Linux Testbed for Multiprocessor Scheduling in Real-Time Systems

About

The LITMUS[RT] project is a soft real-time extension of the Linux kernel with focus on multiprocessor real-time scheduling and synchronization. The Linux kernel is modified to support the sporadic task model and modular scheduler plugins. Both partitioned and global scheduling are supported.

Goals

The primary purpose of the LITMUS[RT] project is to **provide a useful experimental platform for applied real-time systems research**. In that regard, LITMUS[RT] provides abstractions and interfaces within the kernel that simplify the prototyping of multiprocessor real-time scheduling and synchronization algorithms (compared to modifying a "vanilla" Linux kernel). As a secondary goal, LITMUS[RT] serves as a proof of concept, showing that algorithms such as PFAIR can be implemented on current hardware. Finally, "lessons learned" using LITMUS[RT] may find value as blueprints/sources of inspiration for other (both commercial and open source) implementation efforts.

Non-Goals

LITMUS[RT] is not a production-quality system (currently). It is also not "stable," i.e., interfaces and implementations may change without warning between releases. POSIX-compliance is not a goal; the LITMUS[RT]-API offers alternate system call interfaces. While we aim to follow Linux-coding guidelines, LITMUS[RT] is not targeted at being merged into mainline Linux. Rather, we hope that some of the ideas prototyped in LITMUS[RT] may eventually find adoption in Linux.

Current Version

The current version of LITMUS[RT] is 2010.1 and is based on Linux 2.6.32. It was released on 05/19/2010 and includes plugins for the following scheduling policies:

• Partitioned EDF with synchronization support (PSN-EDF)
• Global EDF with synchronization support (GSN-EDF)
• Clustered EDF (C-EDF)
• PFAIR (both staggered and aligned quanta are supported)

Please refer to the download and installation sections on the LITMUS[RT] web site for details.

Earlier versions, which supported additional scheduling policies, include LITMUS[RT] 2008 (based on Linux 2.6.24) and LITMUS[RT] 2007 (based on Linux 2.6.20).

The first version of LITMUS[RT] (implemented in Spring 2006) was based on Linux 2.6.9.

Development Plans

There are plans to port LITMUS[RT] to PowerPC and ARM platforms.

Collaborators

The LITMUS[RT] project is led by Dr. James H. Anderson.

The implementation effort is carried out by students of the Real-Time Systems Group at the University of North Carolina at Chapel Hill:
Björn B. Brandenburg (current maintainer)
Andrea Bastoni (visiting from the University of Rome "Tor Vergata")

Additional collaborators contributed to the previous LITMUS[RT] 2008 and the LITMUS[RT] 2007 versions.

Research Support

Publications

A.Bastoni, B. Brandenburg and J. Anderson "Cache-Related Preemption and Migration Delays: Empirical Approximation and Impact on Schedulability," *Proc. of the Sixth International Workshop on Operating Systems Platforms for Embedded Real-Time Applications*, July 2010.

B. Brandenburg and J. Anderson, "On the Implementation of Global Real-Time Schedulers," *Proc. of the 30th IEEE Real-Time Systems Symposium*, pp. 214-224, December 2009.

B. Brandenburg and J. Anderson "Reader-Writer Synchronization for Shared-Memory Multiprocessor Real-Time Systems," *Proc. of the 21st Euromicro Conference on Real-Time Systems*, pp. 184-193, July 2009.

J. Calandrino and J. Anderson "On the Design and Implementation of a Cache-Aware Multicore Real-Time Scheduler," *Proc. of the 21st Euromicro Conference on Real-Time Systems*, pp. 194-204, July 2009.

M. Mollison, B. Brandenburg, and J. Anderson "Towards Unit Testing Real-Time Schedulers in LITMUS^RT," *Proc. of the Fifth International Workshop on Operating Systems Platforms for Embedded Real-Time Applications*, pp. 33-39, July 2009.

B. Brandenburg and J. Anderson, "A Comparison of the M-PCP, D-PCP, and FMLP on LITMUS^RT," *Proc. of the 12th International Conference on Principles of Distributed Systems*, pp. 105-124, December 2008.

B. Brandenburg, J. Calandrino, and J. Anderson, "On the Scalability of Real-Time Scheduling Algorithms on Multi-core Platforms: A Case Study," *Proc. of the 29th IEEE Real-Time Systems Symposium*, pp. 157-169, December 2008.

B. Brandenburg and J. Anderson, "An Implementation of the PCP, SRP, D-PCP, M-PCP, and FMLP Real-Time Synchronization Protocols in LITMUS^RT," *Proc. of the 14th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications*, pp. 185-194, August 2008. Postscript. PDF.

A. Block, B. Brandenburg, J. Anderson, and S. Quint, "An Adaptive Framework for Multiprocessor Real-Time Systems," *Proc. of the 20th Euromicro Conference on Real-Time Systems*, pp. 23-33, July 2008. Postscript. PDF.

B. Brandenburg, J. Calandrino, A. Block, H. Leontyev, and J. Anderson, "Real-Time Synchronization on Multiprocessors: To Block or Not to Block, to Suspend or Spin?" *Proc. of the 14th IEEE Real-Time and Embedded Technology and Applications Symposium*, pp. 342-353, April 2008.

B. Brandenburg, A. Block, J. Calandrino, U. Devi, H. Leontyev, and J. Anderson, "LITMUS^RT: A Status Report," *Proc. of the 9th Real-Time Linux Workshop*, pp. 107-123, November 2007.

B. Brandenburg and J. Anderson, "Integrating Hard/Soft Real-Time Tasks and Best-Effort Jobs on Multiprocessors," *Proc. of the 19th Euromicro Conference on Real-Time Systems*, pp. 61-70, July 2007.

J. Calandrino, H. Leontyev, A. Block, U. Devi, and J. Anderson, "LITMUS^RT: A Testbed for Empirically Comparing Real-Time Multiprocessor Schedulers," *Proc. of the 27th IEEE Real-Time Systems Symposium*, pp. 111-123, December 2006.

For More Information

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