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 an 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
Directory Service Architecture

JSC-OTF

- Service Application Layer
  - Java
- Common Services
- Core Services
- Common Object Model
- Language Mappings
- Message Abstraction Layer
  - XML
  - HTTP Transport

DLR-GSOC

- Service Application Layer
  - C++
- Common Services
- Core Services
- Common Object Model
- Transport Bridge
- 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

**DLR Action Service Consumer**

**OTF Action Service Provider**

**DLR Gateway**

**OTF Gateway**

<table>
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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

OTF Gateway
Message Abstraction Layer
XML / Binary Encoding

OTF Gateway
Message Abstraction Layer
XML / Binary Encoding

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

XML Encoding
Message Abstraction Layer
Common Object Model
Directory Service

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Bridging Control Centers

CC5 Gateway

Legacy Systems
Mission Operations
CC2 Gateway

Legacy Systems
Mission Operations
CC3 Gateway

JSC Gateway
Mission Operations
Legacy Systems

CC5 Gateway

Mission Operations
Legacy Systems
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 Gateway
- CC2 Service Consumer
- JSC GW Directory Service
- JSC GW Bridge
- JSC Directory Service
- JSC Service Provider
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, S, 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

 DDS Transport Broker

 Provider

 REGISTER

 REGISTER_ACK

 PUBLISH__REGISTER

 PUBLISH__REGISTER_ACK

 *NOTIFY

 *PUBLISH

 PUBLISH__DEREGISTER

 PUBLISH__REGISTER_ACK

 DEREGISTER

 DEREGISTER_ACK
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