Fixed Priorities or EDF for Distributed Real-Time Systems?

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GOAL: to compare how FP and EDF can influence the schedulability of a distributed real-time system under a variety of conditions: different system sizes, deadline/period ratios, different lengths of end-to-end flows, ...; inspired by [1]





Application Profiles

System Specification

- Number of end-to-end (E2E) flows
- Maximum number of steps per E2E
- Number of E2Es with a single step
- Number of processors and networks
- Deadline and period ranges and ratios
- Type of schedulers: FP, local or global EDF

Evolution Rules

- Number of seed models with the same specification
- Initial and last utilization values (%)
- Utilization step (%)
- Utilization distribution (uniform/non-uniform)

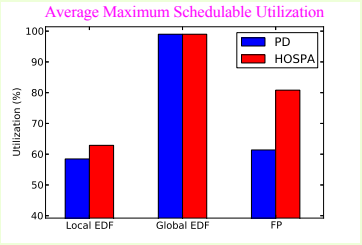
GEN4MAST (Generator)

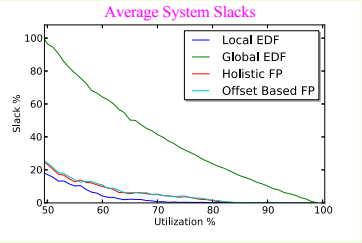
Example specification:
- 20 E2E flows
- Up to 8 steps per E2E flow
- 10 single step E2E flows
- 5 processors
- Maximum periods ratio= 1000
- D=Num. of steps in E2E flow*T
- FP, local and global EDF
- PD and HOSPA

Evolution rules:
- 50 seed models
- Initial and last utilizations: 40%-99%
- Utilization step: 1%
- Uniform utilization distribution

24000 tests executed
- Analysis, optimization and calculation of slacks

Computation times:
- Almost 4 months of CPU time
- Less than 15 hours of supercomputer usage





Results for an Example

Database (HDF5)

- Maximum utilizations reached for scheduling optimization techniques
- Slacks when applying schedulability analysis techniques
- Computation times for tests

GEN4MAST (Results Processing)

Supercomputer scripts

GEN4MAST Core

MAST System Description

MAST Results Description

MAST Analysis Tool [2][3]

Scheduling Parameters Assignment Techniques

Distributed Systems
- HOSPA [9]
- Simulated Annealing
- PD [4]
- NPD [4]

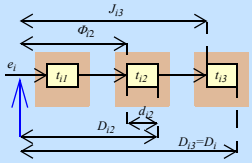
Schedulability Analysis Techniques

Distributed Systems:
- Holistic [11]
- Offset-Based [6][7]
- Local EDF [8]
- Global EDF [10]
- Heterogeneous [9]

Sensitivity Analysis

Slacks:
- System
- Processing Resource
- End-to-end Flow
- Operation

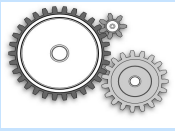
E2E Flow Model [5]



Shared Resources

Calculate Ceilings
Calculate Blocking Times

Other MAST Tools



Model Builders
(Graphical editor,
UML profile,
Ada components, etc.)
Results Viewer
Simulator

MAST home page: `http://mast.unican.es/`

[1] G Buttazzo, "Rate Monotonic vs. EDF: Judgment Day," Real-Time Systems, 29(1), pp. 5-26, 2005.
[2] M. González Harbour, J. Javier Gutiérrez, J.C. Palencia, and J.M. Drake, "MAST: Modeling and Analysis Suite for Real Time Applications," Proceedings of 13th Euromicro Conference on Real-Time Systems, Delft (The Netherlands), pp. 125-134, 2001.
[3] M. González Harbour, J. Javier Gutiérrez, José M. Drake, P. López Martínez and J. C. Palencia, "Modeling distributed real-time systems with MAST 2," In press, Journal of Systems Architecture, Elsevier, 2012.
[4] J. Liu, "Real-Time Systems," Prentice Hall, 2000.
[5] Object Management Group, "UML Profile for MARTE: Modeling and Analysis of Real-Time Embedded systems," 2009 OMG Document, v1.0 formal/2009-11-02.
[6] J.C. Palencia, and M. González Harbour, "Exploiting Precedence Relations in the Schedulability Analysis of Distributed Real-Time Systems". Proceedings of the 20th Real-Time Systems Symposium, IEEE, pp. 328-339, 1999.
[7] J.C. Palencia, and M. González Harbour, "Offset-Based Response Time Analysis of Distributed Systems Scheduled under EDF," Proceedings of the 15th Euromicro Conference on Real-Time Systems, ECRTS, Porto (Portugal), 2003.
[8] Juan M. Rivas, J. J. Gutiérrez, J. C. Palencia, and M. González Harbour, "Optimized Deadline Assignment and Schedulability Analysis for Distributed Real-Time Systems with Local EDF Scheduling". 8th International Conference on Embedded Systems and Applications, in WORLDCOMP'10, Las Vegas (Nevada), USA, 2010.
[9] Juan M. Rivas, J. Javier Gutiérrez, J. Carlos Palencia, M. González Harbour, "Schedulability Analysis and Optimization of Heterogeneous EDF and FP Distributed Real-Time Systems," Proceedings of the 23th Euromicro Conference on Real-Time Systems, Porto (Portugal), 2011.
[10] M. Spuri, "Holistic Analysis for Deadline Scheduled Real-Time Distributed Systems," Tech. Rep. RR-2873, INRIA, France, April 1996.
[11] K. Tindell, and J. Clark, "Holistic Schedulability Analysis for Distributed Hard Real-Time Systems," Microprocessing & Microprogramming, Vol. 40, Nos.2-3, pp. 117-134, 1994.