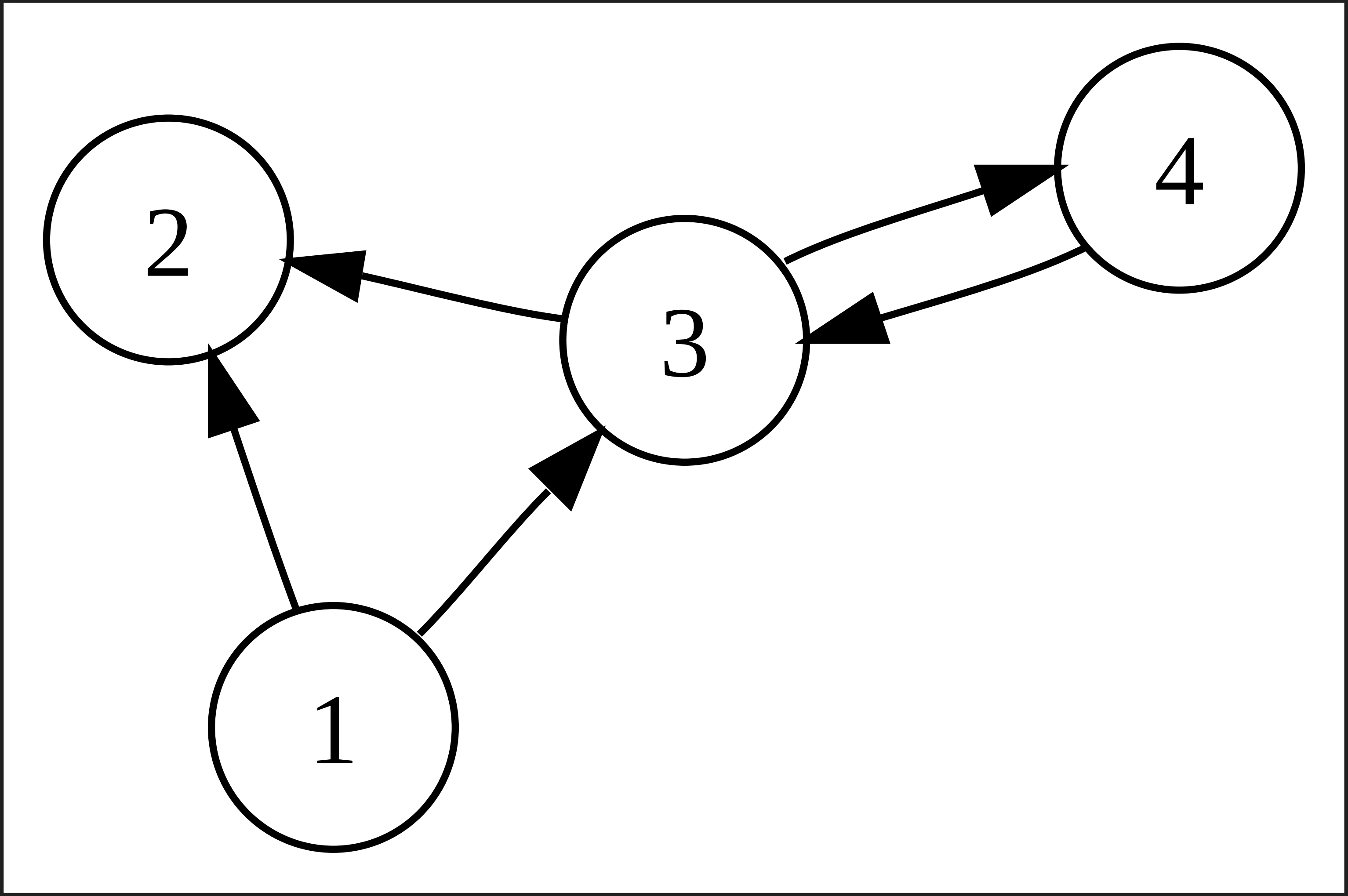
GRAPHS & SHORTEST PATHS

Graph is a collection of things (vertices) that have relationships between them (edges).



GRAPHS ARE SUPER USEFUL, BECAUSE THEY REPRESENT MANY PRACTICAL PROBLEMS:

- Maps (vertex = city, edge = road)
  - How can I get from Ostrava to Brno quickly? (GPS navigation)
- Social networks (vertex = person, edge = friend/follower)
  - Who's the most popular kid on the block?
- Computer networks (vertex = router, edge = Ethernet cable)
  - Which path to choose for a packet from Czech Republic to USA?
- Data structures (trees are graphs - binary, B, AVL, red-black etc.)
- Also used in: graph databases, compilers, language processing, sociology, biology (DNA matching), scheduling, ...

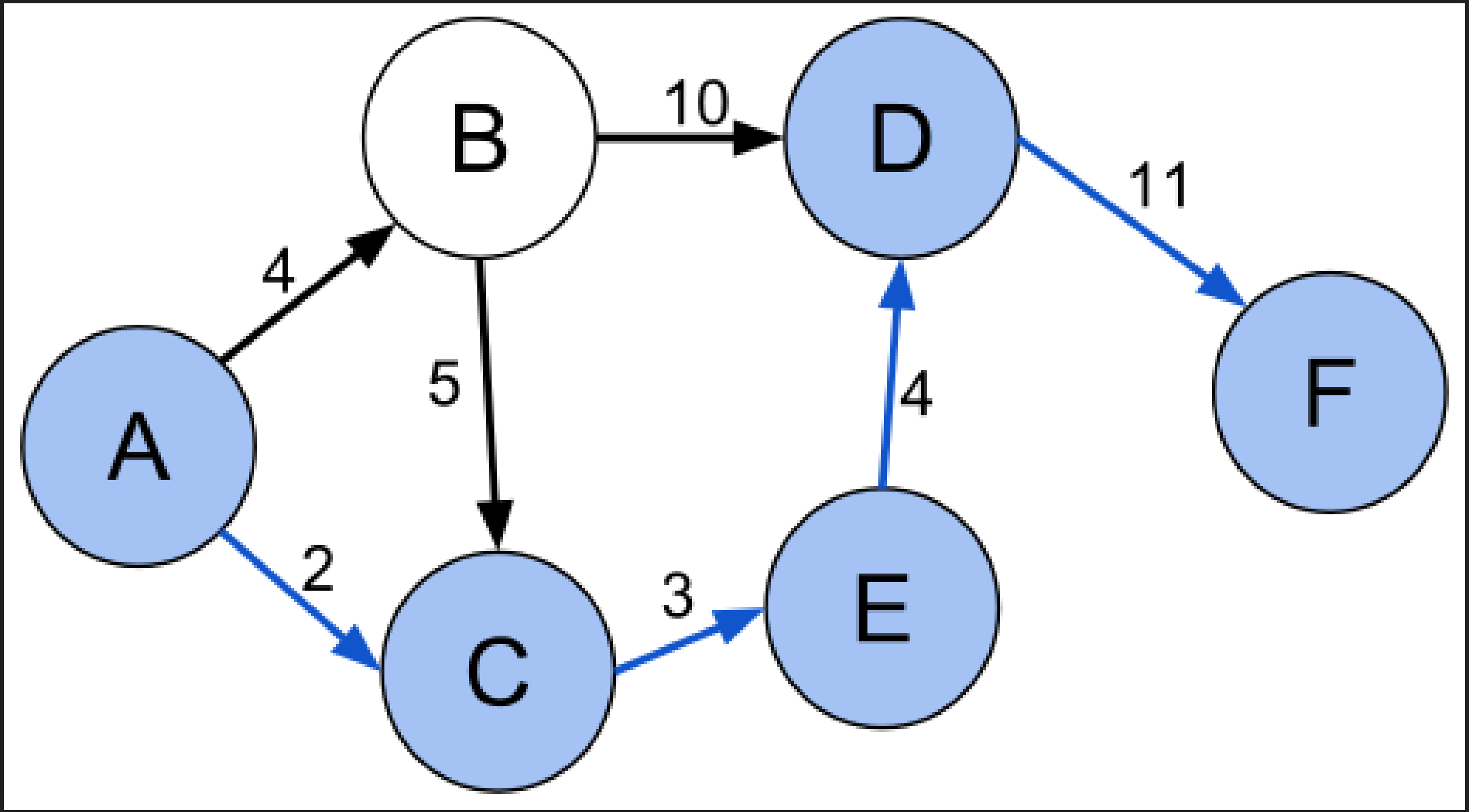
FINDING SHORTEST PATHS IN GRAPHS

- Traffic navigation - TomTom, GPS etc.
- AI pathfinding - robotics, drones, games (how to move NPC from point A to B)
- Network routing - routing protocols used by routers
- and many other uses

Single source shortest paths (SSSP)

- Find shortest path from vertex A to all other vertices
- Easy when edges have same length - BFS (breadth-first search)
- (Slightly) harder with variable edge lengths - Dijkstra's algorithm
- You should know this from ALG I/II and DIM

Shortest path from A to F: length 20, vertices [A, C, E, D, F]



D is a predecessor of F on the shortest path

E is a predecessor of D etc.

BFS REMINDER (PYTHON PSEUDOCODE)

```
def BFS(graph, SRC, DEST):
  put SRC into queue

  while queue not empty:
    V = get item from queue
    for all neighbours N of V:
      if N is not visited:
        put N into queue
        mark N as visited
        save somewhere that V is a predecessor of N

  if DEST not visited, return NOT_FOUND
  path = reconstruct predecessors from DEST to SRC
  return reversed path
```

When a vertex is removed from the queue, a shortest path to it has been found.
Therefore if it's the DEST vertex, you can stop the search.