The problem of job scheduling for Stage 2 involves the optimisation of one or more objectives (e.g., turnaround time) while not violating constraints, such as resource requirements. In this week's workshop, you're required to work out values of three performance metrics for a schedule generated by a particular algorithm.

1 Performance metrics

- Waiting time: For a given job, it is defined as the amount of time taken from the submission to the start time
- Turnaround time: For a given job, it is defined as waiting time + execution time (run time)
- Rental cost: For a given server, it is defined as the total resource usage[1] (in seconds) * the per-second rental cost[2]
- Resource utilisation (or simply utilisation): For a given server, it is defined as the actual resource usage (excluding idle times) / the total resource usage

2 An Example Schedule

The following is the drawing of a schedule[3] generated by FF for `ds-config01--wk9.xml`. The drawing shows where each job is assigned to, indicating job ID, server type, submission time (circle on a dashed line), start time (rectangle on a solid line), and end time (circle on a solid line).

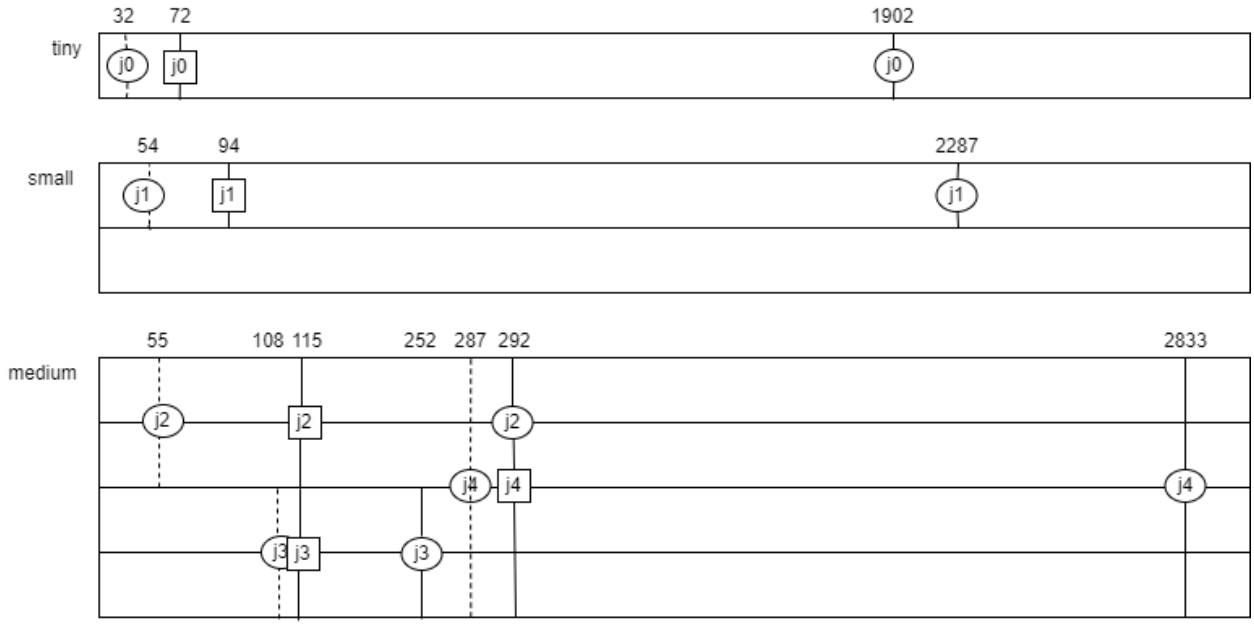

Figure 1: A schedule generated by FF.

[1] For a given server, the total resource usage is defined as the amount of time from the time a server starts to execute the first job (excluding the booting time) to the time the last job completes, including idle times, regardless of the actual amount of resources used. If the server got terminated/turned off and turned back on in the middle, the time it was 'inactive' (turned off) is not included.

[2] The per-second rental cost is calculated as the hourly rental rate / 3600.

[3] The schedule you get in your machine might differ.

3 Exercise

Task 1: Calculate values of the following performance metrics.

Job ID	Server	Submission time	Waiting time	Start time	End time	Turnaround time	Rental cost*	Resource utilisation*
0	tiny 0	32	40	72	1902	1870	$0.20	100%
1	small 1	54	40	94	2287	2233	$0.24	100%
2	Medium 0	55	60	115	292	237	$0.6	100%
3	Medium 0	108	7	115	252	144		100%
4	Medium 0	287	5	2722	2833	2546		100%

Table 1: Performance metrics: FF. * Both rental cost and utilisation should be calculated per server, not per job.

Task 2: Draw a schedule generated by WF. Show and explain how it matches the simulation log.

Job ID	Server	Submission time	Waiting time	Start time	End time	Turnaround time	Rental cost	Resource utilisation
0								
1								
2								
3								
4								

Table 2: Performance metrics: WF.