LAB 2 discussion

Simulation based Process Scheduling

- Explore multiple Schedulers and what OS tracks
- You will learn how to write a Discrete Event Simulator
- Specification of Process and Random Behavior

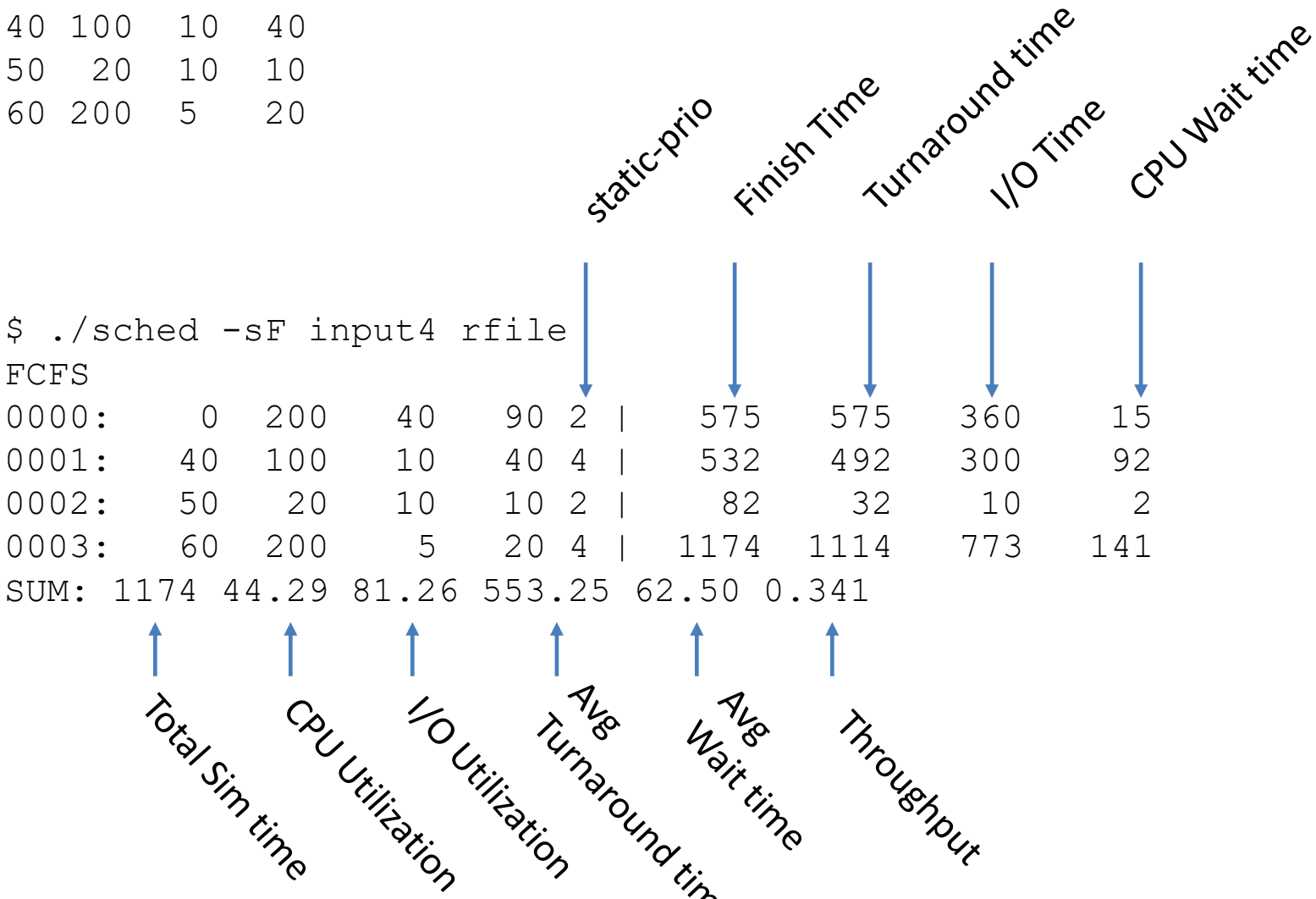
Process-1	0	200	40	90
	40	100	10	40
	50	20	10	10
Process-4	60	200	5	20
	process arrival/start	Total CPU-time	CPU Burst	IO Burst

- Cpu-burst = random (range [1.. Proc.cpu_burst])
- Ioburst = random (range [1.. Proc.io_burst])

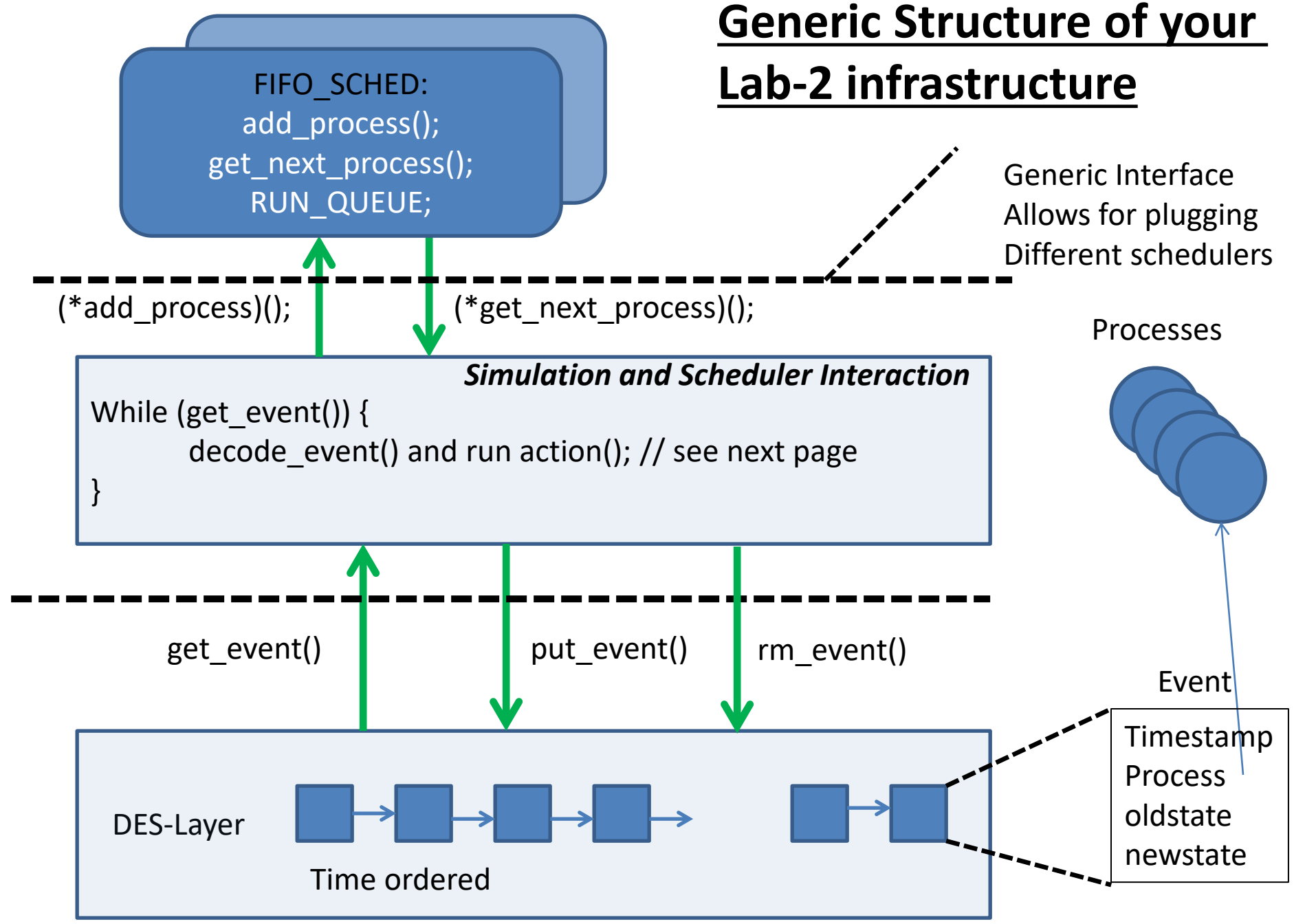
What you will generate ?

```
$ cat input4
0  200   40   90
40 100   10   40
50  20   10   10
60 200   5    20
```

```
$ ./sched -sF input4 rfile
FCFS
0000:    0  200   40   90 2 |   575   575   360    15
0001:   40  100   10   40 4 |   532   492   300    92
0002:   50   20   10   10 2 |    82    32    10     2
0003:   60  200    5   20 4 |  1174  1114   773   141
SUM: 1174 44.29 81.26 553.25 62.50 0.341
```



Generic Structure of your Lab-2 infrastructure



```
void Simulation() {
        EVENT* evt;
        while( (evt = get_event()) ) {
                Process *proc = evt->evtProcess;    // this is the process the event works on
                CURRENT_TIME = evt->evtTimeStamp;
                int transition = evt->transition;   // for accouting
                int timeInPrevState = CURRENT_TIME - proc->state_ts;
                delete evt; evt = nullptr; // remove cur event obj and don't touch anymore

                switch (transition) {  // encodes where we come from and where we go
                case TRANS_TO_READY:
                        // must come from BLOCKED or CREATED
                        // must add to run queue, no event created
                        CALL_SCHEDULER = true;
                        break;
                case TRANS_TO_PREEMPT: // similar to TRANS_TO_READY
                        // must come from RUNNING (preemption)
                        // must add to run queue, no event created
                        CALL_SCHEDULER = true;
                        break;
                case TRANS_TO_RUN:
                        // create event for either preemption or blocking
                        break;
                case TRANS_TO_BLOCK:
                        //create an event for when process becomes READY again
                        CALL_SCHEDULER = true;
                        break;
                }

                if(CALL_SCHEDULER) {
                        if (get_next_event_time() == CURRENT_TIME)
                                continue; //process next event from Event queue
                        CALL_SCHEDULER = false; // reset global flag
                        if (CURRENT_RUNNING_PROCESS == nullptr) {
                                CURRENT_RUNNING_PROCESS = THE_SCHEDULER->get_next_process();
                                if (CURRENT_RUNNING_PROCESS == nullptr)
                                     continue;
                                 // create event to make this process runnable for same time.
                        }
                }
        }
}
```

./sched -v -e input_show rfile

```
ShowEventQ:  0:0  20:1

0 0 0: CREATED -> READY
  AddEvent(0:0:RUNNG):  20:1:READY ==>   0:0:RUNNG  20:1:READY

0 0 0: READY -> RUNNG cb=8 rem=100 prio=1
  AddEvent(8:0:BLOCK):  20:1:READY ==>   8:0:BLOCK  20:1:READY

8 0 8: RUNNG -> BLOCK  ib=2 rem=92
  AddEvent(10:0:READY):  20:1:READY ==>   10:0:READY  20:1:READY

10 0 2: BLOCK -> READY
  AddEvent(10:0:RUNNG):  20:1:READY ==>   10:0:RUNNG  20:1:READY

10 0 0: READY -> RUNNG cb=10 rem=92 prio=1
  AddEvent(20:0:BLOCK):  20:1:READY ==>   20:1:READY  20:0:BLOCK

20 1 0: CREATED -> READY

20 0 10: RUNNG -> BLOCK  ib=7 rem=82
  AddEvent(27:0:READY): ==>   27:0:READY
  AddEvent(20:1:RUNNG):  27:0:READY ==>   20:1:RUNNG  27:0:READY

20 1 0: READY -> RUNNG cb=7 rem=100 prio=3
  AddEvent(27:1:BLOCK):  27:0:READY ==>   27:0:READY  27:1:BLOCK
```

Input file

```
0   100 10 10
20  100 20 10
```

RESULTS OF SIMULATION

FCFS

```
0000:   0  100   10   10 2 |   234   234    89    45
0001:  20  100   20   10 4 |   226   206    77    29
SUM: 234 85.47 57.26 220.00 37.00 0.855
```

./sched -v -e input_show rfile

Input file

0 100 10 10
20 100 20 10

```
ShowEventQ:  0:0  20:1

0 0 0: CREATED -> READY
  AddEvent(0:0:RUNNG):  20:1:READY ==>   0:0:RUNNG  20:1:READY

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8 0 8: RUNNG -> BLOCK  ib=2 rem=92
  AddEvent(10:0:READY):  20:1:READY ==>   10:0:READY  20:1:READY

10 0 2: BLOCK -> READY
  AddEvent(10:0:RUNNG):  20:1:READY ==>   10:0:RUNNG  20:1:READY

10 0 0: READY -> RUNNG cb=10 rem=92 prio=1
  AddEvent(20:0:BLOCK):  20:1:READY ==>   20:1:READY  20:0:BLOCK

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20 0 10: RUNNG -> BLOCK  ib=7 rem=82
  AddEvent(27:0:READY): ==>   27:0:READY
  AddEvent(20:1:RUNNG):  27:0:READY ==>   20:1:RUNNG  27:0:READY

20 1 0: READY -> RUNNG cb=7 rem=100 prio=3
  AddEvent(27:1:BLOCK):  27:0:READY ==>   27:0:READY  27:1:BLOCK
```

line triggered by “-v”
Timestamp pid howlong:
FROM -> TO

One Event

line triggered by “-e”
event added: (time,pid,transition)
EventQ-Before ➔ EventQ-After
(should be time ordered)

./sched –v -t input_show rfile

```
0 0 0: CREATED -> READY
SCHED (1):  0:0
0 0 0: READY -> RUNNG cb=8 rem=100 prio=1
8 0 8: RUNNG -> BLOCK  ib=2 rem=92
SCHED (0):
10 0 2: BLOCK -> READY
SCHED (1):  0:10
10 0 0: READY -> RUNNG cb=10 rem=92 prio=1
20 1 0: CREATED -> READY
20 0 10: RUNNG -> BLOCK  ib=7 rem=82
SCHED (1):  1:20
20 1 0: READY -> RUNNG cb=7 rem=100 prio=3
27 0 7: BLOCK -> READY
27 1 7: RUNNG -> BLOCK  ib=9 rem=93
SCHED (1):  0:27
27 0 0: READY -> RUNNG cb=7 rem=82 prio=1
34 0 7: RUNNG -> BLOCK  ib=1 rem=75
SCHED (0):
35 0 1: BLOCK -> READY
SCHED (1):  0:35
35 0 0: READY -> RUNNG cb=9 rem=75 prio=1
36 1 9: BLOCK -> READY
44 0 9: RUNNG -> BLOCK  ib=9 rem=66
SCHED (1):  1:36
44 1 8: READY -> RUNNG cb=11 rem=93 prio=3
53 0 9: BLOCK -> READY
55 1 11: RUNNG -> BLOCK  ib=4 rem=82
```

Input file

```
0   100 10 10
20  100 20 10
```

line triggered by “-t” to show scheduler runqueue

SCHED(len): { “pid:timestamp” }*

where len is length of RQ followed by RQ entries

Current cpu-burst

Current io-burst

Dynamic priority

Remaining cputime

./sched –p input_show rfile

To help with the preemption (EPRIO)

There are 2 conditions that need to be met:
Cond1: unblocked_process.dynprio > current.dynprio **AND**
Cond2: next event for current proc is > current time

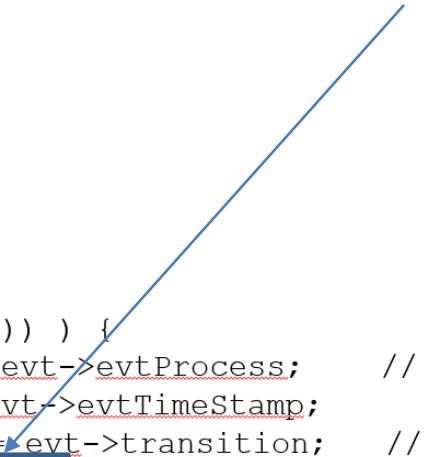
---> PRIOpreempt Cond1=1 Cond2=1 (2) --> YES

---> PRIOpreempt Cond1=1 Cond2=0 (0) --> NO

Time till next event
of current running process

Accounting

- Make sure you do backward accounting (how long was process in a particular state.
- Forward accounting (how long will I be in a state) will not work.
- Charge the right bucket (cpu, blocked, ready) when you get out of its state, not when you get in (otherwise "E" scheduler won't work and forward accounting in real systems is not possible)
- You have all the information how long you were in the state you are transitioning out of.



```
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                delete evt; evt = nullptr; // remove cur event obj and don't touch anymore
```
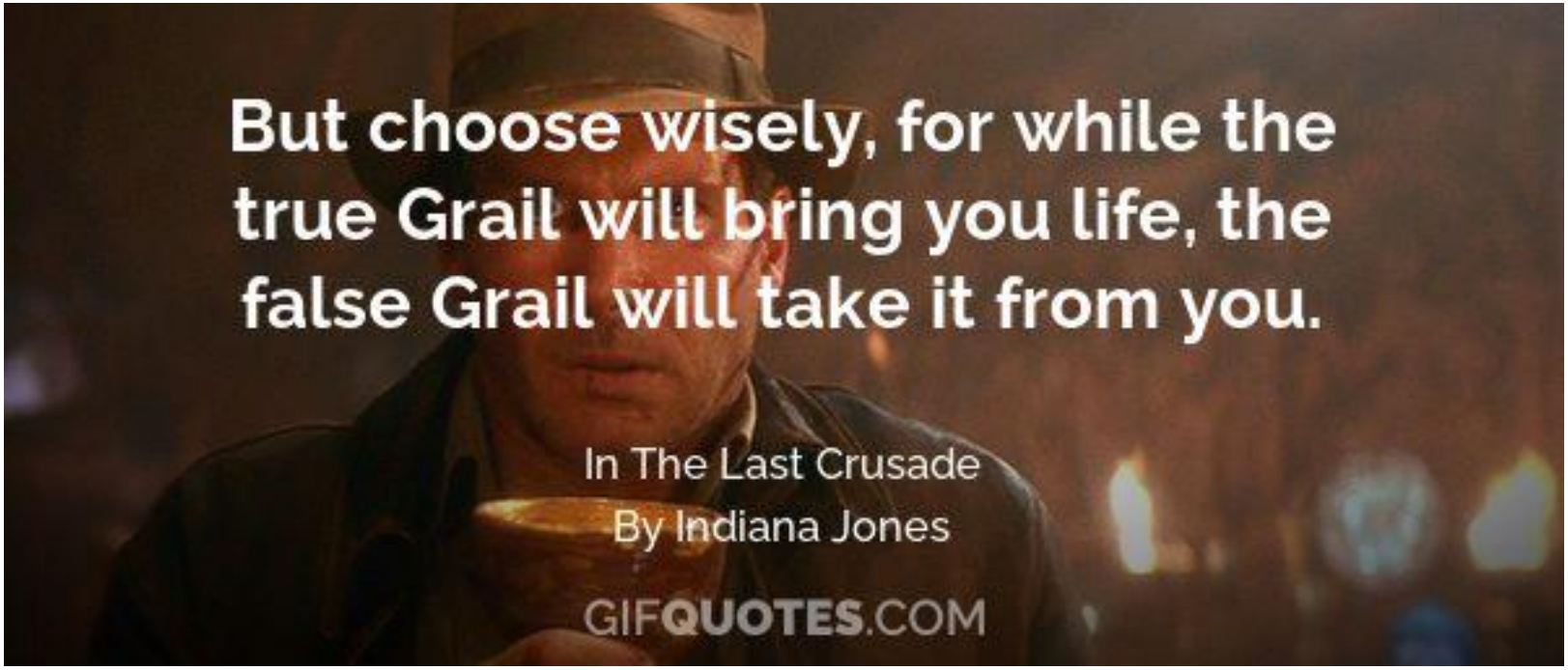

Data Structures

- Schedulers are often about pooling requests and selecting:
  - Queueing , searching , indexing, mapping, priorities
  - Efficiency matters, not just effectiveness
  - Underlying data structures matter



Example: Queue Semantics

- Assume existing "queue" size N
- Consider the following operations
  - Add front / delete tail (FT)
  - Add Tail / delete front (TF)
  - Iterate through queue with
    - C++ iterator (Iter) or C++ [] operator
- Time these operations
- Consider the following container classes:
  - Deque (Q)
  - Vector (V)
  - List (L)

Extract behavior

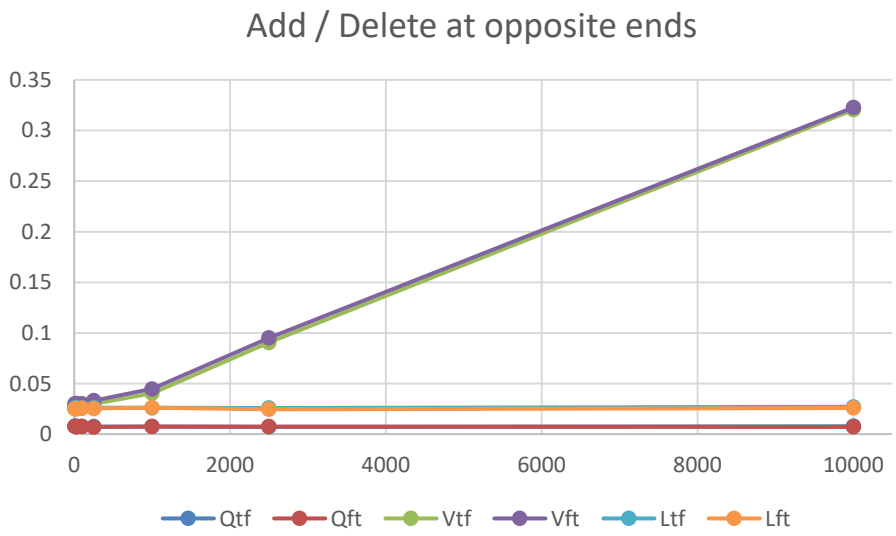
- https://dev.to/pratikparvati/c-stl-containers-choose-your-containers-wisely-4lc4
  excellent article with good graphics

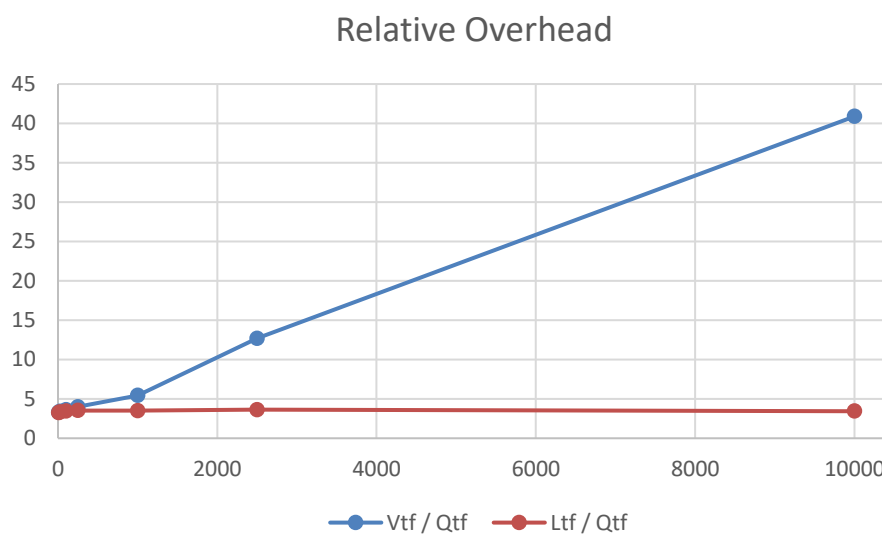
- https://www.geeksforgeeks.org/containers-cpp-stl/

eventQ = list<Event*> because we add in the middle and remove at the front
procqueue = deque<Process*> because we push and pop at the front and end
srtfqueue = list<Process*> because we add in the middle and remove at the front
prioqueue = vector<deque<Process*>>

Add / Delete Opposite ends

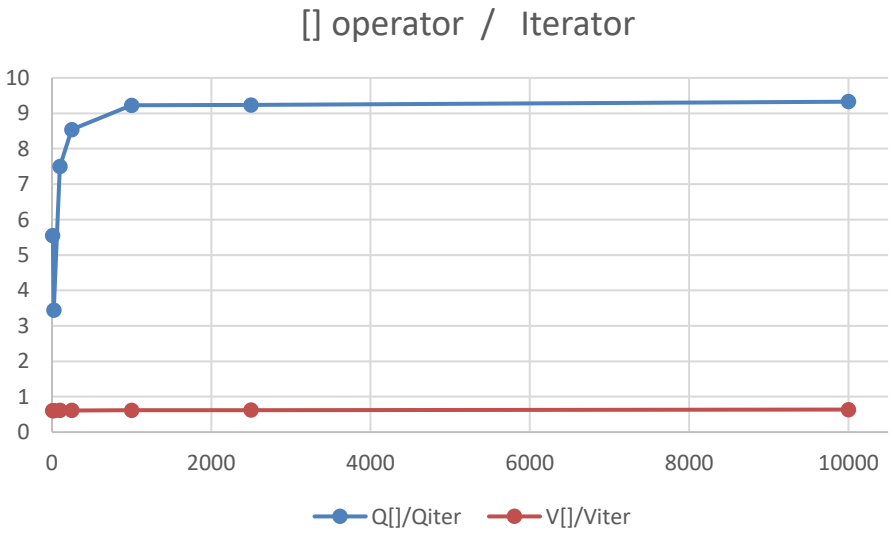
- Scale the size of the queue (x-axis = N)
- TF and FT semantics
- Why are vectors so expensive ?





Iterations

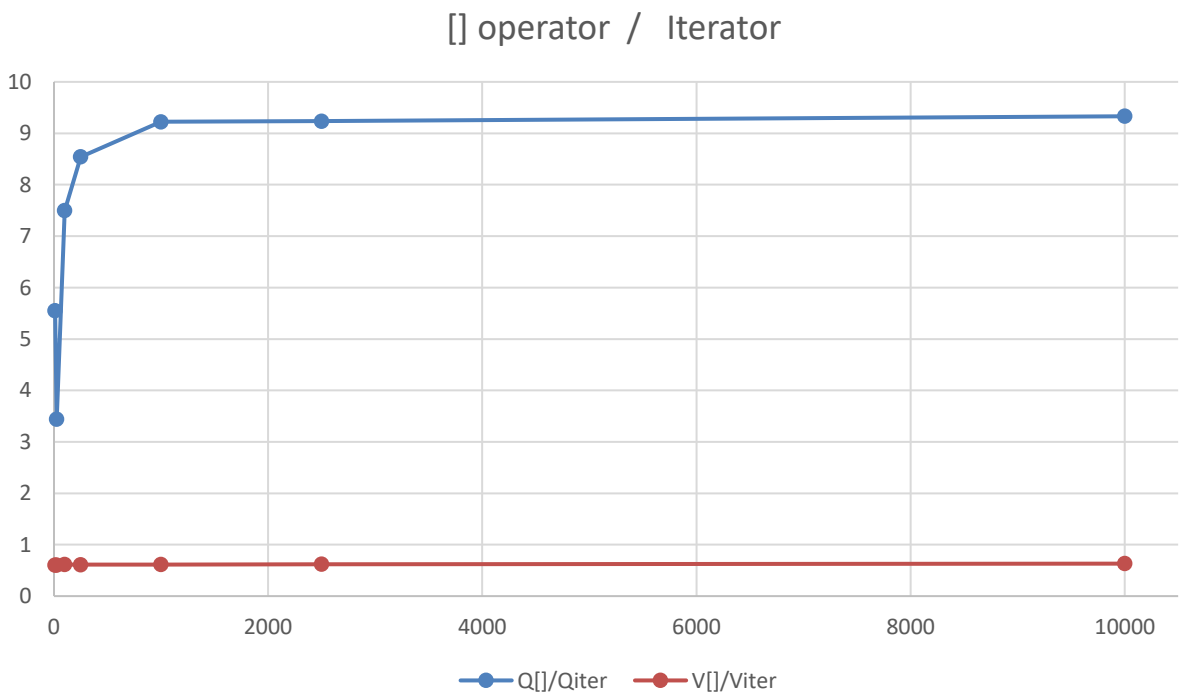
- Iterate by 2 approaches:
  iter: `for ( x : objs ) { x } ;`
  []: `for (i = 0; i<obj.size(); i++) { obj[i]; }`



note: list[] does not exist

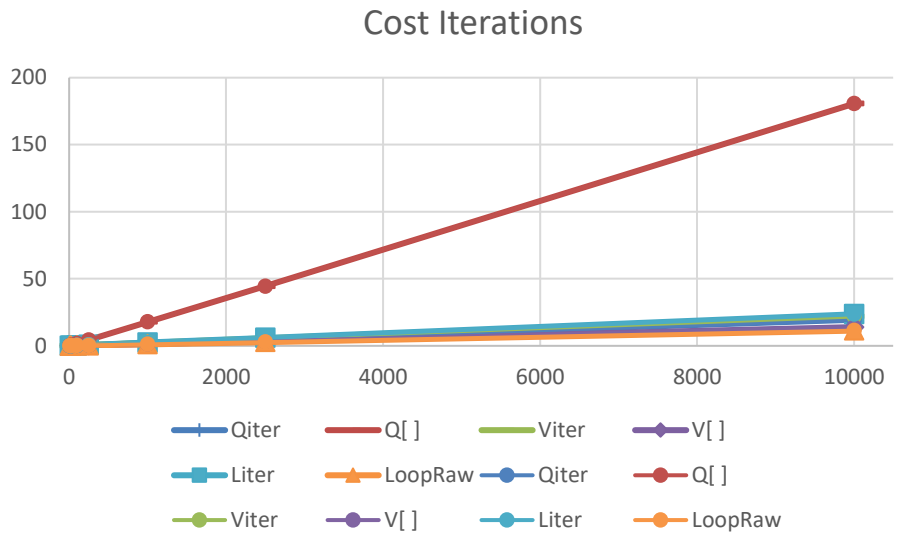
Iteration vector vs deque

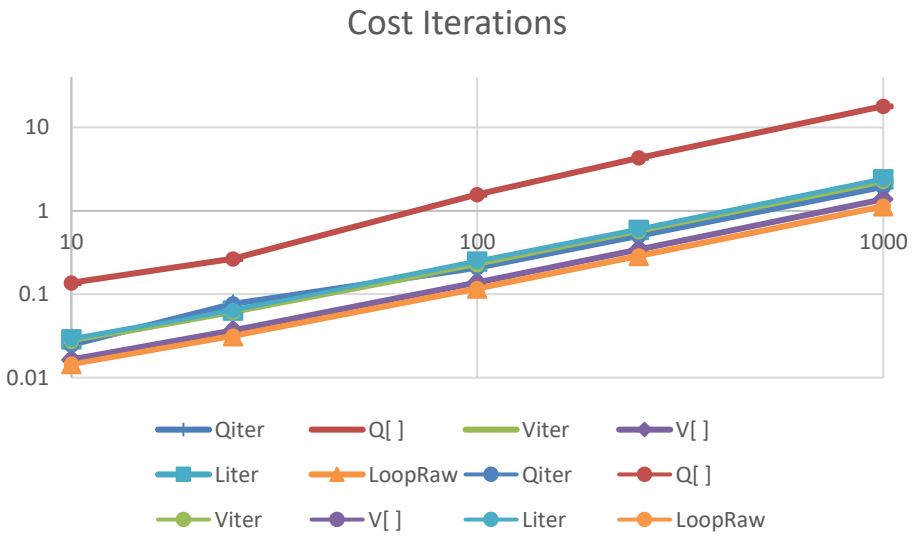
- [] operator relatively expensive for deque over iterator, but not for vector



Iteration vector vs deque vs list

- Avoid [] operator on queues
- Think about underlying data structures how something would be implemented and think about cost of operations.





Moral of the story

- Don't just use STL data structures
- Think how they are being used
- Think a bit about implementation and efficiency