Optimization in
Digital Supply Chain

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PUBLIC

THE BEST RUN **SAP**
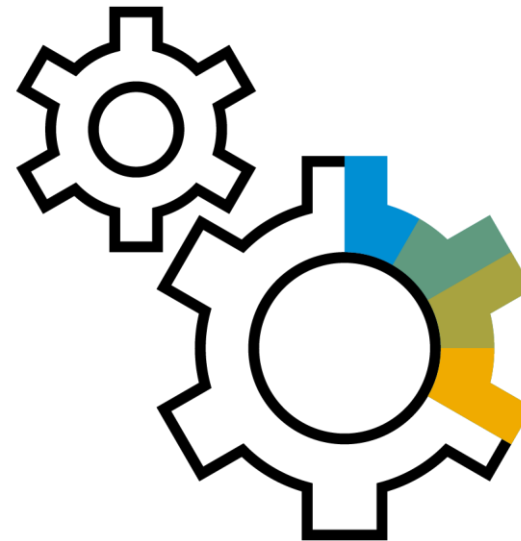
Customers of SAP Optimization ...

... produce more than 80% of the coffee and tea we drink each day.

... produce 75%+ of the world's beauty and fragrance products.

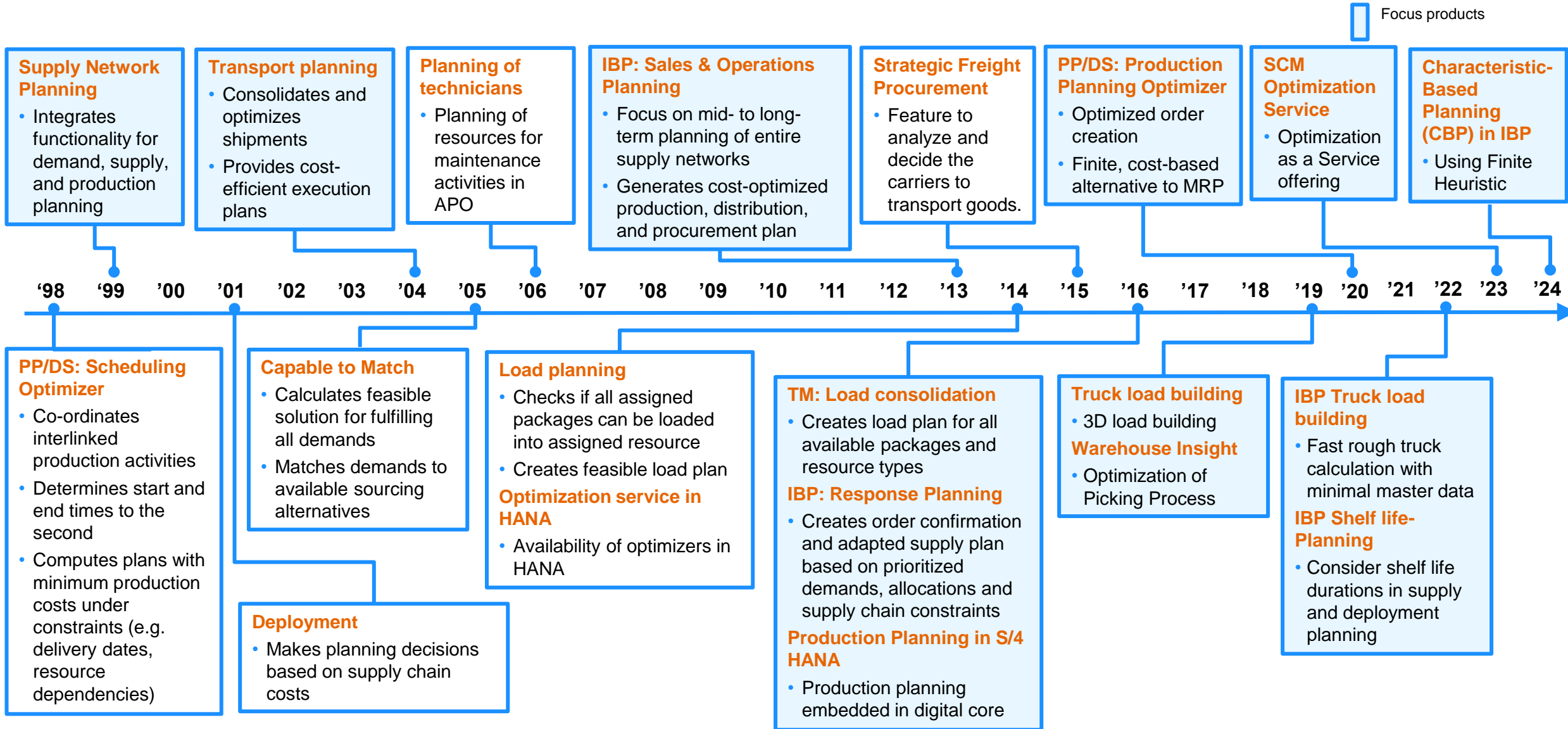**... produce more than 85% of the world's athletic footwear.**

Customers of SAP Optimization ...

... produce more than 77% of the world's beer.

Optimization
in SAP Digital Supply Chain

SAP has developed and delivered optimization solutions in SCM for 25+ years

Focus products

Supply Network Planning
- Integrates functionality for demand, supply, and production planning

Transport planning
- Consolidates and optimizes shipments
- Provides cost-efficient execution plans

Planning of technicians
- Planning of resources for maintenance activities in APO

IBP: Sales & Operations Planning
- Focus on mid- to long-term planning of entire supply networks
- Generates cost-optimized production, distribution, and procurement plan

Strategic Freight Procurement
- Feature to analyze and decide the carriers to transport goods.

PP/DS: Production Planning Optimizer
- Optimized order creation
- Finite, cost-based alternative to MRP

SCM Optimization Service
- Optimization as a Service offering

Characteristic-Based Planning (CBP) in IBP
- Using Finite Heuristic

'98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24

PP/DS: Scheduling Optimizer
- Co-ordinates interlinked production activities
- Determines start and end times to the second
- Computes plans with minimum production costs under constraints (e.g. delivery dates, resource dependencies)

Capable to Match
- Calculates feasible solution for fulfilling all demands
- Matches demands to available sourcing alternatives

Deployment
- Makes planning decisions based on supply chain costs

Load planning
- Checks if all assigned packages can be loaded into assigned resource
- Creates feasible load plan

Optimization service in HANA
- Availability of optimizers in HANA

TM: Load consolidation
- Creates load plan for all available packages and resource types

IBP: Response Planning
- Creates order confirmation and adapted supply plan based on prioritized demands, allocations and supply chain constraints

Production Planning in S/4 HANA
- Production planning embedded in digital core

Truck load building
- 3D load building

Warehouse Insight
- Optimization of Picking Process

IBP Truck load building
- Fast rough truck calculation with minimal master data

IBP Shelf life-Planning
- Consider shelf life durations in supply and deployment planning

Optimization @ Digital Supply Chain
Expertise

Customers
- ~2000 customers
- Different industries
- Optimization engines as standard software
- Included in cloud & on-premise solutions

Algorithms
- Linear and mixed-integer Programming
- Meta-Heuristics (Genetic Algorithms, Evolutionary local search,..)
- Integrated ML (data cleaning, parameter setting)
- Problem dictates algorithm (not the other way around)

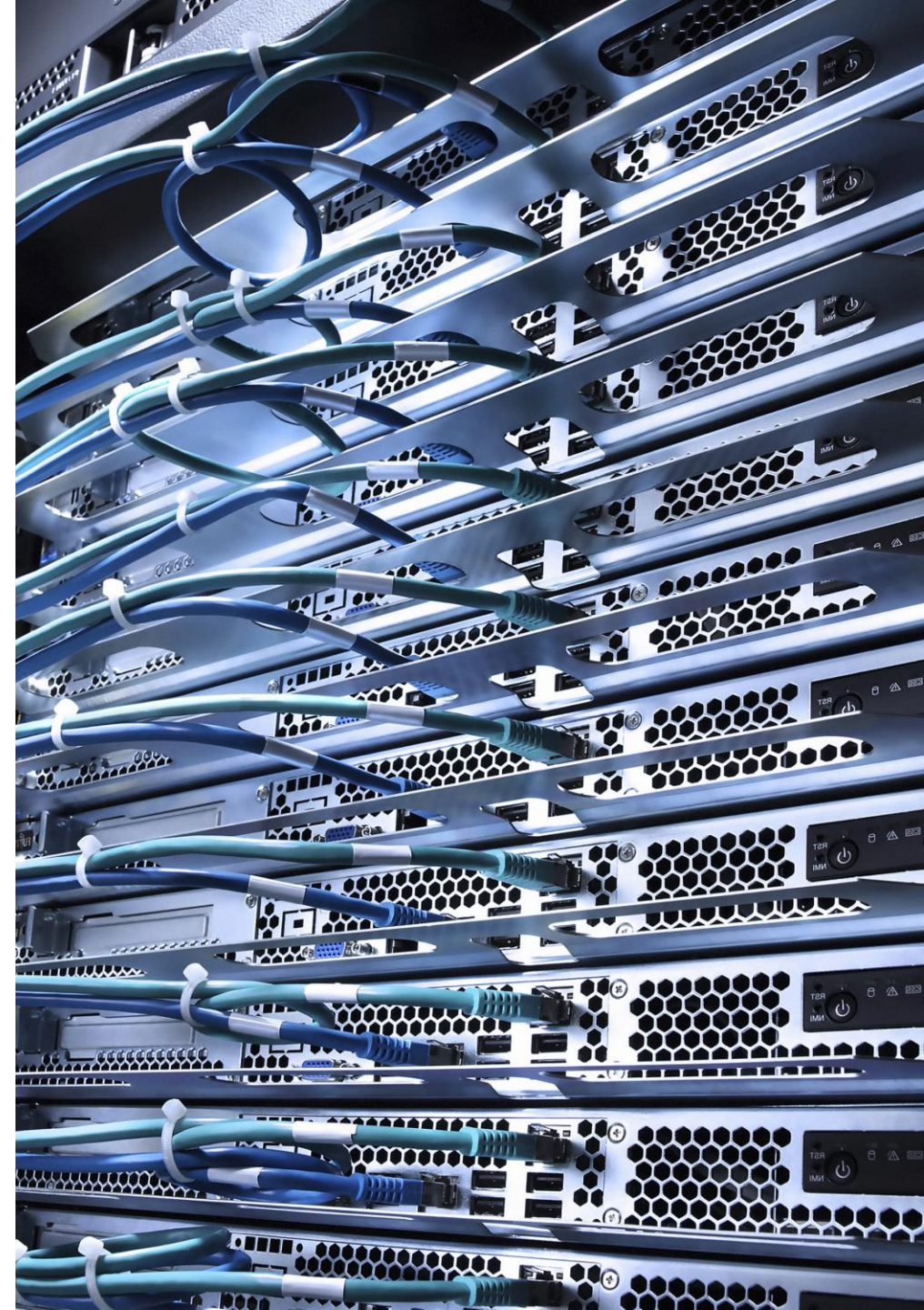**Partners**
- Gurobi strategic optimization partnership
- Zuse Institute Berlin

Research
- Cooperation with TU Munich
- Research Campus MODAL
- >120 student theses

Optimization Team
- 70+ optimization and AI/ML experts
- Located in Walldorf, Munich, Budapest and Montral

Optimization @ Digital Supply Chain
Challenges

Features & Function

- Need to cover multitude of different requirements across wide range of industries
- Divergent perceptions on critical features across customer base
- Extensibility to support additional requirements, also in cloud-based solutions

Performance / Runtimes

- Wide range of model sizes with varying degrees of complexity
- Tight runtime windows
- Increasing model scope and complexity as supply chains grow and business models evolve

Usability

- Productive use requires robust, fail-safe models and limited specialized knowledge on customer side
- Customers expect explanation of optimization results

Service & Support

- Fast delivery of new features and corrections
- Up- and downwards compatibility to reduce maintenance effort
- Extremely high reliability requirements for cloud-based on on-premise solutions
- 24/7 tiered support model

Optimized Planning in Digital Supply Chains – Solution Overview
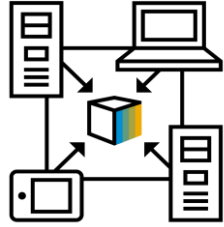
Plan

- Mid-term production, transportation and purchasing planning
- Fast finite heuristic
  - Backtracking
  - High service level and low stocks
- Optimization
  - Inventory planning including fair-share
  - Simplified cost maintenance / generation
  - Specialized Deployment Optimization
- Demand-Driven Replenishment (DDMRP)
  - Decoupled local decision taking
- Inventory Optimization
  - Calculate optimal inventory levels
- Load Consolidation (TLB)
  - Group transports into full truck loads

Manufacture

- PP/DS: Detailed Scheduling Optimization
  - Optimized setup sequences
  - Alternative modes
  - High service level and low stocks
  - Finite capacities

- PP/DS: Production Planning Optimization
  - Alternative to MRP
  - Finite capacities
  - Lot sizing
  - Inventory planning

Deliver

Transportation (TM)
- Efficient and sustainable transportation
- High utilization
- Improved speed
- Routing optimization
- Load consolidation
- Truck load building
- Optimal pallet building
- Operative Carrier Selection
- Strategic Freight Procurement

Warehouse (WI)
- Optimal Picking
  - Minimal picking distances
  - Considering capacities & deadlines

Package Building Optimization

Scenario

Consolidation of product/packages to create pallets in order to minimize number of pallets

Algorithm

Meta Heuristic, Evolutionary Local Search

Remarks:
- Optimized pallet building
- Multi-level packaging
- Stackability matrix
- Incompatibilites (between products in mixed carton and in mixed pallet)
- Height, volume and weight constraints
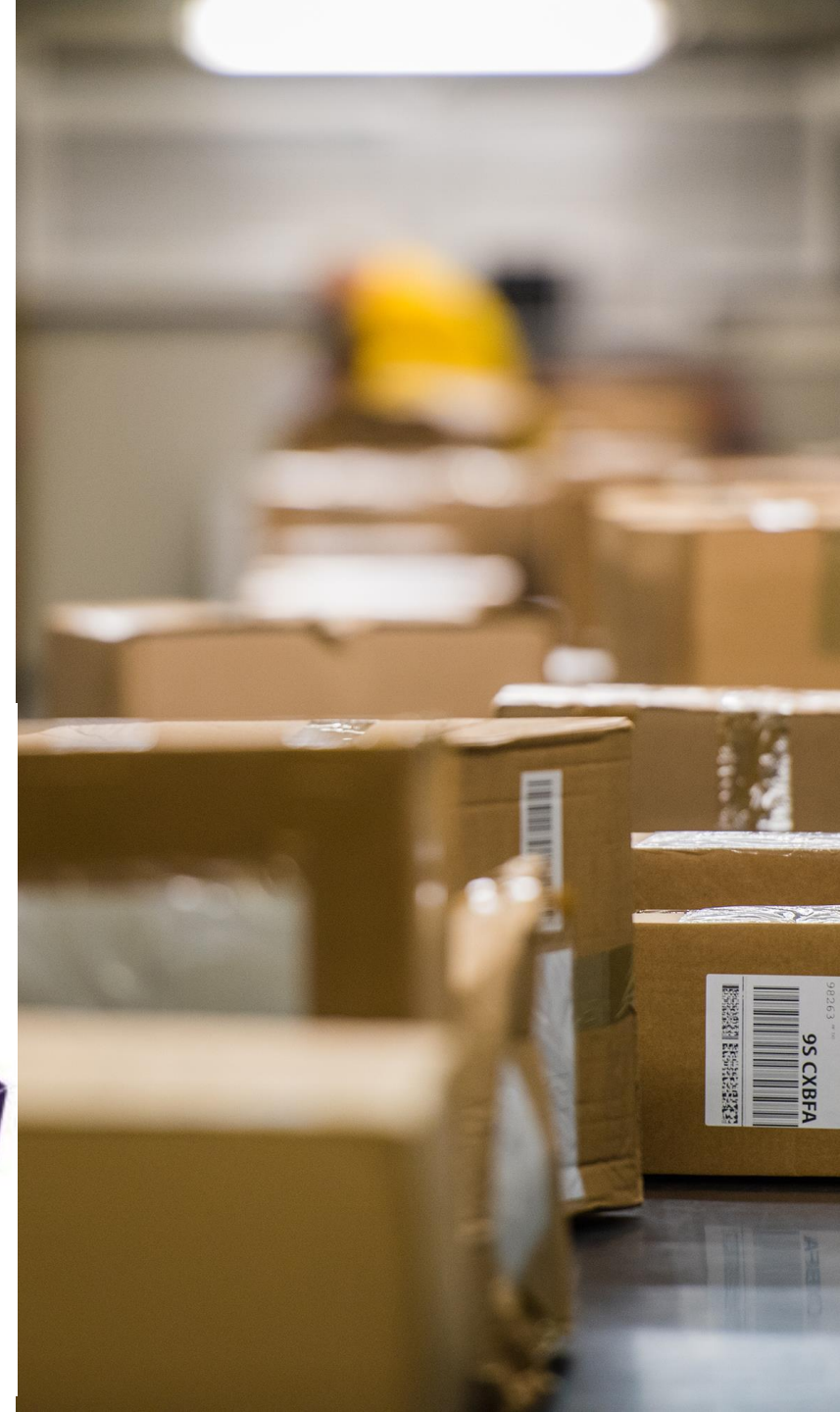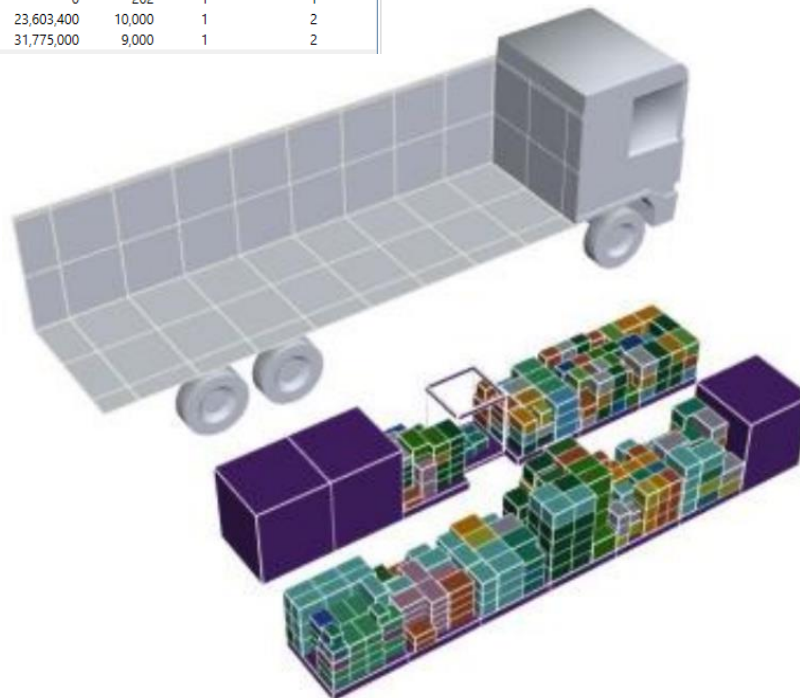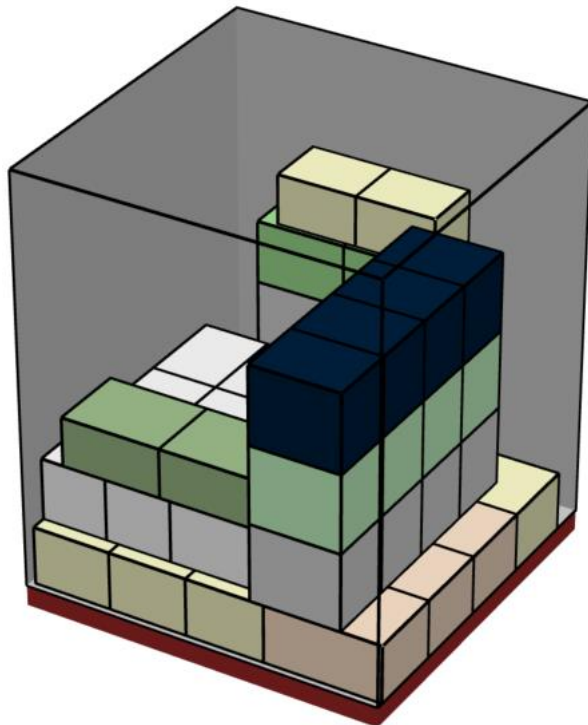- Orientation constraints of the products
- In combination with tour planning: cross-delivery packaging

Package Building Optimization

| ID	Product	Name	Count	Length (mm)	Width (mm)	Height (mm)	Vol sum (mm³)	Weight (g)	Priority	Stack matrix grp	Stack fac
958752	0	250 TETRA X24 F/	1	219	308	136	9,173,472	6,640	1	1	
953218	0	500 PET X12 B BR	1	292	222	191	12,381,384	7,390	1	1	
952352	0	500 PET X12 B BR	1	292	222	191	12,381,384	7,390	1	1	
957603	0	390 PET X24 FANT	10	381	256	191	186,293,760	10,280	1	1	
953555	0	14G BAG X100 GR	2	325	250	160	26,000,000	1,570	1	1	
953685	0	600 FLO X12 P/AD	5	292	222	254	82,326,480	8,130	1	1	
954300	0	600 FLO X12 PADI	1	292	222	254	16,465,296	7,660	1	1	
950200	0	500 PET X12 NTEA	11	292	216	203	140,839,776	6,890	1	1	
950188	0	500 PET X12 NTEA	4	292	216	203	51,214,464	6,890	1	1	
952096	0	500 PET X12 NEST	2	292	216	203	25,607,232	6,890	1	1	
957963	0	350 PET X12 NB V	2	262	200	164	17,187,200	5,530	1	1	
957342	0	390 PET X24 VANI	1	381	256	191	18,629,376	10,280	1	1	
957602	0	390 PET X24 DIET	3	381	256	191	55,888,128	9,900	1	1	
958589	0	1.0KG BAG X1 GR	0	140	90	250	0	1,025	1	1	
958666	0	600 FLO X12 P/AD	4	292	222	254	65,861,184	8,130	1	1	
958668	0	600 FLO X12 P/AD	6	292	222	254	98,791,776	8,130	1	1	
958786	0	1.0KG BAG X1 GR	0	95	60	220	0	1,000	1	1	
						30	0	262	1	1	
						32	23,603,400	10,000	1	2	
						10	31,775,000	9,000	1	2	

Package Building Optimization
Current Research Questions

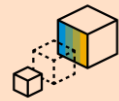Configure meta heuristics and evolutionary local search
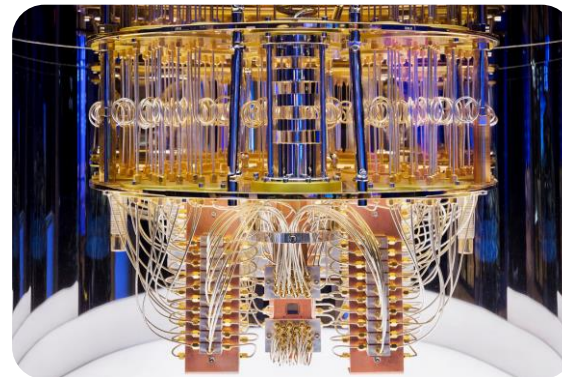
Optimize grouping of packages

SCM Optimization Service

SCM Optimization Service – Motivation

Customer Challenges

Scalability
Allow many parallel optimization/planning runs not restricted by the size of a single instance
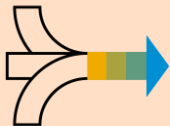
Performance
Allow best of breed performance, without hardware restrictions or parallelization limits (line in HANA)

Extensibility & Customizability
Allow customer code to manipulate the data and IBSO to enhance or replace standard algorithms

Strategic Requirements

Cloud Availability
Consumable by all SAP Cloud solutions independent of HANA

Low Total Cost of Ownership
Smallest possible overhead + hardware sharing between all customers

Synergies between Planning Algorithms
Common platform allowing reuse of common optimization steps

Efficient Operation
Identical handling of many Solutions resulting in common and efficient operations

Standing on shoulder of giants
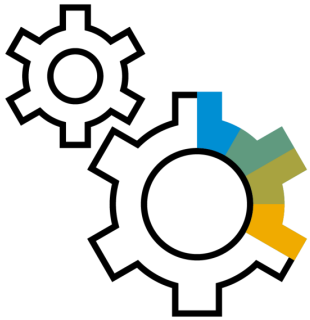Allow to utilize all assets at SAP within planning engines, for example AI Factory
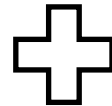
Continuous Delivery
Fast deployment of new features and corrections, even in customer landscapes

SCM Optimization Service – Solution Approach

Best of Breed Algorithms

Included in many SAP Products

Proven and Trusted

Years of Experience

Low level Programming

Numerous Meta-Heuristics

(Mixed-Integer) Linear Programming

+
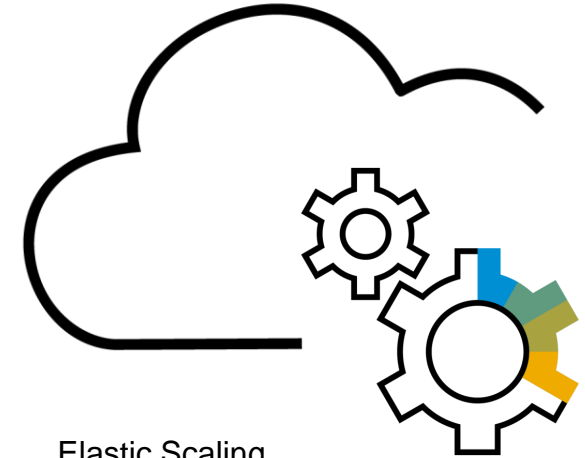
SAP Cloud Platform on Kubernetes

Scalability

Performance

Tailored Hardware

Extensibility

Kubernetes

Gardener

=

SCM Optimization (Service)

Elastic Scaling

High Performance by Design

Common Optimization Solution for SAP

Strong Cloud Qualities

Machine Learning Ready

3rd Party Enabled

SCM Optimization meets AI

Infuse Supply Chain Solutions with Business AI and Analytics

Today, we are already a leader in adopting AI for supply chains as demonstrated by our current projects. Moving forward, we will intensify our efforts with a comprehensive AI acceleration and plan to solidify our leadership position.

Machine Learning

- Gradient boosting algorithms for demand forecasting
- Intelligent slotting
- Failure Curve Analytics
- Automated parameter configuration
- …

Next: Customer collaboration and research partnerships

Optimization

- Transportation plans
- Supply network
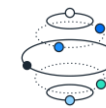- Workflows in a warehouse
- Production scheduling
- …

Next: Combine optimization with ML models, Quantum computing

GenAI

- Explanation of supply chain planning run
- Manufacturing issue analysis and solution assistant
- Advanced Failure Modes Analysis
- …

Next: Customer adoption and value validation

Thank you.

Jakob Witzig

AI & Optimization Algorithm
Architect

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LinkedIn

SAP Bring out your best.