ORTEC

Online Optimization in practice

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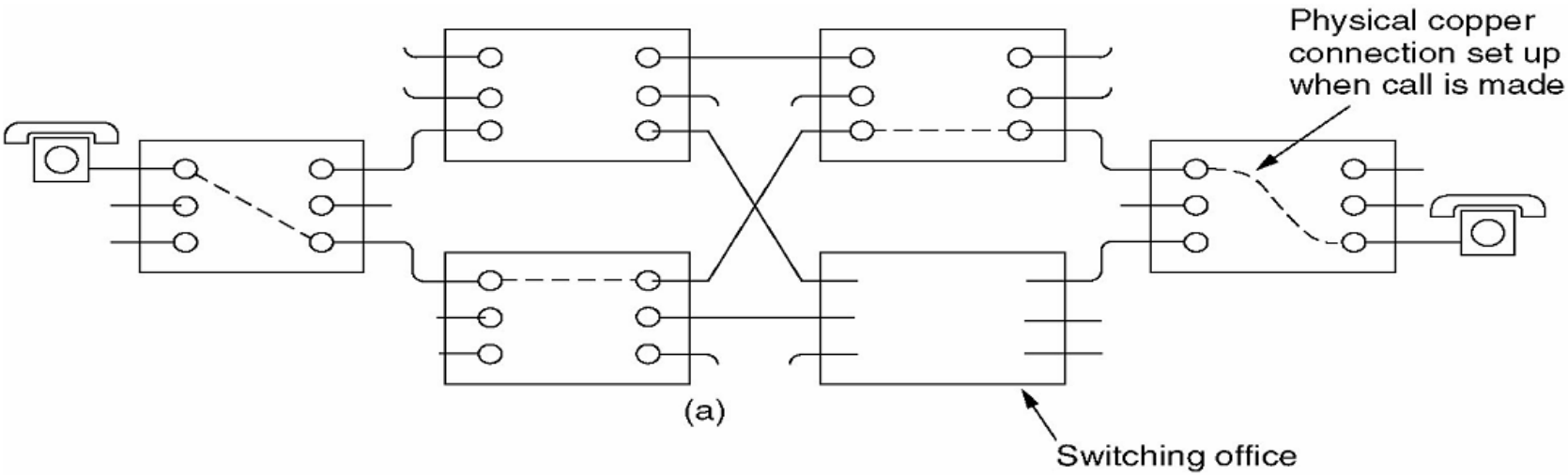
Problem Terminology

- Online
  - A problem whose data reveals itself step by step
  - Not clear when (if ever) the input is complete
  - Data may be only partially revealed
  - Decision upon the course of action needs nevertheless to be taken… online!
- Dynamic
  - The system parameters change over time
  - An existing solution may become infeasible
  - Need to adjusted or completely change solutions over time
- Real-time
  - As soon as new data is known the solution must change
  - The speed of reaction may vary from immediate to quite soon

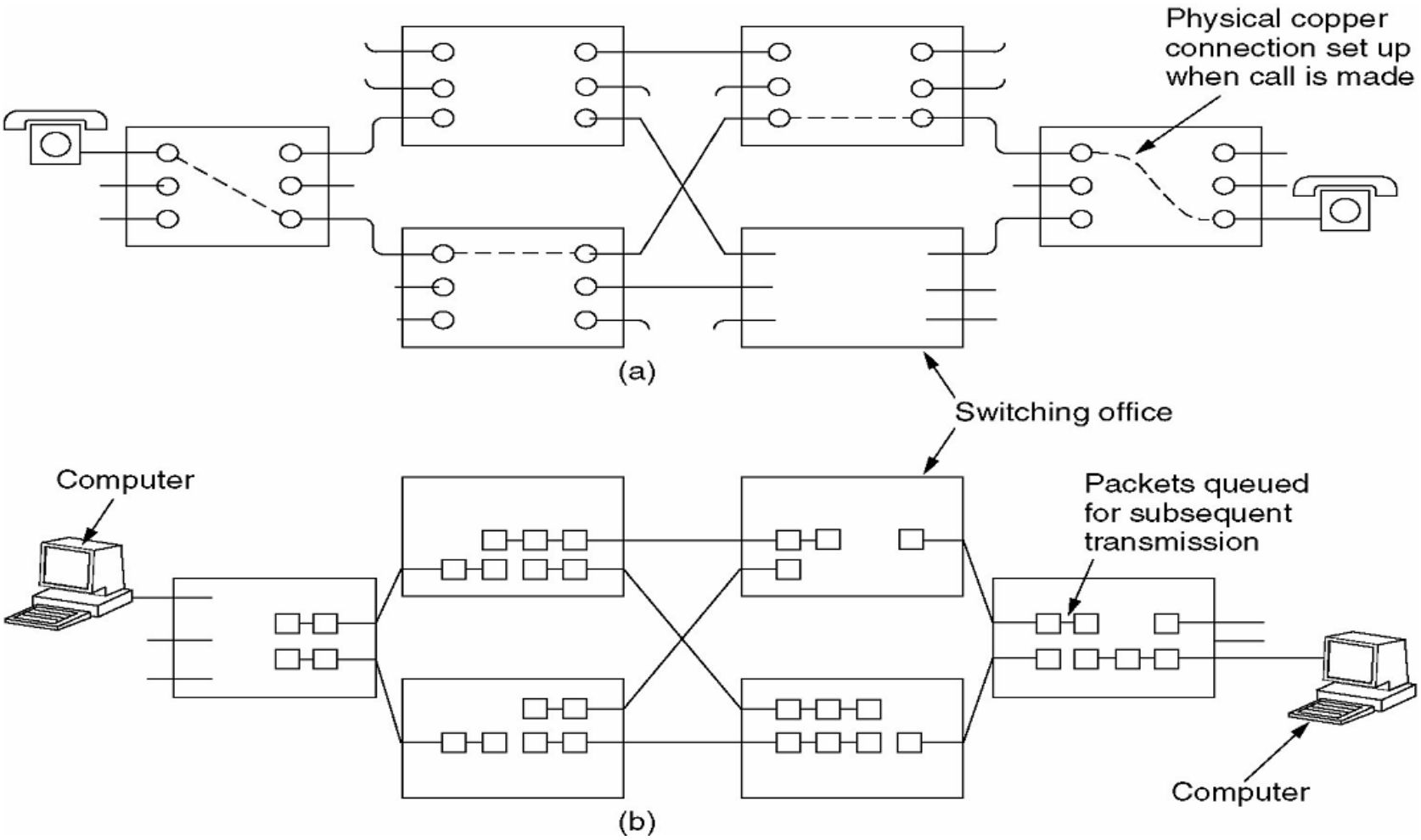
Problem categories

- Continuous optimization
  - ABS
  - Computer assisted avionics
  - Space craft atmosphere re-entry
- Combinatorial optimization
  - Circuit switching
  - Packet switching
  - Pickup and delivery with rolling planning horizon
  - Dial a Ride

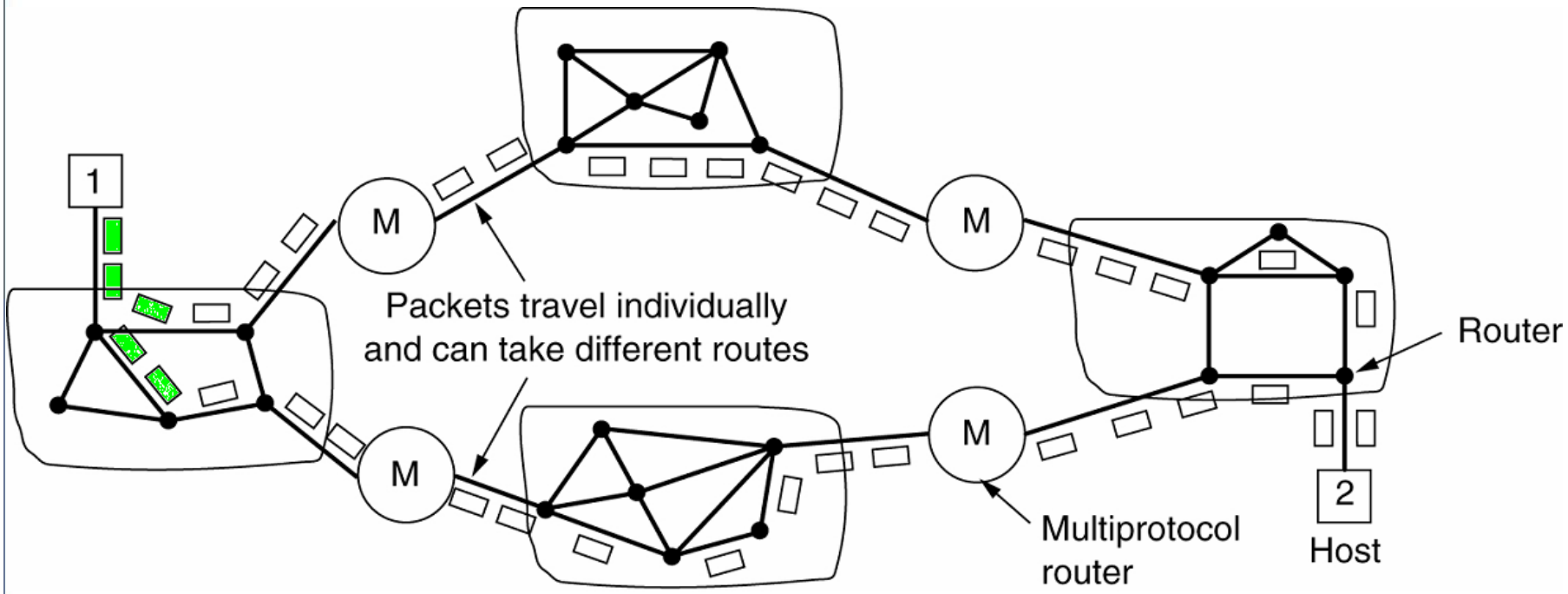
Circuit switching



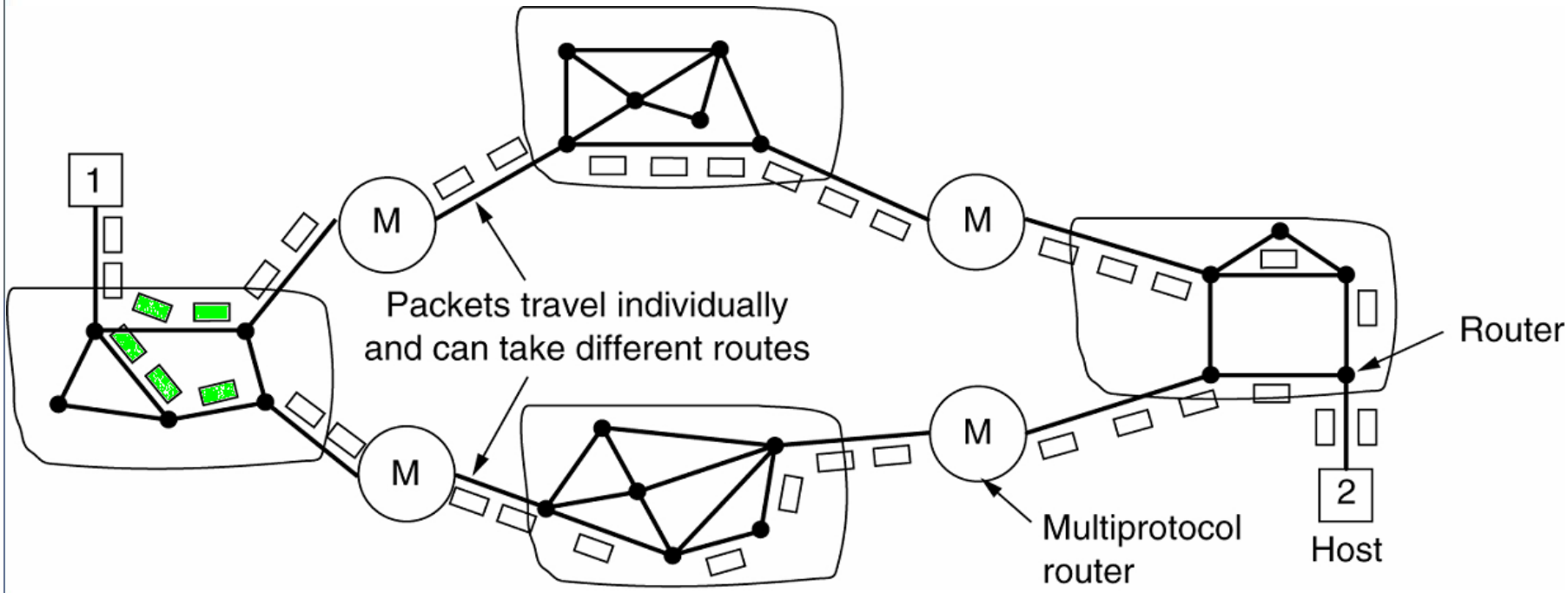
Circuit *versus* packet switching



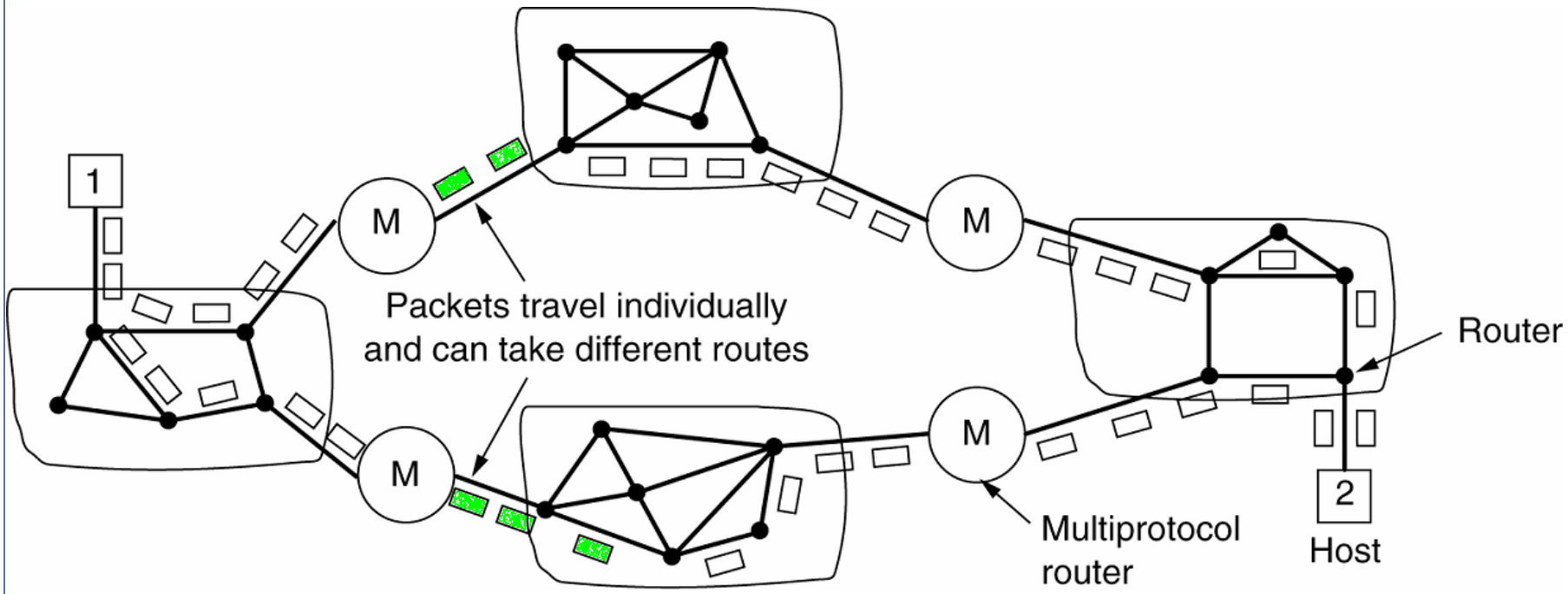
Packet switching



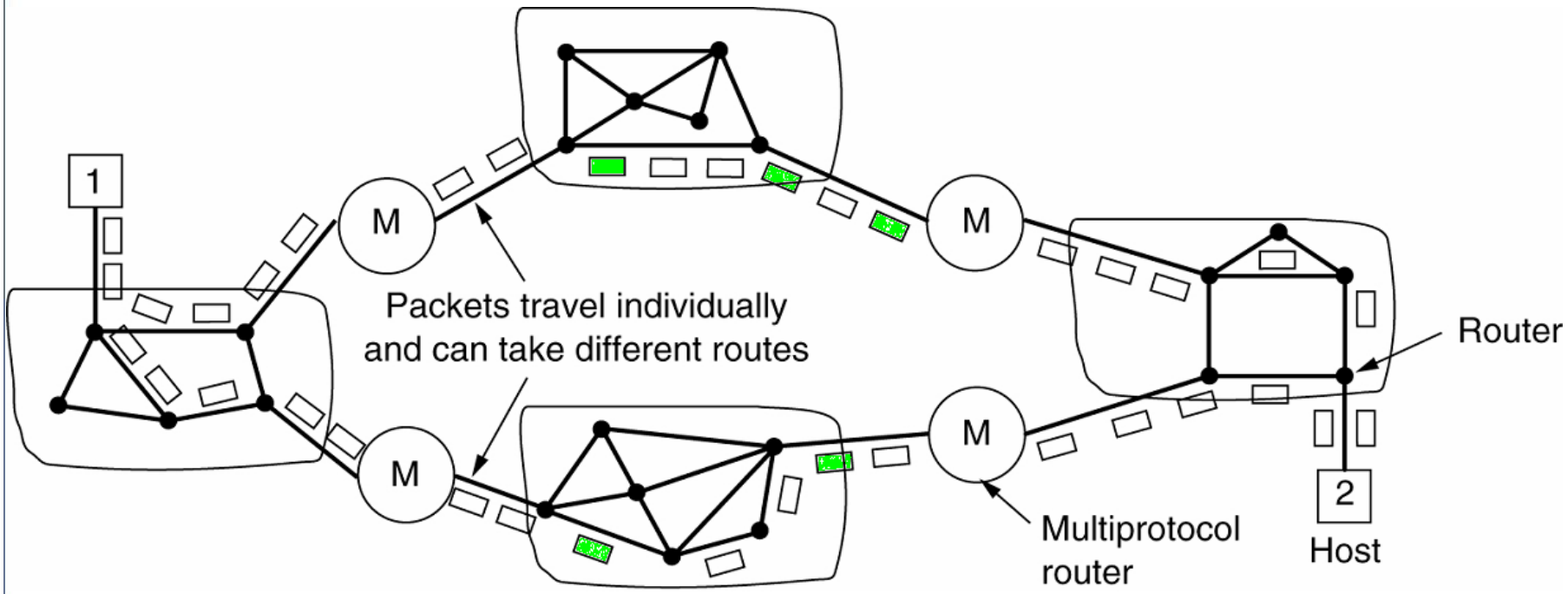
Packet switching



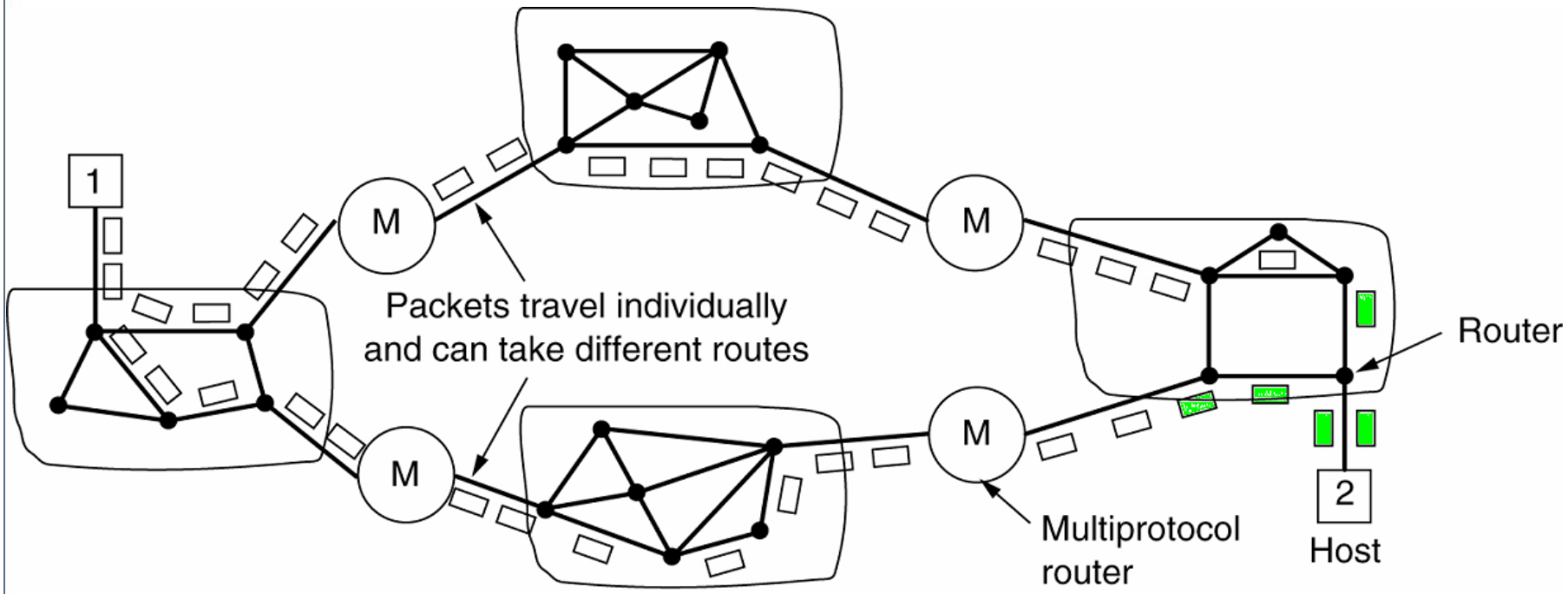
Packet switching



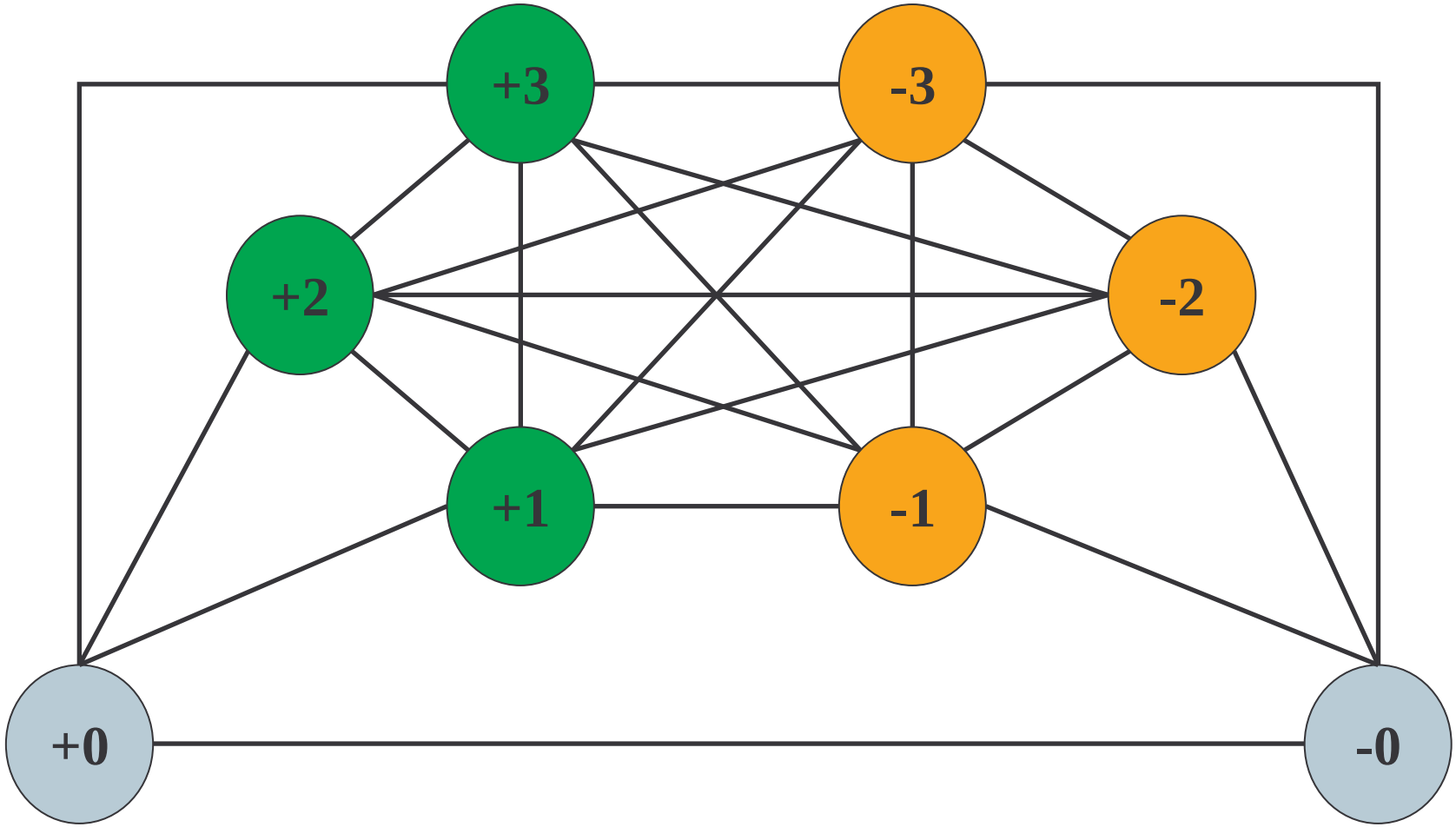
Packet switching



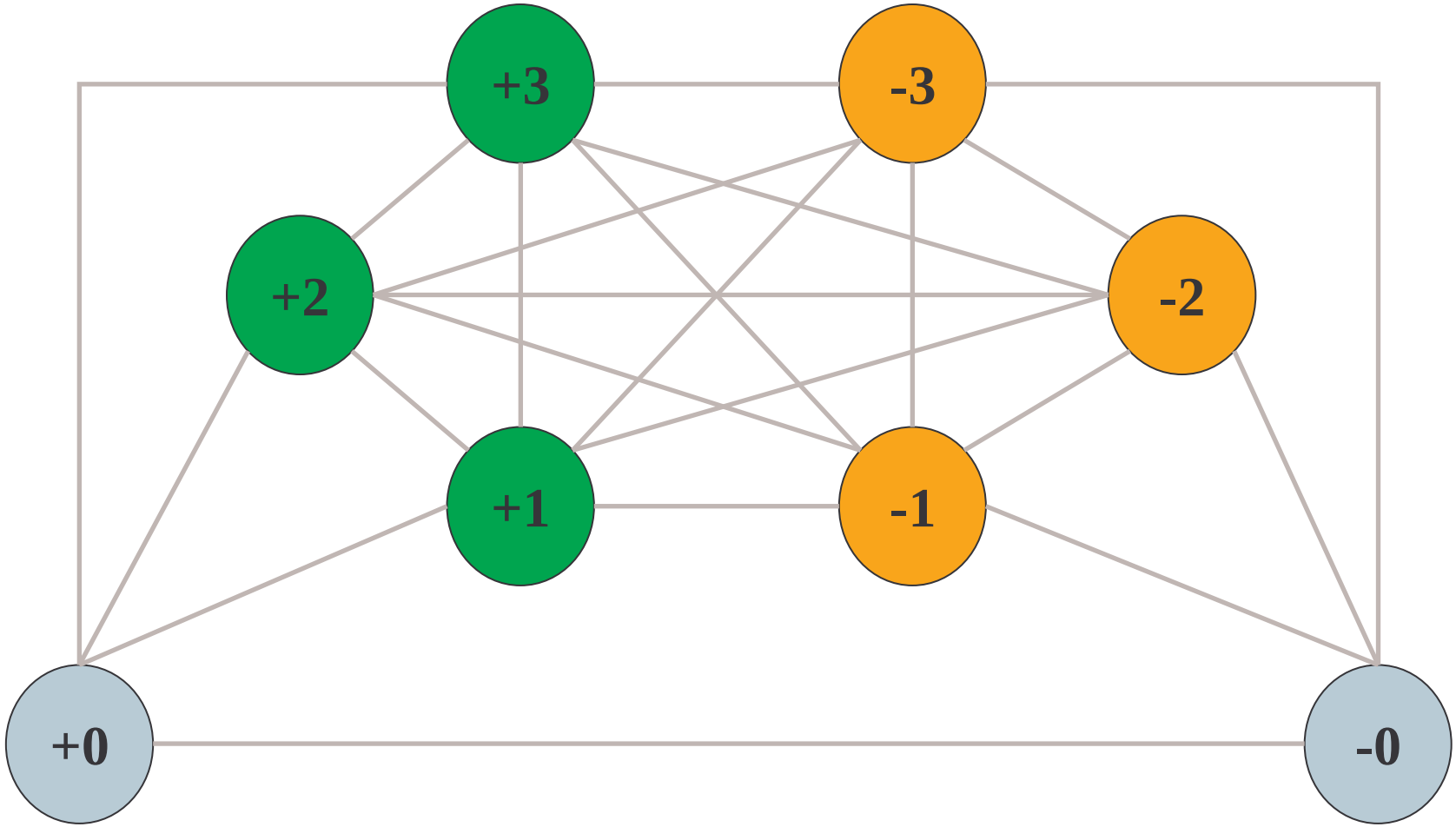
Packet switching



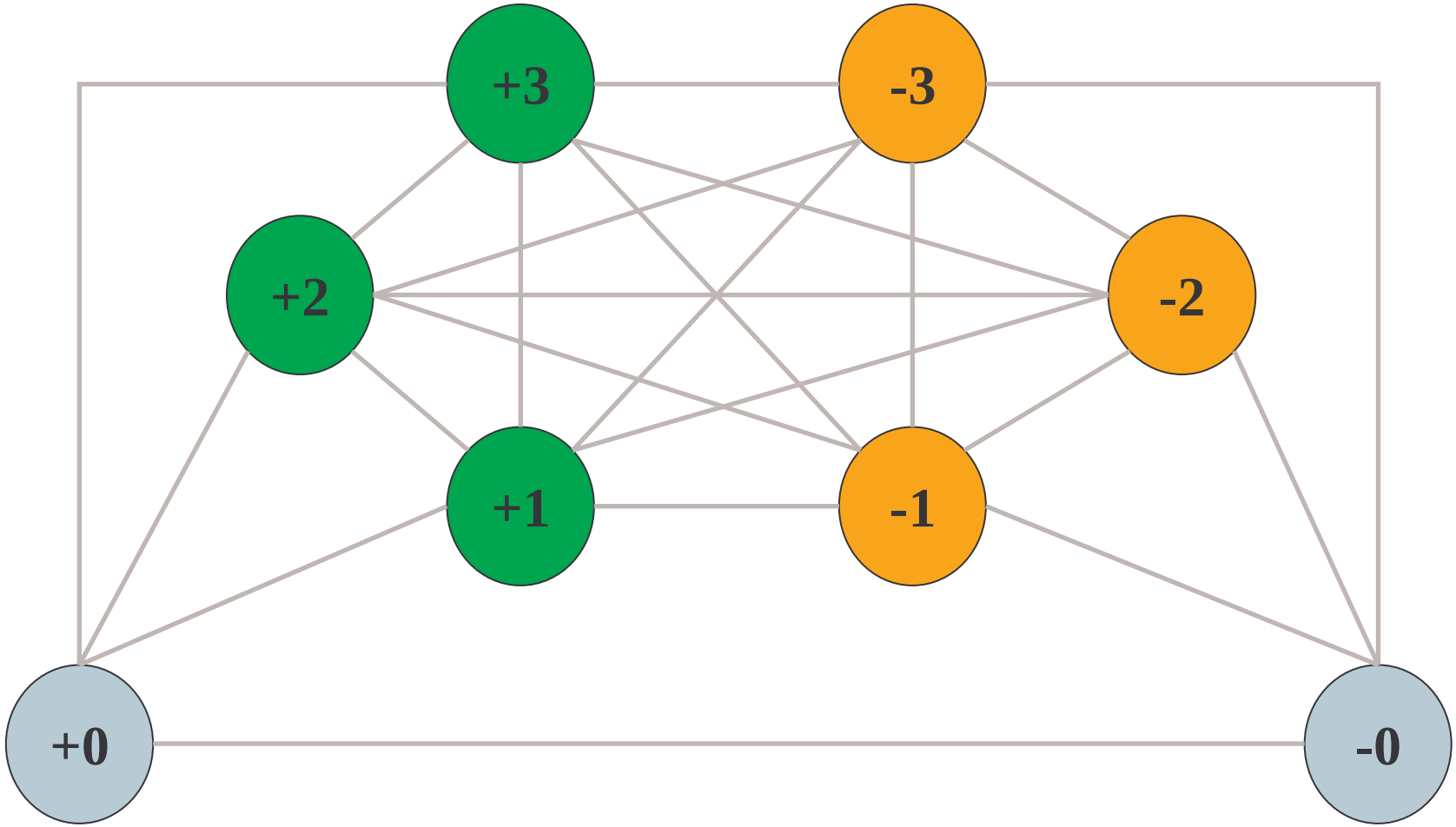
Pickup and Delivery



Pickup and Delivery



Pickup and Delivery capacity = 3



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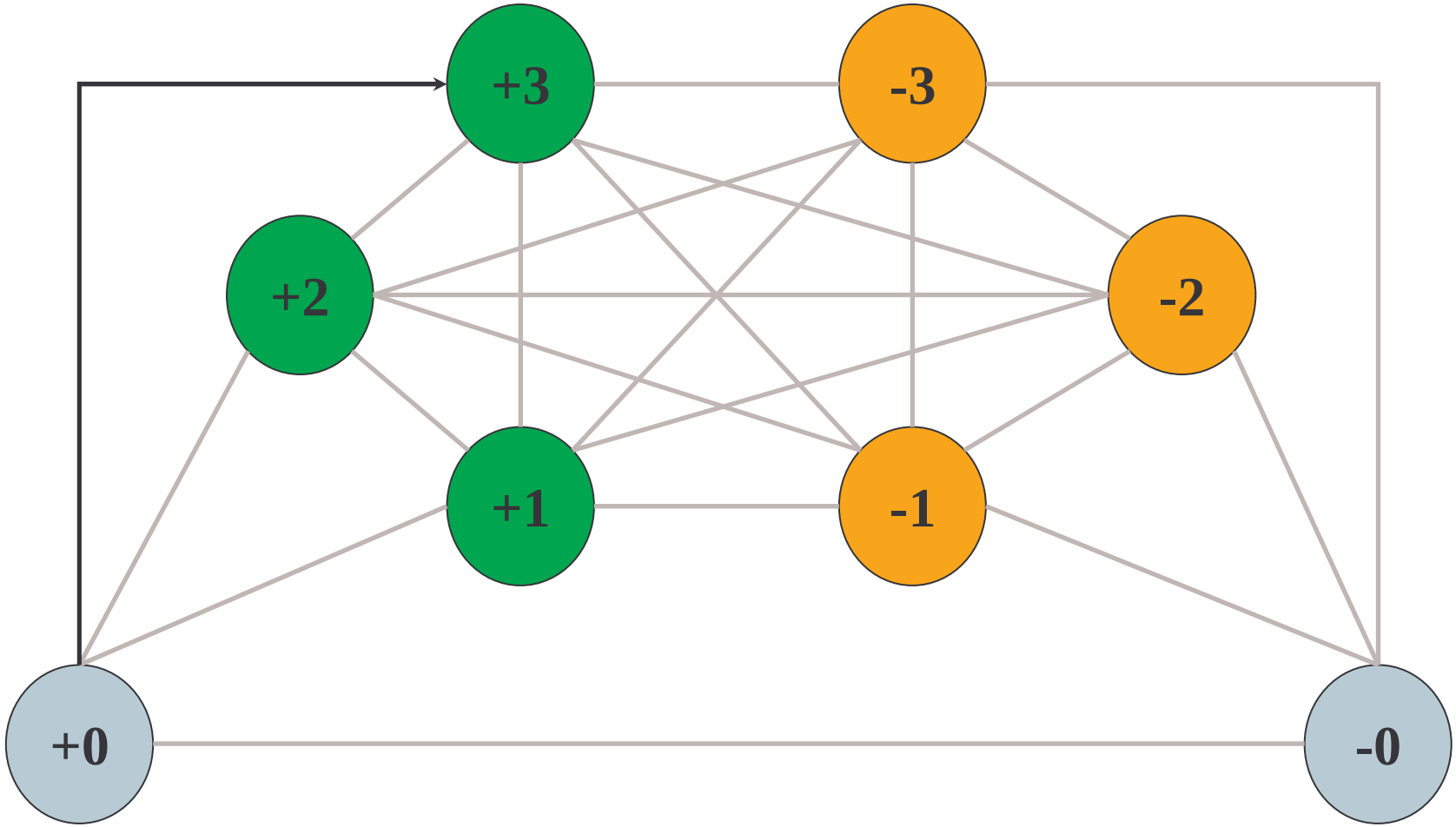

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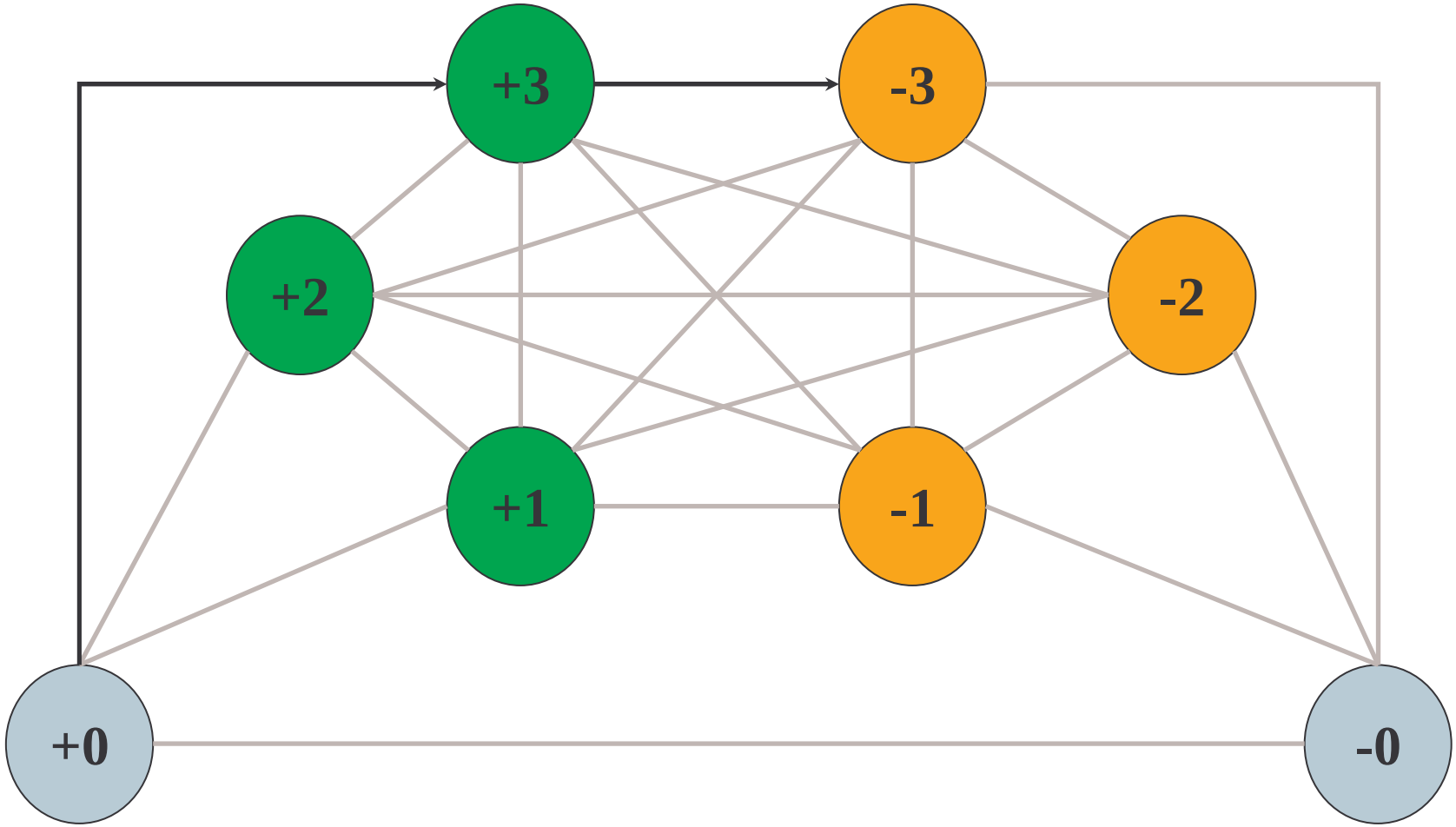

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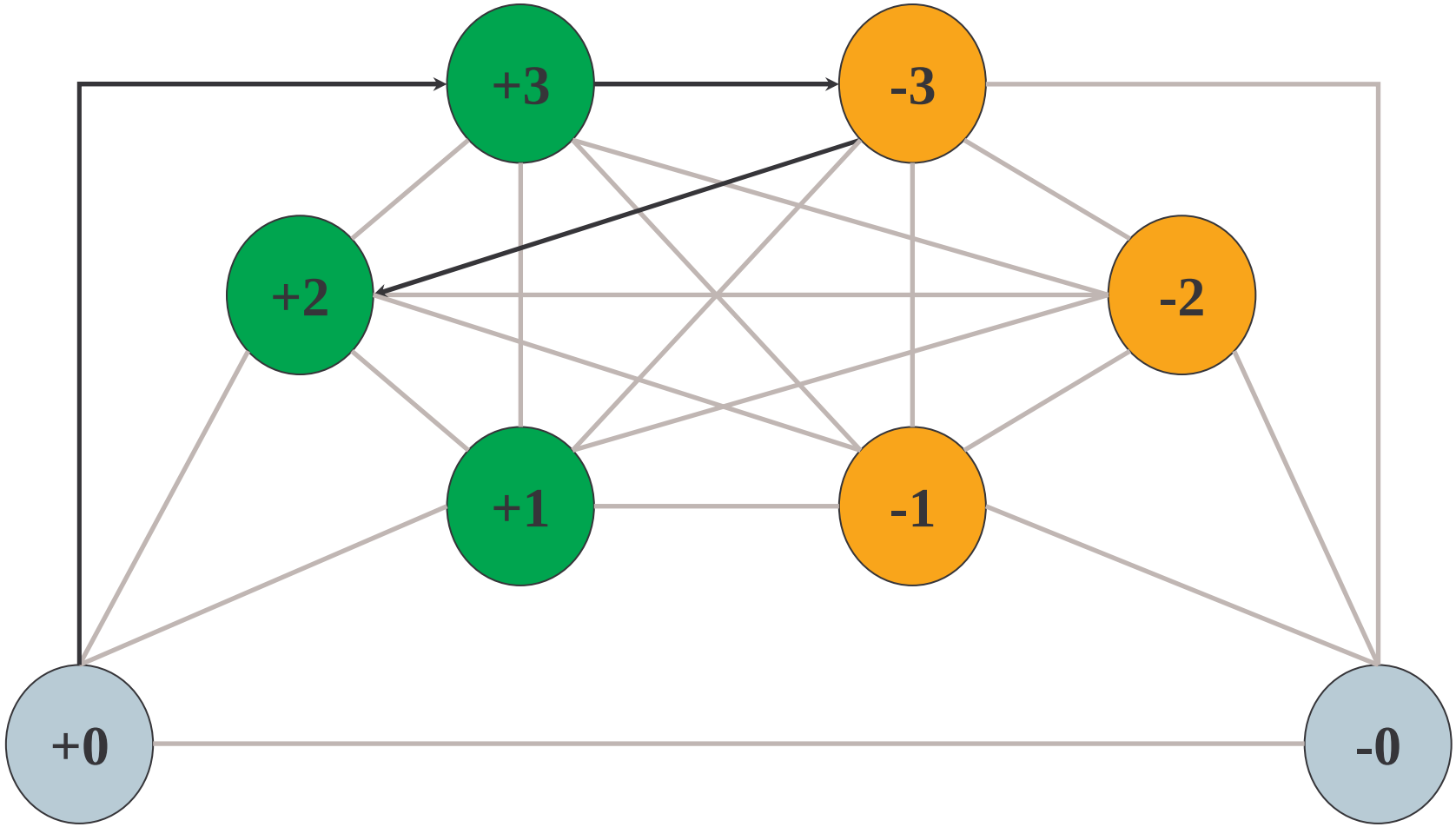

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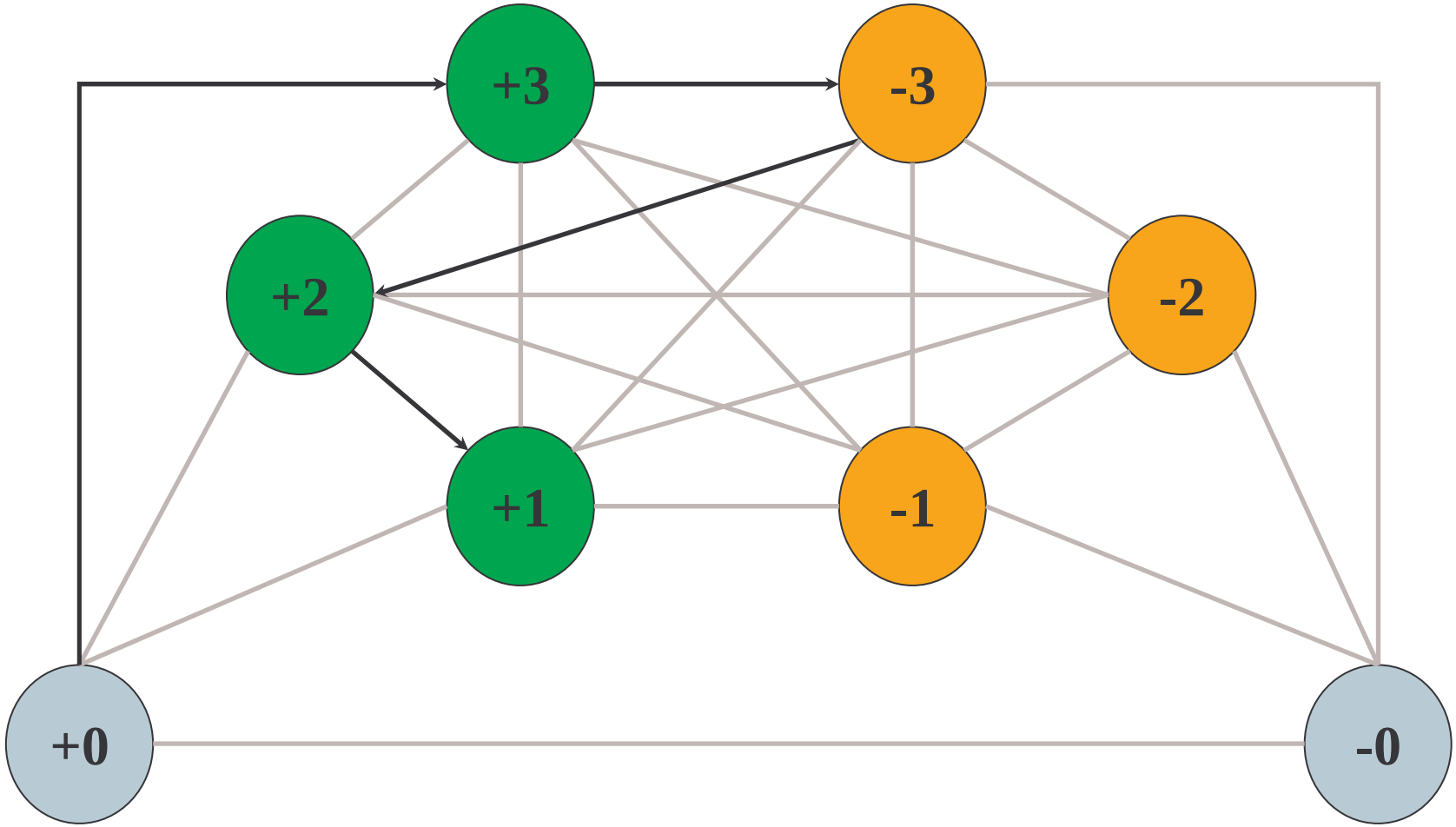

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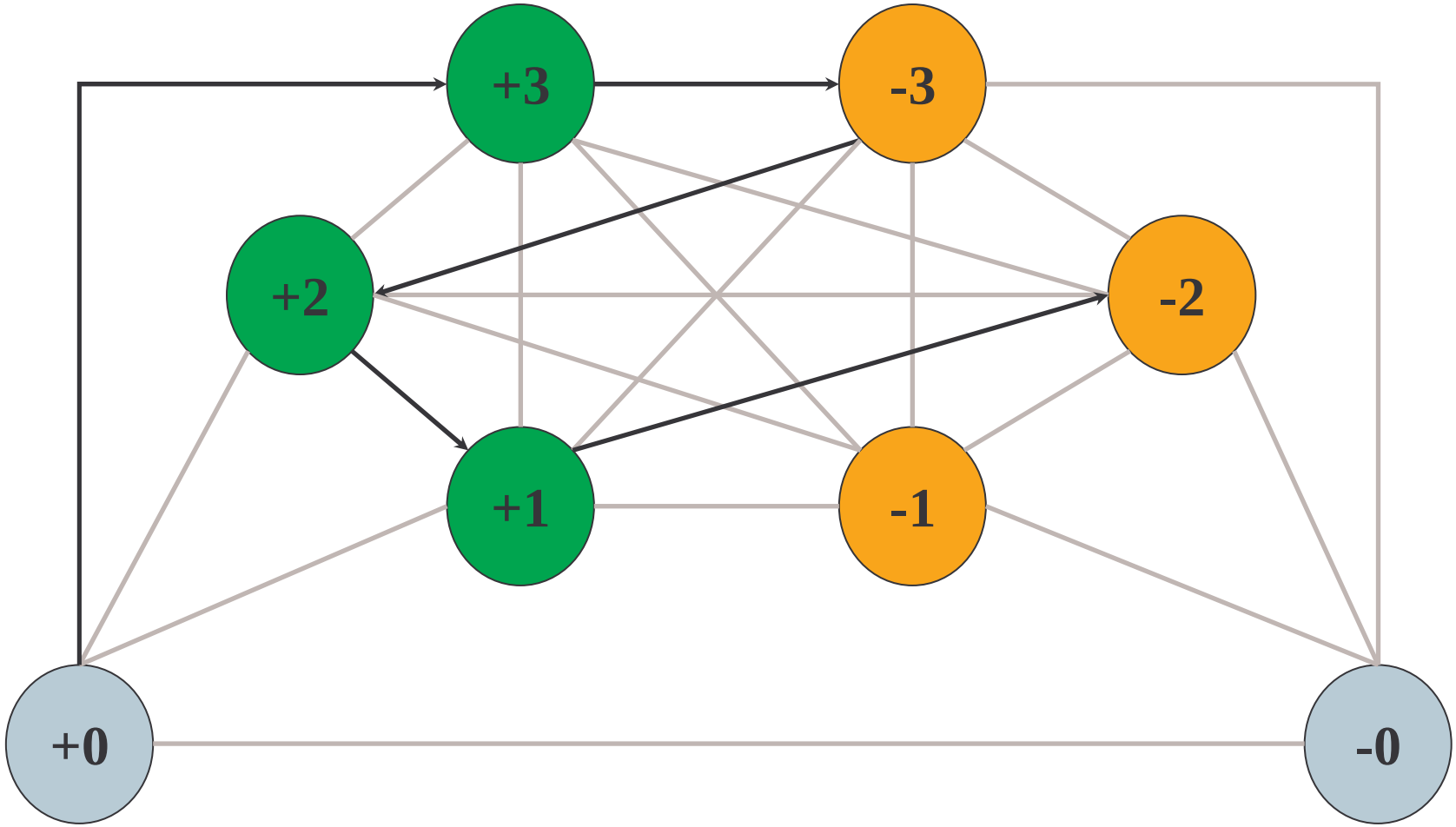

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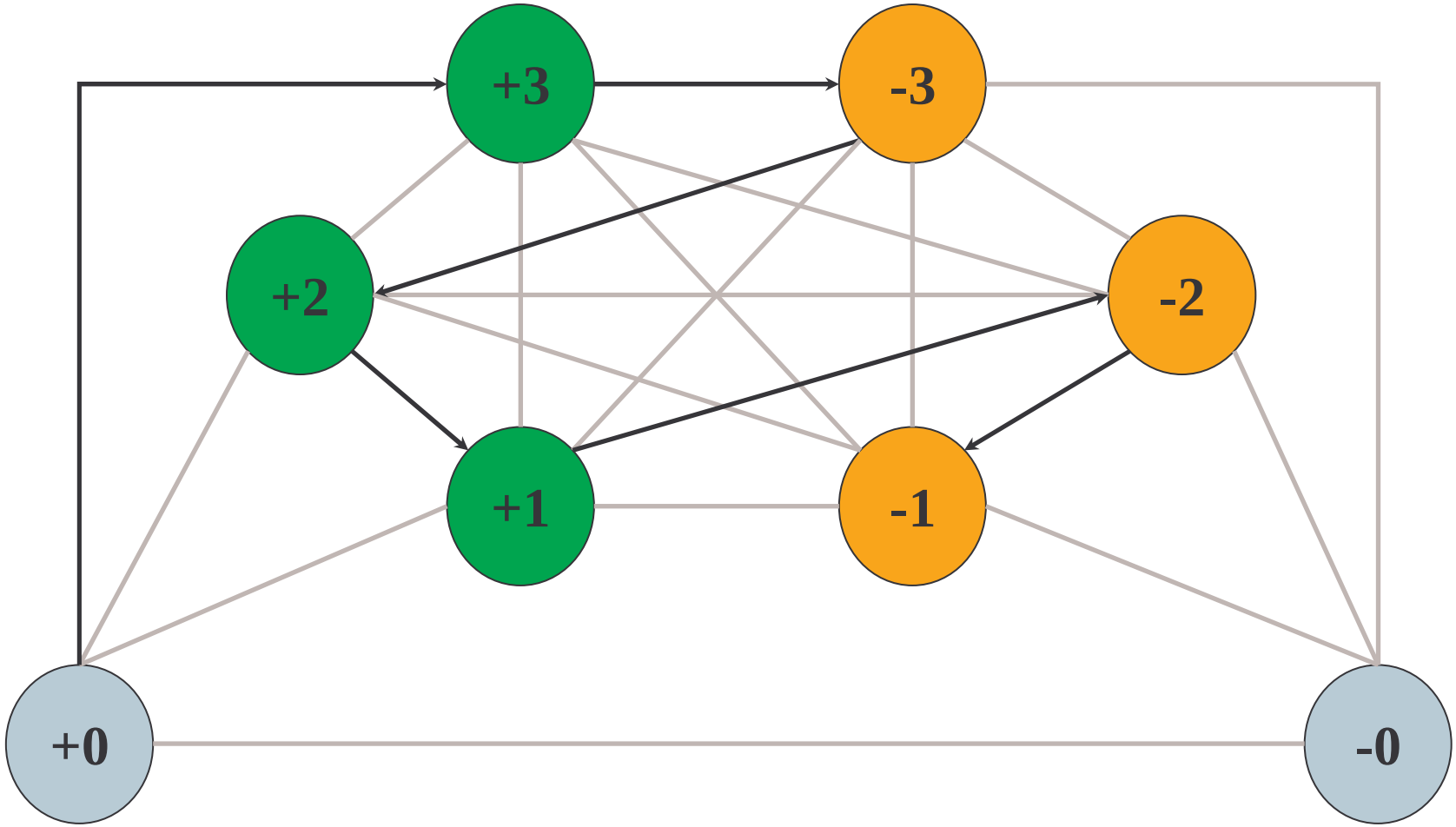

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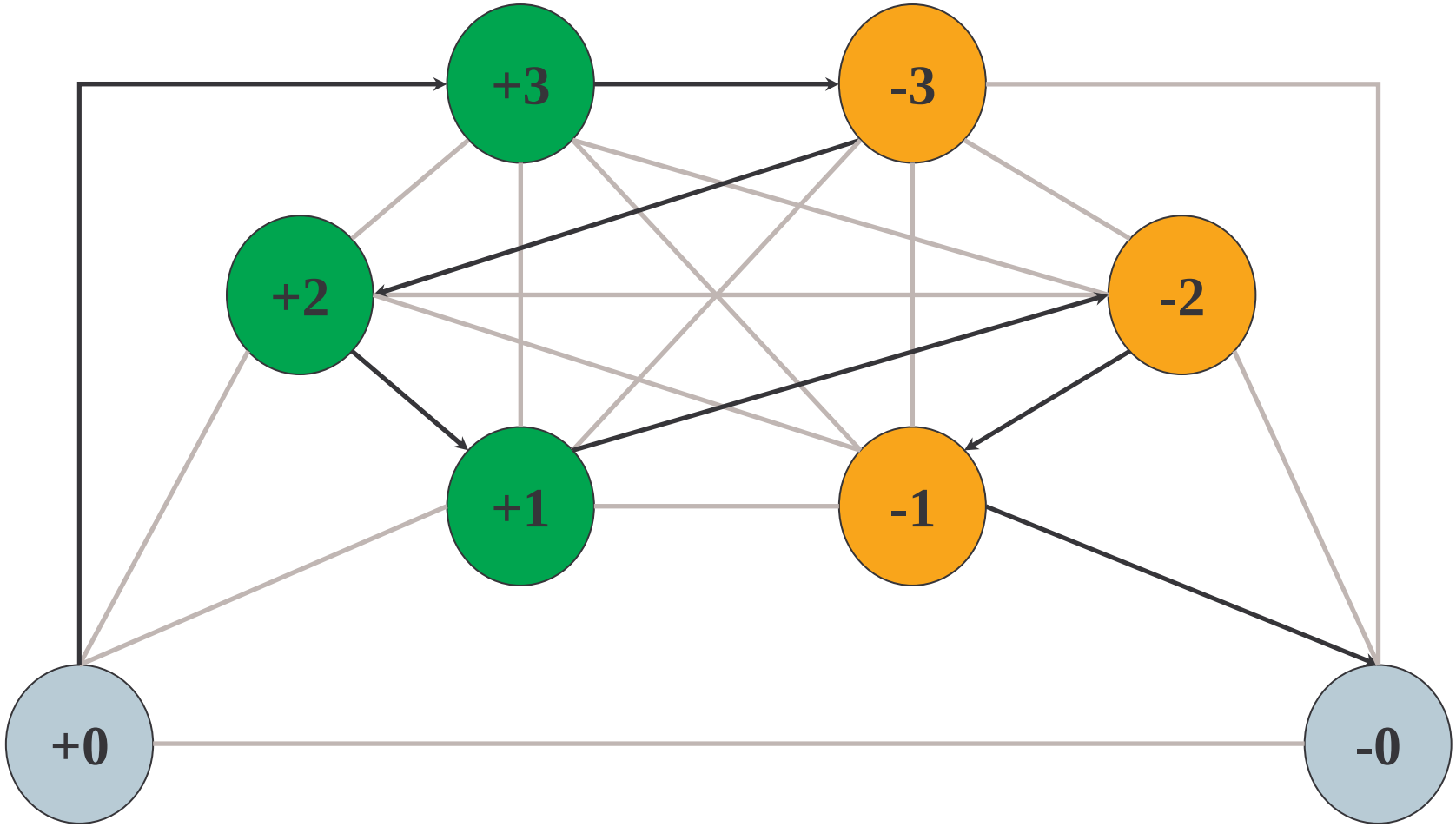

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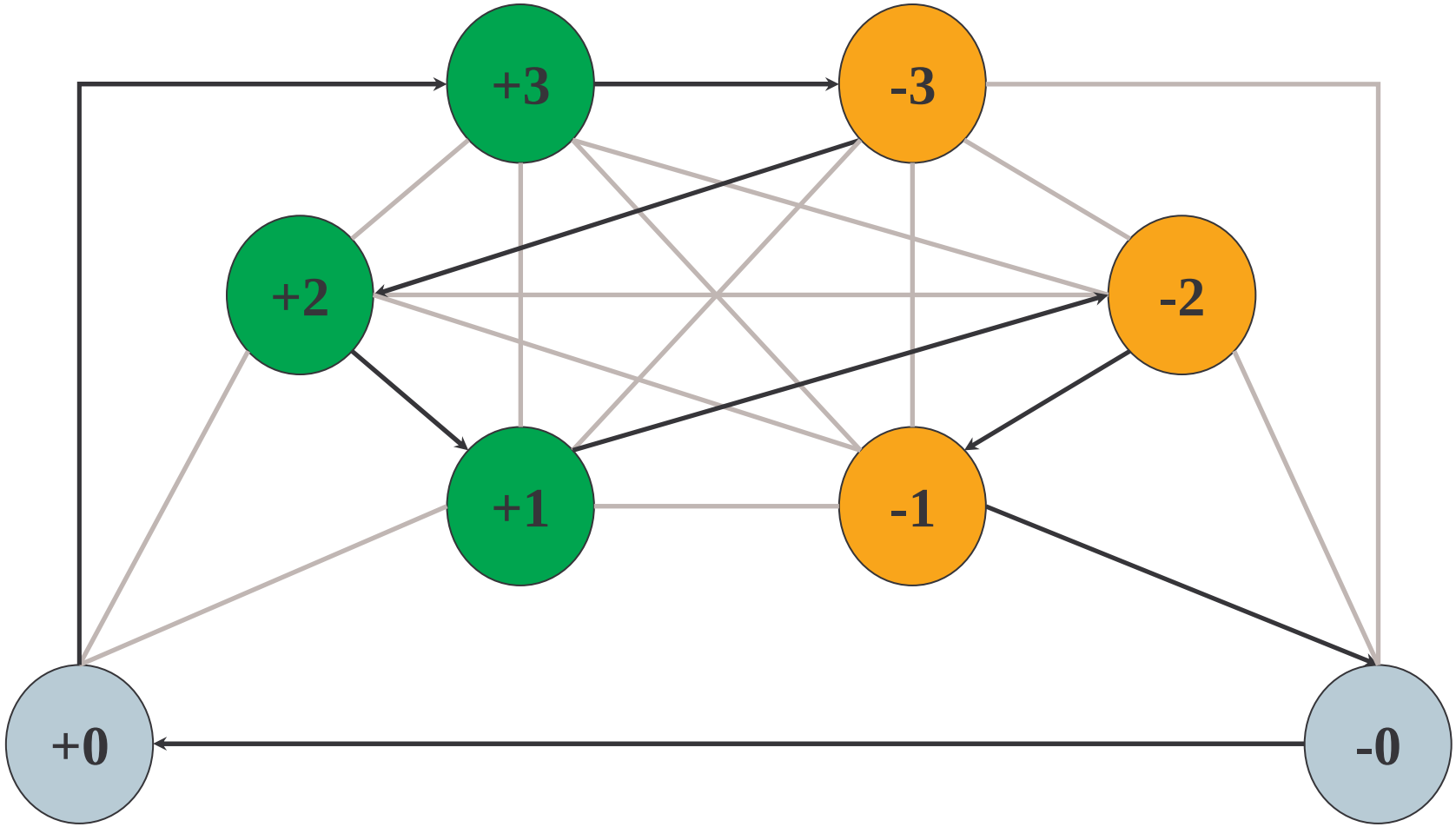
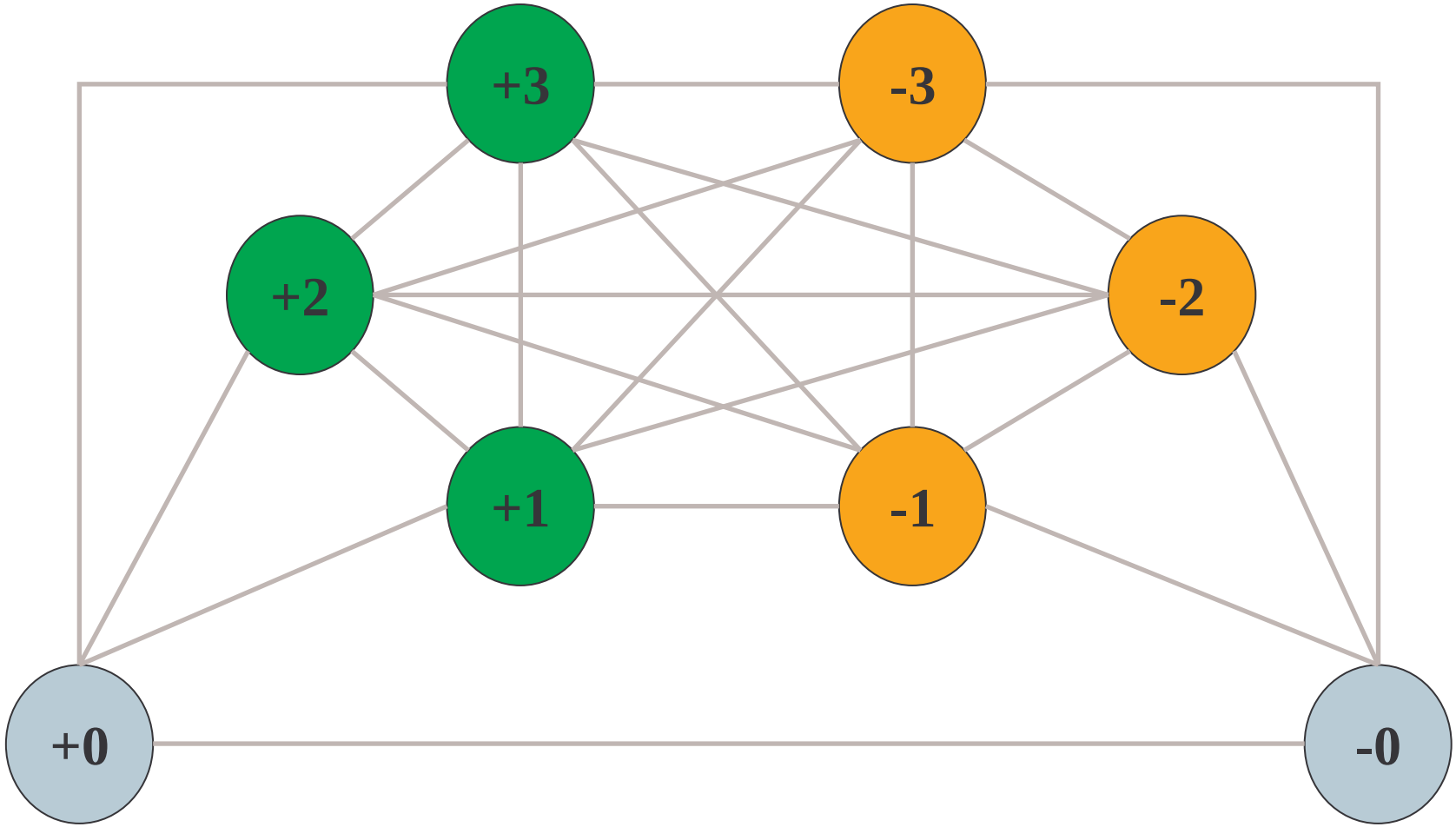


Pickup and Delivery capacity = 5



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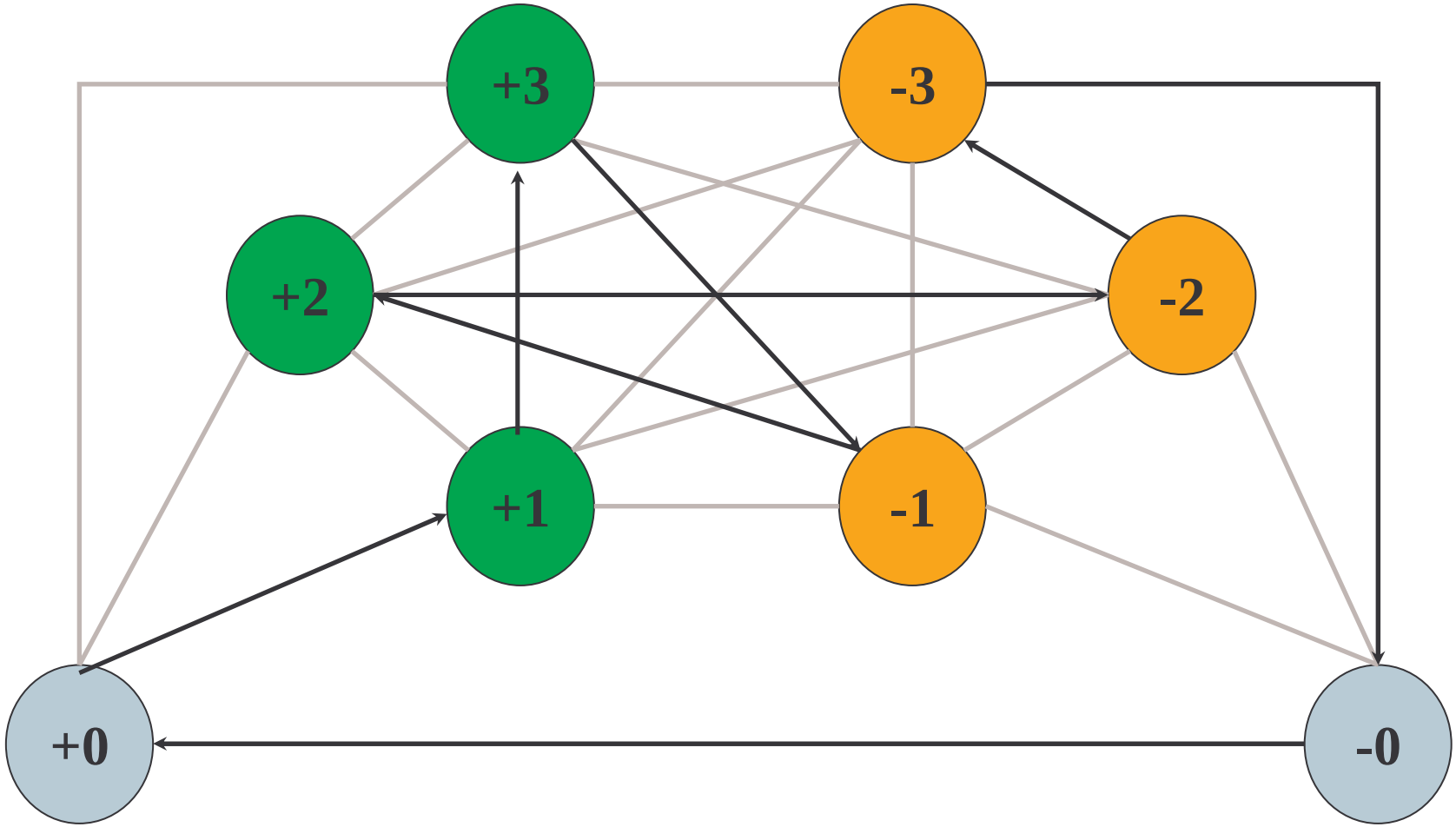
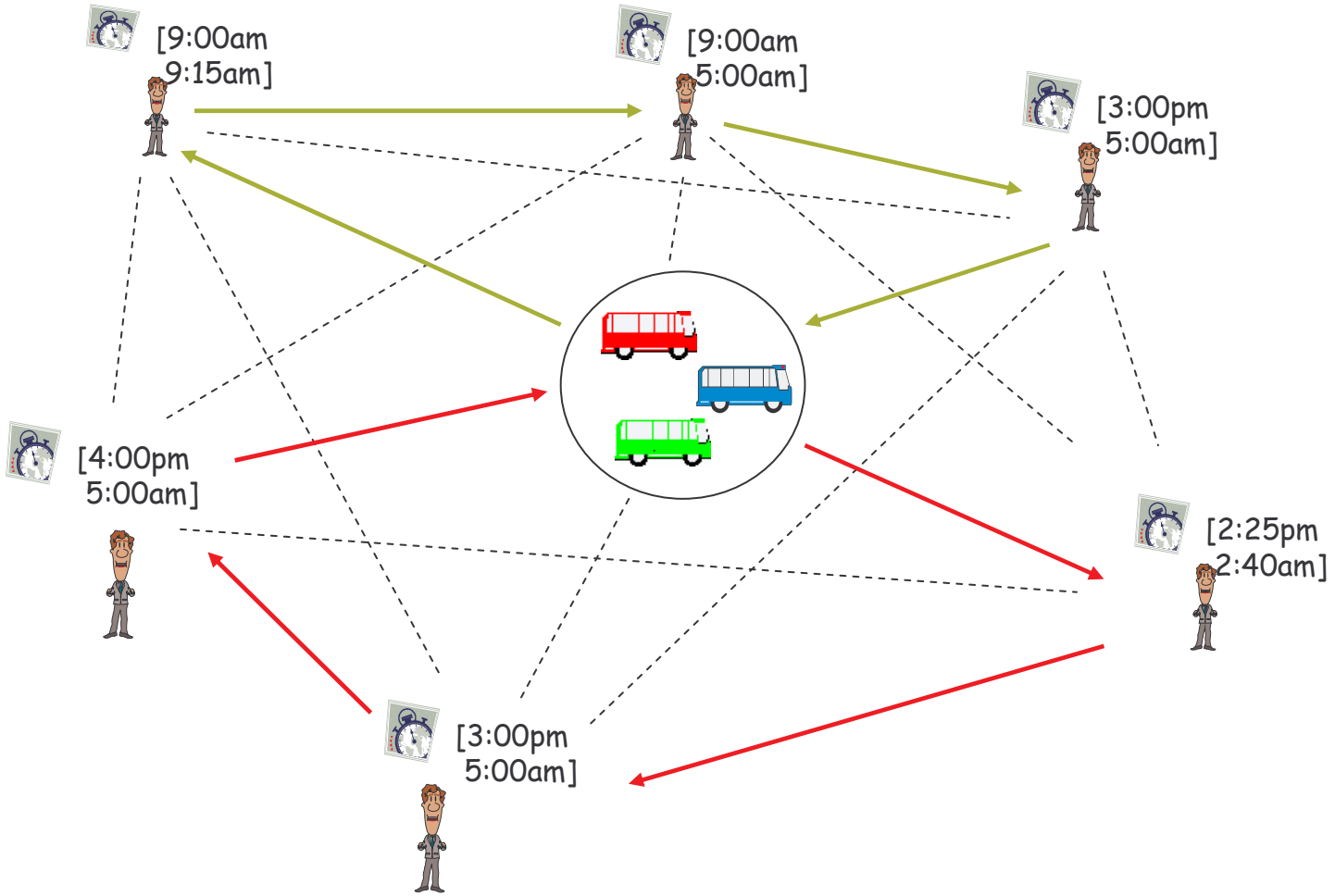


Dial a ride


[9:00am
9:15am]
[9:00am
5:00am]
[3:00pm
5:00am]
[4:00pm
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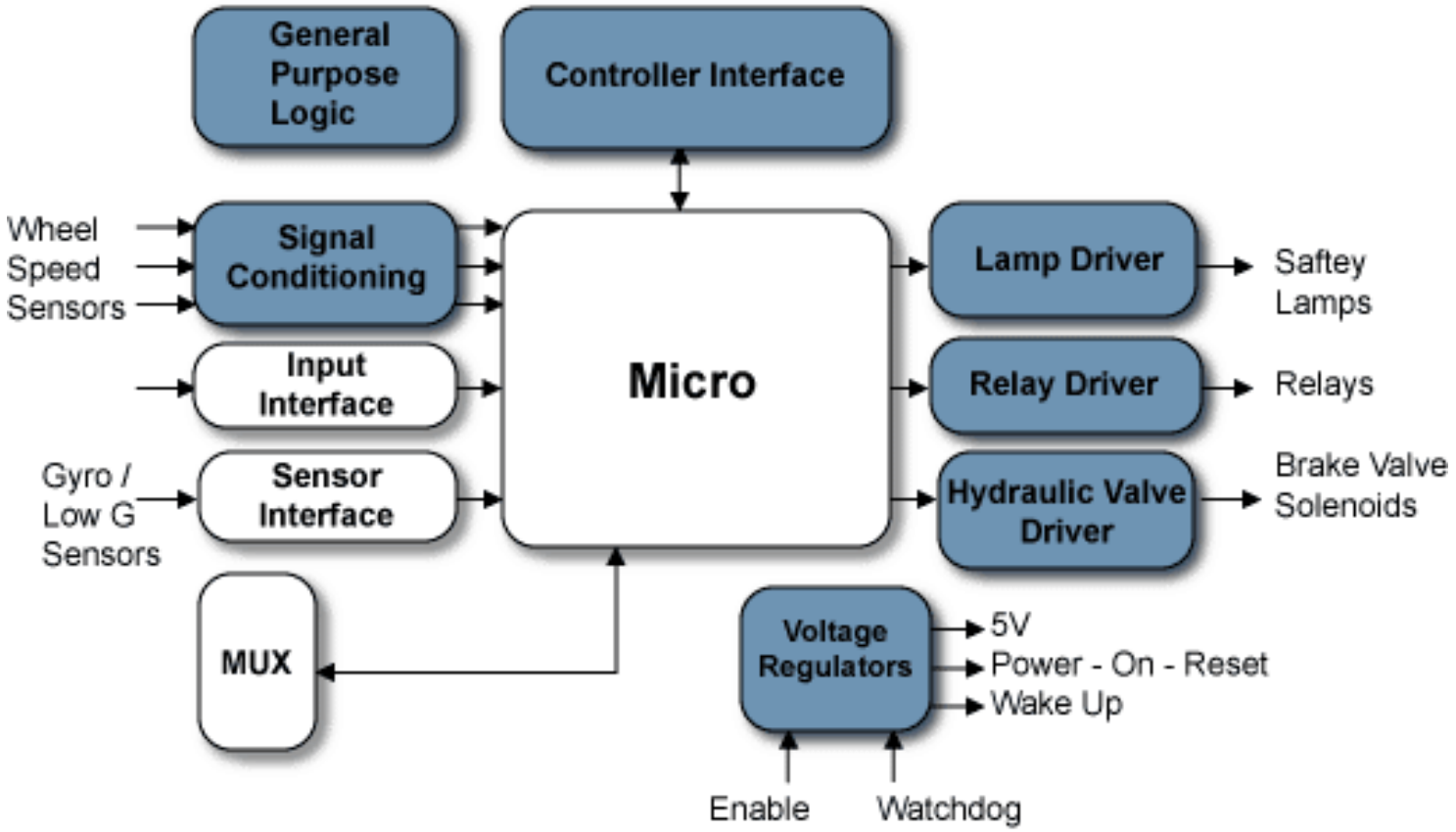
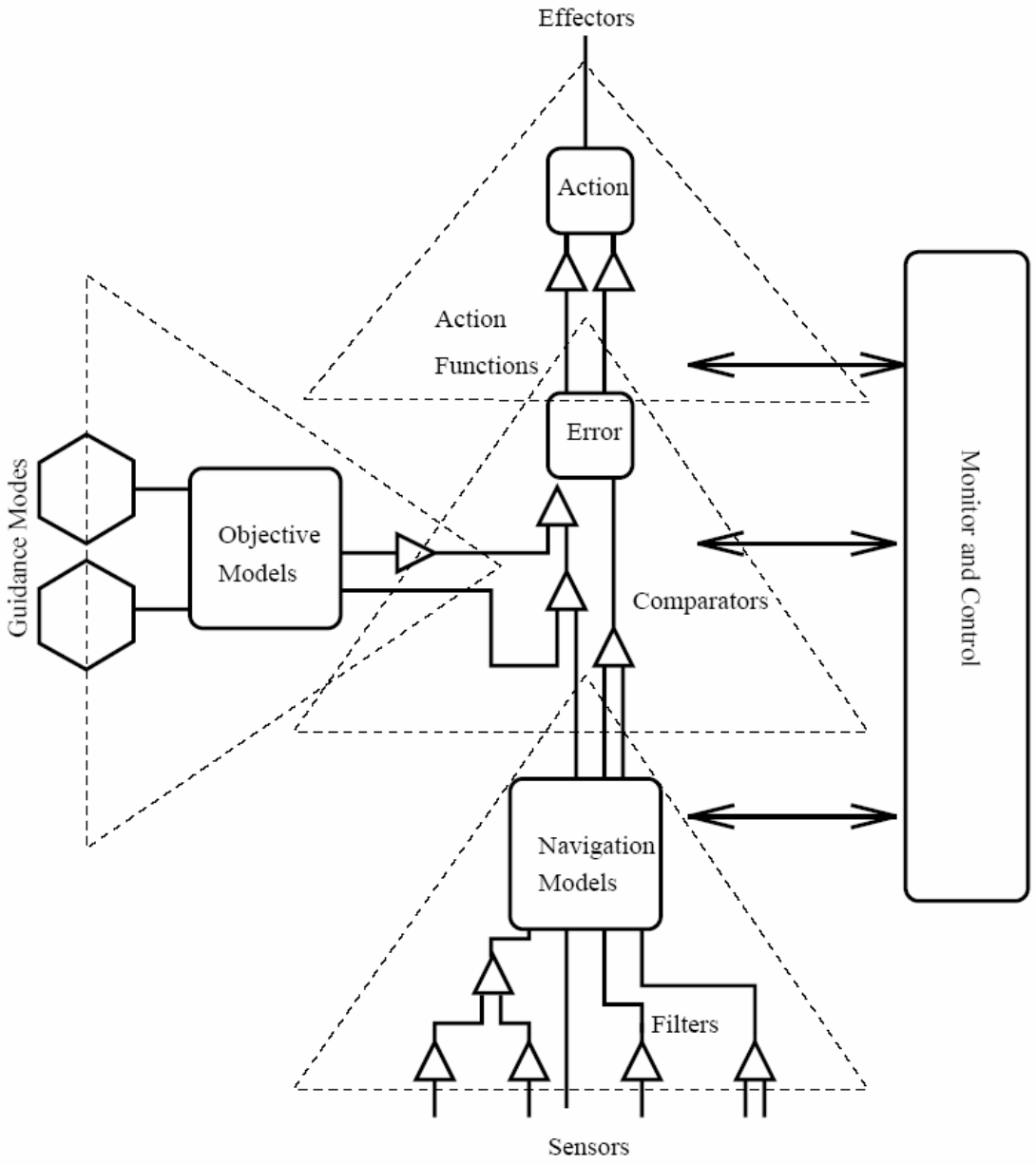
[2:25pm
2:40am]
[3:00pm
5:00am]

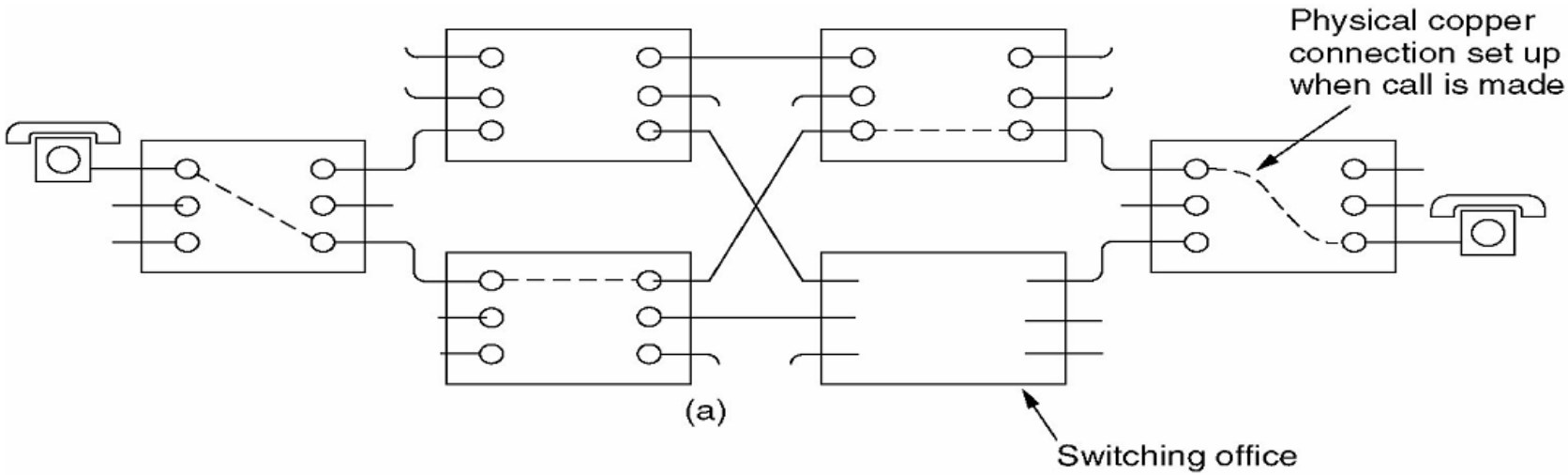
ABS & Traction control



Computer assisted avionics

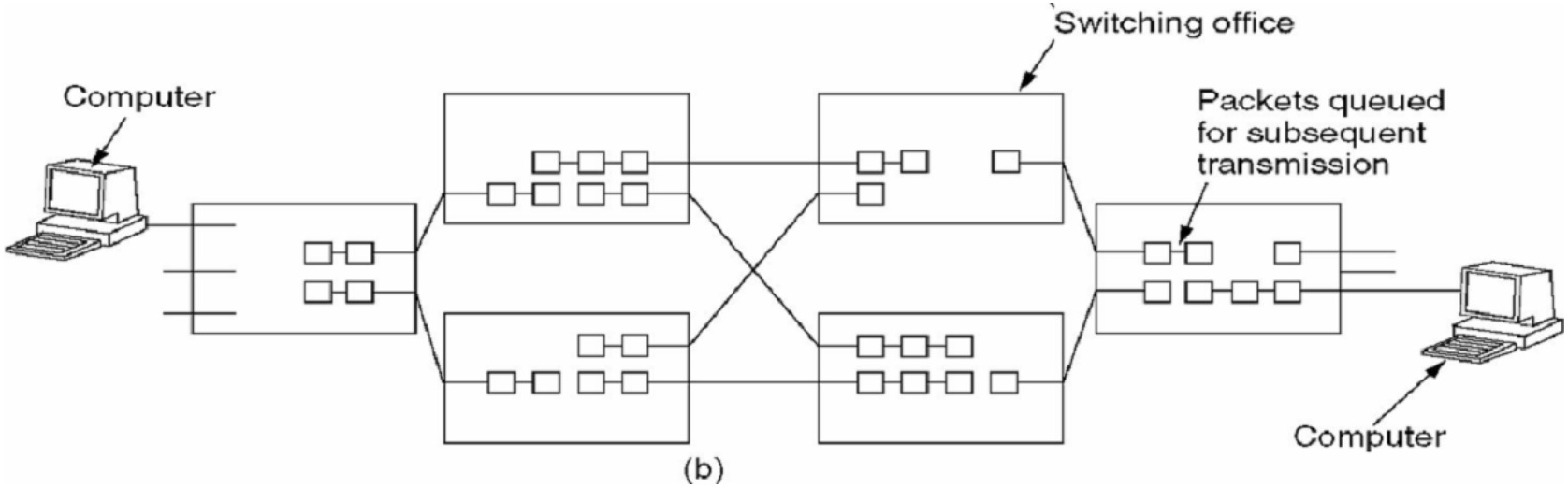


Circuit switching



- Physical infrastructure does not change very often:
  not very dynamic
- Connection set up almost immediately:
  real-time
- The call schedule is unknown and the horizon is open:
  online
- The actual route is a choice among finite options:
  combinatorial
- The system works automatically and without human intervention:
  unattended control

Packet switching revisited



- The Internet changes dramatically and constantly:
  very dynamic
- Connection set up almost immediately:
  real-time
- The communication demands are unknown and the horizon is open:
  online
- The actual route is a choice among finite options:
  combinatorial
- The system works automatically and without human intervention:
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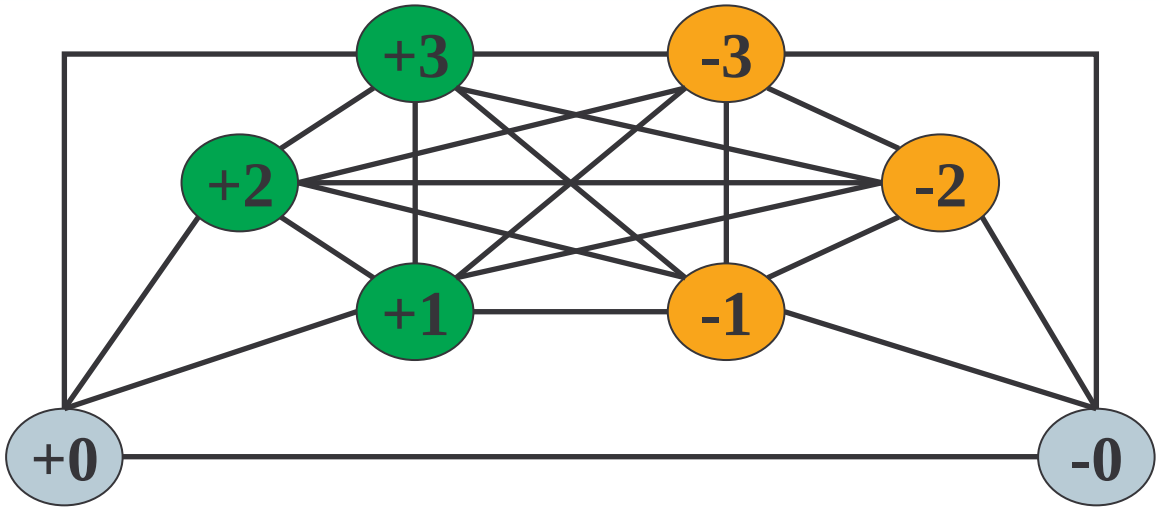
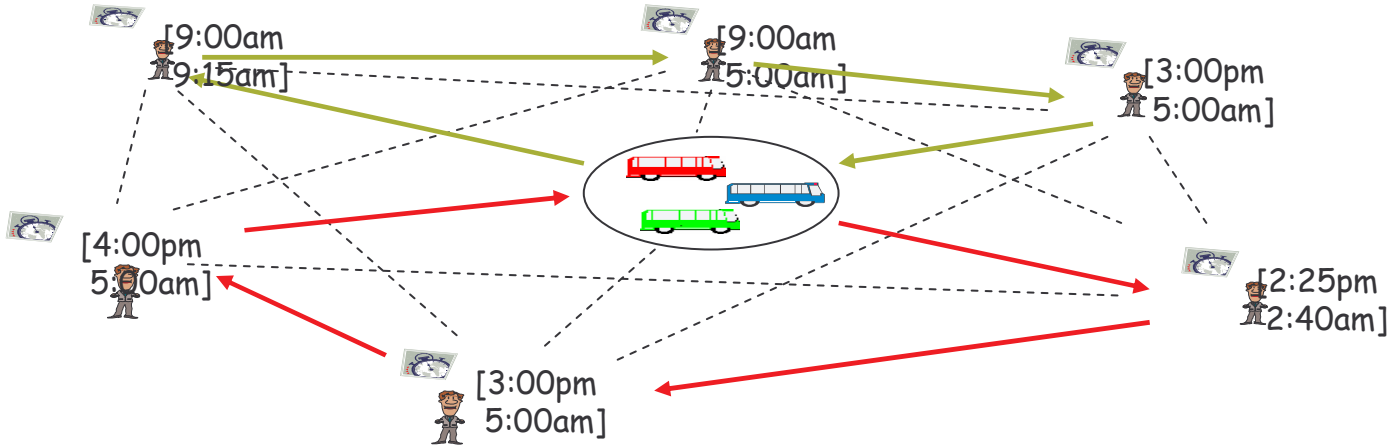
Pickup and Delivery revisited



- Travel speeds may depend on traffic congestion:
  dynamic
- Take a courier: new orders need to be dispatched quickly:
  real-time
- New orders are placed constantly and the planning horizon is open:
  online
- A solution involves many choices:
  combinatorial
- A typical setting involves one or more human planners:
  decision support

Dial a Ride revisited



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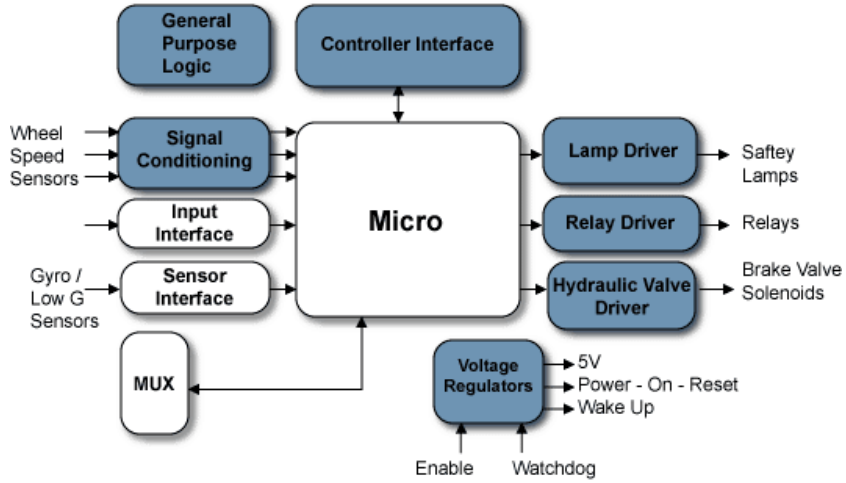
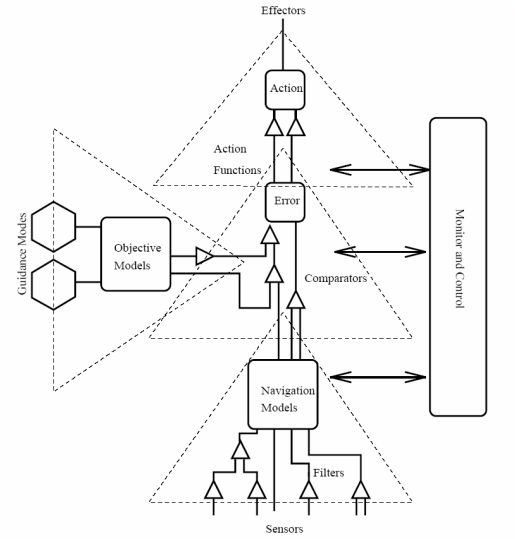


- q System components are stable and fixed:
  not very dynamic
- q Immediate response needed:
  real-time
- q Value of the different parameters changes continuously:
  online
- q The optimal course of action is a control of continuous variables:
  continuous
- q The system works automatically and without human intervention:
  unattended control

ABS and Traction control revisited



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Facts and chalenges

- A good approach to a new situation involves:
  1. Problem analysis
  2. Model identification
  3. Algorithm development
  4. Implementation
- Often the same person(s) are involved through the full approach
- The needed skills are hard to master and often impossible to combine
- Especially in software development the first steps tend to be neglected.
- Especially step 2 is often ignored
- Most real life decision problems are online by nature
- Often they are approached offline
- An offline deliberately ignores future developments

A common pattern

- Decision support means that the decision is eventually taken by a human planner
- This is usually used as an advantage
- The system computes a few alternatives and lets the planner choose

From the planner's prespective…