Overview

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  - What is DDS
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  - DDS Comm Model
  - DDS Infrastructure
- RAPID Design
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- 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

Fig © RTI
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
### RAPID Message Examples

<table>
<thead>
<tr>
<th>PositionConfig, PositionSample</th>
<th>ImageSensorState, -Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Config: Coordinate frame of robot pose estimate</td>
<td>• State: Imager parameters</td>
</tr>
<tr>
<td>• Sample: Pose estimate</td>
<td>• Sample: Image</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>JointConfig, -Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Config: Joint frames</td>
</tr>
<tr>
<td>• Sample: Joint positions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PointCloudConfig, -Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Config: Frame, data-format details</td>
</tr>
<tr>
<td>• Sample: Point cloud</td>
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</tbody>
</table>
## 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