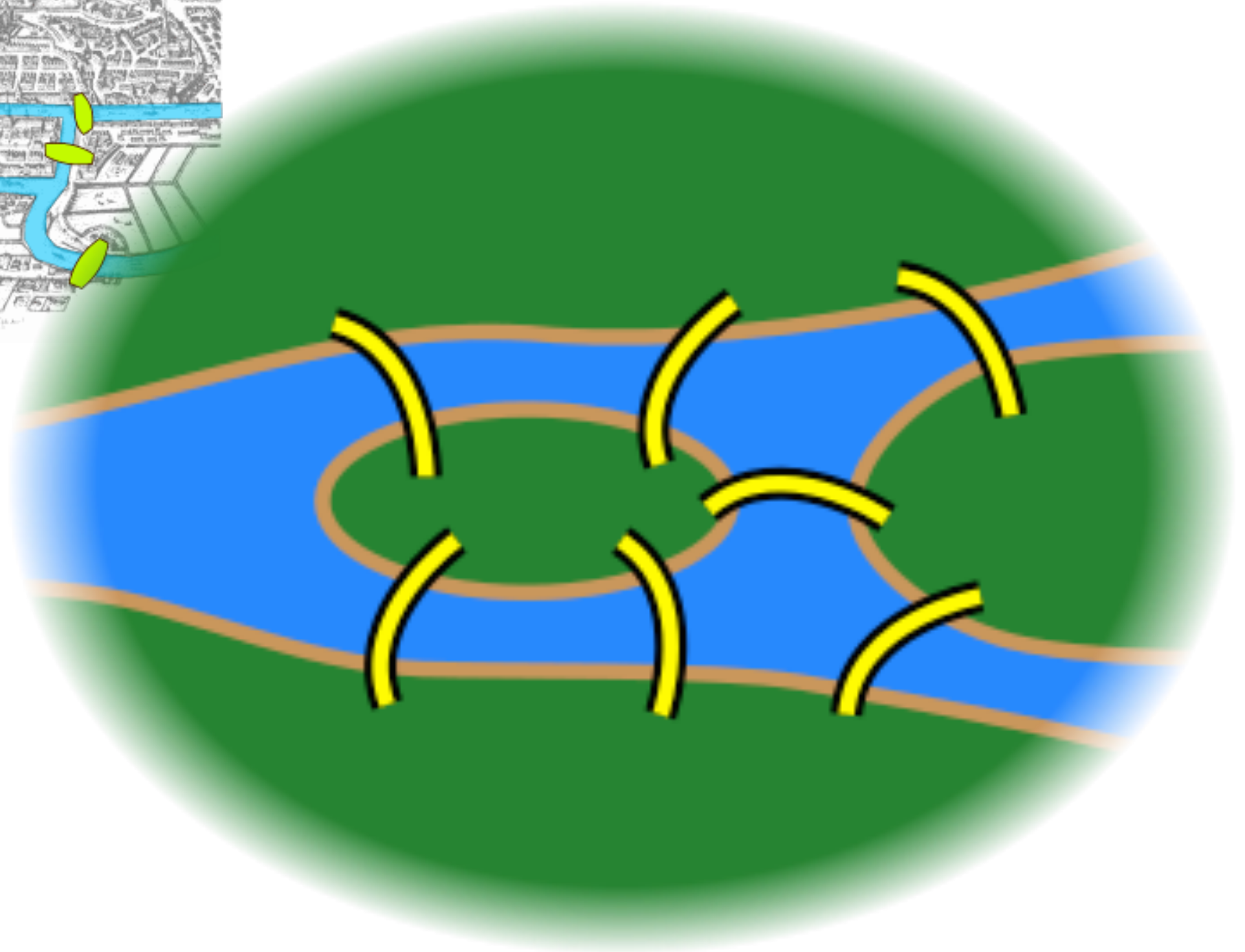
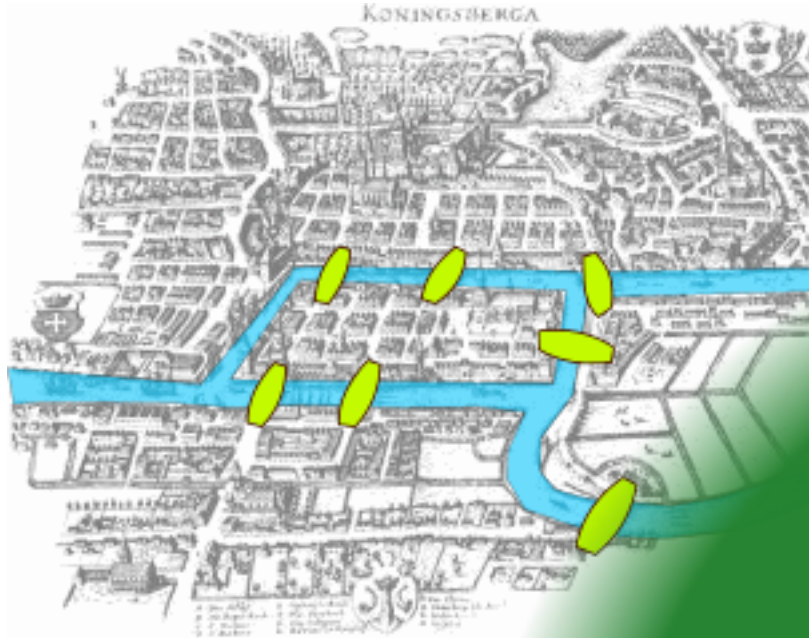


Seven Bridges of Königsberg



Introduction to Graphs

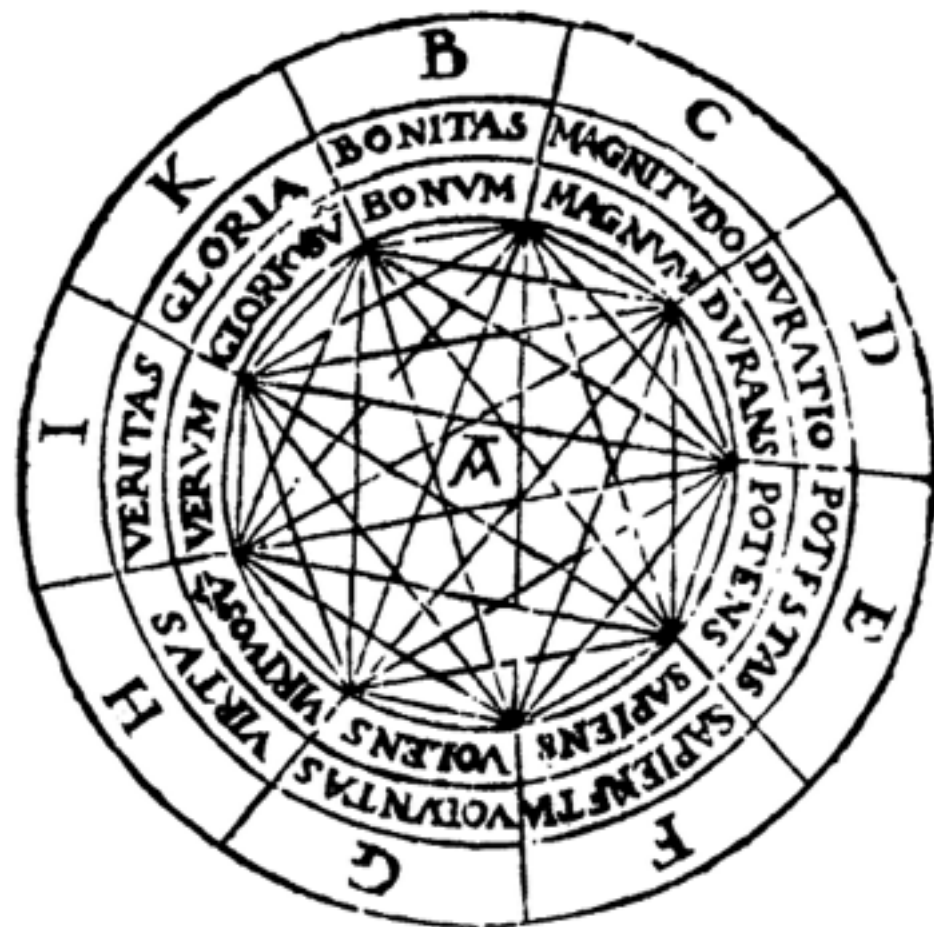
CS 55 - Spring 2016 - Pomona College
Jenny Lam

Informally Graphs

A graph consists of a collection of entities together with a binary “relation”.

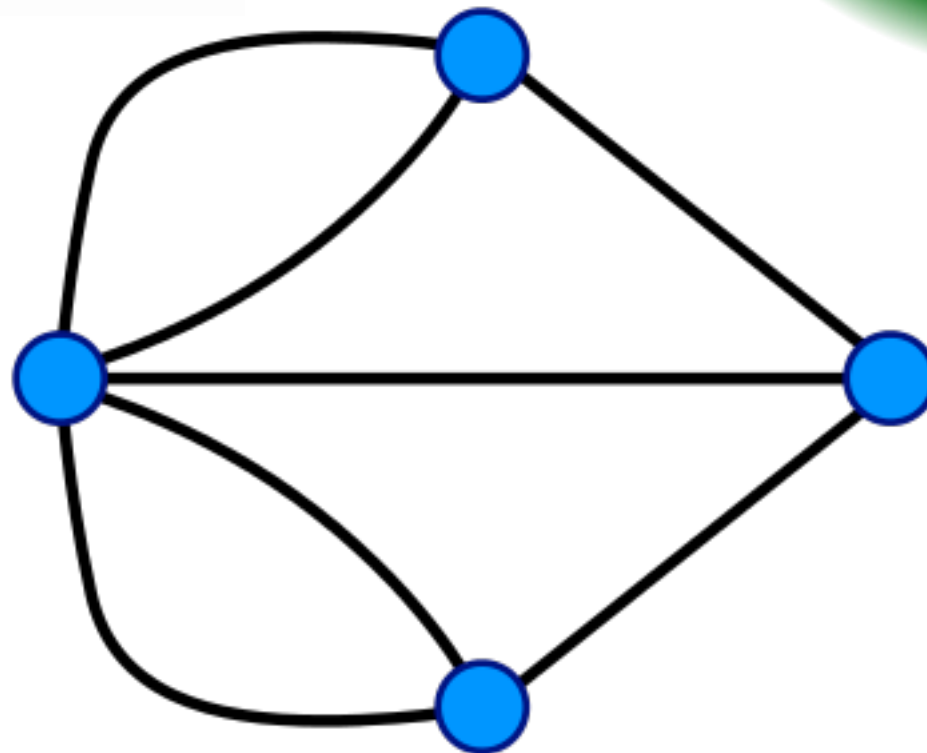
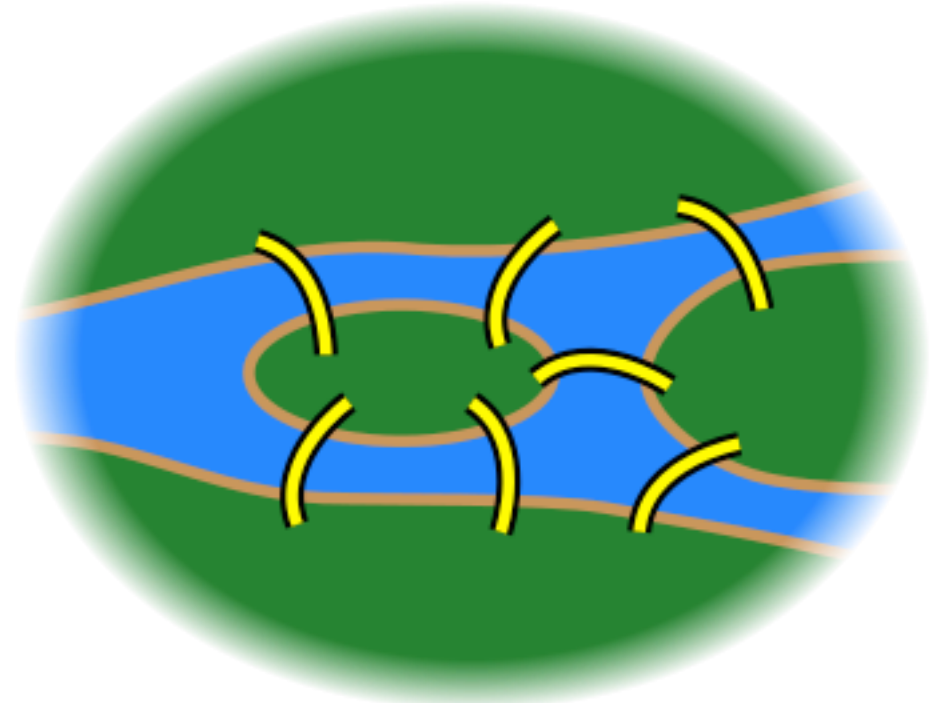
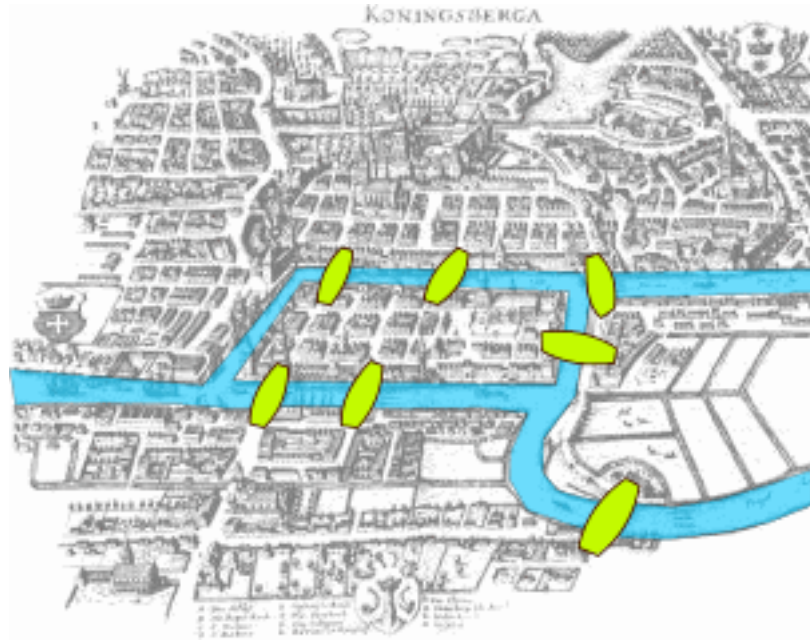
Node-Link Diagrams

Graphs are often communicated best with a drawing. The most common such drawing is a node-link diagram, where vertices are drawn as dots and edges are drawn as lines connecting the dots.

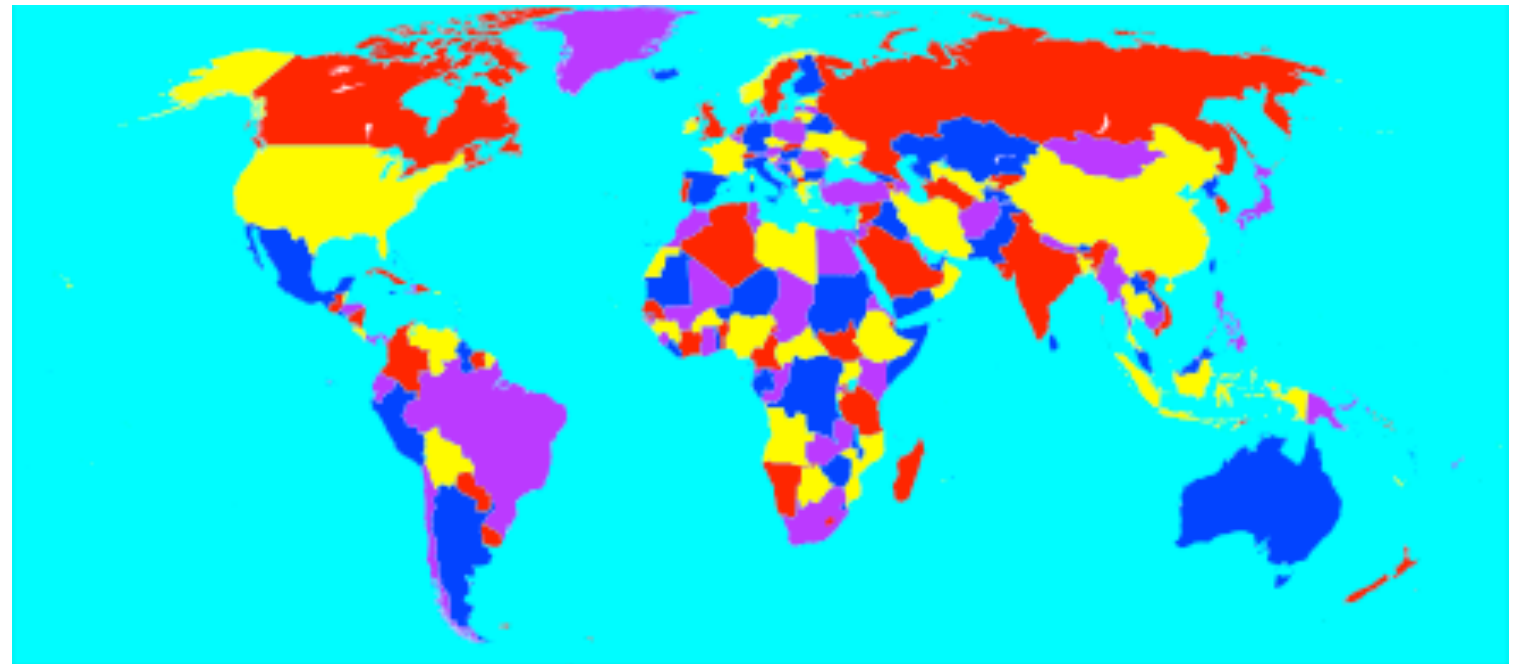
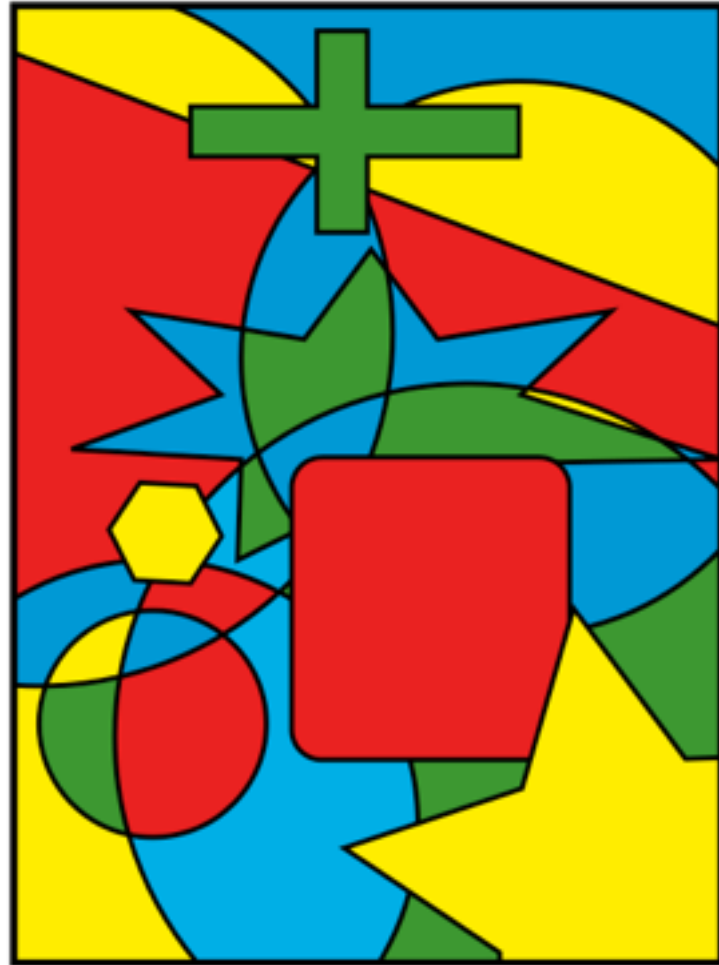


Ramon Llull (circa ~1300) and his drawing

Seven Bridges of Königsberg

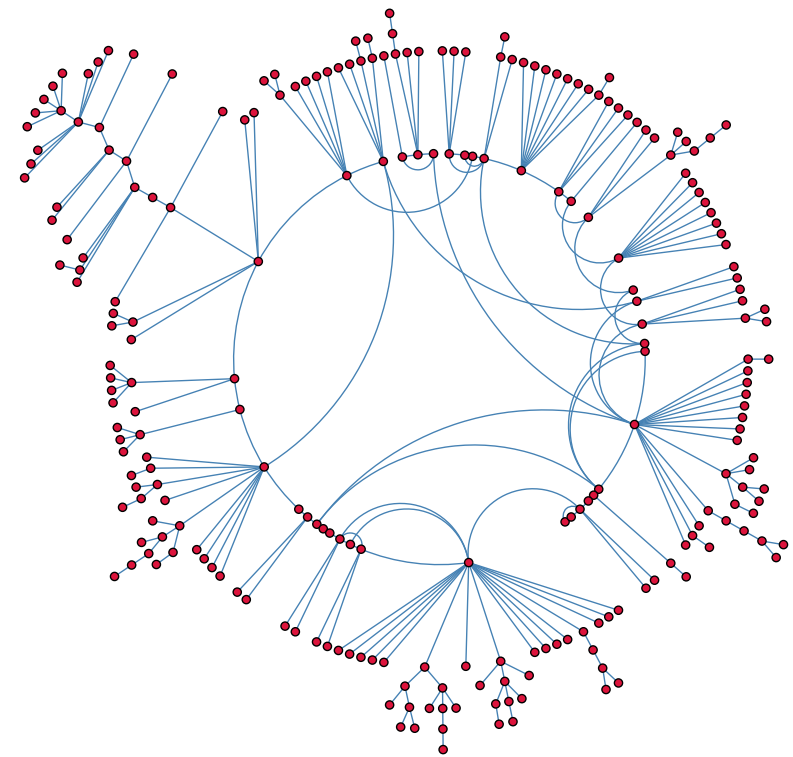
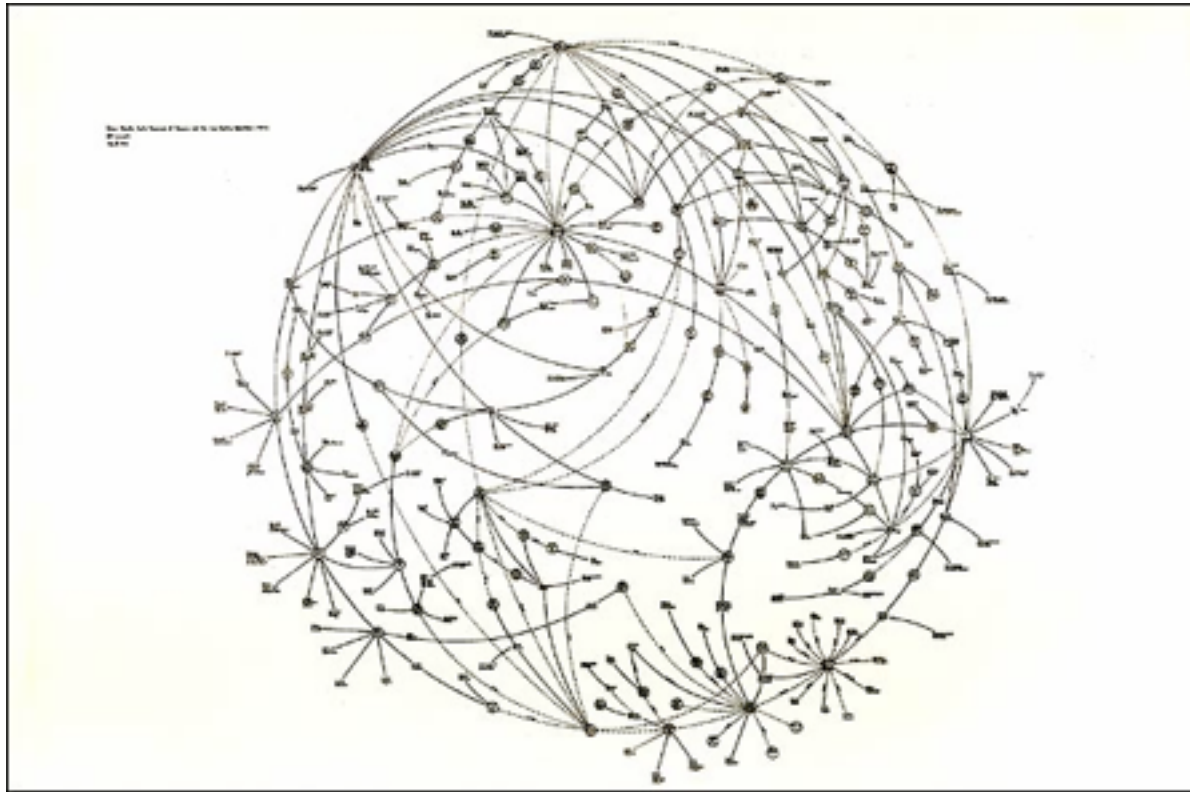


The Four Color Theorem



Any map can be colored using only 4 colors!

Social Interaction Graphs



Communication Networks



Transportation Networks

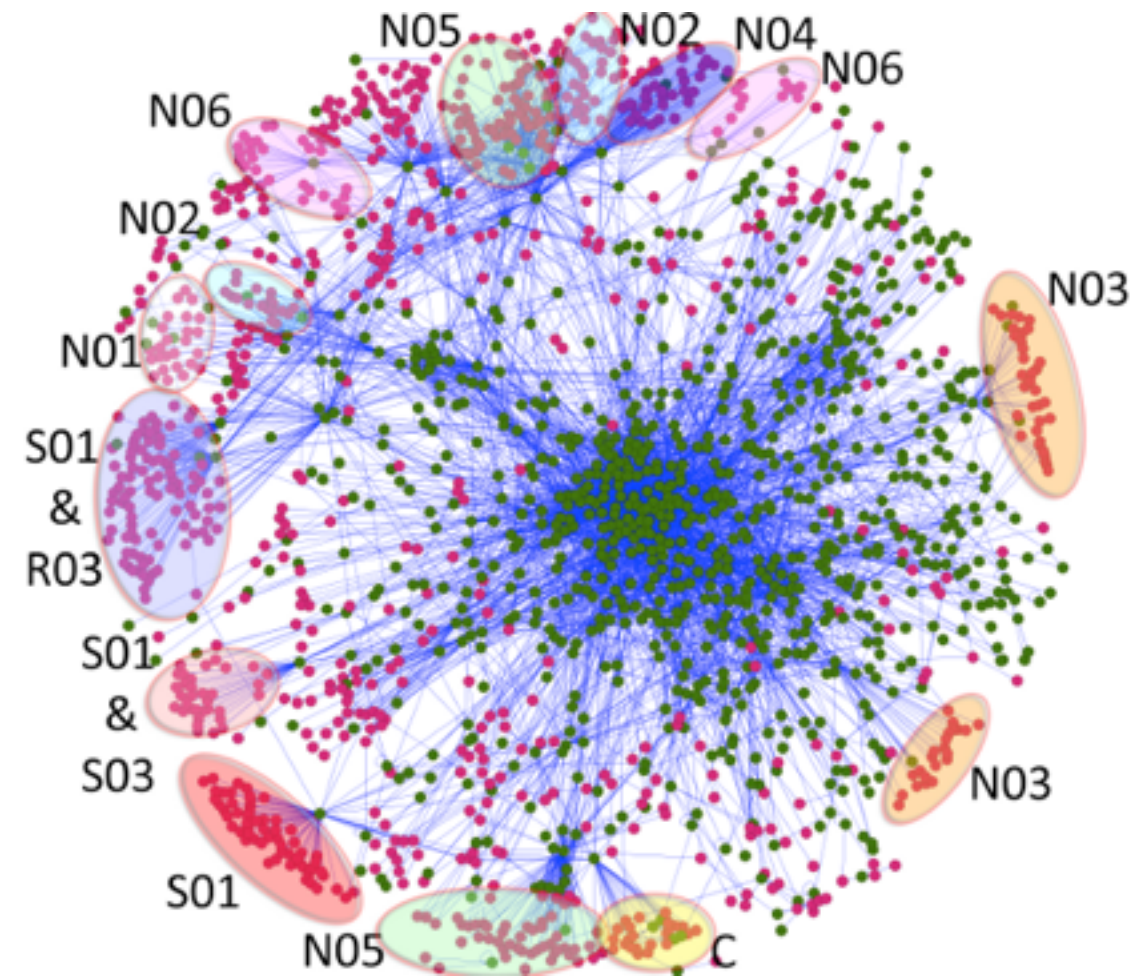
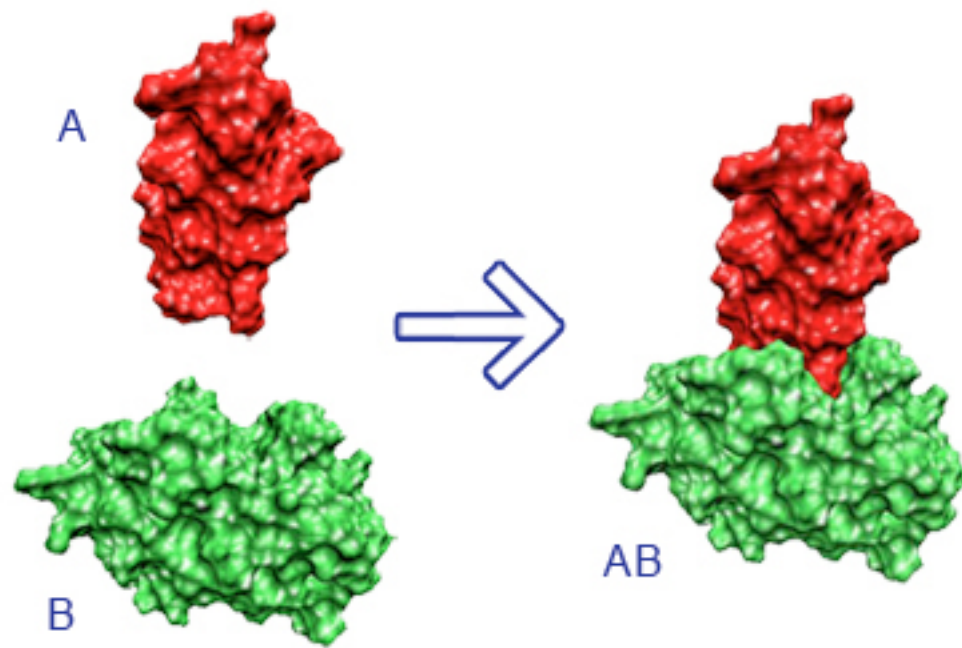


The Solar System A subway map

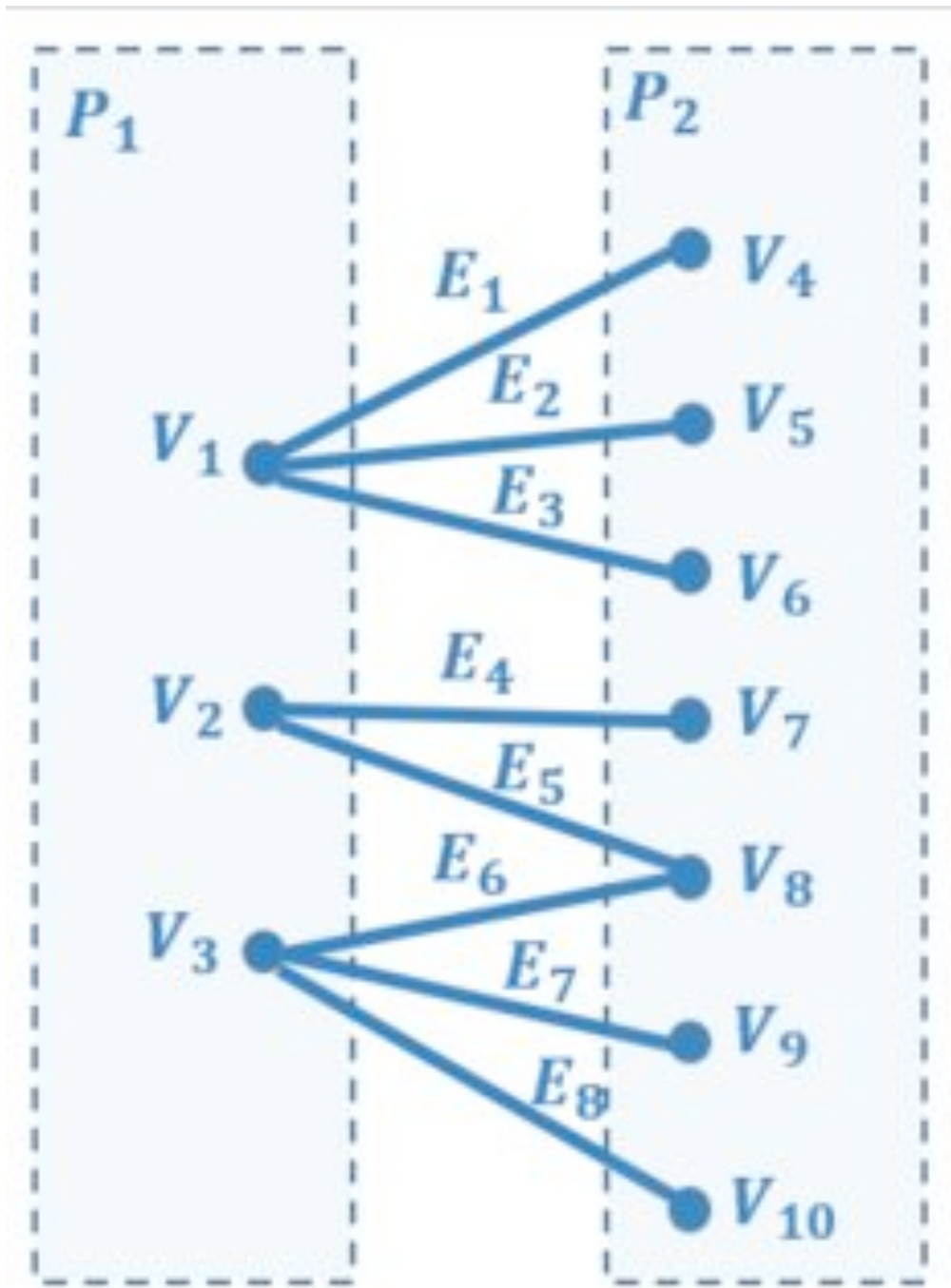
Artwork by Ulysses Carlon.
Original calculations by Ju/Carion/Metaphor.



Protein-protein interaction Networks



Advertising



Online match-making



Formally Graphs

A **(simple) graph** is a pair of sets (V, E) where

V is the set of **vertices** and

E is the set of edges and consists of a subset of the unordered pairs of elements in V .

Alternatively, we can think of a graph as a set V with a symmetric (but not reflexive) relation E .

Directed Graphs

A **directed graph (digraph)** is an ordered pair (V, E)

V is the set of vertices

E is the set of edges or ordered pairs of distinct vertices.

Alternatively, we can think of E as a non-symmetric relation.

Extensions of Graphs

We will often want to consider graph with **data** on the vertices or edges. We can think of vertex data as a function with domain V , and edge data as a function with domain E .

On occasion we will want to allow **parallel edges** and **self loops** in our graphs, but this is rare.

Glossary

Common graph terms:

- $n = |V|$ and $m = |E|$
- Adjacent / neighbors
- Endpoints (source/destination for digraphs)
- Degree (in/out for digraphs)
- Complete graph (clique)
- Subgraph