DDS Foundation Use Case

DDS-Foundation.org

Smart Manufacturing and Industrial Automation Industries

DDS in Maintenance Sensor Networks

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Executive Summary:

This document provides a basic overview of the predictive and preventative maintenance for smart manufacturing and the solution architecture for the DDS use case in the area of maintenance and sensor networks.

Application (Problem statement):

For **Maintenance (predictive and preventive)** in the areas of Smart Manufacturing, Oil & Gas, Smart Power grids & distribution, healthcare, cold storage, waste management**,** there often is a complex sensor network in the system which requires:

1. Lower granularity of data & Real-time exchange
2. No data loss & duplication
3. High flexibility and scalability of the system
4. Lower cost per sensor node/cluster
5. Easy replacement of a sensor node/cluster

In the case of maintenance, the system constantly collects real-time data from its sensor end points (producer) to a central analytics (consumer) platform which uses standard or custom algorithms to create models for the system or component behavior e.g. robot drives, textile spindles, heat exchangers/compressors, etc and indicate its expected lifetime, point of failure, waste generation in order to optimize the system efficiency and reduce the downtime.

Such data collected, are raw electrical, vibration, acoustic data from sensors at a granularity in sub-milliseconds range. The predictive/preventive model algorithms require a consistent data set in a given period to produce accurate models and thus any loss of data or corruption in the collected data set, can have an impact on the generated end result. This creates a need to collect huge volumes of data in periodic intervals and transfer to the analytics engine.

Usually, to avoid data loss; either the sensor node/clusters have higher on-board memory to store raw data collected for a prolonged time and push data to central analytics as bulk data transfers; or a local edge processing unit collects, pre-processes and compresses the data being pushed to the analytics unit, to the reduce the data being transferred over air; or a combination of both.

At the same time, for a system with higher up-time, the sensor nodes/clusters need to be easily replaceable in case of faults and flexible for it to add more nodes into the network. Any need for complex configuration requirements for adding a node into an existing live network and data collection, makes it difficult to maintain and scale the system and can increase system downtime.

Architecture:

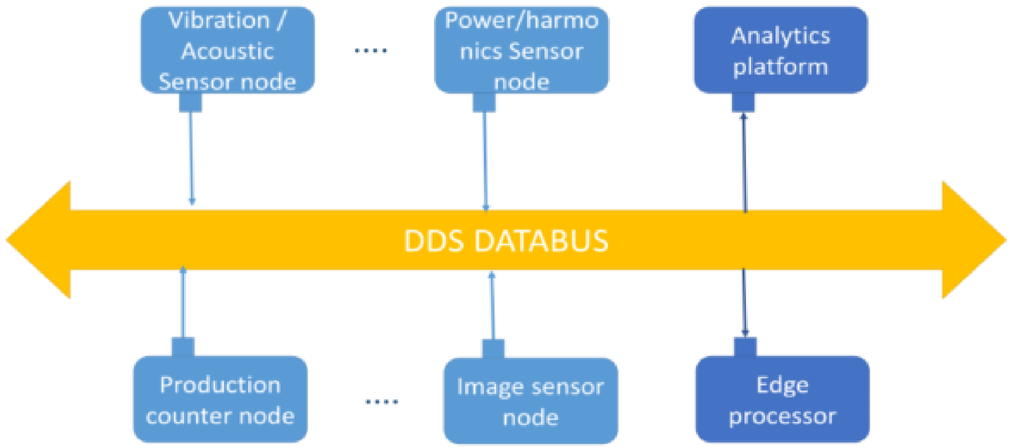

Figure 1: DDS sensor network logical view

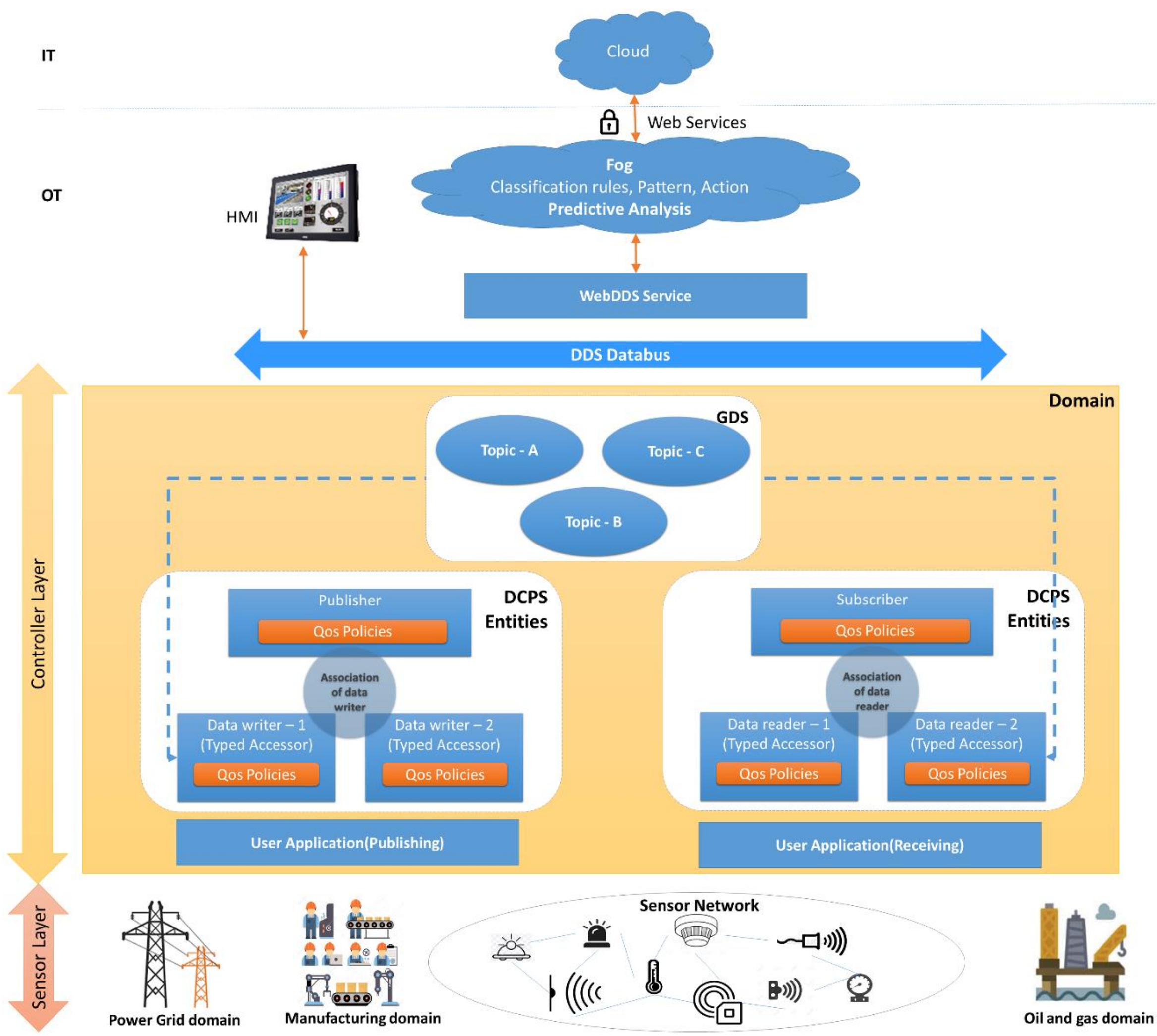

Figure 2: DDS Enterprise Level Architecture

How DDS addresses the need:

1. **RTPS -** DDS provides fast, higher frequency exchange of data in sub-milliseconds. This enables the sensor nodes/clusters to publish and consume raw data as they are produced, in real-time, without the need for much local storage.
2. **Strong QoS policies (deadline, liveliness, data integrity) -** DDS QoS policies ensure that the sensor data is shared on time. It also ensures data freshness and ensures no data corruption in a collected data-set or group which are critical for maintenance data analytics platforms.
3. **Publisher/subscriber -** DDS uses a publisher/subscriber model of communication where each node can publish collected raw data and multiple consumers (edge devices, analytics platforms) can collect it. This reduces the communication overhead of requesting data from individual nodes as in a typical network and avoids data response duplication in case of multiple/redundant consumers of data. This helps in keeping the processing power requirement/cost on the nodes lower, as well as implementing redundancies in the system flexible.
4. **Lower configuration overhead and DCPS -** DDS makes it easier for adding a node and deploying distributed application as the communication stack automatically collects data from all publishing nodes and creates a snapshot database of the latest live data from the network, which can be accessed from user application using standard APIs. In this way, the user application can remain agnostic to any node replacement in the network and scaling a network means updating the user application alone, to process the data from the new nodes, using the APIs. Also, the sensor node can join or leave the network at any time without the need for entire network reconfiguration – i.e. sensors are automatically discovered.
5. **Easy integration and compatibility** – DDS XTypes provides a mechanism to add/remove/modify the data model of the each sensor nodes at run time. This balances the trade-offs such as efficiency, evolvability, compatibility of sensor nodes in brownfield and ease of integration with other technologies (such as Web Services/interfaces – the standard DDS data model is extended it usage to WebDDS object model to monitor and control the sensor nodes from the Live dashboards using REST API)
6. **Secure** – DDS Security allows to define and enforce configurations to handle the sensor data to be encrypted or transmitted confidentially or authenticity for reading the data without any additional overhead. While consuming the sensor data at different layers (within a plant or outside the plant i.e. field to cloud), the use of multicast comes in place for much more efficient data delivery. Unlike transport-level security such as TLS/DTLS which cannot utilize the benefits of multicast, the DDS Security comes with built-in multicast support without compromising performance.

Conclusion:

In summary, DDS is a natural choice as the integration infrastructure for large scale network system. The properties of DDS such as interoperability and portability, loose coupling, extensibility, scalability, efficiency, timeliness and powerful publish/subscribe technology enable ground-breaking growth for IIoT and IoT.

About the Authors:

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Appendix - Resources:

1. **About DDS - https://www.omg.org/spec/DDS/About-DDS/**
2. **DDS security - https://www.omg.org/spec/DDS-SECURITY/About-DDS-SECURITY/**
3. **DDSI-RTPS - https://www.omg.org/spec/DDSI-RTPS/About-DDSI-RTPS/**