PI AF architecture as backbone of digital transformation & advanced analytics developments in MOL Downstream

Tibor Komróczki
Károly Ott
The MOL Group at a Glance

- MOL GROUP IS AN INTEGRATED, INTERNATIONAL OIL AND GAS COMPANY, HEADQUARTERED IN BUDAPEST, HUNGARY
- ACTIVE IN OVER 30 COUNTRIES
- INTERNATIONAL WORKFORCE OF OVER 25,000 PEOPLE
- TRACK RECORD OF MORE THAN 100 YEARS IN THE INDUSTRY

- 4 REFINERIES, 2 PETROCHEM PLANTS
- LOGISTICS INCLUDING 2,000 RETAIL STATIONS
MOL Process Information & Automation

- Closing the gap between process control and business
- Project and CR management
- Overall monitoring of refinery operation
- In-house developed PI solutions

- Team of 18 Process Information & Automation Engineers (APC/RTO/OTS & PI Systems)
- Report to Technology manager & group level
- IT in a supportive role…minimally involved – Operating Systems and SQL Servers

### ADVANCED PROFITABILITY APPLICATIONS
- ADVANCED PROCESS CONTROL
- INFERENTIAL MAINTENANCE
- KPI BREAKDOWN
- SOLOMON CALCULATION
- ENERGY MONITORING
- NAPHTHA POOL OPTIMIZATION

### REFINERY INFORMATION SYSTEMS
- NICE (NATURAL INFO CENTRE)
- PLANT INFORMATION (PI)
- SEMAFOR (KPI SYSTEM)
- SHAREPOINT DEVELOPMENTS
- SIGMAFINE (MATERIAL BALANCE)
- OPRALOG (E-LOGBOOK)

### ADVANCED SAFETY & RELIABILITY APPLICATIONS
- ALARM MANAGEMENT
- INDUSTRIAL NETWORK
- HUMAN MACHINE INTERFACE
- OPERATOR TRAINING SIMULATOR
- CONTROL PERFORMANCE MONITOR
PI SYSTEM OVERVIEW

- 4 HA COLLECTIVES, ~400K TAGS
- USED BY MOL, MPC, LOGISTIC

- ELEMENTS:
  - 350 ELEMENT TEMPLATES
  - 23K ELEMENTS & GROWING (65X SCALE)

- EVENTS:
  - 6K NOTIFICATIONS
  - 10K EVENT FRAMES ANALYSES
  - 50K EVENT FRAMES (EXCEPTION BASED OPERATIONS)
INCREASING PROFICIENCY AND PRODUCTIVITY THROUGH DIGITALIZATION

COMPETENCY MANAGEMENT
INSTRUCTOR LED TRAINING
GAP ANALYSIS

COMPETENCY FRAMEWORK

TECHNICAL PERFORMANCE SUPPORT
LEARNING MANAGEMENT
REVIEW EVALUATION

EMBRACING DIGITALIZATION

WORKFORCE

INVEST IN HUMAN CAPITAL AND DEVELOPMENT THAT PROMOTE DIGITAL THINKING
PI SYSTEM DEVELOPMENT & PI VISION DISPLAYS

PI SYSTEM
- ORION TO PI INTERFACE
- NICE TO PI INTERFACE
- NOTIFICATION WEBSERVICE UPGRADE

ADVANCED APPLICATIONS
- ADVANCED PROCESS CONTROL
- STATISTICAL QUALITY CONTROL
- TANK QUALITY INTEGRATOR

PROCESS INFORMATION SYSTEMS
- UNIT BLOCK DASHBOARD
- GROUP WHITE PRODUCT YIELD
- REFINERY N2 MONITOR
- PLAN FACT REPORT

ENERGY MANAGEMENT
- ENERGY KPI SYSTEM
- ENERGY MONITORING SYSTEM
- EFFICIENCY MONITORING

OTHER REFINERY SYSTEMS
- LABOR EQUIPMENT AVAILABILITY
- ONLINE PRODUCTION PROGRAM
- SULFUR STOCK AND SHIPMENTS
- CATALYST REPORTS
- CHILLER MONITORING

PROCESS SAFETY MANAGEMENT
- 30 DAYS ILOCK MONITORING

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EXAMPLES - PI SYSTEM CONTROL LOOP MONITORING TECHNOLOGY DATASHEET INTEGRITY OPERATING WINDOW INTERLOCK BYPASS MONITORING SOLOMON DISTILLATION EFFICIENCY
PI AF & PI Vision development workflow

Collecting & defining BU cases
- Source: Business necessitates – continuous task

Investigating problems
- Resp: Process Information & Automation group – 3 month’s timeframe

Prioritizing requirements
- Resp: PI&A dedicated team - 1 month’s timeframe

Building PI AF structure
- Resp: PI&A experts - 2 months’ timeframe

Designing and creating displays

Testing & Set up release
- Resp: PI&A experts – 1 month

Resp: PI&A experts BU

INCREASED DEVELOPMENT VELOCITY
BUILDING PI AF SYSTEMS STEP 1

- DEFINING BUSINESS CASE
- UNDERSTANDING PROBLEM
- DEFINING SCOPE
- WORKING OUT METHODOLOGY

MONITORING OF FLARING ACTIVITIES:

TOO MUCH FLARING ACTIVITY IN THE REFINERY

DETECT FLARING (AND SAFETY VALVE BLOW-DOWNS) IN THE REFINERY AND DOCUMENTING IT (IN E-LOGBOOK)

VIA MEASUREMENT OF FLARE FLOWS (DIRECT) AND/OR VIA MEASUREMENT OF PRESSURES, TEMPERATURES, FLOWS, VALVE POSITIONS, ETC. (INDIRECT)
BUILDING PI AF SYSTEMS STEP 2

BUILDING UP AF STRUCTURE

- CREATING THE SKELETON
- FROM TOP TO BOTTOM

LAYERS:

1. SYSTEM
2. FLARES
3. CATEGORY (CONSUMER/SOURCE)
4. UNITS
5. CATEGORY (MEASURABLE OR NOT)
6. EQUIPMENT
BUILDING PI AF SYSTEMS

STEP 3

BUILDING IN FUNCTIONALITY

- CONFIGURING ATTRIBUTES, ANALYSES, NOTIFICATIONS, TABLES, ETC.
- FROM BOTTOM TO TOP (USUALLY)
CREATING DISPLAYS IN PI VISION OVERVIEWS FOR THE DIFFERENT LEVELS

BUILDING PI AF SYSTEMS STEP 4

Unit level overview

<table>
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<th>Nyomás</th>
<th>Kerülő</th>
<th>Blind</th>
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RATIONALIZATION OF ANALYTICS TECHNIQUES

**BUSINESS OPERATIONS**

- Ubiquitous data streams
- Advanced analytics techniques
- Establishment of a digital connection between refinery operation & IoT devices
- Collaborating & leveraging refinery knowledge

**TRANSFORMATION**

- Rich digital representation of processes
- Identification of new system integration & development opportunities
- Commissioning good practices

**PRODUCTIVITY IMPROVEMENTS**

- Maximized asset utilization
- Minimized unit shut-down times
- Driving direct energy efficiency
- Reach mechanical integrity in every level
- Smooth operation
IT / OT CONVERGENCE

- ESTABLISHING ELABORATED PRODUCTION SCHEDULE
- OPTIMIZING OPERATION PROCESSES VIA SUPERVISOR AND AUTOMATIC CONTROL SYSTEMS
- INCREASING THE MECHANICAL AVAILABILITY
THE IMPORTANCE OF HAVING AN OT DATA INFRASTRUCTURE

- Rapid development and scalability of applications
- Reinforce the use of data and analytics based decision making
- Support cultural change and normalization
- Leverage advanced technologies including advanced analytics and IoT to accelerate business value
- Enable sustainable business value
ADVANCED ANALYTICS & IOT

- Utilize operational data to drive proactive E&P decision-making that will reduce cost and improve recovery rate.

- Inject confidence in your decision-making by capitalizing on data science to statistically predict productivity in a quick and cost-efficient manner.

- Increase productivity and efficiency across all major business units through the best practices for data harmonization.

- Deeper understanding of technological processes - alternative crude oil usage as feed.
“OPERATIONAL DATA HUB” TYPICAL APPLICATIONS

KPI monitoring
- White product yield
- Energy consumption
- APC utilization

Asset monitoring
+ notification
- Operation envelope
- IOW monitoring
- HTHA monitoring
- Analyzer validation
- SAP PM integration for CBM
- Flare monitoring
- Environmental reporting
- Control loop mode monitoring
- Failsafe mode monitoring
- Natural gas consumption forecasting (Predictive analytics)

Equipment / Asset models
- Pump efficiency
- Exchanger Fouling
- PSA valve monitoring
- DCU feed composition calculation
ANALYSIS PROCESS – A PARTNERSHIP BETWEEN OT AND IT

Our Team:
- Domain knowledge:
  - Correlations
  - Preconceptions
  - Data scoping

Our Team:
- Operations User
- Operations Side Data Analyst
- PI&A
- Data Scientist
- Data Engineer
- Operator

Expected Defined Business Case Delivery Time <3 months

EXPORTER ANALYTICS & DATA INNOVATION

Operation & Data, PI System Understanding

Cloudera Enterprise Data Hub

Explore & Analyze & Build

Deploy

Operate
DIGITAL TRANSFORMATION APPROACH

- Participation in official OSIsoft training to learn the basic techniques of the PI client application’s usage.
- Share materials with the refinery workers as a simplified PI training session.
- Development teams are divided to groups based on information technology interest and strength.

New business requirements are initiated at first the team process the basic data.

Decision whom are the best candidate to solve the problem.

Insider training is organized to teach the end-users the new solution usage.

Cross functional collaboration.
IIOT WORK MODEL

- Demand for new information/measurement
  - Process control related?
    - YES
      - Device installation according to MGS standards: 4-20mA +HART to DCS or ESD
      - DCS
      - PI
      - HADOOP
    - NO (Diagnostics)
      - Selection of device type
      - Install device
      - Implement new datalink layer
  - Edge computing
    - APC
    - Retrain edge model

- Edge computing
  - Diagnostics
  - Retrain edge model
TYPICAL SITE “OPERATIONAL DATA HUB”

- Human Analytics
- Real Time Streaming Analytics
  - PI Vision
  - PI Notifications
  - PI Datalink
  - Reports

DCS/PLCS/SCADA/IIOT etc.

- SAP PM
  - Work orders
  - Asset policies
  - Inventory
  - Maint. history

- NICE
  - Operating modes
  - Movements
  - Inventory
  - Materials
  - Qualities

- Pimsoft Sigmafine
  - Reconciled movements
  - Reconciled Inventory

- Aspentech ORION
  - Tactical Plan
  - Actual Plan
  - Fact Data
  - Blending Plan
  - Energy Plan

- Infotechnics Opralog
  - Plant logs
  - Special logs
NEW ADVANCED BI IMPLEMENTATION PROGRAM IN MOL REFINING

Architecture Stream

Design, procure and implement on-premise data storage system.

*Technology: Cloudera Enterprise Data Hub (Hadoop technology)*

- **Early 2018**

Primary system integration and data ingestion setup:

- **Sensor Data**
- **Laboratory Measurements**
- **Operating modes**
- **Reconciled Data**
- **Plan Data**
- **Smart Data**

Deployed all scheduled jobs to production, handover for operation team

- **Early 2019**

Integration of Opralog and NICE systems to CEDH

- **2020**

Analytics Stream

- **Development and deployment of an energy nomination support application**
  - **2018**

- **New Analysis Cases (Ongoing)**
  - **2019**

Design and implement production management related reports, dashboards

- **2020**

- **Movements**
- **Inventory**
- **Materials**
- **Daily Unit Logs**
- **Dispatcher Log**
- **Special Entries**
INTRODUCING THE ‘ENTERPRISE DATA HUB’

Features
- Daily upload
- Streaming
- Model Building
- Model Execution
- Supervised by IT
- PI&A enabled

Tables:
- Sensor data: 2 years history, 20 billion records, daily increment, partitioned per month
- Sensor metadata: daily full sync

Operational Data Hub

Enterprise Data Hub

PI AF SDK
PI Integrator (Testing)

System Center Operations Manager

HP Service Manager

Data acquisition “Rich Time Series Data”

Write back

Landing Zone

Datalake

Storage

Query Engines

Cloudera Data Science Workbench

Model Training

Scheduled Execution

Result tables

Analyze & Build & Execution

End Users

PI AF

OSIsoft.

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DROP - DANUBE REFINERY ONLINE PROGRAM

SYSTEM IS PROVIDING THE LATEST PLANNING DATA (THROUGHPUTS, YIELDS, QUALITY REQUIREMENTS) FROM PLANT-FLOOR LEVEL (OPERATORS, SHIFT LEADERS) TO OPERATIONAL MANAGEMENT LEVEL TO FACILITATE TRACKING OPERATIONAL DIRECTIVES CHANGES IN REAL-TIME.

PI SYSTEM COLLECTS THE PLANNING DATA FROM ORION DATABASE, THE OPERATIVE EEM DIRECTIONS FROM OPRALOG AND QUALITY REQUIREMENTS FROM QUALITY MANAGEMENT SYSTEM.
DROP / PI AF DISPLAY

DISPLAYS ARE CREATED BY A STANDARD TEMPLATE VISUALIZING THE FOLLOWING INFORMATION: SCHEDULING DATA (VOLUMES AND YIELDS)

▸ FEEDS AND PRODUCTS FOR THE NEXT 5 DAYS
▸ OPERATIONAL MODES, UNIT STATES
▸ QUALITY REQUIREMENTS
▸ ACTUAL EEM DIRECTIONS
IT INNOVATION – IT & BU COOPERATION TO PROCESS OPERATIONAL DATA

- PROJECTS
- CHANGE REQUESTS
- PROOF OF CONCEPTS

► PART OF MOL GROUP IT CTO TEAM
► PROOF OF CONCEPTS
► 1-3 MONTHS RUN (+ PREPARATION)
► TESTING IDEAS, INTRODUCING TECHNOLOGIES AND SOLUTIONS – BASED ON PI DATA
► PROJECT GENERATION
► MARKETING (PRESENTATIONS, GROUP PORTAL, YAMMER, LINKEDIN)
INNOVATION TOPICS

2017-2018: BIG DATA AND MACHINE LEARNING, IOT/IIOT, CHATBOT
- REFINERY PRODUCTION PLANNING AND OPTIMISATION
- ADVANCED DOCUMENT MANAGEMENT
- UPSTREAM SPECTRA ANALYSES AND ROCK TYPING
- COKE YIELD AND STEAM ERUPTION ANALYSES
- BUTADIENE ANOMALY DETECTION
- RETAIL AND HELPDESK CHATBOT
- …

2019: AUGMENTED AND VIRTUAL REALITY, BLOCKCHAIN
- HIDDEN WORKS VISUALISATION
- MOL CAMPUS VISUALISATION
- POLYOL PLANT VISUALISATION
- RETAIL SHOP VISUALISATION
- …
FOLLOW-UPS

► PROJECTS
  ► SALES DEMAND PREDICTION
  ► DANUBE REFINERY ADVANCED ANALYTICS
  ► ...

► STRATEGY
  ► PI SYSTEM AS DATA SOURCE OPTION
  ► CLOUDERA HADOOP – BIG DATA PLATFORM
  ► CLOUDERA DATA SCIENCE WORKBENCH – MACHINE LEARNING PLATFORM
  ► MICROSOFT POWER BI – VISUALISATION PLATFORM
  ► CHATBOT – NEW COMMUNICATION CHANNEL
  ► …
SLOVNAFT PUMP FAILURE POC

POC’S SCOPE:
- 2 COOLING OIL PUMPS
- LEAKAGES ON THE SEALINGS MORE FREQUENTLY THAN EXPECTED
- ONE PUMP MUST WORK, OTHERWISE SYSTEM SHUTDOWN
- ROOT CAUSES ANALYSIS AND PREDICTION NEEDED
ANALYSIS APPROACH

EXPLORATORY ANALYSIS

- Leakage descriptive analytics
- Leak age clustering
- Pump operational states
- Leak age frequency
- Reactor operational states

CLUSTERING

- Clustering

PREDICTIVE MODELLING

- Long-term trends
- Model Pipeline
- Testing

VERIFICATION

- Quality tags
- Quality model
## LEAKAGE FREQUENCY

<table>
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<tr>
<th>Year</th>
<th>PUMP A</th>
<th>PUMP B</th>
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<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
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</table>

![Bar chart showing leakage frequency by year for PUMP A and PUMP B.](chart.png)
LONG-TERM TRENDS – CLUSTERS OF DAYS

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<tbody>
<tr>
<td>NR OF DAYS</td>
<td>475</td>
<td>318</td>
<td>509</td>
</tr>
<tr>
<td>NR OF LEAKAGE FAILURES</td>
<td>13</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>RATIO OF LEAKAGE FAILURES</td>
<td>2,7%</td>
<td>1,3%</td>
<td>0,2%</td>
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</table>
MODEL TRAINING

Trained on 2014-2016

Marked failure

2x emergency breakdown

Trained on 2016-2017

Marked failure

False positive or ???
PREDICTION METRICS

Operating Time Between Failures

Operating Time Since Last Failure

Operating Time Until Failure (OTBF – OTSLF)
PREDICTIONS

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<th>TEST I</th>
<th>TEST II</th>
<th>Overall 2017</th>
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<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>0.94</td>
<td>0.97</td>
<td>0.96</td>
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<tr>
<td><strong>F1</strong></td>
<td>0.80</td>
<td>0.88</td>
<td>0.84</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td>1.00</td>
<td>0.78</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Recall</strong></td>
<td>0.67</td>
<td>1.00</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>1.00</td>
<td>0.96</td>
<td>0.98</td>
</tr>
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STREAMING SOLUTIONS AND VISUALIZATION

PI Integrator for Business Analytics

OSI PI

Data preparation
ML application

KAFKA

KAFKA – EventHub Connector

OSIsoft PI Advanced Integrator connected PI to Kafka and Hadoop

ON-PREMISE

STREAMING ANALYTICS

MS POWER BI

KIBANA

GRAFANA

MS POWER BI

KIBANA

GRAFANA

OSIsoft PI Advanced Integrator connected PI to Kafka and Hadoop
COMPARISON OF INTEGRATION TOOLS

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>CUSTOM-MADE INTEGRATOR</th>
<th>PI INTEGRATOR</th>
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<tr>
<td>DEVELOPMENT/SETUP TIME</td>
<td>10+ days</td>
<td>1 day</td>
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<tr>
<td>LOAD FREQUENCY</td>
<td>Daily</td>
<td>Minutely</td>
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<tr>
<td>COMPLEXITY</td>
<td>Predefined tags</td>
<td>Selected tags</td>
</tr>
<tr>
<td>PRICE</td>
<td>$</td>
<td>$$$</td>
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"For testing purpose and short-term solutions custom-made integrator can be enough.

For long-term solution PI Integrator is suggested."
The goal is to turn data into information, and information into insight.

Carly Fiorina
Presenters

Tibor Komróczki
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Károly Ott
• Innovation Manager
• Mol Group
• kott@mol.hu
Questions?

Please wait for the microphone

State your name & company

Please remember to...

Complete Survey!
Navigate to this session in mobile agenda for survey

TO DOWNLOAD APP, SEARCH OSISOFT
The MOL Group at a Glance

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