



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

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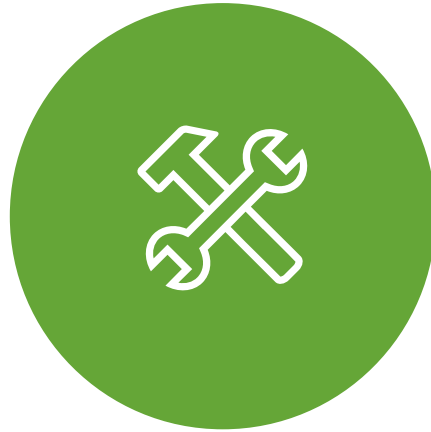
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Your 3 key takeaways from this session



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

130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FI-SW-01"
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Agenda

Computacenter AG & Co.

Europe's leading independent provider of IT Infrastructure services

Computacenter's ambition is to be Europe's preferred IT provider to enable users and their business in a digital world

Computacenter's mission is to maximise user productivity and the business value of IT for Enterprise and Corporate organisations. In doing so, we deliver strong returns for our shareholders and enrich our employees' careers.

WHAT WE DO



Manage & Transform



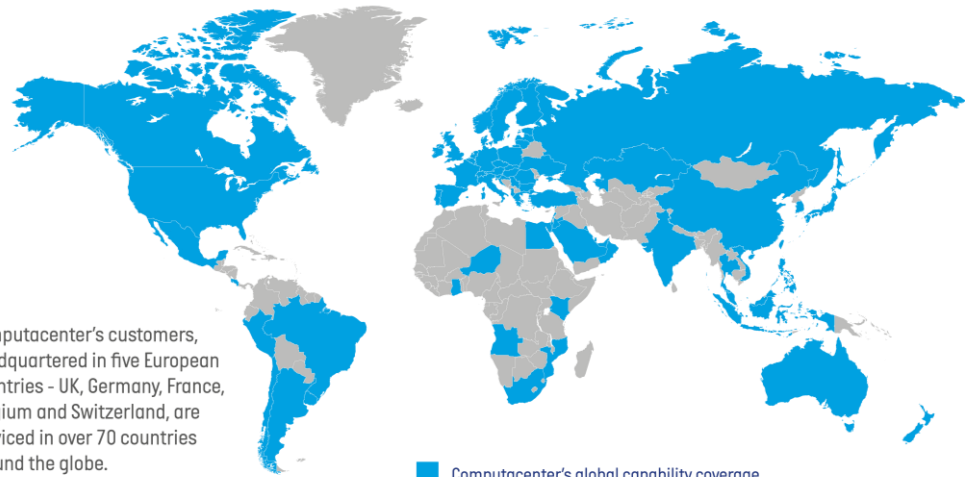
Consult & Change



Source & Deploy

4.2m
Users Supported

Nº.1 For satisfaction in end-user service provision
UK | Germany | France | Belgium | Switzerland
Whitelane Research, 2016, 2015



Computacenter's customers, headquartered in five European countries - UK, Germany, France, Belgium and Switzerland, are serviced in over 70 countries around the globe.

Computacenter's global capability coverage



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

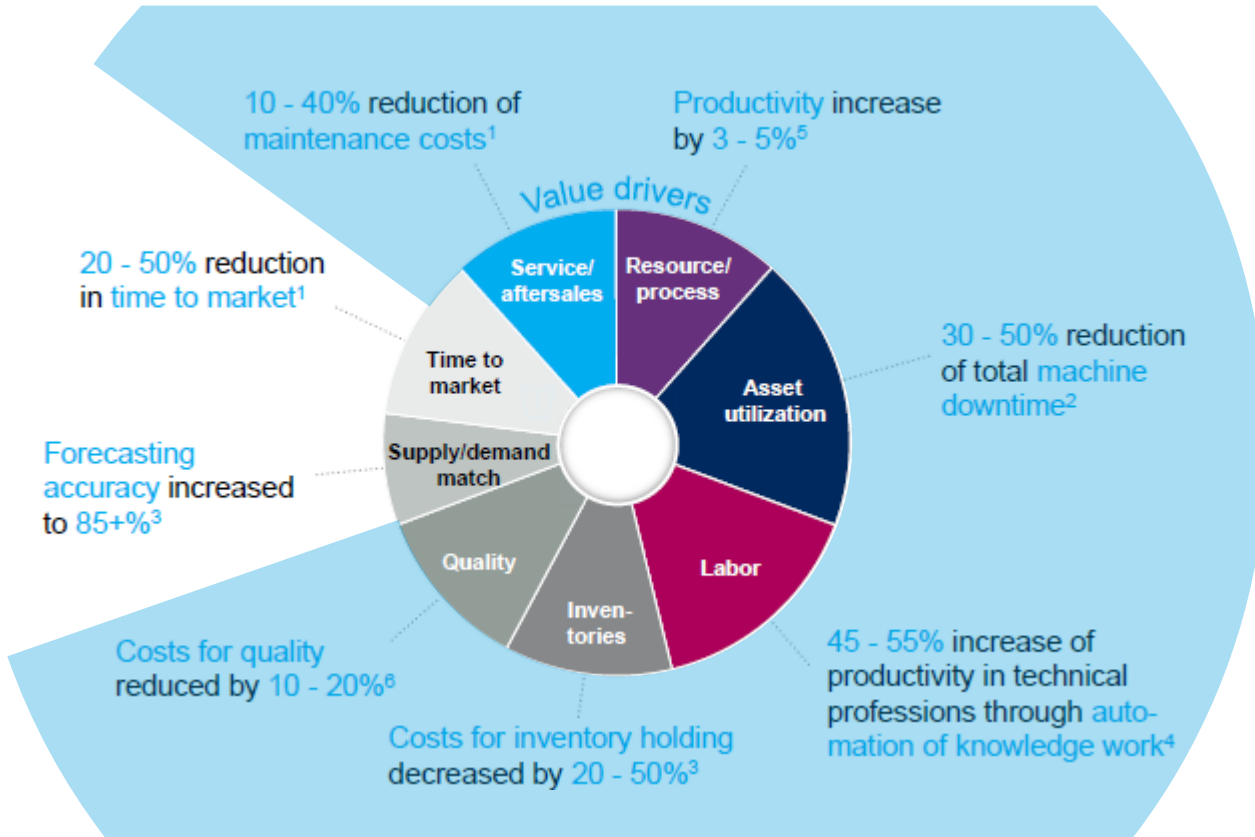
Contact: Sebastian.Schmerl@computacenter.com

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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

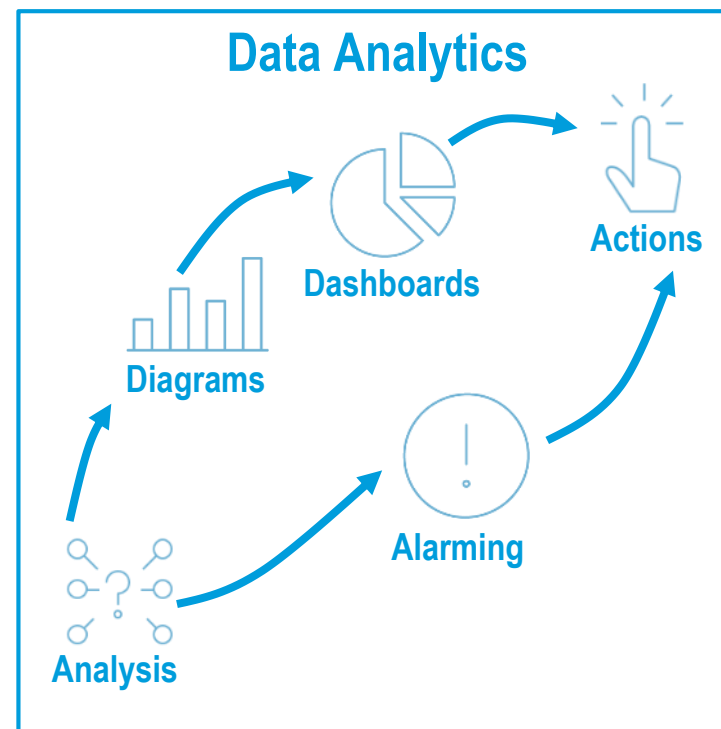
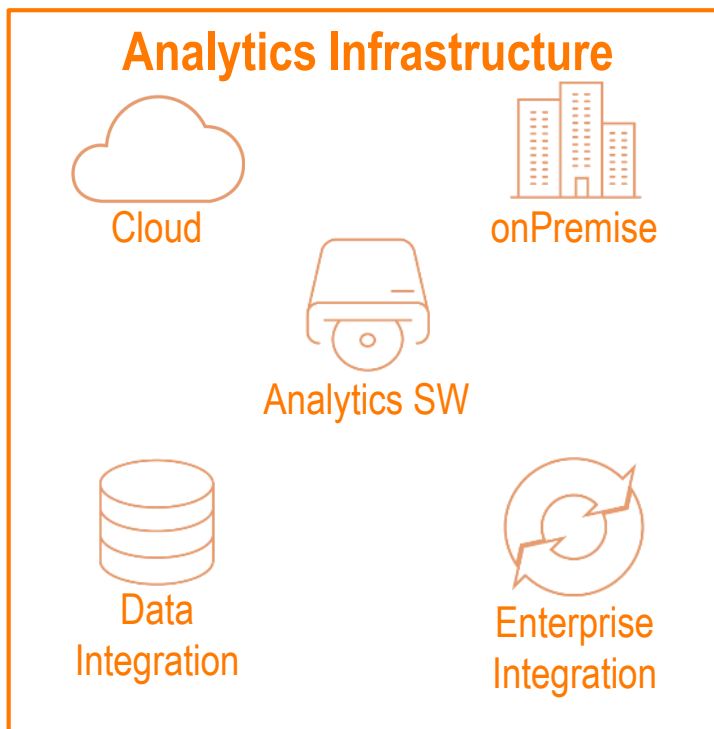
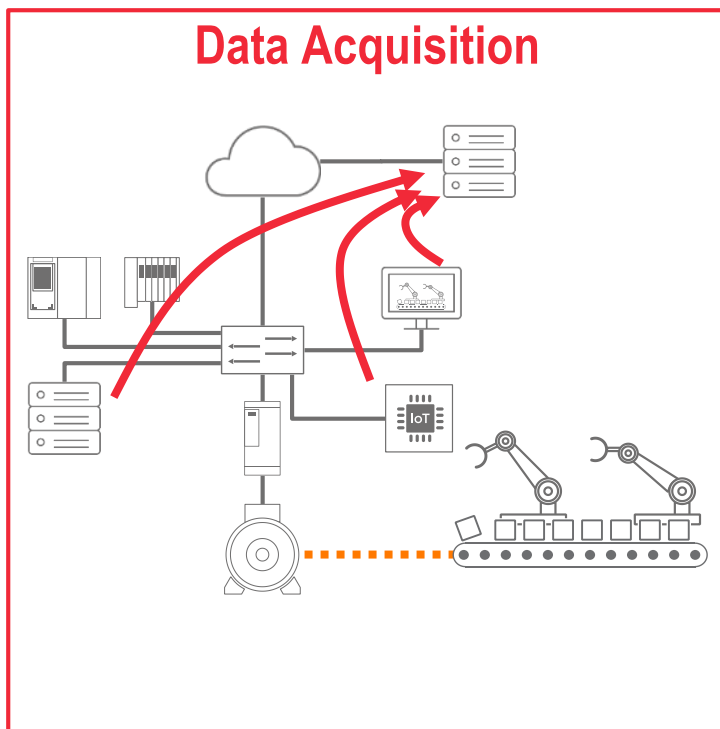
- ▶ Large and complex systems with plenty of components, e.g.:
 - Conveyor systems, robots, gripping systems, welding systems, cluing systems, screwing systems, and safety-system
- ▶ Unique systems, tailored to the production process
- ▶ Build by system integrators
- ▶ Long lifespan ~10 years
- ▶ Maintenance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



Sources: taqplayer.info, cnsanf.com, castrol.com

Production Analytics Challenges

No Data - No Analytics | No Analytics - No Progress



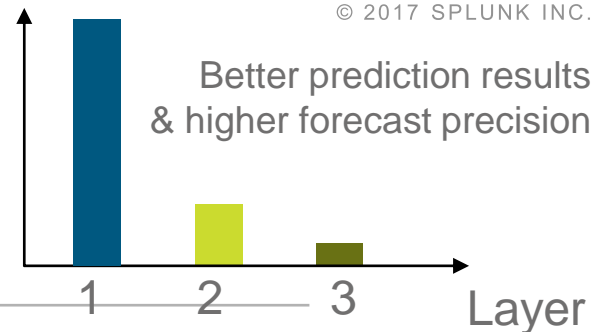
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Production data acquisition

From data layers and non-invasive production data extraction

Production Data Layers

Example from the process industry



High aggregated data nearly status information only

Plant MGMT

Manufacturing execution MES, Data Historian

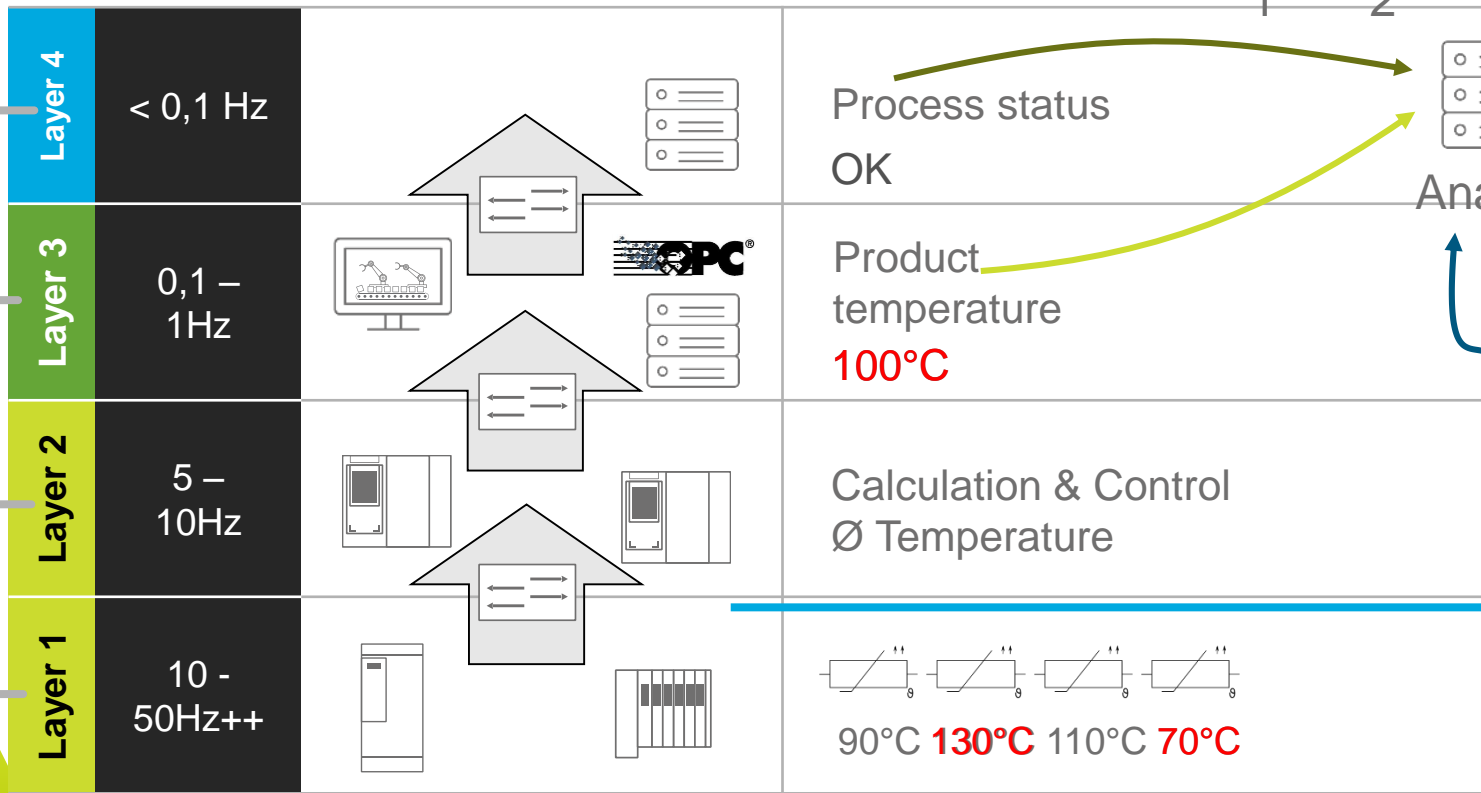
Control Layer PLCs

I/O Layer

Production floor and process Layer

Data Aggregation

Example



Fine grained temporal & sensor values of production data

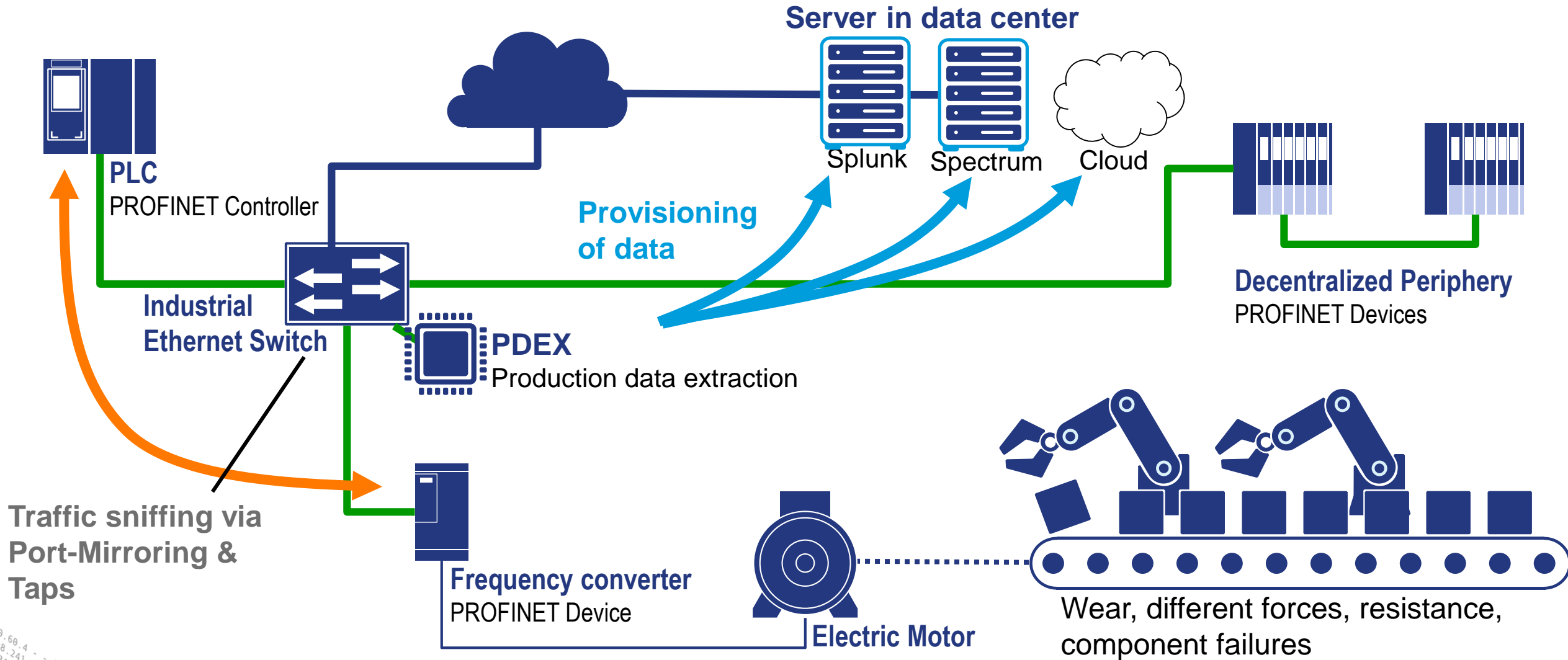
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Active and Passive Data Acquisition

	ACTIVE	PASSIVE
PRO	<ul style="list-style-type: none"> no data transformation no data dissection 	<ul style="list-style-type: none"> non invasive no changes on automation cells no discussions, no re-certifications easy rollout
CON	<ul style="list-style-type: none"> configuration changes polling of information PLC CPU time & memory 	<ul style="list-style-type: none"> more complex



PDEX – Extraction of Production Data



PDEX

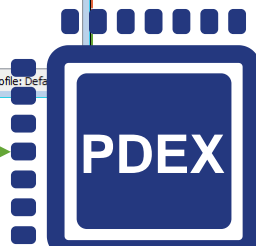
Extraction of production data from network traffic

Raw network traffic with production data

The screenshot shows a Wireshark capture of network traffic. The main pane displays a list of packets with columns for No., Time, Source, Destination, Protocol, Length, Type, Destination, and Info. Several packets are highlighted in green, corresponding to the hex data shown in the bottom pane. The hex data shows a sequence of bytes: 28 63 36 9b ed 40 00 1f f8 bb a9 e8 92 80 02. Below the hex data, the ASCII representation is shown as: (c6..@. 1. 5.

Production data in Splunk

The screenshot shows the Splunk search interface. The search bar contains the query: `index=* extractedsourcetype=profinet:export* Values*`. The results pane shows 53,991 events. A table of results is displayed with columns for Time and Event. The event data includes a long string of extracted values, such as: `128,0,"001FF8215859_286336885E8_32774_1498027605527","42_1281_-1_2_3","2017-07-11 13:14:58.986304000","-11176;-32640;2912;-2;0;0;0;16384;0;"`. A green arrow points from the hex data in the Wireshark screenshot to this specific event in the Splunk results.



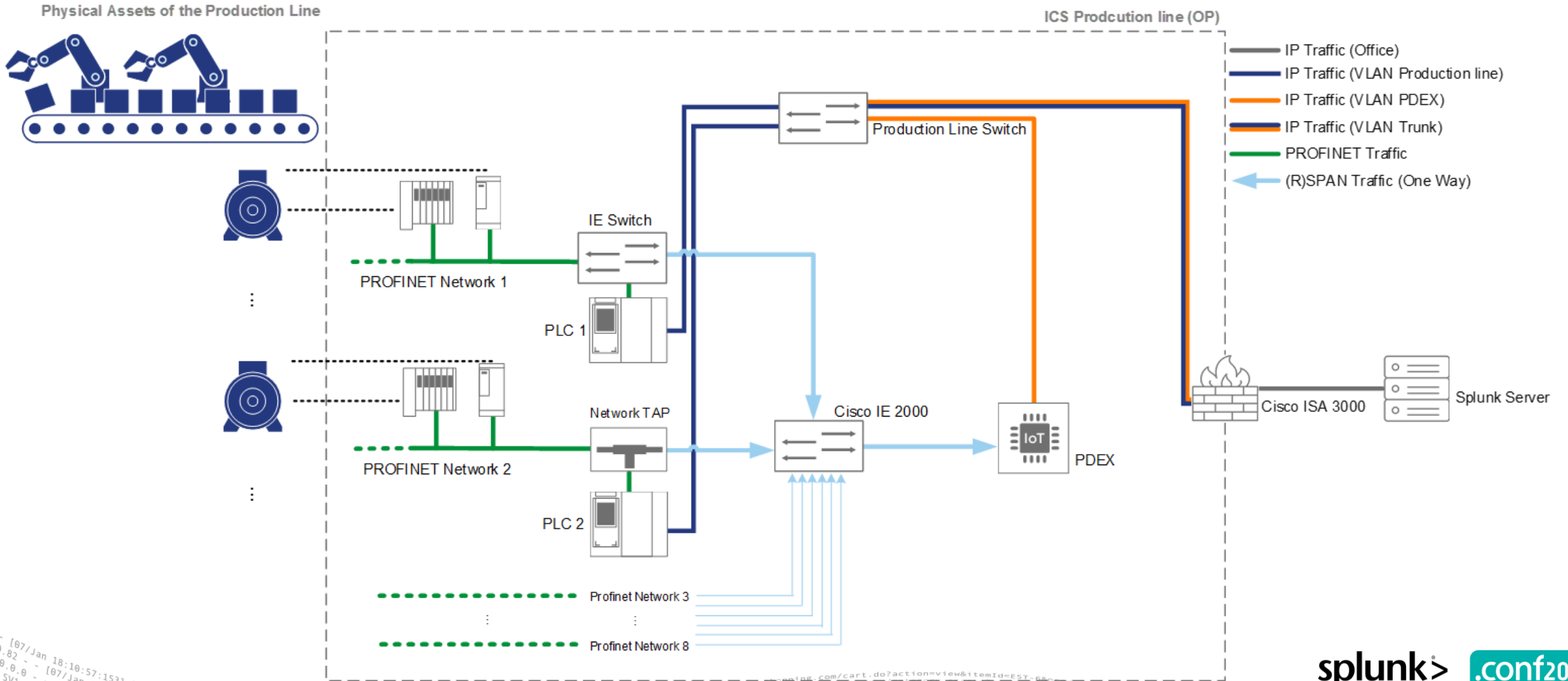
- Communication monitoring
- Rolling Traffic Dumps
- Packet dissection
- Data Extraction
- Data Conversion
- Data Forwarding

Data collection Infrastructure

From aggregation and dissection of network traffic

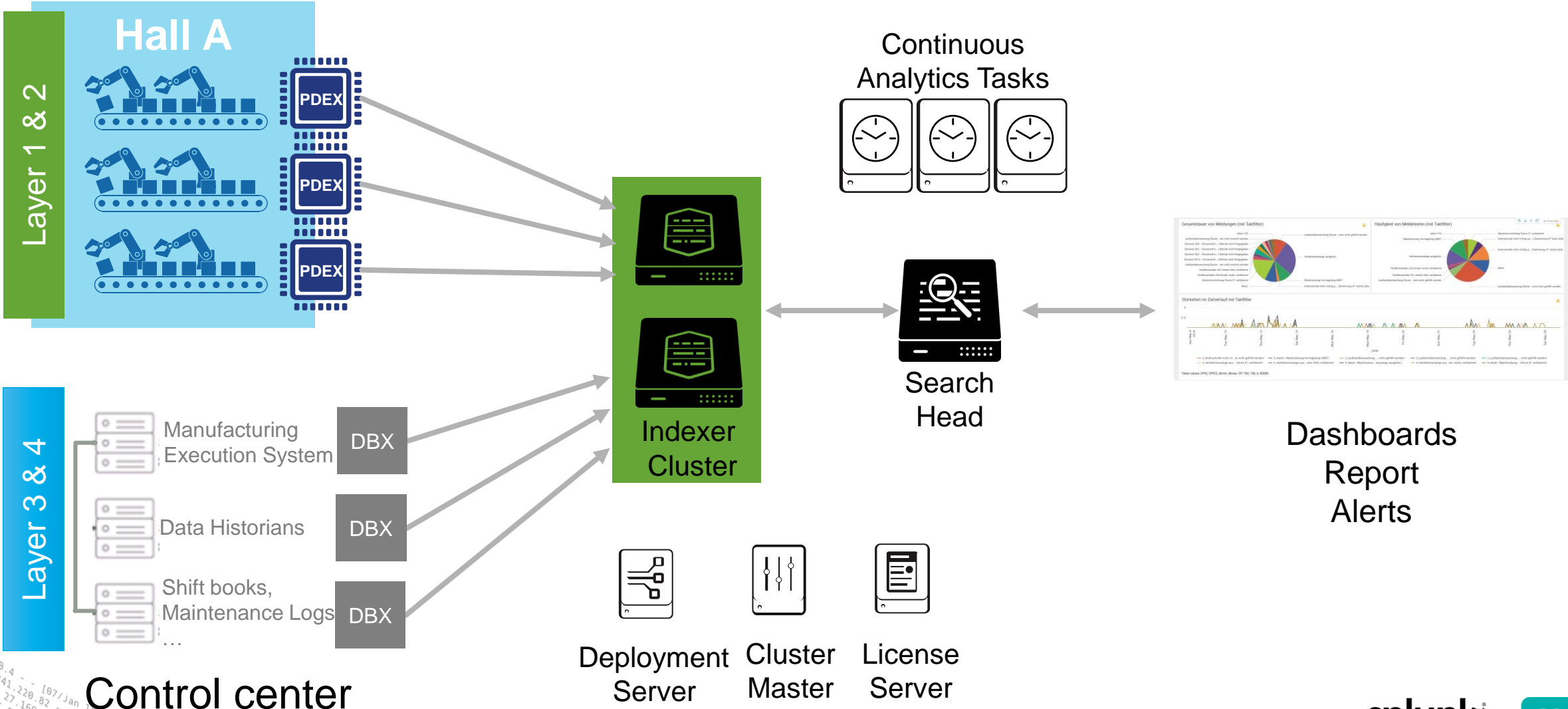
Production Data Collection Infrastructure

for layer 1 & 2 data



130.60.4 - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-26&product_id=RP-LI-02" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0" 128.241.220.82 - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADF9 HTTP 1.1" 404 3322 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=RP-LI-02" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0" 317.27.160.0.0 - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD5SL9FF1ADFF3" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0" 130.60.4 - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-26&product_id=RP-LI-02" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0" 128.241.220.82 - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADF9 HTTP 1.1" 404 3322 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=RP-LI-02" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0" 317.27.160.0.0 - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD5SL9FF1ADFF3" Moz/1.11.0 "Opera/9.80 (Macintosh; Intel Mac OS X 10_11_2; rv:39.0) Gecko/20100828 Firefox/39.0"

Splunk Analytics Infrastructure



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Analysis of working cycles and PLC errors

Analysis of layer 3&4 data production data from automation cells

Predict Production Incidents on Assembly Line

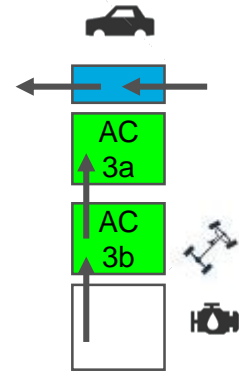
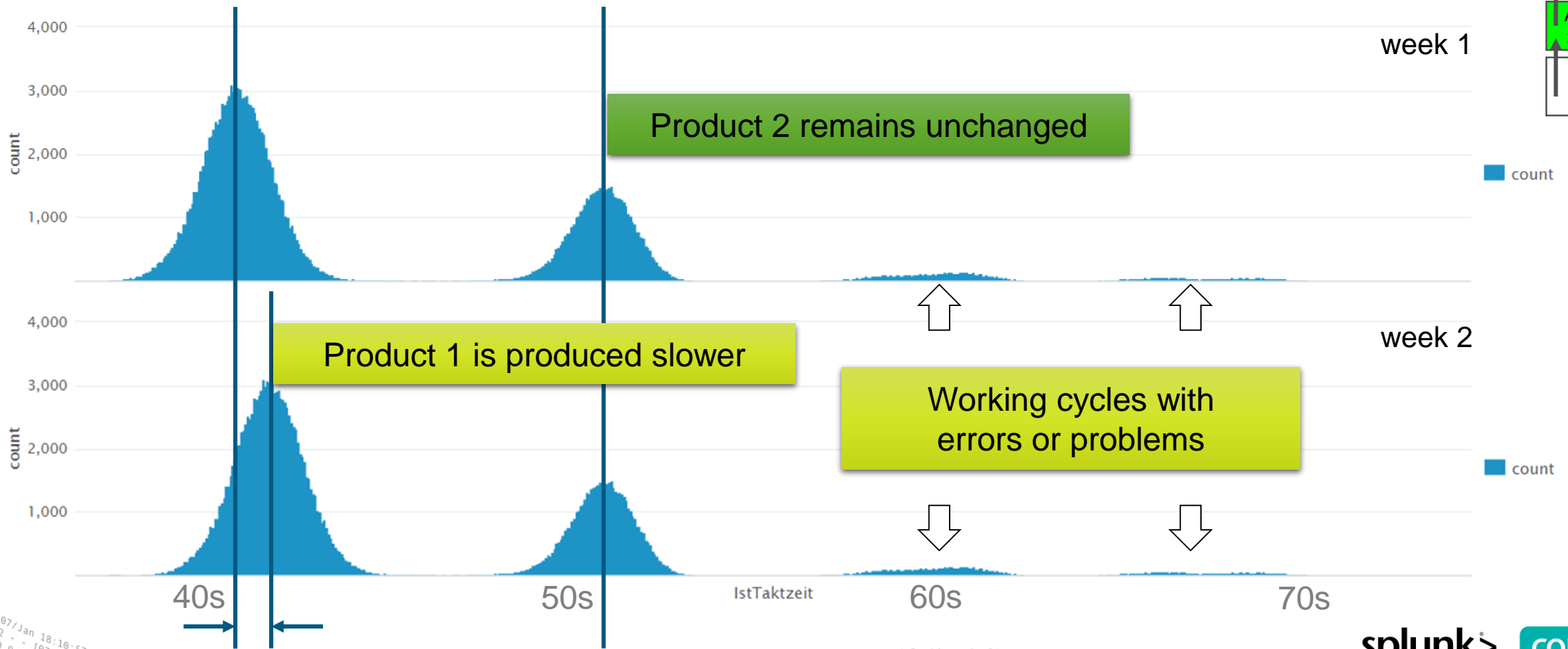
Conveyors, screwing, gluing, robots, humans ... in one line

- ▶ 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

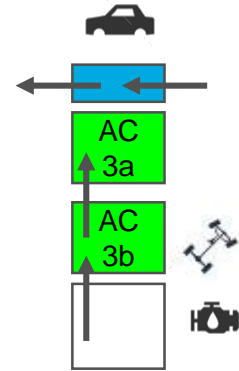
- ▶ Shift in histogram of average working cycles in week by week comparison



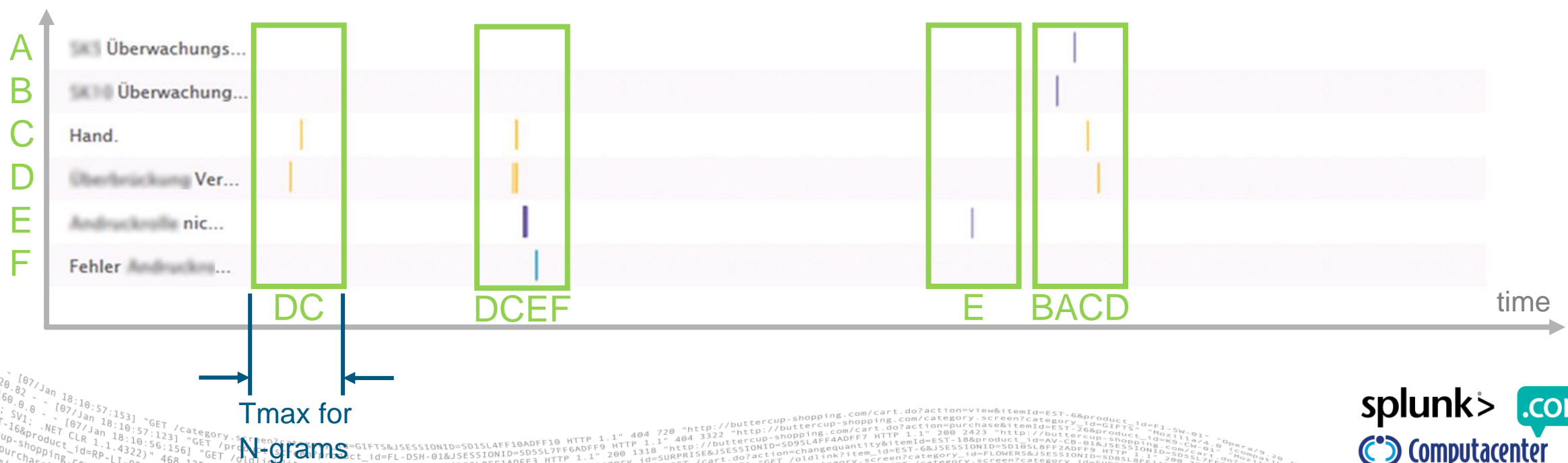
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128.241.220.82 - - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 404 3322 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CU-01"
317.27.160.0.0 - - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD18SL8FF2ADFF9 HTTP 1.1" 200 2423 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CU-01"

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

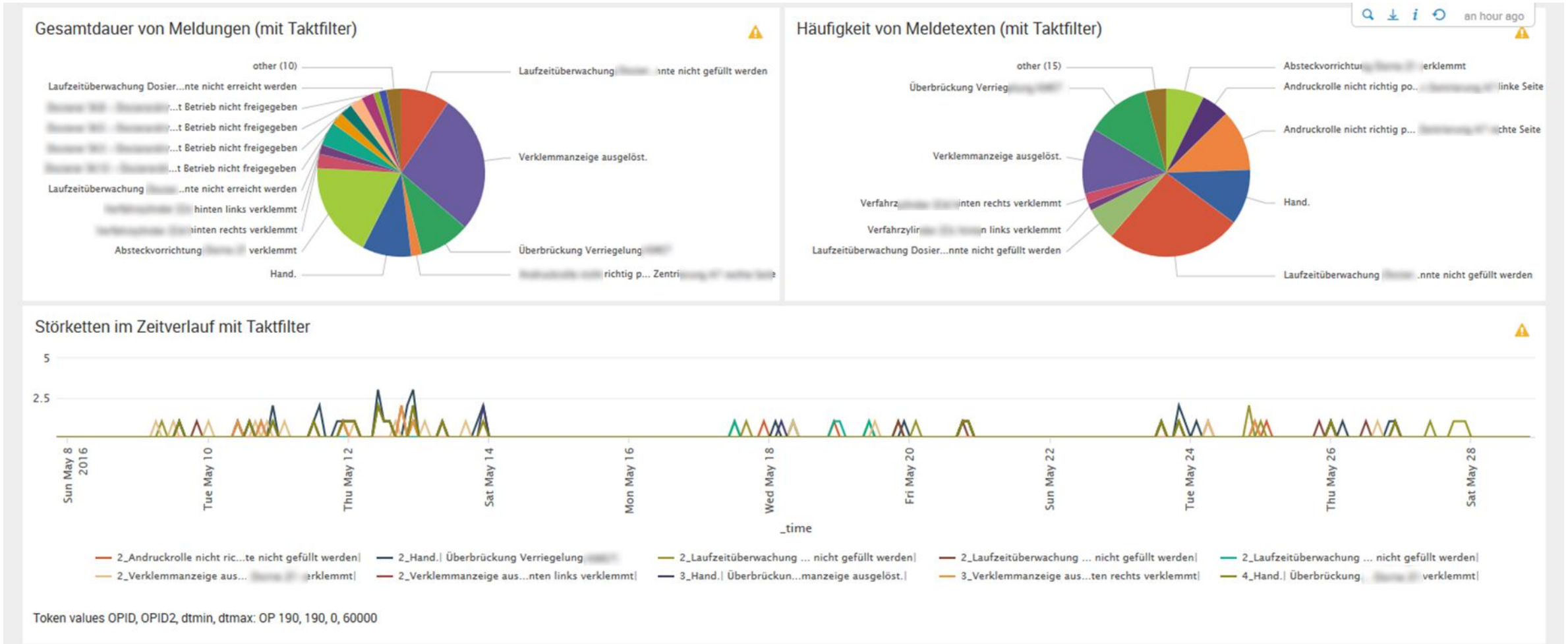


types of events



N-Gram Statistics

What happens when and how often



130.60.4
128.241.220.82
317.27.160.0
ows NT 5.1; SV1;
kitemId=EST-16&product_id=RP-LI-02" "0
ofaction=purchase.com/cl
opping.com/cas

N-gram Analysis

Which error chains causing production impacts?

ng >	c_orig	count	mean(DeltaTakt)
	1	6.00	1488.270000
	1	6.00	544.890000
	1	6.00	544.890000
	1	6.00	544.890000
	1	6.00	505.010000
	1	18.00	436.360000
	1	12.00	436.360000
	1	6.00	436.360000
	1	6.00	431.690000
	1	6.00	423.380000
	1	6.00	423.380000
	1	6.00	418.725000
	1	9.00	418.541875

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

ng >	c_orig	count	mean(DeltaTakt)
	3	1,233.00	30.934540
	123	1,055.00	39.34164
	38	795.00	52.246714
	1	744.00	31.759020
	71	735.00	39.210742
	112	701.00	33.512859
	18	580.00	45.739061
	42	569.00	48.057805
	13	532.00	45.684134
	23	523.00	56.360415
	40	505.00	52.984544
	2	505.00	31.071063
	54	487.00	22.533667
	26	482.00	51.218565
	2	416.00	58.289526
	8	410.00	51.510316
	30	312.00	108.670359
	38	305.00	28.219177
	2	294.00	52.347096

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

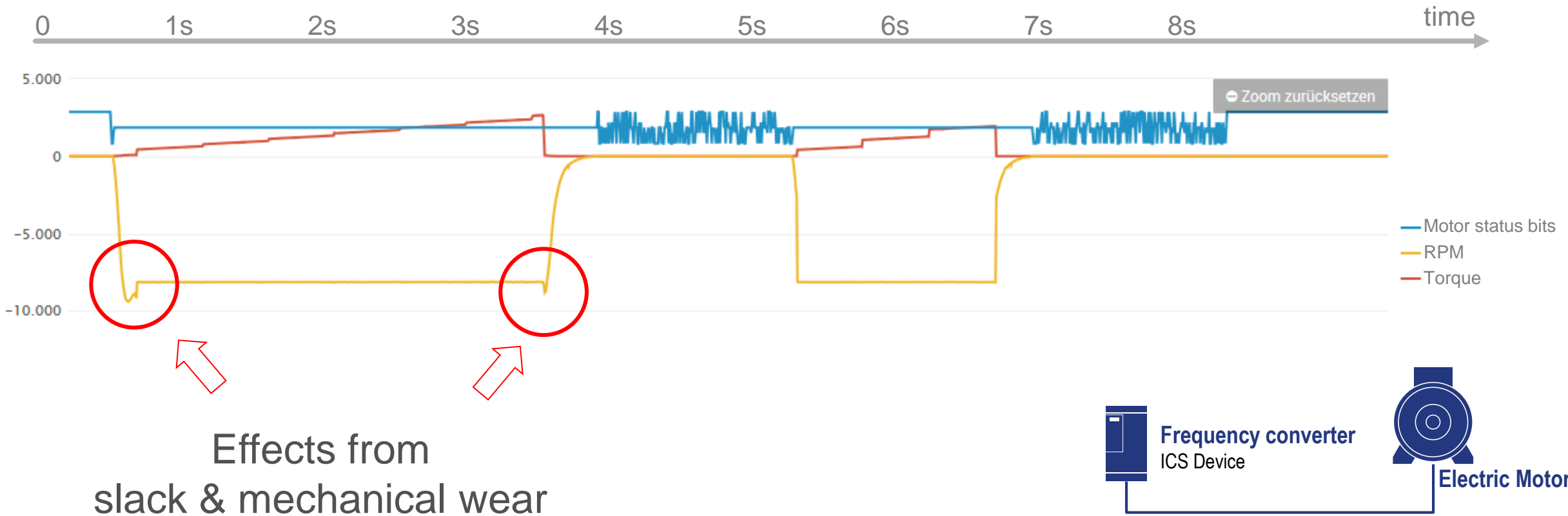
Predictive Maintenance for Electro Motors

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

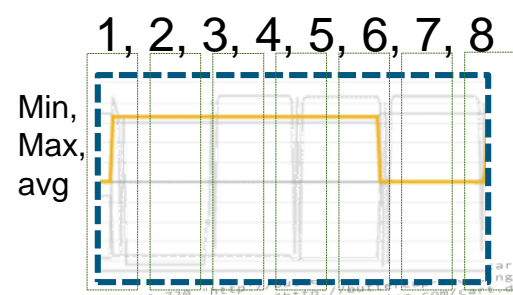
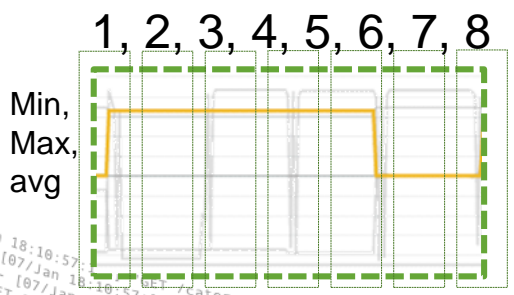
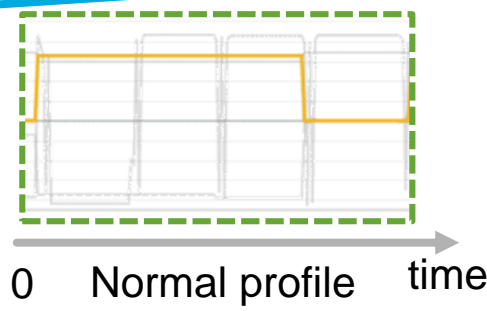
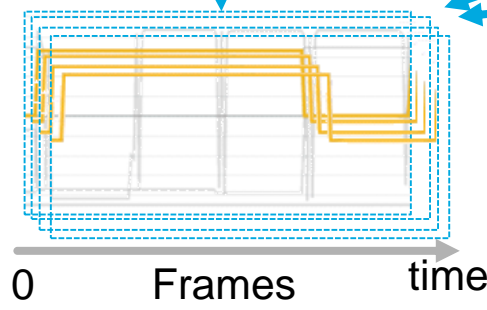
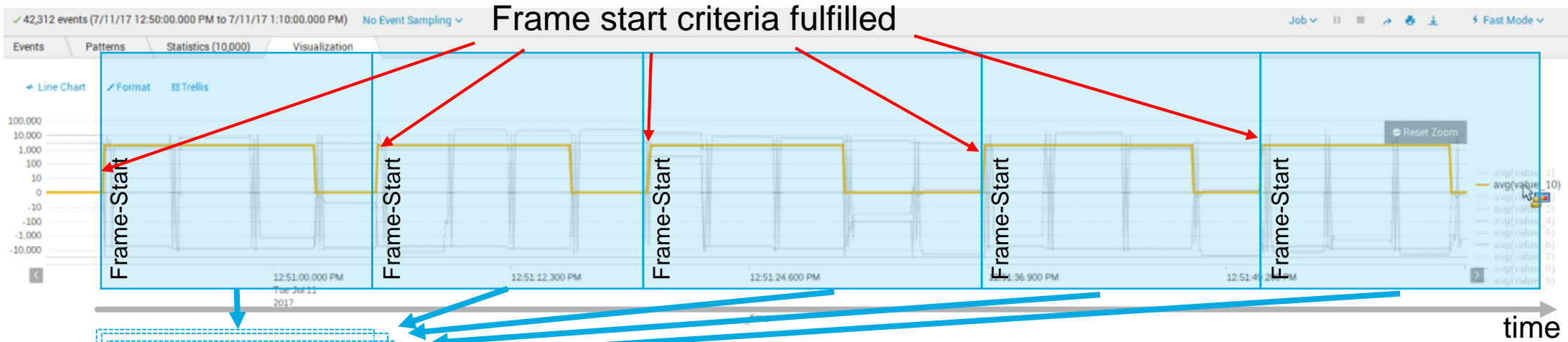


Effects from slack & mechanical wear



130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FL-SW-01" Moz/1.1.0 "Opera/9.80 (Windows NT 5.1; SV1; .NET CLR 1.1.4322)" 468 125.17 14.1
128.241.220.82 - - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 404 3322 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CU-01" Moz/1.1.0 "Comodo Dragon" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 200 3865 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-16&product_id=RP-LI-02" 400 222 "http://shopping.com/cart.do?action=remove&itemId=EST-6&product_id=FL-SW-01" Moz/1.1.0 "Opera/9.80 (Windows NT 5.1; SV1; .NET CLR 1.1.4322)" 468 125.17 14.1
130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FL-SW-01" Moz/1.1.0 "Opera/9.80 (Windows NT 5.1; SV1; .NET CLR 1.1.4322)" 468 125.17 14.1
128.241.220.82 - - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 404 3322 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CU-01" Moz/1.1.0 "Comodo Dragon" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 200 3865 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-16&product_id=RP-LI-02" 400 222 "http://shopping.com/cart.do?action=remove&itemId=EST-6&product_id=FL-SW-01" Moz/1.1.0 "Opera/9.80 (Windows NT 5.1; SV1; .NET CLR 1.1.4322)" 468 125.17 14.1

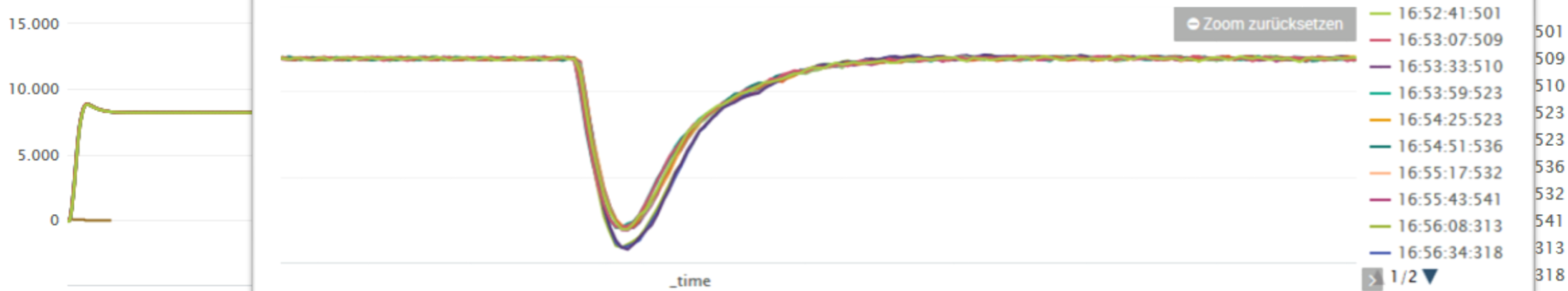
Framing and Slicing Motor Profiles



= Deviation from normal profil

Analysis of Motor Profiles

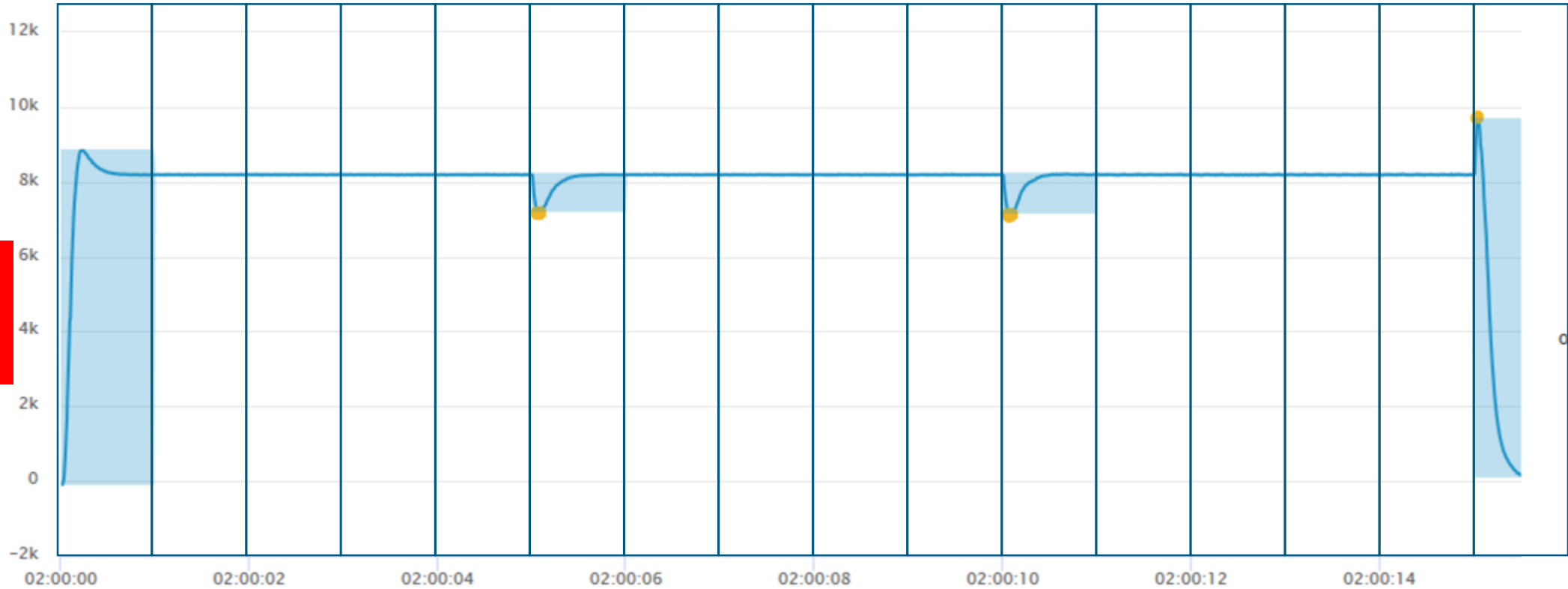
- ▶ 10 Hz frequency raw data from the motor
- ▶ we have 8 OK & 3 NOK motor runs which look very similar



Compare frames against the normal profile

A **non-conform** motor run

Motor run:
Not
Conform



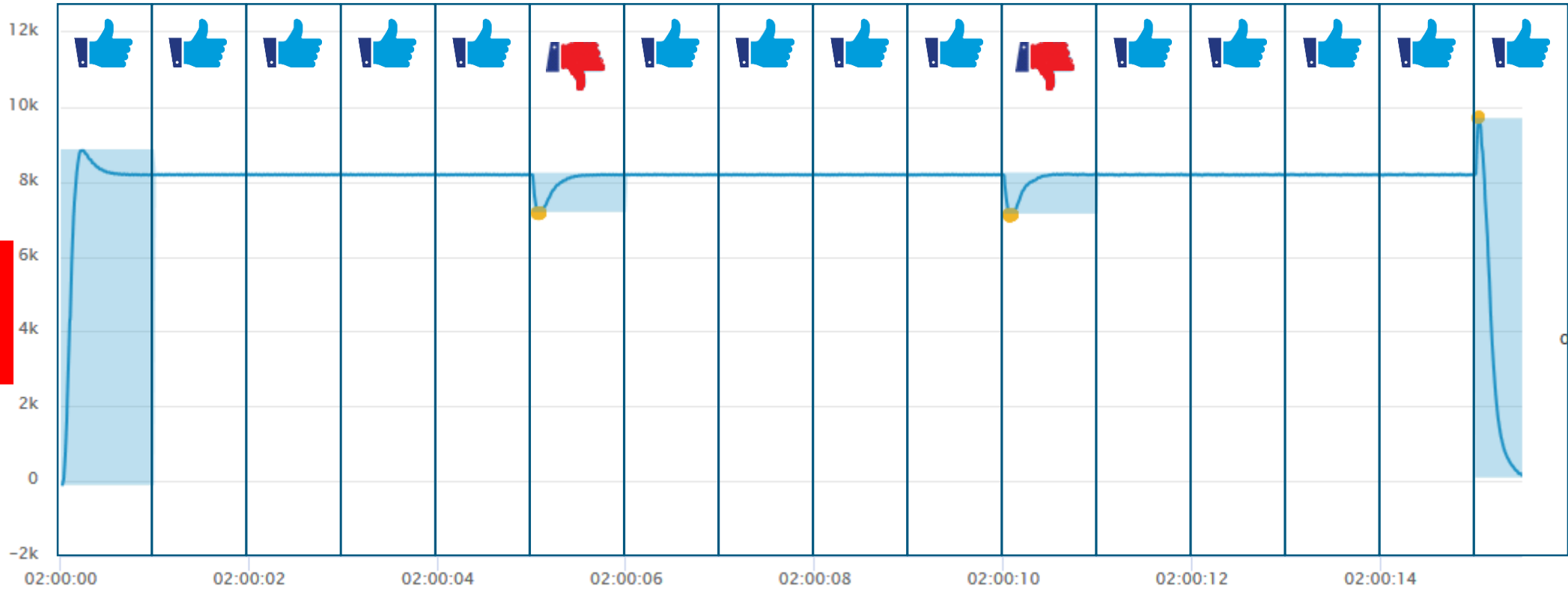
51
outliers

130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FI-5W-01"
128.241.220.82 - - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 404 3322 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-0"
317.27.160.0.0 - - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-1B&product_id=AV-CB-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 200 3865 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-01"
10.0.0.1 - - [07/Jan 18:10:56:189] "GET /category.screen?category_id=FLOWERS&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 3865 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-01"
10.0.0.1 - - [07/Jan 18:10:55:187] "GET /category.screen?category_id=FLOWERS&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 3865 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-01"
10.0.0.1 - - [07/Jan 18:10:55:188] "GET /category.screen?category_id=FLOWERS&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 3865 "http://shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-01"

How we can visualize it...

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

Motor run:
Not
Conform



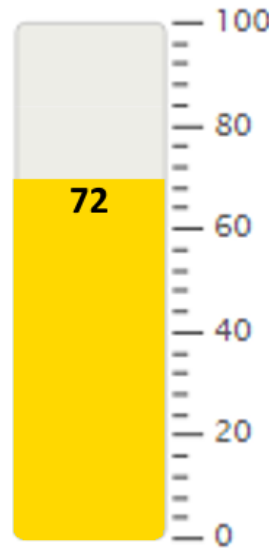
51
outliers

130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FI-SW-01"
128.241.220.82 - - [07/Jan 18:10:57:123] "GET /product.screen?product_id=FL-DSH-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 404 3322 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-26&product_id=K9-CW-01"
131.27.160.0.0 - - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-1B&product_id=AV-CB-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 200 3865 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-16&product_id=RP-LI-02"
130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FI-SW-01"
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131.27.160.0.0 - - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-1B&product_id=AV-CB-01&JSESSIONID=SD5SL7FF6ADFF9 HTTP 1.1" 200 3865 "http://buttercup-shopping.com/cart.do?action=purchase&itemId=EST-16&product_id=RP-LI-02"
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How we can visualize it...

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

But information reduction is key 😊



Motor run conformity

130.60.4 - - [07/Jan 18:10:57:153] "GET /category.screen?category_id=GIFTS&JSESSIONID=SD1SLAFF10ADFF10 HTTP 1.1" 404 720 "http://buttercup-shopping.com/cart.do?action=view&itemId=EST-6&product_id=FI-SW-01"
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ows NT 27.160.0.0 - - [07/Jan 18:10:56:156] "GET /oldlink?item_id=EST-26&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 1318 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD18SL8FF2ADFF9 HTTP 1.1" 200 2423 "http://buttercup-shopping.com/cart.do?action=remove&itemId=EST-18"
item_id=EST-16&product_id=RP-LI-02" 468 125.17.14.189 "GET /category.screen?category_id=FLOWERS&JSESSIONID=SD5SL9FF1ADFF3 HTTP 1.1" 200 3865 "http://buttercup-shopping.com/cart.do?action=remove&itemId=EST-18"
action=purchase&itemId=EST-26&product_id=K9-CU-01" 404 3322 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD18SL8FF2ADFF9 HTTP 1.1" 200 2423 "http://buttercup-shopping.com/cart.do?action=remove&itemId=EST-18"
action=purchase&itemId=EST-26&product_id=K9-CU-01" 404 3322 "http://buttercup-shopping.com/cart.do?action=changequantity&itemId=EST-18&product_id=AV-CB-01&JSESSIONID=SD18SL8FF2ADFF9 HTTP 1.1" 200 2423 "http://buttercup-shopping.com/cart.do?action=remove&itemId=EST-18"



Wrap up

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!

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