

Service Oriented Architecture for Monitoring Cargo in Motion Along Trusted Corridors

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Acknowledgment

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 - Dr. Victor S. Frost
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Outline

- Introduction
- Statement of Problem
- Service Oriented Architecture
- Design & Architecture of TSSN
- Service implementations
- Implementation Results
- Conclusion
- Future Work

Introduction

- Transportation Security SensorNet project
 - Service Oriented Architecture
 - Open Geospatial Consortium
 - Sensor Networks
- Main goals
 - Remote sensor management
 - Alarm notification
 - Use of open standards, tools and software
 - Combination of SOA, OGC and sensor networks

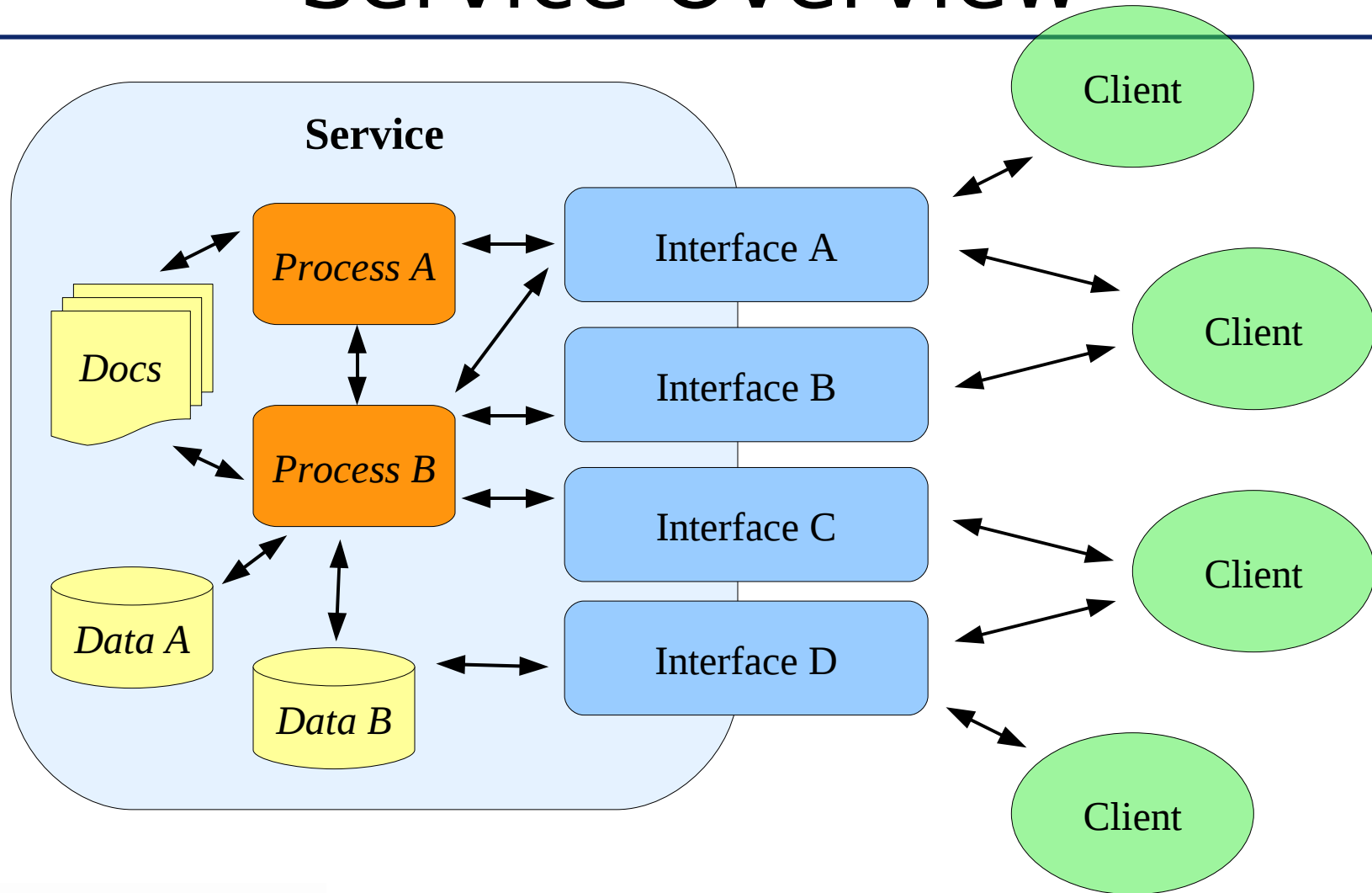
Statement of Problem

“How can a Service Oriented Architecture, open standards and specifications be used to overcome the problems of proprietary systems that are currently in place and provide a reusable framework that can be implemented across the entire transportation industry?”

Service Oriented Architecture

- Concept:
 - Information processing and sharing across various applications using so-called *web services*
 - Components are *web services*
 - *Clients* utilize *web services* through clearly defined open web standards interfaces
- Standard protocols for communication
- Independent of technologies, platforms, programming languages
- Interfaces follow web service standards

Service Overview

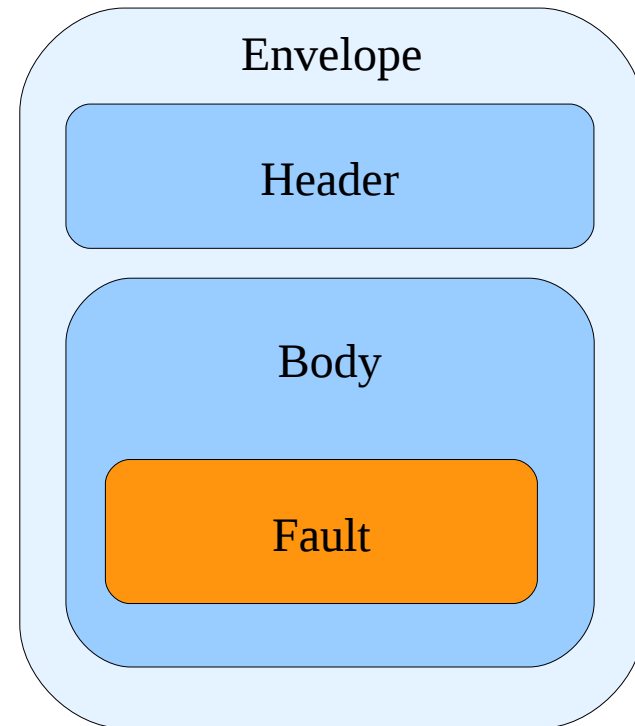


Benefits for TSSN

- Related to the transportation industry:
 - Automation
 - Efficient communication
- Efficient development through modularity
- More reuse of the system
- Simplified maintenance
- Incremental adoption
- Graceful evolution

Web Service Specifications

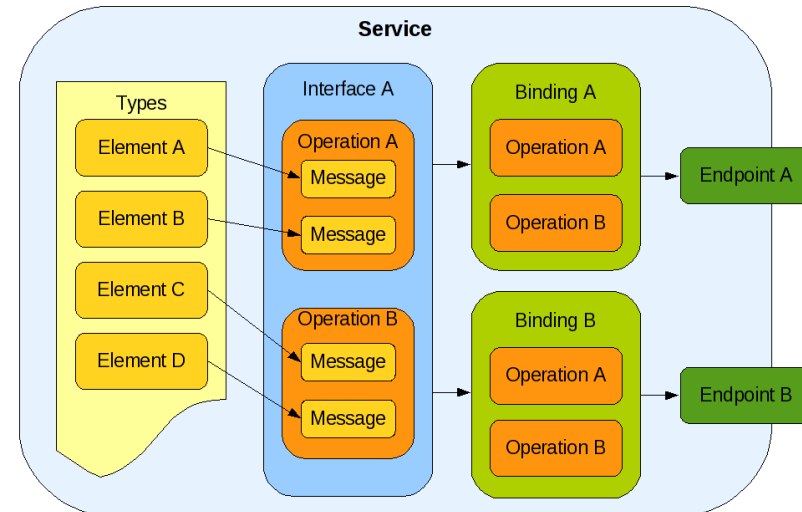
- SOAP
 - Flexible message format
- WS-Addressing
 - Message propagation
 - Routing
- WS-Eventing
 - Event subscriptions and publications
- WS-Security
 - Encryption
 - Signatures



SOAP message format

Web Service Specifications

- UDDI
 - Universal Description, Discovery and Integration
 - Service Discovery
 - Scalability
- WSDL 2.0
 - Web Service Description Language
 - Elements, operations, interface and binding definitions



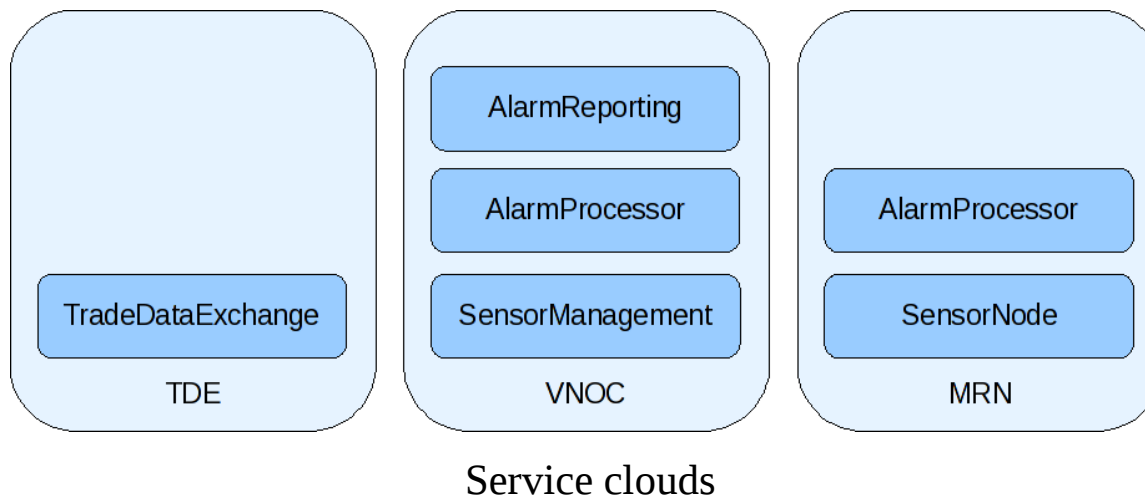
WSDL 2.0 overview

Design & Architecture

- **Transportation Security SensorNet**
 - Based on Service Oriented Architecture
 - Utilize web services and Open Geospatial Consortium specifications
 - Combine web services with sensor network technology
- **Provide:**
 - Service Oriented Architecture for cargo monitoring
 - Remote sensor management
 - Event processing
 - Alarm notifications

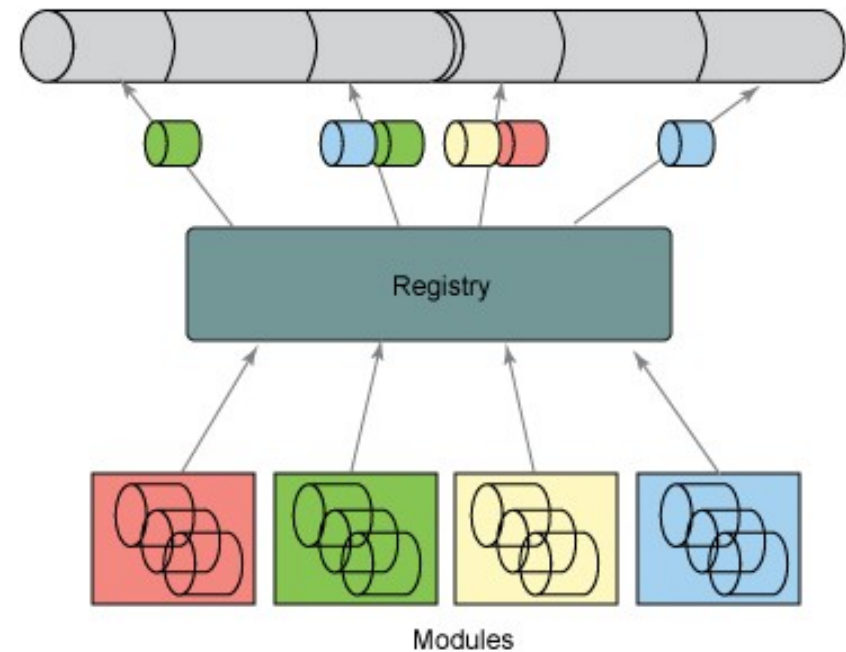
Design & Architecture

- Distributed service clouds
 - Trade Data Exchange
 - Virtual Network Operation Center
 - Mobile Rail Network



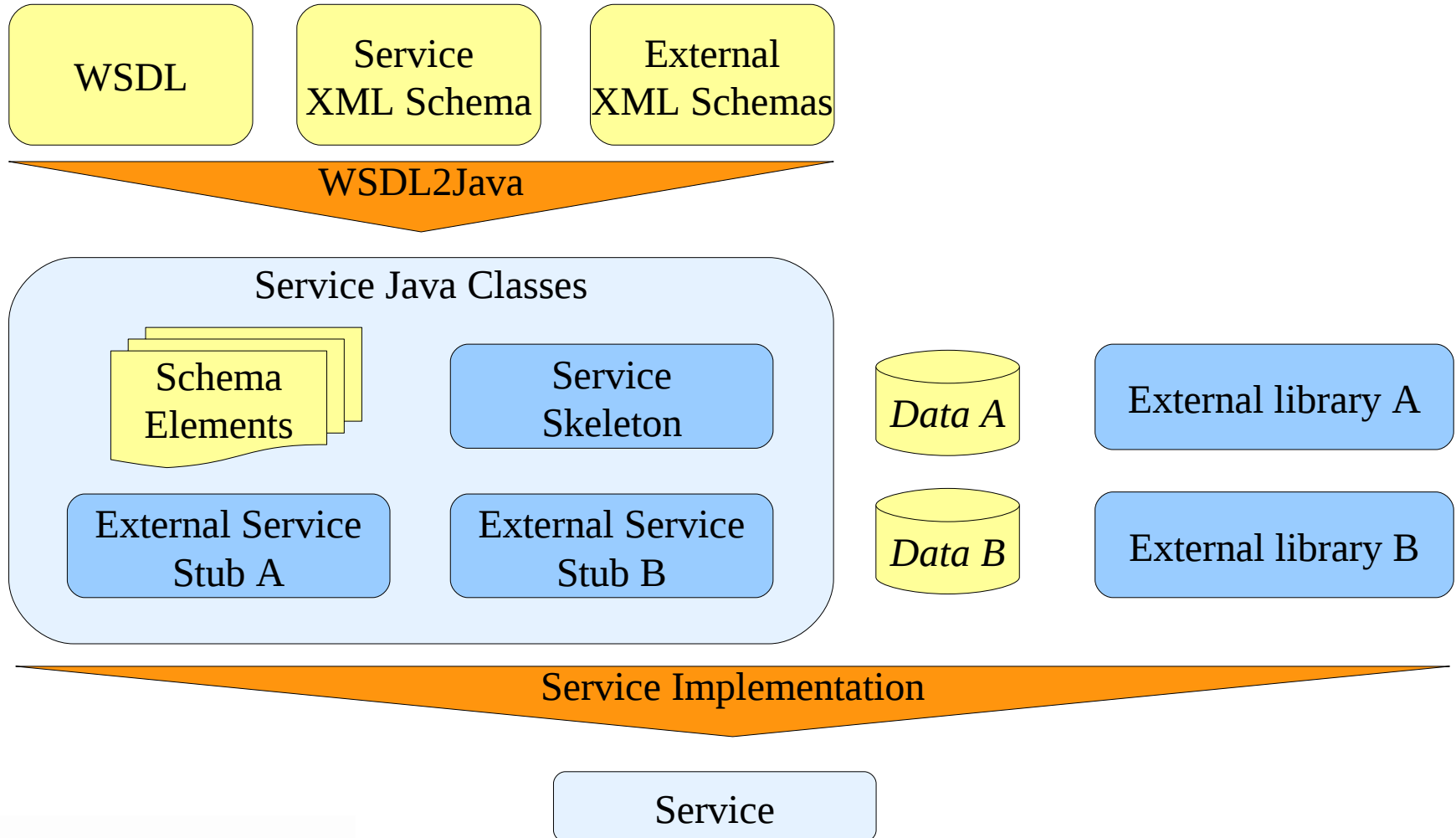
Apache Axis2

- Basis for TSSN
 - Provides basis for web services and clients
 - Supports variety of transports (HTTP, HTTPS, JMS, etc.)
 - Allows several data bindings (Axis Data Binding (ADB), XMLBeans, JibX, etc.)
 - Modular approach to web service specifications



Axis2 module architecture from [16]

Service composition



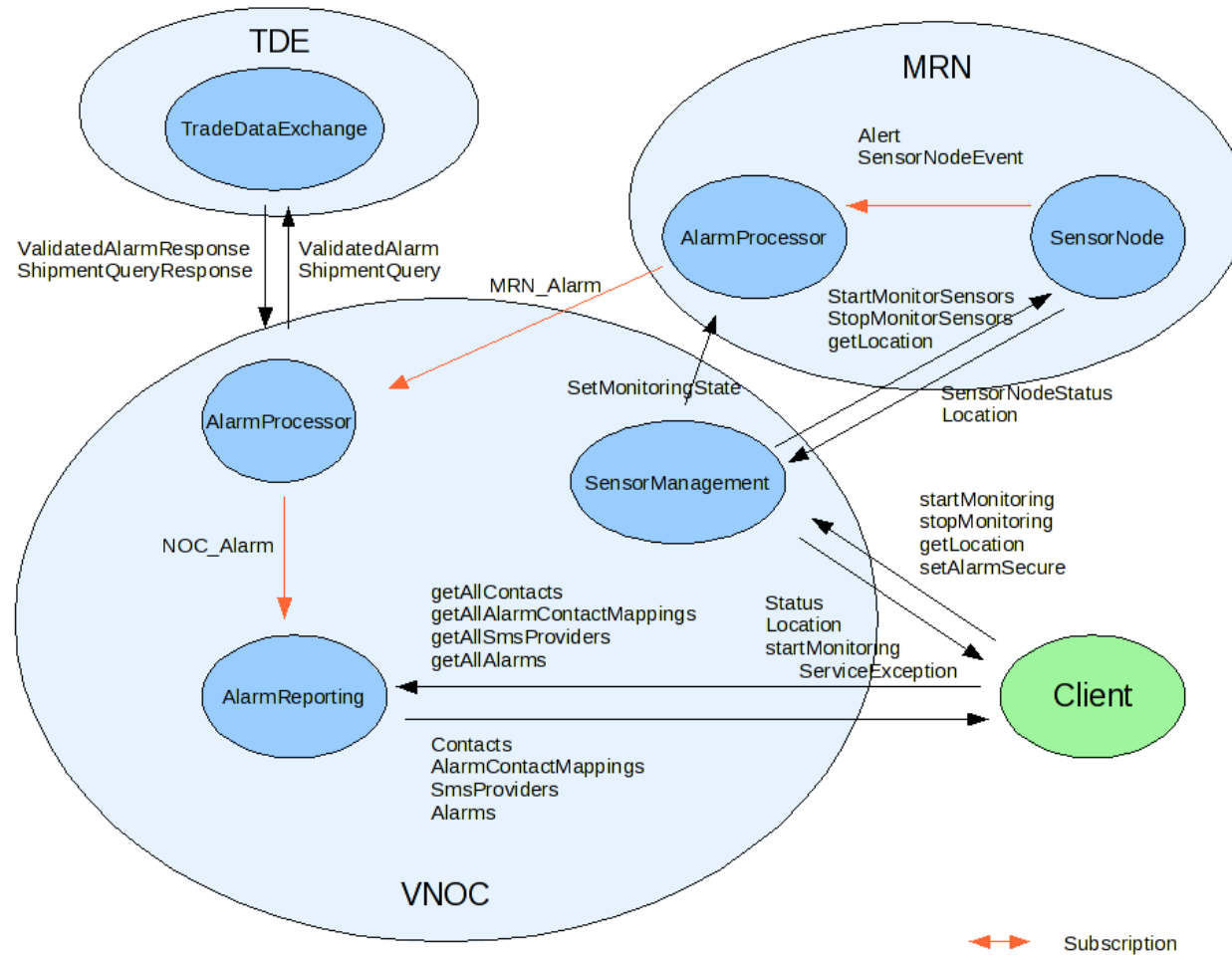
Automatic Code Generation

- Axis2 provides tools for:
 - XML schema compilations -> data bindings
 - Java service classes generation from WSDL
- Use of Apache Ant as a build system
- Improvements to standard implementation
 - Schema compilation of OGC schema elements
 - Ping module
 - Logging module
 - Subscriptions/Publications mechanism
 - Build process

Components

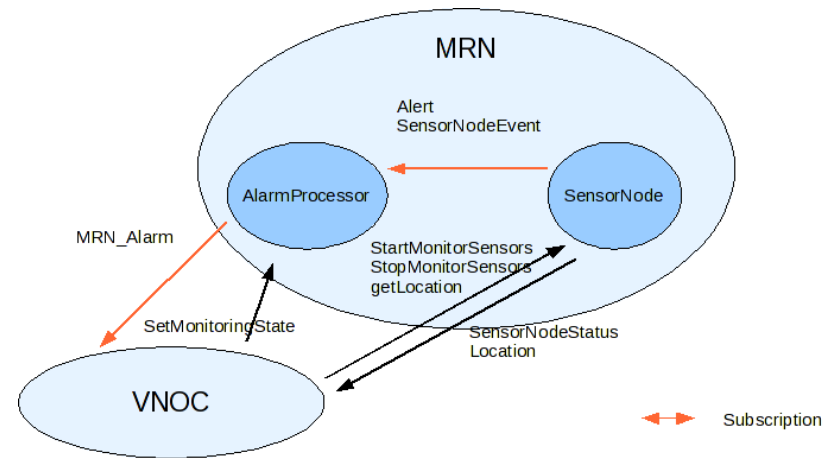
- **Services**
 - Long term storage (MySQL database & Hibernate)
 - Event processing (Esper)
 - Sensor management (Hi-G-Tek (HGT))
 - Location tracking (GPS)
 - Stateless vs. stateful web services
- **Clients**
 - Standalone & embedded in a service
 - User interfaces (Apache CLI & Command Center GUI)
- **Modules**
 - Ping, Logging
 - Web service specifications (Addressing, Savan, Rampart)

Service message overview



Mobile Rail Network

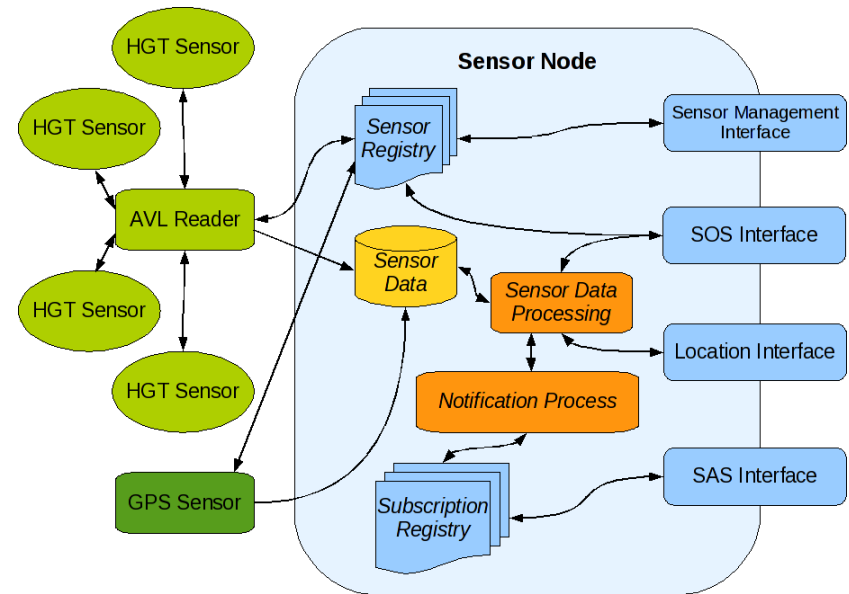
- Located on train
- Responsibilities
 - Sensor management
 - Sensor monitoring
 - Propagation of sensor events



Mobile Rail Network
message overview

MRN Sensor Node

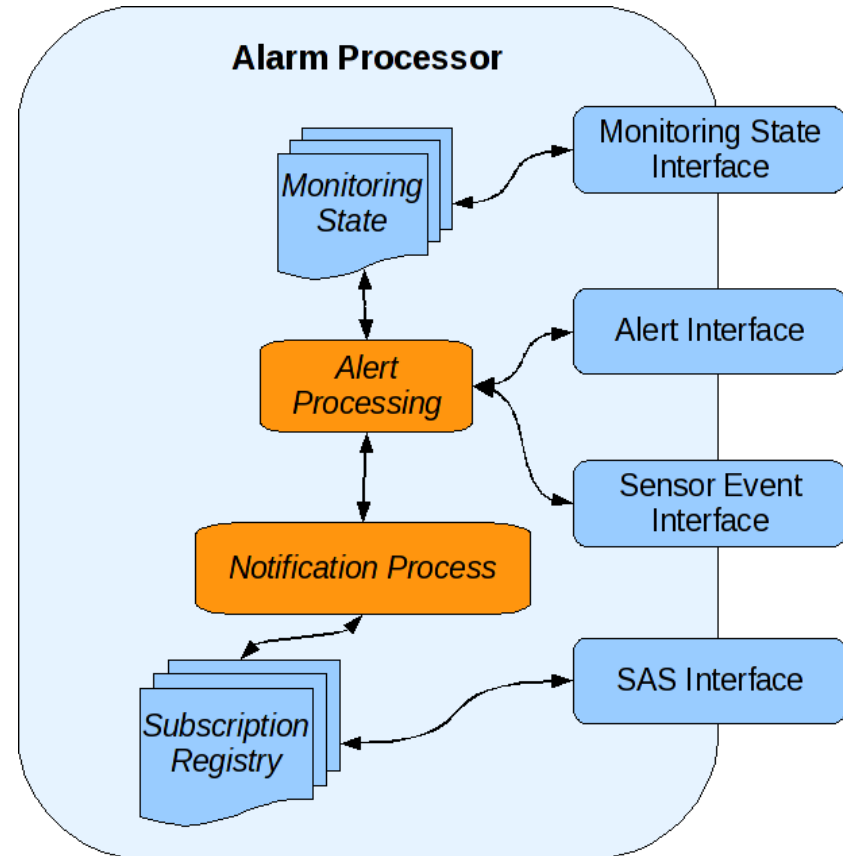
- Abstraction layer to dealing with HGT, GPS and other sensors
- Provides
 - Sensor monitoring
 - Sensor control
 - Location retrieval
 - OGC specifications
 - GetCapabilities and GetObservation (SOS)



Mobile Rail Network
Sensor Node

MRN Alarm Processor

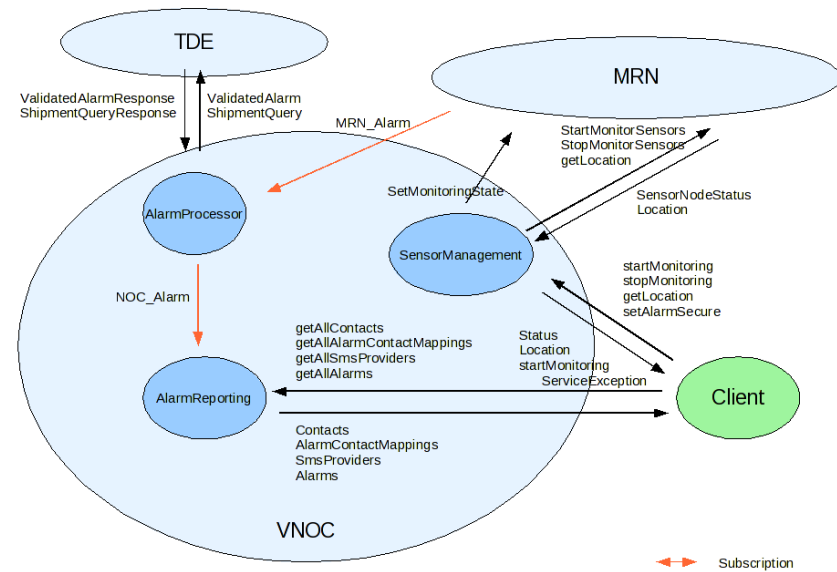
- Processes events that it receives from Sensor Node
- Provides
 - Initial event processing
 - Monitoring state control
 - Security vs. information
 - Alarm notifications



Mobile Rail Network
Alarm Processor

Virtual Network Operation Center

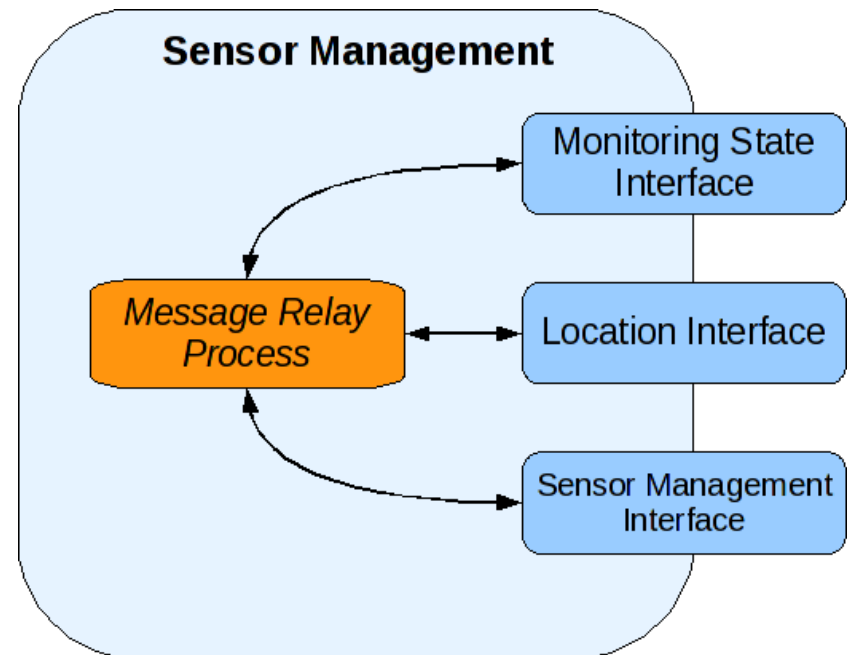
- Located at KU
- Management facility of TSSN
- Responsibilities
 - Sensor management
 - Complex event processing
 - Interfacing with trade information
 - Alarm notifications



Virtual Network Operation Center
message overview

VNOC Sensor Management

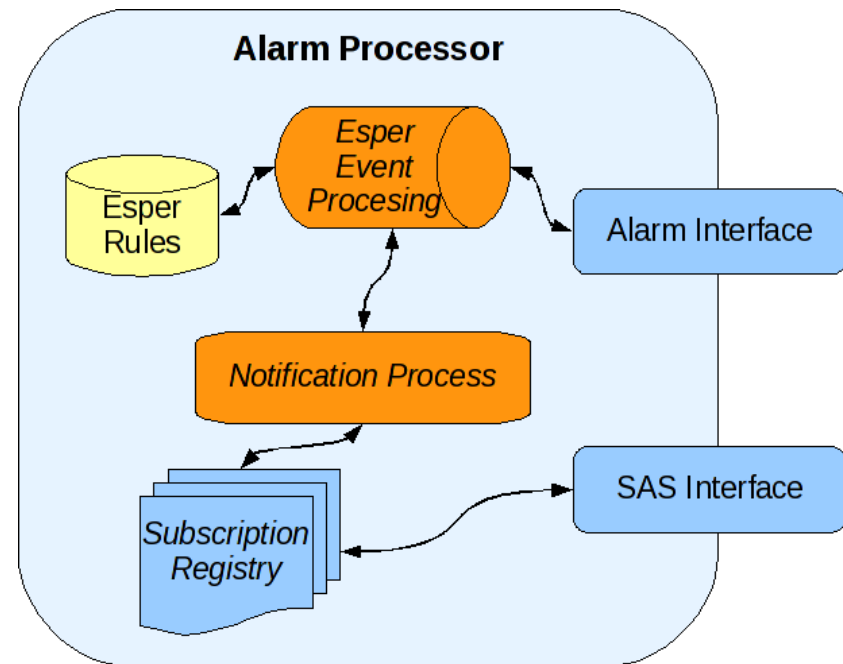
- Remote sensor management via message relay
- Provides
 - Sensor control
 - Monitoring control
 - Location retrieval



Virtual Network Operation Center
Sensor Management

VNOC Alarm Processor

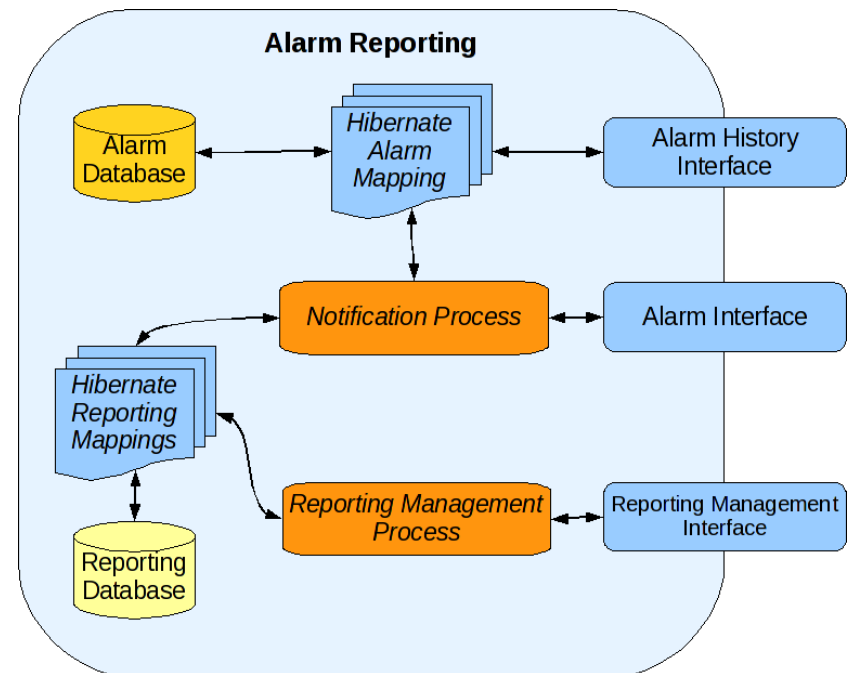
- Processes events that it receives from MRNs
- Provides
 - Complex event processing using Esper
 - Correlation of trade information with events
 - Alarm notifications



Virtual Network Operation Center
Alarm Processor

VNOC Alarm Reporting

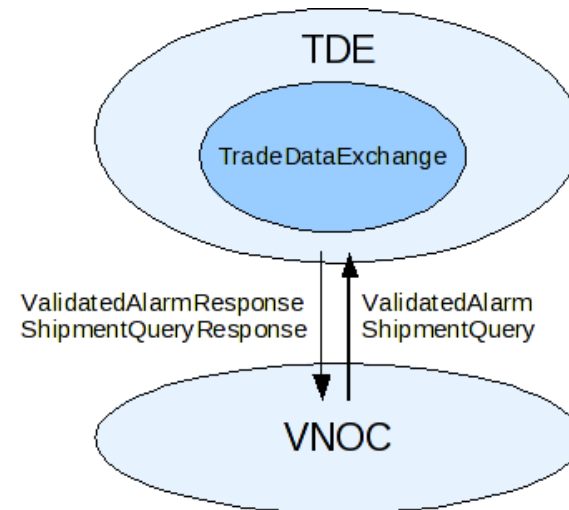
- Sends alarm notifications using email and/or SMS
- Provides
 - Alarm to contact mappings management
 - Alarm history
 - Alarm notifications



Virtual Network Operation Center
Alarm Reporting

Trade Data Exchange

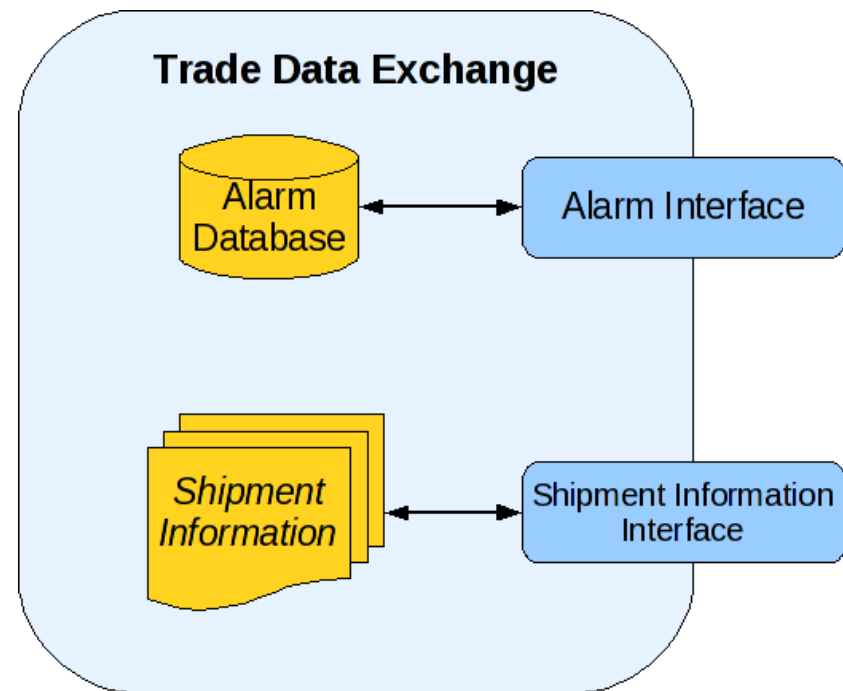
- Located in Overland Park, KS
- Interface to transport systems
- Responsibilities
 - Providing trade data and other information



Trade Data Exchange
message overview

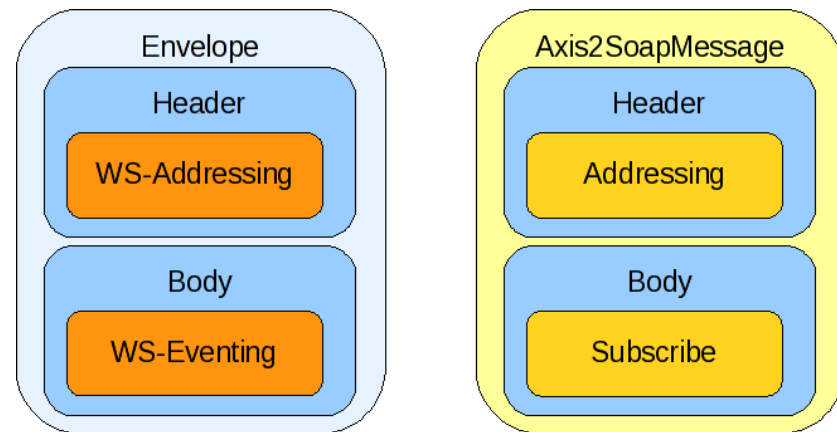
TDE Trade Data Exchange

- Supplies Alarm Processor with trade information
- Provides
 - Alarm storage
 - Shipment information



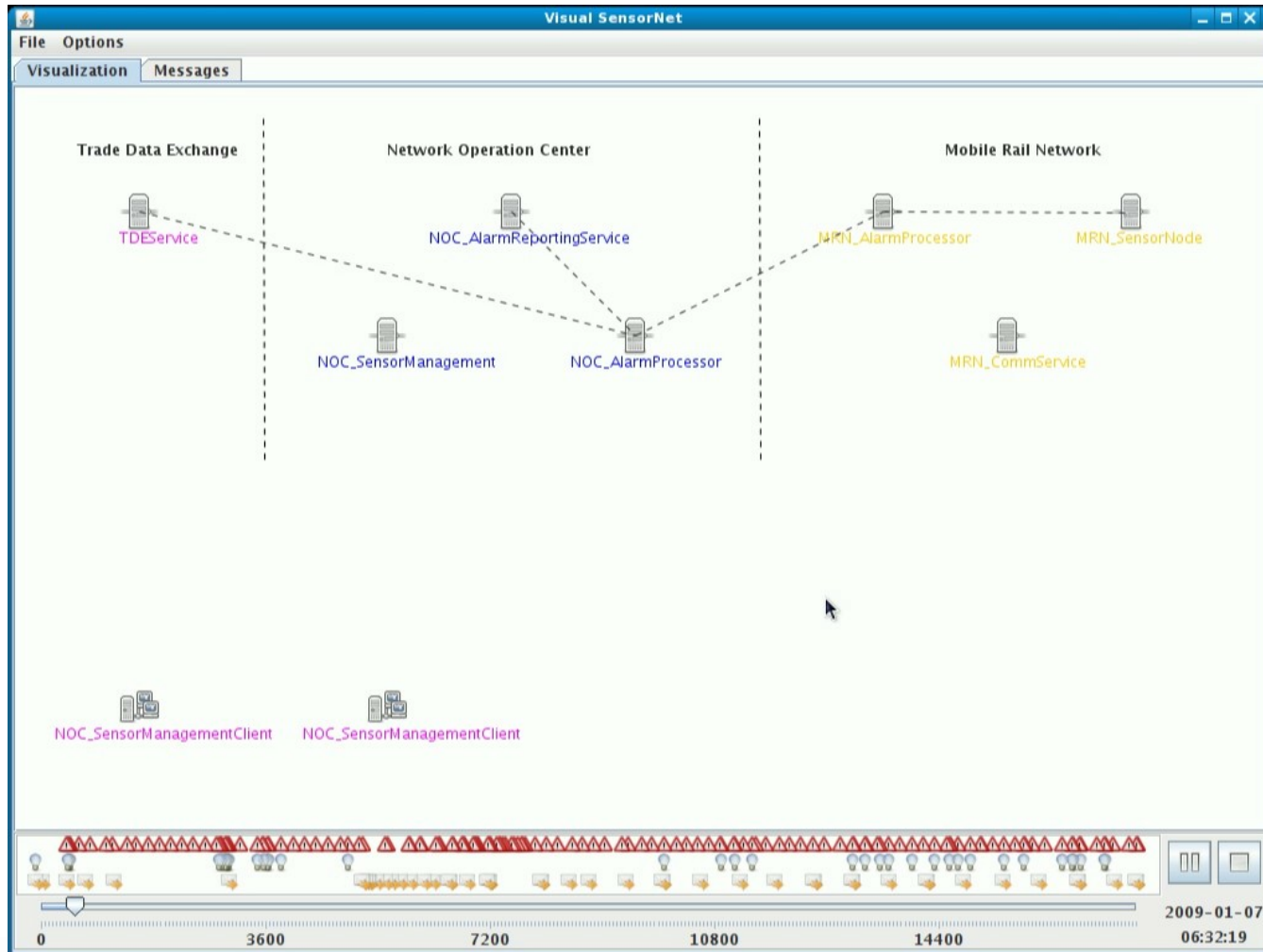
Implementation Results

- Several tools used during trials and analysis
- Logging module
 - Capture message flows
- Log parser
 - Reconstructs messages
 - Provides listing and analysis functionality



SOAP message (left) to Log parser classes (right) comparison

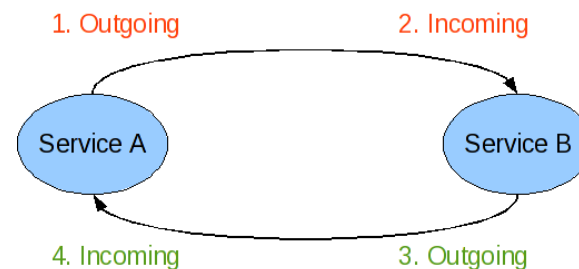
Visual SensorNet



Message Relationships

- **Transmit-Receive Pair**

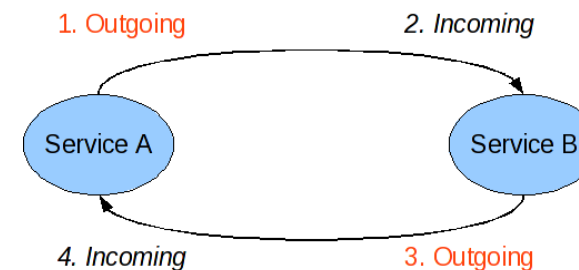
- Combination of outgoing and incoming messages with the same message id
- Allows computation of
 - Transmit times



Two transmit-receive pairs (red and green)

- **Message Couple**

- Combination of outgoing request and outgoing response
- Allows computation of
 - Round trip times
 - Processing times



A message couple (red)

Trial results

- Road tests with trucks
 - MRN deployed on a truck
 - Sensor read range about 400 meters
 - Temporary GSM and GPS loss
 - All messages (sensor management and alarms) successfully sent and received



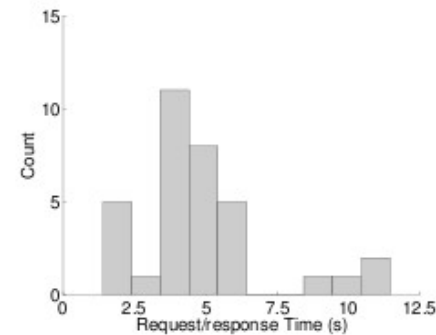
- Short Haul Rail Trial
 - MRN deployed on a locomotive
 - Train traveled approximately 35 kilometers from a rail intermodal facility to a rail yard
 - Similar GSM and GPS issues

Short Haul Rail Trial

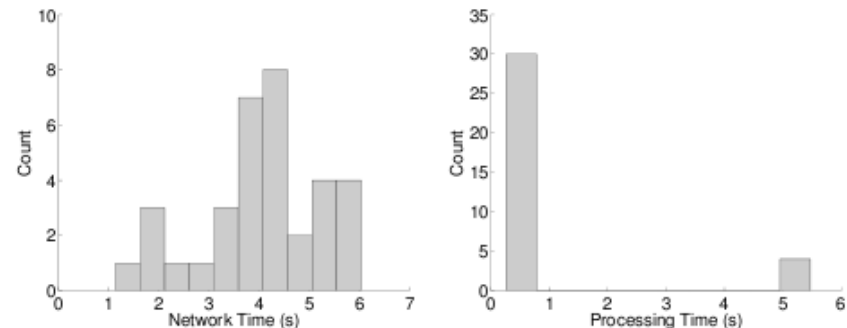
- **Message counts**
 - 546 alerts at the MRN
 - 131 alarms at the VNOCC
 - 63 Shipment information inquiries at the TDE
 - 30 location retrievals
- **Message sizes**
 - Control messages such as getLocation, startMonitoring, etc. on average 690 bytes
 - Alarms from the MRN around 1420 bytes

Request Performance

- Sensor Management to Sensor Node or Alarm Processor
 - Fastest: 0.9 seconds
 - Slowest: 11 seconds
 - Average: 4.4 seconds
- Bottleneck: network
 - Processing on average only 0.6 seconds
 - 85% spent on message transmission



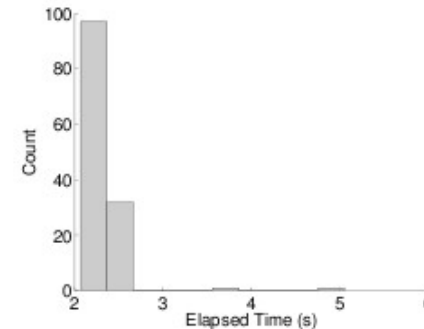
Request performance from [31]



Network transmission and processing performance from [31]

Alarm Notification Performance

- Time going through entire TSSN
 - Fastest: 1.9 seconds
 - Slowest: 4.9 seconds
 - Average: 2.1 seconds
- Problem
 - Clock drift on the MRN
- Solution
 - Approximation using request transmit times



System alarm notification performance from [31]

Conclusion

- Implementation works
 - Trials successful
 - Performance evaluated
- Transportation Security SensorNet
 - Sensor management and alarm notification infrastructure
 - Built using open standards and specifications
 - Integration with OGC standards
- Demonstrates combination of SOA, OGC and sensor networks

Future Work

- Clock synchronization
 - NTP over GPS integrated into Sensor Node
- Service discovery
 - Basic framework in place, bug fixing needed
- Multiple service clouds
 - Most of the services already support this
- Security
 - Policy based security for subscriptions in development
- Asynchronous communication
 - JMS transport implemented for clients and services
 - Deployment using ActiveMQ currently being tested

Thank you for coming today.

Any questions?