

# DISCO – DIStributed Embeddable Systems for COntrol Applications

**Institutions:** Universidade de Aveiro (IEETA Instituto de Engenharia Electrónica e Telemática de Aveiro)  
Instituto Superior de Engenharia de Coimbra  
Escola Superior de Tecnologia do Instituto Politécnico de Castelo Branco  
Instituto de Engenharia Mecânica – IDEMEC

**Objectives:** To investigate techniques and to develop solutions to improve flexibility and adaptability in distributed embedded control systems in order to reduce operation and maintenance costs while maximising the utilisation of system resources.

**Keywords:** *Distributed Systems, Real-Time, Control, Communications*

**Target Systems:** Fieldbus based distributed systems.

Embedded control systems.

Real-time systems for the automotive and robotics fields.

## Project Tasks:

**T1: Determination of flexible control requirements.**

**Consultant:** Professor Tore Hagglund, Lund Institute of Technology

Determination of operating ranges for control parameters (sampling period and jitter). Models for communication induced jitter for different fieldbuses. Figures of merit for the performance of most common control algorithms under jitter conditions.

**T2: Software-based infrastructures**

**Consultants:** Professor Jean-Pierre Thomesse, Institute National Polytechnique de Lorraine, Nancy, France

Professor Giorgio Butazzo, University of Pavia, Italy

Professor Zoubir Mammeri, Université Paul Sabatier, Toulouse, France

Software and/or protocol based on-line scheduling and dispatching techniques (planning scheduler, FTT-CAN, Time-triggered MAC, FPGA-based schedulers, neural networks based scheduling) suitable to handle changes in control systems operational parameters.

Clock synchronisation services to be used by distributed system nodes.

**T3: Scheduling with dedicated hardware**

**Consultant:** Professor Valery Sklyarov, University of Aveiro

Soft-line: scheduling and dispatching techniques, communication protocols, synchronisation, handling of transient situations in systems based in off-the-shelf hardware.

Hard-line: hardware based solutions: FPGAs / microprocessor based co-processors (to overcome limitations imposed by excessive overhead).

**T4: Global systems management**

**Consultants:** Professor Jean-Pierre Thomesse, Institute National Polytechnique de Lorraine, Nancy, France

Professor Giorgio Butazzo, University of Pavia, Italy

- Techniques (network-centric perspective, synchronisation services, global admission control) to achieve global management of embedded distributed systems, integrating tasks and communications management.
- Joint (holistic) scheduling of tasks and messages in a flexible way, using on-line admission control for every change required.

**T5: Assessment and Demonstration**

- Assessment of task results in a distributed experimental prototype, possibly based in CAN, in which several control loops are split between nodes.

- Demonstrator based on a mobile robot in construction in another project, where control electronics will be replaced by an embedded version of previous system.

### Some on-going research work:

Determination of the influence of network-induced jitter in systems identification.

Combining event-triggered and time-triggered traffic in FTT-CAN.

Developing of scheduling coprocessors based on the planning paradigm.

Using genetic algorithms to reduce jitter in periodic variables transmission.

### Industrial Liaisons and Projects:

Fuzzy Control of a Domestic Water Gas Heater

Access Control based on Fieldbuses

Wine Fermentation Supervision and Control

### Related Publications (1999 / 2000):

Luís Almeida, R. Pasadas, J. A. Fonseca - "Using The Planning Scheduler to Improve Flexibility in Real-Time Fieldbus Networks" IFAC, *International Federation of Automatic Control, Control Engineering Practice* Vol. 7, Nº 1, pp. 101-108, Janeiro de 1999, Elsevier Science, Ltd.

V Sklyarov, J. Fonseca, R. Monteiro, A. Oliveira, A. Melo, N. Lau, K. Kondratjuk, I Sklyarova, P. Neves, A. Ferrari - "FPGA - Targeted Development System for Embedded Applications" *Proceedings FPGA'99: Seventh ACM International Symposium on Field-Programmable Gate Arrays*, California, EUA, 21 a 23 de Fevereiro de 1999.

V Sklyarov, J. Fonseca, R. Monteiro, A. Oliveira, A. Melo, N. Lau, I Sklyarova, P. Neves, A. Ferrari - "Development System for FPGA-Based Digital Circuits", *Proceedings FCCM'99: IEEE Symposium on Field-Programmable Custom Computing Machines*, California, EUA, 21 a 23 de Abril de 1999.

José A. Fonseca, Pedro Fonseca, Luís Almeida, Alexandre Mota - "An efficient workbench for rapid tests in CAN-based distributed systems" *Actes du INNOCAP 99 - Colloque Européen sur Réseaux de Capteurs et Communications*, Grenoble, França, 28 a 29 de Abril de 1999.

L. Almeida, J. A. Fonseca - "Schedulability Analysis in the FIP Fieldbus Accounting for Inserted Idle-Time", *Proceedings of Work-In-Progress Sessions of 11<sup>th</sup> EUROMICRO Conference on Real-Time Systems*, York, Reino Unido, 9 a 11 de Junho de 1999.

Teresa Mendonça, Pedro Lago, Alexandre Mota - "MATLAB Implementation of Neuromuscular Blockade Controller", *Proceedings SBC'99 - International ICSC Symposium on Soft Computing in Biomedicine*, Rochester, New York, USA, 22 a 25 de Junho de 1999.

Luís Almeida, Miguel Leon Chavez, José Alberto Fonseca, Jean Pierre Thomesse - "Real time communications in manufacturing" *Proceedings ISAS'99 The 5th. Int'l Conference on Information Systems Analysis and Synthesis*, Orlando, Florida, Estados Unidos, 31 de Julho a 4 de Agosto de 1999 (artigo convidado).

Alexandre Mota, Fernando Santos, José A. Fonseca - "Sistema de Supervisão e Controlo de Fermentação Alcoólica" actas de JA99 - XX Jornadas de Automatica do Comité Espanhol do IFAC, Salamanca, Espanha, 27 a 29 de Setembro de 1999.

Fernando Santos, José A. Fonseca, Alexandre Mota - "GCODE - Gerador gráfico de código para pequenos sistemas de controlo" actas de JA99 - XX Jornadas de Automatica do Comité Espanhol do IFAC, Salamanca, Espanha, 27 a 29 de Setembro de 1999.

L. Almeida, J. Fonseca, P. Fonseca - "A Flexible Time-Triggered Communication System Based on the Controller Area Network" *Proceedings FeT '99 - Fieldbus Systems and their Applications Conference*, Magdeburgo, Alemanha, 23 a 24 de Setembro de 1999.

José A. Fonseca, Luís Almeida - "Using a Planning Scheduler in the CAN Network", *Proceedings ETFA'99 - 7<sup>th</sup> IEEE International Conference on Emerging Technologies and Factory Automation*, Barcelona, Espanha, 18 a 22 de Outubro de 1999.

José A. Fonseca, Luís Almeida, Pedro Fonseca, Zoubir Mammeri - "Scheduling and Synchronisation in CAN based Distributed Systems", *Proceedings 6th International CAN Conference '99*, Turim, Itália, 2 a 4 de Novembro de 1999.