بسم الله الرحمن الرحیم

برنامه ریزی حرکت قطارها

فصل ۸: مدل بلاکینگ واگنها بر اساس مساله طراحی شبکه بودجه ای

مدرس: دکتر مسعود یقینی

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Modeling RBP as BDP
(Newton Model)

Modeling RBP as BDP

- In this chapter, we show that the Railroad Blocking Problem (RBP) can be modeled as a Budget Design Problem (BDP)
- We present an MIP formulation (BLOCK) obtained by adding them to PATH for BDP.

Outline

- Assumptions
- Formulation

Assumptions

Definition of RBP

- We may define the RBP as:
  - Minimize the costs of delivering all commodities
  - by deciding which inter-terminal blocks to build
  - and specifying the assignment of commodities to these blocks,
  - while observing limits on the number and aggregate volume of the blocks assembled at each terminal
  - and limits on the number of blocks used to deliver a commodity.

Modeling RBP as BDP

- The RBP can be modeled as a network design problem where
  - the nodes represent the railroad terminals and
  - the arcs represent potential blocks.
- As with the general BDP, the RBP seeks to minimize the flow costs of delivering all commodities.

Maximum number of blocks

- The RBP constraint on the maximum number of blocks originating at a terminal has the same form as the node-budget constraints which we included in PATH (1.3) formulations for the BDP.
- In RBP, the fixed cost $e_a = 1$ for all arcs.

Balance equations

- The balance equations (1.2a) on the paths in PATH can be used to model the identical balance requirements for BLOCK.

Different service constraints

- However, unlike BDP, the maximum number of arcs (blocks) which may be used in a commodity's path is restricted by a priority constraint.
- The possibility of having different service constraints for some of the traffic from an OD pair requires adding a priority class to the description of each commodity.
- Now commodities are identified by origin, destination, and a maximum number of handlings.

Arc capacity

- Since blocks are assumed to be uncapacitated, the coefficients U_a in PATH are replaced by the maximum possible flow for arc a.

Node Capacity

- However, where the node flows are assumed uncapacitated in BDP, in RBP the nodes (terminals) have a flow volume constraint to model the limit on the total number of cars which can be classified.

Overall budget

- Finally, there is no overall budget for the blocking problem, so constraint (1.3d) from PATH may be omitted.

Formulation

Parameters

$G = (N, A)$ is the graph with node set N and candidate arc (block) set A.

K is the set of all commodities k designated by an origin-destination pair of nodes and the number of intermediate handlings allowed.

v^k is the volume of commodity k (in consistent units).

$orig(k)$ is the origin node for commodity k. $orig(a)$ is the origin of arc a.

$dest(k)$ is the destination node for commodity k. $dest(a)$ is the destination of arc a.

$Q(k)$ is the set of legal paths for commodity k.

Parameters

$c_a \geq 0$ is the per unit cost of flow on arc a (assumed equal for all commodities).

u_a is the capacity of arc a.

$B(i)$ is the number of blocks which may originated at node i.

$V(i)$ is the volume which may be classified at node i.

PC_q^k path cost for flowing one unit of commodity k on path q.

Decision variables

f_q^k proportion of commodity k on path q, $\forall q \in Q(k), k \in K$.

y_a is the binary design variable for including arc (block) a.

$$= \begin{cases} 1 & \text{if arc } a \text{ is selected,} \\ 0 & \text{otherwise.} \end{cases}$$

BLOCK Formulation

$$\min \quad \sum_{k\in K}\sum_{q\in Q(k)} PC_q^k\, v^k\, f_q^k \qquad (4.1a)$$

s.t.

$$\sum_{k\in K}\sum_{q\in Q(k)} v^k f_q^k\, \delta_a^q - u_a y_a \le 0 \qquad \forall a \in A \qquad (4.1b)$$

$$\sum_{q\in Q(k)} f_q^k = 1 \qquad \forall k \in K \qquad (4.1c)$$

$$\sum_{\substack{a\in A\\ orig(a)=i}} y_a \le B(i) \qquad \forall i \in N \qquad (4.1d)$$

$$\sum_{k\in K}\sum_{q\in Q(k)}\sum_{\substack{a\in A\\ orig(a)=i}} v^k f_q^k\, \delta_a^q \le V(i) \qquad \forall i \in N \qquad (4.1e)$$

$$f_q^k \ge 0 \qquad \forall q \in Q(k), k \in K$$

$$y_a \in \{0,1\} \qquad \forall a \in A$$

Constraints

- Constraints (4.1b): ensure that flow is only allowed on arcs (blocks) included in the network
- Constraints (4.1c): ensure all of each commodity is delivered
- Constraints (4.1d): the limit on the number of blocks which may be built at each node is modeled by the node-budget constraints
- Constraints (4.1e): the volume of cars which may be classified at each terminal is modeled
- The balance equations and constraints on the maximum number of handlings are included on legal blocking paths for commodity *k*.

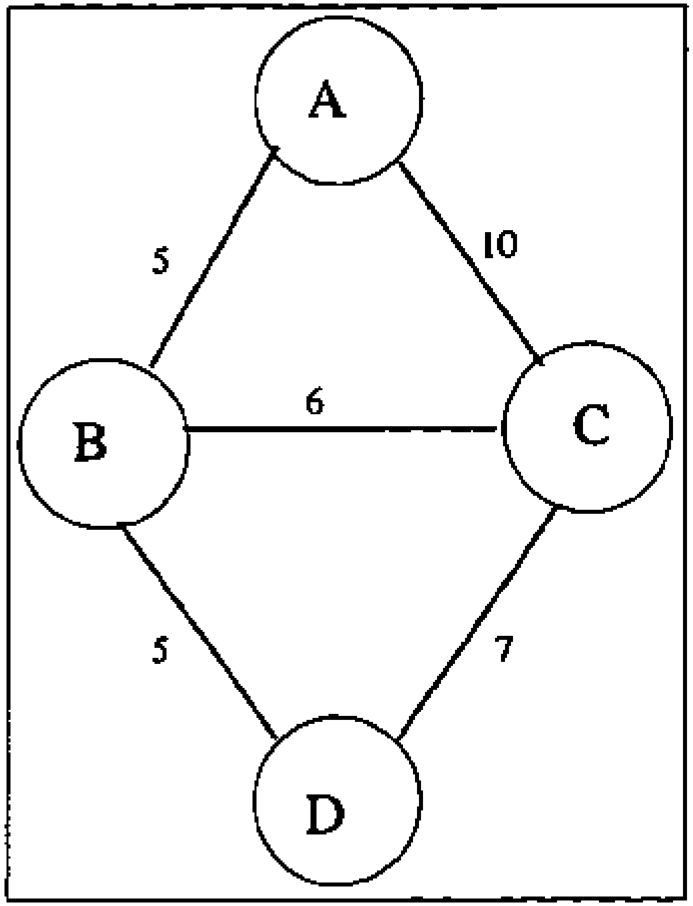
Path cost

- Path costs could be included are:
  - Costs for car-miles (miles that a car following this blocking path will travel)
  - Costs for car-hours (hours of delay for classifications incurred along this blocking path)
  - Labor and equipment costs per car might be different depending on the links and blocks for a commodity

Routing vs. Blocking Path

- We define ***routings*** to be paths through the physical network.
- It is convenient to describe a ***routing*** by the sequence of terminals visited.
- The terms ***blocking path*** or ***commodity blocking assignment*** on the other hand describe the path through the blocking network.
- If the blocking path is also identified by the sequence of terminals, a blocking path for a railcar will be a subsequence of the routing that it followed since blocking will be done at a subset of the terminals visited.

An Example

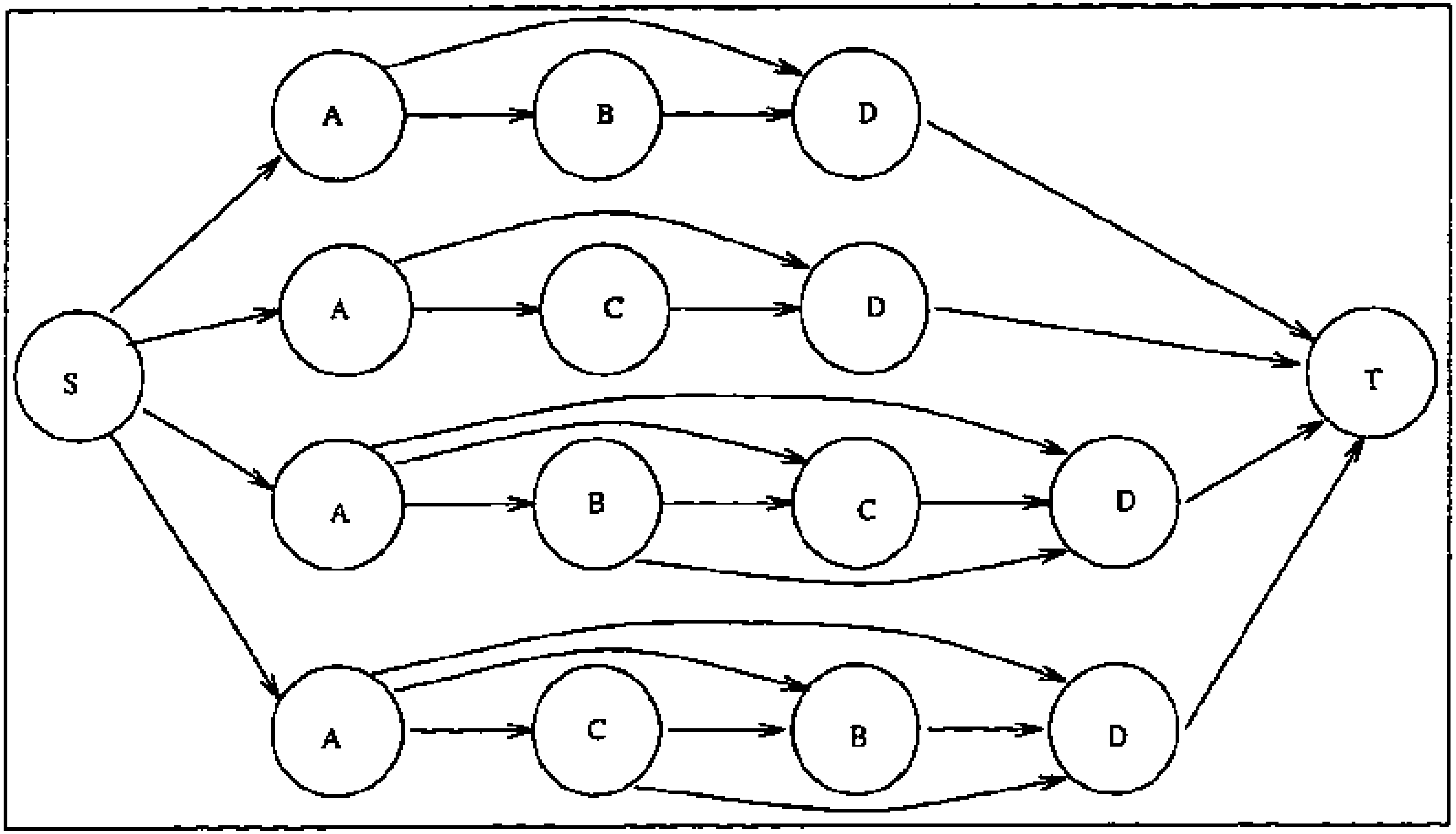


Physical network

Routing

- Consider commodity A-D in the physical network
- The shortest four routings are
  - A-B-D (length 10)
  - A-C-D (length 17)
  - A-B-C-D (length 18)
  - A-C-B-D (length 21)

Blocking paths



Commodity network for shortest 4 paths for commodity A→D

References

References

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