An Annotated Bibliography on Real-Time Database Systems

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1 Introduction

This is an annotated bibliography on real-time database systems, a field which has emerged as a result of the growing interest in applying the principles and techniques of real-time scheduling to transaction management in DBMSs. Today, many application areas supported by a DBMS are characterized by the requirement of timely access to the underlying database. Among those application areas are information retrieval systems, airline reservation systems, stock market, banking, and computer-integrated manufacturing. In addition to maintaining database consistency, an essential scheduling goal in those applications is to satisfy timing constraints associated with transactions accessing the database.

Real-time database systems entered the computer science spotlight with the publication of a special issue in the ACM SIGMOD Record in March 1988. Since then, the results of a considerable number of works addressing various features of real-time database systems have appeared in the literature. This bibliography presents a collection of papers on various aspects of real-time database systems that have been published or identified so far. To our knowledge, this is the first bibliography to appear concerning real-time database systems. The bibliography is available online for anonymous ftp at **gordion.cs.bilkent.edu.tr** in the **pub/bib** directory. We apologize in advance for any errors or omissions. Remarks, corrections, and additions are most welcome and may be sent to the author at the above address.

2 Research Issues

In the following we categorize the papers into various sections based on the specific topic each paper focuses on. Some papers are listed in more than one category, as they deal with more than one topic.

2.1 Survey, Initial Reading

The following papers provide an exploration of the issues in real-time database systems and introduce the research efforts in this area: [Graham 1992], [Kao & Garcia-Molina 1995], [Özsoyoğlu & Snodgrass 1995], [Ramamritham 1993], [Shu & Young 1992], [Singhal 1988], [Son et. al. 1992c], [Ulusoy 1992], [Ulusoy 1995a], [Yu et al. 1994].

2.2 Assignment of Timing Constraints

Very few papers have been published so far regarding the sources and semantics of the timing constraints associated with real-time database transactions: [Kao & Garcia-Molina 1993a], [Kao & Garcia-Molina 1993b], [Ramamritham 1995].

2.3 Transaction Scheduling

The majority of the studies in real-time database systems have investigated various aspects of scheduling transactions that are associated with timing constraints. The major challenge posed to the researchers working in this field has been to adapt the task scheduling methods used in real-time systems to DBMSs. The real-time scheduling methods cannot be directly applied to database systems due to the unpredictability of the execution times of transactions; however, some ideas from real-time scheduling can be and have been used in extending traditional database management techniques to observe timing constraints of transactions. The following subsections provide the list of papers on various aspects of transaction scheduling in real-time database systems.

2.3.1 Priority Assignment

Each real-time database transaction is assigned a priority based on its timing constraint. Transaction priorities are used in resolving data and resource conflicts among concurrently executing transactions. The papers published on priority assignment methods and their performance evaluation can be listed as: [Abbott & Garcia-Molina 1988], [Abbott & Garcia-Molina 1989], [Abbott & Garcia-Molina 1992], [Biyabani et al. 1988], [Chakravarthy et al. 1994a], [Chakravarthy et al. 1994b], [Pang et al. 1992], [Purimetla et al. 1994], [Ulusoy & Belford 1993].

2.3.2 Concurrency Control

Concurrency control in traditional database systems aims to maintain database consistency. Implementation of concurrency control protocols in real-time database systems is difficult due to the conflicting requirements of satisfying timing constraints and maintaining data consistency. The general approach taken in the concurrency control research in real-time database systems has been extending traditional concurrency control techniques by applying time-critical scheduling methods to observe timing constraints of transactions. The results of the substantial amount of research devoted to the development and performance evaluation of concurrency control protocols have appeared in the following papers: [Abbott & Garcia-Molina 1988], [Abbott & Garcia-Molina 1989], [Abbott & Garcia-Molina 1992], [Agrawal et al. 1992], [Bestavros 1993], [Bestavros and Braoudakis 1994], [Biyabani et al. 1988], [Buchmann et al. 1989], [Chakravarthy et al. 1994a], [Chakravarthy et al. 1994b], [Chen & Lin 1990], [David et al. 1994], [DiPippo & Wolfe 1993], [Haritsa et al. 1990a], [Haritsa et al. 1990b], [Haritsa et al. 1992], [Hong et al. 1993], [Huang et al. 1989], [Huang et al. 1991a], [Huang et al. 1991b], [Huang et al. 1992], [Kim et al. 1990], [Kim & Srivastava 1991], [Kuo & Mok 1992], [Lam et al. 1995], [Lee & Son 1993], [Lee & Son 1994], [Lee & Son 1995], [Lin & Son 1990], [Sha et al. 1988], [Sha et al. 1990], [Sha et al. 1991], [Son 1989], [Son & Chang 1990], [Son & Lee 1990], [Son 1990], [Son et al. 1992a], [Son et al. 1992b], [Son et al. 1992d], [Son et al. 1992e], [Son & Park 1993], [Son & Kouloumbis 1993], [Ulusoy & Belford 1992], [Ulusoy & Belford 1993], [Wolfe et al. 1990].

2.3.3 Commitment

It is suggested in [Soparkar et al. 1992a] that the unpredictability and the cost of standard commitment protocols make them unsuitable for real-time database systems. The authors investigate possible methods to make a commit protocol adaptive in the sense that under different loading conditions the system can dynamically change to a different commitment strategy.

2.3.4 Recovery

The following papers discuss how real-time priorities can be involved in preserving transaction atomicity and database consistency in presence of transaction aborts and failures: [Suella & Gruenwald 1994], [Sivasankaran et al. 1995], [Vrbsky & Lin 1988].

2.3.5 Other Transaction-Related Issues

The following papers discuss various other issues related to transaction processing in real-time database systems. These issues include evaluation of various transaction processing policies, new transaction models and correctness criteria, efficient installment of updates in importing a view, predictable transaction scheduling, and query processing. [Adelberg et al. 1995], [Chen & Gruenwald 1994], [Fortier et al. 1994], [Graham 1993], [Hou et al. 1989], [Huang et al. 1989], [Lin 1989], [O'Neil & Ramamritham 1992], [O'Neil & Ramamritham 1995], [Özsoyoğlu et al. 1990], [Özsoyoğlu et al. 1992], [Soparkar et al. 1992b], [Stankovic & Zhao 1988], [Ulusoy 1995b].

2.4 Disk Scheduling

Similar to traditional database systems, an important candidate for performance improvement in real-time database systems is the I/O subsystem. The disk scheduler in a real-time database system primarily concerns the timing constraints of transactions in processing their data access requests. Disk scheduling algorithms developed for real-time database systems are presented in: [Abbott & Garcia-Molina 1990], [Carey et al. 1989], [Chen et al. 1991], [Kim & Srivastava 1991].

2.5 Memory Management

A number of algorithms regarding the allocation/management of memory buffers have also been proposed to be used in real-time database systems. The basic consideration in those algorithms is again the priorities of processed transactions. In the following papers, new priority-based memory management algorithms together with their performance evaluation results are provided: [Abbott & Garcia-Molina 1990], [Carey et al. 1989], [Jauhari et al. 1990], [Pang et al. 1994].

2.6 Data Replication

The potential of data replication for high data availability and improved read performance is crucial to real-time database systems. On the other hand, multiple copy updates lead to a considerable overhead due to the communication required among the data sites holding the copies. The following papers discuss the impact of storing multiple copies of data on satisfying timing constraints of transactions, and propose techniques to enhance the availability of replicated real-time databases: [Lin & Lin 1988], [Son & Kouloumbis 1992], [Ulusoy 1994], [Ulusoy 1995c].

2.7 Security

Security in real-time database systems is difficult to achieve due to the conflicting goals of the timing requirement and the security requirement. The security problem in real-time databases is addressed in: [David et al. 1994], [Son & Thuraisingham 1993].

2.8 Active Real-Time Database Systems

An active database system is characterized by conditions defined on the states of the database that need to be evaluated when predefined events occur, and specified actions that must be performed once the conditions hold. If the application supported by an active database system requires timely response to critical situations, the specified actions must be executed subject to some timing constraints. Various issues concerning the involvement of timing constraints in active databases are discussed in the following papers: [Berndtsson & Hansson 1995], [Branding & Buchmann 1995], [Cornelio & Navathe 1993], [Dayal et al. 1988], [Korth et al. 1990], [Prichard et al. 1994], [Purimetla et al. 1993], [Purimetla et al. 1994], [Sivasankaran et al. 1995].

2.9 Performance Evaluation Models

Several papers have been devoted to the description of performance models for real-time database systems: [Haritsa 1994], [Kavi et al. 1994], [Ulusoy & Belford 1995].

2.10 Prototypes

A couple of prototype real-time database systems have been implemented. The following papers discuss the design and implementation details of those prototypes: [Lortz 1994], [Prichard et al. 1994], [Son et al. 1994], [Wolfe et al. 1994].

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