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A Mobile Phone Ecosystem: MIT and Nokia's Joint Research Venture

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The mobile phone is rapidly becoming the primary personal gateway to access information. In the near future, it will likely become the primary means for accessing services such as personal banking, online purchasing, mobile entertainment, and multiplayer online games. It might also someday replace wallets full of credit cards, cash, and identification cards and become a personal monitoring device, personal trainer, or storage facility for electronic medical records.

Enormous challenges exist in realizing this vision, which is why Nokia and the Massachusetts Institute of Technology's Computer Science and Artificial Intelligence Laboratory have started a joint research venture to refine the vision and develop the required devices, applications, and services. As part of this venture, Nokia formed the Nokia Research Center, Cambridge, which is within walking distance of CSAIL. Researchers are working on six joint research projects, and we believe that constant intermingling of researchers is necessary for deep research collaboration.

The vision: Interactive speech interfaces

Perhaps the biggest challenge we face is determining how to interact with mobile devices, given the small keypad and display. For example, suppose that while driving to the office, Bob realizes that he needs to discuss an urgent matter with Jamey. If Bob were sitting at a terminal, he could easily schedule a meeting using a graphical calendar application and email, but doing so using his mobile phone's small keypad would be practically impossible. The goal is to let Bob schedule a meeting by conversing with his phone's calendar application:

> Bob: Please set up an urgent meeting with Jamey.
>
> Phone: The next free time I can arrange the meeting with Jamey is at 2 p.m. Is that OK?
>
> Bob: What about earlier?
>
> Phone: Jamey is free at 10 a.m., but you have a meeting with George.
>
> Bob: Reschedule it and schedule the meeting with Jamey at 10 a.m.

We can easily imagine many such scenarios for accessing information and applications using a mobile phone. In addition to scheduling meetings, you might ask your phone to

- find the pictures you took in Helsinki,
- send the picture you took of Arvind to Gita, or
- upload the pictures of the Sibelius memorial to Flickr.

Making such scenarios a reality will require addressing challenges related to the mobile terminal and its infrastructure. We must create interactive speech interfaces to applications and deploy these applications—a significant part of which might run on the terminal itself—without needing a hot pad to hold the phone. To enable widespread use of spoken-language interfaces for applications, we should make them easy to create—we can't expect every application developer to employ a group of speech or natural language experts.

In an effort to address these issues, MIT and Nokia are collaborating on the Simone project, led by Jim Glass and Stephanie Seneff, to develop technology for spoken interaction with phones (http://research.nokia.com/research/projects/simone). The focus is on personal calendar applications and image annotation and retrieval. These applications' success depends on the ability to process complex spoken dialogue. On the one hand, mobile phones offer a major challenge in speech recognition because of their noisy operating environment. On the other, they offer a tremendous opportunity because you can personalize them for the user.

The power of large numbers

In 2006, 950 million mobile phones are expected to be sold,[1] in contrast to 234 million PCs.[2] Although there is an increasing need to support similar applications and services on mobile terminals and PCs, the architecture of mobile phones is likely to be quite different because of more stringent battery life and thermal-dissipation constraints. Functionality that could be implemented in soft-

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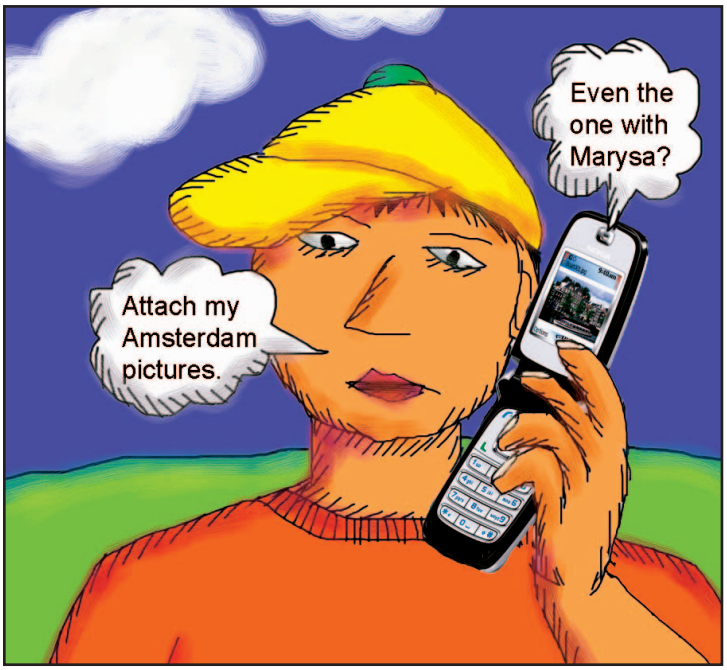
ware for PCs consumes hundreds to thousands times less power when implemented in special-purpose hardware. This technical challenge and market dynamic provides unprecedented opportunity for research in computer architecture.

The Architecture of Mobile Phones project, led by Arvind, Krste Asanovic, and Anantha Chandrakasan, aims to design mobile terminals that can enable the described scenarios and applications without breaking the 3-watt power-dissipation constraint (http://research.nokia.com/research/projects/armo). How can we develop a variety of hardware blocks quickly and cheaply? The goal is to create advanced design flows that enable full system modeling and rapid architectural exploration. We're also exploring the use of subthreshold logic for ultra-low-power designs. To demonstrate these design flows, project members are designing video codecs (H.264) and wireless local area network (802.11a) blocks.



Connecting mobile devices

The MyNet and User Internet Architecture project (UIA) projects, led by Frans Kaashoek and Franklin Reynolds, are exploring ways to make it easy to connect mobile devices to share information and services without relying on access to servers on the Internet (http://research.nokia.com/research/projects/mynet-uia). For example, you might want to synchronize your calendar with another family member's calendar, make a voice-over-IP call from your PDA to your friend's PDA, or upload a picture from your camera to your mom's phone. This project aims to enable global connectivity between all our devices. The idea is "introduce" devices to each other via a local link, such as a Universal Serial Bus, or proximity wireless techniques, such as radio frequency identification or Near Field Communication. Once devices have been introduced, they will be able to communicate remotely. Naming is a key problem: names should make sense to the devices' users but should also be globally unique to enable connectivity. MyNet/UIA leverages social networks and address books to find the globally unique identifier and distributed hash tables to look up the current network addresses.

Mobile telephony, which so far hasn't faced large-scale security and virus issues, won't remain immune to such issues forever. The Asbestos project, led by Robert Morris, is developing information-flow control mechanisms to prevent inadvertent or malicious sharing of sensitive or personal data (http://asbestos.cs.ucla.edu). The goal is to better assure users that it's safe to try out new applications such as using mobile devices to make purchases.

Personalizing applications and services

We also need large-scale (and consequently automatic) semantic tagging of data so that different applications can use that data.

The SwapMe project, led by Tim Berners-Lee, Danny Weitzner, and Ora Lassila, is developing universal data and metadata representations (http://research.nokia.com/research/projects/swapme). SwapMe consists of an RDF repository that integrates data from multiple sources, including relational databases and XML. Daniel Jackson is demonstrating how to construct goal-directed but flexible applications using this RDF repository and his declarative constraint solver known as Alloy. The goal is to develop applications that are aware of the user context, such as user preferences and physical location. The history of phone use and dialogues also offers a rich and useful temporal context.

The ComposeMe project, led by Mike Ernst, is applying machine learning techniques to discover substitutable services by observing a service's I/O behavior in the context of an application (http://research.nokia.com/research/projects/composeme). As more semantic information about services becomes available, it will be easier to construct personalized applications and services.

Nokia and MIT expect to continue the research collaboration beyond the lifetime of the first projects. During the open, precompetitive phase, Nokia and MIT may work with other companies. For example, Texas Instruments is collaborating on subthreshold logic in the Armo project. Each year, as projects end, new joint research projects will be added to work on unsolved problems in the mobile ecosystem. As the joint projects bear fruit, Nokia will start internal projects to transfer the technology into products and services. ■

References

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