Global Scheduling of Periodic Tasks in a Decentralized Real-time Control System

4. Würzburger Workshop
"IP Netzmanagement, IP Netzplanung und Optimierung"
Würzburg, Germany
27-28 July, 2004

TUHH
Technische Universität Hamburg-Harburg

Communication Networks
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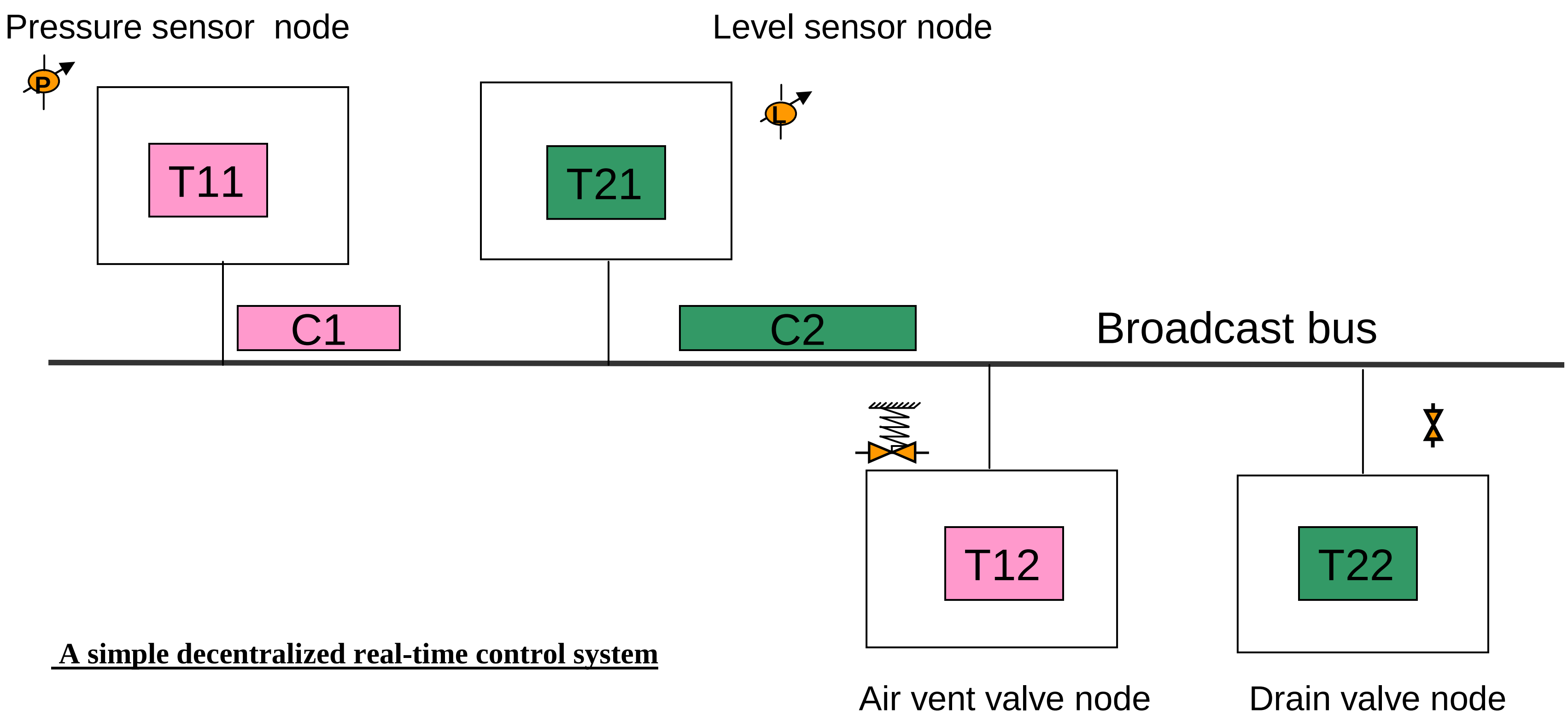
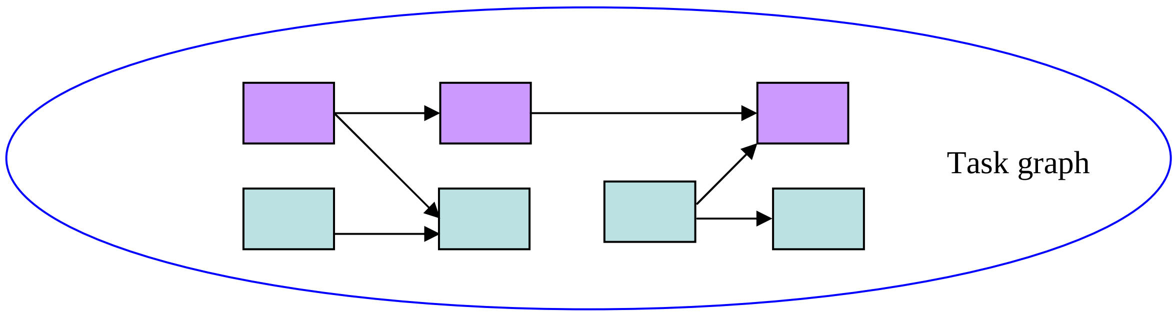
Decentralized real-time control system

A system with loosely coupled nodes, which co-process and communicate with each other to provide the required system control functionality **<u>on time</u>**.



<u>A simple decentralized real-time control system</u>

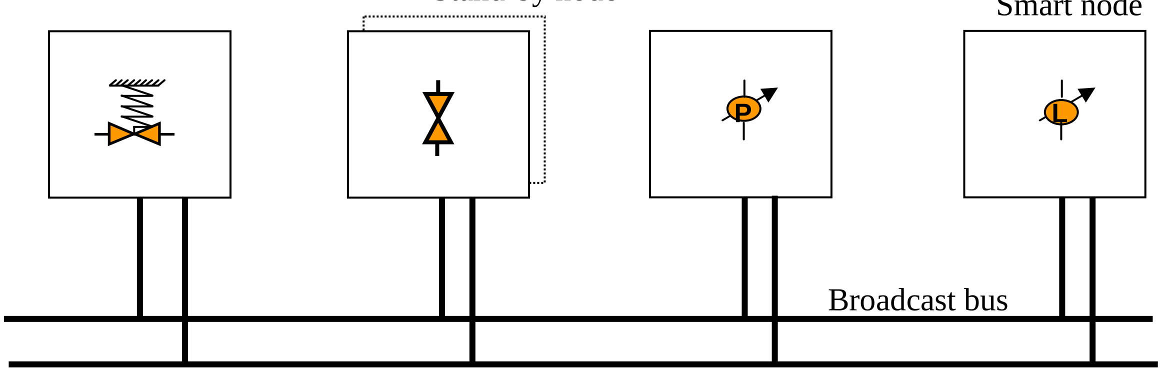
Decentralization of real-time control



Application model

- Timing constraints
- Precedence constraints
- Fault tolerance requirements

⇩ Decentralization



Resource model

- Max. node utilization
- Max. bus utilization

Global scheduling

A plan which defines the space, time and order of execution of tasks and their communications in the node and the bus respectively.

Objective

- Derive a global schedule which has the minimal number of message transfers while not violating the given constraints.

Global scheduling constraints

- No node is utilized above its maximum allowed limit.
- Utilization of the bus is less than the maximum allowed limit.
- Exclusive allocation for fault redundant modules.
- Fixed allocation for resource dependent modules.
- Precedence constraints should not be violated.
- Release times and deadlines should not be violated.

Solution: Mixed Integer Linear Program (MILP)

Mixed Integer Linear Program

Assumptions

- Tasks are periodic.
- Nodes are homogeneous.
- Communication within a node takes zero time.

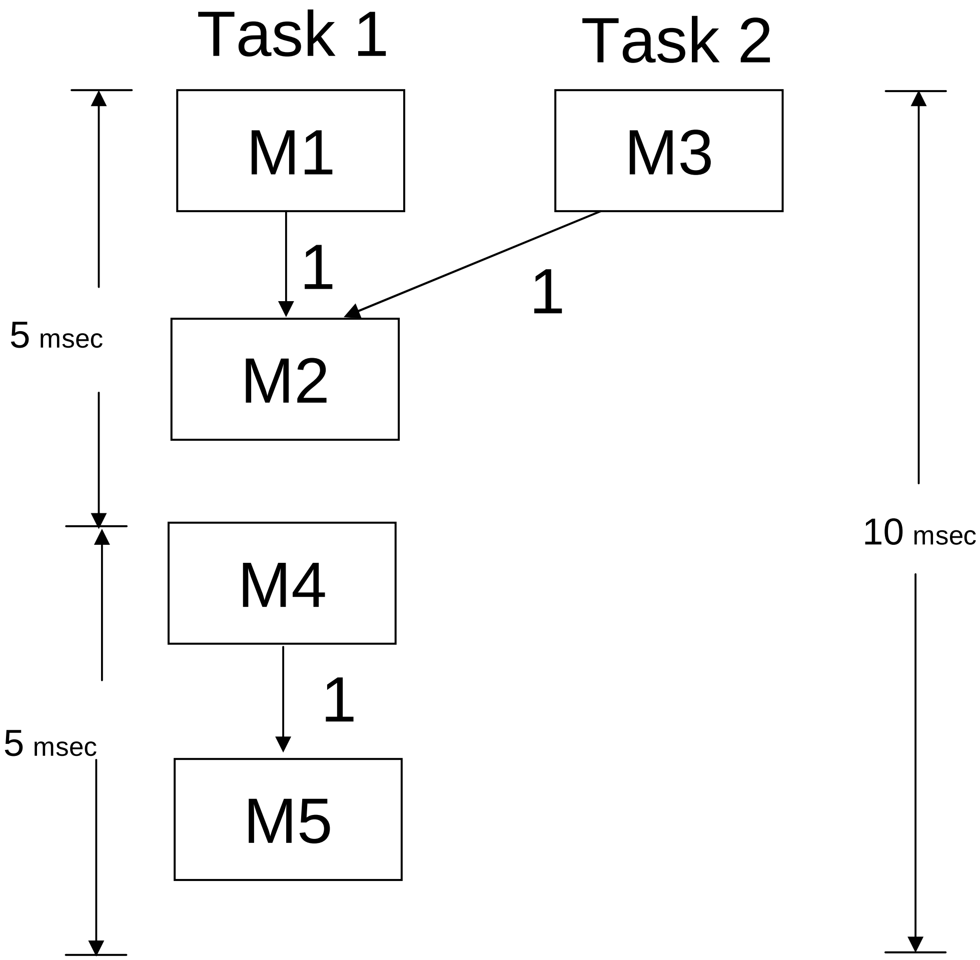
Objective

- Minimize the maximum of all lateness of the given ‘***m***‘ periodic tasks distributed over ‘***n***‘ nodes.

Constraints

- Resource constraints.
- Precedence constraints.
- Timing constraints.

Task graph- Example

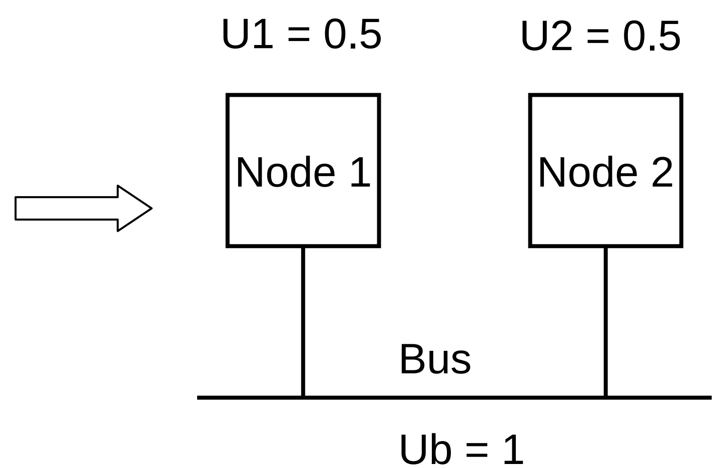


H = 10 msec

e1 = e2 = e4 = e5 = 1 msec

e3 = 3 msec

t = 2 msec



Mixed Integer Linear Program (Contd.)

Objective :

$Minimize: \quad M_L$ **(Maximum Lateness)**

$M_L \geq (S_k + e_k) - d_{ij}$ **(only the leaf modules)**

Constraints :

$A[i,k] = 0 \; or \; 1$ **(module assignment)**

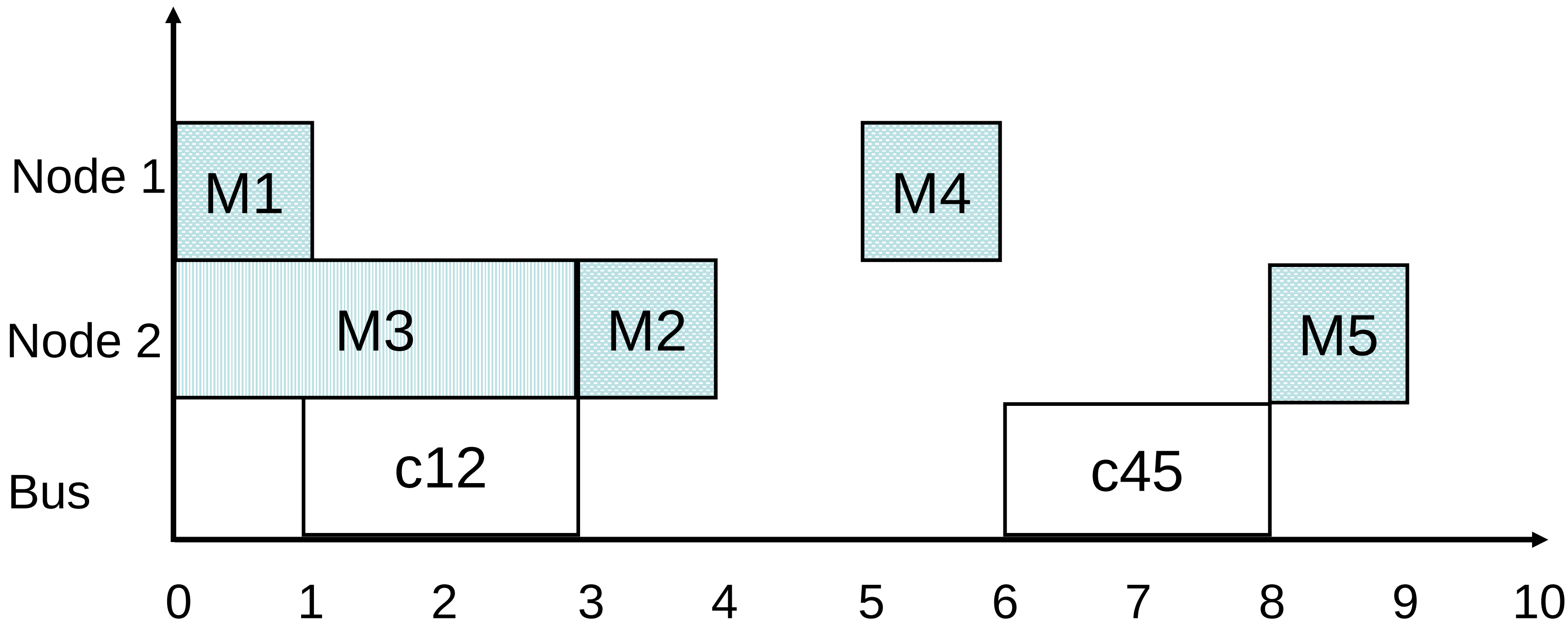
$\sum_{i=1}^{n} u[i] \bullet A[i,k] \leq U[k] \quad , for\ each\ k = 1..n$ **(node utilization bound)**

$A[i,k] = 1 \quad , for\ each\ (i,k) \in R$ **(Resource dependency)**

$0 \leq 1 - A[i,k] - A[i',k] \leq 1 \quad , for\ each\ k = 1..n\ and\ (i,i') \in F$ **(Fault redundancy)**

$r_{k'} \leq S_{k'}, S_k + e_k \leq d_k$ **(Timing constraints)**

Global schedule



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THANK YOU