An introduction to IoT

Michele Stecca, Ph.D.
General Architecture

- **Field**
  - Gateway/Hub

- **IoT Platform**

- **IT systems**
  (ERP, CRM, etc.)

- **End Users**
Dynamic Maintenance Management System for Railway Operators

Leveraging highly granular telemetry data, it becomes possible to shift from standard maintenance schedules to *dynamic plans* that reflect the specific status of each and every component of the train.

**SENSE**
- IT/OT data convergence

**PREDICT**
- Remote diagnostic on the current operational conditions
- Predictive models to derive probability of future failures
- Indicators-based planning, considering current and future detailed life- and health-status of each component

**ACT**
- Dynamic optimization of maintenance schedules based on operational needs, and availability of resources

>700 TB of data managed annually

8 – 10% reduction in maintenance costs

Improved reliability and customer service
Real-Time Aircraft maintenance
Avoid unplanned downtime, increase turn-around-time and service levels

**SENSE**
- ~1 TB per flight
- Trending and alert management framework

**PREDICT**
- Stream and analyze millions of signals/second
- Probability of failures

**ACT**
- Integrate analysis with SAP Plant Maintenance
- Schedule maintenance order ahead of time
- Schedule resources for on-time availability

https://www.youtube.com/watch?v=ZSYITS9pcUE

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DDoS attack shows dangers of IoT 'running rampant'
Experts, U.S. senator call for greater Internet of Things security

By Matt Hamblen | Follow
Senior Editor, Computerworld | OCT 25, 2016 2:02 PM PT

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- After DDoS attack, senator seeks industry-led security standards for IoT...
- Code in the wild to infect millions of IoT devices for crippling DDoS attacks
- Hackers abusing a 12-year-old flaw to attack the internet of insecure things
Major Security Breach Found in Hospital and Supermarket Refrigeration Systems

Report: Freezers and Chillers in Hospitals and Retail Chains Accessible Online

Updated February 12, 2019

Israeli hackers and activists Noam Rotem and Ran L from Safety Detective research lab have uncovered a major security breach in temperature control systems manufactured by Resource Data Management, a Scotland-based remote monitoring solutions company.

These control systems are used by hospitals and supermarket chains all over the world, including Marks & Spencer, Ocado, Way-on, and many others.
## INDUSTRY 4.0

<table>
<thead>
<tr>
<th>DATA TYPES</th>
<th>DATA SIZE (PER WEEK)</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine parameters and error logs</td>
<td>~5 GB per machine</td>
<td>Used to monitor machine performance: dispense height, placement (x, y, z), belt speed, flow rate, oven temperature, laser power, etc.</td>
</tr>
<tr>
<td>Machine events</td>
<td>~10 GB per machine</td>
<td>Used to measure process time: start dispense, end dispense, start setup, and end setup</td>
</tr>
<tr>
<td>Defect images from vision equipment</td>
<td>~50 MB per unit or 750 GB per lot</td>
<td>Used to identify root cause of failure modes, defect commonality, defect mapping</td>
</tr>
</tbody>
</table>

Source: Intel
INDUSTRY 4.0

Preventive Maintenance
Systems are maintained at fixed intervals to ensure continuous availability.

Condition Based Maintenance
Systems are maintained based on simple rules using equipment information.

Predictive Maintenance
Systems are maintained before failure, but run as long as possible without interruption.
INDUSTRY 4.0

Production Lines

<table>
<thead>
<tr>
<th>Line</th>
<th>Current Run</th>
<th>Time Left</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 1</td>
<td>Standard Run</td>
<td>-89 Hours</td>
<td>Failed</td>
</tr>
<tr>
<td>Line 2</td>
<td>Standard Run</td>
<td>-89 Hours</td>
<td>OK</td>
</tr>
<tr>
<td>Line 3</td>
<td>Standard Run</td>
<td>-87 Hours</td>
<td>OK</td>
</tr>
<tr>
<td>Line 4</td>
<td>Standard Run</td>
<td>-88 Hours</td>
<td>OK</td>
</tr>
<tr>
<td>Line 5</td>
<td>Standard Run</td>
<td>-85 Hours</td>
<td>OK</td>
</tr>
<tr>
<td>Line 6</td>
<td>Standard Run</td>
<td>-87 Hours</td>
<td>OK</td>
</tr>
</tbody>
</table>

Facility Calendar

December 15, 2017

Production Line Details

- Choose a line to view its details

Machine Telemetry

- Choose a machine to view its telemetry
INDUSTRY 4.0

% OEE Dashboard for the Plant

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11/1/2015</td>
<td>11/1/2015</td>
</tr>
</tbody>
</table>

- **% OEE**: 53%
- **% Availability (Uptime)**: 61.4%
- **% Performance (Run Rate)**: 87.8%
- **% Quality (Good Units)**: 97%

Plant % OEE for this time period is 0.525117845. At this percentage % OEE falls in the yellow band. For this time period, the components of %OEE were at 1) % Availability is 0.613624386624339. At this percentage % Availability in the yellow = large loss of run time due to downtime 2) % Performance is 0.676206510023712. At this percentage % Performance is green = run rate close to nominal rate 3) % Quality is 0.374445485785892. At this percentage % Quality is green = waste & rework not significant. Main Contributor driving %OEE loss Main Contributor driving %OEE loss is breakdowns. Please perform breakdown analysis in order to identify and reduce or eliminate contributors.

% OEE by Line for Selected Timeframe

% OEE for the Plant for the Selected Time Range

%OEE = %A * %P * %Q
ANOMALY DETECTION

Pipe cutting - Line 2

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Observed</th>
<th>Estimated</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:02 17 Feb 2018</td>
<td>37 ↑</td>
<td>1–15</td>
<td>1</td>
</tr>
<tr>
<td>09:40 17 Feb 2018</td>
<td>50 ↓</td>
<td>60–73</td>
<td>3</td>
</tr>
<tr>
<td>13:04 17 Feb 2018</td>
<td>48 ↓</td>
<td>55–84</td>
<td>4</td>
</tr>
<tr>
<td>17:05 17 Feb 2018</td>
<td>79 ↑</td>
<td>58–78</td>
<td>2</td>
</tr>
<tr>
<td>19:57 17 Feb 2018</td>
<td>99 ↑</td>
<td>50–70</td>
<td>2</td>
</tr>
<tr>
<td>23:27 17 Feb 2018</td>
<td>23 ↓</td>
<td>29–34</td>
<td>5</td>
</tr>
</tbody>
</table>
Forecasting
Edge Computing

Simple Edge Computing Architecture

Cloud Layer

Cloud Server

Internet

Edge Networking

Edge Layer

Edge Node / Server

Device Layer

Mobility

Automotive

Robotics

Factories

Field Services
### Wired

- Modbus
- M-Bus
- X10®
- KNX

### Wireless

#### Short-range
- RFID
- NFC
- Bluetooth

#### Middle-range
- Wi-Fi
- ZigBee®
- Thread
- enocean®
- Z-Wave

#### Wide-range
- 3G
- 4G
- LoRa®
- SIGFOX

*One network. A billion dreams*