System Challenges for Pervasive and Ubiquitous Computing

Roy Want

Intel Research

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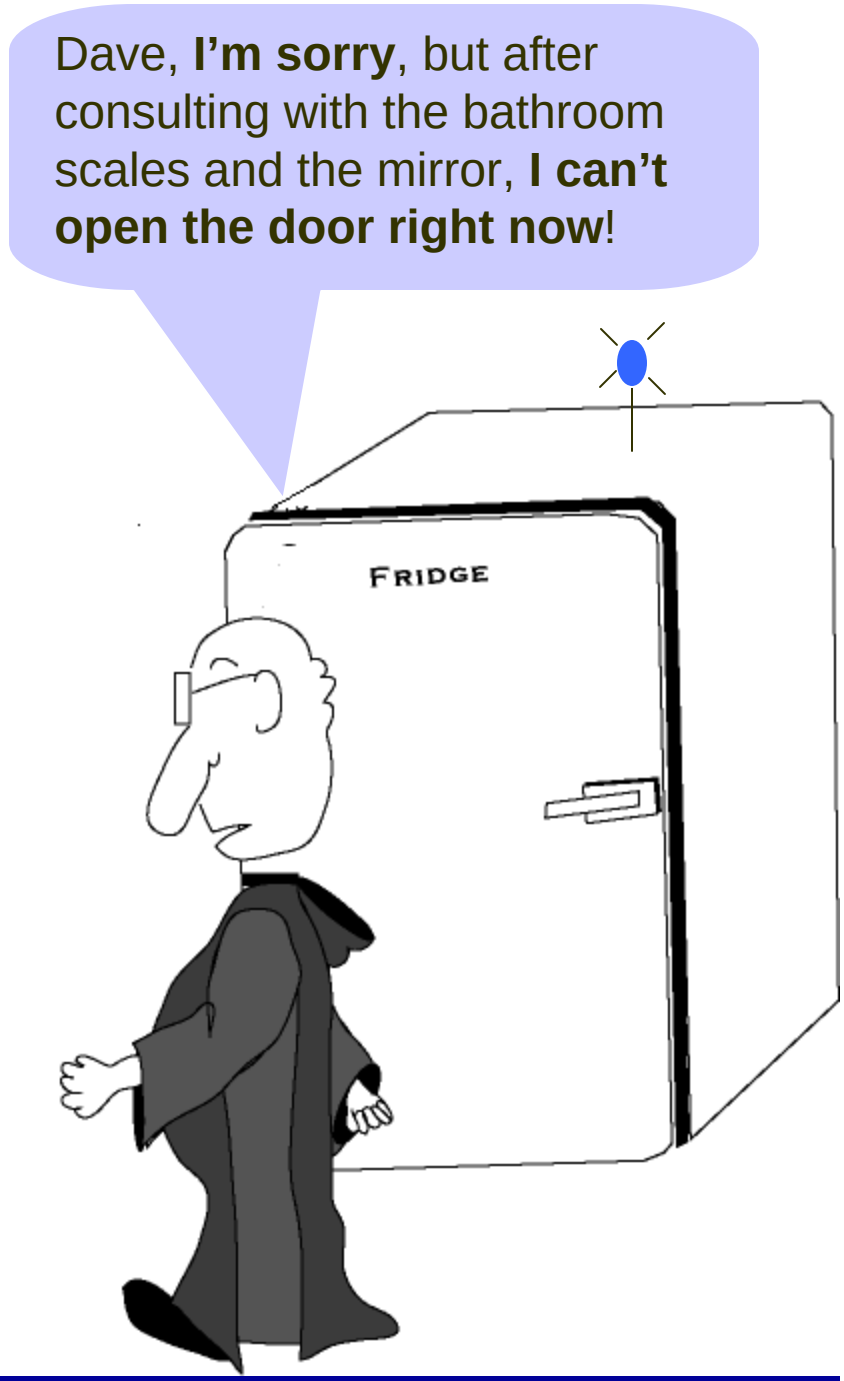
What is Ubiquitous Computing?

" The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

Mark Weiser, Scientific American, Sept 1991

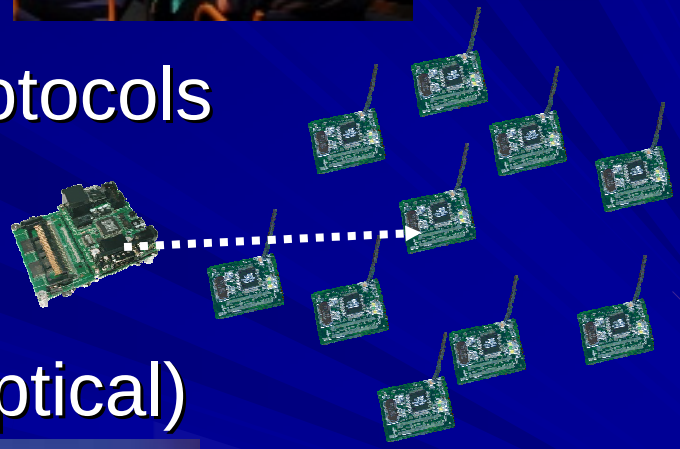
Tongue-in-cheek Ubicomp

- Smart Appliances?
- This is probably not the Ubicomp world that we want to live in.
- We need to create significant value-add to be successful.



Ubicomp covers a lot of ground...

- Smart Environments
- Location Systems & Context
- Radio Designs & Wireless Protocols
- Low-Power Design
- Sensor Networks
- Electronic Tagging (RFID & optical)
- Image Recognition
- Mobile Applications
- ….. and many others

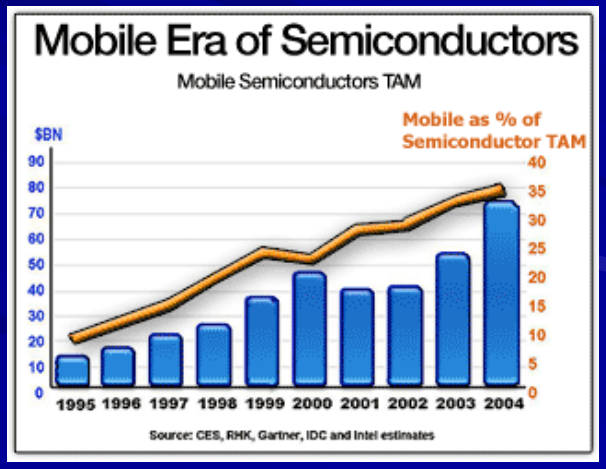


Underlying Driving Trends

1. Computationally Powerful Processors
2. High-Density Storage
3. Wireless Communication (standards)

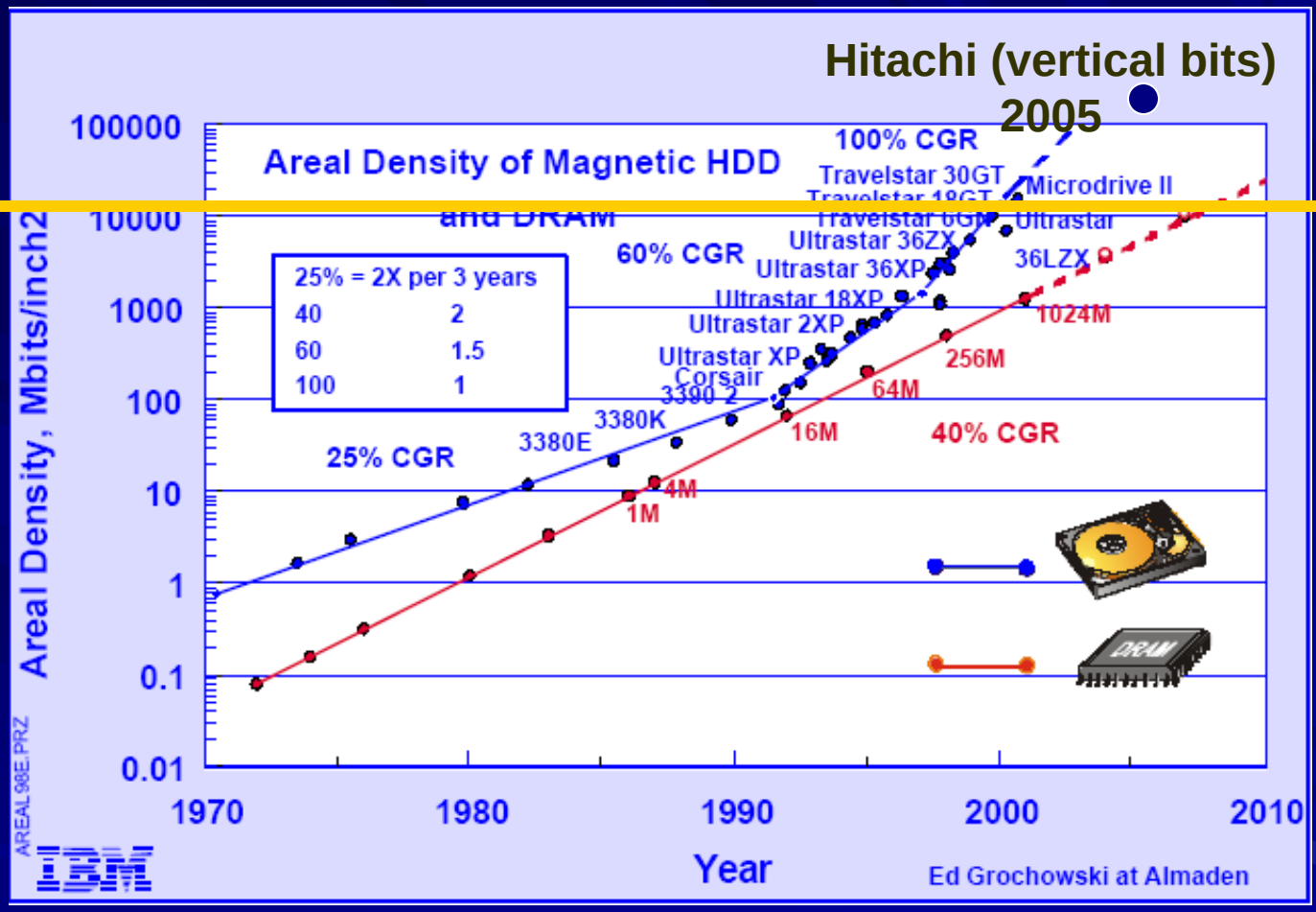
PLUS

Miniaturization & Low Power



Storage Trends

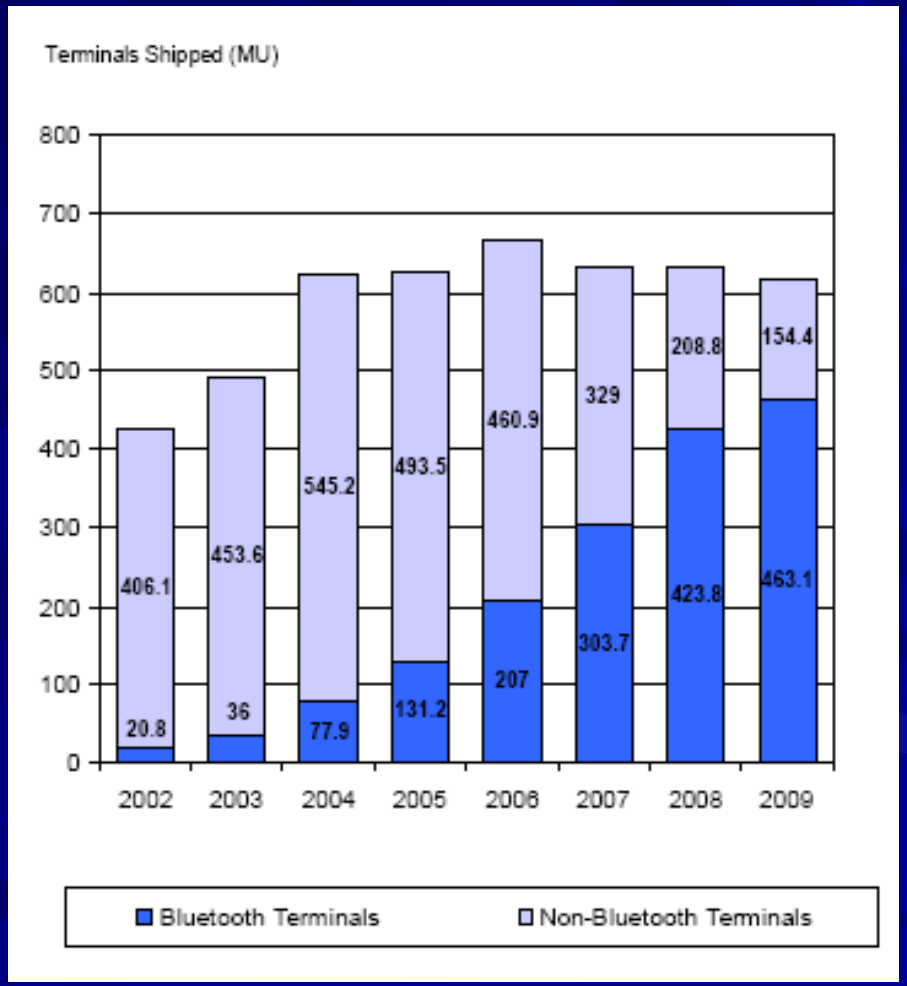
MAGIC LINE



1GB: = 1000 high quality photos, 250 MP3 songs, 1 MPEG4 Movie

Significant Storage for Daily Needs in 1 sq. inch

Cell Phone Shipments: Ubiquitous Computing in Action



The Mobile Phone platform is an Opportunity for Ubiquitous Computing Research

Top Challenges

- Usability issues for Small Mobile Devices
- Fast Wireless Discovery and Connectivity
- Secure Wireless Interaction
- Comprehensive Power Management
- UI Adaptation

Usability Issues for Mobility

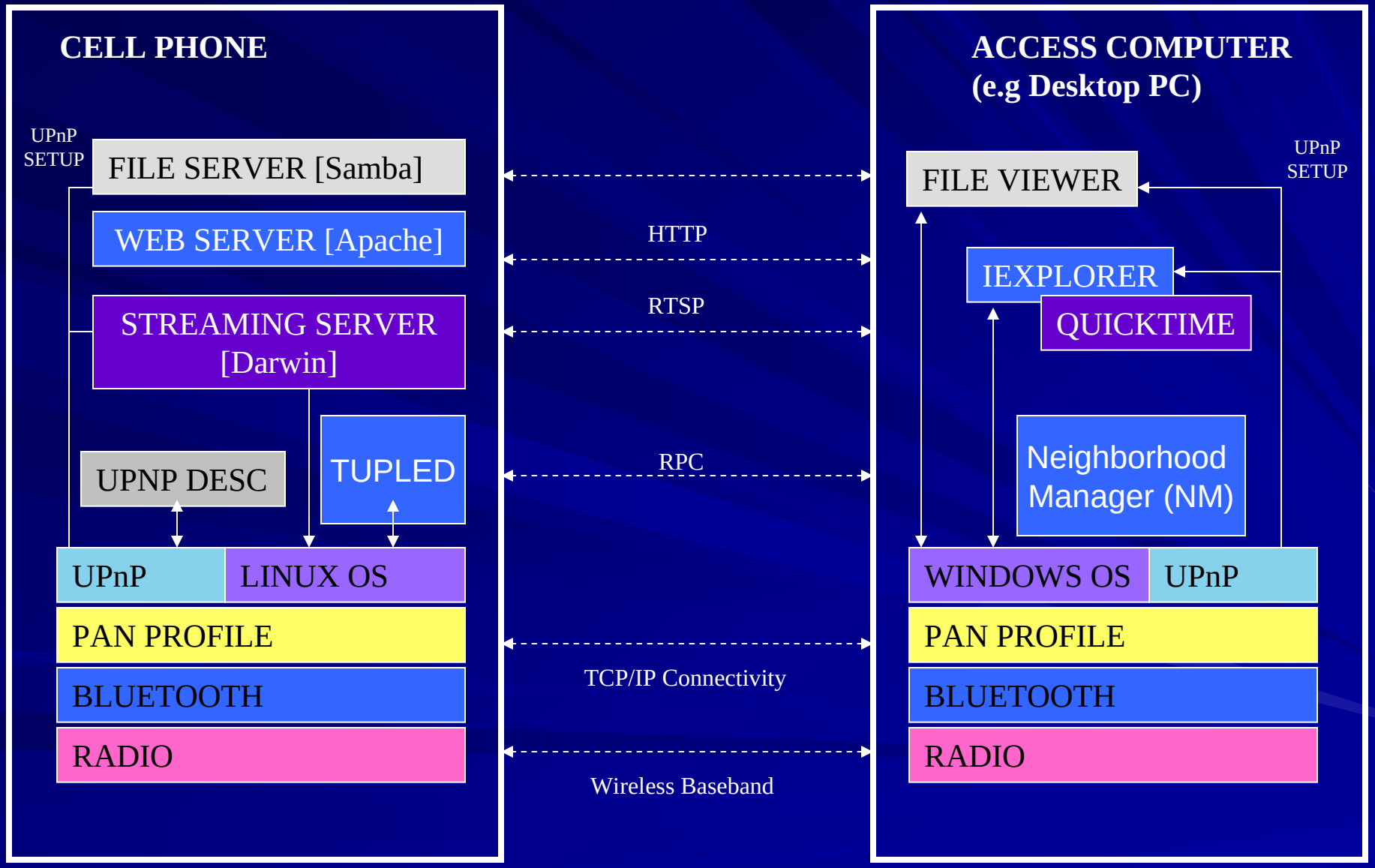
OPPORTUNITY!

NOTEBOOK:
Too large and heavy for anywhere use

PDA: Too small for real work

Wireless Projection – Using Local Infrastructure to Interact with Mobile Devices

Cell Phones could become your Future Personal Computer



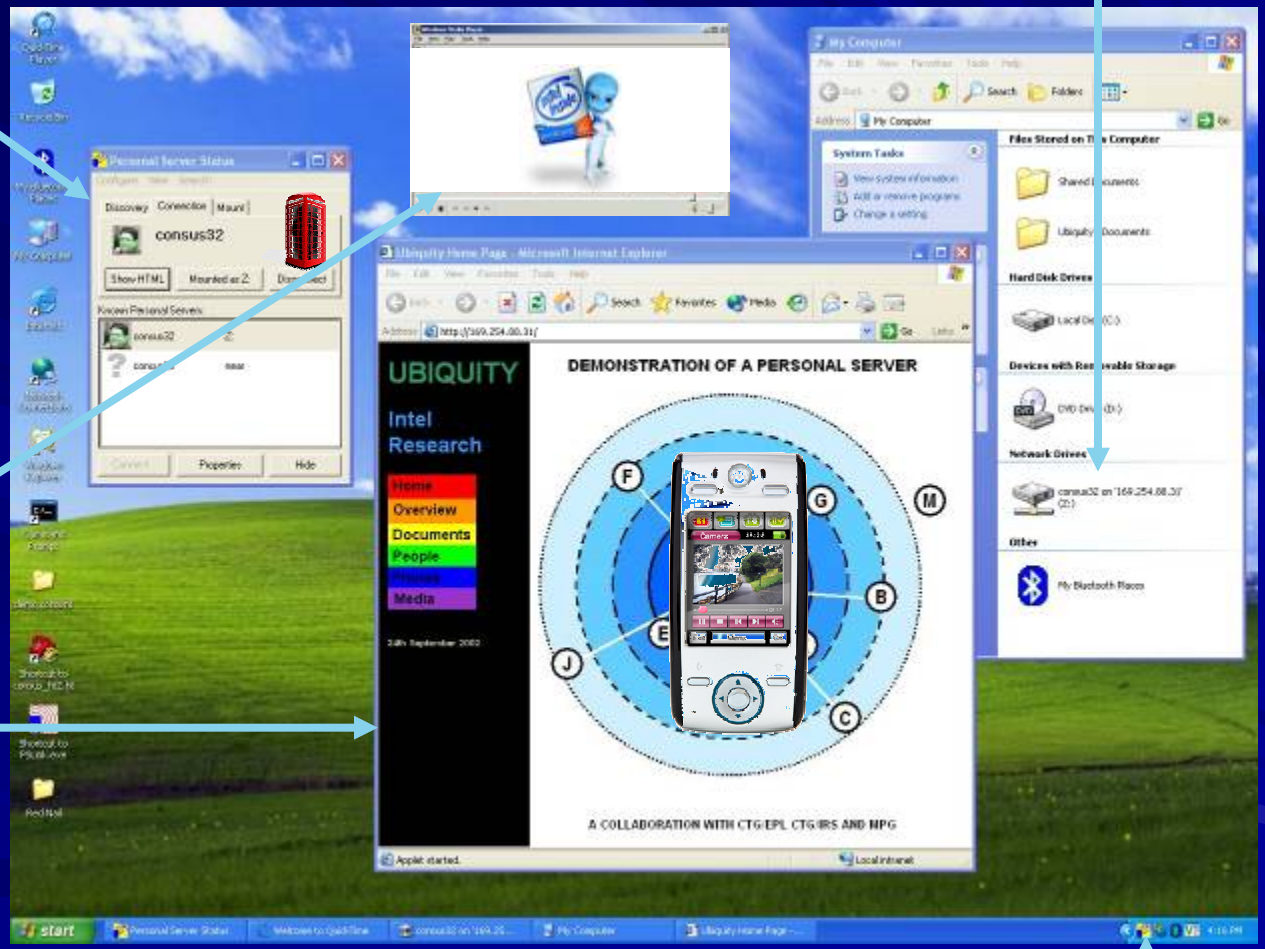
Personal Media Server: video & audio streaming from a cell phone

Wireless Drive Letter

PHONE MANAGER
List cell phones in the locality

Streaming Media Application e.g A video plays in a new window

Documents: access from a Mobile Web Page



Phones Nearby Indication

Resulting Challenges

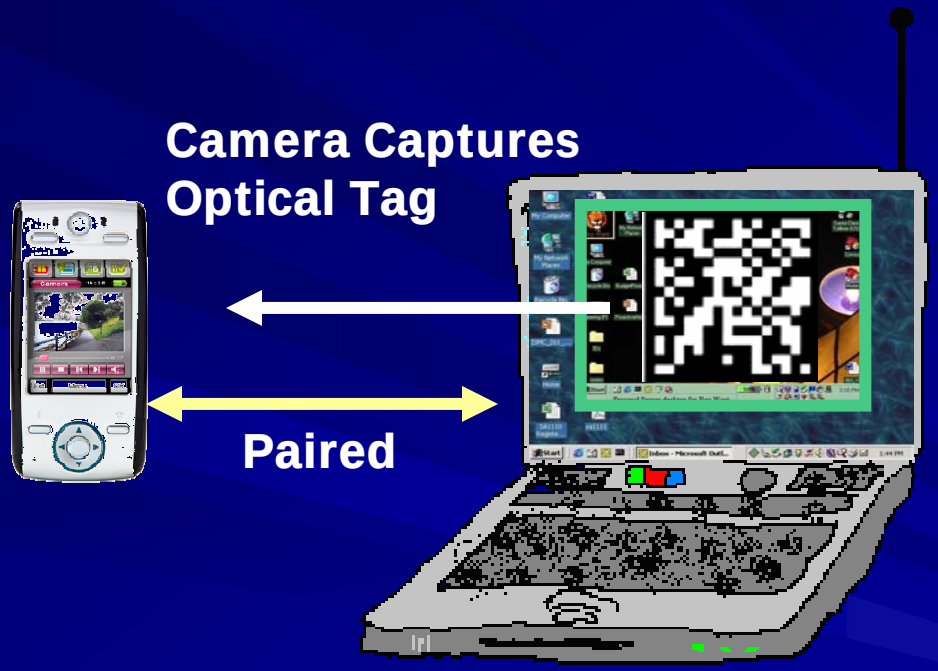
UI Barriers Overcome, but …
Challenge for P2P data-sharing

Drag-and-Drop files/media between cell-phones, by dragging icons on a larger screen (e.g. a PC)

Need to push towards DRM implementations that work for users and content providers

Challenges for Wireless Discovery & Pairing

One solution



Short range physical security ensures that only the camera-phone can capture the information MAC ADDRESS & PIN (128 bit)

Security Challenges

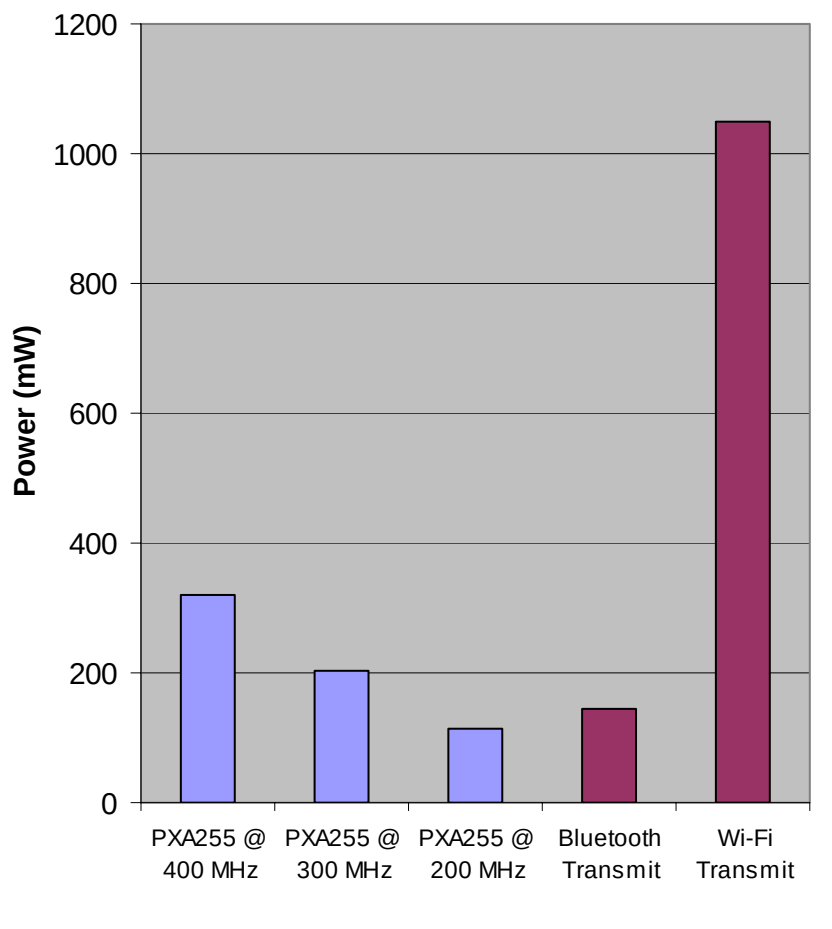
The Problem

If you use a password to access your mobile device using the un-trusted infrastructure, your password will be at risk from key-catchers

Best Solution?

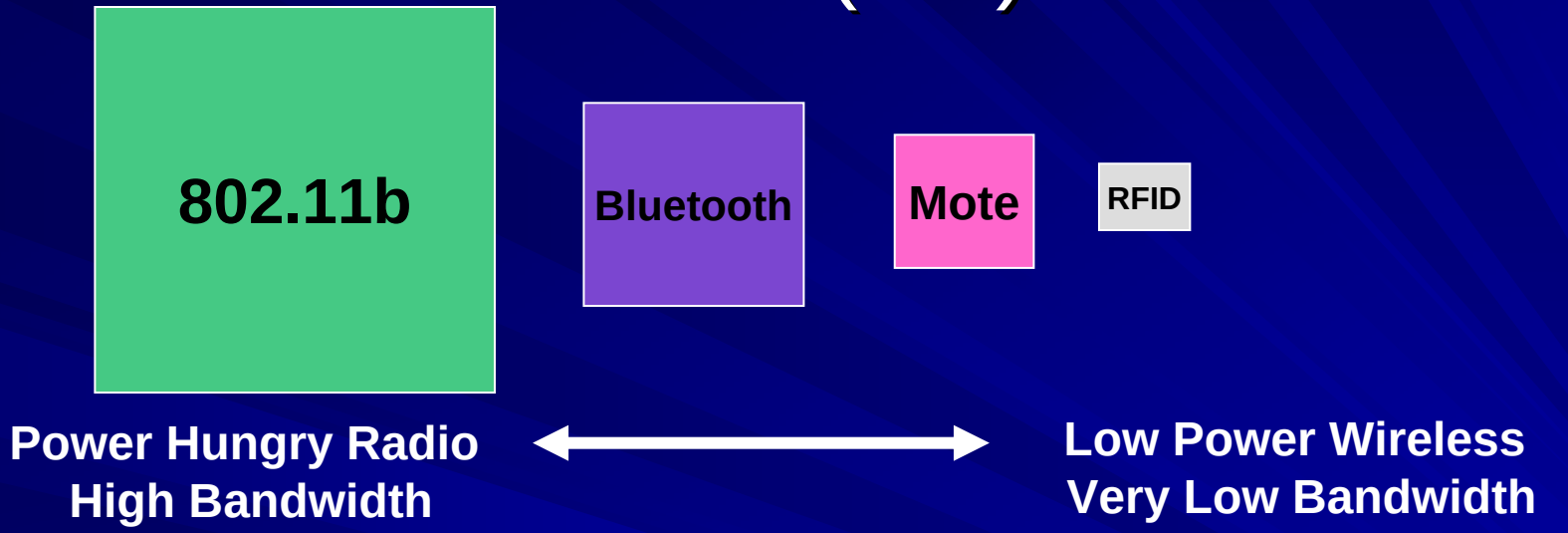
- Challenge/Response: Photographic Authentication/Greeking

Processing vs. Communication Issues



- *10x* for wireless power and bandwidth, greater range than processor power
- Traditional Frequency Scaling and DVM are often less important than managing wireless peripherals

Power Management with Hierarchical Radios (HR)

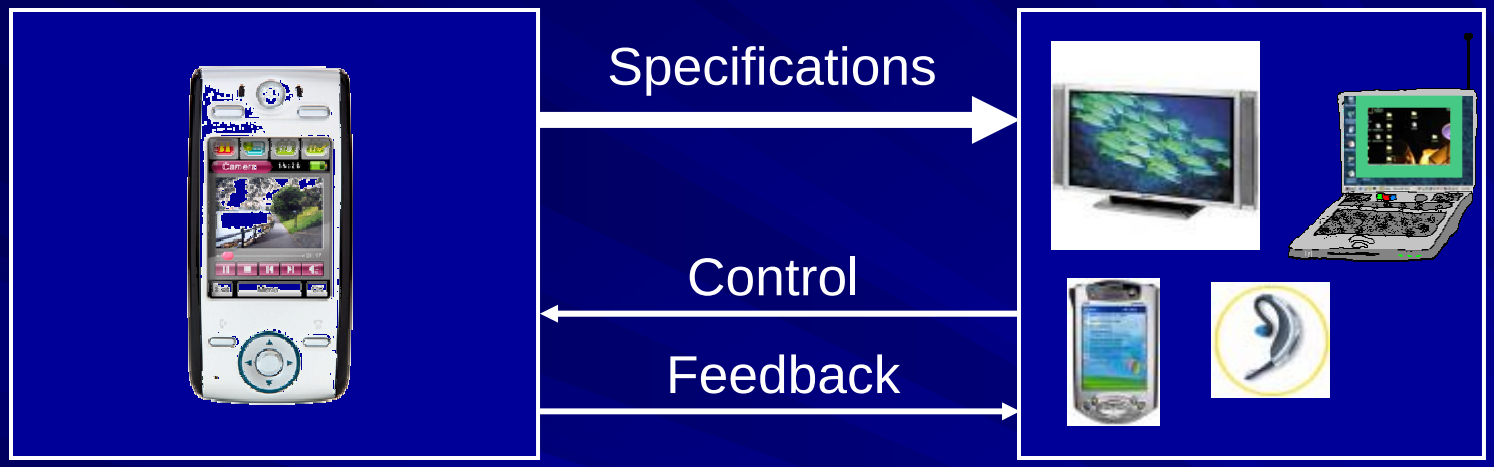


- Trading-off Power and Bandwidth
  - Coordinating the use of Bluetooth and WiFi (and Mote/Zigbee)
  - Use the discovery mechanism of the small radio to turn on the larger
  - Low-power quiescent mode using Bluetooth
  - High-bandwidth transfer using WiFi
  - …use the best aspect of each technology

HR: Policy Challenges

- Application Integration:
  - Manual selection of wireless interface via UI
  - Automatic selection for high-res, low-res, or automatic selection of video format
  - What policies should we be using to make HR transitions? What do the APIs look like to deal with mobile resources?

Need for Adaptive UIs



- **Jeff Nichols' work at CMU is an important contribution**
- **Applications run on the Cell Phone**
  - **Each has an abstract specification of its display functions**
- **Automatic user interface generators run on displays**
  - **e.g. Large displays, handhelds, mobile phones, speech**
  - **User interfaces are customized to the form factor and I/O capabilities of display**
- **Continuous two-way communication between PS and display enables same interactivity as today's desktop applications**
  - **More interactive than web-based UIs**
- **How do we develop standards and toolkits that provide this capability for mobility**

Summary

- Cell Phones present one of the biggest opportunities to build-out the Ubiquitous Computing vision
- There are many new usage models made possible by ubiquitous personal computing
- Following through, these usage models provide us with a new set of system challenges and priorities

Thank You!

Q & A