



A Framework for Extending SAP IBP's Optimization Capabilities with FICO Xpress

October 19th, 2020

S. Poundarikapuram, G. Ayres de Castro, C. Thomas, C.P. Medard, N. Sawhney, S. Maleschlijski
SAP Global COE for DS

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SAP IBP



SAP Data Intelligence



Framework Overview



Sample Optimization Problem



Demo FICO Xpress in SAP DI + IBP

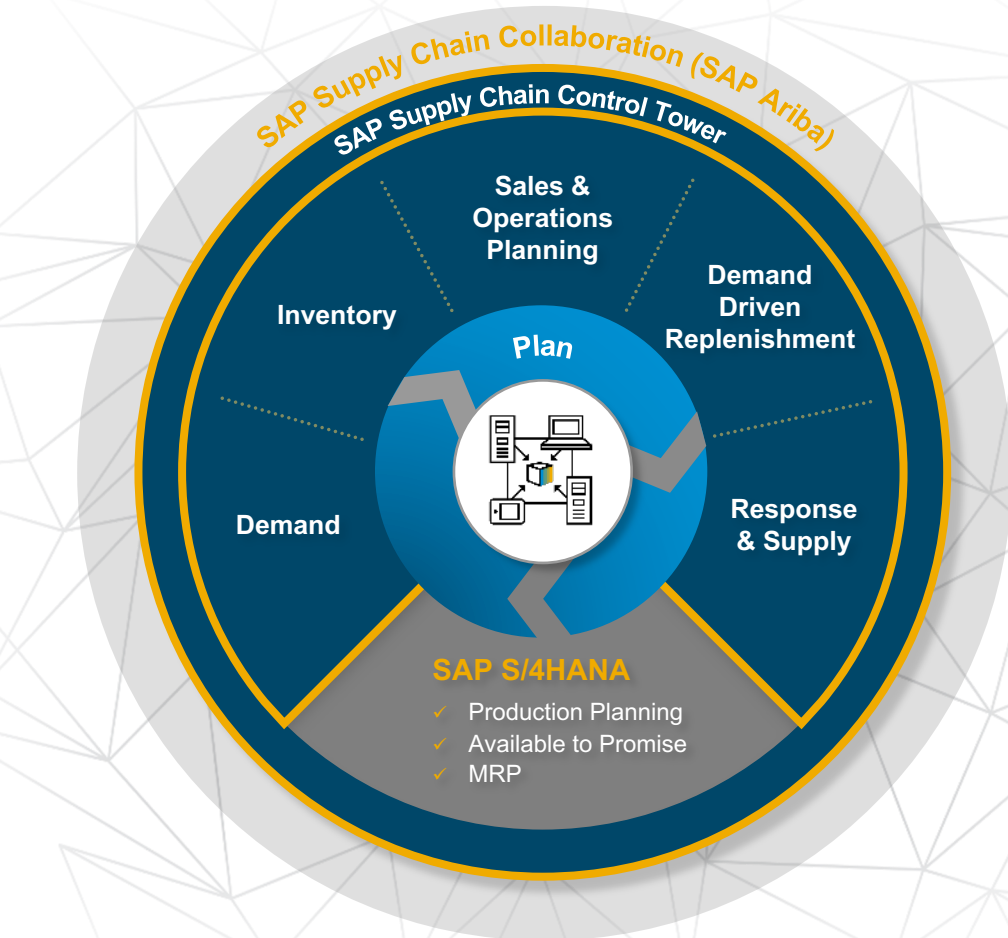


Other OR projects with SAP DI Framework



SAP IBP

Integrated Business Planning for Supply Chain



 SAP Integrated Business Planning



State-of-the-art business processes

Leverage SAP solutions to enable new end-to-end business processes, new business models and new revenue streams



Synchronized planning processes

Avoid planning silos through connected and integrated planning processes



Leverage end-to-end visibility

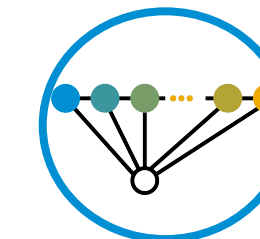
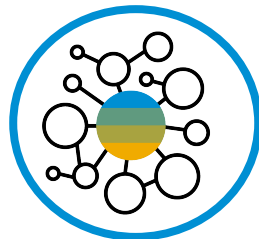
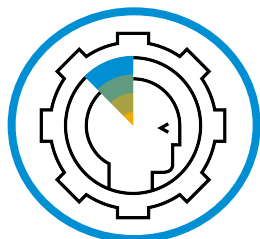
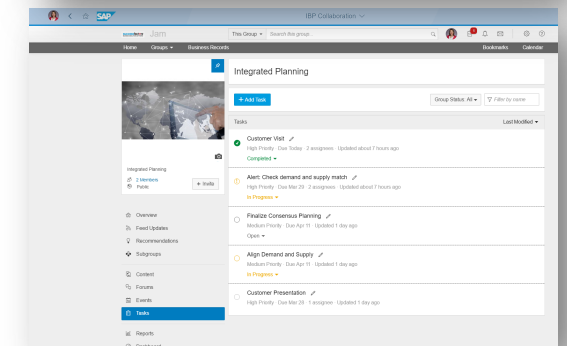
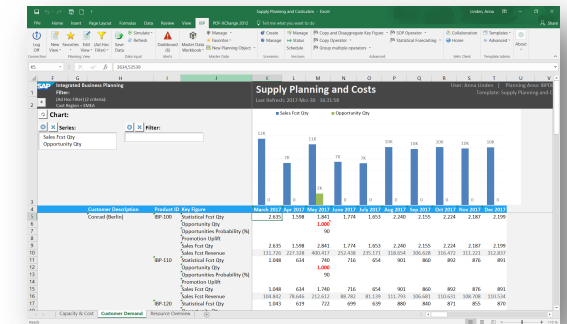
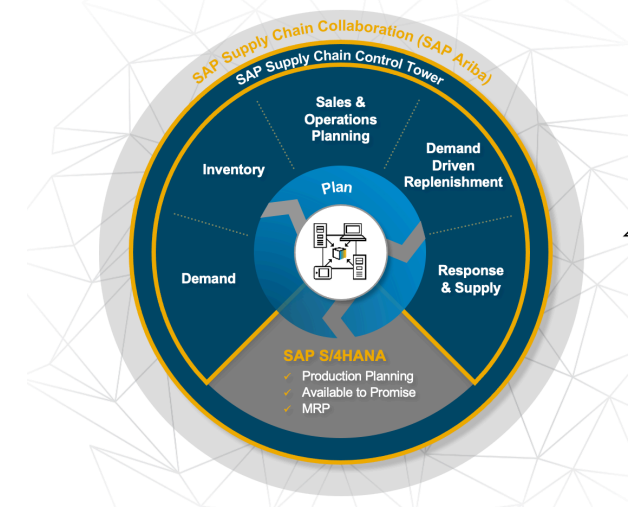
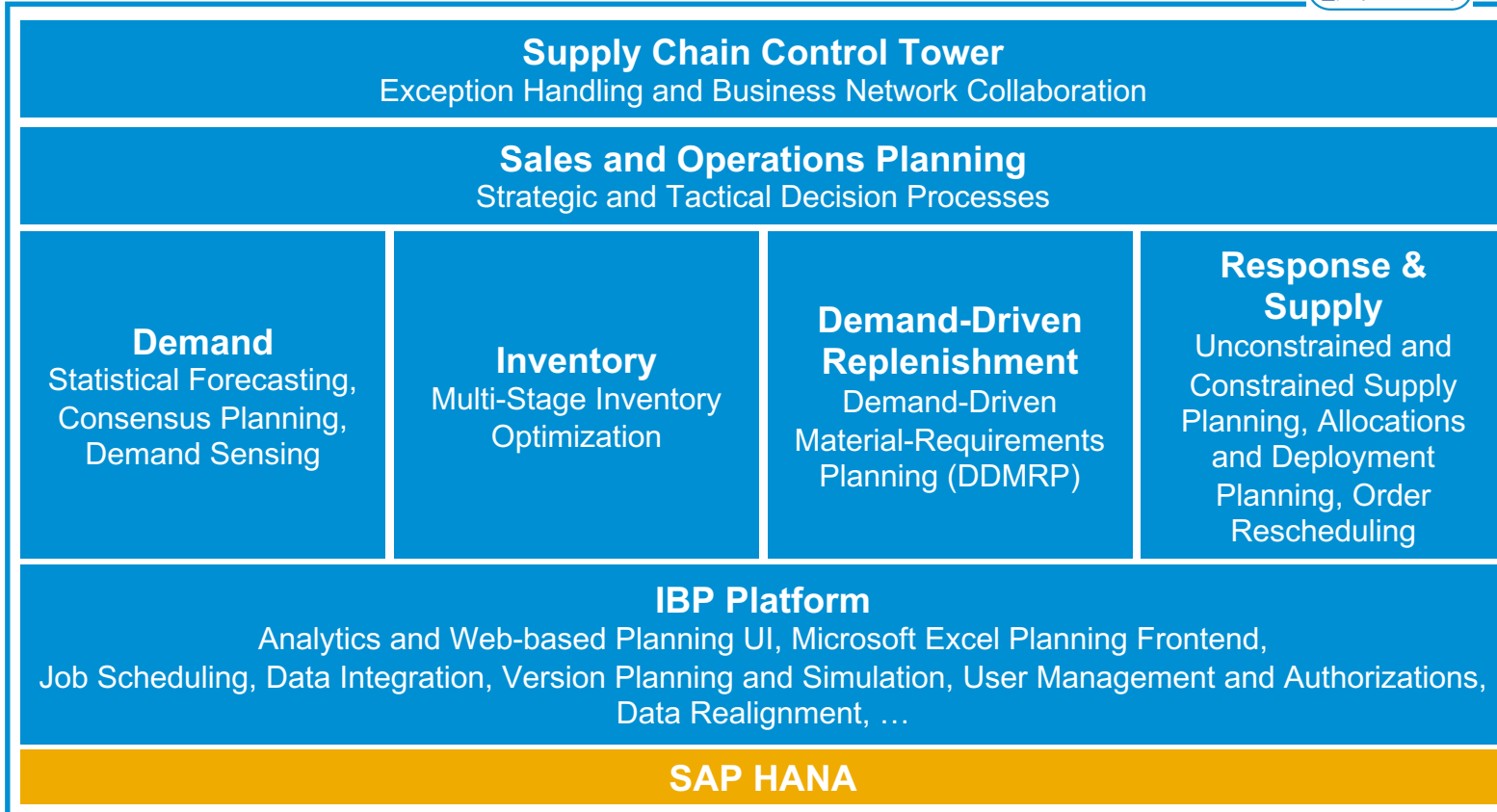
End-to-end visibility on strategic, tactical and operational level and across siloed or external data



Faster planning cycles

React faster to changes in the business through complete integration

Plan and Respond with SAP's Integrated Business Planning Solution



SAP Integrated Business Planning

Sales and Operations Planning



Create the optimal business plan to drive revenue growth and increase market share



Effectively balance demand and supply and attain financial targets



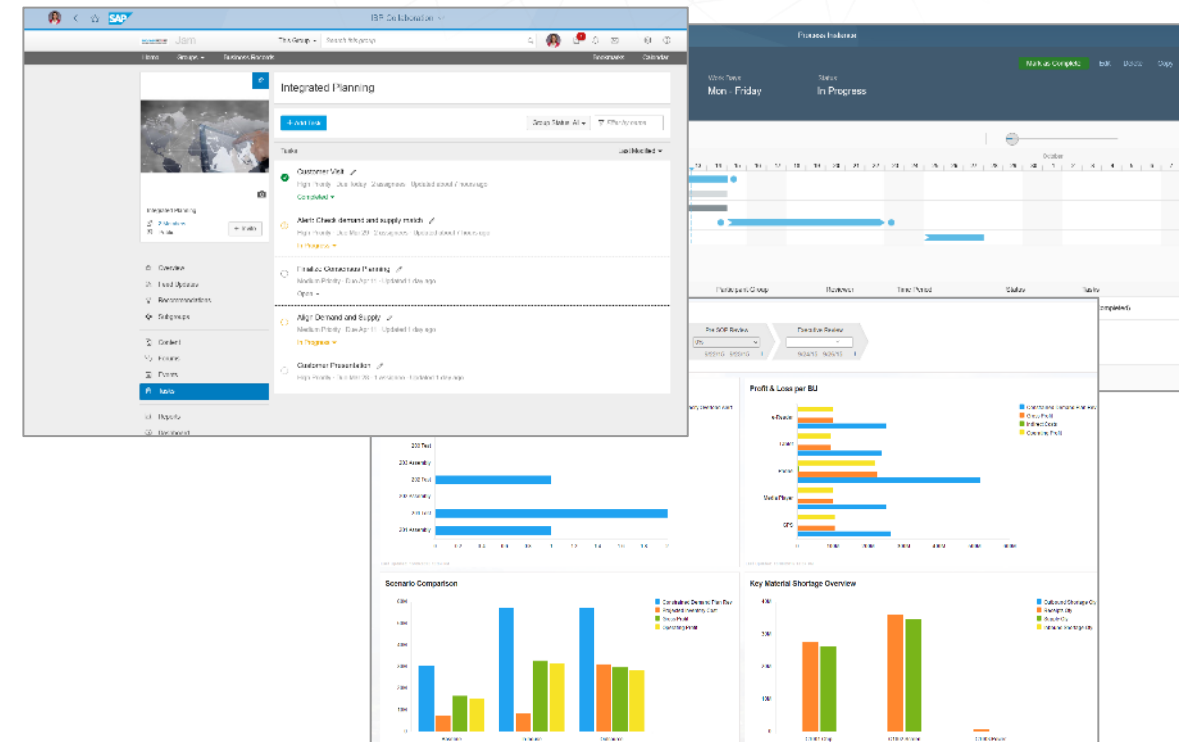
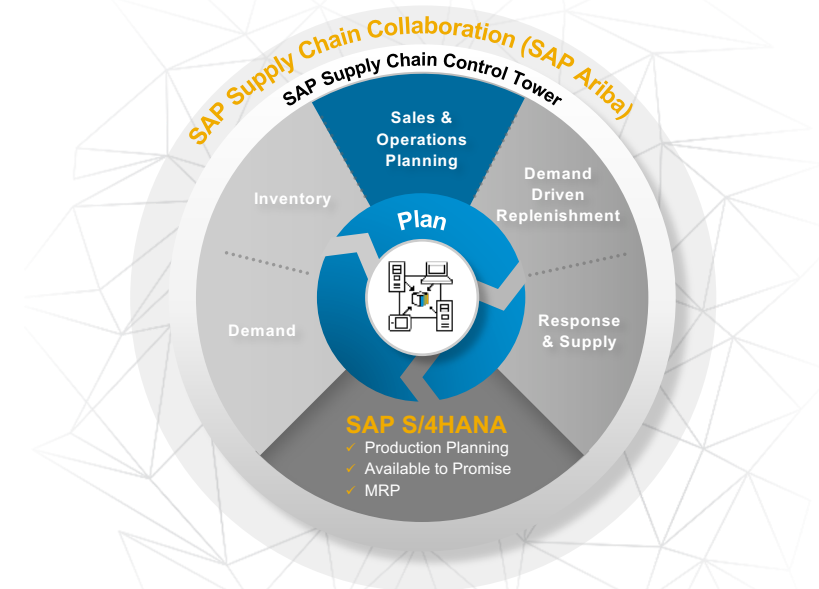
Increase speed and agility of planning and drive most profitable responses



Enable cross-functional process orchestration and collaboration

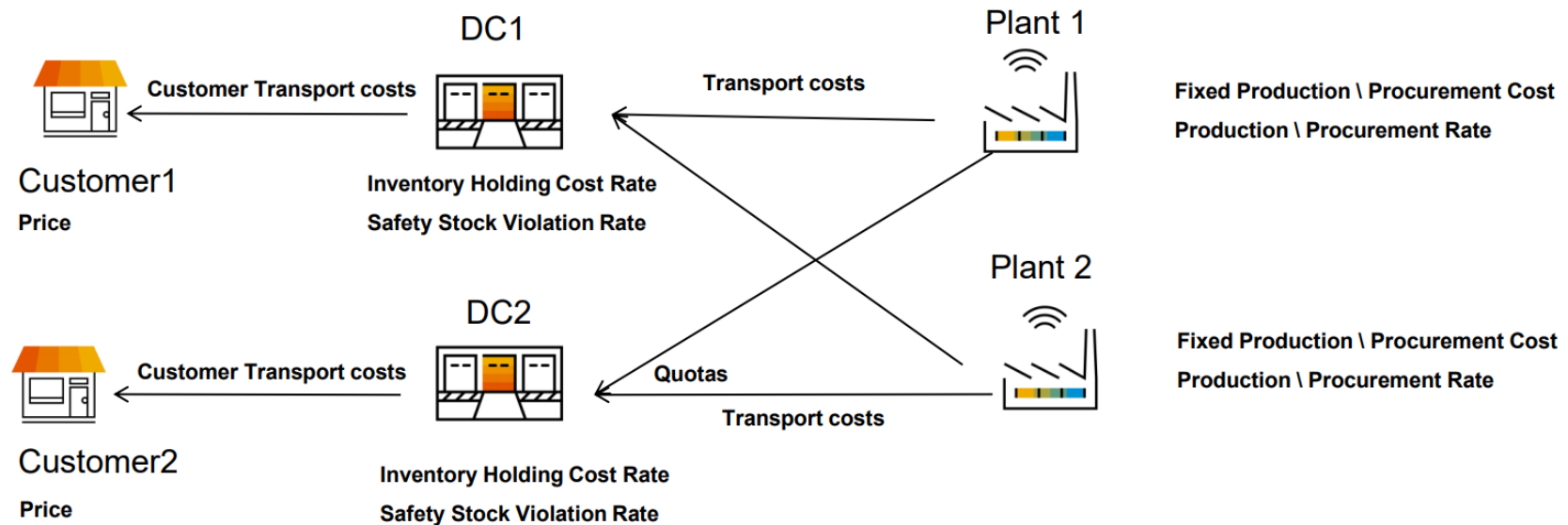


Manage risks, assumptions and opportunities



Supply Optimization Example in IBP

- The objective of the Optimizer is to minimize the total costs or maximize total profit of the supply plan, with many cost factors.
- Optimization is performed via a mathematical model using Mixed Integer Linear Programming (MIP).
- The output is an optimal and feasible Times Series plan that takes into consideration modeling, material, and capacity constraints. Sourcing quotas can be either generated or used as an input to planning run.





SAP Data Intelligence

What is SAP Data Intelligence?

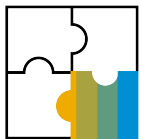
Create powerful data pipelines to **leverage** your data projects and to **orchestrate** the data processing

Harness the advanced machine learning content to **accelerate** and **scale** and **automate** your Data Science projects

Manage metadata across a diverse data landscape and **create** a metadata repository



SAP Data Intelligence is a **comprehensive solution to deliver data-driven innovation and intelligence across the enterprise**, unifying scalable enterprise AI/OR and intelligent information management.



Access & connect data



Govern & discover data



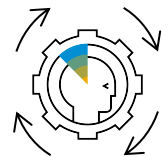
Prepare & label data



Build scalable & flexible data pipelines

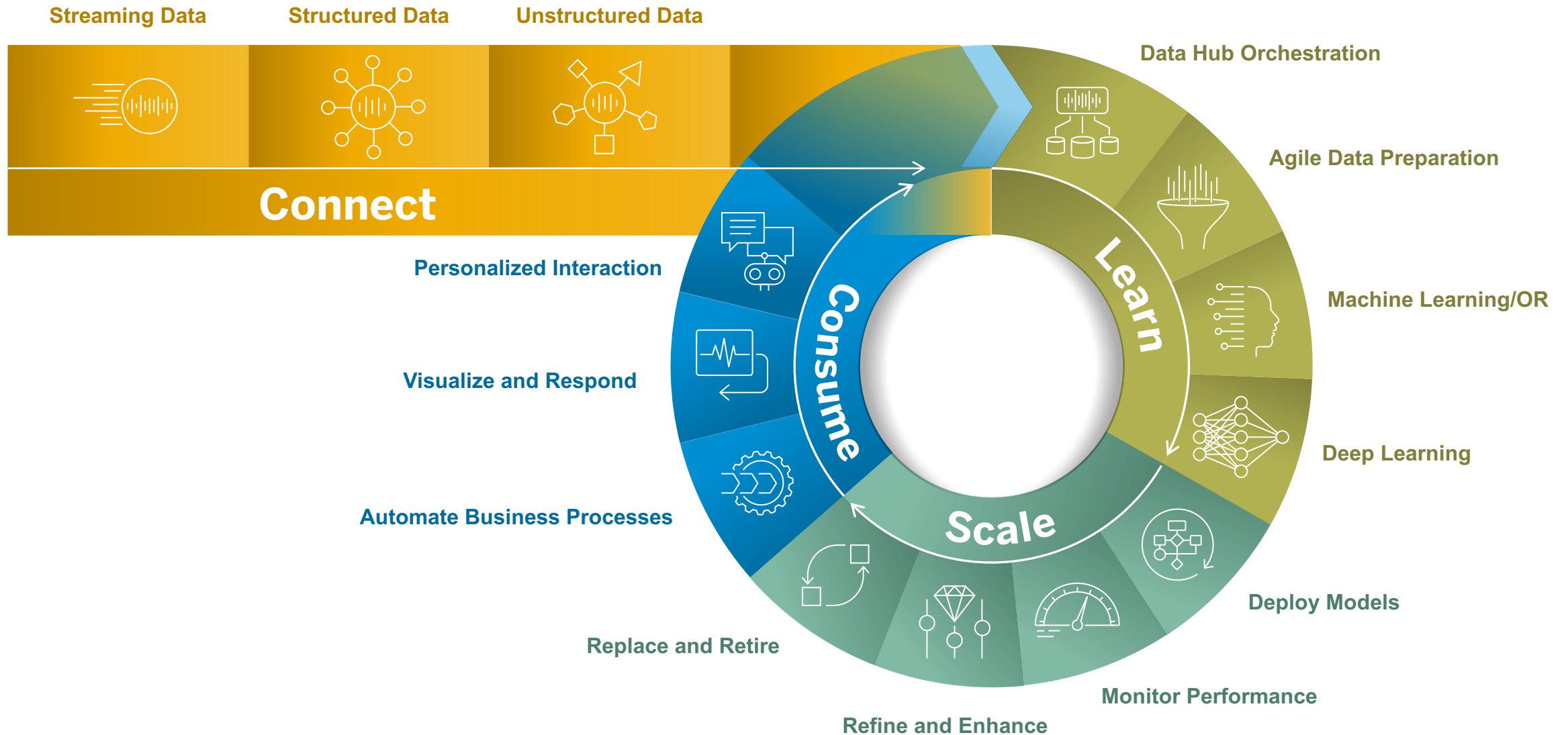


Deploy & integrate intelligent applications



Monitor & orchestrate the lifecycle

The Foundation of the AI/OR Assembly Line



SAP Data Intelligence

One stack to support the End-to-End workflow to deliver intelligent enterprise applications and business processes



Access & Connect Data

- Access data from various SAP and Non-SAP data sources in the cloud and on-premise
- Bring together different data type families as structured data and unstructured data



Govern & Analyze Data

- Make use of data management capabilities as (meta)data governance and data profiling to gain visibility across the landscape
- Get a clear end-to-end understanding of the data's origins and its usage across the connected landscape by applying Data Lineage functionalities
- Accomplish a proper feature extraction. Add, remove or modify them



Prepare & Label Data

- Index the metadata and make them available in the metadata catalog for the purpose of searching, labeling and processing
- Harness a built-in data preparation user interface to apply data transforming as well as data cleansing actions in just a few clicks before feeding them into associated models
- Accomplish a proper feature extraction. Add, remove or modify them



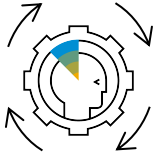
Build & Train Models

- Make use of an integrated JupyterLab environment to leverage and seamlessly integrate the experimental phase
- Carry out a proper feature engineering process
- Harness a visual way of building agile data-driven pipelines by means of both OpenSource tooling and ready-to-use Machine Learning services to train models at scale on distributed compute and GPUs



Validate & Deploy Models

- Create versions of the created ML artefacts and validate the different models against user-defined acceptance and accuracy criteria
- Monitor the performance of the models and compare the outcome of the models to each other
- Make use of one central application to operationalize ML-related artefacts



Integrate & Maintain Models

- Schedule and trigger automatic retraining, redeployment and retirement of the underlying models
- Benefit from the tight integration into SAP applications in the cloud and on-premise to enable intelligent core business processes and to take better and more confident decisions



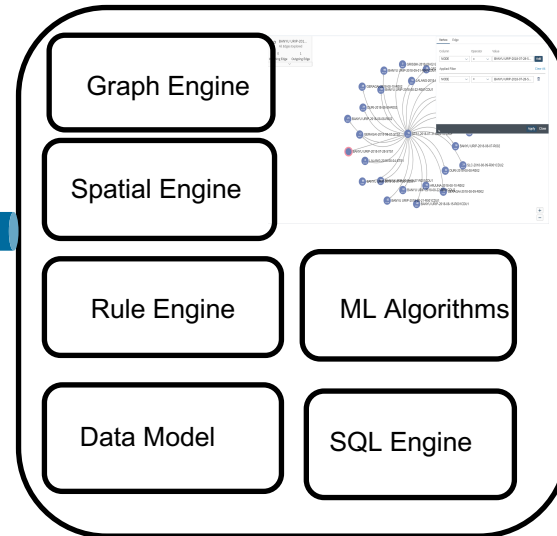
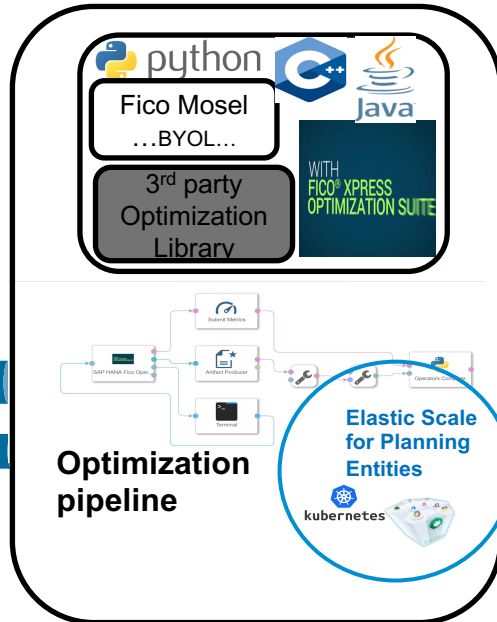
Framework Overview

High Level Target Architecture

Intelligent Logistics



Execution Systems

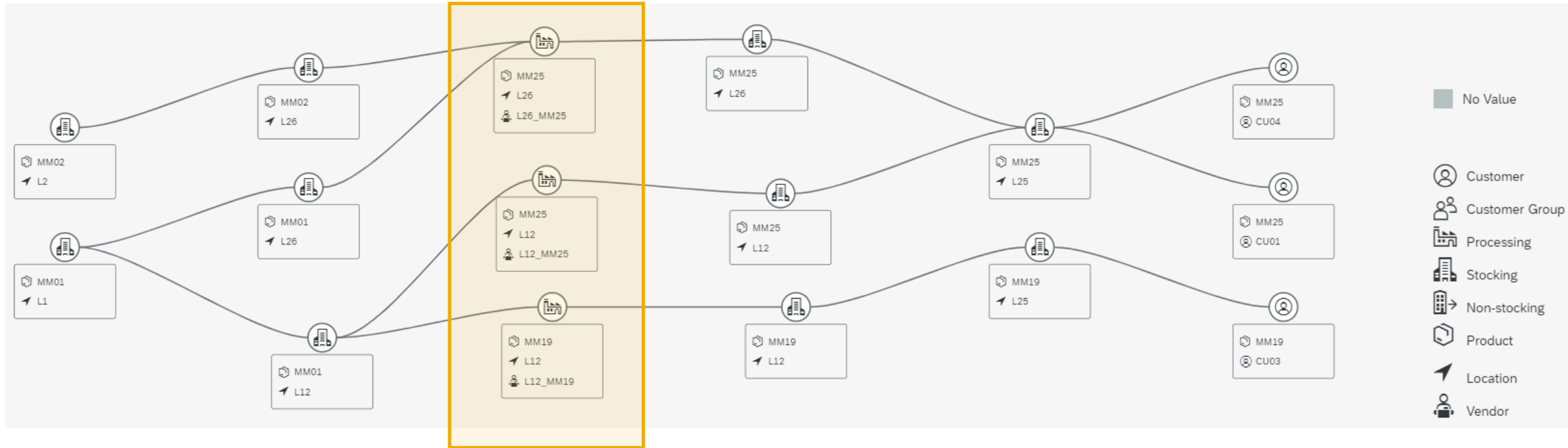


- Optimized Logistics: Scale out Mathematical Formulations & Runtimes with SCP Data Intelligence
 - Other Current Projects :**
 - Mining Company:** Maintenance Program Scheduling, Berth Scheduling, Railway Sheduling, Open Pit Project Scheduling
 - Oil&Gas:** Berth Scheduling & Vessel Route Optimization
 - All required Data piped with SCP Data Intelligence / Data Hub data pipelines. Data souces may vary from IBP, ECC, S4, HANA, and other NON SAP system.
 - Mathematical formulation put into higher level algebraic modelling language Mosel
 - Home Built Custom algorithms (BYOL: python, c++, java,...) hosted and run in SAP DI
 - What if Scenarios modelling at scale
- Data Pipelines & Optimization Compute Run Time inside Docker Containers in Data Intelligence on Kubernetes. Elastic Scale Out Compute power.
- HANA data modelling / rules engine / ML /Spatial/Graph engines
- Option Generator :
e.g. $\min c.x \mid A.x \geq b, x \in \{0,1\}, x \in X$,
where X defines highly complex non linear rules



Sample Optimization Problem

Example of Production Network



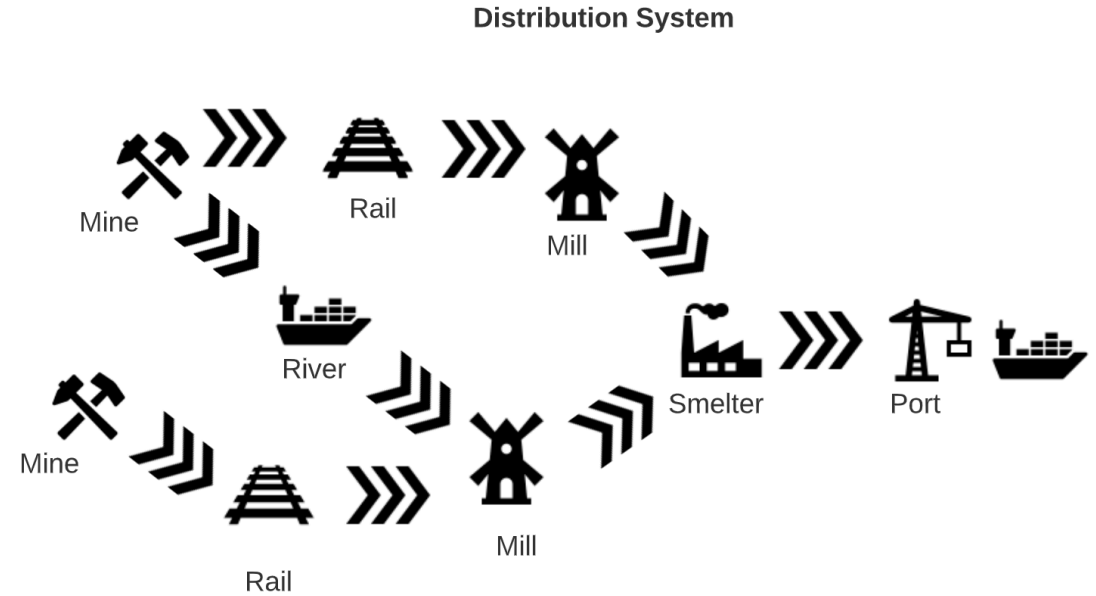
Nonlinear Metallurgical processes

Products are processed and refined as they flow from mines to ports:

- ❑ Copper
- ❑ Nickel
- ❑ Cobalt
- ❑ etc

Metal subproducts of smelting/refining process:

- ❑ Yield is a nonlinear function of sub products going into the smelter and refining
- ❑ Multi-grade/type production induces nonlinearities



Nonlinearity Modeled in Xpress Knitro

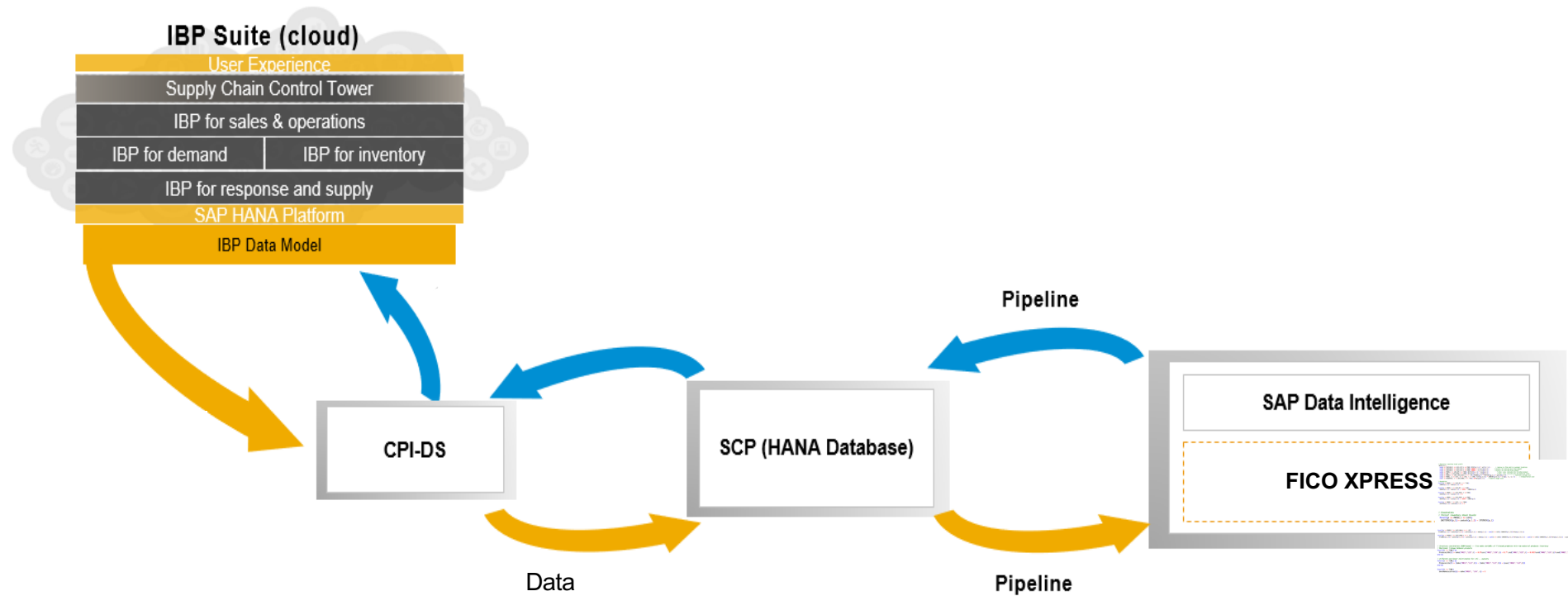
```
! Nonlinear model for the distribution system
! Objective: Maximize profit
! Constraints: Material balance, Capacity, Demand

! Parameters
! Demand (inventory stock levels)
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS

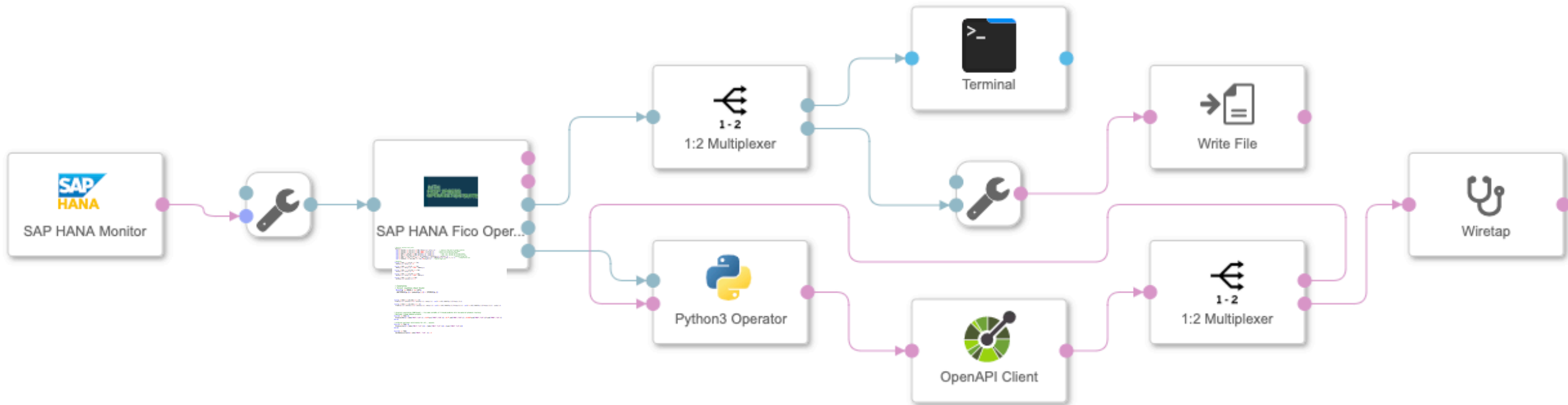
! Constraints
! Demand (inventory stock levels)
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS

! Objective function (profit)
! Maximize profit
! Demand in PRD(i) in LOTS
! Demand in PRD(i) in LOTS
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! Demand in PRD(i) in LOTS
```


Simplified architecture for Demo



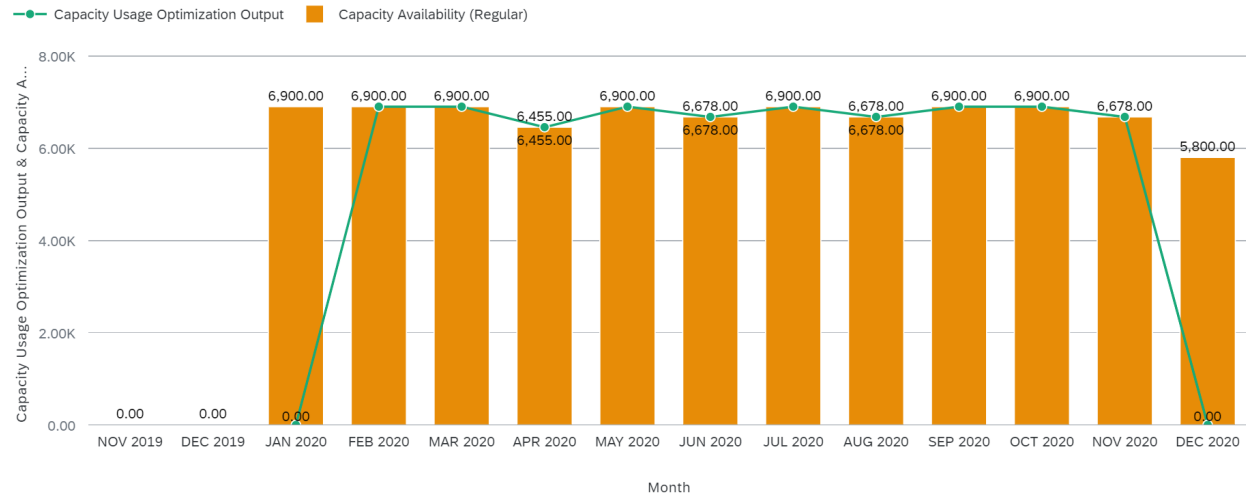
SAP DI Pipeline for optimization



SAP IBP visualization of results

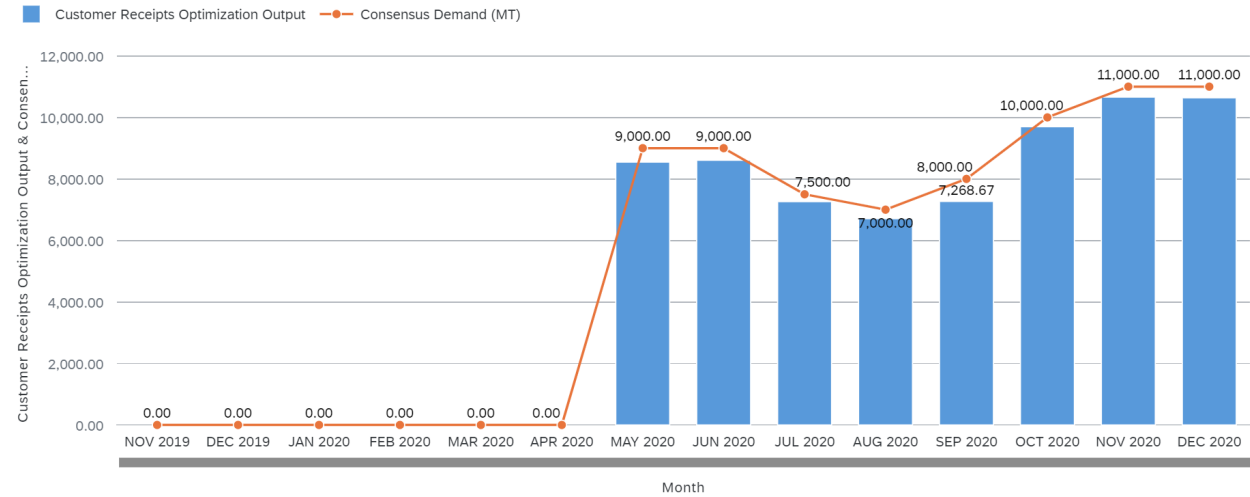
Capacity

now



Demand Fulfillment

1 second ago





Framework Demo

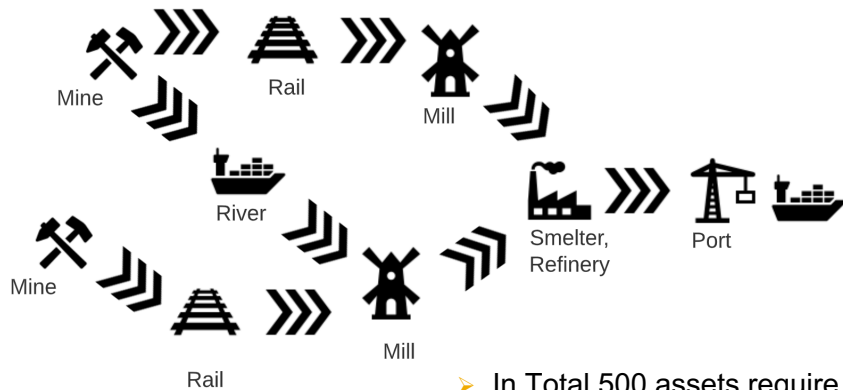


Other Optimization
Solutions with
DI Framework

Integrated Maintenance / Outage Scheduling of Assets

- ◆ Creation of a Maintenance Map from the tactical plans to the execution plans for all **500 assets across all Integrated Production Systems**
- ◆ Increase the capacity of the production chain as a whole, Increase the operational stability of the corridors. Predictability. Provide an integrated view of the assets that interfere with the operation.
- ◆ To group and optimize maintenance orders : Interdependency of assets: when one asset is planned to be in maintenance, other dependent assets in same supply chain production system must also have their maintenance allocated in same time period.
- ◆ Keep Operations going: Limit maintenance orders for redundant assets – alternative production systems, not all systems must be in maintenance at the same time

Distribution System



- In Total 500 assets require maintenance jobs subject to **Never Together and Ideally Together Time Overlap rules** which are often conflicting, **minimize outage time**.
- Due to sheer size of the problem, planners have to divide and conquer and only have visibility on part of the rules. Complex matrix rules makes the scheduling difficult to solve which multiple KPIs Objectives to optimize for

4 Integrated Production Systems (mine – railroad - port)

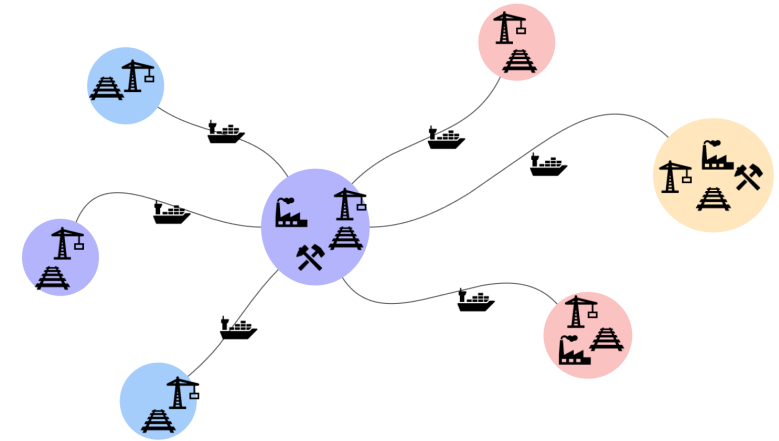
22 Mines in operation - total production of ~ 400Mt in 2018 (Budget). 13 Pelletizing Plants distributed in 4 Global Complexes

4 Railways and 1 Waterway used to interconnect mines with ports

4 Loading Ports

17 large Ports for Blending and Distribution Operation

~ 220 Mt / year of CFR sales (Transport is the seller's responsibility) - about 60% of the total;





Thank you!

Gustavo Ayres de Castro

gustavo.ayres.de.castro@sap.com

Sricharan Poundarikapuram

sricharan.Poundarikapuram@sap.com

Claude Philippe Medard

claude.philippe.medard@sap.com