Achieve Operational Efficiency in Car Manufacturing with Advanced Analytics

Dr. Sebastian Schmerl | Solution Manager Cyber Defense for Production and IoT
Philipp Drieger | Sr. Sales Engineer | SME BA IoT ML

28. September 2017 | Washington, DC
Forward-Looking Statements

During the course of this presentation, we may make forward-looking statements regarding future events or the expected performance of the company. We caution you that such statements reflect our current expectations and estimates based on factors currently known to us and that actual events or results could differ materially. For important factors that may cause actual results to differ from those contained in our forward-looking statements, please review our filings with the SEC.

The forward-looking statements made in this presentation are being made as of the time and date of its live presentation. If reviewed after its live presentation, this presentation may not contain current or accurate information. We do not assume any obligation to update any forward looking statements we may make. In addition, any information about our roadmap outlines our general product direction and is subject to change at any time without notice. It is for informational purposes only and shall not be incorporated into any contract or other commitment. Splunk undertakes no obligation either to develop the features or functionality described or to include any such feature or functionality in a future release.
Your 3 key takeaways from this session

- Understand challenges in industrial production and data driven approaches
- Learn how to collect low layer data from production environments
- Get insights how to gain operational efficiency with data analytics
Agenda
Some brief words about us
Challenges in industrial production environments based on car assembly lines
Production data acquisition
• High and low layers of production data
• Active & passive data capturing
Data collection infrastructure
Data analytics for different levels of production data
• Analysis of layer 3&4 data - MES, Historian Data
• Analysis of layer 1&2 data – raw sensor and actuator data
Some Splunk numbers
Summary, Q&A
Computacenter AG & Co.
Europe’s leading independent provider of IT Infrastructure services

Dr. Sebastian Schmerl
Head of
Production Data Analytics,
Industrial Security,
Cyber Defense

Subject Matter Expert for:
• SOCs
• ICS & SCADA Security
• Industry 4.0 & Data Science

Contact: Sebastian.Schmerl@computacenter.com
Bio: Philipp Drieger
Sr. Sales Engineer

- Splunker since 2015.
- Subject Matter Expert for Business Analytics, IoT and Machine Learning
- Before Splunk: lots of software development, data analytics and visualization
- Enjoys this year .conf with 2 talks:
  - Automating Thread Hunting with Machine Learning (tomorrow 1:10pm!)
  - Achieve Operational Efficiency in Car Manufacturing with Advanced Analytics

- Good chance to meet me at ML or IoT Booths
- Questions? Feedback? Let me know: philipp@splunk.com
Challenges in industrial production environments based on car assembly lines
Digitization of Production
Analytics as main value drivers

Industrie 4.0 - increase in productivity over 20 percent

Plants and Analytics are in Focus

common sense in all market analysis reports

Source: Industry 4.0 How to navigate digitization of the manufacturing sector
Challenges in Car Production Environments

- Large and complex systems with plenty of components, e.g.:
  - Conveyor systems, robots, gripping systems, welding systems, cluing systems, screwing systems, and safety system
- Unique systems, tailored to the production process
- Build by system integrators
- Long lifespan ~10 years
- Maintenance problems can’t be known at construction time.
- Leverage data analysis for process optimization
Production Analytics Challenges

No Data - No Analytics | No Analytics - No Progress
Production data acquisition

From data layers and non-invasive production data extraction
Production Data Layers

Example from the process industry

<table>
<thead>
<tr>
<th>Data Aggregation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1</td>
<td>10 - 50Hz++</td>
</tr>
<tr>
<td>Layer 2</td>
<td>5 – 10Hz</td>
</tr>
<tr>
<td>Layer 3</td>
<td>0,1 – 1Hz</td>
</tr>
<tr>
<td>Layer 4</td>
<td>&lt; 0,1 Hz</td>
</tr>
</tbody>
</table>

- **Process status OK**
- **Product temperature 100°C**
- **Calculation & Control Ø Temperature**
- **90°C 130°C 110°C 70°C**

- **Plant MGMT**
- **Manufacturing execution**
  - MES, Data Historian
- **Control Layer**
  - PLCs
- **I/O Layer**
- **Production floor and process Layer**

High aggregated data nearly status information only

Fine grained temporal & sensor values of production data

Better prediction results & higher forecast precision
# Active and Passive Data Acquisition

<table>
<thead>
<tr>
<th>PRO</th>
<th>ACTIVE</th>
<th>PASSIVE</th>
</tr>
</thead>
</table>
|     | • no data transformation  
|     | • no data dissection      | • non invasive  
|     |        | • no changes on automation cells  
|     |        | • no discussions, no re-certifications  
|     |        | • easy rollout  
| CON | • configuration changes  
|     | • polling of information  
|     | • PLC CPU time & memory  | • more complex |

---

**kepware®**

**PDEX**
PDEX – Extraction of Production Data

Cyclic data exchange

Manifestation in the communicated data

PLC
PROFINET Controller

Industrial Ethernet Switch

Frequency converter
PROFINET Device

Electric Motor

Decentralized Periphery
PROFINET Devices

Wear, different forces, resistance, component failures
PDEX – Extraction of Production Data

**PLC**
PROFINET Controller

**Industrial Ethernet Switch**

**PDEX**
Production data extraction

**Frequency converter**
PROFINET Device

**Electric Motor**

**Server in data center**
Splunk
Spectrum

**Decentralized Periphery**
PROFINET Devices

Traffic sniffing via Port-Mirroring & Taps

Wear, different forces, resistance, component failures
PDEX

Extraction of production data from network traffic

Raw network traffic with production data

Production data in Splunk

Communication monitoring
Rolling Traffic Dumps
Packet dissection
Data Extraction
Data Conversion
Data Forwarding
Data collection Infrastructure

From aggregation and dissection of network traffic
Production Data Collection Infrastructure
for layer 1 & 2 data
Splunk Analytics Infrastructure

Hall A

Layer 1 & 2

Layer 3 & 4

Manufacturing Execution System
Data Historians
Shift books, Maintenance Logs

Control center

DBX

Indexer Cluster

Continuous Analytics Tasks

Search Head

Dashboards Report Alerts

Deployment Server
Cluster Master
License Server

Layer 1 & 2

PDEX

Layer 3 & 4

PDEX

PDEX

PDEX

Control center

DBX

DBX

DBX
Analysis of working cycles and PLC errors

Analysis of layer 3&4 data production data from automation cells
Predict Production Incidents on Assembly Line

Conveyors, screwing, gluing, robots, humans … in one line

- Assembly line with 19 automation cells and 160 PLCs
- 1 year data
- 350MB logs from shift books, maintenance protocols etc.

- Goal: Predict incidents at least 8 hours ahead and reduce maintenance costs
Analysis of Working Cycles of an Automation Cell

- Shift in histogram of average working cycles in week by week comparison

- Product 2 remains unchanged

- Product 1 is produced slower

- Working cycles with errors or problems
N-gram Analysis to Detect Frequent Error Chains

- N-gram analyses let us construct combinations of sequential categorical events in a given window in time.
- Statistics can be applied to count frequencies, detect frequent patterns.
- Correlate subsequent event patterns to identify more complex root cause.

Diagram:
- Types of events: A, B, C, D, E, F.
- Event patterns: DC, DCEF, E, BACD.
- Tmax for N-grams.
N-Gram Statistics
What happens when and how often
N-gram Analysis

Which error chains causing production impacts?

N-Gram with huge Impact, but rare → Not that interesting for the customer

N-grams with smaller impact, but very often → Highly interesting for the customer

Ok, now we know the pain, but we have no data to predict
Predictive Maintenance for Electro Motors

Analysis of layer 1 production data from automation cells
Analysis of Motor Profiles
Wear of mechanics detected by RPM monitoring

- Lag in mechanic transmission is detected with continuous RPM monitoring

Effects from slack & mechanical wear
10 Hz frequency raw data from the motor

we have 8 OK & 3 NOK motor runs which look very similar
Framing and Slicing Motor Profiles

Frame start criteria fulfilled

<table>
<thead>
<tr>
<th>Frame start criteria fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>Min, Max, avg</td>
</tr>
</tbody>
</table>

Deviation from normal profile

0  Frames  time
1, 2, 3, 4, 5, 6, 7, 8
Min, Max, avg
Normal profile slices

0  Normal profile  time
1, 2, 3, 4, 5, 6, 7, 8
Min, Max, avg
Current run slices

= normal profile
Analysis of Motor Profiles

- 10 Hz frequency raw data from the motor
- we have 8 OK & 3 NOK motor runs which look very similar
Compare frames against the normal profile

A non-conform motor run
How we can visualize it...

... and how we visualize it to the customer mainly

Motor run: Not Conform
But information reduction is key 😊

Motor run conformity
Wrap up
Data Volume – Business Value

- 1 assembly line with 160 PLCs and ~4 electric motors → 400 ~ 800 GB per day
Summary

Key takeaways

- Analytics of layer 3&4 data:
  - Data often already exist
  - This layer is good to identify the pain
  - Data often not sufficient for prediction

- Analytics of layer 1&2 data:
  - Active data collection results often in configuration, service, guarantee discussions
  - Passive data collection is complex
  - The data volume is challenging

- Data analytics
  - n-grams, wave transformations, differences, profiles, …
Thank You!

Don't forget to rate this session in the .conf2017 mobile app