Systems Issues in Mobile Computing

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Outline

- What is mobile computing?
- Mobile computing vs. distributed computing
- New research challenges
- Some examples of current research
    - Protocols for mobile hosts
    - Reducing power consumption
    - Context-aware computing
    - Weakly connected data sharing
- Conclusions

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Mobile Computing

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Portable Computers

+

Wireless Networks

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Mobile Computing

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Portable Computers

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Modems

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Telephone Network

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Mobile Computing

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Traditional Workstations

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Traditional Wired Networks

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Mobile Users

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What's a Distributed Computer System?

Three major components:

- Computers

  independent processing, memory, power

- Network

  packet-switched or circuit-switched communication

- Coordination

  what makes it a "system"

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Mobile Computers

compared to workstations are:

- resource-challenged
  - limited CPU capacity
  - limited storage
  - limited battery life
- less reliable
  - more prone to destruction
  - more prone to theft

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Mobile Networks

compared to fixed networks are:

- resource-challenged
  - limited bandwidth
  - higher error rates
- more subject to network partitions
  - voluntary disconnection of laptops
  - limited geographic coverage
- less symmetrical
  - non-transitive connectivity
  - uplink vs. downlink bandwidth
- expensive

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Observation #1: System design based on assumptions

Explicit or implicit

Intentional or unintentional

Such as:

- capacity
- bandwidth
- usage
- expected case
- failure modes

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Observation #1: ...but current assumptions may be wrong

Example: TCP protocol used in the Internet

- Assumes: dropped/delayed packet => congestion
- Backs off when congestion detected then slowly adjusts transmission rate
- Is this the correct behavior in a mobile network? No!

R. Caceres and L. Iftode. The Effects of Mobility on Reliable Transport Protocols. *Proc. 14th Int. Conf. on Distributed Computing Systems*, June 1994, pages 12-20.

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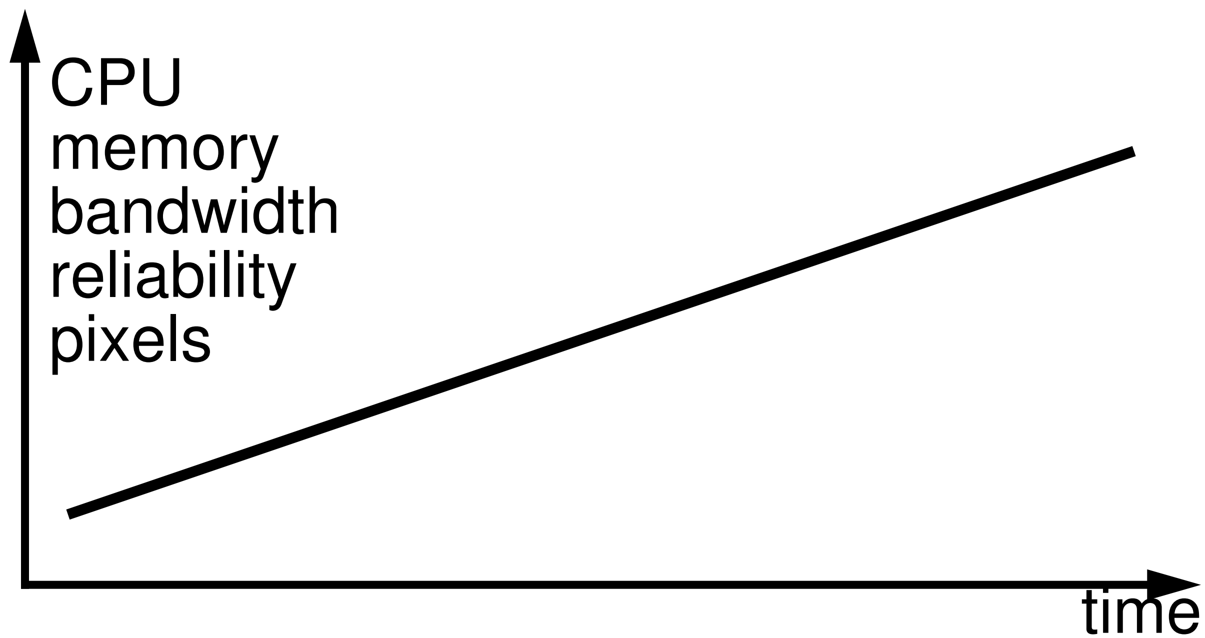
Observation #2: Research based on trends

Traditionally:



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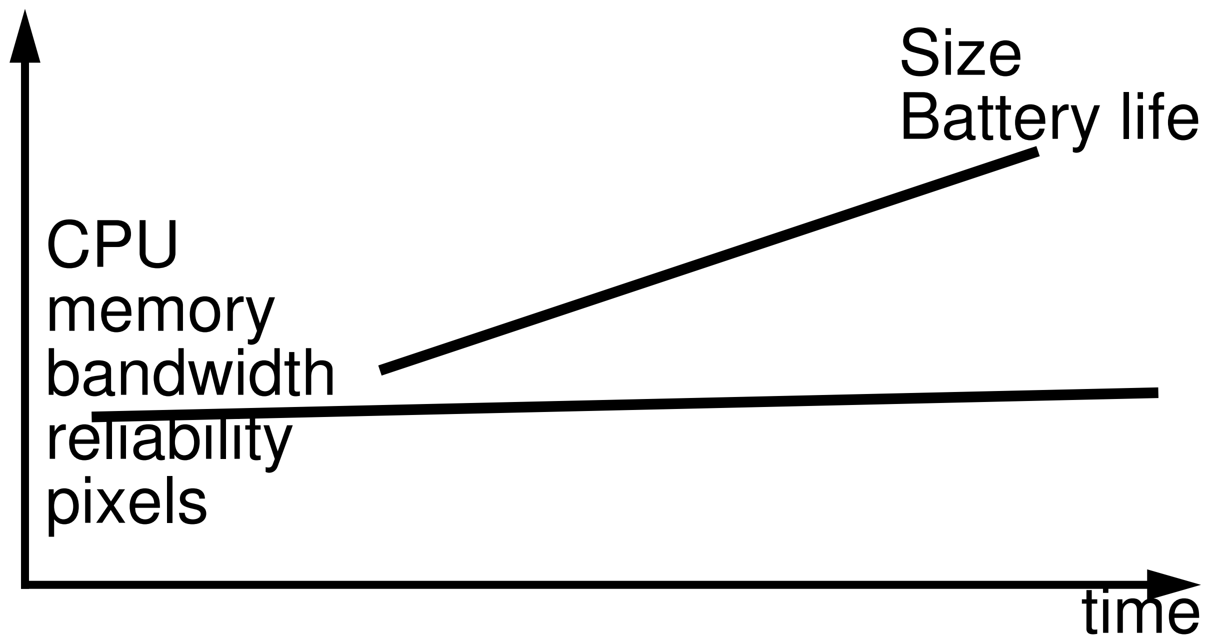
Observation #2: ...but trends are different

with mobile computers:



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Observation #3: Constants are now variables

Some things that used to be fixed but now vary:

- location
- environment
- connectivity
- bandwidth
- I/O devices
- security domain

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Mobile Computing Systems

compared to traditional distributed systems must:

- Deal with wide variations in available resources, bandwidth, etc.
- Support heterogeneity
- Adapt to changes in the environment
- Handle network partitions and partial failures
- Accommodate multiple administrative domains
- Take scalability seriously

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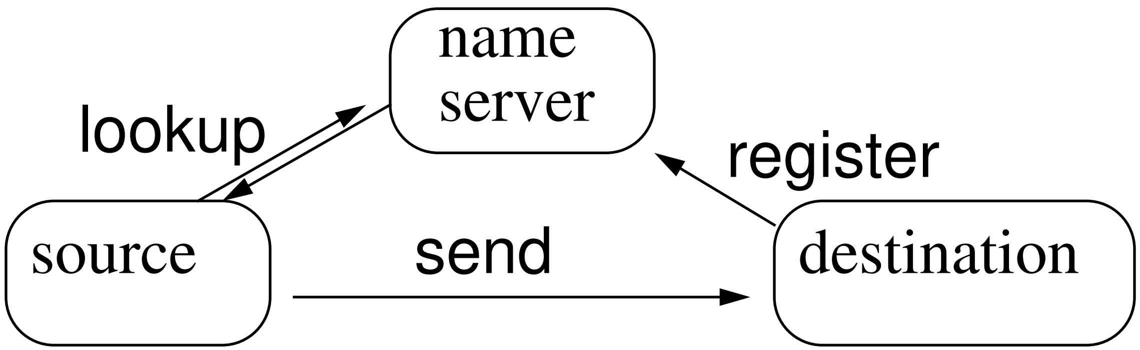
Research Thrust #1: Mobile IP

- Issue: Locating a mobile host
- Traditional solution: Name server



- Problems:

    too expensive to look up address for each message

    how to detect when destination moves?

    existing protocols embed (sub)network in address

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Example: Virtual IP (VIP)

- virtual network (VN) --> physical network (PN)

  often VN=PN
- “home” network keeps track of location

  mobile host must register
- can route packet through “home” network
- gateways can cache VN --> PN mappings

  and use this to dynamically route packets

F. Teraoka, Y. Tokote, and M. Tokoro. A Network Architecture Providing Host Migration Transparency. *Proc. SIGCOMM ‘91*. September 1991, pages 209-220.

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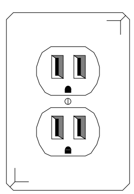
Research Thrust #2: Reduced Power Consumption

- Issue: Saving battery life
- Traditional approach: Plug in and ignore power consumption
- Problem: Can't plug in and remain mobile



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Example: Database query processing

- New query processing cost models
- Optimize for energy usage rather than number of I/Os
- New metric: energy/transaction
- May accept approximate answers

R. Alonso and H. Korth. Database System Issues in Nomadic Computing. *Proc. SIGMOD Int. Conf. on Management of Data*, May 1993, pages 388-392.

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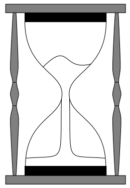
Example: Adjusting CPU clock rate

- C^2 power savings with C speed reduction
- Want to avoid CPU idle time
- New metric: instructions/joule
- New CPU scheduling policies



M. Weiser, A. Demers, B. Welch, S. Shenker. Scheduling for Reduced CPU Energy. To appear in *Proc. Operating System Design and Implementation*, November 1994.

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Research Thrust #3: Location-based Applications

A.k.a. Context-aware computing

- Issue: Informing applications of changes in their environment
  - So they can adjust their behavior
  - Whose around?
  - What's the nearest printer?
- Issue: Giving users control over their whereabouts and their information

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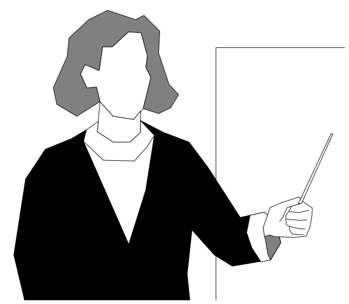
Example: Ubiquitous message delivery

- Message delivery and display based on
  - location of recipient
  - identity of sender
  - importance of message
  - contents of message
  - nearby display terminals
  - others in the vicinity



M. Spreitzer and M. Theimer. Architectural Considerations for Scalable, Secure, Mobile Computing with Location Information. *Proc. 14th Int. Conf. on Distributed Computing Systems*, June 1994, pages 29-38.

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Research Thrust #4: Weakly Connected Data Sharing

Issues:

- Supporting intermittently connected clients
- Providing acceptable levels of consistency
- Methods for detecting and resolving update conflicts
- Moving data “close” to users
- Effectively utilizing low bandwidth networks

Traditional approach: Strong consistency using atomic transactions

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Example: Coda distributed file system

- Supports voluntary disconnection
  - client caching
  - weak consistency
  - automatic reintegration
- Supports involuntary disconnection
  - hoarding
  - what's the best cache replacement policy?

J. Kistler and M. Satyanarayanan. Disconnected Operation in the Coda File System. *ACM Trans. on Computer Systems*, February 1992, pages 3-25.

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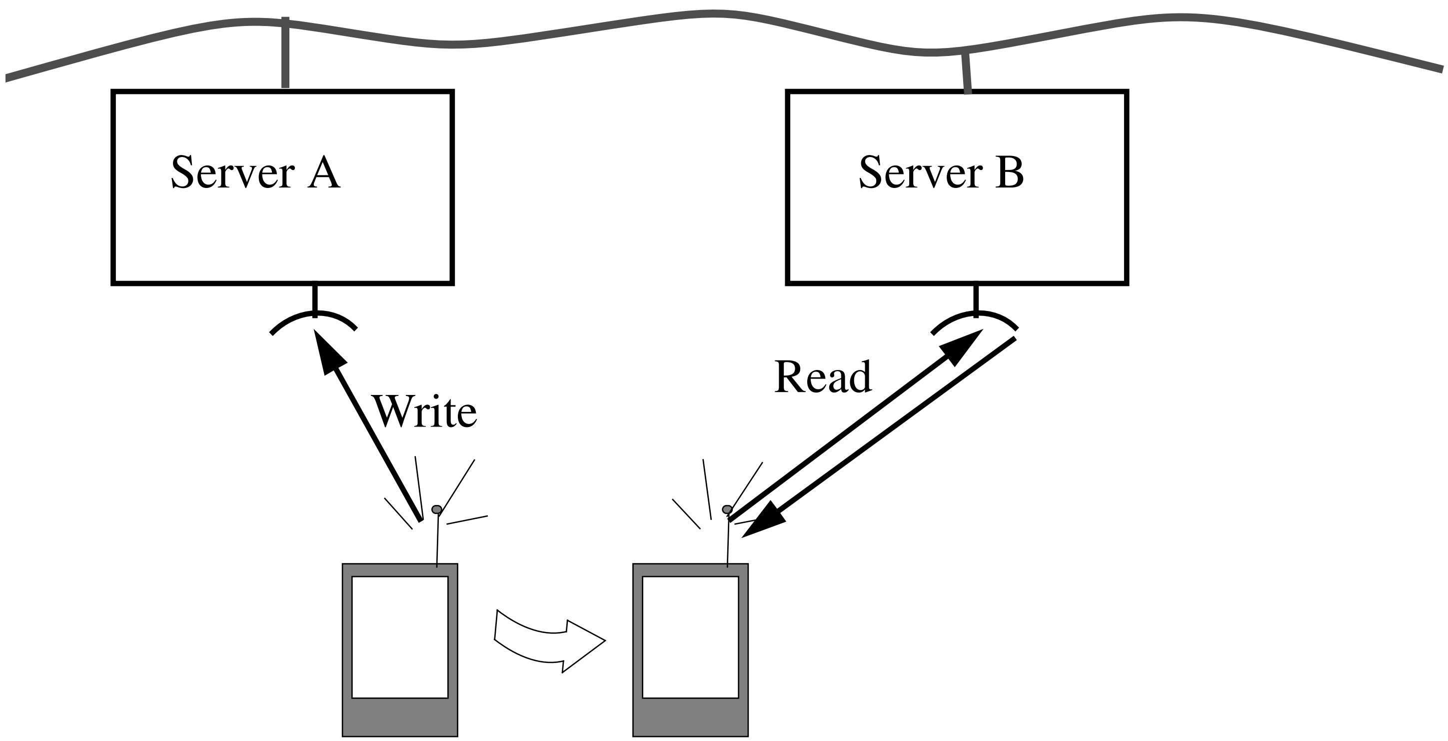
Example: Bayou replicated data manager

Issue: consistent data access for mobile clients



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Example: Bayou replicated data manager (cont.)

- Session guarantees enable a client to observe a database that is consistent with its own actions
- Sessions permit control over the scope and selection of the guarantees
- Implementation tailored for mobile computers

D. Terry, A. Demers, K. Petersen, M. Spreitzer, M. Theimer, B. Welch. Session Guarantees for Weakly Consistent Replicated Data. *Proc. Parallel and Distributed Information Systems*, September 1994, pages 140-149.

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Conclusions

- Mobile computing is hot!
- Driven by recent advances in
  - portable devices
  - wireless networks
- Existing distributed systems may be
  - based on false assumptions
  - insufficiently adaptable
- New (old) challenges exist in designing and building mobile computing systems

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