Efficient Workforce Allocation in Manufacturing Operations Using AnyLogic Simulation

Amanda Murphy & Prashant Tiwari

September 5, 2024

Cargill

Nourishing the world in a safe, responsible & sustainable way

Cargill is a family company committed to providing food, ingredients, agricultural solutions and industrial products to nourish the world in a safe, responsible, sustainable way.

160K+

Employees

70

Countries

125

Markets

159

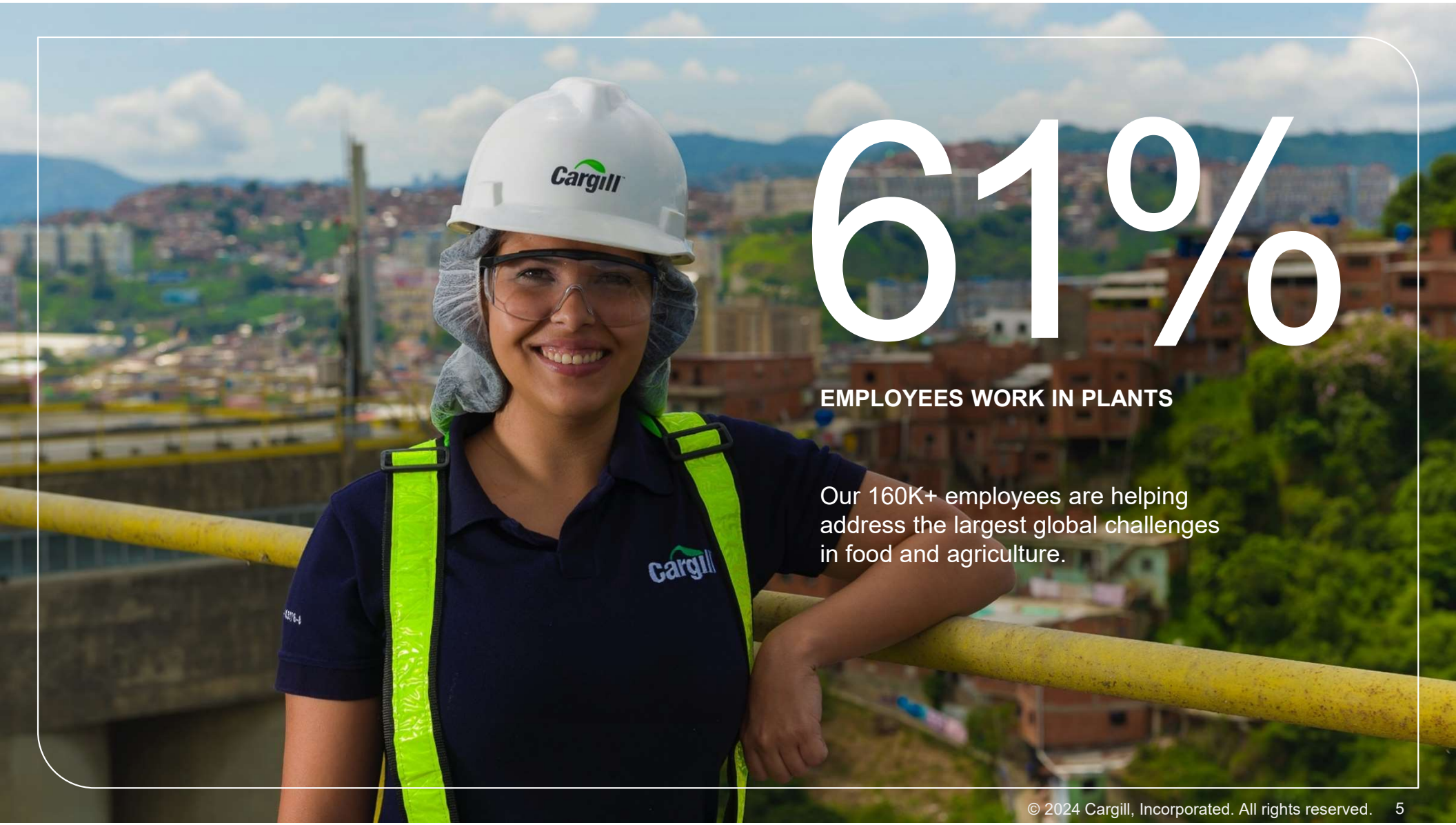
Years

Where can you find Cargill?

https://www.cargill.com/about/cargill-at-a-glance

Many examples

Personal Care	Food for home and restaurants	Home	Farm	Transportation
Coatings for medications	**Premium Beef**	Bio-based **cleaning ingredients**	**Nutritious feed** for dairy cows	**Biodiesels and biofuels**
Natural ingredients for **shampoo and soap**	**Oil and shortening**	Bio-based **polymer foam**	**Growth-enhancing milk** for piglets	**Salt** for safe roads
Cotton in clothing	**Poultry products**	**Salt** for water softening	**Crop trading** and origination	**Bio-based additives** for asphalt
Natural ingredients in **cosmetics**	**Eggs**	**Starches** for paper	**Farmer Risk Management**	
	Culinary salt	Bio-based **insulation material**	**Sustainable farming support**	
	Cocoa and chocolate	**Low-chemical oils** in paint	**Feed** for fish and shrimp	
	Sweeteners	**Pet food** and animal nutrition products		



61%

EMPLOYEES WORK IN PLANTS

Our 160K+ employees are helping address the largest global challenges in food and agriculture.

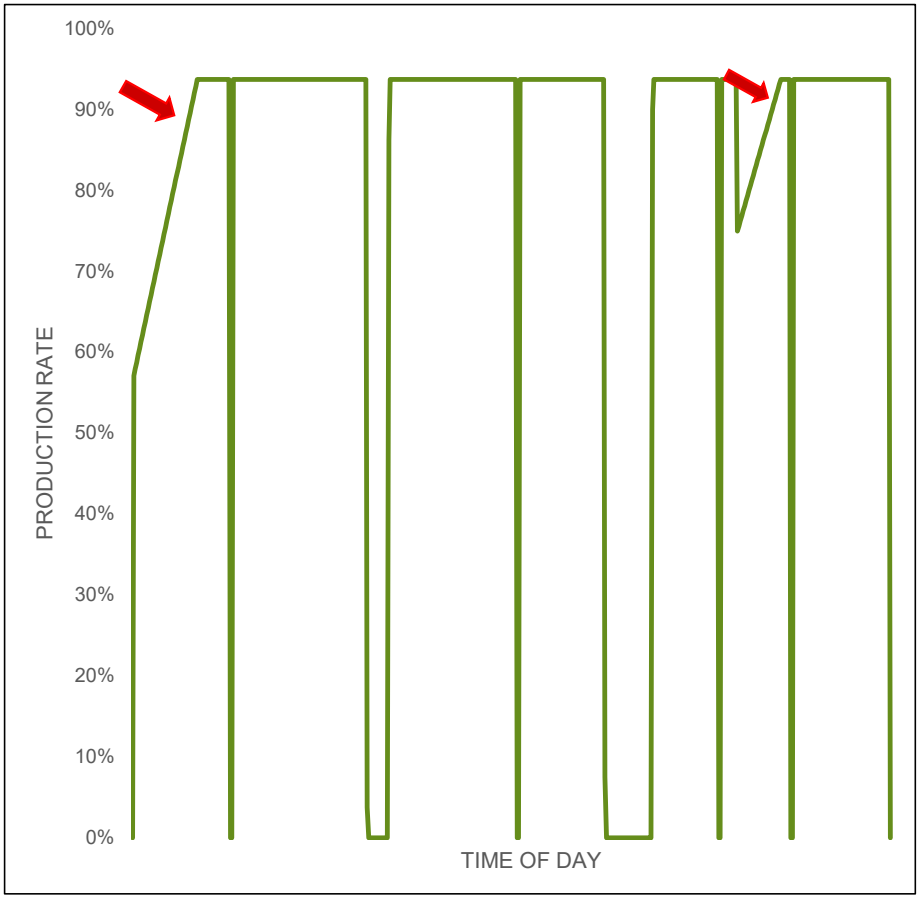
Executive Summary

Executive Summary

- High-volume manufacturing facilities are subject to uncertainty due to unpredictable equipment failures and variable workforce availability
- To address one of these challenges, we developed a Day-of-Operation simulation tool for optimal workforce allocation in uncertain environments
- This allocation tool:
  - is beneficial for workforce-intensive facilities where the production process involves multiple jobs
  - utilizes a workforce proficiency database and considers real-time workforce availability, including overtime workers
  - output is integrated into a workforce-intensive facility's Digital Twin, developed using AnyLogic simulation software

Business Challenge

Production Impact



- Daily expected production not met in labor-intensive facilities
- Production ramp-up period observed during labor arrival and departure
- Production rate set as a flat daily goal, not adjusted for different products

Day-of-Operation Tool

Several Challenges Led to the Development of Day-of-Operation Tool

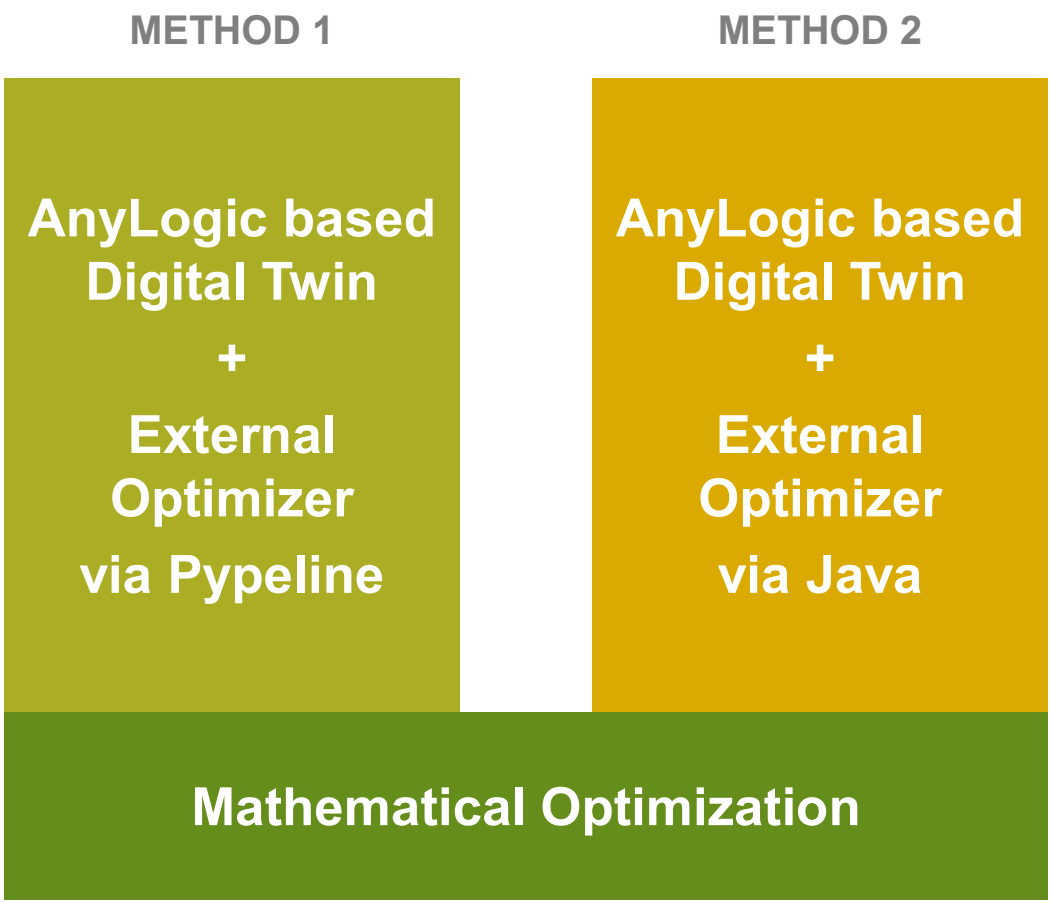
1. Managers address startup bottlenecks due to operator absences and adjust job allocation
2. New/substitute managers struggle with labor allocation planning
3. Management seeks true production rate capability by lot/product for value decisions
4. Allowing for decision to create a high value product (higher labor required) vs low value (lower labor required)
5. Need a minimal time investment tool for daily use

Day-of-Operation Tool

Input Information for the Day-of-Operation Tool

1. Facility includes 15+ departments, each with 40+ operators
2. Operators trained on more than 1 job
3. Jobs designated as “Critical”
4. Workforce absence or no show
5. Operators designated a Full Time Equivalent (FTE) value – 25%, 50%, 75%, and 100%

Methodology



Mathematical Optimization

Objective: *Maximize* *throughput*

Subject to:

***Resource (workforce) constraints*:**

$$\sum_{j \in J} x_{r,j} \leq 1$$

***Job constraints*:**

$$1 \leq \sum_{r \in R} x_{r,j} \leq maxBudgetedLabor_j$$

***Throughput constraints*:**

$$throughput_j \leq \sum_{r \in R} x_{r,j} * FTE_r * ratePerWorker_j$$

$$throughput_j \leq maxAttainableThroughput_j$$

$$throughput \leq throughput_j \quad \forall j$$

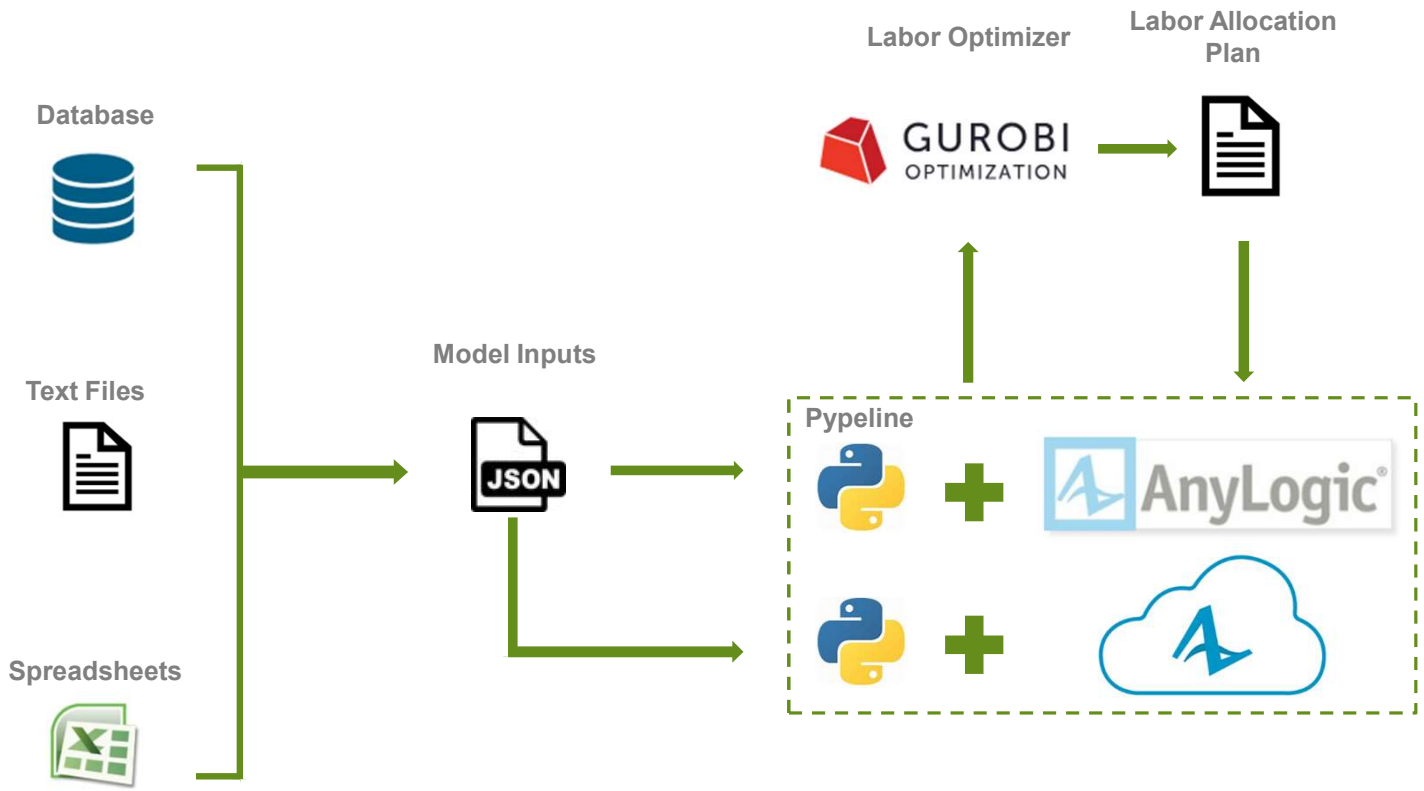
$r \in R - index\ and\ set\ of\ resources$

$j \in J - index\ and\ set\ of\ jobs$

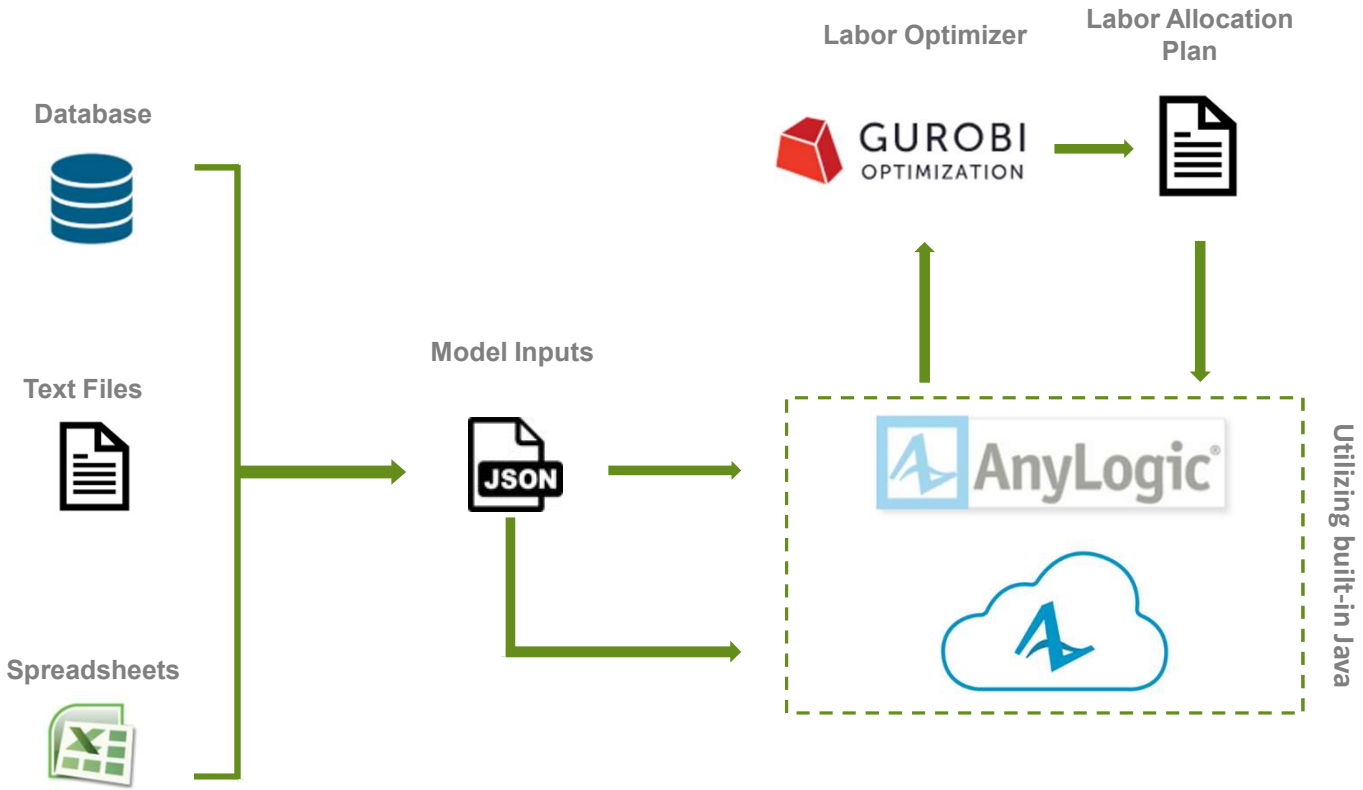
$x_{r,j} = 1\ if\ r \in R\ is\ assigned\ to\ job\ j \in J, and\ 0\ otherwise$

$x_{r,j} \rightarrow Binary\ variable$

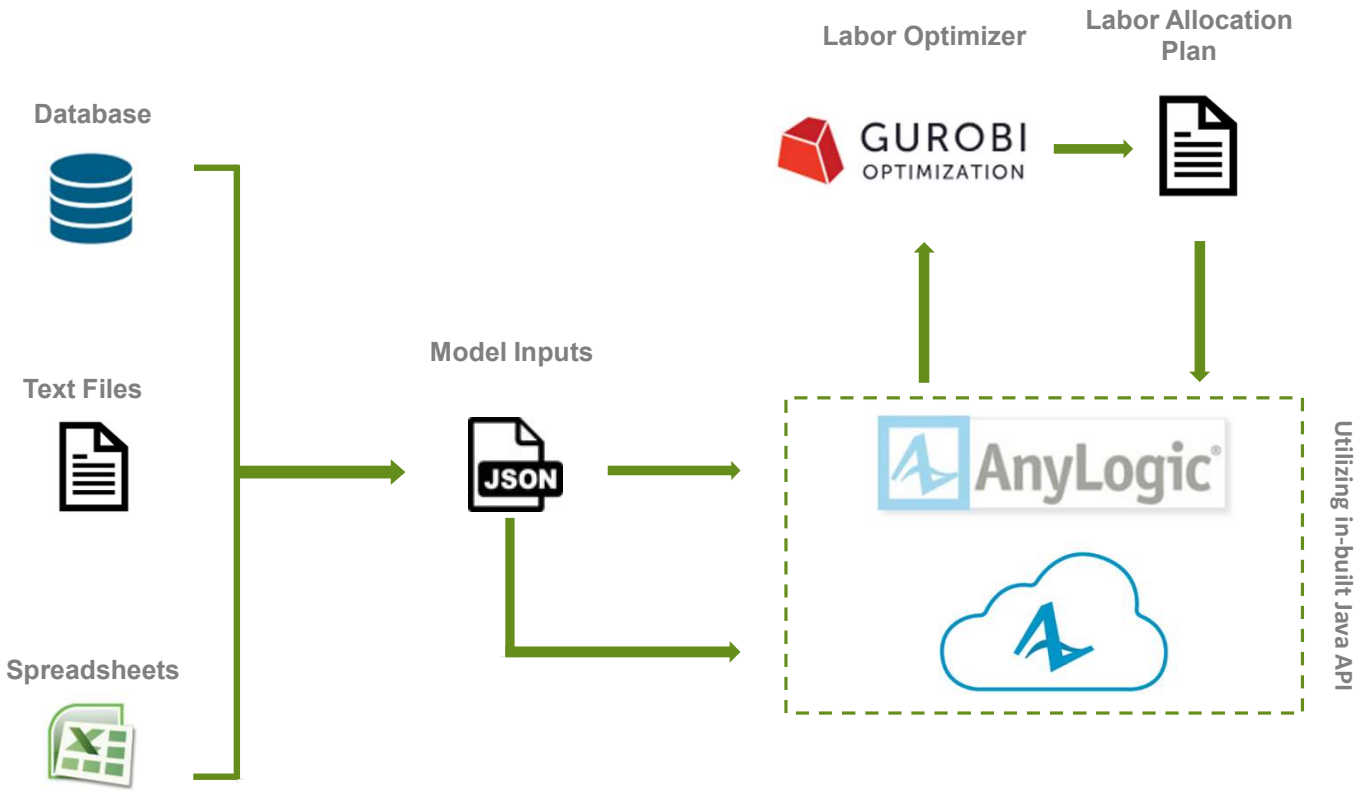
Method 1 – AnyLogic DES + External Optimizer via Pypeline



Method 2 – AnyLogic DES + External Optimizer via Java API

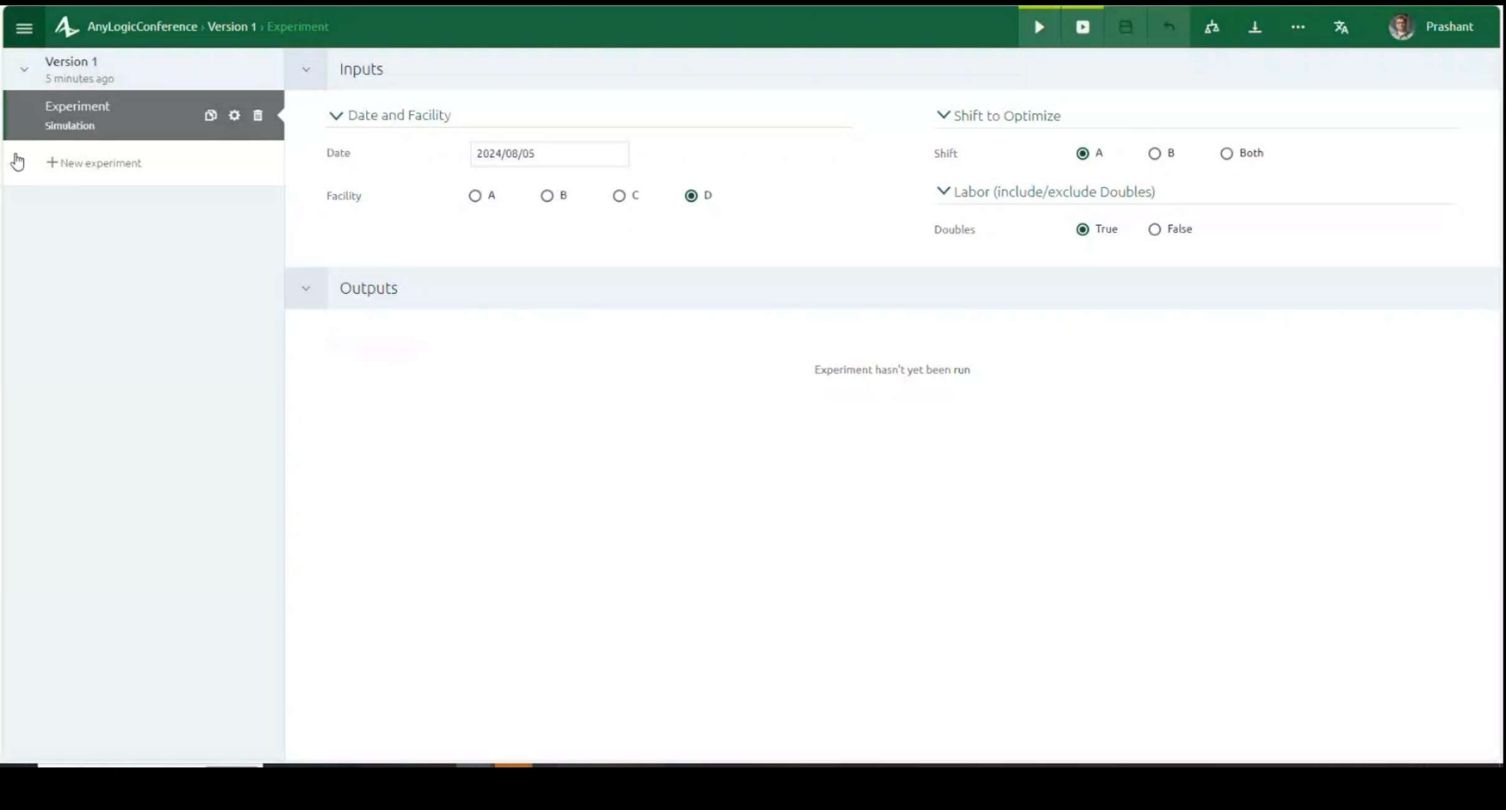


Method 2 – AnyLogic DES + External Optimizer via Java API

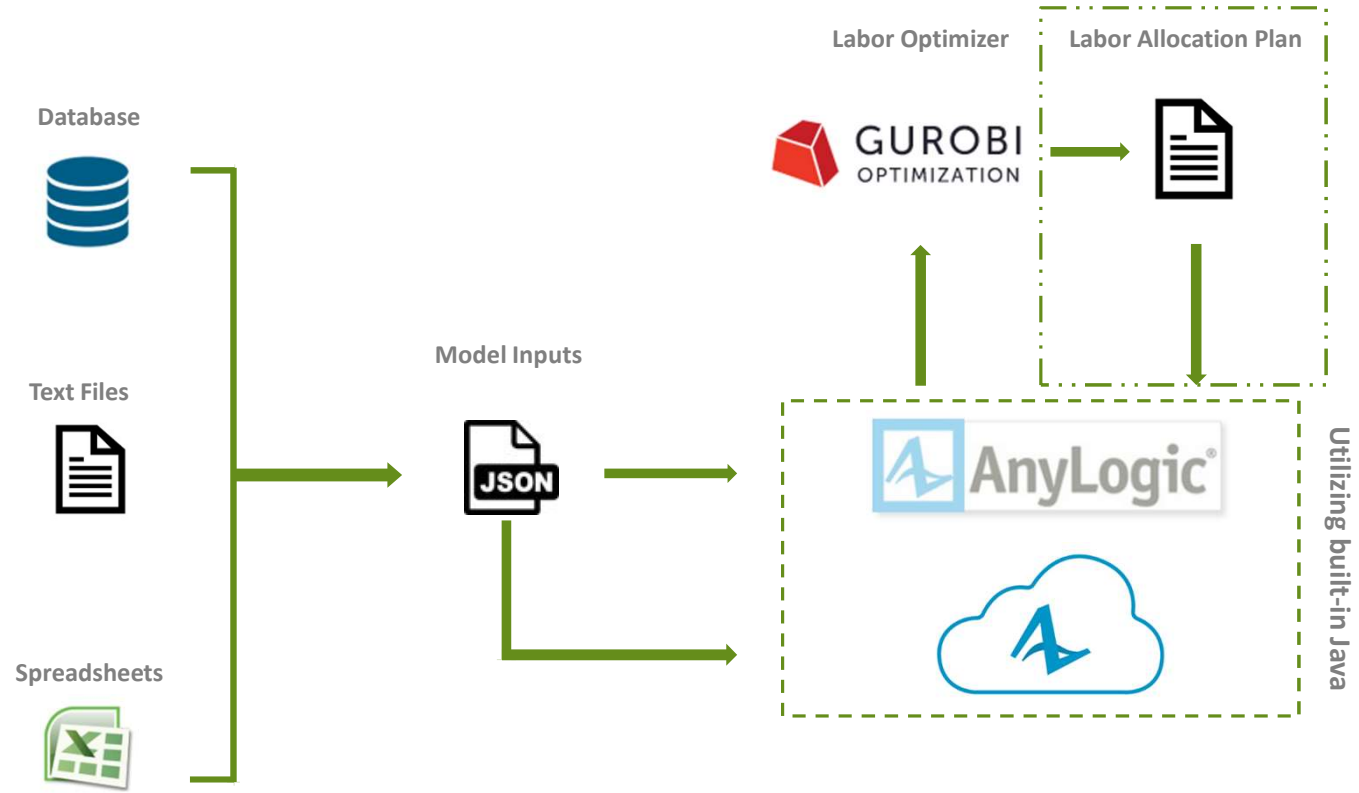



```
//Adding optimized output in AnyLogic's Database

ModelDatabase modelDB =
getEngine().getModelDatabase();

String currentDirectory =
System.getProperty("user.dir");

Database myFile = new Database(this, "sheet",
currentDirectory+"/sheet.xlsx");

modelDB.importFromExternalDB(myFile.getConnection
(), "Sheet1", "sheet1", true, false);


//Printing updated database values
List<Tuple> rows = selectFrom(sheet1)
.list();
```

Demo

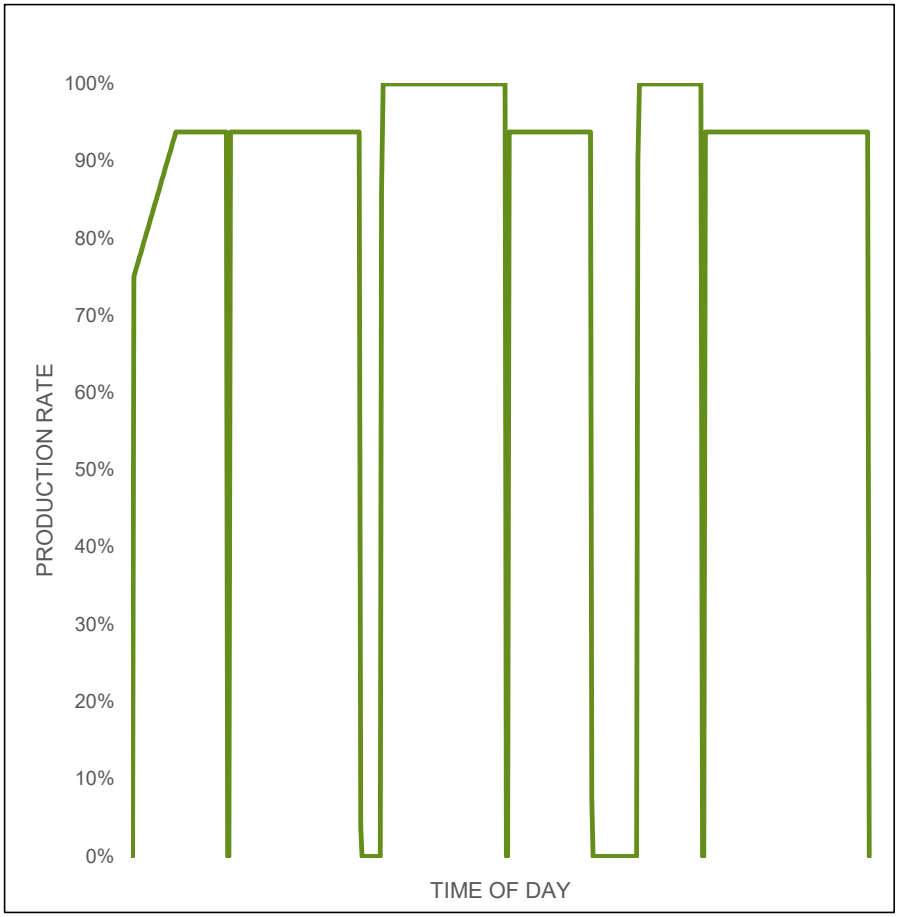

AnyLogicConference › Version 1 › Experiment
Prashant
Version 1
5 minutes ago
Experiment
Simulation
New experiment
Inputs
Date and Facility
Date
2024/08/05
Facility
A
B
C
D
Shift to Optimize
Shift
A
B
Both
Labor (include/exclude Doubles)
Doubles
True
False
Outputs
Experiment hasn't yet been run

Digital Twin + External Optimizer via Java API



Results

Digital Twin Benefits



Total Increased Production: +1.56%

1. Reduced time and impact of ramp up period
2. Eliminated ramp up period after overtime workers leave
3. Demonstrated production of higher value products and incremental margins justified use of extra labor
4. Allowed for labor-based day-of-operation adjustments
5. Increased labor management effectiveness
6. Operator safety by decreasing bottlenecks and strain

Any questions?


Cargill®