بسم الله الرحمن الرحیم

برنامه ریزی حرکت قطارها

فصل ۶: مساله بلاکینگ واگنها

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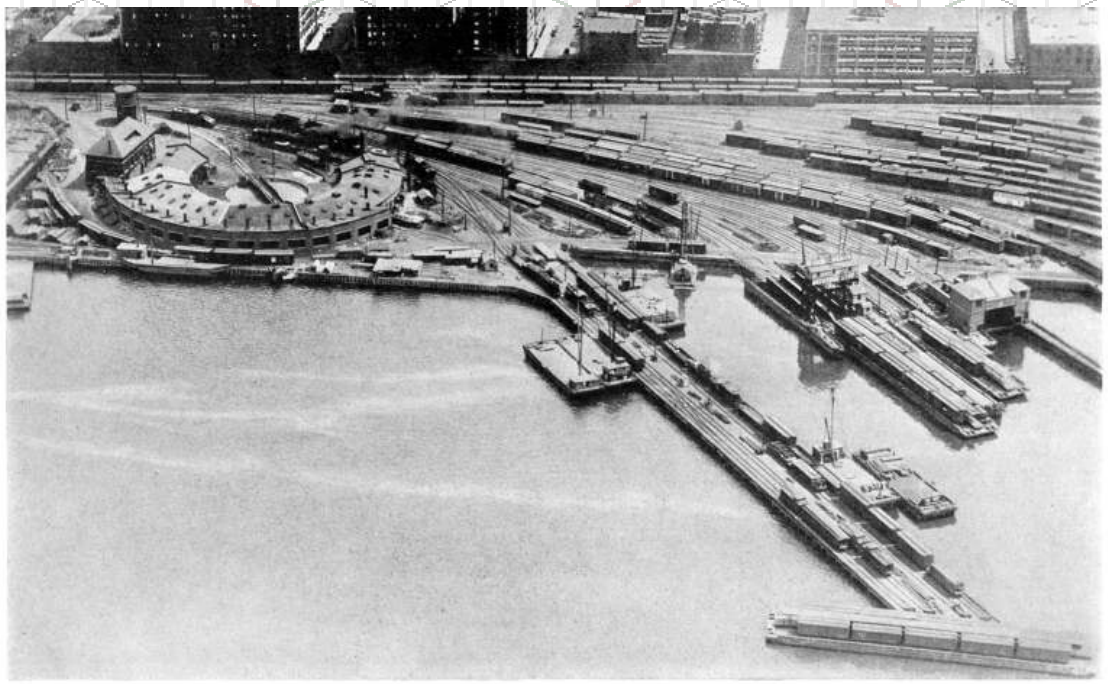
پائیز ۱۳۸۹

Railroad Blocking Problem (RBP)



AN AËRIAL VIEW OF THE WEST 72D STREET FREIGHT YARDS, NEW YORK, SHOWING A BIT OF RIVERSIDE DRIVE IN THE UPPER LEFT CORNER

Below Riverside Drive is a roundhouse, "the iron horses' stable," where some twenty engines may be sheltered. In the lower right corner is a car ferry. The canteloupe loaded into a refrigerator car in Arizona requires about two pounds of coal to bring it to an Atlantic seaboard breakfast table, while a half-pound of ice and locomotive fuel is used in bringing an orange from the Imperial Valley orangery to the Boston market.

Outline

- Introduction
- An Example
- The Blocking Problem Description
- Terminology

Introduction

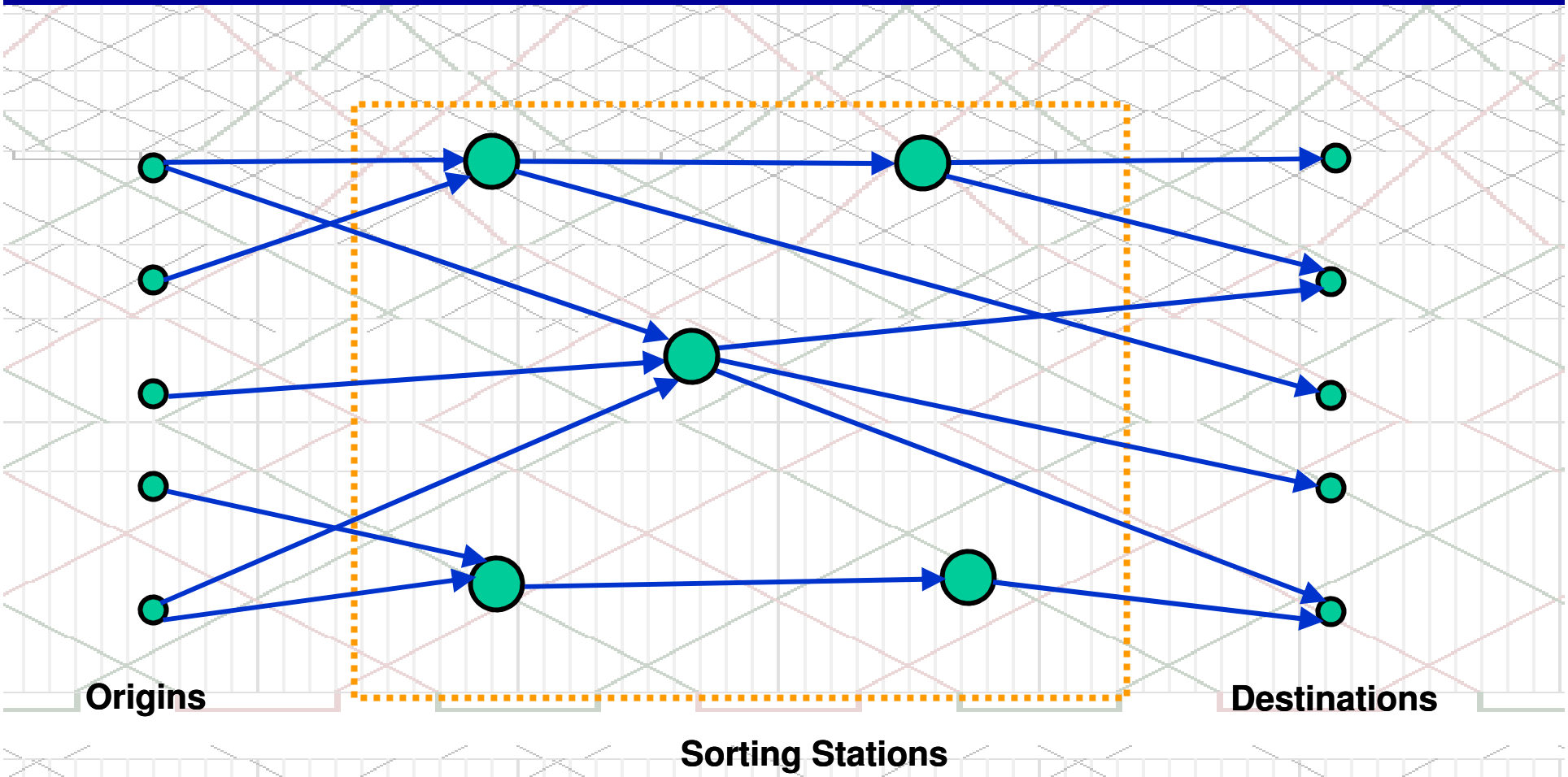
Introduction

- On major railroads, a typical merchandise shipment may pass through many classification yards on its route from origin to destination (OD).
- At these yards, the incoming traffic is reclassified (sorted and grouped together) to be placed on outgoing trains.

Introduction

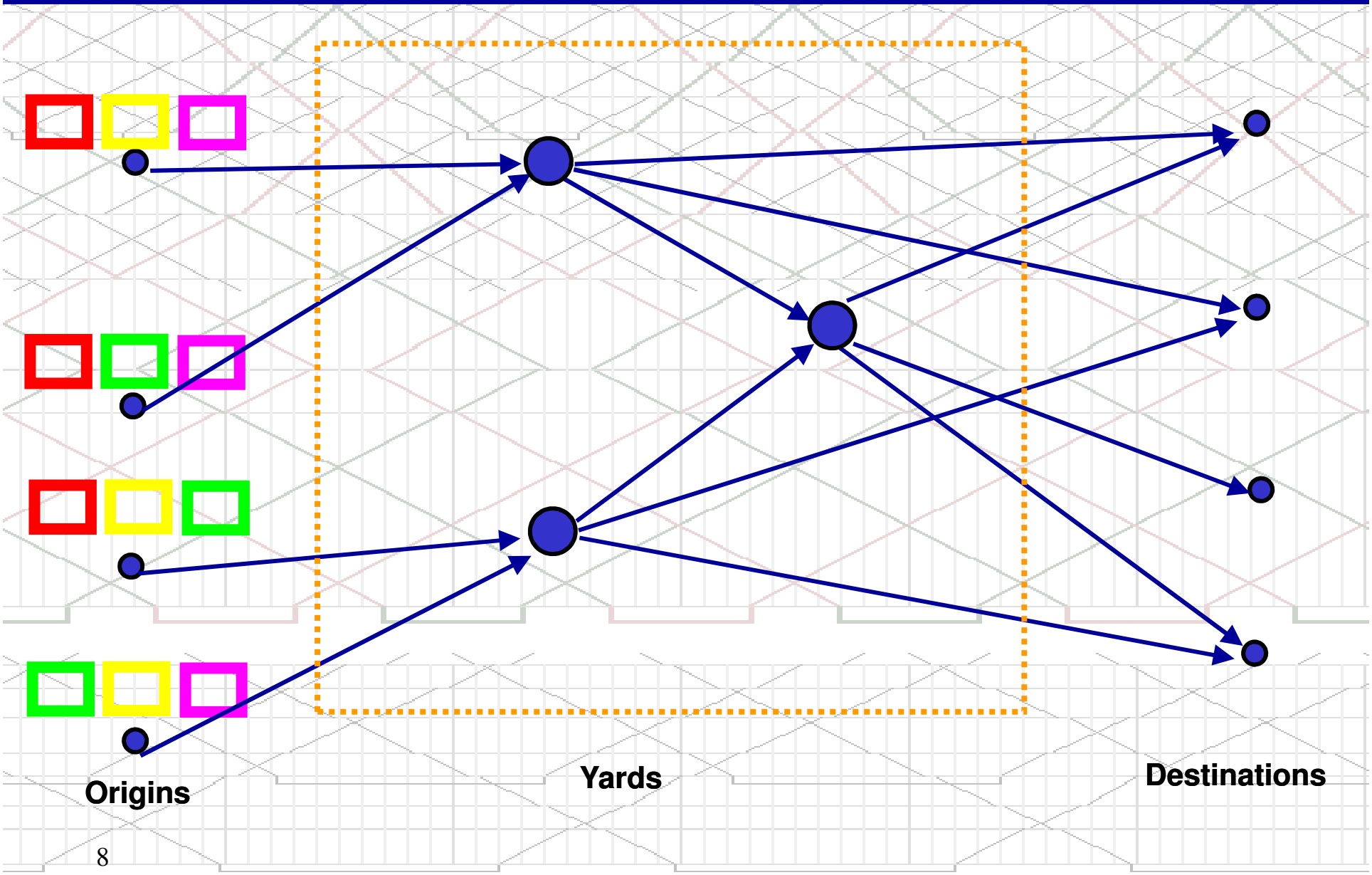
- On average, each reclassification results delay for the shipment.
- The classification process is labor intensive since many workers are needed to sort the traffic
- It is capital intensive since large quantities of equipment are needed for their construction and maintenance

Package Delivery Problem



Design the sorting network and route all packages in it to minimize the weighted sum of travel times and sortings.

Railroad Blocking Problem



Introduction

- To prevent shipments from being reclassified at every yard they pass through, several shipments may be grouped together to form a block.
- A block has associated with it an OD pair which may not be the OD pair of any of the individual shipments contained in the block.
- Once a shipment is placed in a block, it is not reclassified until it reaches the destination of that block.

Blocking Plan

- Over the years, railroads have developed **blocking plans** that dictate which blocks should be built at each individual yard and which traffic should be assigned to each block.
- For the most part, these plans have evolved through **incremental refinement** of an existing plan.
- These refinements are inherently local in nature since they only consider the effects of changing a small number of blocks in the existing plan.

Introduction

- Thus, these local improvement approaches may fail to recognize opportunities for improvement that require more significant changes to the current blocking plan.
- Also, these local approaches may not be sophisticated enough to capture the effects of changes to the plan on the flow of traffic **over the entire rail network**.

Railroad Blocking Problem Objectives

- The objective of the RBP is to develop a feasible blocking plan which in conjunction with other operating policies (such as **train routes** and **frequencies of service**) minimize the total cost of delivering the commodities.
- These costs are usually broken down into:
  - **car-handling**: costs associated with handling (or blocking) a car
  - **car-miles**: costs associated with the movement (conveyance) of a car.

Blocking Network

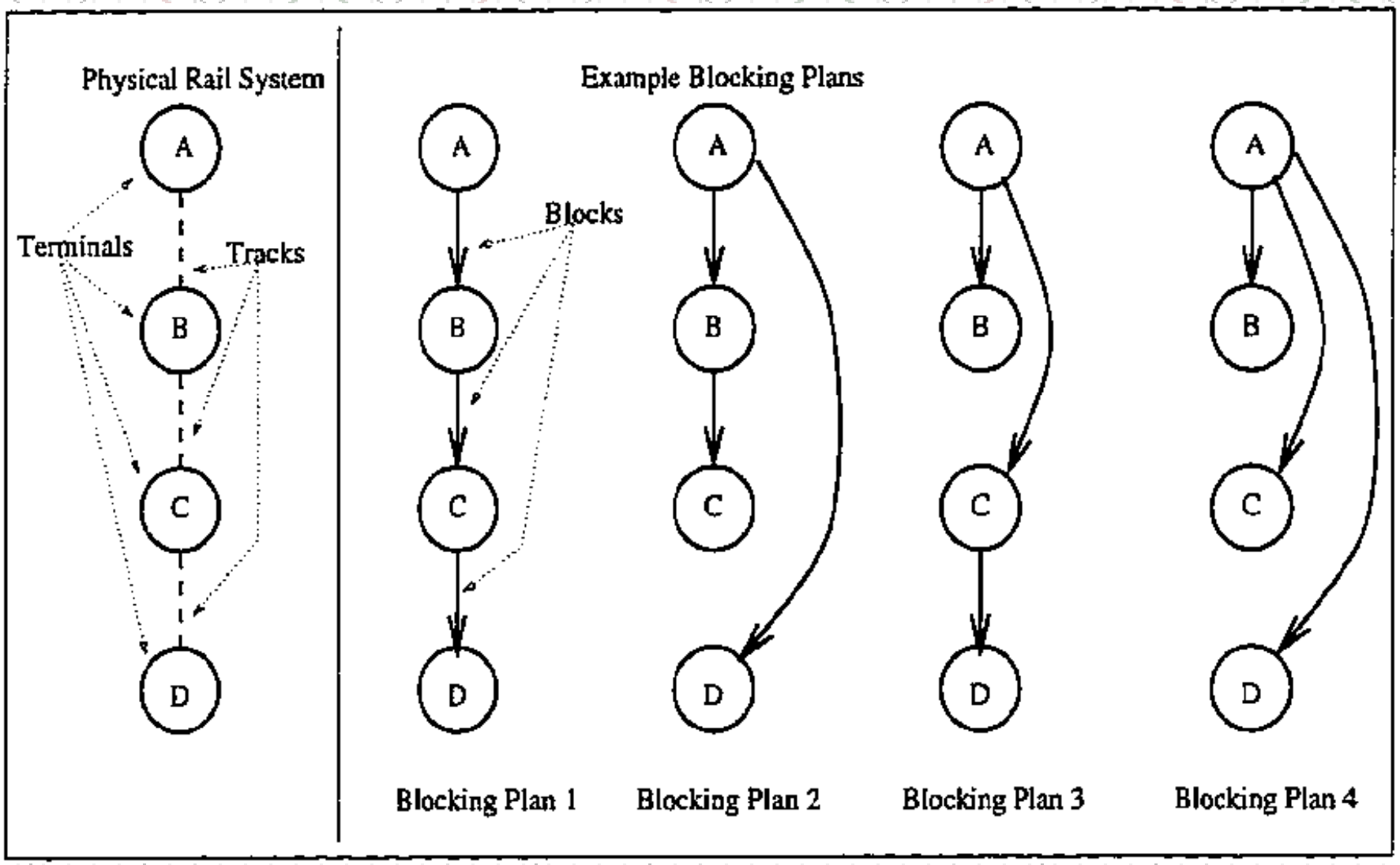
- The **physical rail network** (the railroad terminals and tracks) is already defined.
- The **blocking network** to be constructed is a virtual network that is overlayed on the physical network.
- Commodities are defined as origin-destination pairs of terminals.
- The **blocks** are **virtual arcs** which a commodity may take to have uninterrupted service between two terminals that are not necessarily connected by a physical link.

An Example

An Example

- A rail system with 4 terminals
- Commodities are:
  - A-B with 100 cars,
  - A-C with 80 cars,
  - A-D with 90 cars.
- Number of cars capacity:
  - Terminal A can block 270 cars.
  - Terminal B and C can block 90 cars.
- Number of blocks capacity:
  - Terminal A can build 2 blocks.
  - Terminal B & C can build one block.

An Example: Physical rail system and four blocking plans



An Example

- At each terminal, limited classification resources restrict the number of cars (or car volume) which can be classified and the number of blocks.
- To solve RBP, we must decide:
  - which blocks to include in the blocking plan and
  - which blocks to use to deliver each commodity.
- One performance metric of a blocking plan is the total **number of classifications** necessary to deliver all commodities.

Blocking Plan 1

- At terminal A all three commodities move to terminal B.
- At terminal B, commodity A-B has reached its destination and leaves the system.
- Commodities A-C and A-D are blocked to be move to terminal C.
- At terminal C, commodity A-C has reached its destination and leaves the system, and commodity A-D is blocked to move to terminal D.
- Using this blocking plan:
  - the 100 cars for commodity A-B use one block, (A,B),
  - the 80 cars for commodity A-C use two blocks, (A,B) and (B,C),
  - the 90 cars for commodity A-D use three blocks, (A,B), (B,C), (C,D).

Blocking Plan 1

- There are 530 classifications (100 + 80x2 + 90x3)
- This plan is not feasible because it requires blocking 170 (80+90) cars at terminal B which has a maximum volume of 90 cars.
- The strategy of building blocks only between adjacent terminals, as in blocking plan 1, is referred to as "short blocking."

Blocking plan 2

- Plan 2 provides a "direct" block from terminal A to terminal D.
- Cars which travel in this block will still move along the physical track through terminals B and C, but since they are pre-sorted for terminal D, they do not require classification resources at B or C.
- This plan requires 350 (100 + 80x2 + 90) classifications
- The 90 cars of Commodity A-D now require only one block, (A,D).
- This blocking plan is feasible since it observes the limits on number and total volume of the blocks built at each terminal.

Blocking plan 3

- Plan 3 provides a "direct" block from terminal A to terminal C.
- The blocking plans 3 requires 360 classifications (100 + 80 + 90x2)

Blocking plan 4

- The blocking plan 4 requires 270 classifications
- The plan 4 is infeasible since it requires three blocks for terminal A which has a maximum of two blocks.
- Always blocking commodities directly to their destination, as in blocking plan 4, is referred to as "long blocking."

Summary

	Station Classification			Total
	A	B	C	
Plan 1	270	170	90	530
Plan 2	270	80	0	350
Plan 3	270	0	90	360
Plan 4	270	0	0	270

Optimal Plan?

- So blocking plan 2 with 350 handlings is optimal with respect to the total number of classifications required.
- If the number of cars which could be blocked at B is reduced to less than 80 then blocking plan 2 would be infeasible and Plan 3 with 360 handlings would be optimal.

The Blocking Problem Description

How the Blocking Plan is Used

- The blocking plan provides a menu of blocks that can be built.
- Which blocks are actually built on a given day will depend on what traffic arrives, but most blocks will be built each day.
- A blocking plan occurs at the **tactical level** of decision-making.

How the Blocking Plan is Used

- The blocking plan answer the following questions:
  - What is the total amount of classification work performed in the system?
  - How should this workload be distributed among the terminals?
  - What groups or blocks should be consolidated? (from the incoming traffic to the terminal)

The Constraints

- The Volume and Number of Blocks Constraints
  - The capacity of the classification yard can be approximated by its:
    - The **number of tracks** , and
    - The **number of cars** that can fit in the tracks.
  - Larger volume blocks would be assembled on the longer tracks or several tracks.
  - Sometimes, factors of around 1.25 are used to convert the number of classification tracks into the maximum number of blocks.

The Constraints

- Priority Constraints
  - Express traffic must be delivered in a few days (usually two or three days) and non-express traffic must be delivered in one to two weeks, as specified by the commitment to the customer
  - Since each reclassification can incur a delay, the number of reclassifications for both types of traffic must be limited.
  - We include constraints on the maximum number of times each commodity is reclassified.

Terminology

Terminology

- **A Block**
  - is specified by its origin and destination.
  - cars using the block will be sorted at the block's origin and then not sorted again until reaching the block's destination.
- **An inter-terminal block**
  - has a terminal origin and a terminal destination
- **A local block**
  - originates or terminates at a node which is not a terminal.
- **Classification, Blocking, or Handling**
  - is the process of sorting cars into different blocks.

Terminology

- **A Terminal**
  - is a node of the rail network at which classification may be performed.
- **An End Terminal**
  - is a terminal which may not be used for intermediate classifications for any commodity.
- **An OD pair**
  - is a group of cars with the same origin terminal and destination terminal.

Terminology

- **A Priority Class**
  - is the number of intermediate reclassifications that are permitted.
  - If no intermediate reclassifications are permitted, then the commodity must be blocked for the destination terminal at the origin terminal.
- **A Commodity**
  - is a subgroup of an OD pair which has the same priority class.

Terminology

- **A Routing**
  - for a commodity is a sequence of terminals, starting with the commodity's origin and ending with the commodity's destination
  - Classification will occur at some of the terminals along one of the commodity's routings.
  - We will assume that routings are non-circuitous; i.e., no terminal may occur more than once in the routing.

Terminology

- **A Blocking Assignment or Blocking Path**
  - for a commodity is a sequence of blocks on which a commodity will travel as it moves along its routing.
  - Classification for the commodity will be performed at the starting terminal for each of these blocks.
  - The endpoints of the blocks in the blocking assignment will be a subsequence of the terminals in one of the commodity's routings.

Terminology

- **Train**
  - consists of one or more blocks, a consist of locomotives.
- **Blocking Plan**
  - is a listing of all blocks.
- **Inter-Terminal Blocking Plan**
  - is the listing of all blocks which have a terminal origin and a terminal destination.
- **Local Blocking Plan**
  - lists blocks for which at least one endpoint is not a terminal.

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