Foundations of Information Systems

Winter Semester 2024–25, Exercise 8

For discussion on Wednesday, December 18, 2024

1. Show that if a process occupies m bytes of memory, virtual memory is divided into page frames of s bytes each, and the page table entry for each page requires t bytes of memory, then the optimal size of the page frame is

$$s = \sqrt{2\,m\,t}\,.$$

   Hint: Assume that, on average, half of a page frame is wasted. Also assume that each page needs exactly one page table entry of t bytes.[1]

2. Continuing Problem 1: On 32-bit Intel architectures, the standard size of a page frame is $4\,\text{KB} = 2^{12}\,\text{B}$. A single entry in the page table requires $32\,\text{bit} = 4\,\text{B}$. What is the implicit assumption on the typical size of a process?

3. Continuing Problems 1 and 2: On 64-bit architectures, the size of a page table entry goes up to $64\,\text{bit} = 8\,\text{B}$. How does the result change? Comment!

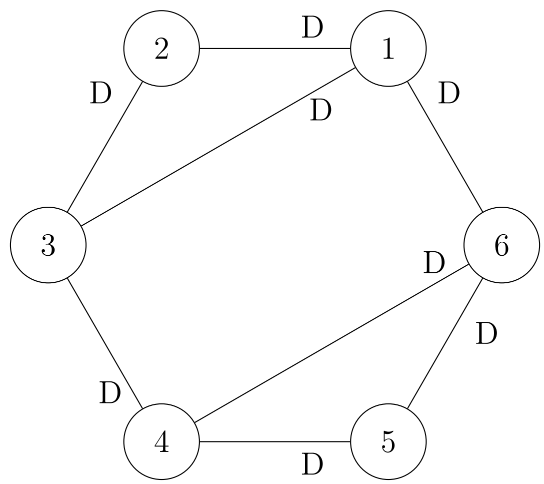
4. (Forouzan, P7-9.) Three processes (A, B, and C) are running concurrently. Process A has acquired `File1`, but needs `File2`. Process B has acquired `File3`, but needs `File1`. Process C has acquired `File2`, but needs `File3`. Draw a diagram for these processes. Is this a deadlock situation?

5. (Forouzan, P7-10.) Three processes (A, B, and C) are running concurrently. Process A has acquired `File1`. Process B has acquired `File2`, but needs `File1`. Process C has acquired `File3`, but needs `File2`. Draw a diagram for these processes. Is this a deadlock situation? If your answer is "no", show how the processes can eventually finish their tasks.

6. One solution to the *dining philosophers problem* demands that only four of the five philosopher sit at the table at any one time. When a philosopher finishes eating, she gets up and lets the standing philosopher take a seat. Is this solution free of deadlock? Is starvation possible?

[1] In practice, things are more complicated as page tables are organized as multilevel trees to be able to efficiently address non-contiguous blocks of virtual memory. So the formula given is just a back-of-the-envelope estimate.

7. Consider the following generalized dining philosopher's problem. There are six philosophers, needing pairwise shared resources to eat. They follow the Chandy–Misra protocol, i.e., resources are either *dirty* ("D") or *clean* ("C"). The resources are attached to edges of the following graph, with the initial configuration as shown:



(a) Show that the initial graph is acyclic.

(b) Assume that all philosophers are hungry at the same time, once they have eaten, they will not get hungry again. In which order do they get to eat? If there is ambiguity, assume that a philosopher who can eat will eat immediately, and before honoring any a request for a resource *before*.