TECHNISCHE UNIVERSITÄT DRESDEN

LOGISTIK BWL

Collaborative Production Planning In Networks Using Variable Optimization Centers

Rainer Lasch, Gregor Schulte
Dresden University of Technology
Chair of Business Management, esp. Logistics
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Agenda

Requirements on collaborative production planning

- Reduction of transmitted information to non critical information on demand
- Achievement of a financial benefit for all partners in the supply chain
- Integration of compensation mechanisms in order to control the profit allocation among the partners
- Avoidance of opportunistic behaviour
- Preservation of the corporation‘s autonomy
- Application to supply networks of any size

Questions:

- How to design a method taking into account all this requirements?
- Which advantages with respect to the costs can be realized?

Selected approaches for collaborative production planning with time varying demand

Model	Planning concept	Needed information	Profit allocation	Liability to opportunism	Network size
Ertogral / Wu (2000)	successive (with center)	little	fix formula	high	unlimited
Zimmer (2001)	successive	mean	flexible contracts	mean	1:1
Dudek (2004)	successive	little	different forms	depending on formula mean until high	m:m
Pibernik / Sucky (2008)	successive	1) minimum 2) mean	1) negotiation 2) automatical	1) minimum 2) mean	1:1

1) equal distributed power 2) unequal distributed power

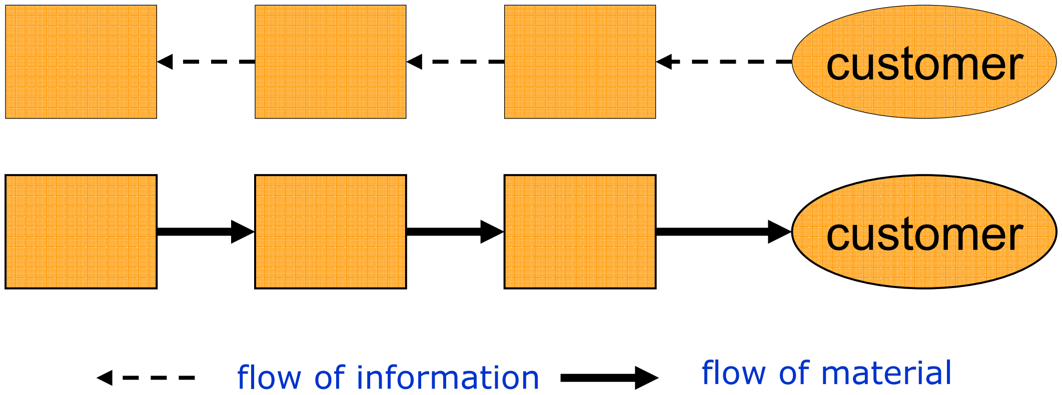
Focus on production planning, in particular short term quantity planning within the network

product	week 1	week 2	week 3	week 4
"P1"	0	200	0	400
"P2"	100	100	200	200
"P3"	600	0	600	0

Traditional planning sequence:

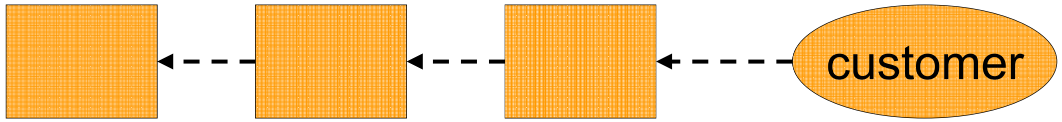
A) planning

B) realization

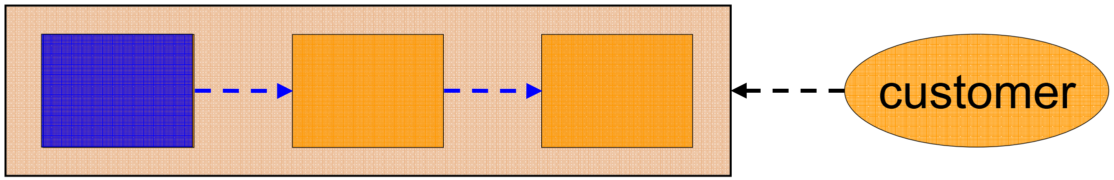


Basic idea for a new method

- following the successive planning approach



- generation of better plans by additional alternatives



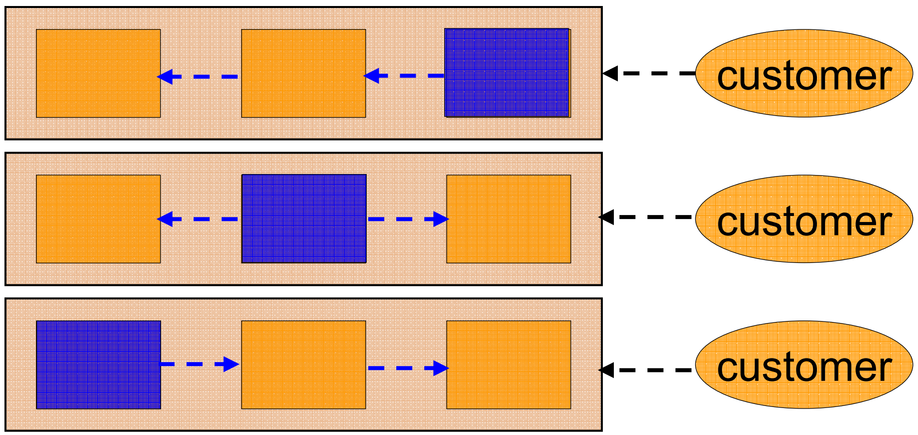
- selection of the best plan

➡ two steps: planning step and selection step

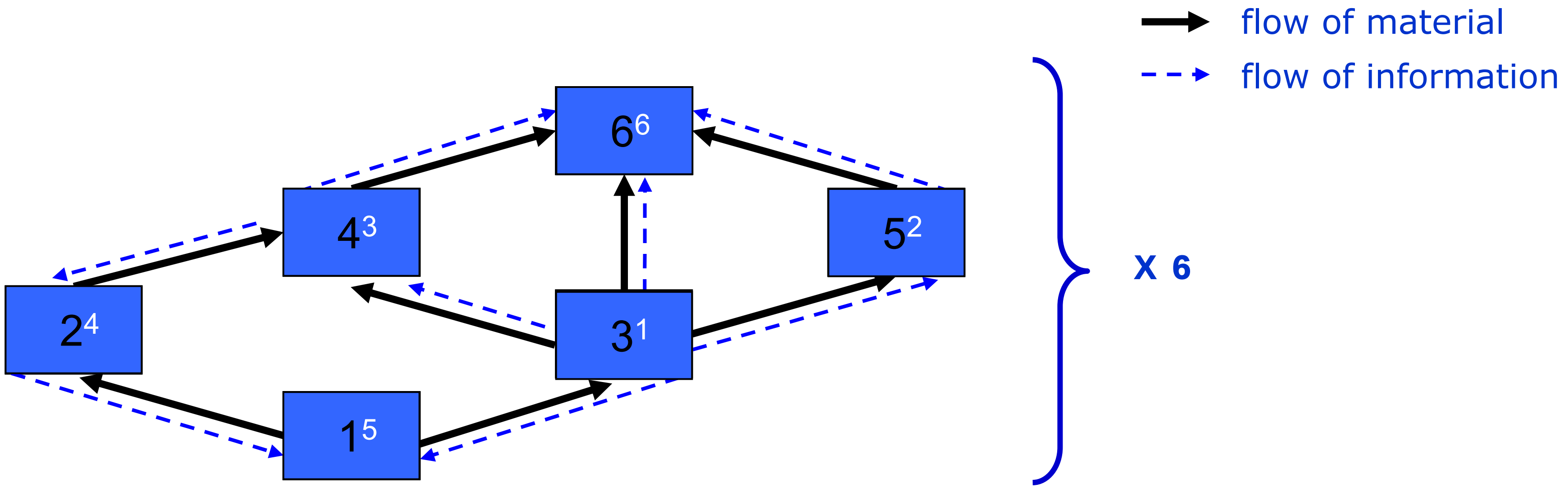
➡ „Method using Variable Optimization Centers (MVOC)“

Main content: generation of alternative plans

- Every partner calculates his individual optimal plan based on the demand of the final customer (is „optimization center OC“).
- Every partner calculates one plan as reaction to the optimal plans of all other (n-1) partners.
- Result: n alternative total plans for the network.



analogous approach for more complex networks



sequence for OC=3:- company 3 (C3) plans first

- transmission of delivery quantity to C1, C4, C5 and C6
- C5 plans next (or C1 or C4)
- C4 plans as third company (or C1, but not C6)
- C2 plans as fourth company (or C6, but not C1)
- finally plan C1 and C6

Features of the planning step:

- exchange of plans only containing lot size information (+)
- multiple planning is necessary (-)
- internal planning procedure is not predetermined for all partners (+)
- because of missing information no convergence to the optimal solution is guaranteed; only comparison of local optimal solutions (-)
- contains the traditional planning approach as one of the alternatives

  → worse solutions are impossible (+)
- unclear:

  - which plan should be implemented?
  - how should the profit be allocated?

  } → selection step

main content: selection one of the n alternative plans

- no cost information is transferred to other companies (necessary for the acceptance of the method)
- selection of a plan without any cost information is not possible (necessary for the realization of the method)
- suggested solution
  - plan comparing institution is a computer program (non human operator)
  - only transfer of cost differences
  - feedback of the overall best plan
- result: the best plan is known but not realized

3.2. Selection step (2)

confirmed best plan is

case B: **a new** alternative

→ negotiations necessary

case A: the traditional planning approach

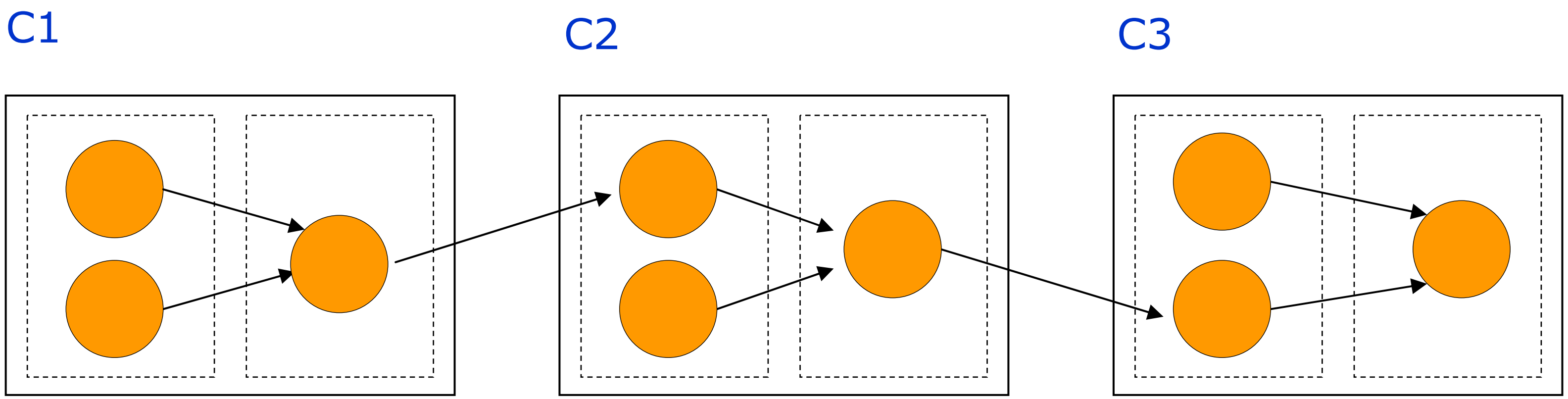
→ no negotiations necessary

→ implementation

- subject of negotiation: overall best plan + fallback solution
- negotiation scheme: roundwise bids and demands from every partner with respect to the level of their own payments or paybacks
  - „loosers " have an incentive to demand a compensation payment
  - „winners" have an incentive to offer payments
- termination as soon as the offers balance the demands

3.2. Selection step (3)

Example for negotiations: linear supply chain with 3 companies



Results of the calculations (cost differences are private information and refer to the traditional planning approach):

	OC=C1	OC=C2	OC=C3	
ΔC0(C1)	-244	-186	0	← known to C1
ΔC0(C2)	+331	-358	0	← known to C2
ΔC0(C3)	+281	+281	0	← known to C3
sum	+187	-263	0	

3.2. Selection step (4)

	OC=C1	OC=C2	OC=C3
ΔC0(C1)	-244	-186	0
ΔC0(C2)	+331	-358	0
ΔC0(C3)	+281	+281	0
sum	+187	-263	0

- Feedback of OC=C2 as best alternative (public information)
- Negotiations with respect to OC=C2 (with OC=C3 as fallback solution):

  round 1: assumtion that every partner offers 50% respectively demands 150%

  payment proposal : 93 (C1), 179 (C2), -422 (C3); sum: **-150**

  round 2: assumtion that every partner offers 65% respectively demands 135%

  payment proposal: 121 (C1), 233 (C2), -379 (C3); sum: **-25**

  round 3: assumtion that every partner offers 70% respectively demands 130%

  payment proposal: 130 (C1), 251 (C2), -365 (C3); sum: **+16**

3.2. Selection step (5)

	OC=C1	OC=C2	OC=C3
ΔC0(C1)	-244	-186	0
ΔC0(C2)	+331	-358	0
ΔC0(C3)	+281	+281	0
Summe	+187	-263	0

payment proposal: 130 (C1), 251 (C2), -365 (C3); sum: **+16**

⇒ payments e.g.: 125 (C1), 245 (C2), -370 (C3); sum: **0**

⇒ resulting profit: 61(C1), 113 (C2), 89 (C3); sum: **263**

Useful negotiation rules:

- offers and demands should be transferred simultaneously
- previously determined maximum number of rounds
- duty to improve the payment proposals in each round

Features of the selection step:

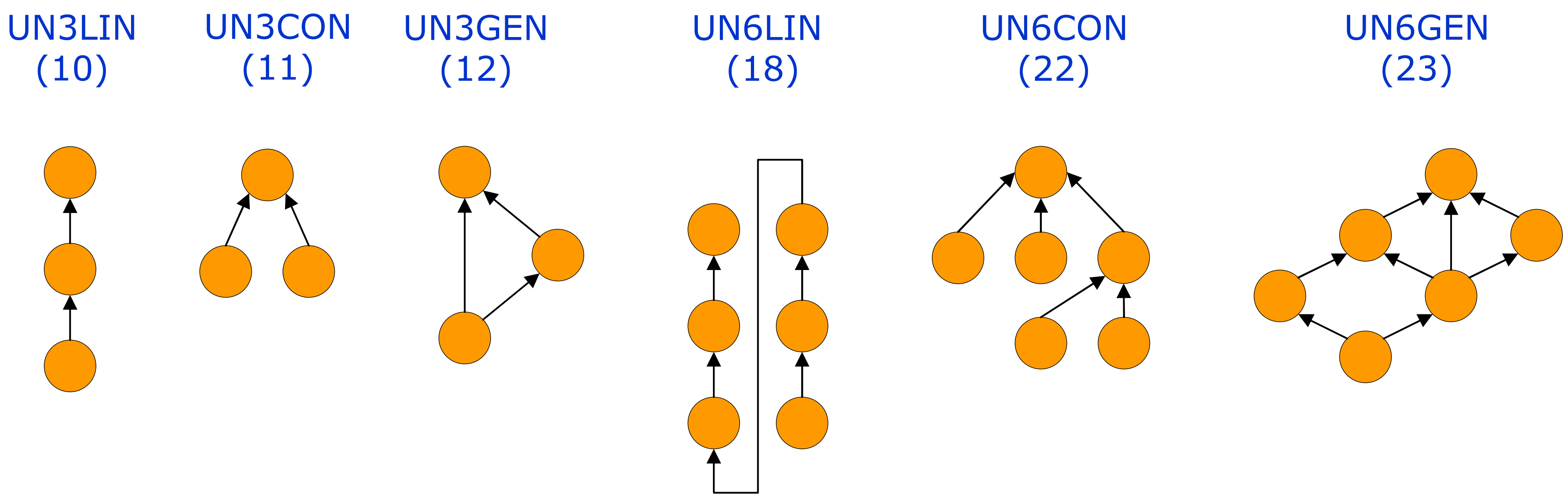
- only transfer of cost differences to a computer program (+/-)
- simple structure of the round of negotiations (+)
- existence of a solution is known → agreement more probable (+)
- no knowledge of the profit of other partners avoids enviousness (+)
- integration of plan agreement and profit allocation (+)
- agreement is not guaranteed (-)
- unknown so far: cost-benefit relation of negotiations

→ simulation to estimate the overall profit

4.1. Data base

Used data:

- MLCLSP as internal planning procedure
  - assumtions of the multi-level dynamic capacitated lot size planning
  - calculation of lot size and inventory level per period
  - inventory cost, fix cost, capacity and cost of overtime
  - integer linear optimization (objective function and constraints)
- Six different network structures:



OF: min $$\sum_{j\in J}\sum_{t=1}^{T}\left(KL_j \cdot l_{jt} + KF_j \cdot y_{jt}\right) + \sum_{r\in R}\sum_{t=1}^{T}\left(KZ_r \cdot z_{rt} + M \cdot n_{rt}\right)$$

minimizes the sum of inventory costs, fix costs and additional capacity costs

s.t.:

$$x_{jt} + l_{j,t-1} = E_{jt} + l_{jt} + \sum_{k\in N_j} b_{jk} \cdot x_{kt} \qquad \forall j \in J, t = 1,\dots,T$$

produced quantity x and inventory level l is equal to the required quantities of the customers (E) and secondary products (b)

$$\sum_{j\in J} a_{rt} \cdot x_{jt} \le K_{rt} + z_{rt} + n_{rt} \qquad \forall r \in R, t = 1,\dots,T$$

forces if possible the capacity limitation

$$x_{jt} \le y_{jt} \cdot M \qquad \forall j \in J, t = 1,\dots,T$$

generates the binary variable y from the lot size

$$l_{j0} = 0 \qquad l_{jT} = 0 \qquad \forall j \in J$$

zero inventory at the beginning and end of the planning horizon

$$z_{rt} \le ZM_{rt} \qquad \forall r \in R, t = 1,\dots,T$$

limitation of additional capacity

$$x_{jt} \ge xug_{jt} \qquad x_{jt} \le xog_{jt} \qquad \forall j \in J, t = 1,\dots,T$$

upper / lower bounds for the lot size

4.1. Data base (2)

➢ Used data

108 systems:

- internal structures (machines and resources) of 6 networks
- marginal echelon storage costs: [-0,2 ; 2,0]
- 2 fix cost variations: low / high fix costs [50 ; 700] (3fold)
- 3 load factors: 50%, 60% and 80%

18 demands:

- 3 average demands: 50, 100 and 200
- 2 demand fluctuations: ± 25% and ± 50% (3fold)

4.1. Data base (3)

- Used data

108 systems:
- internal structures (machines and resources) of **6** networks
- marginal echelon storage costs: [-0,2 ; 2,0]
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18 demands:
- **3** average demands: 50, 100 and 200
- **2** demand fluctuations: ± 25% and ± 50% (**3**fold)

extent of simulation: 1.944 runs (**6** · (**2** · **3**) · **3** · (**3** · **2** · **3**))

JAVA

Random generator
- production system
- demand data

→

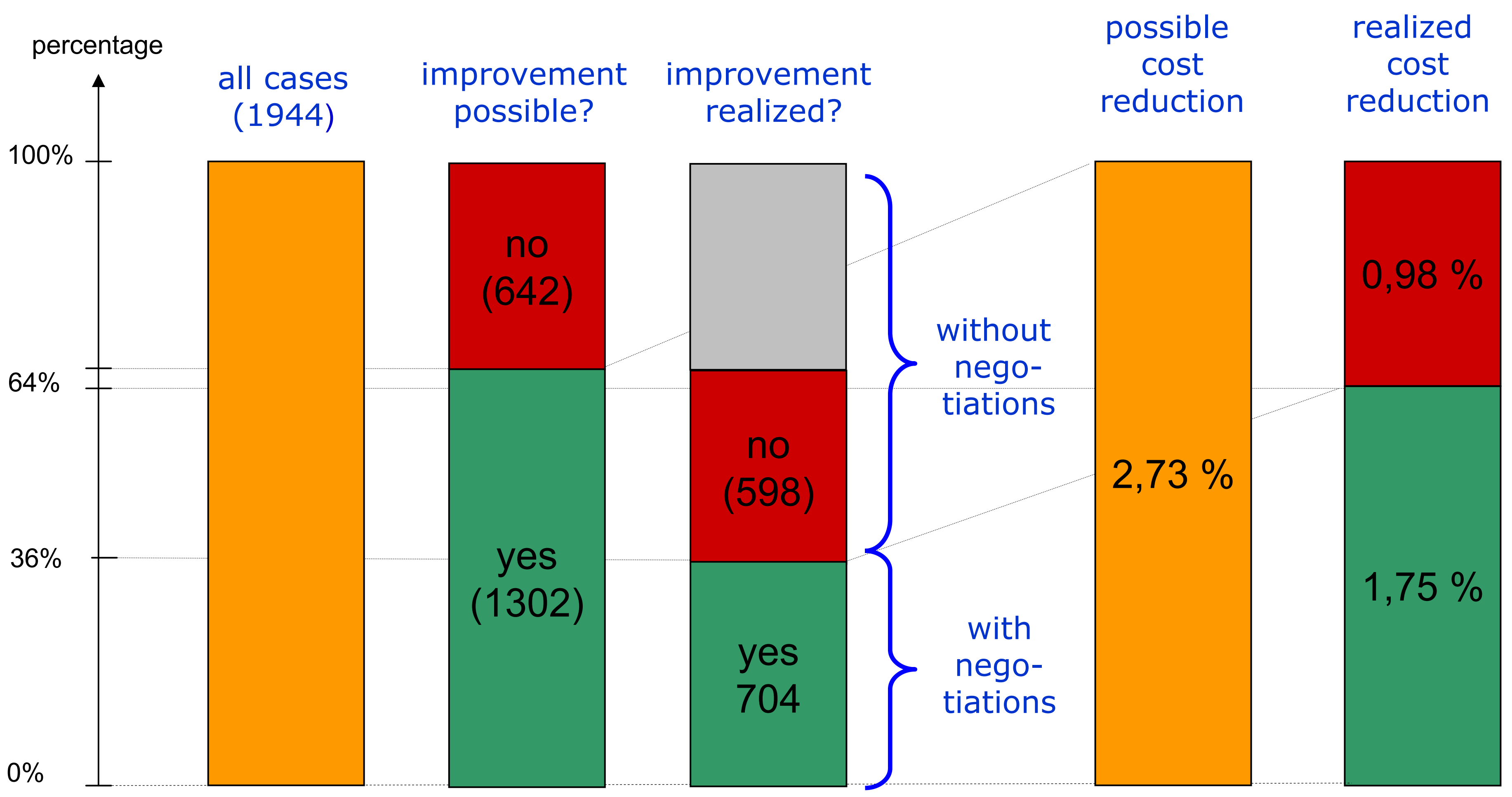
MVOC
- planning sequence
- exchange of plans

⇄

4.2. Results of planning- and selection step

network	UN3LIN	UN3CON	UN3GEN	UN6LIN	UN6CON	UN6GEN	**total**
potential available?	202 of 324 (62%)	215 of 324 (66%)	226 of 324 (70%)	262 of 324 (81%)	248 of 324 (77%)	149 of 324 (46%)	**1302 of 1944 (67%)**
total cost potential	2,40%	2,43%	2,38%	5,69%	2,90%	0,56%	**2,73%**
improvement realized?	134 of 202 (66%)	85 of 215 (40%)	53 of 226 (23%)	210 of 262 (80%)	170 of 248 (69%)	52 of 149 (35%)	**704 of 1302 (54%)**
total cost advantage	1,71%	1,00%	0,69%	4,57%	2,27%	0,25%	**1,75%**
potential fulfillment	71,3%	41,0%	29,1%	80,4%	78,2%	44,1%	**64,1%**

4.2. Results of planning- and selection step (2)



5.1. Critical acclaim

MVOC contains:

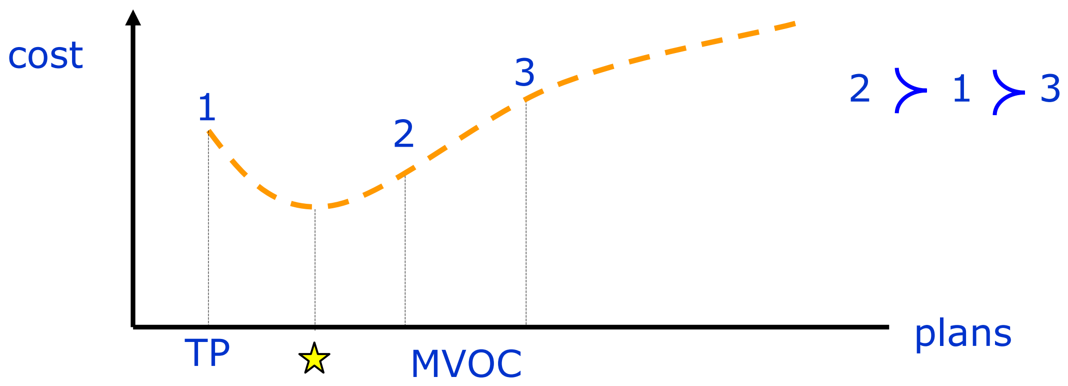
- planning step: generation of additional alternative plans
- selection step
  - cost comparison done by computer program and preselection of one best total plan
  - roundwise negotiations to accept a plan

simulation results

- improvement is possible for 36,2% of all cases (only in this cases negotiations are necessary)
- 64,1% of the total cost reduction potential can be realized

Disadvantages of MVOC:

- complex planning → high planning efficiency necessary (-)
- „only" comparism of several suboptimal solutions (-)



- cost reduction dependent on network structure
- no guarantee for success of negotiations (-)

5.2. Advantages

Advantages of MVOC:

- cost reduction possible +

in terms of hindrance:

- autonomy of companies is preserved +
- no exchange of confidential information +
  - ➢ non critical: customer demands, lot sizes
  - ➢ no capacity,inventory information, no absolute costs
  - ➢ only cost differences transferred to a computer program (?)
- profit allocation on the basis on plan agreement and negotiation +
- no incentives for opportunism +

- simple structure of the procedure
- unlimited network sizes and network structures

Conclusion:

MVOC does not achieve the (theoretical) optimum for every criteria but gets the best results with respect to the discussed hindrances.

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Pibernik / Sucky (2008)	successive	1) minimum 2) mean	1) negotiation 2) automatical	1) minimum 2) mean	1:1
MVOC	successive	little or minimum	negotiation	little or minimum	unlimited

1) equal distributed power   2) unequal distributed power

Thank you for your attention!