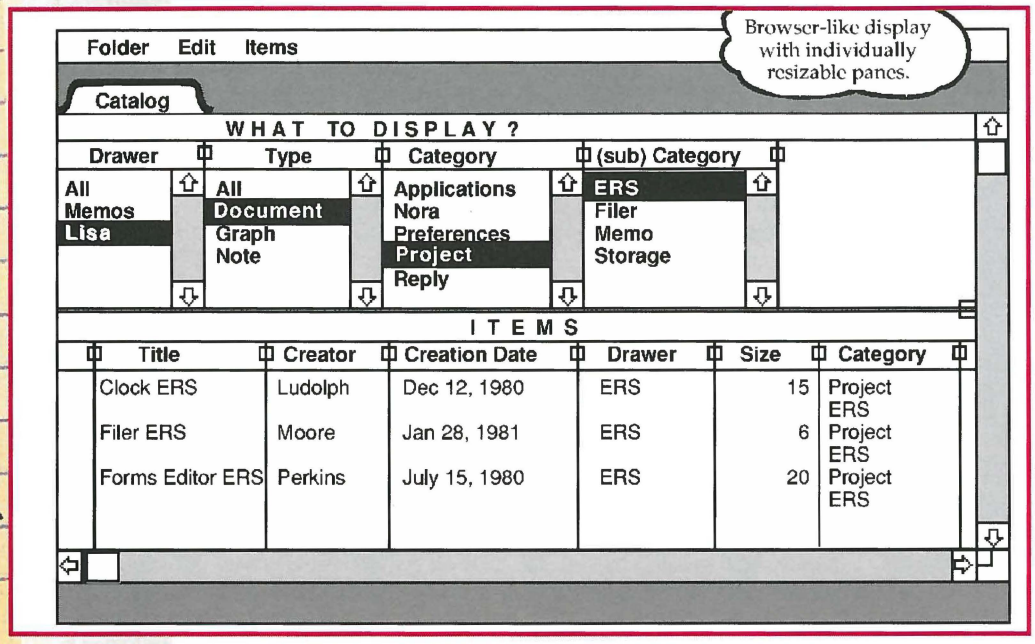


Figure 6
Desktop Manager—The Document Browser (December 1980)

icons. The title tabs could be moved into and out of filing folders by nesting. Destroying an object was accomplished by moving it into a wastebasket icon. Diskettes were to appear on the screen as desk drawers that could be opened to reveal folder tabs.

A number of objections were raised early in the discussion of the icon model. The Lisa had only a 12-inch-diagonal display, and some thought that it was too small to display full-width documents and desktop icons simultaneously. There was concern that simple tasks, such as deleting a document by dragging it to a wastebasket, would be too cumbersome if the user tried to locate the wastebasket buried under open documents. Locating documents in nested folders was also considered too unwieldy. The scenario of opening a series of nested folders, accumulating more and more desk clutter along the way while searching for a document, seemed to be less efficient than a real-world paper filing system. Some suggested that people would spend an inordinate amount of time positioning icons and moving or resizing windows.

Others argued that mimicking the office filing system would simply give people an electronic version of a system that already had many problems. In particular, we thought that most paper filing systems had serious difficulties in both filing and retrieval. With all these things considered, but without producing a more detailed mock-up, we rejected the iconic filing interface as too inefficient and set out to design something superior.

A Document Browser

Our initial attempts at producing a more efficient human interface centered on something resembling the Smalltalk browser. The browser was used to locate and display objects in the Smalltalk system. It had a window with a top portion containing four lists of categories, allowing the hierarchical selection of an object, and an area below in which the selected object was displayed.

We were interested in avoiding a strictly hierarchical filing system (Figure 6). We wanted to free users from having to decide the correct place to file a document and then the converse problem of trying to find where the document was filed. The upper area of our document browser contained various attributes that could be selected to narrow the choice of documents. As attributes were selected, documents with those attributes were displayed in the lower area. In this model, documents could be quickly located by type of document, keyword, author, and so on.

Our paper prototype seemed to work well for selecting a document but became awkward when trying to perform other operations such as moving, copying, or creating something

"What you see is ALL you get"

—Harvey Lehtman

Apple's Lisa was an ambitious commercial product developed and introduced at a time when the best-selling personal computers had crude dot matrix character generation text (based on 5x7 or 7x9 character matrices generally presented on green phosphor displays limited to 40 or 80 columns of text.) Upon introduction in 1983, the Lisa offered a high resolution bit-mapped image with an array of character fonts and graphic images impossible to produce on the Apple II's and III's, IBM PC's (introduced in 1981), Commodore 64's, and Atari machines of the day.

At a time when personal computer user interfaces were still oriented to hobbyists, the Lisa user interface tried to present a style of interaction closer to the language of a general office user with little or no specialized computer experience. The WYSIWYG and desktop metaphor interface was a significant innovation on the Lisa. Following and enhancing on work previously developed at SRI International, Xerox PARC and other research laboratories, and taking advantage of new hardware technologies, these interface innovations consciously attempted to appeal to novice users. The Lisa was the first attempt to make such a system commercially available.

However, in doing so Apple ironically ran counter to the philosophy and system development of the originator of many of the innovations the Lisa commercialized. Doug Engelbart and his team at SRI International, the Augmentation Research Center (ARC), were responsible for the development of the mouse, windowed display editors, linked hypertext, and innovations in computer typesetting, and networking. The group was also among the initial nodes on the ARPANET in 1969 and served for many years as the Network Information Center.

In many ways, the most superficial of Doug's innovations contained in the oNLine System (NLS, later known as Augment) made their way into the systems from Xerox PARC (which included several former members of the ARC team): these included the mouse and windowed displays. Rather than concerning itself with the needs of the novice user, NLS was interested in creating a system that could satisfy the needs of sophisticated individual knowledge workers and experienced teams of knowledge workers while still being accessible to novices through a consistent interface that let useful work be done in a short period of time. The goal was the "augmentation" of the intellect of individuals and teams.

Lisa's (and PARC's) attempted literal mimicking of the desktop and what appeared on the printed page were technical marvels, but largely ignored the power NLS offered for analyzing, filtering, and formatting documents made up of information anywhere in a network of knowledge. The system's facilities, available in the late 1960's, for individual and team customization of functionality and creation of linked recorded dialogs, have only recently resurfaced in systems like the World Wide Web.

WYSIWYG could very easily become WYSIAYG: "What you see is ALL you get." The WYSIWYG and desktop metaphor fall apart as the domain of large data storage and shared file servers. Doug's NLS suggested a world in which the computer's power let users go beyond what they could do in the physical world.

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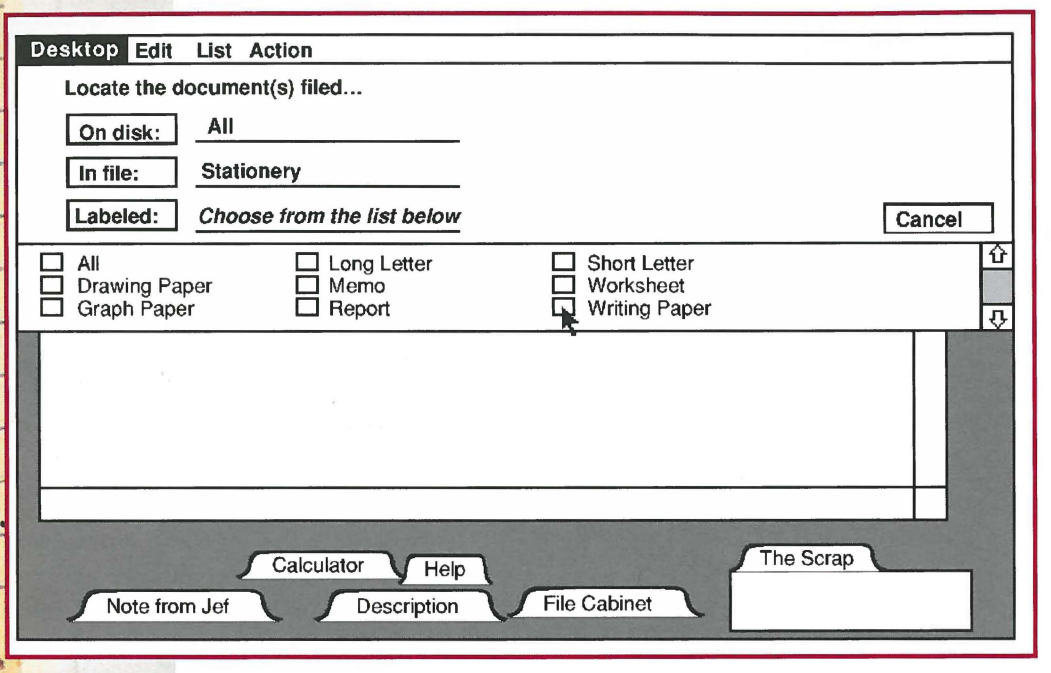


Figure 7
The Twenty Questions Filer (July 1981)

new. It also lacked a certain approachability. Its operation was not at all obvious when first encountered, and other team members felt that it was too abstract for office users.

Twenty Questions Filer

In an attempt to make the system easier for the first-time user we tried a hierarchical browser with more prompting, which became known as the "Twenty Questions Filer" (Figure 7). Selecting Documents from the Desktop menu brought up a dialog window that prompted the user to select a disk, folder, and document, with statements such as "Choose a document from the list below." After the user made a selection, an Action menu would appear with items such as Pull, Refile, Cross-file, and Discard. Selecting one of these menu items would apply the action to the selected document. This system was fast and a bit easier to understand than the previous version but still somewhat abstract. We were running out of time on the project schedule and decided that despite its problems this was to be our filing interface.

The system was fairly efficient because the filing dialogue could be brought up easily from a menu, and only a few mouse clicks were needed. However, after many months of implementation, and some early user testing, a few of us were not satisfied with the interface. Some users were confused about the relationship of the selections in the upper area to the list below. They did not always notice the appearance of the Action menu after a selection was made and would not know how to continue from there. The constant prompting made users feel that they were playing a game of Twenty Questions. It also failed to achieve one of Lisa's major goals—it wasn't fun!

"Son of Dataland"

In a clandestine effort, some of us decided to further investigate the problem on our own and asked Bill Atkinson, who defined many aspects of the global human interface, for help. Bill recalled a trip to the M.I.T. Media Lab in which he saw a futuristic data navigation system called the "Spatial Data Management System" [7]. In this system, a person sat in a chair with two hand controls and faced a large screen, referred to as Dataland. The controls allowed you to "fly" over some data space projected on a large screen in front of you, in this case the Boston area, and then to zoom in to very fine levels of detail, or zoom out to see a huge geographical area.

Bill adapted this idea to the filing problem by creating an enormous virtual desktop, perhaps a mile square, and then providing methods for very quickly moving around and zooming in or out. Documents were represented as small icons that could be organized spatially, with related

Lisa

TIMELINE

10/78 Lisa Proposal

'79

5/79 Jef Raskin proposes project code named Macintosh

Spr '79 Lisa Project Begins

7/79 Rod starts at Apple

8/79 First Lisa application prototyped on Applle II

9/79 Macintosh Project Begins

10/79 First Lisa hardware with Bit-Sliced processor

1/79 First visit to Xerox Parc

'80

2/80 First Lisa hardware with 68000

4/80 Lisa MRD Published

7/80 Larry Tesler Starts at Apple; Personal Apps MRD

8/80 Button Wars

9/80 Lisa User Interface Standards Published

11/80 National Computer Conference (original proposed introduction date)

11/80 Dan & Frank Start at Apple

1/81 Steve Jobs joins Macintosh Group

'81

2/81 Graphics Editor ERS

8/81 IBM PC Announced

10/81 Xerox Star Announced

10/81 User Interface Council Started

'82

1/82 "Dialog Filer" Recipes

2/82 First Cut & Paste between applications

3/82 Jef Raskin resigns from Apple

3/82 Icon Filer Proposal

7/82 First Internal Icon Filer Release

'83

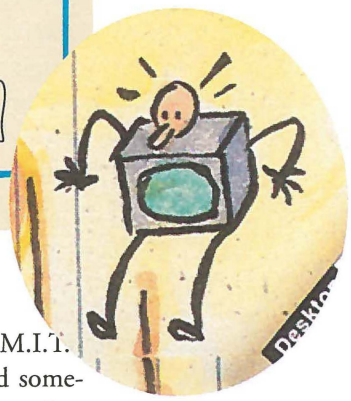
1/83 Lisa Announced

6/83 Lisa Ships

1/84 Macintosh Announced

'84

MRD—Marketing Requirements Document
ERS—Engineering Requirements Specification



documents placed near each other. The idea was incredibly simple but placed quite a burden on the user's memory when the number of documents became large. It also did not work well when multiple disks were online, representing several flat filing spaces.

Office Model

We were drawn to the simplicity of M.I.T. Dataland but thought that we needed something more familiar to the office worker. Our newly formed Macintosh group was also experimenting with icons for its Finder. Slow-

ly, we were migrating back to icons for the sake of simplicity and approachability.

While searching the literature for information on other iconic systems, we uncovered an IBM research proposal for a graphical office system called Pictureworld [8]. In the concept paper, a large screen presented small icons for file cabinets, a desk pad, in/out trays, a wastebasket, and other objects. Touching a file cabinet caused a prompting file folder to appear with a form for specifying search parameters. After the user filled out the form and pressed the "Do" button, a list of matches appeared. Selecting one of these documents caused the list to go away and the desk pad icon to become large in the center of the screen with the full-sized document placed on it. If another document was opened, the current document was reduced to an icon and was shown in the "Pending" box on the desk pad. Documents and other objects were moved by touching arrows that automatically appeared on the screen, indicating valid transfer possibilities. The authors of the proposal perhaps underestimated the power of such an interface by the interesting statement, "We have not implemented a Pictureworld system and we make no claims for it as a potential product."

At about this time, the Xerox Star [10, 12], another office system with an iconic interface, was announced. The Star, however, was an actual implementation. It had a very large screen that easily accommodated the icons and full-sized documents, a luxury we didn't have. Their use of icons though, seemed to give further validity to this approach.

In considering these models, we created several mock-ups that presented two levels of detail to the user. The first view was a look at the office as a whole. Here you could see the desk, filing cabinets, wastebasket, and other office objects. To view a document it was necessary to remove a document icon from the drawer and place it on the desk. The view would then change to one looking down on the desktop with documents at full size. After experimenting with this model for some time we realized that having the two different views (or "world swaps," as they became known) was both confusing and inefficient.

Final Desktop Model

Eliminating the dual-view model brought us very close to the final design. We quickly implemented a working prototype, which presented a single desktop on which both small icons and full-sized documents were kept. Design discussions with a few others helped to refine some of the ideas and prompted additional cute and useful features such as windows zooming open and closed from their icons. We were pleased with how easily the remaining details of the interface fell into place.

Revealing the new interface to the rest of the team drew mixed reactions. Some were thrilled with the new look and simplicity, and others were concerned about the lateness of the schedule. The new design was subjected to the same user testing philosophy that had guided development of the Lisa. It was found that key areas such as speed of learning, speed of task completion, level of comprehension, and error rate were all indistinguishable between the new iconic design and the Twenty Questions Filer. However, no user preferred the Twenty Questions design, and some preferred the iconic Filer because it was more interesting and fun!

Wayne Rosing, the engineering manager at the time, gave the go-ahead, and we raced to catch up with the rest of the Lisa team. After more than a year of looking for something highly efficient, we had come full circle, back to the more approachable, iconic, direct manipulation interface!

In Retrospect

As we look back at our experiences on the Lisa project, there are a few points and lessons that stand out as critical to the success of the user interface. Foremost is that from the very first proposal in 1978, the focus was on the user. This approach affected not only the interface but also the underlying software and hardware. A second critical factor was that the interface was developed through experience, and was not just some programmer's idea of what should work. This experience was gained by extensive testing on representative users and the implementation of several applications. The variety of the applications stressed the interface in unanticipated ways, highlighting weaknesses in

the original design. Finally, management's commitment to ease of use in spite of tight schedules, and strong centralized control of the user interface, encouraged the engineers to make improvements that worked within the metaphor.

The iconic desktop taught us something about the importance of efficiency. Originally rejected for reasons of inefficiency, we later resurrected the iconic desktop to replace the "more efficient" Twenty Questions design. Why? Because it grabbed the attention of new users and enticed them to explore using it. We believe that by adding direct manipulation to an attractive graphical representation of the familiar desktop, the icons and controls shown on the screen became, in some sense, real and the interface began to disappear.

We also learned something about the implementation of metaphors. As a general rule they should, of course, be implemented as faithfully as possible; otherwise, the user may be confused when things don't work as expected. However there are valid reasons for occasionally breaking out of the metaphor. The physical limitations of the computer, such as the display screen's being smaller than a piece of paper, can force some changes. Sometimes the computer removes limitations of the metaphor—a desk does not "know" what is on it, but because a computer can keep track of what is on its screen the Lisa had a menu that listed everything on the desktop for quick access. No matter what the reasons, we worked to keep the total number of differences small because each one burdens the user with another thing to remember.

By combining a clear, concise presentation and an intuitive, smoothly operating set of controls with a distinctive style, the Lisa and Macintosh user interfaces popularized a new way of working with computers. (See [6, 9, 11, 13] for additional viewpoints and details and [12] for discussion of a similar project.)

In these few pages, we could neither record and analyze all the important events in the development of the Lisa interface nor individually credit all the people that contributed significantly to the appearance and operation of the final interface. We hope we have managed to convey a sense of the design process and trade-offs involved.

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