CCSDS SM&C Mission Operations Interoperability Prototype

Space Ops 2010

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April 30, 2010
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

JSC-OTF

Service Application Layer C++

Common Services

Core Services

Common Object Model

Message Abstraction Layer

Binary Encoding

DDS Transport

JMS Transport

Transport Bridge

Binary Encoding

DDS Transport

Binary Encoding

JMS Transport

DLR-GSOC

Service Application Layer C++

Common Services

Core Services

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Message Abstraction Layer

Binary Encoding

DDS 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
Bridging System Domains

- 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>
</table>
| URI to
  ddsbin:action-service@    | URI to      | URI to      | URI to                     |
  jmsbin:otf-gateway@        | URI to      | URI to      | URI to                     |
  jmsbin:dlr-gateway         | URI from    | URI from    | URI from                   |
  jmsbin:action-client       | URI from    | URI from    | URI from                   |
  jmsbin:action-service@     | URI from    | URI from    | URI from                   |
  jmsbin:otf-gateway@        | URI from    | URI from    | URI from                   |
  jmsbin:dlr-gateway         | URI from    | URI from    | URI from                   |

URI to
  ddsbin:action-service@
  jmsbin:otf-gateway@
  jmsbin:dlr-gateway

URI from
  jmsbin:action-client@
  jmsbin:action-service@
  jmsbin:otf-gateway@
  jmsbin:dlr-gateway

URI to
  ddsbin:action-service@
  jmsbin:otf-gateway@
  jmsbin:dlr-gateway

URI from
  jmsbin:action-client@
  jmsbin:action-service@
  jmsbin:otf-gateway@
  jmsbin:dlr-gateway
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

DLR-GSOC DMZ
- DLR Gateway
- Message Abstraction Layer
- XML / Binary Encoding

Login Service
- Message Abstraction Layer
- Common Object Model
- Binary Encoding

Directory Service
- Message Abstraction Layer
- Common Object Model
- XML Encoding
Bridging Control Centers

Legacy Systems
Mission Operations
CC2 Gateway

Legacy Systems
Mission Operations
CC3 Gateway

JSC Gateway
Mission Operations
Legacy Systems

Mission Operations
Legacy Systems
CC5 Gateway
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)
Bridge Request / Reply

1. lookup\(S, \text{CC2-GW}\)

2. send\(\text{To}=S, \text{CC2-GW}, \text{From}=C, C\)

3. send\(\text{To}=S, \text{JSC-GW}, \text{From}=C, \text{CC2-GW}\)

4. send\(\text{To}=S, S, \text{From}=C, \text{JSC-GW}\)

5. send\(\text{To}=C, \text{JSC-GW}, \text{From}=S, S\)

6. send\(\text{To}=C, \text{CC2-GW}, \text{From}=S, \text{JSC-GW}\)

7. send\(\text{To}=C, C, \text{From}=S, \text{CC2-GW}\)
Data Distribution Service

• Prototype uses for bulk data transfer

• Plan to perform benchmark comparisons against legacy telemetry distribution system

• Investigate structured data messages
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