Systems
Q Exam Syllabus

1. Computer Architecture [1 (or 2)]

• *Central Processor Structures:* Instruction Sets [P&H 3], Addressing Modes [P&H 3], Computer Arithmetic [Tanenbaum Appendix A, B; P&H 4], Processor Organization: Data Path and Control [P&H 5], Microprogramming [P&H Appendix E], Interrupts [P&H 5.6], Pipelined and Parallel Processors [P&H 6, 9].

• *Caches [P&H 7]:* Cache Organization, Cache Coherence Problem and Solutions.

• *Input/Output [P&H 8]:* Interrupt Driven I/O, Direct Memory Access I/O (DMA).

• *Virtual Memory [P&H 7]:* Paging, Segmentation.

2. Operating Systems [5 (or 4) and 8 and 9]

• *Concurrent Programming and Synchronization [Silberschatz 4, 6; Bic 2]:* Processes and Other Notations for Concurrent Programs, Shared Memory Synchronization [Silberschatz 4, 6.2-7; Bic 2.1-2.5]: Busy-Waiting (e.g. Peterson's algorithm, Bakery algorithm), Semaphores (binary, general), Monitors (signal delayed, signal-urgent disciplines), Classic problems [Silberschatz 6.5; Bic 2.7]: Bounded buffer, Readers and writers, Dining philosophers, Fairness and Starvation [Silberschatz 6.2, 6.5; Bic 2.3.1].

• *Message Passing [Silberschatz 16, 18; Bic 2.6]:* Remote Procedure Call, Synchronous Communications Primitives, Asynchronous Communications Primitives.

• *Deadlocks [Silberschatz 7; Bic 2.7, 4]:* Necessary and Sufficient Conditions [Silberschatz 7.2; Bic 4.3-4], Characterization and Detection [Silberschatz 7.2-7.3, 6.5; Bic 4.3.1-2], Avoidance Algorithms (Banker's Algorithm) [Silberschatz 7.5],

• *Memory Management Techniques [Silberschatz 8,9; Bic 5.1-5.6]:* Static Binding, Relocation, Fragmentation; Dynamic Binding: Paging and Segmentation, Replacement Algorithms, Thrashing and Working Sets.

• *Kernel Architecture [Silberschatz 2.1-2.5, 3.1-3.3, 5.3; Bic 1.5]:* Context Switching, Device Drivers, Interrupt Handlers, Short-term Processor-scheduling.

• *Protection and Security [Silberschatz 13.1-13.6, 14.2, 14.6; Bic 7.3-4]:* Access Control Lists, Capabilities, Private-, Public-Key Cryptography, Digital Signatures.

• *Elements of Distributed Systems [Silberschatz 16, 18.1, papers 8 and 9]:* Causality and Logical Clocks [Lamport], Global States and Snapshot Algorithms [Chandy].

3. Database Systems [6 (or 7)]

• *Data Models:* Entity-relation Model [Korth 2.1--2.7], Relational Model, Algebra, Calculus [Korth 3.1--3.3]

• *Access & Storage Structures:* Disks, File Organization, Access Methods, Buffering [Korth 10], Indexing and Hashing [Korth 11.1-11.3, 11.5-11.7]

• *Query Processing :* Query Languages: SQL [Korth 4.1-4.8], Query Processing Algorithms, Query Equivalences and Cost-Based Optimization [Korth 12 or Ramakrishnan 12, 13]

• *Transaction Management:* Log-Based Recovery Mechanisms [Korth 15.1-15.4, 15.6-15.7], Concurrency Control: 2PL, serializability [Korth 14.1-14.6], Transaction Processing [Korth 13.1-13.6]

• *Object Database Systems:* New data types, extensibility, [Ramakrishnan 21]

4. General Comments

When studying for the Q exam, it is important to keep in mind that questions can -- and often will -- test your ability to synthesize material from more than one topic, or even from more than one area. We mention this because students who read the syllabus very literally tend to prepare by reviewing topics on a one by one basis, consulting the corresponding sections of the references and trying the questions at the end of the corresponding chapters. The danger with this approach, of course, is that a question that crosses boundaries, or that could be solved using one of several methods, demands a type of thinking for which the student may not have prepared. For this reason, we strongly recommend that students prepare for the Q exam in groups, and that group members take turns making up problems similar to the ones seen on old Q exams (but based on this updated syllabus), solving those problems, and discussing the solutions.

5. References

References are given as a *primary reference* and one or more *secondary references*. Any question we ask will be based on the material in the primary reference, but in some cases (outlined below) the secondary reference is better because it treats a topic more clearly or in more detail.

- For architecture, the primary reference will be Patterson & Hennessy (2) (Computer Architecture: A Quantitative Approach by P & H is also fine, although it covers more advanced topics than tested in the exam).

- For operating systems, use either Silberschatz or Bic as the primary reference on topics covered in both textbooks. However, some practical topics (such as communication abstractions) are not covered at all in Bic, while Silberschatz is often too informal on topics involving concurrency and deadlock -- here, Bic is much clearer.

- For databases, the primary reference is Korth; Ramakrishnan is a secondary reference --- it provides much more detail and insight into several of these topics. It also more recent and hence more current.

(Note: You may consult older editions of the references, but section numbers may be different.)

1. Tanenbaum, A.S. *Structured Computer Organization. Third edition.* Prentice-Hall.

2. Patterson, D.A. and J.L. Hennessy. *Computer Organization and Design: The Hardware/Software Interface. Morgan Kaufmann, 1994.*

3. Patterson, D.A. and J.L. Hennessy. *Computer Architecture: A Quantitative Approach. Morgan Kaufmann, 1st ed. 1990, 2nd ed. 1995.*

4. Bic, L. and A. Shaw. *The Logical Design of Operating Systems.* Second Edition, Prentice Hall, New Jersey, 1988.

5. Silberschatz, A and Galvin, P. *Operating System Concepts.* Fourth Edition. Addison-Wesley.

6. Silberschatz, Korth and Sudarshan *Database System Concepts.* Third Edition. McGraw Hill, 1997.

7. Ramakrishnan, R. *Database Management Systems.* McGraw Hill, 1997.

8. Chandy, K.M. and L. Lamport. Distributed Snapshots: Determining Global States of Distributed Systems. *ACM Transactions on Computer Systems* (February 1985) 3, 1, 63-75.

9. Selinger, et. al.. Access Path Selection in a Relational Database Management System *SIGMOD 1979* (copies available from Praveen Seshadri or Rose Chessman).

10. Michael Stonebraker. Object-Relational DBMS-The Next Wave *Informix White Paper: http://www.informix.com/informix/corpinfo/zines/whitpprs/illuswp/wave.htm)* (copies available from Praveen Seshadri or Rose Chessman).