NISTIR 8124

OAGi/NIST Workshop on Open Cloud Architecture for Smart Manufacturing

Nenad Ivezic
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National Institute of Standards and Technology
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Systems Integration Division
Engineering Laboratory

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Willie May, Under Secretary of Commerce for Standards and Technology and Director

Abstract

This report summarizes the results from the OAGi/NIST Workshop on Open Cloud Architecture for Smart Manufacturing, which was held at the National Institute of Standards and Technology on May 5, 2015. The workshop was a forum for manufacturers and providers of IoT technologies, Cloud platforms, and manufacturing services to share their visions, and identify and prioritize barriers to adoption of Cloud-enabling capabilities and technologies, forming a basis for future follow-on events. The report (1) includes summaries as well as full presentations delivered at the workshop; (2) identifies and prioritizes technical issues; (3) summarizes the discussions that took place during the workshop; and (4) provides the conclusions that emerged from the presentations and discussions.

Acknowledgement

Authors would like to thank Mr. Christopher Peters for his many helpful suggestions during organization of the workshop and for reviewing the final report.

Keywords

Smart Manufacturing, Cloud Architectures, Internet of Things, Standards Development, Standards Adoption, Digital Manufacturing, Industry 4.0

Acronyms

API – Application Programming Interface

B2B – Business-to-Business

B2MML – Business to Manufacturing Markup Language

BOD – Business Object Document

BPMN – Business Process Model and Notation

CC – Cloud Computing

CEO – Chief Executive Officer

DMDII – Digital Manufacturing and Design Innovation Institute

EAI – Enterprise Application Integration

HTTP – Hyper Text Transfer Protocol

IoT – Internet of Things

IIoT – Industrial Internet of Things

ISA – The International Society of Automation

ISV – Independent Software Vendor

IT – Information Technology

JSON – Java Simple Object Notation

LIMS – Laboratory Information Management System

LOL – Land O' Lakes

MES – Manufacturing Execution System

MQTT – Message Queuing Telemetry Transport

NIST – National Institute of Standards and Technology

NRT – Near-Real-Time

OAGi – Open Applications Group Incorporated

OAGIS – Open Applications Group Integration Specification

ODM – Original Design Manufacturer

OEM – Original Equipment Manufacturer

PLM – Product Lifecycle Management

REST – Representational State Transfer

R&D – Research and Development

RT – Real-Time

SaaS – Software as a Service

SCOR – Supply Chain Operations Reference

SDO – Standards Development Organization

SMLC – Smart Manufacturing Leadership Coalition

SME – Small- to Medium-sized Enterprise

SOA – Service-oriented Architecture

UCLA – University of California, Los Angeles

XML – Extensible Markup Language

List of Contributors

Presenter	Position	Affiliation
Jim Davis	Vice Provost IT	**UCLA & SMLC**
Denis Gagne	CEO	**Trisotech**
Shelley Gretlein	Director Product Marketing, Platform Software & Customer Education	**National Instruments**
Gregory Harris	Program Manager DMDII	**Department of Defense**
Ian Hedges	Vice President, Platform at E2open	**E2open**
Jon Hirschtick	Founder and Chairman	**Onshape**
Matt Johnson	Senior Director	**Oracle**
Pawan Joshi	Vice President Strategy	**E2open**
Chris Monchinski	Director, MES	**Automated Control Concepts**
Scott Nieman	Enterprise Integration Architect	**Land O'Lakes**
Dave Noller	Manager, SWG Industrial Sector Strategy & Integration	**IBM**
Dennis Pegden	CEO	**Simio**
Jon Siudut		**MESA International**
Kirk Smith	Solutions Architect, Industrial and Energy Solutions Division, IoT Group	**Intel**
Dan Trout		**Automated Control Concepts**

Executive Summary

While Smart Manufacturing identifies potential great promise in the rapid development of today's technologies, such as Cloud computing and the internet of things, there also is great peril. As the variety of systems development approaches and structures proliferate, so too do the risks associated with trying to manage and control many disparate systems. Addressing these challenges through standards and industry collaboration improves interoperability and helps reduce an organization's risks and costs.

In May of 2015, the National Institute of Standards and Technology (NIST) held a workshop of industry, government, and academia leaders to begin addressing these challenges. This document consolidates and highlights the issues raised in the workshop and articulates the value of overcoming those issues. The intent is to raise awareness of leadership across government agencies as well as industry executives with regards to the workshop findings. It is hoped that future plans for technical work to achieve Smart Manufacturing objectives at government agencies and in industry will address these issues.

The workshop participants agreed that the Cloud-enabled technological advances present an unprecedented opportunity as well as new, very significant issues to the manufacturing community on its way to achieving Smart Manufacturing systems. The following key issues emerged from the workshop:

- Existing standards are inadequate to enable the Cloud-based services needed for Smart Manufacturing.
- Standards adoption is severely impeded by confusion, complexity, and the lack of efficient tools.
- We need new architectures to enable service-oriented Smart Manufacturing.
- We need new standards development and standards management processes to support the rapid evolution of Smart Manufacturing.
- Cloud platforms can provide the infrastructure needed to implement Smart Manufacturing Enterprises, but challenges remain.

The workshop participants expressed belief that addressing the above issues is valuable to the manufacturing industry. Value of overcoming the issues includes the following:

- Reduced costs and time to market for manufacturers.
- Increased supply chain interoperability, enabling supply chains to be formed and re-configured with greater efficiency.
- Enabled new business models that result in greater agility and customization.

Detailed analyses of these and other issues will be the focus of the follow-on workshops, which are planned in collaboration among industry, government, and academic organizations.

The next steps include a series of follow-up events and technical activities, including technical workshops that will lay out a roadmap with target goals and needed research and development (R&D) activities, focused technical projects that will address key research issues, and industry-led assessment activities that will provide evaluation and feedback to the technical activities. These next steps will have as a common objective to help coordinate public and private efforts in developing a next generation of open Cloud solutions to address the identified issues on the path to Smart Manufacturing.

1 Introduction

Right now, the emerging digital world of information technologies is a little like the Old West – Semi-controlled chaos! This is certainly what manufacturers are finding as they attempt to take advantage of technologies such as Mobile Computing, Software-defined Networks, Data Analytics, and Internet of Things (IoT), among others. One of those others, and the focus of this report, is Cloud Computing (CC). Conceptually at least, CC can be thought of as an ecosystem with heterogeneous information-based services. Manufacturers are looking to use such services to improve the management and control of their factories and supply chains. These services used to be provided only by established software vendors in their large, expensive, bundled, monolithic software applications installed on premise. No longer! Both established and new vendors have entered the market with new generation of solutions. These vendors are providing the same services in unbundled "apps", which could be significantly much easier and less expensive to use. Why? Because, they live in the "Cloud," which carries the promise of more manageable, accessible, and cheaper services that are composed from these apps.

Depending on the problem to be solved, however, bundling and integrating heterogeneous Cloud-based services in the form of apps is not always an intuitive job. Management and control are two problem areas The difficulty stems from the fact the solutions to these problems require manufacturers to "mix-and-match" several individual service apps. Fair to say, as the number of apps required to solve these problems increases, the ability to "mix-and-match" them becomes harder. That ability is hampered further because these apps are now being provided by multiple CC platforms. Clearly, there is a need for service vendors, Cloud vendors, manufacturers, and other stakeholders to work collaboratively to reduce the effort needed to "mix-and-match" the apps. That work will require the development of technologies and standards for easier discovery and easier integration of services based on improved interoperability and composability. With such technologies and standards, we can at least minimize the chaos.

Open Applications Group, Inc. (OAGi) and NIST put together a workshop to bring these stakeholders together to discuss the best approaches, from their individual perspectives, to initiate such a development. Stakeholders at the workshop represented two groups: manufacturers and vendors. Manufacturers were given an opportunity to identify their requirements for integration technologies and interface standards to meet their business needs and close their technical gaps. They did this by answering a number of questions sent to them before the workshop. Vendors were given the opportunity to demonstrate their current, and discuss their future plans for, product development. Both groups were given opportunity to exchange ideas about (1) how best to align the requirements and the plans; and (2) what technologies and standards were needed to achieve that alignment.

In this document, we summarize the presentations, discussions, priorities, and findings from this workshop. Section 2 presents workshop objectives and the charges to the participants. Section 3 summarizes workshop presentations and discussions. Section 4 prioritizes, based on difficulty and urgency, the issues discussed in those presentations. Section 5 provides concluding results.

2 Workshop Objectives, Charge to, and Response from the Workshop Participants

In this section, we summarize the initial workshop announcement, including the charge provided to the workshop participants, and their responses to that announcement.

2.1 Workshop Objectives

The objectives for the workshop were to collect information and publish a report detailing the following:

- CC services needed by manufacturing companies and their potential impacts.
- Current and planned offerings of Cloud, services, and IoT providers.
- Strategic and high-level Cloud architectural approaches to match needs with offerings.
- Needs, gaps, and opportunities for integration technologies and standards.

2.2 Charge to Workshop Participants

As part of their charge, we asked participants to answer two questions to help them frame their thoughts and prepare for to the workshop.

Q1: What is the vision for manufacturing to be supported by the IoT, Cloud, and service providers? We asked participants to share their answers, from the perspective of their own organizations in a presentation of 10 to 15 slides, with the following focuses:

- Manufacturers were expected to explain their vision for how they plan to use Cloud services to support their needs.
- Cloud-platform vendors were expected to explain their vision of why and how their offerings will support manufacturing needs.
- Cloud-service vendors were expected to explain their vision for how they plan to use Cloud platforms to provide the apps needed to provide the required manufacturing functionality.

Q2: What's preventing these visions from becoming reality? To answer this question, we asked participants to describe what they, and their organizations, thought were the top few priority issues. Our intent behind the workshop was to produce a prioritized list of issues, based on all of those issues presented by the participants. Second, we also asked them to present arguments for why their issues should be on that final list.

In the course of their presentations, we guided the participants to address as many of the following questions as possible. (We also provided guidance in the form of example presentation summaries):

- Manufacturing Use Case: What are the manufacturing business needs you are addressing?
- Business Challenge: What is the mismatch between the business needs and your current business capabilities?

- Business Benefit: What are cost savings and other quantifiable benefits following from addressing the business challenge and meeting the need?
- Open Cloud Opportunity: Where can open Cloud help address the business challenge and help meet the manufacturers' needs?
- Technical Issues and Initiatives: What technical issues deny the open Cloud opportunity from addressing the business challenge?
- Standards Role: What is the potential role for standards to address the technical issues?

As noted above, we intended to compile a final, prioritized list from the presentations and subsequent discussions. To do this, we asked the participants to prioritize all issues by voting for their top 6 favorites. We discuss the results of the prioritization in Section 4.

2.3 Responses from Workshop Participants

The participants responded to the charge in varied ways. Some were interested only in solving specific technical problems. Some were interested in establishing languages and infrastructures needed to address those technical problems. Others were more interested in addressing the larger organizational issues that Cloud Computing brings to manufacturing. The following sections summarize the participants' contributions and discuss the outcome of their prioritization efforts.

3 Presentation Summaries

In this section, we provide summaries of participants' submissions in the form of presentations made at the workshop. (The summaries are based on abstracts or summaries of the actual presentations, which are provided in full in the appendix.) We organize the summaries chronologically, within the session in which they took place. Within each session, summaries are followed by discussions that took place within the session.

3.1 Position Statements & Issues Identification – Session 1

The following table summarizes presentations included in the first session of the workshop.

Presenter Name, Company	Scott Nieman, Land O' Lakes	Matt Johnson, Oracle	Pawan Joshi, E2open	Denis Gagne, Trisotech
Present-ation Title	**Integration Challenges with Lab Information Management Systems and Manufacturing Process Control Systems**	**Enabling Contract Manufacturing in the Cloud**	**Orchestrating End-to-End Supply Chain & Manufacturing**	**IoT Aware Business Processes Enabling Smart Manufacturing**
Vision	Cloud-enabled enterprise applications: MES and LIMS systems	End-to-end Cloud solutions for manufacturing value chain	Multi-Enterprise Manufacturing Management on the Cloud	IoT devices integrated with multitude of enterprise systems
Perspective	Manufacturing Enterprise	Cloud Platform Vendor & Manufacturing Services Vendor	Manufacturing Service Vendor	Manufacturing Systems Modeler
Key Issues	Technical interoperability issues of connecting an on-premise system to Cloud-enabled LIMS and MES	Heterogeneous enterprise messaging and communication issues; highly variable, proprietary manufacturing and logistics processes	MES vendors lacking interface standards	How to integrate and translate huge amounts of data into relevant information and knowledge

3.1.1 Integration Challenges with Lab Information Management Systems and Manufacturing Process Control Systems

Scott Nieman, Enterprise Integration Architect, Land O'Lakes

At Land O'Lakes Lab, management and control functions are implemented in two systems: Laboratory Information Management Systems (LIMS) and Manufacturing Process Control

Systems, respectively. Each system interacts with hardware using Programmable Logic Controllers or dedicated computers. These interactions often require solutions to a variety of integration problems that arise because many equipment manufacturers still use proprietary data formats such as comma-separated-value (CSV) files. Such formats require integration solutions to be implemented using bi-directional, point-to-point, integration-design patterns. It has been proven many times over that such design patterns are not sustainable over time. This creates a huge problem: new integration solutions must be found, many times over.

Switching to Cloud-based services will not solve this problem directly. Some vendors currently use what are called "code-first" web service Application Programming Interfaces (APIs) such as Representational State Transfer (REST) and OData for software integration. Despite being a step forward, these types of APIs change with each new release of the software, thus recreating the sustainability problems discussed above. Other vendors use "wrapper-based" web services APIs as their user interface. This approach leads to "chatty" integration processes with multiple Hyper Text Transfer Protocol (HTTP) round-trips to perform a single transaction.

What is needed is a new breed of controller software that includes a hardware-specific "front-end" to pass instructions and data back and forth. This new breed would use standardized "contract-first" APIs such as OAGIS and B2MML to facilitate integration and reduce chattiness. It would also leverage IoT paradigms for securing API access using HTTP security protocols such as OAuth2.0 and OpenID Connect, which are needed when coming directly from the Cloud into an enterprise's "trusted zone".

Using standards-based APIs and IoT strategies would have three major benefits. First, it would open the doors for Small- to Medium-sized Enterprises (SMEs) to use "pay-as-you-go" Cloud solutions. Second, it would allow Original Equipment Manufacturers (OEMs) to reduce the cost of replacing aging monolithic software systems. Third, it would provide a foundation for developing a set of standard integration practices.

To help demonstrate the potential for these benefits, an open, integration test bed should be developed. As part of that testbed, methods and measurement tools should be developed as a basis for either a self-certification or third-party-certification process.

3.1.2 Enabling Contract Manufacturing in the Cloud

Matt Johnson, Senior Director, Oracle

Cloud-based solutions must treat both contract manufacturers and third-party logistics providers as part of an end-to-end, life-cycle manufacturing process. A significant number of high-tech manufacturing companies already employ both of them to produce and deliver their products. However, communication among these companies and their suppliers are both intermittent and non-standardized. This has resulted in greater supply volatility and longer manufacturing cycle times. Even a small improvement in the manufacturing cycle time or of third-party process reliability would have an enormous positive impact.

Cloud-based platforms offer a way to get that improvement because they allow trading partners to access a consolidated set of manufacturing application features on a uniform platform. This platform eliminates many of the functional gaps and party variations that often create huge barriers. Moreover, independent companies can still use different in-house solutions that (1) communicate using a variety of methods and message standards; and (2) implement manufacturing and logistics processes with variations in the number and sequence of steps.

By using Cloud services, companies can use flexible, standards-based connectors to communicate more efficiently with contract manufacturers. To enable that, however, Cloud-based-manufacturing service providers should agree upon (1) messages for coordinating onboarding and profile management among their client communities; (2) a common Business-to-business (B2B) messaging standard (OAGIS) that all B2B service providers can support; and (3) standard message choreographies based upon the Business Process Model and Notation (BPMN) for contract manufacturing.

3.1.3 Orchestrating End-to-End Supply Chain & Manufacturing

Pawan Joshi, Vice President Strategy, E2open

More and more supply chain partners of many OEMs reside in countries outside the United States. At the same time, the OEMs themselves operate largely digitally within their own silos, communicating with the partners using only spreadsheets and faxes. However, the increasingly large quantities of data being exchanged between them are making those paper-based tools obsolete. So, OEMs and supply partners must agree on new methods and tools they will use to deal with the flood. E2open's goal is to provide both of them.

Currently, E2open is focused on methods and tools for the macro-supply chain. The strategy of E2open is to enable one version of "truth", and to enable three shared capabilities: visibility, management-by-exception, and empowered decision-making.   OEMs need these three capabilities most critically during introduction of new technologies and products. These are the times when the company owns the design but manufacturing is distributed - more often than not, around the globe. There are two challenges whose resolution requires those three capabilities. How can the OEM keep track of the inventories and shop floor status of their partners when they are scattered around the globe? And, how do the partners provide this information but retain flexibility to prioritize customized products?

From the perspective of E2open, success will depend on how much our products help manufacturers answer these questions. We believe that an opportunity exists to wrap standards around the whole workflow-driven approach. There is however, a big barrier: no standards exist in the MES area. E2open typically has to deal with proprietary flat files, which are very specific and quite different from one MES system to another. Things just go wrong all the time with this approach. We need a better way to be able to communicate with these systems, particularly when dealing with exceptions in manufacturing processes. Standards development organizations, such as OAGi, should establish working groups for definitions of new nouns/Business Object Documents (BODs) and revisit these nouns for their applicability in the Smart Manufacturing era.

3.1.4 IoT Aware Business Processes Enabling Smart Manufacturing

Denis Gagne, CEO, Trisotech

Smart Manufacturing will require manufacturing enterprise systems to interface with IoT devices, third-party logistics, procurement, and ordering, among others. To achieve this, business process management (BPM) will play a key role. BPM provides the means to (1) manage end-to-end, IoT-aware processes; and (2) orchestrate the way enterprise systems take part in them.

Business Process Modeling Notation (BPMN) includes many of constructs needed for modeling BPM-related manufacturing processes. In addition, independent software vendors (ISVs) have recently started to include and demonstrate that BPMN modeling capabilities can take into account IoT. For example, SAP demonstrated a coordinated solution for modeling oil-pipeline sensor data with PLM data and communicating that data to a technician's iWatch. Another company, W4, showed fall-sensing capability in monitoring assisted living spaces. This required managing two layers of business processes: one coordinating sensor information and the other coordinating people activities.

In both cases, however, the best way to integrate and translate the increasingly larger amounts of data into the relevant information and knowledge is not clear. There are three areas where critical advances are needed. The first involves the semantics and analytics needed to ensure that we are collecting only relevant data. The second involves the robust connectivity to ensure that relevant business events are gathered, The third involves the IoT-related ontologies to ensure that better reasoning and better decisions can be made based on current event data.

3.1.5 Discussion

Scott Nieman pointed it was easy to model "the happy path" of process execution but much harder to model "the unhappy paths" of which there are many. Matt Johnson suggested compensatory models as a way to address that issue. Matt Johnson stated that current practice in supply-chain visibility is largely based on portals and spreadsheets.

Pawan Joshi stated that MES vendors typically do not use interoperability standards; instead, they use proprietary flat files specific to the vendor. He made the point that a new, collaborative initiative (supported by adequate NIST involvement) could be started to enable MES vendors to know about and use the desired integration capabilities out of the box.

Denis Gagne pointed at CMMN (Case Management Model and Notation), which is a sibling of BPMN, to address and handle exceptions to the "happy path." Serm Kulvatuntyou asked how to use business processes with smart devices? Pawan Joshi stated business processes will still be needed to orchestrate smart devices, but they will not be prescriptive. Rather they must be abstract, parametrized, and flexible; they must also allow for real-time monitoring and reactive system behavior.

3.2 Position Statements & Issues Identification – Session 2

The following table summarizes presentations given in the second session of the workshop.

Presenter Name, Company	Jim Davis UCLA & SMLC	Jon Hirschtick, Onshape	Dennis Pegden, Simio	John Siudut, MESA International
Present-ation Title	**Smart Manufacturing Leadership Coalition**	**Full-Cloud 3D CAD: An Open Platform For Faster Design and Manufacturing**	**Executing Simulation Experiments on the Cloud**	**Introduction to MESA International**
Vision	Smart Manufacturing enterprise, value chains, and ecosystems	Full-Cloud 3D CAD Systems	Cloud-enabled manufacturing simulation execution	Automated integration of manufacturing enterprise systems/services
Perspective	Manufacturing Enterprise; Value Chain; Ecosystem	Manufacturing Services Vendor	Manufacturing Services Vendor	Manufacturing Enterprise, Manufacturing Services Vendor
Key Issues	Orchestration of workflows; Data management; Apps Access & Execution; Ecosystem management	Lack of solutions for compatible, complete design & manufacturing ecosystem	Data Integration	Lack of method to automate integration; Lack of bottom-up modeling methods to use proprietary efforts that could serve as model

3.2.1 Smart Manufacturing Leadership Coalition (SMLC)

Jim Davis, Vice Provost IT, UCLA & SMLC

Smart Manufacturing enterprises, value chains, and ecosystems have the potential to (1) be more value oriented and responsive to demands of dynamic markets; (2) achieve substantially increased productivity, performance, and innovation agility; (3) accelerate the adoption of new physical and cyber technologies; (4) radically improve environmental sustainability, material waste, and energy productivity; and (5) approach zero field failures and incidents.

Business challenges that must be overcome to achieve that potential include (1) new types of business models and metrics that emphasize business agility, asset management, and supplier integration; (2) the realization that everyone's returns on investment are interdependent but motivated differently; (3) new collaboration models that provide incentives, other than cost reduction, for OEMs to invest in advanced technologies for their SME partners; and (4) new market drivers that favor the use of interoperability standards, inter-system cyber security, low-cost scaled infrastructure and low-complexity technology solutions.

The open Cloud provides a number of opportunities to address these challenges. It will increase the availability of—and lower the risk, the cost, and the barriers to— real-time data, information, analytics, and metrics across the supply network. This will improve access to integrated patterns of operation, untapped performance, productivity, and optimization opportunities. It will also improve cyber security and accelerate smart-system development, deployment, performance, and reuse. The Cloud has the capability to manage provider-neutral, trusted-marketplace access to data, apps, and deployment services for manufacturers. Finally, using the Cloud enables manufacturers to retrofit existing service-based control and automation systems.

To make use of those opportunities, several technical issues must be resolved. Dynamic orchestration of decision/action workflows in heterogeneous environments without losing control of state is still not possible. Data contextualization, modeling support, uncertainly handling, synchronization, and human-in-the-loop are just now becoming important issues. There is an emerging view of apps as code layers associated with application environments. Accessing and executing this view in the Cloud is just beginning now.

Standards will play key roles in addressing these technical issues by enabling (1) standards-based structure for apps and composite apps regardless of function; (2) composability at workflow level, customization at app parameter level, and functional abstraction; (3) co-existing commercial, open products/services, public/private resources, R&D software, and code certifications; and (4) open vendor agnostic architecture, open access, open marketplace, open data, and managed specification.

Successfully addressing all of the aforementioned challenges would enable (1) real-time, enterprise-wide, data analytics and asset optimization; (2) configurable modeling and data analysis; (3) scale-up of IT infrastructure across the entire supply base; (4) increased productivity and more efficient use of resources and suppliers; (5) sustained growth in manufacturing base.

3.2.2 Full-Cloud 3D CAD: An Open Platform For Faster Design and Manufacturing

Jon Hirschtick, Founder and Chairman, Onshape

Originally, three-dimensional (3D) CAD systems were architected with a single designer in mind. Their major output was CAD files written to the designer's local computer disk. Today, design is performed in global teams that are distributed, fragmented, and constantly changing. As a result, these original CAD systems, even with the aid of file management tools, are slowing down design. Problems include (1) difficulty locating the latest version of the design data; (2) locking and unlocking files for check in and check out restricted team productivity; and (3) exchanging files from one computer to another, even using the same CAD system, was expensive and time consuming.

A new generation of Cloud-based 3D CAD systems is envisioned to fix these problems. Everyone on the design team can work together using the full 3D CAD system on any browser, phone, or tablet. The single instance containing the CAD system data and the master CAD data resides in one place in the Cloud and is never copied anywhere. All users look at and edit the same data at the same time. The result is that teams can design products better and faster. And, perhaps they can even have more fun doing it.

Standards are needed to realize this vision. Such standards would include formats for design data exchange (for example: JT format), and standards for REST APIs and associated data in JSON, XML, or other text formats. The combination of full-Cloud 3D CAD with these standards would enable design teams to integrate and link complete, Cloud-based toolchains.

3.2.3 Executing Simulation Experiments on the Cloud

Dennis Pegden, CEO, Simio

Cloud computing provides a powerful new platform for running manufacturing software. For the first time, it is now possible to rapidly scale up to a large number of virtual processors on an as-needed basis. Manufacturing software applications that have a large number of parallel execution streams can exploit this capability to execute in a fraction of the time that would be normally required on a traditional, non-scalable platform.

One of the application areas that is particularly well suited for Cloud computing is simulation applied to both design and operation of manufacturing systems. In these applications, there is typically a need to run many different simulation scenarios, and also replicate each scenario many times using different random number streams. With Cloud computing, the entire simulation experiment can be run simultaneously across all scenarios and all replications. This means that the complete experiment can be run in the time that it would normally take to execute a single replication within the experiment.

This presentation discussed the application of Cloud computing to manufacturing simulation applications. Specifically, this presentation discussed the use of the Simio Portal for executing large-scale simulation experiments on the Microsoft Azure platform.

3.2.4 Introduction to MESA International

Jon Siudut, MESA International

MES independent software vendors (ISVs) face challenges of integration among disparate Cloud-solution providers whenever they interface with other MES providers. Ease of systems interface/integration is a big business opportunity and challenge. Reduction by 20% of integration cost may be possible.

The Open Cloud Opportunity consists of three major services: data, analysis, and authoring. Data services including storage and format translation. Analysis services include asynchronous statistical correlation. Authoring services can be applied to document and file viewers. However, the major technical issue remains: no current method exists to help automate the integration.

From the MES end-users perspective, integrating with external suppliers and their own IT business systems is still a major problems. Here, too, ease of systems interface/integration is a big business opportunity and challenge. Reduction by 20% of integration cost may be possible.

The Open Cloud Opportunity involves definition of supply-chain, and interface definitions based on standards such as Supply Chain Operations Reference (SCOR) model among systems. These interface definitions, however, must be augmented with supply-chain data exchanges needed for controlled communications tied to contracts between the supplier tiers. In addition, Identity Verification Services are needed to ensure person/machine authorization.

A role for standards could include leading interface-specification methods and tools to aid automation.

3.2.5 Discussion

Jim Davis took a very broad view of the Smart Manufacturing enterprise. In that view, the Smart Manufacturing enterprise is at the intersection of agile, demand-driven supply chains, sustainable and safe production, and plant-wide optimization. He stated the need and opportunity to reduce the cost of implementing modeling and simulation of Smart Manufacturing systems by 80%. He pointed that "micro-services" are a novel, potentially influential way to deliver manufacturing functions. The question was raised about whether these micro-services would be more prevalent in the Cloud of the future than monolithic applications. Jon Hirschtick stated the need for graphics software that runs well in the browser.

Dennis Pegden stated the need to drive Cloud computing as a new, scalable platform, which could make it easy to add and provide services to new manufacturing-software users. He also expressed the need for Cloud-based, 3D animation environments and for easy access to distributed model data. Matt Johnson stated a need to learn about the current state of standards for (1) representing distributed simulations for outsourced supply chains; (2) protocols for federating those simulations; and (3) managing the heterogeneity of data, models, and platforms.

Jon Siudut focused on issues facing MES ISVs and end users. He also introduced the concept of component-as-a-service (CaaS). In MESA's view, John stated, CaaS has the potential to revolutionize application design and delivery by allowing composition of functions and components to meet needs of the customers.

John Siudut pointed at the need for meta-data modeling and high-level process modeling, master data management and data definitions for the business process, and transactional data modeling – dropping transactions into the data and at different process levels.

3.3 Position Statements & Issues Identification – Session 3

The following table summarizes the presentations of the third session of the workshop.

Presenter Name, Company	Dave Noller, IBM	Gregory Harris, DoD	Shelley Gretlein, National Instruments	Chris Monchinski & Dan Trout, Automated Control Concepts	Kirk Smith, Intel
Present-ation Title	**Manufacturing in the Age of IoT and Cloud: Opportunity and Challenge**	**DMDII (Digital Manufacturing and Design Innovation Institute)**	**Industrial Internet of Things: The Opportunities and Challenges for Engineers and Scientists**	**Enabling Integration of Manufacturing Operations to the Cloud**	**Smart Manufacturing Architectures, Implementations, and the Internet of Things**
Vision	Cloud, Mobile, IoT for Manufacturing	Connected & Protected Digital Manufacturing Enterprise	IoT-Enabled Manufacturing Enterprise	Cloud-to-On-Premise Integration of Mfg Enterprise and Real Time Factory Floor	Integrated Solutions and Architectures for Smart Manufacturing and IoT
Perspective	Technology Provider	Government Agency and Manufacturing Enterprise	SW/HW Platform and Manufacturing Services Vendor	Manufacturing Standards Development Organization	Cloud Platform and Manufacturing Services Vendor

Key Issues	Role, management & life cycle of industry standards	Non-interoperable enterprise models for manufacturing software; infrastructure gap	Incomplete technical definitions and need for flexible networks of systems	Collaborations among industry groups and SDOs need to be ensured; knowledge management for effective integration; vendor adoption of integration standards	Security, device discovery & provisioning, data normalization, analytics infrastructure, new business model infrastructure

3.3.1 Manufacturing in the Age of IoT and Cloud: Opportunity and Challenge

Dave Noller, Manager, SWG Industrial Sector Strategy & Integration, IBM

The rapid advance of new applications and application-integration models, based on emerging technologies such as Cloud, Mobile, and IoT, presents manufacturing with new opportunities, but also presents new challenges. These technologies promise lowered support costs, accelerated deployment times, simplified creation of "composite applications" (such as those described formerly by Manufacturing 2.0 and now by Industry 4.0), and mobile communications. The challenges, on the other hand, include increasing dependence on technology provided and (in many cases) supported by others, security, and new models for application deployment and development.

The role of industry standards, both for the technology stack as well as for application interoperability, is morphing (by necessity) away from approaches such as Enterprise Application Integration (EAI) and Service-oriented Architecture (SOA).

Like other technology providers, IBM is evolving by developing and acquiring new technology to respond to the changing environment and needs. In the case of IBM, this evolution is based on a strategy of supporting and embracing open-source initiatives (e.g., Open Stack) and releasing products based on those technologies and initiatives. The next logical steps are (1) for vendors, standards organizations, and manufacturers to agree on what needs to be done to update the old notions of industry standards (such as OAGIS) and EAI, or even SOA; and (2) apply them to the new, composite, IoT-enabled applications being realized today in the Cloud.

3.3.2 DMDII (Digital Manufacturing and Design Innovation Institute)

Gregory Harris, Program Manager DMDII, DoD

We need a protected and connected digital enterprise, secure digital thread, secure enabling environment, including handheld devices that we use for multiple activities (similar to financial industry). The challenges we are facing include: (1) Lack of means enabling access and utilization of the unconnected systems in use today; (2) Lack of digital manufacturing business solutions; (3) Lack of platforms on which the digital manufacturing business solutions are hosted; and (4) Cyber security risks (both perceived and real) that keep manufacturers from trusting systems.

Benefits of addressing these challenges include: (1) New businesses will be created, including those providing manufacturing data analysis; (2) Reestablishment of the US industrial base as the world leader in efficient and agile manufacturing; (3) Restoration of a robust American middle class; and (4) Large savings from the efficient transfer of data between disparate systems.

Open Cloud opportunities include the following: (1) Open Cloud allows disruption to occur in manufacturing industry with "apps." In the future, manufacturing software solutions will be small, inexpensive, and user-friendly; (2) Interoperability issues can be addressed broadly instead of on a point-solution basis; (3) Access to tools and capabilities that the Small and Medium Enterprises do not have access to today; (4) Opportunity for Supply Chain growth through collaboration tools; and (5) Enabling plug-and-play digital functionality across the entire digital thread.

Technical issues that need to be addressed include: (1) Enterprise models for manufacturing software are proprietary and not interoperable; (2) Methods ensuring that credentialed identification is accessible, transferrable, and retrievable; (3) From a government perspective, there is a serious infrastructure gap, particularly with the Organic Industrial Base; and (4) Processes and procedures to reuse data in multiple points throughout the life cycle of a system.

Roles of standards are the following: (1) Standards are necessary to bring order to the Wild, Wild, West of Digital Manufacturing and Design that we are experiencing today; and (2) There are gaps and overlaps in standards today that must be bridged and harmonized to bring about interoperability and ease of function for efficient data exchange.

3.3.3 Industrial Internet of Things (IIOT): The Opportunities and Challenges for Engineers and Scientists

Shelley Gretlein, Director Product Marketing, Platform Software & Customer Education, National Instruments

The IIoT concept implies a vast number of connected industrial systems that are communicating and coordinating their data analytics and decision-making to improve industrial performance and benefit society as a whole. Applying this concept to factories and machines will facilitate new solutions to production and logistics problems in ways that were previously inconceivable, thereby improving and increasing innovation considerably.

However, as innovation grows, so does the complexity. This means that implementing the IIoT concept will spawn new challenges that no company can address on its own. For example, IIoT adds strict requirements to its local networks for latency, determinism, and bandwidth. At the machine level, such requirements are necessary because precision machines can fail if the timing of communications is off even by a millisecond. At the supply-chain level, timing is rarely a serious problem, but security is a problem of paramount importance. Global communication networks link supply chain partners, often over vast geographical distances. IIoT systems use these networks to transmit vital information among those partners. Maintaining security is difficult because these systems need to be continually modified and maintained to meet ever-changing functionality and system-maintenance requirements. As more capabilities are added, new security needs can arise. This means that IIOT systems have to be tracked routinely to ensure that they meet those needs.

Open Cloud presents a way forward that involves a platform-based approach. This approach is based on a single, flexible, hardware architecture that is deployed across many applications. This architecture removes a substantial amount of hardware complexity and it makes security and update problems primarily software challenges.

The only way to meet the needs of today and tomorrow is by deploying a network of systems flexible enough to evolve and adapt. The ongoing design of the IIoT represents a massive business and technology opportunity. Engineers and scientists are already implementing systems on the leading edge of the IIoT, but many things still need to be defined and much work needs to be done.

3.3.4 Enabling Integration of Manufacturing Operations to the Cloud

Chris Monchinski & Dan Trout, Automated Control Concepts

Integration between Level 4 Systems and Real Time Factory Floor Automation is being made possible with ISA 95 *Cloud-to-On-Premise Integration of Manufacturing Enterprise and Real Time Factory Floor.*

Four major business challenges make this integration difficult. First, integrating new, Cloud-based, hybrid architectures is increasingly challenging. Security, protection of intellectual property, customer data, and system robustness are all of paramount importance. Second, manufacturers are adopting business-level systems that are increasingly moving toward Cloud-based architectures (software-as-a-service, software rentals, third party contracts and off-site systems). Third, manufacturing systems and IT assets remain fixed assets with real-time requirements (near zero latency) and high availability. Fourth, evolving adoption of “Two-Tiered” systems requires both Cloud-based and locally hosted solutions increasing integration demands.

Business benefits of addressing the challenges will accrue to both Cloud providers and Cloud users. Reducing the risk and cost of integration between Cloud-based assets and fixed assets will benefit both providers and users. Reduced asset costs, increased flexibility, increased reliability, and robust security are all benefits to users. Without the Cloud, typical software projects took 1-2 years and had success rates under 50 %. Using Cloud, typical software projects take 2 months to 4 months and have greater than 90 % success rates.

Standards such as ISA 95 (Control to Enterprise Integration) are facilitators that will allow manufacturers to "plug in" to business-based systems hosted in the Cloud. As such, ISA95 will enable flexible integration and collaboration, both of which will reduce risk and increase speed of implementation and adoption rates of Cloud-based technologies. Finally, ISA 95 provides models and definitions of application boundaries based on function. This allows architects to define hybrid systems using Cloud and fixed-asset systems, as necessary.

To enable standards to fulfil their facilitator role, national and international standards groups need to continue to collaborate and present a unified voice to manufacturers and to platform and service vendors. Once new standards are developed, it is necessary to demonstrate that they actually do enable integration. In addition, the experience gained from these demonstrations must then turn into toolkits, guidelines, best practices, and industry-specific technical reports. Collectively, they will be "key" to facilitating flexible integration strategies that enable manufacturing assets to leverage Cloud technology. Adoption by vendors of integration standards will be a key to reducing risks associated with interoperability among enterprise service vendors.

Here are a few examples. The guidelines and practices outlined in ISA 99 / 62443 will facilitate "integrated" security and best practices for robust integration. ISA 95 / 62264 helps system architects define logical boundaries between systems. This allows manufacturing systems to integrate with Cloud-based systems, thereby exchanging data reliability and securely. B2MML (Business to Manufacturing Markup Language) is an open-source initiative maintained by MESA and is an instantiation of the ISA 95 standard in XML and the Web Services Description Language (WSDL).

3.3.5 Smart Manufacturing Architectures, Implementations, and the Internet of Things

Kirk Smith, Solutions Architect, Industrial and Energy Solutions Division, IoT Group, Intel

Manufacturing has entered the big-data era, with potential access to more information that can be used to increase throughput, boost yields, improve efficiency, and reduce downtime. But for many manufacturers, machine tools and processing areas operate in relative silos, without such access. So, it is still a major challenge to collect, analyze, and act on data generated across the factory floor. IoT is expected to address this challenge.

Enabling IoT for industrial environments requires integrated solutions and architectures that address a number of key issues, including security, automation, normalization, analytics, and infrastructure. World-class security is the foundation for connectivity and traversal of manufacturing and enterprise-service-bus domains. Methods to automate discovery and provisioning of edge devices will ease deployment and management of devices integrated into an IoT architecture. Data normalization, through protocol abstraction, is needed to improve interoperability across Sensor-to-Cloud pathways. Broad analytics infrastructure from Edge-to-Cloud is needed to gain actionable insights and scale quality-of-service across factory, enterprise, and Cloud networks. Infrastructure to monetize hardware, software, and data management from Edge-to-Cloud will enable new, and extend existing, business models.

On-Premise, off-premise, and hybrid solutions will need to extend the levels of interoperability of today's co-mingled architectures to realize longer term value propositions. In this presentation, we discussed the current areas of focus for bringing IoT Platforms to reality across System Integrator and ODM/OEM supplier landscapes. We also discussed the issues of immediate focus that warrant increased levels of attention by industry.

3.3.6 Discussion

Discussion included the topic of bandwidth availability and need to study its impact on the manufacturing Cloud. Also, Dave Noller discussed three possible roles for NIST: to help understand why standards are often not adopted, to develop easier-to-use standards, and come up with light-weight APIs like MQTT and JSON. To adopt new technology such as IOT and Cloud manufacturing, open standards for real interoperability are needed. However, the problem is not the lack of such standards. In fact, there are many existing vertical and horizontal integration standards. Two questions arise, according to Dave: Are these standards adequate for the new technologies? If so, what holds us back from adopting them? A deep analysis is necessary. Also, he stated that MES tends to be trying to act as the vertical integration layer today, but is not well suited to "out of the box" integration needed to support "Industry 4.0" type initiatives. It would be easier if it could be treated as a set of capabilities easily integrated through APIs (services).

Greg Harris suggested that the link between design and manufacturing is still broken, despite years of standards development aimed at forging that link. Often in practice, we need to deal with loss of data, which means it must be recreated. Worse, key data is often not even captured. From DoD's perspective, if it is not explicitly written into a contract, the data is not provided. Even if it is in contract, we frequently don't know how to use it. Manufacturing software exist in silos right now. Product qualification methods are problematic.

Shelley Gretlein pointed at the need for light-weight APIs and light-weight standards for timing. Chris Monchinski and Dan Trout stated it is not clear if and how much of MES functionality should be moved into the Cloud.

Kirk Smith pointed at challenges of collecting, analyzing, integrating, and acting on data generated across the factory floor. One such approach was Software Defined Data Analytics, which may include plug-and-play devices. Another topic was the kind of gateway/communication standards needed to connect the various levels of ISA 95 to Clouds. Kirk also pointed at the need to simplify network traversal across Manufacturing Service Bus (MSB) and Enterprise Service Bus (ESB) network architectures. Also, he stated importance of improving co-existence of near-real-time (NRT) and real-time (RT) networks.

4 Issue Identification and Prioritization

In this section we presents results of the voting that identified top issues considered most challenging or urgent by the participants.

4.1 Top Issues

Participants identified a number of significant issues in their presentations. (Appendix A enumerates these issues.) The following table shows results of the voting on top issues by the participants.

Issue Rank	Technical Issue Description	Proposing Organization
1	There are gaps and overlaps in standards today that must be bridged and harmonized to bring about interoperability and ease of function for efficient data exchange	DoD
2-3	Take a hard look at what is inhibiting adoption of standards today	IBM
2-3	Establish working group for the definition of new nouns/BODs	E2open
4	Semantics and analytics to ensure that only relevant data are collected from devices to generate business events	Trisotech
5	Vendors to create standards-based APIs/application adapters	LOL
6	Simplify network traversal across MSB and ESB network architectures. Improve co-existence of NRT and RT network processing	Intel
7	Cloud-based manufacturing solution providers should agree upon several conditions	Oracle
8-12	Interoperability Test Bed	LOL
8-12	Data contextualization, modeling support, uncertainty handling, synchronization, human in the loop	UCLA & SMLC
8-12	Composability at workflow level; customization at app parameter level; functional abstraction	UCLA & SMLC
8-12	MES tends to be trying to act as the vertical integration layer today	IBM
8-12	Adoption by vendors of integration standards	Automated Control Concepts

4.2 Discussion

Scott Nieman stated that the overlap among standards causes confusion with vendors on exactly where to invest money by implementing specific standards. Denis Gagne suggested that NIST might support standards analysis and capability identification effort as an unbiased party. Dave Noller agreed it would be useful to identify overlaps and gaps in existing standards. Mike Rowell suggested that Dave Noller's graph showing overlaps among standards may be useful for an analysis of standard overlaps and capabilities. Chris Monchinski noted that NIST could be gathering industry representatives together to analyze and address the current state of standards. Matt Johnson pointed out that there are reference models defining capabilities that can be used for standards gap analysis.

Yan Lu pointed out that NIST is working on a landscape of standards relevant to Smart Manufacturing and will publish a report to document this landscape. NIST is planning to get input from SDOs about use of the standards. Denis Gagne mentioned this would be interesting for the quality standards adoption. Scott asked whether this would be a living document? Serm Kulvatunyou also added that NIST has another document analyzing standards for digital manufacturing (factory planning).

Scott Neiman pointed at the need for manufacturers to have means to capture overarching business process models. He asked whether we should reuse certain capabilities in existing standards or should we start afresh from specs. Also, he noticed that security has not been captured among the issues and was wondering why that was the case.

Matt Johnson suggested that the community could invite vendors to talk about how they use standards, and to identify many variations that are taking place in manufacturing. He identified the need to understand better Cloud impact on manufacturing standards. Greg Harris agreed that we need to engage vendors in identifying ways to fix the issues with standards adoption for manufacturing. Scott Neiman wants to get a better understanding regarding what it takes to move into the Cloud. Matt Johnson suggested that, if we assume there are half a dozen Cloud manufacturing systems implementers, it would be feasible to see what the vendors provide in standards-based capabilities and what they provide for manufacturers to have Cloud presence.

5 Conclusions

The Cloud-enabled technological advances present an unprecedented opportunity as well as new, very significant challenges to the manufacturing community on its way to achieving Smart Manufacturing systems. This OAGi/NIST Open Cloud Architectures for Smart Manufacturing workshop brought a variety of organizations from public and private industry sectors to identify, discuss, and prioritize these challenges. Speakers included manufacturers, enterprise architects, integration architects, strategists, system developers, and researchers. The following are key conclusions that emerged from the workshop.

1. Existing standards are inadequate to enable the Cloud-based services needed for Smart Manufacturing

The state of standards for Smart Manufacturing is not ideal, to say the least. Greg Harris stated that gaps and overlaps in standards today must be bridged and harmonized to bring about interoperability and ease of function for efficient data exchange (3.3.2). Denis Gagne pointed that a critical area where advances are needed involves capturing standards semantics and analytics to ensure only relevant data are collected (3.1.4). Jim Davis pointed that composability at the workflow level, customization at the app parameter level, and functional abstraction will need to be enabled by standards for Smart Manufacturing (3.2.1). Dave Noller asked for a deeper analysis to find out whether current standards are adequate for the new technologies and, if so, what holds us back from adopting them (3.3.6). Matt Johnson and Pawan Joshi asserted a need to find about the current state of standards for (1) representing distributed simulations for outsourced supply chains; (2) protocols for federating those simulations; and (3) managing the heterogeneity of data, models, and platforms (3.2.5). Shelley Gretlein pointed at the need for light-weight APIs and light-weight standards for timing (3.3.6).

2. Standards adoption is severely impeded by confusion, complexity, and the lack of efficient tools

Many participants emphasized the importance of adoption and use of standards by ISVs who develop their applications and services for Smart Manufacturing systems. Scott Nieman pointed that standardized “contract-first” APIs, such as OAGIS and B2MML, should be adopted by ISVs (3.1.1). Chris Monchinski and Dan Trout stated that adoption by vendors of integration standards will be a key to reducing risks to interoperability among enterprise service vendors (3.3.4). Matt Johnson pointed that a key to standards adoption is that the Cloud-based-manufacturing service providers agree upon (1) messages for coordinating onboarding and profile management among their client communities; (2) a B2B messaging standard (OAGIS) that all B2B service providers can support; and (3) standard message choreographies based upon BPMN notation for contract manufacturing (3.1.2). Pawan Joshi asserted that MES vendors typically do not use interoperability standards, instead, they use proprietary flat files specific to the vendor. He made the point that a new, collaborative initiative could be started to enable the MES vendors to know about and use the required integration capabilities out of the box (3.1.5).

3. We need new architectures to enable service-oriented Smart Manufacturing

Presentations and discussions identified a number of challenges and gaps in the knowledge within the manufacturing community for architecting Smart Manufacturing systems. Dave Noller stated that manufacturing execution systems (MES) tend to be trying to act as the vertical integration layer today, but is not well suited to "out of the box" integration needed to support "Industry 4.0" type initiatives (3.3.6). Jim Davis states that synchronization and human-in-the-loop are just now becoming important architecture issues (3.2.1). Matt Johnson stated that current practice in supply-chain visibility is largely based on dated solutions, including portals and spreadsheets (3.1.5). Jim Davis pointed to "micro-services" as a novel, potentially influential way to deliver manufacturing functions, which needs to be explored further (3.2.5). CaaS architecture style has the potential to revolutionize application design and delivery by allowing composition of functions and components to meet needs of the customers (3.2.5). Chris Monchinski and Dan Trout pointed at the need for research in Smart Manufacturing since it is not clear if and how much of MES functionality should be moved into the Cloud (3.3.6)

4. We need new standards development and standards management processes to support the rapid evolution of Smart Manufacturing

Presentations and discussions at the workshop pointed that current standards development and management processes are inadequate for enabling the desired agility, flexibility, and capabilities of Smart Manufacturing systems. Pawan Joshi points out that standards development organizations, such as OAGi, should establish working groups for definitions of new nouns/BODs and revisit these nouns for their applicability in the Smart Manufacturing era (3.1.3). Jim Davis stated that data contextualization, modeling support, and uncertainly handling are just now becoming important issues to take into account in standards development (3.2.1). Scott Neiman proposed that to demonstrate benefits of Cloud solutions for Smart Manufacturing, an open, integration test bed should be developed. As part of that testbed, methods and measurement tools should be developed as a basis for either a self-certification or third-party-certification process (3.1.1). Scott Nieman pointed it was easy to model "the happy path" of process execution but much harder to model "the unhappy paths" of which there are many (3.1.5). Denis Gagne pointed at CMMN, which is a sibling of BPMN, to address and handle exceptions to the "happy path" (3.1.5). Pawan Joshi stated that business processes that orchestrate smart devices will not be prescriptive. Rather they must be abstract, parametrized, and flexible, and they must also allow for real-time monitoring and reactive system behavior (3.1.5). Jim Davis stated the need and opportunity to reduce cost of implementing modeling and simulation of Smart Manufacturing systems by 80% (3.2.5). John Siudut pointed at the need for meta-data modeling and high-level process modeling, master data management and data definitions for the business process, and transactional data modeling (3.2.5).

5. Cloud platforms can provide the infrastructure needed to implement Smart Manufacturing Enterprises, but challenges remain

Cloud platforms need to ensure that the Smart Manufacturing systems requirements can be met. Dennis Pegden asserted the need to drive Cloud computing as a new, scalable platform, which could make it easy to add and provide services to new manufacturing-software users. He also expressed the need for Cloud-based, 3D animation environments and for easy access to distributed model data (3.2.5). Jon Hirschtick stated the need for graphics software that runs well in the browser (3.2.5). Kirk Smith pointed at challenges of collecting, analyzing, integrating, and acting on data generated across the factory floor. He also pointed to the need to simplify network traversal across MSB and ESB network architectures, as well as to improve co-existence of NRT and RT networks (3.3.6).

Appendix A – Issues identified by the workshop participants

The following table summarizes the issues identified by the presenters in their submissions, which were provided as input for the voting process to identify top priority issues.

No.	Technical Issue Description	Proposing Organization
1	Vendors to create standards-based APIs/application adapters	LOL
2	Pushing API Gateway capabilities to a more federated IoT model is extremely challenging	LOL
3	Interoperability Test Bed	LOL
4	Independent companies still use different solutions in-house	Oracle
5	Cloud-based manufacturing solution providers should agree upon several conditions	Oracle
6	N/A	OAGi
7	Feedback on fit/non-fit with your architecture	E2open
8	Semantics and analytics to ensure that only relevant data are collected from devices to generate business events	Trisotech
9	Robustness of connectivity to ensure relevant business events are provided	Trisotech
10	Ontologies of IoT sensor and actuator data so we can reason over the provided events	Trisotech
11	Dynamic orchestration of decision/action workflows in heterogeneous environments without losing control of state	UCLA & SMLC
12	Data contextualization, modeling support, uncertainty handling, synchronization, human in the loop	UCLA & SMLC
13	Apps as code layers associated with application environments accessed and executed in the Cloud	UCLA & SMLC
14	Strong data ownership, security and cyberattack protocols, managed community sharing and marketplace	UCLA & SMLC
15	Standards based structure for apps and composite apps regardless of function	UCLA & SMLC
16	Composability at workflow level; customization at app parameter level; functional abstraction	UCLA & SMLC
17	Co-existing commercial, open products/services, public/private resources, R&D software, code certifications	UCLA & SMLC
18	Open vendor agnostic architecture, open access, open marketplace, open data, managed specification	UCLA & SMLC
19	Lack of solutions to ensure compatibility and enable complete design and manufacturing ecosystem	Onshape

20	Standards would include formats for data that could be imported and exported with the Cloud system (example: JT format), and standards for REST APIs and associated data in JSON, XML, or other text formats	Onshape
21	The combination of full-Cloud 3D CAD plus these standards would let design and manufacturing teams integrate and link complete Cloud-based toolchains	Onshape
22	Data Integration	Simio
23	No current method to help automate integration	MESA International
24	Supply Chain Data Exchanges for controlled communications tied to contracts between the supplier tiers	MESA International
25	Identity Verification Services to ensure person/machine authorization	MESA International
26	Lead interface specification methods	MESA International
27	Solutions enabling layered, distributed architecture	MESA International
28	Identify the issue places along the digital thread, integration standards	MESA International
29	Interoperability standards are still not widely adopted, so “mapping” still has to occur somewhere and is difficult	IBM
30	Interoperability standards today are “heavy”, and do not lend themselves to easy usage for “agile” creation of applications (e.g., for mobile) in the “integration Cloud”	IBM
31	MES tends to be trying to act as the vertical integration layer today	IBM
32	Take a hard look at what is inhibiting adoption today, and so on	IBM
33	Enterprise model for manufacturing software is proprietary and not interoperable	DoD
34	Methods ensuring that credentialed identification is accessible, transferrable and retrievable	DoD
35	From a government perspective, there is a serious infrastructure gap, particularly with the Organic Industrial Base	DoD
36	Processes and procedures to reuse data at multiple points throughout the life cycle of a system	DoD
37	Standards are necessary to bring order to the Wild, Wild, West of Digital Manufacturing and Design that we are experiencing today	DoD
38	There are gaps and overlaps in standards today that must be bridged and harmonized to bring about interoperability and ease of function for efficient data exchange	DoD
39	N/A	National Instruments

40	Collaboration with several industry-specific standard groups has facilitated adoption of ISA 95 in a wide variety of industries	Automated Control Concepts
41	National and International Standards groups need to continue to collaborate and present a unified voice to the manufacture and software/service vendors	Automated Control Concepts
42	The ability to leverage the standards and models	Automated Control Concepts
43	Adoption by vendors of integration standards	Automated Control Concepts
44	Promotion and adoption of practices outlined in the ISA 99 / 62443 standard	Automated Control Concepts
45	The ISA 95 / 62264 Control to Enterprise Integration standard helps system architects define logical boundaries between systems	Automated Control Concepts
46	B2MML (Business to Manufacturing Markup Language is an open source initiative maintained by MESA and is an instantiation of the ISA 95 standard in XML and WSDL	Automated Control Concepts
47	Facilitate best practices and increase manufacturing "nimbleness"	Automated Control Concepts
48	Ease/cost of accessing proprietary networks	Intel
49	Protocol abstraction or translation for IoT use cases	Intel
50	Expertise, legacy components, engineering expense	Intel
51	Connect one-way to hardware roots of trust at both ends of the wire	Intel
52	Long timelines likely for system and network migration	Intel
53	Simplify network traversal across MSB and ESB network architectures. Improve co-existence of NRT and RT network processing	Intel
54	Remote connectivity, data normalization, model, interoperability, maintenance models	Intel
55	Improve interoperability and scalable access to analytics at the edge and Cloud for E2E systems	Intel
56	Establish working group for the definition of new nouns/BODs	E2open

Appendix B – Complete Presentations by Workshop Participants

LAND O'LAKES, INC.

Moo-ving to the Cloud - LIMS and Process Control System Integration Challenges and Opportunities

Scott Nieman
Enterprise Integration Architect

Agenda

- Introduction to Land O'Lakes
- Integration Challenges
- LIMS Model
- MES Process Control Models
- Opportunity to move to the Cloud
- Challenges to overcome
- Top Priorities

 LAND O'LAKES, INC.

Land O'Lakes, Inc. today

- ~**10,000** employees
- **3,200** direct producer-members and **1,000** member-cooperatives
- Serve +**300,000** agricultural producers
- **300+** facilities in the U.S.
- **3** diversified businesses
- Annual revenue **+$14 billion**
- Goal to **double revenues and increase international growth** in the next 10 years

 LAND O'LAKES, INC.

An operating company with three diversified businesses

LAND O'LAKES, INC.

Agriculture services, crop inputs | Animal nutrition and feed | Dairy foods

WINFIELD | PURINA | LAND O LAKES

 LAND O'LAKES, INC.

File-based integration challenges

- Unique, proprietary formats increase implementation costs
- Extremely prevalent
- Manually interaction by personnel; very error prone
- Polling for files requires trigger (watch) files to ensure data file completeness
- Folder change events (trapping OS callback interfaces) across WAN is very inconsistent
- Considered "Anti-pattern #1" at Land O'Lakes

 LAND O'LAKES, INC.

'Code-First' Web Services Challenges

- Code-First interfaces are web services (SOAP/ REST) that reflect low level implementation (interface) classes
- Often very chatty
- Current LIMS vendor's API requires 27 round-trips just to integrate one TestMaster 'transaction'; compensatory approach also required
- Process Control System vendor implements OData / REST but exposes internal 'entity' model; each software build to address work-center needs required middleware code changes, retest, and redeployment
- Unique, proprietary formats increase implementation costs
- *Fastest way* to achieve N-Square integration problem (Anti-pattern #2)

 LAND O'LAKES, INC.

‘Contract-First’ Standards-Based APIs

- Presents an opportunity to insulate internal code changes from middleware; APIs do not change
- Requires vendor to expose OAGIS or B2MML based web services
- Requires vendor to provide implementation guidelines, specifically how to map data to API
- Reduces complexity of middleware to pure messaging
- Improved lifecycle / governance; e.g., more controlled upgrade path to newer release of standard

 LAND O'LAKES, INC.

Standards-Based APIs: Current Challenges

- Large documents: kitchen-sink, need the ability to quickly define subsets (contextual); CAM and GEFEG are options
- Semantics sometimes unclear; generic terms aim to solve multiple use cases; even documentation loosely defined
- Lack of real life implementation guidelines describing specific use cases, including data mapping examples
- Lack of vendor support; ideally these are their application APIs
- Lack of vendor mappings from internal APIs to standards
- Implementations ‘bake-in’ specific version of standard

 LAND O'LAKES, INC.

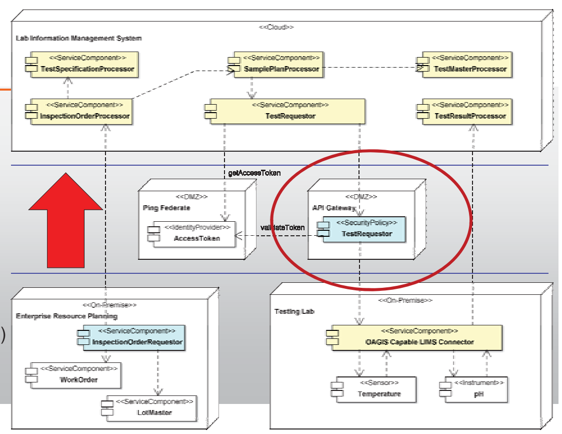
MES/ LIMS Cloud Opportunities

- Reduced footprint in corporate data center
- Multi-tenancy
- Ability to take software patches if no customizations
- Distributed, granular capabilities across multiple cloud providers
- Cloud to Cloud integration when opportunity presents itself
- Cloud vendor may offer responsibility to certify specific equipment, process control systems
- ‘Pay-as-you-go’ model for Small Manufacturers, who could not afford large ERP implementation

 LAND O'LAKES, INC.

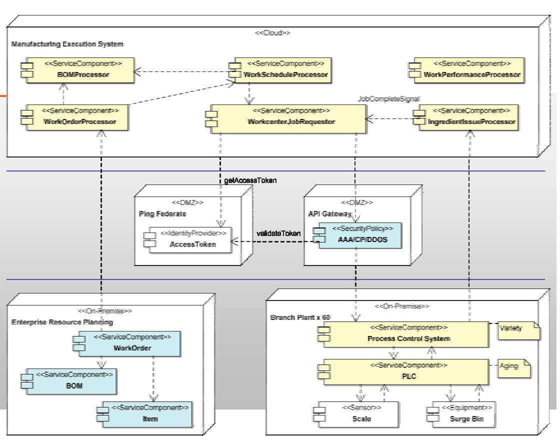
LIMS in the Cloud

- Standards-based LIMS APIs
- Requires use of API Gateway
  - AuthN, AuthZ, Audit (AAA)
  - Content Protection (CP)
  - Distributed Denial of Service (DDOS)



MES in the Cloud

- Similar Cloud Architecture
- Most complex integrations
- Requires use of API Gateway
- Equipment Capabilities vary significantly
- JDE Shop Floor reduced our footprint

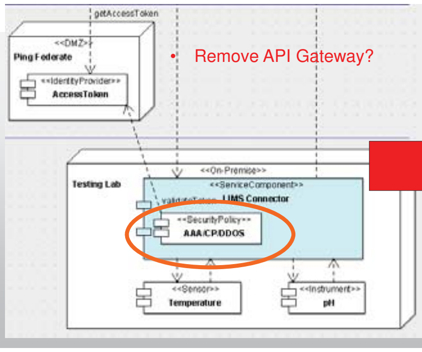


Cloud Challenge

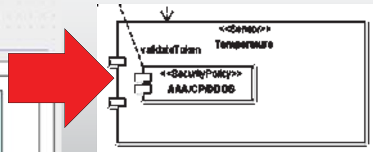
- Connectivity to/from trusted zone (green zone)
  - Some plants are in remote rural areas; limited bandwidth and redundancy
  - File transfer based approaches are painful; folder change events, polling
- API Gateways provide trusted access from Cloud to On-Premise
  - Authentication, Authorization, and Audit (AAA) required but aging systems have old security protocols (NTLM, Kerberos)
  - Content Protection; large files, embedded scripts; distributed denial of service (DDOS)
  - Technical capability may be best served using a distributed model
- Internet of Things model with localized API Gateway capabilities
- OpenID Connect Client Discovery specification could enable new equipment configuration and establish trust as ‘service provider’

 LAND O'LAKES, INC.

Evolution to the Internet of Things



- Remove API Gateway?



Push to device?
Can we realistically put CP and DDOS capabilities in a sensor?

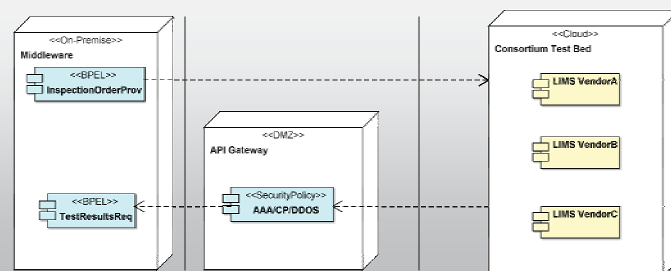
Treating Instruments /Equipment as a Printer

- Need more modern equipment configuration capabilities
- Plug-in model required
- Standard APIs for binding
- Auto-Discovery of Equipment
  - Metadata tags about the equipment and version of embedded system software
  - Equipment capabilities via reference URIs
- Auto-Configuration; wizard-approach to configure endpoints (Cloud URIs, On-prem UNC paths, etc.)

Test Bed Opportunity

- Integration Simulation
  - Send InspectionOrder, receive simulated TestResults
  - Send Work order, receive signal that work-center job is complete, and receive simulated Ingredient issued messages
- Product Certification similar to Drummond Group
- Inter-operability tests for Basic Profile and Optional Profiles
- Customers could swap equipment out without significant work

Test Bed Inter-operability Platform



Priority of technical issues to address

- Vendors to create standards-based APIs/application adapters
  - All business application vendors; MES, LIMS, Process Control, ERP
  - Provide Implementation Guidelines that reflect functional capabilities
  - Concern: vendor reliance on Professional Services revenue impedes progress
- Standard metadata for instrument/device discovery and configuration
- Pushing API Gateway capabilities to a more federate Internet of Things model is extremely challenging
  - Choice of silicon chips or SSD
  - Option must include attack prevention updates
- Inter-operability Test Bed

Thanks!

Enabling Contract Manufacturing in the Cloud

Open Cloud Architectures for Smart Manufacturing Workshop
National Institute of Standards and Technology

May 5, 2015

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions.

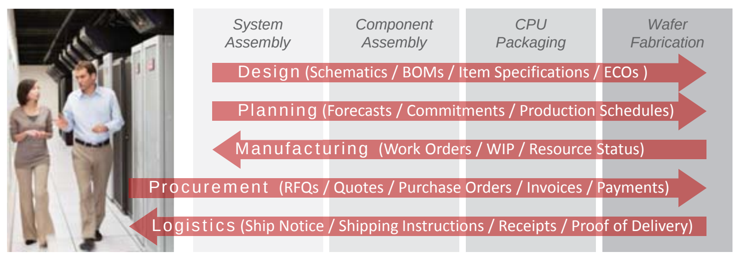
The development, release, and timing of any features or functionality described for Oracle's products remains at the sole discretion of Oracle.

Today's distributed supply chains increase demands on B2B

Example: Delivering Oracle SuperClusters to our customers

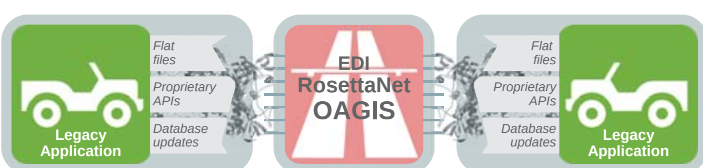
Today's distributed supply chains increase demands on B2B

Collaboration and visibility crosses multiple supply chain tiers



Challenge

Communications among partners are intermittent and non-standardized, resulting in greater supply volatility and longer manufacturing cycle times

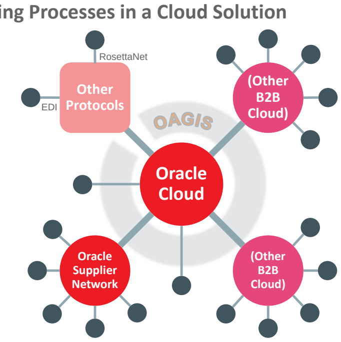


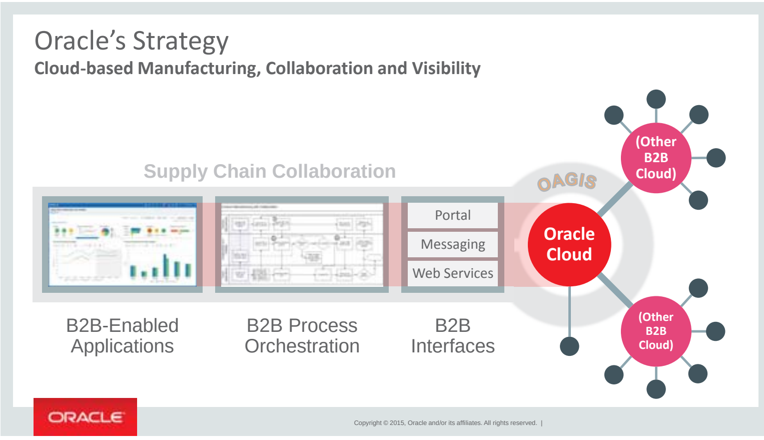
Typical Enterprise | B2B Integration | Typical Enterprise

The Opportunity

Unify Internal and Contract Manufacturing Processes in a Cloud Solution

- Design next-generation applications around B2B best practices
- Coordinate B2B transactions with a common process framework
- Streamline supplier onboarding and communication with B2B service providers
- Offer a world-class user experience to external partners




Oracle's Strategy
Cloud-based Manufacturing, Collaboration and Visibility
Supply Chain Collaboration
OAGIS
(Other B2B Cloud)
Portal
Messaging
Web Services
Oracle Cloud
(Other B2B Cloud)
B2B-Enabled Applications
B2B Process Orchestration
B2B Interfaces
ORACLE
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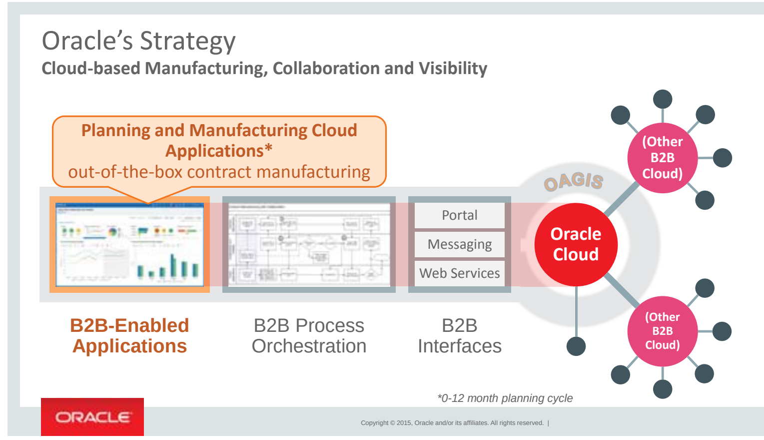
Oracle's Strategy
Cloud-based Manufacturing, Collaboration and Visibility
Planning and Manufacturing Cloud Applications*
out-of-the-box contract manufacturing
OAGIS
(Other B2B Cloud)
Portal
Messaging
Web Services
Oracle Cloud
(Other B2B Cloud)
B2B-Enabled Applications
B2B Process Orchestration
B2B Interfaces
*0-12 month planning cycle
ORACLE
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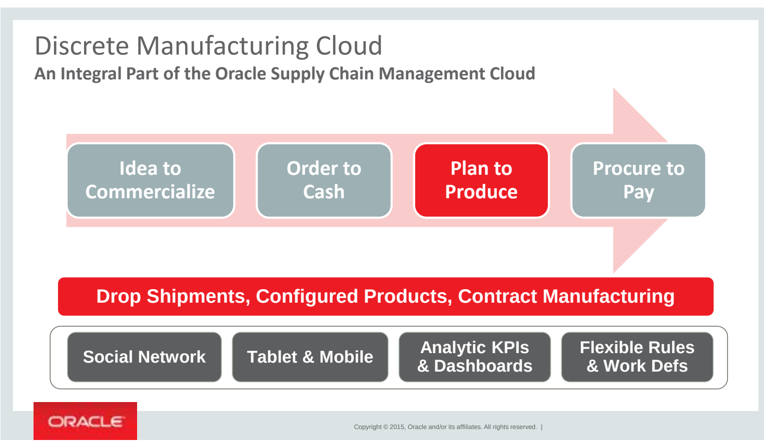
Discrete Manufacturing Cloud
An Integral Part of the Oracle Supply Chain Management Cloud
Idea to Commercialize
Order to Cash
Plan to Produce
Procure to Pay
Drop Shipments, Configured Products, Contract Manufacturing
Social Network
Tablet & Mobile
Analytic KPIs & Dashboards
Flexible Rules & Work Defs
ORACLE
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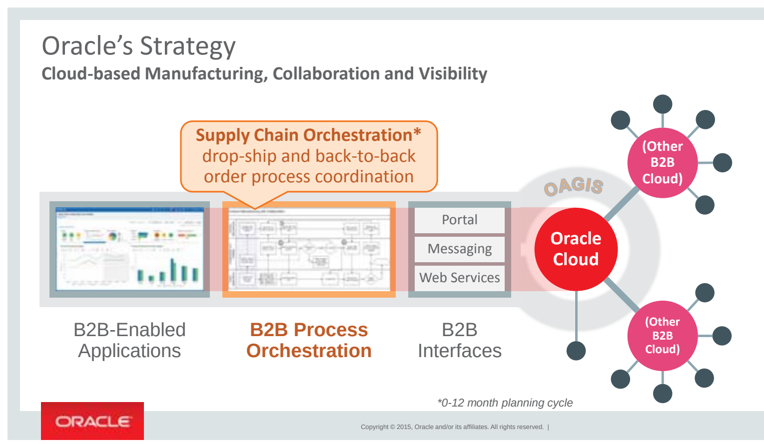
Oracle's Strategy
Cloud-based Manufacturing, Collaboration and Visibility
Supply Chain Orchestration*
drop-ship and back-to-back
order process coordination
OAGIS
(Other B2B Cloud)
Portal
Messaging
Web Services
Oracle Cloud
(Other B2B Cloud)
B2B-Enabled Applications
B2B Process Orchestration
B2B Interfaces
*0-12 month planning cycle
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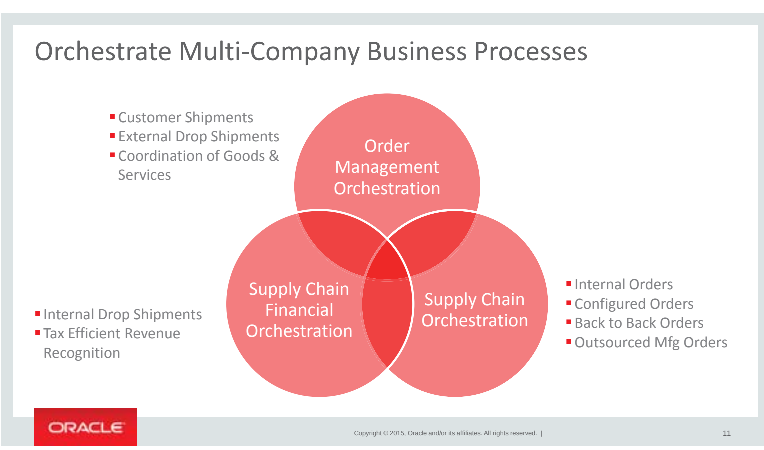
Orchestrate Multi-Company Business Processes
Customer Shipments
External Drop Shipments
Coordination of Goods & Services
Order Management Orchestration
Supply Chain Financial Orchestration
Supply Chain Orchestration
Internal Drop Shipments
Tax Efficient Revenue Recognition
Internal Orders
Configured Orders
Back to Back Orders
Outsourced Mfg Orders
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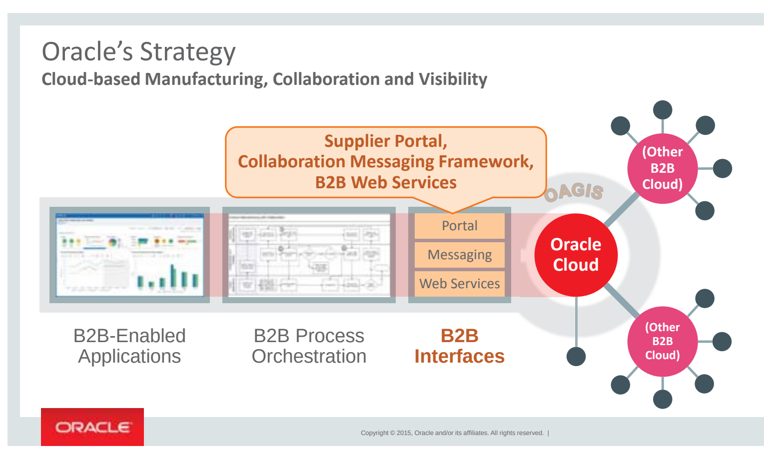
Oracle's Strategy
Cloud-based Manufacturing, Collaboration and Visibility
Supplier Portal,
Collaboration Messaging Framework,
B2B Web Services
OAGIS
(Other B2B Cloud)
Portal
Messaging
Web Services
Oracle Cloud
(Other B2B Cloud)
B2B-Enabled Applications
B2B Process Orchestration
B2B Interfaces
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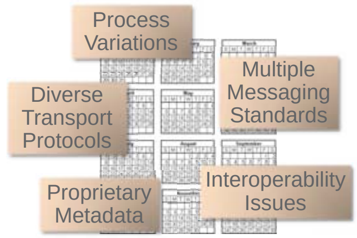
Technical Issue

Expectations vs. Reality of Cloud-Based B2B Solutions

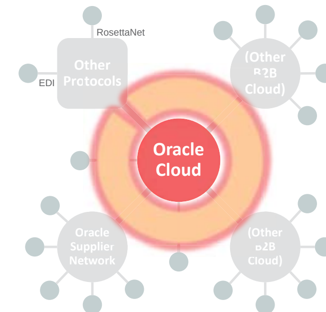
Expectation



Reality

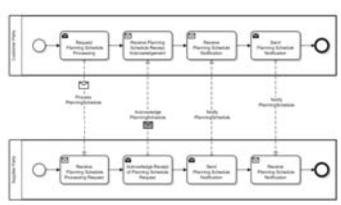
Standards Opportunities for Cloud Service Providers

1) Messages to coordinate onboarding and profile management among client communities
2) A common B2B messaging standard (OAGIS) that all B2B service providers can support
3) Standard BPMN-based contract manufacturing message choreographies



Focus Point: B2B Process Choreographies

- Potential to expand BPMN examples into standard template processes for the industry
- The Smart Manufacturing Working Group may elaborate scenarios (buy-sell collaboration, WIP tracking, etc.)



Manufacturing Use Case (A Need Description)	*Contract manufacturing:* Cloud-based manufacturing solutions need to accommodate contract manufacturers and third party logistics providers as part of an end-to-end process.
Business Challenge	A significant number of high tech companies employ contract manufacturers and 3rd party logistics providers to produce and deliver their products, yet communications among these partners are intermittent and non-standardized, resulting in greater supply volatility and longer manufacturing cycle times.
Business Benefit of addressing challenge	Unknown, but even a small improvement in the cycle time or reliability of 3rd party processes would have an enormous impact.
Open Cloud Opportunity	Cloud solutions offer a way for trading partners to access a consolidated set of manufacturing application features on a uniform platform, eliminating many of the functional gaps and variations the parties faced in the past.
Technical issues & Initiatives	*Issue:* Independent companies still use different solutions in-house, which 1) communicate using a variety of methods and message standards, and 2) implement manufacturing and logistics processes with variations in the number and sequence of steps. *Initiative:* Companies use cloud service providers to communicate more efficiently with contract manufacturers via flexible, standards-based connectors.
Standards Role	Cloud-based manufacturing solution providers should agree upon: 1) Messages for coordinating onboarding and profile management among their client communities 2) A common B2B messaging standard (OAGIS) that all B2B service providers can support 3) Standard message choreographies based upon BPMN for contract manufacturing

Barriers

- Distributed denial of service attacks can impede access to IoT devices
- Social networks do not interoperate
- Analyst firms do not appreciate or promote standards
- No standards for transaction forwarding for multi-tier visibility
- Standards funding is inadequate
- Current environment does not favor standards mandates

Uncovering Needles in the Clouds

Orchestrating End-to-End Supply Chain & Manufacturing

Pawan Joshi
Vice President Strategy, E2open

OAGi/NIST Workshop on Open Cloud Architectures for Smart Manufacturing

Gaithersburg, MD
May 5th, 2015

E2OPEN

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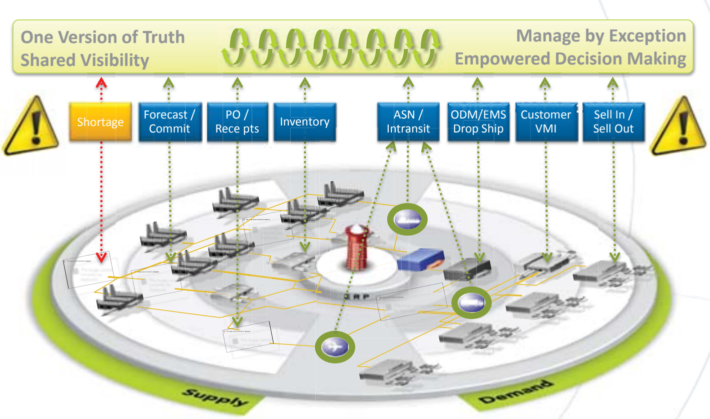
Managing the Extended Business Network

Demand you can't predict with Supply you don't control

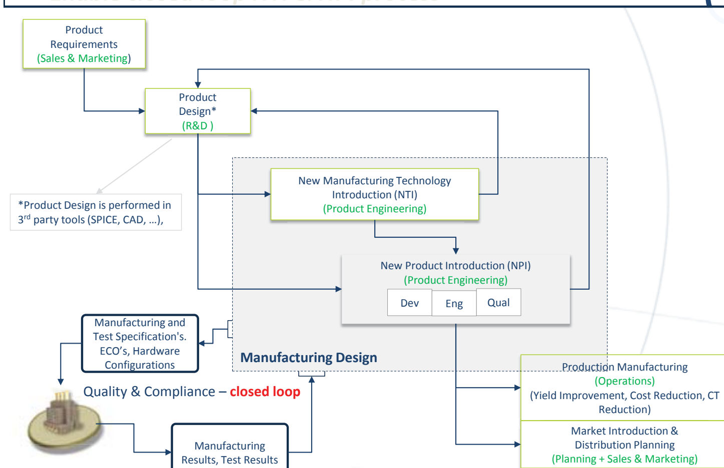
The Challenge

Collaborative Planning & Execution



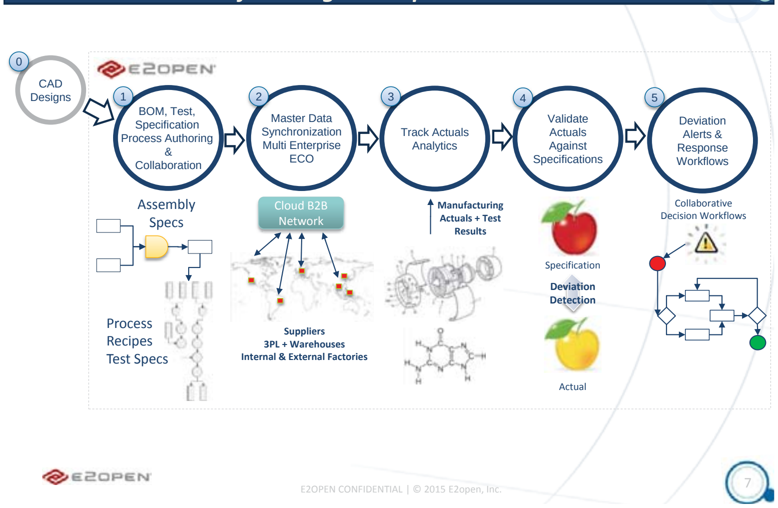
Accelerate your Design Chain

Enable closed loop NTI & NPI process



Improve Quality

Automated Manufacturing & Compliance Validation



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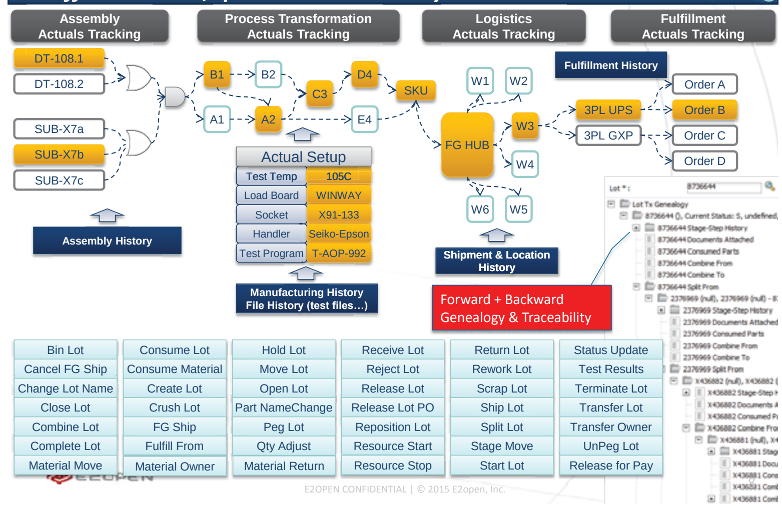
High-Definition Visibility and Traceability

Efficient recall, quarantine and analysis



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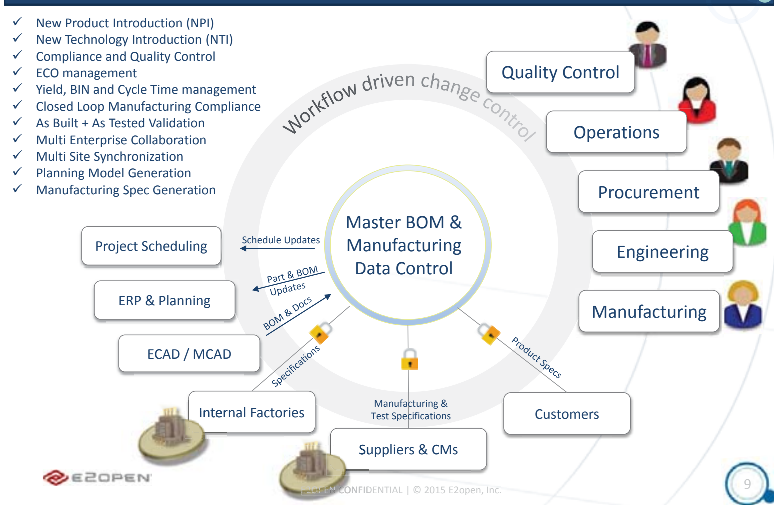
Multi-Enterprise Manufacturing Management on the Cloud

- New Product Introduction (NPI)
- New Technology Introduction (NTI)
- Compliance and Quality Control
- ECO management
- Yield, BIN and Cycle Time management
- Closed Loop Manufacturing Compliance
- As Built + As Tested Validation
- Multi Enterprise Collaboration
- Multi Site Synchronization
- Planning Model Generation
- Manufacturing Spec Generation



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Supporting Ongoing Supply Chain Evolution

Gartner's Five-Stage DDVN Model (2013)

	Stage 1 React	Stage 2 Anticipate	Stage 3 Integrate	Stage 4 Collaborate	Stage 5 Orchestrate
Outcome	Business unit revenue focus, but achieving misaligned and/or siloed objectives	Supply chain functional performance improvements	**Integrated supply chain** decision making, with early connections to product and/or sales	**Profitable demand-driven** fulfillment through **internal and external collaboration**	**Profitable shared value** creation through innovation across **internal and external networks**
Metrics	Business-unit-specific	Functionally specific, competing metrics	**Integrated supply chain** metrics used to manage trade-offs	**Outside-in metrics** across the extended value chain	**Value-based metrics** aligned across the ecosystem
Process Focus	Revenue focus; firefighting with no centralized analysis	Scaling and cost-efficiency within each function	Functional excellence; integration across core supply chain processes	**Integration across the extended value chain** to make profit-driven decisions	**Network- and solution-centric decisions**; translating innovation into execution
Technology	Disparate transactional systems of record with limited functional support	Push for integration of systems of record; siloed functional solutions	Technologies to support **end-to-end supply chain processes**; improved data rationalization and integration capability	Technology that enables **trading partner connectivity** and supports mature **processes in the extended supply chain**	Innovative technology tools to enable **networkwide value creation, risk management and scenario analysis** for profitable trade-offs
Organization	Dominance of the sales or manufacturing groups in decision making	Functional leaders within business units, regions or manufacturing; emergence of centers of excellence (COEs)	**Cross-functional decision making** across internal supply chain; process-focused COEs to enable the business	**Head of supply chain** participates in corporate strategy as end-to-end process owner	**Head of supply chain** shapes corporate strategy

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Collaborative Planning & Execution

Reference Systems Architecture

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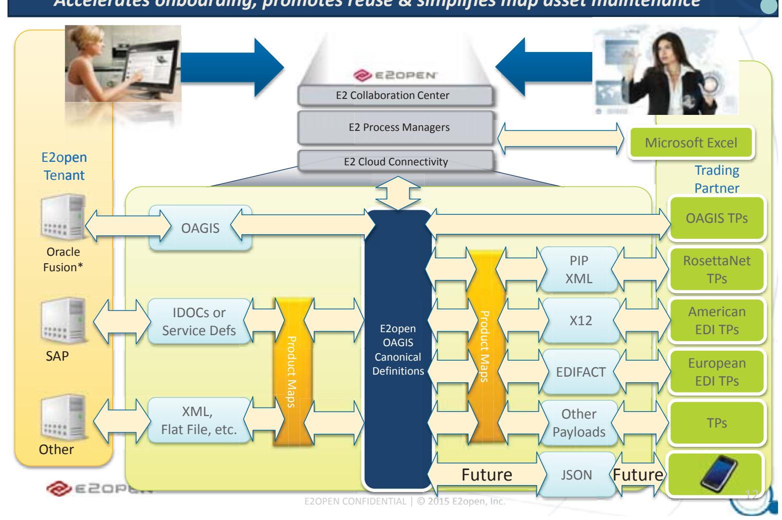
Mapping via an OAGIS canonical format

Accelerates onboarding, promotes reuse & simplifies map asset maintenance



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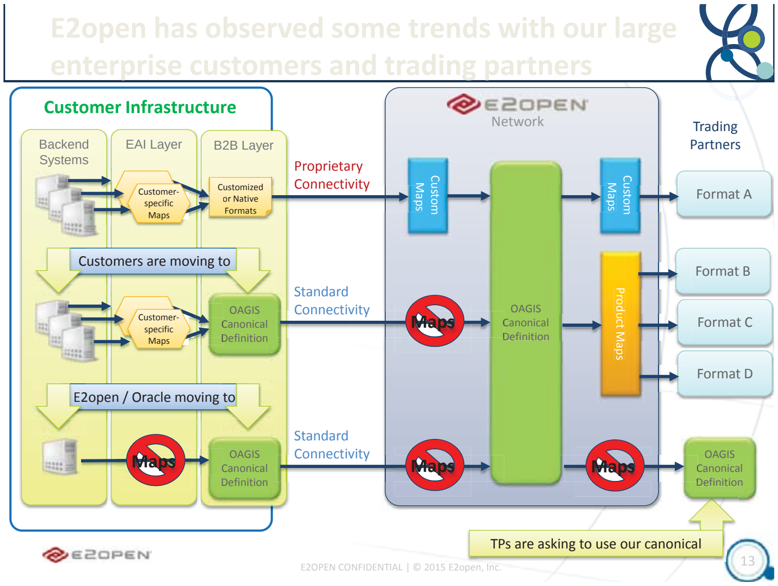
E2open has observed some trends with our large enterprise customers and trading partners
Customer Infrastructure
Backend Systems
EAI Layer
B2B Layer
Customer-specific Maps
Customized or Native Formats
Proprietary Connectivity
E2OPEN Network
Custom Maps
Custom Maps
Trading Partners
Format A
Customers are moving to
Standard Connectivity
OAGIS Canonical Definition
Maps
Product Maps
Format B
Format C
Format D
E2open / Oracle moving to
Standard Connectivity
TPs are asking to use our canonical
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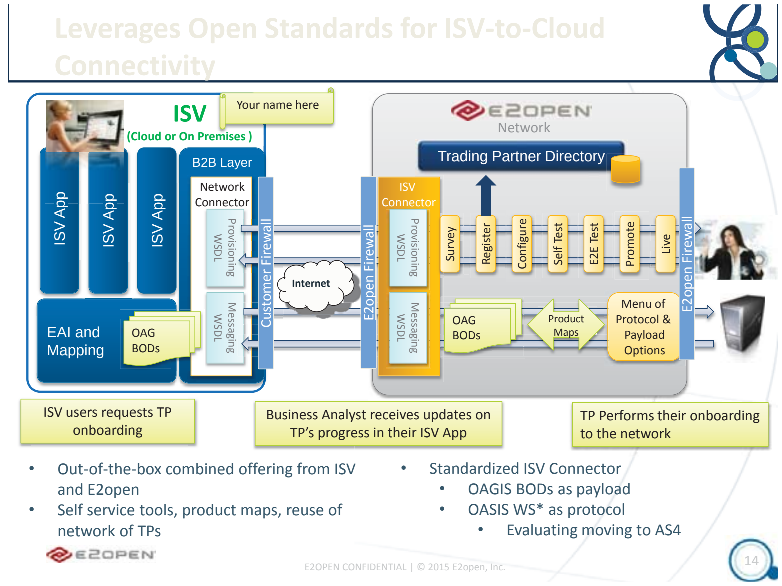
Leverages Open Standards for ISV-to-Cloud Connectivity
ISV
(Cloud or On Premises)
Your name here
B2B Layer
ISV App
ISV App
ISV App
Network Connector
Provisioning WSDL
Messaging WSDL
EAI and Mapping
OAG BODs
Customer Firewall
Internet
E2open Firewall
E2OPEN Network
Trading Partner Directory
ISV Connector
Survey
Register
Configure
Self Test
E2E Test
Promote
Live
OAG BODs
Product Maps
Menu of Protocol & Payload Options
E2open Firewall
ISV users requests TP onboarding
Business Analyst receives updates on TP's progress in their ISV App
TP Performs their onboarding to the network
• Out-of-the-box combined offering from ISV and E2open
• Self service tools, product maps, reuse of network of TPs
• Standardized ISV Connector
• OAGIS BODs as payload
• OASIS WS* as protocol
• Evaluating moving to AS4
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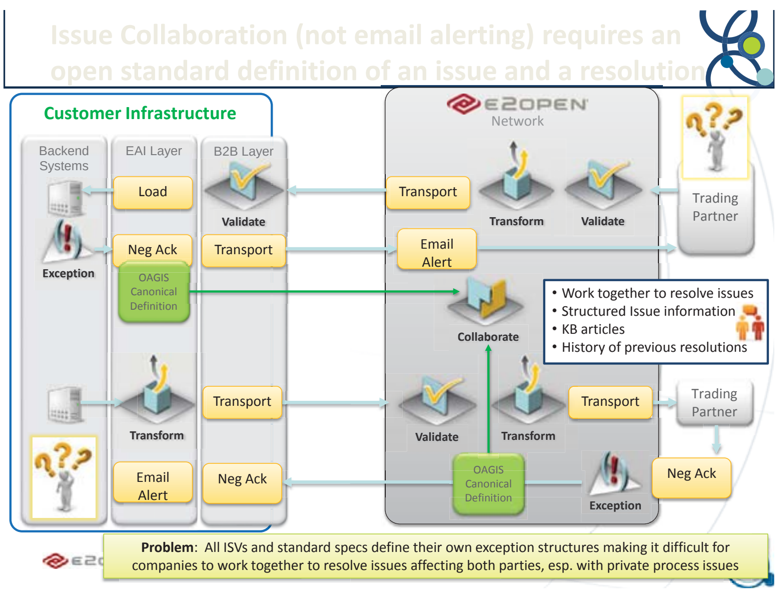
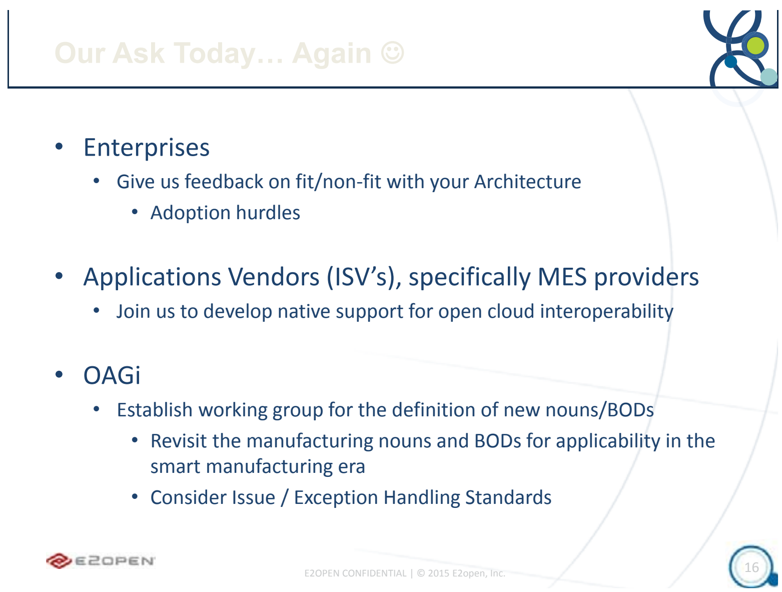

Issue Collaboration (not email alerting) requires an open standard definition of an issue and a resolution
Customer Infrastructure
Backend Systems
EAI Layer
B2B Layer
E2OPEN Network
Load
Validate
Transport
Transform
Validate
Trading Partner
Exception
Neg Ack
Transport
Email Alert
OAGIS Canonical Definition
Collaborate
• Work together to resolve issues
• Structured Issue information
• KB articles
• History of previous resolutions
Transform
Transport
Validate
Transform
Transport
Trading Partner
Email Alert
Neg Ack
OAGIS Canonical Definition
Exception
Neg Ack
Problem: All ISVs and standard specs define their own exception structures making it difficult for companies to work together to resolve issues affecting both parties, esp. with private process issues


Our Ask Today… Again ☺
• Enterprises
• Give us feedback on fit/non-fit with your Architecture
• Adoption hurdles
• Applications Vendors (ISV's), specifically MES providers
• Join us to develop native support for open cloud interoperability
• OAGi
• Establish working group for the definition of new nouns/BODs
• Revisit the manufacturing nouns and BODs for applicability in the smart manufacturing era
• Consider Issue / Exception Handling Standards
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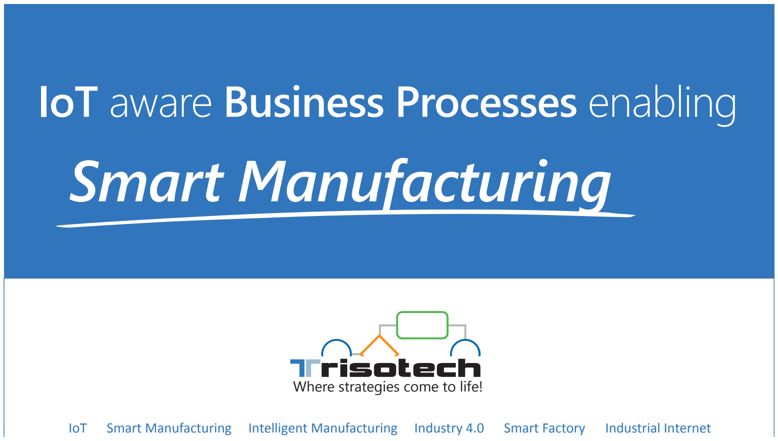
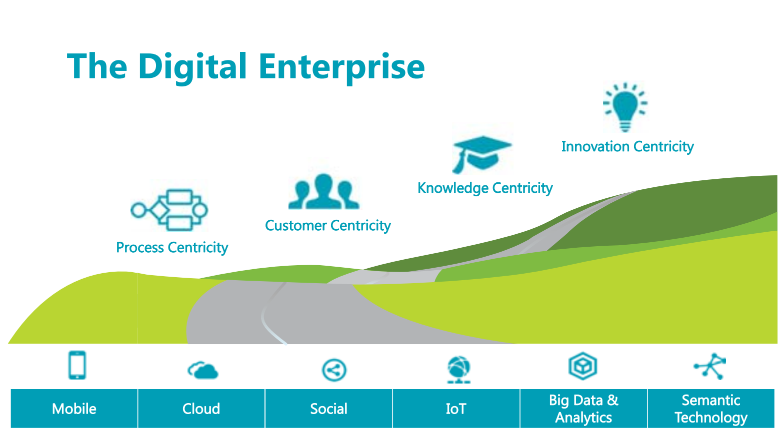
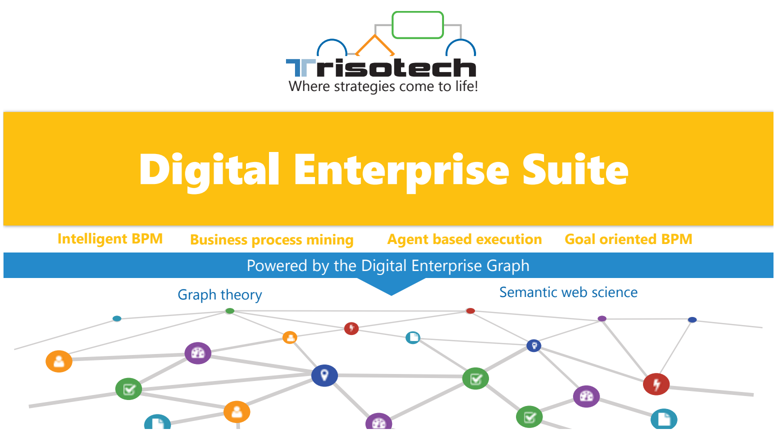
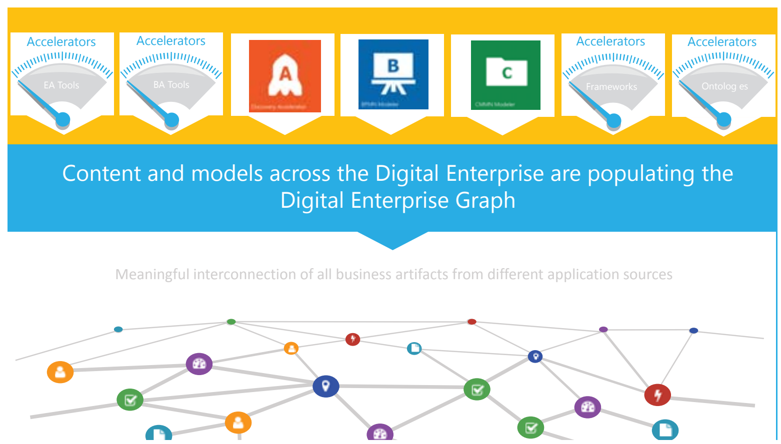
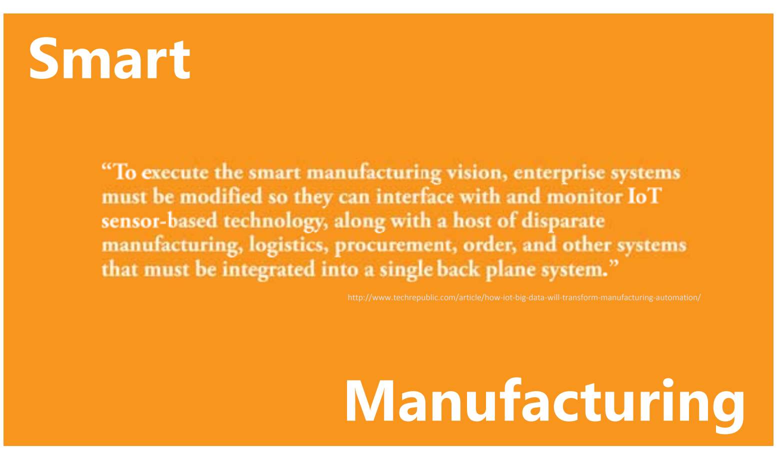
Q & A

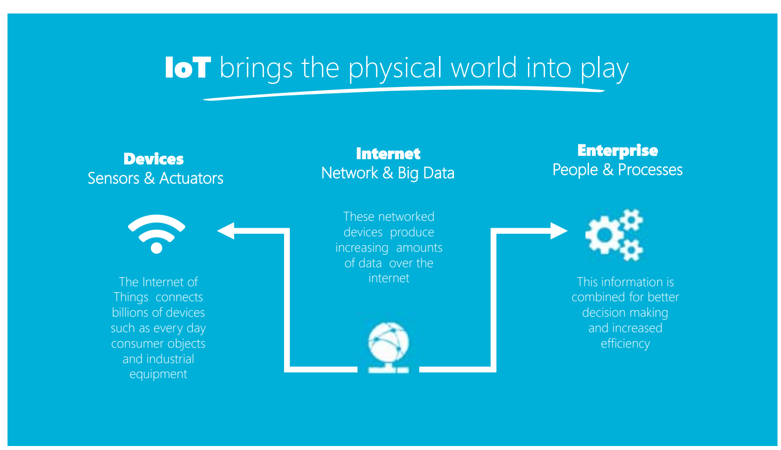

IoT aware Business Processes enabling
Smart Manufacturing
Trisotech
Where strategies come to life!
IoT
Smart Manufacturing
Intelligent Manufacturing
Industry 4.0
Smart Factory
Industrial Internet


The Digital Enterprise
Innovation Centricity
Knowledge Centricity
Customer Centricity
Process Centricity
Mobile
Cloud
Social
IoT
Big Data & Analytics
Semantic Technology


Trisotech
Where strategies come to life!
Digital Enterprise Suite
Intelligent BPM
Business process mining
Agent based execution
Goal oriented BPM
Powered by the Digital Enterprise Graph
Graph theory
Semantic web science


Accelerators
Accelerators
Accelerators
Accelerators
Content and models across the Digital Enterprise are populating the Digital Enterprise Graph
Meaningful interconnection of all business artifacts from different application sources


Smart
"To execute the smart manufacturing vision, enterprise systems must be modified so they can interface with and monitor IoT sensor-based technology, along with a host of disparate manufacturing, logistics, procurement, order, and other systems that must be integrated into a single back plane system."
http://www.techrepublic.com/article/how-iot-big-data-will-transform-manufacturing-automation/
Manufacturing


IoT brings the physical world into play
Devices
Sensors & Actuators
Internet
Network & Big Data
Enterprise
People & Processes
These networked devices produce increasing amounts of data over the internet
The Internet of Things connects billions of devices such as every day consumer objects and industrial equipment
This information is combined for better decision making and increased efficiency

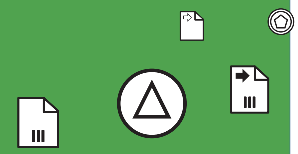
Business Process Management (BPM)

BPM acts as a central nervous system that manages the process from a holistic "end to end" perspective.

Business Process Management Suites (BPMS) can provide the required business oriented environment to orchestrate sensor based technology, along with other manufacturing, logistics, procurement, order, and other systems

The Business Process Model & Notation (BPMN)

Already possesses a lot of the constructs (e.g. events, data objects, etc.) needed for the purpose of orchestrating smart manufacturing.



bpmNEXT 2015

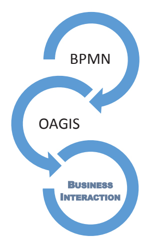
SAP & W4 demoed IoT aware business process.

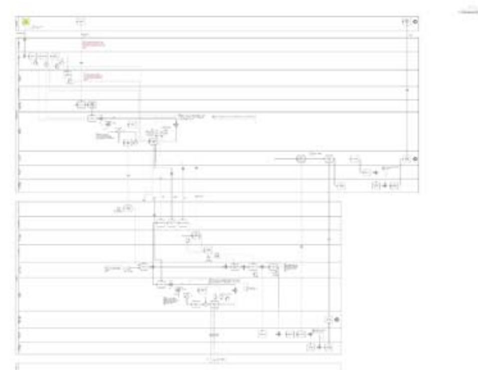
SAP demonstrated an oil pipeline problem with a dispatched service person with the proper pump replacement.

W4 demonstrated a fall sensing capability for managing folks who are living alone without help.

http://jimsinur.blogspot.ca/2015/03/bpmnext-2015-state-of-union.html

BPMN4OAGIS





Smart Manufacturing Workgroup

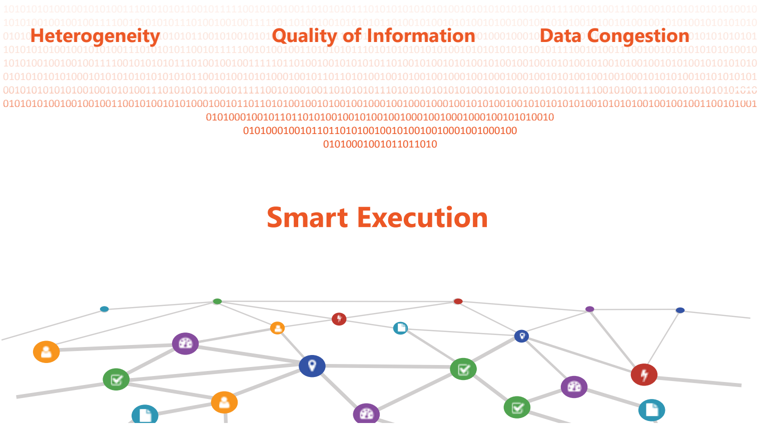
Velocity

Volume

Variety

1100101001010100010010111
110010100101010001001011011010100100101001001000100100010

How to integrate and translate all this data into relevant knowledge



Challenges

- We need semantics and analytics to ensure that only relevant data are collected from devices to generate business events
- We need robustness of connectivity to ensure relevant business events are provided
- We need Ontologies of IoT sensor and actuator data so we can reason over the provided events

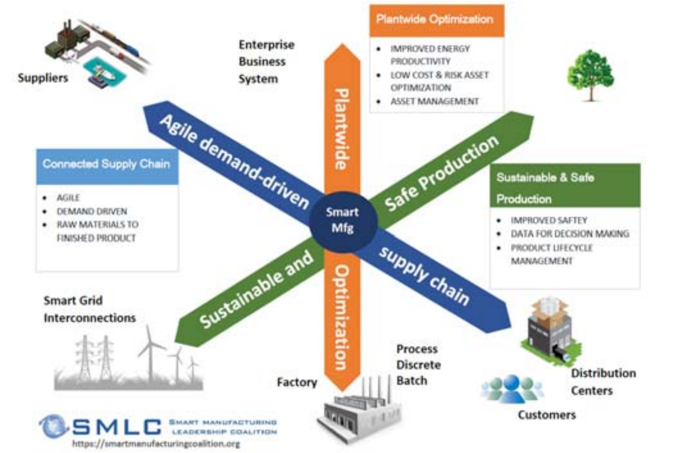
SMLC

SMART MANUFACTURING LEADERSHIP COALITION

www.smartmanufacturingcoalition.org

NIST Workshop on Open Cloud Architectures for Smart Manufacturing
May 5, 2015
Jim Davis UCLA & SMLC

Building Infrastructure Powering Smart Decisions



SMLC Partnerships

Smart Manufacturing

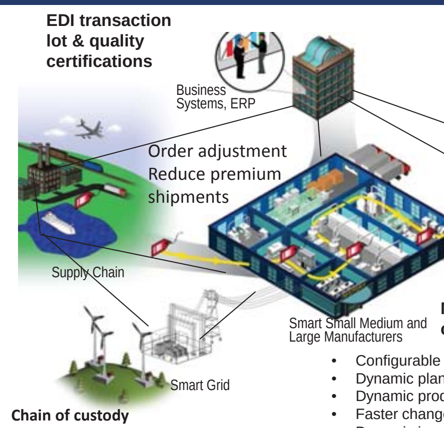
Data
When it is needed
Where it is needed
In the Form it is needed

Throughout the Manufacturing Ecosystem

American Council for an Energy Efficient Economy (ACEEE)
AMP Socal
Alcoa
American Institute of Chemical Engineers (AIChE)
American Society of Quality
ARC
Association of State Energy Research and Technology Transfer Institutions (ASERTTI)
Corning
Department of Energy (DOE)
Emerson
Electric Power Research Institute
General Dynamics
General Electric
General Mills
General Motors
Manufacturing Enterprise Solutions Association (MESA)
MT Connect
National Association of State Energy Officials (NASEO)
North Carolina State University
Nimbis Services
NIST
National Science Foundation (NSF)
OSISoft
Owens Corning
Pacific Northwest National Laboratory
Pfizer, Inc.
Praxair
Purdue University
Rensselaer Polytechnic Institute
Rockwell Automation
Rutgers
Savigent Software
Schneider Electric
Society of Manufacturing Engineers
Southwest Research Institute - SWRI
Sustainable Solutions
Texas A&M Engineering Experiment Station
Tulane – PolyRMC
United Technologies Research Center (UTRC)
University of California, Berkeley
University of California, Irvine
University of California, Los Angeles
UCLA IS Associates
University of Texas - Austin
West Virginia University

What is Smart Manufacturing

Internal & External Value Chain
Networked-Based Manufacturing



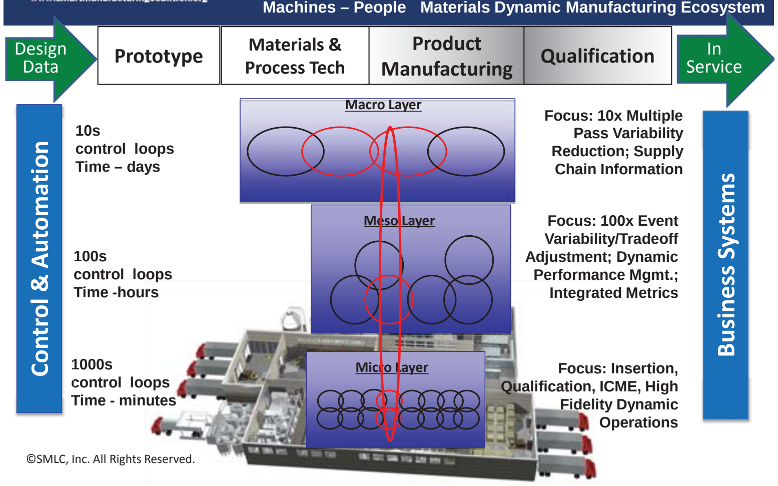
Minimum just in case inventory & corrective actions thru entire system

- Configurable high fidelity/statistical modeling and analytics
- Dynamic plant configuration and readiness
- Dynamic product component/material configuration
- Faster changeovers & more variable order sizes
- Dynamic inventory minimization & management

Use Cases Mike Yost – MESA International

Smart Manufacturing: Multi-Layered Seams, Time, Data & Action

Machines – People Materials Dynamic Manufacturing Ecosystem

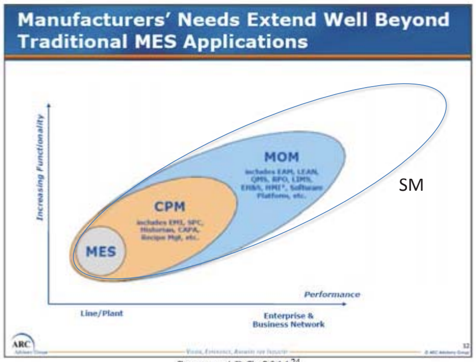


Smart Manufacturing based on ISA 95

ISA 95 Classification					Class of an automation system
Level 4	Business planning & logistics Plant production scheduling, operational management, etc			Establishing the basic plant schedule – production, material use, delivery and shipping. Determining inventory levels Time frame: months, weeks, days	ERP – Enterprise Resource Planning
Leve[l 3]	[Ma]nufacturing operations [Man]agement [Dis]patching production, detailed [pr]oduction, scheduling, [re]liability assurance			Work flow/recipe control to produce the desired end products. Maintaining records and optimizing the production process Time frame: days, shifts, hours, minutes, seconds	MES – Manufacturing Execution Systems
Level 2	[B]atch [con]trol	Continuous control	Discrete control	Monitoring, supervisory control and automated control of the production process Time frame: minutes, seconds, milliseconds, microseconds	SCADA /HMI Supervisory Control and Data Acquisition / Human Machine Interface
Level 1				Sensing the production process, manipulating the production process Time frame: milliseconds, microseconds	PLC/ DCS Programmable Logic Controller/ Distributed Control System
Level 0				The actual production process	Field devices - Plant instrumentation & controls

Source: Frost & Sullivan, 2011[8]

Smart Manufacturing & Vendor Products



Source: ARC, 2011[24]

Technical and Business Drivers for Shared Infrastructure

Achievable Meaningful Use Goals and Magnitude of Impact

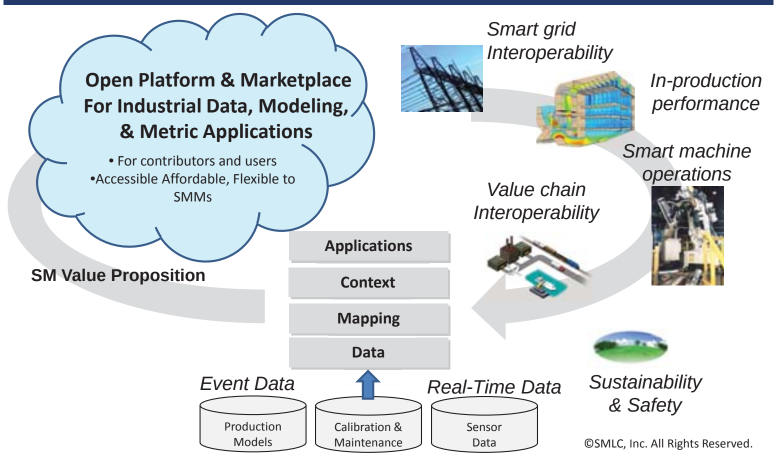
- Demand-driven efficient use of resources and supplies in more highly optimized plants and supply
  - 25% reduction in safety incidents
  - 25% improvement in energy efficiency
  - 10% improvement in overall operating efficiency
  - 40% reduction in cycle times
  - 40% reduction in water usage
- Product safety
  - Product tracking and traceability throughout the supply
- Sustainable production processes for current and future critical industries
  - 10x improvement in time to market in target industries
  - 25% reduction in consumer packaging
- Maintain and grow existing U.S. industrial base
  - Environment for broad innovation
  - 25% revenue in adjacent industries
  - 25% revenue in new products and services
  - 2x current SME's addressing total market
  - More highly skilled sustainable jobs created

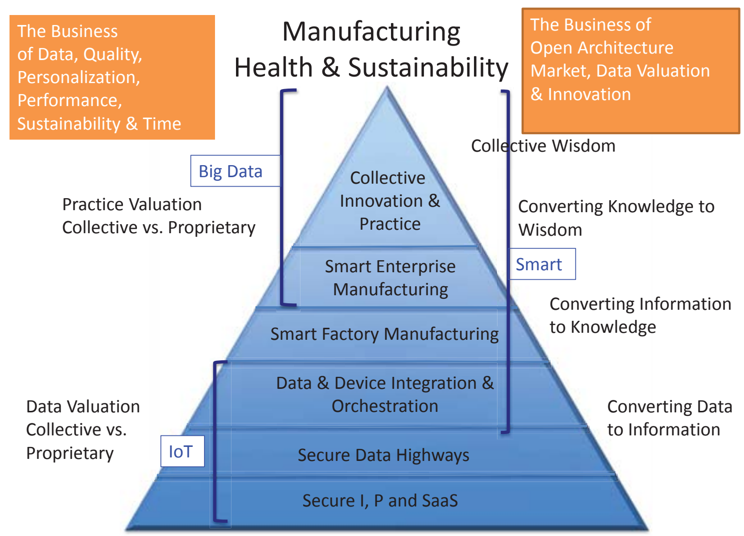
A Set of Issues Beyond Individual Company

- ROI constrained or prohibitive
  - Requires broader infrastructure investment to scale
  - Incremental investment difficult
  - Requires IT investment with 70% of cost non-value
  - Depends on other companies - supply chain
  - Need 80% reduction in cost of implementing modeling and simulation
  - 10x reduction in the cost of sensors and sensor infrastructure
- ROI opportunity comprehensive
  - Multiple systems
  - Integrated global performance metrics
  - Aggregating data
- Installed base of serviceable manufacturing facilities
  - $60 B in IT investment
  - Retrofit
- Risk
  - Major change & New business model
  - Uncertain about technology, security & IP
- Organization
  - IT capability lacking or IT not talking to operations
  - Workforce skills
  - Collaboration

Smart Manufacturing Platform

Bridging Seams Extending the Real Time Infrastructure across Value Chains





ull-Cloud 3D CAD For Manufacturing:c Vision and Issuesc

Jon Hirschtickc
ounder and Chairmanc
Onshape, Inc.c

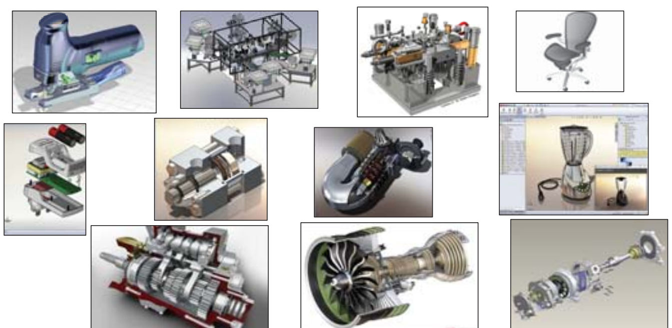
OAGi/NIST Workshop on Open Cloud Architectures for Smart Manufacturingc
May 5, 2015c

Onshape

Manufacturing Use Case (A L Need Description)L	Full-Cloud 3D CAD: Need 3D CAD systems to support design today, which is performed in teams that are often globally L distributed, fragmented and constantly changing. L
Business Challenge	• Existing, traditional 3D CAD systems were architected in the 1980's and 1990's with a single user in mind, writing CAD files L to a local computer diskL • Traditional installed CAD, even with the aid of file management tools, is slowing design.L • Problems include locating the latest version of design data, locking and checkout that restricts team productivity, L expensive and brittle CAD installs on limited varieties of computers, etc.L
Business Benefit of addressing challenge; estimated quantification of benefit	• The design processes will be made more efficient; problems with locating design versions, team productivity restrictions, L brittle CAD installs would be addressed, improving efficienciesL • We hope for a 20%+ speedup in design timeL
Open Cloud Opportunity	• A new generation of full-cloud 3D CAD offers to fix all of these problems.L • Everyone on a design team can work together using the full 3D CAD system on any browser, phone or tablet. L • The single instance of the CAD system and the master CAD data live together in one place in the cloud and are never L copied anywhere. L • The result is teams designing and manufacturing better products faster; And perhaps even having more funL
Technical Issues & Initiatives	• Lack of solutions to ensure compatibility and enable complete design and manufacturing ecosystem. L
Standards Role	• Standards would include formats for data that could be imported and exported with the cloud system (example: JT L format), and standards for REST APIs and associated data in JSON, XML, or other text formats. L • The combination of full-cloud 3D CAD plus these standards would let design and manufacturing teams integrate and link L complete cloud-based toolchains.L

Onshape

3D CAD: Tools For Designing Productsc



Onshape

3D CAD Needs to Evolvec

- >c Traditional 3D CAD architected 20 years agoc
  - SolidWorks, Pro/ENGINEER, etc.c
- >c CAD is installed on each user's computerc
- >c Write files to diskc
- >c Copy the CAD files to each userc
- >c Expensive and difficult to manage for teamsc

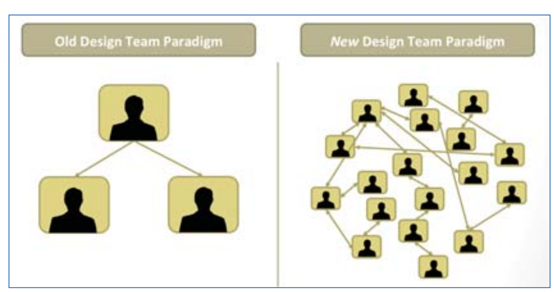
Onshape

Manufacturing Teams Lose Time With CADc

- >c Is everyone on the same version of CAD?Gc
- >c Expensive CAD licenses tough to manage for Gc dynamic, distributed teamsc
- >c CAD files need to be copied to/from "vaults"c
- >c Where's the latest version?c
- >c Checkout, lockingc
- >c Overwriting each other, locking out each otherc

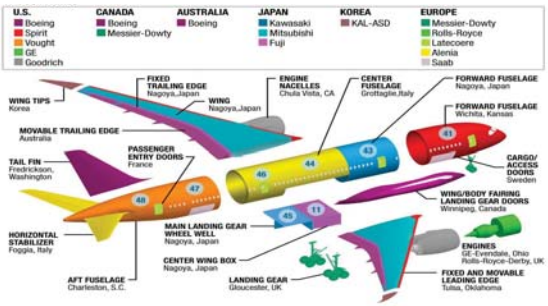
Onshape

Distributed Design And Manufacturingc



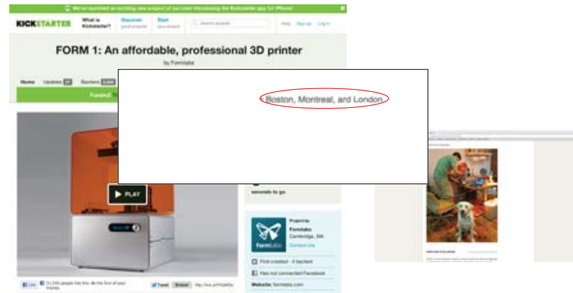
Onshape

Big Companies Do Distributed Manufacturingc



Onshape

Even Small Companies Are Distributedc



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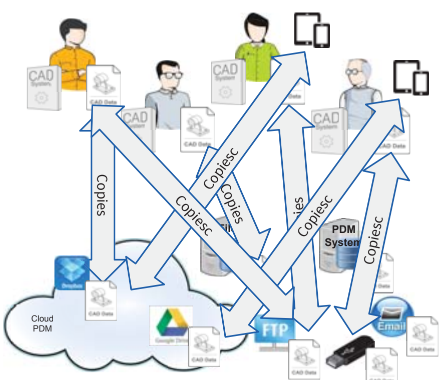


CAD System Problemsc

- Hardware? OS?c
- Installationc
- Updates and service packsc
- Crashes, lost workc
- Downloadsc
- Buy more CAD licenses $$$? Floating?c
- Or free viewer? (different and limited)c
- Is everyone on the same release of the CAD c system?c

CAD Data Problemsc

- Copies of CAD Data everywherec
- Every time you open, you need to worry:c
  - Is anyone else editing?c
  - Are you overwriting someone else's work?c
  - Someone else overwriting your work?c
- Where's the latest version?c
- Separate PDM System?c
  - Checkoutc
  - Lockingc
  - Someone locked your file!c

Onshape

CAD System Problemsc
Hardware? OS?c
Installationc
Updates and service packsc
Crashes, lost workc
Downloadsc
Buy more CAD licenses $$$? Floating?c
Or free viewer? (different and limited)c
Is everyone on the same release of the CAD c

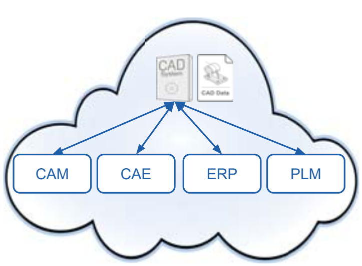
ull-Cloud CAD

Everyone usesc
the same CAD system and CAD datac
at the same time.c
No Copies.c

Time-savings 20%+c
Better productsc
More Func

Onshape

Cloud Manufacturing: More Than Just CADc



Open cloud enables many manufacturing systems c to communicatec

Technical Issuec
- **Building cloud versions of all c manufacturing toolsc**
- **Performancec**
- **raphicsc**

Standards Rolec
- **ormats and protocols for data c exchangec**
- **And possibly standard tools for cloud c software appsc**

Onshape

Thank Youc

Jon Hirschtickc
Onshape Inc.c

jhirschtick@onshape.comc

@jhirschtickc

Onshape

Simio
Forward Thinking

Executing Simulation Experiments in the Cloud

C. Dennis Pegden, CEO
Simio LLC

Cloud computing

- Avoid infrastructure costs.
- Focus on value added activities.
- Shorten development time.
- Less maintenance, easier to manage.
- Scale resources to changing demand.

Cloud Manufacturing

- Cloud-based manufacturing paradigm based on Internet of Things (IoT) and virtualized/service oriented technologies.
- Encompasses the life cycle of a product – design, **simulation**, production, test, maintenance.
- Cloud-based simulation for both *facility design* and production *planning/scheduling*.

Cloud Computing Drivers

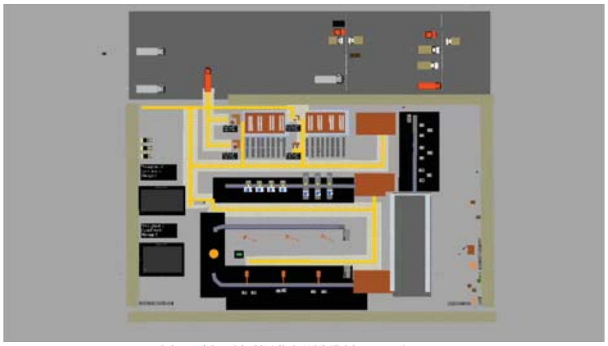
1. Mobile and shared information.
2. Scalable demand.
3. Scalable (parallel) computation.

Most applications leverage 1 and 2.
Simulation applications leverage all three.

Facility Design

- Allow 3D animated simulation models to be built and run in the cloud for improving system design.
  - Model building
  - Data integration
  - Animation
  - Experimentation

Example: Facility Design



Experimentation

- Models are used to compare alternative designs, or optimize design parameters.
- Randomness requires that each scenario is replicated.
- During experimentation animation is not required.
- Multiple processes allow scenarios and replications to be run in parallel.

Cloud Challenges/Opportunities

- Cloud-based 3D animation environments don't exist.
- Model data is dispersed and not easily accessed.
- Experiments can be executed in parallel.

Data interfacing is the highest priority issue limiting the vision.

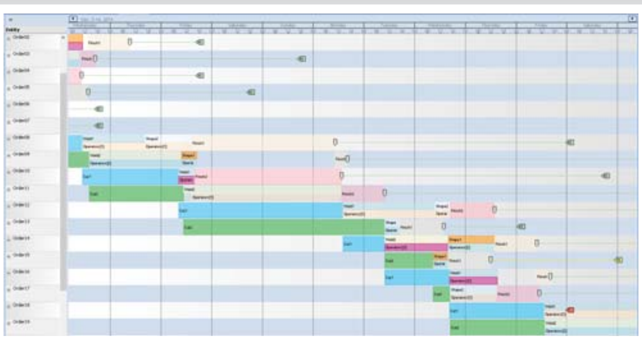
Working within the existing limitations

- Models are built using desktop software.
- Data is first integrated into the model – the project (model + data) is then uploaded to the cloud.
- Experimentation can leverage the full scalable processing power of the cloud (e.g. 25 replications of 10 scenarios simultaneously executed).

Planning and Scheduling

- Allow simulation-based scheduling systems to be executed in the cloud, and the results deployed across the enterprise.
  - Deterministic model used to generate schedule.
  - Interface to ERP/MES data.
  - Evaluate alternative scenarios (expediting jobs, overtime, etc.).
  - Analyze delivery risks by replicating the schedule with uncertainty and unplanned events.
  - Publish the selected plan to mobile devices for execution.

Example: Planning and Scheduling



Risk Analysis

- Deterministic plans assume away uncertainty/unplanned events – they provide optimistic results.
- By replicating the plan with variation/uncertainty added into the model we can estimate schedule risk.
- Multiple processes allow replications for risk analysis to be executed in parallel.

Cloud Challenges/Opportunities

- Cloud-based modeling environments don't exist.
- Model data is dispersed and not easily accessed.
- Experiments can be executed in parallel, providing quick comparisons of alternative schedules and risk analysis.

Data interfacing is the highest priority issue limiting the vision.

Working within the existing limitations

- Models are built using desktop software.
- Data is first integrated with model – the project (model + data) is then uploaded to the cloud.
- Experimentation can leverage the full scalable processing power of the cloud (e.g. 25 replications of 10 scenarios simultaneously executed).
- Risk analysis can leverage the full scalable processing power of the cloud.

Top Priority is Data Integration

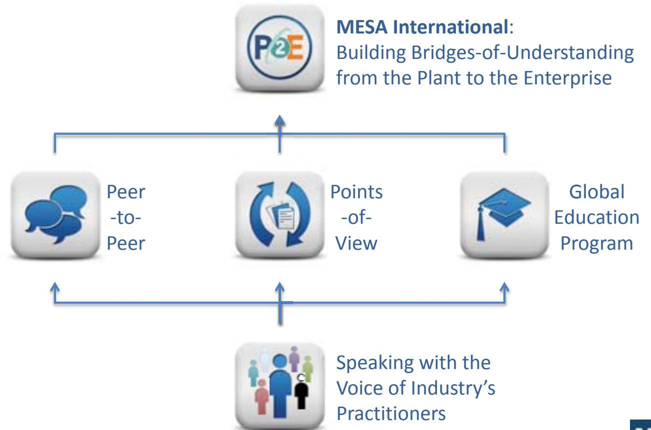
- Cloud manufacturing solutions will initially be hybrid environments (e.g. ERP cloud, MES on premise).
- Solutions must interface to dispersed data – some on premise – some in the cloud.
- Data integration between cloud and on premise components (e.g. ERP, MES, IoT, custom data sources) needs to be simple and seamless.

OAGi/NIST Workshop on Open Cloud for Smart Manufacturing

Jon Siudut

Advancing. Manufacturing. IT.

Introduction to MESA International



Advancing. Manufacturing. IT.

MES Content Providers

Manufacturing Enterprise Solution Content Providers	MES ISVs Need means to interoperate amongst cloud platforms
Business Challenge	Integration with disparate cloud solution providers Interface with other MES providers
Business benefit	Ease of systems interface/integration . Reduction by 1X (~20%) integration cost
Open Cloud Opportunity	Data Services including Storage, format translation , repository (large data) Analysis services include asynchronous statistical correlation Document authoring and File Viewers (ex. CAD formats)
Technical Issues & Initiatives	No current method to help automate integration Proprietary efforts could serve as a model
Standards Role	Lead interface specification methods Derive tool to aid automation

MES End Users

Manufacturing Enterprise End Users	MES End Users – Need means to integrate with manufacturing and business systems
Business Challenge	Integration through manufacturing supply chain Integration within own IT business systems
Business benefit of addressing challenge	Ease of systems interface/integration . Reduction by 1X (~20%) integration cost
Open Cloud Opportunity	Define supply chain SCOR like interfaces amongst systems
Technical Issues & Initiatives	Supply Chain Data Exchanges for controlled communications tied to contracts between the supplier tiers Identity Verification Services to ensure person/machine authorization
Standards Role	Lead interface specification methods Derive tools to aid automation

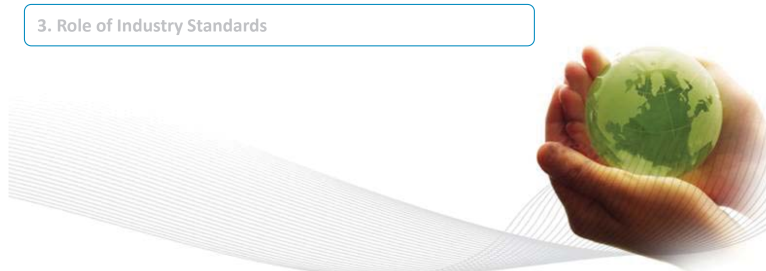
Manufacturing Use Case (A Need Description)	**Based On MESA White Paper "Leveraging Cloud Services for Smart Manufacturing Systems":** Need effective ways to create information threads for complete business processes across departments that do not depend on manual translation of information. This includes any use case that involves manufacturing operations that require deeper visibility into the supply chain for availability or compliance and tracking & multi component, multi location assembly processes.
Business Challenge	• We currently run many interdepartmental business process via paper, email, and with many manual interpretations and translations of data inputs to outputs along the way. These manual interdepartmental business processes are error prone and cannot scale to handle higher volume of transactions
Business Benefit of addressing challenge; estimated quantification of benefit	• New functionality and integration options enabled by cloud-enabled platforms, exchanges and marketplaces. • The availability of quality cloud component services that are easy to assemble into a custom application will change the future of the Information Technology (IT) department.
Open Cloud Opportunity	• Leverage cloud computing-enabled component-as-a-service (CaaS) model. • CaaS that are easy to assemble into a custom application • Enterprise departments assembling CaaS in IT-provided UI, workflow, computation, integration frameworks. • IT departments providing guidelines and frameworks for assembling applications from CaaS, SaaS, ... • Interoperable app-based, customized, (reconfigurable) mfg systems
Technical Issues & Initiatives	Solutions enabling layered, distributed architecture: • enterprise-level bpm & work-flow orchestration • integration mechanism to exchange information across layers from equipment to plant to supply chain • multiple data layers with different persistency requirements • role-specific, enterprise specific customizations of apps including mfg. supervision, control, operation, quality inspection
Standards Role	• Identify the places along the digital thread where we need standards for exchange of

Mfg in the Age of IoT and Cloud: Opportunity and Challenge

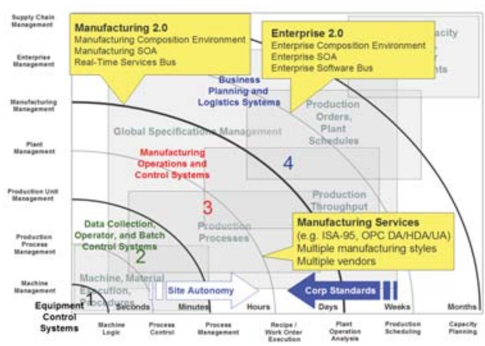
Dave Noller
IBM Industrial Sector Strategy & Integration
nollerd@us.ibm.com

Agenda

1. Background
2. IBM Approach
3. Role of Industry Standards

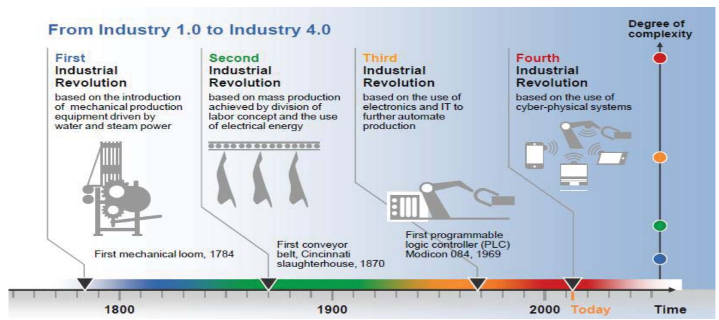


"Mfg 2.0" defined the need for "MES by Composition" (System of Insights from Systems of Record) and paved the way for Industry 4.0



Source: Manufacturing 2.0: Service and Collaboration-Based Architectures for Manufacturing Right First Time—on demand - *AMR Research, 2007*

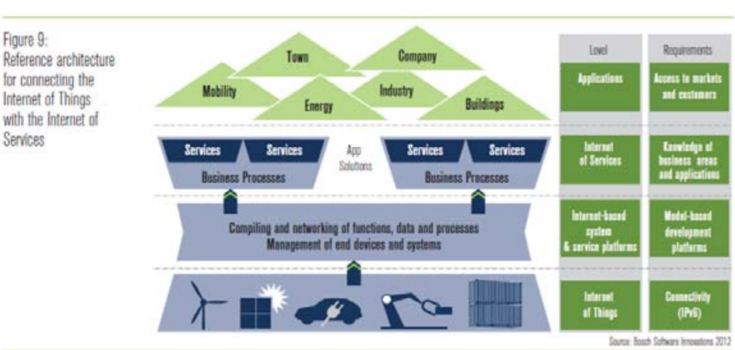
The introduction of IoT into the manufacturing environment is ushering in a fourth Industrial Revolution



Industry 4.0 Characteristics:

- Dynamic business and engineering processes enabling last-minute changes to production
- Personalized, local production and mass customization
- Creating value opportunities through services

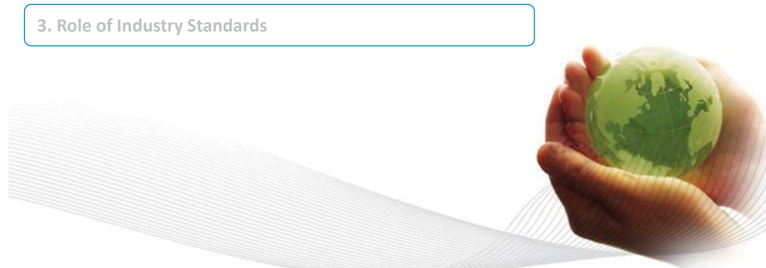
"Industrie 4.0" describes a Reference Architecture for connecting IoT to IoS

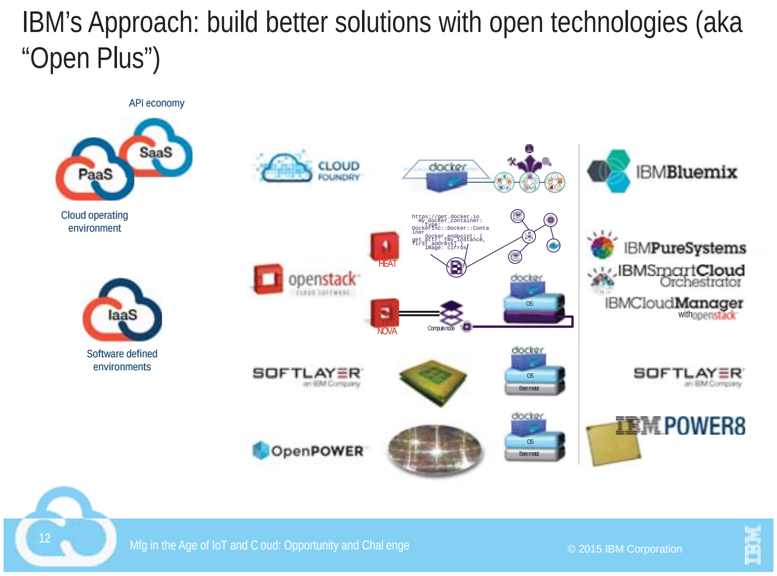


Source: Recommendations for implementing the strategic initiative INDUSTRIE 4.0
Final report of the Industrie 4.0 Working Group, April, 2013

Agenda

1. Background
2. IBM Approach
3. Role of Industry Standards




IBM's Approach: build better solutions with open technologies (aka "Open Plus")
API economy
SaaS
PaaS
Cloud operating environment
IaaS
Software defined environments
CLOUD FOUNDRY
docker
openstack
HEAT
NOVA
SOFTLAYER
OpenPOWER
IBMBluemix
IBMPureSystems
IBMSmartCloud Orchestrator
IBMCloudManager with openstack
SOFTLAYER
IBM POWER8
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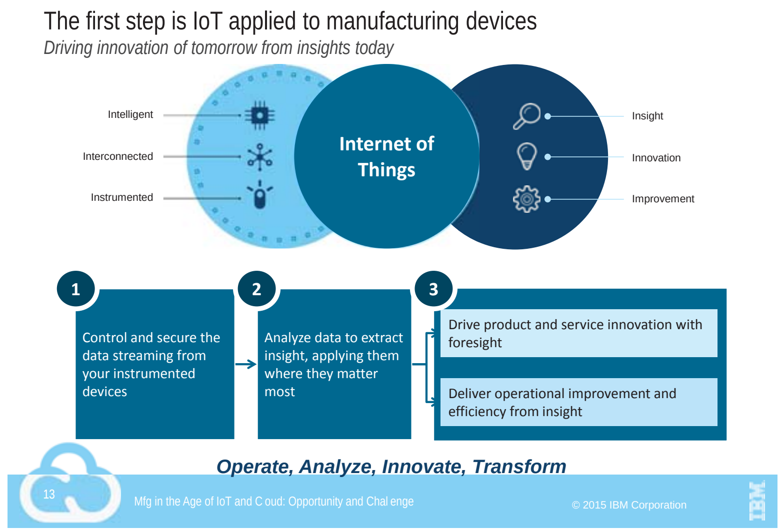
The first step is IoT applied to manufacturing devices
Driving innovation of tomorrow from insights today
Intelligent
Interconnected
Instrumented
Internet of Things
Insight
Innovation
Improvement
1
Control and secure the data streaming from your instrumented devices
2
Analyze data to extract insight, applying them where they matter most
3
Drive product and service innovation with foresight
Deliver operational improvement and efficiency from insight
Operate, Analyze, Innovate, Transform
13
Mfg in the Age of IoT and Cloud: Opportunity and Challenge
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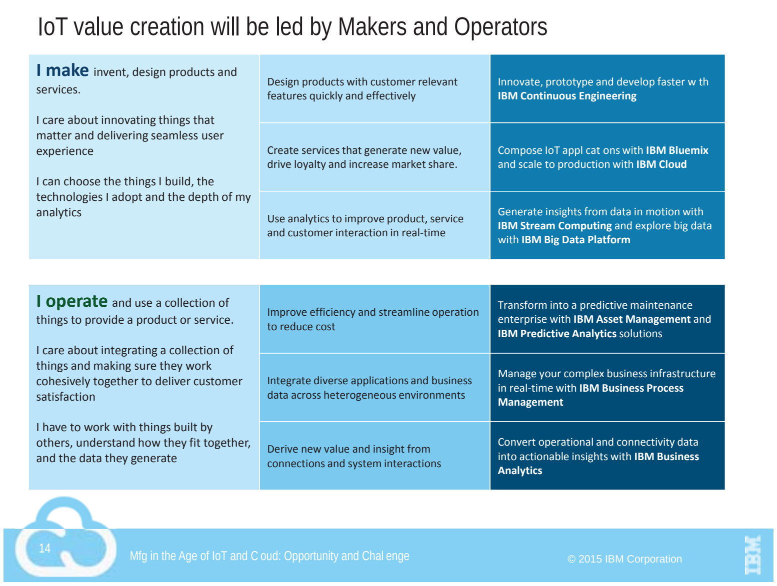
IoT value creation will be led by Makers and Operators
I make invent, design products and services.
I care about innovating things that matter and delivering seamless user experience
I can choose the things I build, the technologies I adopt and the depth of my analytics
Design products with customer relevant features quickly and effectively
Innovate, prototype and develop faster with IBM Continuous Engineering
Create services that generate new value, drive loyalty and increase market share.
Compose IoT applications with IBM Bluemix and scale to production with IBM Cloud
Use analytics to improve product, service and customer interaction in real-time
Generate insights from data in motion with IBM Stream Computing and explore big data with IBM Big Data Platform
I operate and use a collection of things to provide a product or service.
I care about integrating a collection of things and making sure they work cohesively together to deliver customer satisfaction
I have to work with things built by others, understand how they fit together, and the data they generate
Improve efficiency and streamline operation to reduce cost
Transform into a predictive maintenance enterprise with IBM Asset Management and IBM Predictive Analytics solutions
Integrate diverse applications and business data across heterogeneous environments
Manage your complex business infrastructure in real-time with IBM Business Process Management
Derive new value and insight from connections and system interactions
Convert operational and connectivity data into actionable insights with IBM Business Analytics
14
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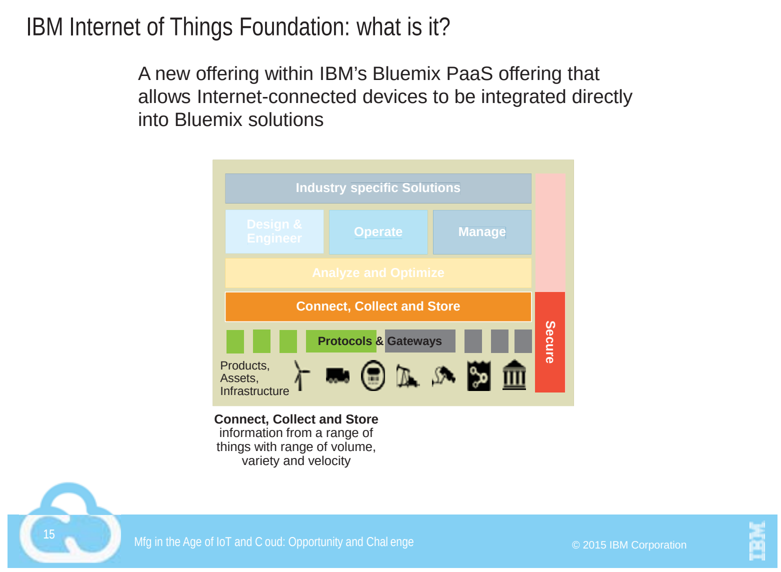
IBM Internet of Things Foundation: what is it?
A new offering within IBM's Bluemix PaaS offering that allows Internet-connected devices to be integrated directly into Bluemix solutions
Industry specific Solutions
Design & Engineer
Operate
Manage
Analyze and Optimize
Connect, Collect and Store
Protocols & Gateways
Secure
Products, Assets, Infrastructure
Connect, Collect and Store information from a range of things with range of volume, variety and velocity
15
Mfg in the Age of IoT and Cloud: Opportunity and Challenge
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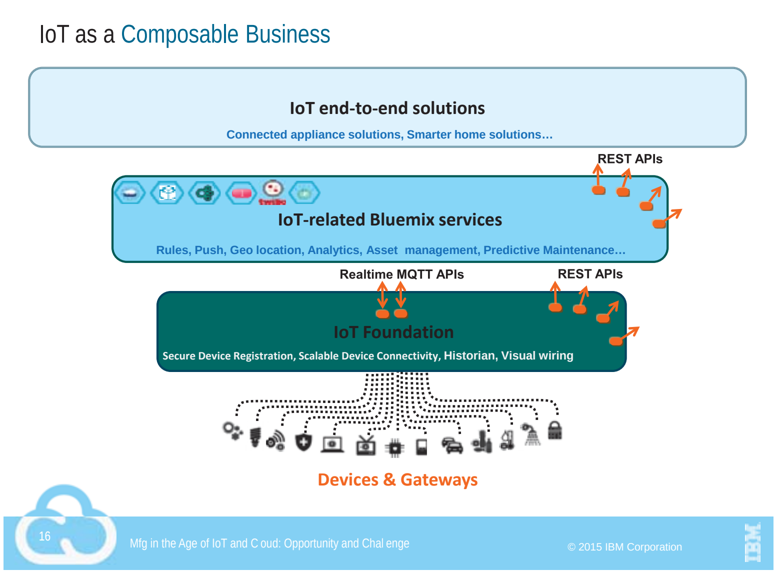
IoT as a Composable Business
IoT end-to-end solutions
Connected appliance solutions, Smarter home solutions…
REST APIs
IoT-related Bluemix services
Rules, Push, Geo location, Analytics, Asset management, Predictive Maintenance…
Realtime MQTT APIs
REST APIs
IoT Foundation
Secure Device Registration, Scalable Device Connectivity, Historian, Visual wiring
Devices & Gateways
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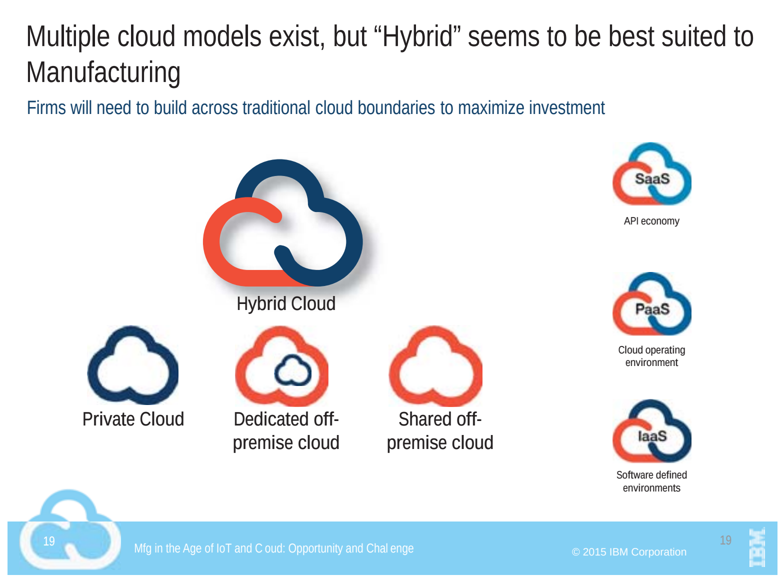
Multiple cloud models exist, but "Hybrid" seems to be best suited to Manufacturing
Firms will need to build across traditional cloud boundaries to maximize investment
Hybrid Cloud
Private Cloud
Dedicated off-premise cloud
Shared off-premise cloud
SaaS
API economy
PaaS
Cloud operating environment
IaaS
Software defined environments
19
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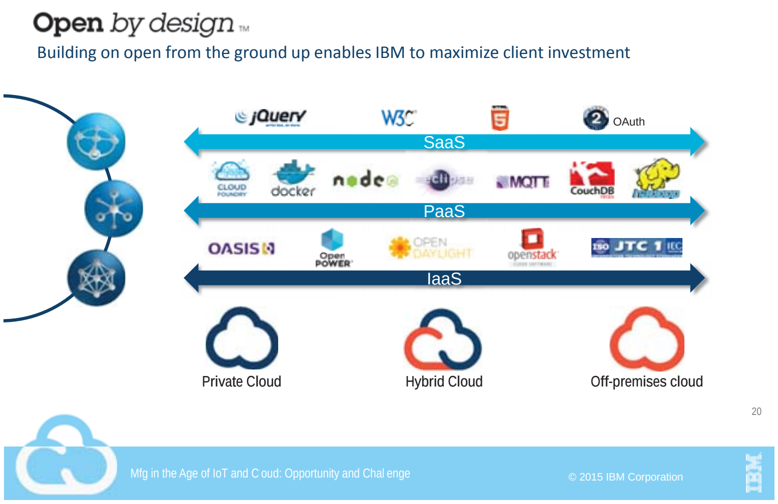
Open by design
Building on open from the ground up enables IBM to maximize client investment
jQuery
W3C
OAuth
SaaS
docker
node
MQTT
CouchDB
PaaS
OASIS
Open POWER
OPEN DAYLIGHT
openstack
JTC 1
IaaS
Private Cloud
Hybrid Cloud
Off-premises cloud
20
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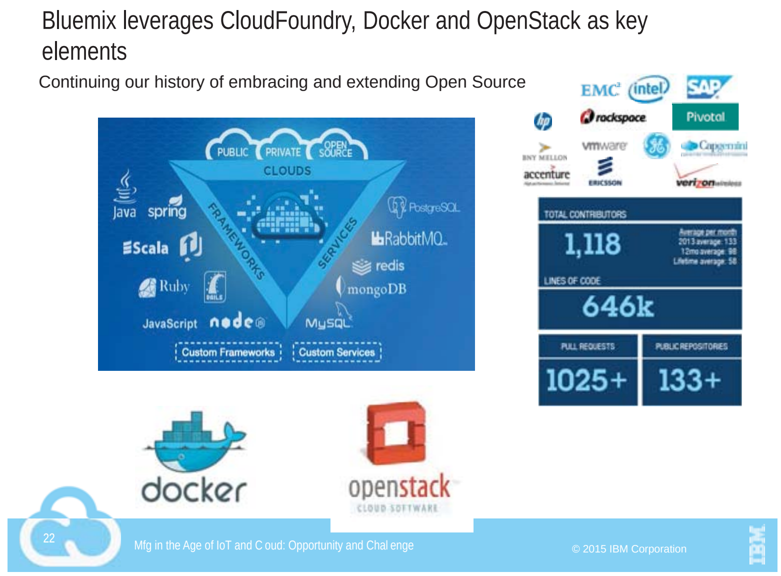
Bluemix leverages CloudFoundry, Docker and OpenStack as key elements
Continuing our history of embracing and extending Open Source
PUBLIC
PRIVATE
OPEN SOURCE
CLOUDS
FRAMEWORKS
SERVICES
Java
spring
Scala
Ruby
JavaScript
node
PostgreSQL
RabbitMQ
redis
mongoDB
MySQL
Custom Frameworks
Custom Services
EMC
intel
SAP
rackspace
Pivotal
vmware
accenture
ERICSSON
Capgemini
verizon
TOTAL CONTRIBUTORS
1,118
LINES OF CODE
646k
PULL REQUESTS
1025+
PUBLIC REPOSITORIES
133+
docker
openstack
CLOUD SOFTWARE
22
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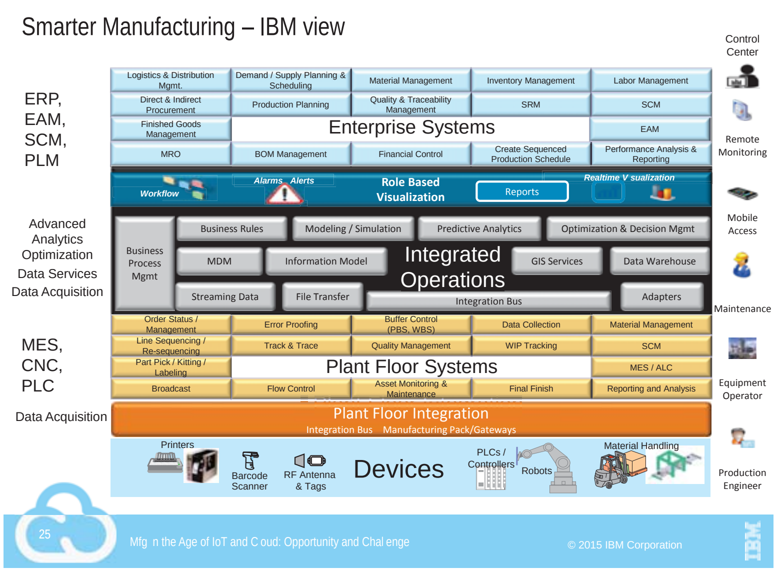
Smarter Manufacturing – IBM view
ERP, EAM, SCM, PLM
Logistics & Distribution Mgmt.
Demand / Supply Planning & Scheduling
Material Management
Inventory Management
Labor Management
Direct & Indirect Procurement
Production Planning
Quality & Traceability Management
SRM
SCM
Finished Goods Management
Enterprise Systems
EAM
MRO
BOM Management
Financial Control
Create Sequenced Production Schedule
Performance Analysis & Reporting
Workflow
Alarms Alerts
Role Based Visualization
Reports
Realtime Visualization
Advanced Analytics
Optimization
Data Services
Data Acquisition
Business Process Mgmt
Business Rules
Modeling / Simulation
Predictive Analytics
Optimization & Decision Mgmt
MDM
Information Model
Integrated Operations
GIS Services
Data Warehouse
Streaming Data
File Transfer
Integration Bus
Adapters
MES, CNC, PLC
Order Status / Management
Error Proofing
Buffer Control (PBS, WBS)
Data Collection
Material Management
Line Sequencing / Re-sequencing
Track & Trace
Quality Management
WIP Tracking
SCM
Part Pick / Kitting / Labeling
Plant Floor Systems
MES / ALC
Broadcast
Flow Control
Asset Monitoring & Maintenance
Final Finish
Reporting and Analysis
Data Acquisition
Plant Floor Integration
Integration Bus
Manufacturing Pack/Gateways
Printers
Barcode Scanner
RF Antenna & Tags
Devices
PLCs / Controllers
Robots
Material Handling
Control Center
Remote Monitoring
Mobile Access
Maintenance
Equipment Operator
Production Engineer
25
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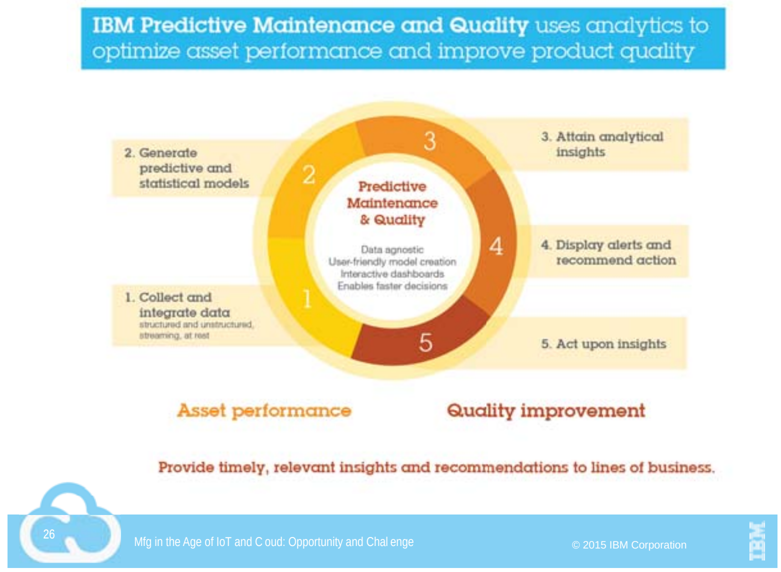
IBM Predictive Maintenance and Quality uses analytics to optimize asset performance and improve product quality
1. Collect and integrate data
structured and unstructured, streaming, at rest
2. Generate predictive and statistical models
3. Attain analytical insights
4. Display alerts and recommend action
5. Act upon insights
Predictive Maintenance & Quality
Data agnostic
User-friendly model creation
Interactive dashboards
Enables faster decisions
Asset performance
Quality improvement
Provide timely, relevant insights and recommendations to lines of business.
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Agenda
1. Background
2. IBM Approach
3. Role of Industry Standards
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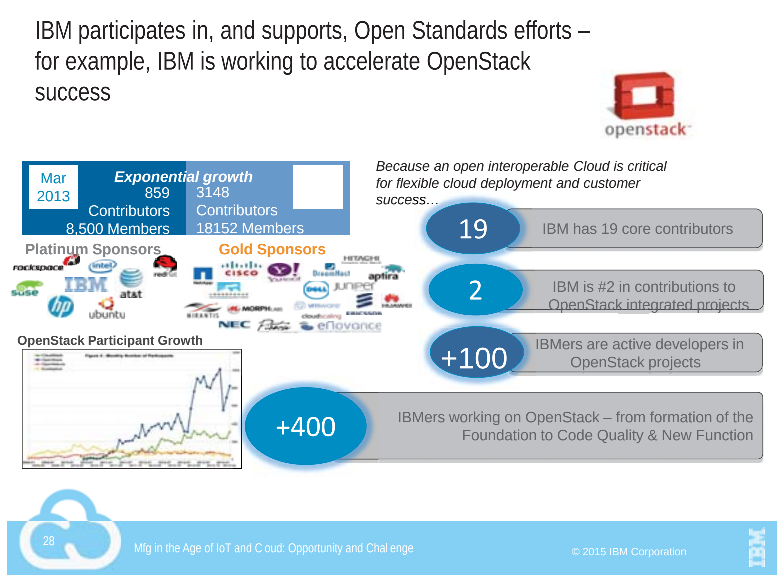
IBM participates in, and supports, Open Standards efforts – for example, IBM is working to accelerate OpenStack success
openstack
Mar 2013
Exponential growth
859 Contributors
8,500 Members
3148 Contributors
18152 Members
Platinum Sponsors
Gold Sponsors
OpenStack Participant Growth
Because an open interoperable Cloud is critical for flexible cloud deployment and customer success…
19
IBM has 19 core contributors
2
IBM is #2 in contributions to OpenStack integrated projects
+100
IBMers are active developers in OpenStack projects
+400
IBMers working on OpenStack – from formation of the Foundation to Code Quality & New Function
28
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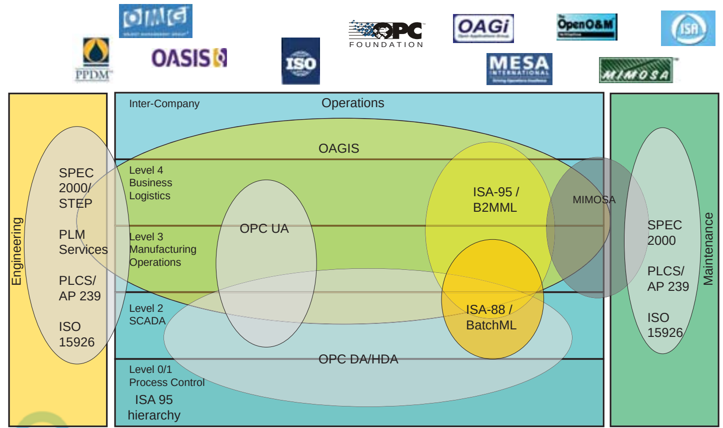
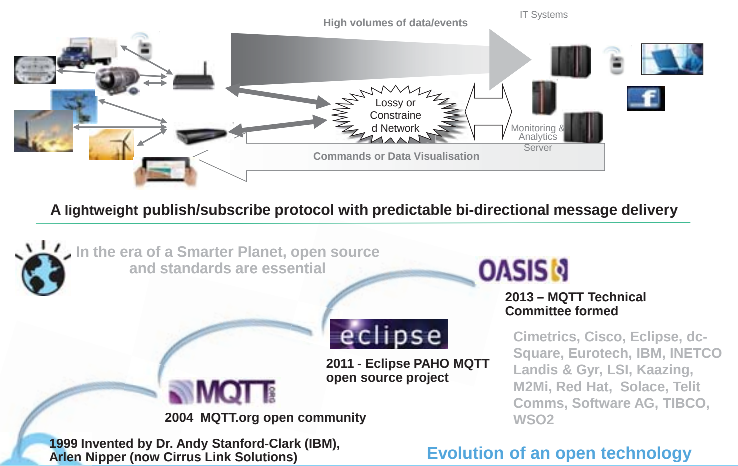
Vertical and Horizontal integration standards (content exchange and information/analytics models) – too many options!



IT standards, e.g. MQTT - open connectivity for Mobile, M2M and IoT



How can industry standards efforts help?

- Do canonical object models for interoperability (e.g. ISA-95, OAGIS, OMG PLM services) really matter? After all this time, to what extent are they really being adopted? If not, why not? These standards do not seem to come up much in "real life" projects.
- Assuming the answer is "yes":
  - Consider new forms that are more web and programming tool friendly, e.g. JSON vs XML
  - Continue to work on rationalizing overlap so that choices are more clear
  - Today's interoperability standards are "heavy", consider developing lightweight versions aimed at IoT integration (e.g. MQTT)

Manufacturing Use Case (A Need Description)	IoT and Cloud Support through migration", not "Big Bang": Adoption of IoT and Cloud needs to consider existing "brownfield" environments in a secure way.
Business Challenge	• Manufacturers wanting to adopt new, innovative technologies such as IoT and Cloud (or the vision of Industry 4.0) need a way to migrate gradually with support of existing systems • Manufacturers want flexible systems that can react to change and minimize vendor lock-in.
Business Benefit of addressing challenge; estimated quantification of benefit	• Evolving existing manufacturing systems today (through upgrades) is very costly and time consuming. New technologies can, potentially, lower the time and cost of bring up new systems or changing existing systems.
Open Cloud Opportunity	• Cloud based systems based on open standards and technology have the potential to address both of the business challenges mentioned above. For manufacturing, however, security concerns and the need for "brown field", or "hybrid" systems must be addressed.
Technical Issues & Initiatives	• Interoperability standards are still not widely adopted, so "mapping" still has to occur somewhere and is difficult. • Interoperability standards today are "heavy", and do not lend themselves to easy usage for "agile" creation of applications (e.g. for mobile) in the "integration cloud". • MES tends to be trying to act as the vertical integration layer today, but is not well suited to "out of the box" integration needed to support "Industry 4.0" type initiatives. Would be easier if it could be treated as a set of capabilities easily integrated through APIs (services).
Standards Role	• Take a hard look at what is inhibiting adoption today (for customers and vendors) • Try to simplify the picture vendors and customers who would like to adopt the interoperability standards

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There is broad alignment for several problems to solve

DMDII

★ Top priority for DMDII
✦ Secondary priority for DMDII

Top ranked problem to solve for:

Theme	Sub-theme	Industry	Academia	Government
Integration of the digital thread	Optimization across va ue chain	☆	☆	☆
	Big data	✧	☆	☆
	Standard data format and machine communicat on	★		★
	Cyber Security	☆	✧	✧
	Make design link	☆	☆	✧
	Tracking product performance in the field		★	✦
	Real time supplier vis bility			
Leadership/ organization capabilities	Commercialization of lab technolog es	✦	✦	
	Articu ation of business case for dig tal	☆		☆
	Workforce train ng/availabil ty	✧	✧	☆
Other	Enabl ng of mass-customization			
	Barriers to user adoption			✦

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Summary of value drivers from digital across groups

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Industry

- Growth vs. cost story:
  - A new era post-commoditization with suppliers
  - Need to rebuild bridges
  - Drive supplier collaboration
  - Move from cost-focus to:
    - Growth/NPI focus
    - To get to market faster
- Connected customer; real-time data/new business model; selling services (miles vs. tire)
- Time to market; data re-use; quality
- Ability to change/agility
  - Reduce non-value added change/rework
  - Execute value-add change
  - Allow experimentation
  - Proactive measurement/adaptability
- Enable other institutions to build on innovations and start to believe that bold change is possible
- Drive economic growth and capability building for US manufacturing base
- Improve the brand value of products made in US

Academia

- Feedback loops back to design
  - Make-design link
  - Data from product performance feeds new product innovation
- Supplier collaboration
  - "Real time" access to production information
- Ability to adapt to system perturbations
  - Improved macro forecasting
  - Downtime reduction between product families
  - Respond to changes in customer preferences
  - Reduced design/manufacturing constraints
- Improved customer service/brand loyalty
  - Address potential field failures proactively
- Reduced time to market
  - Rapid prototyping
  - Reduced qualification time (virtual testing)

Government

- Focus on design for:
  - Manufacturing
  - Maintainability (long lifecycle)
  - Affordability through lifecycle (inc. up-front price and maintenance)
- Commercialization of technology through collaboration (both competitive and pre-competitive)
- 3D design capability reducing cost in the design-make link and improved quality
- Big data definition/standards, new interoperable platforms, analytics, and best practice standards), to drive efficiency and response time (months → days)
- Improving national security through cyber security standards in manufacturing
- Shorten supply chain to reduce costs (e.g., 3D print parts on the battlefield)
- Reduce design/purchasing risk by testing technology earlier and cheaper
- Improve US manufacturing competitiveness to create jobs and economic development

SOURCE: DMDII workshop, May 2014

Key barriers to capturing value from digital were cited across the groups

DMDII

Detailed description of each barrier (common themes across groups)

BARRIERS TO VALUE CAPTURE

Strategy & innovation barriers
- Poor access to technology/best practices
- Lack of a collaborative environment/culture across the value chain
- Require a paradigm shift in manufacturing ('material flow' to 'info flow' systems)

Execution barriers
- Limited financing/bus. cases for digital manufacturing and design technology
- Lack of IT infrastructure (bandwidth, storage, processing), especially for SMBs
- Managing obsolescence of legacy systems (hardware and software)

Talent & organization barriers
- Skills (software/digital) are needed for manufacturing workforce and leadership
- Lack of cross-functional ways of working (silo structures)
- Organization design lacking in manufacturing IT leadership
- Change aversion related to new tools

Technology barriers
- Current manufacturing industry software model
- Lack of 3D design and manufacturing capability
- Software/modeling constraints – need more data availability, open IP

Data barriers
- Ensuring data is captured, standardized, with embedded manufacturing logic
- Cyber security needs to be put in place for manufacturing
- Lack of usable information available to product designers

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SOURCE: DMDII workshop, May 2014

Summary of barriers to value capture from digital across groups

DMDII

Industry

- Trust needed across supply base
- Skills (software/digital)
  - Not found in manufacturing leaders
- Lack of cross-functional ways of working
- Poor access to technology/best practices
- Change aversion related to adopting new tools
- Lack of financing for innovation (for SMEs)
- IT infrastructure
  - Bandwidth
  - Storage
  - Processing power
- ORG design (e.g., IT)
- Manufacturing industry software model
  - Needs to change (still using 20-year old model)
  - Proprietary technology prevents innovation
  - Need more of an 'app' based environment

Academia

- "Over the wall mentality"
  - Lack of a collaborative culture/ environment across value chain
  - Lack of usable information available to product designers
- Software/modeling constraints
  - Greater data availability would help refine models; IP/infrastructure constraints
- Require a paradigm shift in manufacturing
  - Moving from a "material flow" systems design to an "information flow" design
- Skills (software/analytical)
  - Education an issue
- Requirement standardization
  - Intelligent models that integrate wide variety of requirements (e.g. UL, company-specific)
- Data collection and extraction
  - Ensuring that the right data is captured
  - Data standardization
  - Embedding tolerance information
- Managing obsolescence of legacy systems (hardware and software)

Government

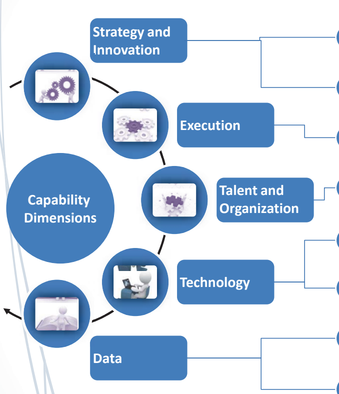
- Key data not captured if not in DOD contract (e.g., 3D data not required, only 2D)
- Ownership of data is often proprietary and held by supplier/not shared with DOD
- Tech data is often separate from tech package
- Lack of 3D design and manufacturing capability within the DOD supply base
- Conversion of legacy systems/data (TDP) slows down progress
- Organizational silos are still major barriers
- Small/medium businesses lack infrastructure to adapt to these new technologies
- Workforce gaps exist relative to new tech (but government is uniquely positioned to help)
- Business case demonstrations are needed to overcome issues with leadership will to act
- Cyber security issues in manufacturing must be tackled

SOURCE: DMDII workshop, May 2014

Industry, academia, and government groups also offered several examples of different problems that DMDII could help solve

DMDII

EXAMPLES: Problems that DMDII could help solve



1. Articulation of business case for digital
2. Manufacturing software business model
3. Optimizing across the value chain
4. Workforce training and availability
5. Reducing cost of qualification
6. Improved access/quality/use of data in product dev.
7. Big data management for manufacturing
8. Standard data formats and machine communications

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SOURCE: DMDII workshop, May 2014

Organizations believe that digital design and manufacturing is an important driver for growth, cost, and quality

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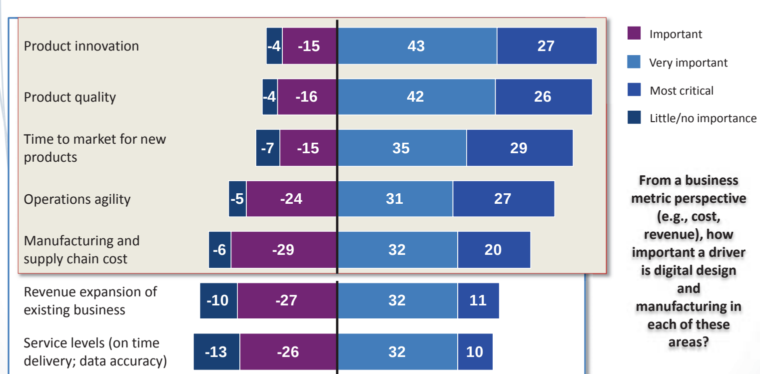

From a business metric perspective (e.g., cost, revenue), how important a driver is digital design and manufacturing in each of these areas?

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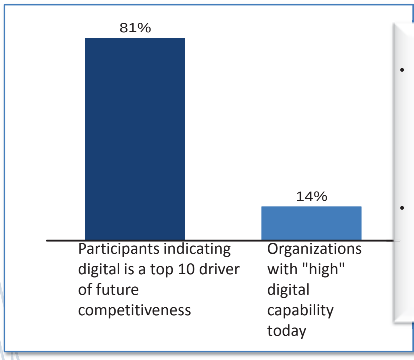
Despite the recognition of importance for digital design and manufacturing, most participants believe their organizations lack capability

DMDII



- There is widespread recognition of the **importance of digital design** and manufacturing to future company success
- Most participants believe this organizations **lack mature digital capabilities**

SOURCE: DMDI survey, Q11, Q15

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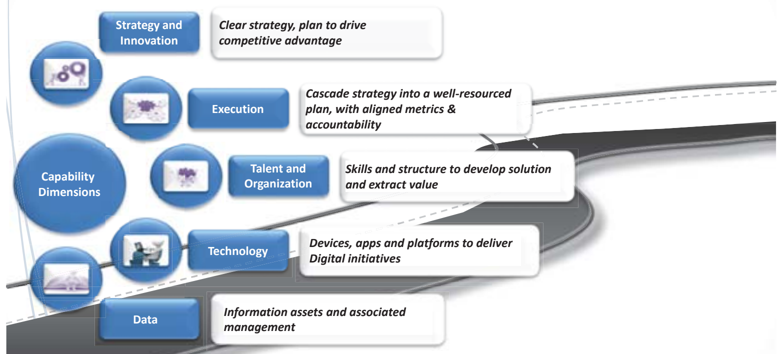
Organizations realize that technology creates no value – on its own

DMDII



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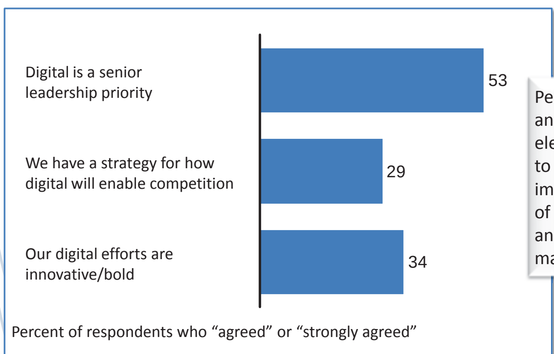
Majority of senior leaders agree that digital is a priority, but few have a clear bold vision and strategy

DMDII



People, culture and leadership elements related to implementation of digital design and manufacturing

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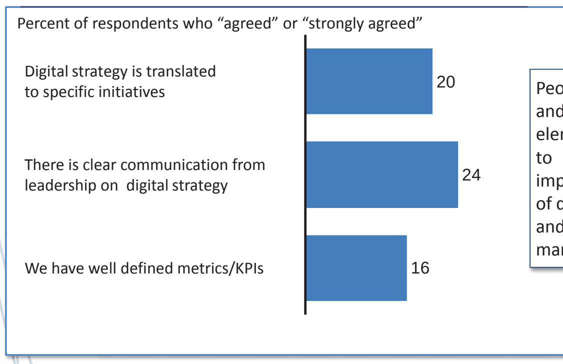
Translating strategy to clear action is a clear gap in a majority of organizations

DMDII



People, culture and leadership elements related to implementation of digital design and manufacturing

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Several capabilities identified as key for AME, IM, and AA

DMDII

Top themes on capabilities for DMDII to help solve

AME

- Collaborative design
- Design for producability – 'DFX'
- Modeling and simulation
- Production flow and intelligent networks

AA

- Advanced analytics to drive diagnostics and prognostics for asset productivity
  - Manufacturing equipment
  - Product lifecycle
    - Capture data
    - Analytics to use data for prognosis/diagnosis
- Design optimization and concept selection
  - Virtual prototyping (multi-physics)
  - DFM / should cost
  - Reliability modeling
  - Modeling & simulation as a learning tool
- Intelligent network design

IM

- Develop common data standards including communication/interchange logic
- Create a supporting open platform and architecture that can span the full value/supply chain using the common data formats
- Launch virtual and physical test-beds to commercialize feedback/control technology
- Create an analytics library for wider use

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Key barriers to capturing value from digital were cited across the groups

DMDII

Detailed description of each barrier (common themes across groups)

BARRIERS TO VALUE CAPTURE

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Data barriers
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- Cyber security needs to be put in place for manufacturing
- Lack of usable information available to product designers

SOURCE: DMDII workshop, May 2014

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Issues and Technology Gaps from DoD perspective

DMDII

- Data interoperability
  - Can we focus on processes and be tool/software agnostic?
  - Day to day operational and legacy data interoperability issues result in significantly increased costs, schedule delays, and decreased quality for weapons systems.
  - The interoperability gap between OEMs and their suppliers negatively impacts nearly every DoD weapons system
    - Increases acquisition and sustainment (life cycle) costs
    - Significant delays in acquisition and sustainment cycle times
    - Frequent first-article quality issues
  - Inability of most small to medium suppliers to seamlessly exchange product data with larger DoD primes.
- Cultural barrier of "not invented here" and "my product is unique."
- Lack of Infrastructure
- Manufacturing processes not included in the weapon system TDP
  - TDPs missing for legacy platform data

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Issues and Technology Gaps from DoD perspective

DMDII

- Integration of Product Data with Metadata and trusting that it will be available throughout the product's lifecycle.
- Contractual issues: IP/Data Rights, product structure annotation & definitions.
- Engineering analysis and design intent of individual parts is not available for sustainment procurement.
- Engineering and manufacturing product information is re-created repeatedly across a products lifecycle.
- Cyber security for data systems.
- Getting the Product Data sync with as Designed, as Produced, and as Maintained Configurations to support the platform thru the total lifecycle, so that it is reuse/repurposed instead of recreated.
- Long manufacturing lead times, high cost of manufacturing and inspection
- Getting data to the right user at the right time in the right format so that parts can be delivered to the warfighter at the right place, right price, and on time.

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14

Future Manufacturing

- Digital link between design and fabrication
- Connected machines, factories, and supply chains
- Transparency and visibility into supplier factories
- Data aggregation, analysis, and action across the product lifecycle
- Leverage the power of data analytics and networks to do more with existing resources

Manufacturing Use Case (A Need Description)	**Greg Harris: Protected and connected digital enterprise, secure digital thread, enabling mostly secure environment, including handheld devices that we use for multiple activities (similar to financial industry)**
Business Challenge	• Lack of means enabling access and utilization of the disconnected systems in use today • Lack of digital manufacturing business solutions available • Lack of platforms on which to place and use the digital manufacturing business solutions • Cyber security risks (both perceived and real) that keep manufacturers from trusting systems
Business Benefit of addressing challenge; estimated quantification of benefit	• New businesses will be created, including those enabling manufacturing data analysis • Reestablishment of the US industrial base as the world leader in efficient and agile manufacturing • Restoration of a robust middle class America • Large savings from the efficient transfer of data between disparate systems
Open Cloud Opportunity	• Open cloud allows disruption to occur in manufacturing industry with "apps." In the future, manufacturing software solutions will be small, inexpensive, and user-friendly. • Interoperability issues can be addressed broadly instead of a point solution basis • Access to tools and capabilities that the Small and Medium Enterprises do not have access to today • Opportunity for Supply Chain growth through collaboration tools • Enabling plug-and-play digital functionality across the entire digital thread
Technical Issues & Initiatives	• Enterprise model for mfg. software is proprietary and not interoperable • Methods ensuring that credentialed identification is accessible, transferrable and retrievable • From a government perspective there is a serious infrastructure gap, particularly with the Organic Industrial Base • Processes and procedures to reuse data in multiple points throughout the life cycle of a system
Standards Role	• Standards are necessary to bring order to the Wild, Wild West of Digital Manufacturing and Design that we are experiencing today • There are gaps and overlaps in standards today that must be bridged and harmonized to bring about interoperability and ease of function for efficient data exchange

Industrial Internet of Things:

The Opportunities and Challenges for Engineers and Scientists

Shelley Gretlein
National Instruments

The idea of a smarter world where systems with sensors and local processing are connected to share information is taking hold in every single industry. These systems will be connected on a global scale with users and each other to help users make more informed decisions. Many labels have been given to this overarching idea, but the most ubiquitous is the Internet of Things (IoT). The IoT includes everything from smart homes and mobile fitness devices, to the Industrial Internet of Things (IIoT) with smart cities, smart factories, and the smart grid.

The IIoT can be characterized as a vast number of connected industrial systems that are communicating and coordinating their data analytics and actions to improve industrial performance and benefit society as a whole. By making machines smarter through local processing and communications, the IIoT could solve problems in ways that were previously inconceivable. But, as the saying goes, "If it was easy, everyone would be doing it." As innovation grows, so does the complexity, which makes the IIoT a challenge that no company can meet on its own.

This challenge becomes even more daunting and complex when comparing the requirements of the industrial Internet to those of the consumer Internet. Both involve connecting devices and systems all across the globe, but the IIoT adds stricter requirements to its local networks for latency, determinism, and bandwidth. When dealing with precision machines that can fail if timing is off by a millisecond, adhering to strict requirements becomes pivotal to the health and safety of the machine operators, the machines, and the business.

- As the IIoT comes to fruition, a big change is in store for historical industrial systems, because systems management and security will be paramount. As massive networks of systems come online, these systems need to communicate with each other and with the enterprise, often over vast distances. Both the systems and the communications need to be secure, or millions of dollars worth of assets are put at risk. One example of the need for security is on the smart grid, which is on the leading edge of the IIoT. As information on the grid becomes more accessible, so does the damage a security breach can inflict.

- In addition to being secure, IIoT systems need to be continually modified and maintained to meet ever-changing functionality and system-maintenance requirements. As more capabilities are added, new systems have to be tacked on to meet those needs. Soon, a tangled web of interconnected components starts to form. The new system must integrate not only with the original system but also all of the other systems. Imagine modifying and updating thousands or millions of systems located all over the world, some in remote locations.

- Developing and deploying the systems that will make up the IIoT represents a massive investment for decades to come. The only way to meet the needs of today and tomorrow is not by predicting the future, but by deploying a network of systems flexible enough to evolve and adapt. The way forward involves a platform-based approach; a single flexible hardware architecture deployed across many applications removes a substantial amount of hardware complexity and makes each new problem primarily a software challenge. By investing in a cohesive hardware/software platform, all efforts surrounding security and updates can focus on a better solution that's deployable across myriad applications.

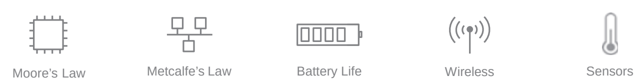
- The ongoing design of the IIoT represents a massive business and technology opportunity for all of us. Engineers and scientists are already implementing systems on the leading edge of the IIoT, but many things still need to be defined and much work needs to be done.

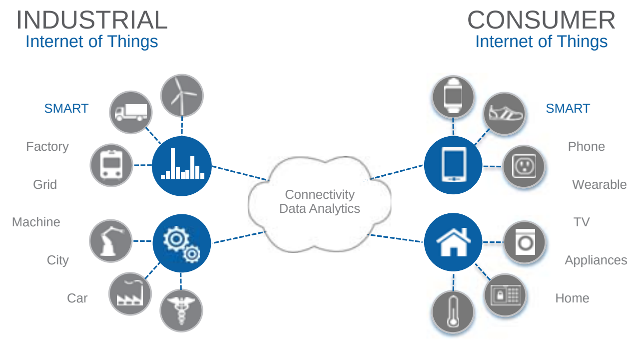
The Escalating Complexity of Systems

Airbus
reduced development time by 10X
with NI solutions.

National Grid
gained visibility and access to critical turbine performance data for 11GW of wind power
with NI solutions.

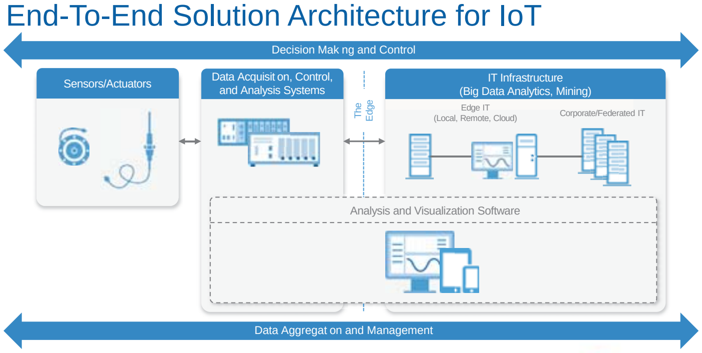
The Internet of Things





Based on Moor Insights & Strategy's report "Segmenting the Internet of Things (IoT)"

End-To-End Solution Architecture for IoT



Big Data Characterized

Industry/IT sources

- Enterprise apps: ERM, CRM, HR
- IT data: events, logs, inventories
- Process and control

Engineering/scientific data sources

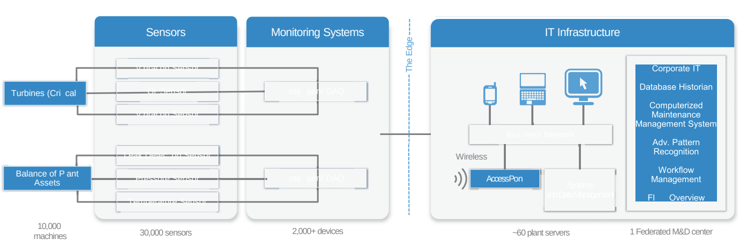
- Physical world: analog phenomenon
- DAQ, A/D

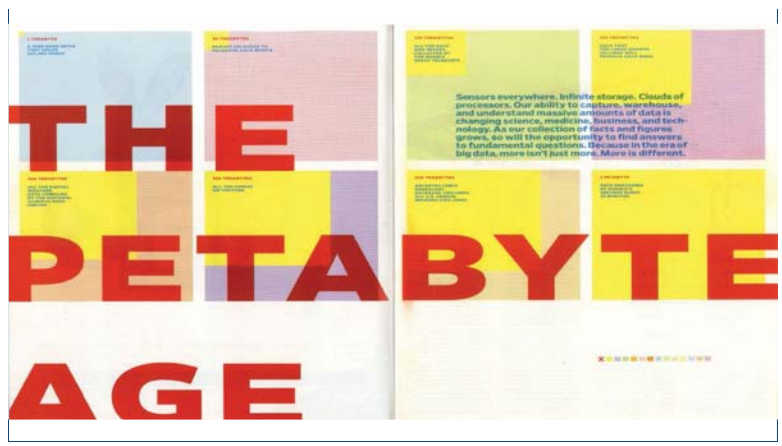
Social data sources

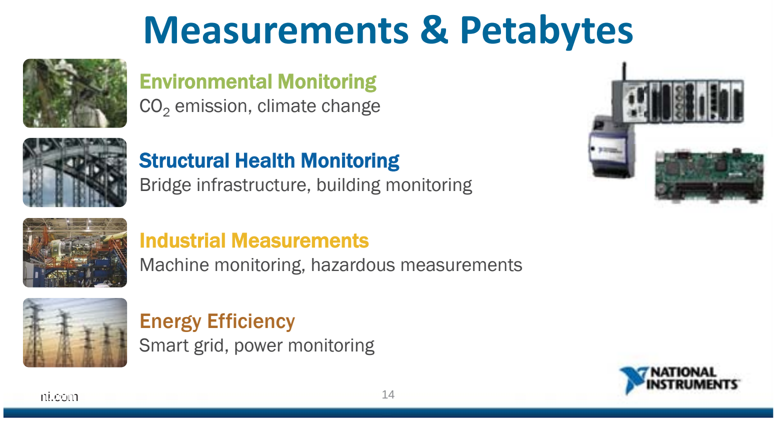
- Social data, behaviors, sentiments
- Tweets, posts, comments

Example Big Analog Data™ End-to-End Solution

Fleetwide Online Asset Condition Monitoring






Measurements & Petabytes
Environmental Monitoring
CO_2 emission, climate change
Structural Health Monitoring
Bridge infrastructure, building monitoring
Industrial Measurements
Machine monitoring, hazardous measurements
Energy Efficiency
Smart grid, power monitoring
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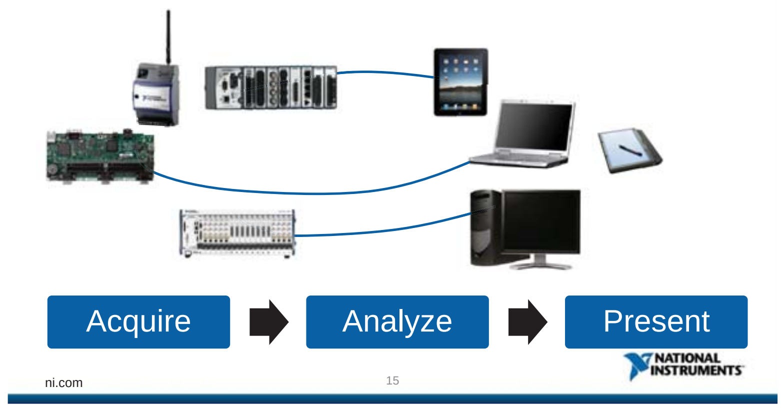
Acquire
Analyze
Present
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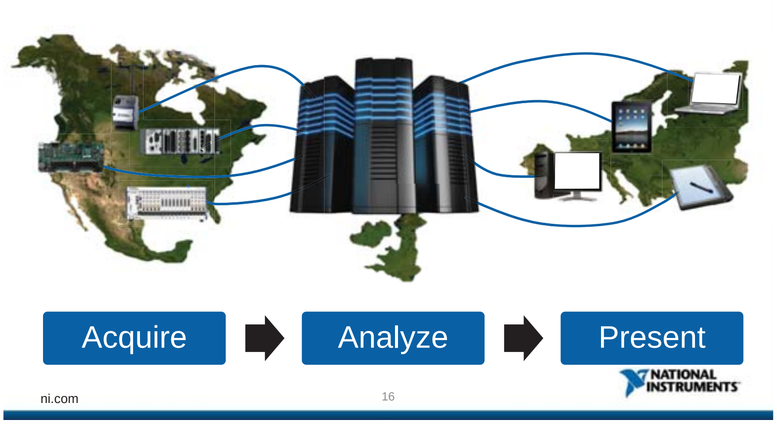
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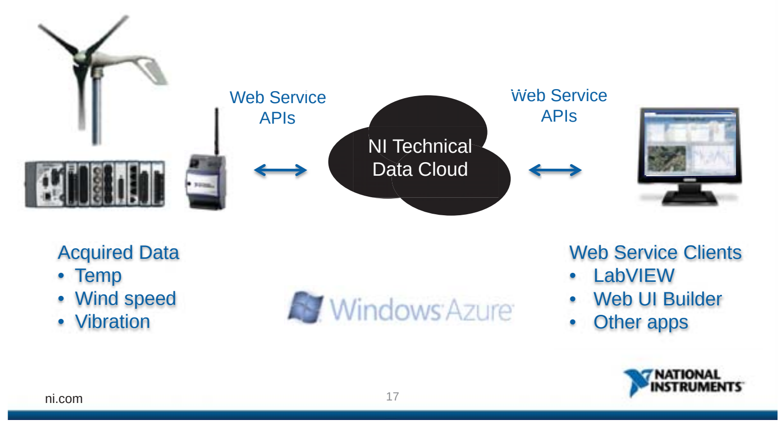
Web Service APIs
NI Technical Data Cloud
Web Service APIs
Acquired Data
• Temp
• Wind speed
• Vibration
Windows Azure
Web Service Clients
• LabVIEW
• Web UI Builder
• Other apps
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LabVIEW
Web Service Application
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LabVIEW Web UI Builder
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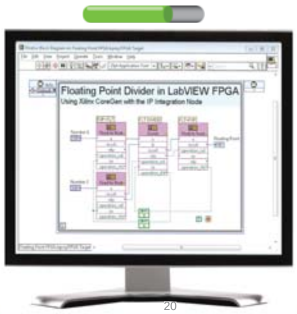
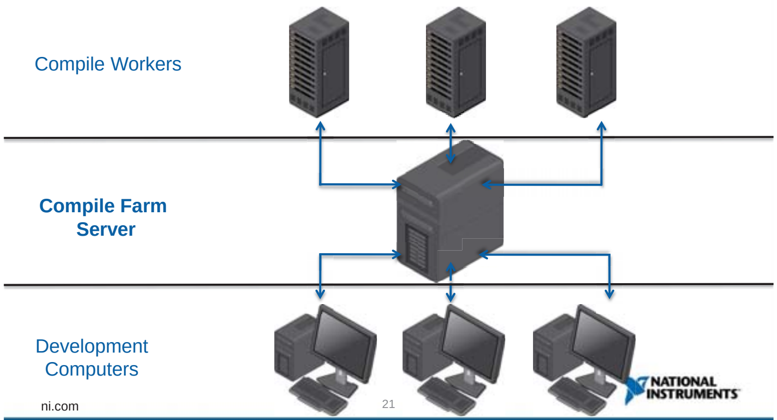
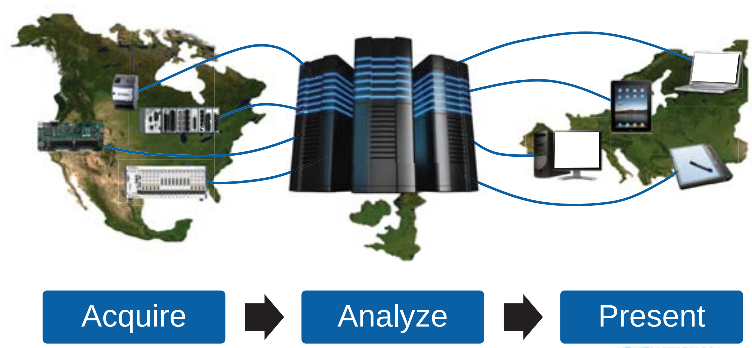
Local LabVIEW FPGA Compile

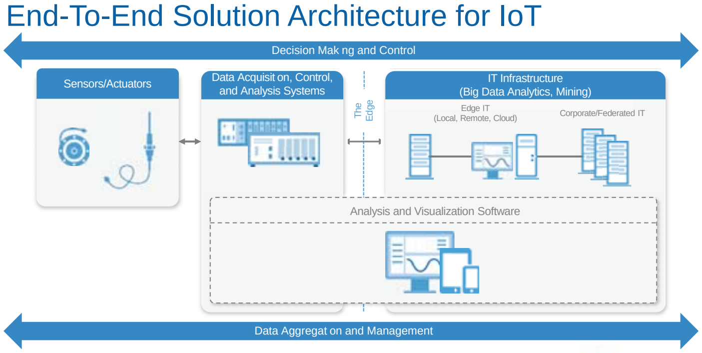




LabVIEW FPGA Compile Cloud Service (Beta)



End-To-End Solution Architecture for IoT



Open Cloud Architectures for Smart Manufacturing Workshop

Enabling Integration of Manufacturing Operations to the Cloud

Chris Monchinski
Co Chair ISA95
Managing Director ISA S&P Board
Automated Control Concepts
www.automated-control.com

NIST National Institute of Standards and Technology U.S. Department of Commerce

Enterprise S95 Control

ACC Automated Control Concepts Inc.

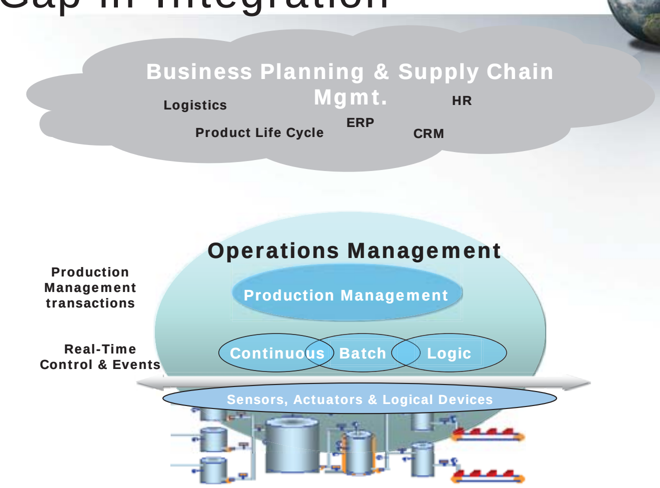
Manufacturing Use Case	Integration between Cloud Based Level 4 Systems and Real Time Factory Floor Automation made possible with ISA 95 *Cloud-to-On Premise Integration of Manufacturing Enterprise and Real Time Factory Floor*
Business Challenge	• Manufacturers are adopting business level systems that are increasingly moving toward cloud based architectures (SaaS, software rentals, third party contracts and off site systems) • Manufacturing systems and IT assets remain fixed assets with real time requirements (0 latency) and high availability. • Integrating these new, hybrid architectures is increasingly challenging. Security, protection of intellectual property, customer data and system robustness are all of paramount importance. • Evolving Adoption of "Two Tiered" systems requires both cloud based and locally hosted solutions increasing integration demands.
Business Benefit of addressing challenge; estimated quantification of benefit	• Reducing the risk and cost of integration between cloud based assets and fixed assets will enable rapid adoption of cloud based solutions • Reduced asset costs, increased flexibility, increased reliability and robust security are all benefits of a well integrated cloud based architecture. • Integration when applying standards • Prior: projects took 1-2 years & <50% successful • After: projects take 2-4 months & >90% successful
Open Cloud Opportunity	• Standards such as ISA 95 Control to Enterprise Integration standard are a facilitator technology that will allow manufacturers to "plug in" to business based systems hosted in cloud computing architectures • Flexible Integration and collaboration reduces risk and increases speed of implementation and adoption rates of these new technologies. • ISA 95 Control to Enterprise Integration standard provides models and definitions of application boundaries based in function, allowing architects to define hybrid systems using cloud and fixed asset systems, as necessary

Manufacturing Use Case	Integration between Cloud Based Level 4 Systems and Real Time Factory Floor Automation made possible with ISA 95 *Cloud-to-On Premise Integration of Manufacturing Enterprise and Real Time Factory Floor*
Technical Issues & Initiatives	• Collaboration with several industry-specific standard groups has facilitated adoption of ISA 95 in a wide variety of industries. This needs to continue. • National and International Standards groups need to continue to collaborate and present a unified voice to the manufacture and software/service vendors. • The ability to leverage the standards and models to demonstrate the ability to integrate systems and then to turn that collective know-how into toolkits (in the form of code, guidance, industry specific technical reports, etc.) will greatly reduce the cost and risk of integration and promote best practices. • Adoption by vendors of integration standards such as ISA 95 Part 6 and 7 will reduce risks associated with interoperability among enterprise service vendors. These tools will be "key" to facilitating flexible integration strategies to enable manufacturing assets to leverage cloud technology. • Promotion and adoption of practices outlined in the ISA 99 / 62443 standard will facilitate "integrated" security and best practices for robust integration
Standards Role	• The ISA 95 / 62264 Control to Enterprise Integration standard helps system architects define logical boundaries between systems, allowing manufacturing systems to integrate to cloud based systems, exchanging data reliability and securely. • B2MML (Business to Manufacturing Markup Language is an open source initiative maintained by MESA and is an instantiation of the ISA 95 standard in XML and WSDL. • Facilitate Best Practices and increase manufacturing "Nimbleness"

Cloud Benefits

- Success with Cloud Technologies in Manufacturing
  - o Adoption of Cloud Technologies
    - *Enterprise Software*
    - *Sales Force Automation*
    - *Customer Relationship Management*
  - o Benefits
    - *Reduced Cost of Ownership*
    - *Pay for the services you use*
    - *Scalability*
- SaaS, PaaS, IaaS Implementations
  - o Logistics
    - *Collaboration between suppliers and distributors*
  - o Sales support functions
    - *Company "know-how" and collaboration with customers*
  - o Product development management
    - *Rapid Implementation*

Gap in Integration



Challenge in Manufacturing

- Manufacturing Operations
  - o Systems comprised of "fixed" resources
    - *Equipment, Materials, People, Energy*
  - o Need for near Real-Time response
  - o Need for High Reliability
  - o Protecting Intellectual Property
  - o Security Concerns
  - o Reduce Integration Costs
  - o Increase Integration Flexibility

Challenge in Manufacturing

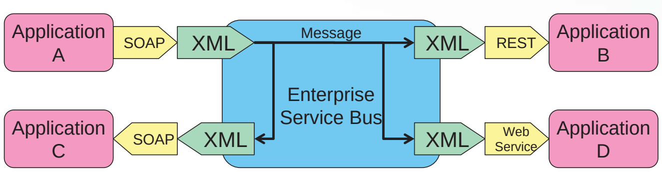
- Evolving Adoption of "Two Tiered" Systems
  - o Use SaaS, PaaS or IaaS for Outsourced ERP, Logistics
  - o Keep Critical Assets and Infrastructure In-house
  - o Allows Customization for Each Location
- Integration Risks
  - o Require High Levels of Integration
  - o But Must Be Flexible, Reliable
  - o Security

Benefits to Enabling Integration

- Standards Applied to Integration
  - o Reduce Risk
  - o Prior
    - *projects took 1-2 years*
    - *< 50% successful*
  - o After
    - *projects take 2-4 months*
    - *>90% successful*
  - o Increase Adoption of Cloud Technology

Integration – Current Practice

- **Message based protocols** have become the standard model for cloud based enterprise integration
- **Enterprise Service Buses** (ESB) have become the standard model for exchanging integration messages
- **XML** has become the standard model for data representation within messages
- **SOAP** and **REST** have become the standard interfaces to ESBs
- **Web services** have become the standard for **SOAP** implementations



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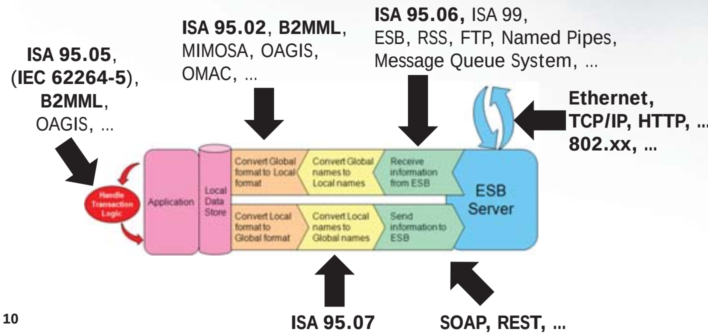
Standards at Each Step

- National/International, de facto, industry standards
- ISA 95, B2MML, SOAP, ISA 99, WS_*



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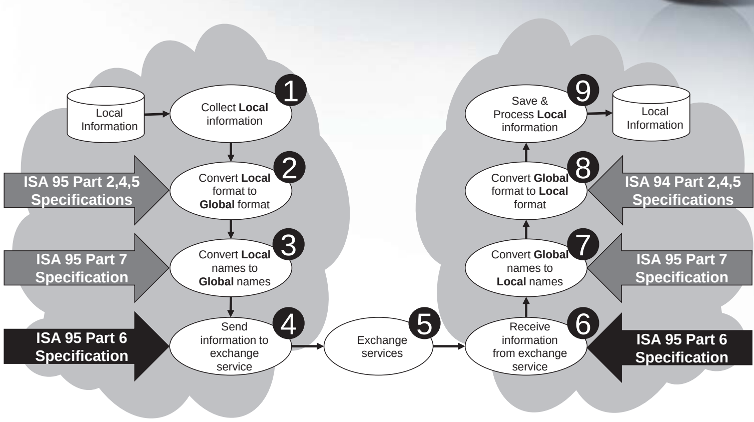
Integration with Standards
A Step by Step Approach



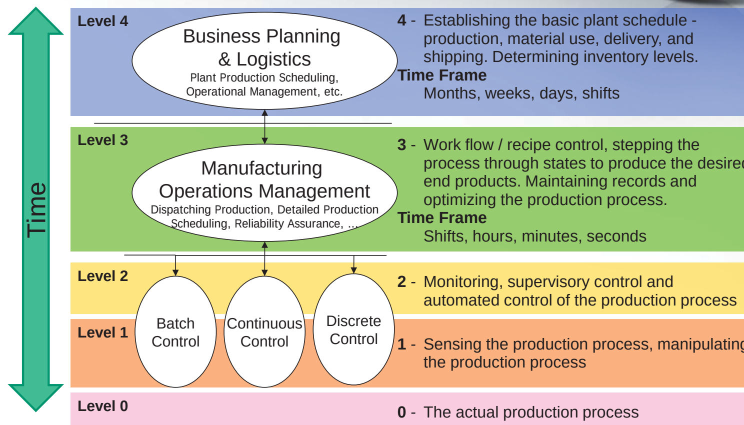
Advantages of the ISA 95 Standard

- Consistent Terminology
  - o Foundation for supplier and end user communications
- Consistent Information Models
  - o Model Recognizing Separate, Distinct Processes in Business and Manufacturing
  - o Foundation for consistency between suppliers
- Consistent Operations Models
  - o Foundation for clarifying product functionality – "how" information is to be used
- Technology Independent

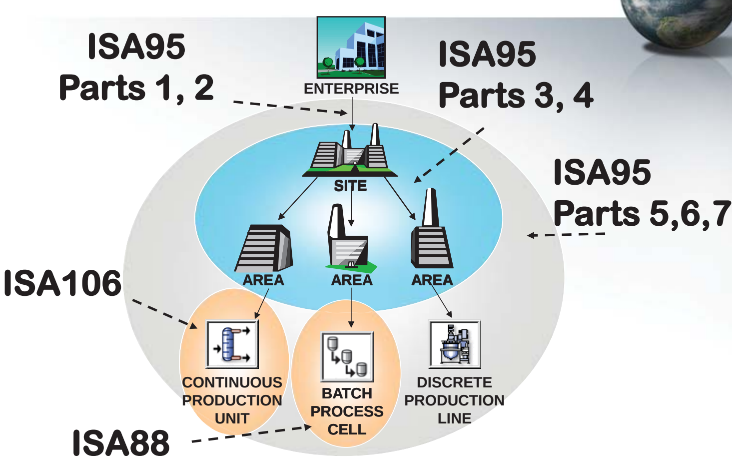
ISA 95 Scope

- Enterprise to Control Systems Integration
  - o A Multi-Part Standard
  - o Define a model of the enterprise, including manufacturing control functions and business functions, and its information exchange. "Enterprise to control system integration"
- Includes batch, continuous and discrete
- The interface between:
  - o Business planning & logistics ("level 4")
  - o Manufacturing operations & control ("level 3")
- B2MML (Business to Manufacturing Markup Language)
  - o Defines an implementation of the ISA models in an XML format
  - o Defines a standard language for representing exchanged information

ISA95 Levels



Where the Standards Fit



The ISA95 Standard

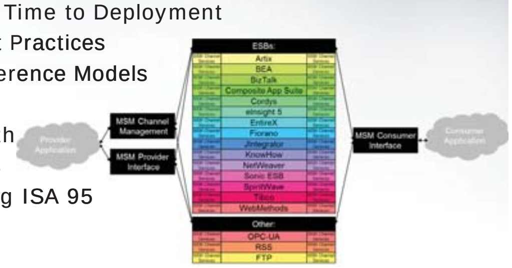
- Part 1: Models and Terminology
- Part 2: Data Structures and Attributes
- Part 3: Activity Models of Manufacturing Operations Management
- Part 4: Object Models and Attributes of Manufacturing Operations Management
- Part 5: Business to Manufacturing Transactions
- Part 6: Messaging Service Model
- Part 7: Alias Service Model

ISA 95 Initiatives

- Better Collaboration Between Standards
  - o Avoiding Standards "Soup"
  - o Guidance for the Market
  - o International Standards Harmonization
- Adoption Across Industry Types
  - o Implementation Guidance for Discrete, Batch, and Continuous Industries
- Collaboration of Vendors
  - o Bridging the gap between Automation and IT service vendors

ISA 95 Initiatives

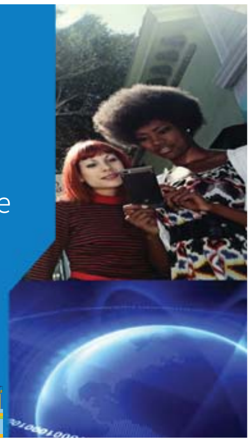
- Better Tools and Toolkits
  - o Automate Integration
  - o Reduction in Code Maintenance
  - o Reduction in Time to Deployment
  - o Capture Best Practices
  - o Working Reference Models
- Adoption
  - o Engaging with
  - o ESB Vendors
  - o Implementing ISA 95



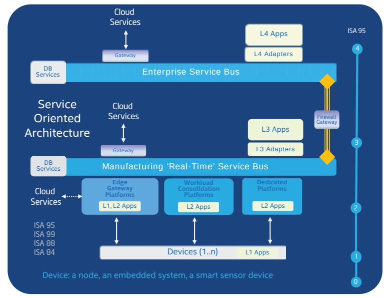
- Security
  - o Leveraging ISA 99 / 62443 Guidance Best Practices
  - o Adopting Security "integrated" into the solution

Smart Manufacturing Architectures, Implementations and the Internet of Things

Kirk Smith
Solutions Architect
Internet of Things Group
Industrial and Energy Solutions Division
Intel Corporation



IoT Smart Manufacturing Areas of Interest



#1 Simplify Bus Communications from Device to Cloud

#2 Enable new E2E Integrated Hardware Root of Trust Security Models

#3 Convergence of OT/IT Manufacturing Architectures

#4 Enable Software Defined and Scalable Analytics at the Edge and Cloud

E2E IoT Security is a Pre-Cursor and Basic Capability that Drives all other Success!

IoT Smart Manufacturing Positons Summary

Use Case	Challenge	Benefit	Opportunity	Issues	Standards
Simplify Bus Communications	Device access, state visibility	State awareness of embedded industrial devices.	Define open data access models for embedded devices	Ease\cost of accessing Proprietary networks.	Protocol abstraction or translation for IoT use cases.
E2E Security Models	HRT linkage	High protection level for critical infrastructure	Lowers barriers for enabling industrial use cases	Expertise, legacy components, engineering expense	Connect one-way to hardware roots of trust at both ends of the wire.
Convergence of OT/IT Manufacturing Architectures	Network fragmentation; Manageability at scale; Access to RT data.	Simplicity, scalability	Lower maintenance and integration costs	Long timelines likely for system and network migration	Simplify network traversal across MSB and ESB network architectures. Improve co-existence of Near RT and RT network processing
Enable Software Defined Scalable Analytics	Access at the edge; skilled resource pool	Higher re-use of assets; more scalable manageability;	Drive secure virtualization deeper into embedded domains	Remote connectivity, data normalization, model, interoperability, maintenance models	Improve interoperability and scalable access to analytics at the edge and cloud for E2E systems.

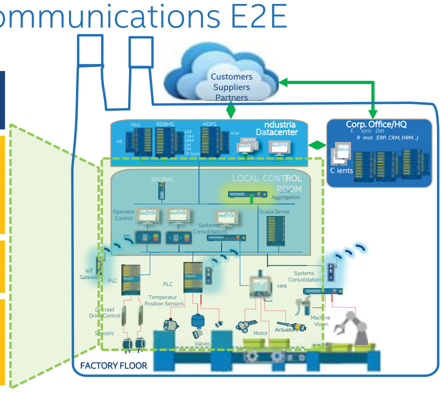
#1 Simplify Bus Communications E2E

Abstract complexity of heterogeneous devices with:

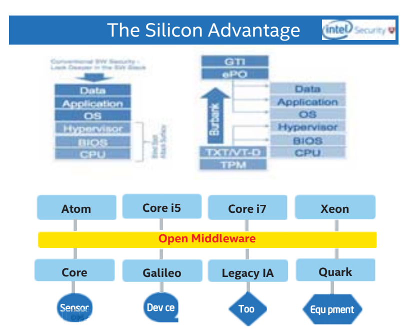
Manufacturing Service Bus
High Bandwidth
Real-time
Standards-based

Secure and Trusted Data:
Unified Security architecture

"Plug and Play"
Add devices and connect E2E
Easily Collect/Transfer Data

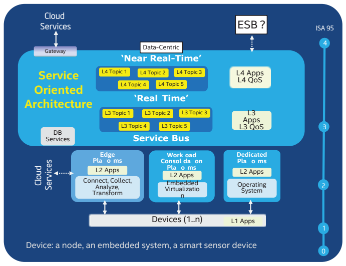


#2 Integrated Hardware Root of Trust Security



1. **Secure:**
   - Intel Hardware Root-of-Trust + Middleware + Intel Security + Wind River Bundled Solutions
2. **Connected:** An Open Middleware Component Model Supports
   - Device to Cloud Integration
   - Middleware to ESB Adaptation Integration
   - High QoS Options
   - Migration Path
3. **Managed:**
   - Intel Security, Wind River, MW Solution Integration

#3 OT/IT Convergence Trends



One configurable QoS defines the service bus communication technology across the factory and supply chain with overall lower TCO.

Increase Access to Highly Actionable Data

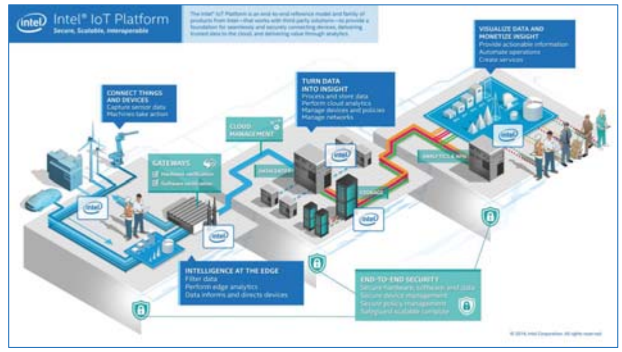
A Single View of the Truth:
Right Information at Right Time to Right Person = Better Decisions!

Dynamic Real-Time Optimization
Supply Chain Frequencies approaching Factory Frequencies

Cost Reductions
Increased production performance, aligned operational / business goals
Lower maintenance, workforce management

Increased Access to Real-Time Data Translates to $$$

#4 Scalable Software Defined Analytics



Reference and Related Collateral:

Intel IoT Insights Day:
http://newsroom.intel.com/docs/DOC-6097

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