Communication Scheduling for Time-Triggered Systems

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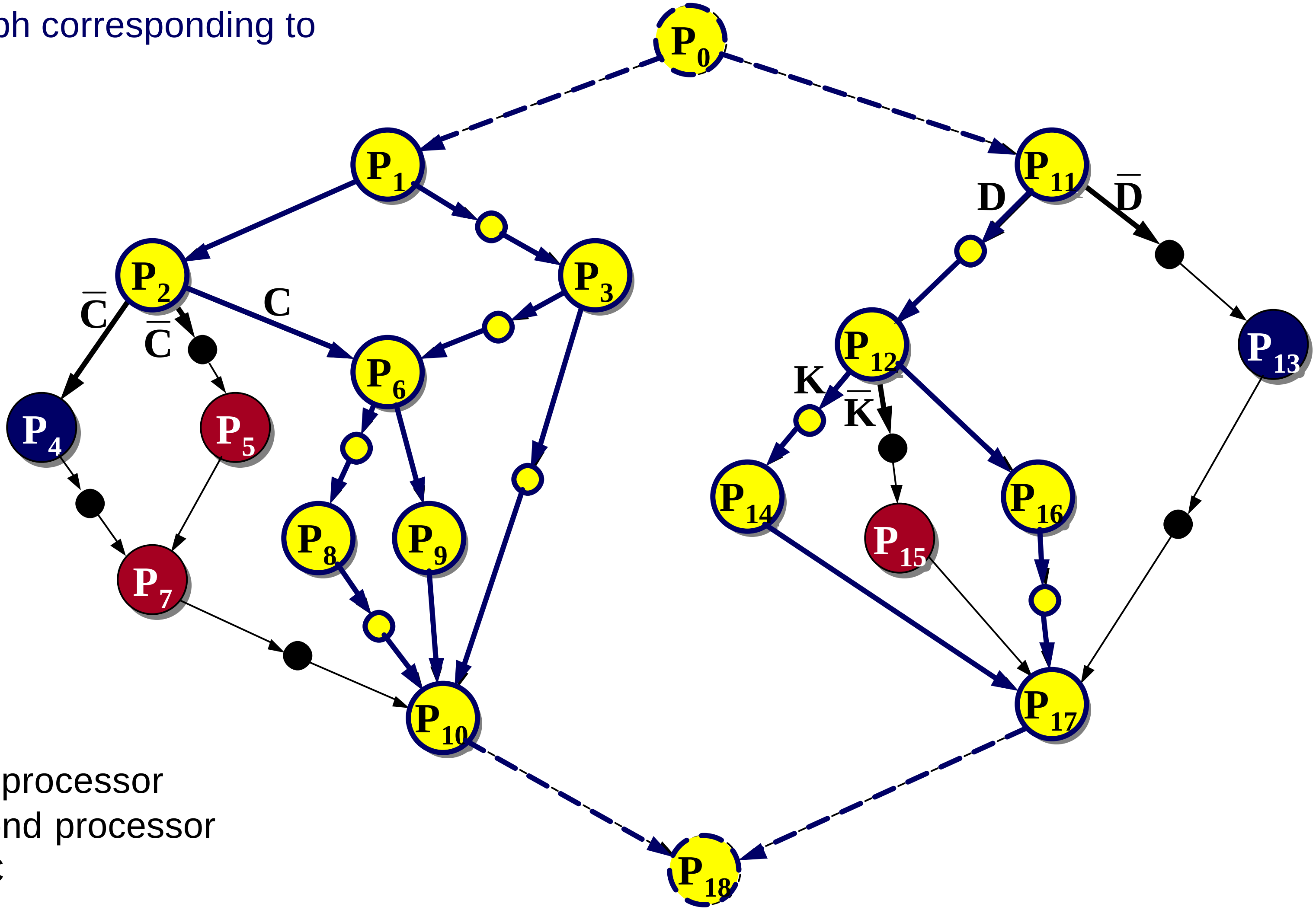
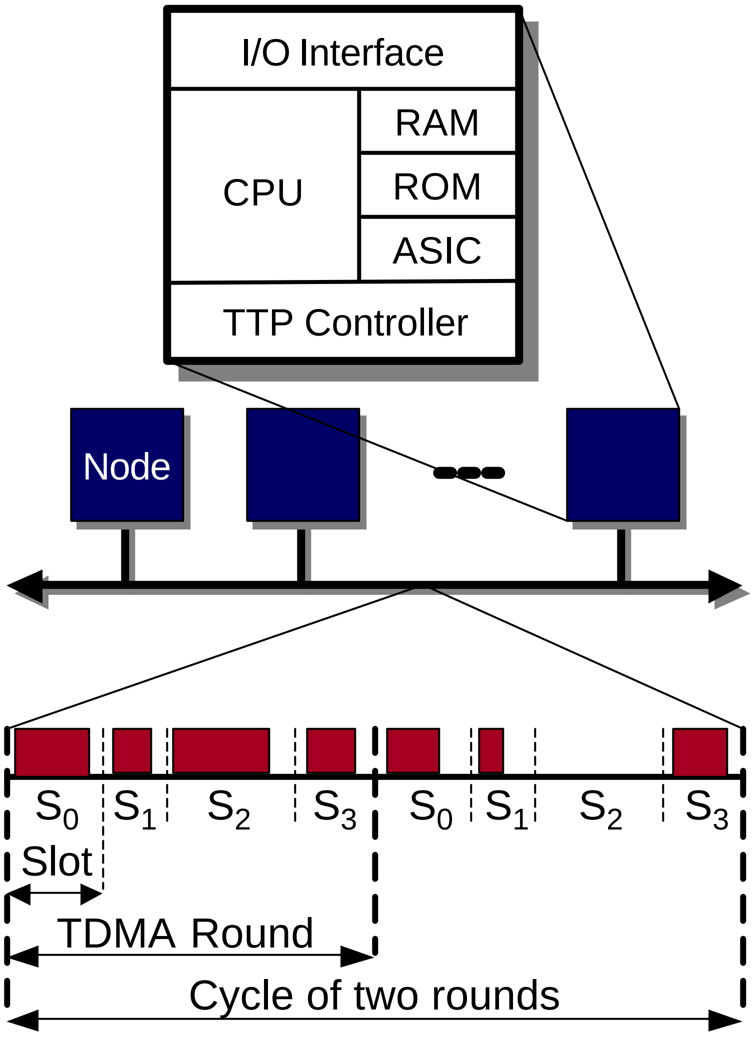
Conditional Process Graph

Subgraph corresponding to
D∧C∧K



- First processor
- Second processor
- ASIC

Hardware Architecture



- Safety-critical distributed embedded systems.
- Nodes connected by a broadcast communication channel.
- Nodes consisting of: TTP controller, CPU, RAM, ROM, I/O interface, (maybe) ASIC.
- Communication between nodes is based on the time-triggered protocol.
- Buss access scheme: time-division multiple-access (TDMA).
- Schedule table located in each TTP controller: message descriptor list (MEDL).

Problem Formulation

Input

- Safety-critical application with several operating modes.
- Each operating mode is modelled by a conditional process graph.
- The system architecture and mapping of processes to nodes are given.
- The worst case delay of a process is known:

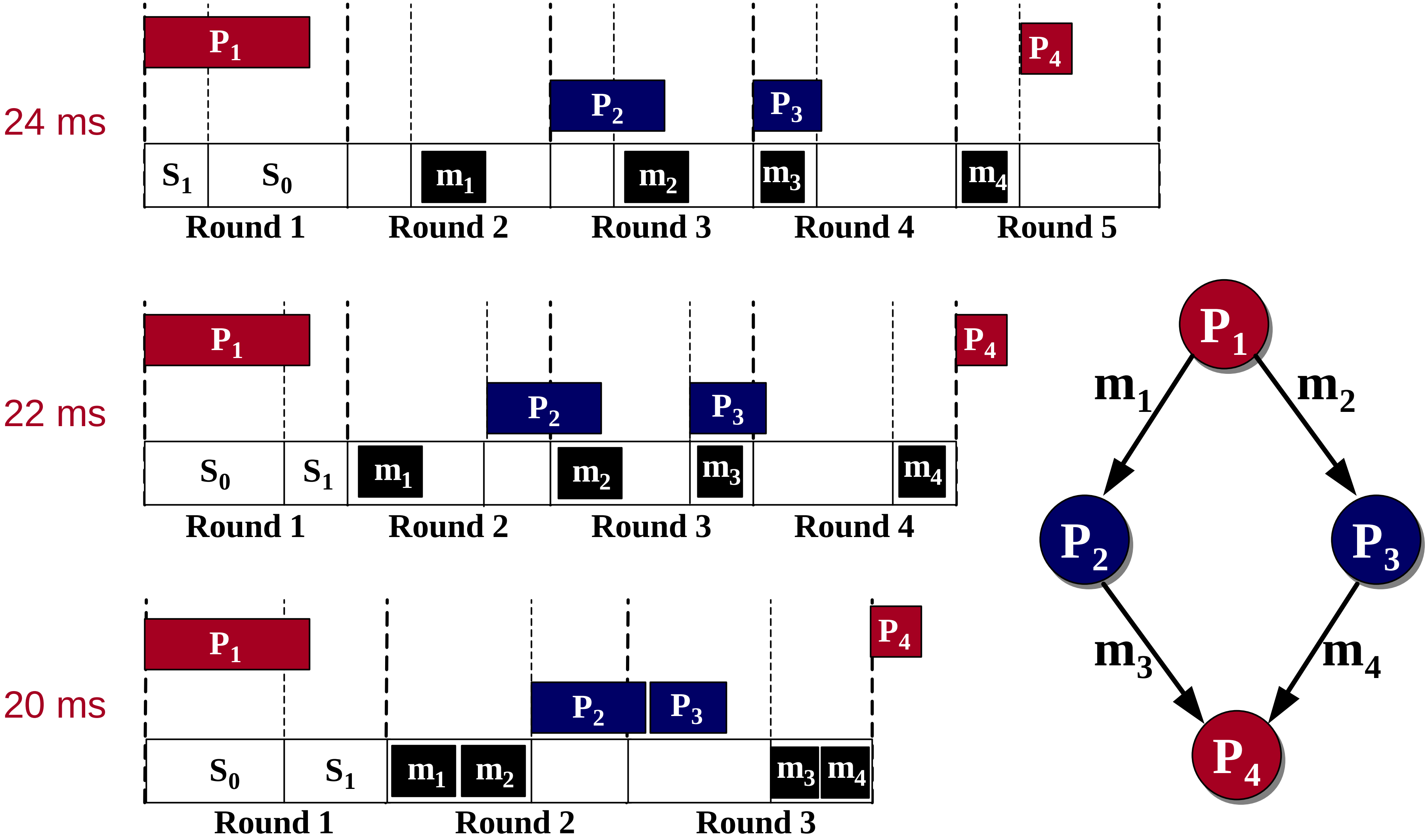
$$T_{P_i} = (d_{PA} + t_{P_i} + q_{C_1} + q_{C_2})$$

$$q_{C_1} = \sum_{i=1}^{N_{out}^{local}(P_i)} d_{S_i} \qquad q_{C_2} = \sum_{i=1}^{N_{out}^{remote}(P_i)} d_{KS_i} + \sum_{i=1}^{N_{in}^{remote}(P_i)} d_{KR_i}$$

Output

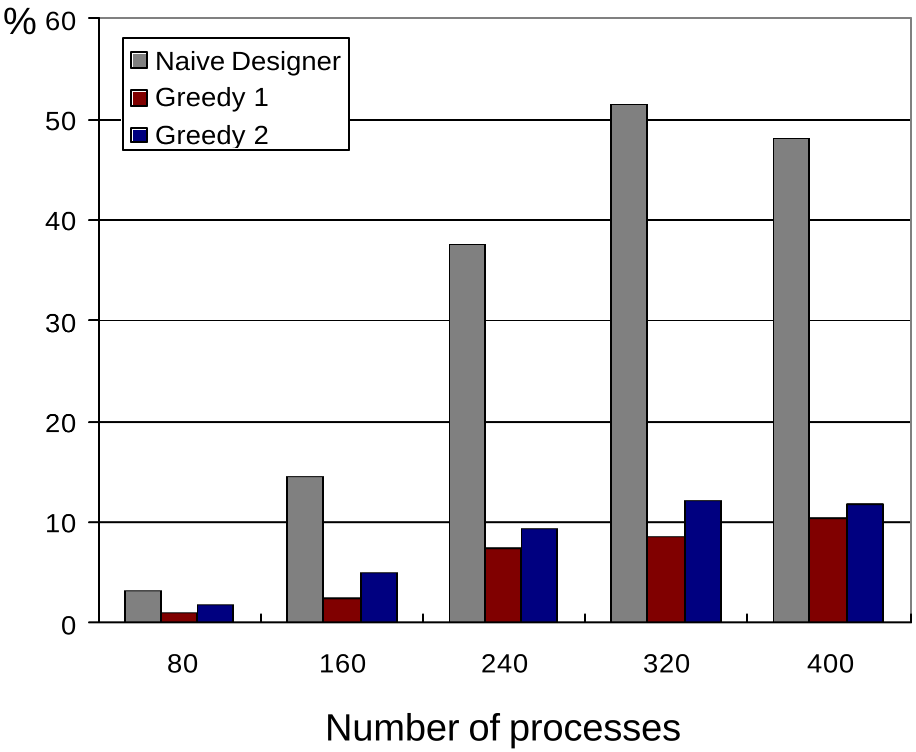
- Local schedule tables for each node and the MEDL for the TTP controllers.
- Delay on the system execution time for each operating mode,
  so that this delay is as small as possible.

Scheduling Example



Experimental Results

Average percentage deviations
from the lengths of near-optimal schedules



- The Greedy Approach is producing accurate results in a very short time (few seconds for graphs with 400 processes).
- Greedy 1 performs slightly better than Greedy 2, but it is a bit slower.
- SA finds near-optimal results in a reasonable time (few minutes for graphs with 80 processes and 275 minutes for graphs with 400 processes).
- A real-life example implementing a vehicle cruise controller validated our approach.