



Ghosts in the Machine: Interfaces for Better Power Management

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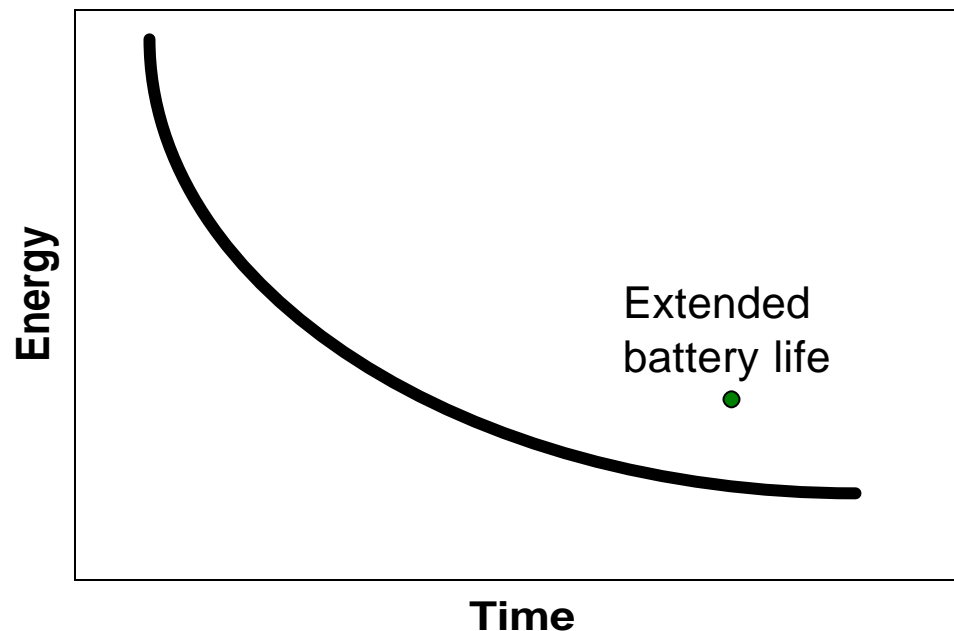


Introduction

- **Power management currently done per I/O device**
- **Applications do not consider current power state of devices**
- ***Result:***
 - **Simple, modular implementation**
 - **System-wide power usage may not be optimal**
 - **Performance, energy may be sacrificed**
- **Careful power management needed**

Tradeoff between energy and performance

- Good performance



- Currently, ... **Inherent tradeoff** exists between performance and energy conservation



Current Device power management

- **Problem:**
Device-centric strategies do not consider the operating environment contexts, such as
 - Base power of mobile computer
 - Activity of other devices
 - Application intent
- **Our Approach:**
Provide an infrastructure to expose additional information about operating environment to both applications and devices



Goals and contribution

- **Goals:**
 - Improve both performance and energy
 - Enable cross-device optimization
 - Allow end users to specify their relative priorities for performance and energy conservation
- **Contributions: Simple interfaces to expose additional contexts**
 - *Power manager* for querying device state
 - *Self-tuning power management (STPM)* modules for disk, n/w
 - *Ghost hints* for cross-device power management

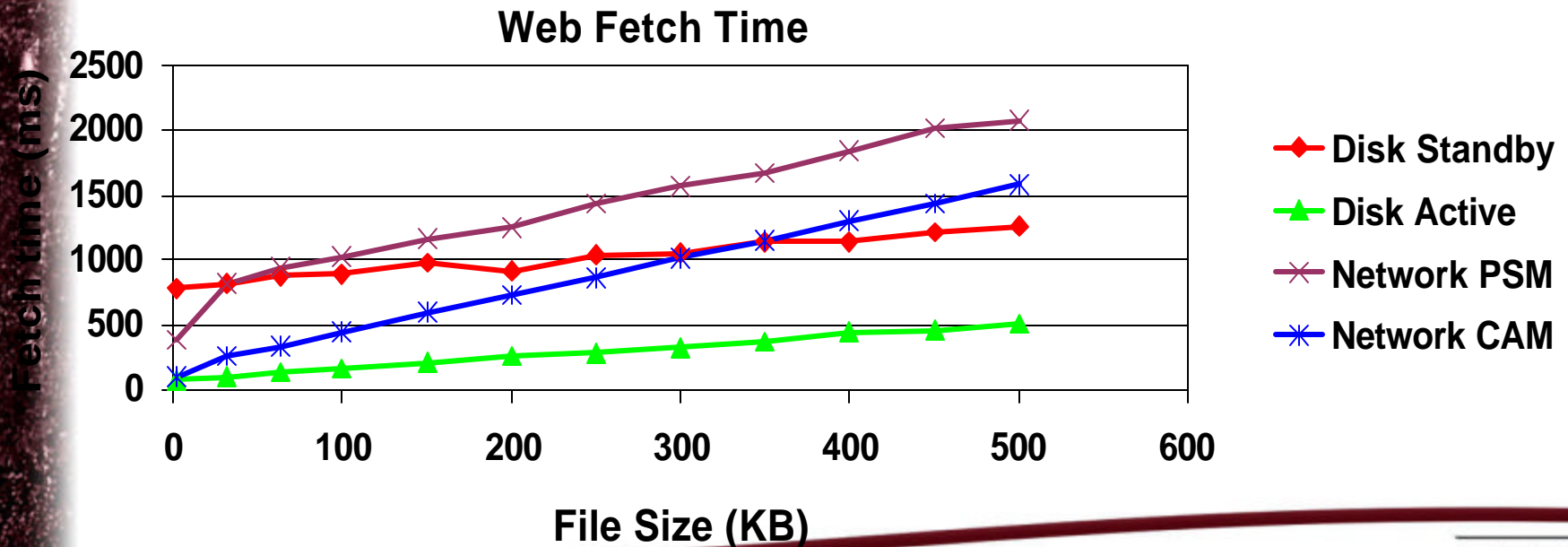


Review: Power Management

- **Network Device: 802.11b wireless**
 - CAM – Continuously Active Mode
 - PSM – Power Saving Mode
 - + power usage reduced by 70 to 80%
 - delay proportional to polling period (100 ms)
- **Disk Device: IBM/Hitachi microdrive**
 - Active
 - Low Power Idle / Standby
 - + power usage reduced by 55% / 90%
 - transition time of 300ms / 800ms

Impact of power management

- Assumption: Local data fetch less costly
- Local access may be more expensive for small files
- Break-even point dependent on device state
- Simple adaptation through cache hierarchy



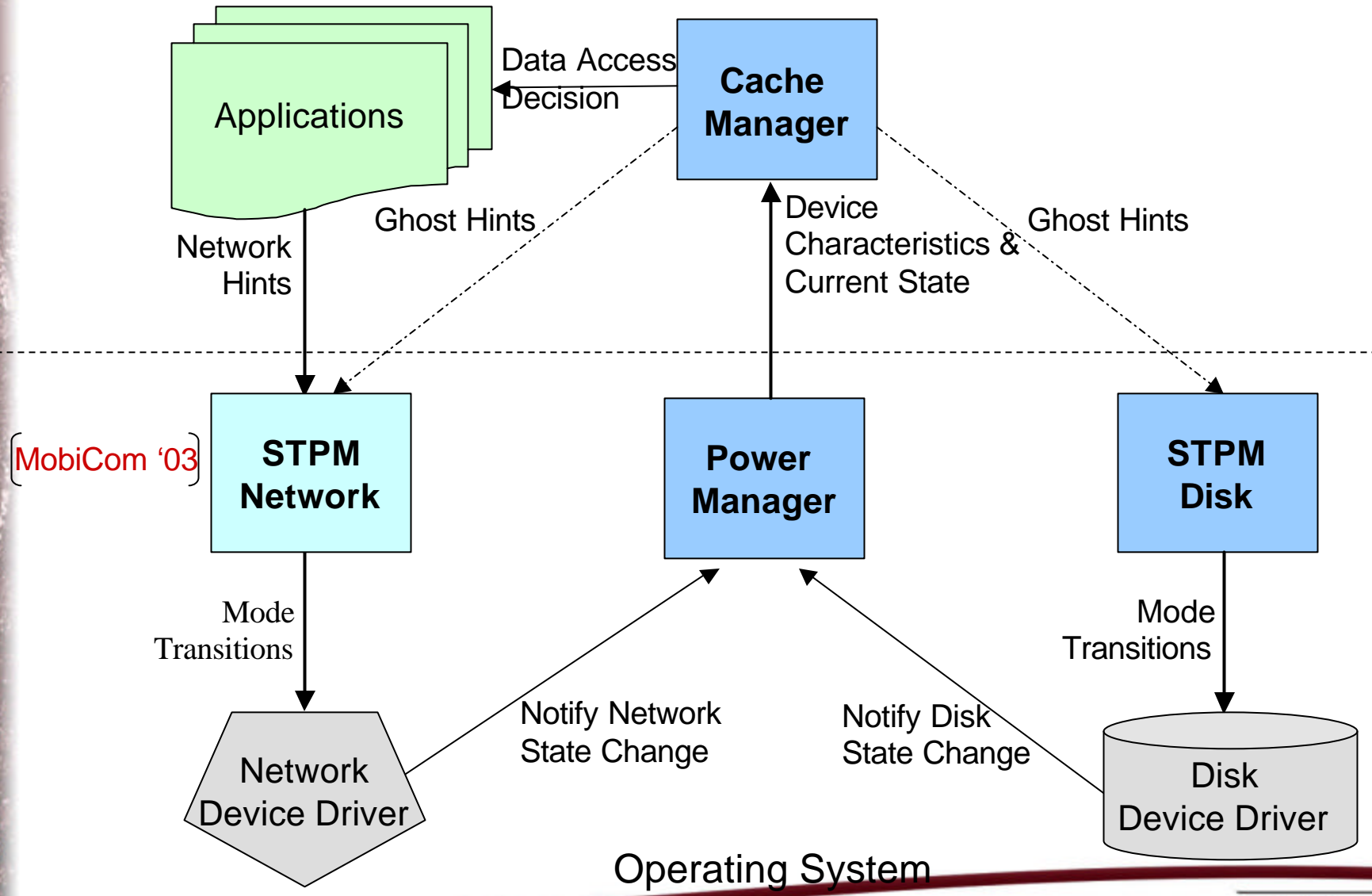


Limitation of adaptation

Example: Browser fetching many small images

- For single image fetching from network is correct
- For many images fetching from disk is correct
 - Amortized transition cost over many reads
- Problem: Reactive adaptive caching does not help
 - Disk continues to be in standby state
- Solution: Apps disclose “accesses that might have been”
 - Authors used *ghost hints* to implement this

Energy-aware architecture



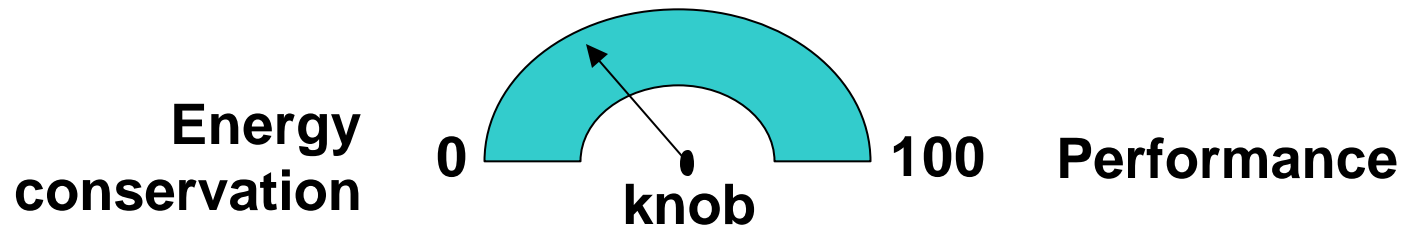


Power manager

- **Central repository that maintains information about:**
 - State of the device
 - Performance characteristics of I/O devices
 - Energy characteristics of I/O devices
- **Power manager interface**
 - 3 calls for devices: register, deregister, notify
 - 5 calls for applications – 4 to query device state and characteristics, 1 for registering callbacks

Self-tuning power management

- **STPM modules consider:**
 - Application access patterns
 - Base power of mobile computer
 - Energy and performance characteristics of the device
 - Relative priority of performance and energy conservation



- **STPM modules decide:**
 - Time to transition to high power state
 - Time to transition to low power state



Disk power management with STPM

Transition to power saving mode employs

- **Break-even heuristic**
 - Disk is likely to remain idle if it has been idle for a period
 - Incorporate the STPM principles

Transition to active mode employs both

- **Reactive strategy**
 - Transition on a request
- **Proactive strategy**
 - Use ghost hints to transition even with no device access

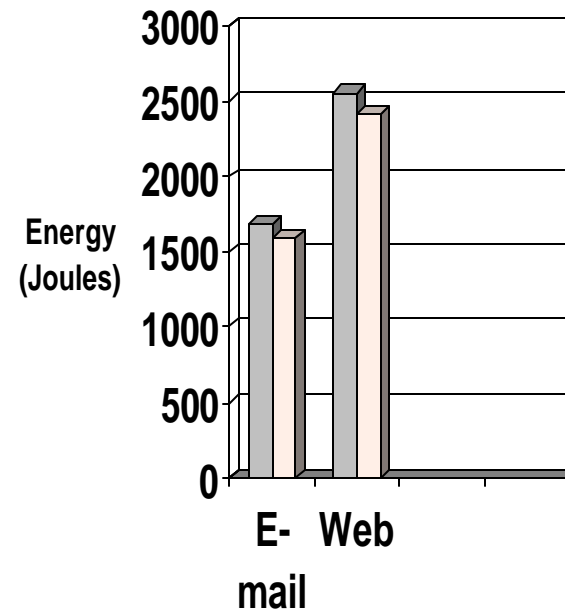
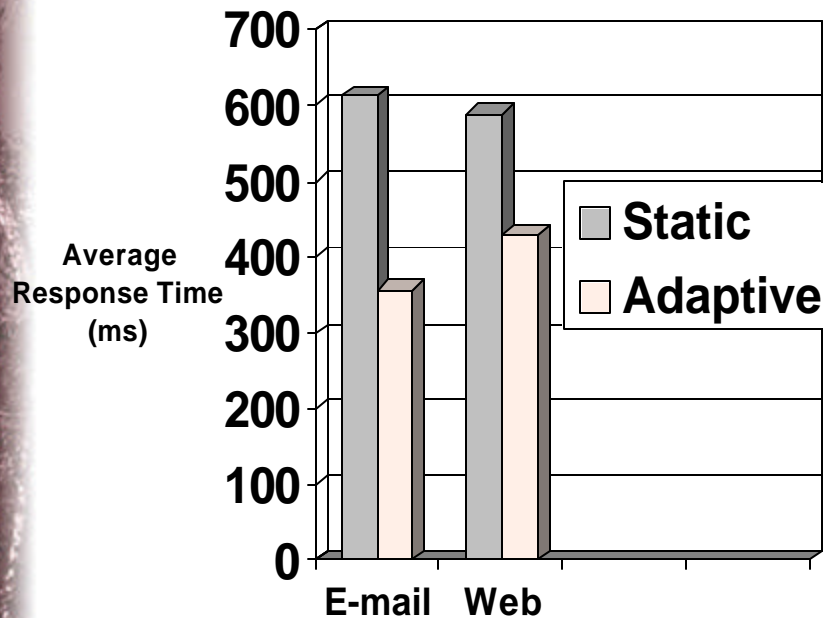
Evaluation

- Goals:
 - Effect of cache manager's adaptive, cross-device strategy
 - Influence of global knob
 - Benefits of ghost hints



- Client: iPAQ handheld with Cisco 350 wireless card and IBM/Hitachi microdrive
- Test applications:
 - Email-sync - recorded e-mail activity
 - Dillo web browser with Berkeley web traces

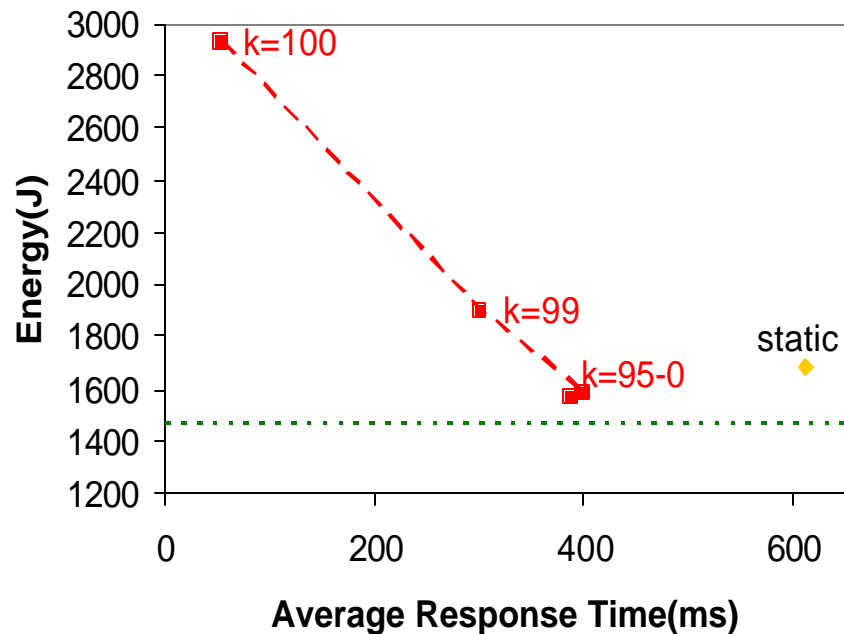
Effectiveness of energy-aware caching



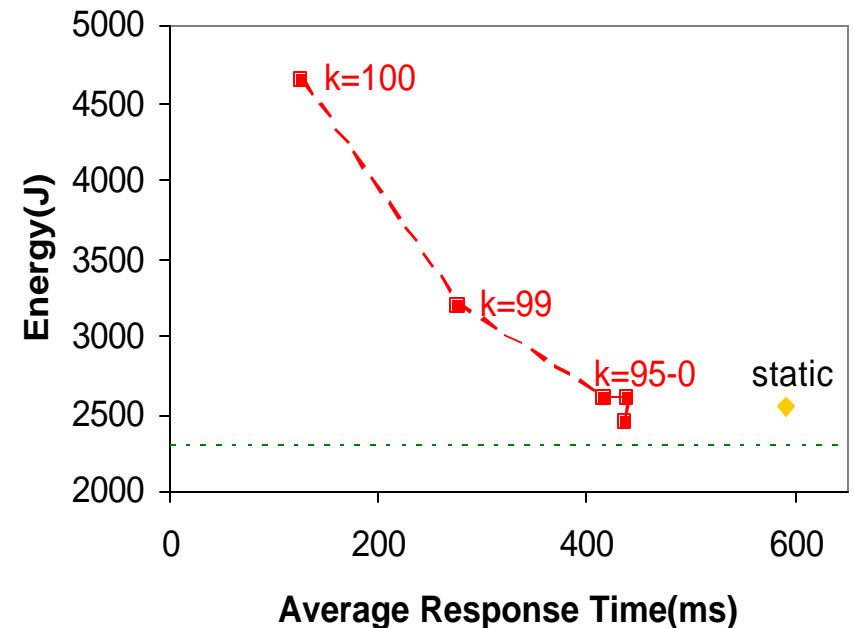
- Equal priority for performance and energy
- Average response time is reduced by 27% to 42%
- Total energy usage is reduced by 5% to 9%

E-mail and web, no ghost hints

E-mail

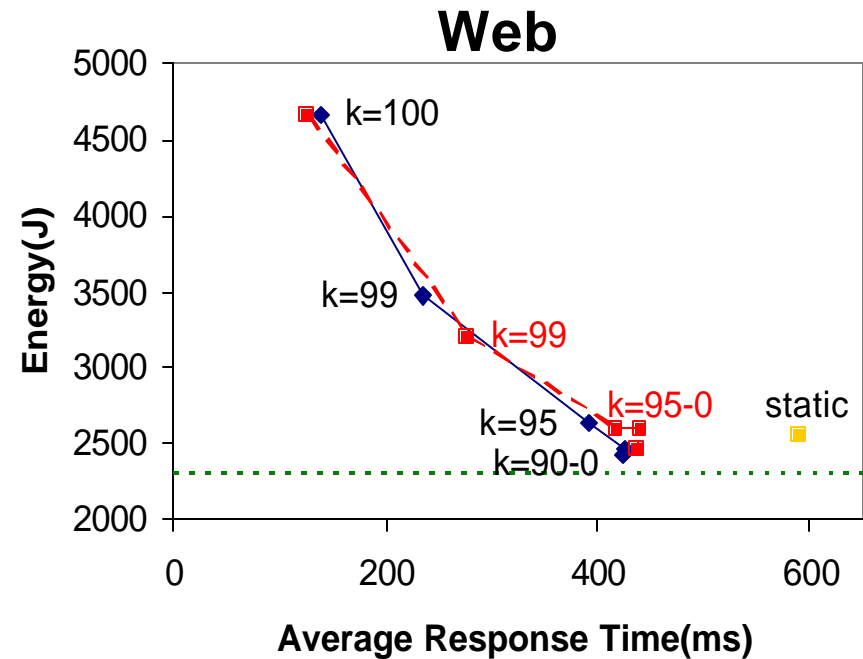
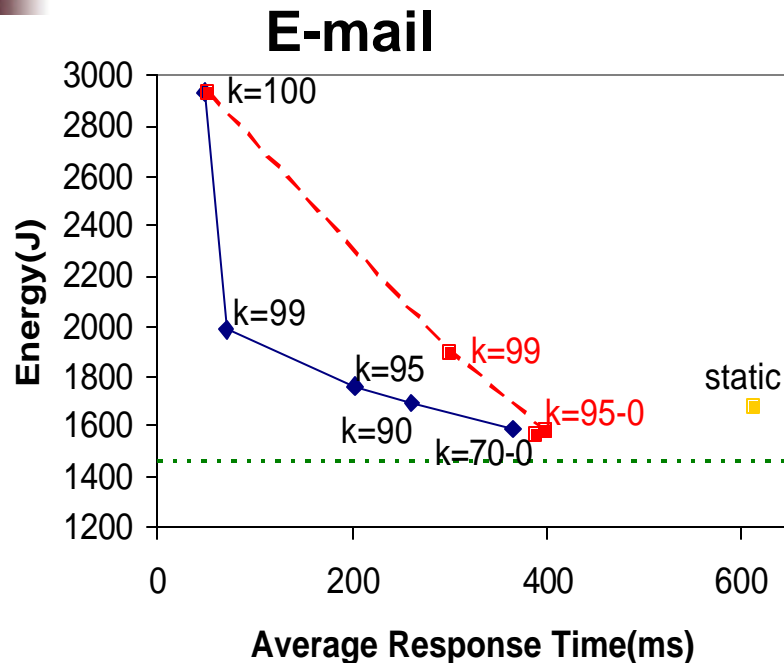


Web



- **STPM modules base their decision solely on device accesses**
- **No change for knob value less than 95**

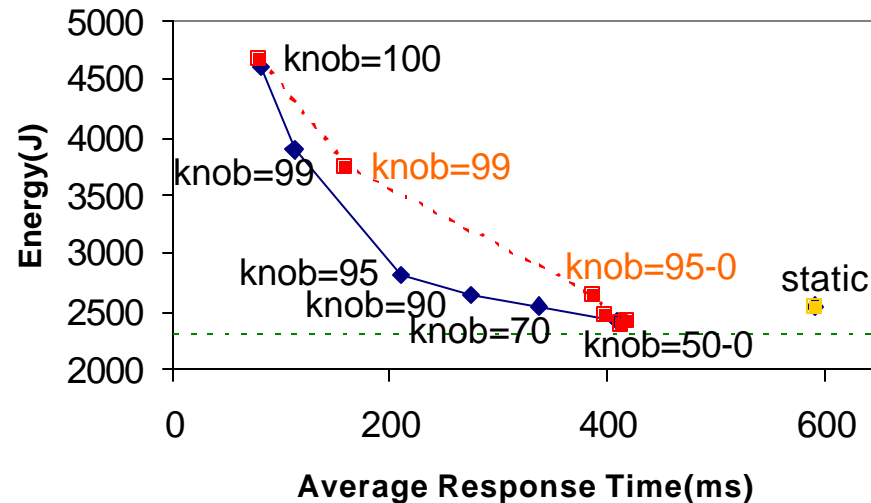
Importance of ghost hints



- **Email: Substantial benefit when performance is high priority**
- **Web: Less likely to see run of accesses clustered together**

Importance of ghost hints

Web with full cache



- **Ghost hints show a positive effect on the system**
- **Ghost hints yield substantial benefit for some workloads, and do no harm in the situations where they seem ineffective**



References

- **MobiSys '04 talk by Manish Anand**