COMET: Component-based Embedded Real-Time Databases

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Outline

• Introduction to why using databases in embedded systems
• Case study at Volvo some minor points
• A tailorable database: COMET
  COMponent-based Embedded real-Time database system
• Conclusion
Project Outline

• What? DATABASE
  – embedded
  – real-time
  – customizable to fit different application types

• Industrial partners?
  – Volvo Construction Equipment Components AB
  – Upright Database Technology AB

Data characteristics in embedded system

• Amount of data in embedded systems is increasing
• Data is normally scattered around the system in various structures
• Data has temporal validity
• Uniform access from applications and from tools outside the system is desired
Data characteristics in embedded system

- Different types of data (Volvo CE)
  - Sensor/actuator raw data
  - Sensor/actuator parameter data
  - Sensor/actuator engineering data
  - Logging data
  - Configuration parameter data

A tailorable embedded real-time database

- Functionality vs size trade-offs
- Effects of the temporal requirements on the functionality
- Integration of diverse data stores
- Support for non-standard data types
- Extensibility "plug-and-play capability"
- Cost of the development time.
- One DBMS product for various application areas
How?

USING COMPONENT BASED SOFTWARE DEVELOPMENT!!

- components for limited resource environment
- real-time components
- customization by composition

SotA: Commercial Embedded Databases

Relational Client/Server
- Progress
- Ardent Software
- InterSystems
- Velocis (Centura)
- IBM DB2 Everywhere
- MSDE (Microsoft)
- Oracle8i Lite
- Sybase SQL Anywhere
- Pervasive.SQL 2000
- Empress RDBMS
- TimesTen
- Solid Embedded
- Ptime
- Mnesia
- TelOrb
- Upright Embedded DB

O-O Client/Server
- Objectivity/DB
- PowerTier
- POET Object

Embedded Libraries
- RDM, db.linux
- C-tree Plus
- Gdbm
- C-ISAM
- Berkely DB
SotA: RTDBs Research Platforms

- BeeHive
  - University of Virginia, Charlottesville, USA
- DeeDS
  - University of Skövde, Sweden
- Rodain
  - University of Helsinki, Finland
- RT-Genesis
- Starbase
  - University of Virginia, Charlottesville, USA
- STRIP
  - Stanford University, USA
- Berkely DB
  - Berkeley, USA

COMET Project Goals

- Development Tools
  - Configuration Tools
    - support when tailoring a system
    - support when choosing components from the library
  - Analysis Tools
    - real-time analysis
    - reliability analysis
    - resource demands analysis

- Component Library
  - Database Systems
    - concurrency control
    - scheduling
    - main-memory techniques
    - ...
Component vs. Monolithic DBMS

- **monolithic DBMS**
  - good reliability
  - extensions and modifications are not easily possible
  - increasing functionality → increasing complexity
  - performance and cost penalty for unneeded functionality
  - complex system evolution

- **component DBMS**
  - easy modification or extension
  - reduced system complexity
  - simplified system evolution
  - reduced unnecessary functionality
  - performance
  - component development process is more complex

**COMET Unified Component Model**

- **Application oriented**
- **Platform dependent**

<table>
<thead>
<tr>
<th>Temporal constraints</th>
<th>WCET-01</th>
<th>WCET-02</th>
</tr>
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<tbody>
<tr>
<td>Resource demand</td>
<td>Memory - O1</td>
<td>Memory - O2</td>
</tr>
<tr>
<td>Portability</td>
<td>OS type</td>
<td>Hardware type</td>
</tr>
</tbody>
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- **Plug-in Components**
- **Database Middleware**
- **DBMS Service**
- **Configurable DBMS**
COMET Database Architecture

Components

Transaction
Real-Time

Weaving at "Join points"

COMET: Type of Aspects

Embedded Real-Time Database Aspects

Composition
- Compatibility
- Versioning
- Flexibility

Application
- Security
- Transaction
- Memory Management
- Real-Time
Research Challenges

- Real-time component models
- Weaving of cross-cutting aspects
  - Aspect specification using languages
- Composition of white boxes and COTS (grey & black boxes)
- Integration to run-time system, maintaining real-time properties

Results and Status

- Project started January 2001
- 2 ARTES PhD students
- State of the art survey
  - Industrial and research platforms
- Case study
- Initial design of COMET
Summary

• Tailorable device-embedded databases needed
• COMET approach
  – Composition using components
  – Aspect weaving of inter-component dependencies
    • real-time, memory management…
  – Focus on design tools and configuration tools

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