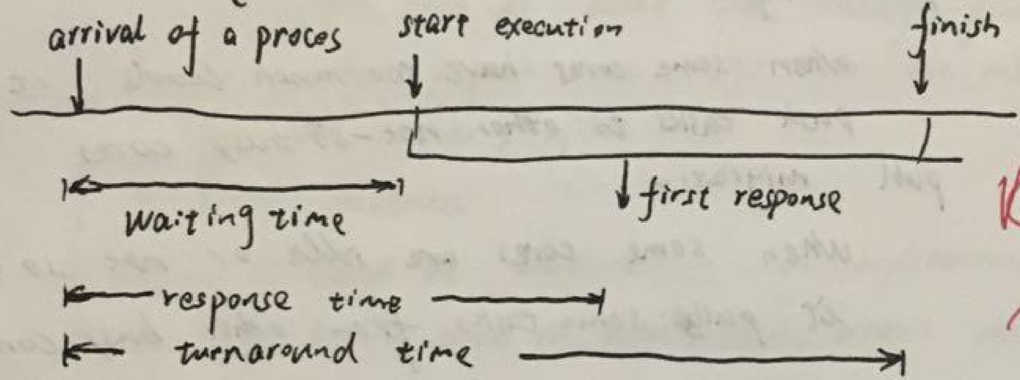
2. When an operating system wants to run multiple applications at once, the act of deciding which one to run is called **scheduling**. Tell me what you know about it, with regards to both **single-core processors** and **multi-core processors**.

° General scheduling (Single - core)

- criteria

performance related:
1) to maximize CPU utilization
2) to maximize throughput (average process finish in a time unit)
3) to minimize avg. process's waiting time
4) to minimize avg. process's response time
5) to minimize avg. process's turnaround time



Really NICE!
5/5

non-performance related:
1) do not starve
2) prefer processes with higher priorities
3) fairness (even though hard to define :))

- algorithm & effects
1) First-come-First serve
easy but may starve later coming process if first coming ones take too long
2) Short time first: execute shortest burst time's tasks first
hard to get a right estimate of bursting time and may fail to response to urgent processes
3) Round Robin
Feasible but sometimes it fails to respons to vital process and the time slices if not fairly design may waste too much
4) multi-level queue
consist of multi level queues where each represents a priority processes may change between queues.
Rather fair, but there is never a best solution

(See backwards for multi-core stuffs)

- multi-core scheduling
  - need to judge sequential tasks and paralleled tasks
  - ~~-need~~
  - more a load balancing stuff and estimate burst time accurately
  - need to consider synchronization and cache coherence

    generally use more mutex locks or semaphores to protect

  - Some detailed mechanism ~~are that when multi-core~~ some cores

    push migration:

    when some cores have too much loads, it push tasks to other not-so-busy cores

    pull migration:

    when some cores are idle or not so busy, it pulls some tasks from other busy cores.

3rdQuestion.md - Grip

The communication through threads and processes are generally called inter process communication (IPC)

IPC

IPC Implementation by theory

1. Could be implemented via shared memory like mailboxes
2. Could also be done via message queue where a sender push some messages queue resides in the receiver's space
3. Could be implemented via interrupt, so when a message sent, the other thread got interrupted and check it in interrrupt handler
4. Could be done via polling, aka. receiver checks it periodically

Some features

1. Could be unidirectional or bidirectional
2. A link could be established within more than 2 threads
3. More than one linke could be established between 2 threads

Some unix implementation examples

pipe, file, send/recv (socket)

hardware involved

- need to offer some shared memory and interrrupt mechanism
- may offer some register as pointer of message queue if it has already offered many registers for context switching use (like Sun Sparc)

Synchronization

It is vital to prevent race condition in multi-thread tasks, i.e. other thread won't affect current thread to generate a different result.

A famous example could be read & write problems.

To prevent from race condition, we can

- don't share data
  - sounds stupid but it works
- disable interrrupts to ensure one thing at a time won't work if multi cores involved
- use test and set mechanism
  - need some cache-coherence to help if we want it work as well in multi-core
- use special designed lock like :

```
DisableInterrupt();
DoStuffAboutCriticalSection();
EnableInterrupt();
```

Hardware invovling

- Test-and-set / compare-and-swap mechanism needs hardware offer some places of memory to help.
- Other software mechanism like mutex lock / semaphore needs hardware supports cache-coherence if using in multi-core environment.