



# NTT Data

NTT DATA Mathematical Systems Inc.

Data & Intelligence Global One Team

NTT DATA Mathematical Systems, Inc.

## 'Optimization'

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Trusted Global Innovator

NTT DATA Group

**NTT Data**

## 1. What is Optimization

- Control & Constraint

## 2. Examples

- Production Planning ( maxworkload .vs. inventory)
- Production Planning ( costly equipment )
- Cutting Stock
- Stock Allocation

## 3. Optimization project in Reality

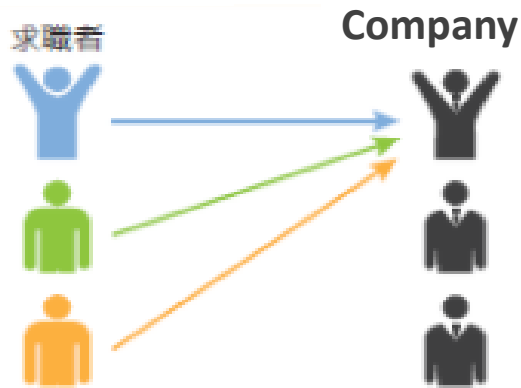
- Our Standpoint
- Manager & Practitioner
- Driver Required!
- **Let's PoC together**

# What is Optimization ?

# Constrained Recommendation

- Maximize compatibility (objective) under matching **constraint**

Job Applicant



Typical  
Recommendation

Job Applicant

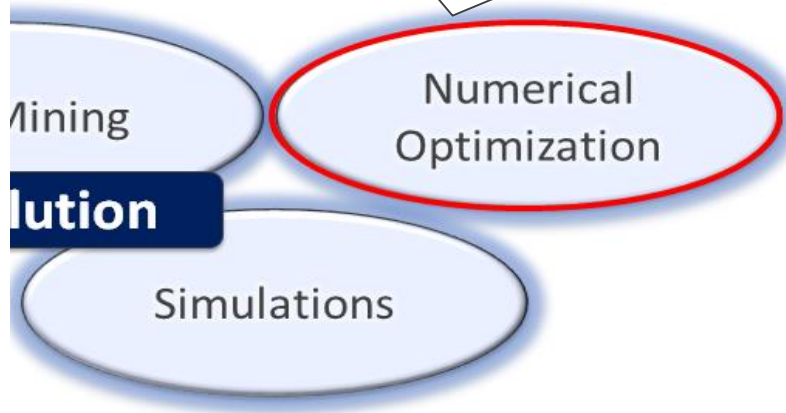


Constrained  
Recommendation

$\# \text{applicants} \geq N \ (\propto \text{pay})$   
for each Company

# What is Mathematical Optimization ?

Find the optimal **CONTROL** or **DECISION**  
that satisfies **CONSTRAINTS**



# Examples

# Production management (Orders with various due date)

	A	B	C	D	E	F
1	Date	due	amount	natural production Date	push forward	optimal production Date
174	9 th-Day	3 days after	3units	11 th-Day	0Days	11 th-Da
175	9 th-Day	4 days after	12units	12 th-Day	0Days	12 th-Da
176	9 th-Day	5 days after	32units	13 th-Day	0Days	13 th-Da
177	9 th-Day	6 days after	16units	14 th-Day	0Days	14 th-Da
178	9 th-Day	7 days after	16units	15 th-Day	0Days	15 th-Da
179	9 th-Day	8 days after	8units	16 th-Day	0Days	16 th-Da
180	9 th-Day	9 days after	7units	17 th-Day	0Days	17 th-Da
181	9 th-Day	10 days after	1units	18 th-Day	0Days	18 th-Da
182	10 th-Day	1 days after	3units	10 th-Day	0Days	10 th-Da
183	10 th-Day	2 days after	4units	11 th-Day	0Days	11 th-Da
184	10 th-Day	3 days after	6units	12 th-Day	0Days	12 th-Da
185	10 th-Day	4 days after	15units	13 th-Day	0Days	13 th-Da
186	10 th-Day	5 days after	24units	14 th-Day	0Days	14 th-Da
187	10 th-Day	6 days after	17units	15 th-Day	0Days	15 th-Da
188	10 th-Day	7 days after	16units	16 th-Day	0Days	16 th-Da
189	10 th-Day	8 days after	7units	17 th-Day	0Days	17 th-Da
190	10 th-Day	9 days after	5units	18 th-Day	0Days	18 th-Da
191	10 th-Day	10 days after	3units	19 th-Day	0Days	19 th-Da
192	11 th-Day	1 days after	21units	11 th-Day	0Days	11 th-Da
193	11 th-Day	2 days after	8units	12 th-Day	0Days	12 th-Da
194	11 th-Day	3 days after	20units	13 th-Day	0Days	13 th-Da
195	11 th-Day	4 days after	35units	14 th-Day	0Days	14 th-Da
196	11 th-Day	5 days after	64units	15 th-Day	0Days	15 th-Da

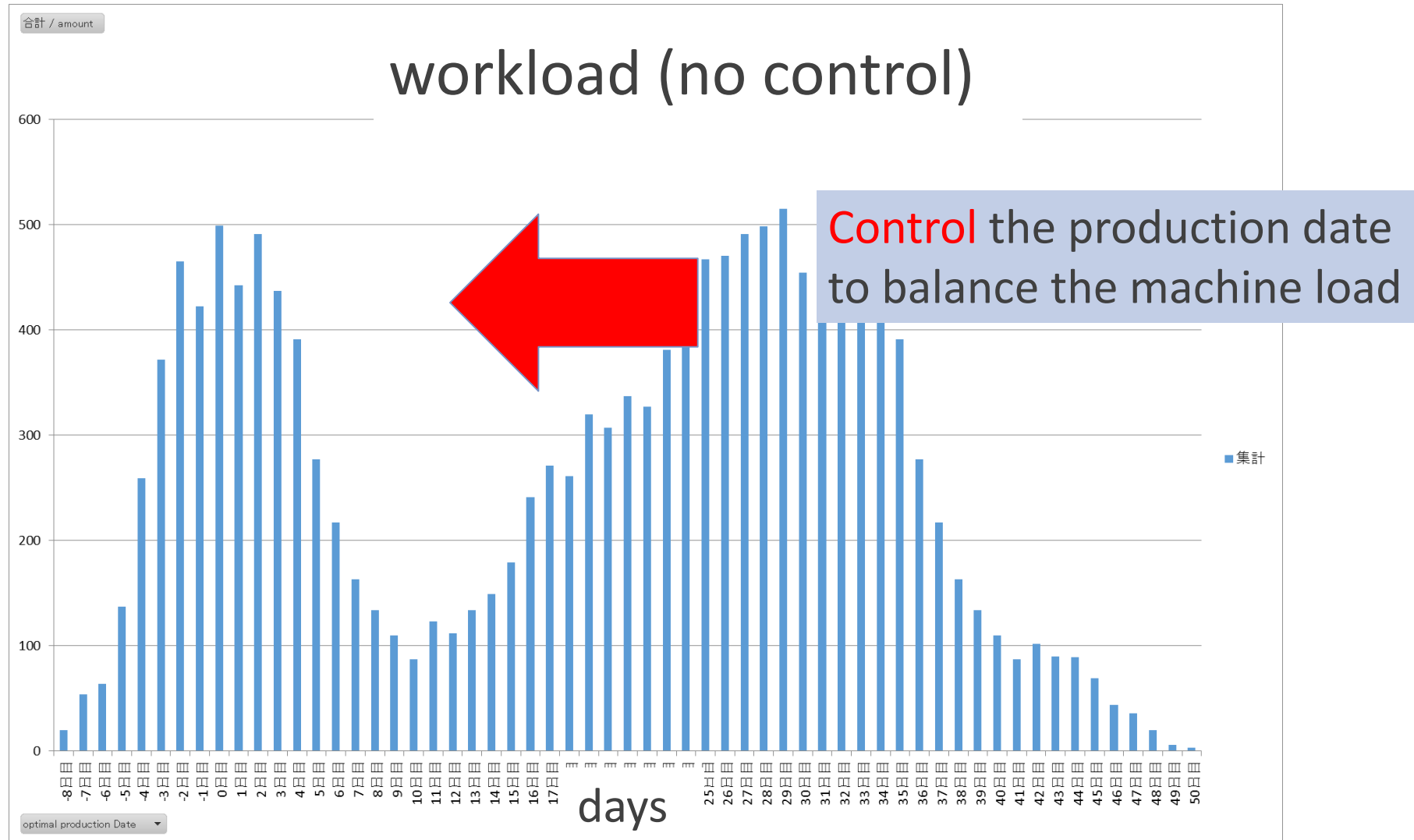
# Production management (Orders with various due date)

	A	B	C	D	E	F	G	H	I	J	K
1	合計 / amount	列ラベル									
2	行ラベル	1 days after	2 days after	3 days after	4 days after	5 days after	6 days after	7 days after	8 days after	9 days after	10 days after
15	4 th Day	5	8	3	14	25	22	13	5	1	4
16	5 th Day	3	5	5	17	25	17	7	6	6	9
17	6 th Day	7	6	4	8	22	27	7	7	7	5
18	7 th Day	3	4	10	9	27	26	11	2	1	7
19	8 th Day	3	7	5	19	25	14	11	5	5	6
20	9 th Day	3	2	3	12	32	16	16	8	7	1
21	10 th Day	3	4	6	15	24	17	16	7	5	3
22	11 th Day	21	8	20	35	64	63	42	7	16	24
23	12 th Day	14	12	15	28	66	70	43	18	13	21
24	13 th Day	13	10	16	47	64	58	50	15	11	16
25	14 th Day	20	10	14	37	66	79	36	9	12	17
26	15 th Day	17	10	14	34	74	71	34	15	16	15
27	16 th Day	5								12	14
28	17 th Day	13								15	17
29	18 th Day	14								15	20
30	19 th Day	16	9	17	46	74	59	47	6	13	13
31	20 th Day	22	22	28	78	121	119	59	21	17	13
32	21 th Day	29	17	25	61	118	118	70	26	22	14
33	22 th Day	24	26	25	76	118	108	70	15	18	20
34	23 th Day	20	23	18	69	110	107	78	30	26	19
35	24 th Day	31	24	24	77	105	111	69	23	18	18
36	25 th Day	22	18	28	69	120	117	79	10	17	20
37	26 th Day	26	23	24	81	98	116	53	26	28	25
38	27 th Day	21	30	27	52	115	111	71	17	31	25
39	28 th Day	37	23	22	59	118	120	61	23	20	17
40	29 th Day	25	19	18	65	125	118	75	14	22	19

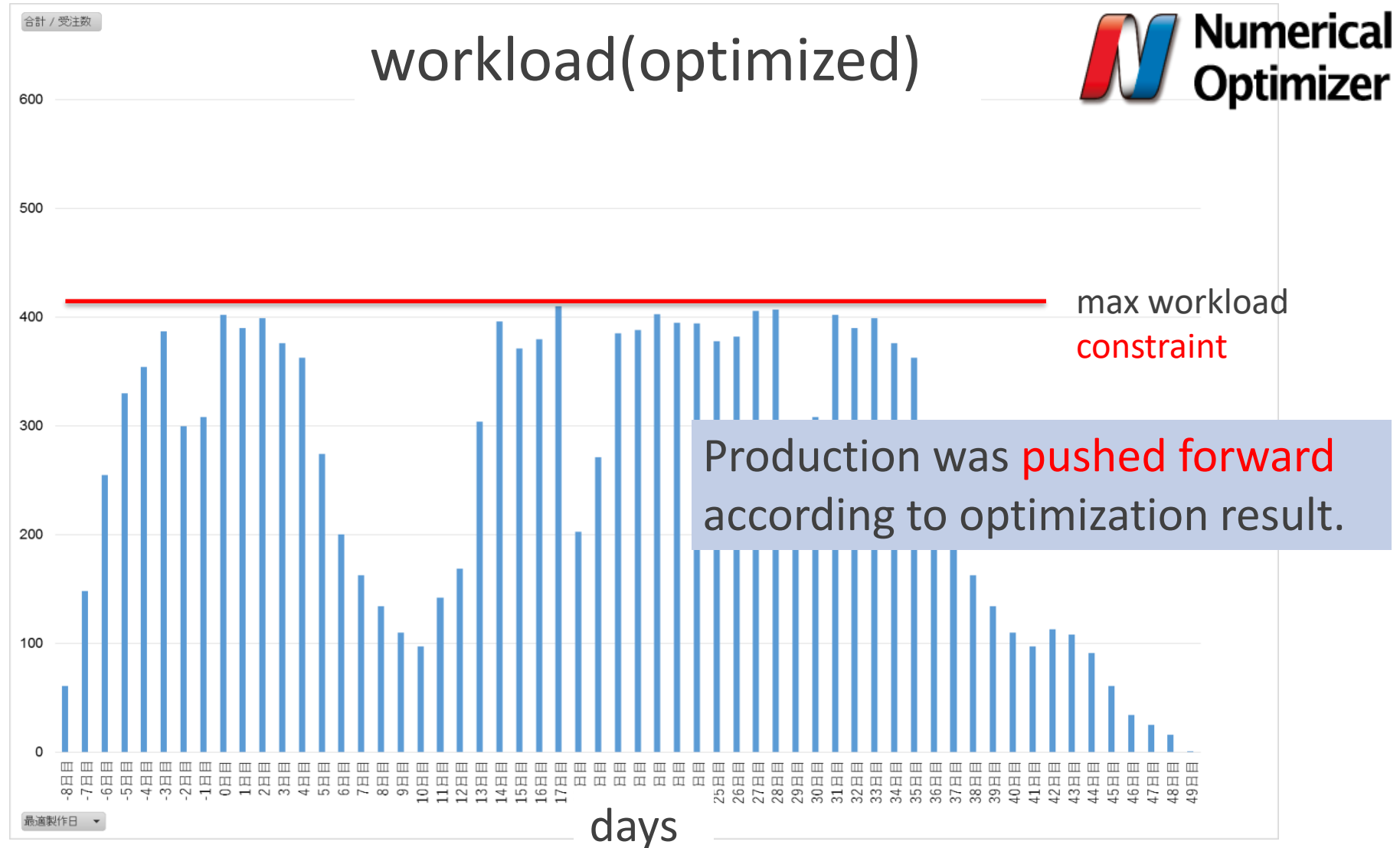
When to produce ?



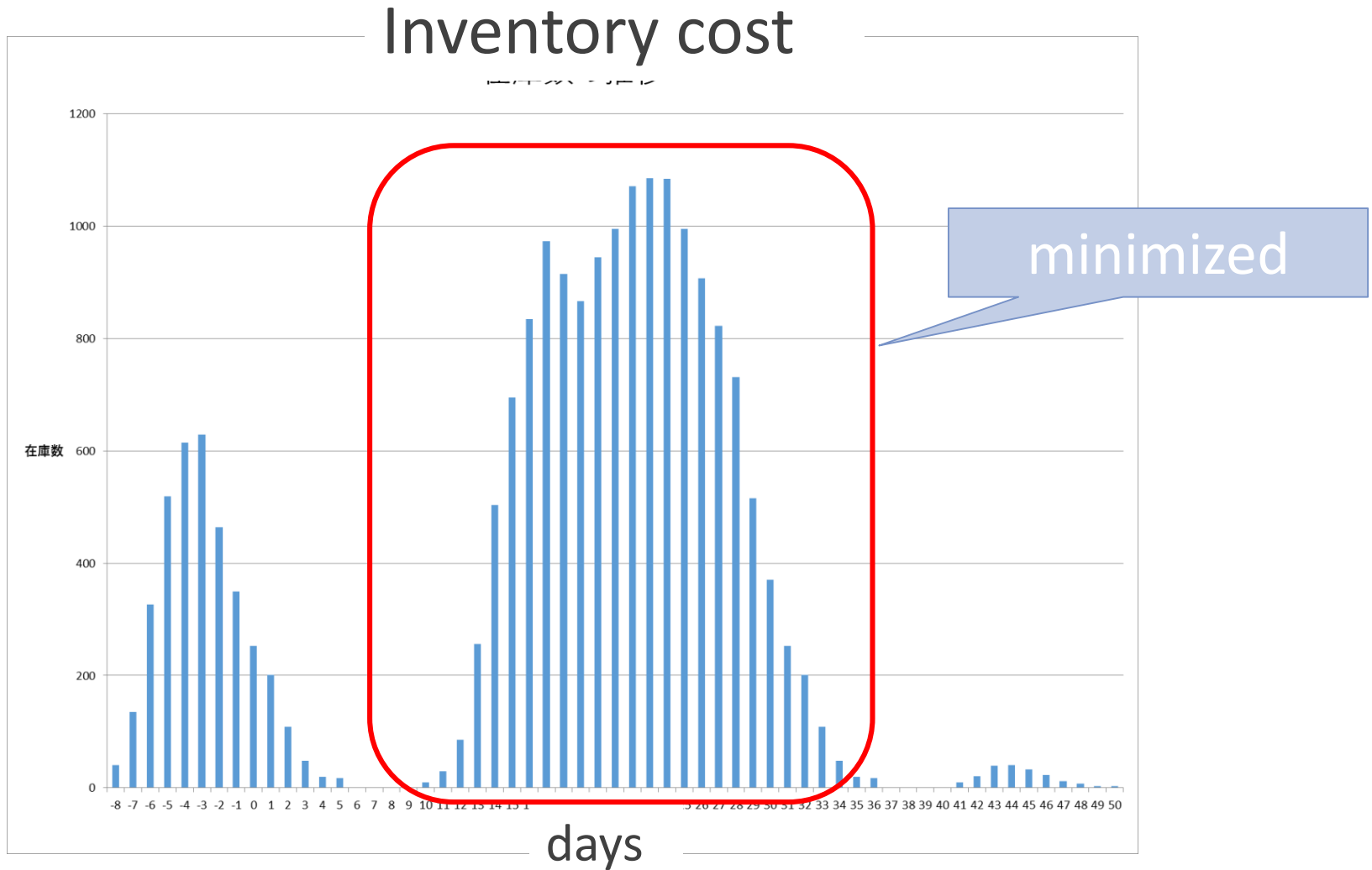
# Production planning : Balance workload ?



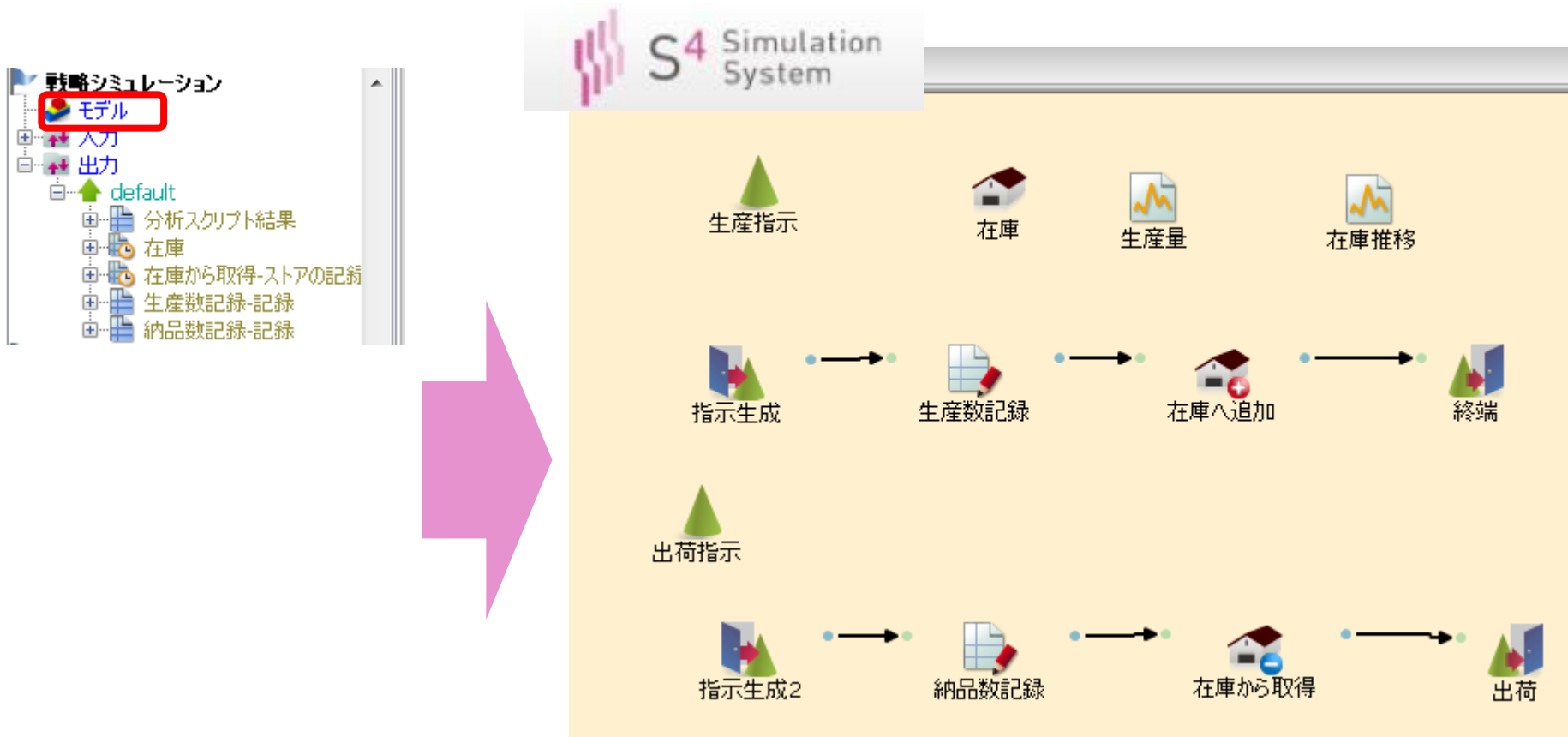
# Production planning : Constrain the workload



# Production planning : Inventory minimized

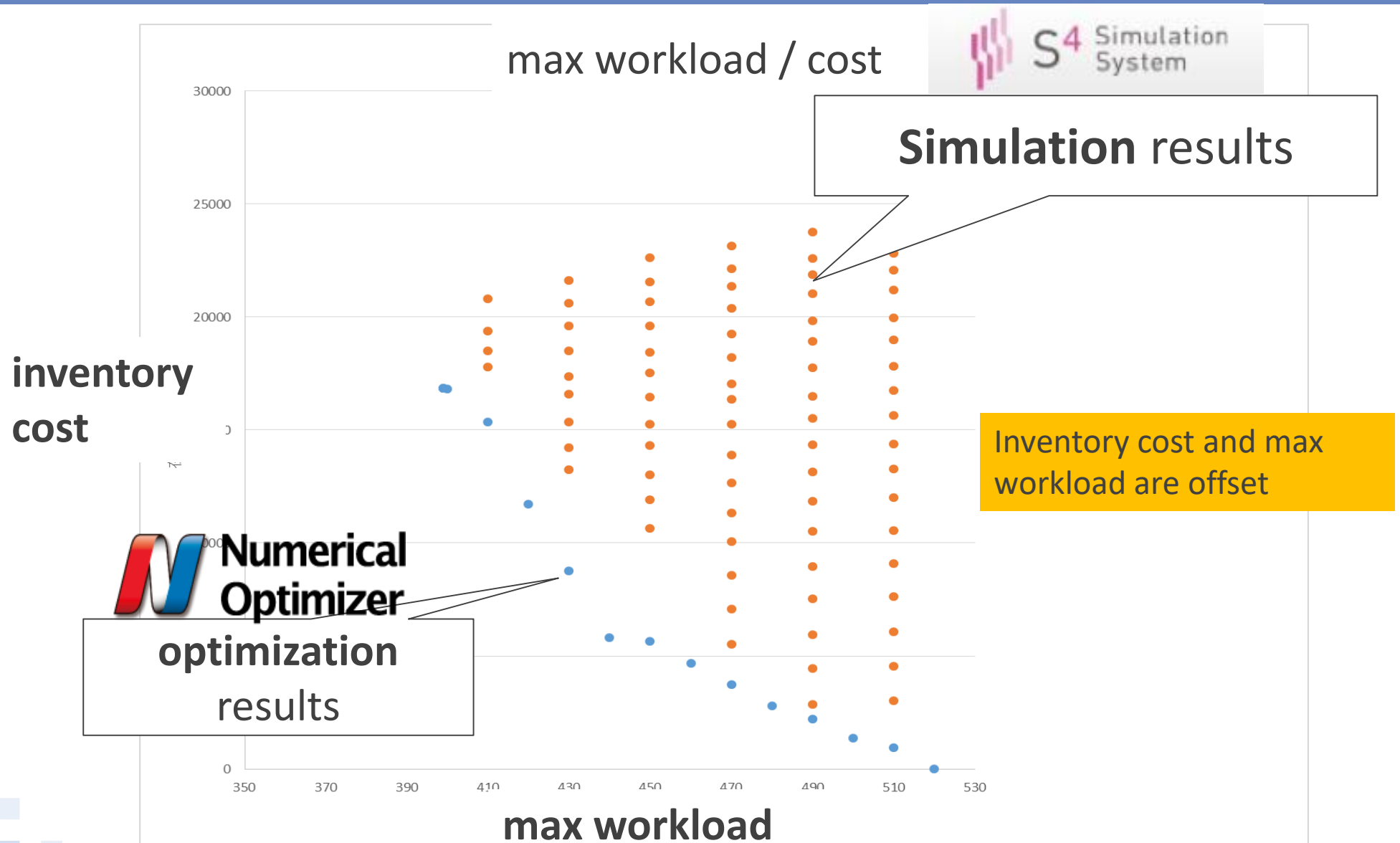


# Greedy strategy tested with Our Simulation Tool S4



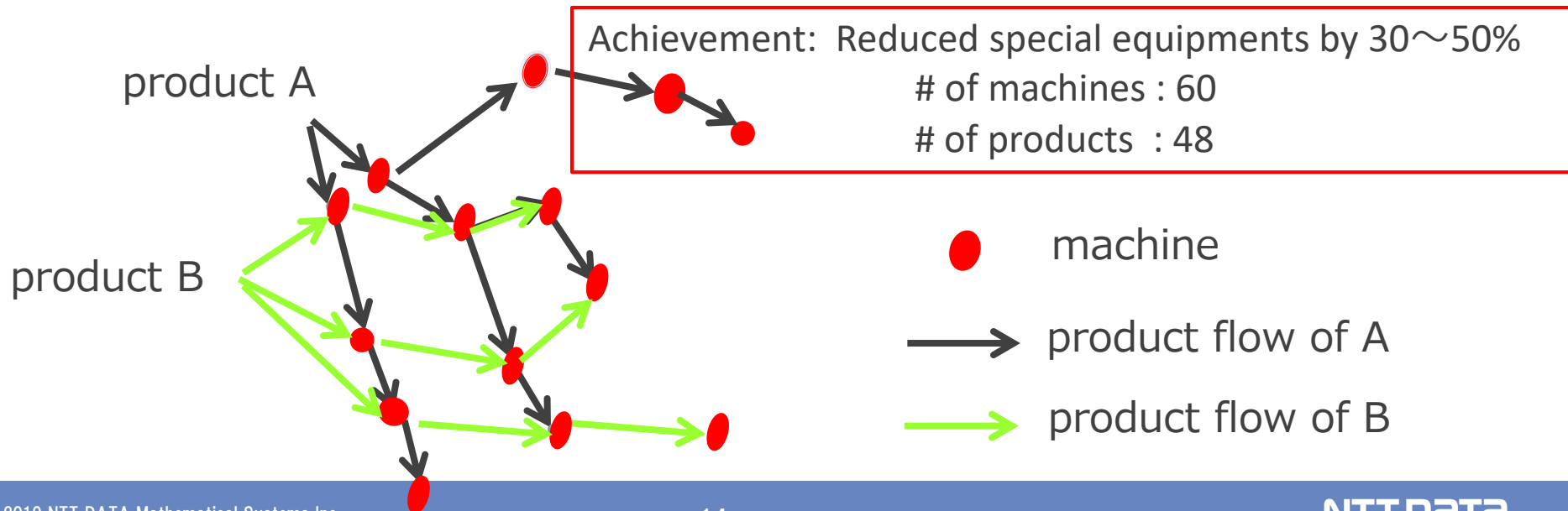
Push forward **all** the production to the workload limit !  
With various inventory maximum (parameter)

# Simulation and Optimization



# Production Resource Planning at a Japanese Manufacturer (2013-)

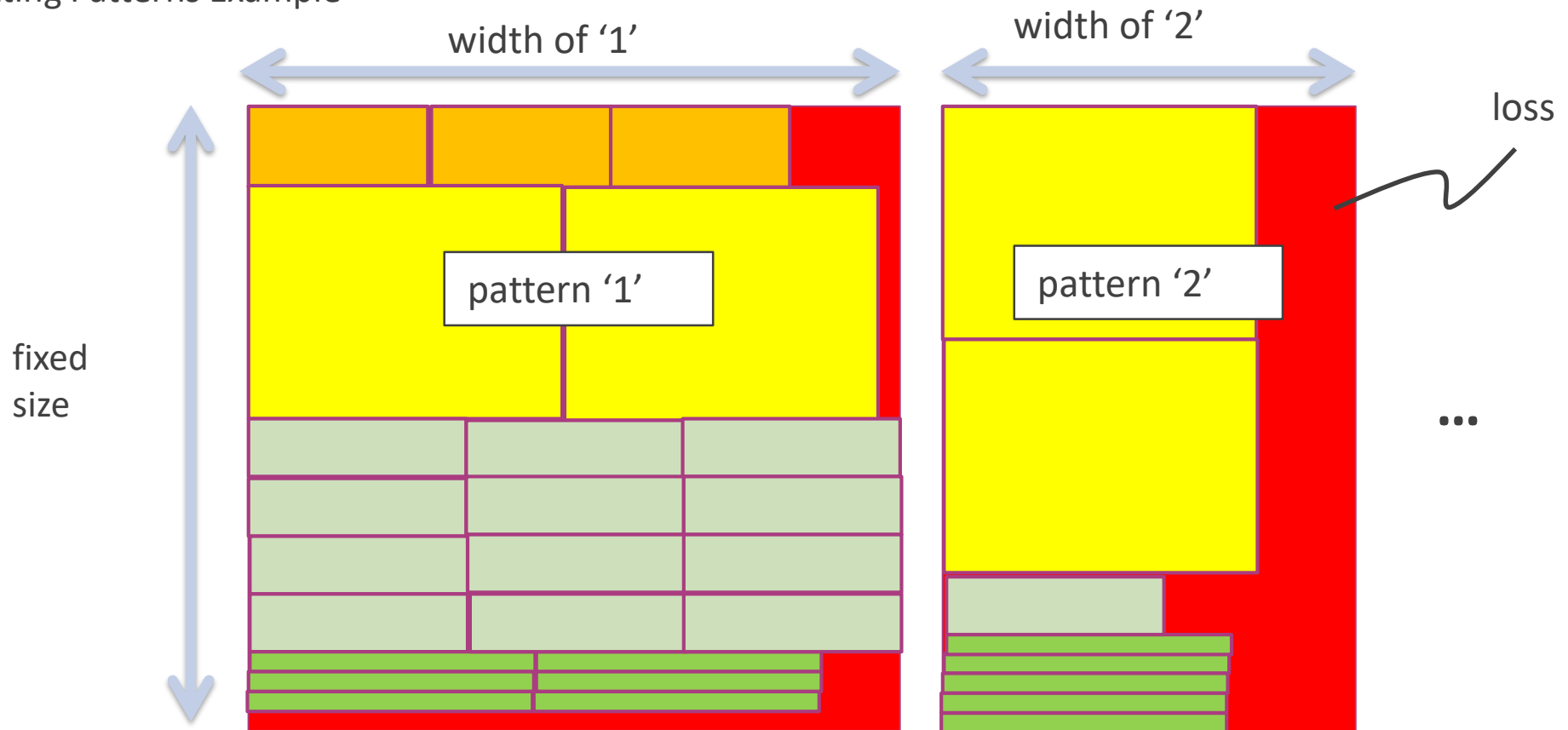
- ✓ You can **control** the product flow
- ✓ Each product requires certain machine resources we should allocate
- ✓ Each machine needs costly **special equipment** to handle each product's process
- ✓ Reduce equipment keeping the production output within the available machine resource



# A Cutting Stock Problem for Film Manufacturer (2017-)

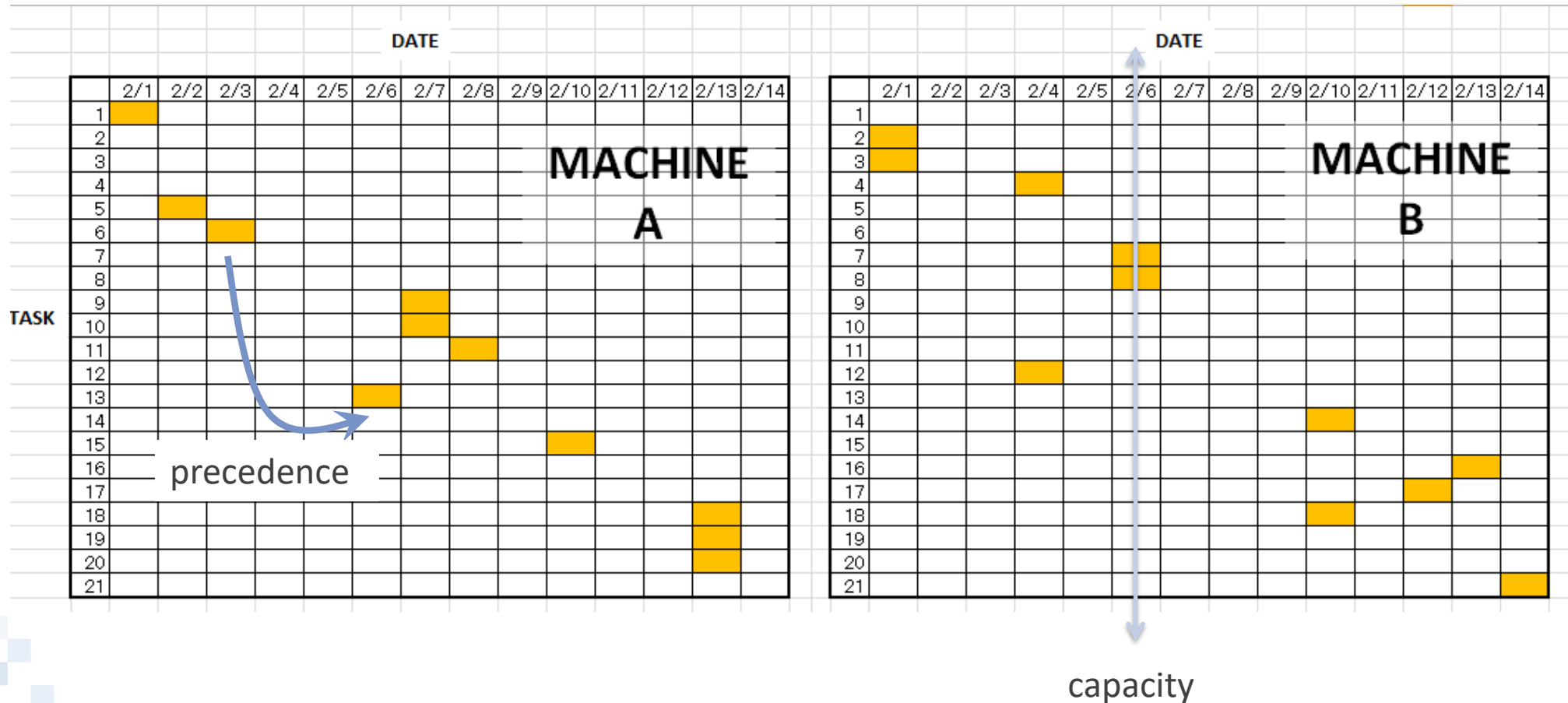
- ✓ **Determine** Cutting Pattern (2D region tiled by rectangular products)
- ✓ Product requirement constrained
- ✓ Reduce (# of Cutting Pattern)  $\Leftrightarrow$  (amount of loss)

Cutting Patterns Example



# Data Maintenance Schedule for IT company (2018-)

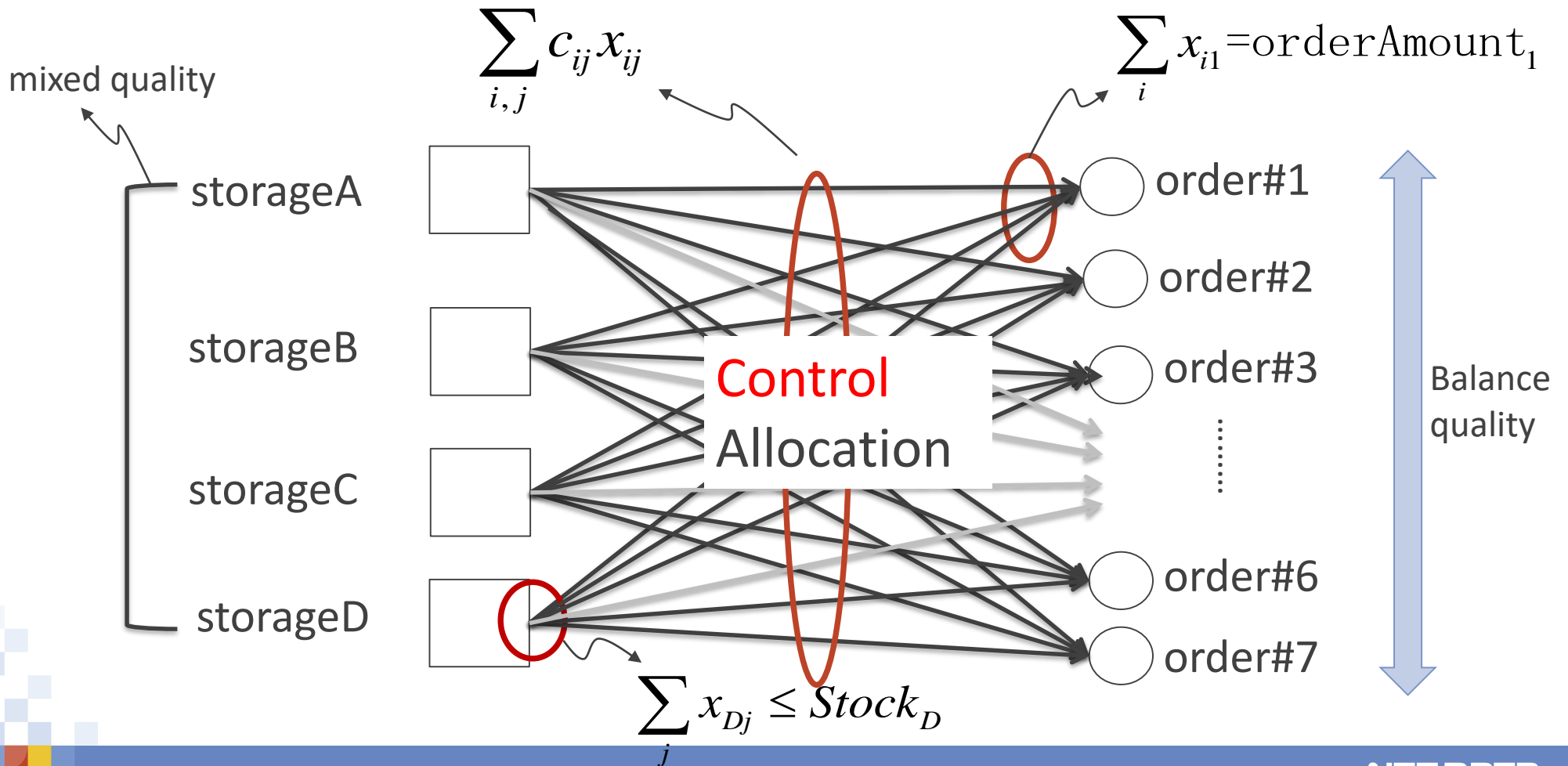
- ✓ **Assign** Data maintenance/counting task (#500) to either of 2 machines
- ✓ Due date / precedence / capacity constraint should be fulfilled.



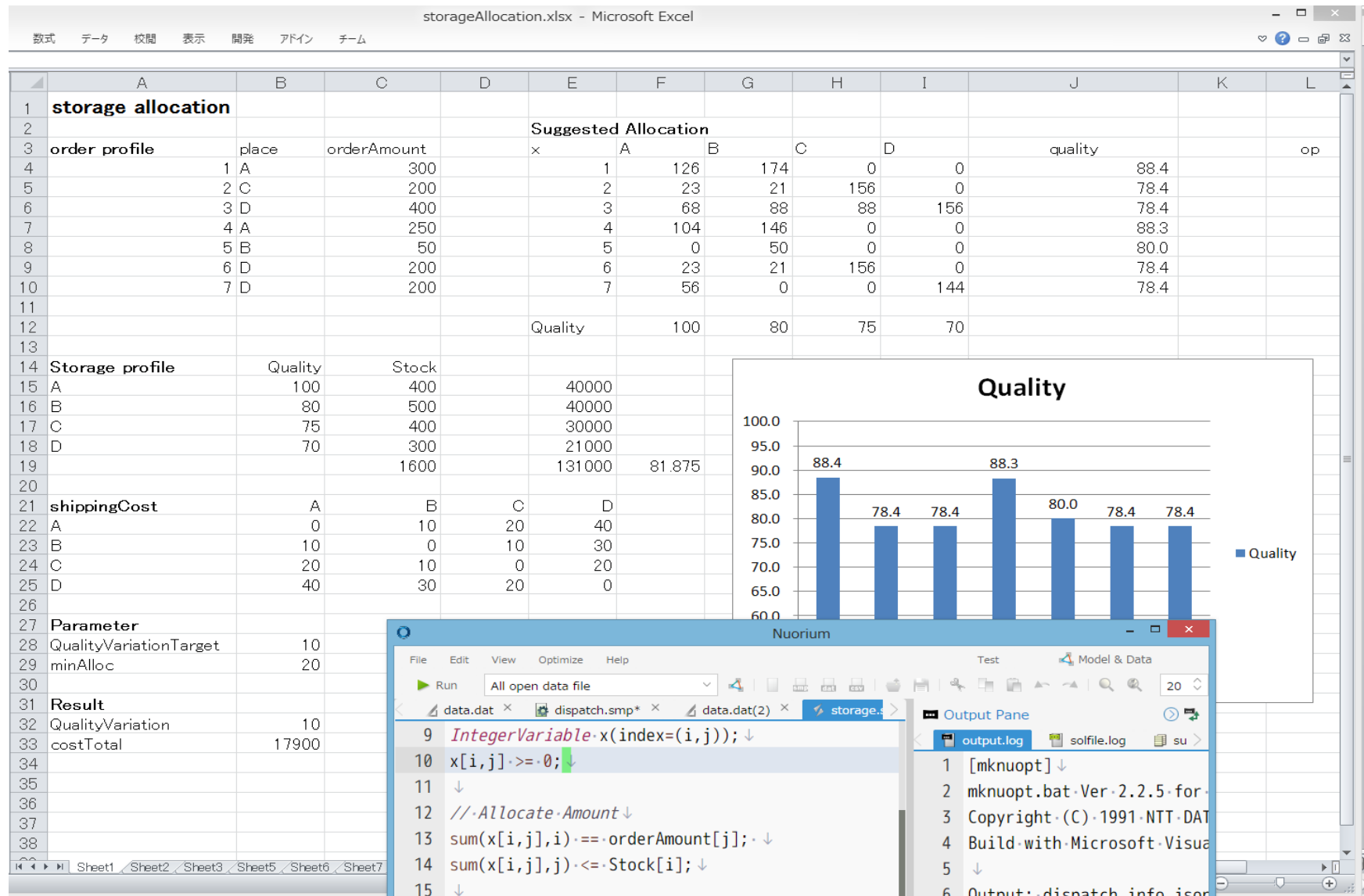


# Stock allocation

- ✓ **Control** stock allocation for orders at {A,B,C,D}
- ✓ Allocate from neighbouring storage is cost-minimum
- ✓ Quality balance offsets shipping cost



# Stock allocation demo



# Optimization in Reality

# Our Standpoint

Solve real world problem for business practitioners

⇒ Our packaged softwares are 'stock in trade' for this purpose  
(Numerical Optimizer  is one of them)

**Business  
Practitioners**



**MSI**



**Academia**



Business  
requirements



software

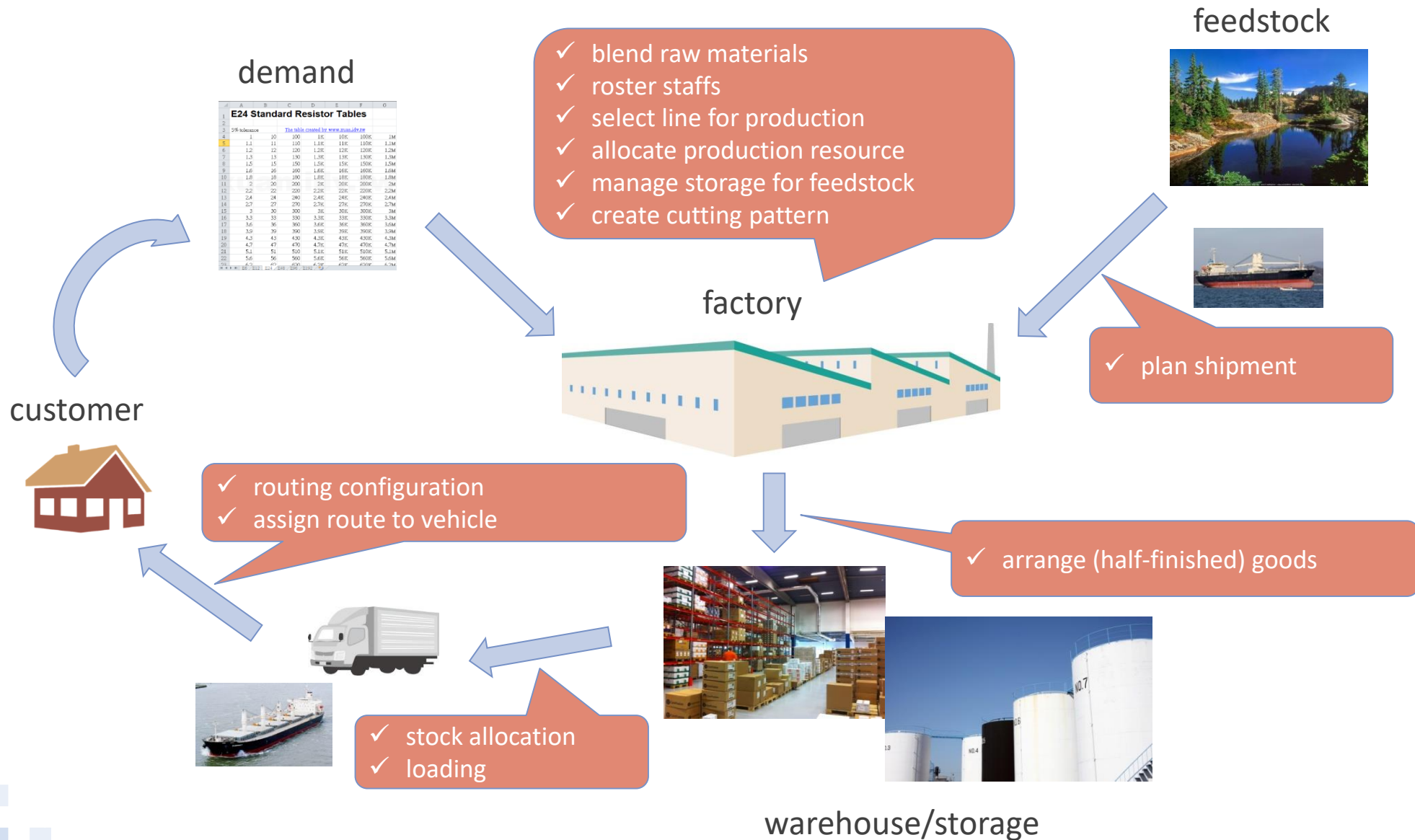
mathematical  
models



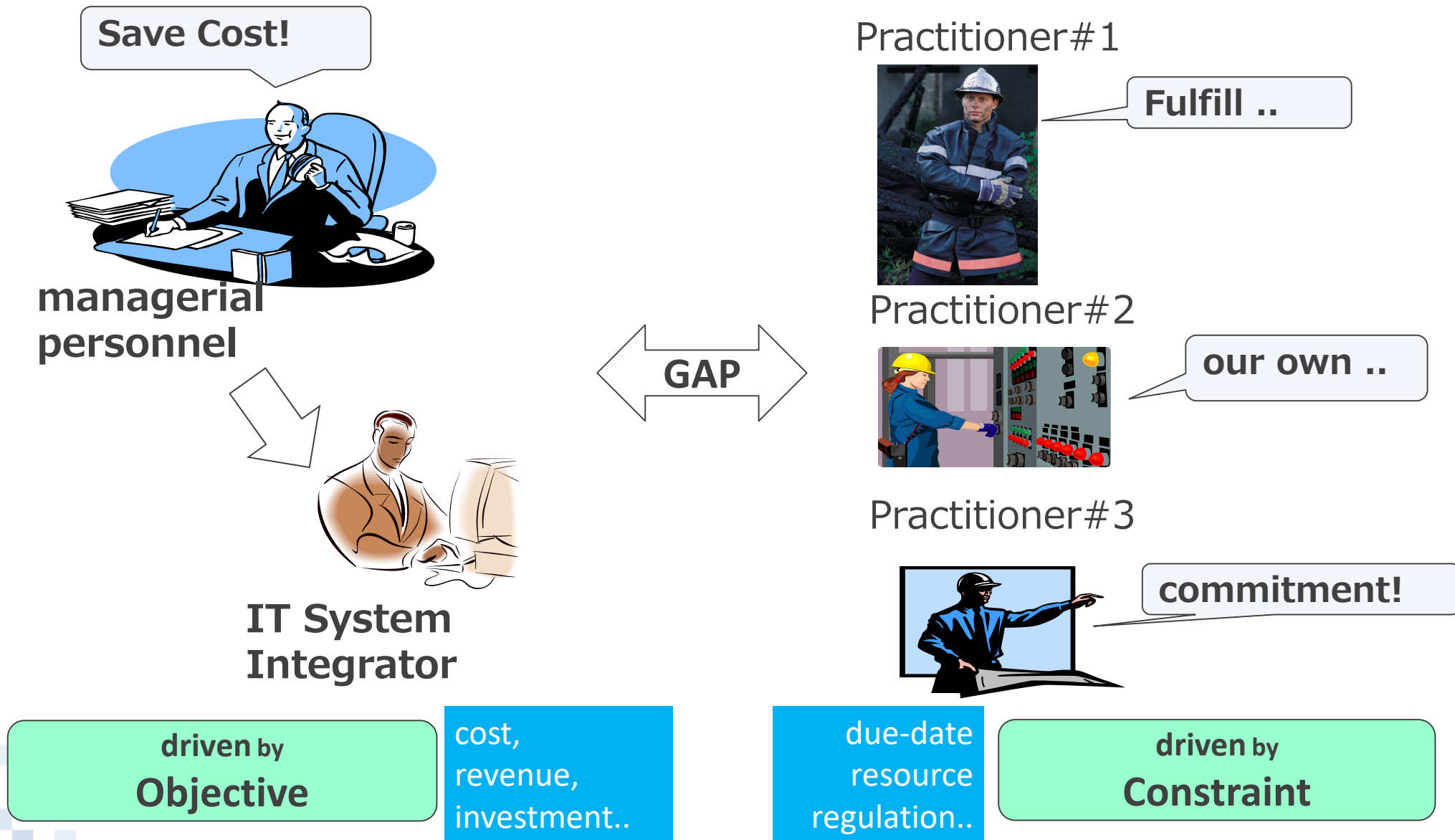
algorithms

theories

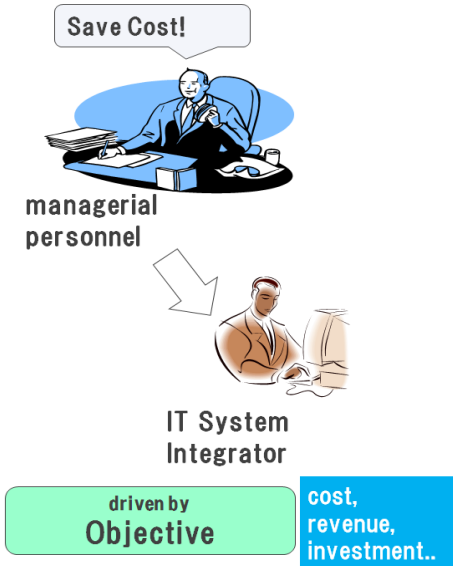
# 'Optimization' everywhere ! (supply chain)



# Managers and Practitioners



# Traditionally in Japan ..



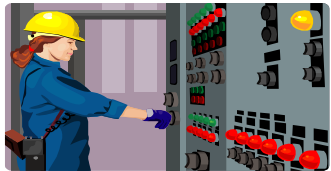
untouchable

Practitioner# 1



Fulfill ..

Practitioner# 2



our own ..

Practitioner# 3



commitment!

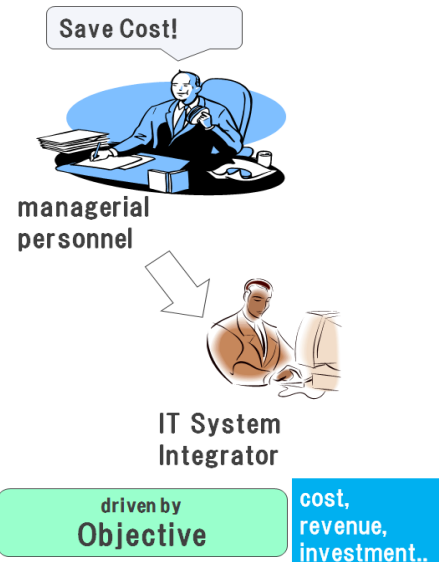
due-date  
resource  
regulation..

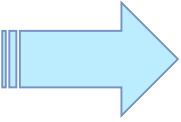
driven by  
**Constraint**

But ..

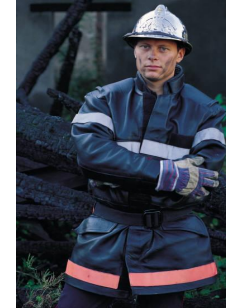
## Mathematical Optimization

  
appeals!



  
untouchable

Practitioner#1



Fulfill ..

Practitioner#2



our own ..

Practitioner#3



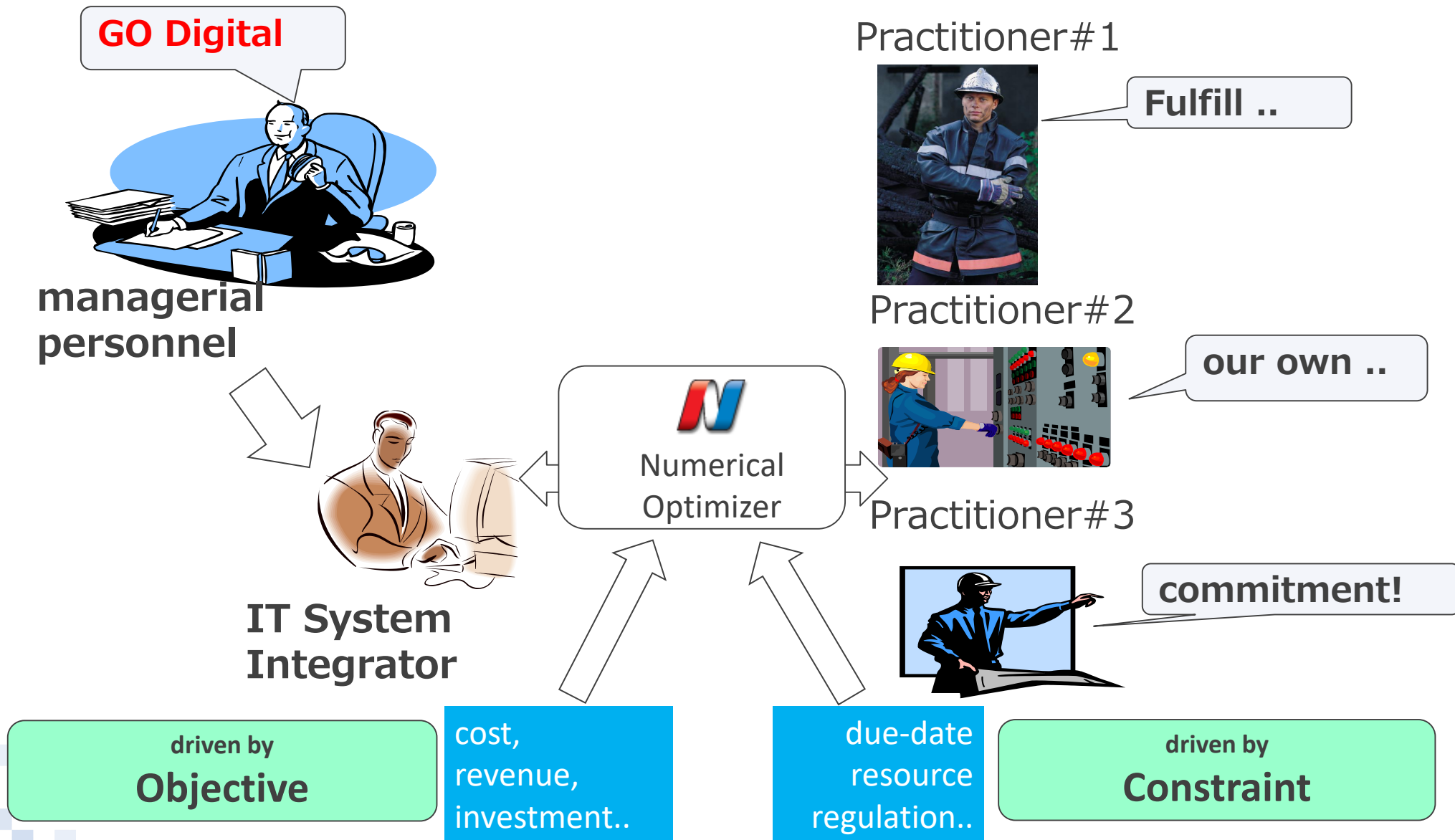
commitment!

due-date  
resource  
regulation..

driven by  
**Constraint**



# Mathematical Optimizaion promotes communication



Collect Data ;  
Build Model ;  
Solve ;

```
while (!satisfy(output)) {  
    Collect Data ;  
    Build Model ;  
    Solve ;  
    Examine Result;  
    if ( budget? ) exit;  
}
```



Something is  
wrong with  
this solution ..



I'll fix it by  
modifying the  
model !

**Trial & Error**

# Responsible Leader Required !

Who knows value of the final outcome  
 $\neq$  data scientist



- Go to that goal !
- What happened ? Now choose plan B !

```
while (!satisfy(output)) {  
    Collect Data ;  
    Build Model ;  
    Solve ;  
    Examine Result;  
    if ( budget? ) exit;  
}
```



# Aiming for Deploy ...

optimization  
integrated system



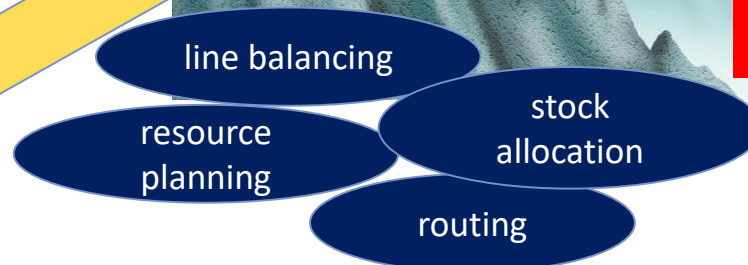
**Our optimization engine is working  
in Domestic sites:**

**JR-station  
Chain Store  
Call Center  
Production center  
Air conditioning ...**

**EVERY DAY**

**CHASM**

```
while (!satisfy(output)) {  
  Collect Data ;  
  Build Model ;  
  Solve ;  
  Examine Result;  
  if ( budget? ) exit;  
}
```



optimization  
integrated system



Why don't we start Optimization  
Proof of Concept  
by applying it to your actual situations?

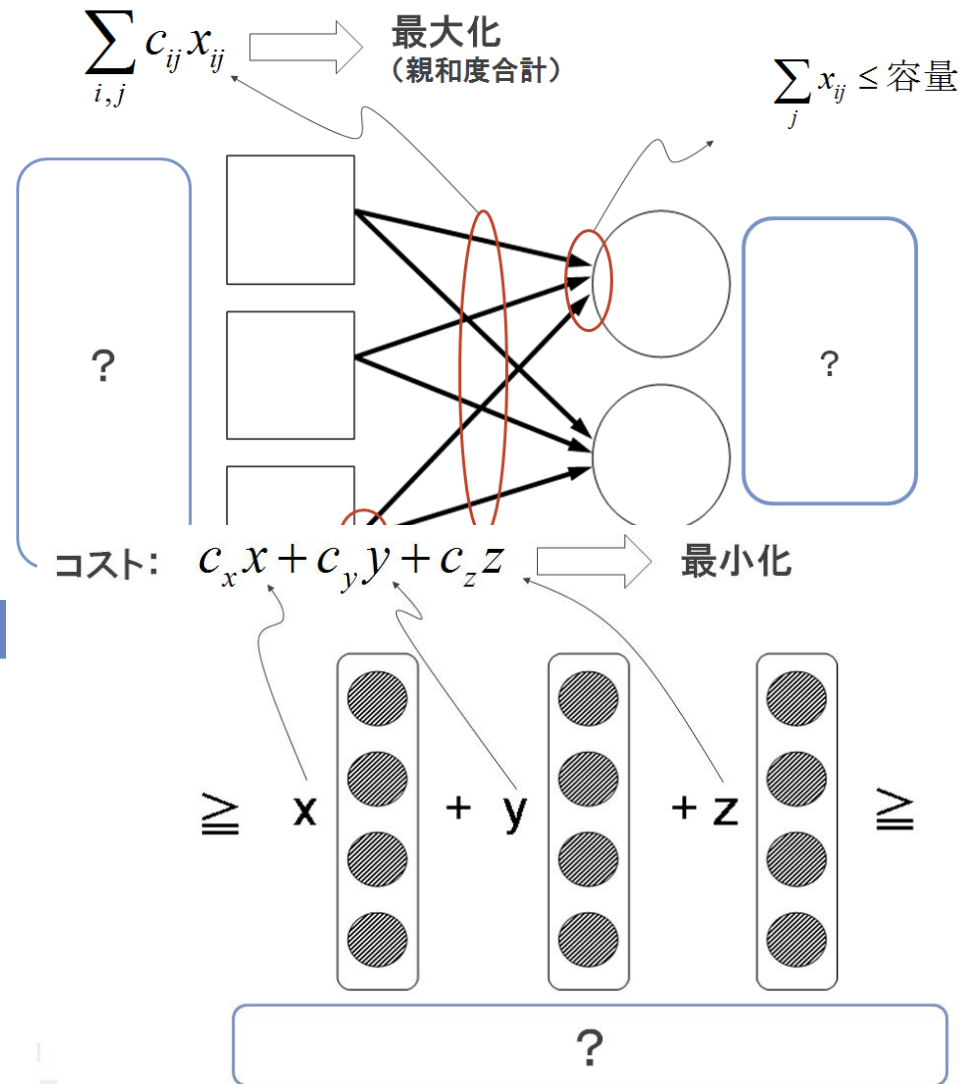
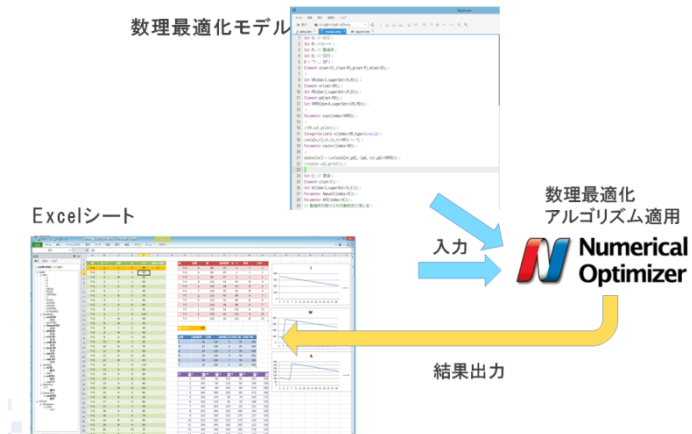
```
while (!satisfy(output)) {  
  Collect Data ;  
  Build Model ;  
  Solve ;  
  Examine Result;  
  if ( budget? ) exit;  
}
```



**CHASM**



# We can also provide materials to introduce optimization



## 「列挙+重ね合わせ」戦略の効用

### 1. ルートの列挙

- ✓ 実務の要件を制約として捉えると制約の記述が増える
- ✓ 「思いもよらない」結果は嫌われることが多い
- ✓ 狭い範囲の検証では人間の感覚は鋭い

⇒ 有り得る解を列挙してもらうのが有益

ルート	品名	数量	コスト
7-3	1	1	40
7-3	2	1	40
7-3	3	1	40
7-3	4	1	40
7-3	5	1	40
7-3	6	1	40
7-3	7	1	40
7-3	8	1	40
7-3	9	1	40
7-3	10	1	40
7-3	11	1	40
7-3	12	1	40
7-3	13	1	40
7-3	14	1	40
7-3	15	1	40
7-3	16	1	40
7-3	17	1	40
7-3	18	1	40
7-3	19	1	40
7-3	20	1	40
7-3	21	1	40
7-3	22	1	40
7-3	23	1	40
7-3	24	1	40
7-3	25	1	40
7-3	26	1	40
7-3	27	1	40
7-3	28	1	40
7-3	29	1	40
7-3	30	1	40
7-3	31	1	40
7-3	32	1	40
7-3	33	1	40
7-3	34	1	40
7-3	35	1	40
7-3	36	1	40
7-3	37	1	40
7-3	38	1	40
7-3	39	1	40
7-3	40	1	40
7-3	41	1	40
7-3	42	1	40
7-3	43	1	40
7-3	44	1	40
7-3	45	1	40
7-3	46	1	40
7-3	47	1	40
7-3	48	1	40
7-3	49	1	40
7-3	50	1	40

### 2. 選択重ね合わせ

- ✓ 全体を見通して合算する操作は人間よりも機械の方に分がある (探索範囲は広い)
- ✓ 範囲が限定されている選択(割り当て問題)は比較的解きやすい

実務的な最適化案件において、汎用性が高い



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