

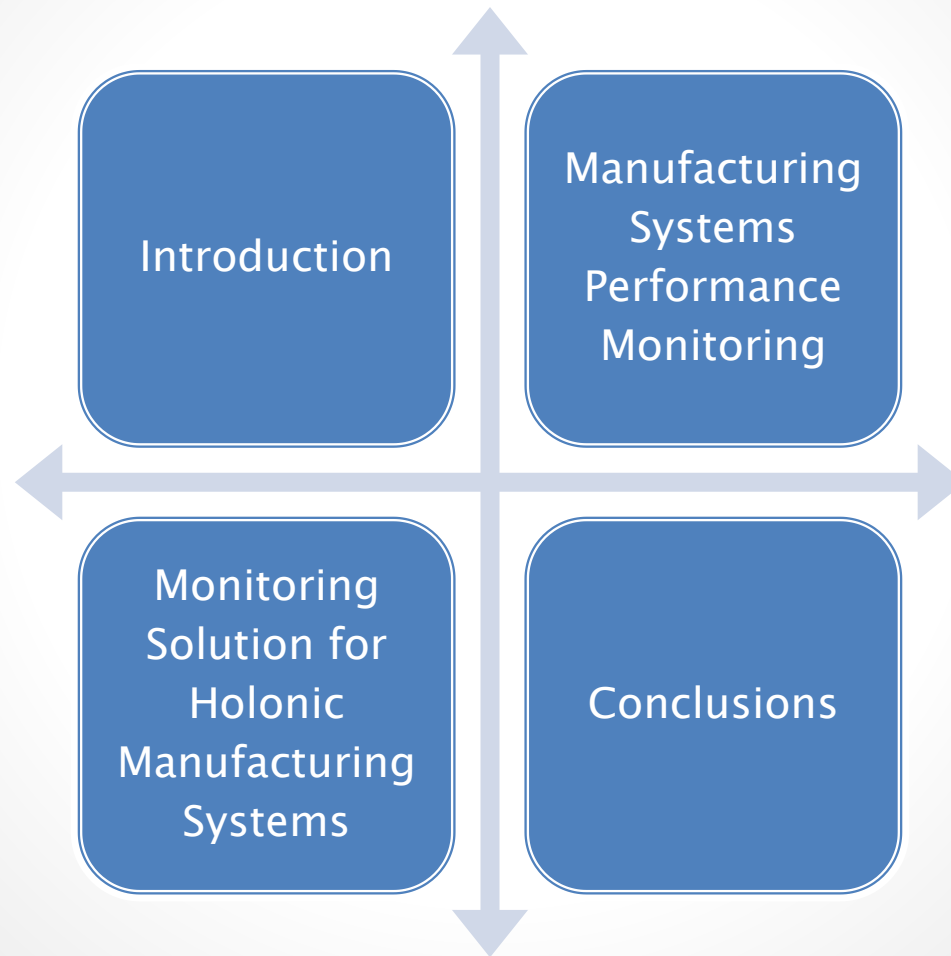
# Resource, Service and Product Real-Time Monitoring Solution for Service Oriented Holonic Manufacturing Systems.

Services Development from INSEED in the  
Manufacturing and Supply Chain Domains.

Theodor Borangiu  
UVHC, ENSIAME 2013



# Agenda



# Introduction

## The need for a monitoring solution



- ▶ Three inter-related vectors that define the effectiveness of the manufacturing system:
  - Robustness (scheduling, algorithms, etc.)
  - Composability (service orientation, SOA, etc.)
  - **Observability (monitoring)**
- ▶ A partial system failure can cause a complete failure if it cannot be detected, isolated and handled in a timely manner

# Introduction Observability



- ▶ Any manufacturing system needs to provide means to determine:
  - the current state it is in
  - the state history from the beginning of the execution to the current state.
- ▶ In other words, it must provide means to be observed, or monitored in real time.

State1

State2

# Introduction

## Observability in manufacturing systems



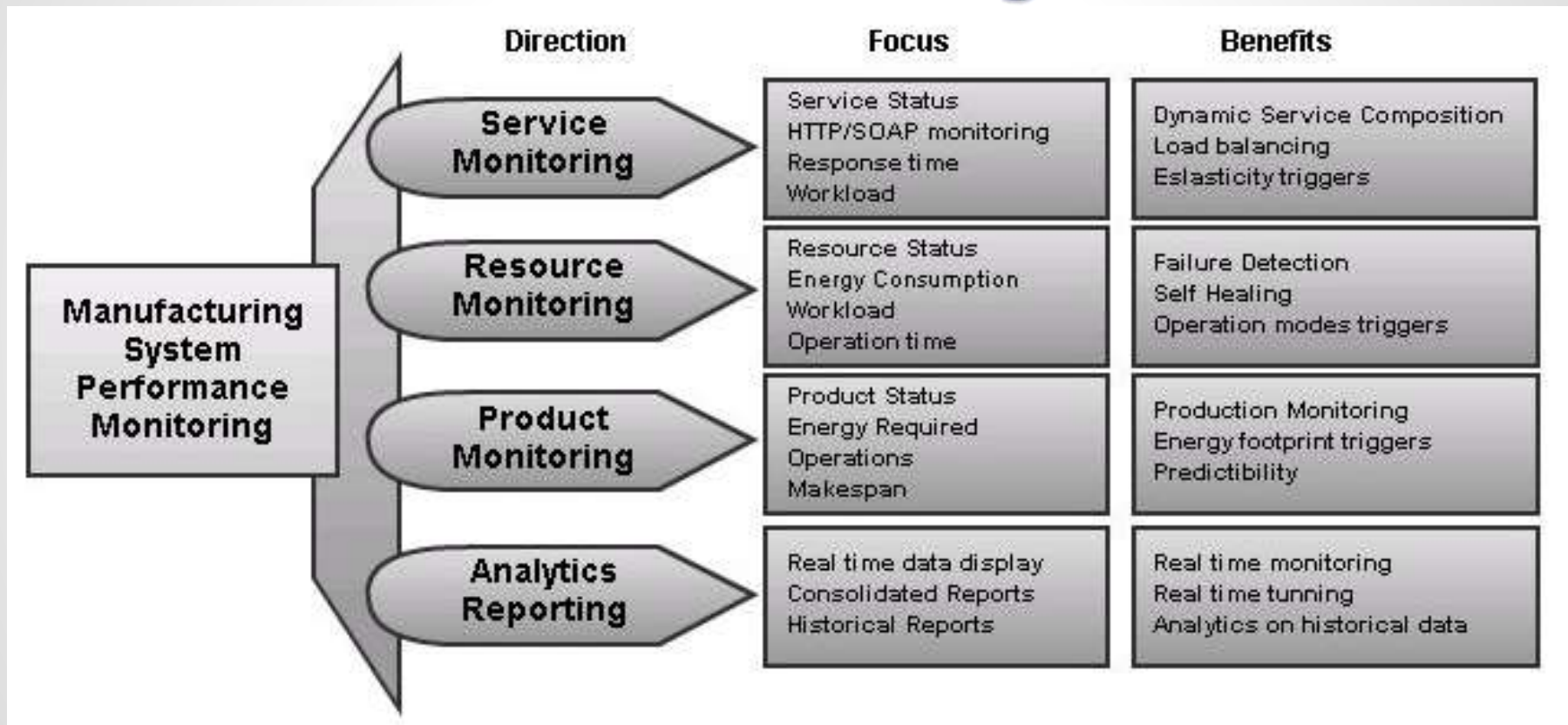
- ▶ For manufacturing systems, **observability** has concrete meanings:
  - energy consumption at shop floor level
  - resource utilization
  - time per operation
  - average make-span
  - others

# Application Performance Monitoring (APM) Conceptual Framework



- ▶ Published in 2010 by Gartner Research
- ▶ Defines five directions for APM:
  - end-user experience
  - run-time application architecture
  - business transactions
  - component monitoring
  - reporting

# Manufacturing Systems Performance Monitoring (MSPM)



# Manufacturing Systems Performance Monitoring (MSPM)



- ▶ MSPM framework has four main directions:
  - **service monitoring:** focuses on the actual web services exposed and used by the system sub-modules. Monitoring is done at the HTTP/SOAP protocol layer and the data consists in service status, response time for requests and overall workload.
  - **resource monitoring:** refers to the actual robots on the shop floor. The focus here is on the resource status, the energy consumption and on the resource utilization.



# Manufacturing Systems Performance Monitoring (MSPM)



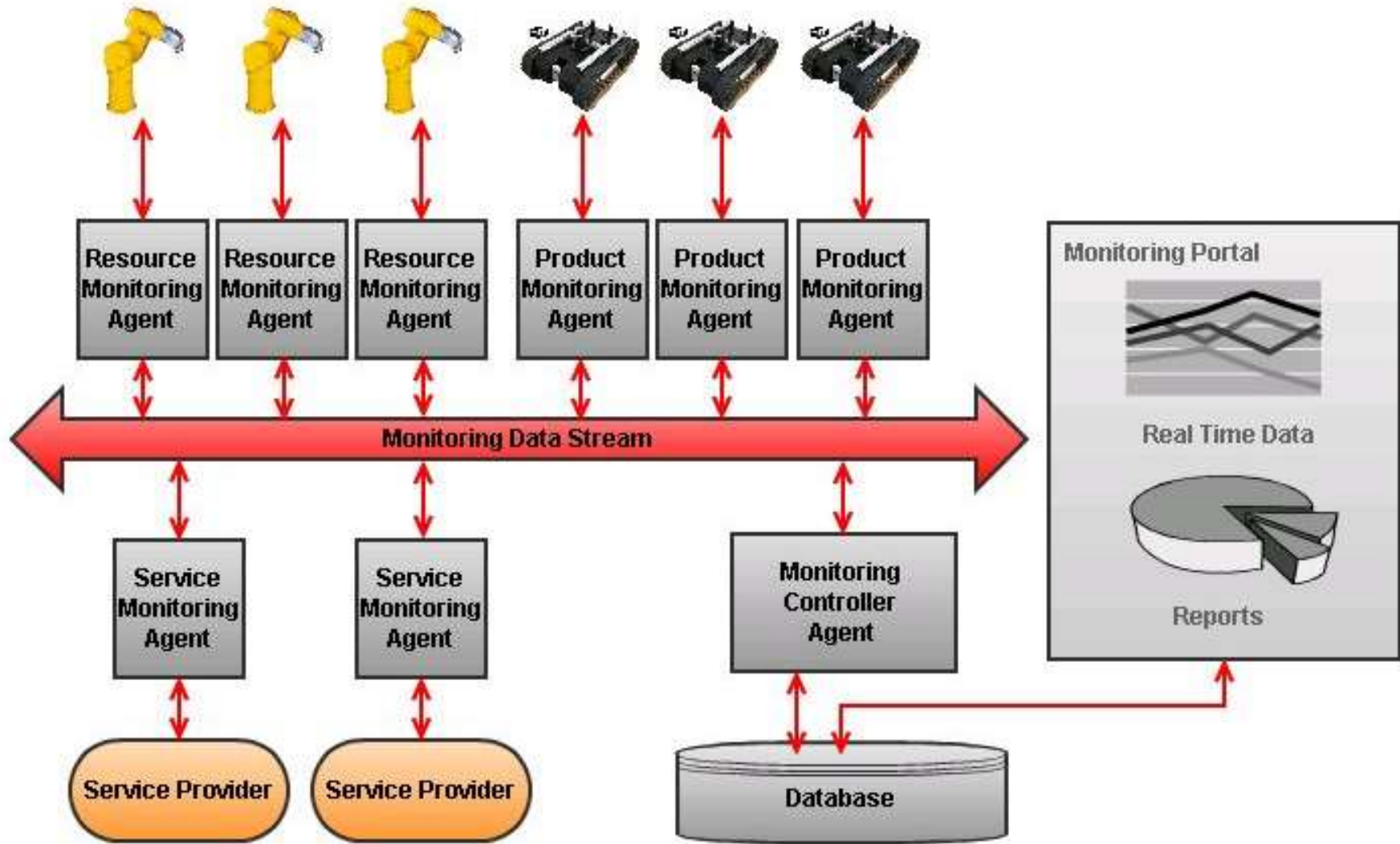
- **product monitoring:** is used to keep track of the products that are in production at any given time. The data collection focuses on energy consumption, real time status and make-span.
- **analytics/reporting:** represent the mechanisms to consolidate the collected data around relevant key performance indicators (KPIs) for the manufacturing system.

# Monitoring Solution for Holonic Manufacturing Systems



- ▶ Two functional modules:
  - **Data collection module:** responsible for gathering real time data from monitored targets and consolidate it in a persistent storage
  - **Monitoring portal:** provides a rich user interface for data visualization

# Architecture



# Monitoring Solution for Holonic Manufacturing Systems



- ▶ Four types of agents developed for this solution:
  - **resource monitoring agent:** JADE agent with a cyclic behavior. The agent does a cyclic poll at 5 seconds interval on the resource in order to gather information about the resource status, energy usage and the operations performed.
  - **product monitoring agent:** a JADE agent with a consumer behavior. The agent runs on the embedded device attached to the product pallet and it is notified after each operation performed.
  - service monitoring agent
  - controller agent.

# Monitoring Solution for Holonic Manufacturing Systems

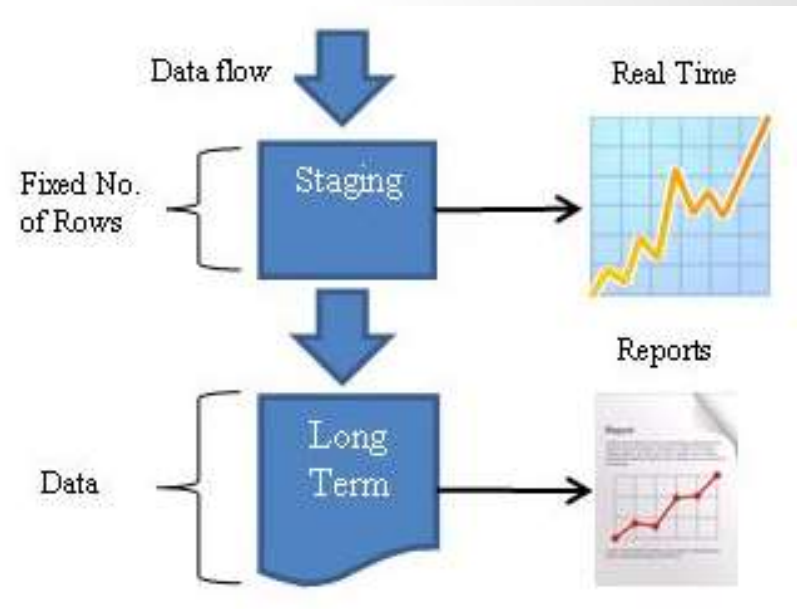


- **service monitoring agent:** is implemented as a HTTP filter for Apache HTTP server. The filter is a shared library that is called for each request and response.
- **controller agent:** is a JADE agent that implements a cyclic behavior and consumes the monitoring messages sent to the monitoring data stream. The agent aggregates the data based on the monitoring target and saves it in the persistent storage.

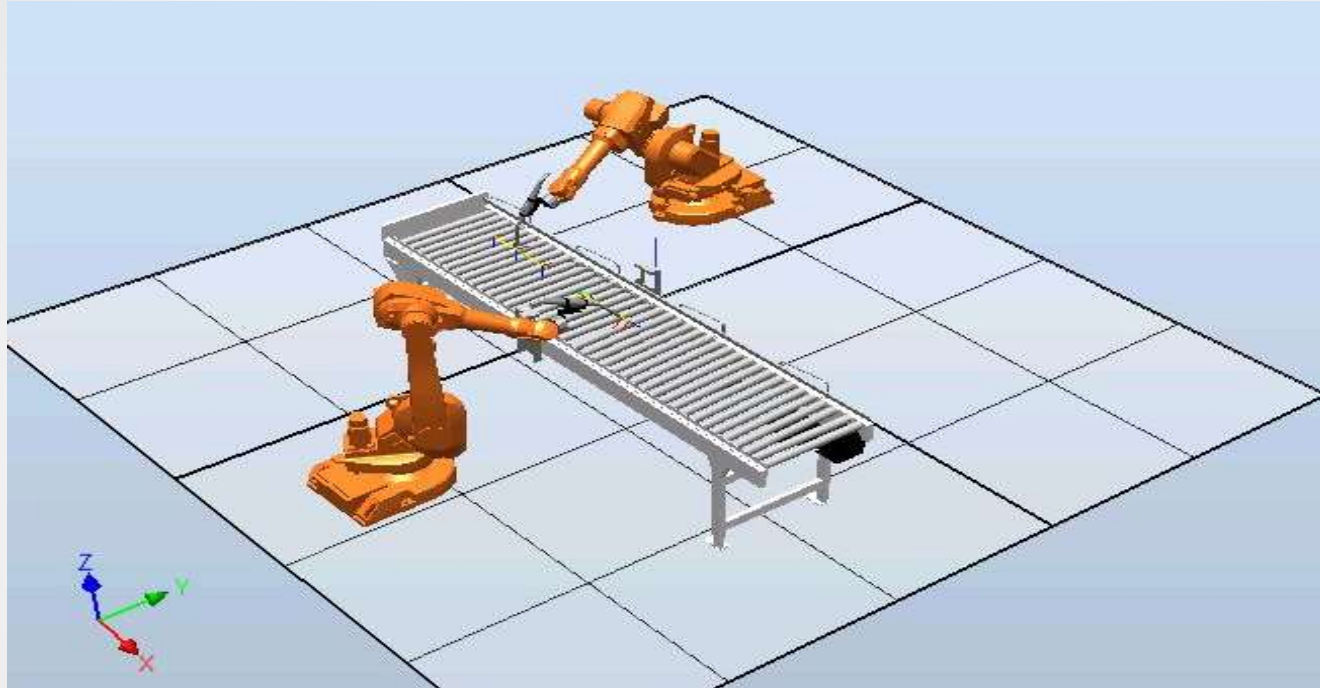
# Data Storage Strategy



- **Short term storage (Staging):** consists in a rolling table with a fixed number of rows, having a *timestamp* as a primary key.
- **Long term storage:** consists in a table containing averaged data for each metric for given time intervals (i.e. one hour).

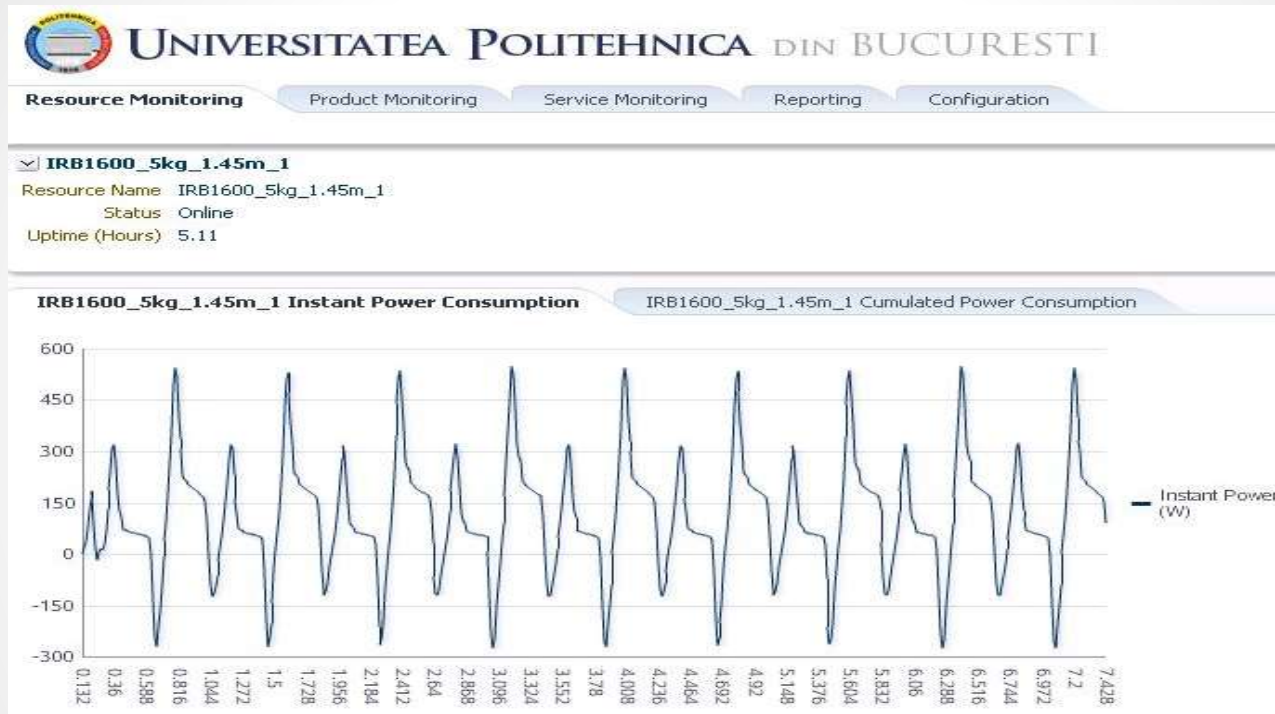


# Simulation Environment



- Virtual shop floor created using ABB RoboStudio 5.15 application
- Simple layout with two IRB1600 stations performing repeated translation movements with different speeds

# Monitoring Portal



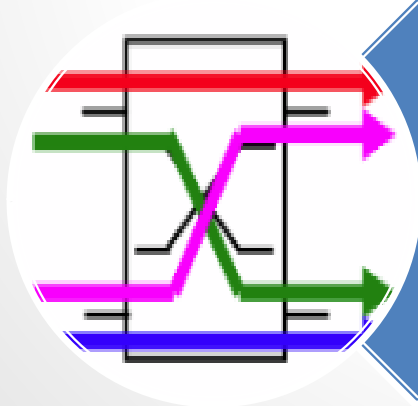
- The energy consumption of the motors for these operations
- Real time data
- Automatic page refresh for real time monitoring
- Real time status and resource uptime display



# Conclusions



Monitoring energy consumption provides valuable information that can be used for tuning of the system and for long term reporting.



Product monitoring provides real time information about material flow and together with resource stock monitoring represent direct integration points for supply chain management applications.

# Thank you!

