# MetaHeuristics

## INF273

## #4: Introducing some COPs

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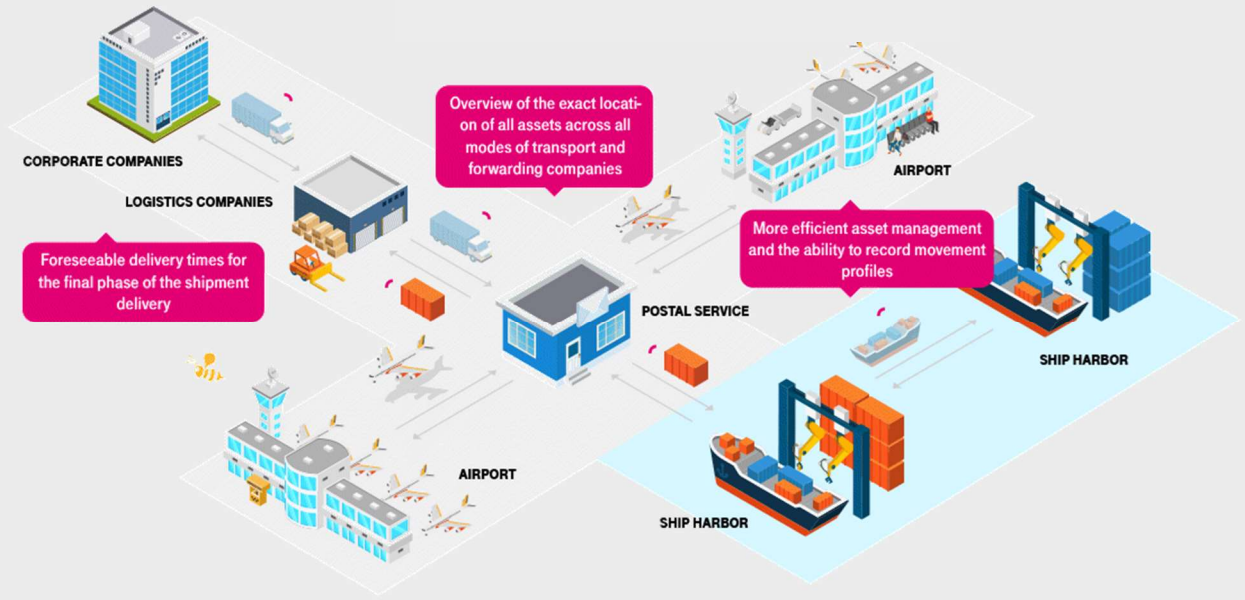
# Agenda

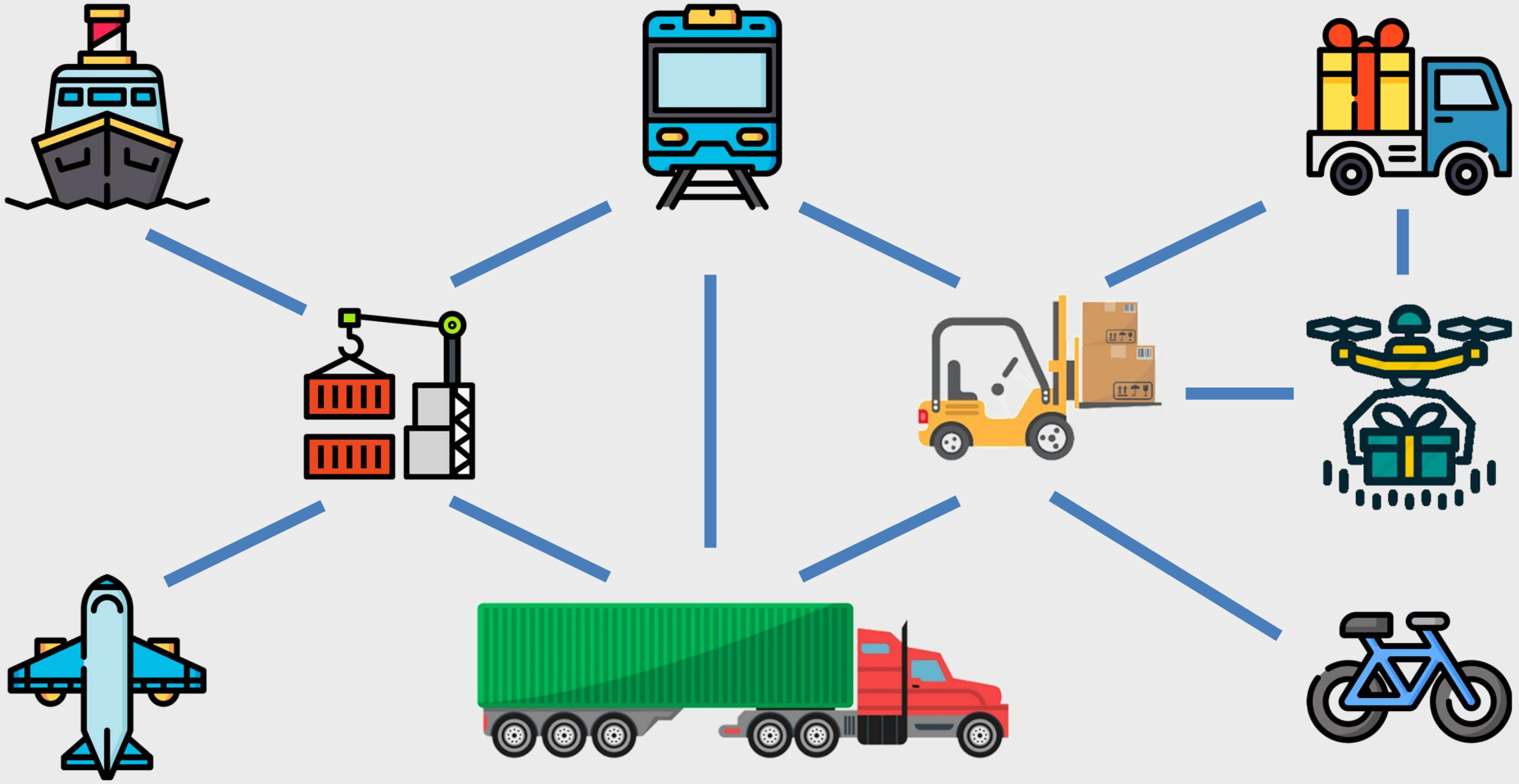
- PDPTW
- Truck and Drones Multimodal System
- Liner Shipping
- Assignment #1 and #2

# Transportation and Logistics

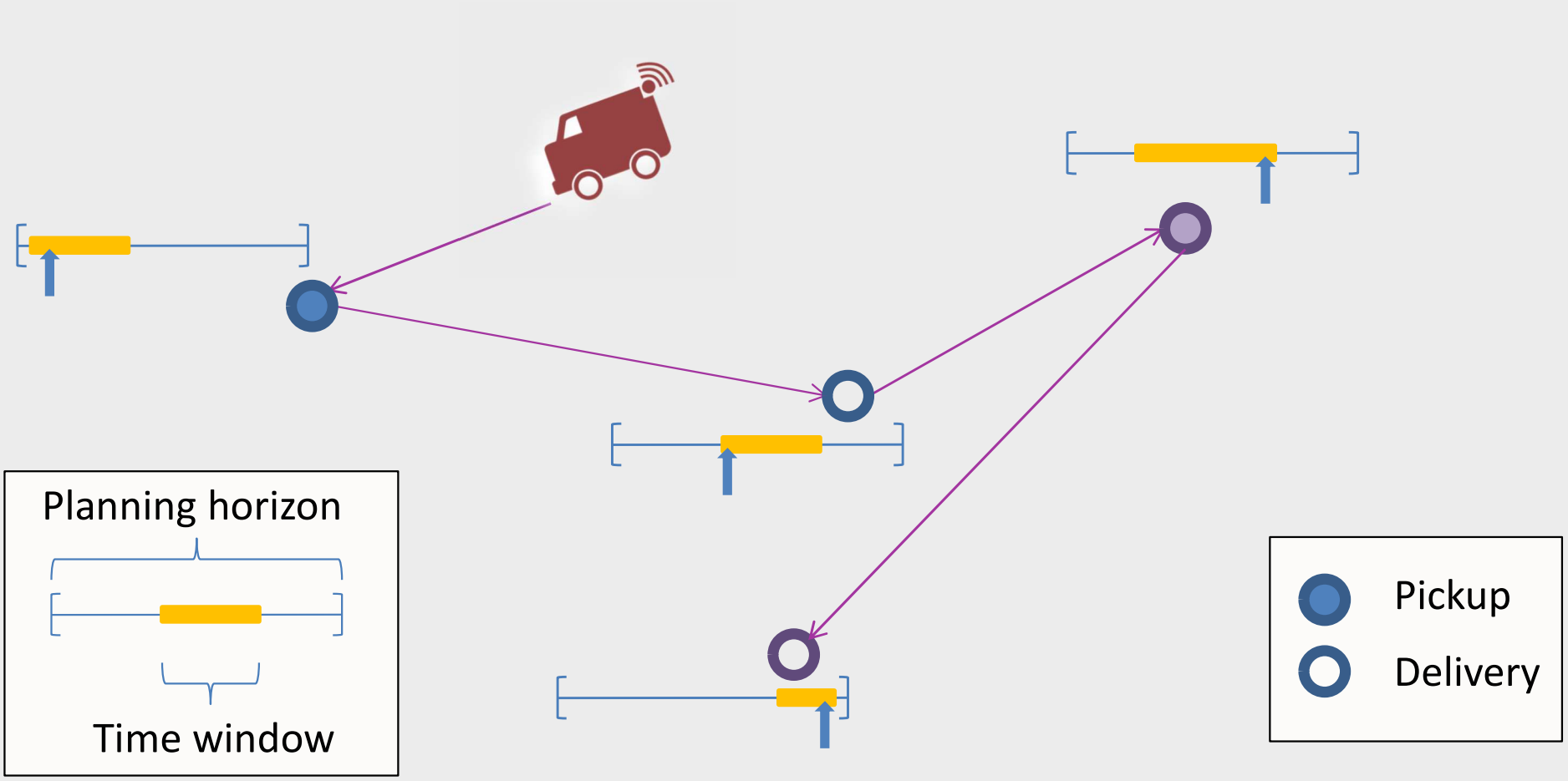


# TRANSPORTATION

**InterContinental** **Long Haul** **Last mile**



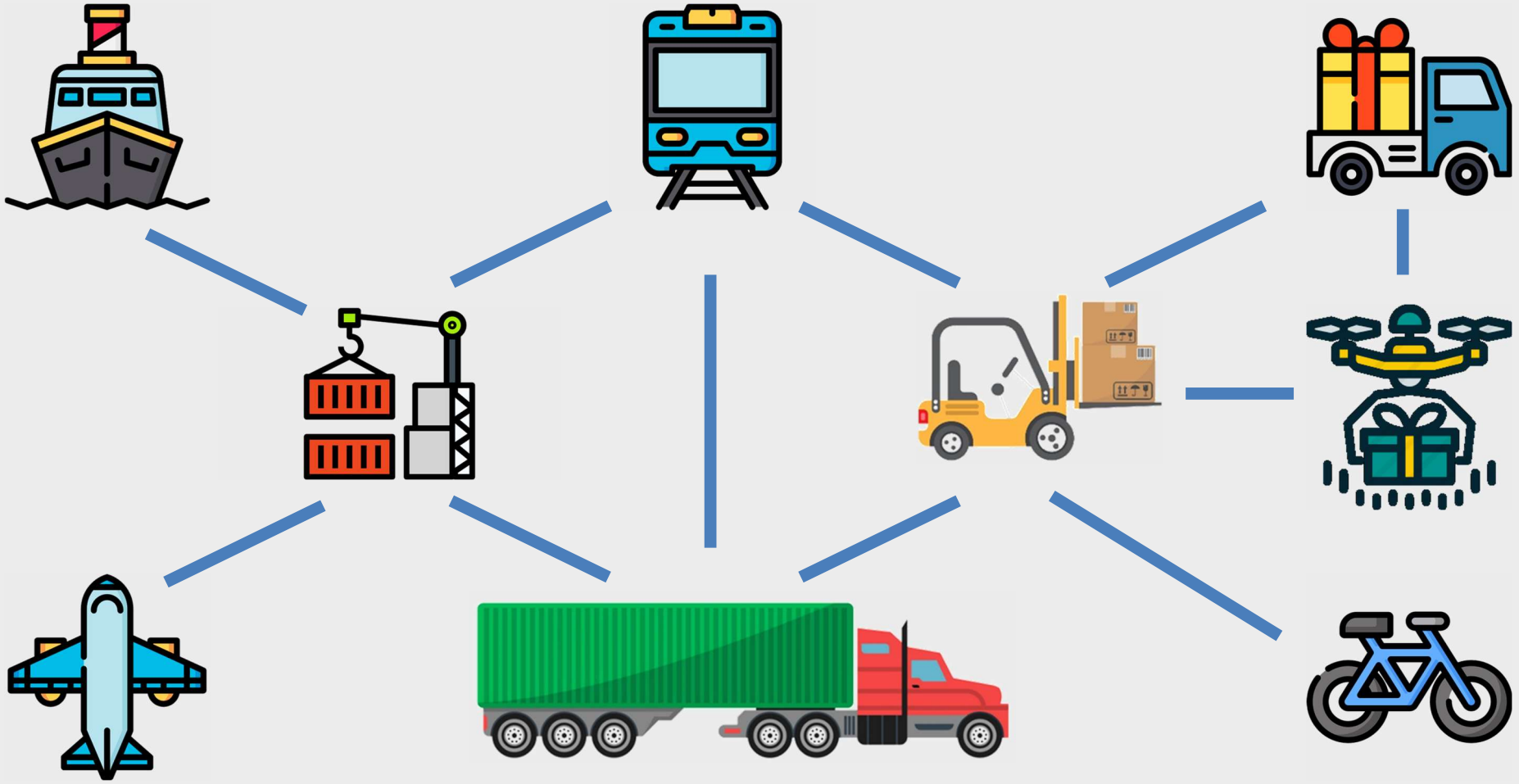
# Pickup and Delivery with Time Windows




**Request**: Origin, Destination, Size, Time windows at origin and destination

# TRANSPORTATION

**InterContinental** **Long Haul** **Last mile**



# Time Line…

| 2013 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|
| Amazon Prime Air | Workhorse | Mercedes Benz | UPS | Drone Delivery Canada |
| | Matternet | Domino's | Alphabet, Google Wing | |
| | DHL | Zipline | MIT | |











# Why Drones for Logistics?



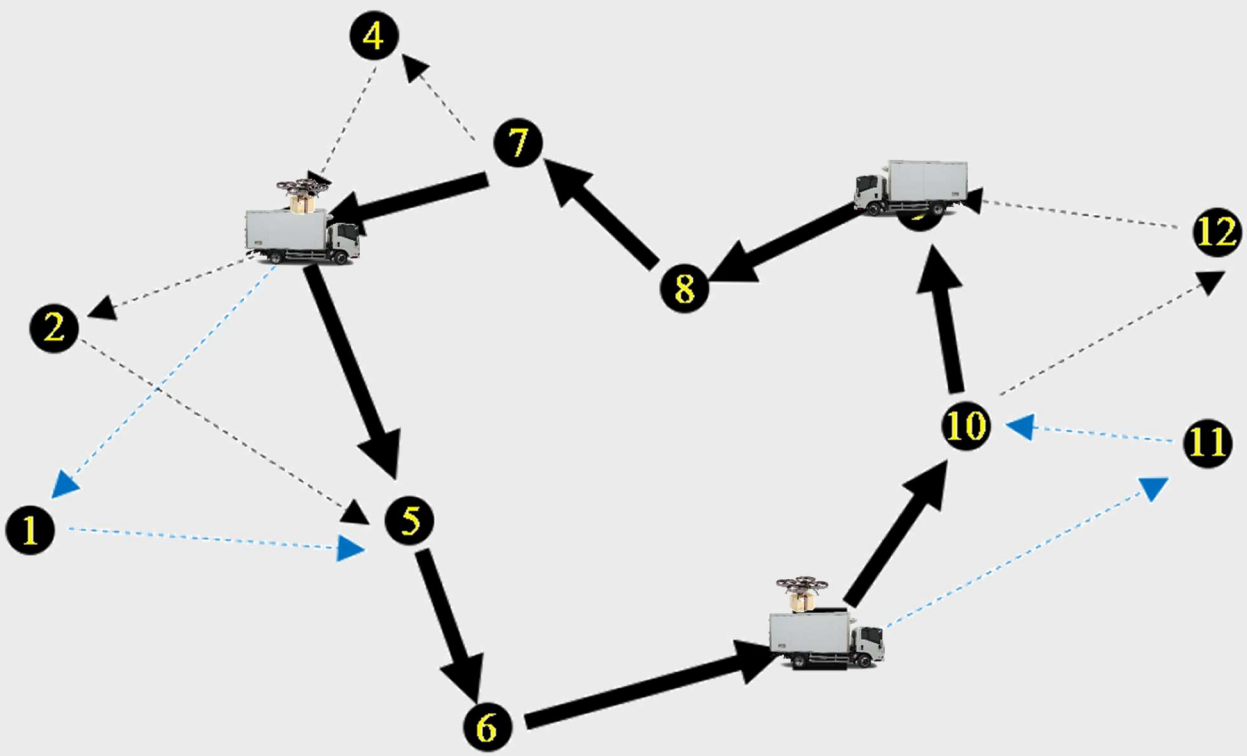

- Advantages:
  1. High travel speed: More than 100 MPH.
  2. Three dimensional travel-space:
     - » They can access rural areas, islands, valleys, and flooded areas.
  3. No need for road:
     - » Drones are not limited to traffic

- Limitations
  1. Travel range constraint mainly due to limited battery
  2. Capacity constraint (size and weight)

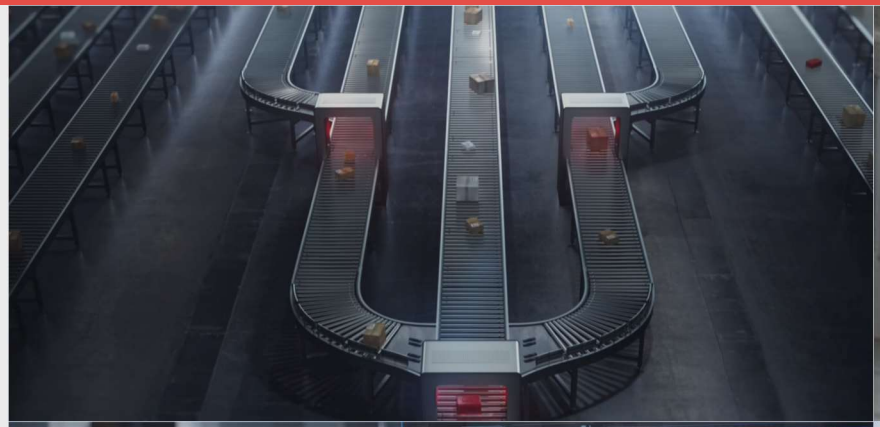
# Challenges

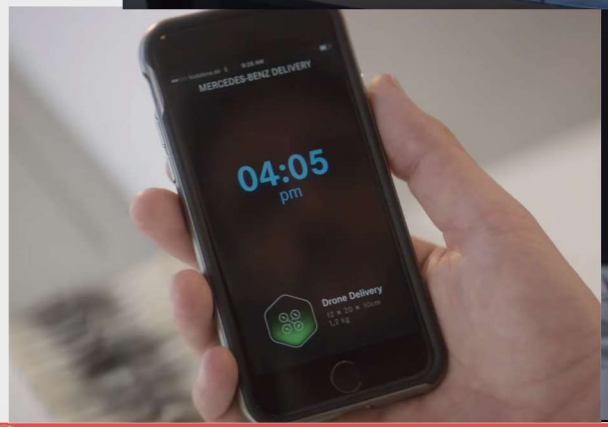
- Technology: Battery, recharging
- Infrastructure: Landing, Drop-off, Pick-up
- Safety and Security

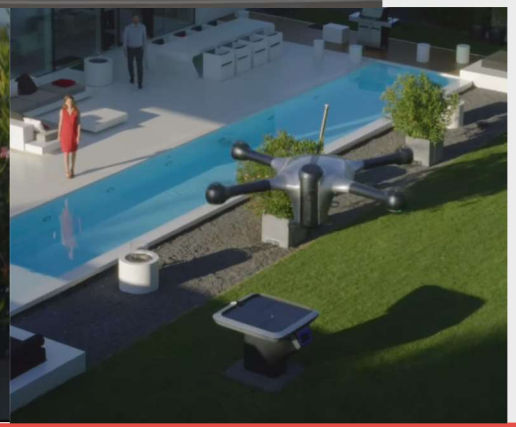
# Truck and Drones Multimodal System



# Infrastructure



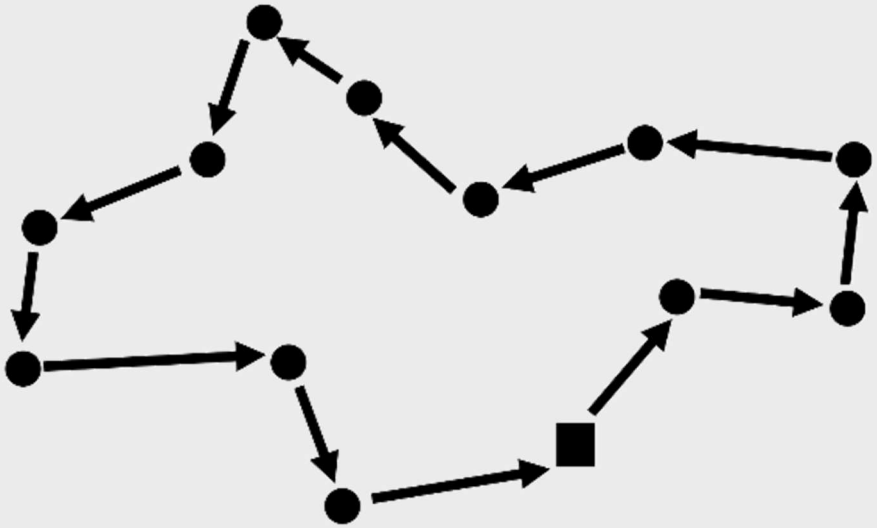


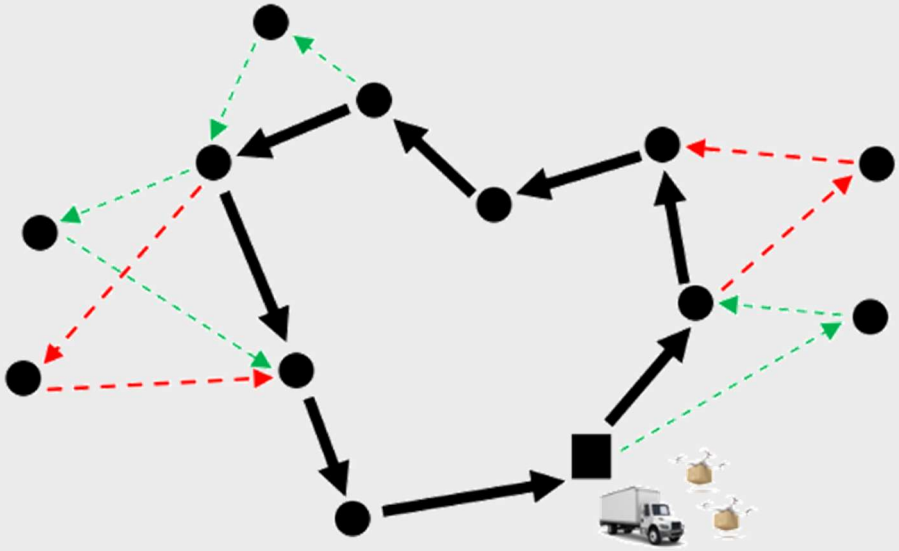
# Infrastructure

# Truck and Drones Multimodal System

Traveling Repairman Problem
(**TRP**)



Truck And Drones Multimodal System



Minimize total waiting time

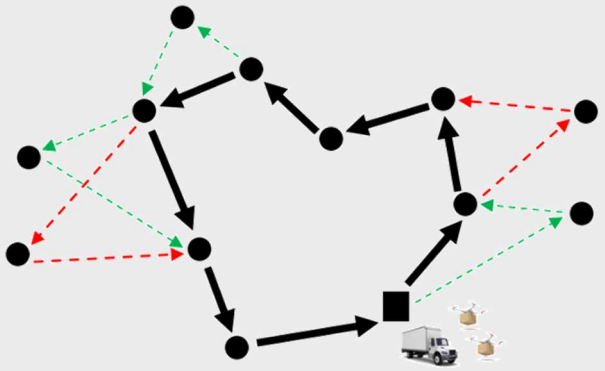
# Truck and Drones Multimodal System

Assumptions:

1. A single truck with multiple drones
2. Truck can launch and receive drones at customer locations
3. Each drone can serve one customer in each trip
4. Drone flight time is limited

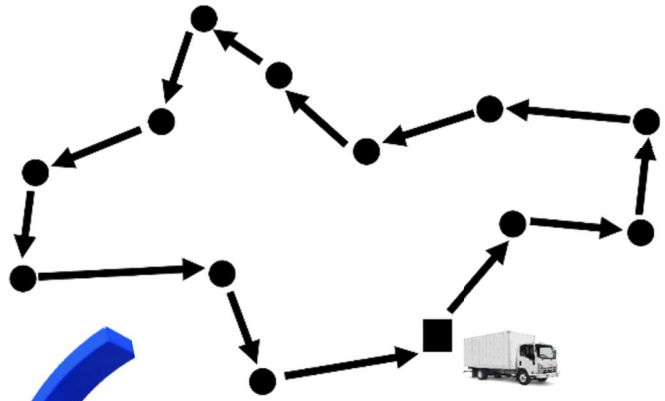
Goal:

Minimize the total waiting time



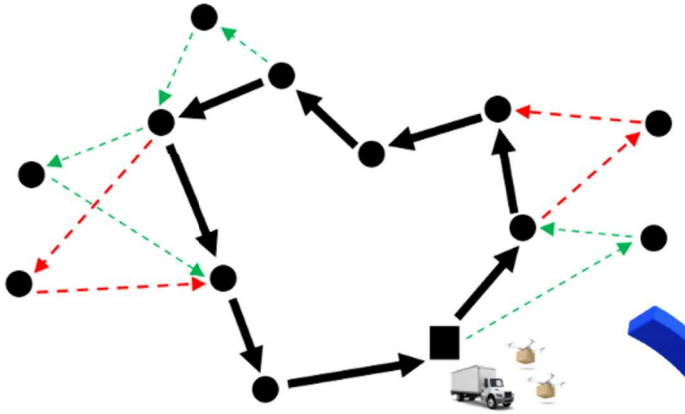
# Truck and Drones Multimodal System

Only One Truck



$N!$

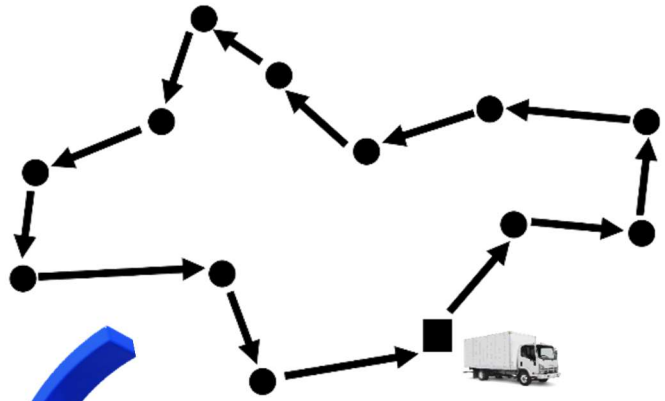
One Truck + Two Drones



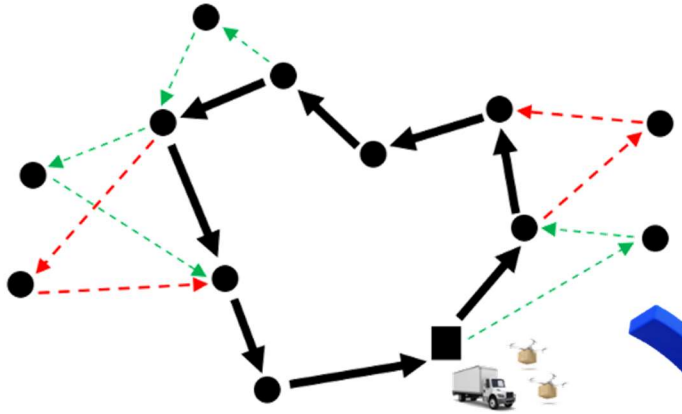
$$\binom{N}{D} N!\ e^{N}$$

# Truck and Drones Multimodal System

Only One Truck

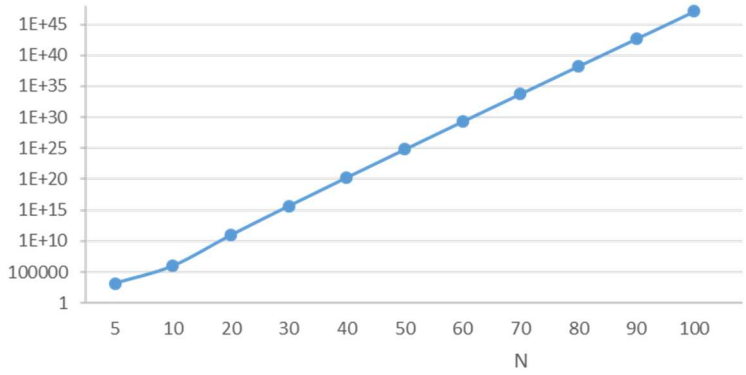


One Truck + Two Drones



$N!$

The value of $\binom{N}{D} e^N$ for different N when D=2




$\binom{N}{D} N!\ e^N$

# TRANSPORTATION

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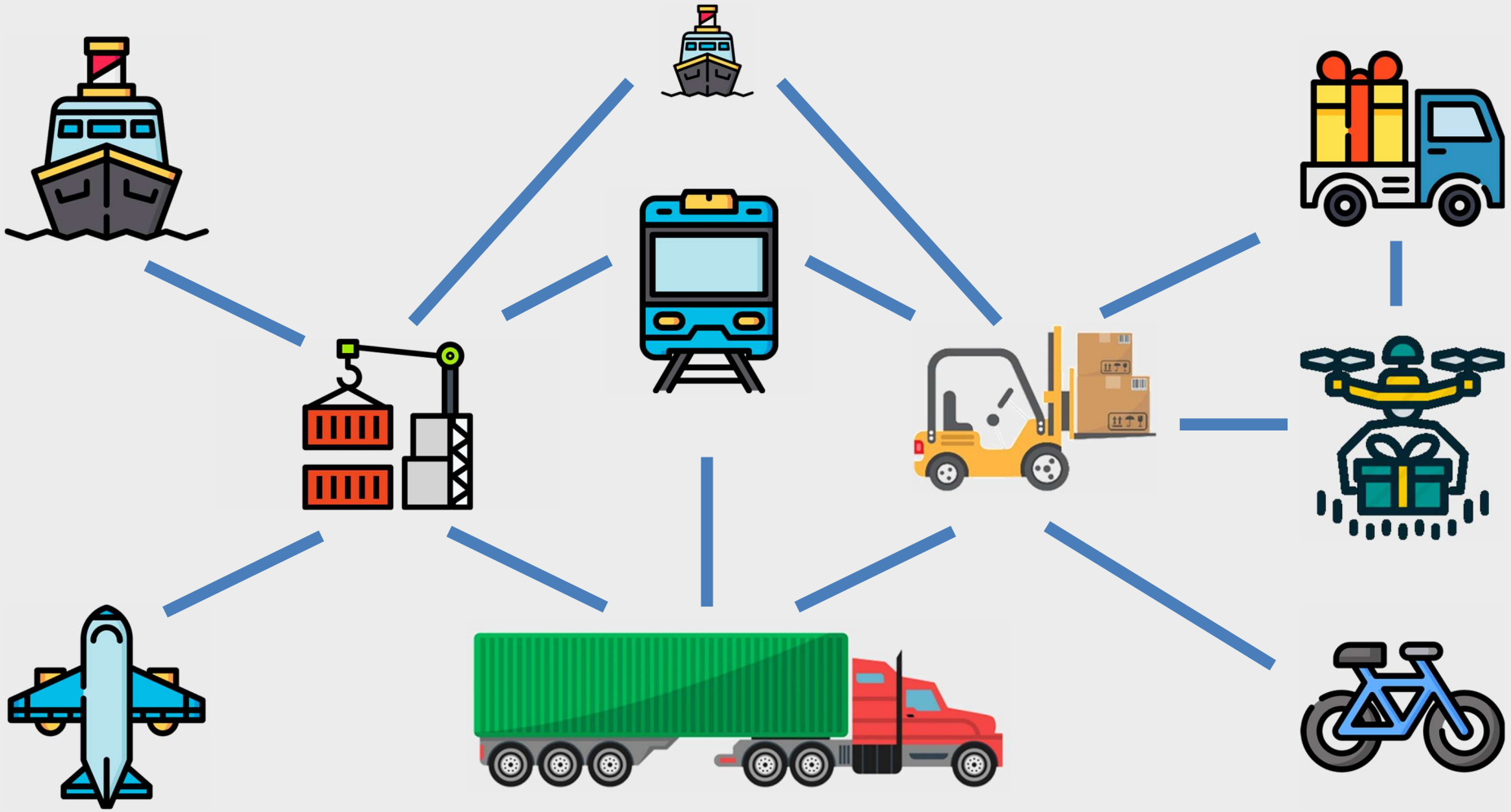
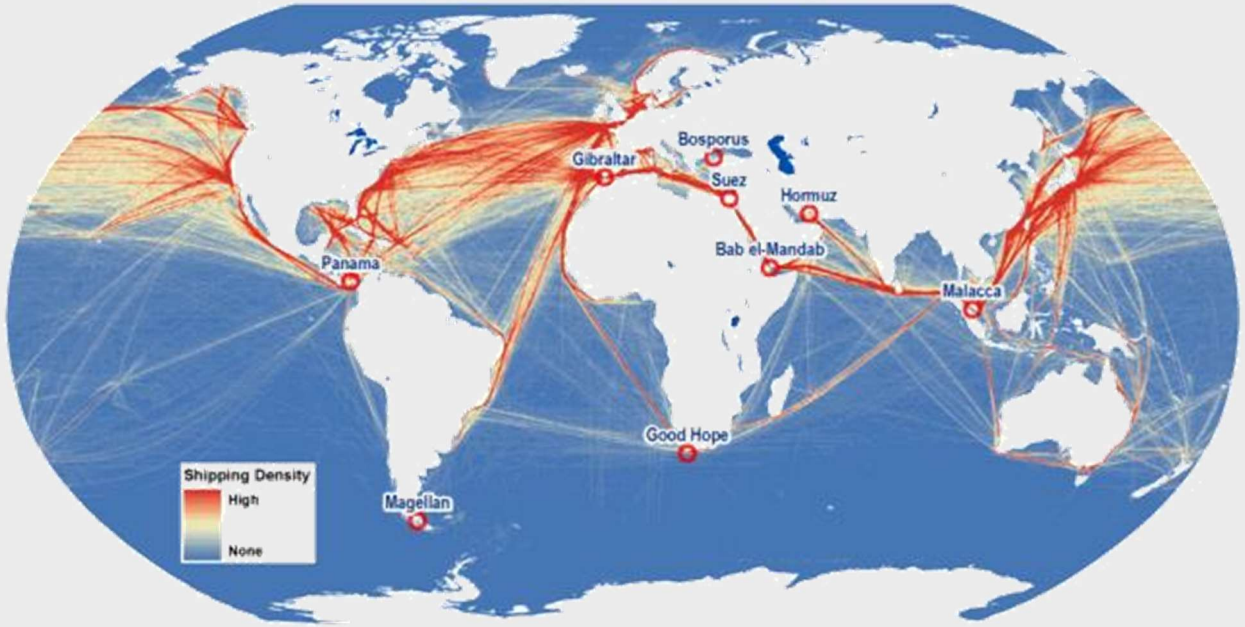


# MARITIME TRANSPORTATION – BACKBONE OF INTERNATIONAL TRADE

- Around 80% of the volume of world trade and 70% of the value of all goods are carried by sea (UNCTAD, 2015)
- More than 10 billion tons of goods carried at sea annually by a world fleet with a capacity of more than 1.8 billion deadweight tons. (UNCTAD, 2015)



# Maritime Transportation – backbone of international trade

- Maritime transportation is the obvious choice for heavy industrial activities where large volumes are transported over long distances.
- Operational efficiency of maritime transportation can have a huge effect on consumers by reducing final product costs.
- This is already exploited by industries related to a wide range of products from oil and chemicals to cars and foods.

# MARITIME TRANSPORTATION – BACKBONE OF INTERNATIONAL TRADE

The maritime industry is the most globalized of Norway's industries

#10 Norway is currently the world's tenth largest shipping nation in terms of **tonnage**

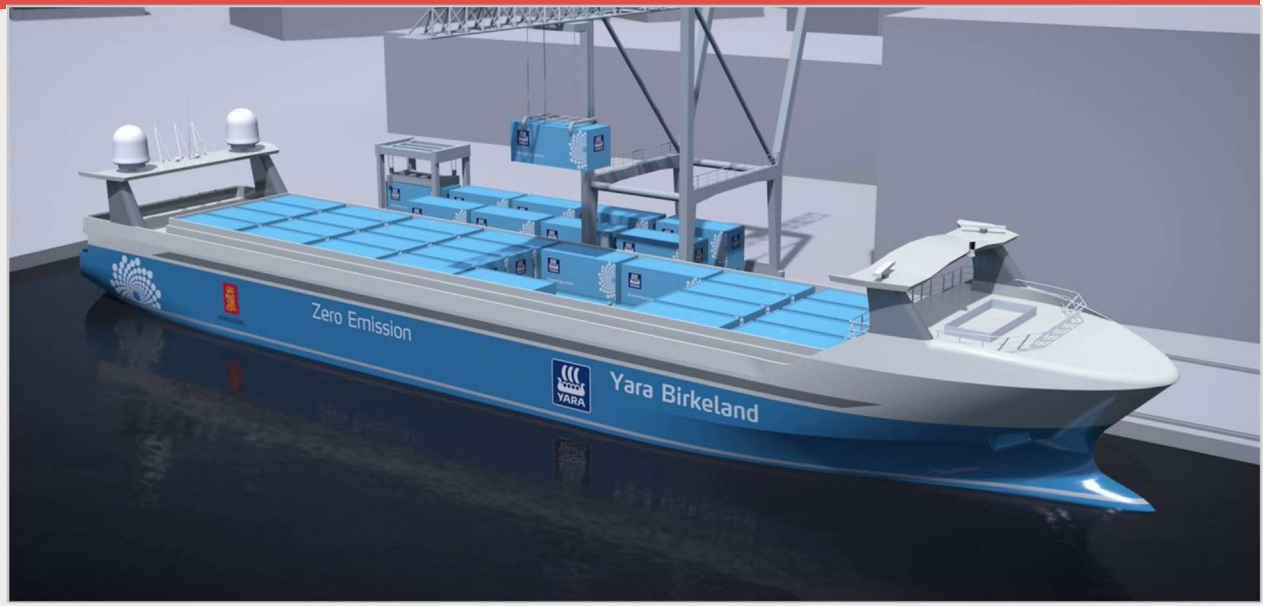
#7 The world's seventh largest shipping nation in terms of the number of **vessels**

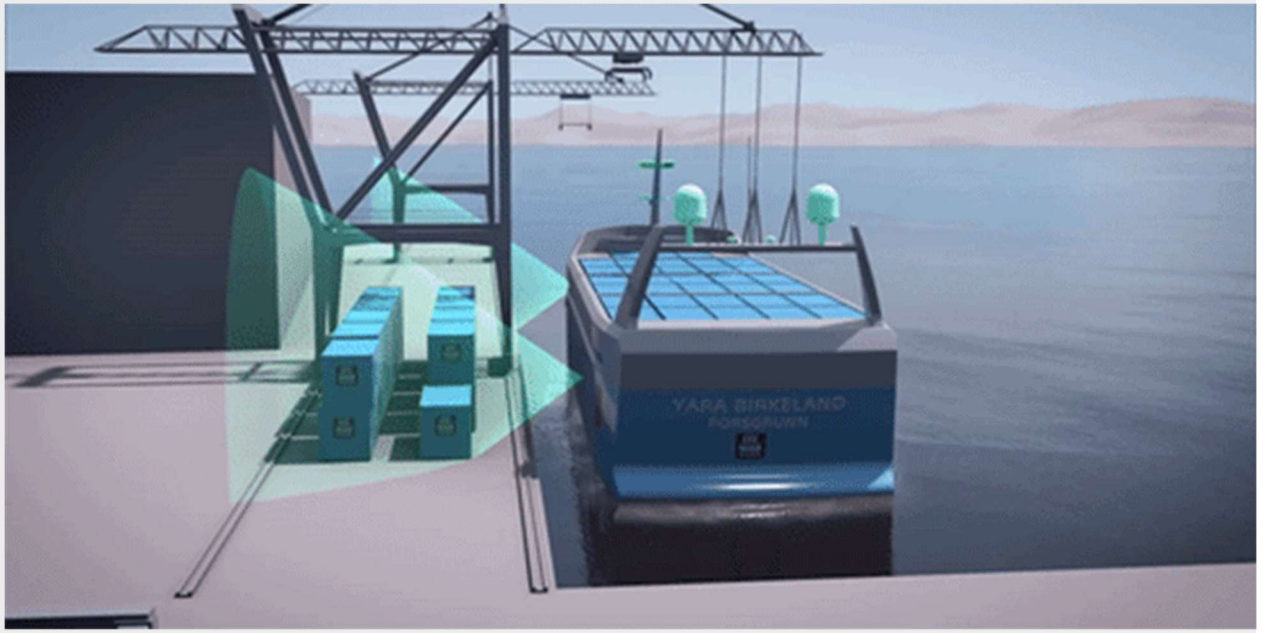
#6 Norwegian fleet is the world's sixth largest in terms of **value**.

Source: Menon Business Economics

# Zero Emission Autonomous Vessels

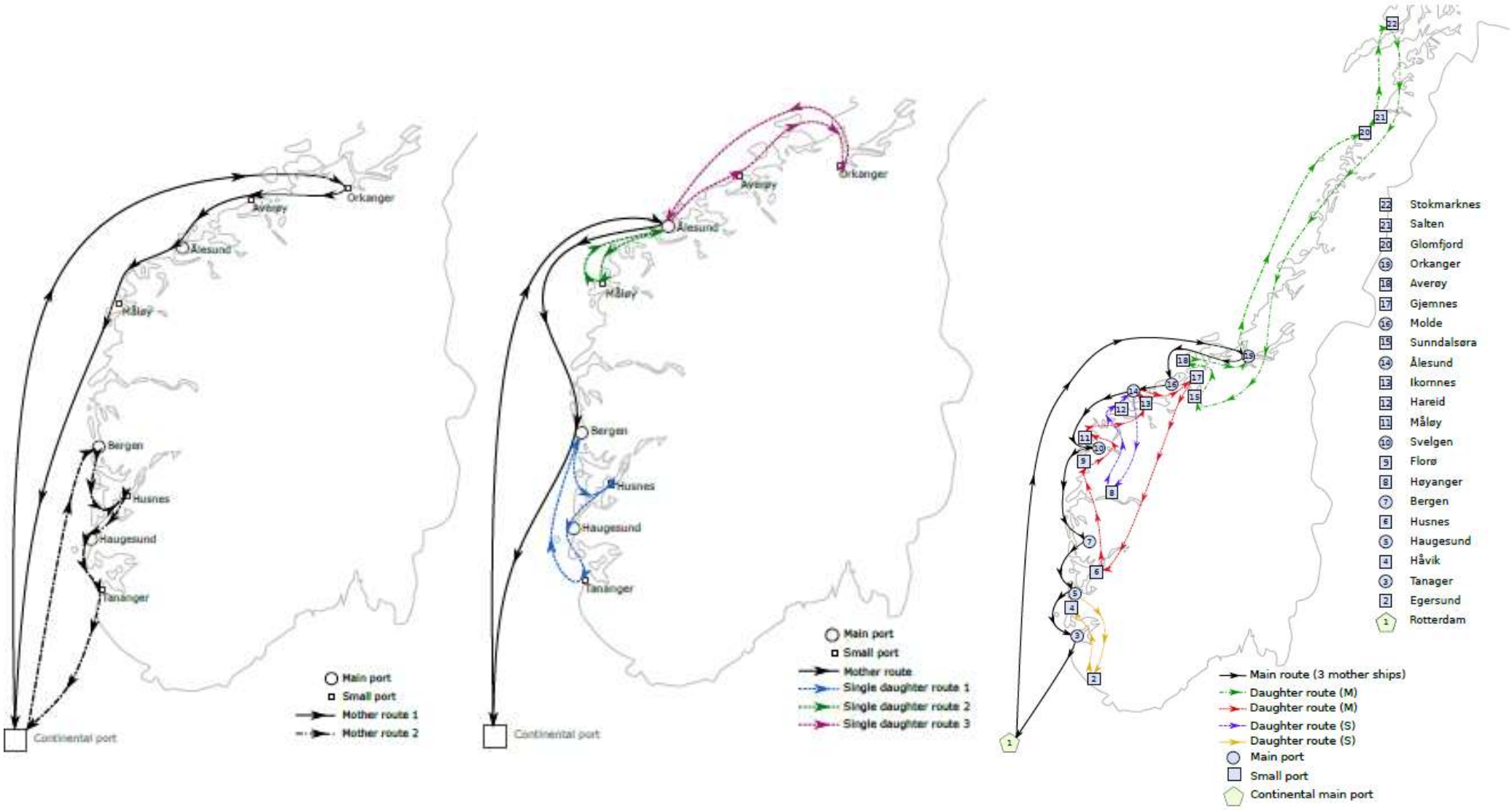
The Yara Birkeland project is planned to be the first fully autonomous logistics concept from industrial site operations, port operations and vessel operations in the world.



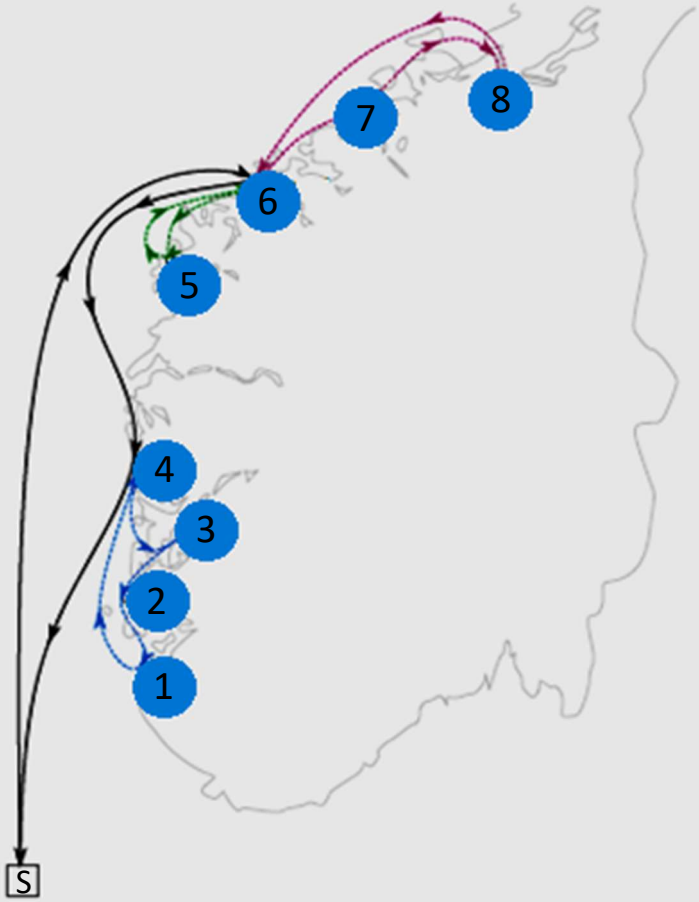
- **Industrial shipping**
  - Cargo owner (shipper) controls the fleet of vessels (owned)
  - Vertically integrated companies
  - Decisions: Routing and scheduling
  - Must ship all cargoes while minimizing costs
- **Tramp shipping**
  - Ships follow the available cargoes, similar to a taxi service
  - Combination of contract and optional spot cargoes
  - Decisions: Routing/scheduling and selection of spot cargoes
  - Maximize profit
- **Liner shipping**
  - Ships follow a published schedule, similar to a bus line
  - Container, ro-ro and general cargo vessels

# Liner Shipping



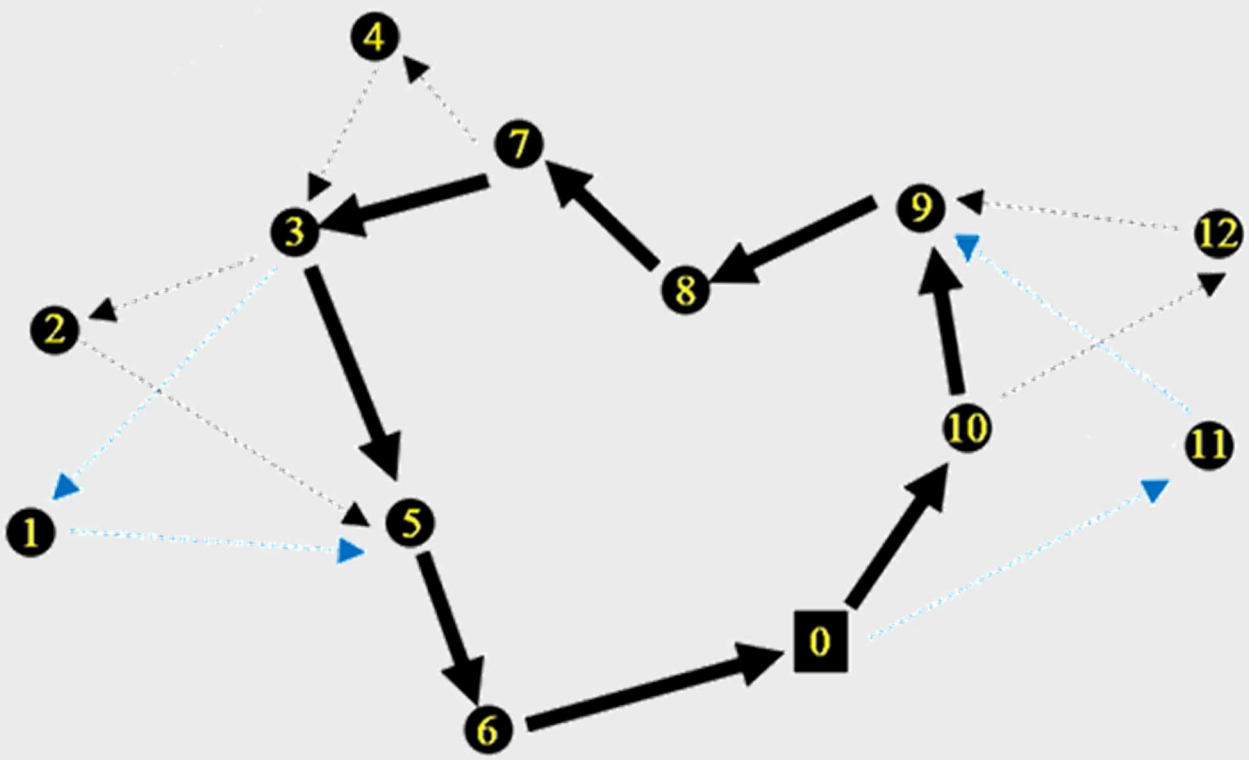
# Assignment #1–a

Suggest a good (?!) solution representation. Not more than one page of explanation.

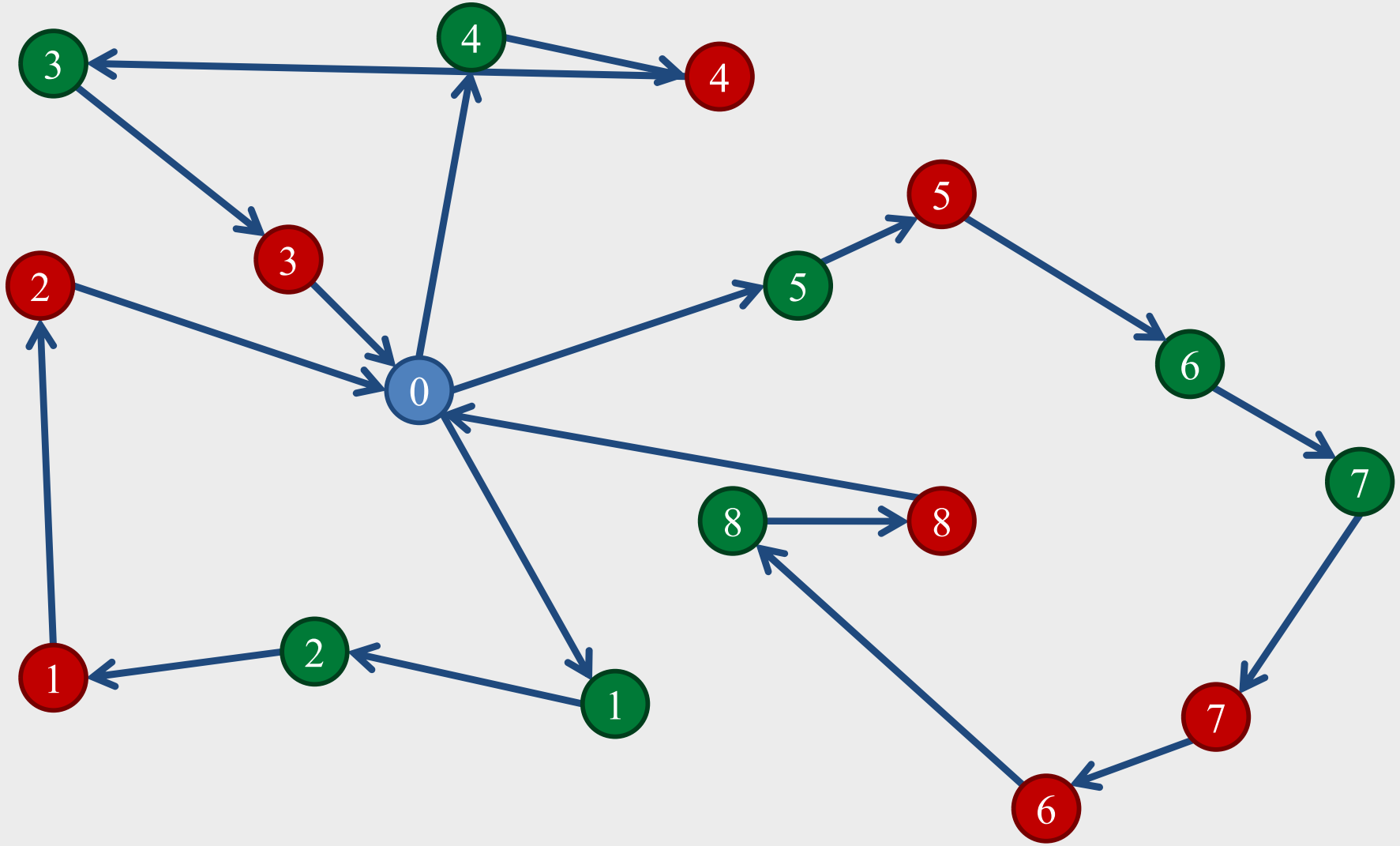


# Assignment #1–b

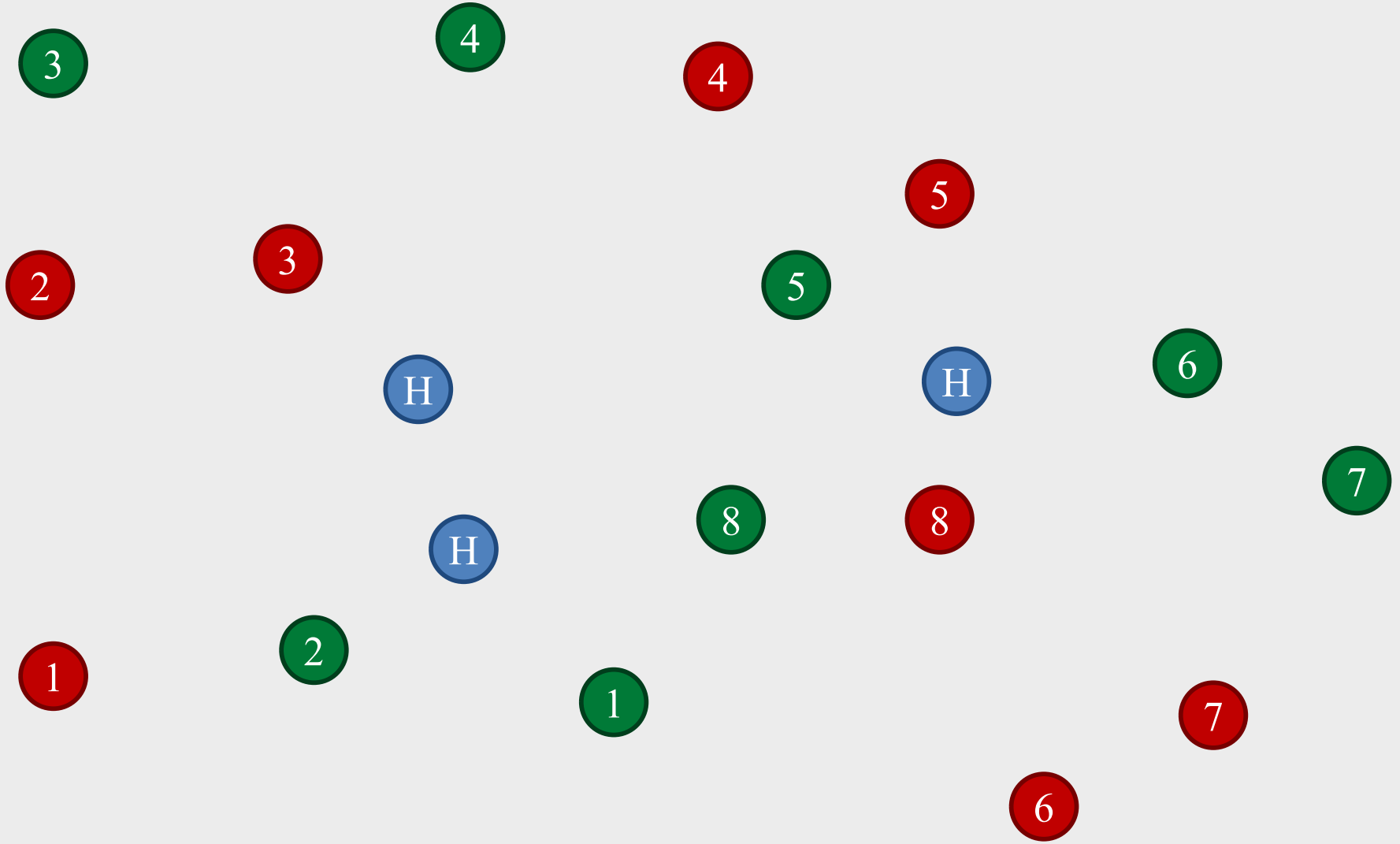
Suggest a good (?!) solution representation. Not more than one page of explanation.



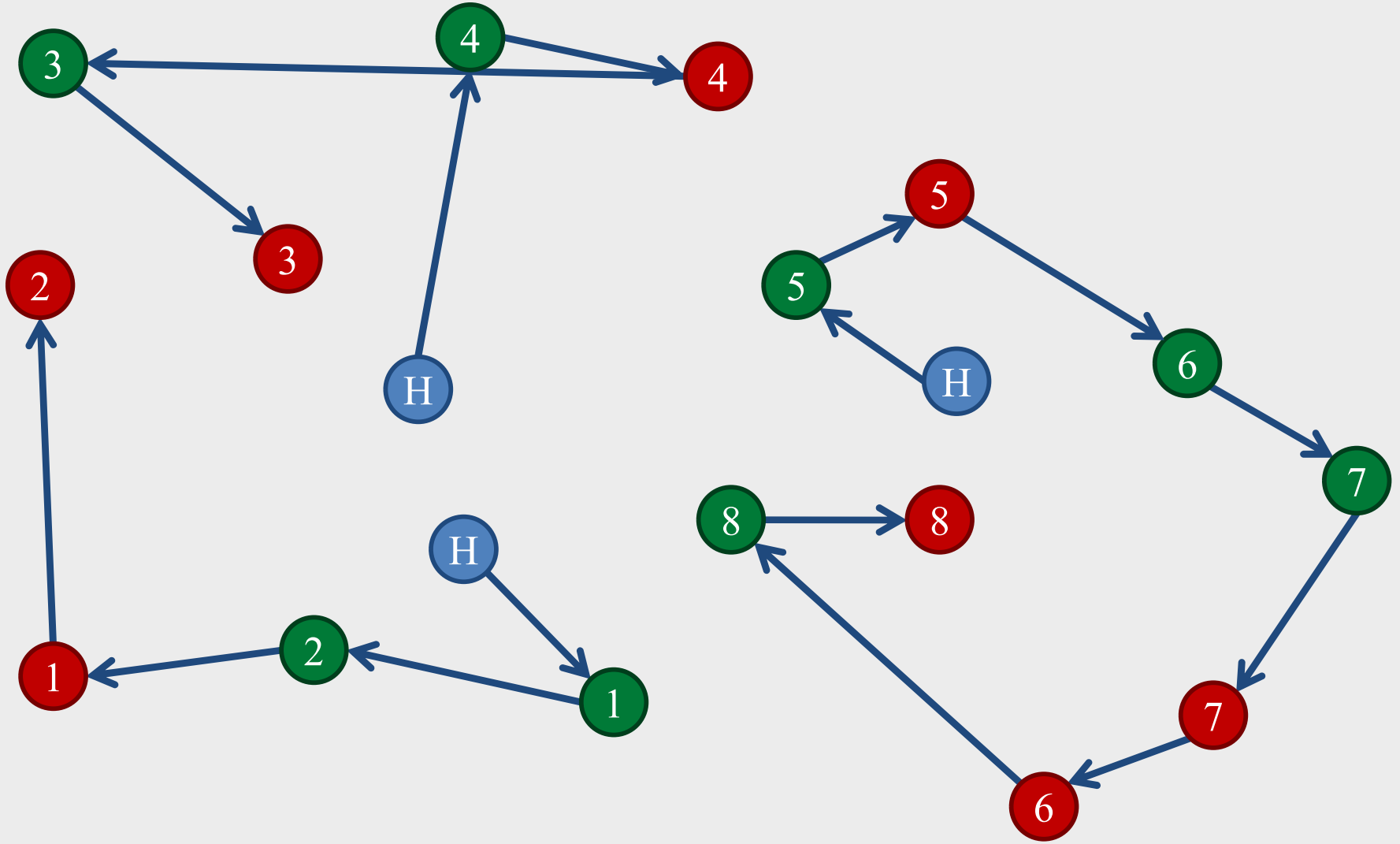
# Pickup and delivery



# Pickup and delivery



# Pickup and delivery



# Assignment #2

- Read data from the text file
- Generate a random solution (a function which gets inputs and gives a random valid but not necessarily feasible solution)
  - Have a dummy vehicle for the calls that are not handled.
- Check the feasibility (a function which gets a solution and checks if it is feasible)
  - Capacity of the vehicle
  - Time windows at both pickup nodes and delivery nodes
  - Calls and vessels compatibility
- Calculate the objective function (a function which gets inputs and a solution and gives the cost)
  - Cost of reaching to the first customer from home (vehicle does not return home)
  - Cost of transportation
  - Origin and destination node costs
  - Cost of not transporting

# Assignment #2

- Make sure you know all the assumptions – e.g. if a vehicle arrives early, it should wait until the node opens
- We will have more assignments in continuation of assignment #2 (they will be built on it)
- The final project will be very relevant to the series of assignments (doing this assignment is not a waste of time!)

# ASSIGNMENT #2

## Blind random search

**1:** Input: initial solution ($s_0$),

**2:** Input: evaluation function $f$, $f(s) \longrightarrow$ the cost of $s$

**3:** $BestSolution \Leftarrow s_0$

**4:** **for** iteration = 1 to 10000

**5:** $Current \Leftarrow Generate\ a\ random\ solution$

**6:** **if** $Current$ is feasible and $f(Current) < f(BestSolution)$ then

**7:** $BestSolution \Leftarrow Current$

**8:** **end if**

**9:** **end for**

# ASSIGNMENT #2

- Six test instances are given (you can find them at mitt.uib under the data files)
- Run them 10 times for each instance and report six tables (one for each problem instance) in the given format
- Report  the best-found solution for each instance
- Improvement (%) = 100 * (Objective of Initial solution – Best objective) / Objective of Initial solution

| Instance name (e.g. Call_7_Vehicle_3) | | | | |
|---|---|---|---|---|
| | Average objective | Best objective | Improvement (%) | Running time |
| Random Search | | | | |

# Next Lecture

## Lecture #5:

## Local Search