Intra- and Inter-facility Logistics

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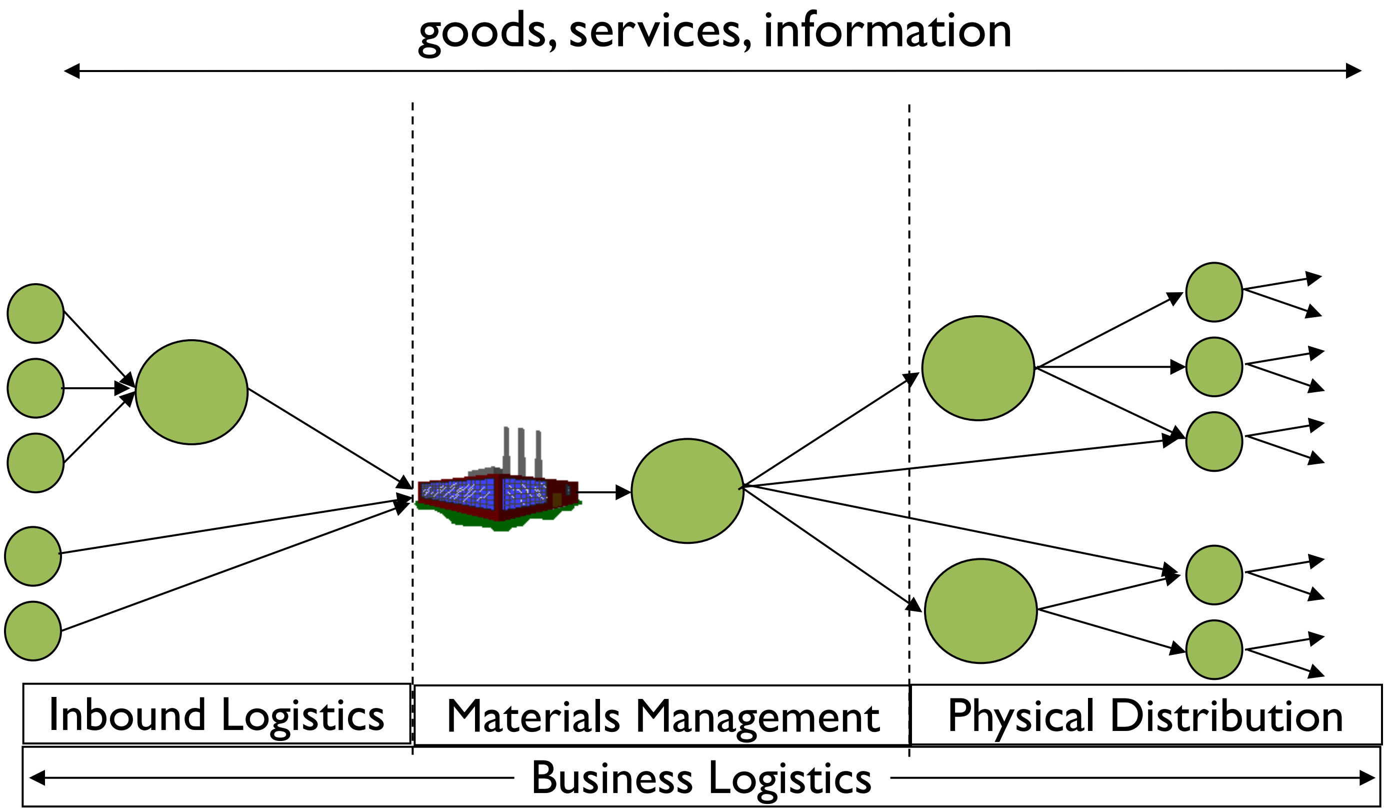
LOGISTICS DECISIONS

What is Logistics?

- Council of Supply Chain Management Professionals (CSCMP) definition
  - "Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements."
- Key Ideas
  - Forward and reverse flow
  - Efficient and effective
  - Plans, implements, and controls
  - Part of supply chain management (SCM)

…forward and reverse flow…



…efficient, effective…

- Effectiveness: delivering on what is committed
  - Price
  - Quality
  - Response time
  - Flexibility

Achieving desired *objective* while minimizing *costs*

- Efficiency: using resources in the "best" way

…plans, implements, and controls…

Long Term → Medium Term → Near Term

Strategic (Long Term)

-Corporate Objectives
-Number of Facilities
-Facility Location & Capacity
-Resource Requirements

Tactical (Medium Term)

-Material Flow
-Resource Allocation
-Capacity Allocation
-Inventory Policies

Operational (Near Term)

-Scheduling
-Routing
-Warehousing
-Tracking/Tracing

Supply Chain Network Importance

- Cost
  - 2016 logistics costs in the U.S.: 7.5% of GDP, or $1.39 trillion

  CSCMP's 28th Annual State of Logistics Report, Council of Supply Chain Management Professionals, prepared by A.T. Kearney
- Environmental Impact
  - Packaging
  - Fuel emissions
- Competitive Advantage
  - Speed
  - Flexibility

Key Decisions

- Intra-facility logistics (warehousing)
  - Warehouse design
  - Which skus where
  - Equipment, technology
- Inter-facility logistics (transportation)
  - Mode choice
  - Comprehensive network planning
  - Routing
  - Fleet and driver assignment

DECISION SUPPORT TOOLS: MODE CHOICE

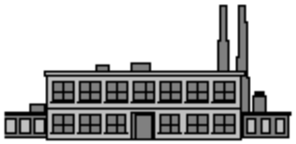
Mode Choice Problem

- Given the cost profiles of different modes for a particular shipment, which option is most economical?
  - Normalize all costs to common unit and time
  - Compare total cost of each mode

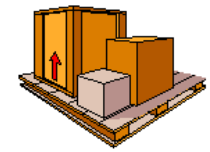
Logistics System Cost Classification

- Useful to classify costs under essential types, e.g.,
  - Transportation costs: movement via vehicle; loading/unloading
  - Handling costs: packing/unpacking boxes, bags, pallets; intra-facility storing and picking movements
  - Holding costs: opportunity cost of capital for time waiting
  - Facility rent costs: economic “rent” for facility space, storage infrastructure, and maintenance

Example

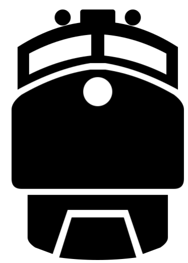


- 1 plant, 1 product
- Produce 10 units/day
- Keep no safety stock
- Space cost = $20/unit*year
- Item value = $500/unit



- 1 warehouse
- Avg demand 10 units/day
- Keep 100 units safety stock
- Space cost = $25/unit*year
- Item value = $512/unit

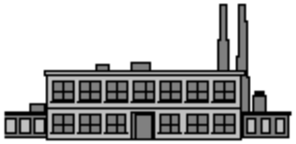
Inventory holding cost rate = 25% of value per year



- Railcar capacity = 400 units
- Cost = $1200/carload
- Transit time = 20 days

- Truck capacity = 100 units
- Cost = $700/truckload
- Transit time = 3 days

Example



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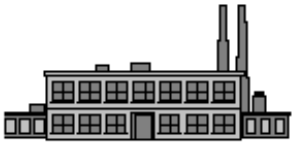
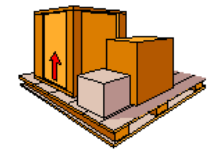
Costs at the Plant

- Inventory space cost = (*# units per shipment*) x (*space cost per unit*year*)
  = *q units* x $20/*unit*year*
- Inventory holding cost = (*avg inventory held*) x (*value per unit*) x (*inventory holding cost rate*)
  = *q*/2 *units* x $500/*unit* x 25% *per year*

Example





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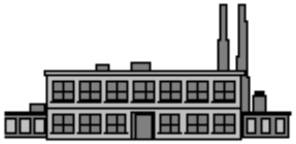
Costs at the Plant

- Inventory space cost = (*# units per shipment*) x (*space cost per unit*year*)
  = *q units* x $20/*unit*year*
- Inventory holding cost = (*avg inventory held*) x (*value per unit*) x (*inventory holding cost rate*)
  = *q*/2 *units* x $500/*unit* x 25% *per year*

Costs at the Warehouse

- Inventory space cost = (*# units per shipment + safety stock*) x (*space cost per unit*year*)
  = (*q* + 100 *units*) x $25/*unit*year*
- Inventory holding cost = (*avg inventory held*) x (*value per unit*) x (*inventory holding cost rate*)
  = (*q*/2 + 100 *units*) x $512/*unit* x 25% *per year*

Example



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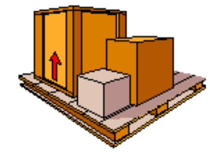

- 1 warehouse
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Costs in Transit

- Pipeline inventory cost

= (*# units shipped*) x (*time in transit*) x (*value per unit*)

x (*inventory holding cost rate*)

= 3650 *units* x (*time in transit*) x $506/*unit* x 25% *per year*

- Transportation cost

= (*cost per shipment*) x (*# shipments per year*)

Railcar capacity = 400 units

Cost = $1200/carload

Transit time = 20 days

Truck capacity = 100 units

Cost = $700/truckload

Transit time = 3 days

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Example

COST SUMMARY USING FULL CONTAINERS					
Mode	At Plant	At Warehouse	Pipeline Inventory	Transport	Total Cost
Rail	$33,000	$50,900	$25,300	$10,950	**$120,150**
Truck	$8,250	$24,200	$3,795	$25,550	**$61,795**

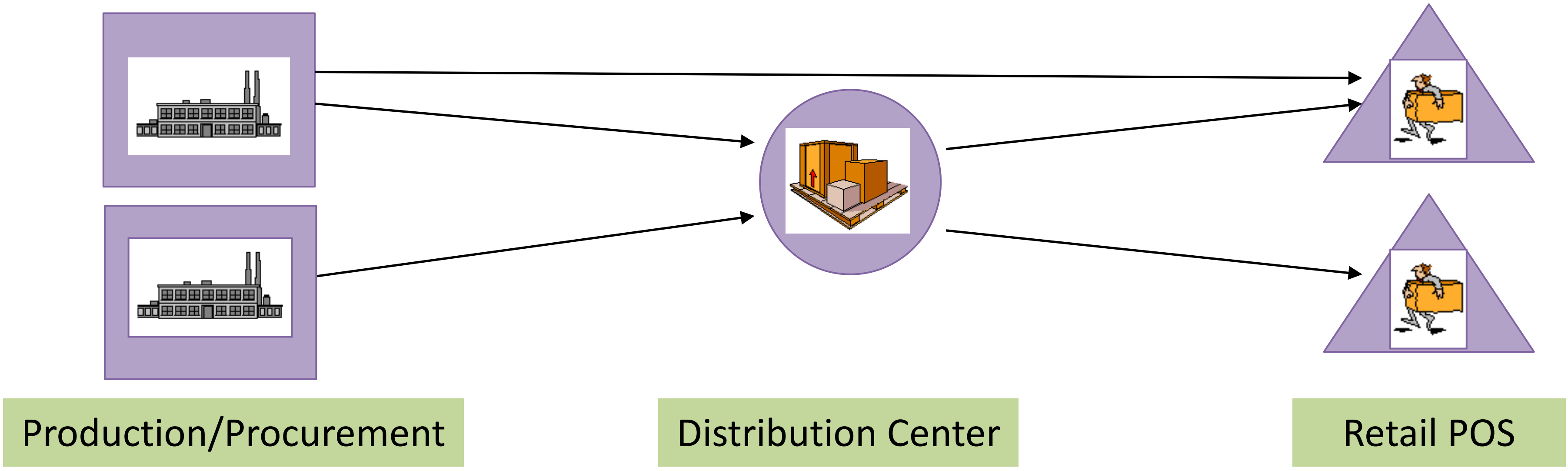
- What are the key factors?
  - Large container size, if used, increases inventory space costs
  - Long transit time increases inventory holding costs
- What's missing?
  - Stochastic, dynamic components
  - Other costs, e.g., emissions

DECISION SUPPORT TOOLS: NETWORK PLANNING

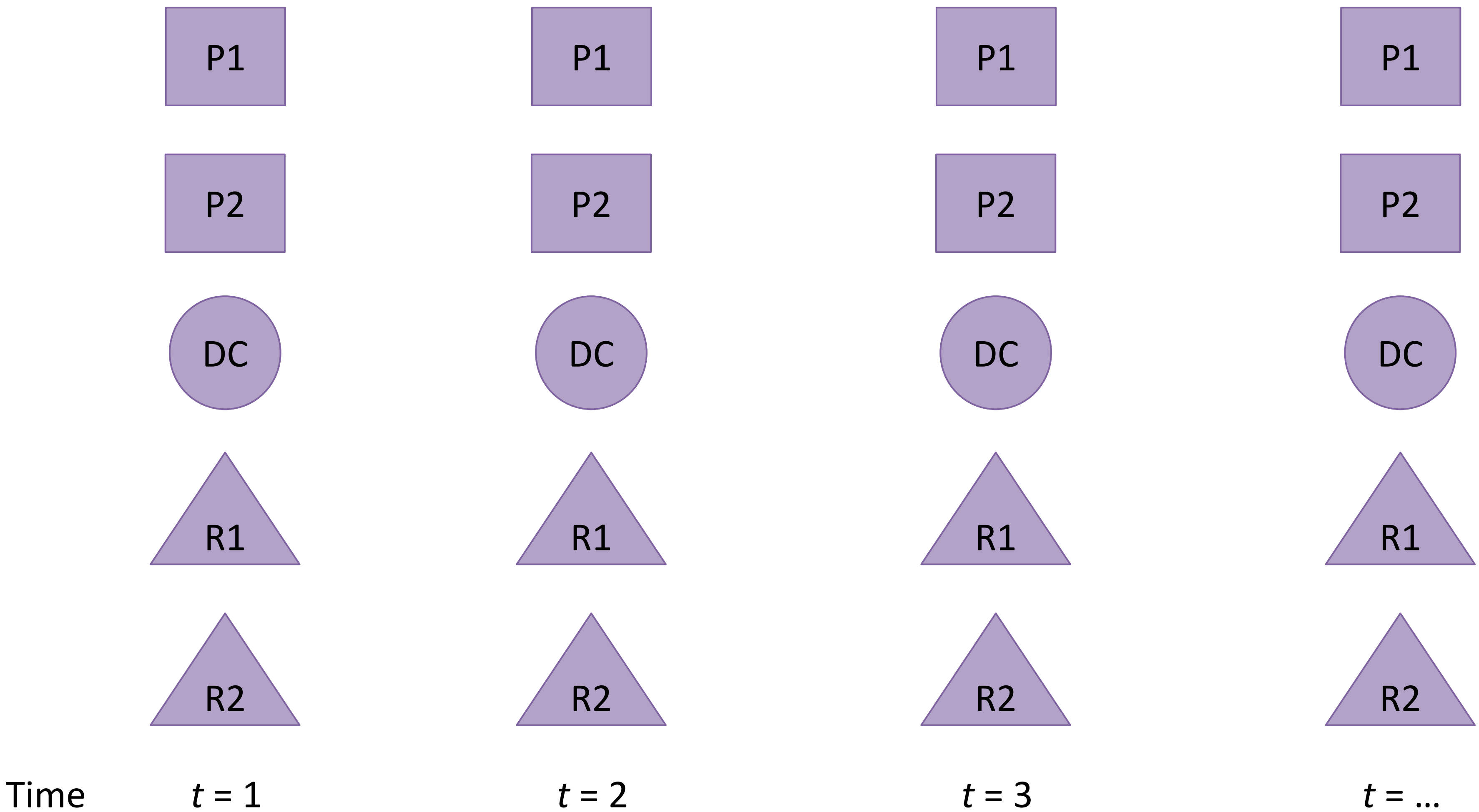
Shipper Problem

- Given a demand profile, supply sources, and distribution network, what flow through the network optimizes total cost?
  - Choose appropriate planning horizon
  - Capture relevant costs

Physical Network Representation



Time-expanded Network Representation



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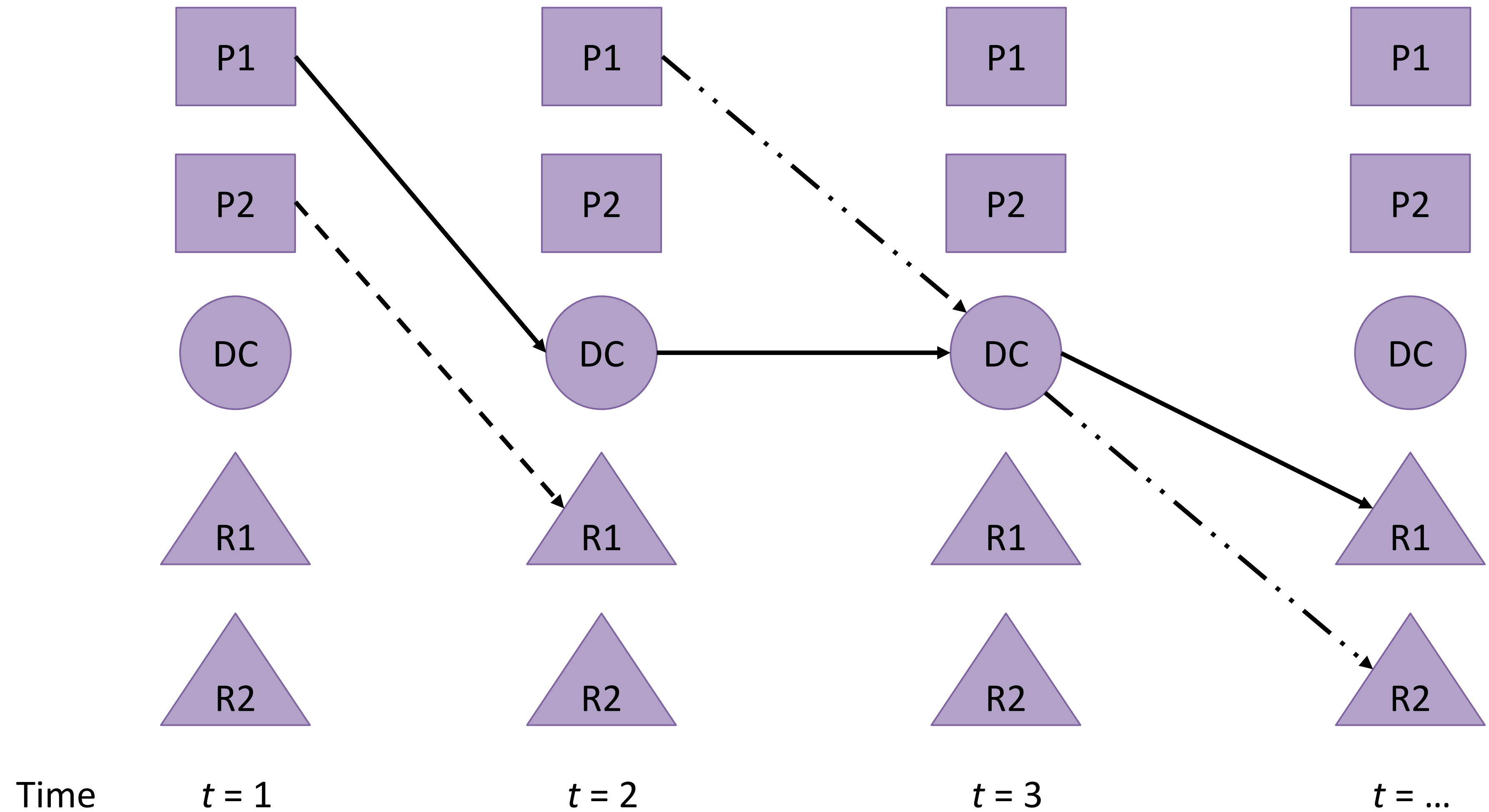

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Network Flow Optimization

Network Representation

- Arcs in the network
- Costs on each arc
- Capacities on each arc
- Nodes in the network

Optimization Model

- Decision variables (how much flow?)
- Objective function contribution
- Flow capacity constraints
- Flow conservation constraints (out = in)

Network Flow Optimization

- Easy case: “imaginary” mode with linear costs
  - Minimum cost network flow model
  - Easy (computationally) to solve, even for large-scale networks
  - Foundation of all network optimization approaches
- Generalizations
  - Multi-commodity flow
  - Economies of scale

Resources

- Warehouse management principles and tools
  - https://www.warehouse-science.com/
- MHI (formerly Material Handling Institute), material handling, logistics, and supply chain industry group
  - http://www.mhi.org/
- Council of Supply Chain Management Professionals
  - http://cscmp.org/
- Institute of Industrial and Systems Engineers
  - Main site: http://www.iise.org/Home/
  - Logistics and Supply Chain Division: http://www.iise.org/details.aspx?id=33757
- Institute for Operations Research and the Management Sciences
  - Main site: https://www.informs.org/
  - Transportation Science and Logistics Society: http://connect.informs.org/tsl/home
  - Railway Applications Section: http://connect.informs.org/railway-applications/home
  - Section on Location Analysis: http://connect.informs.org/sola/home