I. EXOKERNEL

1) problems of traditional OS abstraction:
   a) denies domain-specific optimizations.
   b) discourages changes to implementations of existing abstractions.
   c) restricts the flexibility.

   (general-purpose implementations of abstractions force applications that do not need a given feature to pay substantial overhead costs.)
2) methods: secure binding, visible revocation, abort protocol *why not virtual machine?* severe performance penalty
3) secure binding: decouples authorization from the actual use of a resource (seperate protection from management)
   a) implementations: 1, hardware mechanisims; 2, software caching; 3, downloading application code. (*benefits of downloading code*: 1, eliminate kernel crossings; 2, execution time of downloaded code can be readily bounded (no need to be scheduled))

II. NON-SCALABLE LOCK

1) model:
   - a: avg lock acq time on single core.
   - $a_k = (n-k)/a$: arrival rate.
   - s: time in serial section.
   - c: time for home dir to respond to a cache line req.
   - $s_k = 1/(s + ck/2)$: service rate.

   If a large number of waiters, hard to go back. s_k rapidly decays as k grows, for short serial section. (ans to why so rapidly)

III. LEARNING FROM MISTAKES

1) bug pattern: 1, Dead lock. 2, Atomicity violation. 3, Order violation. 4, Others.
2) fixing strategies:
   - non-deadlock: condition check(while-flag; consistency check); code switch; design change; lock (add/change; adjust cric sec regions); others.
   - deadlock: give up resource; split resource; change acq order.

IV. LFS

1) structures
   a) inode map: Current location of each inode. Blocks are written to log; addresses of blocks in checkpoint region. Almost always cached in main memory.
   b) segment usage table: 1, the number of live bytes in the seg. 2, most recent modified time of any block in the seg. Used by cleaner. Blocks are written to log, addresses of blocks in checkpoint region.
   c) checkpoints: Special fixed position on disk. Addresses of all the blocks in inode map, seg usage table, current time, pointer to last seg written. Two checkpoint regions, operations alternate between them. Time: perriodically, when FS unmounted, system shut down.
   d) directory operation log: Operation code, location of dir entry (inum and pos within dir), contents (name and inum), new ref count. In log, before corresponding dir block or inode.