Development of the Space Object Technology Group Reference Architecture

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Overview

- Description
- Genesis
- Objectives
- Definition
- Futures
What is the SOTG?

- Space Object Technology Group
  - Informal standards effort
  - CORBA-focused
  - Satellite command and control domain

- Cross-government initiative
  - NRO
  - NASA Goddard Space Flight Center

- Establish standard for interoperability
  - NRO interest
    - establish draft standard that can be carried forward in the government
    - approach other government agencies
  - GSFC interest
    - facilitate standard development via OMG
    - working group has formed
    - SOTG can form basis of proposals
SOTG Genesis

- Initiated through NRO/GSFC communication
  - Begun in September 1998
  - Emmett Rigsby (NRO)
  - Leslie Boyce (GSFC)
- Initial participants
  - NRO
    - Raytheon
  - GSFC
    - CSC
    - Altair
SOTG Contributors

- **Primary contributors**
  - Altair
  - AppNet
  - CSC
  - Logicon
  - Raytheon
  - STI

- **Government sponsors**
  - NRO
  - GSFC

- **Other participants**
  - AI Solutions
  - Boeing
  - Integral Systems
  - Lockheed Martin
  - GSFC
    - WFF
    - 501
    - 581
    - 582
    - 583

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SOTG Domain is S/C Command and Control

• Contact processing
  – telemetry processing
  – commanding
  – processor modeling
  – logging and playback

• Flight dynamics processing
  – orbit
  – attitude
  – maneuvers

• Planning and scheduling
Purpose of the Reference Architecture

• Software reuse
  – Specify common service interfaces used in domain
  – Allow reuse of implementations in more than one system
  – Encourage multiple, compatible implementations from vendors

• Used by
  – System developers
  – Application developers
  – Library developers
Reference Architecture Requirements

• Interoperability
  – Different products work together
  – Lower integration costs
  – Provide more options

• Platform independence
  – Hardware and OS
  – Ground and spacecraft

• Extensibility
  – Add, modify elements with very low impact
  – Adapt to new systems, evolution, operations concepts

• Efficiency
  – Maximize use of network and processors
  – Scale with hardware solutions
Target Architecture
Requirements

• Performance
  – Throughput (bus telemetry 128 KBPS and higher)
  – Latency (1/10ths of seconds low end)
  – Accuracy
  – Highly variant among systems and subsystems

• Availability
  – 7 x 24, 4 or 5 nines
  – Coupled to hardware availability

• Security
  – Authorization needed
  – Privacy, non-repudiation typically not needed
  – Highly variant among systems
    • must be part of organizational security structure
    • most systems operate at single security level
Influence of Control Channel Toolkit

- Control Channel Toolkit
  - NRO-sponsored command and control product line
  - Also CORBA-based
- CORBA-based reference architecture definition
- Product specification
  - Domain definition
  - Reference architecture
  - IDL specification
- Phased, spiral developments
Development

- Phase I
  - September 98 – December 98
  - Products
    - Create government management plan
    - Create domain definition
    - Outline architecture

- Phase II
  - December 98 – March 99
  - Products
    - Prototype architecture definition activities
    - Defined requirements and interfaces
      - Key SOTG services
    - Data Acquisition
    - Automation

- Phase III
  - March 99 – December 99
  - Products
    - Remaining requirements and interfaces
    - Remaining services
Process

- Highly informal
- Spirals for each subdomain, services
  - Identify requirements up front
  - Select subset of interfaces
  - Design
  - Integrate
- Communication
  - Quasi-monthly TIMs
  - Email
  - Telecons
- Integrated Product Teams
  - Domain IPT
  - Subdomain and services IPTs
Process

1. Develop subdomain requirements
2. Allocate requirements to interfaces
3. Select subset of interfaces
   - List
   - Define SOTG services required
     - Define subdomain services
       - Integrate into domain model
         - IDL Specification
           - Baseline IDL
             - Assessment
             - Integrate
               - Update RA/Targets
4. For each subdomain / service
   - SOTG Services
     - Description

Subdomain IPT Activities
- Domain IPT Activities
  - List Description
SOTG Reference Architecture

- Document initially based on the CCT’s
- Architecture requirements, mechanisms and constraints
- Multiple views
  - OMA profile
  - Logical
  - Dynamic
- Architecturally driving requirements
- System scenarios
- IDL
  - End product is OMG vertical-domain-like specification
  - IDL interfaces, structures
  - Accompanying semantics
Standards and Approaches: CORBA

• SOTG is specified with respect to CORBA
  – intended to be deployed on CORBA
  – positioned to support OMG vertical domain standard

• CORBA provides standard mechanisms and tools
  – interoperable
  – portable
  – extensible
  – efficient
  – provides services for events, security
SOTG Profile of CORBA OMA

CORBAservices
- Naming
- Event
- Property

SOTGservices
- Coordinate Conversion
- Fault Tolerance
- Fetch
- Group
- Message Handling
- Persistent
- Profile
- Publish-subscribe
- State
- Stream
- Time Conversion
- Time Synchronization
- Transform

Data Acquisition
- Orbit

Commanding
- Attitude

Logging and Playback
- Maneuver

Automation
- Planning and Scheduling

Vehicle
- Remote System

Object Request Broker
SOTG Subdomains (1)

- **Automation**
  - State and status determination, reactive control

- **Data Acquisition**
  - Distributing and processing data, typically in realtime context

- **Commanding**
  - Command commutation, release and verification

- **Remote Systems**
  - On-board processor load management

- **Logging and Playback**
  - Logging and retrieval of system data

- **Planning and Scheduling**
  - Define, plan and generate operational schedules
SOTG Subdomains (2)

- **Orbit**
  - Orbit determination, prediction, and event generation
- **Attitude**
  - Attitude determination, prediction,
- **Maneuver**
  - Implement and target spacecraft maneuvers
- **Vehicle**
  - Analytic vehicle model for state propagation
SOTG Services (1)

- **Coordinate Conversion**
  - Defines and provides conversions between coordinate systems
- **Fault Tolerance**
  - Defines framework for managing availability and performance
- **Fetch**
  - Untyped service
  - Positioned for inheritance
- **Group**
  - Associates identifiers with naming hierarchy
  - Used for measurands, states, logical stores
- **Message Handling**
  - Generates, formats operator, system messages
- **Persistence**
  - Defines simple protocol for loading and saving state
- **Profile**
  - Manages collections of implementation related data
- **Publish Subscribe**
  - Untyped service
  - Positioned for inheritance
SOTG Services (2)

- **State**
  - Model for controlling servers with state behaviors

- **Stream**
  - Management of opaque data flows
  - Based on OMG stream service

- **Time Conversion**
  - Defines time formats and systems, provides conversions

- **Time Synchronization**
  - Basic time and synchronization services
  - Based on pending OMG standard

- **Transform**
  - Untyped service
  - Positioned for inheritance
CORBA Services

- SOTG Specifies use of
  - Event
  - Naming
  - Property
- Also use of Authorization (CORBAmed)
- Additional services may be specified later as well
  - CORBA is an evolving standard
- Other services may be used in target architecture
  - e.g. Licensing, Security

No CORBA Facilities are specified by SOTG
Architecture Mechanisms

- **Object Request Broker**
  - Interoperability, platform independence, extensibility
  - Security (through CORBA Security Service)
- **Events**
  - Extensibility, efficiency
  - Performance
- **Callbacks**
  - Interoperability, extensibility, efficiency
  - Performance
- **Publish-Subscribe**
  - Interoperability, extensibility
  - Performance
  - Builds on callbacks
- **Fetch**
  - Interoperability, extensibility, efficiency
  - Builds on callbacks
- **Transform**
  - Interoperability, extensibility
  - Builds on callbacks
Standard Architecture Extensions

• Authorization
  – Supports security requirements
  – Apply authorization to existing SOTG interfaces
  – Does not address privacy, non-repudiation

• Fault Tolerance
  – Supports availability and performance requirements
  – Extend SOTG compliant implementations to support externally managed fault tolerance
  – Complements, does not substitute for hardware availability

• Prioritization
  – Supports performance requirements
  – Apply priority specification to existing SOTG interfaces
  – Used where resource contention can not be otherwise avoided
Architecture Issues/Risks

• Interoperability vs. Flexibility Trade
  – Simultaneously wish to increase interoperability as well as flexibility
  – Interoperability requires higher levels of specification
  – Data specification insufficient to guarantee high interoperability

• Tracking CORBA evolution
  – SOTG based on current CORBA specification
  – CORBA undergoing rapid expansion
  – Maintaining coherent working specification will be difficult

• CORBA style
  – Pervasive use of callbacks
  – Pervasive use of oneway calls

• Telemetry performance
  – Definition does not make explicit use of multicast scaling
  – Left to implementations

• Granularity of services may impede aggregation
  – Force IP in interoperable solutions
  – Impact performance
  – Transform
Future SOTG Work

- Not all subdomains completed process, review
  - Orbit, attitude, maneuver
  - Remote systems
  - Planning and scheduling
  - Known issues exist
- OMG work has begun (RFI’s issued)
  - Space, Satellite and Ground System Working Group
  - SOTG participants chair working group
- NRO work has begun
  - SOTG has entered the NRO standards process
  - Demonstration work is under procurement

See sotg.gsfc.nasa.gov