

## COMPUTER SCIENCE TRIPOS Part IA – 2021 – Paper 2

### 3 Operating Systems (ek264)

- (a) Assume a simple paging system with  $2^{32}$  bytes of physical memory,  $2^{48}$  bytes of logical address space and pages that are  $2^{20}$  bytes in size. Further assume that each page table entry contains 4 bits indicating protection and validity of the entry.
- (i) How many bits are used for the frame number and how many for the frame offset? [1 mark]
  - (ii) What is the total size of the page table in number of bits? [2 marks]
  - (iii) Assume that the working set of a typical process is fixed throughout the process lifetime and consists of 20 pages. How many entries would you suggest for the Translation Lookaside Buffer (TLB) for this system? What would its total size be in number of bits? Explain your answer. [4 marks]
  - (iv) Further assume that TLB search time is 20ns, TLB hit ratio is 80% and memory access time is 100ns. How many page table levels would you need to achieve an effective access time of 160ns, and why? [3 marks]
- (b) (i) A Unix i-node has 12 disk addresses for direct disk blocks and three addresses for single, double, and triple indirect blocks. If each indirect block contains 256 disk addresses, what is the maximum file size supported by this system? Assume disk blocks of 4KB. [3 marks]
- (ii) Assume that you are *user1* in a Unix file system and that you need to read the file `/home/user1/test/test1.html` which is stored in 4 disk blocks. Further assume that the `/` directory i-node is kept memory and each i-node and directory file fits in one disk block. How many disk accesses are required to read `test1.html`? Explain your answer. [4 marks]
  - (iii) Assume that *user1* wants to read `/home/user1/test/test2.html` immediately after reading `/home/user1/test/test1.html`. Further assume that file `test2.html` is stored in 4 disk blocks. How many disk accesses are required to read `test2.html`? Explain your answer. [3 marks]