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Carry Small, Live Large

Roy Want

One of the great computing revolutions of our time has been the dramatic reduction in size of processing components and the power they consume, making mobile computing a reality. The term *mobile computer* spans many types of devices, from laptop or notebook computers—now central to much of our work—to the smallest cell phones, which can not only provide a mundane telephone connection but also serve as an electronic organizer. The PDA, also originally part of this mobile revolution, has already largely been subsumed by the smart-phone market.

The key ingredients enabling this revolution are high-performance low-power processors, high-density memory, and standardized wireless communication. The latter isn't a requirement for mobile computing per se but has become an essential ingredient of a computer's everyday use; after all, a computer without a networking capability is no longer an interesting proposition.

Despite technical progress in designing and building true palm-sized computers, their use has tended to be limited in scope. Most people would probably agree that for any kind of serious computing task, certainly in the realm of enterprise applications, a notebook computer's form factor is close to the bare minimum needed for effective HCI. We can conclude that one of the main barriers for effective work on a smart phone is the tiny display and keyboard and the poor user experience that results from the size-limited interaction.

The form factor of a modern day laptop design has been honed over time, shaped by the design principle that form follows function. We might one day experience a revolution in GUI design, but I doubt this will radically change the baseline laptop's size requirements. Many people have tried to improve the WIMP (windows, icons, menus, pointing devices) interface for many years with only minor success. As a result, for now, the best bet we have for improving the mobile computing experience is to augment the I/O peripherals to provide scaled-up interaction.

The first short-range wireless standards were realized in the late '90s—a turning point for mobile computing.

My Intel colleague Natalie Nielsen recently summed up this notion with the phrase "Carry Small, Live Large." This embodies the idea that for mobility, small computers are attractive; they fit in a pocket and can be carried without encumbering their owner. "Live large" speaks to the idea that we have high expectations for our interactions with computers, and we expect them to positively impact our lives.

CARRY SMALL

Since the early '90s, I've been researching ways to overcome the limitations of small mobile computers, and I've helped build several prototypes that address different aspects of the problem. An idea for implementing the Carry Small, Live Large ideal became apparent to me after the first short-range wireless standards were realized in the late '90s—a turning point for mobile computing. We no longer needed to interact with a mobile device directly; instead, much larger and more convenient nearby computers could provide the interface.

My research group's Personal Server project embodied this concept.[1] Our goal was to extend the established paradigm of the personal computer and change how we think about using it. We aimed to design a personal server that you could carry in your pocket or purse and that you wouldn't need to physically access. Instead, using wireless discovery and connection, you could interact with the server through another device across a wireless link.

Our initial prototypes used a client/server Web metaphor, and we based our first implementation on an XScale microprocessor running the Linux OS and a Web server. The device included enough solid state memory to store gigabytes

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Published by the IEEE Computer Society ■ 1536-1268/07/$25.00 © 2007 IEEE

worth of movies, music, photographs, and office documents—all accessible from a Web browser client running in the nearby computer infrastructure over an optimized wireless Bluetooth link.

Later, our Personal Server design was ported to a commercial cell phone based on the next-generation XScale processor. This gave users direct access to X-applications running on the device, all accessible using a Remote Frame Buffer protocol in communication with a remote client. The cell phone market continues to enjoy tremendous growth—selling over one billion units in 2006[2]—which shows the potential for a personal-server-integrated cell phone to impact mobile computing across the globe.

REMAINING BARRIERS

What barriers must we overcome for the Carry Small, Live Large model to flourish?

First, currently only a few smartphone products can provide the computational resources that applications need for effective operation. The capabilities of inexpensive low-power mobile processors will certainly increase with time, so in the future we're sure to see more cell phones with the potential to support enterprise-quality applications. Processing and memory capabilities continue to grow exponentially, so it won't be long before the gap closes.

Second, there's a lack of infrastructure. Any PC could in fact be a client to support this use model, but when users have access to a desktop PC, they should also be able to use the desktop for their actual work. The compelling new value proposition for a small mobile computer comes from the opportunity to serendipitously use displays and keyboards found nearby in unfamiliar locations.

LIVE LARGE

An opportunity to solve this problem may result from the revolution we're now seeing around large LCD displays—in part driven by the consumer electronics market and the digital home. Digital high-quality LCD displays are in a booming market as a result of attractive pricing and the FCC's mandate that broadcast TV switch from analog to digital by 17 February 2009. So we're likely to see a flurry of new TV purchases between now and then, which represents a market that all the big consumer electronics manufacturers will be keen to be part of. This will further drive down prices as the competition mounts. In fact, it has already resulted in considerable price reductions for large plasma and LCD TVs, now as low as one-fifth of the original introductory price.

These TVs come with built-in computing capabilities, and manufacturers will see the opportunity to use computation to differentiate their products. This year's Consumer Electronics Show introduced flat-panel TVs with built-in Digital Media Adapters (DMAs) and the ability to connect to a network using Wi-Fi to access media stored on a home PC. With several companies actively making plans for digital movie download services to the home in the near future, the challenge will be how to enable a living-room TV—rather than the office or den PC—to show these movies. A DMA built into a TV can solve this problem while opening up a resource for mainstream use of the Carry Small, Live Large device interaction model. Once it's available for the consumer electronics market, this technology, driven by the associated reduction in pricing, stands a good chance of becoming ubiquitous.

GOING URBAN

The applications for large high-quality displays aren't limited to the home and are in fact widespread and equally applicable to the office and other shared spaces—in particular, urban public spaces. I'm continuously amazed by how many flat-panel screens are popping up around our towns and cities to display mundane information—restaurant menus, signs, corporate logos, transport schedules, and so forth. Even supermarkets are being fitted with multiple screens to display special offers as we walk through the aisles. Each of

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these venues has the potential to support a Carry Small, Live Large experience.

Urban computing today is mainly associated with direct interaction using the devices we carry and with the data that service-provider networks deliver. In the future, this could be a far richer experience, involving close coupling of the computation you carry with the displays and keyboards that you find around you.

Technology trends that will further support this use model are high-bandwidth short range radio, such as UltraWideBand, a standard now being introduced to support Wireless USB with speeds of up to 480 Mbps. At some point in the near future, we'll cross a processing threshold, and our smart phones will be capable of running most of the high-end applications we're interested in using. Furthermore, the short-range wireless bandwidth will be high enough for us to effectively connect to large wireless displays. At that point, urban computing will take on a whole new experience, and we'll move closer to the pervasive computing vision. P

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