Finding an Open Least Common Denominator for Live Integration of Non-space-system-standard Components within Constraint Budgets

Ruediger Gad
Terma GmbH, Darmstadt, Germany
Outline

• Context
• Run-time Integration
• Choices & Experiences
• Message-oriented Middleware
• Conclusion
Context

- **Two ESA Studies**
  - Improve ESA Operations & Ground Systems with
    - a) Virtual Reality
    - b) Augmented Reality

- **Ground Segment**

- **Software Systems**
  - ESA Software Systems
    - Mission Control System, Simulator
  - Third-party Systems
    - Virtual Reality, Augmented Reality

- **Constraint Budgets**
Context

- Virtual Reality (VR) Study

VR
(Unity, C#, Windows)

Web-based Prototype
(Firefox, A-Frame,
JavaScript, Windows)

SIMSAT
(C++, CORBA, Linux)

MOE
(Java, WebServices,
CCSDS-MO, Linux)

Non-space Components
„Space Systems/Standards“
Run-time Integration

- Communication Infrastructure/Middleware
  - E.g., Sockets, CORBA, RMI, Message-oriented Middleware, …

- Serialization/Data Representation
  - E.g., Protocol Buffers, XML, JSON, CORBA, …
Run-time Integration, Trade-offs

- **Ease of Use**
  - Available Libraries
  - Boiler Plate Code
    - E.g.: Connection Setup & Management, Data Transfer, …
  - Code Generation
    - “Interface Definition Languages”
      - E.g.: CORBA, Protocol Buffers

- **Flexibility**
  - How easy are changes?

- **Performance**

- **Platforms**
  - E.g.: Desktop vs. HoloLens
Choices & Experiences

VR (Unity, C#)

OpenWire

Message-oriented Middleware Broker

STOMP

Adapter

CORBA

SIMSAT (C++, CORBA)

Web-based Prot. (A-Frame, JavaScript)

MOE (Java, CCSDS-MO)
Choices & Experiences
Choices & Experiences

VR (Unity, C#)
OpenWire
Message-oriented Middleware Broker
STOMP
Adapter
CORBA
SIMSAT (C++, CORBA)

OpenWire
Web-based Prot. (A-Frame, JavaScript)

Adapter
„CCSDS-MO“
MOE (Java, CCSDS-MO)
Choices & Experiences

- VR (Unity, C#)
- Web-based Prot. (A-Frame, JavaScript)
- OpenWire
- STOMP via WebSockets
- STOMP
- Adapter
- Adapter
- CORBA
- SIMSAT (C++, CORBA)
- "CCSDS-MO"
- MOE (Java, CCSDS-MO)
Choices & Experiences

- VR (Unity, C#)
- AR (Unity, C#)
- Web-based Prot. (A-Frame, JavaScript)

Message-oriented Middleware Broker

- OpenWire
- STOMP via WebSockets
- STOMP
- OpenWire

Adapter

- CORBA
- SIMSAT (C++, CORBA)

Adapter

- „CCSDS-MO“
- MOE (Java, CCSDS-MO)
Choices & Experiences

VR
Desktop

AR
HoloLens

Web-based Prot.
(A-Frame,
JavaScript)

OpenWire

Message-oriented
Middleware Broker

STOMP via
WebSockets

STOMP

Adapter

CORBA

SIMSAT
(C++, CORBA)

Adapter

„CCSDS-MO“

MOE
(Java,
CCSDS-MO)
Choices & Experiences

VR Desktop  AR HoloLens

OpenWire  MQTT

Message-oriented Middleware Broker

Web-based Prot. (A-Frame, JavaScript)

STOMP via WebSockets

OpenWire

Adapter

CORBA  SIMSAT (C++, CORBA)

Adapter

„CCSDS-MO“

MOE (Java, CCSDS-MO)
Choices Summary

- **Communication Infrastructure/Middleware**
  - Message-oriented Middleware (MoM)
  - One Central Broker
  - Protocols
    - STOMP, OpenWire, STOMP via WebSockets, MQTT

- **Serialization/Data Representation**
  - JSON -> UTF-8 String -> Byte Array
  - No Complex Class Hierarchies
  - Generic Data Structures
    - Key-value (Map, Dict, …)
    - Sequence (List, Vector, …)
  - Primitive Types
Message-oriented Middleware

- Wrapper/Abstraction
  - bowerick
    - Based on:
      - Apache ActiveMQ, Eclipse Paho, Spring Messaging, …
    - Eclipse Public License
    - https://github.com/ruedigergad/bowerick
• Focus
  • Ease of Use
  • Flexibility

• Performance
  • VR Study: 75,000 parameters/second
  • Publication:
    • Up to ~750 Mbps
Conclusion

- Two Studies
- Integration of Non-space-standard Components
- Least Common Denominator
  - Communication Infrastructure/Middleware
    - Message-oriented Middleware
      (OpenWire, STOMP, MQTT, STOMP via WebSockets)
  - Serialization Data Representation
    - JSON -> UTF-8 String -> Byte Arrays
- Subjective Evaluation: 😊
- “Message-oriented Middleware in Space”:
  - CNES ISIS (ZeroMQ), EGS-CC (Apache ServiceMix), GSOC (possibly MQTT?)
Thank you very much for your attention.

Questions?

ruga@terma.com
https://github.com/ruedigergad/bowerick
Meet us at

www.terma.com

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