

Final Exam Guide

Objective questions (concepts)

1. Memory hierarchy and Caching

- Types of memory and relative speeds
- Memory hierarchy rationale and organization
- Localities of reference
 - Temporal and Spatial
 - Examples and analysis
- MMU responsibilities
- Cache designs/policies
 - Direct-mapped
 - Fully associative
 - Scalability issues
 - Set associative
 - Terminology: n-way set-associative
 - Multi-byte/word blocks
 - Cache alignment
 - Replacement policies (operation and analysis)
 - FIFO, LFU, LRU
 - Write- through / back / around / allocate
 - Cache metrics
 - hit rate
 - miss rate
 - hit time
 - miss penalty
 - Multi-level caching
- Cache optimization
 - Design principles
 - Blocking

2. Dynamic memory allocation

- Process memory layout
- Heap organization
 - brk pointer
- DMA responsibilities and goals
 - Measuring utilization (peak memory utilization)
- Self-describing blocks
- Internal and External fragmentation
- Implementing a DMA (in C)
 - malloc/realloc/free API: semantics and usage
 - DMA restrictions (e.g., no moving)
 - Basic concerns (implementation and analysis)
 - Metadata vs. Data
 - Block metadata
 - Boundary tags
 - Alignment

- Free space search/reuse policies
- Coalescing
- Common designs (implementation and analysis)
 - Implicit list
 - Explicit list

3. Garbage collection

- Premise and Rationale
- Reference counting GC
 - Manual vs. Automatic
 - Compared to explicit memory management (malloc/free)
 - Basic issues
 - Retain/Release mechanisms
 - Strong/Weak pointers
 - Handling circular references
- Tracing GC
 - Memory as graph
 - Root vs. Heap nodes
 - Mark-and-Sweep algorithm (operation and analysis)
 - Conservative garbage collection
 - Additional heuristics and optimizations
 - e.g., generational and copying GC
 - Overhead and non-deterministic behavior

Discussion / Computational questions

- Structure size computation (factoring in component size and alignment)
- Cache lookup procedure
- Cache hit/miss rate prediction (given code and cache organization)
- Peak memory utilization computation
- Internal / External fragmentation computation
- DMA design considerations (discussion)
 - Minimum block size computation
- Garbage collection analysis and critique

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