How to Remotely Monitor Systems with Time Series and DDS

Brett Murphy, Senior Director Market Development, Industrial IoT, RTI
Kyoungho An, Senior Research Engineer, RTI
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Technical problems?

- Click on the “Question Mark Symbol” on the upper right hand corner of your screen, where you will be directed to a list of system checks
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- Within 7 days, an archive with Q&A will be posted
- We will send an email to registered attendees with hyperlink
- Can also access from www.controleng.com home page
**Speakers**

**Presenter:** Brett Murphy, Senior Director of Market Development, IIoT, RTI

**Presenter:** Kyoungho An, Senior Research Engineer, RTI

**Moderator:** Mark Hoske, Content Manager, Control Engineering and CFE Media & Technology
Industrial IoT Systems run on RTI

Software connectivity framework that delivers system resiliency, security, performance, scale and interoperability.

Foundational to over 1,200 systems.
# Digital Transformation Maturity Matrix

**Connext DDS Enables Advanced IIoT Systems**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Business transformation</th>
<th>Connected Supply Chain Building Information Management (BIM)</th>
<th>Autonomous Vehicle Fleet Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major business transformation</td>
<td>Ride Hailing Platforms (e.g. Uber, LYFT)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**New revenue streams, customer experience**

<table>
<thead>
<tr>
<th></th>
<th>Servitization (e.g. R-R) Predictive Maintenance Drone Inspections</th>
<th>Facilities Management (FM) Connected Vehicle Drone delivery</th>
<th>Smart Traffic Management Distribution Grid Management</th>
</tr>
</thead>
</table>

**Efficiency, cost savings**

|-----------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Monitoring, reporting</th>
<th>Control</th>
<th>Autonomy</th>
</tr>
</thead>
</table>

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Connext 6: Platform for Distributed System Connectivity

- **Connext DDS Professional**
  Connectivity software for developing and integrating IoT systems.

- **Connext DDS Secure**
  Designed for systems requiring robust, fine-grained security.

- **Connext DDS Micro**
  Designed for resource-constrained systems.

- **Connext DDS Cert**
  Designed for safety-certifiable systems.
Layered Databus for Edge to Cloud

- Widely used across advanced Industrial IoT systems
- Resilient, secure, fast, scalable
Connext DDS Resilience

• DDS controls the 6.8 GW Grand Coulee Dam
  - Largest power plant in North America
  - Fastest-responding major power source on the Western Grid
  - Requires 24x7 operation

• Connext DDS met the challenges
  - Extreme availability
  - Wide area communications
  - Multi-level routing
  - High security

Fault tolerance protecting against even minimal downtime
Connext DDS Security: A Demanding Test

- USS Secure cybersecurity testbed
  - Collaboration between the NSA, DoD, Navy, Naval Research, John Hopkins Univ APL, RTI

- Objectives
  - Immunize against cyberattack and to rapidly recover when impacted
  - Determine the best cyber-defense technologies without impacting real-time performance

- Results
  - Thumbs Up for RTI Connext DDS Security

Data secured end-to-end and access managed per user and application
Connext DDS Security: Unique Capabilities

• Beyond endpoint and network security, Connext uses DDS Security to secure the data streams individually
  – Better protects against malicious insider attacks and segregates data by user and application
• Connext provides seamless end-to-end data communication security
  – Works over any network and even between apps on one compute node
• Connext allows you to balance performance and security in the system
Connext DDS Performance

- The NASA Kennedy launch control is the world’s largest single-system SCADA
- It combines 400k data points, at 500k msgs/sec

Low-latency, high throughput data comms
Connext DDS Scale

• Raytheon uses RTI middleware to control the new Zumwalt DDG 1000 destroyer
• The system connects hundreds of computers, 1,500 teams building thousands of applications, and more than 10m publish-subscribe pairs

Widely shared data and many applications integrated
Connext DDS Interoperability

- Open DDS Connectivity Standard
- Supports Data Models
- Provides Data Centric Modularity

Open standards: software and device modularity, interchange and portability
Integration of RTI Connext DDS and InfluxDB
Telegraf Plugin for Connext DDS enables monitoring architecture with DDS and InfluxDB

- System Stats
- DDS Stats & Events
- Applications
- Logs & Traces

Telegraf Plugin for Connext DDS

Telegraf: Agent for Collecting and Reporting Metrics and Events
InfluxDB: Time Series Database for Monitoring
Grafana: Web-based Interface for Monitoring and Analytics

CONNEXT DATABUS
Why did RTI decide to use the InfluxDB stack?

- Telegraf uses **push-based** metric collection, which is a better fit for DDS (event-based based pub/sub model)
- Many **out-of-the-box plugins** for system monitoring
- **Mature** and widely adopted **open source** technology with **commercial** offering/support
DDS and InfluxDB
DDS Terminology

Domain Participant
Subscriber
Data Reader
Publisher
Data Writer
Data Writer
Subscriber
Data Reader
Data Reader
Publisher
Data Writer

Topic
Topic
Data Domain
Mapping of DDS and InfluxDB concepts
DDS is fully distributed and supports decoupled publish/subscribe communications.
DDS is data-centric and supports content-based filtering.
DDS can control data flows and resource usage

<table>
<thead>
<tr>
<th>Quality of Service</th>
<th>Quality of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURABILITY</td>
<td>USER_DATA</td>
</tr>
<tr>
<td>HISTORY</td>
<td>TOPIC_DATA</td>
</tr>
<tr>
<td>READER DATA LIFECYCLE</td>
<td>GROUP_DATA</td>
</tr>
<tr>
<td>WRITER DATA LIFECYCLE</td>
<td>PARTITION</td>
</tr>
<tr>
<td>LIFESPAN</td>
<td>PRESENTATION</td>
</tr>
<tr>
<td>ENTITY FACTORY</td>
<td>DESTINATION ORDER</td>
</tr>
<tr>
<td>RESOURCE LIMITS</td>
<td>OWNERSHIP</td>
</tr>
<tr>
<td>RELIABILITY</td>
<td>OWNERSHIP STRENGTH</td>
</tr>
<tr>
<td>TIME BASED FILTER</td>
<td>LIVELINESS</td>
</tr>
<tr>
<td>DEADLINE</td>
<td>LATENCY BUDGET</td>
</tr>
<tr>
<td>CONTENT FILTERS</td>
<td>TRANSPORT PRIORITY</td>
</tr>
</tbody>
</table>

VOLATILITY
INFRASTRUCTURE
DELIVERY
TRANSPORT
REdundancy
Presentation
User
DDS supports reliable delivery on top of UDP and multicast.
DDS can deliver historical data for late joiners

- Durable Publisher
  - Temp Publisher
    - Temp = 125
    - Temp = 136
    - Temp = 157
- Late Joining Subscriber
  - Temp Subscriber
    - Temp = 125
    - Temp = 136
    - Temp = 157
Telegraf has many out-of-the-box input plugins and plugin APIs to easily extend
InfluxDB supports built-in time-series functions

```sql
> SELECT MAX("water_level") FROM "h2o_feet"
```

<table>
<thead>
<tr>
<th>name</th>
<th>h2o_feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>max</td>
</tr>
<tr>
<td>2015-08-29T07:24:00Z</td>
<td>9.964</td>
</tr>
</tbody>
</table>

```sql
> SELECT MEAN("water_level") FROM "h2o_feet"
```

<table>
<thead>
<tr>
<th>name</th>
<th>h2o_feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>mean</td>
</tr>
<tr>
<td>1970-01-01T00:00:00Z</td>
<td>4.442107025822522</td>
</tr>
</tbody>
</table>

InfluxDB integrates visualization tools such as Grafana and Chronograf
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CONNEXT DATABUS

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Agent for Collecting and Reporting Metrics and Events

InfluxDB
Time Series Database for Monitoring

Grafana
Web-based Interface for Monitoring and Analytics
How is the plugin implemented?
We used RTI Go Connector for developing Telegraf plugins

- RTI Go Connector is **simplified API** for DDS in Golang
  - Built on top of DDS C API
  - Very few methods
  - Experimental products developed by the RTI research team
  - Free!

https://github.com/rticommunity/rticonnextdds-connector-go
The DDS consumer input plugin is developed as a service input plugin

type ServiceInput interface {
    Input

    // Start the ServiceInput.
    Start(Accumulator) error

    // Stop stops the services and closes any necessary channels and connections
    Stop()
}
Initially, it creates DDS entities and a service thread

```go
func (d *DDSConsumer) Start(acc telegraf.Accumulator) error {
    // Create a RTI Connector
    d.connector, err = rti.NewConnector(d.ParticipantConfig, d.ConfigFilePath)

    // Get a DDS reader
    d.reader, err = d.connector.GetInput(d.ReaderConfig)

    // Start a thread for processing DDS samples
    go d.process()
}
```
A service thread reads and processes DDS data samples

// Take DDS samples from a DataReader and ingest them to Telegraf outputs
func (d *DDSCONSUMER) process() {
    for {
        d.connector.Wait(-1) // Wait until a new DDS sample arrives
        d.reader.Take() // Take DDS samples
        numOfSamples := d.reader.Samples.GetLength()
        for i := 0; i < numOfSamples; i++ {
            json, err := d.reader.Samples.GetJSON(i) // Return a DDS sample in JSON
            metrics, err := d.parser.Parse(json) // Parse the JSON object
            // Add metrics to an output plugin
How to use the plugin?
Creating an XML configuration file

<dds>
<!-- Data Types -->
<types>
  <struct name="ShapeType" extensibility="extensible">
    <member name="color" stringMaxLength="128" id="0" type="string" key="true"/>
    <member name="x" id="1" type="long"/>
    <member name="y" id="2" type="long"/>
    <member name="shapesize" id="3" type="long"/>
  </struct>
</types>
</dds>
Creating an XML configuration file

<domain_library name="MyDomainLibrary">
    <domain name="MyDomain" domain_id="0">
        <register_type name="ShapeType" type_ref="ShapeType"/>
        <topic name="Square" register_type_ref="ShapeType"/>
    </domain>
</domain_library>
Creating an XML configuration file

<!-- Participant library -->
<domain_participant_library name="MyParticipantLibrary">
  <domain_participant name="Zero" domain_ref="MyDomainLibrary::MyDomain">
    <subscriber name="MySubscriber">
      <data_reader name="MySquareReader" topic_ref="Square"/>
    </subscriber>
  </domain_participant>
</domain_participant_library>
</dds>
Creating a TOML configuration file

[inputs.dds_consumer]

# XML configuration file path
cfg_path = "example_configs/ShapeExample.xml"

# Configuration name for DDS Participant from a description in XML
participant_config = "MyParticipantLibrary::Zero"

# Configuration name for DDS DataReader from a description in XML
reader_config = "MySubscriber::MySquareReader"
Creating a TOML configuration file

# Tag key is an array of keys that should be added as tags.
tag_keys = ["color"]

# Override the base name of the measurement
name_override = "shapes"

# Data format to consume.
data_format = "json"
Demo
Shapes Demo

- Telegraf Input Plugin for RTI Connext DDS
  - Delivering historical data for late joiners
  - Content-based filtering

https://www.rti.com/free-trial/shapes-demo
Thank you!

rti.com
Free trial of Connext DDS

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https://www.rti.com/developers/rti-labs
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Questions?
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Please take a moment to answer a few questions on our exit survey that will pop up on your screen at the conclusion of the webcast. We use the answers to help make improvements to our webcast program.

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