WHITEPAPER

RTI Connext

Your systems. Working as one.

Abstract

Smart, connected systems are changing many industries. The need for high-performance real-time intelligent systems abounds in defense, industrial automation, medical devices, automotive, and more. The fundamental value driver is easy integration of applications into subsystems, of subsystems into systems, and of systems into larger systems of systems.

Connecting the physical control systems to the enterprise business infrastructure has potential to allow optimization of entire enterprises. This trend is a direct value driver; it saves real costs and enables new business strategy and efficiency.

To deliver this value, however, all of these components must be hooked together, maintained independently, and operated as a single, reliable system. These connected distributed systems need fast, easy, flexible communications.

RTI's Connext product line provides infrastructure to connect all of these systems. It spans the gap between technologies; it can connect the tiniest of devices to mission-critical real-time computers through to enterprise information systems. It makes many different systems work together as one application.

Connext combines extreme real-time technology with flexible integration capability. No other technology can deliver the performance, scalability, and reliability that physical systems need while enabling the interconnection of large systems.

Introduction

Today's fast processors and networks are driving a new generation of smart, connected systems. Those that connect people, social networks, and web integration, are well known. This same base technology is also enabling connections between machines and devices, and between those systems and online business and human networks. This integration improves efficiency and enables new applications.

The most demanding of these are real-time applications that deal with physical equipment. These "operational technology" (OT) systems require very-high-speed connectivity, reliable 24x7 operation, flexible communications, and increasingly large scale. Today, operational systems mostly run purpose-built software. Increasingly, they are adopting more powerful networking middleware technologies.

The M2M Revolution

This revolution in "machine-to-machine" (M2M) technology is both profound and challenging. It is profound because it enables, for the first time, truly intelligent operational systems to communicate with each other and with the business infrastructure. Connecting systems in real-time delivers tangible business value, as information both enables new applications and optimizes existing operations.

It is challenging because this increasing integration drives unprecedented scale and complexity. For instance, no current technology can quickly pick out and deliver a few values from the millions, or soon billions, of data items flowing in a large operational system such as an energy grid. Of course, that is exactly what a human operator or a business optimization algorithm needs to succeed.

These systems require an infrastructure layer capable of handling more complexity exponentially. The infrastructure must collect information from devices large and small, communicate it at extreme speeds, and integrate complex applications. It must deal with the realities of working with legacy systems, adapting as technologies change, and evolving as its components change and evolve.

RTI's Connext product line addresses the challenge of integrating these complex networks of real-time systems. Connext can connect small-embedded devices through high-performance networks all the way to enterprise data centers. Its ability to build systems of systems allows RTI to address enterprise-scale systems in tomorrow's connected industrial and energy systems, across online fleets of vehicles, in the network-centric future of defense, and between medical devices in instruments and integrated care facilities.

IT/OT Integration Trend

While integrating OT systems is important, going forward, connecting them to information technology (IT) systems will be increasingly critical. Traditionally, engineering organizations develop and maintain OT separate from the IT departments. However, management and integration of these disparate systems as a holistic enterprise is becoming increasingly important. With the connection, IT business intelligence, BPM, and resource management promise the ability to optimize the entire connected enterprise.

As an example, Siemens Wind Power is using RTI to build a holistic system by using Connext to not only control turbines and connect large wind farms but also to more efficiently predict the maintenance required and schedule updates accordingly. This requires IT access to operational data in real-time.

According to Gartner (November 2011), ineffective IT / OT management will risk serious failures in over 50 percent of asset-dependent enterprises through 2015. Further, by 2015 more than 50 percent of enterprise asset management (EAM) software solutions are expected to promote integration with OT environments as equally as or more important than enterprise resource planning (ERP) integration. Connext allows customers to capitalize on this trend as the interconnection of operational systems with each other and with the enterprise becomes more mainstream and administrators look for faster and more scalable data distribution infrastructure solutions.

Application Experience

Connext excels in large, high-performance environments requiring high availability and low latency. The technology has evolved from deep experience; there are over 350,000 RTI software licenses running in over 500 unique projects deployed. Applications include:

- **Lockheed** – Uses RTI in dozens of projects, including the core of the Navy's flagship Aegis system
- **Siemens Wind Power** – Develops new control system for wind turbines
- **Volkswagen** – Uses RTI's middleware in its "advanced driver assistance" systems that detect impending accidents and take corrective actions
- **General Atomics** – RTI underlies the Advanced Cockpit Ground Control Station (GCS), responsible for controlling unmanned aircraft systems

More detailed case studies are presented toward the end of this document.

Edge-to-Enterprise Connectivity Overview

The Connext family leverages RTI's distributed networking DataBus™, a data-centric messaging bus. DataBus is a multicast-capable messaging transport. Its unique, direct-peer-to-peer design can deliver messages hundreds or thousands of times faster than "enterprise" messaging platforms. It offers performance, 24x7 reliability, and flexible scalability proven in hundreds of demanding real applications.

The Connext products all build upon RTI's DataBus. Thus, they can interoperate and communicate in the same system. The Connext product line includes:

RTI Connext Micro is a small-footprint messaging middleware for deeply embedded applications. Connext Micro can run in resource-constrained environments with minimal memory, and low-power or slow CPU. It supports many embedded operating systems and network stacks. It can even run without an operating system. Connext Micro is designed to become a certifiable component of flight or medical systems.

RTI Connext DDS is the world's leading data-centric messaging middleware for integrating distributed real-time applications. Connext DDS accelerates development of complex distributed systems and features an application programming interface (API) that is compliant with Object Management Group (OMG) Data Distribution Service (DDS) integration standard.

RTI Connext Messaging expands Connext DDS into a universal messaging platform that delivers powerful tools and an expanded application range. Connext Messaging is compatible with multiple API standards and communication patterns, offering flexibility to reduce development, integration and testing costs, and enable rapid implementation of new system requirements. Connext Messaging includes multiple tools and infrastructure services such as persistence, record and replay, administration, monitoring, and logging.

RTI Connext Integrator is a distributed service bus that implements a real-time SOA to connect highly diverse systems, often with extreme performance requirements. Connext Integrator implements a flexible integration infrastructure that connects disparate OT systems, legacy systems, and bridges to IT applications. Its many communications adapters and flexible configuration connect existing or modified systems with little or no modification.
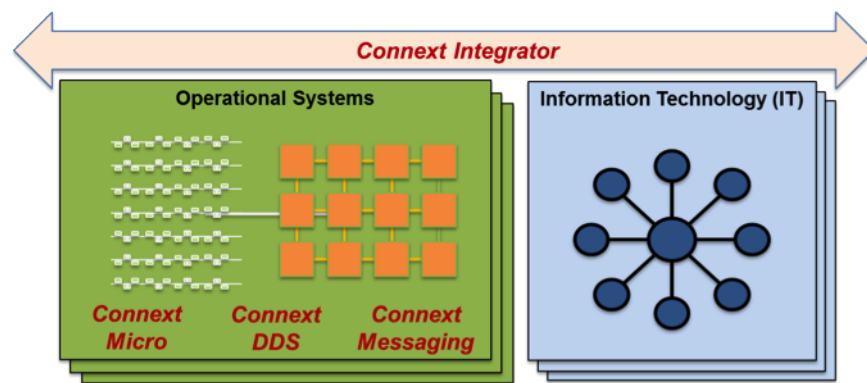
Connext Edge-to-Enterprise

RTI Connext spans the gap from deeply embedded environments, through high-performance real-time networks, all the way to integration with enterprise IT systems. It is the only true embedded-to-enterprise real-time SOA.
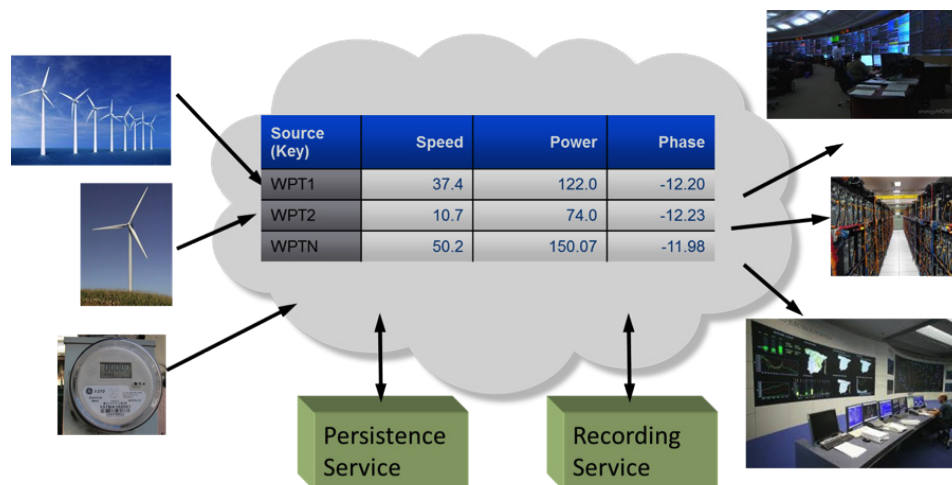
The DataBus Foundation

RTI's DataBus technology delivers extreme performance in demanding systems. Using a peer-to-peer architecture, the DataBus can deliver millions of messages per second with latencies measured in micro-seconds. Current developments are extending the scale to handle hundreds of millions of independently addressable data items. Direct delivery is thousands of times faster and more scalable than alternative IT networking technologies like web services. The RTI DataBus™ offers proven 24x7 reliability, simple administration, and extreme flexibility. It supports several standard APIs and all on-the-wire communications comply with the international DDS-RTPS standard.

Data-Centric Design

Perhaps most importantly, the DataBus is a "data centric" transport. Databases are also data-centric; the DataBus can be thought of as similar to a database, except the information is in motion instead of stored. Just as a database structures stored data by tables and indices, the DataBus structures moving data by topics and instances. Databases revolutionized data storage by providing data structure and fast relational access. Data-centric messaging will similarly accelerate distributed communications by providing data structure and fast relational delivery.

The DataBus implements a virtual "global data space;" programs interact with the global data by simply reading or writing. In actuality, there is no physical global data store; under the hood, the DataBus updates all items as they change across the system. Each node caches the information that it cares about.

Source (Key)	Speed	Power	Phase
WPT1	37.4	122.0	-12.20
WPT2	10.7	74.0	-12.23
WPTN	50.2	150.07	-11.98

Persistence Service

Recording Service

The DataBus Virtual Dataspace Model

The DataBus implements a virtual global data space. Applications communicate with the data space by simply writing or reading structured values. Under the hood, when one application updates a value, the DataBus quickly transmits it to all interested nodes. Because the structure is known, services can also interact with the data space easily. Although there is a notion of central "truth," there is no actual central data store. Each node caches the data of interest.

Data centricity offers a fundamentally different — more powerful — communications model compared to most messaging systems. For instance, the DataBus can track values and types of individual data items. Thus, applications can ask to be updated with the "last value" of a data item (or the last 50 values). Generic tools can connect to the bus and display the contents of flowing information. This is in stark contrast to a message-centric system, which understands only that messages were sent between participants. Data-centric systems ease integration, optimize and filter messages, and simplify system design.

Because all information on the bus is of known structure, tools, services, and applications can interact with that data flow easily. For instance, RTI offers a plugin integration with Microsoft Excel. The Excel plugin can parse the data types on the bus, and automatically populate a spreadsheet with all values. It can also publish results of spreadsheet calculations back on to the bus. Similar integrations support interchange with databases, with debugging and visualization tools, and with protocol connectors such as Integrator.

Peer-to-Peer Architecture

With no intermediate hops, peer-to-peer networking is fundamentally faster than broker or daemon-based designs. Quality of Service (QoS) control allows configurable reliability, from simple "best efforts" to fully reliable, exactly once, guaranteed delivery. Reliable multicast technology avoids most of the overhead that other designs suffer with high reliability to large fanouts.
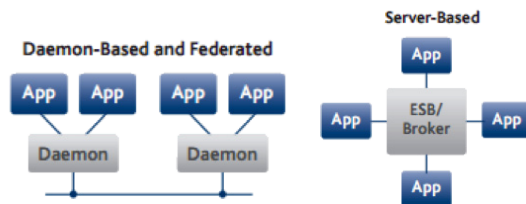
RTI: Peer-to-Peer DataBus   *Non-RTI Architectures*
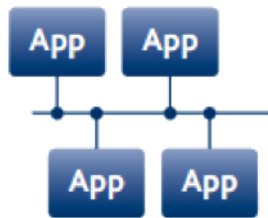
Benefits of RTI's Decentralized Architecture:

- *Ultra low latency and jitter*

- *High throughput and capacity with virtually unlimited scalability*

- *Fault tolerance – no single point of failure*

- *Easily embedded – applications do not depend on any external software*

Disadvantages of Other Architectures:

- *Much higher latency and jitter – with at least one or two intermediate processes and additional message hops*

- *Constrained throughput – limited to the capacity of the server or daemon*

- *Single point of failure – either per-system or per-node*

Features

The DataBus supports very flexible and efficient communications. For instance, all applications can specify required QoS parameters such as reliability, liveliness, resource usage, and more. The DataBus ensures that the QoS between nodes is compatible, and then enforces correct interaction. This func-tionality guarantees that new joining applications will interact correctly, thus enforcing controlled, reliable operation across the entire bus. The fundamental communications paradigm is publish-subscribe. However, it naturally supports many patterns. Powerful writer-side filtering ensures that no extraneous data loads the network.

The DataBus delivers extreme reliability. It supports redundant sources and sinks of data. If an application fails, backups automatically take over. Even the network itself can be redundant; the information will be sent over all configured transports. Duplicate information is resolved before presentation to the receiver.

Also, the DataBus has a unique and powerful discovery mechanism. Rather than the central "name server" design of older technologies, the DataBus automatically sends data requests between nodes as "meta data." This avoids a single-point-of-failure, and supports reliable recovery, even from extreme events like a severed network. Discovery also simplifies administration. New data sources and sinks are automatically connected.

Key DataBus features include:

- Peer-to-peer messaging delivers ultra-low latency, high throughput and non-stop availability – without message brokers, daemon processes or costly servers.
- Data-centric publish/subscribe interfaces provide loose coupling, eliminate complex point-to-point connectivity, and make large-scale systems much more robust.
- Writer-side filtering keeps unneeded data off the network, greatly increasing efficiency.
- Top performance can send millions of messages per second with latency measured in microseconds.
- Advanced discovery, caching, and filtering enable massive scalability.
- DDS wire-spec compliance enables both interoperability and portability, eradicating closed stovepipe systems and vendor lock-in.
- Broad platform, transport and real-time QoS support provide seamless edge-to-enterprise connectivity with a single middleware technology – including mobile and embedded systems.
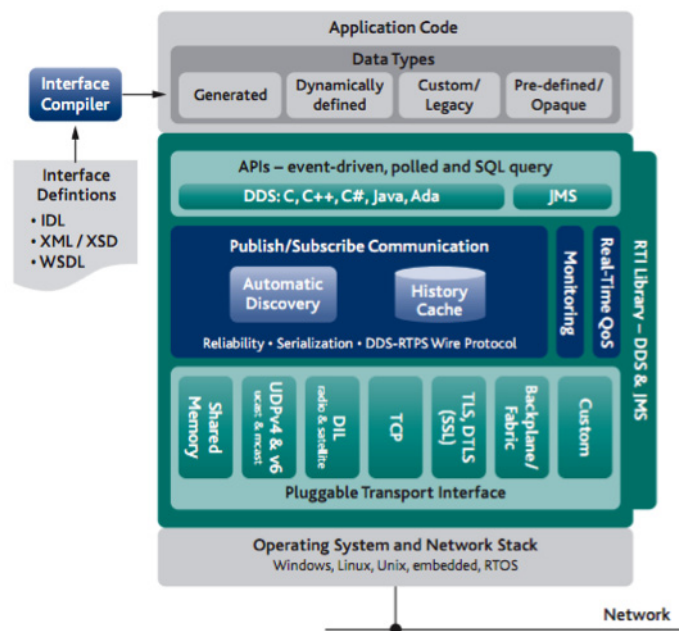

DataBus Architecture

The DataBus is very flexible. Pluggable transport modules support multicast Ethernet, wide-area TCP, wireless "DIL" (disadvantaged, intermittent, lossy) links, shared memory, and more. It translates transparently between languages, operating systems, and processor architectures. Automatic discovery greatly simplifies administration.

The Connext Product Line

RTI Connext

The RTI Connext product line spans the gap from deeply embedded systems through system-of-system integration and IT interface. All products use the common DataBus infrastructure. This design allows all components to work together efficiently and naturally.
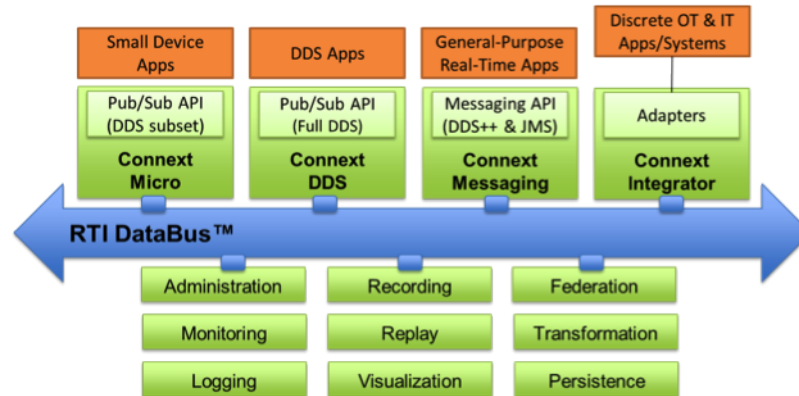
Connext Product line

The Connect product line spans from real-time applications running on tiny devices up to integration with business applications on data center servers. All components communicate over the high-performance DataBus with a common, standard protocol. Key infrastructure services provide a powerful environment.

RTI Connext Micro

Connext Micro provides a high-performance messaging infrastructure for constrained environments such as automotive controllers, industrial equipment, medical devices, and avionics systems. Connext Micro can run in resource-constrained environments with limited memory, CPU power, and embedded operating systems or even without an operating system.

Connext Micro makes it easy to connect sensors, actuators, displays, and logic components. By abstracting out low-level networking details and providing a loosely coupled framework, Connext Micro reduces software complexity. It minimizes the amount of application code that has to be created. This accelerates integration, eases certification, and facilitates long-term maintenance.

Connext Micro integrates seamlessly with the entire Connext product line, thus connecting these constrained environments directly to enterprise IT and business intelligence applications.

Connext Micro Highlights

- Modular and user extensible architecture
- Small footprint; approximately 130 kilobytes & 20,000 lines of code
- Seamless interoperability with Connext DDS and Connext Messaging
- Deterministic memory utilization with no dynamic allocation after startup
- Based on DDS and RTPS standards
- Enables loose coupling and network centricity
- Full source code distribution
- Pluggable transport interface can support many transports
- Supports Linux, Solaris, VxWorks, MicroC/OS, FreeRTOS operating systems; portable to any or no operating system
- Designed to be a certifiable component for flight or medical systems

Interoperability

Because they share standard interfaces, applications written for RTI Connext DDS and Connext Messaging transition to Connext Micro with minimal effort. Additionally, the wire protocol standard provides run-time interoperability between all three products. This allows developers to create distributed applications with a combination of non-embedded, embedded, and high-assurance components.

Certifiability

Connext Micro is designed to be a component of a system undergoing certification. The code and development process guidelines ease certification. For instance, it supports true deterministic behavior; all memory allocation is done at startup and no memory is freed at run-time. Software development, test and verification, configuration management, requirements, design and coding standard artifacts are available. With an overall count of less than 20,000 lines of code Connext Micro provides a cost-effective foundation for safety certification.

The COTS solution

Developers of deeply embedded systems have traditionally had to create, maintain and certify their own inter-application and inter-processor communications. Connext Micro is the first middleware to satisfy demanding real-time performance requirements, and stringent resource limits on specialized operating systems and hardware platforms. By providing a commercial, high level and standards compliant alternative to in-house development, RTI significantly reduces the cost and risk associated with embedded software development, maintenance and certification.

Connext Micro
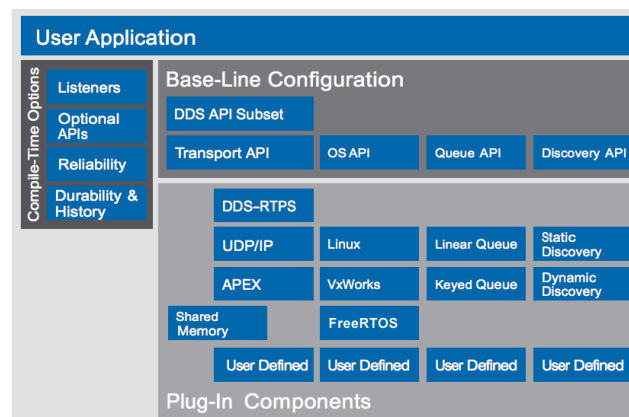
Connext Micro provides standards-compliant messaging for automotive controllers, industrial equipment, medical devices, and avionics systems. It delivers high-performance connectivity between devices, to real-time networks and to the enterprise.

RTI Connext DDS

RTI Connext DDS provides data-centric messaging middleware for advanced distributed systems and applications. Connext DDS addresses the sophisticated data requirements in complex systems including an API that is compliant with the Object Management Group (OMG) DDS specification. Connext DDS is the leading DDS implementation with hundreds of applications.

Connext DDS Highlights

- Proven in over 350,000 deployed CPUs, 500 unique product designs and 350 research and university projects
- Industry-leading performance, scalability and security
- Delivers millions of messages per second with latencies in microseconds
- Scales to handle hundreds of millions of data items
- Fully compliant with DDS API and DDS-RTPS wire interoperability protocol
- Support for C/C++/Java/C#/Ada
- Advanced QoS support
- Comprehensive platform and network transport support
- Seamless interoperability with Connext Micro and Connext Messaging

Optimized for Real-Time and Embedded Systems

Connext DDS leverages the RTI DataBus to deliver a completely decentralized architecture. It leads the industry in performance, with ultra-low latency, high throughput, and virtually unlimited scalability.

Applications directly exchange data in a true peer-to-peer manner. There are no servers, message brokers or daemon processes acting as bottlenecks or single points of failure. Zero-copy interfaces and shared memory communication speed inter-process.

Broad platform support

RTI Connext DDS runs on over 70 platforms as standard product. All leading enterprise, embedded and real-time operating systems are supported. This includes MILS separation kernels and ARINC 653 operating systems.

Applications are independent of the underlying transport and protocol. The pluggable protocol interface supports many options, including UDPv4, UDPv6, TCP, shared memory, wireless, and switched fabrics.

Well-Suited for Mission-Critical Systems

RTI's serverless architecture has no single point of failure. Systems configure and heal automatically when applications disconnect and reconnect. Automatic failover provides continuous availability when an application is no longer accessible.

Secure Architecture

Because applications directly communicate, security policies can be enforced by the operating system (OS) — such as a Mandatory Access Control (MAC) or partitioned OS. Secure TLS and DTLS transports are provided for authentication and encryption.

Connext DDS
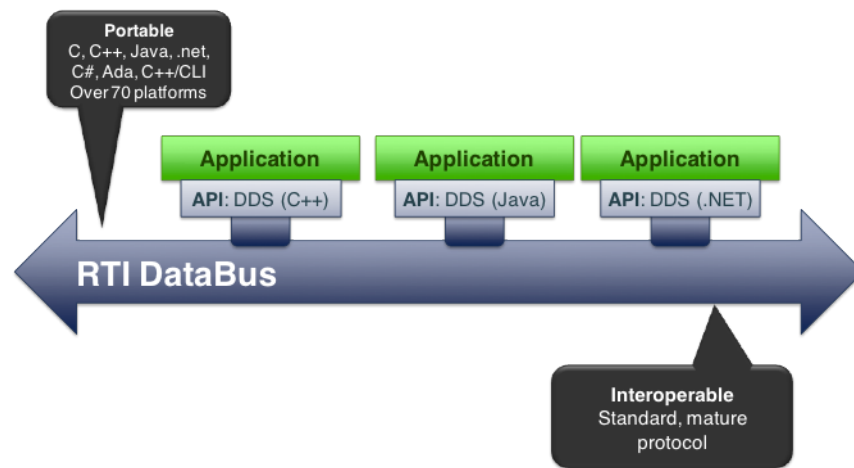
Connext DDS is the world's leading implementation of the OMG DDS standard. It offers unmatched performance, reliability, and maturity.

RTI Connext Messaging

Connext Messaging builds Connext DDS into a versatile and highly scalable messaging middleware. Connext Messaging adds support for many communication patterns, powerful tools, and multiple API standards. Connext Messaging also includes tools and infrastructure services such as persistence, record and replay, administration, monitoring, and logging. Connext Messaging flexibility reduces development, integration and testing costs, and enables rapid implementation of new system requirements.

Connext Messaging Highlights

- Communication patterns for publish/subscribe, request-reply, command/response, point-to-point with queues, or a hybrid of patterns for unique customization
- Persistence Service supports late joiners and guaranteed delivery
- Recording Service captures real-time data for deep analysis, archiving, and stimulating test networks.
- API's for JMS and DDS standards
- Tools to remotely configure, monitor, analyze and debug complete systems
- Adapters for integration with existing applications and IT systems
- Seamless interoperability with Connext Micro and Connext DDS

Complete Development Environment

Connext Messaging completes the development environment for maximum productivity. The Eclipse-based development console provides a central launching point for all RTI products. It can connect to all services on the network, configure them, and show live operating status. Powerful tools include remote monitoring, connection analysis, record/replay, and connection analysis.

Tools

- RTI Monitor provides extensive visibility into a running system, including health, performance and topology. Designed for developers, integrators and operators, it eases application integration and testing, aids in diagnosing unusual behavior, reduces risk associated with connection problems and network usage, and provides ongoing insight into your system and components.
- RTI Distributed Logger provides a graphical analysis of log information from distributed applications. It allows you to receive error and warning notifications in real-time, and store messages to disk for later analysis and troubleshooting.

- RTI Recording Service non-intrusively records published data for future analysis, debugging and archival purposes. Recorded data can be converted into a variety of formats including XML, HTML and CSV. It can also be replayed for simulation and back-testing.

- RTI Analyzer provides non-intrusive visibility into a system's topology. It provides visual views of nodes and Connext DDS entities including participants, publishers, subscribers, topics, data types and QoS properties. It allows you to detect QoS incompatibilities and to compare snapshots of system state to identify changes and problems.

- Wireshark network protocol analyzer integration allows you to capture and view network-level traffic. It displays DDS discovery metadata and user data. This aids in the diagnosis of network-level connection and timing issues.

- RTI Connext products are integrated with leading design and modeling tools, including those that support the Unified Modeling Language (UML):
  - Atego Artisan Studio
  - IBM Rational Rhapsody
 - Sparx Systems Enterprise Architect (EA)
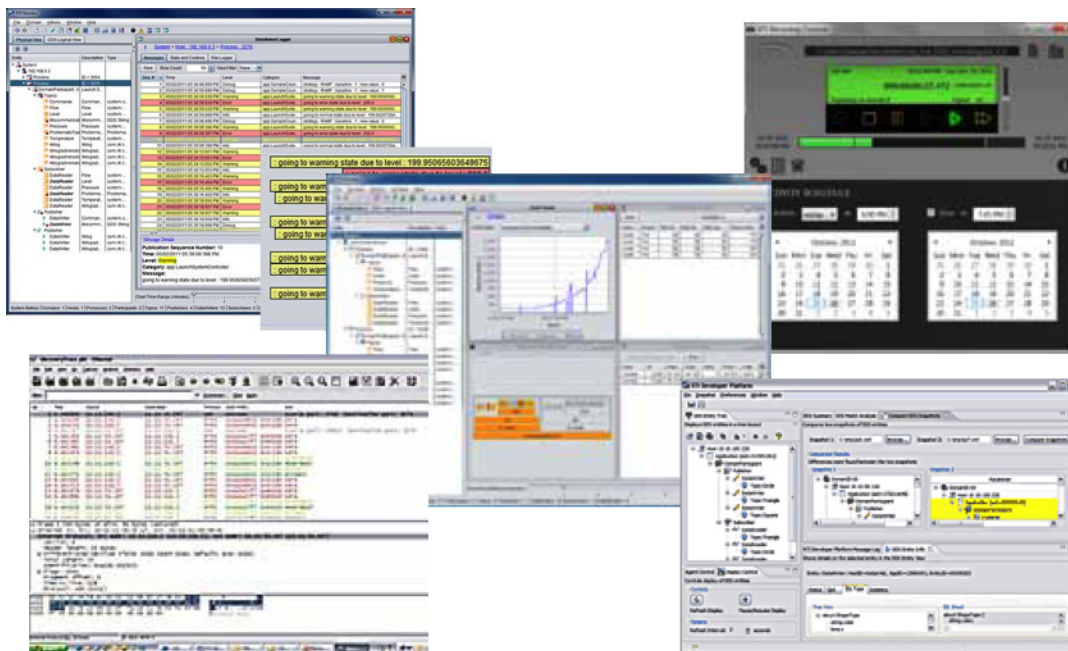
Connext Messaging Tools

Connext Messaging adds extensive development tools. The tools help debug, monitor, analyze, and record network activity.

Services

Connext Messaging also includes several runtime services. These services connect to the DataBus and provide functionality to all connected applications.

- Persistence Service provides an optional broker for Connext Messaging. By default, with RTI's peer-to-peer architecture, late joining and durable consumers receive historic data and messages directly from the original producer's cache. However, in some cases, it is desirable to persist data independently:
  - When producers are transient or connected via intermittent or low-bandwidth networks
  - To offload producers when they are CPU constrained or there are many consumers
  - For fault tolerance in the event a producer becomes inaccessible and there is no backup

- RTI Spreadsheet Add-in for Microsoft Excel™ provides bidirectional integration between Connext DDS and Microsoft Excel. It allows cells, formulas and charts to include subscriptions to real-time data streams, such as market data and sensor data. Values update automatically and in real-time. Formula results can also be published in real-time to other applications and spreadsheets.

- The Federation Service included with Connext Messaging connects applications and systems across both local and wide-area networks (WANs).

Connext Messaging
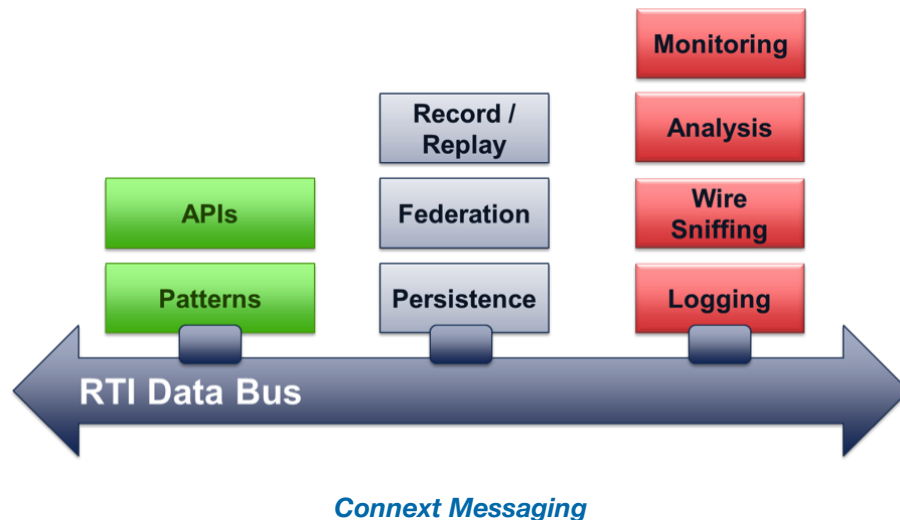
Connext Messaging combines a powerful, general messaging system with extensive tools. Bundled services add common functionality to the DataBus.

RTI Connext Integrator

Connext Integrator is a distributed service bus that implements a real-time Service Oriented Architecture (SOA). A SOA design separates a large distributed system into independently-executing applications called services. That structure isolates changes in applications from the total system. However, connecting highly diverse systems with different data models and communications patterns is difficult. Worse, since the various applications change over time, those connections must adapt. Some services, such as legacy applications or previously-tested components, cannot be modified at all.

In the enterprise, an Enterprise Service Bus (ESB) solves these problems. The ESB has many adapters for various protocols, including customizable adapters for unique applications. The ESB routes messages through the adapters to the different services, thus creating a connected whole. ESBs don't require much programming beyond the adapters; system integrators configure the system with scripts or tools.

Unfortunately, enterprise ESBs are not appropriate for real-time systems for several reasons. First, they typically run on a very powerful central server. They translate the incoming connections into a common data structure before sending to the appropriate destination. This centralized design makes them very configurable, but also very slow.

The Connext Integrator works like an ESB, except it translates incoming connections into a data model that can flow on the DataBus. This has two advantages: it's very fast, and it's fundamentally distributed. For a highly-reliable distributed real-time system, those are critical advantages.

With this design, Connext Integrator can flexibly connect and bridge disparate OT systems to IT applications. Its many communications adapters and flexible configuration connect existing or modified systems with little or no modification. The redundant, fast, timing-aware DataBus makes it both reliable and capable of extreme real-time performance.

Connext Integrator Highlights

- Matches connection patterns, allowing systems to combine many types of protocols
- Matches data models, translating between mixed formats from different applications
- Converts protocols – with support for DDS, JMS, files and custom sockets protocols; an adapter software development kit (SDK) eases support of other technologies
- Integrates standards including JMS, SQL databases, file, socket, Excel™, OPC, STANAG, LabView and Web Services
- Eases database integration for Oracle, MySQL and other relational databases
- Bridges between networks and security domains – including between local and wide area networks, unsecured and secured networks, and IPv4 and IPv6
- Optimizes connection configuration with content-based routing
- Leverages tools for visualizing, debugging and managing systems in real-time
- Replaces custom bridges with easily maintained XML configuration
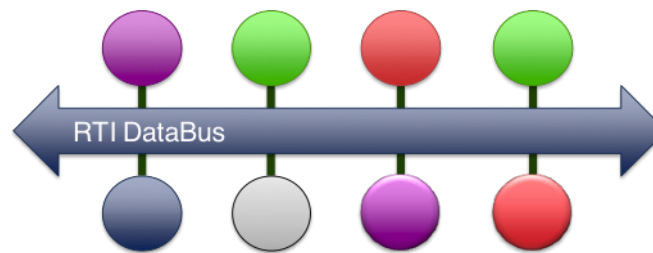
Connext Integrator

Connext Integrator is a real-time service bus. It creates a flexible, high-performance, real-time SOA. The SOA can combine and integrate different applications and technologies without requiring custom software bridges.

Case Studies

Case Study: Siemens Wind Power

Siemens Energy is a provider of comprehensive solutions for the generation, transmission, and distribution of power. Siemens Wind Power, the world's #1 manufacturer of wind turbines, standardized on RTI. Siemens' next-generation turbines uses RTI's messaging software to deliver resilient, high-performance and scalable data distribution. Siemens produces turbines standing 17 stories high with 100m blades and generating more than two megawatts each. Farms of up to 500 turbines can be deployed on land or at sea.

Siemens faced several challenges that led them to RTI. First, the control systems within the giant turbine, itself a complex machine, required high-performance real-time networking. Second, the farms produce copious amounts of data — a farm of 500 turbines may have close to one million data points. Third, Siemens deploys wind power solutions in a wide range of environments where network services vary, from fast LAN (local area network) to mid-range broadband to slow wireless or satellite communications. Fourth, the entire farm must be controlled, managed, and maintained from remote monitoring stations.

RTI's real-time messaging and QoS control enable Siemens to control the high-speed turbines and manage dynamic effects like turbulence to optimize performance and wear. RTI's multiple network transports allow Siemens to build large farms and intelligently integrate them over the various networks. Smooth IT integration allows Siemens to remotely monitor and troubleshoot the wind farm's operations, thereby assisting with business imperatives such as predictive maintenance. In the future, RTI's system-of-systems scalability will allow Siemens to network multiple farms and business systems. In sum, edge-to-enterprise connectivity achieves the highest possible performance, control and business systems integration, giving Siemens a competitive edge.

Siemens Wind Power

Siemens Wind Power uses RTI to build a scalable, high-performance operational network and integrate it with business intelligence software. A wind farm can comprise 500 turbines and millions of data points. Integrating with on-shore business infrastructure allows key efficiency benefits such as predictive maintenance.
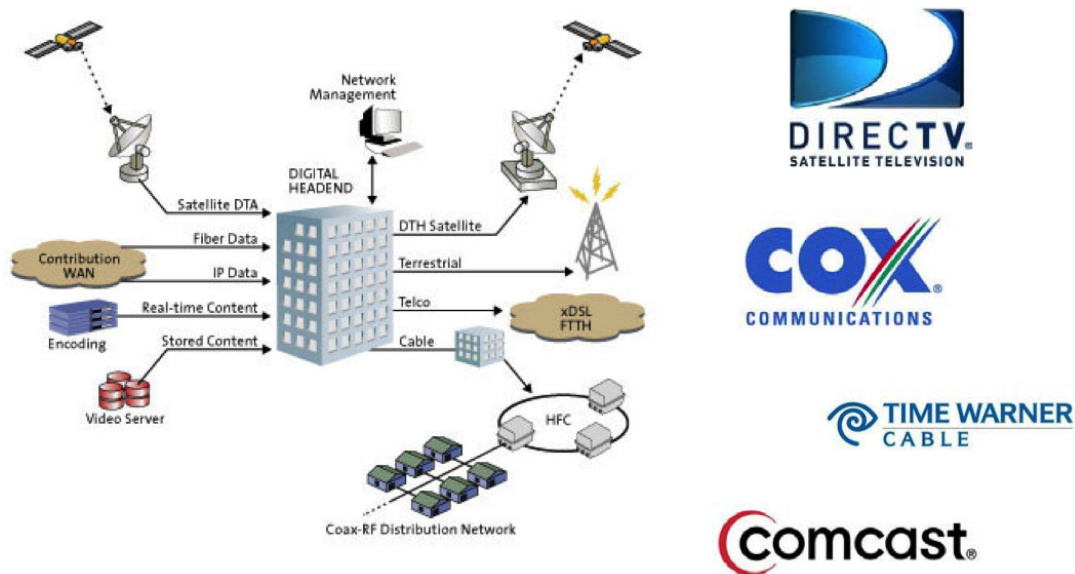
Case Study: Harmonic

Harmonic, Inc. offers a market-leading portfolio of video infrastructure solutions, spanning content production to multi-screen video delivery. Harmonic customers efficiently create, prepare, and deliver video services over broadcast, cable, Internet, mobile, satellite, and telecom networks. Harmonics equipment manages, monitors, and distributes video content. Harmonic customers include the most prominent providers of media transmission, including DIRECTV, Cox, Time-Warner, and Comcast.

Harmonic uses RTI middleware to control its distributed video equipment. Data comes from many disparate sources and then the Harmonic equipment assembles it in real time to provide a smooth video output. For example, consider an unmanned "head-end" in a remote location. If a local car dealership purchases a 30-second commercial during the game, it will be stored locally on disk. During a live football game, the broadcast stream indicates a 28-second gap. Harmonic's equipment will compress the commercial slightly and feed it seamlessly into the outgoing video stream. RTI's middleware coordinates all these sources and switches. It also enables remote management and monitoring. Harmonic is one of RTI's highest-volume runtime customers.

Using standard off-the-shelf middleware helps Harmonic meet tight schedules at low cost. It also ensures that Harmonic can scale and extend their solution in the future.

Harmonic Video Processing

Harmonic builds high-performance, connected video systems with RTI middleware. Harmonic successfully ships thousands of systems with RTI middleware every year.

Case Study: Blue Force Tracker

The US Army Software Engineering Directorate (SED) chose RTI middleware for the communications backbone of its Network Operation Center (NOC) because it provides a true broker-less solution with no single point of failure. RTI provides:

- Auto-Discovery of publishers and subscribers – No need to statically set IP addresses of nodes within the NOC for the purpose of message routing and functional applications can be placed where compute resources are under utilized
- A data-centric design allows "filtering" data on sending and receiving, optimizing network use
- Intra-node communications through shared memory – Very fast and efficient use of memory resources
- Inter-node communication through multicast and unicast
- 25 times faster performance
- Reduced development time

"This would not have been possible with any other known technology."
— Harold D. Pirtle, NOC, Technical Lead US Army SED/BTI

US Army Blue Force Tracker
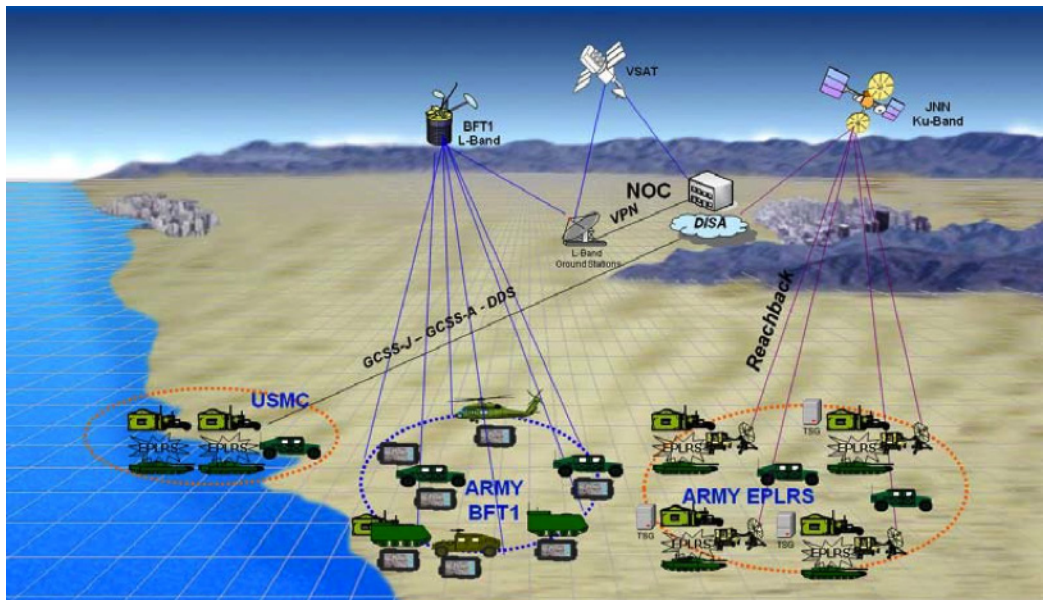
The JBC-P system illustrates the dramatic cost savings and efficiency provided by RTI's technology. Compared to the legacy middleware used in each NOC, RTI reduced development time from eight years to one year, provides at least 25x higher performance, and requires less than one-fifth the hardware. Leveraging the advanced functionality will reduce the lines of application source code in the new design to one-tenth that of the legacy system.

Case Study: Aegis

The Aegis Weapon System, developed by Lockheed Martin, is the world's premier naval surface defense system and is the foundation for Aegis Ballistic Missile Defense, the primary component of the sea-based element of the U.S. Ballistic Missile Defense System. The core of the Aegis Weapon System is the SPY-1 radar, the U.S. Navy's most advanced computer controlled radar system. When used in conjunction with Lockheed Martin's MK-41 Vertical Launching System, it is capable of delivering missiles for every mission and threat environment in naval warfare. The Aegis Weapon System is currently deployed on 78 ships around the globe, with more than 25 additional ships planned. In addition to the U.S. Navy, Aegis is the maritime weapon system of choice for Australia, Japan, South Korea, Norway, and Spain.

Lockheed Martin needed a solution that incorporated standards in a comprehensive data distribution framework. Real-time performance with a guaranteed response time was required. The Navy needed to replace decades of old proprietary combat-system software and replace it with modern open architecture solutions. This transition could be costly, but in the long run could save billions of dollars.

Lockheed Martin originally chose RTI as the foundation of the SPY-1 radar. RTI now provides the communication infrastructure to coordinate all Aegis subsystems, including radar, weapons, displays, and command and control. Lockheed is now expanding RTI usage into many of the almost 500 programs in Lockheed's Mission Systems and Sensors (MS2) division. RTI provides standards-based messaging middleware with the ability to insulate each subsystem from changes in adjacent subsystems. RTI's solution optimizes development time and provides a better lifecycle alternative than the only alternative with sufficient capability: a custom solution.

Aegis Combat System

RTI middleware forms the core nervous system of the Aegis system. It Aegis coordinates radar, weapons, displays, and command and control.

Case Study: Volkswagen

Volkswagen's Electronics and Vehicle Research department is using RTI's real-time messaging middleware across different projects to integrate advanced driver assistance systems into the car. These control systems need very high bandwidth to handle fast streaming data, coupled with low-latency command throughput for driver assistance. RTI DDS will be used by Volkswagen to investigate a new network topology, which facilitates integration of the high-speed network requirements of this innovative driver assistance system with existing low-bandwidth in-car networks.

Volkswagen's advanced driver assistance systems must integrate, in real-time, complex environment perception algorithms that require the use of a high-bandwidth network. By contrast, existing in-car CAN bus networks are focused on low-bandwidth, low-latency command oriented sub-systems, for example for communication between braking systems and the powertrain.

RTI Data Distribution Service provides a high-performance messaging infrastructure that allows Volkswagen to ensure real-time prioritization of critical operations and data across its new driver assistance network and the existing in-car control network, in spite of the very different characteristics of the two networks. RTI's middleware was designed specifically to meet a wide range of real-time, inter-system communication demands; implementation in Volkswagen's driver assistance design illustrates how RTI's technology can be applied to the challenges of next-generation automotive systems designs.

Volkswagen AG Advanced Driver Assistance Systems

RTI's middleware integrates complex environment perception algorithms in real-time to ensure prioritization of critical operations and data across Volkswagen's driver assistance network and the existing in-car control network.

Unique Technology Summary

RTI Connext has many unique and powerful features and benefits, including:

- **True Edge-to-Enterprise** – Connext spans deeply embedded systems to high-performance networks and enterprise IT. It is the first infrastructure to enable system-wide connectivity.

- **Plug-and-Play Integration** – Applications are automatically discovered and connected at run-time. No system administration or directory service is required, allowing use in autonomous, dynamic and ad hoc systems.

- **Proven Technology** – More than 350,000 copies are in use in over 500 unique designs. Proven in successful U.S. Department of Defense missions, it qualifies for the highest Technology Readiness Level, TRL 9.

- **Peer-to-Peer Communication** – An innovative, completely decentralized architecture delivers ultra low latency, high throughput and virtually unlimited scalability. Applications directly exchange data in a true peer-to-peer manner. There are no servers, message brokers or daemon processes acting as bottlenecks or single points of failure.

- **High-Performance Architecture** – Peer-to-peer design, zero-copy interfaces and efficient communication combine to deliver millions of messages with tens of microseconds latencies.

- **Extreme Scalability** – Connext uses reliable multicast, advanced filtering, and flexible discovery to deliver exactly the right data to the right destination…even in systems with 100s of millions of data items.

- **Transport Flexibility** – Applications are independent of the underlying transport and protocol. From TCP/IP to wireless to direct shared memory, RTI's protocol supports facile connection.

- **Optimized Publish / Subscribe** – Data can be reliably multicast to multiple subscribers for extremely efficient streaming data distribution. Messages are routed and filtered by the switch, not by software.

- **Real-time Quality of Service (QoS)** – Applications have comprehensive control over and visibility into real-time behavior, including timing, deadlines, resource utilization and system state. QoS can be specified per-topic and per-subscriber.

- **Wire Efficiency** – The DDS-RTPS wire protocol is extremely wire efficient. Data is sent in a compact binary representation. Most metadata is only exchanged once, at discovery time. Writer-side filtering puts only the needed data on the network.

- **Flexible Interface Specification** — Integration interfaces can be specified programmatically, using a variety of standard description languages, or generated by all leading UML tools.

- **High Availability** – RTI's serverless architecture has no single point of failure. Systems are self-healing when applications disconnect and reconnect. Automatic failover provides continuous availability when an application is no longer accessible.

- **Security** – Security policies can be enforced by the operating system (OS). Secure transports are also supported for authentication and encryption.

About RTI

RTI is the world leader in delivering fast, scalable, communications software that address the challenges of building and integrating real-time operational systems. RTI Connext solutions meet the needs of enterprise-wide integration — from the operational edge to the enterprise data center. The RTI standards-based software infrastructure improves the efficiency of operational systems while facilitating better decisions, actions and outcomes for the business enterprise.

For over ten years, RTI has delivered industry-leading products and solutions for customers in markets ranging from Aerospace & Defense, Process Automation, Financial Services, Energy, Automotive, Health Sciences and Transportation Management.

Founded in 1991, RTI is privately held and headquartered in Sunnyvale, California.

rti

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