

3 Operating Systems (rmm1002)

Consider an operating system that uses hardware support for paging to provide virtual memory to applications.

(a) (i) Explain how the hardware and operating system support for paging combine to prevent one process from accessing another's memory. [3 marks]

(ii) Explain how space and time overheads arise from use of paging, and how the Translation Lookaside Buffer (TLB) mitigates the time overheads. [3 marks]

(b) Consider a system with a five level page table where each level in the page table is indexed by 9 bits and pages are 4 kB in size. A TLB is provided that is indexed by the first 57 bits of the address provided by the process, and achieves a 90% hit rate. A main memory access takes 40 ns while an access to the TLB takes 10 ns. The maximum memory read bandwidth is 100 GB/s.

(i) What is the effective memory access latency? [4 marks]

(ii) A colleague suggests replacing the system above with one that provides 80 GB/s memory read bandwidth and main memory access latency of 30 ns. Explain whether you should accept the replacement or not, and why. [4 marks]

(c) A creative engineer suggests structuring the TLB so that not all the bits of the presented address need match to result in a hit. Suggest how this might be achieved, and what might be the costs and benefits of doing so. [6 marks]