# Primary Tasks and Peripheral Awareness: A Field Study of Multiple Monitor Use

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**ABSTRACT**

This paper describes a field study of people who use multiple monitors for a variety of tasks. The size of a standard computer display has increased slowly, but the amount of information that we can access has increased dramatically. Two monitors on a single computer is a relatively inexpensive improvement that is available today: operating systems now support the dragging of windows and objects across multiple monitors. Interviewing and observing people who use a variety of configurations for a range of tasks, I conclude that people do not use a second monitor as extra workspace. They use it in different ways, generally for "peripheral awareness" of information that is not their main focus of activity. Secondary monitors often display the status of background tasks, events in the world, and communications from coworkers, family, and friends. The conditions are right for rapid growth in multiple monitor use, providing an opportunity for application developers.

**Keywords**

Guides, instructions, author's kit, conference publications

## INTRODUCTION: THE WORLD THROUGH A 17-INCH WINDOW

Most computer users view their digital worlds through a monitor. A large monitor a few feet away takes up about 5% of our visual field with head fixed, the area we can focus on by moving only our eyes. It takes up less than 1% of the area we can see with a simple, rapid neck movement. We would find it very frustrating to navigate and understand our physical surroundings if our view was restricted to 1% to 5% of normal.

The size of a standard monitor has increased slowly. It has not kept pace with Moore's Law—it has not doubled every couple years. However, the size of our digital world—the amount of potentially useful information that is accessible to us from our drives, over our intranets, via the Internet, and on the Web—has increased much faster than Moore's Law. There is information related to our tasks, information about the status of team members and their activities and work products, organizational information, communications from relevant professional and educational organizations, information about commercial opportunities and leisure activities, news, sports, and financial bulletins, messages from friends and family, and so forth.

Some of this we would like to have delivered as soon as it is available. Other information we would like to have batched and sent to us periodically. Then there are things that should not interrupt us when they arrive, yet be available at a glance when we have time for them. Other information we prefer to get only upon request.

The standard computer monitor, or even a large desktop monitor, is not keeping up. It is not an adequate window onto this huge world of information. Researchers are working industriously at several approaches to addressing the problem.

*Much larger high-resolution monitors.* A wall-sized flat-panel display is desirable and is plausibly on the horizon. It can be simulated now, as in the GMD DynaWall composed of three SmartBoards merged into one continuous display through software [4]. For the foreseeable future, these will be restricted to settings where an extremely high cost can be justified.

*Head-mounted displays and other immersive environments.* These will also be useful in places. Head-mounted displays may come down to a reasonable cost, but they have drawbacks. They are inherently single-user, difficult to hold a conversation around, inhibiting interaction. Navigating a virtual space requires mastering new input devices and adjusting to a disorienting mismatch between real and perceived movement.

*Ambient information.* As exemplified in experiments by Ishii and his colleagues [e.g., 2], external events of interest can be signaled by digitally controlled environmental lighting, sounds, air motion, and perhaps even smells.

*Ubiquitous computing, information appliances.* Instead of a single computer and display, many artifacts could each have specialized displays or other output devices [e.g., 3]. This is coming, at its own pace and price. In a sense, it is an extreme case of multiple monitors. The infrastructure and design issues to make this practical are major research and development concerns. In the meantime, the infrastructure for dual or multiple monitors is already in place.

*Better awareness and notification indicators.* This is arguably the approach garnering the most intense research and development activity. It accepts the limitations of today's monitors and focuses on how to make the best use of the limited space. Notification boxes can pop up and sounds can be triggered to alert us to events, lights and motion are squeezed around the borders of the display where they are unlikely to be covered up by windows, small windows have been designed that block "full screen" expansion of a work window and thus are not easily covered up, "alpha-blending" to create the appearance of translucent windows that float over other windows, simple key sequences that bring different windows or entire desktops "to the surface" or into view, and so forth. For example, Gutwin et al. [1] tested six different awareness indicators and identified two that performed best.

*Dual or multiple monitors.* For a decade or so, Macintoshes have allowed a person to use two monitors attached to one machine as a single space, dragging objects from one to the other. Windows 98 and Windows 2000 also allow two or more monitors to be treated as a single surface.

Multiple monitor use has two noteworthy advantages for someone who wants more display real estate: It is available today, and it is relatively inexpensive. It requires only a second monitor and video card. Monitor prices are falling and two standard monitors cost much less than one very large monitor.

Dual monitors have drawbacks. They take up a lot of desk space. Not all computers support them—in particular, not many PC laptops can be used in a two-monitor configuration. Multiple monitors are not supported by older PC operating systems. Another problem—and opportunity—is that applications and operating systems that support multiple monitors do not do so very intelligently, about which I will have more to say.

The most interesting constraint is that the displays do not connect seamlessly: monitor bezels or cases separate the surfaces, so that the contents of a window that straddles two monitors is divided vertically by a few inches of metal. At first glance this is purely a hindrance, but it provides two substantial benefits. It provides ways for the system and applications to deduce (or more often be told) where on the display a user's attention is directed, so that they can behave in a more appropriate fashion. And it forces users to think about how they size and where they place windows and other information; otherwise, it is often left to the "maximize window" command and to relatively casual decisions that accrete over time.

Despite the drawbacks, multiple monitors solve a problem that is escalating with incalculable rapidity: the explosion in information that is of interest and suddenly accessible to us. We have few places to turn for help. Multiple monitors are very popular with those who try them.

This study addresses the following questions: How do multiple monitor users make use of the extra space? Is the second (or third) monitor an extension of their workspace, or do they use each monitor for a different purpose? In light of how people use multiple monitors, how could systems and applications detect and exploit this capability more intelligently? The next sections present the study and describe the results. The discussion section examines the implications for design, and the paper concludes by outlining why a relatively unglamorous approach to expanding our digital horizons could quickly become very popular soon.

## FIELD STUDY OF MULTIPLE MONITOR USE

The simplest conception of multiple monitors is a single processor with multiple video cards and monitors in simultaneous use. The displays are independent but the surface is a single continuously addressable space from the perspective of the system, so objects can be dragged from one monitor to another, and can straddle monitors.

This was the arrangement at most of the sites studied, but a few variants were included that involve the simultaneous use of multiple interrelated displays. Thus, the focus of the field study was on the behavior of people working with multiple monitors, with the underlying technology important only insofar as it constrained the behavior.

### Method

Participants were recruited primarily through two channels. Within Microsoft there is an email distribution list for those with an interest in "multimon." A query was sent to this list and 7 volunteers recruited. Another 7 participants were recruited from outside the company using an extensive volunteer database maintained by the usability support group. The database does not include information on monitor quantity, so the recruiters inquired in the course of telephone calls seeking participants for other experiments. As it happened, none of them had participated in a usability test or experiment before. Another 4 interviews were obtained opportunistically, including two external telephone interviews that were focused on hand-held computer use but turned out to be relevant, and two internal employees discovered to be using multiple monitors.

Apart from the two phone interviews, all participants were interviewed in their workplace during work hours with their system at hand. They were generally not doing any work

during the interview, but their currently open windows provided a snapshot of their work when I arrived, and part of the interview consisted of exploring that configuration and discussing other activities that they carried out on the system. Interviews were scheduled for an hour and usually ran over. I photographed their office or workspace, and a few people sent me screen captures of their configurations (screen capture software, like most software, was not designed to make intelligent use of multiple monitors, however). Participants received an appropriate gratuity.

### Participants

The nine Microsoft participants included four developers, three testers, one usability engineer, and one program manager. Some had begun using multiple monitors out of interest, but most had at one time or another been involved with developing or testing multiple monitor capability on Windows 98 or Windows 2000. Only a couple of those were actively involved with multiple monitor development at the time of the interview, but all had continued using them and certainly could be considered technically expert or knowledgeable users.

The nine external participants included four CAD designers, two managers of small businesses who worked primarily from home offices, a field sales engineer, and a 911 operator.

Two-thirds of the participants had been using multiple monitors from one to three years; two had been using it for 4 months or less.

### Configurations

Nine of the 18 participants had the basic multimonitor arrangement: one processor and two stationary desktop monitors. Three participants had a third monitor, one of which had been added just prior to my visit. Of these 12, half had monitors that varied in size and half had same-size monitors. Monitor sizes were 15" (for the smaller of a pair only), 17", 19", and 21," with 17" and 19" the most common. In addition, one person had managed to configure a laptop to behave as a second monitor, varying from the norm only in that one monitor is mobile (and smaller).

The five remaining participants have more radical variations. Two have hand-held computers that they leave connected and constantly synchronizing with their desktop system when at their desk. In this case, it is not possible to drag a window from one display to another with a mouse, but the handheld display is being used as an extension of the primary monitor. One person had a second monitor receiving the same image as the first, but with a different resolution. Often used for graphics, one monitor displayed the big picture, one a subset in greater detail. One participant actually had two PCs and two keyboards, but had opened portals on each PC that allowed him to drag objects (but not open windows) back and forth with ease. The 911 operator was not actually a multiple monitor user; she had a single monitor that with a single keystroke could bring in a second display. (This is actually an orthogonal capability: the CAD designers had multiple monitors *and* the ability to switch among desktops, which changes both monitor.)


*Figure 1. A 2-monitor configuration.*

*Figure 2. A 3-monitor configuration.*

### Observations

#### *People place monitors in a logical spatial relationship*

All of the participants with multiple full-sized monitors arranged them horizontally on their desks, and arranged them the same way logically when they configured them. That is, operating systems supporting multiple monitors permit one to place monitors in any relationship to one another: monitors that are physically side by side could be arranged logically as one above the other, in which case dragging something down to the bottom of one monitor will cause it to appear at the top of the monitor next to it. No one was observed making use of this capability.

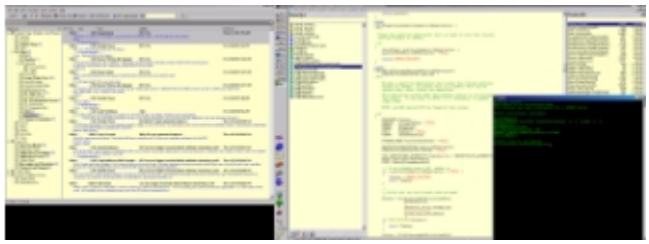

*Figure 3. A bitmap from a 2-monitor configuration.*

*People do not treat a second monitor as "additional space".*

A key observation is that a second (or third) monitor is used for different purposes than the primary monitor. People report rarely or never extending a single window across two monitors. The frames around the displays would make this awkward. However, participants often did not even place their monitors as close together as possible (as in Figure 2), further confirming that they did not try to use the displays in this way. Figure 3 shows a typical arrangement (as a bitmap, which of course eliminates the space between displays). The smaller monitor on the left is devoted to email, the larger monitor on the right holds source code and programming windows.

*Peripheral awareness*

Of course, people generally devote one monitor to their principal computer-based task. There was a considerable range in the uses of the second (and third) monitor, but it was never described as being an extension of the first monitor: people repeatedly indicated that "I use the second monitor for" other tasks. At times the second monitor is co-opted as an equal partner in the primary task, notably when material from one object is being copied into another.

What are the uses of the second monitor? They include email; instant messaging, ICQ and Groupwise Notify (linking participants to colleagues, friends, and/or family); news alerts (general headlines, sports bulletins, Kosovo developments, stock quotes) from different external sources, often set to intervals such as every half hour or twice a day). Web browsers were frequently exiled to the secondary monitor.

For example, one developer who is on a large number of project-related distribution lists filtered incoming email into folders. His secondary monitor was primarily devoted to displaying his email folder hierarchy. The count of unread messages in each folder is indicated parenthetically in blue by the folder name. He reported that frequently during the day he would glance over to note these counts, interrupting his work to determine the reason for unusual activity.

Of course sometimes communication becomes the primary task. Some participants mentioned that when they decided to focus on "doing email," they would move that window to their primary monitor. This reinforces the notion of one monitor as workspace, one primarily for awareness.

Another type of use is for secondary tasks associated with the principal work task. Developers and testers working with source code on their primary monitor often devoted the second to a large number of windows used to identify variables appearing in the code, report on compilation tasks, provide debugging readouts, and so forth. Once these windows were dragged to the second monitor they were used more for readout than for interacting.

CAD designers had a variation on this practice. They reported rarely extending a drawing to cover two monitors, but to maximize the drawing space on the primary monitor, they dragged as many toolbars as possible from the primary to the secondary monitor and dropped them there. This included opening and dragging advanced toolbars that they otherwise would not have sacrificed display real estate for.

Other uses of the secondary monitor were for background resources such as To Do lists, contact lists, and audio controls for those playing digital music.

The two participants who keep their palmtop computers docked next their monitors on their desktops, constantly synchronizing, are interesting examples. One kept his calendar visible on the palmtop, the other kept email visible.

*A button click is too much.*

It may occur to ask why, given the ease of minimizing and restoring a window, is a second monitor desired? Repeatedly, people indicated that they considered it a great relief not to have to use buttons, "escaping from the need to Alt-Tab." One of the hand-held computer users summarized "it's not intrusive in the sense that I have to click a button to see my calendar."

It would be very hard to measure an efficiency gain by eliminating a few keystrokes that would match the subjective enthusiasm for it. There may be an "out of sight, out of mind" element. Windows that are covered by other windows or minimized can be inadvertently neglected.

*People like multiple monitors.*

"I would not go back" is a direct quote and frequent refrain among the multimonitor users. A few users reported frustration with the single monitor on the computer at home and said they were considering buying a second monitor. One CAD designer said that he had initially been skeptical, but now was sold, and said that CAD designers who had visited from another office were lobbying their management for second monitors.

*Applications do not make good use of multiple monitors.*

The principal effort in developing system support for multiple monitors has been very much at the level of getting the display software and the application program interface to work, with little attention to the human computer interface. Thus, even within a multimonitor installation program, clicking on a menu item on one monitor might cause a dialogue box to appear on the far corner of the other monitor. Because both displays are

handled by assuming a single numerical space, software that does not explicitly look for the demarcation among monitors will calculate placement by an algorithm that will not surprisingly have unpredictable results. At the system level, with the basic functionality in place, some attention is turning to these issues, which are seen as embarrassments rather than bugs.

Applications also exhibit random or inconsistent placement of dialogue boxes and other items spawned from a monitor. Memory for where interface elements were left when an application is closed is another problem. Several informants laboriously rearranged multiple windows every day. "Thank God they finally made it multimon aware," one said about an internally developed utility.

One developer described the ultimate in frustration. He plays a typical game during the lunch hour in which one amasses points by executing a variety of maneuvers to commit mayhem. When he wishes to take advantage of an unfamiliar advanced feature, he has to pause the game, bring up the Help display, then close the display and restart the game. In the meantime, his second monitor is blank, unused, asking to have Help and Status information on constant display.

## DISCUSSION: OPPORTUNITIES FOR DESIGN

There is no question that the amount of information available online that we would like to have at our fingertips is growing very rapidly. Doubling (or tripling) display space will not solve this problem, but it will help. It is also clear that information overload is a severe problem, as frequent references in the media to 'trying to drink from a firehouse" attest. Not all information is equal—some we want brought to our attention, some we want available in the periphery. Multiple monitors are very convenient for this purpose, in that they segment display space in a manner that is clear to both the human and the software… but only if the software takes notice.

The steady decline in standard monitor prices makes multiple monitors a realistic option for many computer users. We observed that most multiple monitor users naturally denote one monitor the place for the focal task and the second monitor for peripheral awareness and for less frequently used resources. This is done despite the provision of very little assistance from applications. More often, the systems and applications make awkward use of the capability when it exists.

At a minimum, operating systems and applications should not take clearly indefensible actions, such as popping up a dialogue box on one monitor in response to a button click on the other. The next level is to make some very basic functionality available on a second monitor when it is there. For example, heavy users of some applications can now open all of the advanced toolbars and drag the then to the second monitor. The system or application should at the very least remember where toolboxes were left and default to those positions, but even better would be to arrange a logical, orderly arrangement of such toolbars on the second monitor as an option.

Another step could be taken by every designer facing tradeoffs and alternative design options: Add multiple monitor use as one of the many use scenarios that you consider. When two design alternatives are otherwise roughly comparable, one may lend itself to more graceful use in the multimonitor case.

Stronger consideration of multiple monitors would lead to designs that exploit their presence. Games should make not only allow players to see status information on a second monitor, they should put it there by default. And almost every application could find some peripheral information that would usefully be placed in the periphery.

However, there is a risk that our primary applications will slowly colonize the second monitor, squeezing out the notification and awareness of external events. Thus, careful thought must be given to the division of features between the primary and secondary monitor, and applications should resist the temptation to use all the available space.

The final step would be to design suites of awareness and notification features that draw on the full range of communication and agent software that someone selects. Possibly a space could be segmented according to events originating with team members, organizational changes, news and alerts arriving over the Internet, and communications from friends and family.

The enthusiasm expressed by multiple monitor users, and signs that the enthusiasm is contagious to co-workers, suggests that multiple monitor use could increase rapidly. Better support for it by the next generation of operating systems, together with a continued decline in monitor prices, and the myriad developers working to provide content that is useful (or at least attention-grabbing) create the conditions for snowballing use of multiple monitors. Intelligent design can get ahead of this curve, and increase the acceleration along it.

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