Collaborating Through Shared Displays and Interacting Devices

by Dr. Steven Greenspan, Research Staff Member, CA Labs, CA Technologies

Information devices are getting both smaller and larger as we move beyond the traditional desktop. On the one hand, the lighter, smaller and more portable smart phones and tablets are replacing devices such as desktop computers and laptops (see Figure 1). On the other hand, desktop displays have increased in size or have multiplied on a single desktop, and shared displays have grown to cover entire walls or to form rooms that users can enter. This trend has continued for more than a decade but has accelerated with the introduction of the iPhone, iPad, dense flash memory, and inexpensive large screen monitors.

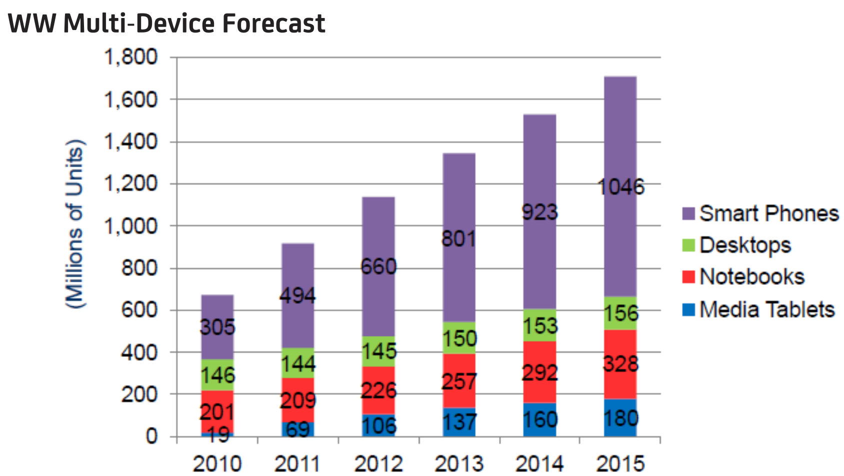

Figure 1

Source: IDC, Mobile Devices: The Truth about Tablets, Touch, Platforms, PCs and Phones, #DR2012_T6_BO, March 2012

The next phase of computing beyond the desktop monitor will explore how these new devices interact with one another to support collaborative data collection, analytics, sense-making, and performance.

There are five primary display modalities:

- Ambient (or glance-able) displays with physical sensors (such as a thermostat that changes color whenever there is a power shortage)
- Handheld displays that can easily slip into a pocket or purse
- Personal document displays (tablets, ultrathin laptops) that are mobile and good for reading and editing
- Large desktop monitors used as personal workspaces for simultaneously viewing information from several sources or perspectives
- Very large shared displays that support data immersion or shared viewing; these range from the size of large televisions to the size of walls and may be horizontal (tabletop monitors) or vertical

For each of these, there are debates among users over form and function. For example, within the personal document display modality, some people prefer the editing power of a laptop keyboard and others prefer the interactivity and portability of the tablet.

About the author

Dr. Steven Greenspan is a Senior Vice President at CA Technologies and a Research Staff Member in CA Labs. He is working with university researchers to examine fundamental issues in computer-human interaction that can be leveraged into new business opportunities and competitive advantages for CA Technologies.

His current research focus is on cognitive overload, collaboration, usable visualization and knowledge management within and across organizations.

In addition to his research responsibilities, Dr. Greenspan was elected President of the CA Council for Technical Excellence in 2009 and again in 2010. In 2011, he led business development efforts for the CA Innovation Center. Dr. Greenspan is currently chair of the Industrial Advisory Board of the Center for Dynamic Data Analytics (at Rutgers and Stony Brook Universities), and is co-inventor on seventeen U.S. issued patents.

A sixth display modality, the smart lens, has been promised for over a decade, and is now emerging. A recent NY Times article (Bliton, 2012) suggests that Google Goggles will provide augmented reality by superimposing visual data onto real-world environments. (Will Apple release iGlasses?) Some argue that augmented reality displays will eventually mimic and replace all other displays.

As suggested in the preceding list, different physical formats provide different benefits and encourage different forms of interaction. Over the past decade, we have seen a steady movement away from desktop computer to mobile devices, and from solo tasks to collaborative teamwork. In addition to continuing the integration of social media and crowdsourcing into work practices, the next phase of enterprise computing will extend the use of personal devices to interact with shared displays and shared data. The goal will be to support collaborative sensemaking of big data and rapid responses to dynamic situations. Indeed, the growing availability of big data, and the need for collaboration in real-time analytics, necessitates this evolution.

These trends will impact data centers, network operating centers, and command and control centers. Their future is in delivering highly-optimized, automated services, on a massive scale. Nonetheless, things will inevitably go wrong and the unexpected will happen. Human judgment will be needed, and network and security professionals will be expected to monitor, analyze, and quickly act upon an ever-increasing volume of real-time and historic data. While some of these professionals may be collocated, it is expected that many teams will collaborate across time zones and political boundaries. The technological and psychological challenge is to develop abstraction, visualization, collaboration, policy and measurement techniques that encourage teams to perform optimally when confronted with a myriad of real-time, complex data sources.

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Very large and very small display screens each create ergonomic and perceptual challenges. These include ensuring readability and consistently-perceived colors across multiple visual angles that might be experienced in a large room, and reducing the strain of holding tablets at ergonomically, suboptimal distances that allow for both readability and multi-touch interactions.

These perceptual and ergonomic challenges are reasonably well understood. However, the cognitive problems encountered with information overload, situation awareness, and collaboration in an information-rich environment are poorly understood and are topics of intense research.

One of key problems in collaboration is work coordination. When talking to one another, participants must attend to the same aspects of a problem (sharing common ground) and, when working in parallel, they need to minimize redundancy. As an example, team members may need to know that one person is monitoring a sub-network looking for security intrusions, so that others on the team can decide to act upon other types of problems in that sub-network or to look in another sub-network. Likewise, managers need to know how individuals within a team and across teams are distributing and prioritizing the workload.

As they conduct their work, managers and staff will have available to them different information devices ranging in size from very small mobile devices to very large wall-sized monitors. Each type of device suits different collaboration styles. Personal devices (handhelds, tablets and laptops) enable remote fieldwork, mobility within a large workspace, and individual data explorations. Very large wall and tabletop displays allow multiple teams to scan immense networks, crowds of people, multiple graphs of data, etc. In contrast, tabletop displays encourage greater interactivity within the team and with the screen itself. Recent work on collaborative tabletop displays explores how gestures, such as tapping the screen and pointing, can be conveyed to remote users (Genest & Gutwin, 2012).

However, these large surfaces are not as good for personal, in-depth explorations of data that include reading text. Increasingly, personal information devices will be used to interact with data on large screens. For example, users could position a tablet vertically on a tabletop map to view more detailed information about events at that section of the map. Ambient displays can also be developed to interact with tabletop monitors. Moving differently shaped objects to different regions of a very large display could create an array of alarms in which the objects change color when certain events happen at their locations; tapping the same colored tab on a tablet could provide more detailed information.

Thus, ambient, handheld and tablet displays will, in concert, offer new techniques for manipulating and navigating shared data. Onsite and remote staff can work together, each carrying a personal tablet, in the following ways:

- Moving information on and off the big screen
- Privately analyzing data on their tablet, drilling down (or up) for more (or less) detail relative to the shared view
- Quickly ascertaining where others are looking and what they are doing, without having to navigate to another screen or send a query to that person
- Arranging physical or virtual ambient displays to signal important events

Combining devices in this way will help address the goals defined by Douglas et al (2007): alerting teams to changes in their environment, displaying information about these changes in the optimal format to support “situation awareness, decision making, and collaboration,” and allowing individuals the personal space to creatively analyze the situation.

As information gets easier to share, questions naturally arise concerning the efficacy of sharing information across personal monitors or on very large displays. Several empirical studies provide a direction for answering this question.

As information gets easier to share, questions naturally arise over how much information should be shared.

In practice, large shared monitors in control centers tend to be composed of “repeater” displays (Douglas, 2007) that duplicate information from several personal desktops. As might be expected, these tend not to be used and are treated as “eye candy”. There are multiple factors that lead to this underutilization:

- They duplicate information that is readily available on the personal displays
- If the shared display is an unfiltered version of a user’s display, that user’s control icons and cursor are distracting and can obscure data
- The colors and display format that are appropriate for the personal display are often not appropriate for the larger screen

If users customize the look and feel of their displays, the problems are compounded.

Even if colors and formats are standardized, and cursors and widgets are hidden, introducing new technologies into a well-performing center can degrade team and system performance. For instance, chat applications in military settings have been found to degrade overall team performance (Cummings, 2004). Similarly, experimental evidence (Bolstad & Endsley, 1999) suggests that providing a large screen that simply duplicates the displays available to each user increases mental workload and degrades performance in high workload conditions.

However, in high workload conditions, sharing data through large common displays can improve productivity and coordination if the shared information is carefully crafted. Presenting the relevant subset of data that is required for coordination, as opposed to all the data present on each user's screen, improves team performance and coordination (Bolstad & Endsley, 2000).

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In addition to relevancy, format also matters. A series of studies indicate that multiple-attribute displays are better on small displays, but spatially-grouped, individual displays (for each attribute) work better on very large displays (Yost & North, 2006). Thus, large screens should be used for monitoring and exploring situations that would otherwise clutter personal displays, provide a common ground to support collective situation awareness, and/or permit comparison of different levels of data representation or different sets of data.

We are just beginning to learn how to best coordinate information across different display modalities and how different devices can interoperate to facilitate collaboration, shared situation awareness, and problem-solving. Current research directions and technology trajectories suggest that the command center of the future will increasingly incorporate remote and collocated teams using multiple types of devices that communicate with one another to automatically modify their respective displays.

At CA Labs, with university partners such as the HotSoft Research Group at Carleton University, we are exploring new technologies for visualizing big data, automatically merging and transforming data to appropriate formats as a function of display modality, tasks, and user identities and roles. We are examining how attention can be guided within a team by other team members and by software (as in the case of alerts), and how multiple devices can be used in combination to synergistically enhance situation awareness and responsiveness.

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