Need for an operating system

- Many applications are complex enough that writing one program does not suffice.

- When multiple operations must be performed at widely varying times, a single program can easily become complex.

- Process: clearly defines the state of the executing program

- Operating system: The mechanism for switching the execution between processes.

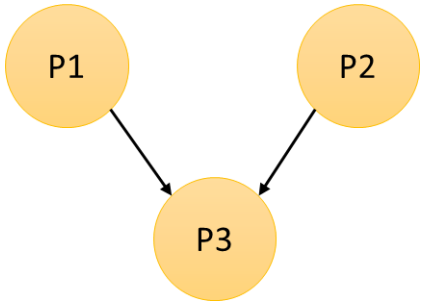
- Real-time Operating system: an operating system that can meet timing requirements.

Reactive Systems

- Respond to external events.
  - Engine controller.
  - Seat belt monitor.
- Requires real-time response.
  - System architecture.
  - Program implementation.
- May require a chain reaction among multiple processors.

Tasks and processes

- A task is a functional description of a connected set of operations.
- (Task can also mean a collection of processes.)



A task made of three subtasks

A process is a unique execution of a program.

- Several copies of a program may run simultaneously or at different times.

A process has its own state:

- registers;
- memory.

The operating system manages processes

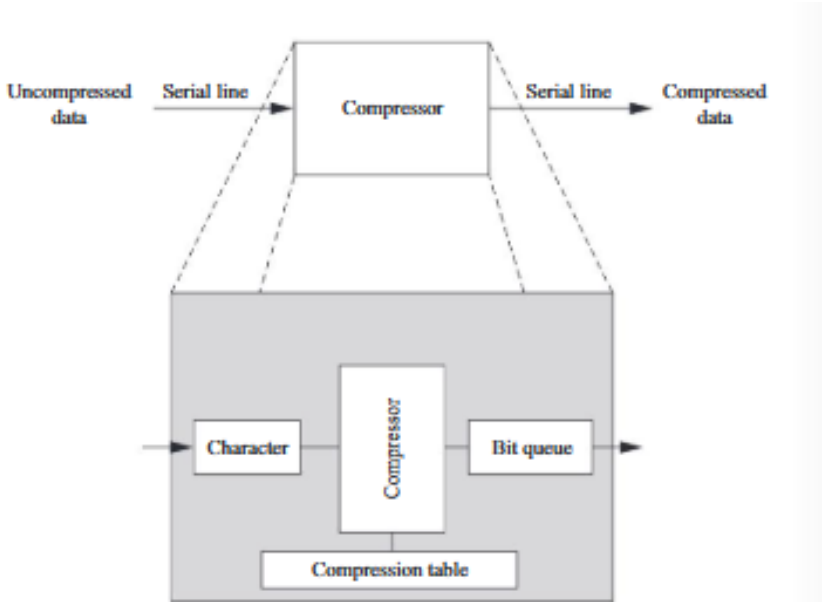
Multiple Processes

- Multiple tasks means multiple processes.
- Processes help with timing complexity:
  - multiple rates
    - multimedia
    - automotive
  - asynchronous input
    - user interfaces
    - communication systems

Multi-rate Systems

- Tasks may be synchronous or asynchronous.
- Synchronous tasks may recur at different rates.
- Processes run at different rates based on computational needs of the tasks.

Text compression engine



Multi-rate system: input is always 7 bits but after characters are compressed their size can vary

Can include an asynchronous input: user can choose not to compress data

Engine Controller

Variable	Full range time (ms)	Update period (ms)
Engine spark timing	300	2
Throttle	40	2
Air flow	30	4
Battery voltage	80	4
Fuel flow	250	10
Recycled exhaust gas	500	25
Status switches	100	20
Air temperature	Seconds	400
Barometric pressure	Seconds	1000
Spark (dwell)	10	1
Fuel adjustment	80	8
Carburetor	500	25
Mode actuators	100	100

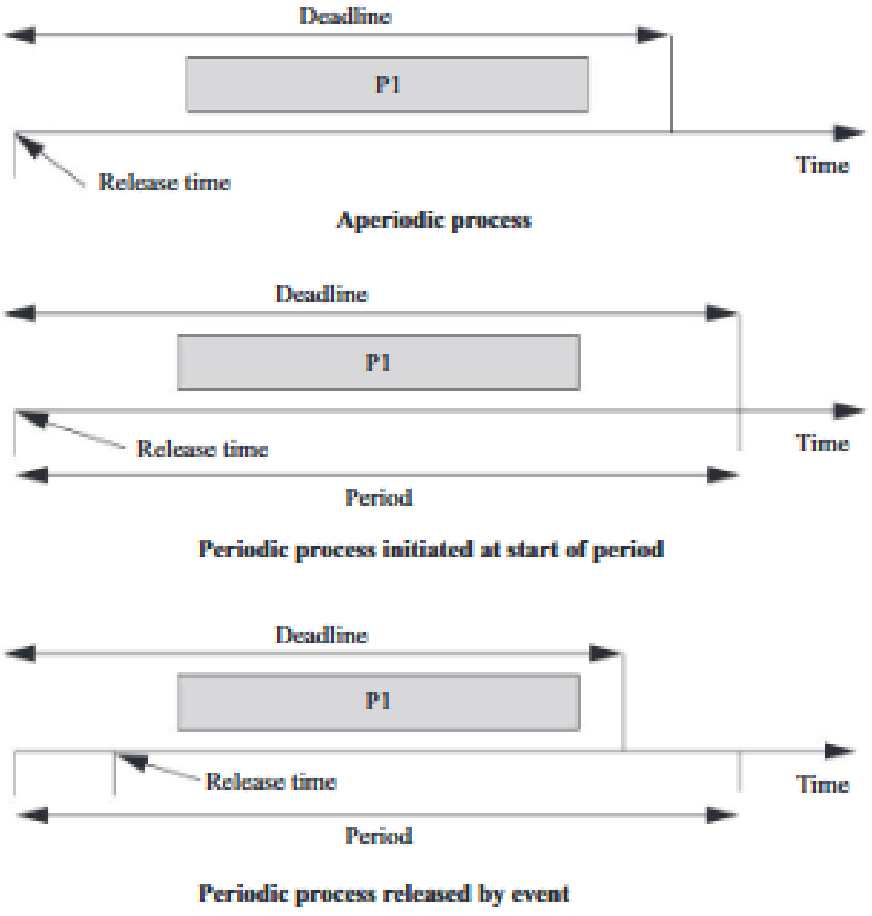
Real-time Systems

- Perform a computation to conform to external timing constraints.
- Deadline frequency:
  - Periodic.
  - Aperiodic.
- Deadline type:
  - Hard: failure to meet deadline causes system failure.
  - Soft: failure to meet deadline causes degraded response.
  - Firm: late response is useless but some late responses can be tolerated.

Timing specifications on processes

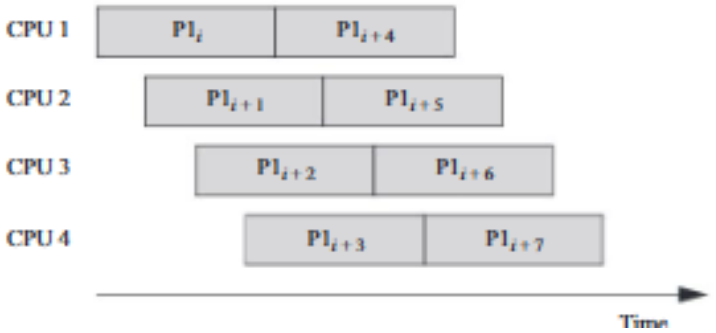
- Release time: time at which process becomes ready.
- Deadline: time at which process must finish.

Release time and Deadlines



Rate requirements on processes

- Period: interval between process activations.
- Rate: reciprocal of period.
- Initiation rate may be higher than period--- several copies of process run at once.



Timing violations

What happens if a process doesn't finish by its deadline?

- Hard deadline: system fails if missed.
- Soft deadline: user may notice, but system doesn't necessarily fail.

Task graphs

- Tasks may have data dependencies---

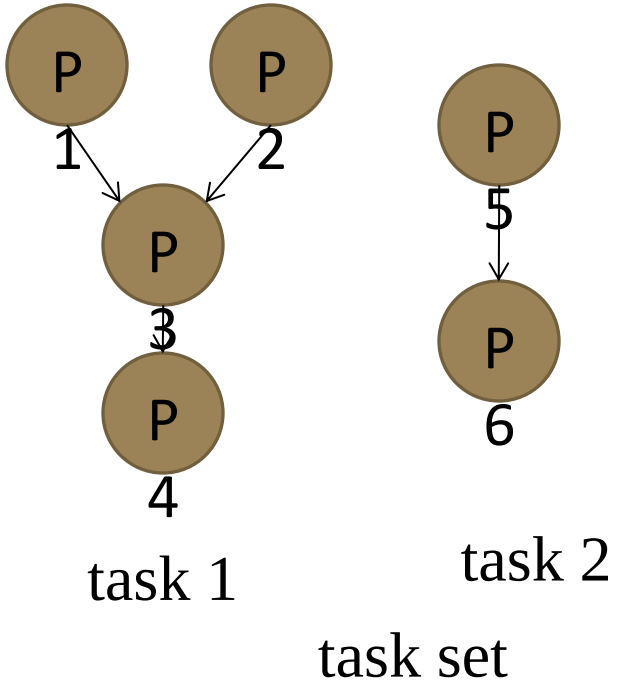
  must execute in certain order.

- Task graph shows data/control

  dependencies between processes.

- Task: connected set of processes.

- Task set: One or more tasks.



Communication between tasks

- Task graph assumes that all processes in each task run at the same rate, tasks do not communicate.
- In reality, some amount of inter-task communication is necessary.
  - It's hard to require immediate response for multi-rate communication.