White Paper

Evolving Manufacturing Connectivity

Challenges to Brownfield Development

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In the arena of manufacturing, emerging Internet of Things (IoT) technology has ushered in the Industry 4.0 initiative, departing from conventional automated production to IoT-based intelligent automation, improving on semi-automated or standalone automatic machining to network-connected process based on M2M (machine to machine) and M2P (machine to person) communication. This, in combination with corporate information systems and analytics, creates endless possibilities for the smart factory model.

Through IoT-driven intelligent process, smart factory operations can reduce dependence on manpower, improve precision, accuracy and efficiency, optimize throughput and quality, and reduce costs, increasing corporate competiveness.

The Unconnected Landscape

According to IDC, worldwide revenue potential for IoT in the manufacturing sector will grow from $472 billion in 2014 to $913 billion in 2018 at a 17.93% CAGR, constituting the largest share (27%) of a projected $14.4T IoT market value.

Further, Cisco estimates that 92% of 64 million manufacturing machines in worldwide operation are unconnected to any network, despite remaining in full use on production lines everywhere. While in theory, they should be replaced with new smart machines, this is impractical for many manufacturers for reasons of cost. Having already invested heavily in production and automatic equipment, these operators are compelled to utilize the equipment for years to recoup investment.

Accordingly, a viable solution to optimize existing machines is to connect them to the Internet, thereby integrating them into the Smart Factory system and enabling acquisition and analysis of operational data, within acceptable cost constraints.

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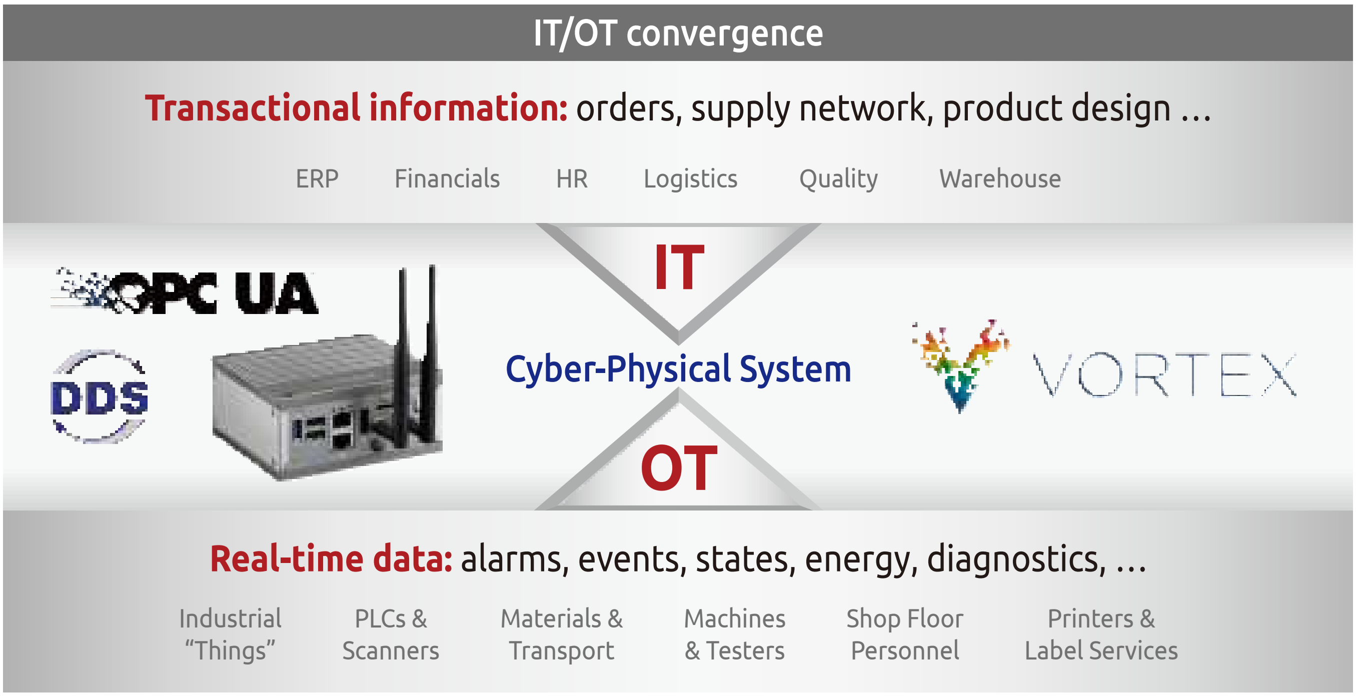
Challenges Become Opportunities

Achieving an IoT-based manufacturing environment combines utilization of operational technologies to connect equipment and devices at the floor level for tasks such as machine automation, Manufacturing Execution Systems (MES), environmental monitoring and energy management, and information technologies related to applications at the administrative level, including Enterprise Resource Planning (ERP), Customer Resource Management (CRM), various analytical applications, and many others.

These elements, when linked together, populate widespread cyber-physical systems supporting multiple subsystems. In such scenarios, operations need reliable and secure data flow among devices and application systems with minimal latency. As a result, network connectivity and efficient data flow becomes a fundamental requirement. Once, however, actual connection of legacy equipment and other assets on the floor level is to be implemented, a multitude of challenges are encountered.



Fragmented technologies

Over time, since the very beginnings of automated manufacturing, a wide variety of technologies and standards have been developed for use, in many cases being deployed simultaneously in a single operating environment among diverse facilities under a single administration. With the introduction of Industry 4.0, all individual production elements must be connected to the network, providing access to data critical for management and operational decision making. Unfortunately, a significant roadblock in the achievement of Smart Manufacturing is presented by scenarios such as:

- A considerable variety of controllers is commonly employed in the field, including Programmable Logic Controller (PLC), PC-based Programmable Automation Controller (PAC) and embedded Micro Controller Unit (MCU), all from diverse suppliers and utilizing different technologies

- While, over time, numerous PLC suppliers have developed their own fieldbus protocols for communication between PLC and the fieldbus I/O, no single protocol, despite them all having many followers in the market, has emerged as the sole standard, with the result that a single operation may need to deploy a variety of protocols simultaneously

- Some existing elements may be physically unequipped to support connectivity, such as legacy devices lacking even LAN/COM ports

OEM IP protection

OEM providers often don't release source code for their operating protocols, in the interest of securing their IP. This prevents integration of the specific devices into the complete system. In some cases, the OEM may no longer even exist.

Invasive reconfiguration resistance

Element owners/administrators often object to system integrators adding/deleting/modifying the software content of existing systems and devices.

Brownfield development challenges can become opportunities

Inadequate real-time data extraction

While many PC based legacy machines generate log files, commonly used for machine data extraction, the log files are not generated in real-time and in many cases miss information. Further, different OEMs provide different log file data formats, complicating repetition and scalability.

Key Considerations for Connecting the Unconnected

When implementing conversion of existing facilities into IoT-connected smart factories, the following should be taken into consideration.

Universal and Scalable Solution

The solution needs to be independent of the various fragmented technologies described. It must be able to scale out equally to all types of legacy machines to minimize maintenance efforts.

Cost effectiveness

For many manufacturers considering implementation of smart factory connectivity, the first consideration will be whether eventual benefits will justify the necessary expenditure, requiring solution providers to generate a rational cost structure. This is especially important for more complicated manufacturing operations, where large numbers of expensive elements are expected to function for years to come, generating acceptable return on investment. Optimally, the deployment should require little or no downtime to overcome manufacturers' reluctance to implement.

Real-Time information extraction

In the IoT-enabled system, real-time information from all elements can determine the success of tomorrow's business model. Accordingly, extraction of information from these legacy elements must be in real-time, to support critical and immediate decision making.

Non-invasive methods

To minimize impacting owner assets, it is preferable to deploy a solution with minimum or no modification of existing equipment software and hardware, preventing system instability, damage and minimizing downtime.

Maximizing Data Bandwidth

As increasingly more elements connect to the IoT-enabled system, more data will be transmitted in shorter periods of time. Efficient network bandwidth utilization (>85%) becomes more and more important in order to accommodate more devices in the network.

Dynamic Discovery

In an IoT-based system, factory throughput is critically linked to business decisions, with resulting equipment layout and process adjustment occurring more frequently. A mechanism providing dynamic discovery of all equipment and process with a minimum setup time requirement is a must, to reduce overall production down time.

Scalable and reliable

Since the IoT system has to connect a large number of individual devices and equipment, an ideal solution should maximize scalability to effectively manage diverse element profiles and forecasted expansion, with all elements connected in a reliable manner, thereby supporting time-deterministic and mission-critical applications.

High security

Unlike conventional standalone devices, an IoT-based system's connection can present a risk to data security, requiring smart factory solutions to integrate meaningful protective measures.

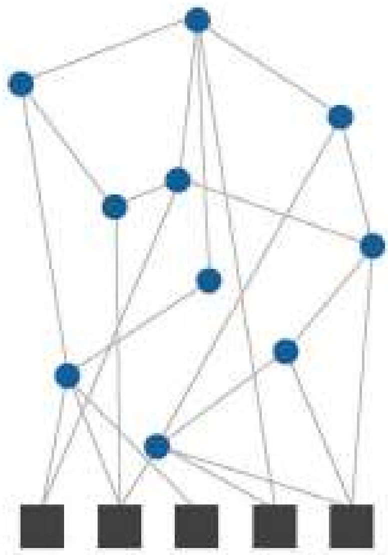
Flexible CPS (Cyber Physical System) Architecture

By enabling legacy equipment connection to intelligent autonomous equipment, cyber-physical systems combine communications, information and communication technology (ICT), data and physical elements and interconnect ability among devices. This IT transformation elevates the manufacturing process from a patchwork of isolated silos to a nimble, seamless and fully integrated system of systems (SoS), matching end user requirements in the manufacturing process. Data from each sub-system can be shared autonomously and efficiently anytime, enabling the acquisition of smart manufacturing.

Flexible CPS (Cyber Physical System) architecture

Unlike conventional 5-layer architecture, the Pub/Sub based Cyber-Physical System (CPS) can share data autonomously and efficiently anytime, enabling the acquisition of smart manufacturing.

Today	Future
5-layer architecture	*Cyber-physical system (CPS) based automation*



Steps to establishing Smart Manufacturing

While Smart Manufacturing implementation can effectively evolve not only manufacturing activities and business management, but also vertical communications, economic realities can easily preclude development into a full-fledged smart factory in a single step. This necessitates prioritization of constituent tasks, for example starting with connection of legacy machines and instruments, with resulting energy savings as ROI. Enabling new machinery in a scalable CPS architecture can follow, with gradual increase of applications finally completing the migration to connectivity.

Connection of Legacy Machines and Instruments

While this step constitutes probably the biggest challenge in implementing connected manufacturing, it is a critical foundation for the entire process. Without this process, operations lack machine data needed for smart decision-making. It may take years for the entire field to fully realize the Smart Manufacturing goal.

Gateways equipped with protocol convergence and domain operational intelligent middleware are important to interconnect all the unconnected equipment, sensors, meter and instruments at the shop floor level, extracting data from the OT side, and converging the OT data formats such as Modbus and Zigbee into IT protocols such as MQTT, DDS and RESTful, thereby easing connection of legacy machines.

With equipment connected and data collected, operators at the shop floor level can view operational status of the machines and administrators can oversee overall production, review the status of specific machines, and assess environmental parameters and energy expenditure, all from centralized control facilities.

Energy Conservation

Deployment of Manufacturing Execution, Warehouse Management, Facility Monitoring and Management, and Energy Management Systems allows consumption of water, power, gases and other forms of energy to be monitored, informing implementation of conservation measures to limit costs. Once benefits of connected manufacturing are recognized, likelihood of continued investment and further asset development increases commensurately.

Enhance Data Sharing Platforms

In this stage, establishment of a data sharing platform enhances integration of IoT features into the system and amplifies the benefits of smart manufacturing. Malfunctions and errors in data transmission carry the potential for significant financial detriment. A reliable data sharing platform can assure efficient and accurate sharing of critical data throughout the entire connected environment and beyond. Real-time M2M communication provides instantaneous notification of even minor problems, practically eliminating the chances of malfunctions perpetuating and impeding efficient operations.

A decentralized Data Distribution Service (DDS) improves significantly on conventional Client/Server models, providing a more flexible architecture with its flat, simple, and decoupled structure, allowing peer-to-peer communication, multi-cast and dynamic discovery, and eliminating single-point failure or latency, boosting time-determinism for IIoT applications.

Develop Cloud/Fog Applications

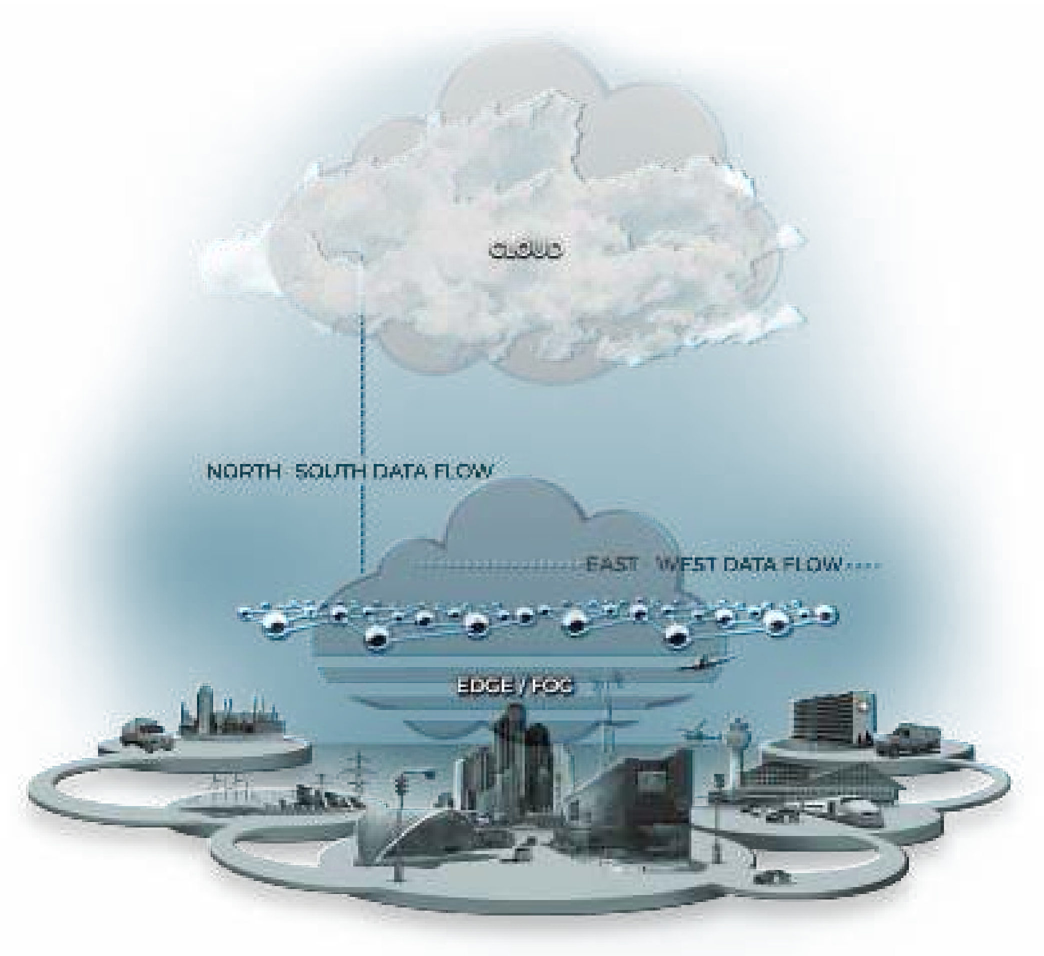
With IoT data sharing in place, operational data can be pushed to the Edge/Cloud for big data analysis and development of new applications, some of which can, in turn, be implemented at the edge of network to increase efficiency, namely Fog subsystems.

For example, with the use of machine learning modules, Preventive Maintenance Systems can be implemented to predict element lifecycles forecasting expected failure and end of life, allowing the implementation of preemptive repair and maintenance measures to prevent unexpected interruptions in service and minimize their impact on operations.
The IoT system can further connect existing applications at the operational level, such as Manufacturing Execution and Energy Management Systems to information systems at the business level, such as Enterprise Resource Planning (ERP), Inventory Control, Customer Relationship Management (CRM) systems, and others.

With all systems and their elements connected to the overall administrative IoT system, data flows freely across all subsystem boundaries, allowing multiple associated and supporting applications and functions to be generated accordingly.

Administration can oversee operations of all facilities in real time as well as review historical behavior and statistics acquired from cloud-level databases. IoT-controlled smart manufacturing also enhances QC measures across multiple facilities, improving both resource deployment and inventory control.

Big Data Analysis enables database deep access, allowing acquisition of valuable operational intelligence, enabling development of more insightful and predictive business strategies.



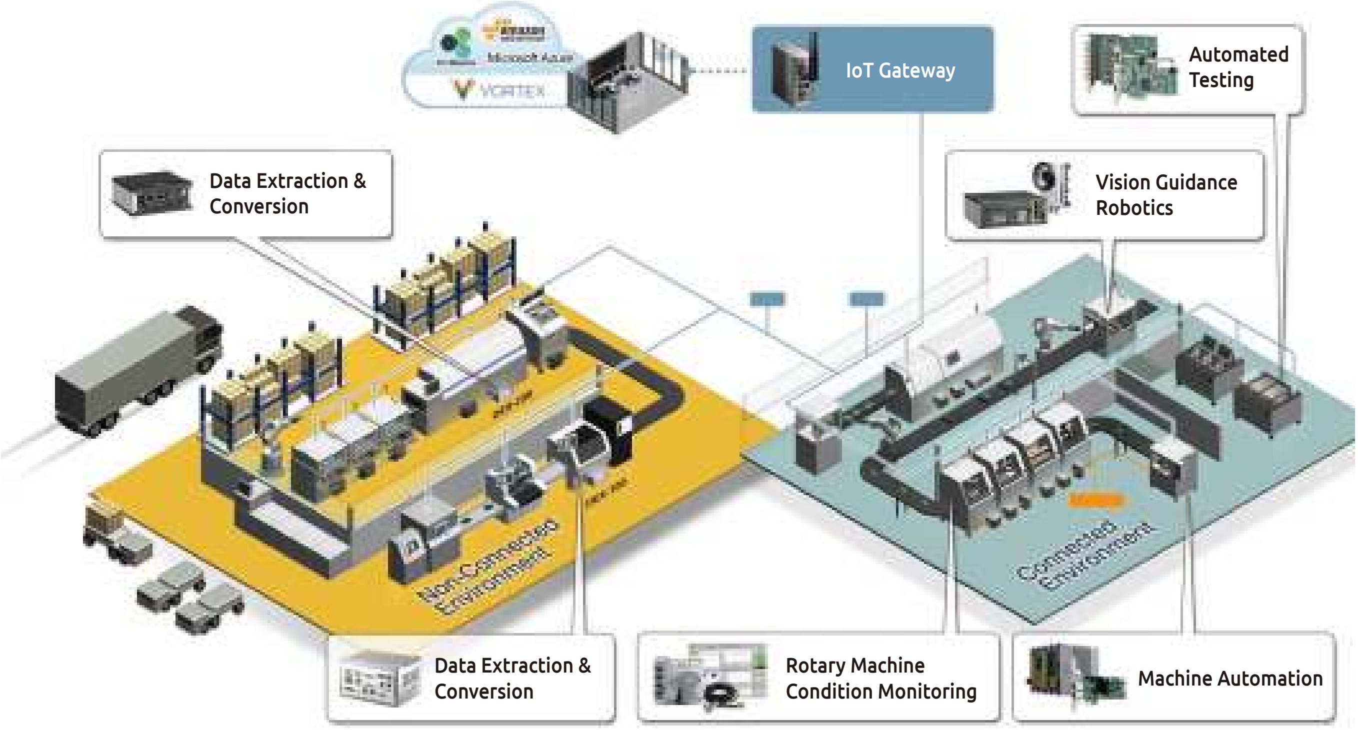
Building a Smart Factory of the Future

Intel has recently embarked on a pilot smart factory implementation project with prominent electronics manufacturers, with the aim of providing a model for widespread implementation of connected manufacturing to be realized in the near future.
An existing electronics factory is selected as the pilot environment, with the goal of connecting legacy production line elements to improve production quality and efficiency.

The IIoT-based manufacturing platform jointly provided by Intel and ADLINK (a Premier Member of the Intel® IoT Solutions Alliance) enables:

• Efficient data capture among existing elements, newly installed elements, and data analysis platforms
• Full smart production lines integrating legacy elements
• Secure and stable connection across the entire environment
• Customized IoT platform providing edge, cloud, workshop, and ERP services, supporting optimization of large-scale production.

IoT-based smart manufacturing



Accordingly, the solution installs Remote Terminal and Remote Control Units (RTU/RCU), providing remote control & operational data retrieval from non-connected installations at legacy elements, for transmission to backend platforms via IoT gateways equipped with Data Distribution Service (DDS), enabling operational monitoring of production in real time.

Data directly acquired from the production line includes machine names, material numbers, programming names, standard parameters; production statistics production pass/fail counts, machine status, indicator and alarm code info, runtimes of all stats, and more.

To ensure secure and stable overall connection, the Data Distribution Service (DDS) standard is preferred, employing Publish/Subscribe-based communication with a flat, simple, decoupled and distributed architecture allowing peer-to-peer and multicast communications requiring no broker. The result eliminates data latency from single-point failure, presenting a distinct advantage for time-deterministic applications demanding high reliability and scalability.

The system records production volume and component use at the production line level and implements analysis on quality inspection results of semi-finished products via workflow and real-time parameter reporting, all factors affecting quality and safety. Alert systems are implemented based on user-defined parameters.

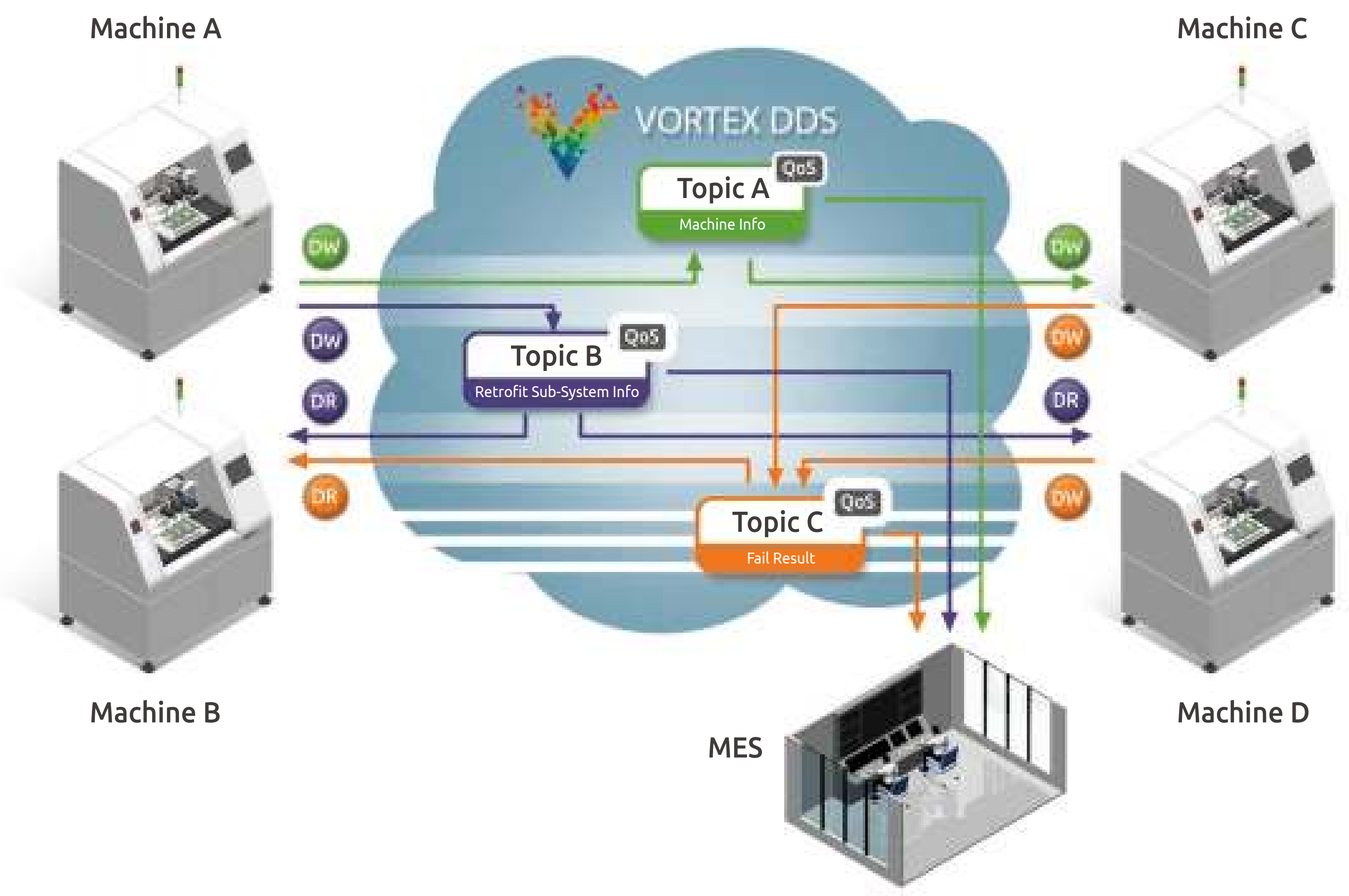
When an alarm is issued, notification is uploaded to admin systems and affected workstations directed to respond appropriately to prevent further mis-operations and avoid line breakdowns or stoppages.

When the system has accumulated sufficient historical data, problem forecasting can be developed, to generate preemptive repair and maintenance operations in advance, preventing device failure and minimizing downtime.

As well, by accumulating data from quality inspection, the system can generate models to refine measurement and reduce production loss from inspection errors, improving yield.

M2M communication via Vortex DDS

Peer to peer communication: Simple, Flat and Decoupled



ADLINK Solutions

ADLINK combines market-proven technology expertise with years of experience in automation, communication and industrial computing. Pre-validated hardware and utility integration further enable OEMs to deliver solutions to the market faster and deploy them with minimal adjustment.

The ADLINK smart factory solution accelerates brownfield deployment, breaking down obstacles to achievement of the Industry 4.0 standard and empowering optimization of production, efficiency, and profit, by leveraging the benefits of IIoT-based intelligent manufacturing, based on a comprehensive portfolio of platform elements, including:

MXE-200i Series IoT Gateway

A robust, reliable and application-ready embedded edge computer that helps sensor-equipped assets to connect and share data with other edge devices and/or cloud applications. Based on the Intel® Atom™ processor E3826, supporting the Intel® IoT Gateway Technology, with pre-loaded Wind River® IDP XT 2.0/3.1 enabling full IoT function, the MXE-200i Series offers the most reliable embedded IoT Gateway available, suitable for harsh environments and compliant with industrial grade EMI/EMS (EN61000-6-4,61000-6-2), securing customer assets and reducing TCO.

MXE-5500 Series Fanless Embedded Computers

PC-based data extraction is based on this range of rugged quad-core fanless computers, featuring 6th generation Intel® Core™ i7-6820EQ/i5-6440EQ/i3-6100E processors, delivering outstanding performance, boosting computing power by up to 30% over previous generation CPUs, 30% faster graphics performance, and accelerated HW media codecs supporting Ultra HD 4K display.

ADLINK, as a Premier Intel IoT Solutions Alliance Partner, provides DDS-based hardware and utilities in conjunction with newly acquired PrismTech, focused on developing DDS-based IoT platforms with complete cloud/gateway/fog product offerings.

In the coming months, ADLINK will be introducing complete end-to-end platform solutions meeting all the needs of Brownfield deployment, providing painless, cost-effective recipes for successful connectivity in virtually any manufacturing environment.

About ADLINK

ADLINK Technology is enabling the Internet of Things (IoT) with innovative embedded computing solutions for edge devices, intelligent gateways and cloud services. ADLINK's products are application-ready for industrial automation, communications, medical, defense, transportation, and infotainment industries. Our product range includes motherboards, blades, chassis, modules, and systems based on industry standard form factors, as well as an extensive line of test & measurement products and smart touch computers, displays and handhelds that support the global transition to always connected systems. Many products are Extreme Rugged™, supporting extended temperature ranges, shock and vibration.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance and is active in several standards organizations, including PCI Industrial Computer Manufacturers Group (PICMG), PXI Systems Alliance (PXISA), and Standardization Group for Embedded Technologies (SGeT).

ADLINK is a global company with headquarters in Taiwan and manufacturing in Taiwan and China; R&D and integration in Taiwan, China, the US, and Germany; and an extensive network of worldwide sales and support offices. ADLINK is ISO-9001, ISO-14001, ISO-13485 and TL9000 certified and is publicly traded on the TAIEX Taiwan Stock Exchange (stock code: 6166).

About the Intel® Internet of Things Solutions Alliance

ADLINK is a Premier member of the Intel® Internet of Things Solutions Alliance. From modular components to market-ready systems, Intel and the 400+ global member companies of the Intel® Internet of Things Solutions Alliance provide scalable, interoperable solutions that accelerate deployment of intelligent devices and end-to-end analytics. Learn more at: intel.com/iotsolutionsalliance

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