

Reducing Product Development Effort for OPC Unified Architecture

Case Study

OPC* Unified Architecture (UA)

Unified Automation* SDK

Intel® Atom and Core™2 Duo Processors

Standards-based Industrial Communication



OPC specification enhancements, pre-tested platforms and SDKs shorten time to market

Developers of industrial systems are turning to the industry standard OPC* (open connectivity) Unified Architecture (UA) for data exchange between the plant floor and enterprise devices. The new OPC Foundation UA specification - enabling more platform and operating system independence - provides a service-oriented architecture that facilitates secure, reliable interoperability across corporate firewalls and platforms. Now, developers have a wider choice of platforms, an easier path to legacy system integration and higher communications performance, all at the same time.

With more CPUs and operating systems options for deploying OPC UA, system designers may wonder which platform delivers the right balance of communications performance and cost. This question is answered by independent laboratories that test platforms and publish conformance and performance results. For example, Ascolab* GmbH has tested two Intel® processor-based platforms on a variety of operating systems, to confirm compliance with OPC UA profiles and measure performance.

Using the results from pre-tested platforms, system designers can quickly gauge the level of hardware performance they require and possibly eliminate the need to test systems themselves. OEM production devices based on pre-tested platforms can be certified more quickly because testing laboratories already have applicable platform experience and test infrastructure. Further reducing development time and increasing product quality, software development kits (SDKs), from vendors like Unified Automation, contain proven, production-ready OPC UA software stacks. This case study discusses how the combination of the OPC UA specification, pre-tested platforms and SDKs can reduce development effort, thereby shortening time to market for industrial OEMs.

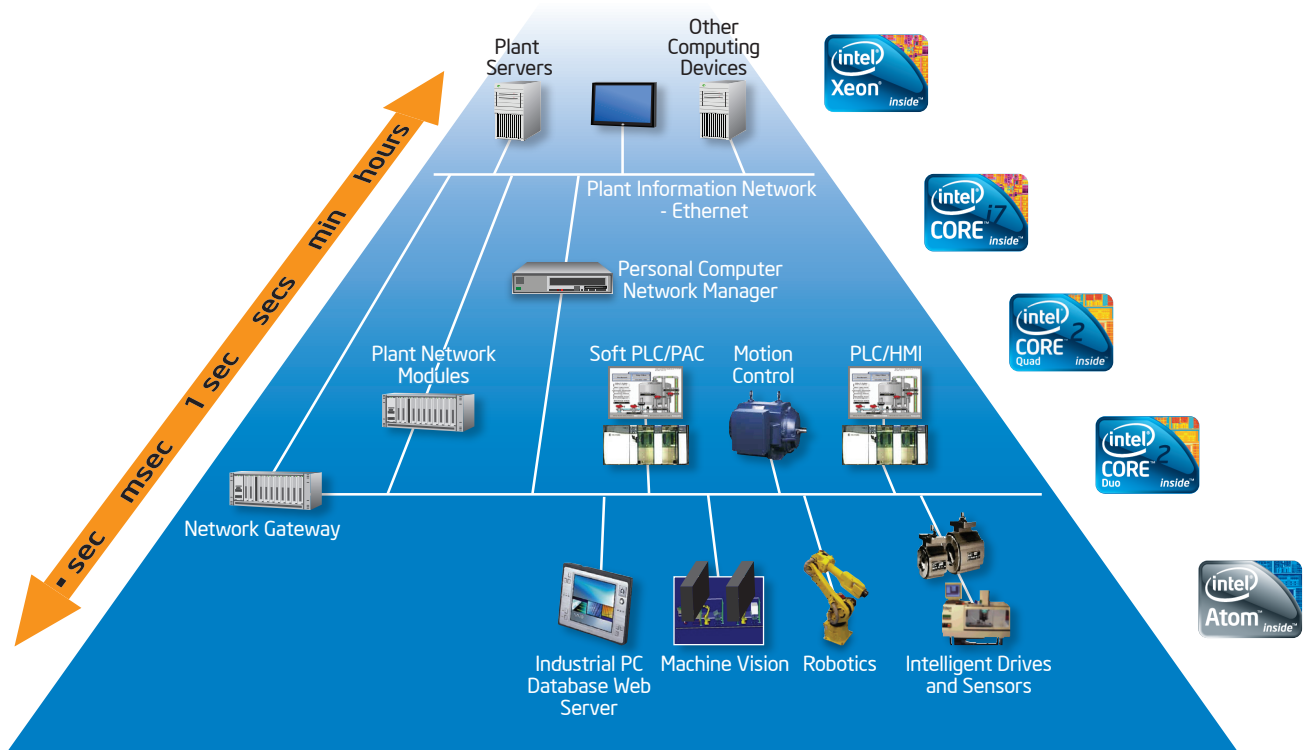


Figure 1. Interoperability Opportunities in an Industrial Plant

Standards-based Industrial Communication

Automation system developers are tasked with eliminating islands of equipment and improving data sharing between top-floor and shop-floor systems. This becomes more challenging when communication networks must support diverse, multi-vendor devices, like sensors, PLCs, HMIs, and manufacturing execution systems (MES), as seen in manufacturing, oil, gas and mineral industries. Offering a unifying solution, the OPC Foundation creates and maintains the OPC specification for standardizing the communication between plant floor devices and enterprise systems based on general computing technology, as shown in Figure 1.

OPC has been successfully applied to enable greater interoperability between industrial automation and enterprise systems. The scope of OPC includes accessing current data, alarms, events and historical data. Since OPC is an open standard maintained by the OPC Foundation, it remains a scalable technology evolving along with industry demands. For more information, visit www.opcfoundation.org.

Examples of OPC Capabilities

The OPC specification addresses many platform capabilities intended to improve the interoperability between devices on different industrial networks from different vendors. Some of these capabilities include:

- Real-time plant access – Industrial solution vendors are providing products coupling OPC data services and real-time control applications, such as HMIs or equipment condition monitoring software.

- Electronic Data Interchange (EDI) – OPC enables data sharing between different factory devices and corporate systems using EDI systems, such as XML.
- ERP connectivity – Solution vendors seamlessly integrate data between the enterprise resource planning (ERP) applications and the industrial automation environment.
- Service-Oriented Architecture (SOA) – This design framework loosely couples services with operating systems, programming languages and other technologies, which eases the effort to exchange data between applications.

OPC Creates New Unified Architecture

With recent architecture changes, the OPC foundation broadened OPC interface options beyond Microsoft COM/DCOM, which couldn't be integrated into automation devices running other operating systems. This meant the main OPC use case, communication of HMI (Human Machine Interface) applications with automation devices, required a proprietary communication link from the device to the OPC interface running on a PC.

The new OPC Unified Architecture (UA) not only runs on Windows-based PC systems, it can directly integrate into embedded systems as well as into Linux* / UNIX* based enterprise systems. OPC UA runs on many operating systems (OSs), such as Microsoft Windows and Windows CE, Linux, Wind River VxWorks and TenAsys INtime, and provides a higher level of abstraction, hence simpler portability

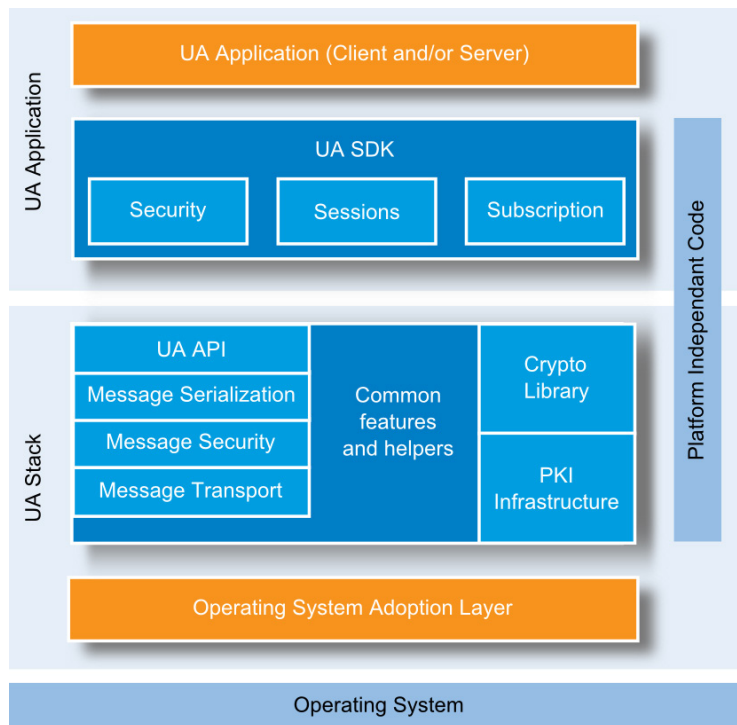


Figure 2. OPC UA Software Components

among OS's. This abstraction is provided by the Operating System Adoption Layer, shown in orange in Figure 2. When porting the software stack to another operating system, only the Operating System Adoption Layer needs to be modified.

The majority of the OPC software stack is platform independent and can be obtained with an SDK. Some SDKs support multiple programming languages and higher level toolkits. Even developers on Windows-based platforms will have great advantages using the highly optimized communication stack and firewall-friendly communication, which can be scaled and tailored to the particular needs of the application.

“The OPC Foundation’s Unified Architecture is technology for linking plant floor and enterprise systems, including legacy automation products, enabling greater interoperability and decentralization. Intel is poised with new technologies, products and a vision to meet today’s needs and tomorrow’s challenges.”

– Tom Burke, OPC Foundation president and executive director

Features	Benefits
Platform independent architecture	<ul style="list-style-type: none"> ▪ Supports devices ranging from plant floor to enterprise ▪ Adapts to legacy devices ▪ Gives developers more choice
Standards-based	<ul style="list-style-type: none"> ▪ Assures higher quality connectivity ▪ Eliminates costs associated with maintaining a custom solution ▪ Reduces development cost because software is easily reused
Service-Oriented Architecture (SOA)	<ul style="list-style-type: none"> ▪ Provides a single set of services to expose the OPC data models (e.g., Data Access, Alarms and Events and Historical Access)
Backward compatibility	<ul style="list-style-type: none"> ▪ Preserves prior development investments

Table 1. OPC UA Features and Benefits

Now OEMs can choose software suppliers based on application features and not on whether vendors have a software driver for a unique device. OEMs no longer need to create a custom interface, which saves development and upgrade costs incurred when operating systems or device vendors change. OPC UA is platform independent, standards-based, SOA-compliant and backwards-compatible, which provide the benefits listed in Table 1.

SOA enables a higher level of interoperability and code reuse. It provides a single set of services to expose the OPC data models (DA, A&E, HDA). Web services software is available in highly optimized binary formats, ensuring high performance and minimal resource consumption on embedded systems.

OPC UA Software Layers

OPC UA uses a client-server concept; however, it's quite possible for an application to be both a UA server and client at different times:

- Information providers, like complex sensors or controllers, are called UA servers
- Information consumers, like asset management systems, are called UA clients

A typical OPC UA application is composed of three software layers – client or server application, UA SDK and UA stack – as shown in Figure 2. Today, complete software stacks are implemented with C/C++, .NET, or JAVA, but OPC UA is not limited to these programming languages and development platforms.

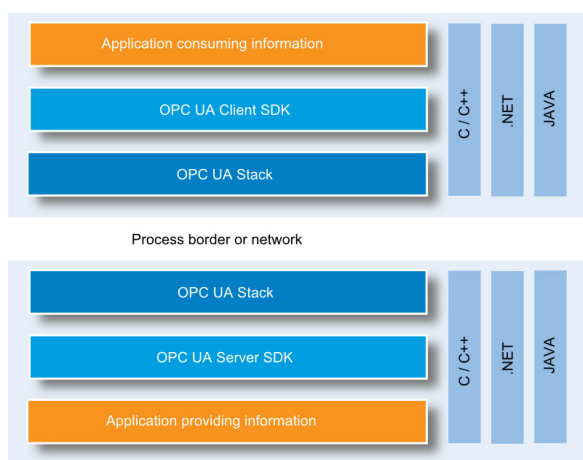


Figure 3. Software Layer of a Typical OPC Application

OPC UA Testing

The purpose of OPC UA testing is to 1) ensure the device under test (DUT) properly performs OPC UA functions, as defined by the Address UA profile, and 2) measure the communications latency (round trip) and jitter and data throughput for data change notification, as described in the following:

Tests	Measurements
Service Roundtrip	Measurement of roundtrip time (client to server) for Read and Write Services
Jitter Data Change	Jitter and data throughput measurement for Data Change notifications (e.g., publish service)

Table 2. OPC UA Test Methodology

The OPC UA specification defines profiles for subsets of functionality, such as opening a secure connection and reading/writing data, which clients and servers use to govern their interactions. Profiles related to hardware platforms define the minimum number of client connections and subscriptions, which are containers for variables monitored for Data Change. The minimum number of monitored variables per subscription is also defined by these profiles. The test uses typical sampling rates for Data Change events, which are 100 milliseconds (ms) for control applications and 500 ms for human-machine interface (HMI) applications.

OPC UA testing verifies whether systems can meet the profile specifications (e.g., total number of monitored variables) with typical sampling rates without exceeding 1.5 times the request rate and without overloading the CPU since OPC only addresses an application's communication function. Tests are constructed to model different types of systems and configurations using the following OPC UA test parameters:

- The number of variables for Read / Write / Data Change functionality
- The sampling rate for Data Change
- The ability to support various variable data types and structure sizes (e.g., character strings and byte arrays)
- The number of clients, subscriptions and variables per subscription
- The processor platform
- The network performance (e.g., 100 Mbps or 1 Gbps network)

Accelerating OPC UA Deployment

Independent test laboratories, like Ascolab, perform OPC UA testing on computing platforms for different OPC UA use cases. The resulting performance measurements can help industrial device manufacturers choose the right processor for their requirements without having to test systems themselves. The laboratories also gain platform expertise that enables them to more quickly certify OEM production devices based on pre-tested platforms. Device manufacturers can further accelerate UA deployments by leveraging software development kits (SDKs) containing production-ready OPC UA software stacks, offered by vendors like Unified Automation.

The main challenge for testing laboratories is to develop a software stack and development tools that work on different operating systems. In other words, the software test infrastructure is the same for all operating systems, including the server application providing data and the client application measuring performance. Having accomplished this, Ascolab verified OPC UA operation on the Intel® Atom™ Processor Z530 (512K Cache, 1.60 GHz, 533 MHz FSB) and Intel® Core™2 Duo Processor SU9300 (3M Cache, 1.20 GHz, 800 MHz FSB) for the different operating systems listed in Table 3. Intel is the first silicon vendor to complete the OPC UA test process.

Operating System Platforms
Linux* (OSADL) (kernel v2.6.24.7)
QNX* 6.4.1
Wind River* VxWorks* 6.6
Windows* CE* 6.0
Windows Vista* SP1
Windows XP* embedded
Windows XP embedded with TenAsys* Intime* version 3.1

Table 3. Operating Systems Support by Intel® Processors

Examples of performance measurement data¹ collected on two different Intel platforms are listed in Table 4. The Intel Atom processor was tested using two profiles, the Embedded UA Server and the Standard UA Server. The embedded profile requires monitoring 500 variables spread across 5 subscriptions. It was tested with a variable sampling rate of 100 ms, the processor load was a negligible 2 percent. The standard profile is more rigorous with 37,500 variables spread across 75 subscriptions. The load on the Intel Atom processor for 1,000 ms and 500 ms sampling rates was 20 and 40 percent, respectively. The higher performance Intel Core 2 Duo processor was tested using the Standard UA Server profile and a 200 ms sampling rate, which resulted in an acceptable 10 percent load on the CPU.

In other testing, the roundtrip latency was measured for both platforms, using scalar values and data blocks. Roundtrip times for scalar values depend on the number of variables per call and the network speed, while data type, such as Boolean, integer or double, isn't a significant factor. Roundtrip times for single variable per calls requesting data block, byte array or string, depend on the block size and the network speed.

Processor on Platform	Test Conditions	Intel® Atom™ processor Z530	Intel® Core™2 Duo processor SU9300
Embedded UA Server Profile (500 variables across 5 subscriptions)	sample rate / CPU load	100 ms / 2% load	
Standard UA Server Profile (37,500 variables across 75 subscriptions)	sample rate / CPU load	1,000 ms / 20% load	
		500 ms / 40% load	
			200 ms / 10% load
Roundtrip for scalar values	10 variables	0.9 - 1.1 ms	0.2 - 0.4 ms
	10K variables	120 - 180 ms	27 - 54 ms
Roundtrip for data blocks	1 Kbytes	1.2 - 1.4 ms	0.4 - 0.8 ms
	2.5 Mbytes	118 - 300 ms	32 - 223 ms

Table 4. Examples of Performance Measurement Data¹

About Ascolab GmbH

Ascolab provides industry independent consulting, design and development services for manufacturers developing OPC-based solutions. They offer services focused on advice and assistance in the area of server and client-side software development, including software certification. For more information, please visit www.ascolab.com.

Unified Automation products offer application providers a cross-platform OPC UA C/C++ software development framework that supports vertical information integration from embedded device manufacturers up to enterprise application developers. It uses the ANSI C communication stack provided by the OPC Foundation to its member companies. For more information, visit www.unifiedautomation.com. SDKs from Unified Automation include:

- C++ OPC UA Server and Client SDKs ease development of full featured OPC UA client and server applications.
- ANSI C OPC UA Server SDK supports embedded OPC UA servers with special requirements like static memory or a single threaded and single task environment.
- Platform adoption layers provide ANSI C communication stacks for several operating systems (see Table 3).

The combination of SDK's by United Automation and testing services by Ascolab can help device manufacturers reduce the time required to implement OPC UA compliant products.

Intel® Processors in Industrial Computing

Embedded Intel® Architecture processors run OPC UA software stacks and the full range of OPC UA operating systems, as verified by Ascolab. Intel's processor roadmap scales to support field-level devices with Intel Atom processors, HMI with Intel Core 2 Duo processors and servers with Intel® Xeon® processors 5500 series. It's possible to deploy the same OPC UA software on all platforms, even if they are running different operating systems, which saves development and certification time. System developers have a choice of embedded Intel Architecture processors that protect product investments with software compatibility and seven years of lifecycle support.

Intel Xeon and Core 2 Duo processors supply the computing horsepower needed to consolidate multiple applications onto a single platform and deliver real-time response when time-critical functions

run on dedicated processor cores. These multi-core processors also increase the performance and data security of virtualization software by providing hardware-based assistance called Intel® Virtualization Technology² (Intel® VT). The technology improves the performance of virtualization software by reducing its footprint and complexity and speeding up commonly used virtualization operations, like memory address translation.

Virtualization can eliminate the need to port legacy code to a new operating system. If an industrial device manufacturer has legacy applications running on an old operating system, the application and operating system can run in their own silo (e.g., virtual machine) while other applications run on different operating systems. Since legacy software was typically written to run on its own dedicated hardware, silos provide an environment where it can't interfere with other applications.

Shortening the Time to Market for OPC UA-based Products

OPC UA enhancements are enabling platform independence and a higher level of software portability for standards-based industrial communication. The OPC Foundation, seeking to improve interoperability in a multi-vendor environment, is working with Intel to address real-time plant access and communications. Intel platforms, based on the Intel Atom and Core 2 Duo processor, have been tested by Ascolab, and their efforts allow device manufacturers to quickly evaluate these platforms and reduce time for selecting the right platform to satisfy device requirements.

SDKs from United Automation give system developers a solid OPC UA software stack, shortening software development time and allowing them to focus on the core features of the product. The combination of the OPC UA specification, pre-tested Intel platforms and SDKs can shorten the time to market for industrial device manufacturers.

About Unified Automation

As a leading OPC UA technology provider, Unified Automation offers products and services in the field of standardized communication for automation industry and beyond. Based on OPC Unified Architecture technology, Unified Automation products offer a cross-platform OPC UA software development framework to enable vertical information integration for application providers, from embedded device manufacturers up to enterprise application developers.

Additional information about Intel® embedded products can be found at:

<http://www.intel.com/products/embedded/index.htm>.

⁴ Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See www.intel.com/products/processor_number for details.

¹ Performance tests and ratings are measured using specific computer systems and/or components and reflect approximate performance of Intel® products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/resources/benchmark_limitations.htm


² Intel® Virtualization Technology (Intel® VT), Intel® Trusted Execution Technology (Intel® TXT), and Intel® 64 architecture require a computer system with a processor, chipset, BIOS, enabling software and/or operating system, device drivers and applications designed for these features. Performance will vary depending on your configuration. Contact your vendor for more information.

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