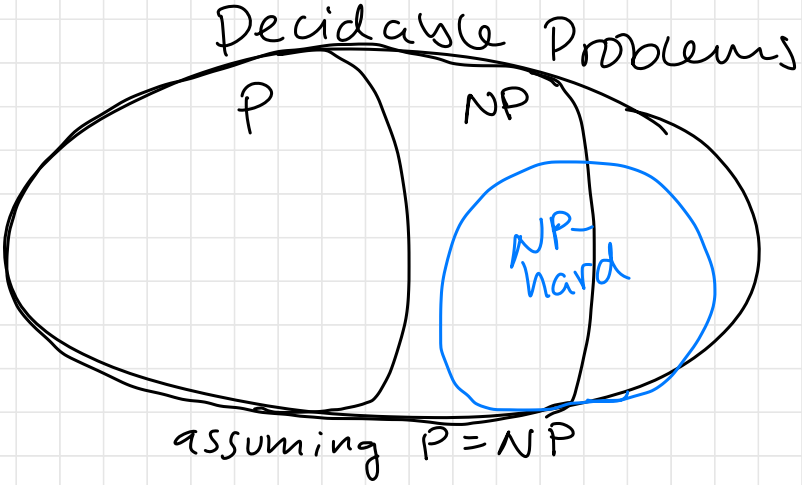
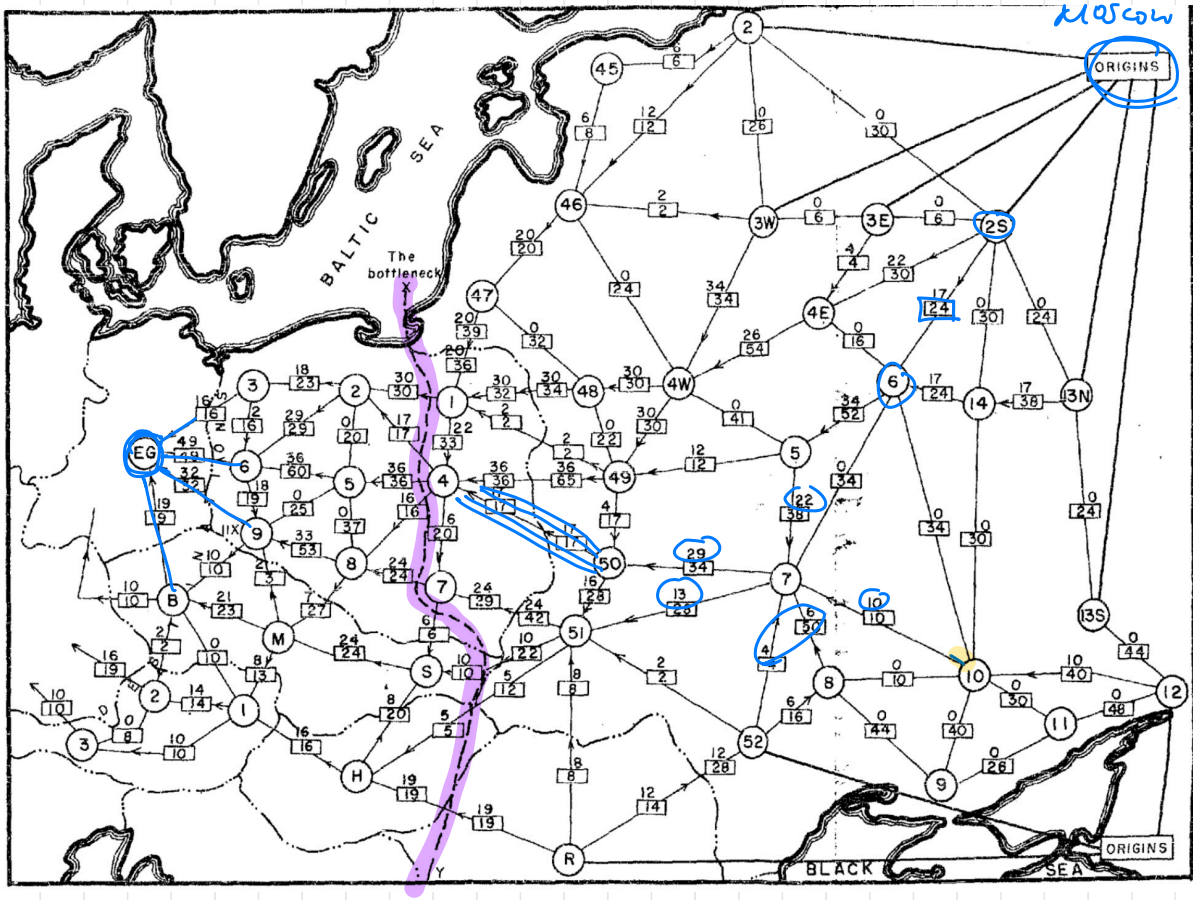


What to do if a problem is NP-hard?

- if input size is small, just solve it
- use an approximation algorithm
  (first week after break)
- use a heuristic algorithm
- try a different problem
  e.g. Ham path (NP-hard)
  Eulerian path (linear)
  → week 12
- use a SAT solver or an ILP solver
- Solve P=NP

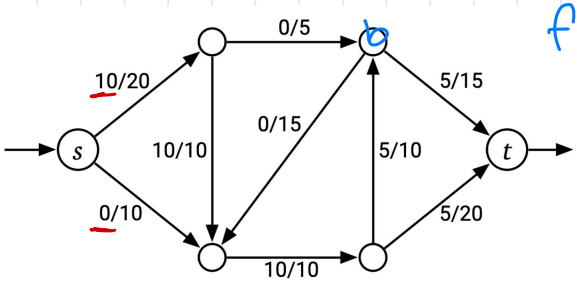
Max Flows / Min Cuts



Soviet Union: how many trains can I send from Moscow to East Germany

US: what is the min # of train lines to destroy to disconnect Moscow and EG?

Maximum Flow Problem



flow/capacity

$c((b,t)) = 15$

input: directed graph $G = (V, E)$

with special nodes s, t

s: source, t: target

capacity function $c : E \to \mathbb{R}^{\geq 0}$

output:

flow function $f : E \to \mathbb{R}^{\geq 0}$

such that

- for all $v \in V \setminus \{s, t\}$ $\sum_u f(u \to v) = \sum_w f(v \to w)$

  conservation of flow

- for all $e \in E$ $0 \leq f(e) \leq c(e)$

  feasibility

- $|f| = \sum_w f(s \to w)$ is maximized

(1) $|f|$?
(2) does it satisfy cons., feas.?
(3) is it max?

Minimum Cut Problem

input: same as max flow

output: partition of verts V into S and T

$V = S \cup T$

$S \cap T = \emptyset$

"the capacity of the cut"

such that $\|S, T\| = \sum_{v \in S} \sum_{w \in T} c(v \to w)$ is min.