<table>
<thead>
<tr>
<th>Speaker</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meg Duncan</td>
<td>Marketing Manager, Object Management Group</td>
</tr>
<tr>
<td>Lynne Canavan</td>
<td>Director of Ecosystems at Real-Time Innovations and VP of Marketing at the DDS Foundation</td>
</tr>
<tr>
<td>Daniel Herring</td>
<td>Associate Staff at MIT Lincoln Laboratory, and TMS Lead Engineer</td>
</tr>
</tbody>
</table>
About the DDS Foundation

• Mission: To advance the use of DDS in complex, high-performance, distributed applications

• Nonprofit organization of DDS users, government institutions, researchers, universities and technology companies

• Goals:
  • Drive future requirements for the DDS standard
  • Define industry-specific data models and adaptations of DDS
  • Vendor interoperability
  • Support industry-specific adaptations and implementations of DDS
  • Industry education: Build a library of use cases, data models, application software, and system architectures

• Managed by the Object Management Group® (OMG)
Tactical Microgrid Standard (TMS)
Using DDS for Secure Communications

DDS Foundation Webinar

Daniel Herring

May 2020
DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

This material is based upon work supported by the Department of the Army under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Army.

© 2020 Massachusetts Institute of Technology.

Delivered to the U.S. Government with Unlimited Rights, as defined in DFARS Part 252.227-7013 or 7014 (Feb 2014). Notwithstanding any copyright notice, U.S. Government rights in this work are defined by DFARS 252.227-7013 or DFARS 252.227-7014 as detailed above. Use of this work other than as specifically authorized by the U.S. Government may violate any copyrights that exist in this work.
The Need for New Power System Architectures

Disasters

New Technologies

Attacks

Better Integration

Open Architecture

Simple

Efficient

Resilient

Modular

Scalable

Extensible
Canonical Power System Architecture and Example Power Missions

Supervisory Control

Source
Transmission
Heavy Industry
Distribution
Consumer
Off Grid

Fuel

Disaster Response
Critical Infrastructure Operations
Forward Deployed Operations

Example Missions
 exemple missions

Disaster Response

Critical Infrastructure Operations

Forward Deployed Operations

Off Grid

Fuel

Source
Transmission
Heavy Industry
Distribution
Consumer

Supervisory Control

Canonical Power System Architecture and Example Power Missions
Microgrids Power DoD Forward Deployed Operations

Example Forward Operating Base

- Self-sufficient power
- Warfighter owned and operated
- Thousands of sites
- Each site unique

Supporting Missions

- Communications
- Sensors
- Weapons
- Climate Control
Microgrids Power DoD Forward Deployed Operations

Example Forward Operating Base

- Self-sufficient power
- Warfighter owned and operated
- Thousands of sites
- Each site unique

Operational Challenges

- Rapid Deployment
- Operator Training
- Dynamic Loads
- Equipment Failures
- Organic Growth
- Insert New Tech

Supporting Missions

- Communications
- Sensors
- Weapons
- Climate Control
Tactical Microgrid Architecture Options
Before TMS

- **Spot Generation**
  - Simple setup
  - Inefficient
  - Fragile generation
  - Minimal distribution
  - Extensible, modular

- **Consolidated Generation**
  - Complex setup
  - Efficient
  - Fragile generation
  - Fragile distribution
  - Extensible, modular

- **Central Microgrid**
  - Simple setup
  - Efficient
  - Backup generation
  - Fragile distribution
  - Resilient distribution

- **Distributed Microgrid**
  - Very complex setup
  - Efficient
  - Spread out generation
  - Resilient distribution
  - Proprietary vendor lock

**Typical DoD Approach**
- Limited Use
- Initial Deployment
- Prototyping Today
Tactical Microgrid Architecture Options
With TMS

Spot Generation

- Simple setup
- Inefficient
- Fragile generation
- Minimal distribution
- Extensible, modular

Consolidated Generation

- Complex setup
- Efficient
- Fragile generation
- Fragile distribution
- Extensible, modular

Central Microgrid

- Simple setup
- Efficient
- Backup generation
- Fragile distribution
- Open Architecture

Distributed Microgrid

✓ Simple Setup
✓ Efficient
✓ Resilient generation
✓ Resilient distribution
✓ Open Architecture

Typical DoD Approach
Limited Use
Initial Deployment
Prototyping Today
Tactical Microgrid Standard (TMS)
Open Architecture Defines

Components

Control Services
- Microgrid System Manager (MSM)
- Microgrid Controller (MC)

Power Devices
- Source (SRC)
- Distribution (DIST)
- Conversion (CONV)
- Load (LOAD)

Interfaces

Power Regulation

Source
- Power Hardware
- Control Hardware
- Data Model

Cybersecurity

Communications Protocol

Health and Status Messages

Command and Control Messages

Other voltage or frequency
Tactical Microgrid Standard (TMS) in Operation

DoD & Commercial Equipment
... Upgraded with TMS

Input Test Disturbances

Rapid Deployment  Dynamic Loads  Add & Remove Devices  Equipment Failures
Tactical Microgrid Standard (TMS) in Operation

DoD & Commercial Equipment
... Upgraded with TMS

Input Test Disturbances

- Rapid Deployment
- Dynamic Loads
- Add & Remove Devices
- Equipment Failures

Generator Current

(3-phase, 120/208 V, 60 Hz AC)
Tactical Microgrid Standard (TMS) in Operation

Example: Resilient Power Sharing

- Grid Voltage
- Battery Current
- Generator Current

Input Test Disturbances

- Rapid Deployment
- Dynamic Loads
- Add & Remove Devices
- Equipment Failures

(3-phase, 120/208 V, 60 Hz AC)
Why Data Distribution Service? (OMG DDS)

• OMG DDS is a communications middleware ➔ modular software re-use.

• Strong Technology
  – Fully distributed publish/subscribe (pub/sub)
  – Machine-readable Interface Definition Language (IDL)
  – Rich Quality of Service (QoS)
  – Portable API
  – Interoperable wire protocol
  – Security architecture

• Healthy Ecosystem
  – Open standard
  – Stable governance
  – Multiple independent commercial implementations
  – Continuous innovation
  – Used across multiple industries
OMG DDS Adoption Experience

Challenges

• Planning requirements
  – Hardware: CPU, memory, and network
  – Software: language, OS, …

• Getting started
  – Choosing an implementation
  – Finding beginner documents

• Navigating all the options
  – Terminology, DCPS object model
  – Samples, keys, filters, buffers
  – Event handling
  – Topics, IDL, and QoS

• Debug and testing tools

• Optional parts of the standard

Takeaways

• Beginners surprised by
  – Imposing size
  – Steep learning curve
  – Cost to start (time, effort, and money)

• TMS provides domain-specific
  – Documentation, FAQ
  – Topics, IDL, and QoS
  – Tools

• Beginner response after code works
  – Powerful capability
  – Easy to extend and maintain
  – Long path to mastery
  – Plan to use DDS even more
For more information,

• DDS Foundation
  • https://www.dds-foundation.org/join-dds-foundation/
  • https://www.dds-foundation.org/join-dds-foundation/#faq
  • email ddsfoundation@omg.org

• TMS
  • email dherring@ll.mit.edu