Verilog Scheduling and Event Queue

Consider

```
   always_ff @( posedge clk ) c = reset ? 0 : c + 1;
   always_ff @( posedge clk ) over_th = c + 1'd1 > threshold;
```

Is `over_th` computed using the new or old `c`?

(Answer: either one, and so code is unreliable.)

Terminology

Event:

Sort of a to-do item for simulator. May include running a bit of Verilog code or updating an object's value.

Event Queue:

Sort of a to-do list for simulator. It is divided into time slots and time slot regions.

Time Slot:

A section of the event queue in which all events have the same time stamp.

Time Slot Region:

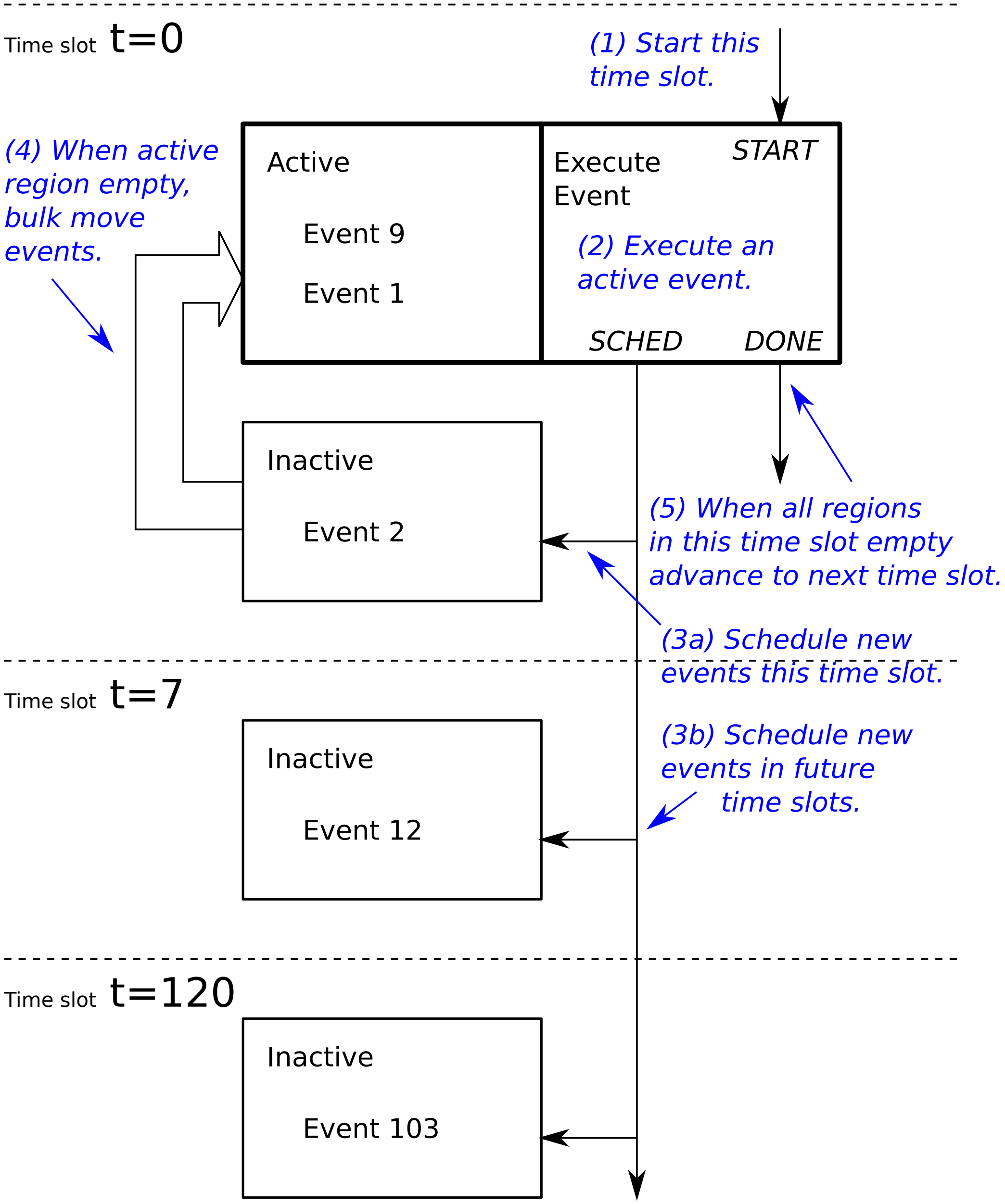
A subdivision of a time slot. There are many of these. Important ones: active, inactive, NBA.

Scheduling:

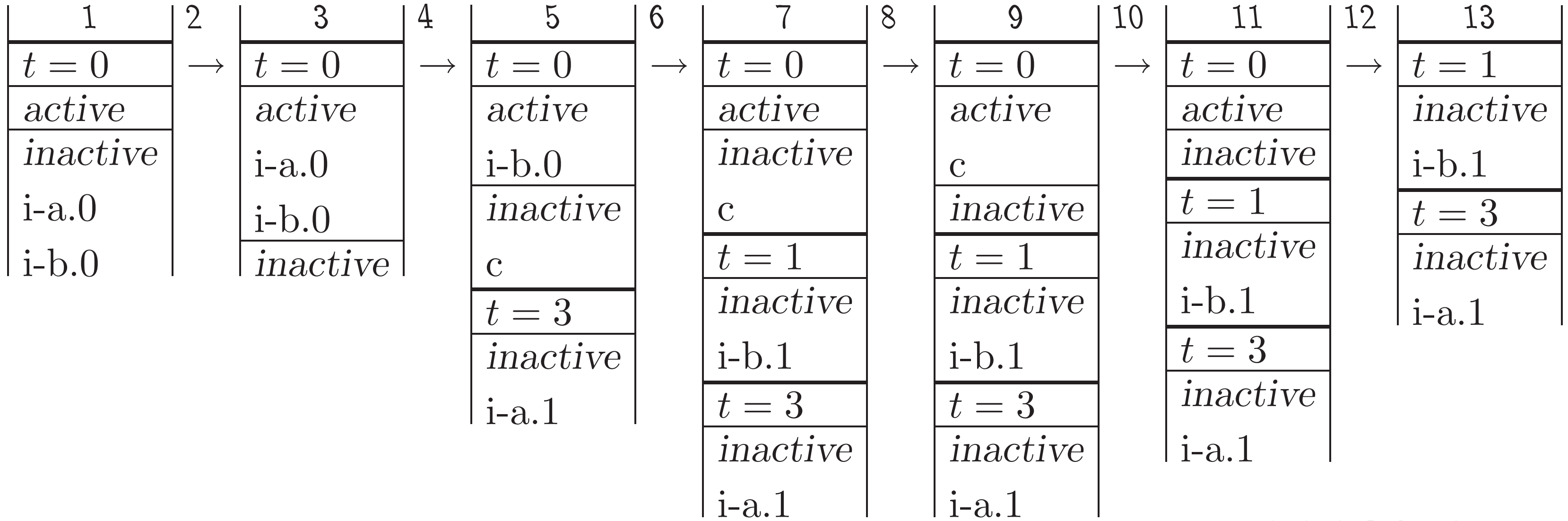
Determining when an event should execute. The when consists of a time slot and a time slot region.

Update Events:

The changing of an object's value. Will cause *sensitive* objects to be scheduled.


Time slot t=0
(1) Start this time slot.
Active
Event 9
Event 1
Execute Event
START
(2) Execute an active event.
SCHED
DONE
(4) When active region empty, bulk move events.
Inactive
Event 2
(5) When all regions in this time slot empty advance to next time slot.
(3a) Schedule new events this time slot.
Time slot t=7
Inactive
Event 12
(3b) Schedule new events in future time slots.
Time slot t=120
Inactive
Event 103

Example



1
$t = 0$
active
inactive
i-a.0
i-b.0

2 →

3
$t = 0$
active
i-a.0
i-b.0
inactive

4 →

5
$t = 0$
active
i-b.0
inactive
c
$t = 3$
inactive
i-a.1

6 →

7
$t = 0$
active
inactive
c
$t = 1$
inactive
i-b.1
$t = 3$
inactive
i-a.1

8 →

9
$t = 0$
active
c
inactive
$t = 1$
inactive
i-b.1
$t = 3$
inactive
i-a.1

10 →

11
$t = 0$
active
inactive
$t = 1$
inactive
i-b.1
$t = 3$
inactive
i-a.1

12 →

13
$t = 1$
inactive
i-b.1
$t = 3$
inactive
i-a.1

1: Verilog puts all `initial` blocks in $t = 0$ inactive region.

2: Active region is empty, and so inactive copied to active.

3: Event `i-a.0` executes and schedules event `c` for $t = 0$ and `i-a.1` for $t = 3$.

Note: Events (of this type) initially placed in inactive region).

4: Event `i-a.0` removed from active region (it is now not scheduled anywhere).

```
initial begin
   // i-a.0
   a = 1;
   #3;
   // i-a.1
   a = 2;
end

initial begin
   // i-b.0
   b = 10;
   #1;
   // i-b.1
   b = a;
end

assign c = a + b;  // c
```

`5,6`: Event `i-b.0` executes and schedules `i-b.1` for $t = 1$.

`7,8`: Since active region is empty, inactive region is bulk-copied to active region.

`9`: Event `c` executes.

`10-12`: Since all regions in time slot 0 are empty, move to next time slot, $t = 1$.

Event Scheduling

Time-Delay Scheduled

Scheduled by a delay: `#4 a = b;`

Sensitivity List Scheduled

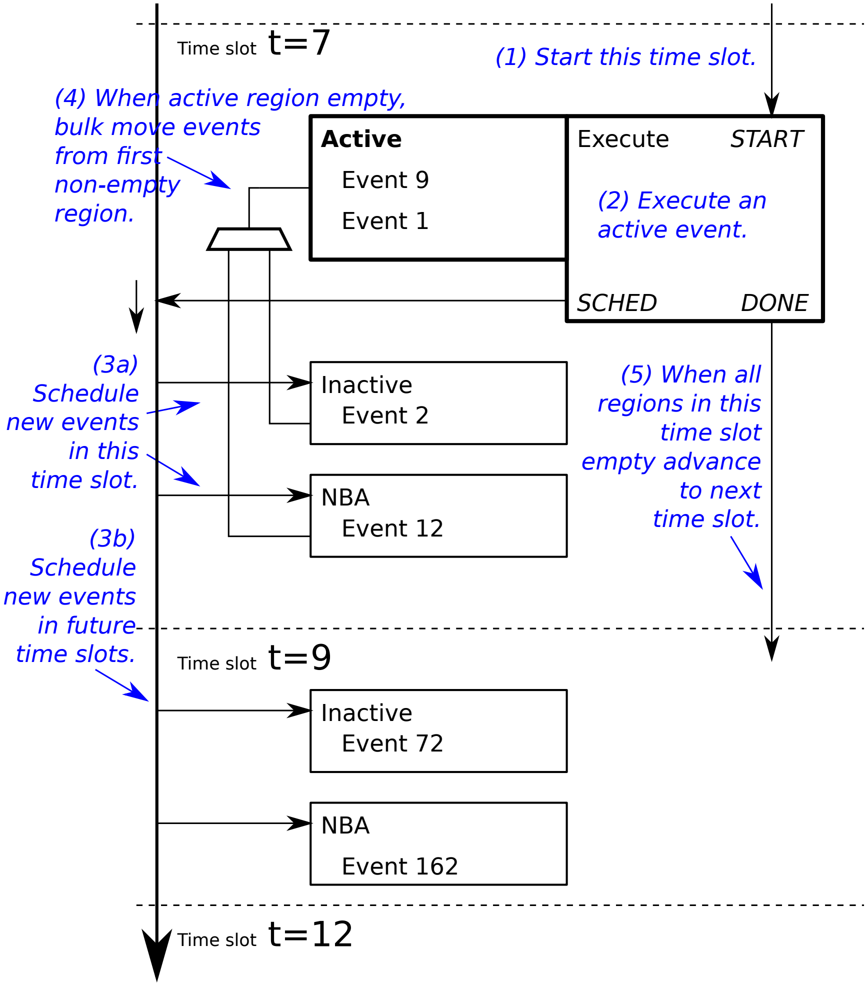
Explicit event `@( a )`, `@( posedge clk)`, `wait( stop_raining )`

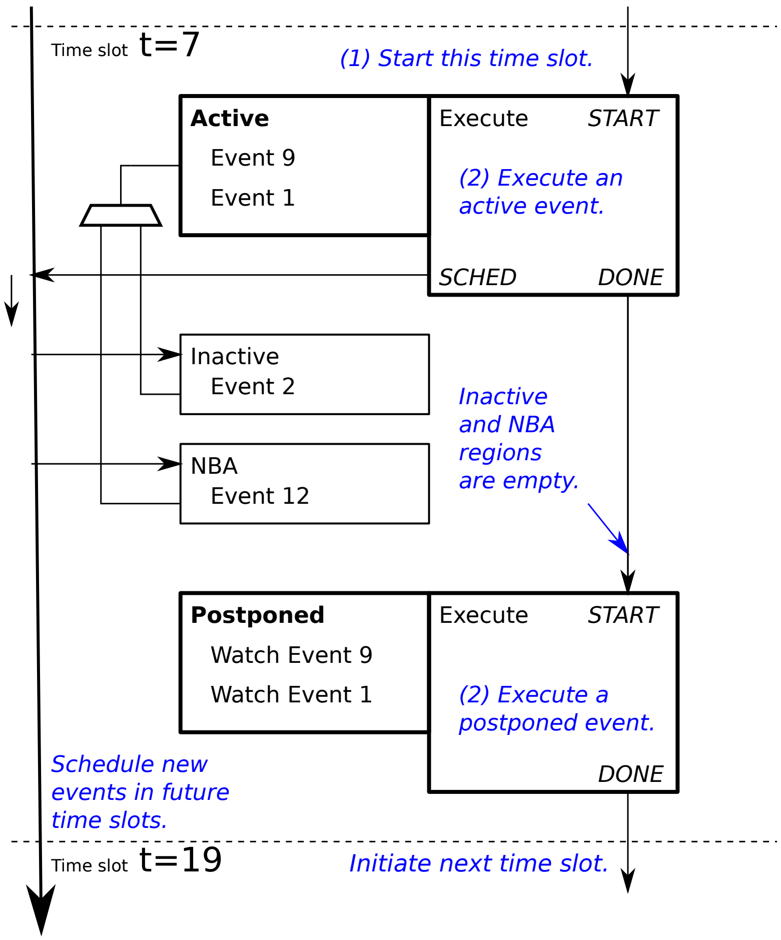
Continuous assignment: `assign x = a + b;`.

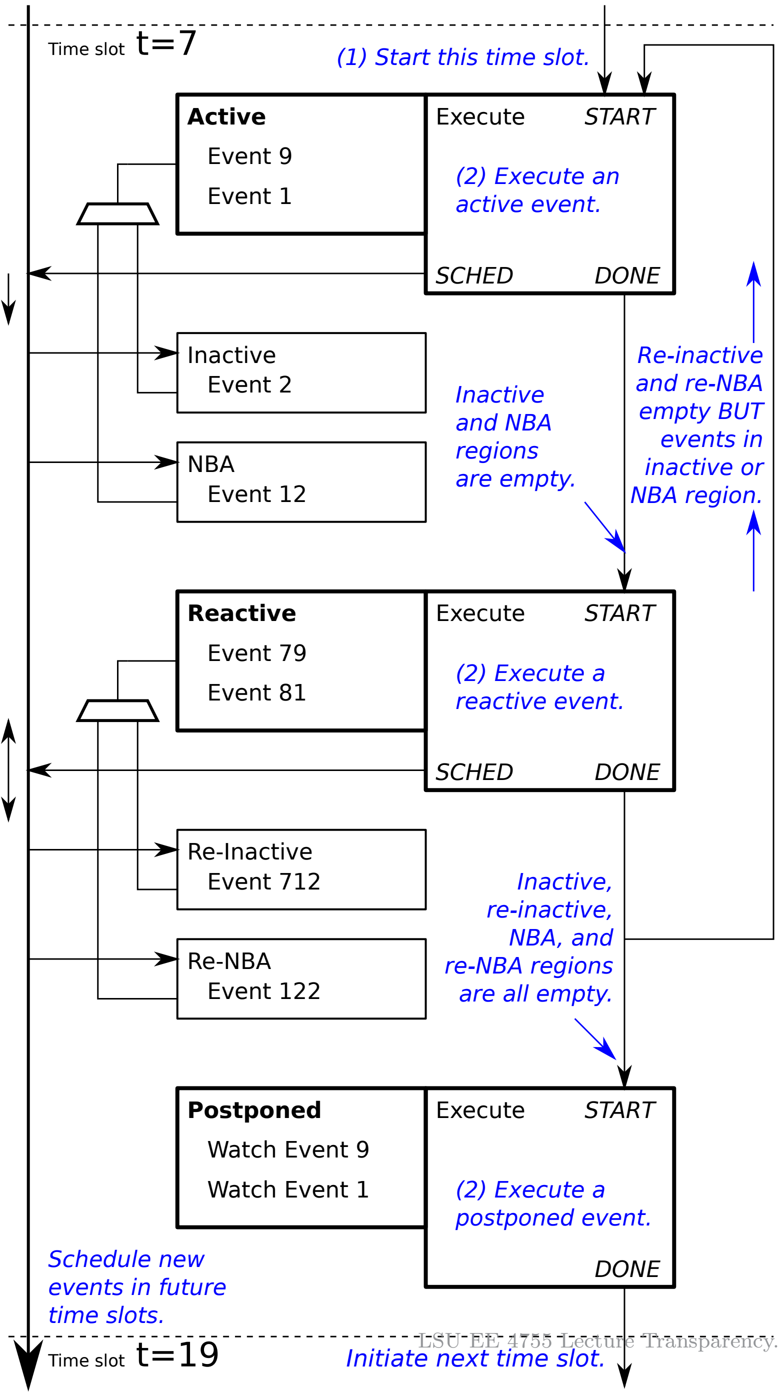
Module or primitive ports: `and myAndGate(x,a,b)` .

Permanently Scheduled

Watch lists: `$watch(a)`.


Time slot t=7
(1) Start this time slot.
(4) When active region empty, bulk move events from first non-empty region.
Active
Event 9
Event 1
Execute
START
(2) Execute an active event.
SCHED
DONE
(3a) Schedule new events in this time slot.
Inactive
Event 2
NBA
Event 12
(5) When all regions in this time slot empty advance to next time slot.
(3b) Schedule new events in future time slots.
Time slot t=9
Inactive
Event 72
NBA
Event 162
Time slot t=12


Time slot t=7
(1) Start this time slot.
Active
Event 9
Event 1
Execute
START
(2) Execute an active event.
SCHED
DONE
Inactive
Event 2
NBA
Event 12
Inactive and NBA regions are empty.
Postponed
Watch Event 9
Watch Event 1
Execute
START
(2) Execute a postponed event.
DONE
Schedule new events in future time slots.
Time slot t=19
Initiate next time slot.



Time slot t=7

(1) Start this time slot.

Active
Event 9
Event 1

Execute START

(2) Execute an active event.

SCHED DONE

Inactive
Event 2

NBA
Event 12

Inactive and NBA regions are empty.

Re-inactive and re-NBA empty BUT events in inactive or NBA region.

Reactive
Event 79
Event 81

Execute START

(2) Execute a reactive event.

SCHED DONE

Re-Inactive
Event 712

Re-NBA
Event 122

Inactive, re-inactive, NBA, and re-NBA regions are all empty.

Postponed
Watch Event 9
Watch Event 1

Execute START

(2) Execute a postponed event.

DONE

Schedule new events in future time slots.

Time slot t=19

Initiate next time slot.

Schedule [verb]

Event

Evaluation Event

Update Event

Time

Time Slot