Mobile Computing
#MC03 Data Synchronization

CS60002: Distributed Systems
Winter 2006-2007

What kind of sync?

- “Sync” is an overloaded phrase
  - ✗ Not semaphores `synchronized () { ... }`
  - ✗ Not shared memory and not cache coherenc
  - ✗ Not instruction pipelining
  - ✓ SyncML, ActiveSync, cvs merge, database replication, ...
- Data synchronization
  - Two copies of data: on mobile and on server
  - Need to keep them in sync

Data Sync

Wireless Network

Contact Entry

Name: Ravi Patel
Home: +91-33-2424-5555

Mobile: +91-9999912345
Email: Ravi@xyz.com

Contact Entry

Name: Ravi Patel
Home: +91-33-2424-5555
Work: +91-33-2424-6666
Mobile: +91-9999912345

What to sync?

Create, Update & Delete	Contacts, Calendar, Tasks, App databases, Config data	Radio Code, OS and VM, Application Code
Create & Delete only	SMS, Call Logs, EMail	MP3s, Ringtones, Photos
	Structured	Unstructured

Sync Complexity

- Communication Complexity
  - Alice and Bob wonder if they have the same string
  - Can they decide without communicating all n bits?
  - No!
- Assumptions help us optimize
  - Assumption#1: Change log
    - What if Alice and Bob knew what has changed since they had the same string?
  - Assumption#2: Blind faith in digital hashes
    - May miss differences

Types of sync

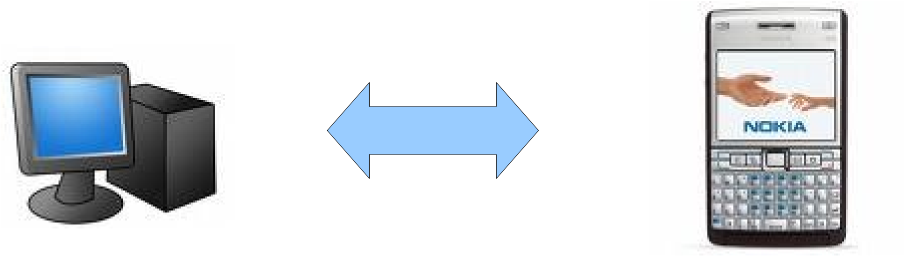
- File sync
  - Bit buckets. No semantics.
  - Master/Slave only.
  - No conflict resolution
- Application sync
  - Application events
    - e.g., “Meeting postponed”, “task declined”
  - Conflict resolution
  - Bi-directional sync

	File	Application
Change log	cvs merge	SyncML HotSync ActiveSync ....
Hash-based	rsync, OTA-DM	(None)

Sync using Change Logs

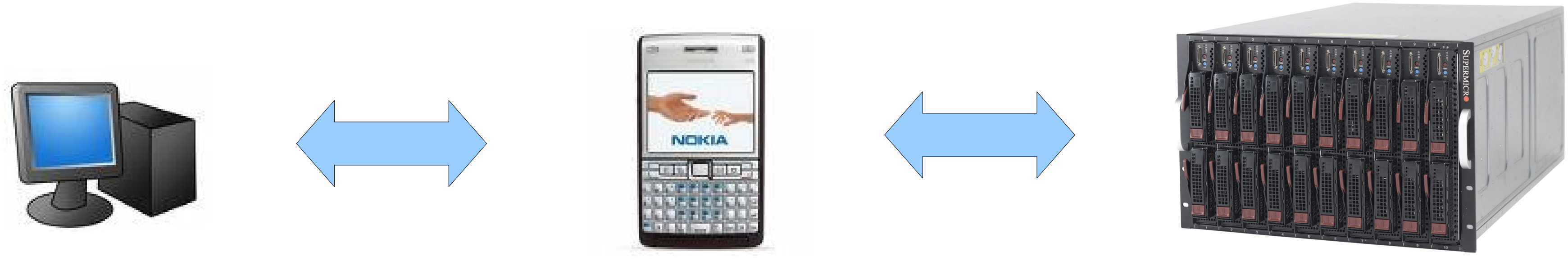
- Universal applicability
  - Used in File Sync (e.g., cvs merge)
  - ✓ Used in Application Sync (e.g., Palm HotSync)
- Both Mobile and Server maintain change logs
  - Log may detail actual create/update/delete entries
  - Or just a timestamped list of modified items
  - Or just a “changed-since-last-sync” marker
- Two types of sync operations
  - Fast Sync (always sync to the same server)
  - Slow Sync (sync to multiple servers)

Fast Sync



- What has changed since we last met?
  - Same item+field changed in both copies => Conflict
  - Jointly decide how the other party gets the edit
- Optimizations
  - Mobile is resource constrained. Server is not.
  - Mobile sends all changed items to server.
  - Server collates and sends edits back to Mobile.

Slow Sync



- Works when Fast Sync does not
  - Mobile is synced to >1 Servers (no “changed” flags)
  - Change log overflowed, or is not trustworthy
  - It has been too long since the last Slow Sync
- Simple, but inefficient
  - Mobile sends all records to Server
  - Server collates, and sends edits back to the client

Optimizations for Change Log Sync

- Use change logs, not just “changed” flags
  - Maintain complete log of changes
  - Log overflow => Next sync is a Slow Sync
- Trickle Sync (aka Replication)
  - Soft-real-time bidirectional stream of change events
- Fall back to Slow Sync
  - Periodically when connected over WiFi or USB
- Resource constraints on Mobiles
  - Battery, RAM, Flash

PDA/Mobile Sync Products

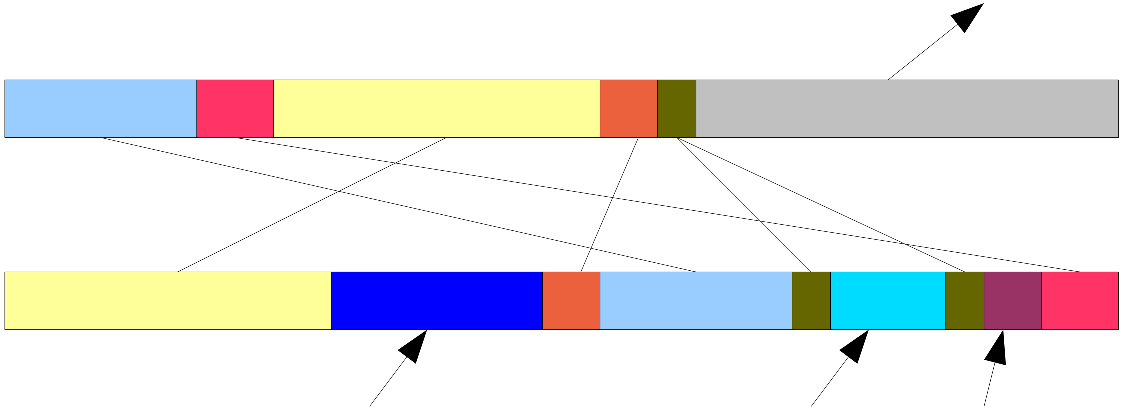
- HotSync
  - Palm OS
- IntelliSync
  - Acquired by Nokia
  - “Anywhere” Server
- ActiveSync
  - Microsoft Mobile
  - Renamed(?) in Vista

- SyncML
  - OMA standard
  - Sync two DOM's
    - PIM, email, code, ...
  - Widely supported
- BlackBerry
  - Proprietary

Hash-based Sync

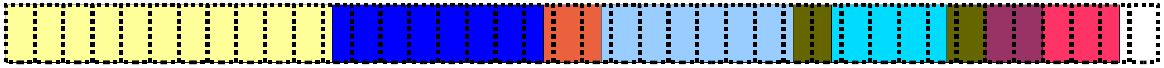
- No change log required
  - Will sync two snapshots without any history
  - Used for “merge”, and not for bi-directional sync
  - Can be wrong
- Interesting problems
  - Substring identification
    - Cut-n-paste editing
    - “Replace all” edits
  - Lossless compression and other encodings

rsync



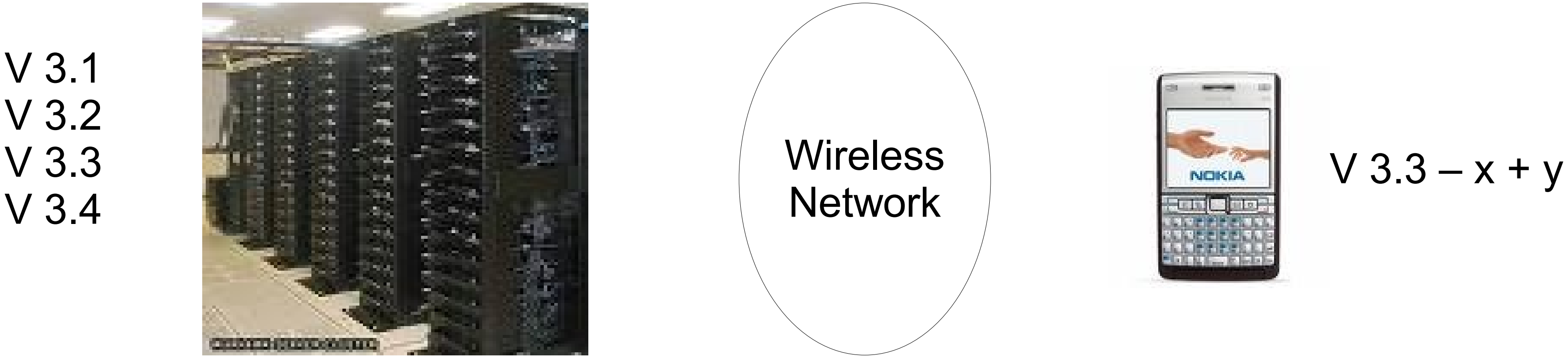
- File synchronization problem
  - Bob wishes to have Alice's copy
  - Should Alice just send the whole file to Bob?
  - No. rsync can help
    - Andrew Tridgell, Paul Mackerras, “The rsync algorithm”, http://rsync.samba.org/tech_report/tech_report.html

rsync



- Bob
  - Partitions string into fixed blocks of size S
  - Sends weak rolling hash and strong hash for each
- Alice
  - Trusts hashes to locate those blocks
  - Sends stream of “insert block” & “insert data”
- Bob
  - Follows commands to construct Alice's copy

Code/Firmware update



V 3.1
V 3.2
V 3.3
V 3.4

Wireless
Network

V 3.3 – x + y

- A special case of sync (or data compression)
  - Mobile to Server: “I have V 3.3 – x + y”
  - Server to Mobile: “Apply these deltas ...”
- Constraints
  - Server: Scale to support millions of Mobiles
  - Network: Bandwidth
  - Mobile: Battery, RAM, Flash

Three Problems in Code Sync

1) Small patches

bsdiff

- Compute small delta from V3.3 to V3.4
- Plenty of resources, since patches will be reused

2) Data compression

- Plenty of resources for compression
- Limited resources for decompression

3) Application of patches

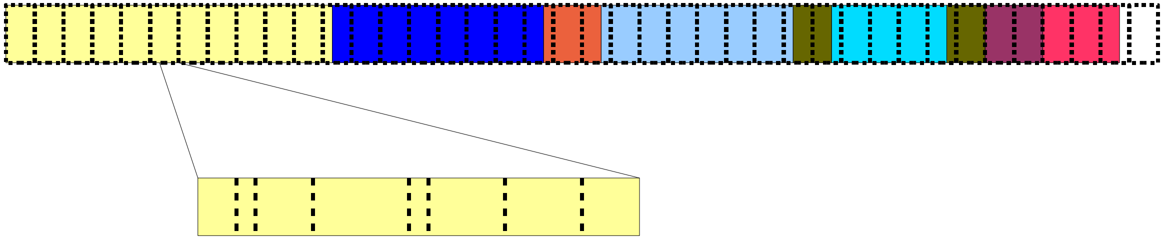
- Limited “disk” space
- Rollback on failure

Prefix Sort

“ACAIA”	0: ACAIA	4: A
	1: CAIA	0: ACAIA
	2: AIA	2: AIA
	3: IA	1: CAIA
	4: A	3: IA

- Several linear time algorithms
  - e.g., Juha K¨arkk¨ainen and Peter Sanders, “*Simple Linear Work Suffix Array Construction*”, ICALP 2003
- Can be used to find substring in O(m+log n)
  -

bsdiff



- Problem
  - Generate small patch from V3.3 to V3.4 binaries
  - “Replace all” changes to data & branch addresses
- Solution
  - Allow 50% mismatches in 8-byte segments
    - Control file (add/insert)
    - Difference file (fix small mismatches)
    - New content file
  - Colin Percival, Naive differences of executable code, http://www.daemonology.net/bsdiff/, 2003

Recap

- File and Application Sync
- Sync using Change log
  - Fast vs. Slow
- Hash-based Sync
  - Rsync Please read!
- Code Sync
  - Prefix sort Please read!
  - bsdiff Please read!