FMCG scheduling

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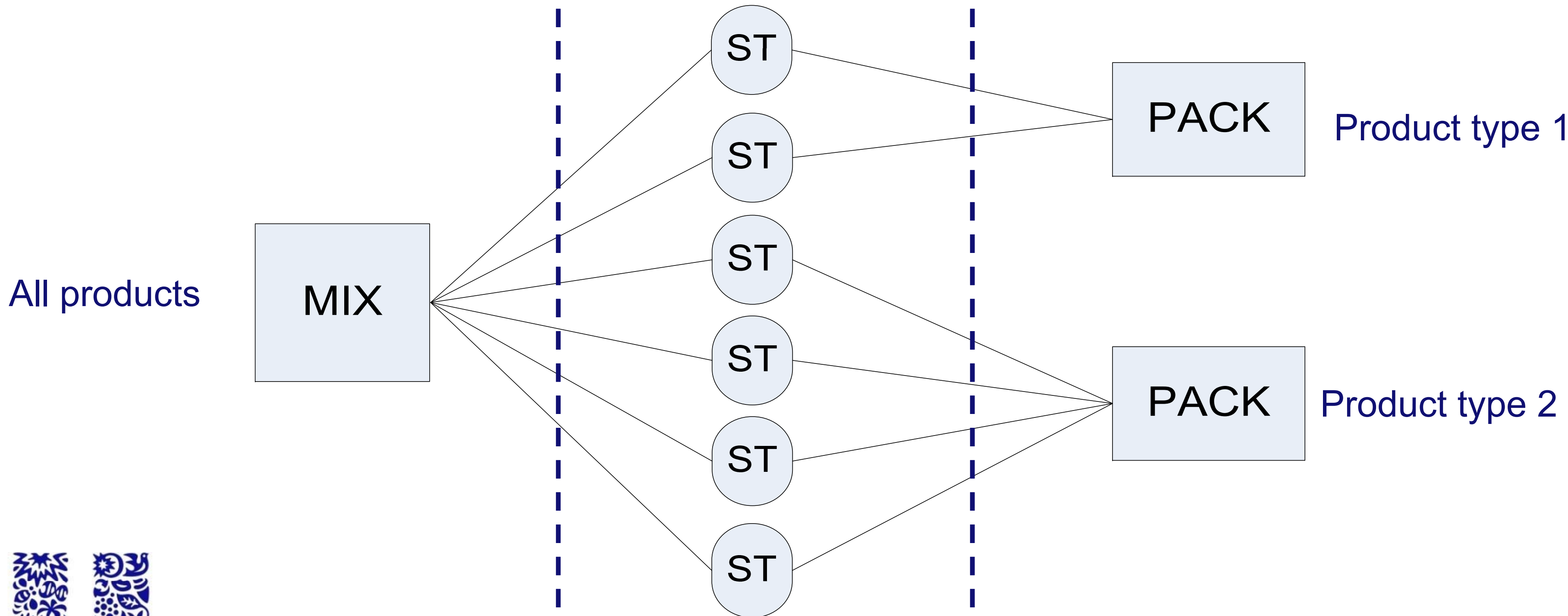
Where innovation starts

Outline

- Problem Overview
- Modeling Approach
- Results
- Future Work

Problem overview

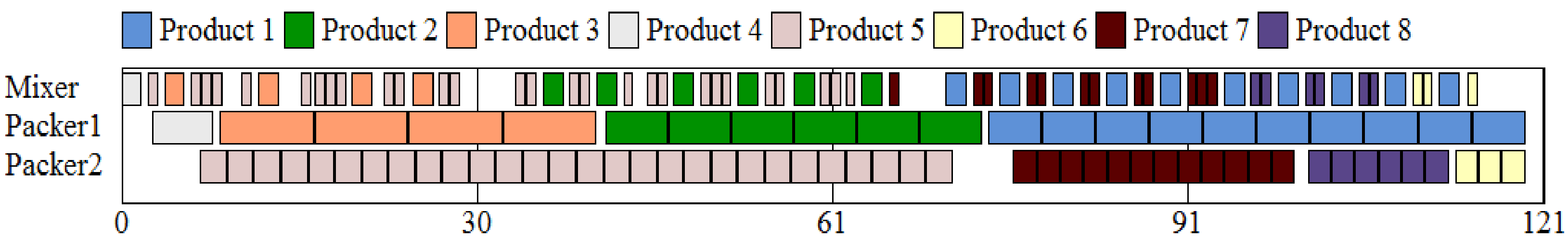
Stage 1	Intermediate Stage	Stage 2
• Mixing of products • Processing	• Intermediate Storage • Maturing	• Packing



Main Challenge

- **Large computational times**
  - **Intermediate inventory**

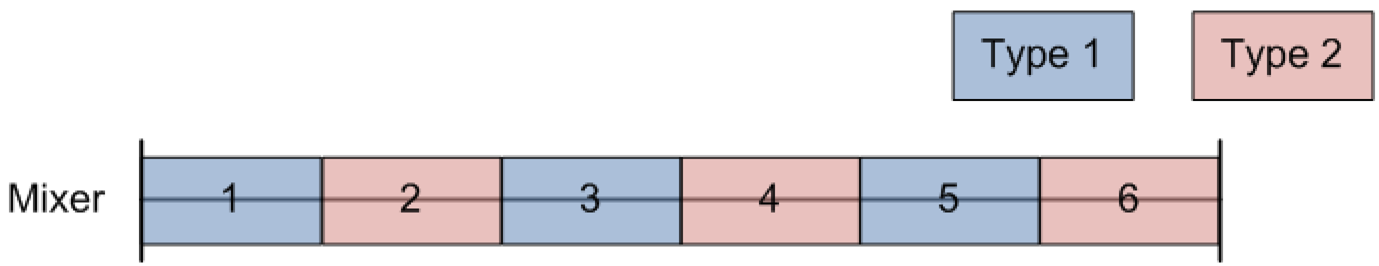
1. **Limited storage capacity ➔ Many mixer switches ➔Many periods ➔ Large models**



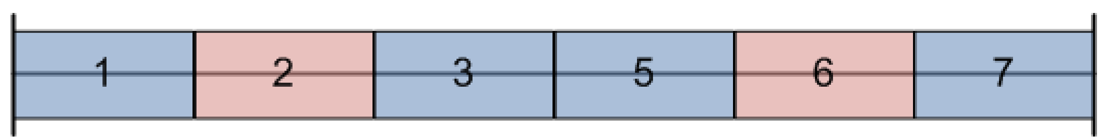
2. **Considerably more storage tanks than mixers and packers**
   – **Model size largely determined by storage stage**

Dedicated time slots

1. **Limited Storage → Many Periods → Large Models**
   - **Observation: Almost never two consecutive mixing runs of the same product class (same packer)**
   - **Dedicate product types to periods → Smaller model**

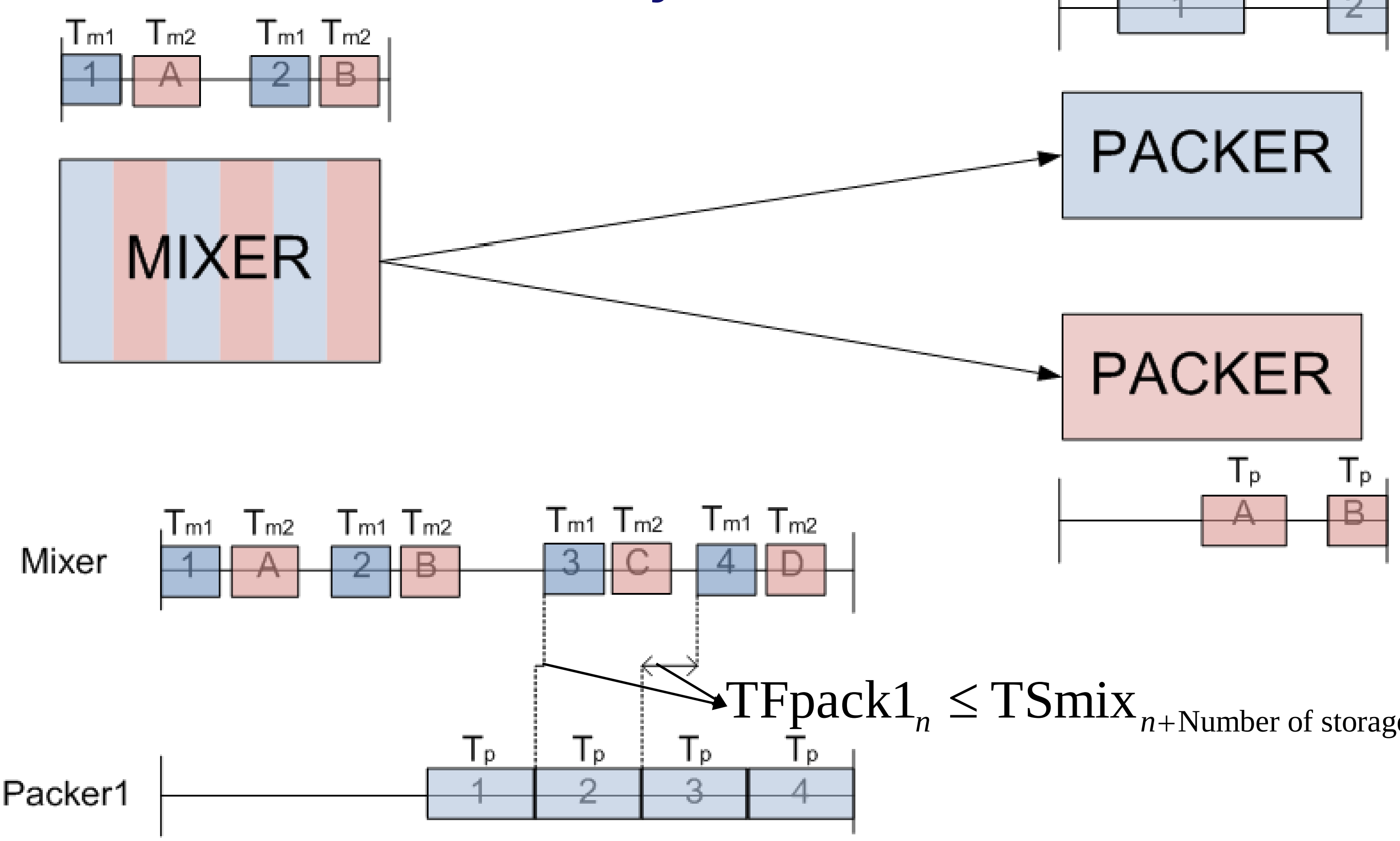


   - **Empty periods ensure flexibility**



Related Period Model

2. Model size determined by # of tanks



$$TFpack1_n \leq TSmix_{n+\text{Number of storage tanks}}$$

Results: Small Example Problems

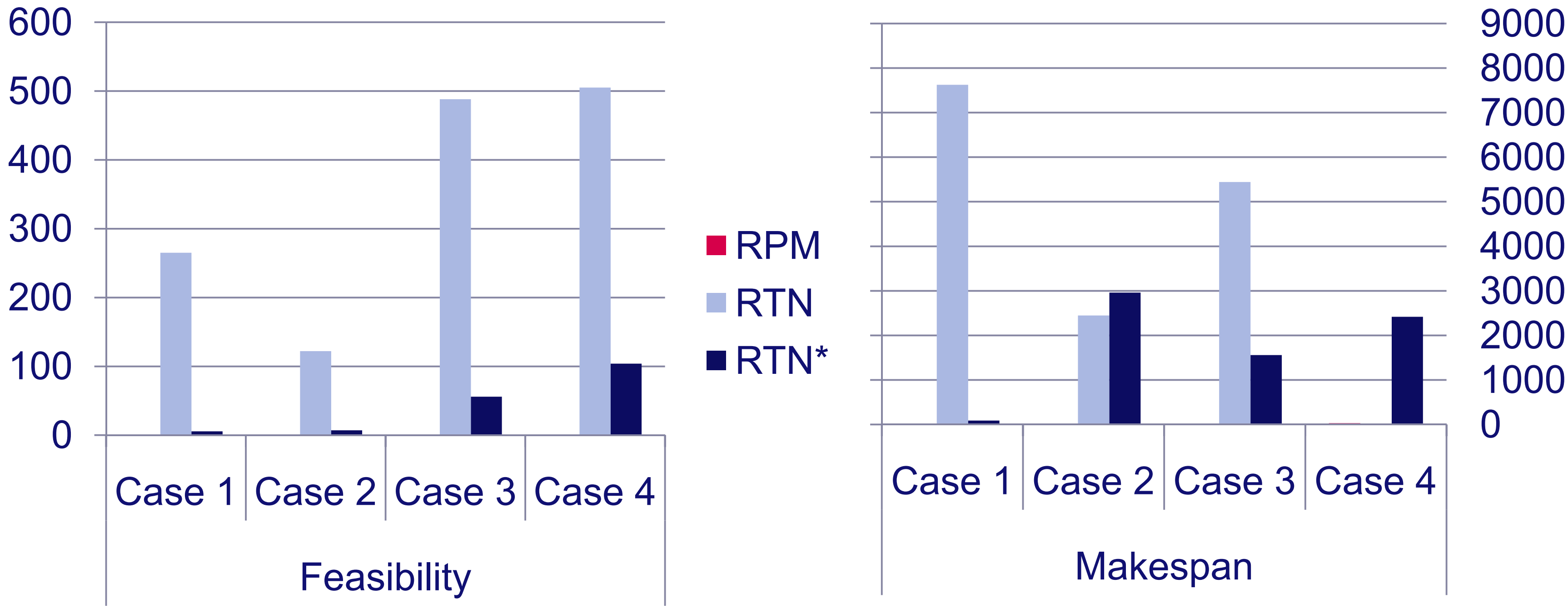
- **Horizon: 48 hours**

- **Demand**

		Case 1	Case 2	Case 3	Case 4
Product Type 1	**Product 1**	40,000	40,000	32,000	-
	Product 2	24,000	16,000	32,000	16,000
	Product 3	-	-	-	16,000
	Product 4	-	-	-	16,000
Product Type 2	**Product 5**	40,000	40,000	48,000	-
	Product 6	24,000	20,000	20,000	-
	Product 7	-	-	-	40,000
	Product 8				32,000

Results

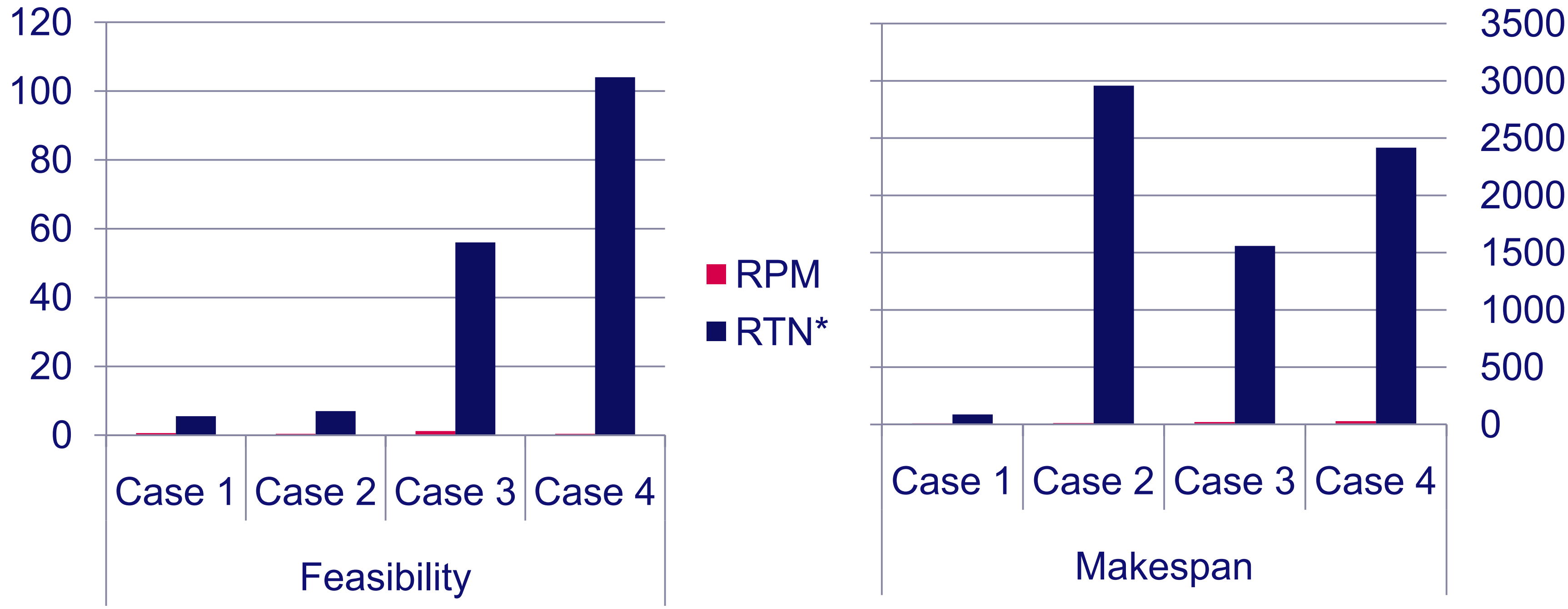
- **Required computational time**
  - **Gurobi 3.0**



  - **RTN by Shaik and Floudas (2008)**

Results

- Required computational time
  - Gurobi 3.0



  - RTN by Shaik and Floudas (2008)

Full scale example case

- Same set up: 1 mixer, 6 storage tanks, 2 packers
- 120 hour horizon
- 4 hour cleaning period every 72 hours

Product	1	2	3	4	5	6	7	8
Demand [kg]	80,000	48,000	32,000	8,000	112,000	12,000	48,000	24,000

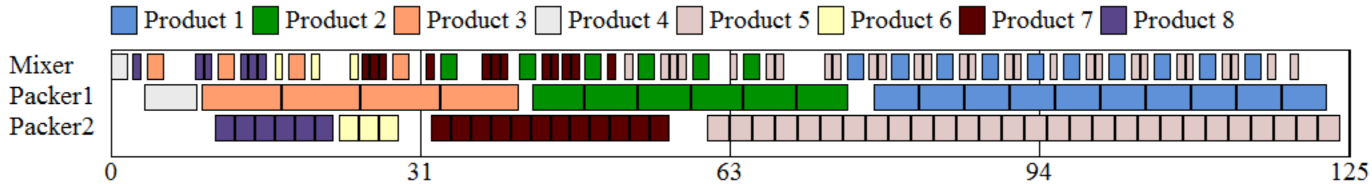
- No solution within 36 hours

Heuristics

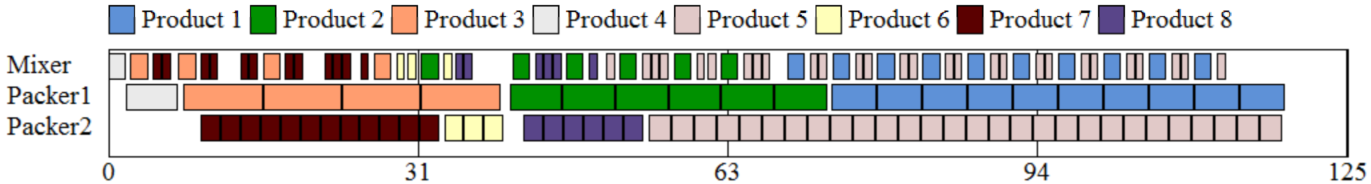
- Bottleneck
  - Minimum makespan 1st packer: 118.33 hr
  - Minimum makespan 2nd packer: 109.44 hr
- Products on the 1st packer in optimal order
  - 4-3-2-1
- Feasibility optimization: 28 hours

Algorithm

- Step 1: Order products on bottleneck stage
- Step 2: Relax horizon → feasibility optimization
  - 170s, 124.19hr makespan

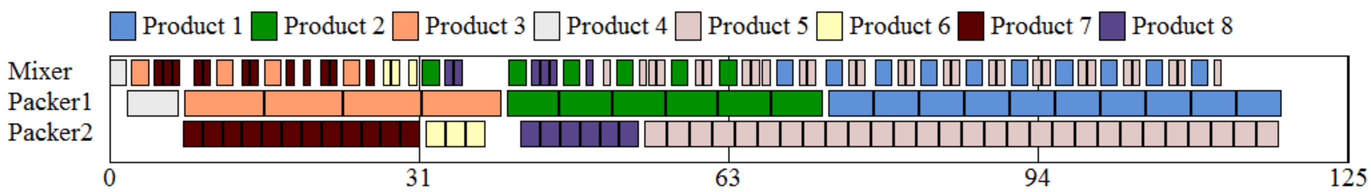


- Step 3: Fix bottleneck allocation → MS minimization
  - 358s, 118.74hr makespan



Algorithm

- Step 4: Fix 2nd half allocation → MS minimization
  - 692s, 118.33hr makespan



- For example case with algorithm
  - 528s to first feasible solution
  - 1220s to optimal solution

- No guarantee of global optimality

Conclusions

- RPM model more efficient than RTN models
  - Dedicated time periods improve efficiency
  - Indirectly modeling inventory improves efficiency

- Algorithm
  - Required for larger cases
  - Cannot guarantee global optimality
  - Gives good results within reasonable time

Future work

- **Tactical Planning model**
  - **1-1.5 year horizon**
  - **Fast moving consumer goods**
    - **Large number of products**
    - **Seasonality → Weekly time periods**
    - **Large uncertainty in demand and supply**
  - **Capacity Estimation**
    - **How to determine maximum capacity utilization?**