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Recent Research Trends in Active Real-time Database Systems

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Abstract: This paper presents an overview of research trends in Active Real-time Database Systems. Active real-time databases have emerged as a research area in which concepts of active databases and real-time databases are combined into a real-time database with reactive behaviour. This paper addresses active real-time database system, as well as projects which have done research on active real-time database systems.

Keywords: active real-time database, real-time database, transaction scheduling, transaction model, trigger.

I. INTRODUCTION

In general, applications that require automatic situation monitoring of their environments and need to react to events with respect to timing constraints, requires an active real-time database system (ARTDBS). Both active and real-time databases are considered as important technologies for supporting non-traditional applications such as process control, network database services, network management, air traffic control, cooperative navigation systems and computer integrated manufacturing (CIM) [1,2,3]. Generally active database systems support ECA (Event-Condition-Action) rules, which are triggered and executed within the context of database transactions. Applications that require execution of transactions with respect to time constraints require a real-time database system.

Before presenting description of the ARTDBS, we give a brief introduction to active databases and real-time databases. The building block of an active database system is the event-condition-action (ECA) rule. The semantics of the ECA rule is that, if the specified event occurs and if the condition is true, then the specified action is to be executed. A condition is usually a predicate on the database state [4]. An action is the transaction that is executed in reaction to a specific situation, which is a combination of events and conditions. The transaction that fires the rules is called the triggering transaction, and the action that is executed because of the rule firing is called the triggered transaction. We refer to the transactions that trigger other transactions as active transactions or parent transactions. An active transaction has a set of triggered transactions that are executed either as part of the active transaction or separately, depending on the type of the coupling mode between the parent and the triggered transactions [5]. There are three types of coupling modes: immediate, deferred and detached (independent). The transactions triggered in those modes are referred to as immediate, deferred and detached transactions, respectively. Due to the rule firings, an active transaction dynamically generates additional work.

Active database systems support different mechanisms for triggering of transactions to react to the critical events occurred in the external environment [6]. The newly created transaction is called triggered transaction. However, active database systems are lacking mechanisms to guarantee that the triggered transactions can be completed before their deadlines. Their processing is “passive” even though their generations are “active”. It is unpredictable and completely dependent on how the system schedules them. A real-time database system (RTDBS) can be viewed as a system, which inherits mechanisms of both traditional database systems and real-time systems. It is a transaction processing system that is designed to handle workloads where transactions have completion deadlines. The objective of such system is to meet these deadlines, that is, to complete processing transactions before their deadlines expire. On the other hand, RTDBS supplements the deficiencies of the unpredictability in active database systems by using different scheduling algorithms to minimize the number of deadline missing.

The integration of real-time database systems with active databases creates new scheduling problems. Triggering of transactions represent the generations of actions (in the form of triggered transactions) to respond to the occurrences of critical events in the external environment. It is important to commit these transactions. If the critical events are beneficial, missing the deadline of a triggered transaction means the loss of a good opportunity. If the occurred events are harmful, missing the deadline may result in disasters. Triggering of transactions decreases the predictability of the system as the triggered transactions increase the system workload and the probability of data conflicts suddenly [7].

In this section introduced active real-time database systems, section 2 describes ARTDBS model. In section 3 related issues of ATRDBS are given. Current research trends in ARTDBS are discussed in section 4. Finally conclude in section 5.

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II. ACTIVE REAL-TIME DATABASE SYSTEM MODEL

An active real-time database system (ARTDBS) has to provide capabilities for timely trigger of time-constrained transactions and at the same time to process them, concurrently with others transactions, in a real-time manner. Mostly, triggered transactions are critical transactions. The newly created transaction is called triggered transaction.

An ARTDB system model given below (figure 1) uses a queuing model of a single-site shared-memory multiprocessor database system. This model is similar to those presented in other simulation studies e.g., [8,9].

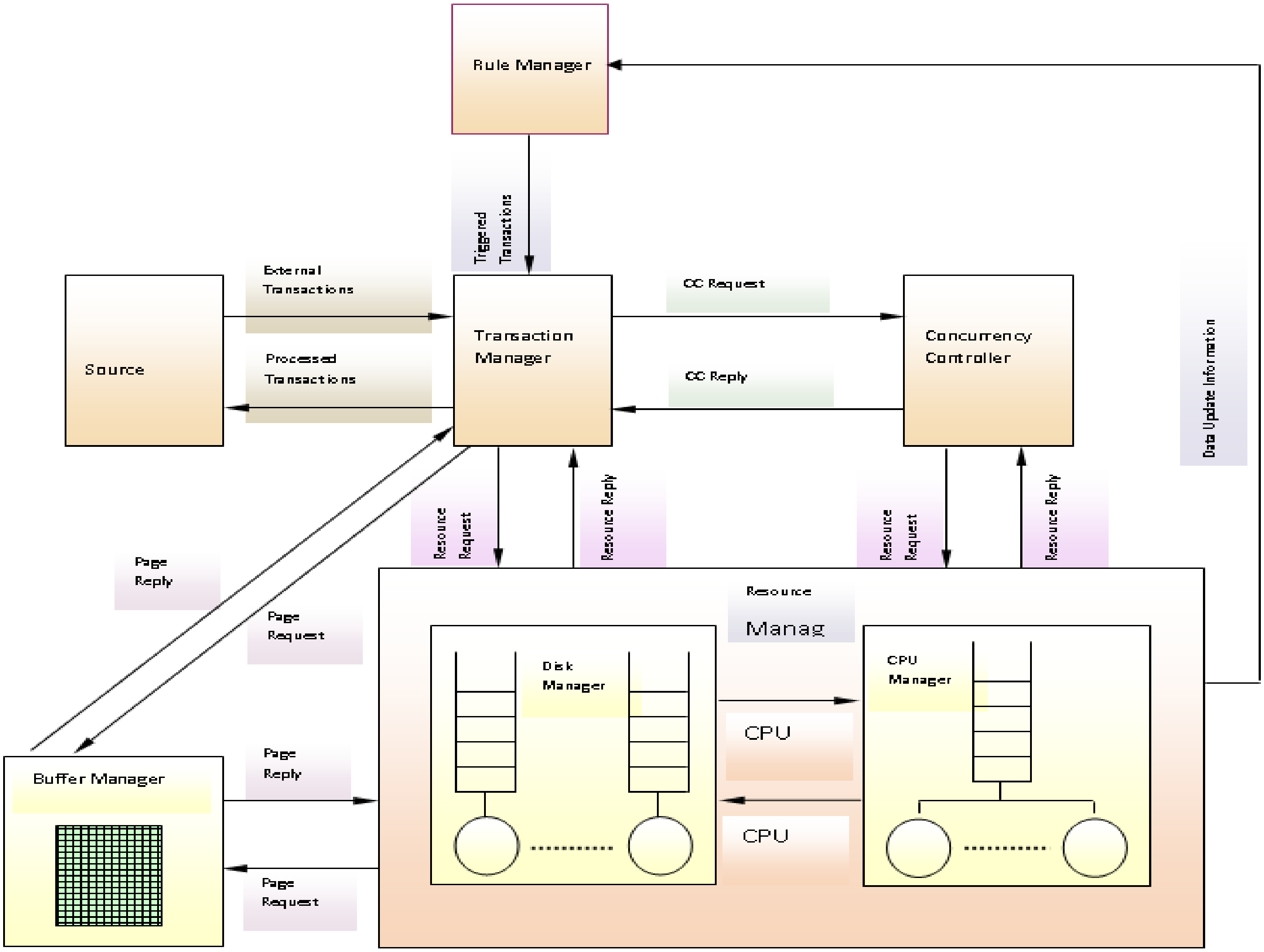

Figure 1. `An Active Real-time Database System Model.

In this section, an ARTDBS system model is presented as shown in figure 1 is referred from [10]. The figure 1 shows that model of ATRDBS consists of six components: include *six active components*, namely, Source (transaction generator), transaction manager, concurrency control manager, memory manager, resource manager, rule manager, and *one passive component*, namely, the database.

A Source also known as transaction generator that generate the non-triggered, or external workload of the system. A Transaction Manager (TM) that models the execution details of the transactions. It handles the various stages of transaction execution, such as begin, commit and abort. A Concurrency Controller that implements the (e.g. OPT-BC) protocol for managing concurrency. A Resource Manager that consist of the CPU Manger and the Disk Manager, that manage the system's CPUs, disks and the associated queues by using scheduling policy such as Earliest Deadline (ED) protocol, and a Rule Manager which implements the active functionality. Rules are triggered when a specified event occurs. When the event notification arrives at the rule manager, all rules triggered by this event must be retrieved from the rule base and be prepared for execution.

The time to retrieve rules brings potentially unpredictable overhead to the system, and it is therefore critical to keep this time to a minimum. Methods for storing and retrieving rules must be carefully considered to allow predictable and efficient retrieval. There is always a compromise between flexibility and efficiency; the more static a system is, the more decisions

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can be made off-line, and thereby run-time overhead can be kept low. If a rule base can be made static, that is, no rules are added, deleted or altered at run-time, the rules can be analysed, optimised and compiled into the rule manager, thereby improving efficiency. Buffer Manager is associated with the use of main memory during reading and writing data from and to the disk. When the main memory has a plenty of space, the database is preferred to reside in the main memory ("memory resident database system") to enable fast and predictable access [12,13].

The transaction manager interacts closely with the concurrency controller, memory manager and the resource manager. The TM first interacts with the concurrency control manager to seek permission for data access or to see if marked for restart/abort. The rule manager manages the active workload of ARTDB. This module simulates a rule base in which a transaction triggers other transactions when a condition becomes true. The concurrency module simulates concurrency control mechanism to maintain database consistency [10].

III. RELATED WORK

Initial research work on active databases and time constraint data management was carried out in HiPAC project [13]. HiPAC was the first large project that addressed active real-time databases, although no complete system emerged from that project. We will elaborate here on active real-time database systems that been built or that currently under development. Today there are mainly the following research prototypes.

HiPAC (High Performance ACtive database system) project is investigating active, time-constrained database management. HiPAC has proposed Event-Condition-Action (ECA) rules as formalism for active database capabilities [2,6].

DeeDS (Distributed activE real-timE Database System) is a main-memory fully replicated database with support for a mix of hard and soft deadlines, multipurpose event monitoring and ECA-rules. A dedicated deadline-driven transaction scheduler guarantees that discarding soft and firm deadlines and switching to contingency actions meet all hard deadlines [14].

REACH (REal-time ACtive and Heterogeneous mediator system) [15,16] in-corporate reactive mechanisms with temporal constraints in a heterogeneous environment.

BeeHive [17,18] is a global database, which is designed for applications where properties such as real-time guarantees, quality of service and dependability are desirable, for example in multimedia applications over the Next Generation Internet. The ECA paradigm is a core component, where rules are used to ensure freshness of data, to change modes of operation, to issue contingency actions in case of overload, etc.

RADEx (Real-time Active Database Experimental system) is a simulator for the purpose of experimental evaluation. RADEx is a real-time, active, temporal database simulator. It supports research on time cognizant concurrency control protocols, real-time transaction scheduling, and real-time logging and recovery [19].

KRAFT [20] An Active Real-Time DBMS for Signal Streams. KRAFT is an extension of traditional DBMS. The KRAFT has distinguished features such as scheduler-level thread control mechanism for continual event monitoring, similar sequence retrieval for signal processing, UPS write ahead logging for predictable timely processing of transaction.

An **Agilor** [21] is active real-time database system having active object model to incorporate timing and active features into object-oriented data model. Agilor architecture consists of some kernel modules and critical services. An important building block of the Agilor is ECA rule.

IV. CURRENT RESEARCH TRENDS IN ARTDBS

Current research trends in active real-time database system are given below. Recently active real-time databases are being studying and used with some different aspect.

In [22] an architecture for reactive systems using an active real-time database with standardized components are explored. In [23] present a communication architecture that uses a distributed active real-time database system as its communication medium. In [24] distributed active real-time database functionality in information-fusion infrastructures with real-time requirements is described. In [25] time-triggered communication approach in the time-triggered architecture (TTA) which offers deterministic, fault-tolerant communication services. Avionic case study is used to explain model based design aspect of time-triggered architecture.

In [26], Electronic brokerage design also explains about new form/way of ECA definition using RTL language. Active real-time functionalities for Electronic brokerage application are explored in [27] where supports for timeliness requirements and allow users to express complex preferences using ECA rule model. In [28] approach for developing active application is presented. The aim is to verify transformations between timed automaton specification and ECA rules.

Recently there is a strong move towards developing ECA rule structure and processing rules in ARTDBS, which is being given in [29]. To express complicated quantitative temporal information in the ARTDBS system. [29] present graphical ECA rules with a set of novel temporal events to specify real-time constraints. In [30] develop a reasoning mechanism for active and real-time database (ARTDB). Also present a real-time inference algorithm based on ECA rules – RTIAE, which exploits the heuristic search on the rule graph to accomplish the reasoning. In [31] discusses two methods developed specifically to address data management in resource-constrained environments, the on-demand updating and active behavior using COMET (COMponent-based Embedded real-Time database). In [12] KRAFT is an active real-time database for signal processing, has distinguished features such as scheduler-level thread control mechanism for continual event monitoring, similar sequence retrieval for signal processing, UPS write ahead logging for predictable timely processing of transaction. In [32] a study of concurrency control in real-time, active database systems. This study contributes toward understanding transaction processing in active real-time database systems. In [33] study and design of the realization of active mechanism base on the architecture

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of micro-kernel in the real-time database system is proposed and design the trigger model base on the active mechanism.

V. CONCLUSION

The area of ARTDBS has received much attention in recent times because of its vast application in network management, manufacturing process control, program trading also different categories of applications are work flow management systems, co-ordination infrastructure for distributed object systems, stream-oriented systems and multimedia systems (synchronization). A novel application of ARTDB in electronic brokerages in financial markets is developed. These emerging applications have similar characteristics and involve accessing and manipulating large amounts of data, and taking actions under time constraints. Data in these applications have short temporal validity and the value of actions taken diminishes rapidly with elapsed time.

From above related work and current research trends it is identified that there is need of ARTDBS, which will be generalised to accommodate the need of all type of applications that requires reactive and timeliness behaviour. To achieve this goal there is need to investigate in some aspects of ARTDBS such as new transaction scheduling technique, overload management module. Also one important aspect is generalised transaction model, which is a fruitful aspect for a new generalise ARTDBS.

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