Ames Research Center

RAPID and DDS

Hans Utz
Intelligent Robotics Group
Hans.utz@nasa.gov
Overview

- **RAPID vs. DDS**
  - What is RAPID
  - What is DDS

- **DDS Components**
  - DDS Comm Model
  - DDS Infrastructure

- **RAPID Design**
  - RAPID Messages
  - RAPID Services

- **Impact on RoverSw**
  - DDS and RoverSw
  - RAPID and RoverSw
What is RAPID

Rover API Delegate
- Interoperability layer for ETDD robots
- Originally implemented as robot-bridge
- Open-source

Inter-center standard
- Supported by (Tri-)Athlete, K10, LER
- Interest by ESA
- Targeted as NASA standard

Addressed functionality
- Robot telemetry
- Robot geometry
- High-level commanding and sequencing
What is DDS

Distributed System Middleware
- Publish/subscribe architecture
- Extended by relational data model
- Extensive QoS
- Orthogonal to CORBA
- Competitor of CORBA Notification Service

Open Standard (OMG hosted)
- Multiple vendors (RTI, Prismtech, Open-source)
- Push for interoperability (young standard)

Target Domains
- Distributed, embedded, real-time systems
- High throughput, low jitter
- Complex (non-uniform) network characteristics
DDS Communications Model

Multi-cast messaging core
- Data bus
- One-to-many communication
- Unreliable core protocol

Shared information space concept
- Data-type instances are entities of shared information
- DDS manages, how this information is shared within a domain
  - Distribution
  - Updates
  - Ownership
  - ...

Fig 3 © RTI
**DDS Communication Entities**

**Domain**
- Defines a shared information space
- Participant manages membership (protocol, ports, etc)

**Partition**
- Defines communication sub-groups within domain
- Publisher/Subscriber manages membership (among other resources such as threads/msg queues etc)

**Topic**
- Defines name and type of a set of data instance(s)
  - Unkeyed data: topic names a single datatype instance
  - Keyed data: topic manages set of instances, differentiated by key
- Communicates samples of instance(s) of one specified data-type
- DataWriter/-Reader reads/writes & manages samples of a topic

Fig © RTI
DDS Quality of Service (QoS)

QoS at every level
- Ports, Multi-cast groups, discovery, etc
- Sometimes more than you’d want to care about

Topic level QoS
- Reliability
  - Best effort
  - Reliable (TCP-like resending)
- Durability
  - Transient
  - While writer instance is available
- History
  - How many samples to store per instance
  - On writer-side required for reliability
  - Can be used on reader-side as histogram queue
- Filtering – reader triggered
  - Message-timeout filter for rate-filtering
  - Partitions for per-robot filtering
- Flow Control – writer triggered
  - Required to protect small links
  - Token-bucket filter
DDS Infrastructure (RTI)

DDS Core
- (CORBA) IDL defined data types
- Communication of data samples between publishers/subscribers of a domain

Routing Service
- Manage message replication between DDS domains
- Used to manage/restrict traffic on thin links (satellite etc)

RT-Connect & Recorder
- Linking of DDS topics/instances to SQL database tables and entries
- Can be used for logging
- Possible interface to GDS services

Analyzer and Monitor
- Run-time analysis: Connectivity, QoS mismatches, bandwidth etc
- Very powerful, very necessary
- Too little static analysis tools so far
RAPID Design

Config messages
• Subsystem configuration (typically static)
• Potentially verbose specification
• Reliable & durable
  ➢ Send once, subscribe and analyze on client startup

State messages
• Subsystem state changes
• Concise
• Reliable & durable
  ➢ Send on change, might be bursty

Sample messages
• Fixed (high) rate telemetry
• Mostly continuously changing parameters
• Best effort, transient
  ➢ Classic telemetry
# RAPID Services

**Telemetry**
- Robot pose
- Robot joints
- Images & Point-clouds

**FrameStore**
- Classic tree of coordinate frames
- Tree-walking for coordinate transformations
- Local instance, updated from robot telemetry
- Provides location awareness between robots

**Sequencer**
- Synchronous command queue
- Designed for time-delayed teleop

**Access Control**
- Cooperative management of teleop access
<table>
<thead>
<tr>
<th>RAPID Message Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PositionConfig, PositionSample</strong></td>
</tr>
<tr>
<td>• Config: Coordinate frame of robot pose estimate</td>
</tr>
<tr>
<td>• Sample: Pose estimate</td>
</tr>
<tr>
<td><strong>JointConfig, -Sample</strong></td>
</tr>
<tr>
<td>• Config: Joint frames</td>
</tr>
<tr>
<td>• Sample: Joint positions</td>
</tr>
<tr>
<td><strong>PointCloudConfig, -Sample</strong></td>
</tr>
<tr>
<td>• Config: Frame, data-format details</td>
</tr>
<tr>
<td>• Sample: Point cloud</td>
</tr>
<tr>
<td><strong>ImageSensorState, -Sample</strong></td>
</tr>
<tr>
<td>• State: Imager parameters</td>
</tr>
<tr>
<td>• Sample: Image</td>
</tr>
<tr>
<td><strong>FrameStoreConfig</strong></td>
</tr>
<tr>
<td>• Coordinate frame tree with initial values</td>
</tr>
<tr>
<td><strong>AccessControlState, QueueState</strong></td>
</tr>
<tr>
<td>• Current controller and control requests</td>
</tr>
<tr>
<td>• Queued and executed commands</td>
</tr>
</tbody>
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DDS and RoverSw

**Replacement for EC**
- Notify Pipe Svc
- LogSvc and LogPlayer
- Telemetry-types mostly stay unchanged
  (some changes to header information)

**Configuration and state related parts of GRI CORBA interfaces**
- Readonly attributes become Config message
- Periodic SSubsystemState become reliable/durable

**Not a good replacement for commanding**
- No request/reply pattern
- No object oriented method-call
- Mix of CORBA & DDS is part of the COBA Component Model (CCM)
- It's two big libraries to carry around
RAPID and RoverSw

KN rovers support it
- knRapidSvc RAPID bridge
- Resending GRI telemetry as RAPID telemetry
- Redirecting RAPID commands to GRI interfaces
- RAPID sequencing and access control protocols honored

Core RAPID services are part of IRG core technologies
- FrameStore (C++) implementation part of VisionWorkbench/knSvcs
- FrameStore (Java) implementation part of Verve/Eclipse
- Updates of frames directly from GRI telemetry

Might replace telemetry messages where redundant
- SJoints vs JointSample
- SPose vs PositionSample