About Linux

- Open Source Operating System
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- 100s or more contributors
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- 7 contributors with rutgers.edu emails
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- cute mascot
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Two Level Memory

- RAM

  - low latency - nanoseconds
  - small capacity
  - high bandwidth - GB/s

- Disk
  - enormous latency - milliseconds
  - large capacity
  - medium bandwidth - 10s of MB/s
Two Level Memory

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Latency/Bandwidth Ratio

- use blocks
Latency/Bandwidth Ratio

- use blocks
- amortized latency = latency / block accesses
Latency/Bandwidth Ratio

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- amortized latency = latency / block accesses
- exploits locality of reference
Memory Abstraction

Virtual Memory
Memory Abstraction

- Virtual Memory
- Hide real location of data
Memory Abstraction

- Virtual Memory
- Hide real location of data
- Evict pages when needed
Eviction

- Clean vs Dirty
Eviction

- Clean vs Dirty
- Dirty write back costly
Eviction

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- Dirty write back costly
- Eviction Policy
  - Least Recently Used
  - Least Frequently Used
LRU in Linux

- active list
LRU in Linux

- active list
- inactive list
LRU in Linux

- active list
- inactive list
- on reference, move up
LRU in Linux

- active list
- inactive list
- on reference, move up
- periodically, refill inactive
LRU in Linux

- active list
- inactive list
- on reference, move up
- periodically, refill inactive
- only approximation to LRU
LRU insufficient

- Databases do own memory management
LRU insufficient

- Databases do own memory management
- Clashes with OS
Properties of Disk

- mechanical movement
- disk seeks slow
- small writes costly
Properties of Disk

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- the big secret
  - page write cost = track write cost
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- about 30 pages per track
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- about 30 pages per track
- try to cluster page writes
- benchmark
  - Sequential page writes - 8 MB/s
  - Random page writes - .35 MB/s
Aggressive Write back

- LRU decides to evict a page
Aggressive Write back

- LRU decides to evict a page
- Aggressively write back nearby pages
Aggressive Write back

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- Relatively easy to bolt on
Aggressive Writeback

- LRU decides to evict a page
- Aggressively write back nearby pages
- Relatively easy to bolt on
- Theoretically wrong
Better Idea

- dirtiness should be bigger factor
Better Idea

- dirtiness should be bigger factor
- prefer dirtier tracks
Better Idea

- dirtiness should be bigger factor
- prefer dirtier tracks
- out of scope of project
Progress

- some source code level understanding
Progress

- some source code level understanding
- printing out data structures in kernel
Progress

- some source code level understanding
- printing out data structures in kernel
- no behavioral modification yet
Acknowledgements

- DIMACS
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- All the REU students