

Real-time Data Access Requirements

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24 January 2002**

Background

- **The RT Data Access Services (DAS) Subgroup of the Real-Time Advisory Group (RTAG) is concerned with data access in the real-time environment (embedded and non-embedded; hard and soft real-time)**
 - **Challenge: should programs continue to “roll-their-own”?**
- **Have established requirements for selecting and/or promoting suitable products**
- **Have surveyed DBMSs, other related products, and relevant applied research to identify:**
 - **Commercial products to use “as is”**
 - **Promising applied research to promote for product status**

Working Definitions (1/3)

● Real-time

- Assumption that tasks are performed to ensure deadlines are met. “Average response time” *is not compatible* with real-time. Speed a contributor to but not the defining characteristic of real-time performance. Key criterion is *schedulability*.

● Hard Real-time

- Condition where all required computations must be completed to the required accuracy on all data while meeting deadlines imposed by a process (or processes) external to and beyond the computer/system’s control. Failure to satisfy any criterion results in *mission failure*.

● Soft Real-Time

- Condition where deadlines are tight but not absolute. Penalty for a task missing its deadline is a *degraded quality of service* but not complete mission failure.

Definitions (2/3)

- **Embedded System**

- A system that is often an integral part of some larger entity such as an aircraft, missile, or submarine
- Not necessarily a simple “closed-loop” system (i.e., may include an embedded Real-time operating system (RTOS))

- **Embedded Real-Time**

- All hard real-time constraints plus additional constraints:
 - Severe limits on power, weight, memory, bandwidth, volume
 - Required time performance, reliability, or functionality may drive special purpose hardware
 - Operate in non-benign and/or remote environment

Working Definitions (3/3)

- **Database**

- A collection of shared data organized to support storage, retrieval, and/or modification by application programs. May be persistent or exist as long as power applied to main memory.

- **DBMS**

- A reusable software component for managing and encapsulating one or more databases.

- **Concurrency Control**

- The activity of coordinating the actions of processes that operate in parallel, access shared data and therefore potentially interfere with each other.

- **Time**

- Measured in units as small as microseconds (or less)

Real-time Database Requirements^[1] (1/2)

- **Predictable and bounded execution times**
 - Tools/Models with which to predict and plan for worst case data access scenario
- **Bounded resource consumption**
 - Tools/Models with which to predict and plan for worst case resource consumption
- **Run unattended for long periods (months) without degradation of performance**
 - Provide 24x7 availability
 - Fragmentation of storage area is an issue
 - No memory leakage
- **Uses a data model appropriate to the application or environment**
 - Support alternate data structures, e.g., circular queue (appropriate for track data)

Real-time Database Requirements (2/2)

- **Support data storage in volatile memory or persistent storage**
 - Ability to allocate as appropriate
 - Persistent storage is not necessarily a rotating disk
- **Minimal Inter-process Communications within DBMS**
 - e.g., Single address space
- **Efficient concurrency control mechanism**
- **Provide fault tolerance**

More characteristics of a Real-Time Database [2]

- **An extension of “predictable and bounded execution times”**
- **Transactions can have associated timing constraints**
- **Data can be defined in terms of “timing semantics”**
 - **Semantics that define the time interval during which data is valid**
- **Transaction Correctness**
 - **A transaction that meets its timing constraints and uses data that is time consistent both in the relative and absolute sense**
- **Absolute Time Consistency**
 - **Individual data items used in a transaction are temporally valid and reflect reality accurately**
- **Relative Time Consistency**
 - **Multiple data items used in transaction are updated**

Progress

- **Identified 8 commercial products and 1 “applied research” product (potential for GFS status)**
- **Reviewed an independent RT DBMS Trade Study performed for a DoD program^[3]**
 - **Broad-based “key requirements” validated our requirements set**
 - **Adapted their evaluation methodology to create an Evaluation Framework for our own trade study**

Products Considered

- Lockheed Martin
FIRM/RODEO [4,5]
- Centurasoft (RAIMA) RDM++
- Polyhedra
- TimesTen
- RTI NDDS*

FIRM = Functionally Integrated Resource
Manager
RODEO = Real-Time Object Distributed
Database with Extensions to ODMG

- Talarian SmartSockets*
- Empress
- THALES SPLICE*
 - To be evaluated
- Matisse
 - To be evaluated

*RT Publish/Subscribe Products

Is this list complete? What products are missing?

Open Issues

- **How to characterize a real-time database with respect to data management properties (e.g. ACID properties)**
 - **Example: may want to relax ACID properties in a controlled fashion in some cases to improve performance**
- **Are we discussing Real-time DBMS or Real-time Data Access Services?**
 - **We need to develop a taxonomy to describe the spectrum of capabilities**
 - **Organized to characterize system requirements, product capabilities, etc.**

References

- [1] M. Roark, M. Bohler, and B. Eldridge; “Embedded Real-Time and Database: How do They Fit Together?”; Preliminary Draft of presentation to STC-96; 25 April 1996.
- [2] J. Stankovic, S.H. Son, J. Hansson; “Misconceptions About Real-Time Databases”; *IEEE Computer*; June 1999.
- [3] UDLP Crusader Software Architecture Team, “Architecture Note #23: An Evaluation of DBMS Products for Use On Crusader”, 12 April 2000.
- [4] M. Card; “ES-RODEO is:”; Presentation to DII COE Real-Time Technical Working Group; 24 May 2000
- [5] M. Card and P. Springer; “The Best of Both Worlds: Distributing Objects with CORBA and an ODBMS”; presentation to STC-98; May 1998.