

Sistemi in tempo reale
Anno accademico 2009 - 2010
Cambi di modo

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Outline

State machines and real-time

Modes

Problems with mode changes

Consistency

Mode manager

Scheduling

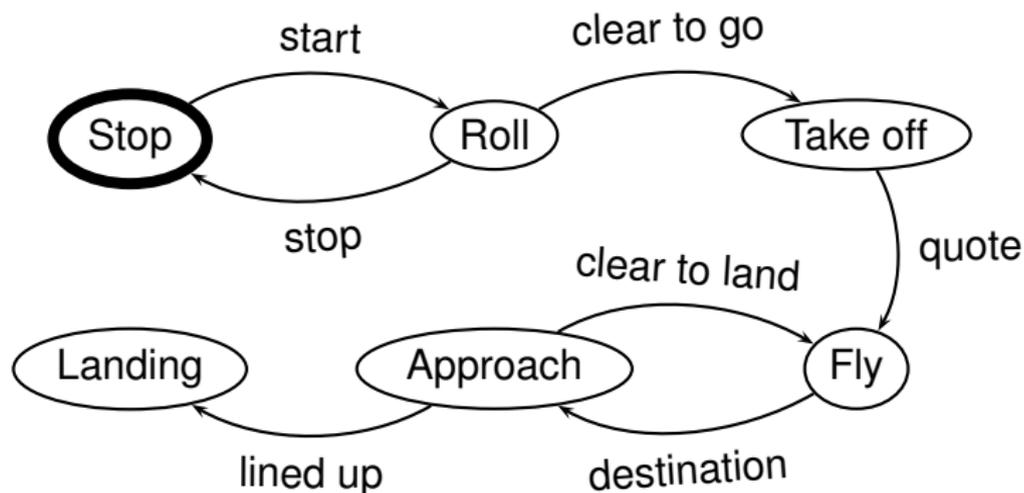
Mode change protocol

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 transitions

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



Modes and transitions

- ▶ 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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- ▶ Typical code of the task;

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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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 - ▶ Task implementation is simple and scales well
 - ▶ The code of each task is self-contained and does not depend on the number and types of the modes in the system
 - ▶ Therefore, we can easily reuse this task.
 - ▶ 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:
 - ▶ divide each control algorithm in different blocks
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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

```
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]);
    }
  }
  task_endcycle();
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- ▶ The manager is a periodic task that periodically checks for occurrence of mode changes.
- ▶ It waits for a change of mode (function modeIsChanged())
- ▶ 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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- ▶ Suppose we are changing from mode 1 to mode 2, and that \mathcal{T}_1 is the set of tasks active in mode 1 and \mathcal{T}_2 is the set of tasks that are active during mode 2.

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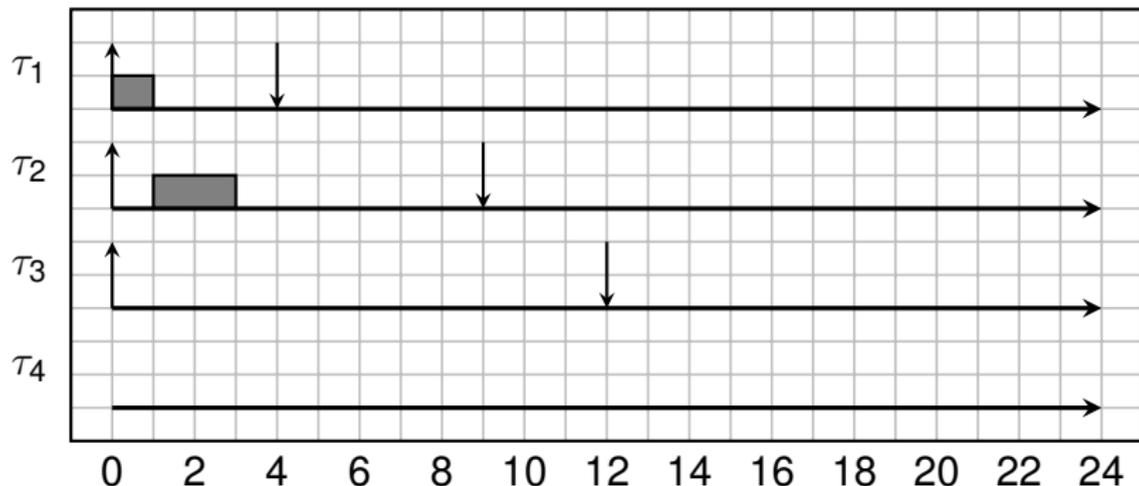
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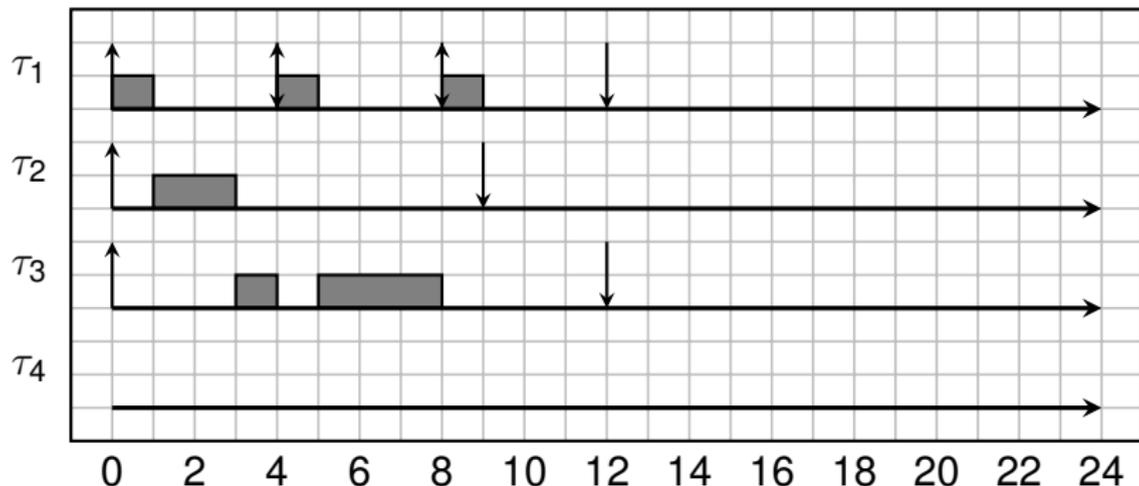
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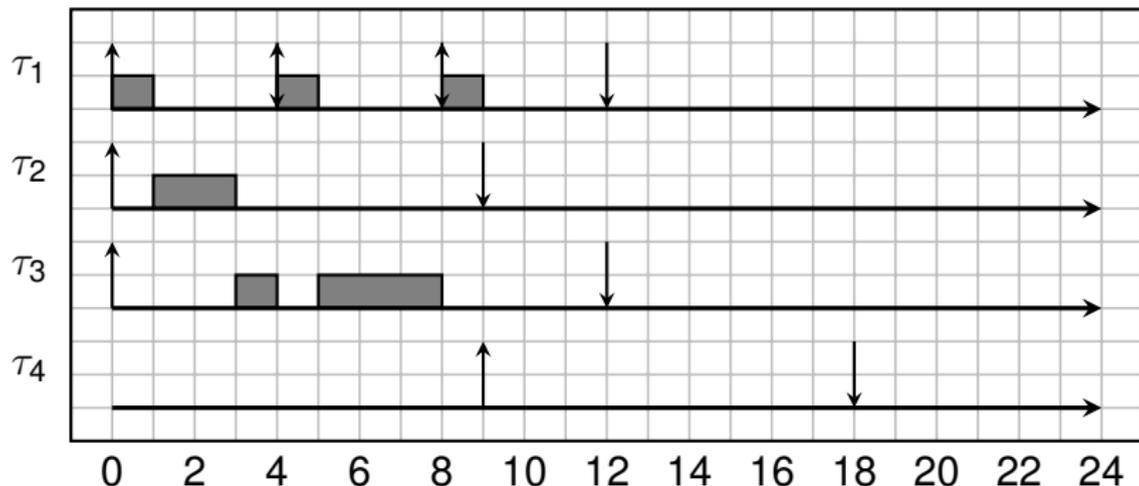
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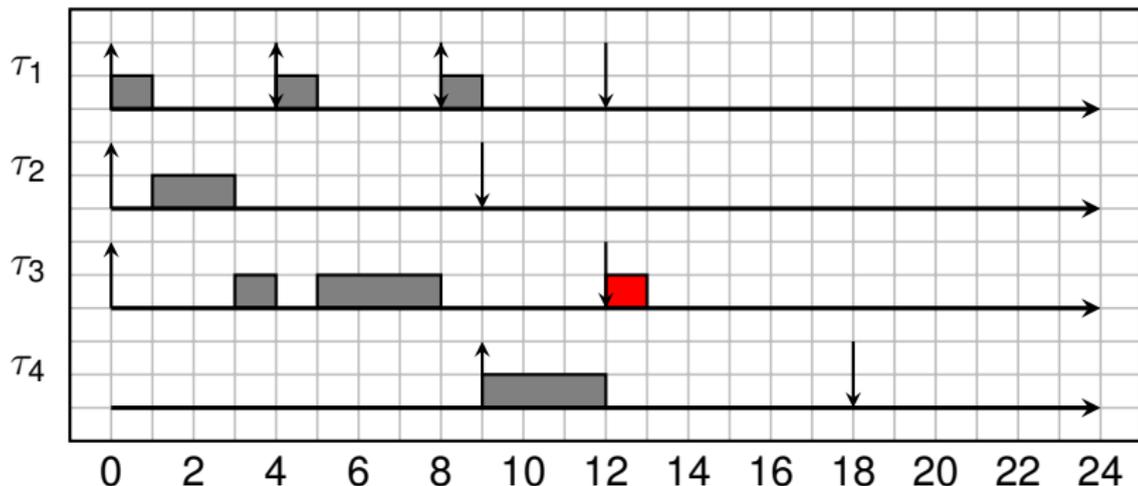
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