Departament d'Enginyeria de Sistemes, Automàtica i Informàtica Industrial
UNIVERSITAT POLITÈCNICA DE CATALUNYA

DCS Distributed Control Systems
Control, computing and communication

Efficient Utilization of Bus Idle Times in CAN-based Networked Control Systems

Pau Martí*, Antonio Camacho*, Manel Velasco* and Mohamed El Mongi Ben Gaid**

*Automatic Control Department, Technical University of Catalonia, Barcelona, Spain.

**Technology, Computer Science, and Applied Mathematics Division, IFP, 92852 Rueil-Malmaison, France.

Goal - Increase control performance for a set of control loops that exchange control data over the Controller Area Network (CAN)

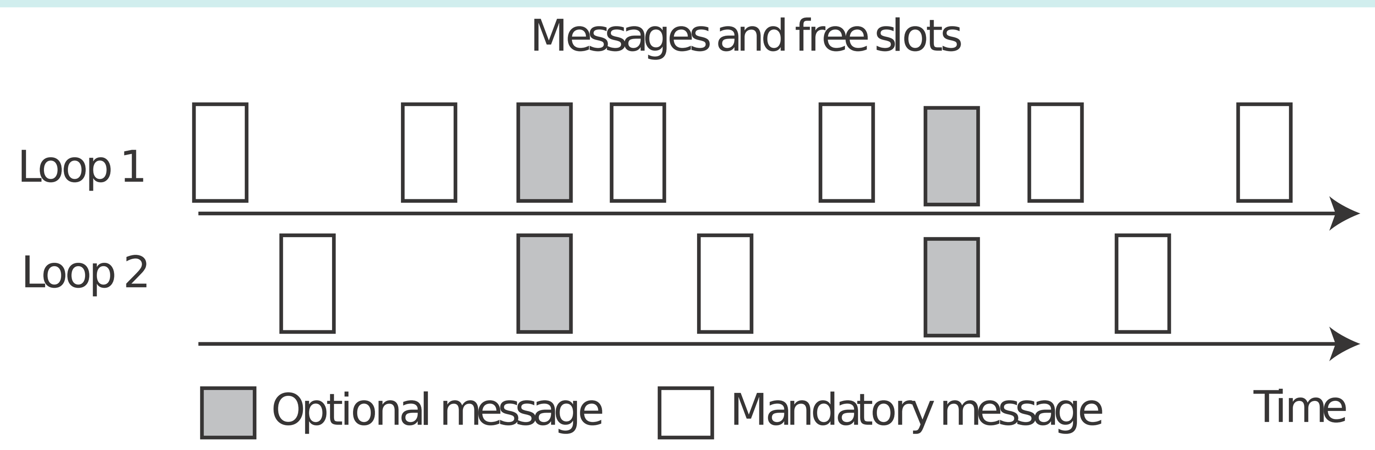
Idea - Fight for idle resources using possible performance improvement as network Id

Model $\dot{x}(t) = A\,x(t) + B\,u(t)$, $y(t) = C\,x(t)$

Each control loop performance is measured by an infinite-horizon continuous-time quadratic cost function

$$J_c = \int_0^\infty x(t)^T Q_{c1} x(t) + u(t)^T Q_{c2} u(t) dt,$$

The control signal updates are mandatory at kh, $k = 0, 1, 2, \ldots$ and h the system's sampling period



There are free slots on the bus which can be used to improve the overall performance. A criterium is needed to choose which control loop will use them.

Medium access Policies - A decentraliced model for overall performance improvement

Centralized model (MC model)

By encoding in each sensor message identifier each argument $c_i^{total}(t_k)$ of the min function in

$$\arg\min_i \{c_i^{total}(t_k) \mid i = 1, \ldots, n\}, \quad (1)$$

in bus contention, the bitwise arbitration of CAN would give access to the message encoding the minimum overall cost.

Cons

The state information of all plants must be known at each sensor node

Decentralized model (MD model)

By encoding in each sensor message identifier the difference

$$d_i(t_k) = c_i^{Nopt}(t_k) - c_i^{opt}(t_k). \quad (2)$$

between the performance of sending an extra message and the performance of not sending it, the bitwise arbitration of CAN would produce the desired result.

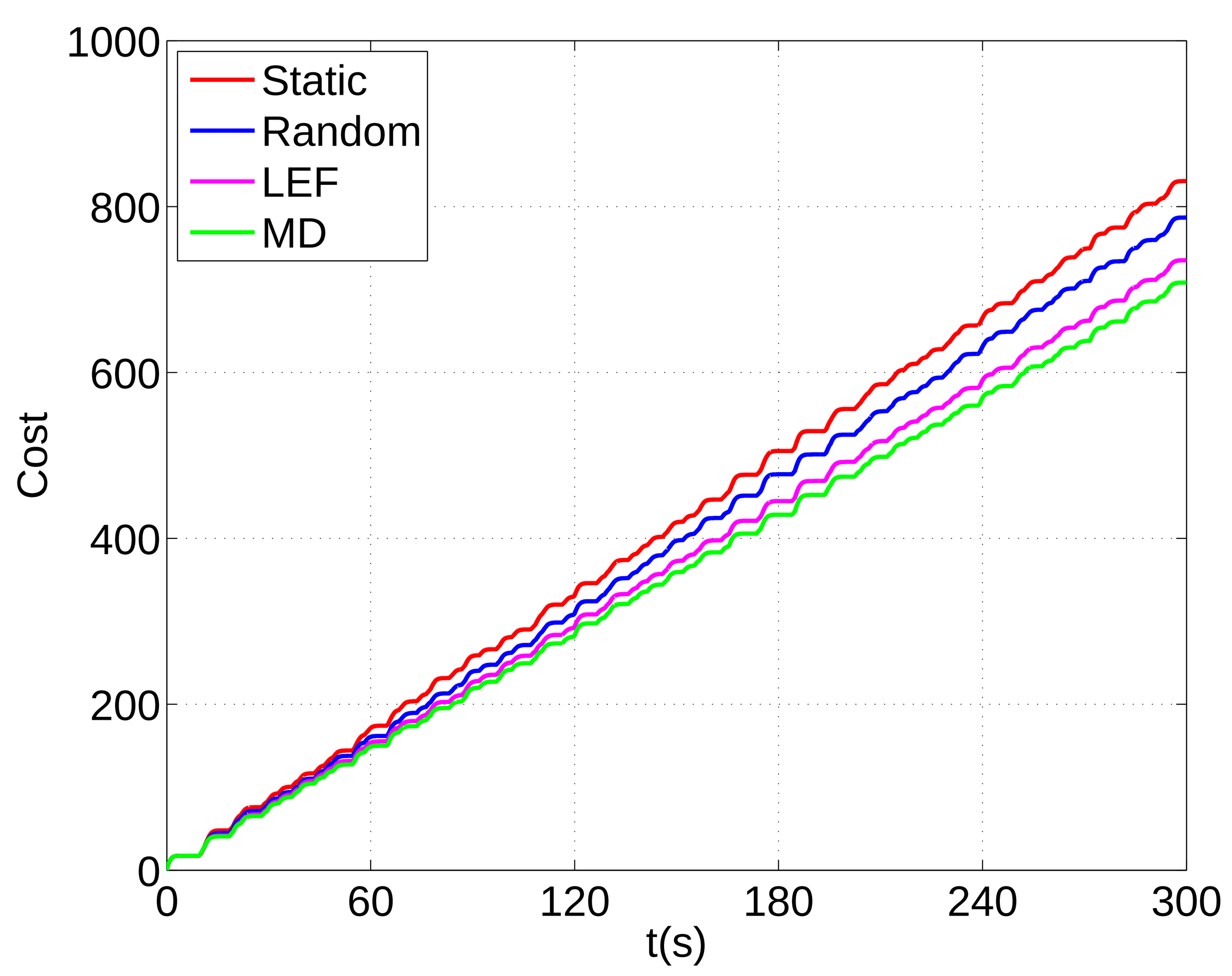
Pros

There is no need of full knowledge of the rest of plant's states

Advantages of MD implementation

- The required number of matrix operations at each sensor node for each optional control job reduces to 3
- The number of matrices to be stored in memory reduces to $\frac{h}{h_s} - 1$
- There is no need of extra messages informing of plant's states

Simulations



Comparative of a static resource assignment vs. a random resource assignment vs. a larger error first (LEF) and the maximum difference policies

Conclusions

- The MD policy permits to chose at run time which loop should execute an additional control job each time the bus is idle.
- the policy can be efficiently implemented in CAN.
- Is feasible in terms of resource demands.
- Simulations show that the MD policy provides the best performance compared to previous and/or alternative policies.
- Given the fact that at run time there is no knowledge of possible future idle windows at the bus, it could happen that an alternative sequence of job assignments would rise with a better performance.

DCS Distributed Control Systems
Control, computing and communication

Departament d'Enginyeria de Sistemes, Automàtica i Informàtica Industrial
UNIVERSITAT POLITÈCNICA DE CATALUNYA