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REAL-TIME ANOMALY DETECTION USING DEEP LEARNING TO PREDICT ROBOTS' FAILURES

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With the great support from Nir LOTAN, Machine Learning, Deep Learning Products Manager
Intel - Advanced Analytics

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Advanced Analytics

- Applying IoT and AI at Intel, for example:

Fan filters predictive maintenance	Robots failure detection	Multi-params fault detection	Visual inspection	Health Clinical Trial Platform

Vision: Put AI to work for human experts

DEEP DIVE: ROBOTIC FAILURE DETECTION USE CASE

Use Case Background Video

Robotic failure – problem statement

- High volume manufacturing employ large number of robots
- Robots faults affect production yield, equipment downtime and factory throughput
- Detection of anomaly in the robots is done manually during scheduled maintenance

So what did we do?

ALGORITHMIC CHALLENGES

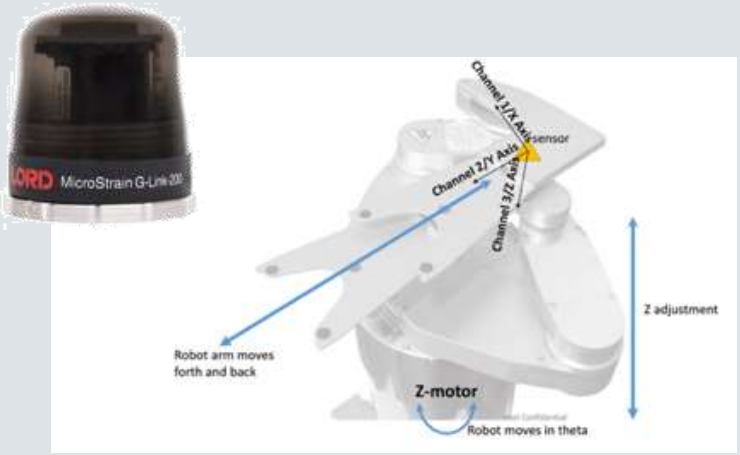
How can we get data?

Consider that:

We want to be as little intrusive as possible.
The robots are moving within a machine

Approach:

2 Accelerometers were placed on each robot
Each accelerometer sends data at freq. of 512Hz
Accelerometers transmit their readings wirelessly

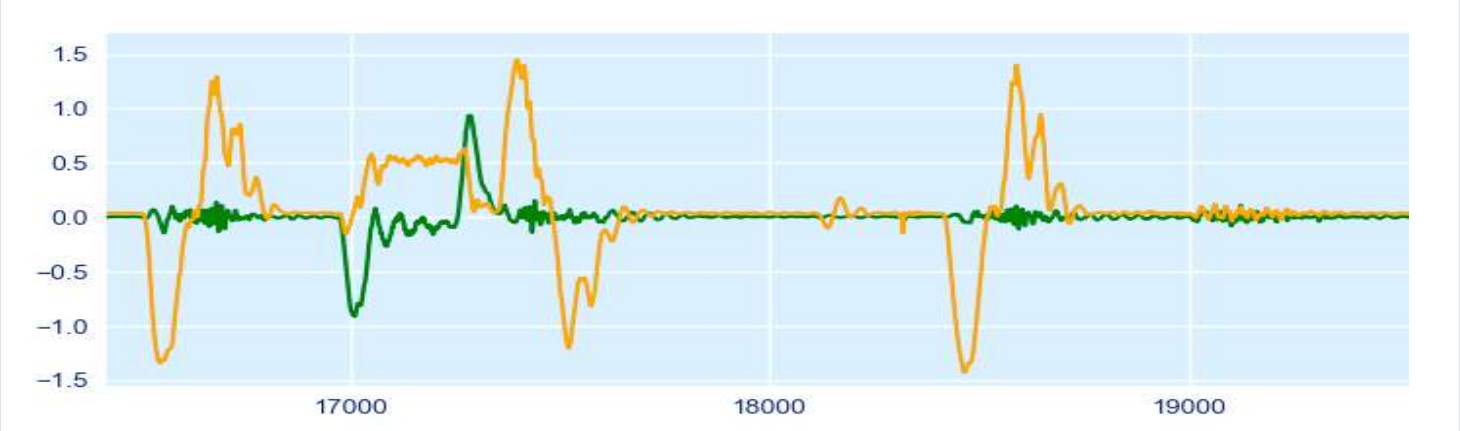


Target: Real time failures detection based on the robot's vibration

How can we analyze the data?

Consider that:

Basic / User defined rule don’t work on this kind of data



Approach:

Use machine learning (a.k.a. “A.I”)

– implement a system that is able to "learn" with data, without being explicitly programmed

How can we get “tagged” data?

Consider that:
Machine learning needs a lot of examples – good and bad

Approach:
Use an “unsupervised” approach:
Learn only the good behavior, and treat any anomaly as “bad”

Intuition!

Think about your spelling checker

How to create a scalable solution?

Consider that:
We need an algorithm that works on hundreds of robots

Approach:
Take an “online learning” approach – the algorithm learns as it goes (or builds a baseline)

How to create a good predictor?

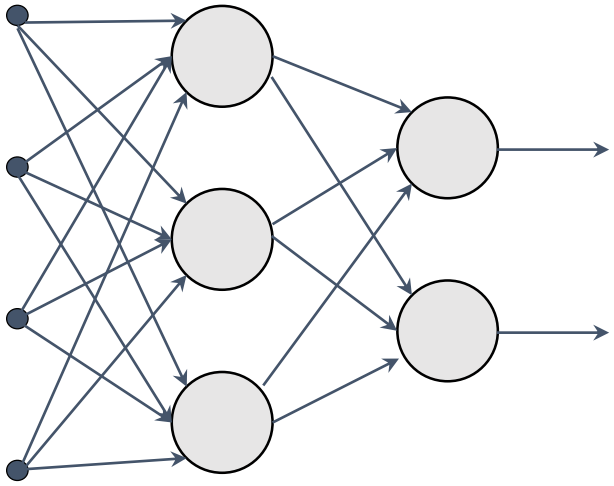
Consider that:

The robot behavior is not repetitive and unpredictable, it has practically infinite number of “recipes”

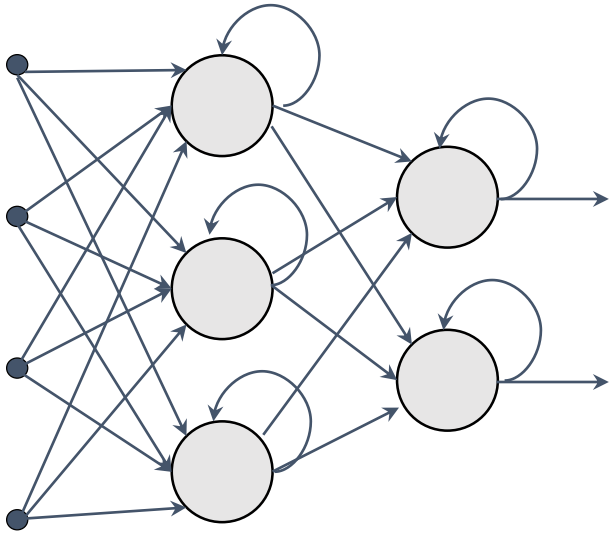
Approach:

Traditional machine learning did not provide good prediction, so we selected Deep Learning RNN - LSTM

Deep learning RNN - LSTM



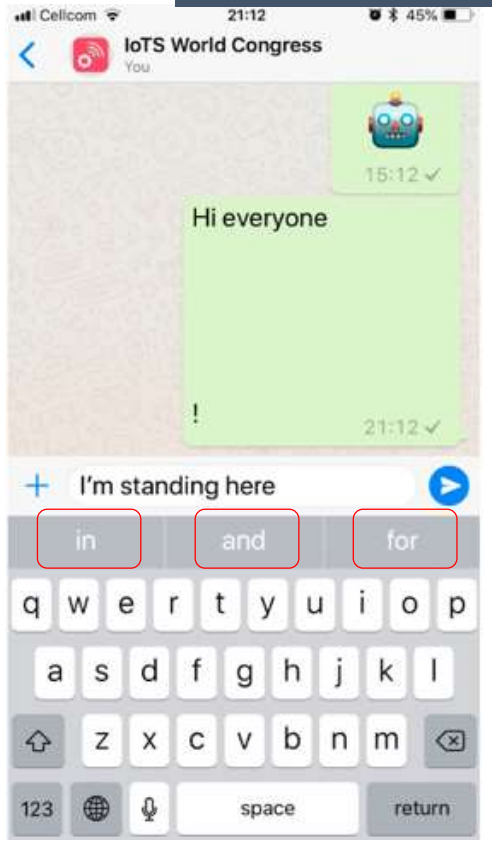
Feed-Forward Neural Network



Recurrent Neural Network

Intuition!

Think about your phone keyboard predicting your next word



Results

few seconds for detection prior to failure
Allowing real time actuation

100% detection rate

~0% false alarm rate

ENGINEERING CHALLENGES

Data Size & Frequency, IP Sensitivity & security

Remember:

Each accelerometer provides 3 data points at rate of 512Hz

Data is sensitive, and we don’t want the data to leak or anyone externally to have access to the system

Approach:

Choose/develop an on-premise solution

Latency & Actuation

Remember:
Our algorithm predicts the robot failure just a few seconds before it happens

Approach:
We need to be close to the machine and act immediately – choose an edge/fog solution

Scale

Remember:

We want the project to scale, and be as cost effective as possible

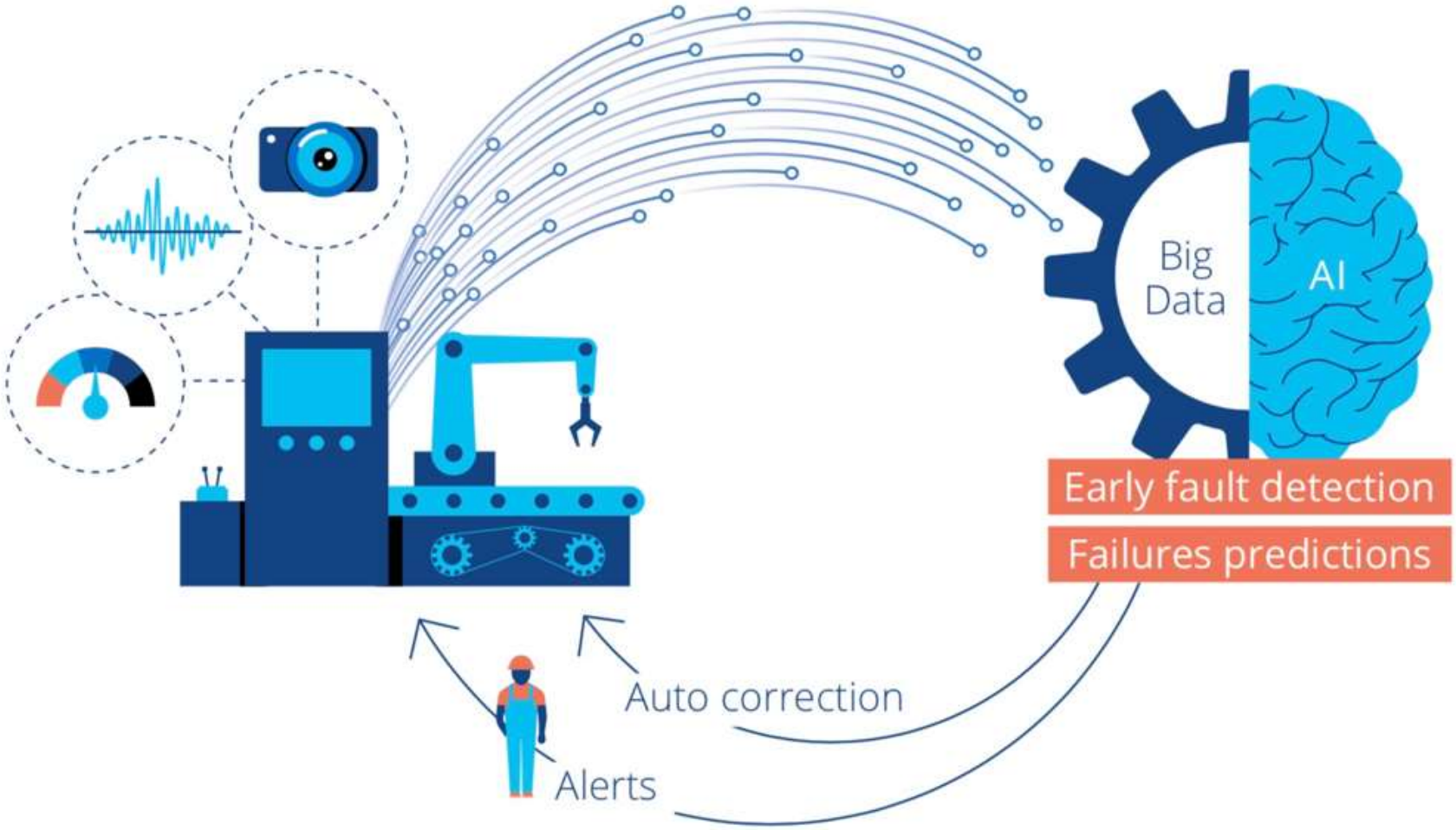
Approach:

Choose Intel core i5 platforms with small footprint (NUC)

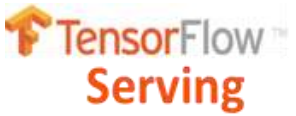
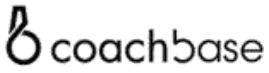
They are cheap, but have relatively powerful compute power

Industrial AI platform

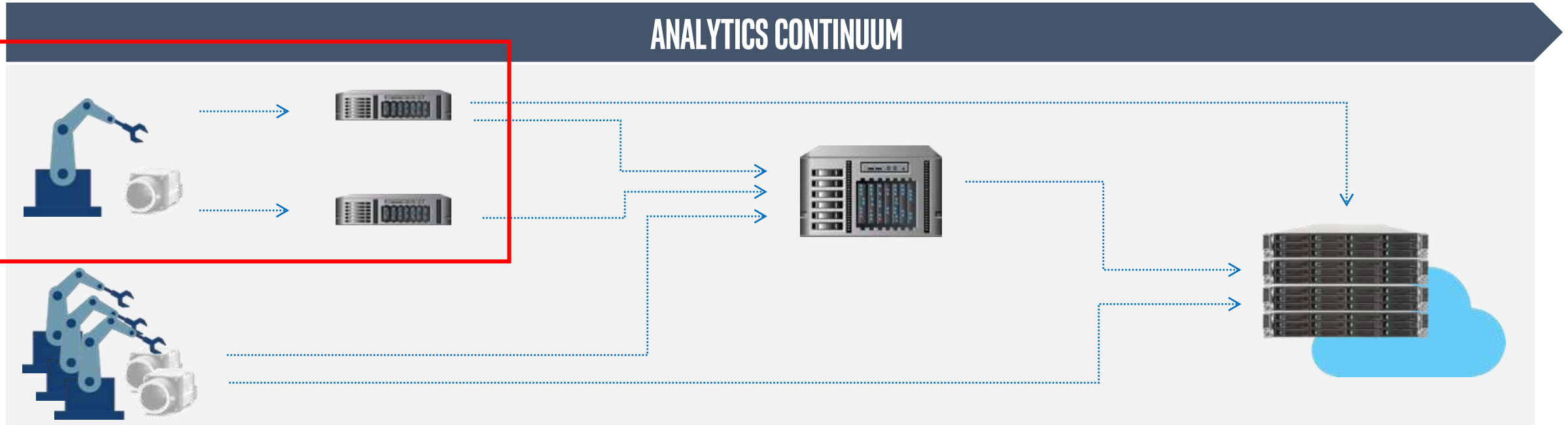
AI platform for continuous real time fault detection and failures prediction



FOG SOFTWARE TECHNOLOGY STACK

PROGRAMMING LANGUAGES	   
ML & DEEP LEARNING – INFERENCE	Intel® MKL & DAAL 
STREAM ANALYICS LAYER	**Python for Kafka Streams** 
STORAGE LAYER	  
CONTAINER TECHNOLOGY	  
OPERATING SYSTEM	 

Choose the right solution for your problem



KEY FEATURES	Single device monitoring Local mgt. (UI)	Multi devices monitoring Centralized mgt. (UI) Auto. retrain Reports & Dashboards	Multi devices monitoring Big Data analytics Centralized mgt. (UI) Auto. retrain Reports & Dashboards
	Low Foot Print Short Latency	Single Machine → Cluster Short Latency	Data Center/Cloud High Compute/Storage

Takeaways

- **Its not trivial** – analytics/algorithmics (don't expect miracles)
- It is doable! **Take the leap of faith!**
- Come and talk to us –we are doing this every day!

Thank you!

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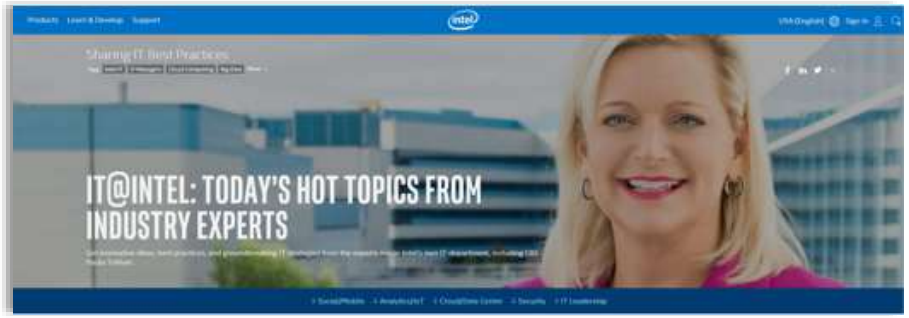

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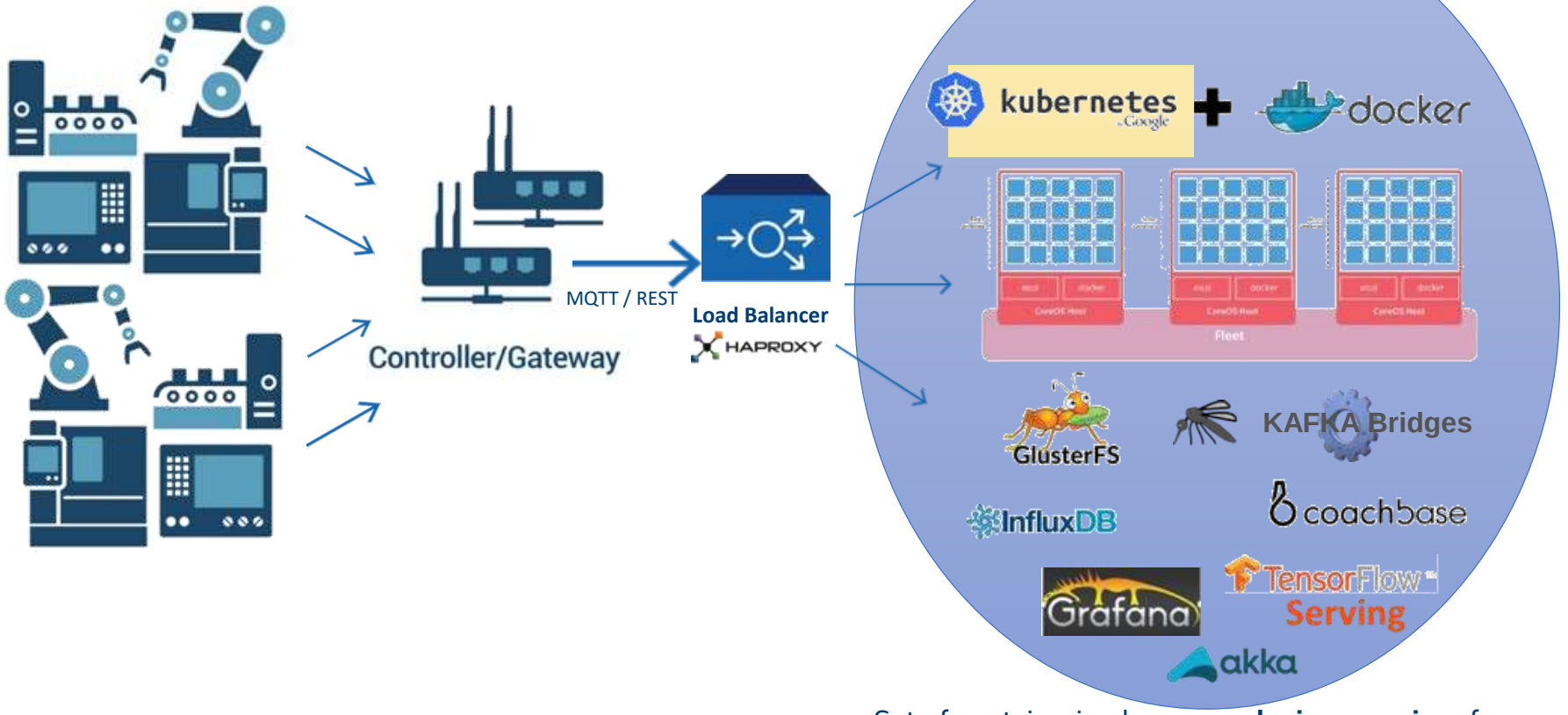
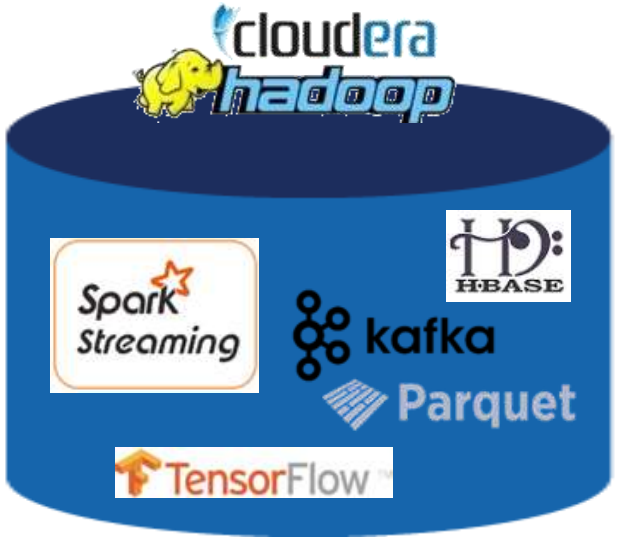
HIGH LEVEL ARCHITECTURE



Set of containerized **managed micro-services** for **modularity** & ease of deployment

Cloud/Data Center Infrastructure



Scalable and efficient Big Data storage & processing

software Architecture