Vortex at the Edge Whitepaper

The benefits of ADLINK's Vortex DDS for Industrial IoT Gateway's and Edge Nodes

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2017

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1. Introduction

To support the required data volume, data sharing, data velocity, data security, data dependency and data variety in an Industrial IoT (IIoT) system, a Cloud-centric architecture alone is not sufficient. Just some of the reasons are outlined below:

1. Volume: There will not always be sufficient bandwidth to push all IIoT data to Cloud services (e.g. SaaS applications)
2. Dependency: The data sources (Things – machines/devices) will not always have a Cloud connection
3. Velocity: The latency and jitter between Things and Cloud services will not always be low enough for critical applications (e.g. autonomous decision-making through analytics)
4. Cost: The cost of connectivity to a Cloud service (especially via public Clouds) can be an unacceptable for the data volumes required
5. Security: Some system owners will not be comfortable (because of privacy or security concerns) with pushing operational data to a Cloud service
6. Sharing: Peer-to-peer device (Thing) inter-operability is often preferable or required - as well as device to Cloud inter-operability - for latency, security, risk or distributed computing reasons

To overcome such limitations, the latest generation of IIoT systems is embracing Edge Computing as a complementary technology to Cloud Services. Edge introduces an intermediate processing layer between the devices/machines (the Edge of 'Things') and a Cloud, thus effectively extending and enhancing the capabilities of Cloud computing to local support at the Edge of an IIoT system. Edge Computing thus enables analytics, decision-making and actionable insights to be deployed and generated much closer to the source of the data, namely the Edge machines and devices. The required data processing can also be better distributed and coordinated between devices at the Edge. Edge-based processing also reduces cycle-time latency and efficiently minimizes the use of valuable and expensive network bandwidth, as only selected data (or meta-data) need to be sent to a Cloud for additional processing (e.g. for long-term trend analysis). Edge Computing should not be viewed as a replacement for Cloud Services, as these approaches are complementary and both are necessary in IIoT systems.

A Edge tier consists of one or more network of processing nodes, either dedicated Edge platforms or possibly multi-mode IoT Gateways that provide compute, storage and communication capabilities at the Edge of the system.

To enable these platforms, ADLINK's Vortex DDS can make use of network capabilities, such as UDP multicast, to enable efficient, low-latency and reliable data-sharing between devices/machines and edge nodes. Vortex DDS also adapts to the underlying network capabilities when necessary. For example, to connect to Cloud Services, Vortex DDS will use TCP connections when UDP unicast or multicast is not available. Vortex Link thus enables transparent, secure interest-based routing and UDP multicast to TCP mediation between LAN-based subsystems (e.g. edge networks) and WAN-based endpoints (e.g. Cloud Services, TCP enabled devices and/or remote subsystems).

Vortex Link also enables Boundary Security for LAN-based subsystems. Security is assured by a combination of certificate-based authentication between subsystems and individual devices (e.g. a Mobile phone) connecting into the subsystem, secure encrypted communications and access control rules defining the privileges each subsystem or TCP-enabled device has to read or write data.

2. Connectivity at the Edge

When considering connectivity challenges for Gateways and/or Edge nodes, there are three different aspects to consider in any end-to-end system:

1. Northbound connections, which are the connections between Gateways/Edge nodes and a Cloud service (public or private)
2. Southbound connections, which are the connections between the Gateway/Edge node and the Edge devices/things/sensor networks
3. East/West connections, which are the connections between Gateways/Edge nodes themselves, so that they can share data without requiring, Cloud connectivity

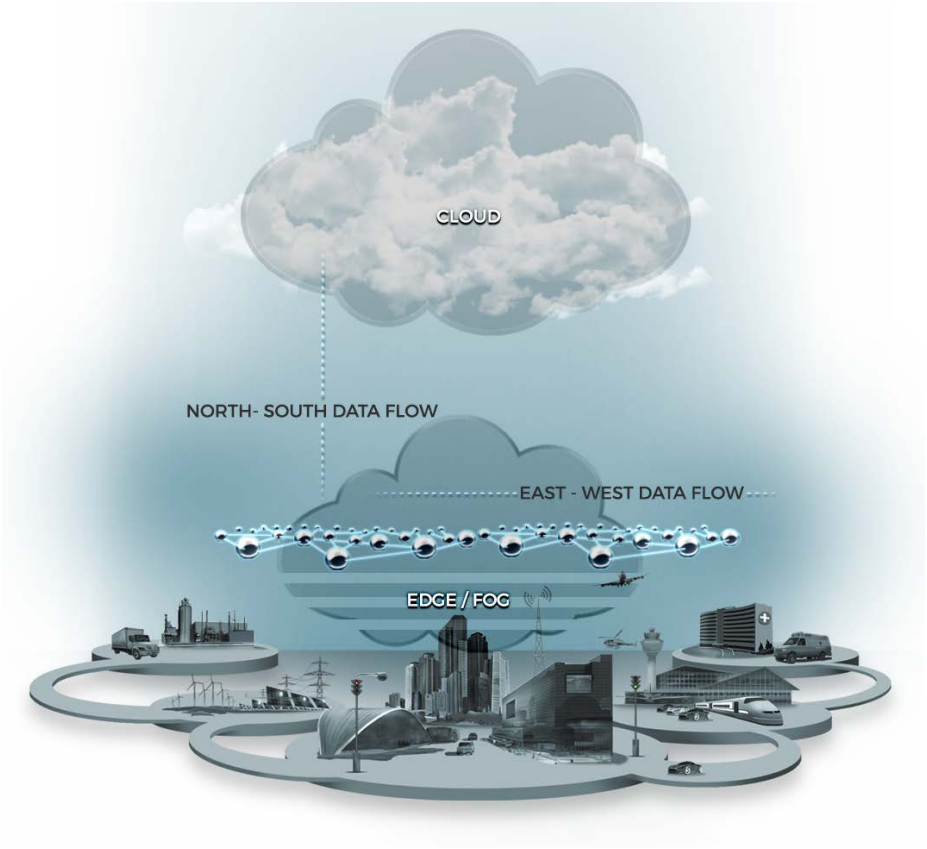

Figure 1 – IIoT Systems Require both North-South and East-West Data

2.1 Northbound Connections

1. Connectivity to a public or private Cloud service
2. Not all data can be transmitted to a Cloud, so interest-based routing is important
3. Not all data should be accessible, so security is important
4. Bandwidth is expensive, so efficient communications are important

2.2 Southbound Connections

1. Connectivity to Edge devices/Things
2. Determinism (latency & Jitter) will probably be important
3. Fault tolerance (fail-over/redundancy/recovery) is important
4. Reliability (discovery and robustness) is important
5. It is important when pushing data from a device/Thing to a Gateway that data can be easily ingested from a variety of sources using different protocols/data formats and then converted into a normalized data format to be shared with other applications within the system. The infrastructure therefore needs to be extensible and pluggable to be able to support data ingestion from different protocols
6. Edge devices/Things that are pushing data directly to a Gateway will typically have resource constraints and small memory footprints

2.3 East/West

1. Connectivity to other Edge tier appliances (e.g. Gateway to Gateway)
2. Latency and throughput

3. Reliability and fault-tolerance
4. Automatic discovery for deployment
5. Take advantage of UDP multicast if supported by the network
6. Not all data should be shared and/or exposed so interest-based routing & security are important

3. Data Management at the Edge

Not only is N/S/E/W connectivity important for Gateways and Edge nodes, but in order to be able to act autonomously, perform analytics and put decisions into action at the Edge, they must also manage data at the Edge. The data management capabilities required include (but are not limited to):

1. Data normalization, which is ingesting, aligning and enriching the data from different sources (Things, devices and sensors) into a common data model with well understood semantics
2. Filtering and querying data, so that applications and analytics can efficiently access and use the data relevant to them
3. Integration with Edge analytics, because the whole reason for capturing these data is to be able to analyze them, create new actionable insights, make decisions and put those decisions into action
4. Transforming data into different representations and formats, for the purposes of integrating with the IIoT ecosystem
5. Aggregating data and/or abstract meta-data, as preparation for local analytics or pushing it to Cloud services, for example

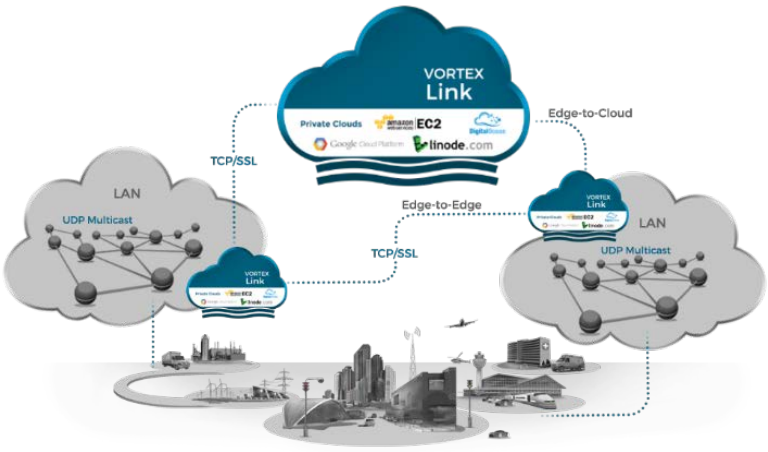

Figure 2 – Vortex DDS Provides Native Support for Both Cloud and Edge

Some the ways in which Vortex DDS supports data management in Edge platforms (e.g. Gateways or Edge nodes) are:

- Vortex DDS is an implementation of the Data Distribution Standard (DDS)
- Vortex DDS supports the definition of strongly-typed, structured, user-defined data models
- These data models allow the natural representation of physical and virtual entities characterizing the application domain
- The unit of exchange is a data value and Vortex DDS understands its context and can ensure interested subscribers have a consistent view of the data
- Data values are uniquely identified by the adoption of the notion of 'keys' in the data-models (like in RDBMS)
- Vortex DDS is data-centric in that it provides lifecycle-awareness (e.g. first/last appearance, liveliness) of instances of modeled things and their related data-flows
- Vortex DDS can access the data and by providing support for "filtering" to ensure applications only ever receive the sub-set of data they interested in
- Data models are extensible, thus allowing incremental updates and upgrades as an IIoT system evolves and grows

- Vortex DDS is a data virtualization platform, meaning it supports data-centricity rather than platform, application or domain-centricity. Data-centricity is thus ideal for the IIoT.
- Built-in support for durable data and integration with ‘data at rest’ technologies
- Open source integrations for aggregation, transformation and screening
- Supports the IIoT deployment of native, mobile and web applications
- Data-centric approach simplifies the development and deployment of Edge analytics
- Supports configurable QoS (as defined by the DDS standard) for the optimal combination of performance, determinism, efficiency, robustness, fault tolerance, recovery, etc.

4. Conclusion

Due to the massive increase in volume, variety and velocity of data that will be generated from thousands and perhaps millions of connected things, the next generation of IIoT systems can no longer rely on exclusively Cloud-centric solutions to address their data sharing requirements.

For bandwidth, cost, security and connectivity reasons shipping all of the data to the Cloud for analysis may not be practical and the time it takes means that any opportunity to act on the insights derived from the data may be lost.

The Vortex DDS Intelligent Data Sharing platform can natively support both Edge and Cloud environments. Where there is a requirement to manage high volume, high velocity data, at the network edge, Vortex DDS can make use of network capabilities such as UDP multicast to enable efficient, low-latency reliable device-to-device data sharing between Edge nodes.

Vortex DDS can be used to rapidly create scalable southbound connections between things/devices and Gateways, or northbound connections between Gateways and the Cloud. Additionally, it is possible to federate Gateways and Edge nodes through east/west connections. The federation makes it possible to leverage the unused resources of the Gateways to analyze and manage data at the Edge in much the same way as in the Cloud.

Connectivity is one aspect of an IoT system but data management is also key requirement. Vortex DDS provides advanced features for data management at the Edge. Fundamental to Vortex DDS is the ability to get the right data to the right place at the right time. Vortex DDS also provides the ability to query, filter and store data which can be made available to “late joining” applications when required.

Vortex Link is a key component of the Vortex DDS Intelligent Data Sharing Platform and when used in conjunction with other Vortex DDS platform technologies can provide ubiquitous end-to-end data sharing for IIoT systems including the first standards based unified Edge-Cloud connectivity solution.

5. References

1. Data Distribution Service for Real-Time Systems Version 1.2, OMG Available specification formal/07-01-01
2. The Real-Time Publish-Subscribe Wire Protocol DDS Interoperability Wire Protocol Specification Version 2.1, OMG Document Number: formal/2009-01-05

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