Engineering the Industrial Internet of Things (IIoT) for Predictive Maintenance

Lodovico Menozzi
Asset Monitoring & IIoT Business Development - Europe
Long-Term Track Record of Growth

- **7,500+ Employees**
- **50+ Countries**
- **$1.23 Billion** in 2015
- **35,000+ Customers Worldwide**
- **Over 18% Investment in R&D**

Revenue in millions USD

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<tr>
<th>Year</th>
<th>Revenue (in millions USD)</th>
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## Our Customers’ Success

<table>
<thead>
<tr>
<th>Industrial Machinery</th>
<th>Aerospace and Defense</th>
<th>Electronics and Semiconductor</th>
<th>Academic and Research</th>
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Three Primary Businesses

**Electronics Test**
- High Throughput and Accuracy
- Integration of Disparate Measurements

**Lab and Research**
- Ease of Use
- Software Flexibility

**Industrial Embedded**
- Customizability
- Analog Measurements and Analysis
IoT is just hype

IoT is real!

Educate me

Sell me an IIoT solution!
Based on Moor Insights & Strategy's report "Segmenting the Internet of Things (IoT)"
50 BILLION CONNECTED DEVICES BY 2020

~50% OF CONNECTED DEVICES DEPLOYED BETWEEN 2015 AND 2025 WILL BE INDUSTRIAL
Operations optimization:
- Increase productivity 10 - 25%

Predictive maintenance:
- Reduce costs by 10 - 40%,
- Reduce downtime up to 50%
- Reduce capital investment 3 - 5%
The World of Converged Devices
The World of Converged Devices

More capability defined in software

Functions change rapidly

Addressing increasingly complexity to system design and test
The “Things” of the Industrial IoT

Test Assets
- Test Cells
- HALT chambers
- Test Benches
- ATE

Production Equipment
- Part handling machines
- Packaging machines
- CNC and tooling

Operational Assets
- Pumps, motors, etc.
- Wind/steam turbines
- Intelligent devices used by utilities

Transportation & Heavy Equipment
- Ag tractors/combines
- Mining/Earth movers
- Rail/freight equipment
- O&G Pump Set-ups
Industrial IoT Architecture

THINGS OF THE IIOT

Operational Assets
Production Equipment
Transportation & Heavy Equipment
Test Assets

OPERATIONAL TECHNOLOGY (OT)

Sensors and Actuators
Edge Nodes

INFORMATION TECHNOLOGY (IT)

On-Premises IT
Cloud IT
Industrial IoT Architecture

THINGS OF THE IIOT
- Operational Assets
- Production Equipment
- Transportation & Heavy Equipment
- Test Assets

Sensing
- Sensors and Actuators

TECHNOLOGY (OT)
- Edge Node

Analysis

Communication

Processing

Control

INFORMATION TECHNOLOGY (IT)
- On-Premises IT
- Cloud IT

THE EDGE

NATIONAL INSTRUMENTS®
IDC predicts that by 2019, at least 40% of IoT-created data will be stored, processed, analyzed, and acted upon close to, or at the edge of, the network.
The Edge Node Advantage

- **E** Edge-Ready Hardware
- **N** Nanosecond Analysis and Control
- **O** Open Connected Software
- **S** Synchronized Data and Edge Node Hardware
- **D** Data Acquisition From Any Sensor
The Edge Node Advantage

**E**  Edge-Ready Hardware

**N**  Nanosecond Analysis and Control
Assess and respond to inputs 860X faster than the average human.

**O**  Open Connected Software
4 million IoT software developers by 2020.

**D**  Data Acquisition From Any Sensor
Synchronize edge nodes to within 100 nanoseconds of each other.

**S**  Synchronized Data and Edge Node Hardware

- Over 78 exabytes of data from industrial equipment by 2020.
Operations at the Edge

Distributed intelligence at the edge, optimizes network bandwidth utilization and promotes faster response times

Software Defined Instrumentation that evolves and adapts as requirements change

Advanced Diagnostics to detect early faults through performance comparisons, pattern recognition, and predictive analytics
FLEXIBLE Integration
Enable data to be shared with third-party applications.
CLOUD STORAGE OPTIONS

Cloud Connection APIs

Edge System

- AWS APIs
- MS Azure APIs
- Google APIs
- Predix APIs
- Bluemix APIs
- Other

LabVIEW APIs
- Authenticate
- Config
- Data
- Send/Receive
- Call Cloud Functions

Cloud Storage

Server

- Amazon AWS
- MS Azure
- Google Cloud
- GE Predix
- IBM Bluemix
- Other

Other
ThingWorx IoT Platform
Case Studies
Project Airbus Factory of the Future

Customer Profile
- Commercial Aircraft Manufacturer
- €67 billion Revenue, 55,000 Employees
- 17,000 Aircraft Sold Worldwide

Business Need
- **Increase Competitiveness**: Increase uptime, quality and optimize workforce activity.
- **Simplify the Production Process**: Enable a smarter, operator-centric production that allows operators and machines to collaborate in the same physical environment.
- **Improve efficiency**: Remove physical data logs and manuals, and automate tool configuration.

Challenge: Factory-wide Online Monitoring and Control

1. Manufacturing airplanes involves tens of thousands of steps
2. Process mistakes could cost hundreds of thousands of dollars
3. Manual processes and human error adds risk to production
Project Duke Energy Smart Generation

Customer Profile
- Largest power generation in US
- 38 GW Fossil Generation Capacity

60+ Sites 10,000 Assets to Monitor 30,000 Sensors 60,000 Manual Rounds/Month for Data Collection

Business Need
- **Increase Revenue**: Increase uptime and service offerings, and optimize asset maintenance activity.
- **Reduce Costs**: Reduce warranty repair costs, frequency of unscheduled downtime, and optimize the workforce.
- **Increase Safety**: Reduce worker exposure to dangerous machines/environments.
- **Reduce Risk**: Prevent catastrophic failure and unscheduled outages.

Challenge: Better leverage new technologies to address increasing reliability demands and workforce optimization.

1. Aging plants with critical equipment at end-of-life
2. Scarcity of specialists
3. Inefficient workforce utilization, 80% Data Collection, 20% Analysis
Increase Uptime With Predictive Maintenance

Using CompactRIO, London Underground added an estimated 39,000 operational passenger hours per year on the Victoria Line by implementing a large-scale distributed system for remote condition monitoring of 385 deep Tube track circuit assets.
Predictive maintenance at Large Contract Electronic Manufacturer to reduce unplanned downtime

Predicting alarms 24 hours in advance, with a 91% accuracy
A global FOOD leader increases productivity

5 to 8% improvement in productivity
Time Sensitive Networking (TSN)

- Industry 4.0
- Interoperability
- Real-Time Ethernet
Modern Machines

- **High Performance I/O**
  - Waveform Streaming for Video and Data (50 – 500 Mb/s)
  - Interoperability with Other Equipment (EtherCAT, PROFINET, Ethernet/IP, OPC-UA, Modbus TCP)
  - Security and IT Integration

- **Multi-Axis Motion Controller**
  - Closed-Loop Control at 5kHz

- **Safety Systems**
  - 1µs

- **Local HMI**
## Technical Needs of Communications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Need</th>
<th>Needed For</th>
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</thead>
<tbody>
<tr>
<td>Guaranteed Bandwidth</td>
<td>Enable validation &amp; analysis of system ability at design time</td>
<td>Reliable Operations</td>
</tr>
<tr>
<td>High Bandwidth</td>
<td>Enable high channel data and high speed streaming</td>
<td>Streaming of Data</td>
</tr>
<tr>
<td>Bounded Latency (and low)</td>
<td>Prioritize isochronous data over best effort on the same interconnect to maintain specified latency</td>
<td>Control Applications</td>
</tr>
<tr>
<td>Clock Synchronization</td>
<td>Allowing producers and consumers of isochronous data to be phase coordinated Allow Application synchronization</td>
<td>Synchronized IO and Distributed Control</td>
</tr>
<tr>
<td>Distance</td>
<td>Enable separation of IO from controller or measurements of physically large systems</td>
<td>Application Dependent</td>
</tr>
<tr>
<td>Topology</td>
<td>Provide physical options for wiring</td>
<td>Application Dependent</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>Enable the inclusion of third party devices such as drives</td>
<td>Application Dependent</td>
</tr>
</tbody>
</table>
Standards Efforts

Standards effort through IEEE 802 to improve latency and performance while maintaining interoperability and openness

Time Sensitive Networking (TSN) will provide:

- Time synchronization
- Bandwidth reservation and path redundancy for reliability
- Guaranteed bounded latency
- Low latency (cut-through and preemption)
- Bandwidth (Gb+)
- Routable to support complex networks and wireless
Time Sensitive Networking: Key Elements

- Time Synchronization
- Traffic Scheduling
- System Configuration
New Features in Ethernet Standard

Time Sensitive Networking

TSN ≠ Communications Protocol

TSN = Evolution of Ethernet
<table>
<thead>
<tr>
<th>Standard</th>
<th>Area</th>
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<tbody>
<tr>
<td>IEEE 802.1ASrev,</td>
<td>Timing &amp; Synchronization</td>
<td>Enhancements and Performance Improvements</td>
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<td>IEEE 1588</td>
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<tr>
<td>IEEE 802.1Qbu &amp;</td>
<td>Forwarding and Queuing</td>
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<td>IEEE 802.1Qci</td>
<td>Time Based Ingress Policing</td>
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<td>IEEE 802.1CB</td>
<td>Seamless Redundancy</td>
<td>Frame Replication &amp; Elimination for Reliability</td>
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<td>…</td>
<td>Additional Projects</td>
<td>Continual Evolution of the Standard</td>
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</table>
TSN-Based “Hard Real-Time” Ethernet Devices

TSN Ethernet

- Key industrial, embedded, and automotive vendors collaborating to drive requirements
- Best-in-class approach for control AND interoperability
- Bounded latency and guaranteed bandwidth
- Scales with Ethernet
Additional Standardization Investments

Avnu Alliance
- Avnu Alliance – certification body for TSN-based Ethernet solutions
- Assures an interoperable and conformant ecosystem so system integration is possible

Industrial Internet Consortium
- Develops architectures to simplify multi-vendor systems targeted at vertical applications
- Hosting a testbed focused on TSN for Smart Manufacturing
Growing Ecosystem of TSN Vendors at IIC

Key Facts:

- **18 Vendors** participating today
- **6 Plugfests** conducted
- **2 Testbed facilities**
- **Demonstrations at 6 major shows**
- **Collaboration with multiple standards**
Optimize The “Things” That Matter Most

Unlock insights from real-world data with NI’s unmatched capabilities in measurement, control, ruggedness, connectivity, IIoT know-how, and an expert partner ecosystem.
NI Industrial IoT Lab

A Space to Collaborate
A Space to Innovate
A Space to Showcase
Industrial Internet Consortium Testbeds

- Microgrid Communication and Control
- Condition Monitoring and Predictive Maintenance
- Time Sensitive Networking
Industrial IoT Lab Sponsors
THANK YOU!