Towards Restructuring Approach in Combinatorial Optimization

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Towards Restructuring Approach in Combinatorial Optimization

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PLAN:

0. Modification of solutions in combinatorial optimization (CO)
1. Restructuring approaches CO:
   - 1.1. One-stage restructuring
   - 1.2. Multi-stage restructuring
   - 1.3. Restructuring over changed element set   --
2. Usage of restructuring in CO problems (knapsack, multiple choice: assignment, clustering, spanning trees)
3. Illustrative applied example for location of files on discs
4. Conclusion

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0. Some basic trends of modeling in CO

Trend 1.Multicriteria models
Trend 2.Models under uncertainty (e.g., fuzzy set based estimates)
Trend 3.Dynamic (online) models
Trend 4.Modification in optimization
(<A,X.F>, where A – problem parameters,
X-problem arguments/solution,
F-objective function):
4.1.Modification of problem parameters A
(augmentation problems,
inverse problem, reverse problems)
4.2.Modification of solution(s) (reoptimization, restructuring)

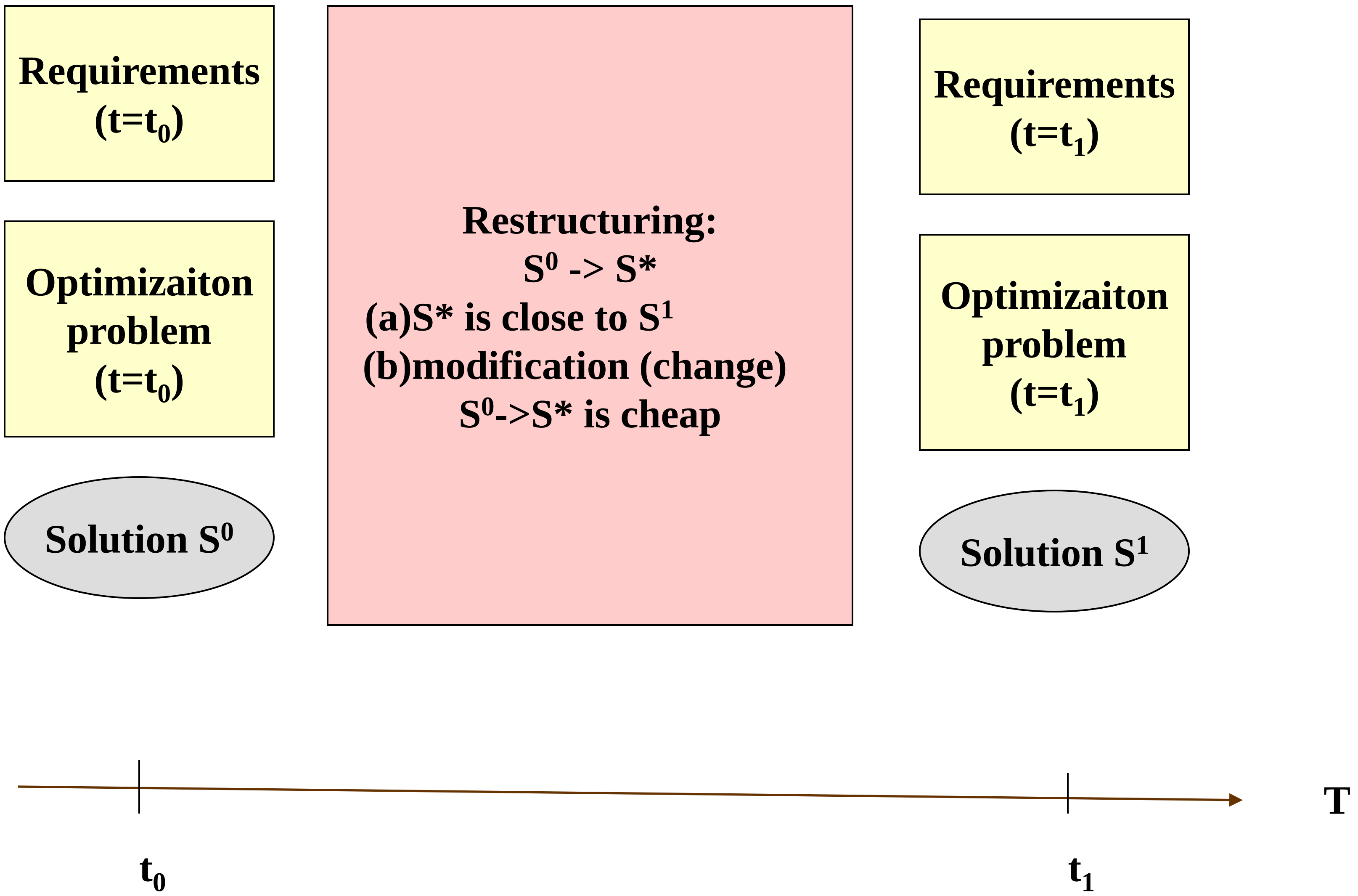
0. Modification of solutions in CO

1. **Modification as re-scheduling, re-assignment, re-linking, re-positioning, editing, re-coloring (basic techniques in local optimization)**
2. **Reoptimization: small correction of solution to improve solution quality (i.e, value of objective function), e.g., TSP, …**
3. **Augmentation approach: addition/correction of solution components (e.g., edges/arcs) to obtain required property of solution (e.g., connectivity)**
4. **Restructuring: modification of solution while taking into account two criteria: (a)minimum modification cost, (b) proximity of new solution to optimal solution at the next time stage**
5. **Dynamic problems (e.g., online problems)**
6. **Multi-stage restructuring of problem solution (design of solution trajectory)**
7. **Restructuring over set of changed elements**

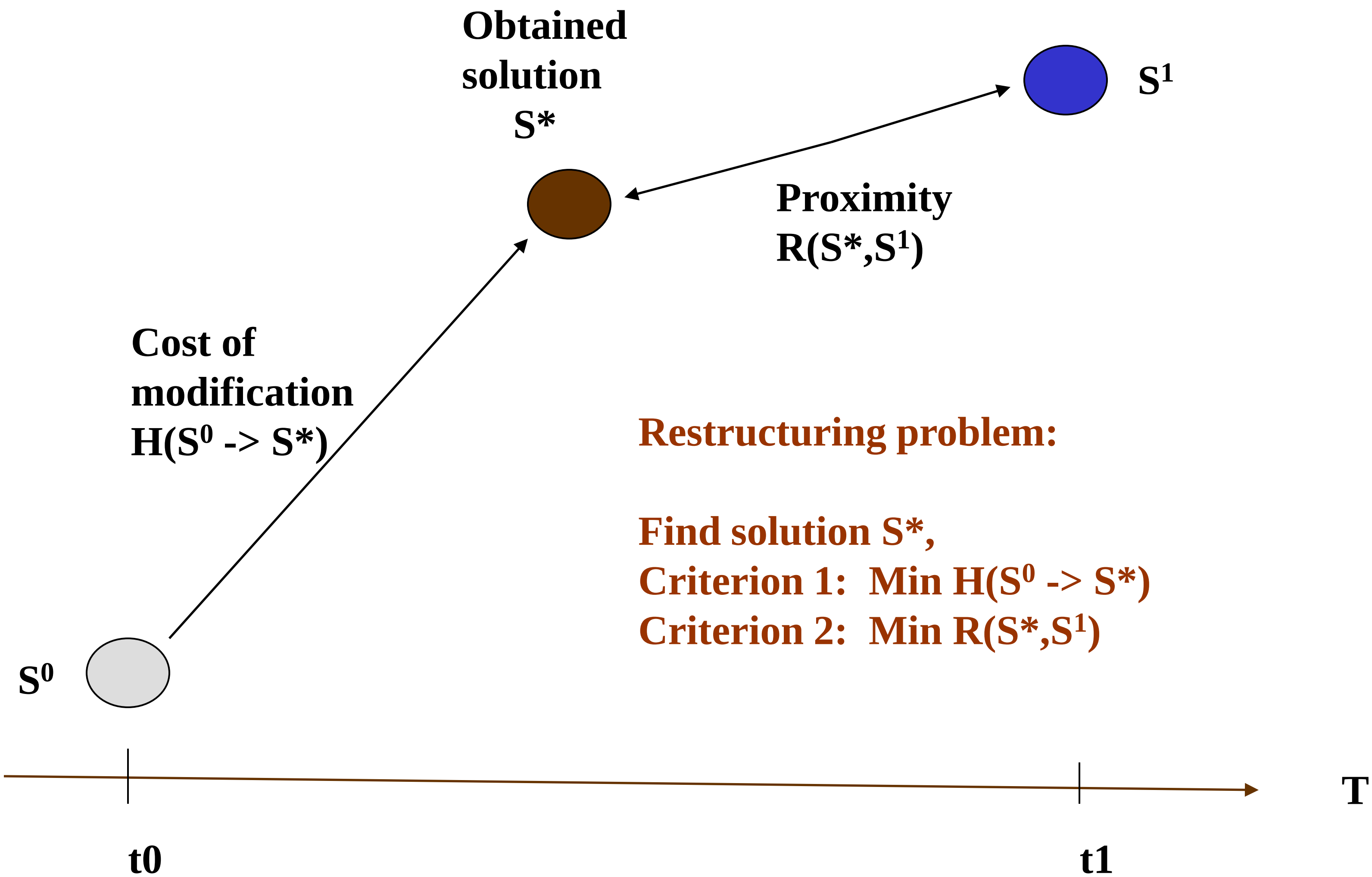
Importance of restructuring approach (taking into account the modification cost) is based on real world applications (e.g., mobile communication systems)

My basic recent reference:
M.Sh. Levin, Towards integrated glance to restructuring in combinatorial optimization. Electr. preprint, 31 p., Dec. 20, 2015, http://arxiv.org/abs/1502.06427 [cs.AI]

1.1. One-stage restructuring - framework



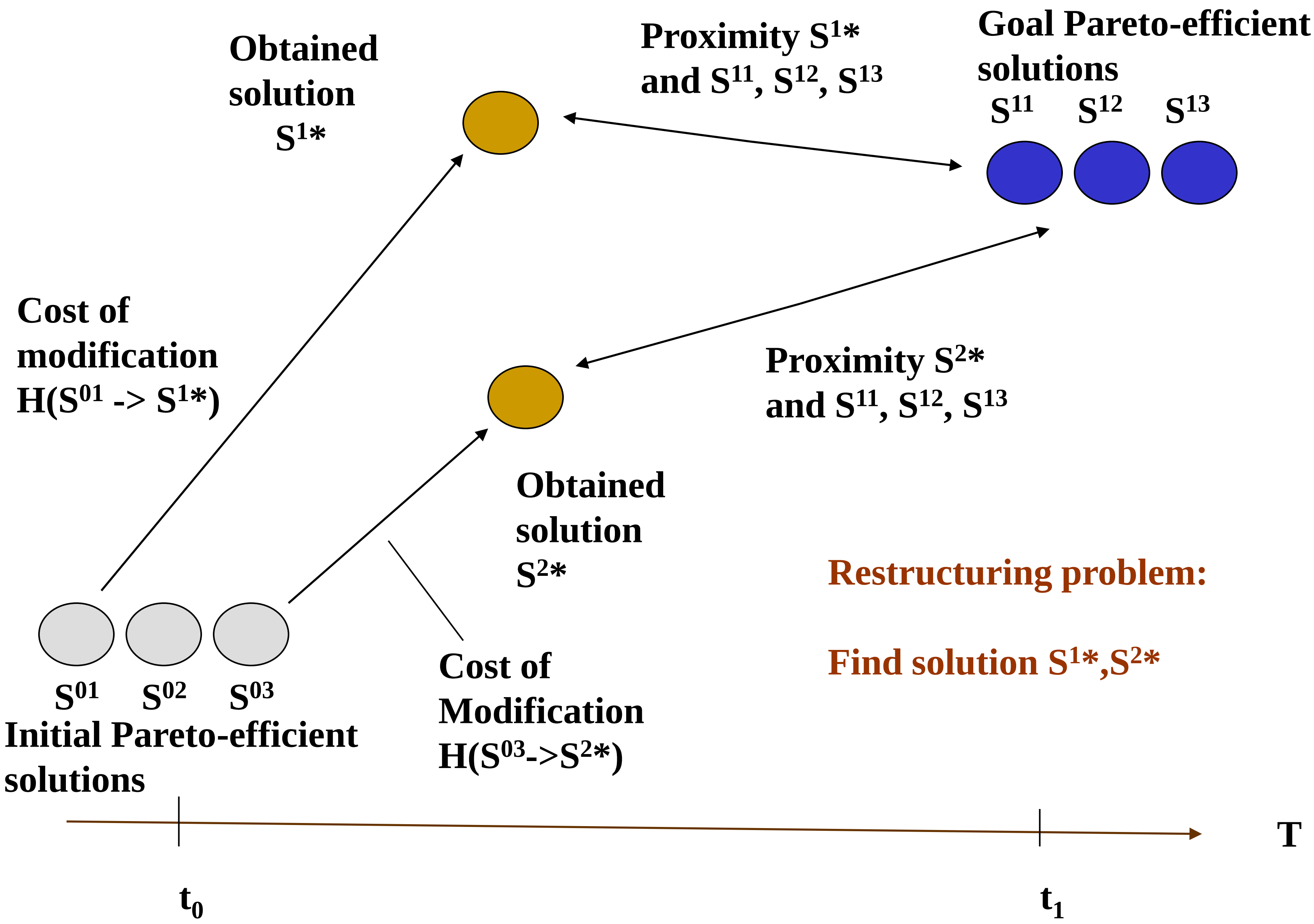
1.1. One-stage restructuring – illustration



Restructuring problem:

Find solution S*,
Criterion 1: Min $H(S^0 \rightarrow S^*)$
Criterion 2: Min $R(S^*, S^1)$

1.1. One-stage restructuring (multicriteria case) – illustration



1.1. One-stage restructuring - models

One-stage case $S^0 \to S^*$

Problem 1:

Minimizing closeness of S^* to S^1: $\min R(S^*,S^1)$

s.t. $H(S^0,S^*) \le h$ (constraint for modification cost)

Problem 2.

Minimizing proximity : $\min H(S^0,S^*)$

s.t. $R(S^*,S^1) \le r$ (constraint)

Problem 3 (two-criteria):

$\text{Min } R(S^*,S^1)$

$\text{Min } H(S^0,S^*)$

1.2. n-stage restructuring - framework

Requirements
($t=t_0$)

Optimizaiton problem
($t=t_0$)

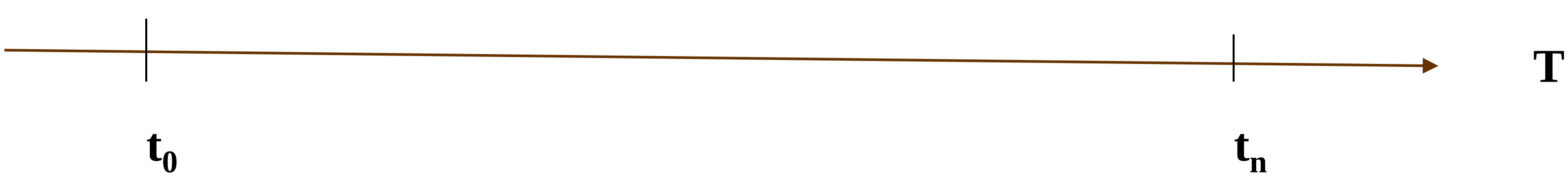
Solution S_0

Restructuring:
$S0 \rightarrow \{S^{1*}, S^{2*}, \ldots, S^{n*}\}$
(a) S^{1*} **is close to** S^1,
S^{2*} **is close to** S^2, …,
S^{n*} **is close to** S^n
(b) Modifications are cheap:
$S^0 \rightarrow S^{1*}$,
$S^{2*} \rightarrow S^2$,
… ,
$S^{n*} \rightarrow S^n$

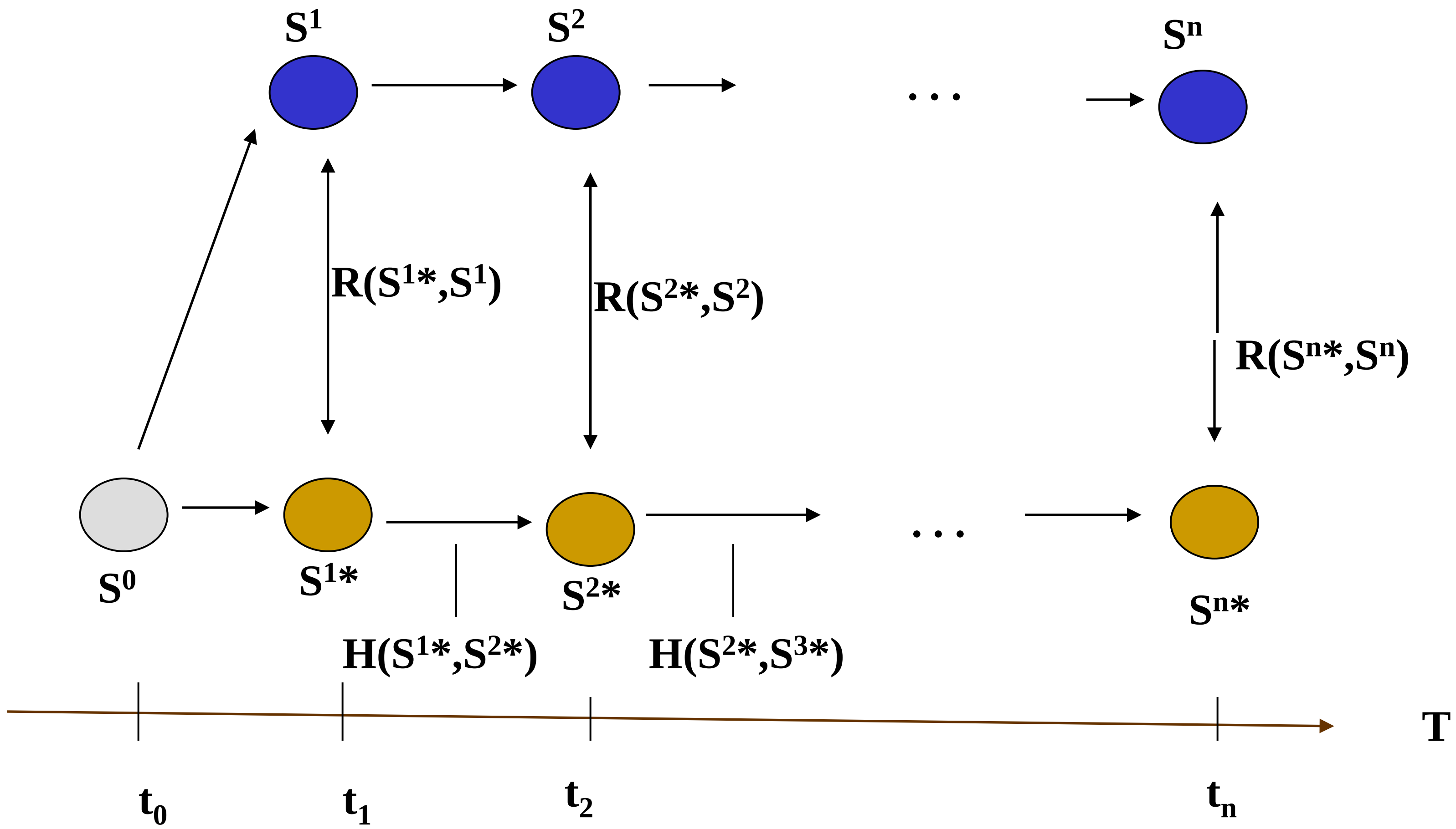
Requirements for time moments:
$t_1, t_2, \ldots, t_n$

Optimizaiton problems for time moments
$t_1, t_2, \ldots, t_n$

Solution $S^1, S^2, \ldots, S^n$



1.2. n-stage restructuring – illustration



Problem:
Searching for trajectory
< S^0->S^{1*}->S^{2*}->…->S^{n*} >
(total change cost, total proximities)

1.2. n-stage restructuring – models

Two trajectories:

(a) Basic trajectory of optimal solutions: $S^{opt} = < S^0 \text{->} S^1 \text{->} S^2 \text{->} \ldots \text{->} S^n >$

(b) Searched trajectory of restructured solutions: $S^{rest} = < S^0 \text{->} S^{1*} \text{->} S2^* \text{->} \ldots \text{->} S^{n*} >$

Problem (searching for the restructuring trajectory):

$H(S^{rest} \text{ -> } S^{opt}) \text{ -> min}, \quad R(S^{rest}, S^{opt}) \text{ -> min},$

where (total change cost, total proximities):

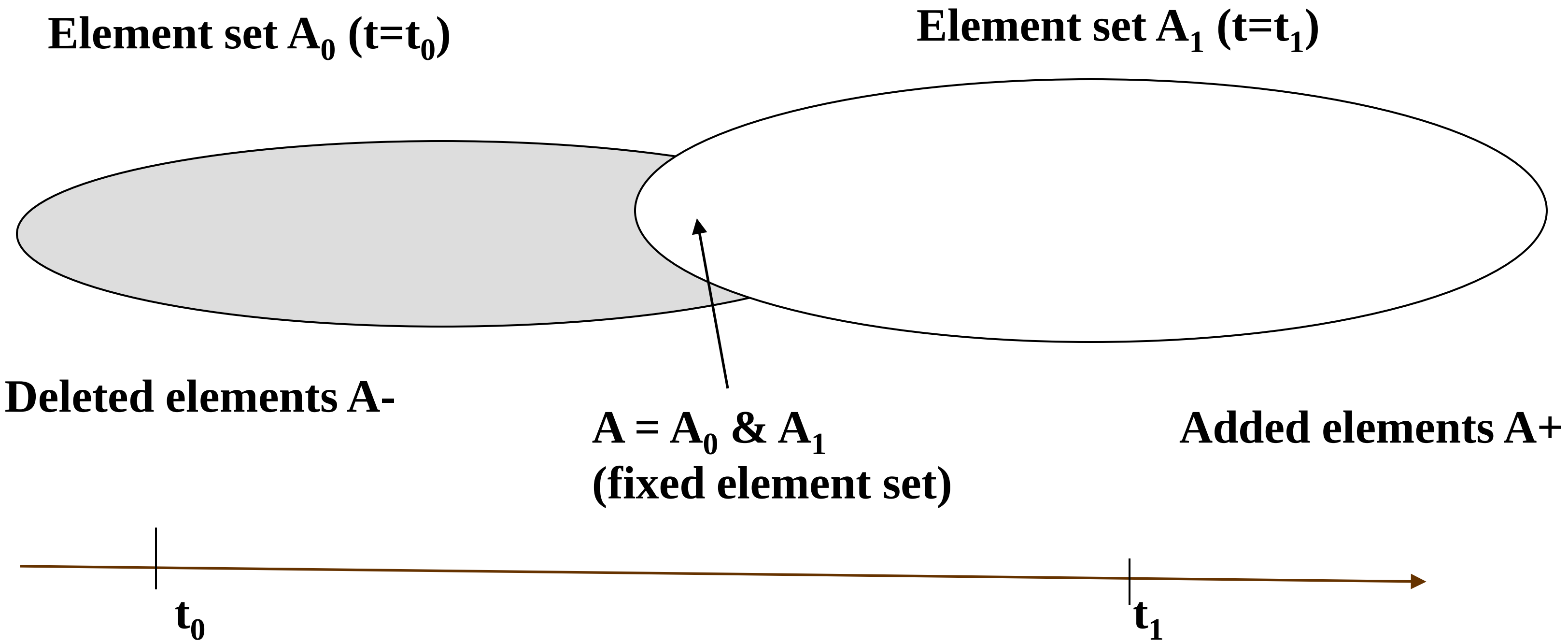
$H(S^{rest} \text{ -> } S^{opt}) = (H(S^0 \text{ -> } S^{1*}), H(S^{1*} \text{ -> } S^{2*}), \ldots , H(S^{(n-1)*} \text{ -> } S^{n*}),$

$R(S^{rest}, S^{opt}) = (R(S^{1*}, S^1), R(S^{2*}, S^2), \ldots , R(S^{n*}, S^n),$

Simplified problem is:

$\text{Min } R(S^{rest}, S^{opt}), \quad \text{s.t. } H(S^{rest} \text{ -> } S^{opt}) \le h$

1.3. One-stage restructuring (change of element set)



$G_0 = (A_0,E_0)$ ====> $G_1 = (A_1,E_1)$

Example of application: mobile networks

2. Application of restructuring in CO problems

Recent examinations
(e.g., see Electronic Preprint above, etc.):
***1.Knapsack problem**
***2.Multiple choice problem**
***3.Assignment problems**
***4.Morphological clique problem**
***5.Clustering**
***6.Multicriteria ranking (sorting)**
***7.Spanning trees (minimum spanning tree, Steiner tree)**
8.Bin packing problems ---

General idea of modeling is based on knapsack problem (one-stage case S^0 -> S^*):

Initial elements:
Set of deletion elements (for each element: profit, cost)
Set of addition elements (for each element: profit, cost)

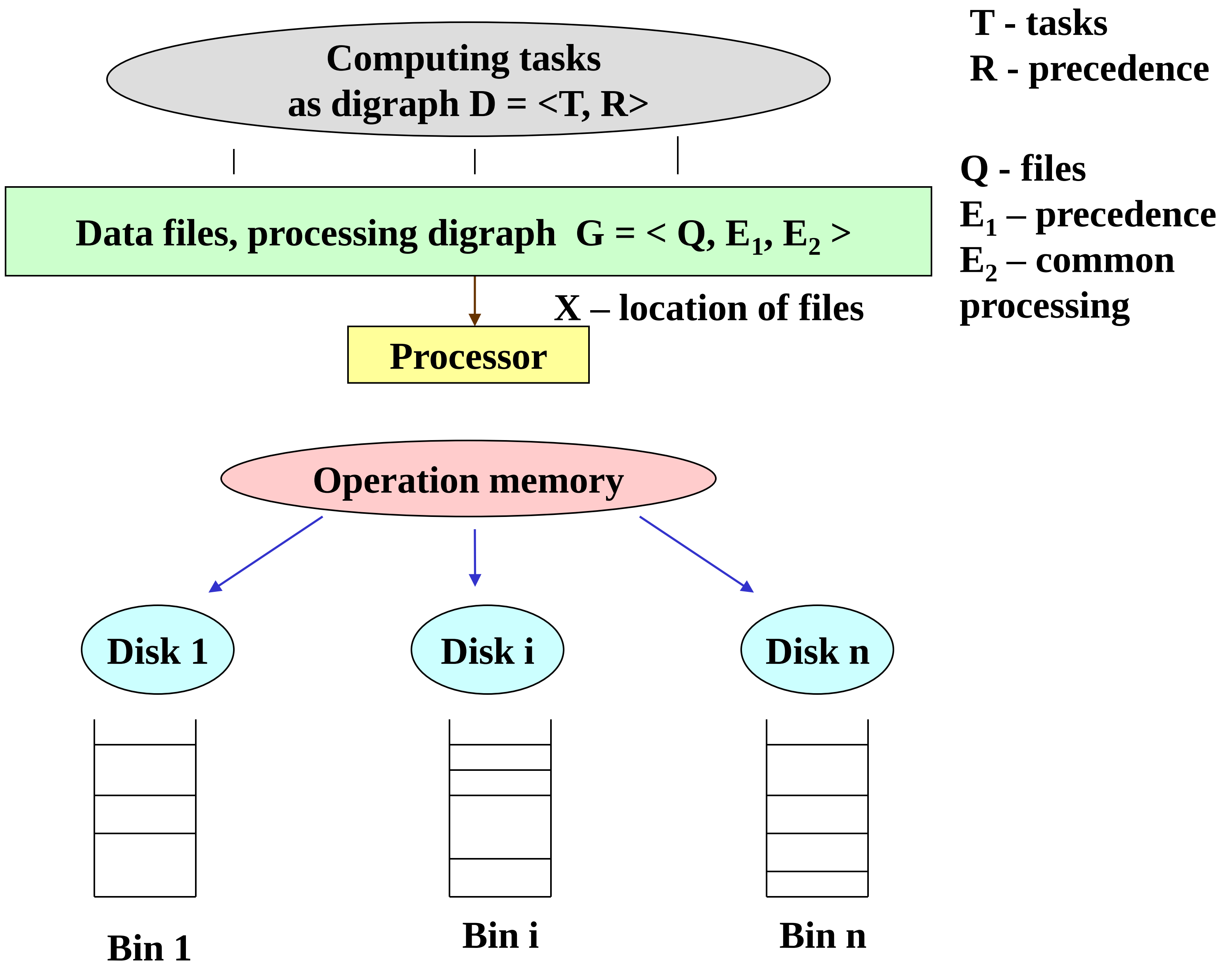
3. Illustrative applied examples of restructuring approach

1. **Routing in network: modification of route**

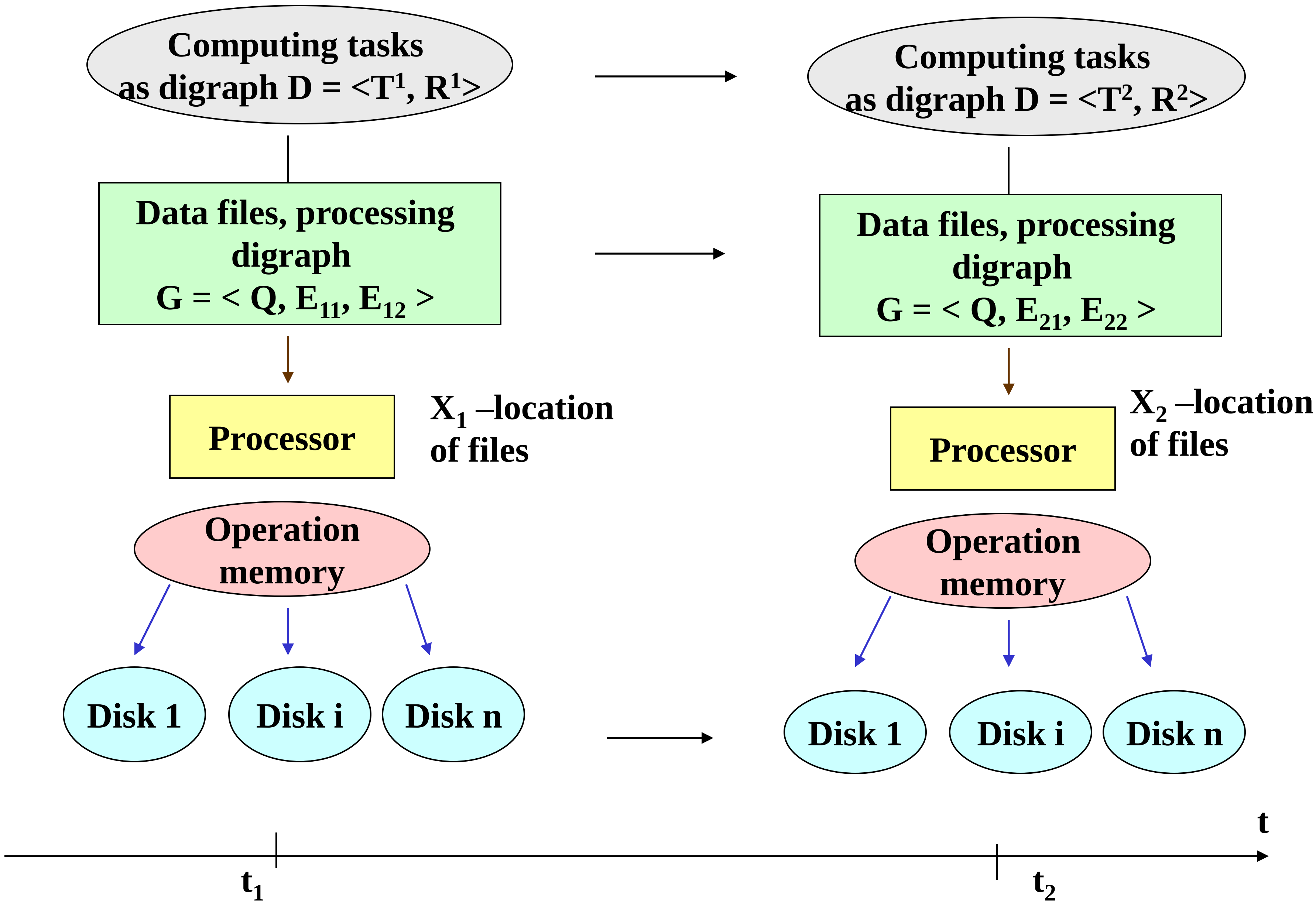
2. **Reorganization of data base (NB!)**

3. **Allocation of data files on magnetic disks**

3. Applied example: Allocation of data files on disks (2-level storage)



3. Applied example: Allocation of data files on disks (2-level storage)



Conclusion: future research directions

I.GENERALLY:

1.1.Multistage restructuring

1.2.Restructuring problems over element set change

II.New combinatorial problems

1.Study of bin packing problems with various combinations of relations over items/bins (i.e., composite bin packing problems), including various colored problems, with ordinal estimates, vector estimates, with multiset estimates)

III.Applications:

3.1.Network applications in networks (e.g., communication)

3.2.Consideration of various applications of bin packing

IV.Education

4.Usage of the material in engineering/management education

Gr8 Thanks!

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