

# **Introduction to Mobile Computing**

**CEN 5531**

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# Fantastic Breakthrough Technology

- **Wireless communication networks**
  - multiple networks “covering” the globe
  - world-wide deregulation and spectrum auctions
  - standard communication systems and air link interfaces
- **Portable information appliances**
  - laptops, notebooks, sub-notebooks, and MNCs
  - hand-held computers
  - PDAs and smart phones
- **Internet:**
  - TCP/IP & *de-facto* application protocols
  - ubiquitous web content

# New Forms of Computing

- Distributed Computing (Client/Server)

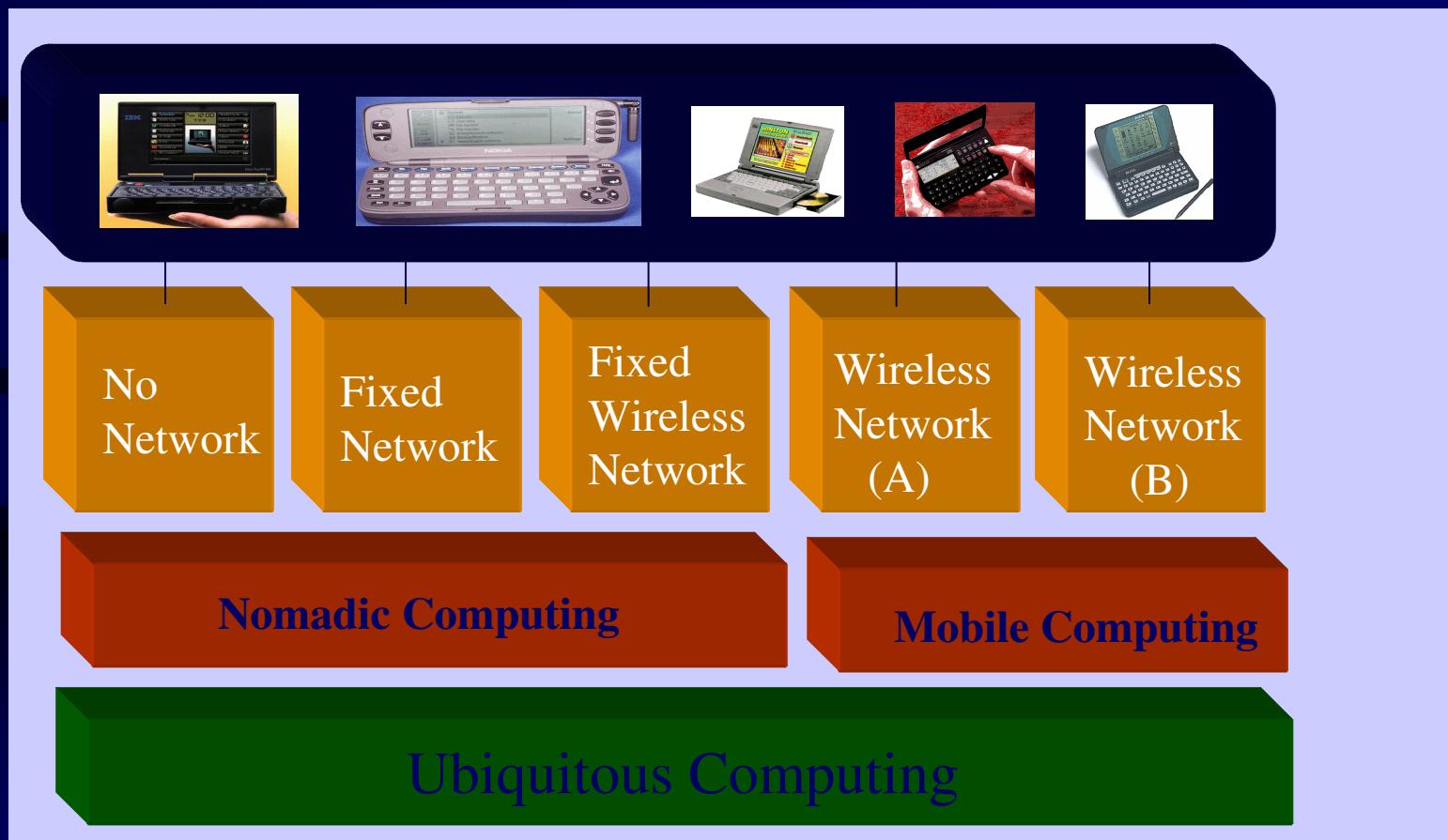


- Wireless Computing
- Nomadic Computing
- Mobile Computing
- Ubiquitous Computing
- Pervasive Computing
- Invisible Computing
- *Metamorphic Computing*

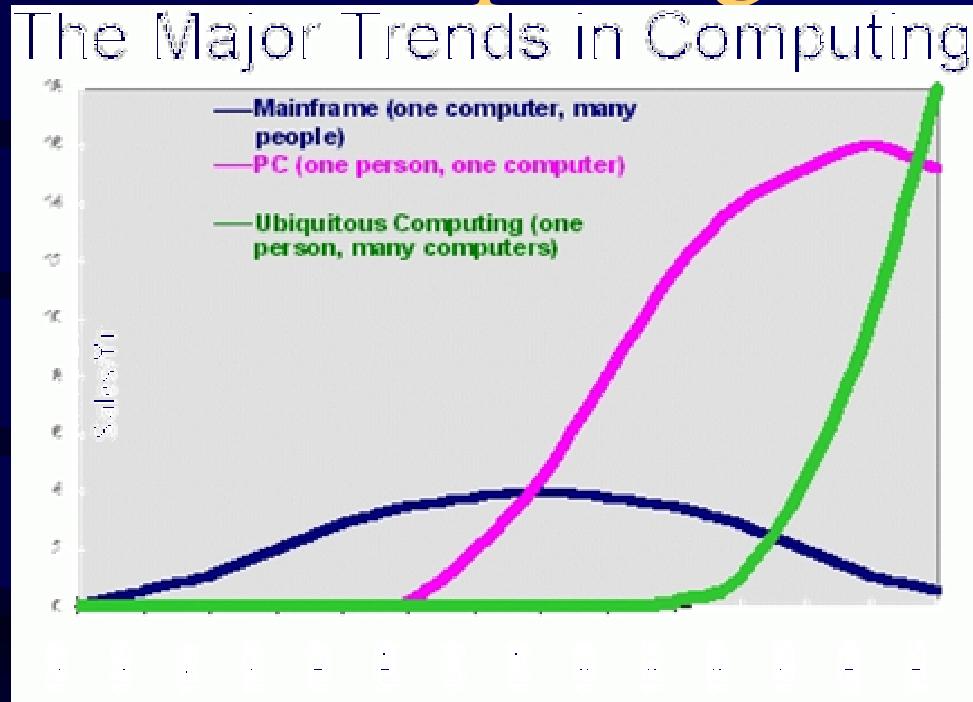
# Mobile Computing

- Using:
  - small size portable computers, hand-helds, MNC, and other small wearable devices,
- To run stand-alone applications (or access remote applications) via:
  - wireless networks: IR, BlueTooth, W-LANs, Cellular, W-Packet Data networks, SAT. etc.
- By:
  - nomadic and mobile users (animals, agents, trains, cars, cell phones, ....)

# Nomadic, Mobile & Ubiquitous

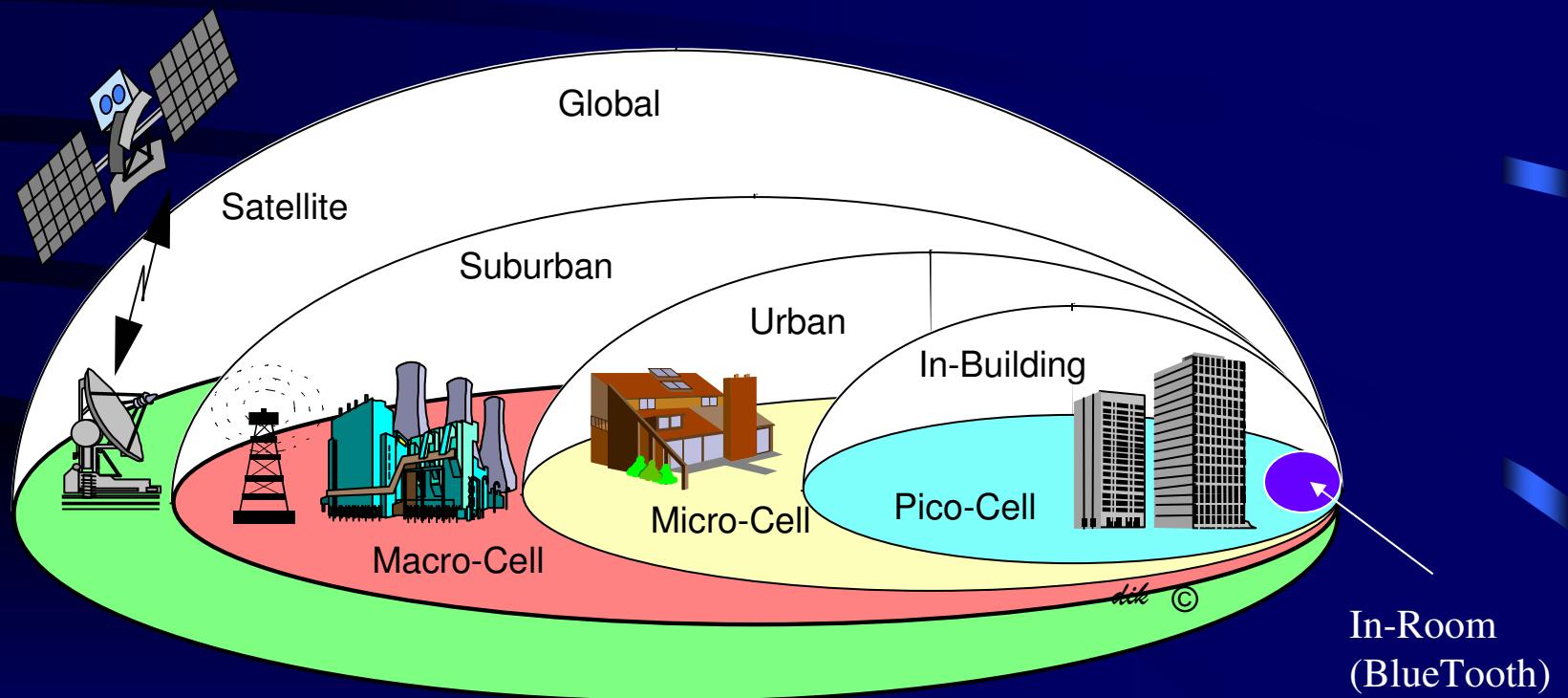


# Another View of Ubiquitous Computing

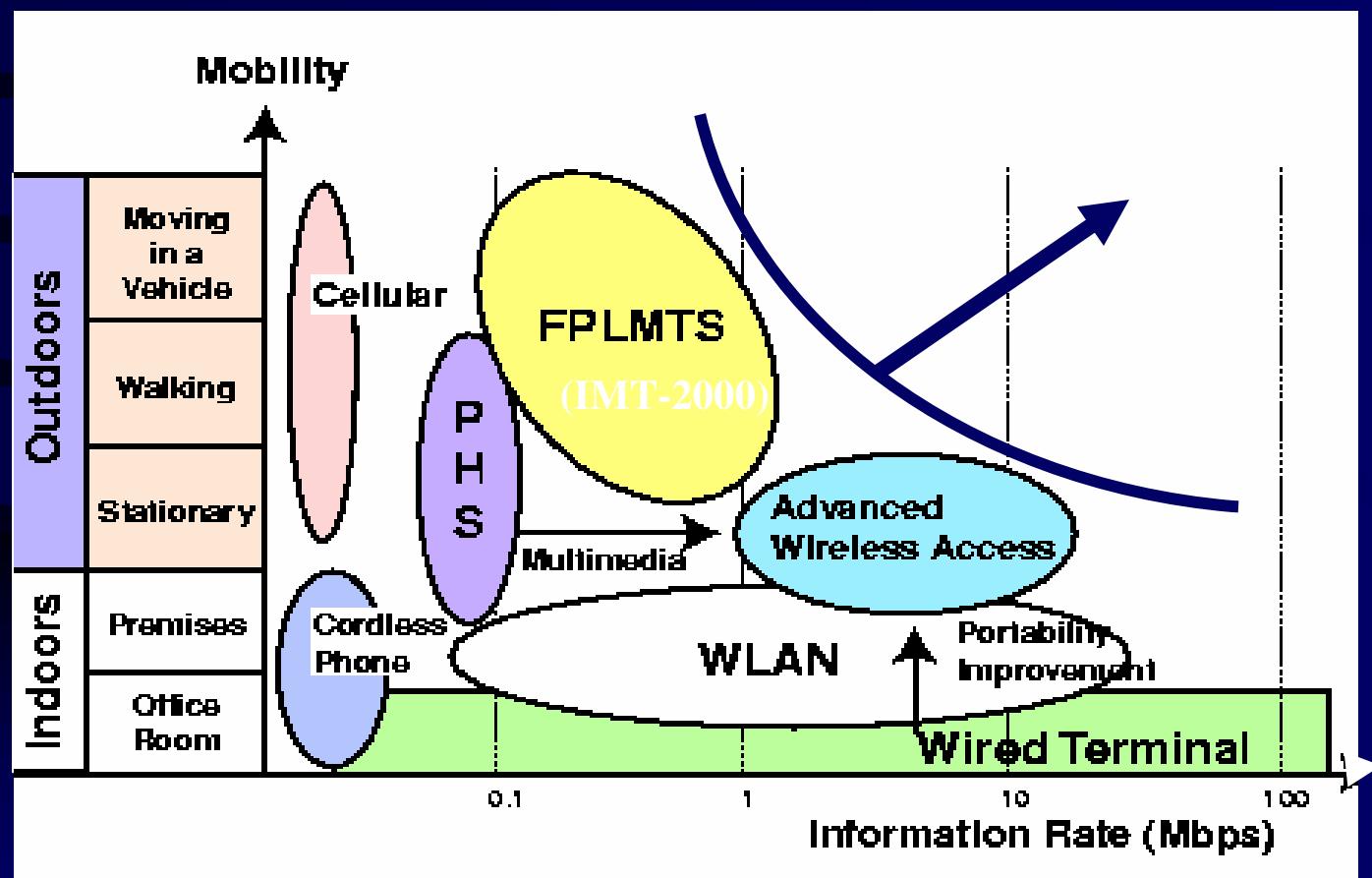


- Mark Weiser's views
- <http://www.ubiq.com/hypertext/weiser/UbiHome.html>

# Impressive Wireless Infrastructure!



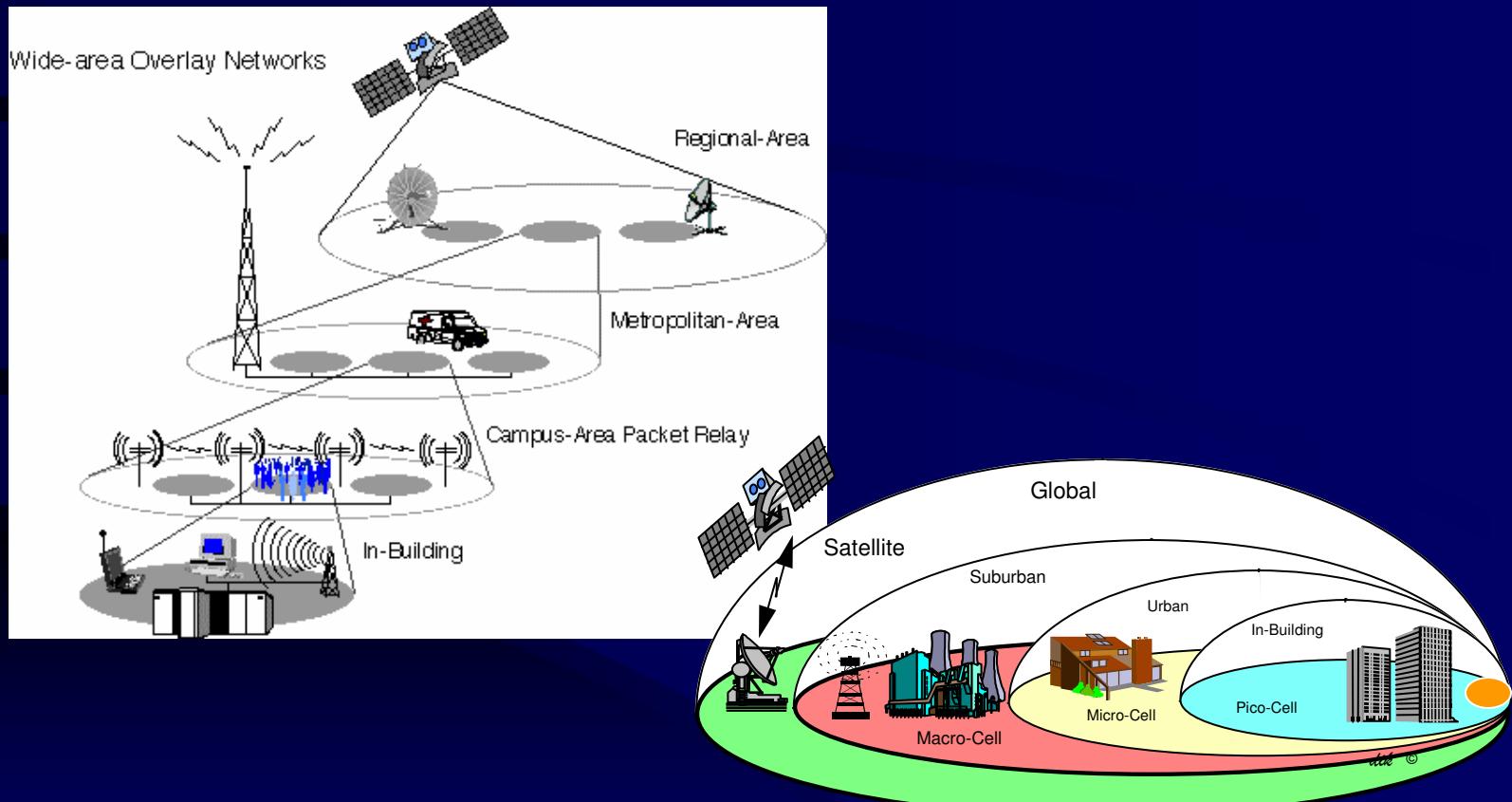
# Wireless Communication Technology



# GSM Base Stations in Europe

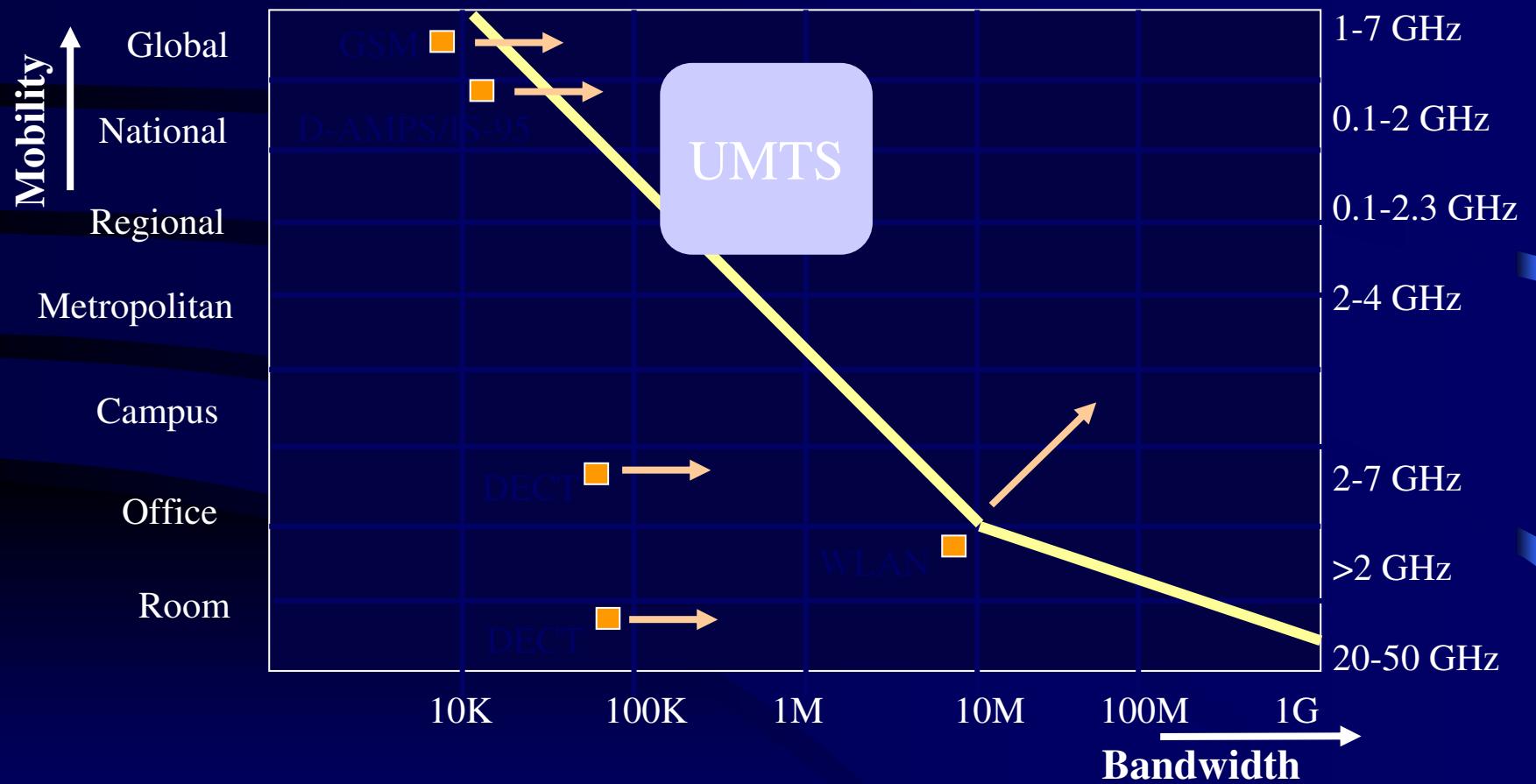


# Wireless Network Overlay



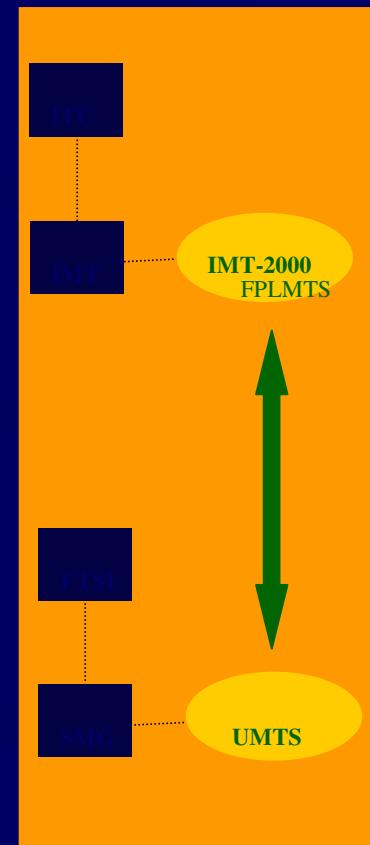
# Wireless Network Convergence

## 2G/3G Mobility-Bandwidth Trade-off

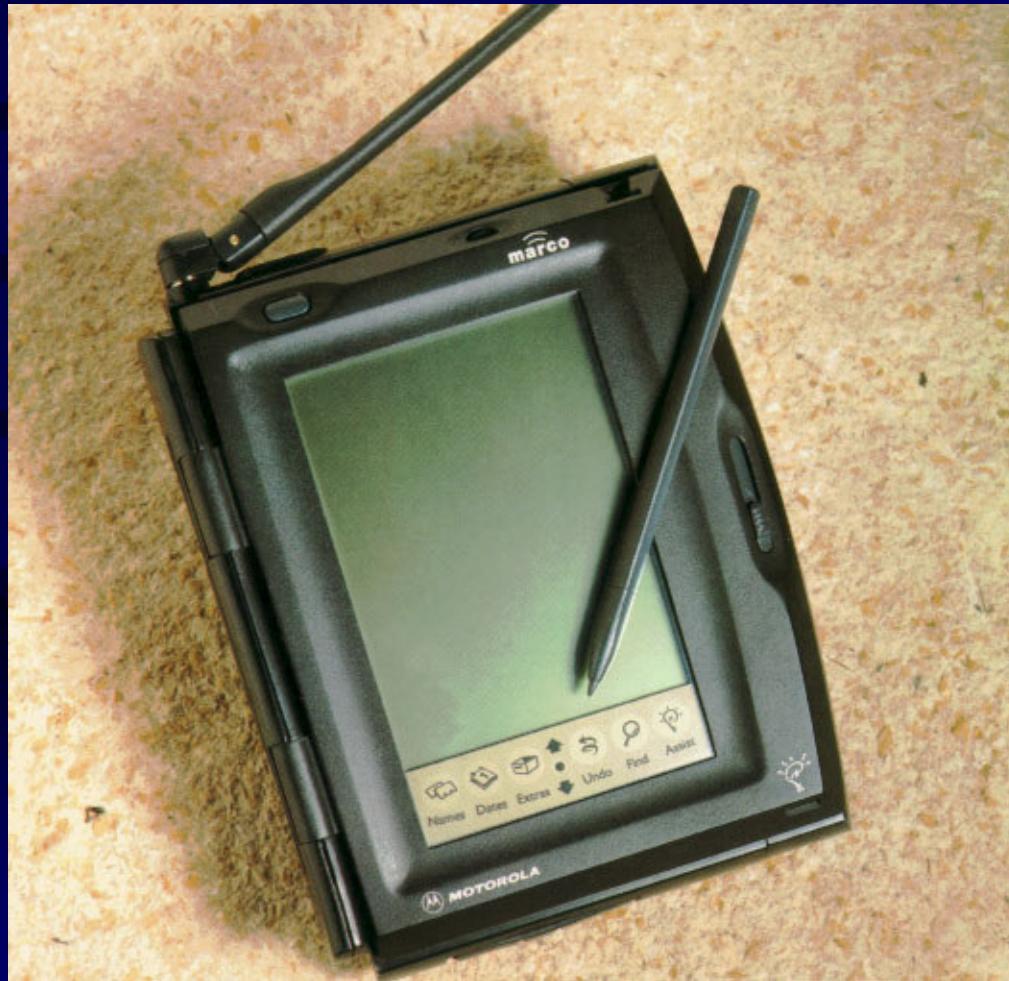


# UMTS: Universal Mobile Telecomm. Standard

- Global seamless operation in multi-cell environment (SAT, macro, micro, pico)
- Global roaming: multi-mode, multi-band, low-cost terminal, portable services & QoS
- High data rates at different mobile speeds: 144kbps at vehicular speed (80km/h), 384 kbps at pedestrian speed, and 2Mbps indoor (office/home)
- Multimedia interface to the internet
- Based on core GSM, conforms to IMT-2000. Deployment as early as 2002.



# Motorola Marco



# Motorola Envoy



# The Palm



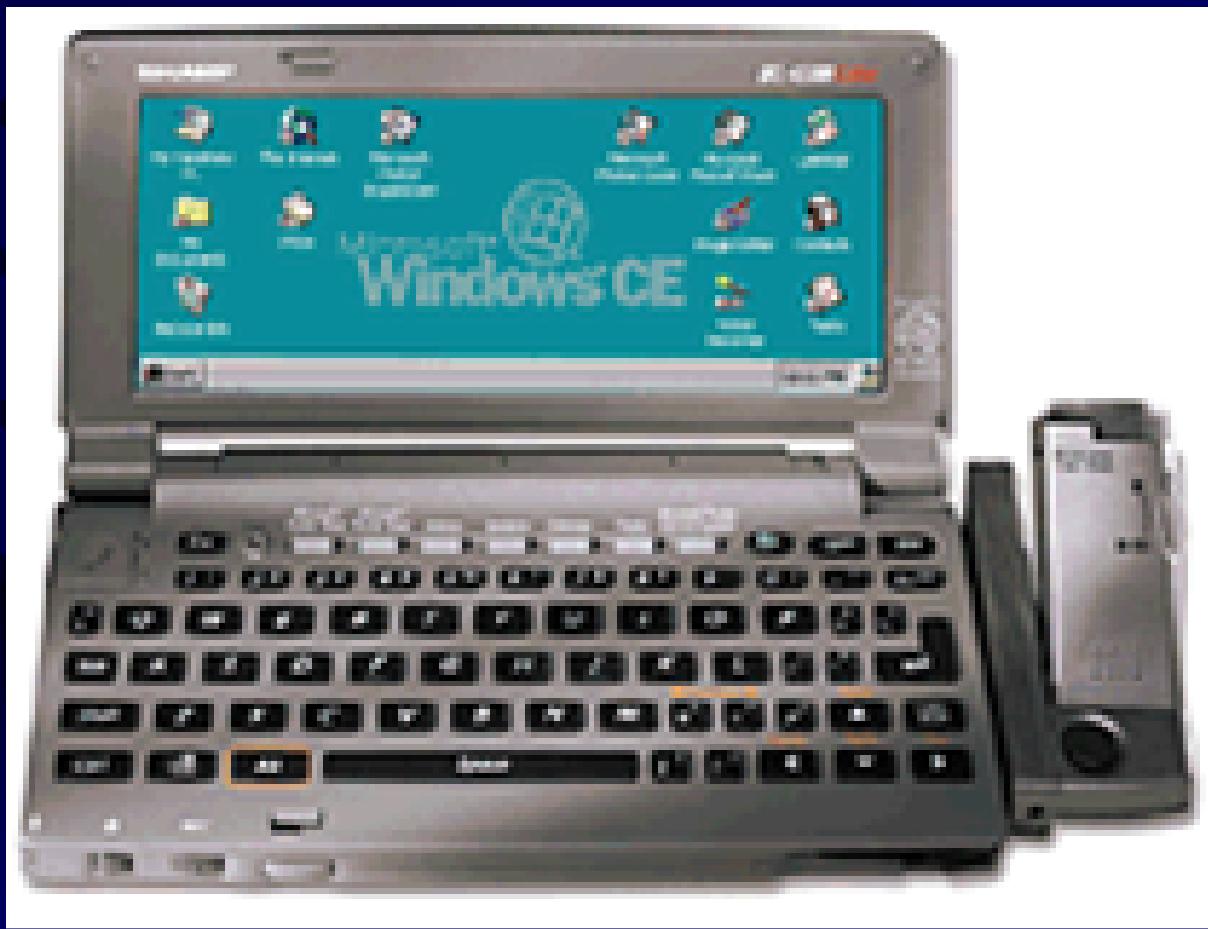
# The Pocket PC



# The Nokia 9000 Communicator



# The Sharp Zaurus



# The Vadem Clio



Clio™   
The ideal PC Companion

# Fujitsu Stylistic 2300/3400



# Sub-Notebook



# Notebook



# The First Wrist PC: Ruputer

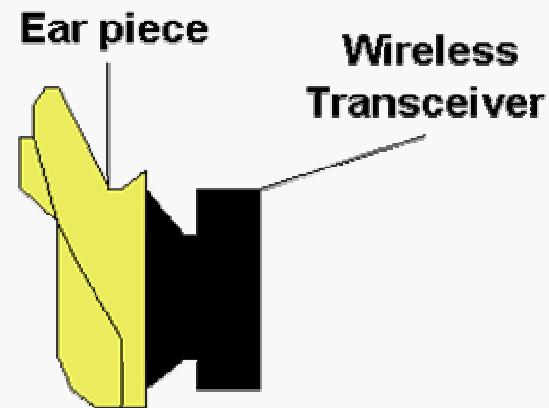


# Japan's PHS Phone, Year 2001



# Ear Phone

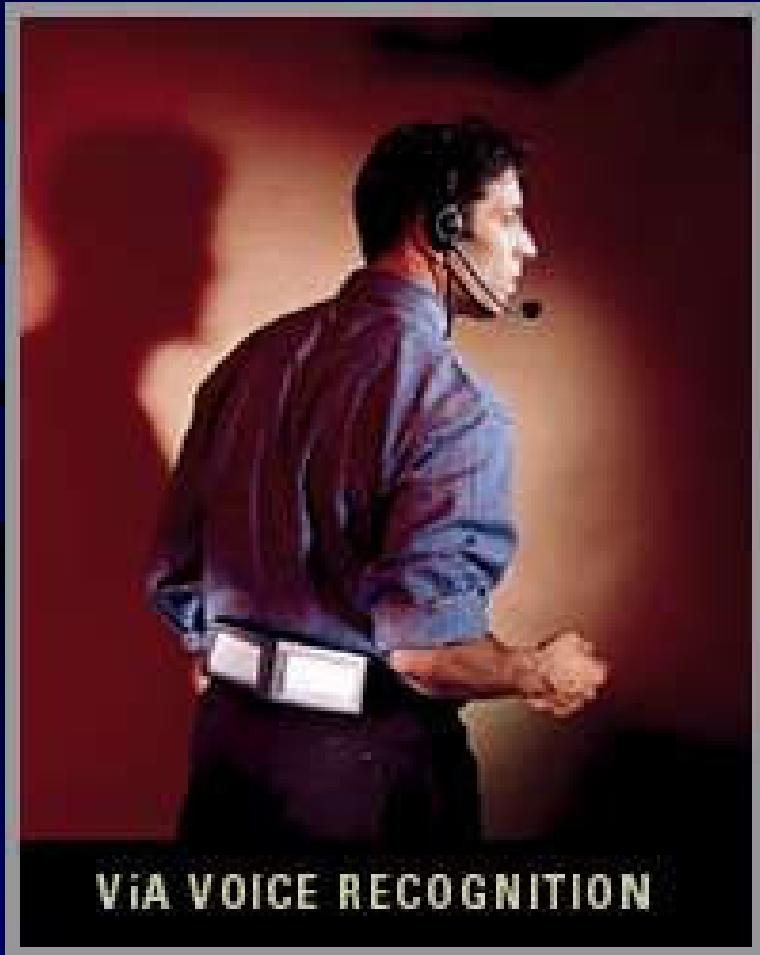
- Hearing aid form factor
- Integrated microphone & speaker
- Low power / short range RF (like Blue Tooth)
- Embedded IP address
- Voice processing: external to unit, controlled by software agents



# Wearable Computers



# More Wearable -- Via PC

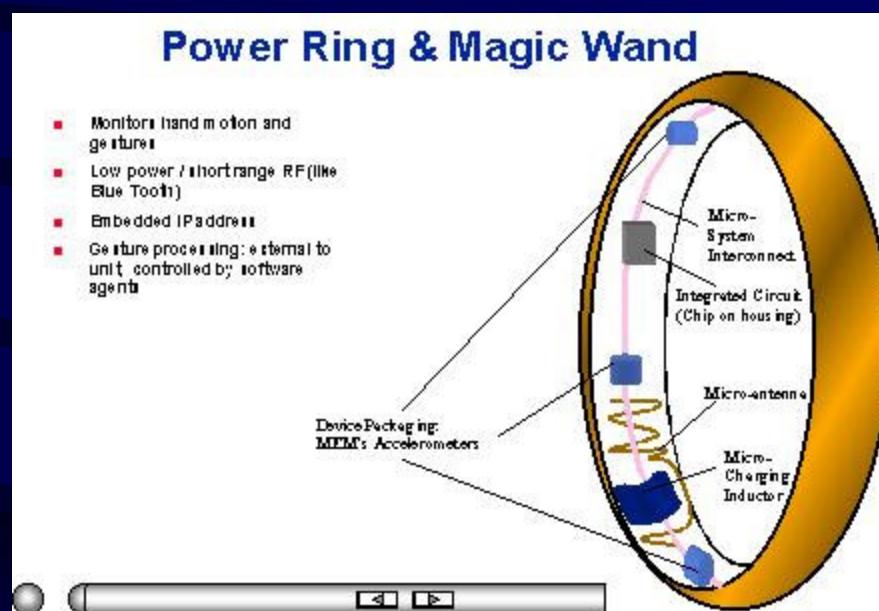


VIA VOICE RECOGNITION

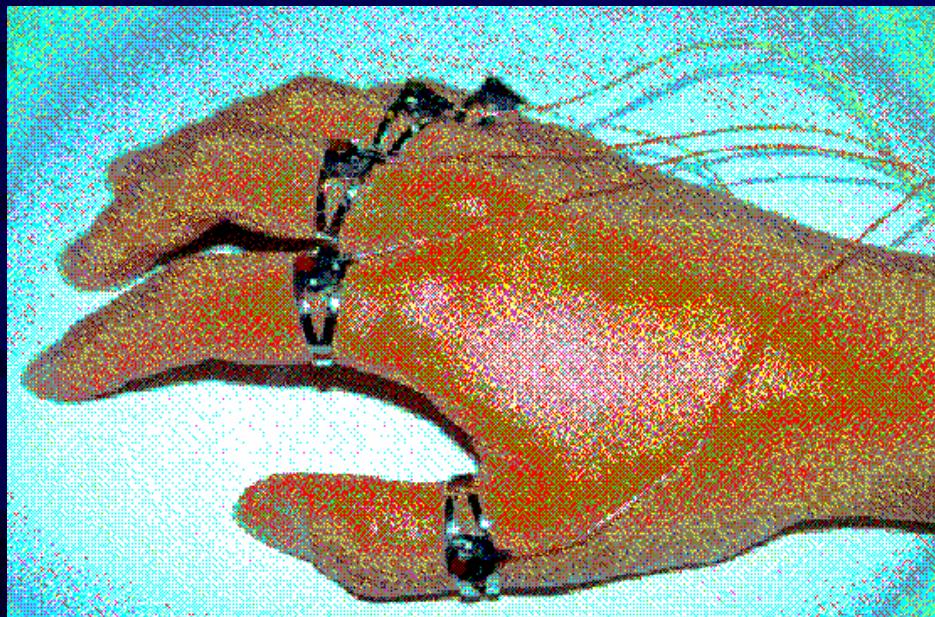


[Http://ww.via-pc.com](http://www.via-pc.com)

# The Power Ring



# NTT Key Fingers



# The Projection Keyboard

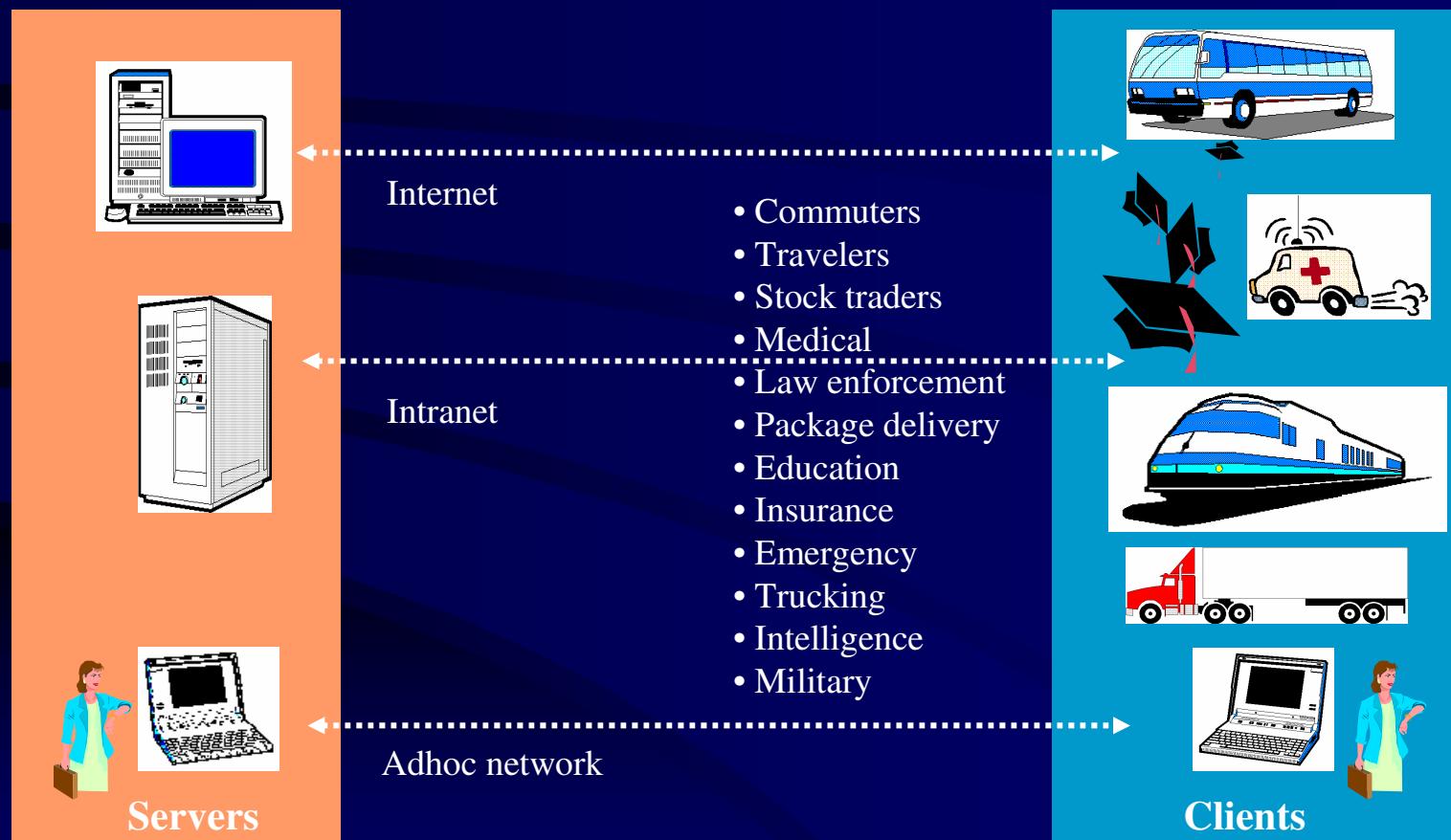


<http://www.canesta.com>

# Portable Information Appliances



# Beneficiaries of Ubiquitous Computing



# Limitations of the Mobile Environment

- Limitations of the Wireless Network
  - heterogeneity of fragmented networks
  - frequent disconnections
  - limited communication bandwidth
- Limitations Imposed by Mobility
- Limitations of the Mobile Computer

# Frequent Disconnections

- Handoff blank out ( $>1ms$  for most celluar)
- Drained battery disconnection
- Battery recharge down time
- Voluntary disconnection (turned off to preserve battery power, also off overnight)
- Theft and damage (hostile environment)
- Roam-off disconnections

# Limited Communication Bandwidth

- Orders of magnitude slower than fixed network
- Higher transmission bit error rates (BER)
- Uncontrolled cell population
- Difficult to ensure Quality of Service (QoS)
- Asymmetric duplex bandwidth
- Limited communication bandwidth exacerbates the limitation of battery lifetime.

# Limitations of the Mobile Computer

- Short battery lifetime (max ~ 5 hours)
- Subject to theft and destruction => unreliable
- Highly unavailable (normally powered-off to conserve battery)
- Limited capability (display, memory, input devices, and disk space)
- Lack of *de-facto* general architecture: handhelds, communicators, laptops, and other devices

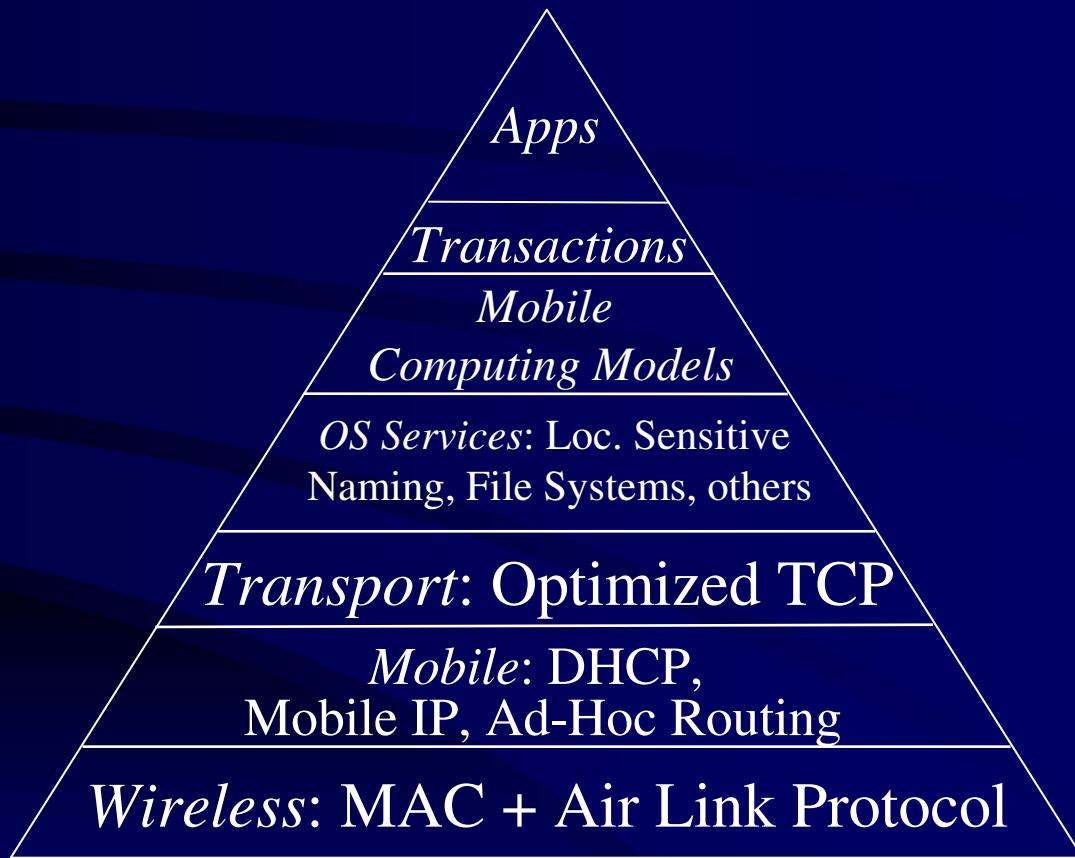
# Caesar and Brutus



# Limitations Imposed by Mobility

- **Lack of mobility-awareness by applications**
  - inherently transparent programming model (object-, components-oriented, but not aspect-oriented)
  - lack of environment test and set API support
- **Lack of mobility-awareness by the system**
  - *network*: existing transport protocols are inefficient to use across heterogeneous mix of fixed/wireless networks
  - *session and presentation*: inappropriate for the wireless environment and for mobility
  - *operating systems*: lack of env. related conditions and signals
  - *client/server*: unless changed, inappropriate and inefficient

# Research Roadmap



# Mobile and Wireless Networking Issues

- Mobile IP
- Wireless Transport
- Ad-Hoc Networks
- Location Management
- Wireless Network Benchmarking
- Ad-Hoc Network Simulation
- Wireless Link Simulation

# Wireless and Mobile Computing Models

- Mobility-aware Client/Server using Proxies
- Disconnected Operations
- Application-aware Adaptations
- Mobile Agents and Objects
- Thin Client/Server
- Mobile Caching and Replication
- Broadcast Disks
- Service Advertisement and Brokering
- Smart Pones

# Mobile file and Database Systems

- Wireless File System Access
- Disconnected File Systems
- Mobile Access to C/S or Distributed Databases
- Ad-Hoc Database Systems
- Checkpointing
- Database recovery
- Mobile Database Design

# Mobile Transaction and Workflow

- ACID Relaxation
- Mobile Transaction Models
- Optimistic Data Replication
- Semantic-based Conflict Resolution
- Consensus in Mobile Environment

# Wireless and Mobile Applications and Services

- Application Design for Wireless networks
- Application Design for Mobility
- Wireless WWW Access
- Active Badges (Teleporting)
- Wireless Classroom (Wireless Campus!)
- Mobile Groupware
- Location-sensitive Yellow Service
- Pervasive Computing and Smart spaces
- .....

# Performance and QoS

- QoS Measures in Wireless and Mobile Environments
- QoS Guarantees
- Simulators and Emulators of Wireless Links
- Simulators of Mobile and Ad-hoc Networks
- Wireless Networking Benchmarking

# Emerging Standards

- The 802.11b
- The BlueTooth Standard
- The Wireless Application Protocol (WAP)
- The CompactHTML
- The Network Computer Reference Specification
- Telecom Standards: UMTS
- .....