Fixed-Priority Preemptive Scheduling Semantics
of AADL in UPPAAL Timed Automata

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The scheduling automaton providing the required thread execution semantics is shown in Figure 1. The labels of the scheduling automaton are defined as follows:

- `(int)ready_queue[x]`: is a sorted queue of currently dispatched threads. The queue is sorted according to a given scheduling policy where the first element in the queue (x=0) is the (identifier of the) thread being processed and where the second element is the next thread to be processed, and so forth.

- `(clock)sch_clocks[x][2]`: is a list of clocks in sets of two, each set referenced by an identifier x of a currently dispatched thread. Each dispatched thread has two clocks, the first (sch_clocks[x][0] of thread with identifier x) is used to keep track of a thread’s execution time, and the second (sch_clocks[x][1] of thread with identifier x) is used to keep track of a thread’s deadline.

- `(int)sch_info[x][3]`: is a list of threads’ scheduling properties (integers) in sets of three, each set referenced by an identifier x of a currently dispatched thread. Each dispatched thread has three scheduling properties, the first (sch_info[x][0] of thread with identifier x) is the execution time, the second (sch_info[x][1] of thread with identifier x) is the deadline, and the third (sch_info[x][2] of thread with identifier x) is the priority. Note that the required properties are related to a given scheduling policy. For example, we consider priorities of threads since we assume a fixed priority scheduler in this particular example.

- `(int)preempt_stack[x][2]`: is a stack of sets of currently preempted threads (integer identifiers) and the amount time each thread has been preempted. Given a stack of preempted threads, the first set of elements in the stack (preempt_stack[0][0] is the thread identifier and preempt_stack[0][1] is the amount of time) corresponds to the thread that first was preempted.

- `(int)nr_preempted`: number of currently preempted threads.

- `(int)threads`: number of currently dispatched threads.

- `(int)check_preempt`: holds the identity of a thread that is dispatched at the same time as another thread is running. It is used to check if the dispatched thread preempts the running thread.

- `(chan)dispatched[(int)x], (chan)run[(int)x], (chan)complete[(int)x], (chan)preempt[(int)x]`: are channels used to synchronize every thread transition of every thread in the system. Synchronization
with a particular thread is done through its identity. For example, run[2] is a synchronization channel with thread having identity equal to 2.

- (void)schprotocol((int)x): is a function sorting threads in the ready_queue according to a given scheduling policy. The function is called each time a thread dispatches where the thread’s identity is given as argument to the function. In this example, we assume fixed priority scheduling.

- (void)completion((int)x): is a function removing threads from the ready_queue. The function is called each time a thread completes its execution, where the thread’s identity is given as argument to the function.

- (void)addTime(): is a function adding preempted time to the threads in the preempt_stack. The function is called when a preemption occurs, whereupon the execution time of the thread causing the preemption is added to the preemption time of every preempted thread.

- (void)checkTime((int)x): is a function adding preempted time to the threads in the preempt_stack[x][2] stack. The function is called when a thread dispatch not causing any preemption occurs, to check if the dispatched thread is prior to any preempted threads in the ready_queue whereupon preemption time is added.

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\text{MissedDeadline} \quad \text{Preemption} \quad \text{Schedule2} \\
\text{Running} \\
\text{sch_clocks[ready_queue[0]][0]} \leq \text{sch_info[ready_queue[0]][0]} + \text{preemptedTime()} \\
\text{Empty} \\
\text{sch_clocks[ready_queue[0]][1]} > \text{sch_info[ready_queue[0]][1]} \\
\text{dispatched[i] ? schprotocol(i), sch_clocks[i][1] = 0, threads ++, checkTime(i), dispatch()} \\
\text{threads = 0} \\
\text{nr_preempted > 0 and ready_queue[0] == preempt_stack[nr_preempted-1][0] and sch_clocks[ready_queue[0]][0] >= sch_info[ready_queue[0]][0] + preemptedTime()} \\
\text{complete[ready_queue[0]]} \\
\text{nr_preempted > 0 and ready_queue[0] == check_preempt} \\
\text{checkTime(check_preempt)} \\
\text{threads --} \\
\text{fig. 1. the scheduler automaton.}
Fig. 2. Example of a thread automaton controlled by the scheduler