ETH
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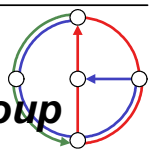
Distributed Computing Group



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Discrete Event Systems
Exercise 12

1 Bin Packing

In order to finance your studies you accept a job on the assembly line of a production firm. Your duty is very simple: You have to pick the items delivered to you on the assembly line, put them into a bin and close the bin.

Now assume that there are n items of size $s_i \leq 1$ while the bins have size 1. Moreover, assume your algorithm is a very simple one: You handle the items in order of their arrival and put them into a bin as long as there is enough space left. If an item arrives that does not fit into the bin anymore, you close the bin and start with a new, empty bin.

Calculate the competitive ratio with respect to the total number of bins you need compared to an offline algorithm which distributes the items optimally among the bins.

2 Paging

Paging plays an important role in almost every computer system. Typically, there is a fast cache which allows fast access, but which has limited space. On the other hand, access to the disk is slow, but space is plenty.

We consider a simple system in which the cache has enough space to store 3 pages. Given a request for a page p_i, the system must make p_i available in the cache. If p_i is already in the cache (called a *hit*), the system does nothing. Otherwise (a *miss*), the system incurs a *page fault* and must copy the page p_i from the disk to one of the 3 locations in the cache. In case all 3 slots in the cache are already occupied with other pages, the system is faced with the problem of which page to evict from the cache in order to make space for p_i.

In our model, we have to pay a price of 1 for each page fault, while accessing a page that is already in the cache is for free. In this exercise, we analyze the competitiveness of several well known paging strategies.

a) Consider the following paging strategies. Which of them are competitive and which are not?

- FIFO (First-in/First-out): Replace the page that has been in the cache longest.
- LFU (Least Frequently Used): Replace the page that has been requested the least since entering the fast memory.
- LIFO (Last-in/First-out): Replace the page most recently moved to the cache.
- LRU (Least Recently Used): When eviction is necessary, replace the page whose most recent request was the earliest.
- FWF (Flush When Full): Whenever there is a page fault and there is no space left in the cache, evict *all* pages currently in the cache.

Hint: An online strategy is *not competitive* if its competitive ratio is unbounded.

b) All the above strategies are deterministic. Prove a lower bound on the competitive ratio of any deterministic paging strategy.