Monitoring of Distributed Real-Time Systems

Ulrich Schmid

Technical University of Vienna, Department of Automation (183/1),
Treitlstraße 3, A–1040 Vienna.
Phone: 0043-222/58801-8189, E-mail: s@auto.tuwien.ac.at

An important part of a major research activity on *real-time-performance analysis of event driven systems* pursued at our department is devoted to monitoring of distributed real-time systems: The project VTA[1] aims at the development of the research prototype of a flexible monitoring system (the *Versatile Timing Analyzer VTA*), which is required for observing the external and internal (timing-)behaviour of a distributed real-time system; see [SSt] for an overview.

The scope of applicability of such a monitoring system comprises

1. *Theoretical research*
   Another project within our major research activity is devoted to the (mathematical) analysis of deadline meeting properties of event driven real-time systems subjected to general dynamic event arrivals: Hard real-time systems usually rely on the assumption of (essentially) cyclic events, where deadline meeting guarantees may be given. On the other hand, dynamic models suitable for general aperiodic arrivals and associated (soft) real-time computations have not been known yet — despite of the large number of event driven real-time applications demonstrating that such systems are common in practice.
   Therefore, we tried to find dynamic event arrival models which
   (a) apply reasonably well in practice,
   (b) permit the definition of significant real-time performance metrics,
   (c) render a rigorous analysis of such metrics feasible.
   We found that the above requirements are —to a certain extent— satisfied by a simple model based on independent, generally distributed event arrivals during a constant (application-dependent) cycle time in conjunction with independent task sets. In a number of papers (e.g. [SB], [DS]), we analyzed the appropriate deadline missing probabilities for a few simple scheduling disciplines. The results, as limited as they are, convinced us that our (non-queuing theory) analysis approach works and provides a suitable basis for further research.
   However, we recognized soon that we —and it seems, scientific work on real-time systems as a whole— lack realistic information concerning event arrivals

[1] Supported by the Austrian Science Foundation (FWF), Grant P8390-PHY.

in existing real-time systems. Without it, however, an answer to the question wether our models are appropriate in practice or not is impossible. Consequently, a flexible and powerful monitoring system is needed to facilitate the process of gathering the required information. Note that an observation of the "raw data stream" accessible via the environmental interface of a real-time system is usually not sufficient, since the most important events appear in "higher-level data streams" generated by various preprocessing stages.

2. *System checking*
   A certain class of applications of a monitoring system support —in a certain sense— the requirements engineering phase within real-time systems' development: Since there is a certain danger to build a real-time system upon wrong assumptions concerning the controlled environment, a continuous monitoring of its behaviour is invaluable to decrease the risk of a failure due to a specification error. Note that this is especially true for static systems.
   Another very important application of a monitoring system is to use it as a testing tool. Due to the usually poor conceptual basis of today's real-time systems, many of them are designed rather ad hoc. Consequently, one should at least check their timing properties by an actual measurement, e.g. by checking
   (a) deadline meeting properties,
   (b) internal (timing) behaviour,
   (c) resource (under-)utilization,
   instead of believing in their correctness/appropriatness only.

Given such requirements, it is clear that flexibility and extendability are two essential features of a monitoring system suitable for our purposes. Consequently, we designed our VTA according to the so-called *event-action model* relying on user-programmable monitoring actions triggered by the occurrence of user-definable events within the observed real-time system's hardware and software. Despite of some valuable research experience from traditional event-based debugging, however, the development of our VTA involves a lot of interesting research in many fields and —last but not least— laborous design and implementation work to be done.

References

[SSt] Schmid, U., Stöckler, S.: A Versatile Monitoring System for Distributed Real-Time Systems. Proc. SAFECOMP '92, Zürich (to appear)

[SB] Schmid, U., Blieberger, J.: Some Investigations on FCFS Scheduling in Hard Real Time Applications. J. Comput. Syst. Sci. (to appear)

[DS] Drmota, M., Schmid, U.: Exponential Limiting Distributions in Queueing Systems with Deadlines. SIAM J. Appl. Math. (to appear)

This article was processed using the LaTeX macro package with LMAMULT style