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AUTOMATING ASSET KNOWLEDGE WITH MTCONNECT

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ABSTRACT

In order to maximize assets, manufacturers should use real-time knowledge garnered from ongoing and continuous collection and evaluation of factory-floor machine status data. In discrete parts manufacturing, factory machine monitoring has been difficult, due primarily to closed, proprietary automation equipment that make integration difficult. Recently, there has been a push in applying the data acquisition concepts of MTConnect to the real-time acquisition of machine status data. MTConnect is an open, free specification aimed at overcoming the “Islands of Automation” dilemma on the shop floor. With automated asset analysis, manufacturers can improve production to become lean, efficient, and effective. The focus of this paper will be on the deployment of MTConnect to collect real-time machine status to automate asset management. In addition, we will leverage the ISO 22400 standard, which defines an asset and quantifies asset performance metrics. In conjunction with these goals, the deployment of MTConnect in a large aerospace manufacturing facility will be studied with emphasis on asset management and understanding the impact of machine Overall Equipment Effectiveness (OEE) on manufacturing.

Keywords

MTConnect, asset management, Overall Equipment Effectiveness (OEE), manufacturing, Computerized Numerical Control (CNC), network

Nomenclature

AGFM American Gesellschaft für Fertigungstechnik und

	Maschinenbau
AGV	Automated Guided Vehicle
API	Application Programming Interface
CMM	Coordinate Measuring Machine
CNC	Computer Numerical Control
CTLM	Contour Tape Laying Machines
DCOM	Distributed Component Object Model
DST	Dörries Scharmann Technologie
EDM	Electro Discharge Machining
Focas	Fanuc OpenFactory CNC API Specifications
HSSB	High Speed Serial Bus
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
KPI	Key Performance Indicator
MTC	Manufacturing Technology Connect
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
PC	Personal Computer
SCM	Service Control Manager
SHDR	Simple Hierarchical Data Representation
SPC	Statistical Process Control
URL	Uniform Resource Locator
XML	eXtensible Markup Language
XSD	XML Schema Definition

1 INTRODUCTION

Production knowledge consists of understanding, organizing, and managing the machines, processes, and the tasks to be performed in a manufacturing facility. The focus of this paper

will be on managing the machines, commonly referred to as assets. In an industrial context, asset management maximizes the performance of production resources for achieving manufacturing objectives – producing products faster, cheaper, and better. For shop floor equipment, this means having a clear understanding of how machines operate and how to improve manufacturing. Informative and timely asset management can be used to accurately assess manufacturing operation and to make adjustments to meet shifting manufacturing conditions. Example manufacturing roles for asset management include:

- accumulating resource knowledge for calculating accounting functions such as the actual machining cost of a part for bidding, and determining profits [1–4],
- identifying production bottlenecks [5–8],
- building up machine histories in order to perform predictive maintenance [9–12],
- incorporating equipment and process knowledge dynamically on a machine [13–15],
- recognizing excessively high asset utilization as a prerequisite to determining procurement needs [16–18].

Although timely machine status feedback during factory operation is not a complex concept, the collection and dissemination of the necessary status data in a timely and integrated manner has been a challenge within the discrete parts industries. The breadth of machines in the discrete industries is extensive, from additive and subtractive machine tools, robots, and automated guided vehicles (AGV). Plus, vendors, Original Equipment Manufacturers (OEMs), and end-users in the discrete industries have all been reluctant to adopt a global integration solution and instead prefer a proprietary approach. Clearly issues stem from the over-abundance of industrial standards from which to choose [19–26]. MTConnect is a standard to address many of these shortcomings, and is gaining traction in the discrete parts industry [27–29].

This paper discusses the automated collection and analysis of real-time machine status data based on the integration of MTConnect and machine status reporting. The second section gives a brief overview of MTConnect and the machine tool information model used for status reporting. The third section gives a background on ISO 22400 and its model of asset management. This section will include a mapping of MTConnect machine status into ISO 22400 asset management concepts. The fourth section describes a case study of asset management using MTConnect on the shop floor at a large aerospace factory. The final section contains a discussion on the benefits of machine tool status data in terms of support asset management as well as the problems encountered developing automated machine status feedback and the future work envisioned in this area.

2 MTConnect Overview

In order to reduce costs, increase interoperability, and maximize enterprise-level integration, the MTConnect specification has been developed for the discrete manufacturing industry [30]. Although aimed at solving the “Islands of Automation” problem prevalent in the discrete manufacturing industries, MTConnect is flexible and can be easily adapted to other asset management or other manufacturing applications [31]. MTConnect is a specification based upon prevalent Web technology including eXtensible Markup Language (XML) [32] and Hypertext Transfer Protocol (HTTP) [33]. Using this prevailing technology and providing free software development kits minimize the technical and economic barriers to MTConnect adoption.

Figure 1 shows the basic elements in an MTConnect solution. MTConnect “Agent” is a software process that acts as a bridge between a MTConnect “Device” and a Client Application. An MTConnect “Device” is a piece of equipment, like a CNC machining center or robot, organized as a set of components that provide data. MTConnect defines Events, Samples, Conditions, and Asset data items, whose XML format is all rigorously specified by XML Schema Definition (XSD) [34] schemas. Optionally, an MTConnect “Adapter” can be installed natively on the machine, which is a process that provides a communication link between a device and the agent. Agents can have a specialized remote Adapter or embedded “Backend” to communicate to the Device, (e.g., Simple Hierarchical Data Representation or SHDR [35] or OPC [36]).

The MTConnect standard defines XML schemas in order to exchange standard XML information. MTConnect defines the XSD content for Devices, Streams, Assets, or Errors necessary for retrieving factory device data, where:

- The MTConnect Devices XSD is an Information Model that describes each device and its data items available.
- The MTConnect Streams XSD is an Information Model that describes a time series of data items specified in the Devices XML including samples, events, and conditions.
- The MTConnect Error XSD defines the XML to describe one or more errors that occurred in processing an HTTP request to an MTConnect Agent.
- The MTConnect Asset XSD defines the XML pertaining to a machine tool asset, which is not a direct component of the machine and can be relocated to another device during its lifetime. The concept of MTConnect Asset refers to communication of resource asset knowledge and not the physical resource discussed in this paper. MTConnect Asset examples include tooling, parts, and fixtures.

Currently, MTConnect Agent supports four main types of requests:

- Probe request – response describes the devices whose data is being reported.

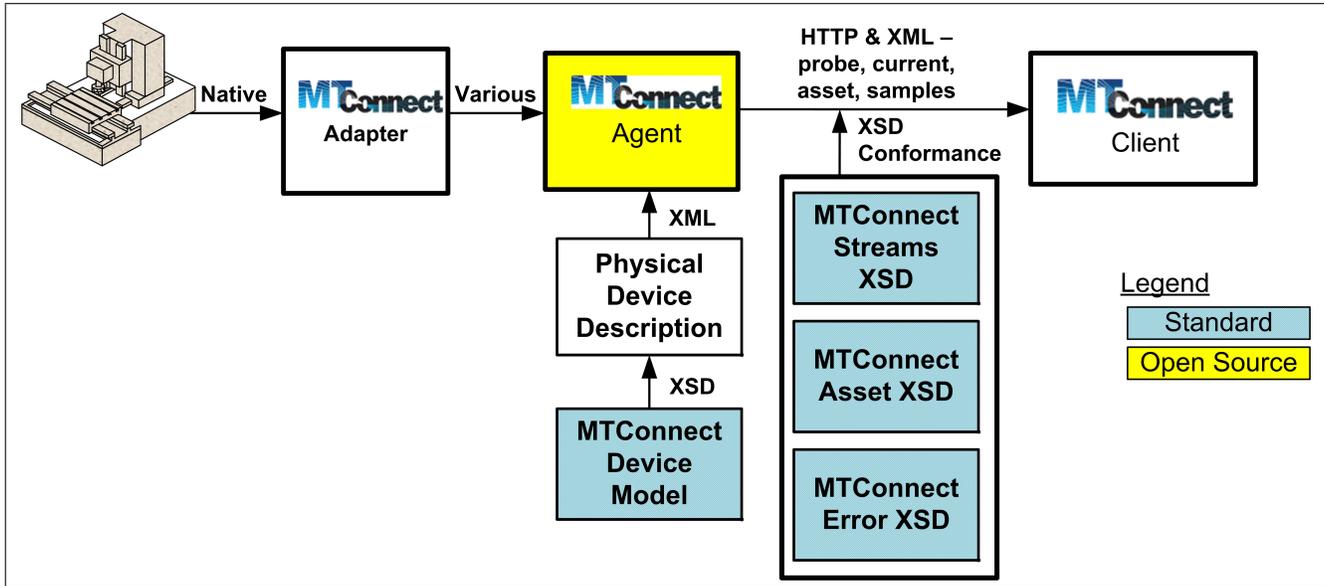


FIGURE 1: MTConnect Solution Overview

- Current request – retrieves the values of the devices data items at the point the request is received.
- Sample request – retrieves a list of past and/or current values for one or more data items.
- Asset request – retrieves data describing the state of an asset. Within an asset stream, there exists the ability to embed third party developed standards, (e.g., ISO 13399 [37]) within the response.

HTTP is the protocol used by MTConnect (as well as the World Wide Web) to define legal messages [38]. MTConnect also establishes what constitutes legal commands through the use of decorated Uniform Resource Locator (URL) such as <http://agent.MTConnect.org/probe>. MTConnect follows the rules of HTTP to fetch and transmit the requested MTConnect command, be it “probe”, “current”, “sample”, or “asset”.

In a “probe”, an MTConnect Device is modeled in XML which conforms to the Device XSD. The “Device Data Model” provides the Device(s) description that the world will see, which will typically be a subset of the total possible data from a device. The MTConnect Device model is not hardwired; rather users assemble an XML information model to match their device and their data requirements. Each MTConnect implementation uses a Device Data XML document to describe the data that will be conveyed from one or more devices. In effect, of the thousands of data items that may be available from a controller, MTConnect provides an XML document that enumerates which data items are in fact available. For example, suppose an MTConnect user is interested in the parameter “following error” of a servo drive, then the user would have to see if the Device is configured to

supply “following error” data.

MTConnect Stream and Device XML Document are similar to all XML documents in that they are a tree representation. At the root, “Devices” define one or more “Device” (e.g., machine tool), which in turn defines a set of components, which in turn contain “Data Items”. Thus, an “MTConnect Device” is a machine organized as a set of components that provide data. Figure 2 shows a simple MTConnect hierarchy. In this MTConnect example, “cnc1” is composed of components: “power”, “controller”, and “axes”. Each component then has event or sample Data Item definitions. In this example, the “axes” component has sample data items: Srpm, Xabs, Yabs, and Zabs. In contrast, the “controller” component has two event data items: mode, and execution; and one sample data item: feedrate. Sample tags (e.g., Xabs, Yabs, Zabs) exhibit numerical values as strings. Some event tags have an enumeration string, e.g., the mode event can be either: MANUAL, MANUAL_DATA_ENTRY, AUTOMATIC.

Generally, MTConnect performance is low bandwidth (i.e., 1 to 2Hz), so that start/stop/program changes/alarms and other machine specific events are easily identified at this sampling rate. Higher bandwidth techniques are available in MTConnect, but are out of scope for this document.

3 ASSET MANAGEMENT

Manufacturing companies create products by converting raw materials, stock, or supplied goods into a finished product to sell. In general, manufacturing is complicated due to the parallel machine operation, dynamic job arrival, multi-resource require-

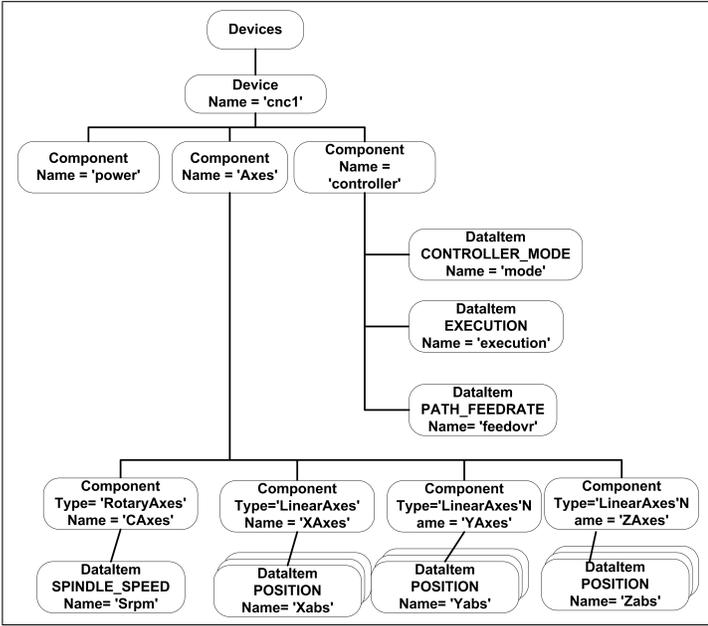


FIGURE 2: MTConnect Device Hierarchy Example

ments, and general job precedence constraints. At its most basic, manufacturing is handled by a set of machines, with a varying degree of flexibility and control; a material handling system that allows jobs to move between machines; and a set of computers for command and control. Preferably, the set of computers is all fully integrated on an enterprise network.

Asset management quantifies the performance of production resources in achieving manufacturing objectives. Asset management can be used to build up machine histories, which can be used to make informed business decisions, such as, capital avoidance (when to hold off on equipment purchases) or intelligent purchasing (formal evaluation of a given CNC model’s actual performance, not anecdotal based on estimated data). Asset management can be used to store information on equipment within processes for use in undertaking corrective actions. The patterns of equipment operation can be analyzed for bottlenecks or underutilization and then used to improve the production process and reduce costs and improve product turnaround.

Depending on the individual or organization, possibly from different technical and geographic points of origin, assets may have a differing interpretation. Therefore, the consistent definition of an asset must be in place that is universally understood and adopted. Fortunately, the International Organization for Standardization (ISO) has established a manufacturing standard, ISO 22400 [39] “Automation systems and integration Key performance indicators (KPIs) for manufacturing operations management” that defines the concept of an asset and quantifies the associated performance metrics.

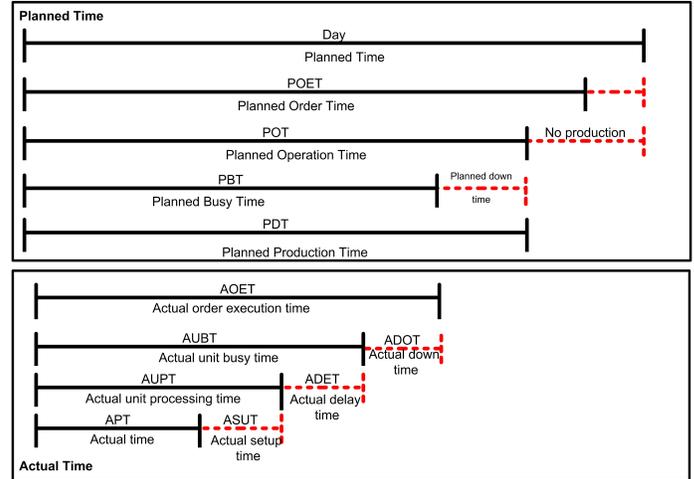


FIGURE 3: ISO 22400 Work Unit Formalism

Foremost, ISO 22400 offers consistent manufacturing concepts and terminology. Such that if KPIs are to be used in multiple locations and are to be searched, shared, and analyzed, a common vocabulary (as well as models) is a prerequisite. In addition, unnecessary cost from mistranslation, misunderstanding, and misinterpretation is avoided. Thus, common terminology and models are helpful in identifying and monitoring enterprise needs and outcomes by pooling data from multiple sources in a systematic method.

The ISO 22400 standard is presented according to high-level ISA 95 Manufacturing Operations Management (MOM) [40] information categories – the machinery and equipment, the product manufactured and its quality, the manufacturing personnel, the inventory, and other related manufacturing elements. Although ISO 22400 covers a complete production model, of interest to this paper is the ISO 22400 formalism to model individual assets or “Work Units” (i.e., ISA 88 terminology for resources or machines [41]) on the shop floor. ISO 22400 includes factors such as costs, quality, time, flexibility, environmental and social issues, and energy efficiency many of which are important but out of scope for this paper.

ISO 22400 formally breaks down the Work Unit production model into planned activities and actual production. Figure 3 shows the ISO 22400 formalism for “planned” and “actual” Work Unit modeling used to assess asset performance. ISO 22400 states that a day is the planned maximum time available for production and maintenance tasks, and a day depends on the number of shifts. In ISO 22400, OEE is calculated by the equations below:

$$\begin{aligned}
 \text{Availability} &= PBT / PDT \\
 &= \text{Planned Busy Time} / \text{Planned Production Time} \\
 \text{Effectiveness} &= (PTU \times PQ) / PDT \\
 &= (\text{Production time per unit} \times \text{Produced quantity}) / PDT
 \end{aligned}$$

$$Quality = \text{PartCountGood} / (\text{PartCountGood} + \text{PartCountBad})$$

$$OEE = Availability \times Effectiveness \times Quality$$

In above equations, *Availability*, *Effectiveness*, *Quality* and *OEE* units are percent. The *Availability* determines how strongly the capacity of the machine for the value-added functions related to the planned availability is. *Availability* takes into account planned time loss, e.g., meetings, coffee breaks, and maintenance. *Effectiveness* is the measure for the efficacy of a process comparing target cycle time to the actual cycle time. *Effectiveness* is also called efficiency factor or performance. The *Quality* rate is the relationship of the proper quantity to the produced quantity. *Availability* takes into account planned down time loss, *Effectiveness* takes into account delays and speed loss, and *Quality* takes into account part loss.

Unfortunately, OEE can be rendered meaningless due to the lack of appropriate data. Specifically, OEE requires a quality component in its calculation, which in discrete parts production is often impossible or can be difficult to determine since quality assessment is typically done later in the manufacturing process and is disconnected from the machining process. In this case OEE degrades into an asset utilization metric. For our analysis, we will assume quality is a meaningful component.

3.1 Mapping ISO 22400 to MTConnect

ISO 22400 distinguishes between performance data (such as Work Unit busy, delay, down, queued, etc.) and KPI (e.g., Work Unit OEE) [42]. It is the role of MTConnect to supply the machine status data. However, ISO 22400 is geared toward asset management with production flow between machines. In other words, ISO 22400 defines delay to include the concepts of blocked, starved, and queued as well as faulted or idle. For the case study that follows, a job shop is a more appropriate model of machine-part relationship and the concepts of blocked, starved, or queued are generally not relevant in a job shop part flow.

The terminology correspondence between ISO 22400 and MTConnect is not a perfect match, so it is best to clarify the data terminology. For ISO 22400, “Down” is the same concept as machine “Off”. Likewise the ISO 22400 concept of “Delay” incorporates the concepts “Idle” and “Faulted”. Long term “Faulted” effects the *OEE Availability* of the machine, and would be a loss due to unscheduled maintenance. This leads to an ISO 22400 state model of down, idle, faulted, or busy while ignoring the starved and blocked states. (Idle as represented by the part queued state is a data parameter for a separate KPI.)

For MTConnect systems, the basic process to provide OEE performance data is to interpret MTConnect state logic using mode, execution, and other MTConnect tags to determine the machine status of busy, idle, faulted, and off. Although different, it is possible to map the MTConnect data into asset management state model. Table 1 shows the mapping of MTConnect status

data items into state formalism corresponding to the ISO 22400 asset model. The MTConnect Data row (first row) details the expected raw data available from the MTConnect Device. The first column abbreviations (e.g., APT, ASUT, ADET) correspond to the ISO 22400 abbreviations from Figure 3.

TABLE 1: Mapping MTConnect State Data into Machine Status Data

Data	Parameters
MTConnect Data	Timestamp, Machine, Power, Mode, Execution, Spindle, Conditions, Feed override
Parameters	Data Mapping
APT \equiv Busy	$MTC_{program} \neq \emptyset$ and $MTC_{execution} = Active$
ASUT \equiv Setup	$MTC_{mode} \in Manual$
ADET \equiv Delay	$MTC_{program} = \emptyset$ or $MTC_{execution} = Stopped$ or $MTC_{execution} = Interrupted$ or $MTC_{mode} = Manual$ or $Faulted$
Down \equiv (Off)	$MTC_{power} = Off$
Faulted	$\exists MTC_{condition} = faulted$ until $\forall MTC_{condition} \neq faulted$

Some of the *OEE* loss is not explicitly covered by ISO 22400. For example, $MTC_{feedoverride} < 100\%$ implies that the operator is slowing down machining and increasing cycle time, either to avoid chatter or for some other reason. This negatively impacts *OEE Effectiveness* ratio. Another example of *OEE Effectiveness* loss, that is not directly covered in ISO 22400, is if the operator is performing first part dry run testing, when spindle $rpm = 0$. Likewise the operator could be probing the part with machine axes moving but again spindle $rpm = 0$.

4 CASE STUDY

A case study was performed that investigates the MTConnect status data requirements for an aerospace manufacturing facility that produces a wide variety of airplane parts, (e.g., brackets, body joints, etc.). The Boeing Company Auburn facility is 195000 square meters (2.1 million-square-foot) and is reportedly the largest airplane parts plant in the world, making and storing more than 200000 parts for commercial jetliners [43]. Part materials vary and include aluminum, stainless steel, titanium, and inconel. The facility can produce parts ranging from a few

ounces to over a ton, with dimensional control in the range of ± 0.0254 mm to ± 0.00254 mm (± 0.001 inch to ± 0.0001 inch). The disparity of part requirements means that there are many types of manufacturing machines, including horizontal mills, vertical mills, routers, waterjet, and wire electro discharge machining (EDM). For confidentiality, the actual performance data has been normalized; however, the analysis is representative of the data that is frequently encountered in facilities such as the one described in this study.

The flow of parts through the facility is determined by a workorder for each part(s). A process planner prepares a workorder for a part(s) that assigns resources, which incorporates constraints based on the asset configuration (e.g., 3 versus 5 axis), surface finish (e.g., high speed machining versus normal milling), machine horsepower, and feature tolerances, among a myriad of part requirements. At the same time the workorder is prepared, the corresponding part program based on the version and revision of the part is uploaded to the program database. The workorder is eventually routed to a machine operator, and in preparation uses one of the designated asset types, gets the raw material, downloads the part program from the database, and does a set up according to the workorder. Should the workorder specify that a large number of parts are to be made, a test try out is done on one part to insure correctness of the plan. Often after the test part is made, the part is inspected, and when the part meets or exceeds the quality requirements, the remainder of the parts are machined according to the workorder. This process is repeated until the test part satisfies the quality requirements. Overall, the flow of parts through the facility resembles a job shop, as opposed to a production line.

The Boeing Auburn plant has been an early adopter of MTConnect and has extensive MTConnect connectivity throughout the factory. The plant use of MTConnect, although not 100 %, encompasses a wide variety of machines and vendors: Mazak, Jomach, Northwood, DST, ATA Group, American Gesellschaft fr Fertigungstechnik und Maschinenbau (AGFM), and Nikon, as well as a variety of controllers: Original Equipment Manufacturer (OEM), Fanuc, Mitsubishi, and Siemens controllers. Most MTConnect Agents were installed as Windows Services that ran as a 24/7 operation. Since the MTConnect agents were a service and not application “exes”, only the Windows Service Control Manager (SCM) can start/stop the programs. Whenever possible, native MTConnect solutions from the CNC vendor were preferred. However, this is not always possible, so custom MTConnect solutions were developed. Fortunately, MTConnect provides open source software solutions for the Agent and a wide range of Adapters, which can be found at <https://github.com/MTConnect>, and were used extensively.

Many of the implementations used an embedded MTConnect Adapter in the controller to perform the communication between a device and the agent (e.g., SHDR, Fanuc High Speed Serial Bus (HSSB) FOCAS). MTConnect also supported special-

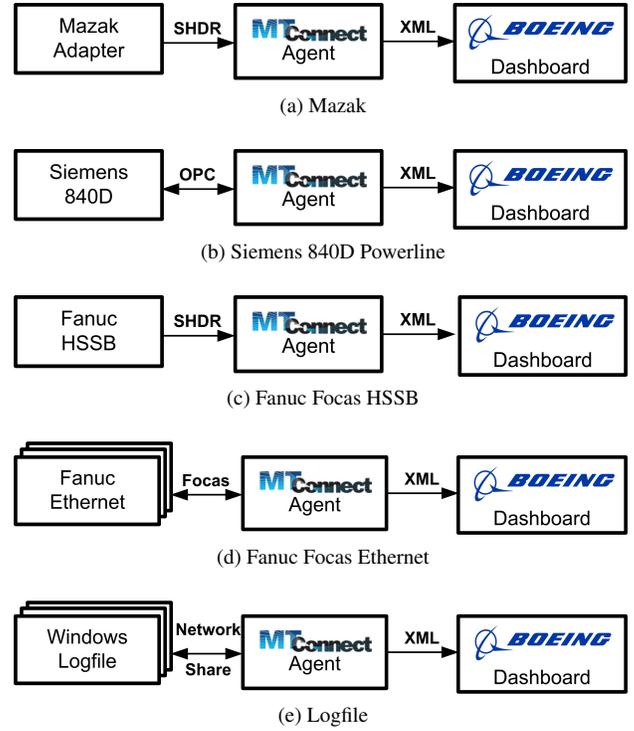


FIGURE 4: MTConnect Case Study Solutions

ized “Backends” in the Agents to communicate to the device via some other remote access protocol, (e.g., OPC, Fanuc Ethernet FOCAS, Logfile). Below is a snapshot of some of the MTConnect solution strategies employed.

- Mazak provides native MTConnect support, supplying a SHDR Adapter and MTConnect Agent. Installation of the MTConnect components were handled by a Mazak service representative. Figure 4a shows the Mazak controller emitted SHDR data to the MTConnect Agent, which translated the data updates into XML.
- Dörries Scharmann Technologie (DST), Jomach, and Echospeed CNC machines, use a Siemens 840D controller. The older Siemens 840D (i.e., Powerline models) support OPC Data Access “Classic” [44]. Figure 4b shows two-way OPC communication using customized MTConnect Agent software with an OPC adapter backend. Heightened cybersecurity precautions make the use of traditional OPC with Distributed Component Object Model (DCOM) connection very problematic.
- Northwood, Cincinnati, Heian Router, and numerous contour tape laying machines (CTLM) used a Fanuc controller. There were many different Fanuc iSeries controller models with subtle differences in functionality. Fanuc machines required the FANUC OpenFactory CNC API Specifications

(Focas) library to communicate to the controller. Focas provides a DLL with API to manage and query the state of the CNC machine. Focas supplies two communication methods using Focas: High Speed Serial Bus (HSSB) and Ethernet. Figure 4c shows the HSSB Focas solution, where one Focas SHDR Adapter is installed on each CNC and then an MTConnect Agent reads the Focas CNC data items using the SHDR protocol. Figure 4d shows the Ethernet Focas solution, which allows MTConnect to remotely access status of multiple controllers.

- For ATA Group, AGFM, and Nikon Coordinate Measuring Machines, status data was obtained from the controller log file. Figure 4e shows a Windows networked file sharing approach used in conjunction with controller log file monitoring. The networked file sharing approach is an easy deployment method as the controllers do not require any special software interface, and need not be aware of the MTConnect monitoring. Cybersecurity protection prevented traditional file access as even file sharing from the MTConnect service across the network needed logon authentication.

Cybersecurity and safety protection of the machines and humans are major concerns. Two cybersecurity schemes were in place. One scheme has a dual Ethernet solution where the MTConnect Agent runs on a front end Personal Computer (PC) and talks to the asset through a local network connection. The second scheme uses a hardware firewall on the machine to block any network traffic, except from the computer running an MTConnect Agent. In each case the goal is to isolate the machine from the corporate Intranet but still allow connectivity by MTConnect.

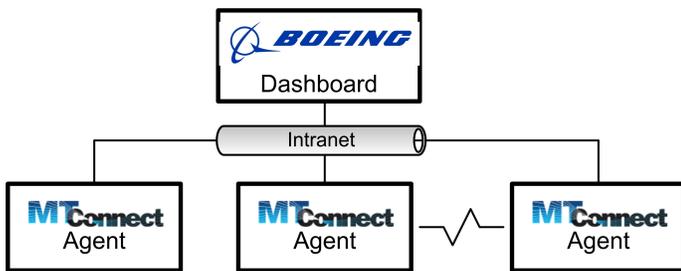


FIGURE 5: Dashboard Client Application Architecture

A stack light dashboard client application monitored enterprise as well as the case study factory machine status in real-time. Figure 5 shows the dashboard architecture, which is a centralized, Web-based software application that collects machine status data from a large collection of MTConnect agents scattered throughout the enterprise, not just at the Auburn facility. All the MTConnect agent front-ends were nearly identical, while the

dispersed assets themselves were wide-ranging with varied functionality. All machine status data was gathered using MTConnect using the Intranet as the communication backbone. Managers can visually see which machines are up as well milling and get an intuitive feel for factory performance. With some historical logging of the factory dashboard performance and drilling down on the actual use of a set of machines, one can perform asset management with real data.

Previous to MTConnect networking of assets, machine status monitoring would have to be done manually. Manual data collection is error prone and sporadic. Moreover, with an automated process, operators are able to spend less time on non-value added reporting activities and more on productivity-oriented tasks. However, this automated approach must be easy to integrate or the benefits will never materialize.

The goal for Auburn and other world class discrete manufacturers is to achieve an 85 % OEE. Numbers higher than 85 % could indicate a bottleneck. When MTConnect asset management is used in conjunction with real time production log files, actionable knowledge is garnered where bottlenecks can be determined so that resources can be directed to mitigating the problem. Numbers lower than 85 % indicate lost productivity. A simple example illustrates the lost revenue that is identifiable with real OEE values [45]. To determine a part *BuildTime* given the asset OEE:

$$BuildTime = Idea\ Cycle\ Time / OEE$$

where *Ideal Cycle Time* is the time required to produce the product if the asset was producing at 100 % of planned OEE capacity. Assuming an *Ideal Cycle Time* 270 minutes leads to the equations:

$$\begin{aligned}
 BuildTime &= 270 / .85 \\
 &= 317\ minutes \\
 BuildTime &= 270 / .50 \\
 &= 540\ minutes
 \end{aligned}$$

If we assume a machine burn rate of \$1000 per hour, a loss of approximately 2 hours equates to \$2000.

OEE done with MTConnect asset management also helps provide hard numbers when assessing capital expenditures. An accurate OEE can determine asset capacity when combined with actual customer demand for product based upon planned production time (PDT). Capacity will vary based upon the utilization of the asset which changes based on the PDT or Planned Production Time (i.e., number of shifts per day, number of days per week, breaks, holidays, etc.). Assuming a baseline PDT capacity of 3 shifts/day reduced by breaks yielding 20.4 hours per day total that will be further limited by the OEE reflected in the *BuildTime*:

$$CurrentCapacity\ (CC) = PDT / BuildTime$$

$$\begin{aligned}
 .85 \times OEE &= 1224 \text{ min}/317 \text{ min} \\
 &= 3.8 \text{ parts/day} \\
 .50 \times OEE &= 1224 \text{ min}/540 \text{ min} \\
 &= 2.2 \text{ parts/day}
 \end{aligned}$$

Assuming a 30 day month and the customer wants 90 parts a month, then if the *OEE* is 0.50 % additional assets will be required to satisfy the customer needs. Likewise, using a similar approach, an anticipated increase in part demand can be strategically planned to see if current capacity coverage is sufficient. One of the primary benefits of quantifying asset performance is cost avoidance.

5 Discussion

Asset management is the monitoring of machine operation to quantify performance for manufacturing. The key goals of asset management include trouble-free integration within the enterprise, collection and management of asset *OEE* information, real-time monitoring for preventive and reactive maintenance, and introspective process monitoring for adaptive control and error compensation. To attain a goal of automated asset management, MTConnect has been shown as a standard and facilitated an automated way to integrate discrete factory floor machines into the enterprise.

This paper detailed the use of MTConnect at a large aerospace facility. MTConnect is an open factory communication standard that leverages the Internet and uses XML for data representation. Reliance on dominant and standard technology made integration easier. Deployment did include custom approaches to integrating assets. These custom approaches leveraged MTConnect open source solutions available for many controller models. In addition, third party integrators provide affordable MTConnect solutions for a number of controllers. In spite of the benefits, CNC vendor support for MTConnect varied, so complete integration of MTConnect on all factory machines remains challenging.

Once integrated, asset management can be performed by collecting machine status data. Traditionally, manual recording of activities is used to assess productivity. The use of real-time machine status and recorded historical activity are important developments in the quest for improving manufacturing. Using real-time and historical data, one can verify that the machine utilization is running as expected and if not, actionable procedures can be identified and undertaken.

One final caveat is in order. Measured *OEE* is necessary, but not sufficient, in order to enact production improvements. Understanding the type and severity of delays within production is required to remediate process problems and improve *OEE*. MTConnect can offer insight into some of the delays associated with

an asset. Such problems can include the under-performing operator, difficult setup, or chatter among numerous potential troubles, which can require further examination to truly understand the root cause. Clearly hard real data can be beneficial in understanding the manufacturing process. Informed management can make better decisions based on facts not guesses, which leads to better manufacturing.

In the discrete part industry, integrating enterprise assets through their automated data collection is a daunting task. Automated factory data collection using MTConnect need not be contained to simple asset management. Expanding the scope to include advanced asset techniques, such as prognosis and condition based health monitoring, are possible given improved data collection. However, just collecting the data may not be sufficient, as a results-driven, automated analysis of an asset is imperative to taming the potential voluminous windfall of data. In addition, even simple asset management could benefit from automated analysis and decision making, as automated and integrated data collection in itself does not make an intelligent system.

Disclaimer

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