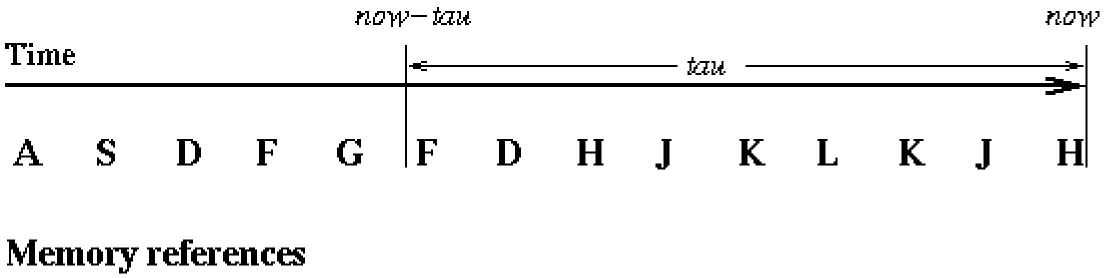
CS 537 Notes, Section #21: Working Sets

Working Sets are a solution proposed by Peter Denning. An informal definition is "the collection of pages that a process is working with, and which must thus be resident if the process is to avoid thrashing." The idea is to use the recent needs of a process to predict its future needs.

- Choose tau, the working set parameter. At any given time, all pages referenced by a process in its last tau seconds of execution are considered to comprise its *working set*.



- A process will never be executed unless its working set is resident in main memory. Pages outside the working set may be discarded at any time.

Working sets are not enough by themselves to make sure memory does not get overcommitted. We must also introduce the idea of a *balance set*:

- If the sum of the working sets of all runnable processes is greater than the size of memory, then refuse to run some of the processes (for a while).
- Divide runnable processes up into two groups: active and inactive. When a process is made active its working set is loaded, when it is made inactive its working set is allowed to migrate back to disk. The collection of active processes is called the *balance set*.
- Some algorithm must be provided for moving processes into and out of the balance set. What happens if the balance set changes too frequently?

As working sets change, corresponding changes will have to be made in the balance set.

Problem with the working set: must constantly be updating working set information.

- One of the initial plans was to store some sort of a capacitor with each memory page. The capacitor would be charged on each reference, then would discharge slowly if the page was not referenced. Tau would be determined by the size of the capacitor. This was not actually implemented. One problem is that we want separate working sets for each process, so the capacitor should only be allowed to discharge when a particular process executes. What if a page is shared?
- Actual solution: take advantage of use bits

- OS maintains *idle time* value for each page: amount of CPU time received by process since last access to page.
- Every once in a while, scan all pages of a process. For each use bit on, clear page's idle time. For use bit off, add process' CPU time (since last scan) to idle time. Turn all use bits off during scan.
- Scans happen on order of every few seconds (in Unix, tau is on the order of a minute or more).

This actual solution is an approximation algorithm known as *WSClock*.

Other questions about working sets and memory management in general:

- What should tau be?
  - What if it is too large?
  - What if it is too small?
- What algorithms should be used to determine which processes are in the balance set?
- How do we compute working sets if pages are shared?
- How much memory is needed in order to keep the CPU busy? Note than under working set methods the CPU may occasionally sit idle even though there are runnable processes.

THIS ENDS THE SECTION ON MEMORY MANAGEMENT
