Event Lists (aka Pending Event Sets)

Fetch-next, insert, and cancel operations
- Fundamental operations in discrete-event simulations (up to 40% of sim time)
- So far we have used clock-reading vectors
- For M events, it takes $O(M)$ time to get next event
- Unsuitable for large-scale simulation

Alternative: event lists
- For GSMP’s with unit speeds
- Idea: Maintain list of (event_type, event_time) pairs
  - event_time = (absolute) time when event is scheduled to occur
- Challenge: support operations efficiently (priority queue with removals)

Linked Lists

Goal: Maintain events in sorted order
- Singly-linked lists
- fetch-next is $O(1)$, insert and cancel are $O(M)$
- Doubly-linked lists
Linked Lists, Continued

- Indexed doubly-linked lists

```
head 20.3 23.7 34.0 tail
```

- Faster lookup
- Need to maintain median element
- Cost outweighs benefit for more than one index

Implicit Binary Heaps

Binary tree that maintains min-heap property

- Parent has smaller value than children
- Can store efficiently as an array
- Fetch-next is $O(1)$ plus an $O(\log M)$ update

Heaps, Continued

- Insert is $O(\log M)$

```
2.1 5.3
2.3 5.8
1.3 7.2
10.2 12.6
3.4 5.1
25.5 29.1
```

- Cancellation is $O(M)$ search + $O(\log M)$ update

- Python solution for $O(1)$ cancellation
  - Use `heapq` to implement heap
  - Use a dict for $O(1)$ find
  - Mark event as "canceled" and
  - Ignore cancelled events upon fetch
  - OK if not too many cancellations
  - See code on website

Hybrid Data Structures

Bucket System

- Event time "hashes" to a bucket
- Recycle buckets when they become empty

Henriksen’s algorithm

- Used in many early commercial systems
- Combines binary search tree with doubly-linked list
- Can have bad worst-case behavior
Lazy Queue [Ronngren et al. 1991]

- Three parts:
  - Near Future (NF): a sorted linked list
  - Far Future (FF): an unsorted bucket system
  - Very Far Future (VFF): an unsorted linked list

- Sorting only happens when FF bucket is moved to NF
- Occasional *adaptive* resizing of # and length of buckets
- Dominates most other event list schemes for > 50 events