Tangle/IOTA

Using a DAG instead of a blockchain

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IOTA

Micropayments

General idea

- Small payments
- Day to day payments
- IOT devices
    - M2M micropayments

Micropayments

IOT

- Scenario: **EVM Smart Charging**
  - Decentralised Peer-to-Peer energy trading
  - A network of electric vehicle charging stations located throughout a city
    - Equipped with smart meters and sensors
      - Monitor energy consumption
      - Authenticate EVs
  - Electric vehicles can autonomously connect to these charging stations for recharging
  - The entire process is automated
  - Example: Trondheim!

Micropayments

Problems

- **Problem:** Block delay
  - Solution:
    - Committee-based blockchains

Micropayments

Problems

- **Problem:** Forks
  - Discarded forks are wasted energy
  - Maybe 2 blocks are not conflicting
    - Same parent
  - Solution:
    - Change blockchain structure
      - GHOST

Micropayments

Problems

- **Problem:** Scalability
  - More users —> more transactions
  - More miners —> harder to get consensus —> more forks
  - Solution:
    - Select few miners to run consensus
      - Committee-based blockchains

Micropayments

Problems

- **Problem:** Transaction fees
  - Miners need incentives
  - Solution:
    - Use none-economical incentives
      - Tit-for-tat
        - Removes the mining process!

IOTA

Introduction

- An open-source distributed ledger technology
- Designed for IoT devices
- Scalable
- Efficient
- Fee-less
  - No miners
- It has a currency: MIOTA

IOTA

Introduction

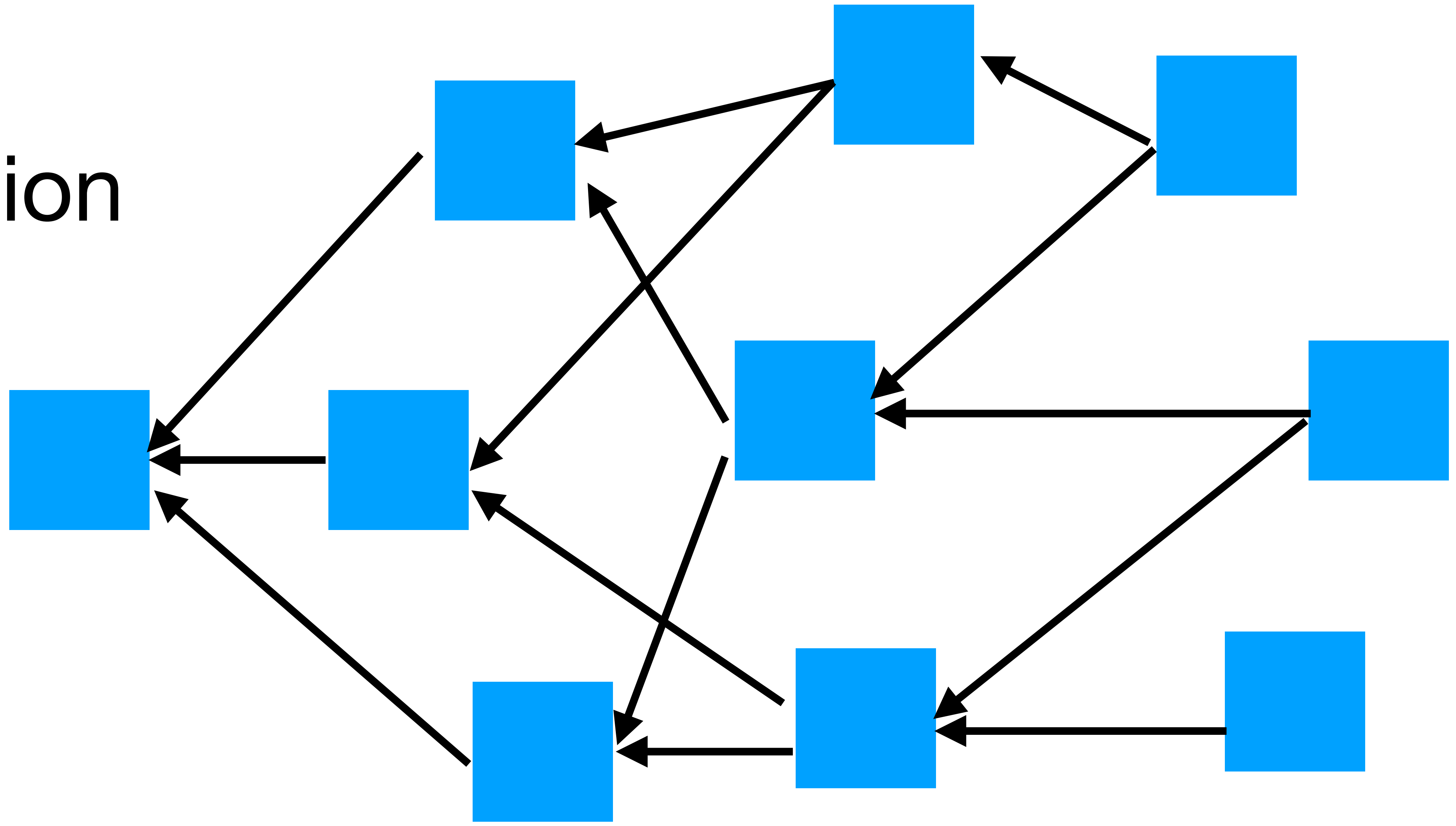
- No fees and economical incentives —> no miners
- “Help others, and others will help you”
  - “If you don’t help others, others will not help you”
  - Collaborative system
    - All users are miners
- No miners —> no blocks
- No blocks + “Help others” —> DAG —> Tangle

Tangle

Tangle

DAG

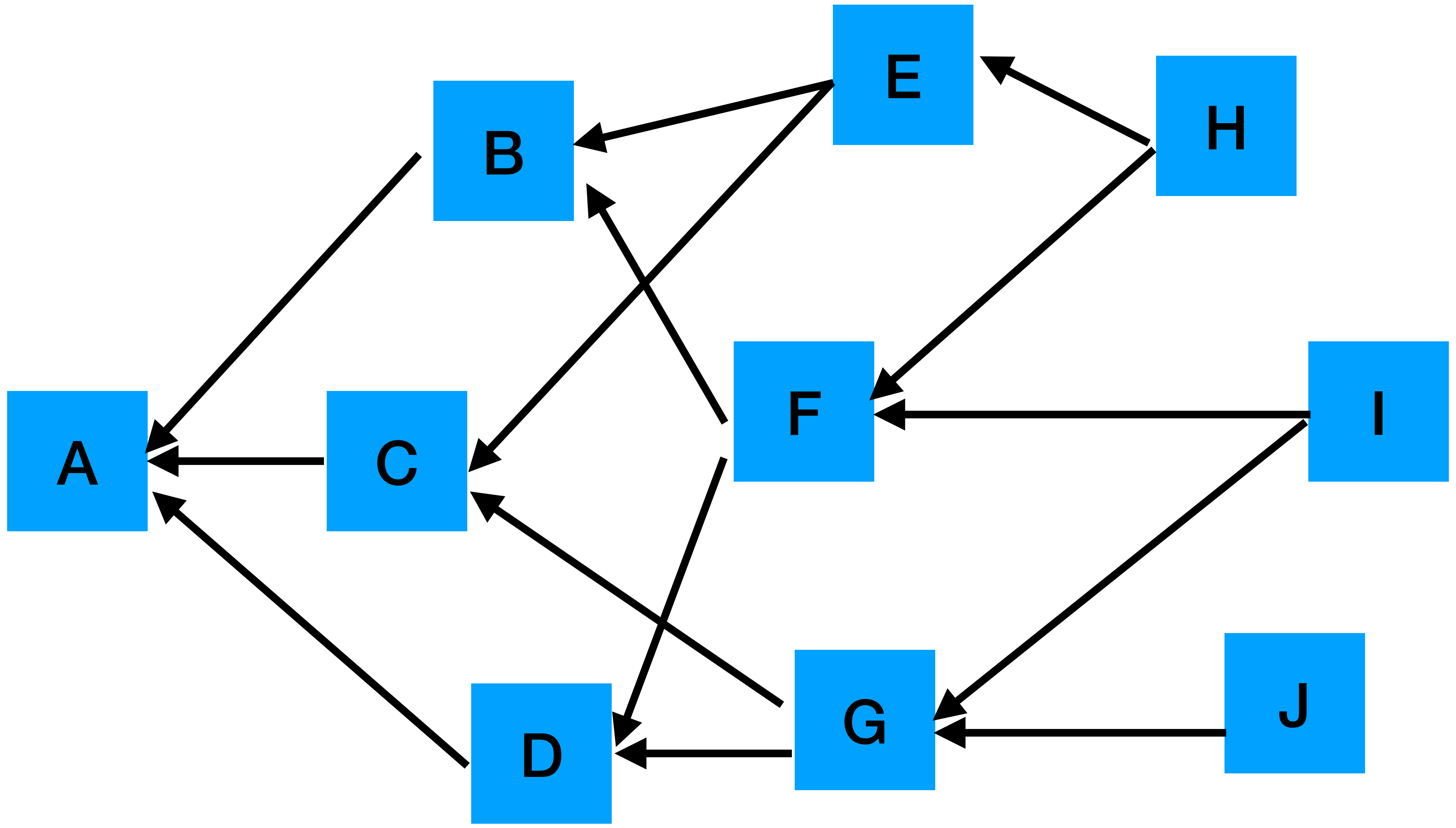
- Directed Acyclic Graph
  - Nodes connected with edges
  - Each edge has a one-way direction
  - No loop



Tangle

Nodes and edges

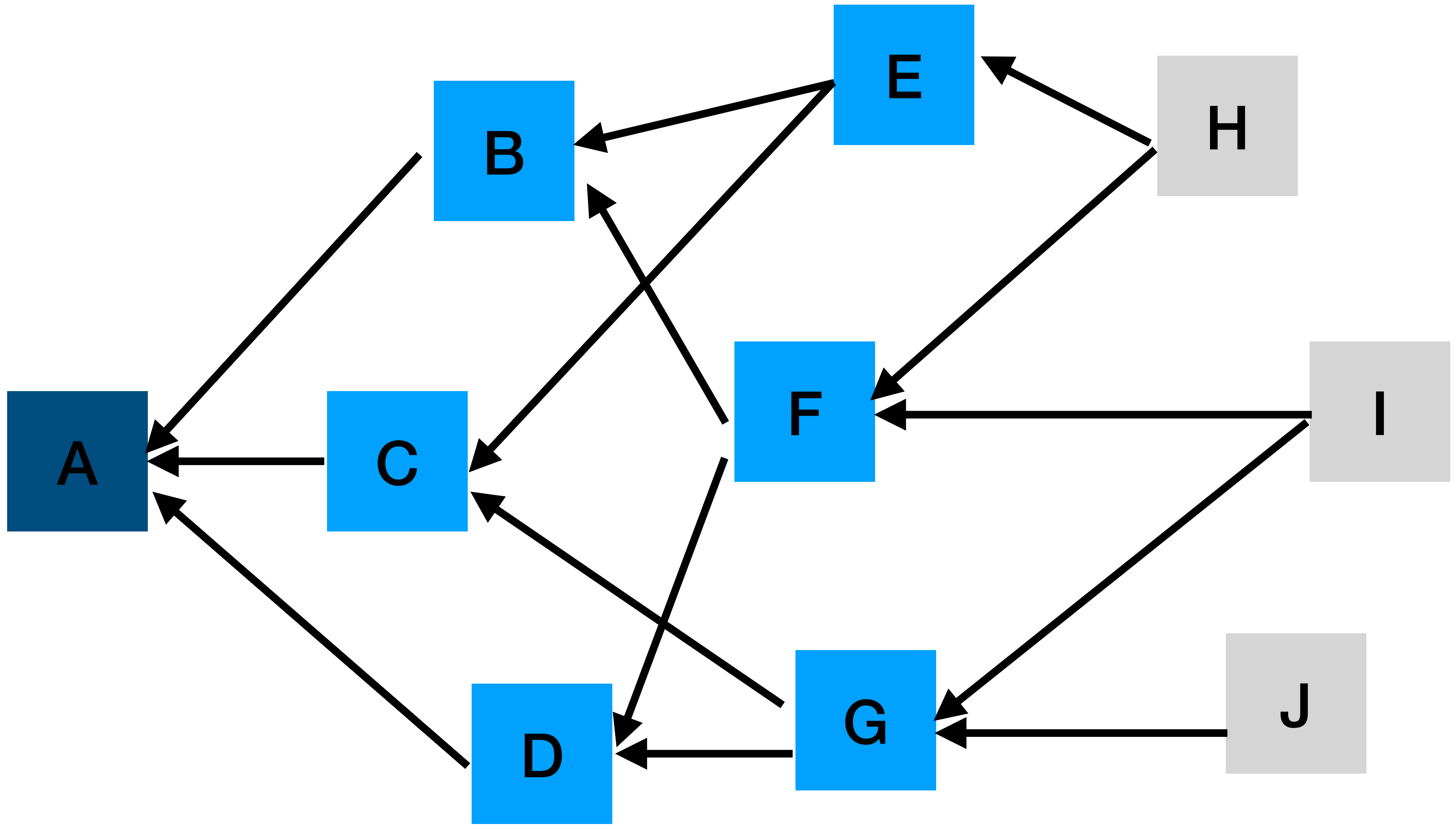
- Nodes (sites) are transactions (no blocks)
- Edges show approvals
  - Direct approval
    - e.g. I directly approves F
  - Indirect approval
    - e.g. H indirectly approves B



Tangle

Tips

- Tips
    - Newly generated transactions
    - No approvals
- Confirmed
    - Approved transactions
- Genesis
    - First transaction, approved by all



Tangle

Issuing a transaction

- Anyone wants to issue a transaction needs to contribute in the system
    - Users = miners
- Contribution means approving transactions
- A valid transaction needs to have two things
    - PoW
    - References to two other transactions

Tangle

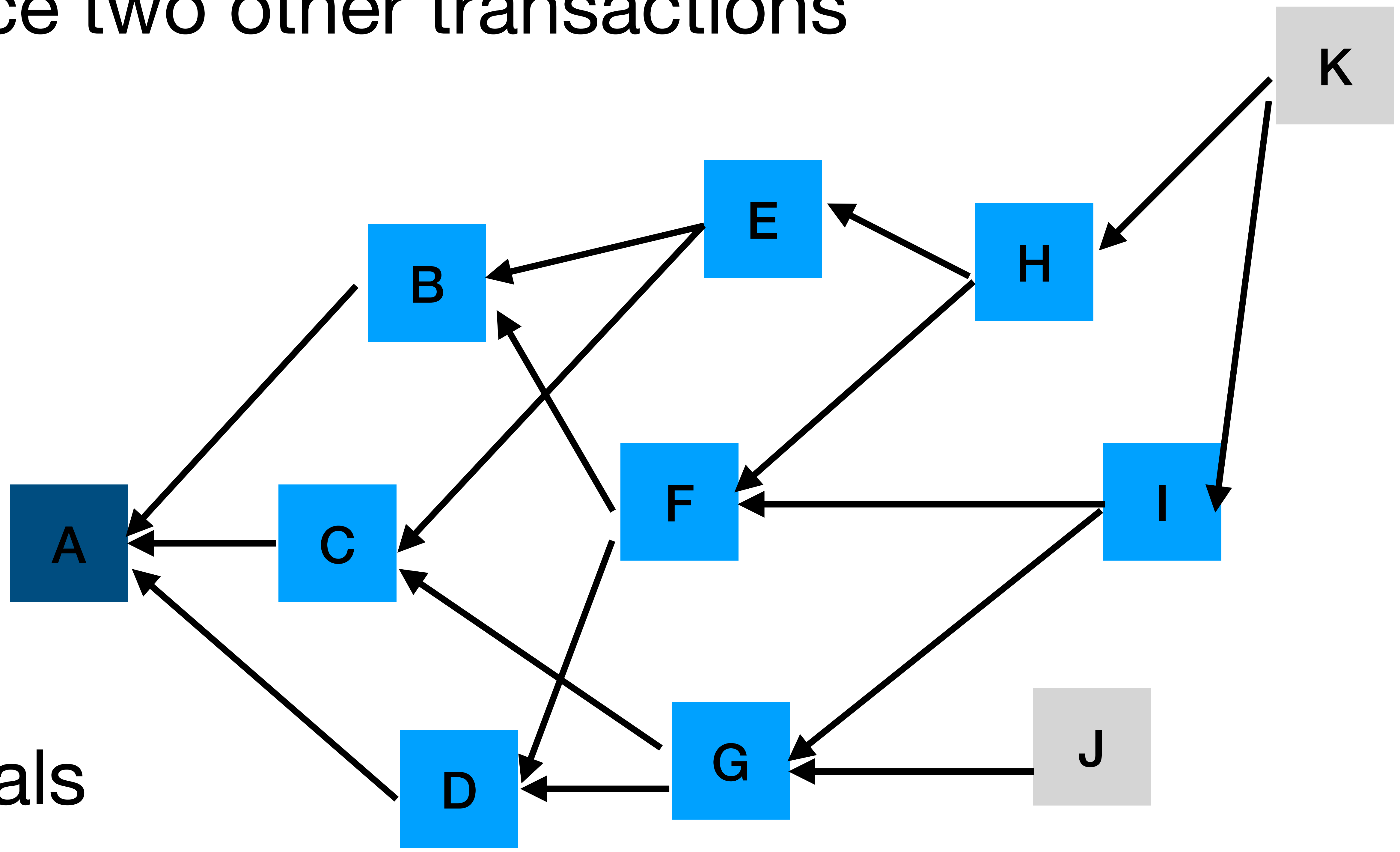
PoW

- Users need to compute a PoW similar to Bitcoin for each transaction
- PoW in Tangle is very light
  - IoT devices can compute the puzzle
- PoW makes it hard for others to spam the network with invalid transactions
  - Users need to invest computational resources
- A transaction with better PoW is considered safer, and has more weight in the system

Tangle

Approving others

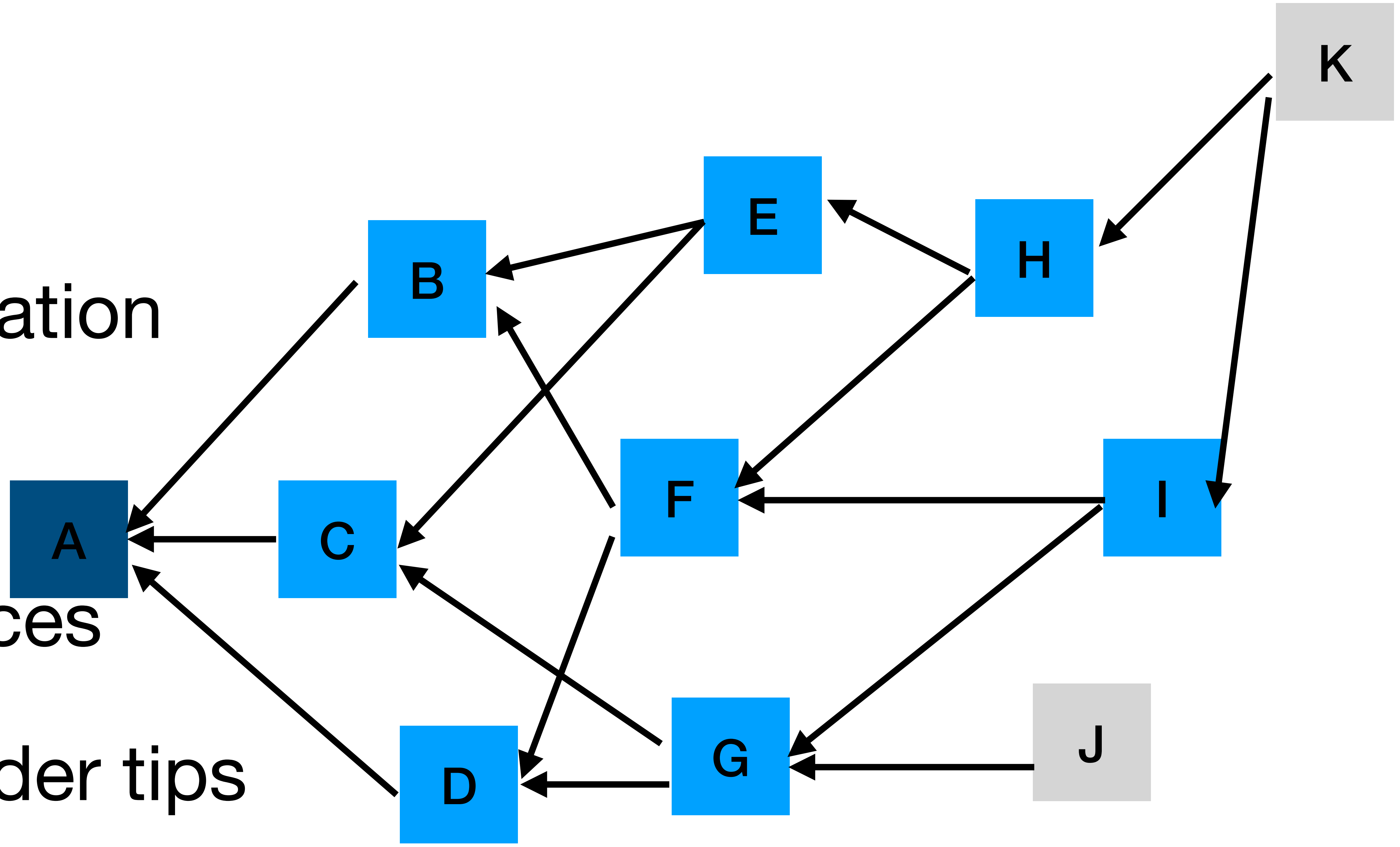
- Each transaction needs to reference two other transactions
- References are approvals (edges)
  - Users verify other transactions
- Users contribute by verifying
- Confirmed transactions
  - Transactions with lots of approvals



Tangle

Approving others

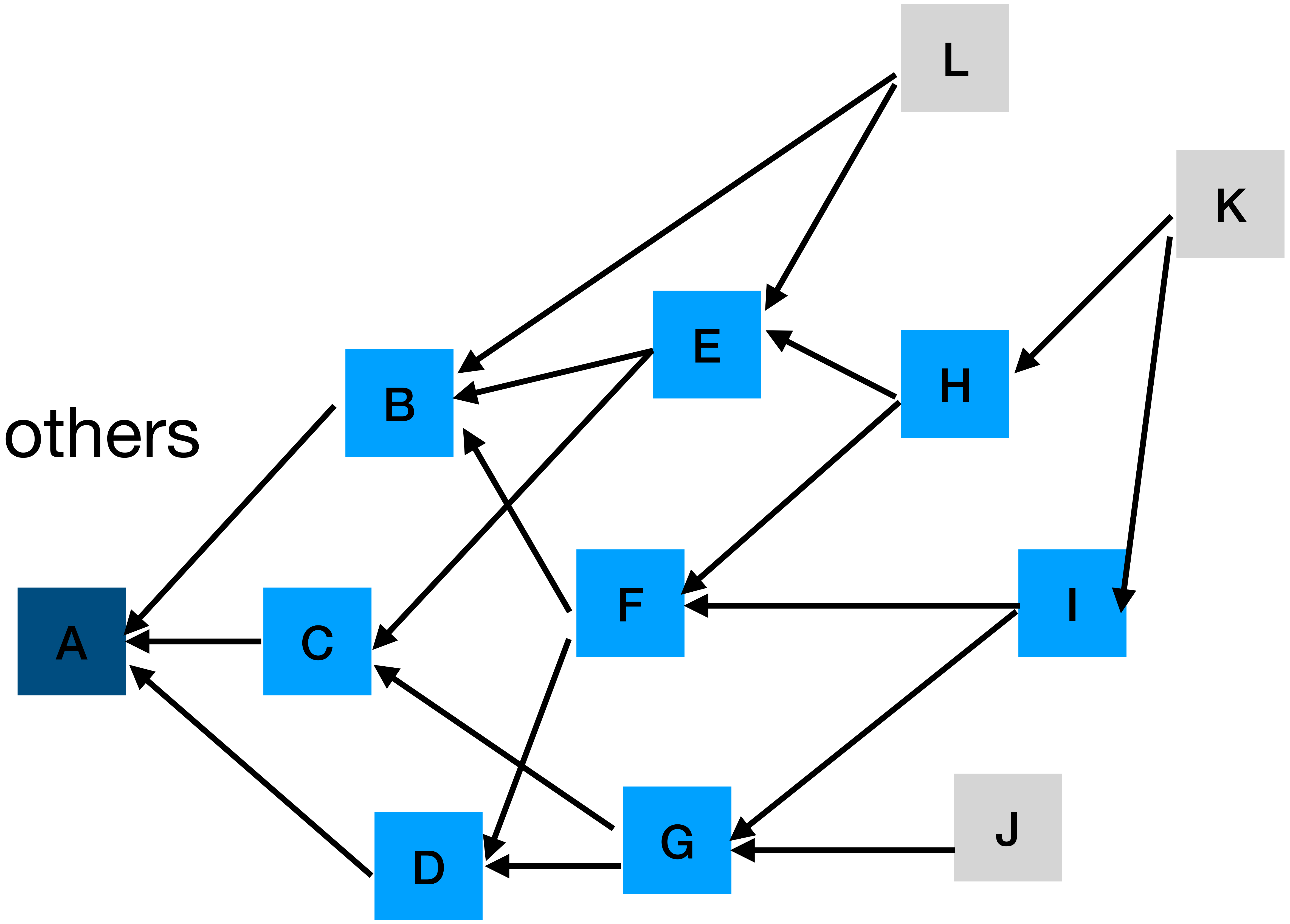
- Simple rule
  - Approve two other transactions
- Tips should be prioritized in verification
  - They don't have approvals
  - Indirectly approves their references
- Ideally new tips should approve older tips



Tangle

Lazy tips

- Simple rule
  - Approve two other transactions
- Why waste resources on verifying others
  - Approve already approved ones
- Lazy tips
  - Not helpful for the system



Tangle

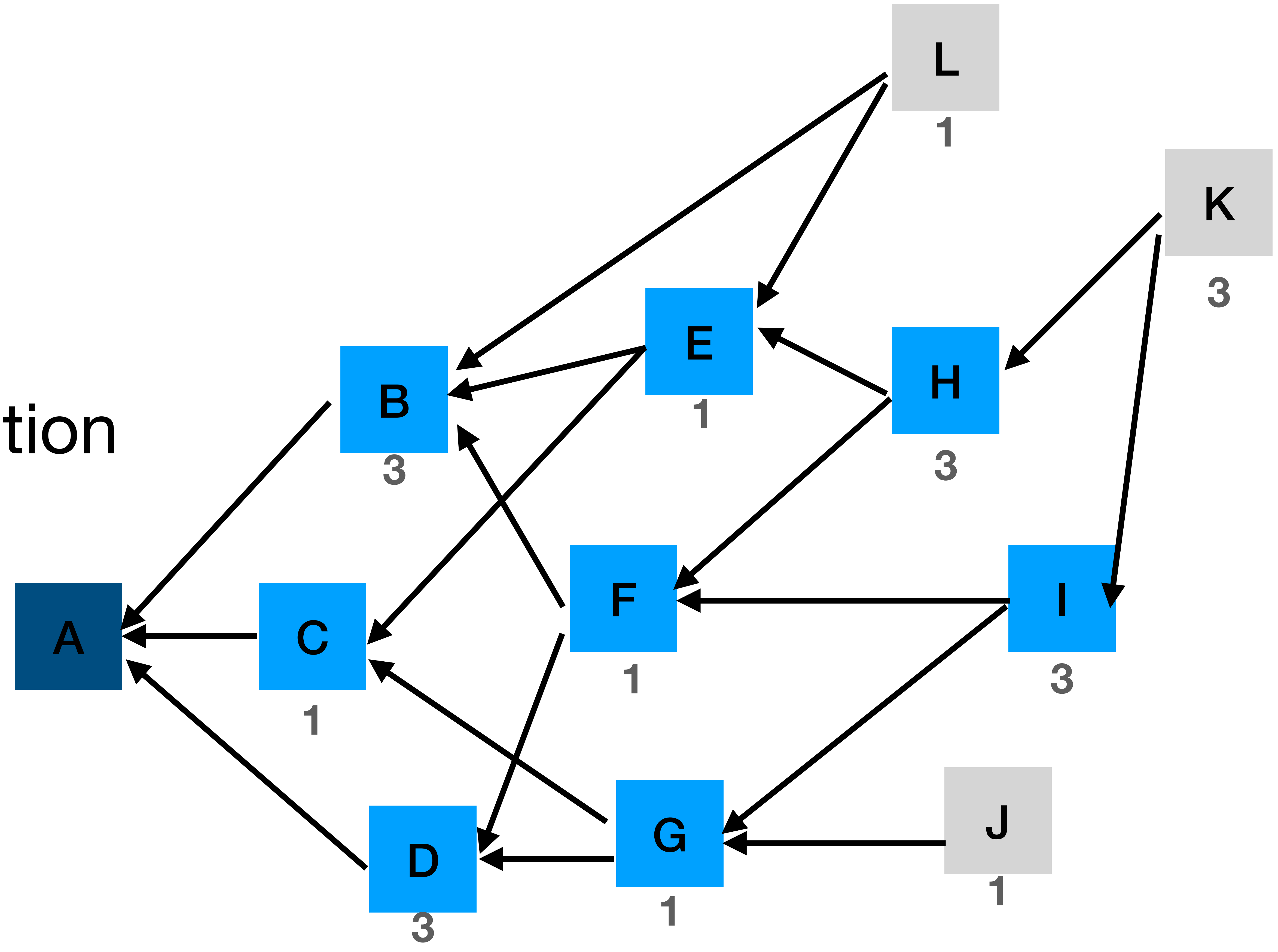
Weights

- How to prevent lazy tips?
  - Others don’t reference lazy tips
    - Won’t be confirmed
  - Need for a common tip selection algorithm
    - Everyone follow the same algorithm
      - Users are mostly IoT devices
- Which transaction should be selected?
  - Transaction weight

Tangle

Weights

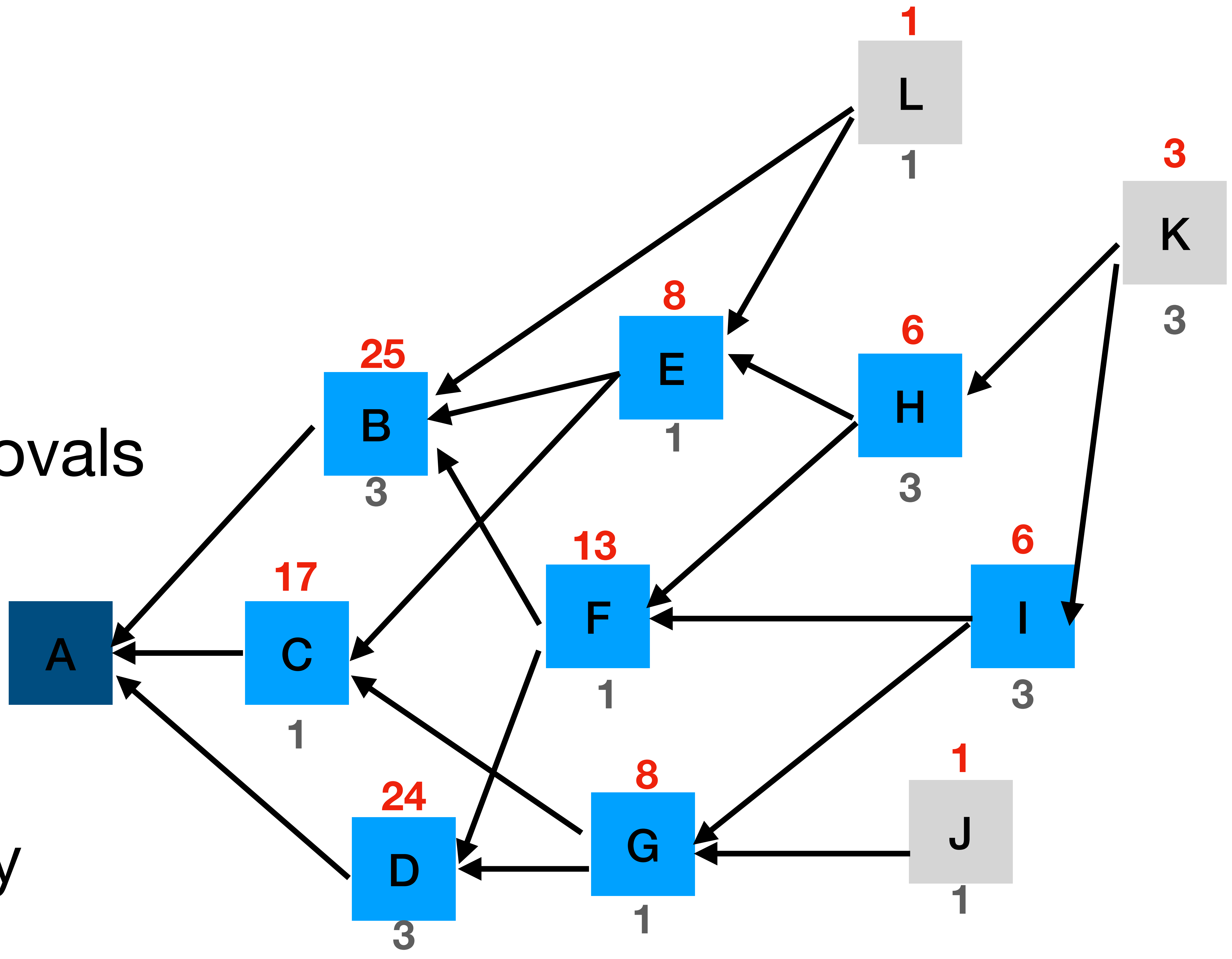
- Two weights for each transaction
- Own weight
  - The score given to each transaction
  - Determines how secure it is
  - Based on the provided PoW



Tangle

Weights

- Two weights for each transaction
- Cumulative weight
  - Sum of own weight and all approvals
  - Direct and indirect
  - Larger cumulative weight
    - Larger confirmation probability



Tangle

Random walk

- Transaction selection
  - Tips should be prioritised over already approved sites
    - Tip selection
  - Sites with more approvals are more secure
    - Cumulative weights
  - Selection should be evenly distributed based on weights
    - Tips with same weight have equal chances of being selected

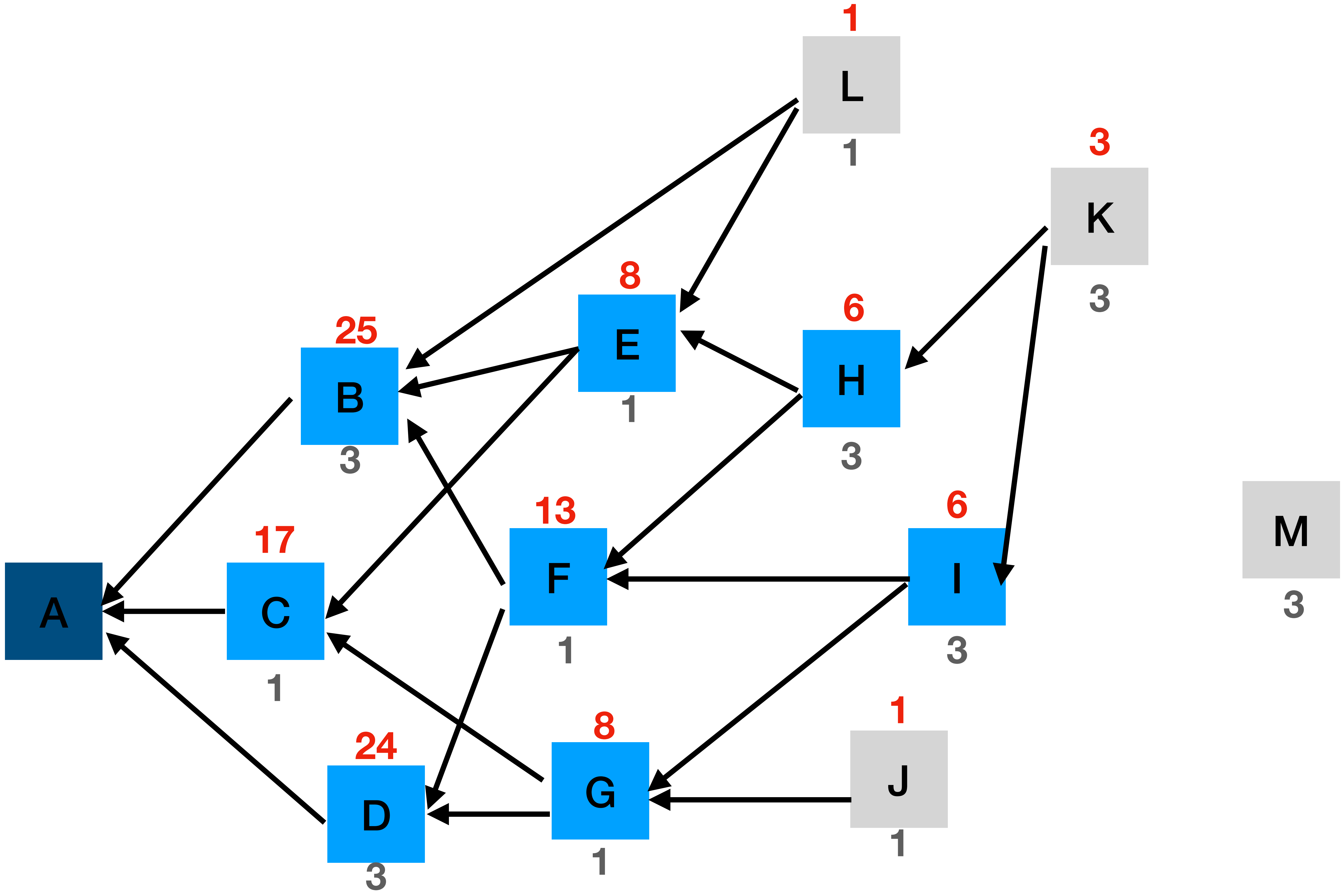
Tangle

Random walk

- Random walk
    - Start from genesis
    - Gather a list from all sites who referenced the transaction
    - Randomly choose one based on their cumulative weights
    - Repeat until it’s a tip

Tangle

Random walk



Tangle

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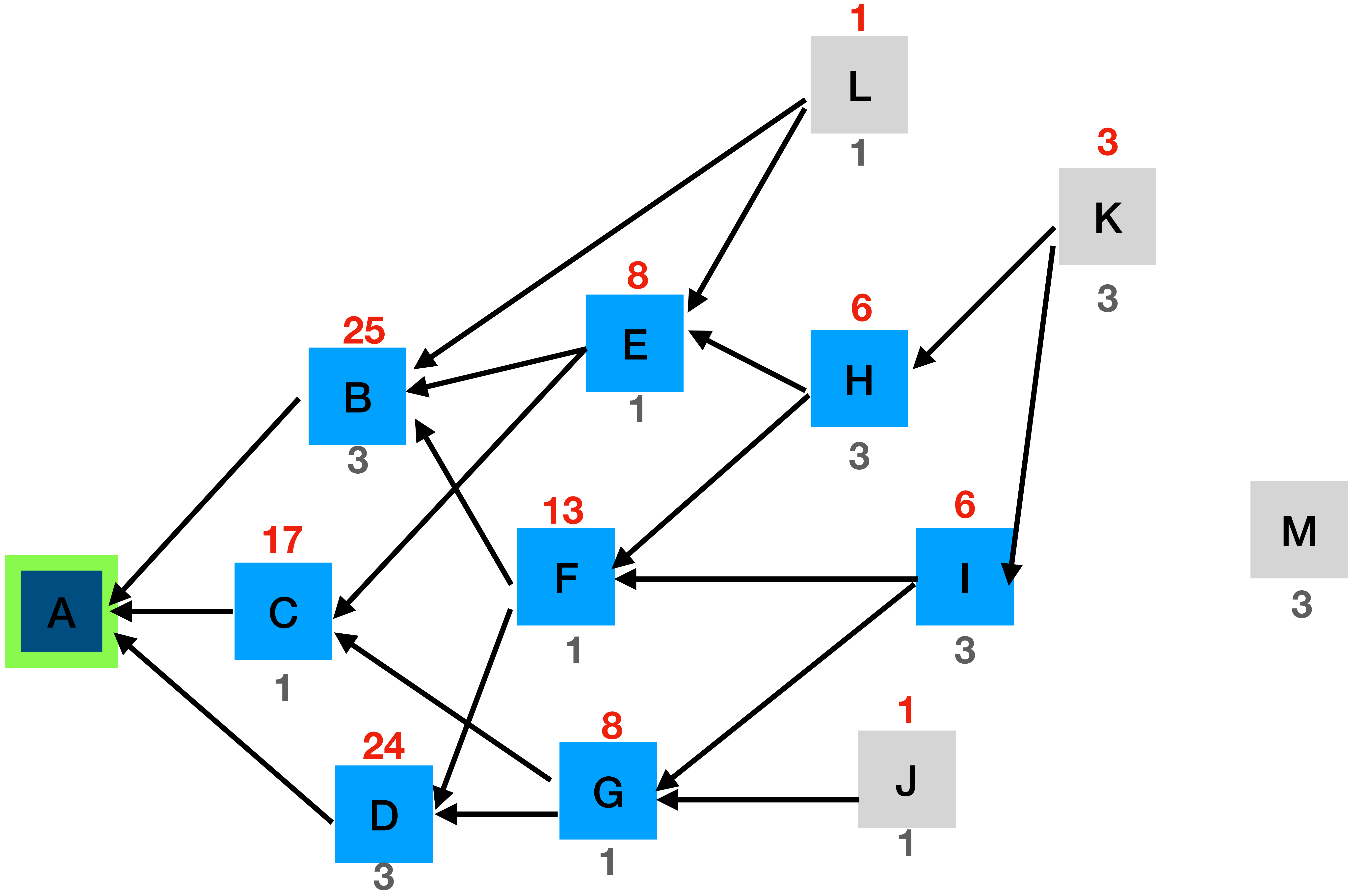

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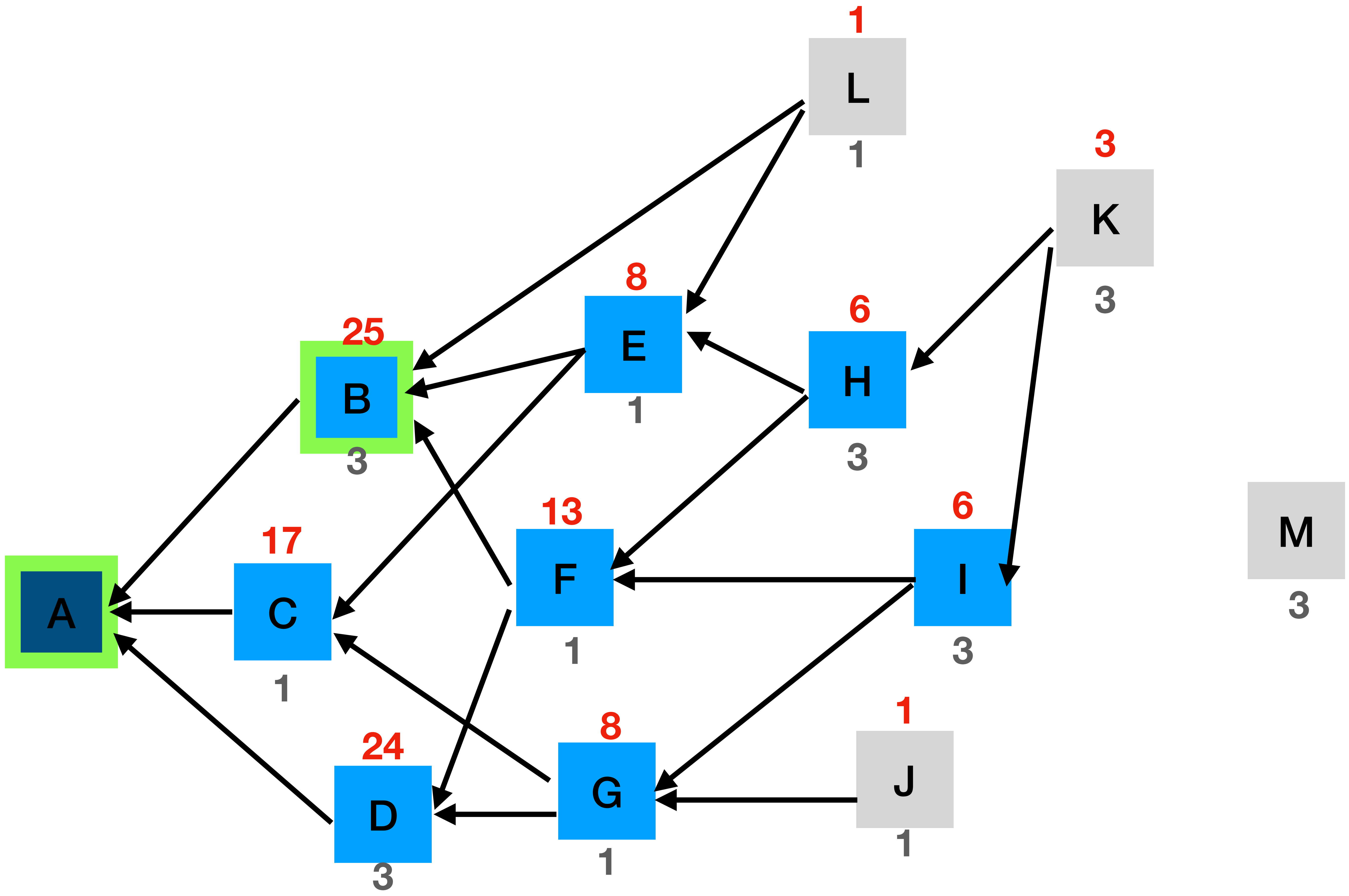

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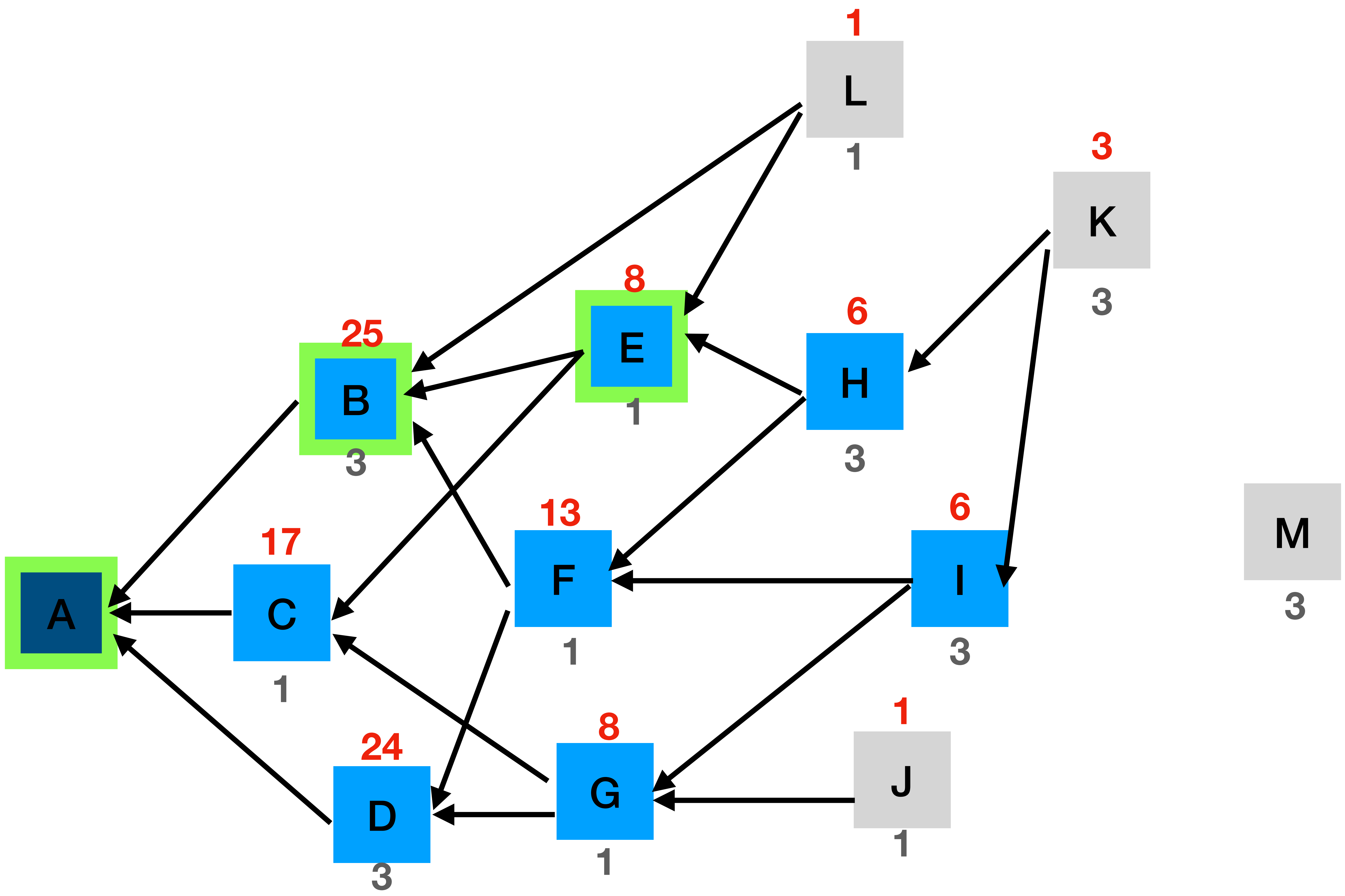

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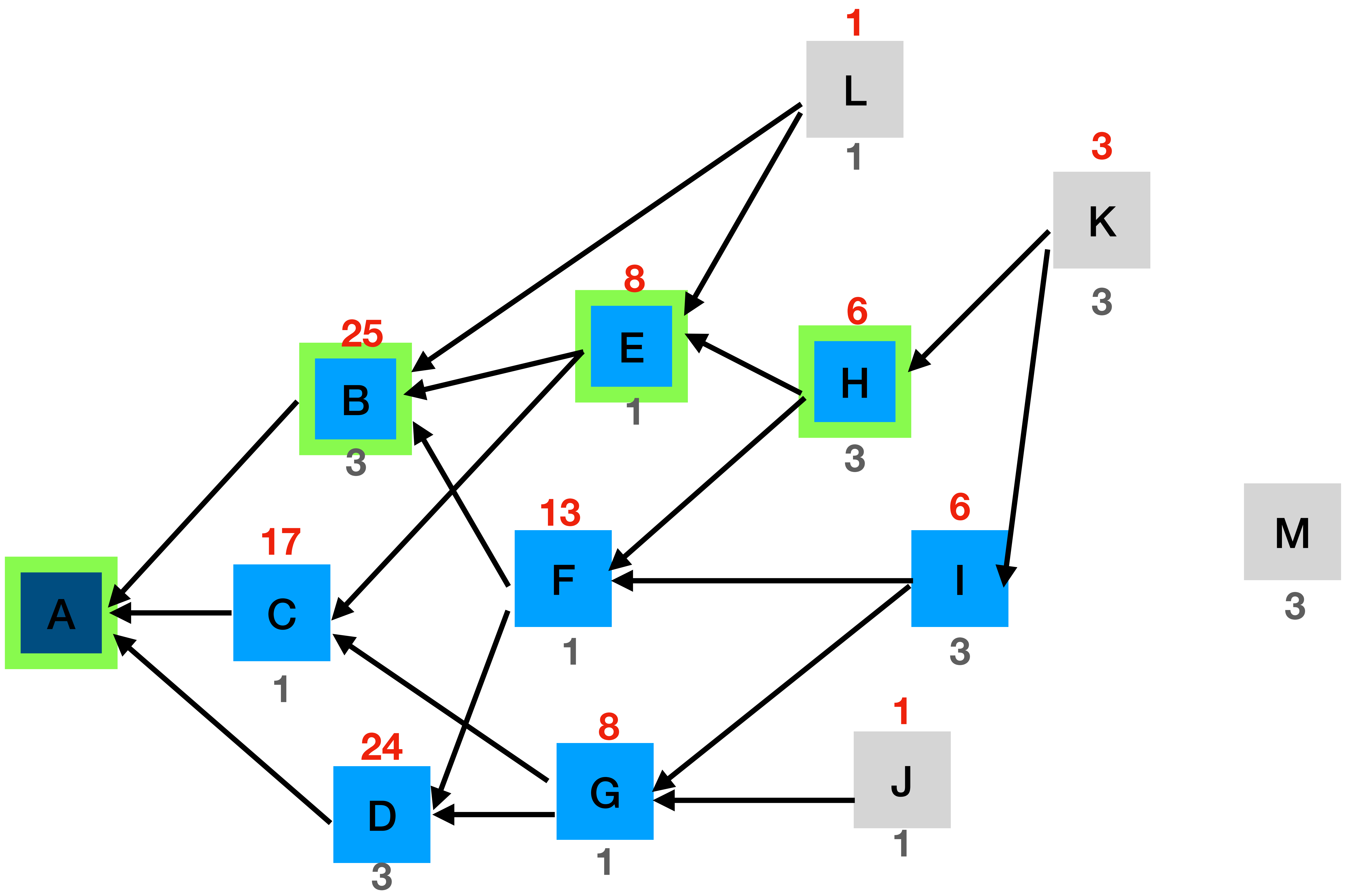

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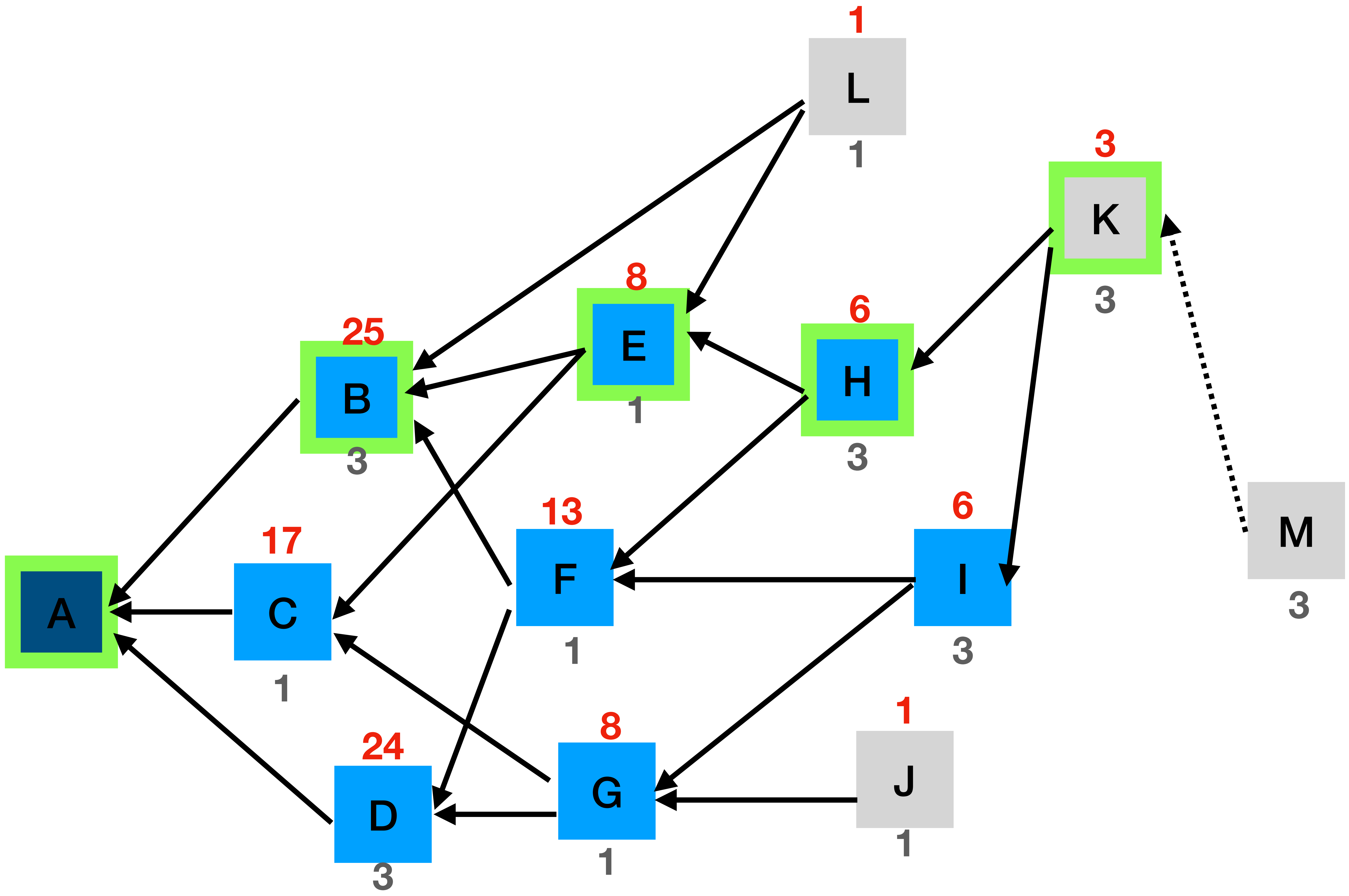

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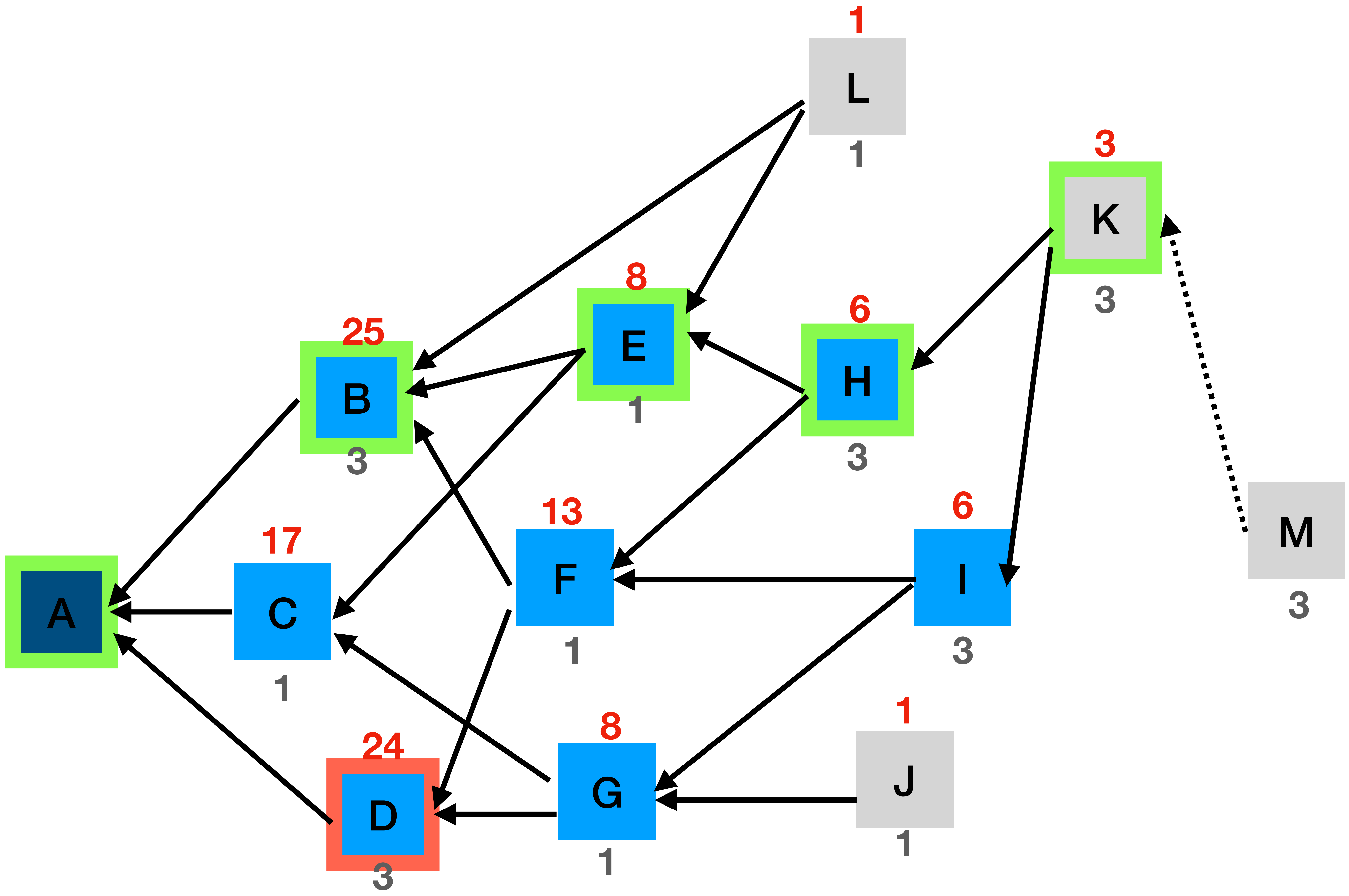

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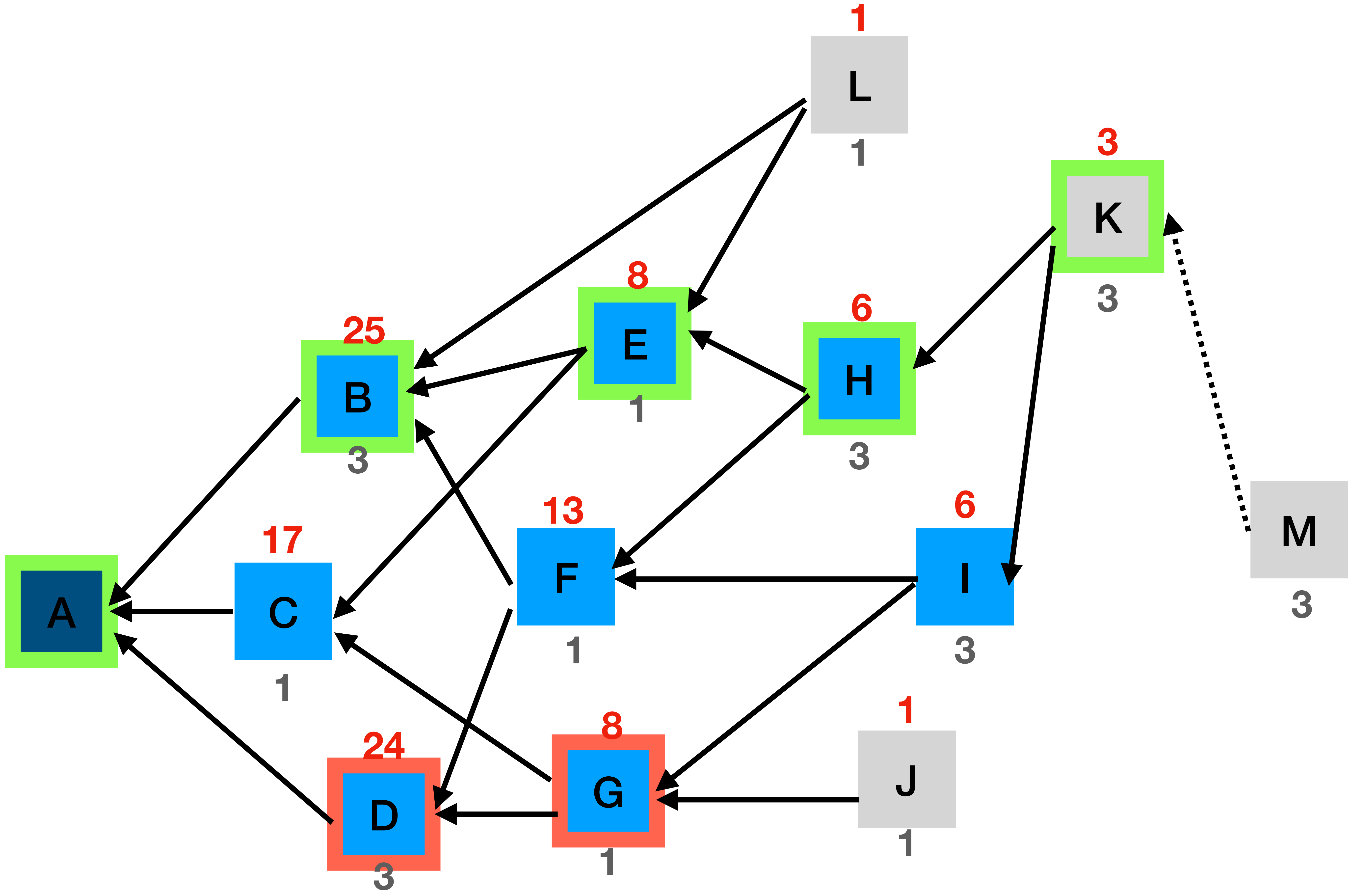

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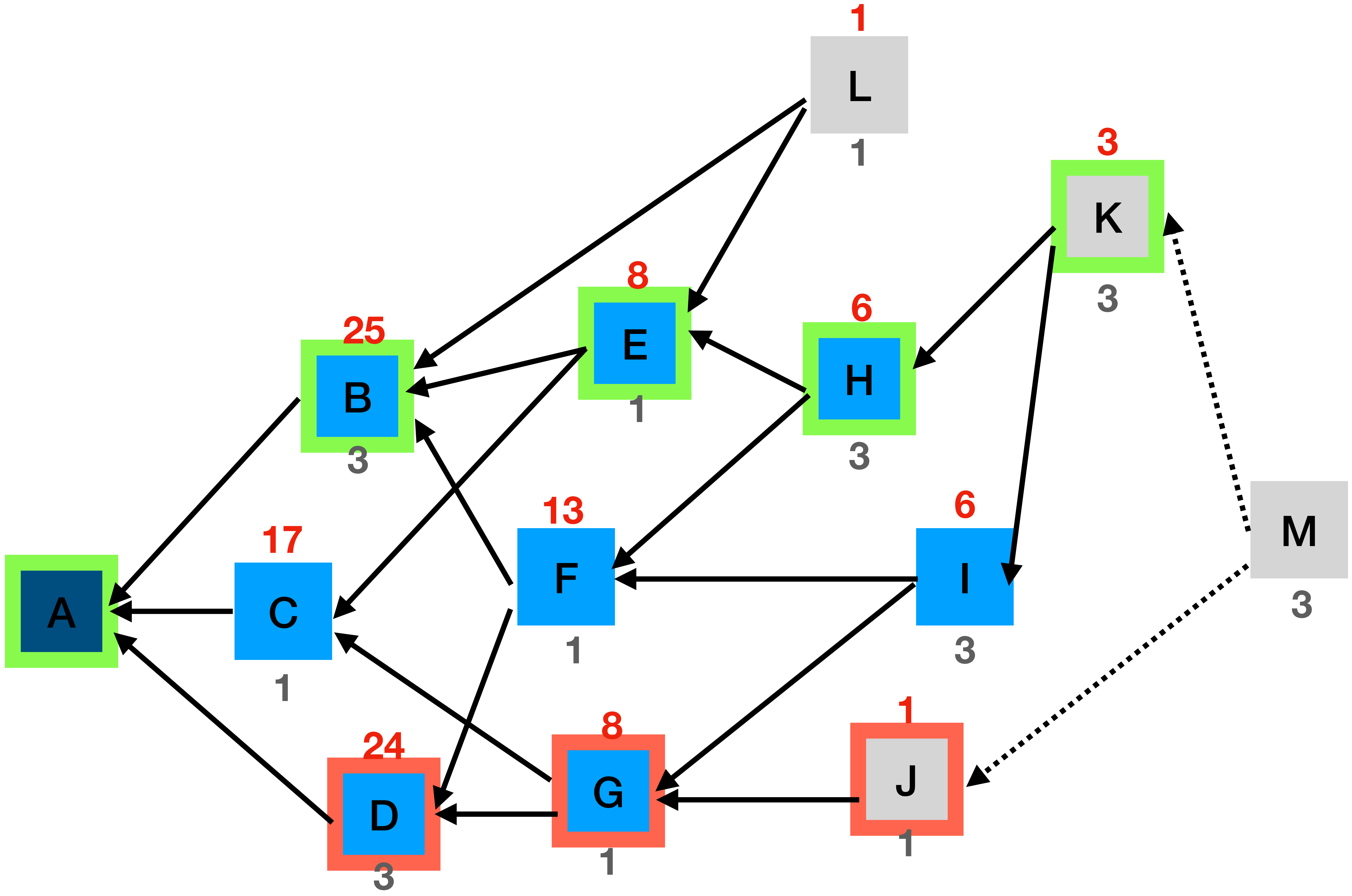
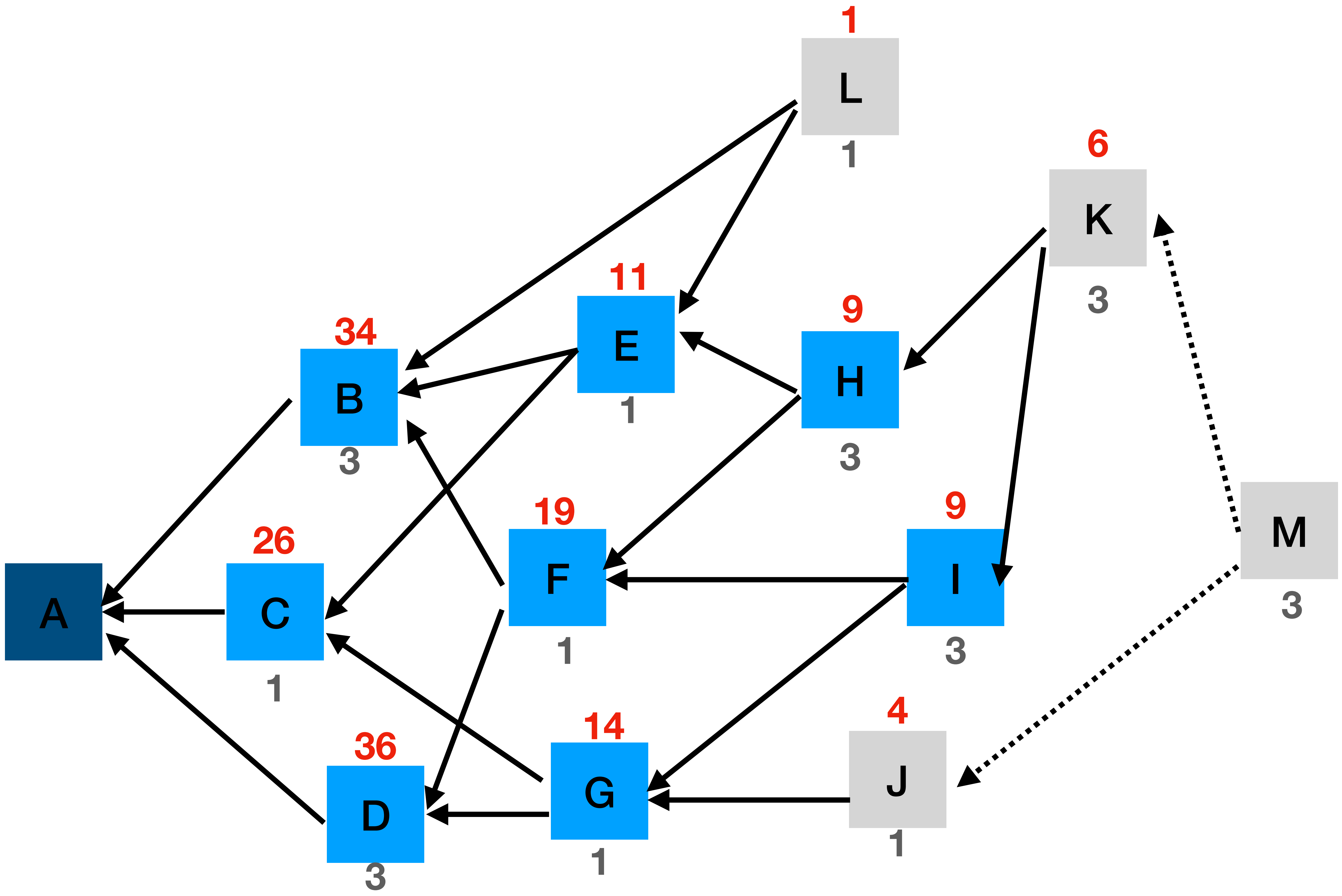


Tangle

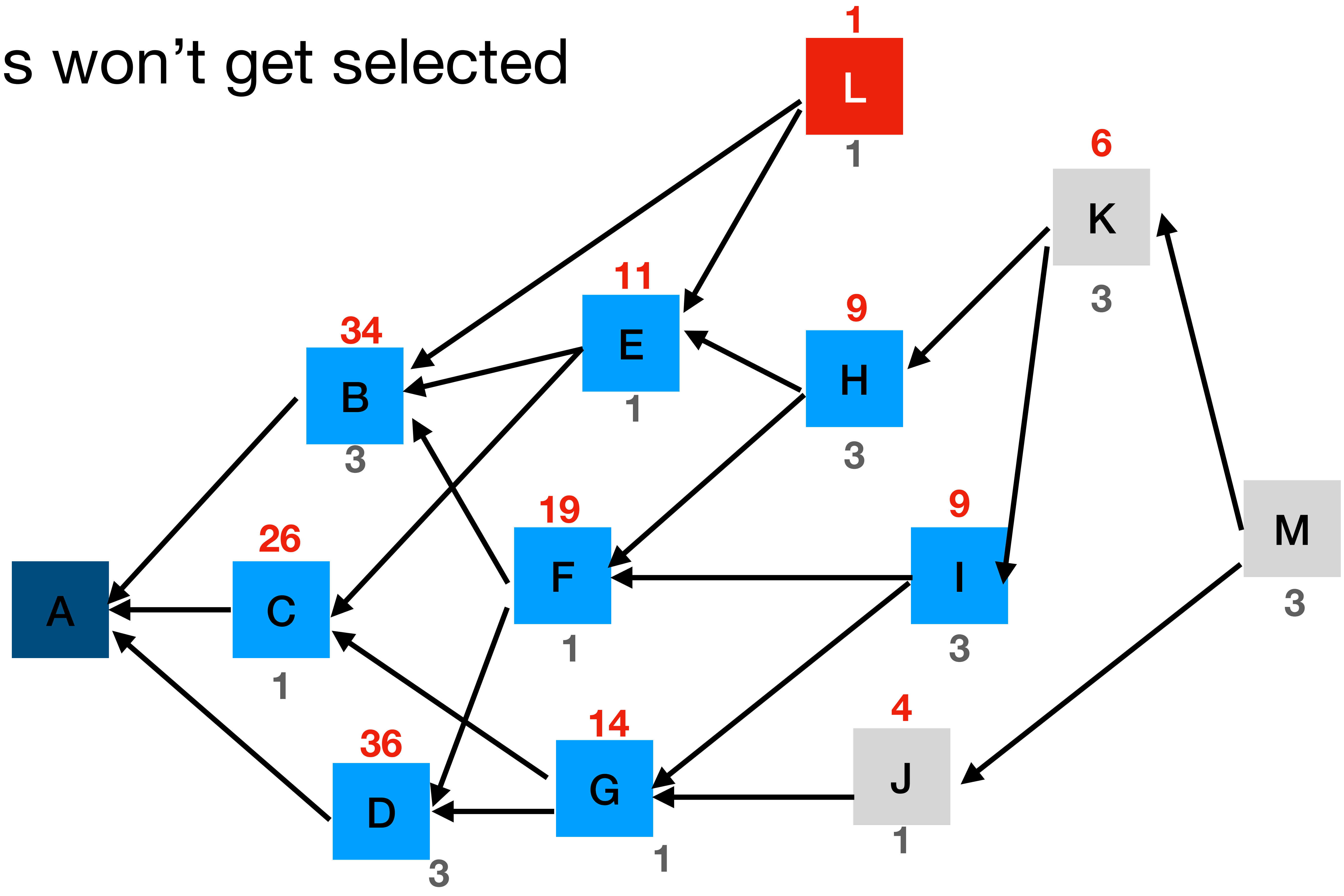
Random walk



Tangle

Orphan tips

- Due to random walk, lazy tips won't get selected
  - They get orphaned
  - Discarded after a while



Tangle

Milestones

- Random walk is slow
- It’s expensive to keep track of whole Tangle
- Milestones
  - Special transactions
  - Checkpoints
  - Mark the state of Tangle

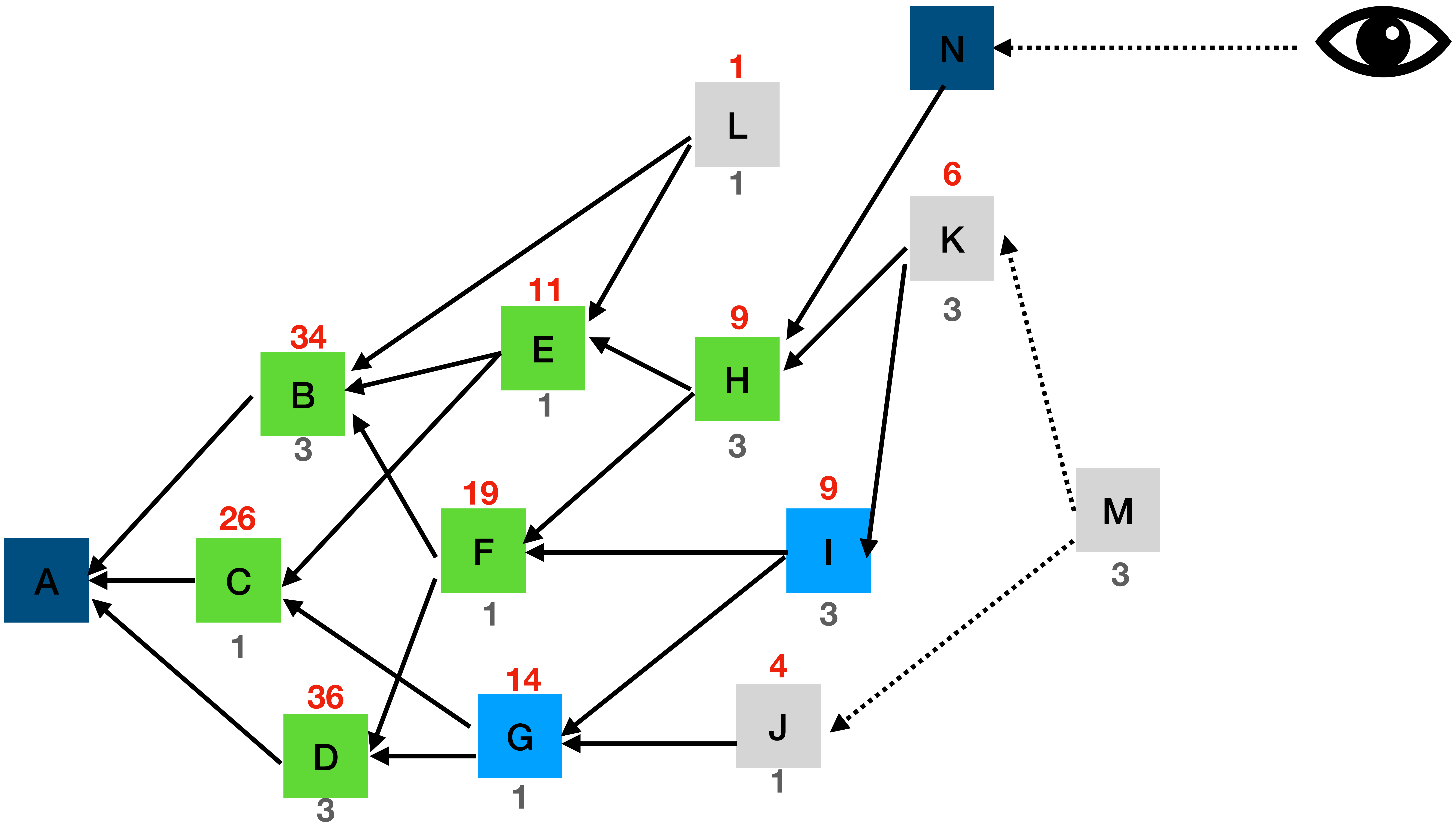
Tangle

Milestones

- Coordinator
  - Introduced in IOTA
  - Coordinators issues milestones
  - It orders Tangle
  - Milestones issued by coordinator are final
    - Anything directly or indirectly approves by a milestone is approved
    - Can be used as initial point for random walk

Tangle

Milestones



Tangle

Milestones

- Coordinator makes the system centralized
    - Single point of failure
- Instead, nodes can vote for determining the milestones
- But without economical incentives, how can they motivate participation?

Tangle

Mana system

- A reputation system
  - How trustworthy a node is
- Nodes gain Mana (reputation) by certain tasks
  - Being active in the network
  - Holding tokens for a certain period
  - Participating in voting rounds

Tangle

Mana system

- Mana is used for several stuff
    - Random walk takes Mana into account
        - Transactions with higher Mana are approved faster
    - Have a saying in consensus
        - Nodes can have a saying in determining milestones or other consensus related stuff

Tangle 2

Upgrades and future

- Coordicide
  - Removing the coordinator
- Shift from accounts to UTXO
    - Better aligned with the reputation-system
- Introducing smart contracts
- Introducing blocks instead of transactions
- Sharding