Meals on Wheels

Bahar Y. Kara


Meals on Wheels
888-886-8971
Delivering Delicious Nutritious Meals to your Neighborhood Seniors

Meals on Wheels (MOW)

- Programs that deliver meals to individuals at home who are unable to purchase or prepare their own meals.
  - Many of the recipients are the elderly, and many of the volunteers are also elderly but able-bodied and able to drive wheeled vehicles, usually a van.

MOW History

- Meals on Wheels originated in Great Britain
- The Women's Volunteer Service (WVS) for Civil Defense provided food and the name evolved
- The first home delivery of a meal on wheels following World War II was made by WVS in England in 1947.

MOW History

- In Australia, Meals on Wheels started in 1952 in South Melbourne
- The meals were delivered by a lady on a tricycle
- When it became to much for her to cope with Red Cross took over.

MOW History

- The first home-delivered meal program in the United States began in Philadelphia, Pennsylvania in 1954.
- At the request of the Philadelphia Health & Welfare Council, and funded by a grant from the Henrietta Tower Wurtz Foundation, Margaret Toy, a social worker pioneered a program to provide nourishment that met the dietary needs of homebound seniors and others who otherwise would have to go hungry

MOW History

- Many participants were people who did not require hospitalization, but who simply needed a helping hand in order to maintain their independence.
- Volunteers would prepare, package and deliver food to the elderly and disabled through their community.

John J. Bartholdi

A Case Study

MOW in Fulton County, Atlanta

- Deliver prepared lunches to homes of people who cannot cook or shop for themselves
- Hot meals for Monday-Friday
- Frozen meal at weekends

MOW in Fulton County, Atlanta

- Weekdays at 8:30 a.m. prepared meal delivered to center at mid-Atlanta : by institutional caterer
- Heated in a holding oven till 9:15 am
- At 9:30 am 4 paid part-time employees arrive at the center

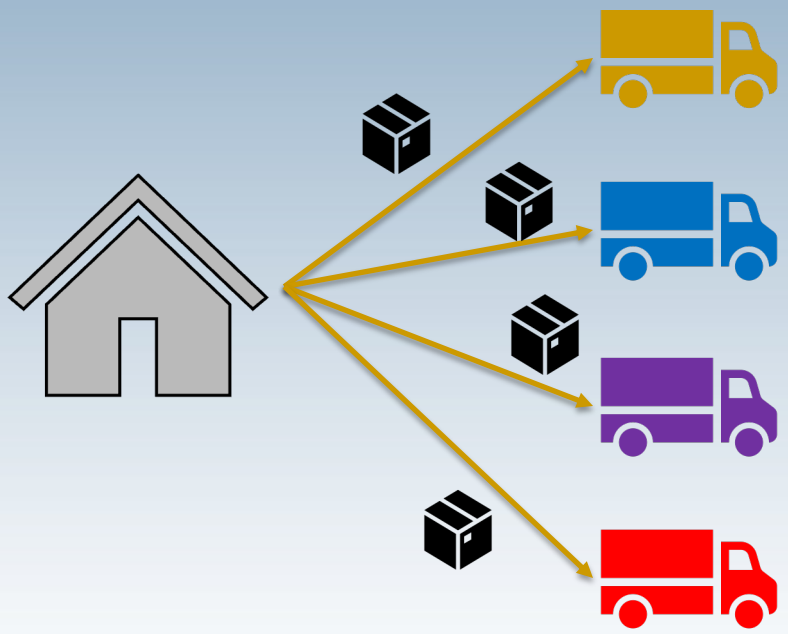
MOW in Fulton County, Atlanta

- The four employees load the meals into insulated bulk containers and then into their four vehicles.
- Each driver is given a "route manifest" (suggested order of visit)
- Each route includes
  - 40–50 meals to
  - 30–40 locations
  - between 10 am and 2 pm

8:30-9:30

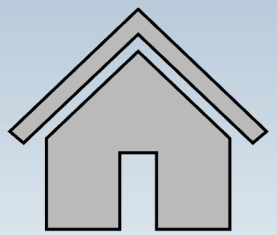
Caterer

9:30

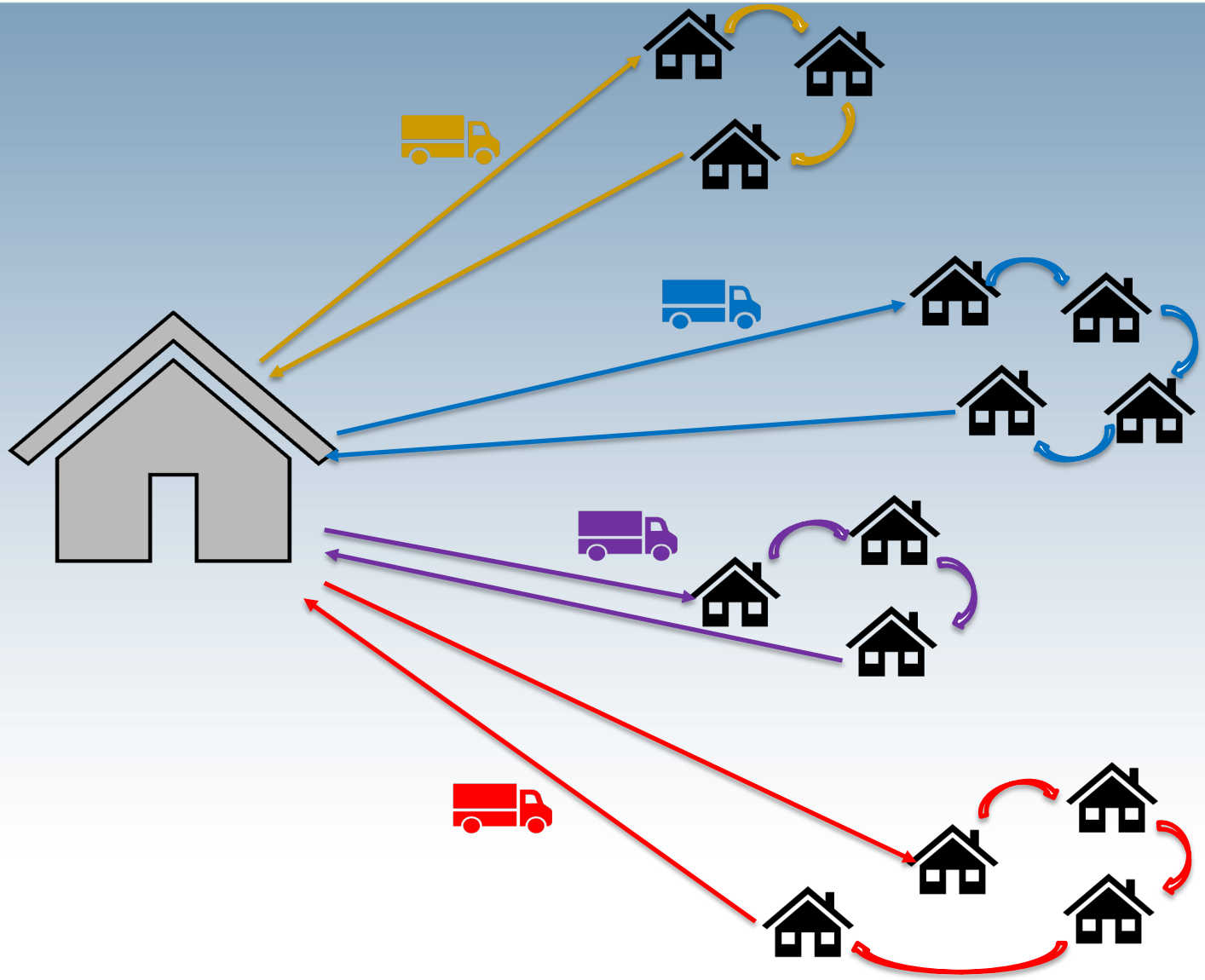


Part-time
employees

“Route manifest”



Individual routes



MOW in Fulton County, Atlanta

- The delivery vehicles are usually station wagons,
  - they can easily carry sufficient meals,
  - so vehicle capacity is not an effective limitation.

MOW in Fulton County, Atlanta

- The insulated containers will keep the meals properly warm (at least 140◦, as required by the public health department) for four hours.
  - Thus, all meals must be delivered within four hours (usually not a problem)

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- The insulated containers will keep the meals properly warm (at least 140◦, as required by the public health department) for four hours.
  - Thus, all meals must be delivered within four hours (usually not a problem)
- In fact, neither vehicle capacity nor delivery time is likely to become an active constraint unless the system grows considerably.

MOW in Fulton County, Atlanta

- MOW maintains two lists of clients:
  - *an active list* of those to whom meals are currently delivered, and
  - *a waiting list* of those hoping to join the system when space or additional resources become available.

MOW in Fulton County, Atlanta

- These lists are volatile. They change at a rate of about 14% each month because of the nature of the clients: most are elderly or ill.
  - They may die, or
  - recover from illness, or
  - receive care elsewhere (in a hospital, nursing home, or family) and so leave whichever list they are on.
- Clients may be added to the active list either from the waiting list, or as emergency special cases (perhaps referred to MOW by a social worker).

MOW in Fulton County, Atlanta

- MOW is managed by a devoted, energetic woman who is a full-time employee.
- As in many charitable organizations, the manager is over-worked.
- Her responsibilities are many,
  - including management of the MOW budget and
  - meal delivery:
    - planning menus,
    - ordering meals from the caterer,
    - monitoring the quality of meals, maintaining the insulated containers for the meals, and
    - supervising part-time employees.

MOW in Fulton County, Atlanta

- She also recruits and trains volunteers, and coordinates her services with social workers.
- The manager has little time and no additional resources to devote to routing.

MOW in Fulton County, Atlanta

- The project:

- We set out to design a method to help the busy manager
  - quickly generate efficient routes from a volatile list.

The Problem?

- For each of the four part-time employee
  - Design delivery routes

- In the current structure
  - The employees report that they see each other during delivery !
    - Their routes are overlapping

The Problem?

- Given:
  - Demand points to be served on a particular day
  - Particular demand of each point
    - Dietary needs
    - Additional frozen meal delivery on fridays
  - The time it takes to travel between demand points
- Find the routes of each employee

The Problem in OR ?

- Travelling Salesman Problem (TSP)

Given n locations, find a tour of minimum total length that visits all demand points.

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- Travelling Salesman Problem (TSP)

Given n locations, find a tour of minimum total length that visits all demand points.

- This belongs to the class of “network flow problems”

Network Flow Problems

- Focuses on "how objects move through a network"
  - Assignment problem:
    - a network of tasks and workers
  - Transportation problem:
    - a network of customers, suppliers and depots
  - Maximal flow problem:
    - a network of sink, source and intermediate nodes

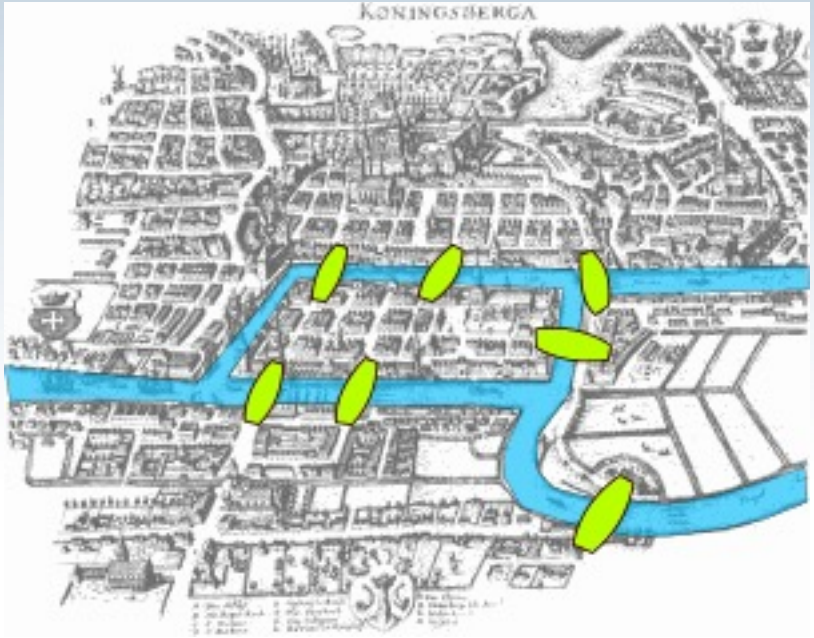
  …

History of Network Flow Problems

- 1736: Euler's work on the Koenisgsberg Bridges
- 1800s: Kirchoff constructed network flow models to analyze current flows
- 1857: Hamilton's puzzle
- 1940s: Kantorovich, Hitchhock & Koopmans considered transportation problems
- 1947: Dantzig pioneered Linear Programming
- 1956: Ford & Fulkerson proved max flow min cut theorem and developed a labelling algorithm for max flow. (Start of algorithmic developments)

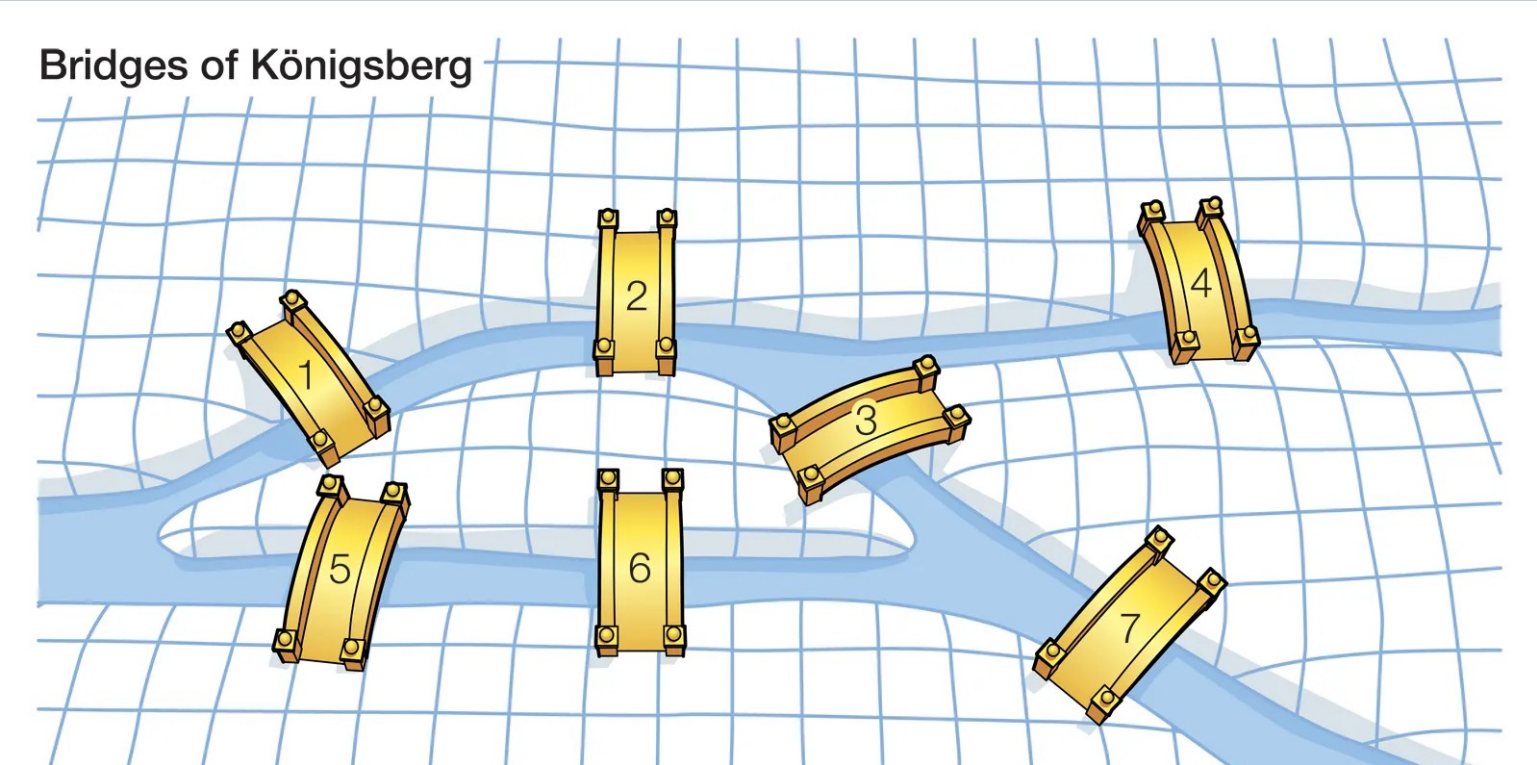
The Bridges of Koenigsberg: Euler 1736

- The city of Königsberg in Prussia (now Kaliningrad, Russia) was set on both sides of the Pregel River, and included two large islands which were connected to each other and the mainland by seven bridges.



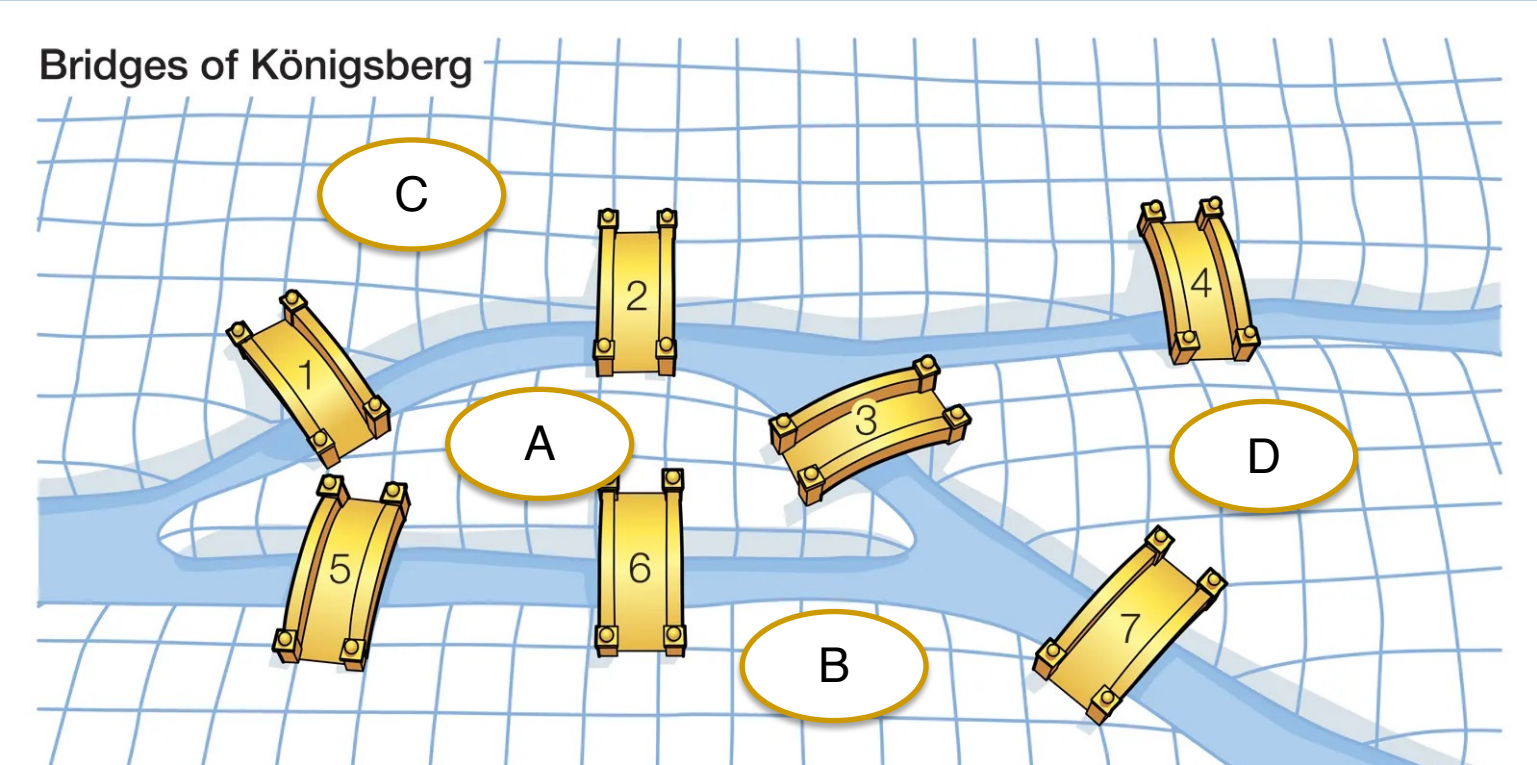
The Bridges of Koenigsberg: Euler 1736

- Can the seven bridges all be traversed
  - in a single trip,
  - without doubling back,
  - given that the trip ends in the same place it began



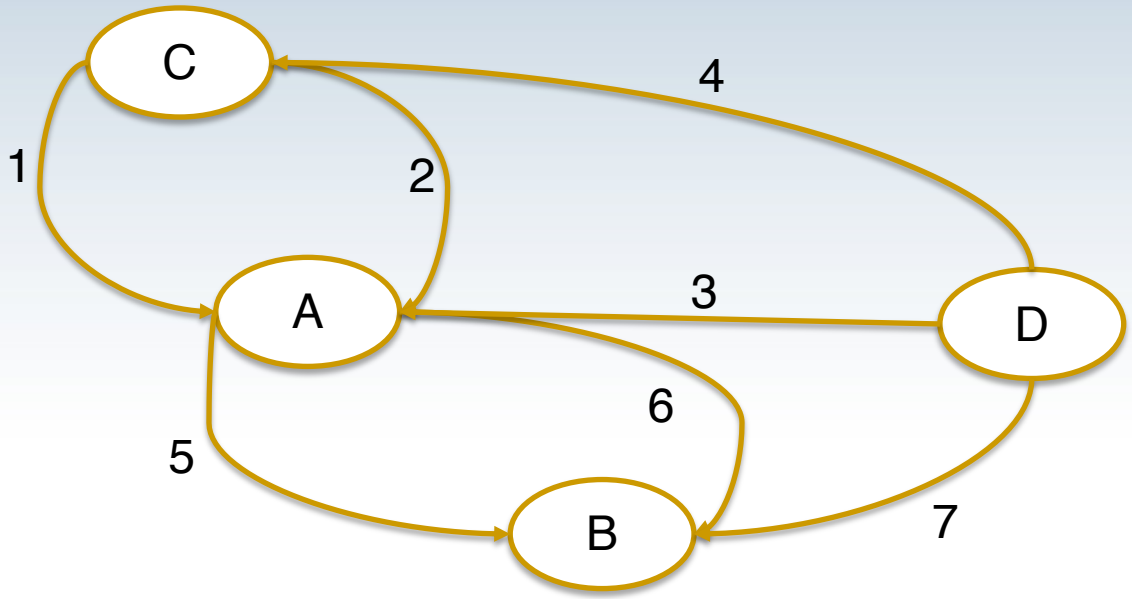
The Bridges of Koenigsberg: Euler 1736

- Conceptualization:
  - Land masses are “nodes”.
  - Bridges are “arcs”.



The Bridges of Koenigsberg: Euler 1736

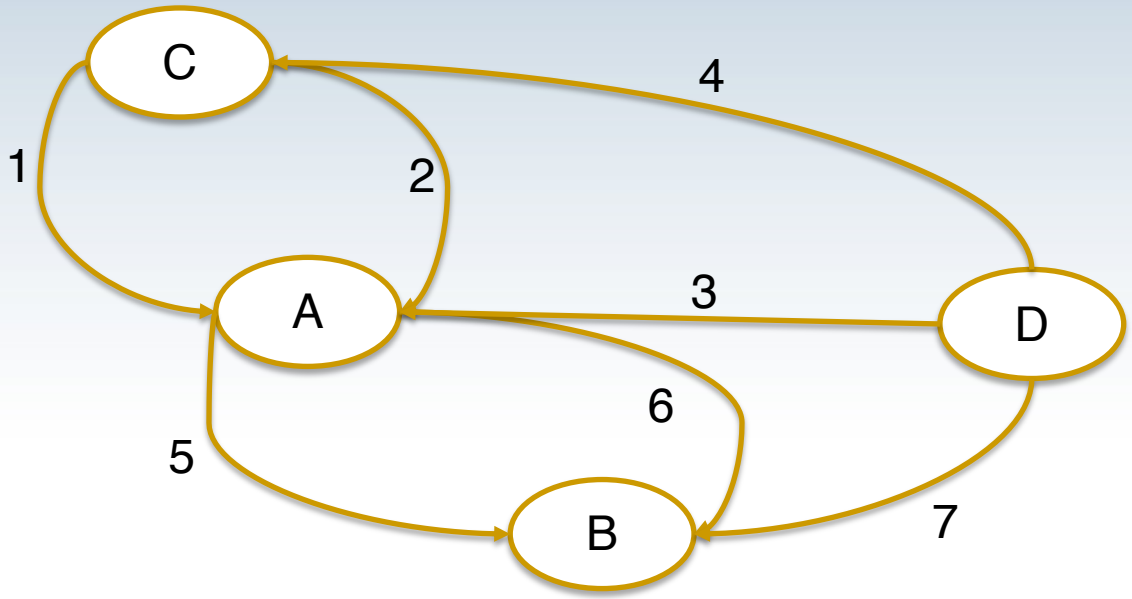
- Is it possible to start in C, cross over each bridge exactly once, and end up back in C?



The Bridges of Koenigsberg: Euler 1736

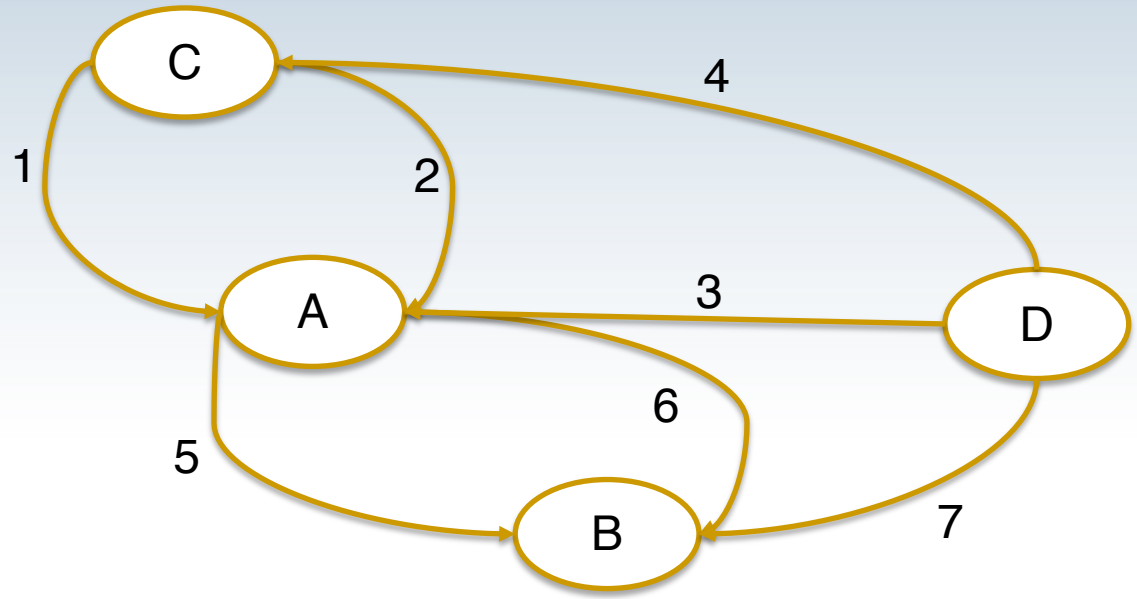
- Is it possible to start in C, cross over each bridge exactly once, and end up back in C?

- NO



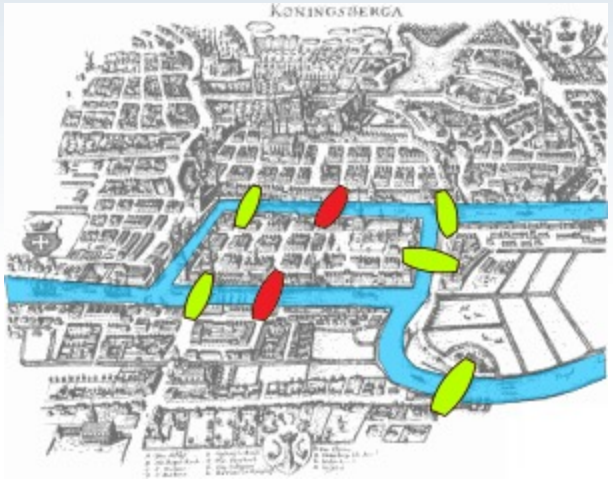
The Bridges of Koenigsberg: Euler 1736

- This led to the development of the branches of mathematics known as topology and graph theory



Present State of the bridges

- Two of the seven original bridges were destroyed during the bombing of Königsberg in World war II
- Two others were later demolished and replaced by a modern bridge
- The three other bridges remain, (one was rebuilt in 1935).
- Thus as of 2011, there are now five bridges.

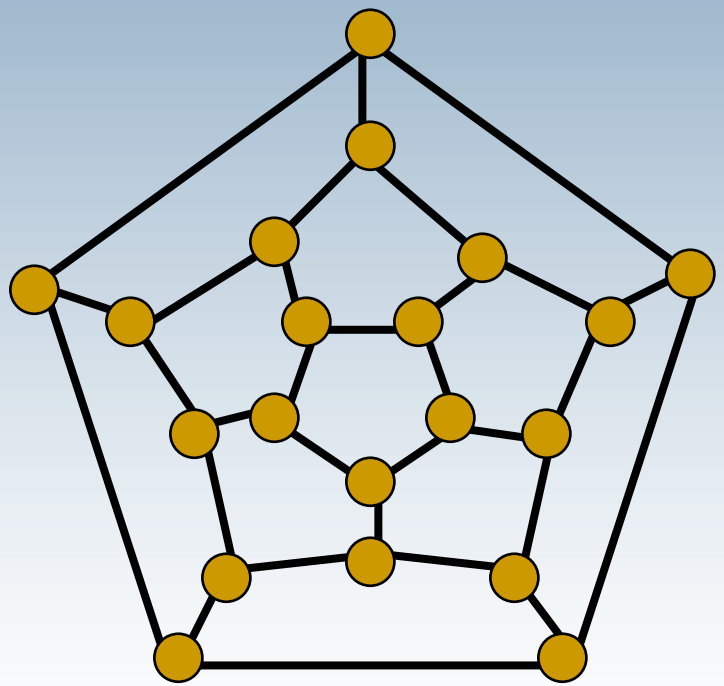


Hamilton's Around the World Game (Icosian game)

In 1857, the Irish mathematician, Sir William Rowan Hamilton invented a puzzle.

Hamilton's Around the World Game

The objective was to make what we call a hamiltonian cycle.



Hamiltonian cycle in a graph is a is a simple cycle that passes through each node exactly once

Hamilton's Around the World Game

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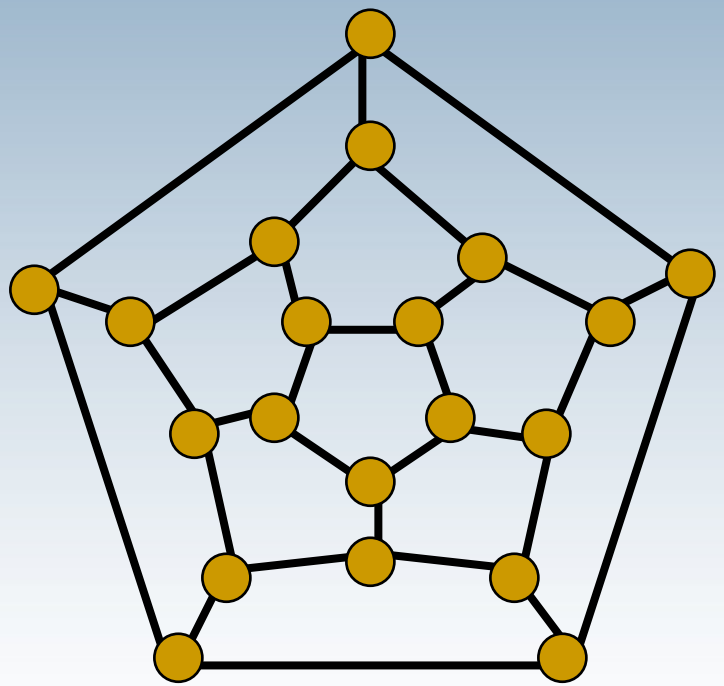

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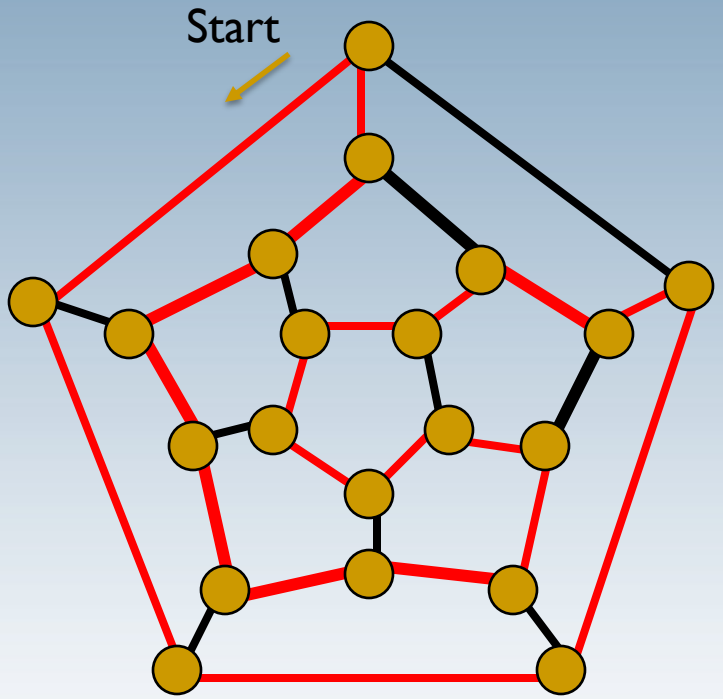
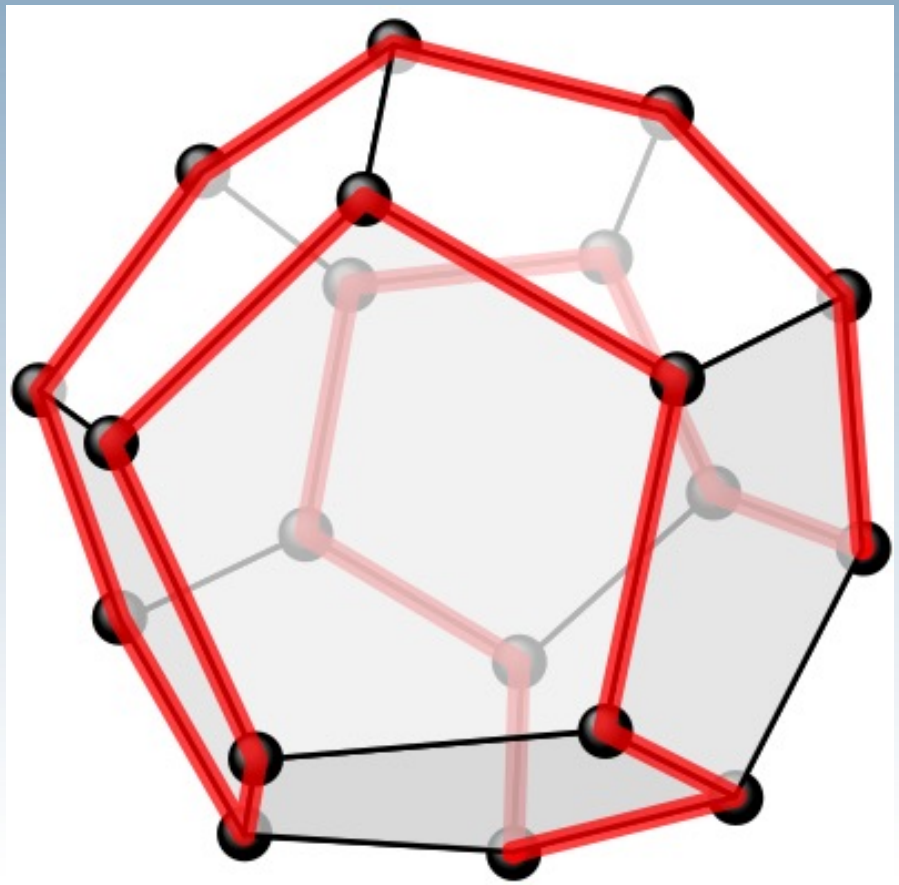
This is the traveling salesman problem.

Hamilton's Around the World Game



Hamilton's Around the World Game



Travelling Salesman Problem

- Inputs:
  - a list of cities and their pairwise distances
- Output:
  - a shortest possible tour that visits each city exactly once

- TSP is an NP-Hard problem.

Travelling Salesman Problem

- The problem was first formulated as a mathematical problem in 1930 and is one of the most intensively studied problems in optimization.
- It is used as a benchmark for many optimization methods. Even though the problem is computationally difficult, a large number of heuristics and exact methods are known, so that some instances with tens of thousands of cities can be solved.

Travelling Salesman Problem History

- The origins of the TSP are unclear.
  - A handbook for travelling salesmen from 1832 mentions the problem and includes example tours through Germany and Switzerland, but contains no mathematical treatment.
- The TSP was defined in the 1800s by the Irish mathematician R. W. Hamilton (the game)
- The general form of the TSP appears to have been first studied by mathematicians during the 1930s in Vienna and at Harvard, notably by Karl Menger
  - who defines the problem,
  - considers the obvious brute-force algorithm, and

observes the non-optimality of the nearest neighbour approach

From: A brief History of the Travelling Salesman Problem

Travelling Salesman Problem

- Notes ☺️

Travelling Salesman Problem

- Solution methods
  - Optimization models
    - Usually branch & cut algorithms that include subtour elimination on a need basis

Travelling Salesman Problem

- Solution methods
  - Optimization models
    - Usually branch & cut algorithms that include subtour elimination on a need basis
  - Heuristics
    - Construction heuristics
      - Nearest neighbour…
    - Improvement heuristics
      - 2-opt, 3-opt,…
    - Meta heuristics
      - Tabu, simulated annealing, genetic, ant,…

Back to MOW

- 4 employees deliver food to 40 destinations within 2 hours with small vehicles

Back to MOW

- 4 employees deliver food to 40 destinations within 2 hours with small vehicles
- **This is <u>not</u> a TSP**
- TSP does not have any limitations on time or capacity and it assumes only one vehicle will serve all customers
- When we relax (at least) one of these assumptions

⇒ We have a Vehicle Routing Problem (VRP)