TECHNICAL INSIGHT

An Introduction to UMAA and DDS

Never has the need to quickly develop military systems been greater than it is today. Adversaries can develop and deploy systems faster than ever before. Add to this the rapid and iterative advancements made in weaponry observed during ongoing conflicts, and it becomes clear that joint forces need a path toward faster development and rapid deployment with an ability to quickly iterate capability.

The Modular Open Systems Approach (MOSA) addresses this situation. Its goals are to:

- Reduce cost and time to deploy,
- Enable fast upgrades,
- Enhance interoperability, and
- Support "plug and play" capability, allowing fast incremental upgrades in the field with newer, more effective technology.

This initiative was determined to be so critical that it was eventually passed into law.*

Recently, the Navy adopted a fast-track development stream (Advanced Concepts and Disruptive Capabilities) in support of quickly creating new systems based on the modern battlefield experience. Everything is pointing toward a fast iterative development cycle.

Unmanned Maritime Autonomous Architecture

Applying this approach to autonomous Naval systems, PMS406 (Unmanned Maritime Program Office) has worked toward creating the Unmanned Maritime Autonomous Architecture (UMAA) specification, which fits the bill when it comes to addressing MOSA objectives as they apply to UUV (Unmanned Underwater Vehicle) and USV (Unmanned Surface Vehicle) development — one of the fastest growing areas in the Navy.

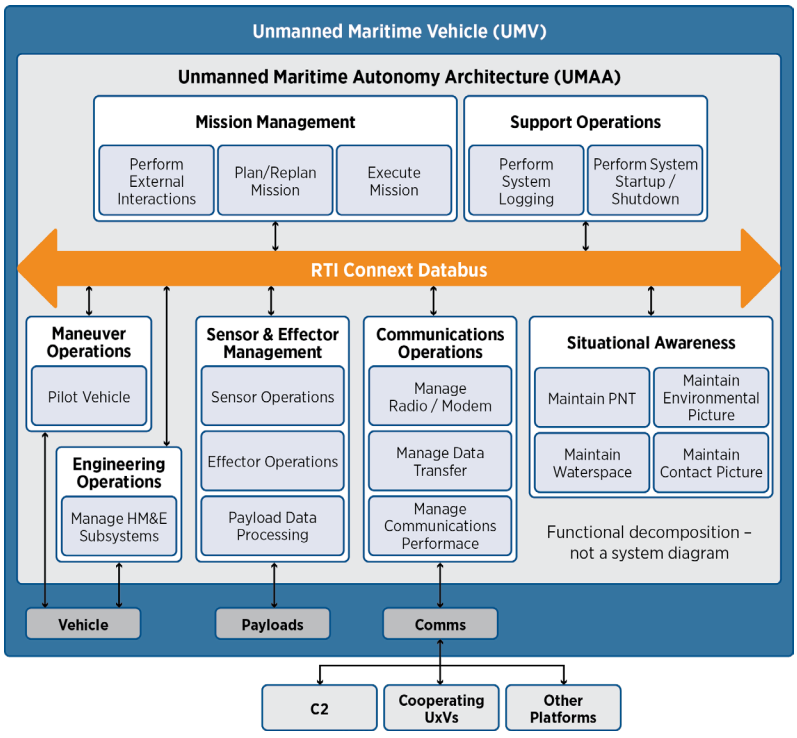

Figure 1: UMAA Architecture

UMAA stands as a pivotal initiative that is aimed at standardizing the software development process for unmanned maritime vehicles. The goal is to foster the creation of common, modular, and scalable software that can be applied across a variety of unmanned vehicles, regardless of their specific autonomy implementation. This standardization is essential for several reasons:

1. Standardization promotes interoperability, allowing components developed by different vendors to seamlessly communicate and collaborate. This leads to a more integrated and effective ecosystem of autonomous maritime systems.
2. Software components can be easily replaced or upgraded, allowing systems to evolve and adapt to new technologies and mission requirements.
3. Systems can be expanded to handle increased complexity without requiring major redesigns.

From a functional perspective, UMAA defines the on-board operations of unmanned surface and underwater vehicles through eight high-level components (as outlined in Figure 1):

1. Communications Operations
2. Engineering Operations
3. Maneuver Operations
4. Mission Management
5. Processing Operations
6. Sensor and Effector Operations
7. Situational Awareness
8. Support Operations

Each of these components provides standard interfaces for specific services, paving the way for modular development and the seamless upgrade of capabilities. This modularity further enables programs to leverage pre-existing capabilities across different systems that adhere to the standard — this ultimately fosters code reuse, while minimizing development time and reducing costs.

The Data Distribution Service (DDS™) standard serves as a critical enabler of the UMAA vision. The autonomy bus (or databus) upon which the autonomy messaging system operates is able to provide a foundation that can facilitate real-time, reliable, and efficient communication between various components of an autonomous system.

The selection of DDS as the communication middleware for UMAA is strategic and directly addresses the core requirements of the architecture. Here's a deeper look at how DDS aligns with UMAA:

- As a loosely coupled communication architecture, DDS adopts a publish-subscribe model that decouples communication between software components. This means that components can interact and exchange data without requiring direct knowledge of each other's existence or location. A component simply publishes data to a specific topic, and any other component interested in that data can subscribe to that topic. This decoupling brings significant advantages as it simplifies system design. Developers can focus on the functionality of individual components without worrying about intricate communication protocols.
- Modularity is enhanced so that components can be easily added, removed, or replaced without disrupting overall system operation.
- Scalability is improved, allowing the expansion of systems which can incorporate a greater number of components and handle more data with minimal impact on existing components. This type of scalable architecture allows systems to grow and adapt to increasing complexity, seamlessly accommodating the increased load without compromising performance.
- UMAA-compliant systems can operate in real time and respond promptly to dynamic changes in the computing environment. DDS is engineered specifically to support real-time applications, ensuring low-latency data delivery, enabling the system to make timely decisions and react swiftly to evolving situations.
- DDS fosters a data-centric approach, where data becomes the focal point of communication. Instead of focusing on specific communication paths between components, DDS emphasizes the sharing and distribution of data across the system, regardless of transport protocols. This paradigm promotes increased interoperability, allowing components to share data seamlessly even if they are developed by different vendors or use different programming languages.
- DDS incorporates features that help ensure reliable data delivery, even under less-than-ideal network conditions. Components confirm the receipt of messages, guaranteeing that data is not lost in transit using a message acknowledgment scheme. Data can also be replicated across multiple network nodes, ensuring availability even if some nodes experience failures.

Now, let's look at the realization of a hypothetical system. Consider a mission scenario where an unmanned underwater vehicle needs to navigate a predefined route. The Mission Management component would define the mission plan, specifying waypoints, objectives, and any constraints. This plan is then published onto a DDS databus. The Maneuver Operations component subscribes to the mission plan data and takes charge of controlling the vehicle's movements to execute the plan effectively. DDS ensures that the mission plan is reliably communicated to the relevant agents and that any updates to the plan, such as changes in waypoints or objectives, are propagated in real time. Additionally, other components like Sensor and Effector Operations can leverage DDS to share sensor data and control effectors based on the mission's demands and the prevailing situation.

The utilization of DDS underscores its vital role in achieving the core objectives of UMAA. The publish-subscribe model enables the seamless coordination of different agents responsible for various aspects of the mission. The real-time capabilities of DDS ensure that data is exchanged promptly, allowing for responsive and agile

maneuvering of the unmanned vehicle. The data-centric nature of DDS facilitates the efficient sharing of information across the system, enabling a comprehensive understanding of the operating environment to support informed decision-making. The reliability and scalability of DDS enable the system to operate effectively, even in challenging underwater environments, as well as adapt to future expansion and evolving mission requirements.

RTI is no stranger to UMAA and the U.S. Navy, and has worked closely with defense contractors to research and develop viable solutions for this initiative. One outcome has been the creation of the UMAA Starter Kit which is available in RTI's Case + Code collection. The starter kit offers a pre-built foundation for developing UMAA-compliant systems. It includes XML definition of DDS entities for core UMAA components such as Autopilot and USVNAV, based on the UMAA v1.0 Component Definitions release. This saves developers significant time and effort compared to building these components from scratch. It also allows for a single point of configuration, regardless of whether teams are developing in Python or C++.

The kit was designed to minimize the complexities of starting development with UMAA and provides clear instructions for building and running the examples, including the source code. This makes it accessible even for developers new to DDS and UMAA. Additionally, it showcases the capabilities of RTI Connext® with example applications simulating interaction between UMAA interfaces. These applications, available in Modern C++ and Python APIs, illustrate how to instantiate UMAA components, manage configuration, and use the provided writers and readers.

Conclusion

The combination of UMAA's standardized architecture and the powerful capabilities of DDS provide a solid foundation for the advancement of unmanned maritime systems. As the market leader in products compliant with the DDS standard, RTI Connext provides a robust DDS implementation that supports and simplifies UMAA development efforts. RTI's UMAA Starter Kit lowers the barrier to entry for UMAA development, providing developers with a foundation to quickly build and deploy UMAA-compliant systems. It helps teams accelerate development efforts by providing pre-defined components, example applications, and simplified configuration management.

As maritime autonomy continues to evolve, the synergy between UMAA, DDS, and tools such as RTI's starter kit can play a crucial role in helping to shape the future of unmanned maritime operations.

*MOSA is the DoD preferred method for implementation of open systems, and it is required by United States law. Source: www.dsp.dla.mil/Programs/MOSA/

ABOUT RTI

RTI is the real-time data-streaming company for intelligent distributed systems. RTI Connext® software is the critical nervous system for over 2,000 designs across Aerospace and Defense, MedTech, Automotive, and Robotics.

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