

# AlarmSolutions

## – AI-based alarm management

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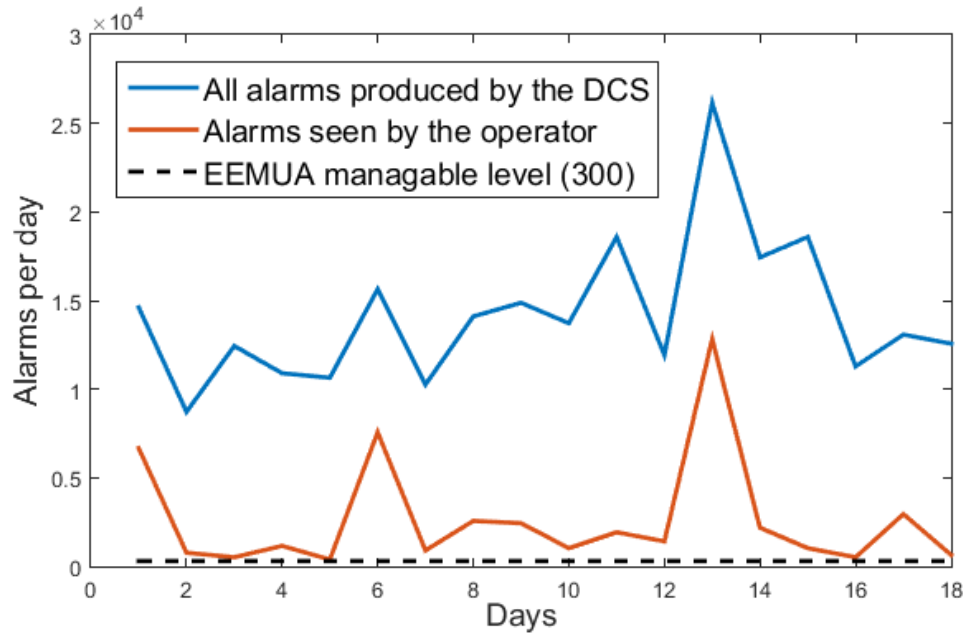
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*<sup>3</sup>MTA-PE Lendület Complex Systems Monitoring Research Group*

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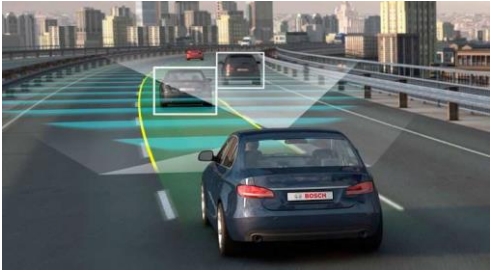
# Do we need operators?



# They still interact...

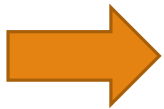
Alarm performance metrics based on 30< days of data		
Metric	Target Value	
	Acceptable	Max.
Annunciated alarms per hour per operator console	~6	~12
Annunciated alarms per 10 minutes per operator console	~1	~2
Percentage of 10-minute periods containing more than 10 alarms	~<1 %	
Maximum number of alarms in a 10-minute period	≤10	
Percentage of time the alarm system is in a flood condition	~<1 %	
Percentage of the top 10 most frequent alarms to the overall alarm load	~<1 % to 5 % maximum	
Quantity of chattering and fleeting alarms	Zero	
Stale (standing) alarms	Less than 5 present on any day	
Annunciated priority distribution 3 priorities: (Low-Medium-High)	80 – 15 – 5 %	

# “Self-driving” operation



## Tasks

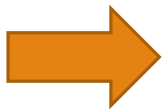
Exploring the alarm messages



Exploring the alarm-control action connections



Validation of the control actions



## Results

Alarm load is decreased

Recommendation system

Fully automatized (and optimal) control

# Alarm & Event Log Databases

From	To	Production Unit	Unit	Tag	Event Type	Description
10/24/2018 16:02	10/24/2018 16:04	Distillation	Main column	Head temp.	Alarm	High alarm
10/24/2018 16:02	10/24/2018 16:04	Distillation	Main column	Cond. cooling	Operator action	Open

⋮ Millions of data points

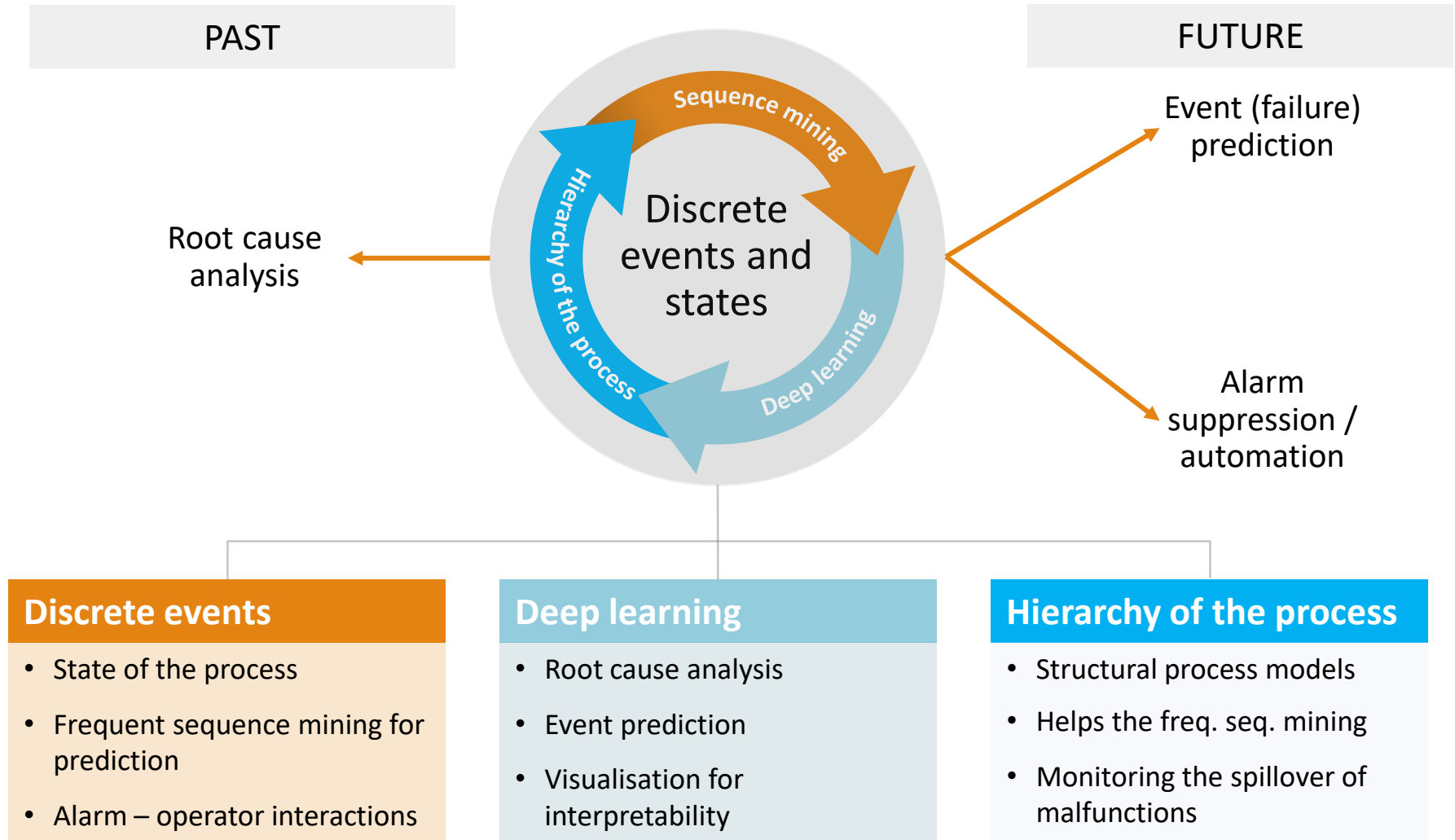


Data (process) mining, machine (deep) learning...



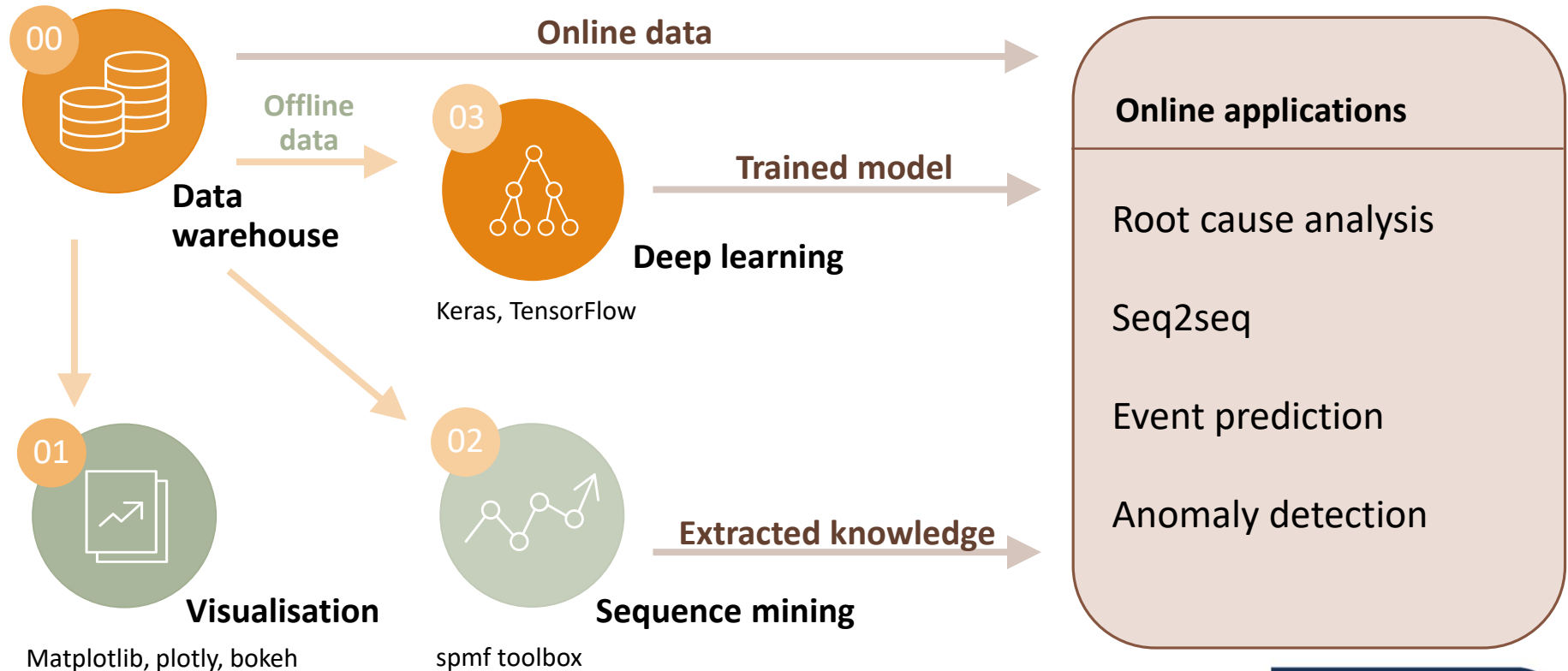
Something useful ?

# Concept



# The method and the framework

Open source machine learning tools are applicable in the process industry



Where is the problem?



# Visualisation of alarms

webSCADA ← → 🏠 | 🔄 📄 📊 📱 📶 bejelentkezte | kijelentkezés aktuális idő 2019. 10. 18. 10:13 | 🔒 📄 🔊 ⚙️  
 Administrator 0 perc múlva

webSCADA ← → 🏠 | 🔄 📄 📊 📱 📶 Administrator 0 perc múlva 2019. 10. 18. 10:24

Slope chart Dotchart (dotchart) Követési mátrix (adjmatrix) Szekvencia elemzés (sankey) sankey-online-pred id

Eseménynapló 📄 📄 📄 📄 📄 📄 📄 📄 📄 📄

AlarmStatistics

Dashboard Heatmap

Stacked Area

Start time: 3/19/2019, 13:10 End time: 3/19/2019, 15:10 Attribute tag Interval 10 Get stacked area

Stacked area chart

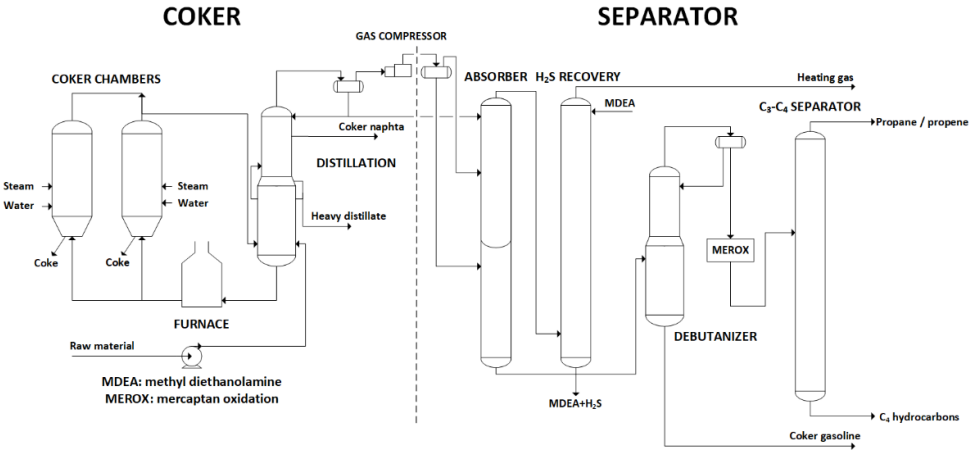
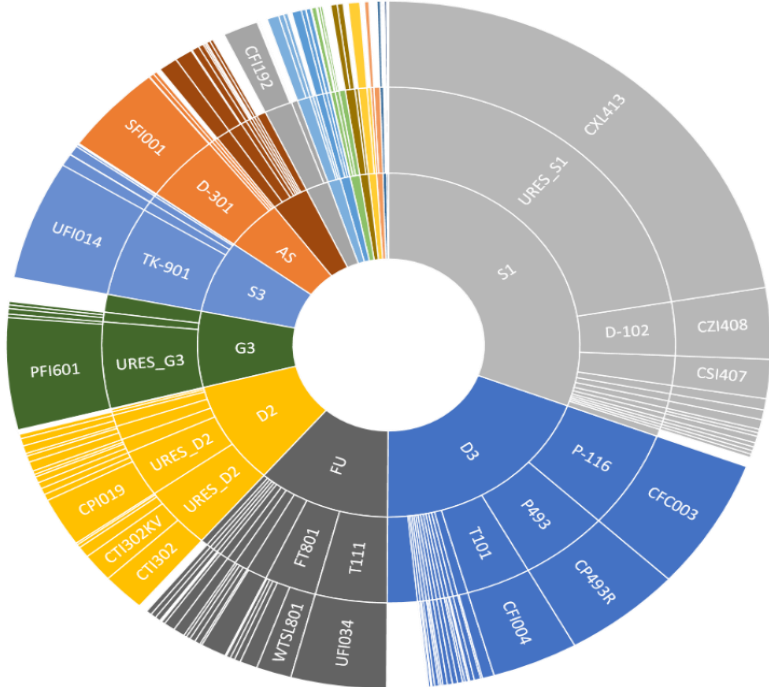
Values

19yyy-10M-19d 13... 19yyy-20M-19d 13... 19yyy-30M-19d 13... 19yyy-40M-19d 13... 19yyy-50M-19d 13... 19yyy-00M-19d 13... 19yyy-10M-19d 14H 03m:55s30010000 0M-19d 14... 19yyy-30M-19d 14... 19yyy-40M-19d 14... 19yyy-50M-19d 14... 19yyy-00M-19d 15...

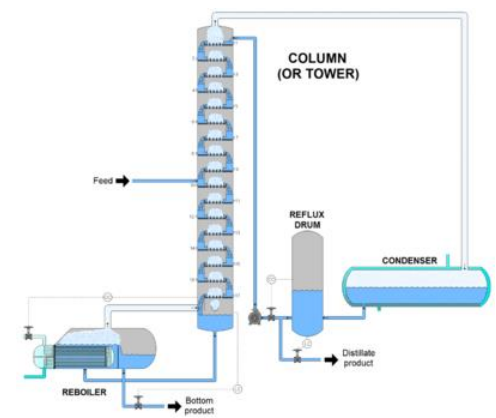
- Zalaegerszeg.Channel\_4.Bucsuszentlaszlo.buc\_s23uza: 0
- Zalaegerszeg.Channel\_4.Bucsuszentlaszlo.u2k\_kutszabuza: 0
- Zalaegerszeg.Channel\_4.Bucsuszentlaszlo.u3k\_kutszabuza: 0
- Zalaegerszeg.Channel\_4.Bucsuszentlaszlo.u3k\_szinthm: 0
- Zalaegerszeg.Channel\_4.Nematem.neh\_s23uza: 0
- Zalaegerszeg.Channel\_4.Nemesszentandras.ukmax: 1
- Zalaegerszeg.InternalTags.bucelot\_szintria: 0
- Zalaegerszeg.InternalTags.het\_szintria: 2
- Zalaegerszeg.Kephiba.Nemeshetes: 0
- Zalaegerszeg.Kephiba.Nemesszentandras: 1

Dashboard Data Alarm statistics Heatmap Stacked area Dotted chart Sequence analyses Anomaly detection

# Distribution of alarms



# Sequence mining



## Alarm messages

*Fouling*



$F_{reflux}^L \Rightarrow p_{condenser}^H \Rightarrow T_{column\ top}^H \Rightarrow T_{condenser}^H \Rightarrow A_{product}^L$

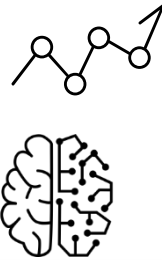
## Operator actions

$Flow_{pump}^H \Rightarrow Q_{cooling}^H \Rightarrow Flow_{inflow}^L \Rightarrow Bypass$

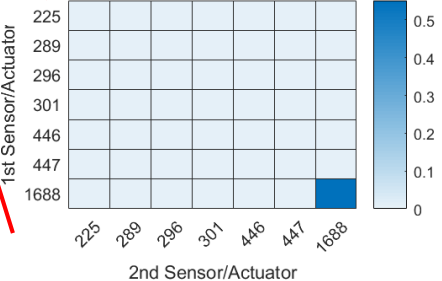
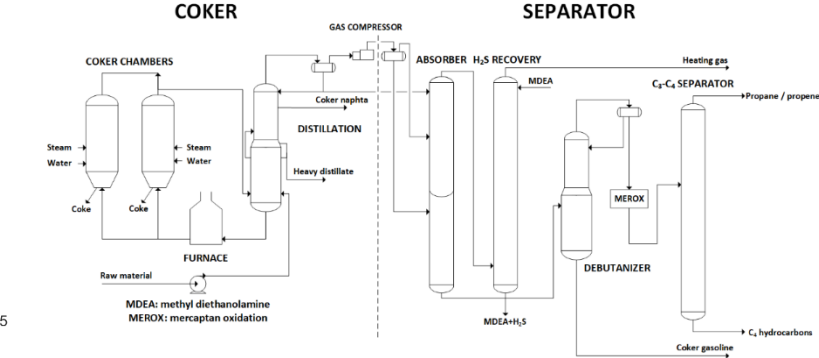
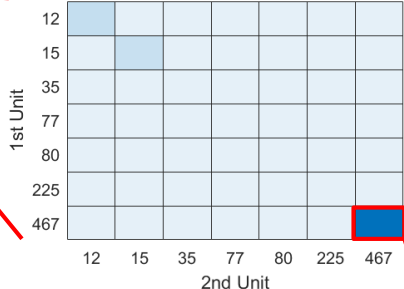
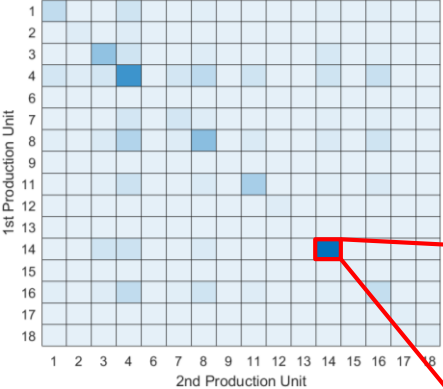
Causal relations?

## Techniques

- Frequent sequence mining
- Deep learning

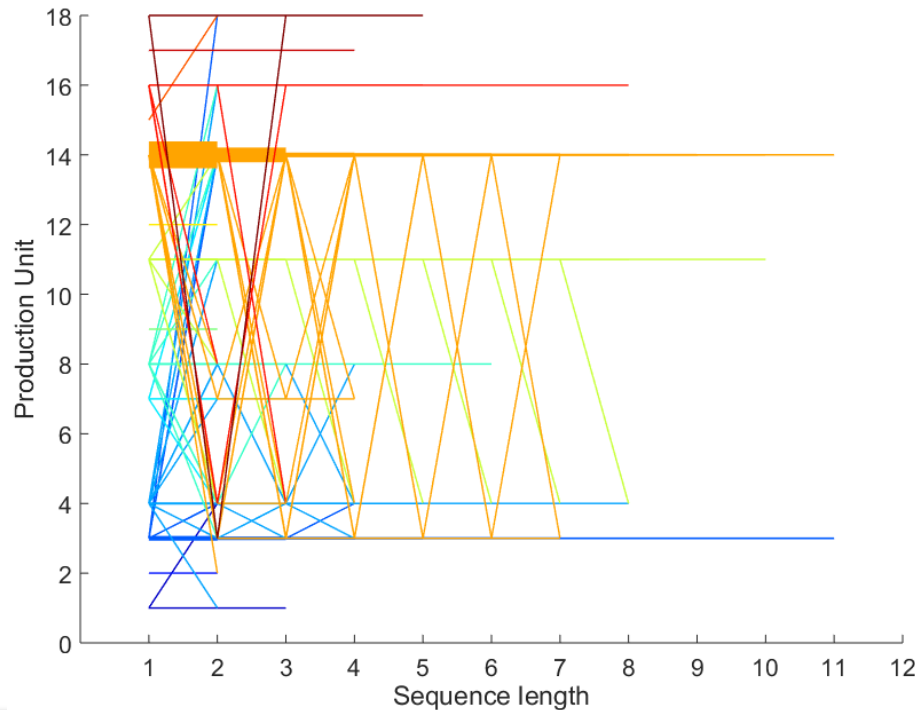
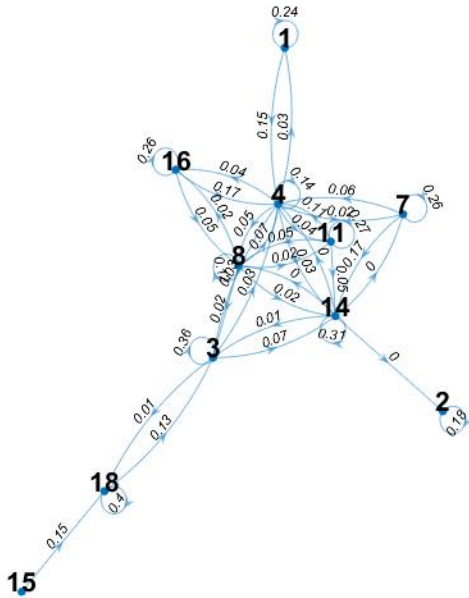


# Sequences of hierarchical levels



# Spillover effect of malfunctions

- Nodes – production units
- Edges – direction
- Weights – probability of spillover



- x – length, y – prod unit
- Polyline – sequence
- Color - start of alarms
- Thickness – frequency

ID	unit	unitname
1	AS	DCU AMINE REGENALO
2	D1	DCU RAW MATERIAL SYSTEM
3	D2	DCU H-101 FURNACE
4	D3	DCU COKE TANKS
5	D4	DCU MAIN FRACTIONATOR
6	D5	DCU LCGO HCGO PRODUCT SYST.
7	D6	DCU BLOWDOWN SYST.
8	FU	FLARE SYSTEM
9	G1	DCU MOIST. GAS SYSTEM
10	G2	DCU HEATING GAS LINE
11	G3	DCU C3/C4 SEPARATION
12	G4	DCU C3/C3= SEPARATION
13	G5	DCU BENZIN SEPARATION
14	S1	DCU UTILITY SYSTEMS 1
15	S2	DCU UTILITY SYSTEMS 2
16	S3	DCU UTILITY SYSTEMS 3
17	S4	DCU UTILITY SYSTEMS 4
18	AC	ADVANCED CONTROL
19	C3	CLAUS UNIT

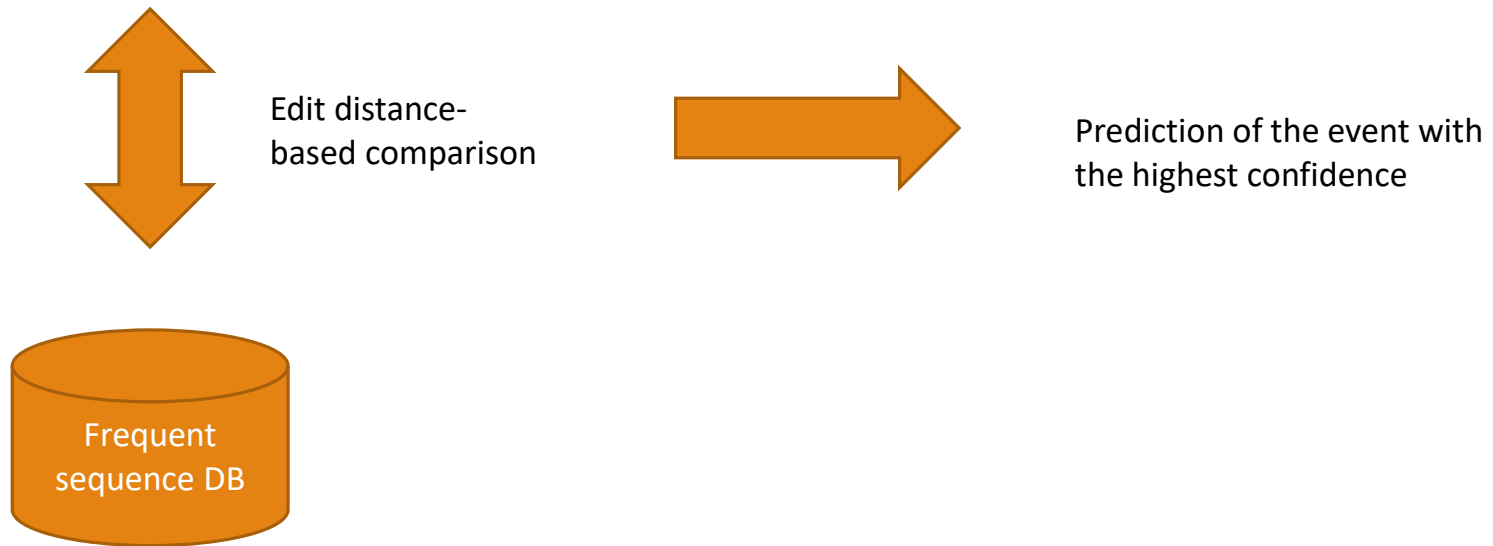
# Prediction of alarms

# Alarm prediction

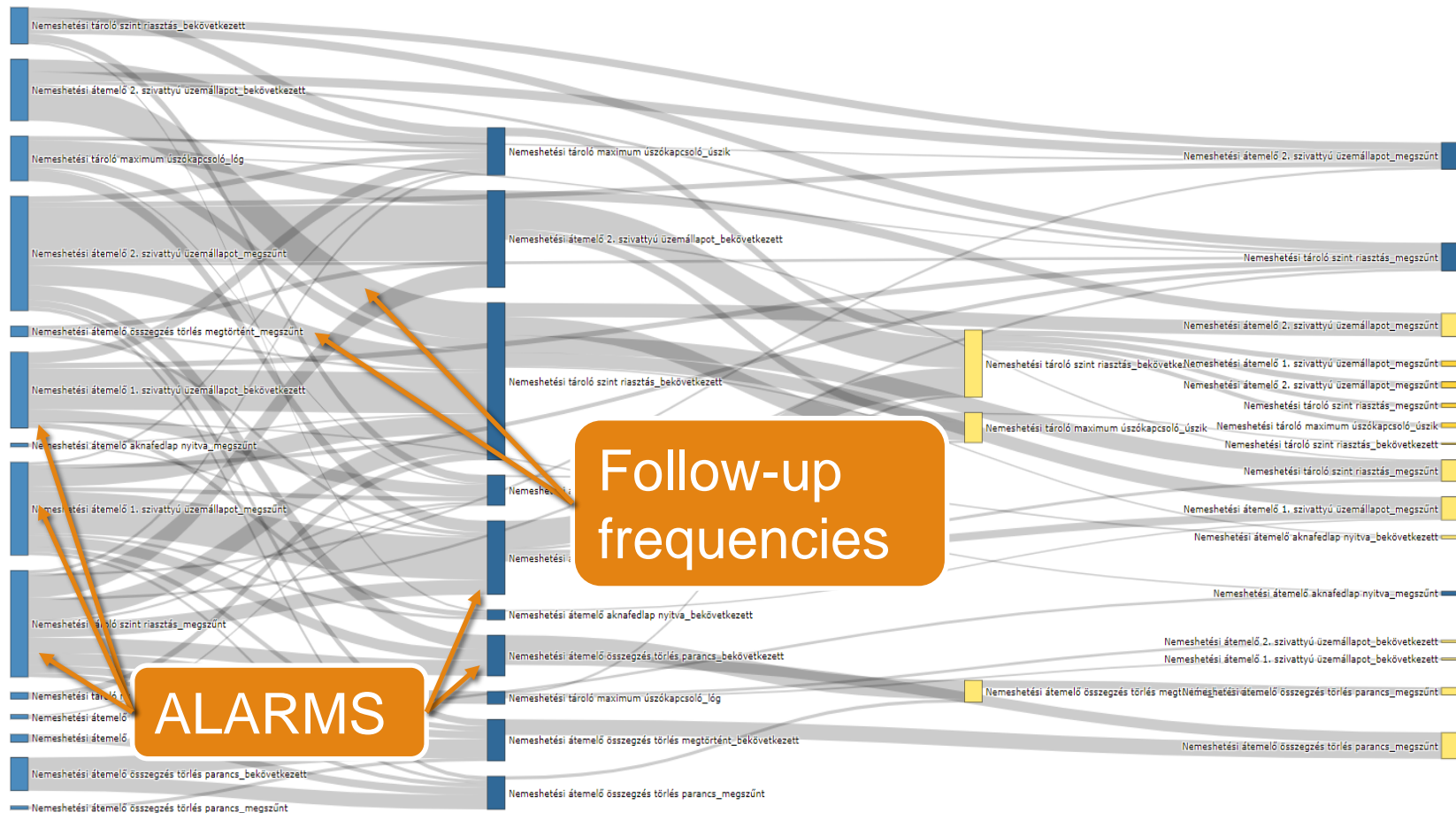
Online occurring sequence:

82 ⇒ 191 ⇒ 41 ⇒ ... ⇒ 31

Confidence-based prediction  
High variability!



# Visualising the sequences – water system



Sankey diagram - Proportional to support values (occurrences)



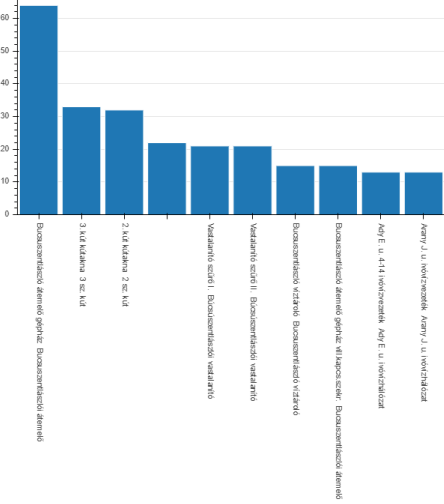
# Maintenance monitoring

# Maintenance monitoring

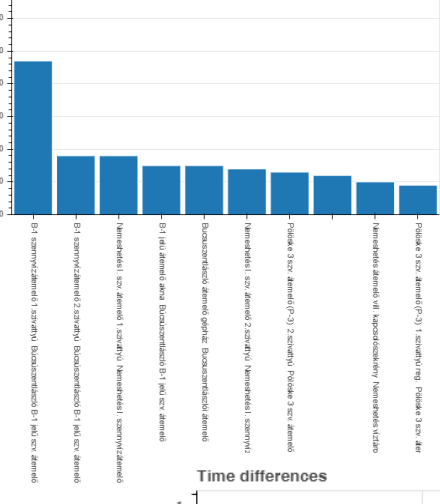
## Maintenances

## Errors

Karbantartások előfordulása



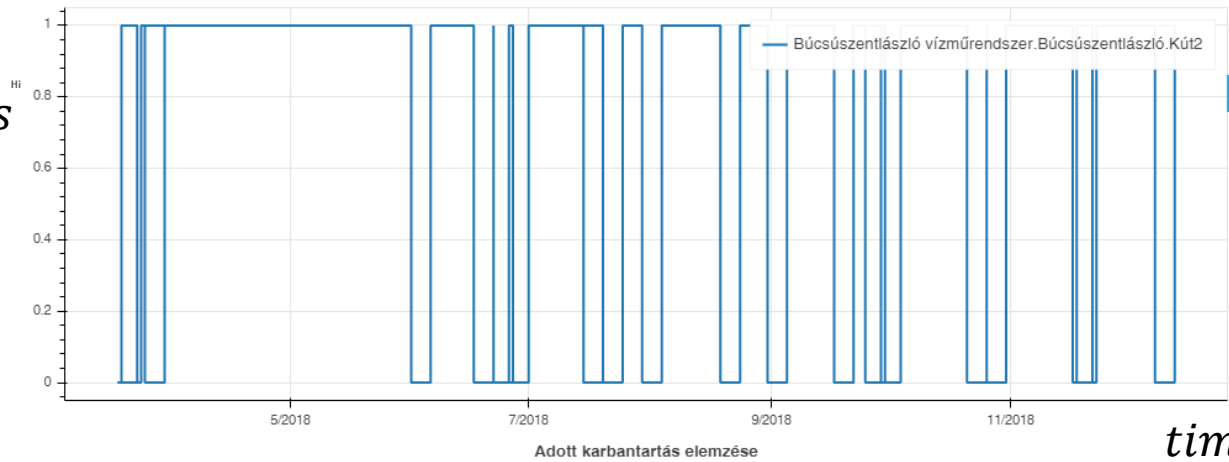
Hibaelhárítások előfordulása



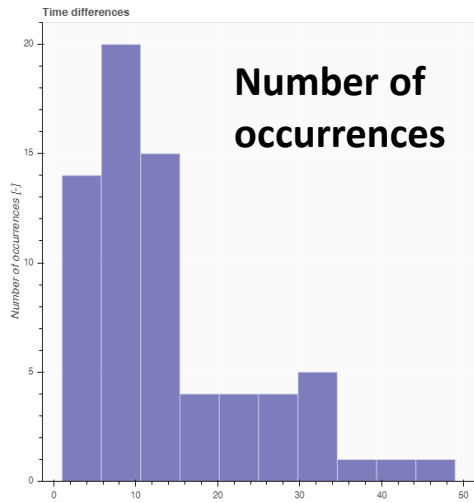
Karbantartások előfordulása leírás

*Down times*

Time differences

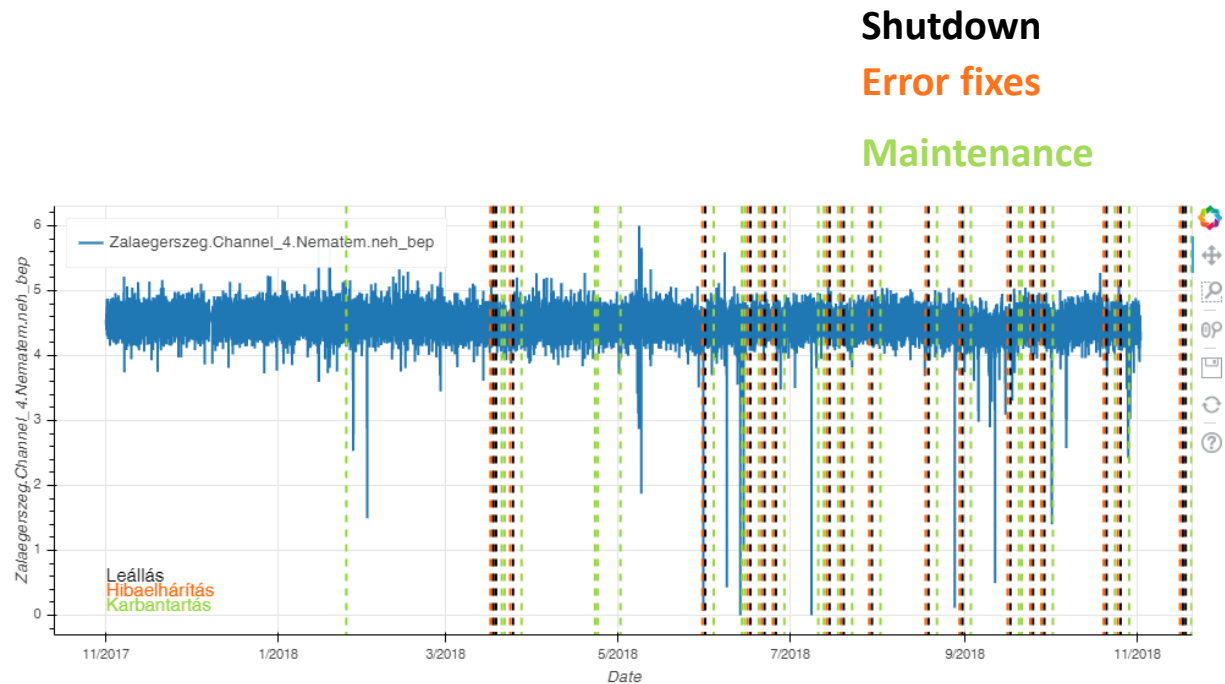


# Predictive maintenance - How to schedule maintenances?



Time differences between maintenances

PV



# Conclusions – act now!



- The number of sensors is increasing!
- The number of operators is decreasing!
- The monitored data is unused – acquired, stored, managed...
- Costs?

## AlarmSolutions

### Szolgáltatásaink



#### Alarm rendszerek vizsgálata

Statisztikai adatvizualizáció – online megoldások az alarm rendszer állapotának időszakos felmérésére. Gyökérokok keresése és jövőbeli vészjelzések predikciója.



#### Anomália detekció

Gépi tanulási modellek segítségével számítjuk a folyamat erőforrásigényét és eltérések esetén figyelmeztetést adunk ki.



#### Prediktív karbantartás

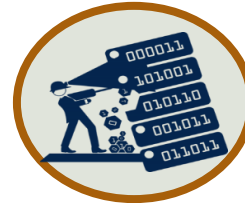
Gépi tanulási alapú karbantartáselőrejelzés.

# Rabbit Miner – The process systems engineers

- Optimization
- Process systems engineering
- Process/Data mining
- Data science applications
- Industry 4.0 solutions



## Rabbit Miner



Data-driven  
process development



Smart monitoring  
system



Root cause  
analyses



Decision support  
based on process simulation



TOP 50 in BIG BANG Startup competition,  
University of California, Davis USA

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E-mail: [miner@rabbitminerlab.com](mailto:miner@rabbitminerlab.com)

# Thank You for your attention!

