NEC Laboratories America
Relentless passion for innovation

Revisiting Storage for Smartphones

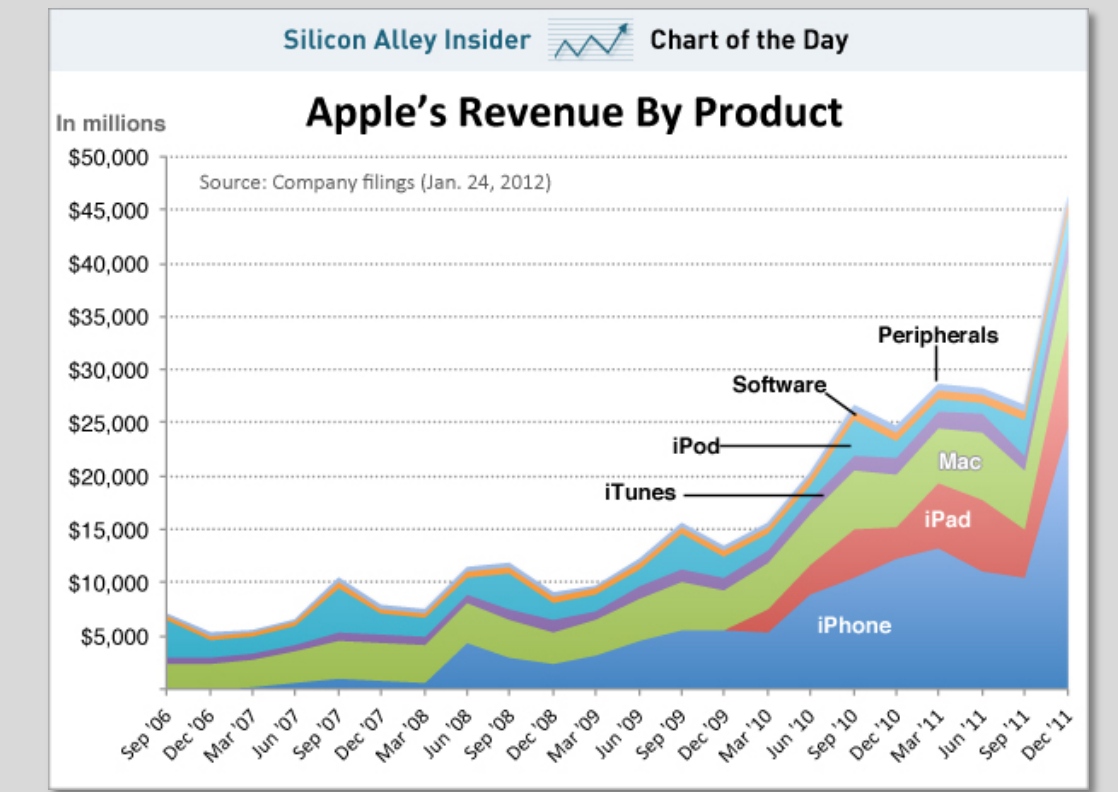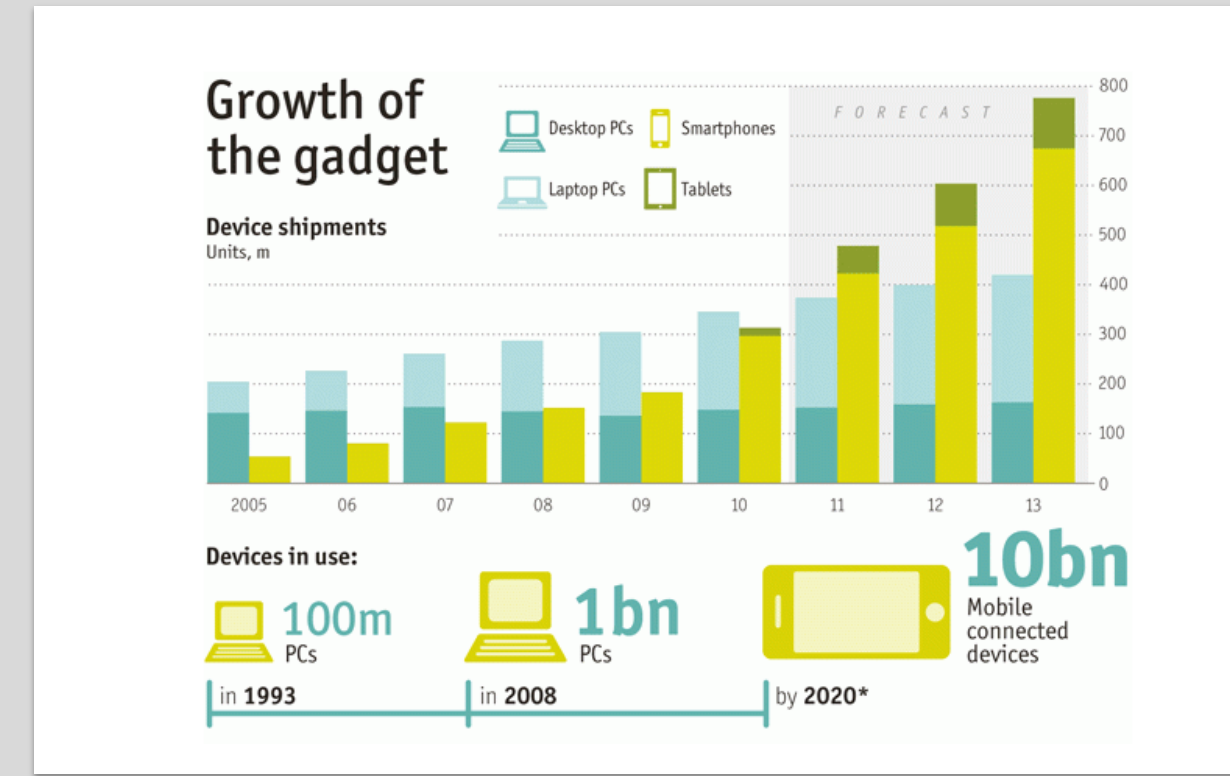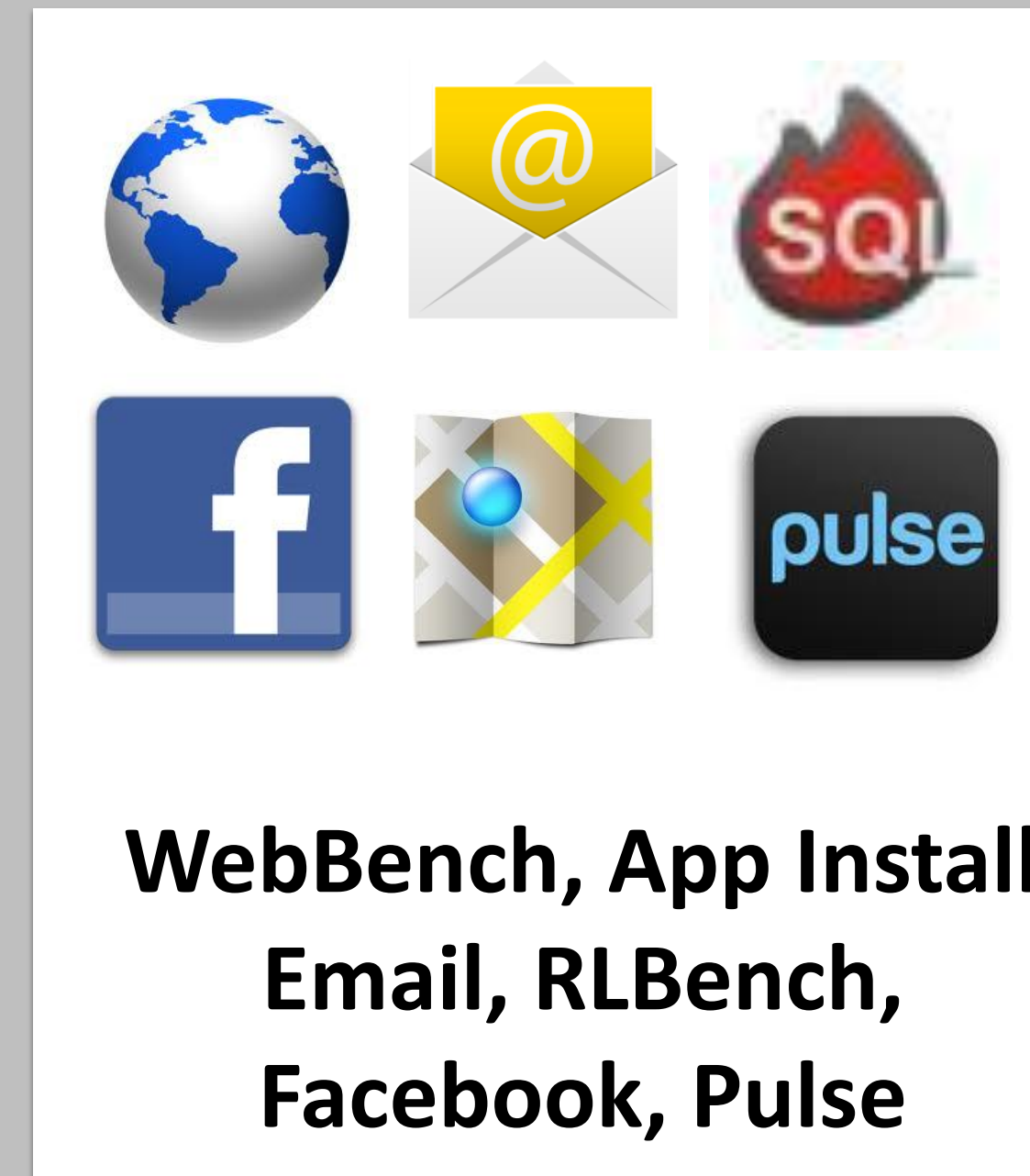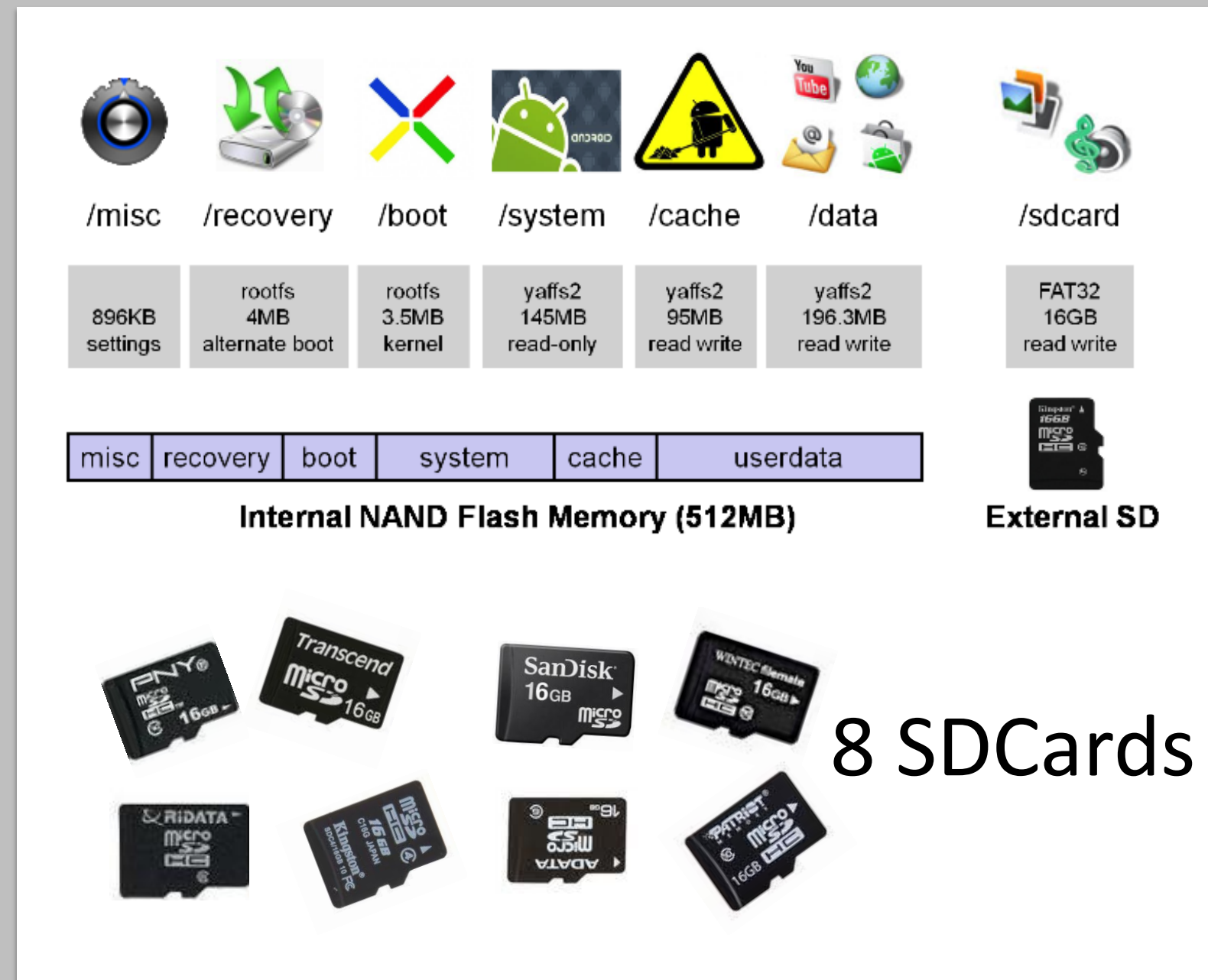Hyojun Kim, Nitin Agrawal, Cristian Ungureanu

Questions

Mobile devices are becoming more important!

1. Does the mobile storage subsystem affect the performance of popular applications?

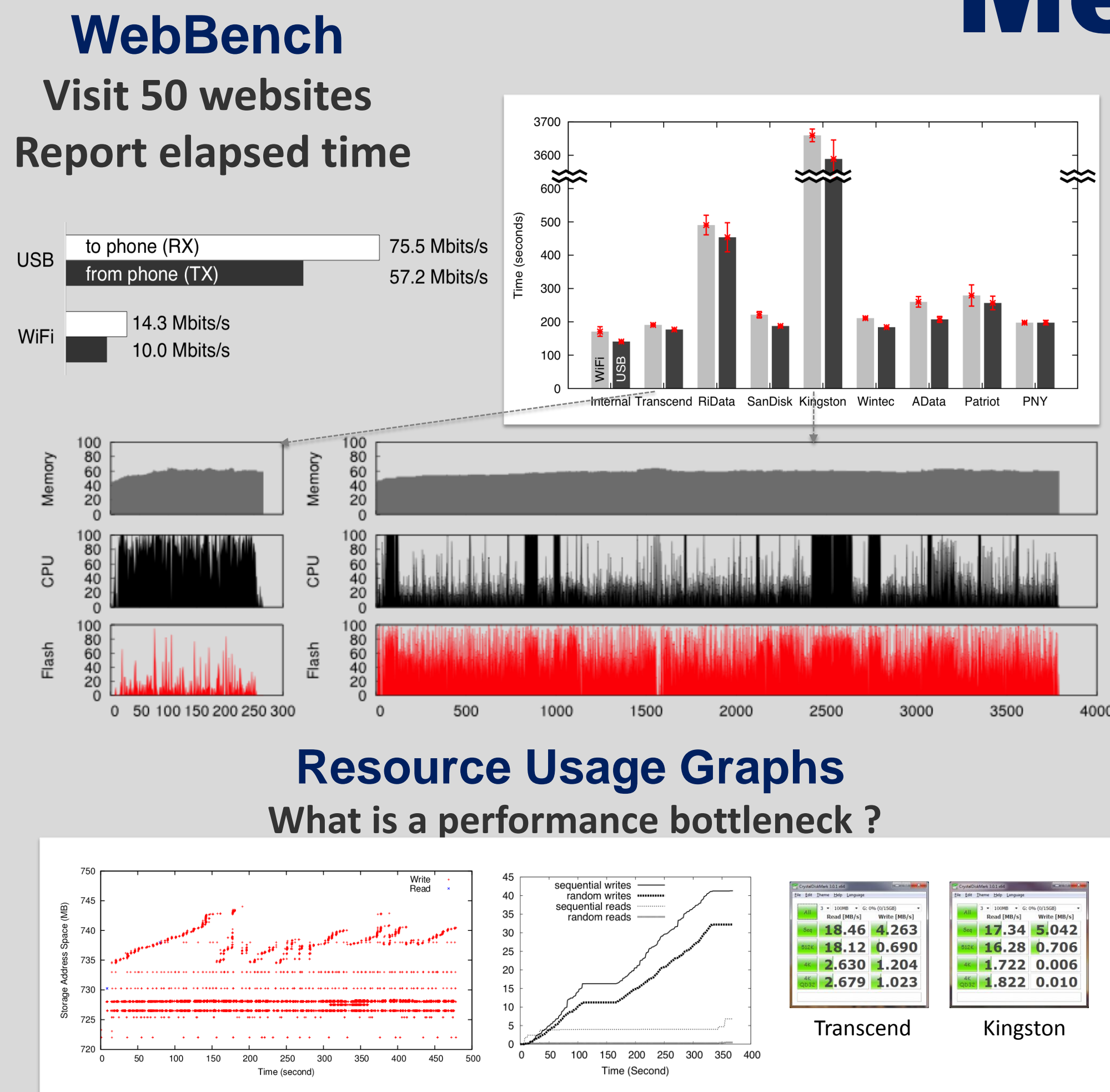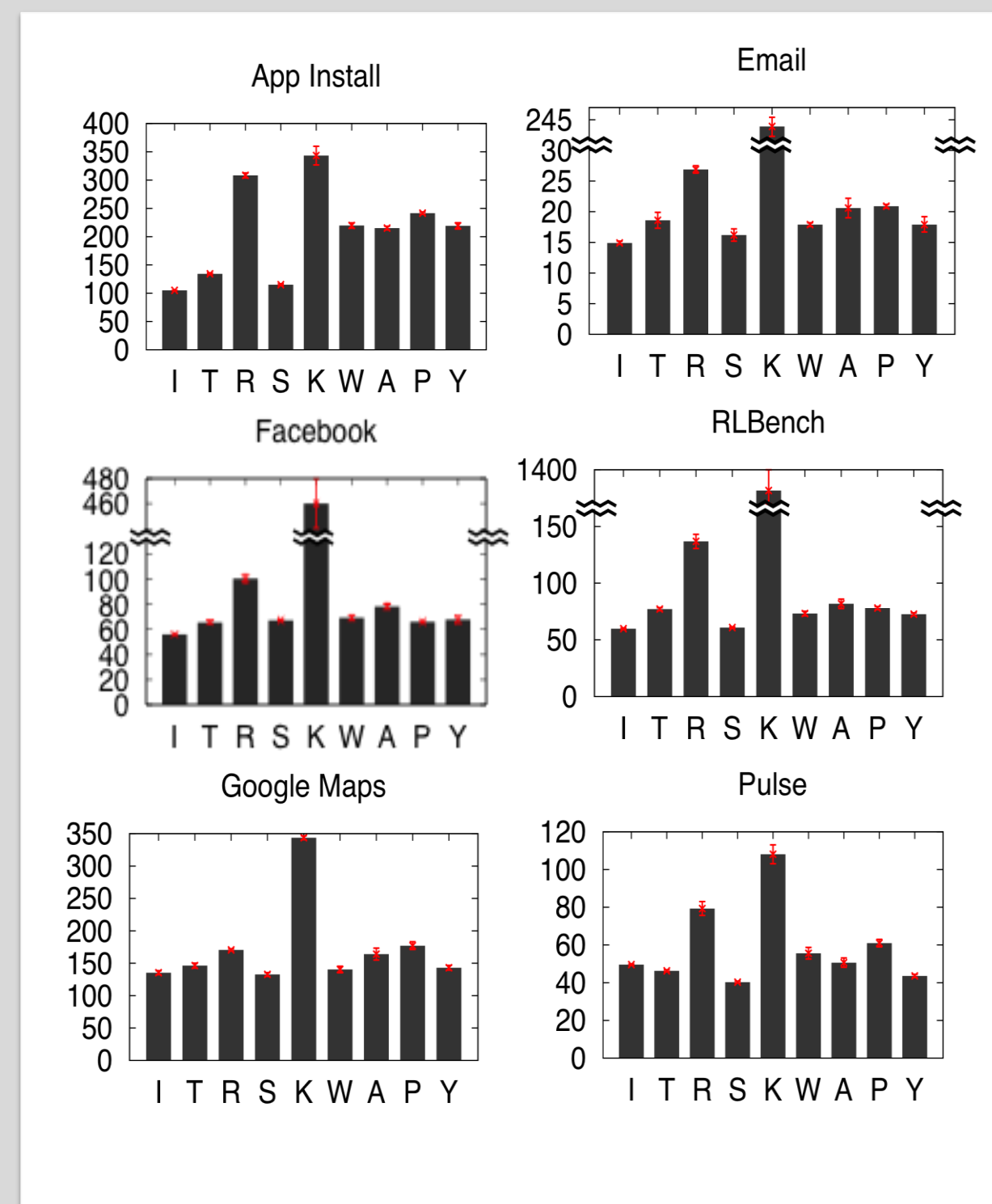2. How can we improve app performance?

Growth of the gadget

Apple's Revenue By Product

Methods

/misc /recovery /boot /system /cache /data /sdcard

| 896KB settings | rootfs 4MB alternate boot | rootfs 3.5MB kernel | yaffs2 145MB read-only | yaffs2 95MB read write | yaffs2 196.3MB read write | FAT32 16GB read write |

misc | recovery | boot | system | cache | userdata

Internal NAND Flash Memory (512MB)

External SD

**Google Nexus One
Android (AOSP)**

8 SDCards

WebBench, App Install, Email, RLBench, Facebook, Pulse

Resource Usage Monitoring

CPU: /proc/stat
Memory: /proc/meminfo
Network: /proc/net/dev
Storage

- **Read, Write amount from** /proc/diskstats
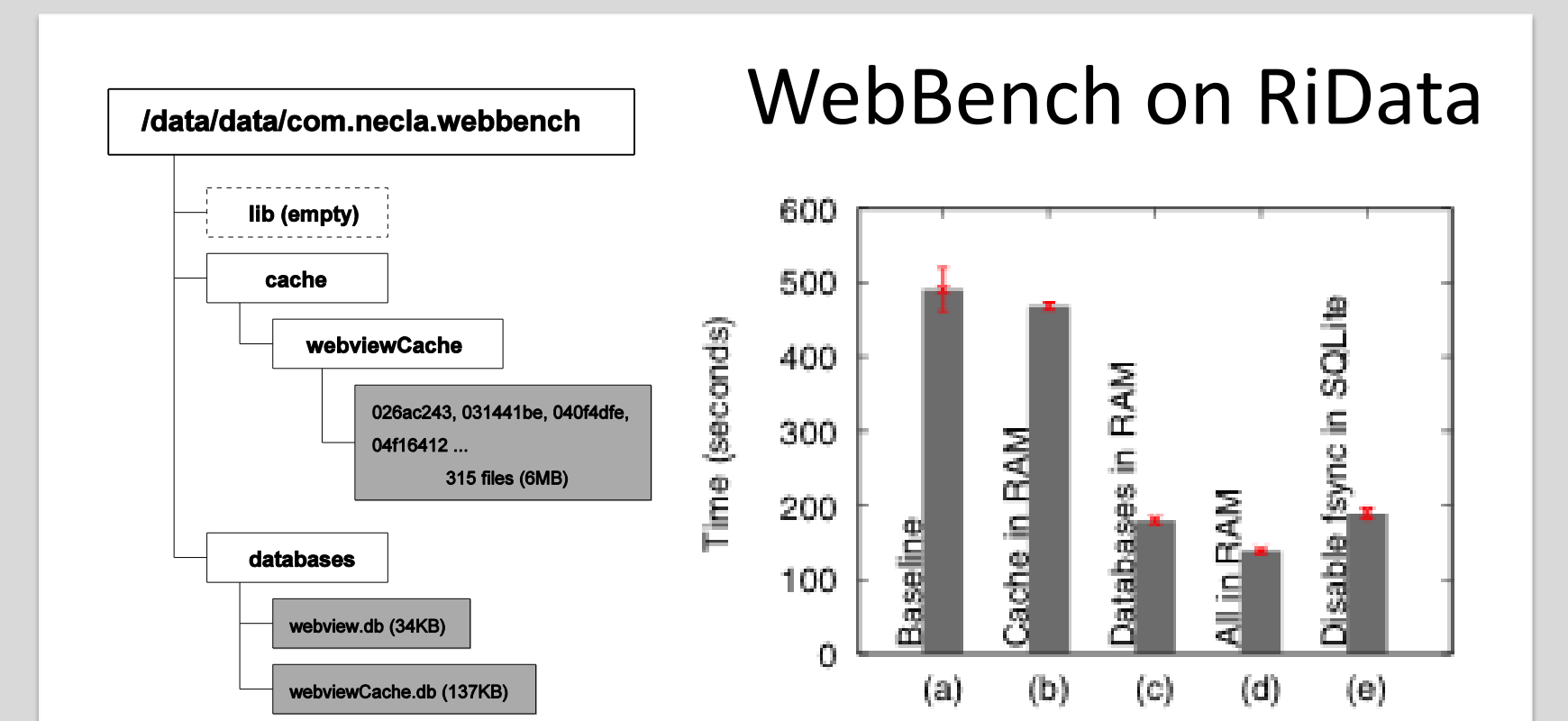- **Device busyness (custom modification) from** /proc/storage_usage

Measurements

WebBench
**Visit 50 websites
Report elapsed time**

USB — to phone (RX) 75.5 Mbits/s / from phone (TX) 57.2 Mbits/s
WiFi — 14.3 Mbits/s / 10.0 Mbits/s

Internal Transcend RiData SanDisk Kingston Wintec AData Patriot PNY

Memory / CPU / Flash

Resource Usage Graphs
What is a performance bottleneck?

18.46	6.263		17.34	6.042
18.12	0.690		16.28	0.706
2.630	1.204		1.722	0.006
2.679	1.023		1.822	0.010

Transcend | Kingston

Trace Analysis
**WebBench generates random writes
Random writes perform very differently on different devices**

Similar Trend from Other Apps

App Install | Email | Facebook | RLBench | Google Maps | Pulse

I T R S K W A P Y

What-If Analysis

/data/data/com.necla.webbench
- lib (empty)
- cache
  - webviewCache
    - 028ac243, 031441be, 0404dfx, 04f16412
    - 315 files (6MB)
- databases
  - webview.db (34KB)
  - webviewCache.db (137KB)

WebBench on RiData

Time (seconds)

(a) Baseline (b) Cache in RAM (c) Databases in RAM (d) All in RAM (e) Disable fsync in SQLite

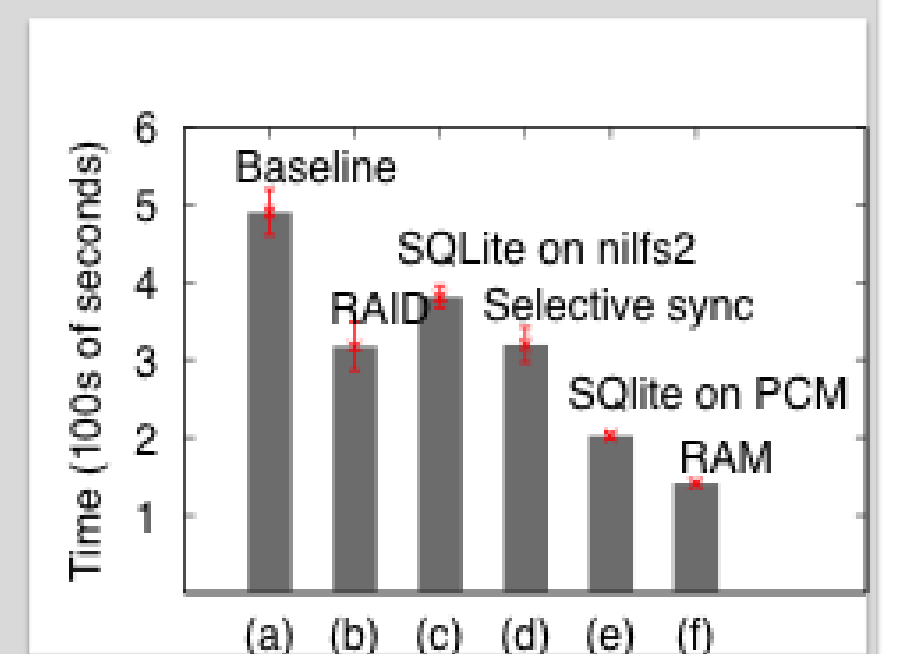### Pilot Solutions

1. **DB (App) level**
   - Selective fsync in SQLite
   - Turn-off FSYNC only for WebCacheDB file
2. **File System Level**
   - Log-structured FS for DB
   - Put DB files on NILFS2 partition
3. **Block Driver Level**
   - RAID with Internal flash and External SD card
   - A simple software RAID driver
4. **Device Level**
   - Phase Change Memory for DB
   - PCM Emulator with RAM

Time (100s of seconds)

Baseline / SQLite on nilfs2 Selective sync / RAID / SQLite on PCM / RAM

(a) (b) (c) (d) (e) (f)

More Results in Paper

- Application Launch time
- Concurrent Application
- CPU Consumption
- RAW device performance
- Explanation of RAID speed up, *and so on …*

Answers

Does the mobile storage subsystem affect the performance of real applications?

Yes, it does!

How can we improve application performance?
Pilot solutions are tested. We are continuing work to refine solutions for deployment!