Digital Twin + Industrial Internet
for Smart Manufacturing
A Case Study in the Process Industry (Steel)

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Digital Transformation

- New Services
- New Business Models
- New Economic Systems

- Sensor Technology
- Cloud Computing
- Big Data
- 5G
- AI
- Industrial Internet
- OT & IT Convergence
- Smart Manufacturing
- Flexibility
- Agility
- High Efficiency
- Environment
- Enterprise Total Performance
- Technology Development
Industrial Internet

an enabling technology for the digitalization …

data-driven…
optimizing systems & processes, informing business strategy

…creating values, transforming businesses…

Improvements from IIoT platforms, analytics and digital tools

LNS Research, 2018
Industrial Internet in Manufacturing

Digitalization of industrial technologies & know-hows through analytic models & software

Material • Equipment • Processes • Product • People

Business Processes

Product Design & Process Engineering

Data

Analytics

Application

Better Business Decision Making

Optimized Production Processes

Desc: Describe
Diag: Diagnose
Pred: Predict
Pres: Prescribe

Top IIoT Use Cases
- Remote monitoring: 28%
- Energy efficiency: 27%
- Asset reliability: 25%
- Business model transformation, e.g., selling capacity instead of products: 24%
- Production visibility: 22%
- Quality improvement: 22%
- Asset and material tracking: 17%
- Internet enabled products: 15%
- Traceability and serialization: 13%
- Customer access to information: 8%
- Improving safety: 6%
- Supplier visibility: 6%
- Improving environmental performance: 4%

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Production Systems - Complex Systems

Production Process – Complex Processes

- Sintering
- Blast Furnace
- Converter
- Continuous casting

Rolling

Production Process:
- Sintering
- Blast Furnace
- Converter
- Continuous casting

Rolling:
- Continuous Rolling/Furnace
- Slab Breaker
- Finish Rolling
- Cooling

Additional processes:
- Continuous Casting
- Hot Rolled Sheet
- Pickled Sheet
- Shot Blasted Coil
- Hot Rolled Steel Coil
- Pickled Steel Coil
- Shot Blasted Coils
many-entity (equipment, material & parts, products)
many-flow (material, energy, information, value)
many-domains (design, process, quality, energy efficiency, maintenance, production planning & execution, order, purchase, sales, delivery, service, …)
Many-product,
many-engineering-process,
many-production-process, …
Manufacturing Information System Architecture Evolution

• Hierarchical layered structure,
• large, monolith, complex integrated multi-functional applications
• Hard to interoperate & extend, barrier to innovation
Industrial Internet – Increasing Model Complexity

Analytic model is at the core of optimization capturing operational technologies and industrial know-hows, & enabling reuse.

Calling for a new & systematic approach…
The Hype about Digital Twin

Digital Twin Search Trend

Digital Twin Search Return Entries

Gartner Hype Cycle for Emerging Technologies, 2017

Gartner Hype Cycle for Emerging Technologies, 2018
Digital Twin - Characteristics

**Digital Twin**

What is it: A full lifecycle dynamic digital replica of a physical or logical object in the real world.

What does it do: Describe, simulate and predict the state and behavior of its real world twin based on analytics on historical and real time data.

What is it for: deep understand, correct deduction and precise operation of its real-world twin.

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The digital & real-world twins born, grow together…

Engines, navigation systems, landing gear, aircraft, runways, weather, flight control systems...

Valves, machine tools, production lines, workshops, factories...

Production process, organization, logistics process, management process...

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A systematic way for building the digital world ground-up
# Digital Twin – Core Elements

## Design
- Specifications, models, process and engineering data

## Production
- Human, machine, material, method, quality data

## Operation
- Real-time & historical status & configuration data, maintenance records

## Business
- Transaction records

## Service
- Data
- Model

## Data
- 1st Principle
  - Physics, Chemistry, Engineering, Simulation…

## Visualization
- Statistical, Machine learning/Artificial Intelligence…

## AR
- 3D Models…

## Service
- Predictive
- Diagnostic
- Descriptive
- Prescriptive

## Visual Augmented Reality
A systematic approach to represent complex real world systems in the digital space

A multi-level digital twin system forms the basis for intelligent operations of the physical world.
Industrial Data OS (iDOS) – Refactored, Horizontalized, Decoupled Architecture

- based on Industrial Internet

Methodology: Abstraction and Simplification – Systematically solving complex problems

Bring cloud computing, machine learning & big data technologies to the production environment
Digital Twin Framework –
Symmetrically Represent the Real World in the Digital Space

Based on biz requirements
Asset Characteristics

Define Digital Twin Classes

reuse
abstract
concrete

Based real deployment
environment Configuration

Instantiate the Digit Twin Classes

After solving the structural complexity problem,
the models are still the core capability

Most valuable for complex systems, large systems, large number of assets, lots of
data & app, in-deep analytics
Define Digital Twin Classes:
- Define data structures
- Built models
- Define relationship

Instantiate Digital Twins

Collect

Connect

Digital Twin

Asset

Data

Insight

Develop APP

Yo-i Thingswise iDOS

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Asset, Process, Business Data

PLC, SCADA, DCS, PCS, MES, ERP, ...

Business Logic

System Logic

Natural Logic

Data Logic
Digital Twin Configurator

Support Both Multi-level Hierarchical Digital Twin Construction & Associational Relationships
GUI-based Designing Tools

- Digital Twin Designer
- Data Visualization
- Data Flow Designer
- Model Designer (off-line)
- App Designer
- API Mgmt
A New Architecture for Smart Industrial Apps

An architectural upgrade, building a solid technical foundation for continuing digital transformation...

One platform collect & manage all the data across production processes & application domains

Supported by cloud computing, machine learning & big data technologies

Business logic- & data-driven smart feedback loop

Deployable on-premise & in the cloud
An Architectural Refactoring?

vertically layered architecture ➔ horizontalized flatten app architecture
Smart Apps for the Steel Industry
Our Company – The New Yo-i

A startup based in Shanghai with deep industrial operational (OT) expertise

Recently merged with Thingswise, LLC with deep industrial internet (IT) expertise
Our Business Approaches

**Industrial Internet Platform**
Powered by Thingswise

- Unified Data, Model & App runtime
- Scalable & Reliable
- Deployable on-prem & in the clouds
- Support physical modeling & Machine Learning

**Continuous Process Industry Smart Apps**
Advanced by Yoi-Wise’s Apps

- ★-wise Smart Industrial Apps
- Smart App Suites

- Based on & solving real world problems
- Role-based operational recommendation delivery
- Extendable for solving simple to complex problems
- Built-on an unified platform expending apps across application domains

**Consultation, Planning & Solutions**
Enabled by Yoi-i Insight

- Diagnosis, Consultation & Planning
- Industrial Talent Training
- Total Solution Integration

- Steel ∙ Power Generation ∙ Chemical ∙ Nonferrous ∙ Cement

Focus: Focused ∙ In-depth ∙ Effective

Open ∙ Enabling ∙ Cooperative

Insight, Implement, cultivation
Smart Apps for the Steel Industry – A Case Study

Customer: A Steel Manufacturer in Shandong, China,
- with production capacity of 3 million ton of steel
- eager to employ industrial internet technologies to increase operational efficiency
- invested in installing Thingswise iDOS Platform and data collections from large amount of assets.
- installed a number of smart apps to optimize production processes
Smart Apps for the Steel Industry

- Sintering Machine Terminal Temperature Prediction & Operation Recommendation
- Furnace Heat Efficiency Optimization
- Oxygen Pipeline Optimization
- High Level Analysis System
- Steel Quality Management System
- Oxygen Intelligent Control System
- More...
Sintering Process Optimization
Oxygen Supply and Demand Balancing Optimization

Sintering

Blast Furnace → Converter → Continuous Casting

Rolling
Furnace Heat Efficiency Optimization

Sintering

Blast Furnace

Converter

Continuous Casting

Rolling

Continuous Rolling Furnaces

Skin Pass Mill

Shearing Line

Blast Furnace

Pig Iron

Converter

Vacuum Degassing

Continuous Casting

Hot Rolled Coil

Sintering Plant

Iron Ore

Skimmary Plant

Coal

Coking Hobt
Online Demos

Sintering Process Optimization

Oxygen Supply and Demand Balancing Optimization

Furnace Heat Efficiency Optimization
Learnings

• Need deep knowledge about operational/production processes to understand what the customers’ needs (pain-points) are and where optimizations are most valuable and feasible (low-hanging fruits)

• Need committed customers – not only in financing the projects but also a strong willingness to adapt the workflows to the new tools and to train the operators to use them.

• After the initial installation of the solutions, it needs continuing effort to collaborate with the customers to improve them and gather new requirements.

• OT & IT convergence is not only in the customer environment but also in house– OT experts, data analytic experts and app developers (IT) need to collaborate seamlessly in order to deliver quality products

• Collecting and validating data from the large number of equipment, meters, sensors and other systems are still the most daunting tasks in the implementation

• The Industrial Internet Platform + Digital Twin Frame do greatly simplify the implementation of the solutions and provides a solid foundation for adding new solutions.
Thank You!