Sistemi in tempo reale
Anno accademico 2009 - 2010

Cambi di modo

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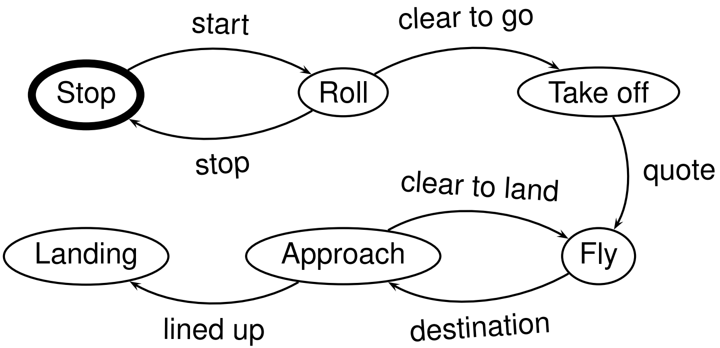
Outline

Modes

- A real-time system can have different working *modes*
- Each mode defines the same system under different working conditions;
- Example: airplane
  - Typical modes are take-off, cruise, and landing;
  - During each mode, the system has different control goals; and it must run different control algorithms.
- Example: elevator
  - Clearly, an elevator goes across different states: idle, opening/closing doors, moving, etc.
  - Depending on the abstraction level, each mode can be sub-divided into internal modes. For example, when a elevator moves, we can distinguish between acceleration, stable state, deceleration. Also, we may need to distinguish between moving up and down

Modes and transistions

- Modes can be represented by a state machine. For example, consider the previous example of airplane control:



Modes and transistions

- A mode is a node in the diagram (a *state*)
  - Each mode is associated with a set of periodic or sporadic tasks
  - Different modes may have different task sets, or tasks with different characteristics
  - When the mode is active, the corresponding tasks are executed (steady state)
- A transition is an edge between two nodes:
  - A transition happens when certain conditions are verified;
  - For example, a user command, an external condition on the altitude or temperature, the landing of the airplane, etc.
- Upon the occurrence of a transition:
  - terminate all tasks that are in the current mode and will not be active in the new mode;
  - optionally, call a *transition function*;
  - activate the new set of tasks to be executed.

Modes and tasks

- To implement modes:
  - One *manager task* that identifies when modes must be changed;
  - One global variable that identifies the current working mode (currmode);
- Modes can be implemented in two basic ways;
  1. **Type 1** A fixed set of tasks for all the modes; each task can execute different algorithms depending on the current mode;
  2. **Type 2** A different set of tasks for each mode.
- Of course, it is also possible to mix the two implementations.

Implementation type 1

- **Type 1:** In this case, each task executes different code depending on the mode
- Suppose we synchronize at the beginning of the task instance. The code for each task is something like the following:

```
while(1) {
  switch (currmode) {
  M1 : // control algorithm
       // for mode 1
       break;
  M2 : // control algorithm
       // for mode 2
       break;
  default : break;
  }
  task_endcycle();
}
```

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  - If task i is active in mode currmode, then modes[i][currmode] is true, otherwise it is false.

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  - The primitive task_disable() suspends the periodic activations; they will be enabled again by an explicit task_activate() on the current task

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  - However, the mode manager task is more complex, as it must take care of deactivating/activating tasks in the proper way

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- Now we start dealing with problem 3.

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  - The “easiest” checkpoints are at the beginning and at the end of the task instance.

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- To introduce other checkpoints, we could complicate the code:
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- The code becomes much more complex!

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  - The mode manager sends *a signal* to the control task and waits for it to respond
  - The control task will respond (and finish its execution) when reaching a propose *checkpoint*

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- The mode manager implements the state machine and controls transition between modes.
- From now on, we consider only **type 2** implementations.

Implementation type 2: manager

- The task manager is structured as follows

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while (1) {
  if (modeIsChanged()) {
    old_mode = curr_mode;
    curr_mode = getNewMode();
    transition(old_mode, new_mode);
    for (i=0; i < NTASK; i++) {
      if (mode[i][curr_mode] && !mode[i][old_mode])
      task_activate(tid[i]);
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- When it happens, deactivates old mode tasks and performs transition functions, then activates all tasks belonging to the new mode and not active in the old mode.

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- From a software point of view, for each transition we must call a set of functions to adjust the initial conditions of all control algorithms
- This can be done, for example, by specifying an appropriate *entry* behavior for the states

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State machines and real-time
- Modes
- Problems with mode changes
- Consistency
- Mode manager

Scheduling
- Mode change protocol

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- Even if $\mathcal{T}_1$ and $\mathcal{T}_2$, each one considered in isolation, are schedulable, if the transistion is not done properly, some deadline could be missed during the transitory.

Example of deadline miss during transition

- Consider $\mathcal{T}_1 = \{\tau_1, \tau_2, \tau_3\}$ and $\mathcal{T}_2 = \{\tau_1, \tau_2, \tau_4\}$ with:
  - $\tau_1 = (1, 4)$, $\tau_2 = (2, 9)$, $\tau_3 = (5, 12)$, and $\tau_4 = (3, 9)$
- Transition starts at time $t = 9$
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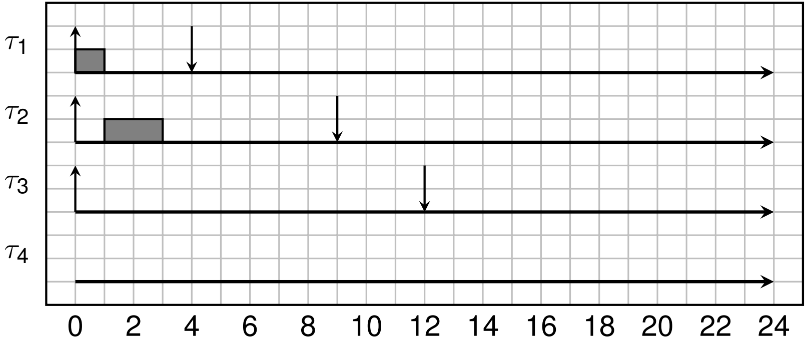

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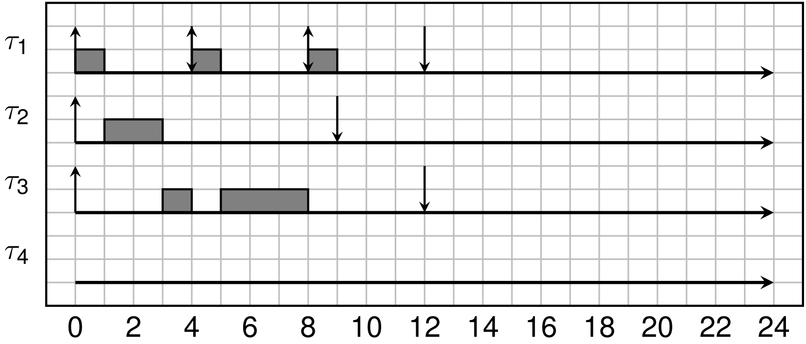

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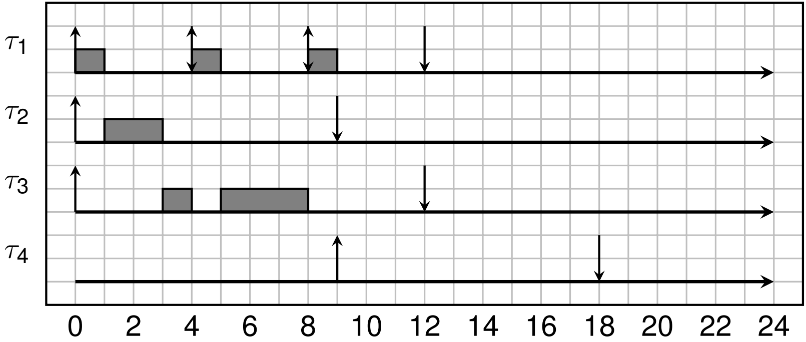

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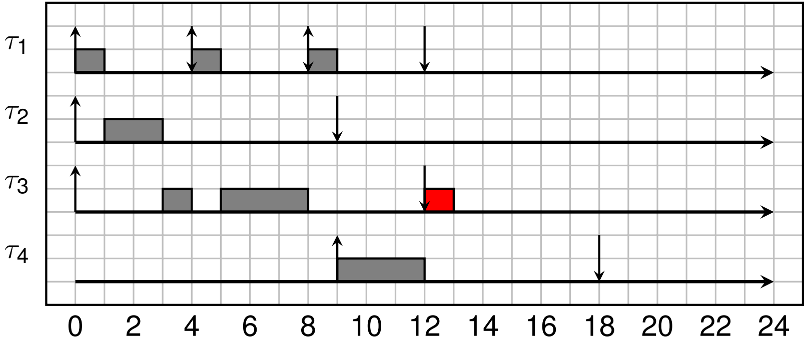

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     - Advantages: reduce the transition delay
     - Drawbacks: require schedulability analysis, may be difficult to implement

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