## DDS Analysis

General Questions

1. Does DDS (or Connext DDS Professional) **contain ACE/TAO** in any form? If yes, why, how and what is the purpose?
   1. RTI DDS does not contain ACE/TAO, though the RTI CORBA compatibility kit does support ACE/TAO, as discussed in https://community.rti.com/static/documentation/connext-dds/5.3.0/doc/manuals/corba/RTI\_CORBA\_Compatibility\_Kit\_ReleaseNotes.pdf.
   2. OpenDDS *does* contain ACE/TAO. Please see <http://opendds.org/about/> for more details. Also, all the source code for OpenDDS is available in open-source format for inspection from <http://opendds.org/downloads.html>.
2. Understanding the **DDS ecosystem**
   1. Who are the key players (persons, DDS providers, DDS users, organizations, consortia, etc.)?
      1. Following <https://de.slideshare.net/PrismTech1/dds-and-opcua-explained> slide 10, there are further organizations world-wide which recommend DDS. Which organizations are these and what is the connection here? Are they part of any DDS driving organization?
         1. The organizations listed on this slide are largely government agencies in the USA and Europe. These organizations influence DDS via the OMG DDS standardization processes.
      2. How does DARPA/DoD influence DDS? How is DDS (and Connext DDS Prof.) geared towards requirements/wishes of the DARPA/DoD?
         1. Many DoD programs use and/or mandate DDS since it is intentionally designed for distributed real-time and distributed systems.
   2. Which roles do the players have?
      1. Please see <http://portals.omg.org/dds/vendors/> for a list of key DDS vendors.
   3. Which significance and influence do the players have?
      1. The two main DDS vendors are RTI and PrismTech. They largely influence the technical specifications in the DDS standard.
   4. How do the mentioned organizations collaborate and/or synchronize with each other and how are things being incorporated into the official DDS standard?
      1. These organizations collaborate through the OMG DDS standardization process to create the open DDS specifications, which are available at <http://portals.omg.org/dds/omg-dds-standard/>.
3. DDS is already **in use** across different **industry sectors**
   1. What is the relevance of the various implementations of DDS mentioned on the OMG website?
      1. As mentioned above, the two main DDS vendors are RTI and PrismTech. Their products are used in the vast majority of DDS deployments around the world.
   2. How many nodes/devices are connected typically (in avg. or max.)?
      1. The answer to this question varies quite a bit based on the specific products by specific vendors, e.g., some products/vendors are optimized for “hard” real-time deployments (which are typically limited to a single backplane and/or /LAN), whereas others are optimized for “soft” real-time deployments (which can run over WANs).
   3. How does the usage of Connext DDS Professional typically look like (e.g., communication patterns, usage of gateways, and usage of real-time scenarios)?
      1. Please see <http://mic.omg.org/news/meetings/workshops/RT-2007/00-T5_Hunt-revised.pdf> for a good overview of the typically communication patterns and real-time scenarios supported by RTI DDS.
4. **SWOT-Analysis** of DDS and Connext DDS Professional (i.e., including limitations / weaknesses with respect to PACELC/CAP theorem).

**Note – We can write a market white paper that answers questions 2, 3, and 4 in more detail.**

1. **Setup and configuration of DDS**
   1. How does DDS (e.g. Connext Prof.) distribute data? What does data-in-motion mean technically? What does optimized pub-sub mean (difference to ordinary pub-sub)?
   2. How does the architecture of a distributed application look like (e.g., UML component/deployment diagram)?
   3. Are there any reports/publications published on challenges with configuring commercial DDS solutions? (need for consultants, …)

**Note** – Yes, there are several reports and tools for this including a number of PhD dissertations from DOC group at Vanderbilt. We can help explain this further. Please also see our relevant publications on DDS at

* <http://www.dre.vanderbilt.edu/~schmidt/PDF/MDASD-DQML.pdf>
* <http://www.dre.vanderbilt.edu/~schmidt/PDF/debs2014_submission_163.pdf>
* <http://www.dre.vanderbilt.edu/~schmidt/PDF/gpce48-otte.pdf>
* <http://www.dre.vanderbilt.edu/~schmidt/PDF/CrossTalk-2008-final.pdf>
* <http://www.dre.vanderbilt.edu/~schmidt/PDF/doa_svi2011_sip.pdf>

1. **Tolerance of DDS in case of node/subnet/system resource limits or hardware defects**
   1. How elastic is the system in such cases, that is, does it automatically choose a different routing or node/subnet? Does the system handle such defects automatically?
   2. How fast (based on real performance numbers) does the system handle such situations?
   3. In case of limits, defects, or if new hardware is being added: is a reconfiguration of the network necessary or does DDS adapt itself in such a way that the whole system/network remains in balance? To which extend do such automatisms work?
   4. What impact do limits, defects, or new hardware have on the redundancy mechanisms and the performance?
   5. For a dedicated node/subnet, is it possible to trace/log the current workload in order to deduce the load and resource state? Are there quality metrics available for such situations?
   6. Is it possible to predict whether a node/subnet will be able to handle the payload based on its bandwidth?

Note – These are good questions and the answers depend on the transport/network layer used. RTPS is resilient and it operates well within a subnet. It can also be used in a WAN, as discussed in some of our publications listed above. We can benchmark the performance and show the overhead of the network (see <http://www.dre.vanderbilt.edu/DDS/> for a DDS benchmarking suite we created in previous projects), which is required to answer question f. Question d – is not clear. Question C- there is limited adaptation. We should discuss this further via a call.

Questions regarding runtime performance and scalability based on measurements

1. **Runtime performance and scalability measurements**: How does DDS (e.g. Connext DDS Professional) behave for different scenarios according to Table 2 (in terms of round-trips, latency, bandwidth, jitter, etc.) when using a measurement baseline according to Table 1?
2. How do the different subscriber notification mechanisms affect the runtime performance across the different scenarios from Table 2??
3. How does the **usage of core gateways** (potentially not in the setup available) affect the performance and scalability?
4. **Real-time**
   1. How real-time is DDS (e.g. Connext DDS Professional) or how real-time can it be?
   2. Which requirements (topology, network, etc.) need to be satisfied in order to achieve specific industry real-time scenarios (e.g., order of microseconds as advertised)?
   3. Are there any (industry related) numbers on real-time scenarios using DDS?
5. How do the performance numbers look like for **domains instead of devices** inTable 2 (e.g., 1D-ND, broadcast from one domain to N domains)? Similar or larger difference?

**Note:** A benchmark application will help test this, e.g., the DDS benchmarking suite described earlier. Please see <http://www.dre.vanderbilt.edu/~schmidt/PDF/SPIE_PAPER.pdf> for a paper describing DDS benchmarking in prior work. An OMG workshop presentation of this paper appears at http://www.omg.org/news/meetings/workshops/RT\_2006\_Workshop\_CD/02-1\_Parsons.pdf.

Table 1: Measurement baseline

|  |  |
| --- | --- |
| Version of DDS | Connext DDS Professional (RTI) |
| Scale of system | > 150 devices, e.g., 256 devices for strong scalability measurements (note Martin: assume we start this year with your existing 64 node cluster) |
| Target device hardware | Beaglebone |
| Network topology | Realistic topology based on existing IIoT systems, e.g., mesh topology |
| Data rate | Varying (increasing in powers) |
| Network bandwidth | > 100Mbps |
| Latency | Publisher clock for round trip timings (see required scenarios below in Table 2) |

Table 2: Measurements using devices in mesh configuration.

|  |  |  |
| --- | --- | --- |
| Device setup | Measurement metric | Form of results |
| * 1. (Single-device) | * Uni-trip/Round-trip * Latency and Jitter * Bandwidth saturation (varying payload size) | * Distribution function plot (and characteristics) * Mean value * Median value * Min value * Max value * Variance value * Strong scaling plots |
| 1-N (Broadcast) | * Round-trip * Latency and Jitter * Bandwidth saturation (varying payload size) * Strong scalability (varying N) |
| N-1 (Reduce) | * Round-trip * Latency and Jitter * Bandwidth saturation (varying payload size) * Strong scalability (varying N) |
| N-M (All-to-All) | * Round-trip * Latency and Jitter * Bandwidth saturation (varying payload size) * Strong scalability (varying N) |

Some of the comments/answers so far (need further clarifications). Maybe something is missing?

1. Which Products to be analyzed ?

Test with OpenDDS and RTIs Connext DDS Professional

1. Which Versions?

Newest Versions

1. Centralized broker approach?

 It has to be a decentralized architecture, such as implemented in RTIs DDS Connext. In one paper the decentralized version of DDS is used.

1. Approximate the interconnect (dds latency low), which network to use?

* PROFINET/PROFIBUS, Industrial Ethernet (ISO or TOP)
* Base load DOF: e.g., 60% over the network and then conduct measurements. Maybe with 0%, 30%, and 60% as load  and then stress test

1. Towards stress test:

* Scaling of load towards stress test (similar to graphs from papers)
* Number of connected devices as large as possible (e.g., >= 256)
* Number of messages: 1….1000 messages/sec
* Message frequency: 1…1000 writes/sec per device
* Volume: Fill 0.1Gbit/s network, 1Gbit/s network, if possible 10Gbit/s network
* Measure latency: should stay below < 1ms

1. Rough context on what we are working (use cases?)

Use cases: We use real-time devices and non-real-time devices combined according to picture below

1. How difficult would it be to have OPC-UA Gateway + also conduct measurements with device connected in OPC-UA domain?

