IIoT – Introduction to Industrial Analytics

IIoT Solves OLD problems in new and innovative ways

Leverages key developing technologies
• High bandwidth communications and massive cost-effective storage in the cloud
• Low-cost pervasive sensor technology
• Advanced analytics (big data) technologies and machine learning
• Device inter-operability standards

Changes the way of how and where work is done
• Remote collaboration (owner / vendor / OEM)
• Enables Center of Excellence
• Captures and applies knowledge
• Routine monitoring done by machines
Addressing Core Industry Problems Using the IIoT

HCP Analytic Solutions

Production Efficiency
Operator Effectiveness
Reduce Off - Spec
Optimize Process

Process Reliability
Asset Surveillance
Predictive Maintenance
Expert Guidance

Supply Chain Optimization
Planning & Scheduling
Inventory & WIP Reduction
Enterprise Supply Chain Execution

Connected Process + Connected People + Connected Assets = Connected Plant
**IIoT Connection Architecture**

**Inspire Service Platform**
- Uniformance Insight®
- Asset Sentinel
- PKI Manager
- Pulse

**Big Data Analytics**
- Cognitive Learning
- Tableau, R, etc

**Digital Twin**
- UniSim®
- 3rd Party Models

**3rd Party Apps**
- INspire™ Partners

**3rd Party Vendors**
- INspire™ Partners
- Supply Chain
- Service Management Platforms

**Cloud Historian**

**Stranded Assets**

**Asset Health and Diagnostic Data**

**Secure Data Exchange**

**SDX**

**DCS**

**IIoT**

**Historian**

**LIMS**

**ERP**

**Plan**

**MES**

**IIoT**

**3rd Party Apps**
- INspire™ Cloud Platform
- 3rd Party Apps
- INspire™ Partners

**3rd Party Vendors**
- INspire™ Partners
- Supply Chain
- Service Management Platforms
The Digital Twin

- Unifies existing data silos into a virtual entity
- Federates data across different applications to drive end-to-end integration
- Leverages process simulation technology beyond current scope of process design
- Utilizes Cloud to overcome maintainability issues and enables 3rd party expertise

CAPTURING THE COMPLEXITY OF AN ENTIRE PROCESS INTO A SCALABLE DATA MODEL
Big Data Analytics Myths

• Storing big data in the cloud is cheap or free

• Big Data / Analytics replaces the need for process knowledge / engineering experience

• Data Analytics is a replacement for fundamental models

• You don’t need GOOD data as long as you have a LOT of data

• You don’t need to change your work processes to get full value from big data

• All analytics software is about the same – it is all shareware downloaded from the internet

All Not True

Without Insight - Big Data Analytics is a solution looking for a problem to solve
Runtime Analytics Platform

- Connect process intelligence to business KPIs
- Apply powerful analytics to detect and predict issues
- Organize and visualize data in asset context
- Capture real-time process and event data

Visualization
- Ad-hoc Analysis
- KPI Dashboard
- Notifications

Collaboration Across Functions
- Engineering
- Operations
- Management
- Maintenance & Reliability

Ad-hoc Analysis KPI Dashboard Notifications
What do Industrial Analytics Offer?

- **Prescriptive Analytics**
  - **Optimisation:** “What’s the best action?”
  - **Random Testing:** “What if we try this?”
  - **Predictive Modeling:** “What will happen next?”
  - **Statistical Modeling:** “What is the pattern?”

- **Diagnostic Analytics**
  - **Discovery/Alerts:** “Where should we look?”
  - **Query/Drill Down:** “Why did it happen?”
  - **Ad Hoc Rpt/Scorecards:** “How many, when, where?”
  - **Standard Reports:** “What happened?”

- **Descriptive Analytics**
  - **Ad Hoc Rpt/Scorecards:** “What happened?”

- **Predictive Analytics**
  - **Statistical Modeling:** “What is the pattern?”
  - **Random Testing:** “What if we try this?”

**First Principles Modeling**
Uses known physics & chemistry
Process Analytics Overview

Run-time Analytics
Unit / Site

- Event Detection
  - Deviation Detection
    - Heuristic
    - Trained

- Model
  - Normal & Abnormal
    - First Principles
    - Statistical
    - State estimation

- Process Data
  - Real-time & Historical (Small Data)

Off-Line Analytics
Unit / Site / Multi-Site

- Additional Models / Rules

Visual Data Analytics

- Pattern search
- Value Search
- Combinations
- Cleanse / Filter

Data Driven Analytics

- Multivariate statistical (PCA, PLS...)
- Black-box (Neural Nets...)

Machine Learning Big Data
- Data vol. & variety (unstructured / text)
- Feature Selection / Extraction
- ML (Random Forest, SVM, Naïve Bayes...)

Time Required / Skillsets Required

Process Engineer
- Process Data

Data Scientist
- Additional Models / Rules

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## Run-time Predictive Analytics Approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Application</th>
<th>Technology</th>
<th>Complexity</th>
<th>Applic-ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical Model (1st Principles)</td>
<td>Basic perf mon for broad set of assets &amp; detection deviation from predicted vs actual</td>
<td>Embedded &amp; External via UniSim</td>
<td>Low</td>
<td>Many</td>
</tr>
<tr>
<td>2. Univariante Prediction</td>
<td>Predicting single variable time to reach a value – e.g. predict heat exchanger fouling</td>
<td>Regression w error correction (H_TimeFit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Adaptive Filtering/Thresholding</td>
<td>Anomaly detection for Equipment (temp, press, vib)</td>
<td>Data cleansing &amp; compare current to historical averages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Multivariate Pattern</td>
<td>Detect behavior of group of sensors according to learned/historical expectations</td>
<td>Detected patterns (equations) with rules detecting abnormal relationships</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Data Driven - Multivariate Early Event Detection</td>
<td>Broad set of process and equipment monitoring scenarios</td>
<td>Statistical pattern detection and recognition including OLS, PLS, PCA, Neural Nets, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Machine Learning</td>
<td>Capture insights from Big Data to build better algorithms (e.g. Aero APU example)</td>
<td>Big Data using variety of data sources including maintenance and reliability data</td>
<td>High</td>
<td>Few</td>
</tr>
</tbody>
</table>
Uniformalance® Asset Sentinel

Mgt. Reporting & KPI's

Engineering Reliability, Maintenance, & Process

Orchestration web Service

Asset Model

Tempates
- Attributes
- Calculations
- Rules

Equipment Lib.

- Heat Exchanger

Uniformalance Sentinel

Analytics
- Embedded
- User Defined
- UniSim
- Other

Notifications (E-mail & Alerts)

Event Detection (Symptoms/Faults)

Real-time / Historical Data

DCS / PLC

Smart Instruments

Historian

Visual Inspections

Vibration Monitoring

Other Applications

Historian

Operator

Maint. Mgt

Calc Results

Alerts & Data

SAP Maximo

SAP Maintenance

Work Requests

Notifications (E-mail & Alerts)
Continuous Calculations & Monitoring

Embedded Models
- Gas / Steam Turbine
- Pump
- Compressor
- Heat Exchanger
- Furnace

Fault Models
- Head = 3960*HP
- Flow

Calculations

Continuous Trends
- Make Problems Visible
- Dashboards
- Notifications

Single Version of Truth

Process Intelligence
- Rollup KPIs
- Rollup Metrics

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# Industrial Analytics Projects

<table>
<thead>
<tr>
<th>Operational Data</th>
<th>Analytics</th>
<th>EBS Alerts</th>
<th>Analysis</th>
<th>Advice/Plan</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near / Real Time</td>
<td>Sentinel for Analytics</td>
<td>Event Management</td>
<td>Analyst</td>
<td>Specialist</td>
<td>Engineer</td>
</tr>
</tbody>
</table>

## Supply Chain Integration
- **What is it:** Three manufacturing sites in supply chain. Move data from sites to enterprise cloud and optimize the value chain using Data Analytics.
- **Technology:** Sentence Cloud / Analytics for insight and overall quality model and batch tracking, on-line predictive analytics and alerts.

## Reactor Uptime Optimization
- **What is it:** Data Analytics to determine optimal reactor change out time to increase OEE and reduce CAPEX.
- **Technology:** Visual, Statistical, Big data, Analytics, performance models, on-line predictive analytics and alerts.

## Heat Exchanger Optimization / Monitoring
- **What is it:** Online monitoring using process analytics, leading to event based maintenance of fouling.
  - Avoid excess corrosion events.
  - Optimize cost of lost HX performance vs maintenance/cleaning costs
- **Technology:** UniSim, Visual, Statistical Analytics, predictive modeling

## Shift Handover & Rounds Management:
- **What is it:** Implement OM-Pro & Movilizer for electronic records.
  - Future use of cognitive analytics / NLP for productivity improvement & knowledge capture
- **Technology:** Visual, Statistical, Big data, Analytics, Multi-variate Models.
## Industrial Analytics Projects

### Process Safety: Furnace Flooding
- **What is it:** Data analytics to develop early detection of furnace flooding condition to prevent unsafe operating conditions & reduce production losses.
- **Technology:** Analytics for insight and modelling, on-line predictive analytics and alerts.

### Aeroplane Brake Disc Manufacturing
- **What is it:** Data analytics to gain insight into unexplained and ongoing issues with batches on stopping distance tests.
- **Technology:** Visual, Statistical Analytics, predictive modeling.

### Supply Chain Insights: Supplier Quality
- **What is it:** Data analytics to analyze yield and defect on key production line parameters in semiconductor fabs tied to upstream feedstock supplier.
- **Technology:** Visual, Statistical, Big data, Analytics, Multi-variate Models.

### KPI linkage to Root Cause Analysis
- **What is it:** Visual process data analytics to gain rapid insights linking KPI parameters and process performance to operating variables.
- **Technology:** Visual Process Analytics, Statistical Analytics, Predictive.

### Predictive Compressor Faults
- **What is it:** Data analytics to gain insight on Compressor performance decline, On-line performance monitoring with predictive alerts.
- **Technology:** Visual, Statistical, Big data, Analytics, performance models, on-line predictive analytics and alerts.

### Process Surveillance
- **What is it:** Visual process data analytics to gain rapid insights into process conditions that can be rapidly converted into on-line Sentinel based analytics.
- **Technology:** Visual Process Analytics, Sentinel rules, Predictive Analytics.
A.I. Based Product Demand Forecasting Model

This model takes derived variables such as differences and ratios of crude oil price index as inputs.

- Nonlinear dependence if feature influences the sales both pos and neg
- Linear dependence if feature influences the sales in one of the directions
New Analytics POC Development Areas

Analytics POCs

- **Natural Language Processing**
  - NLP Manuals & Operator Logs
    - UOP Russell Gas Plant
    - External customer TBD
  - External Client TBD

- **Forecasting Applications**
  - Product Demand
    - UOP CAS
    - External Client TBD

- **Predictive Analytics**
  - Equipment Health Monitoring
    - Asset component failure
    - Anomaly detection

- **Machine Learning Artificial Intelligence**
  - Digital Twin Creation
    - UniSIM auto parameter fitting
    - UOP CPS model
    - External UniSIM Client TBD
    - Geismar / Pottsville / Baton Rouge

- **Business Intelligence**
  - Multi-Plant analytics
UOP CPS
Connected Performance Services
Delivering the Connected Plant with CPS

Solving Key Customer Challenges

- **Unplanned Downtime**
  - Process issues
  - Equipment failures

- **Underperforming Assets**
  - Sub-optimal operations
  - Performance vs peers

- **Energy and Emissions**
  - Emission standards
  - Energy reduction

- **Human Capital Challenges**
  - Knowledge gaps
  - Operational excellence

CPS Architecture

- Analyze plant performance to reveal full potential through a cloud-based service
  - Around-the-clock monitoring of plant data and rigorous simulations
  - Provides on-going, operational recommendations to close performance gaps
  - Leveraging UOP Process Models & longstanding experience in operational support and troubleshooting
- Customer value of $0.30-$0.50/bbl in refining & $10-$20/MT in Petrochemicals

Customer Site

Secure UOP Cloud

- Proactive, ongoing dialogue and recommendations, UOP expert review
- Ongoing capture of plant (process/lab) data
- DATA COLLECTION
- DATA CLEANSING
- ADVANCED COMPUTATION
- VISUALIZATION
- CPS solution-specific calculations and models UOP expert reviews

DATA

- Purity
- Production
- Energy
- Capacity
CPS – Process Reliability Advisor

What Does It Do?
• Monitoring of unit performance
• Constraint limitations
• Event detection & mitigation
• Knowledge transfer

What Is Behind It?
• Matches unit configuration
• Tuned UOP process models
• Technology specific fault models
• Embedded UOP knowledge, context, and background
CPS – Process Optimization Advisor

• Advisory Service to Maximize Profits as Conditions Change

What Is Behind It?
• Rigorous simulation to match unit configuration
• Tuned UOP process models
• SQP Optimizer driving an economic objective function
• Cloud hosted & Maintained by UOP

What Does It Do?
• Maximize process economics against constraints
• Provide operational recommendations
## CPS – Impact of Optimizing an Aromatics Complex

### Base Case
- Typical UOP aromatics complex
- Unconstrained feed

### Optimization Problem Setup
- Maximize obj. function ($):  
  - Products (PX + Bz + By-Products) – Feed – Utilities

### Key Actions

<table>
<thead>
<tr>
<th>FEED RATE</th>
<th>PARA-XYLENE</th>
<th>BENZENE</th>
<th>LIGHT NAPHTHA</th>
<th>PROFIT CHANGE ($US million/yr)</th>
<th>KEY ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feed A</strong></td>
<td>↑2%</td>
<td>↑1%</td>
<td>↑2%</td>
<td>↑4%</td>
<td>+3.5</td>
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<td></td>
<td></td>
<td>• Lower Reflux - Xylene &amp; Raffinate Columns</td>
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<td>• Reduce Tatoray Conversion</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>• Enables Increased Feedrate</td>
</tr>
<tr>
<td><strong>Feed B</strong></td>
<td>-</td>
<td>↑2%</td>
<td>↑8%</td>
<td>↓4%</td>
<td>+5.0</td>
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<td></td>
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<td></td>
<td></td>
<td>• Naphtha Splitter – Increase C6s to Plat</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Enables Feed Increase to Top of Complex</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Debottleneck to Rebalance PIX Loop</td>
</tr>
<tr>
<td><strong>Feed C</strong></td>
<td>↑5%</td>
<td>↑5%</td>
<td>↑4%</td>
<td>↑5%</td>
<td>+9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Full Complex under-utilized</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Increase feedrate until constraint met</td>
</tr>
</tbody>
</table>

Assumptions: $380 Naphtha to PX spread, $180 Naphtha to Bz. Complex size 600KMTA
The Future of Industrial Analytics?

• Industrial Analytics is moving fast and increasing pace

• Manually coded Python and R open source code – now embedded in or replaced by highly efficient commercial software offerings

• Machine Learning is reducing the need for Data Analysts in performing big data analytics

• Key areas for industry where analytics will play a key role
  • Predictive Analytics – Forecasting / Equipment Reliability
  • Knowledge Capture – NLP / Deep Learning
  • Collaboration – Cloud / Unstructured Data storage
  • Turning data into Information for IIoT pervasive sensing
  • Enhanced use of new data types – Sound / Images