CCSDS SM&C Mission Operations Interoperability Prototype

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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
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

DLR-GSOC

- Service Application Layer C++
- Common Services
- Core Services
- Common Object Model
- Message Abstraction Layer
- Binary Encoding
- JMS Transport
Directory Service Architecture

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

DLR-GSOC
- Service Application Layer
  - C++
- Core Services
- Common 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

**DLR Action Service Consumer**

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

URI to
- jmsbin:action-client@

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

**DLR Gateway**

**OTF Gateway**

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

URI to
- jmsbin:action-client@

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

**OTF Action Service Provider**
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**
  - Action Service
  - Parameter Service
  - Alert Service
    - Common Object Model
    - Message Abstraction Layer
      - Binary Encoding
    - OTF Gateway
      - DDS
      - HTTP
      - XML / Binary Encoding

- **MCC Message Bus**
- **JSC-OTF**
  - Prototype Message Bus
    - Binary Encoding
    - Message Abstraction Layer
    - Common Object Model
    - Login Service
    - Directory Service
- **JSC-OTF DMZ**
  - OTF Gateway
    - DDS
    - HTTP
    - XML / Binary Encoding

- **JSC-OTF DMZ**
  - DLR Gateway
    - SMS
    - HTTP
    - XML / Binary Encoding

- **DLR-GSOC DMZ**
  - DLR Gateway
    - SMS
    - HTTP
    - XML / Binary Encoding

- **Common Object Model**
- **Message Abstraction Layer**
- **Binary Encoding**
- **XML Encoding**
- **Directory Service**
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, JSC-GW

JSC Directory Service
JSC GW Directory Service
JSC GW Bridge
S, S

CC2 Service Consumer
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=S, 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  Provider

REGISTER  REGISTER_ACK  REGISTER

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