CS 537 Notes, Section #4: Independent and Cooperating Processes

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Chapter 6, Section 6.1, in **Operating Systems Concepts**.

Independent process: one that is independent of the rest of the universe.

- Its state is not shared in any way by any other process.
- Deterministic: input state alone determines results.
- Reproducible.
- Can stop and restart with no bad effects (only time varies).

Example: program that sums the integers from 1 to i (input).

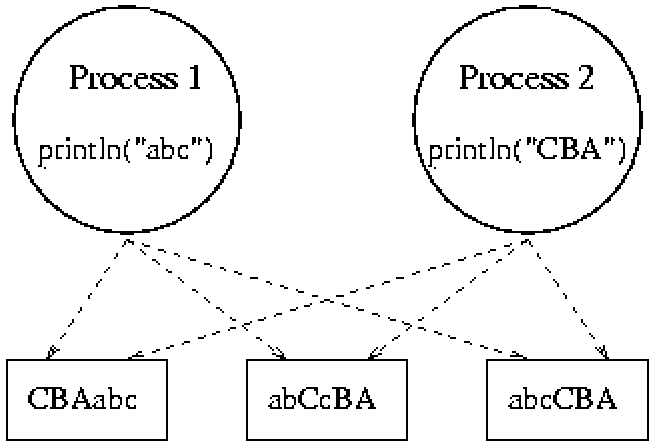
There are many different ways in which a collection of independent processes might be executed on a processor:

- Uniprogramming: a single process is run to completion before anything else can be run on the processor.
- Multiprogramming: share one processor among several processes. If no shared state, then order of dispatching is irrelevant.
- Multiprocessing: if multiprogramming works, then it should also be ok to run processes in parallel on separate processors.
  - A given process runs on only one processor at a time.
  - A process may run on different processors at different times (move state, assume processors are identical).
  - Cannot distinguish multiprocessing from multiprogramming on a very fine grain.

How often are processes completely independent of the rest of the universe?

Cooperating processes:

- Machine must model the social structures of the people that use it. People cooperate, so machine must support that cooperation. Cooperation means shared state, e.g. a single file system.
- Cooperating processes are those that share state. (May or may not actually be "cooperating")
- Behavior is *nondeterministic*: depends on relative execution sequence and cannot be predicted a priori.
- Behavior is *irreproducible*.
- Example: one process writes "ABC", another writes "CBA".



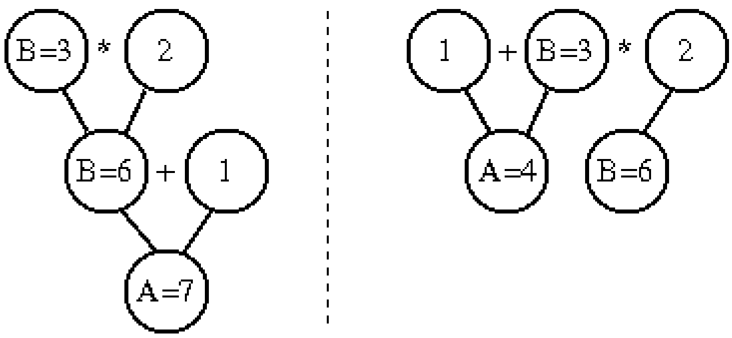
When discussing concurrent processes, multiprogramming is as dangerous as multiprocessing unless you have tight control over the multiprogramming. Also bear in mind that smart I/O devices are as bad as cooperating processes (they share the memory).

Why permit processes to cooperate?

- Want to share resources:
  - One computer, many users.
  - One file of checking account records, many tellers.
- Want to do things faster:
  - Read next block while processing current one.
  - Divide job into sub-jobs, execute in parallel.
- Want to construct systems in modular fashion. (e.g. tbl | eqn | troff)

Basic assumption for cooperating process systems is that the order of some operations is irrelevant; certain operations are completely independent of certain other operations. Only a few things matter:

- Example: A = 1; B = 2; has same result as B = 2; A = 1;
- Another example: A = B+1; B = 2*B cannot be re-ordered.



Race conditions: Suppose A=1 and A=2 are executed in parallel?

Atomic operations: Before we can say ANYTHING about parallel processes, we must know that some operation is *atomic*, i.e. that it either happens in its entirety without interruption, or not at all. Cannot be interrupted in the middle. E.g. suppose that println is atomic -- what happens in println("ABC"); println("BCA") example?

- References and assignments are atomic in almost all systems. A=B will always get a good value for B, will always set a good value for A (not necessarily true for arrays, records, or even floating-point numbers).
- In uniprocessor systems, anything between interrupts is atomic.
- If you do not have an atomic operation, you cannot make one. Fortunately, the hardware folks give us atomic ops.

- If you have any atomic operation, you can use it to generate higher-level constructs and make parallel programs work correctly. This is the approach we will take in this class.
