CCSDS SM&C Mission Operations Interoperability Prototype

Space Ops 2010

Steven A. Lucord

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Introduction

• Future manned missions present unique challenges:
  - Require interoperability among space agencies
  - Reduced budgets for operations and development

• Mission Operations identifies two benefits of interest:
  - Increase interoperability among space agencies
  - Reduced cost of mission-specific deployment

• Interoperability Prototype covers three main topics:
  - Validation of the Mission Operations Protocol
  - Integration of legacy systems in an SOA
  - Exploration of the Data Distribution Service
Motivation

- Common exchange format between NASA control centers is necessary

- Investigating ground-to-ground standardization

- Negotiation of a data exchange format between control centers can be challenging.
Validation of MO Protocols

• Collaborate with the German Space Operations Center (DLR) to implement an interoperability prototype
  - Prototype implements five MO services:
    ◦ Action Service
    ◦ Parameter Service
    ◦ Alert Service
    ◦ Directory Service
    ◦ Login Service (internal access control)

• Identify additional capabilities for the services to meet human spaceflight operations concepts
Action, Alert and Parameter Service Architecture
Directory Service Architecture

JSC-OTF

Service Application Layer
Java

Common Services
Core Services

Common Object Model

Message Abstraction Layer
XML
HTTP Transport

Language Mappings

Transport Bridge

XML
HTTP Transport

JMS Transport

DLR-GSOC

Service Application Layer
C++

Common Services
Core Services

Common Object Model

Message Abstraction Layer
XML
HTTP Transport

JMS Transport
Encoding Specifications

- Encoding is currently mission implementation specific

- Developed a BNF like grammar to describe a binary encoding with emphasis on simplicity

- Developed an XML schema for encoding of the data structures necessary for the Directory Service
- Use an “in care of” address to specify the routing information
  - otf-service-uri@otf-gateway-uri

- The Message Header URI contains the complete routing sequence similar to USENET addresses
In Care of Address Example

<table>
<thead>
<tr>
<th>DLR Action Service Consumer</th>
<th>DLR Gateway</th>
<th>OTF Gateway</th>
<th>OTF Action Service Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>URI to ddsbin:action-service@jmsbin:otf-gateway@jmsbin:dlr-gateway</td>
<td>URI to ddsbin:action-service@jmsbin:otf-gateway@jmsbin:dlr-gateway</td>
<td>URI to ddsbin:action-service@jmsbin:otf-gateway@jmsbin:dlr-gateway</td>
<td>URI to ddsbin:action-service@jmsbin:otf-gateway@jmsbin:dlr-gateway</td>
</tr>
<tr>
<td>URI to jmsbin:action-client</td>
<td>URI to jmsbin:action-client</td>
<td>URI to jmsbin:action-client</td>
<td>URI to jmsbin:action-client</td>
</tr>
<tr>
<td>URI from jmsbin:action-client</td>
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</tr>
</tbody>
</table>
Additional Capabilities

• Human spaceflight requirements for Action Service
• Significant departure from traditional unmanned environment:
  - Control a few number of resources with a large number of people
  - Consequences of sending the incorrect command are more serious when humans are aboard
  - Provides a distributed work environment to allow flight controllers and operators to collaborate
  - Maintain a dynamic and shared command repository
Integrating Legacy Systems

- Action Service interfaces with the ISS Command Server
  - Treated as just another client
  - Identified a set of eleven Station commands
- Parameter Service interfaces with the telemetry distribution system for ISS and the Space Shuttle
  - Identified a set of twenty corresponding ISS telemetry parameters
- Alert Service interfaces with the advisory service for ISS and the Space Shuttle.
Prototype Architecture

Spacecraft Simulator

MCC Systems

MCC Message Bus

JSC-OTF

Action Service
Parameter Service
Alert Service
Common Object Model
Message Abstraction Layer
Binary Encoding

JSC-OTF DMZ

OTF Gateway
Message Abstraction Layer
XML / Binary Encoding

JSC-OTF DMZ

OTF Gateway
Message Abstraction Layer
XML / Binary Encoding

DLR-GSOC DMZ

DLR Gateway
Message Abstraction Layer
XML / Binary Encoding

Login Service
Message Abstraction Layer
Common Object Model
Directory Service

XML Encoding
Message Abstraction Layer
Common Object Model
Directory Service
Bridging Control Centers
Extend Prototype Bridge

• Prototype bridge solution requires knowledge of complete routing sequence
• Extend solution to accommodate an arbitrary number of gateways.
• Maintain only the next hop routing information in the URI
Bridge Publish Availability

1. publish(S, JSC-GW)
2. notify(S, S)
3. publish(S, JSC-GW)
4. addLink(S, JSC-GW)
5. notify(S, JSC-GW)
6. publish(S, CC2-GW)

CC2 Directory Service

CC2 GW Directory Service

CC2 GW Gateway

S, JSC-GW

S, S

JSC GW Directory Service

JSC GW Bridge

JSC Directory Service

JSC Service Provider

CC2 Service Consumer
Bridge Request / Reply

1. lookup(S, CC2-GW)

2. send[To=S, CC2-GW, From=C, C]

3. send[To=S, JSC-GW, From=C, CC2-GW]

4. send[To=S, JSC-GW, From=C, JSC-GW]

5. send[To=C, JSC-GW, From=S, S]

6. send[To=C, CC2-GW, From=S, JSC-GW]

7. send[To=C, C, From=S, CC2-GW]
Data Distribution Service

• Prototype uses for bulk data transfer

• Plan to perform benchmark comparisons against legacy telemetry distribution system

• Investigate structured data messages
Transport Broker

Consumer

REGISTER

REGISTER_ACK

DDS Transport Broker

PUBLISH__REGISTER

PUBLISH__REGISTER_ACK

*NOTIFY

*PUBLISH

PUBLISH__DEREGISTER

PUBLISH__REGISTER_ACK

DEREGISTER

DEREGISTER_ACK

Provider
Conclusion

- Specifications are sufficiently robust to allow NASA missions to collaborate

- Specifications are not yet capable of replacing existing systems

- Encourage NASA space centers to participate in the working group and propose capabilities necessary for mission support
Thank You

• Questions