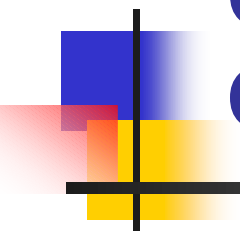

GWiQ-P: An Efficient, Decentralized **G**rid-**Wi**de **Q**uota Enforcement **P**rotocol

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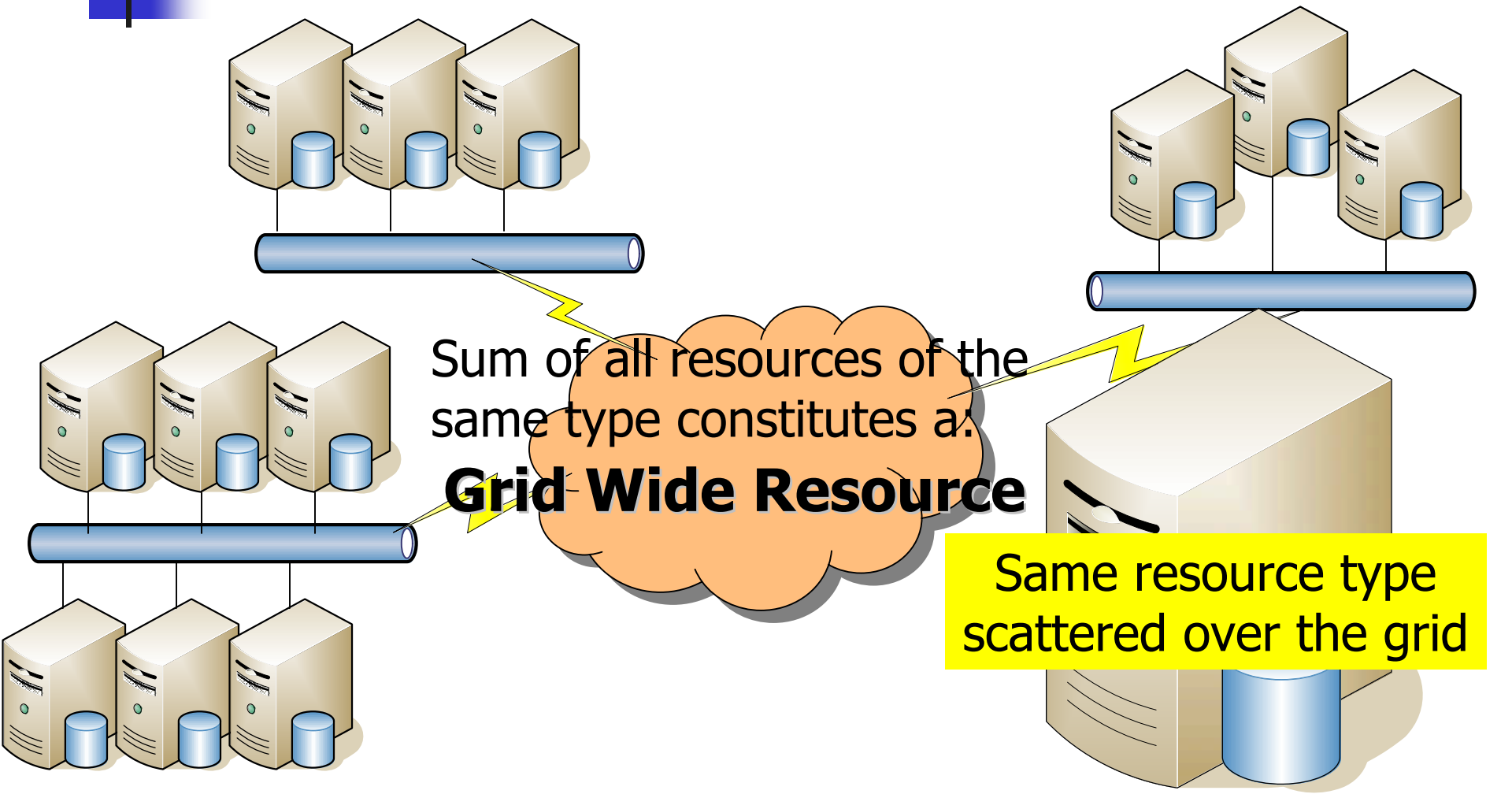
SYSTOR 2007

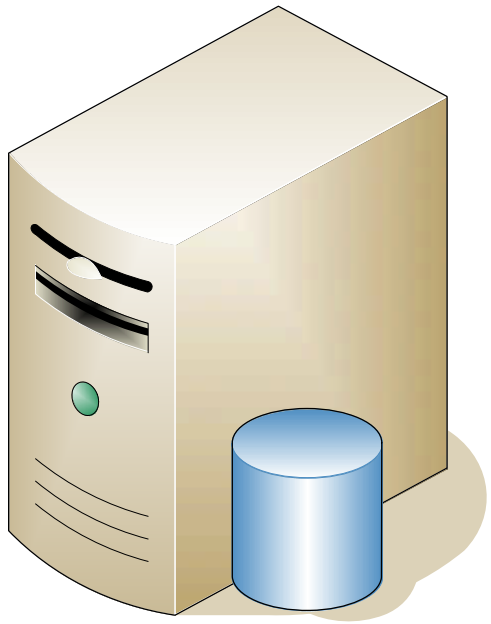
IBM HRL, Haifa, Israel

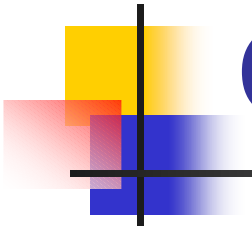
Background – Grid Resources



Background – Grid Resources

- Grid Wide Resources
  - CPU hours
  - Disk space
  - DB Connections
  - Outbound traffic
  - Concurrent number of CPUs
  - Allocated RAM
  - Floating Software Licenses
  - Open sockets
  - Etc…



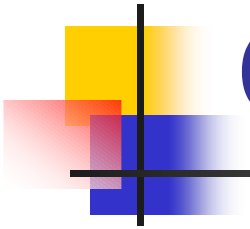


GWiQ Motivation

- A grid wide resource tends to be huge and can be exploited
- Grid Wide Quota Enforcement is vital:
  - Security: Prohibit malicious use
  - Fail Safe: Prevent resource leaks (bugs)
  - Financial: Moderate use per paid share

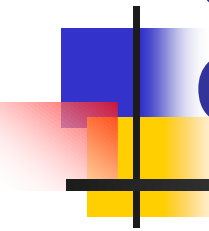
Centralized GWiQ Enforcement

- Central server holds the GWiQ bounds for each (user, resource) tuple
- Per request, resource usage permits are leased until the GWiQ is exhausted.



Objectives

- We strive for a Grid Wide Quota enforcement protocol that is:
  - Decentralized: No hotspots, No single point of failure.
  - Efficient: Overcome latency caused by grid's physical distribution.
  - Scalable: Can handle Mega-Grids



GWiQ-P:
Grid **Wi**de **Q**uota enforcement **P**rotocol

GWiQ-P: Basic Concept

GWiQ Enforcement

⇔

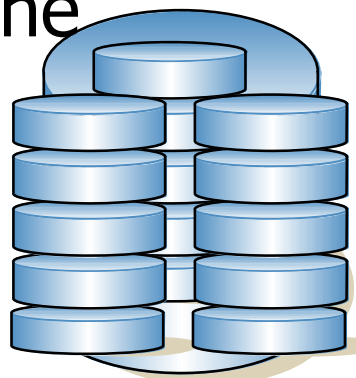
At all times the sum of all local quotas < GWiQ

- Using sandboxes to enforce local quotas
- Given a attempt to access the resource:
  - If (local-quota >= request) then
    - Grant access
    - local-quota = local-quota – request
  - Else
    - Freeze job execution until local-quota reinforced

GWiQ-P: Resource Coins

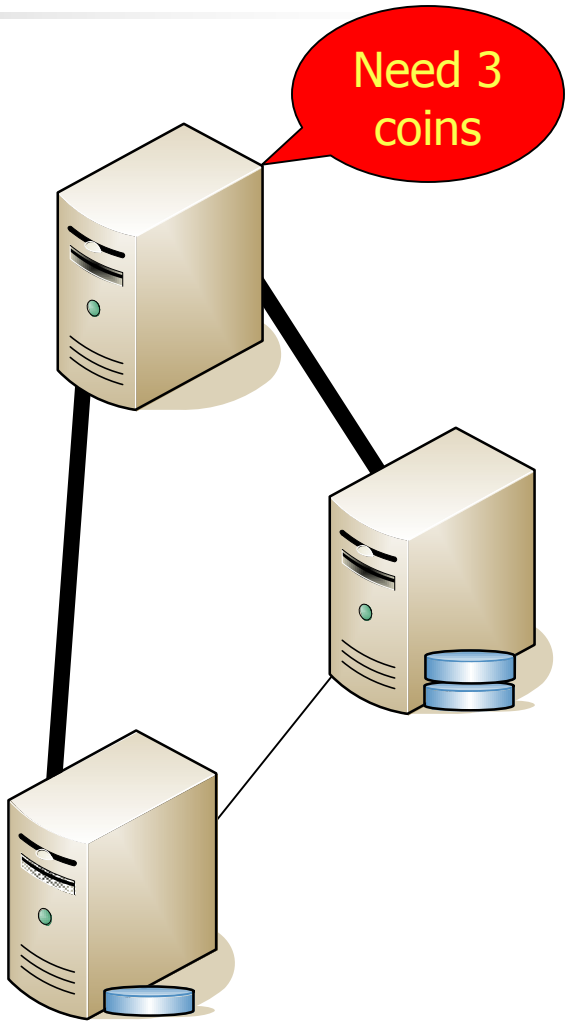
- A resource coin denotes the smallest consumable portion of a grid resource.
- Each (user, resource) GWiQ is broken down to coins.
- A user's job may use the resource up to the amount that the coins are worth.
  - i.e. Depositing four 1MB coins grants the job (another) 4MB to use

Local Quota = Hosting SBox's resident coins

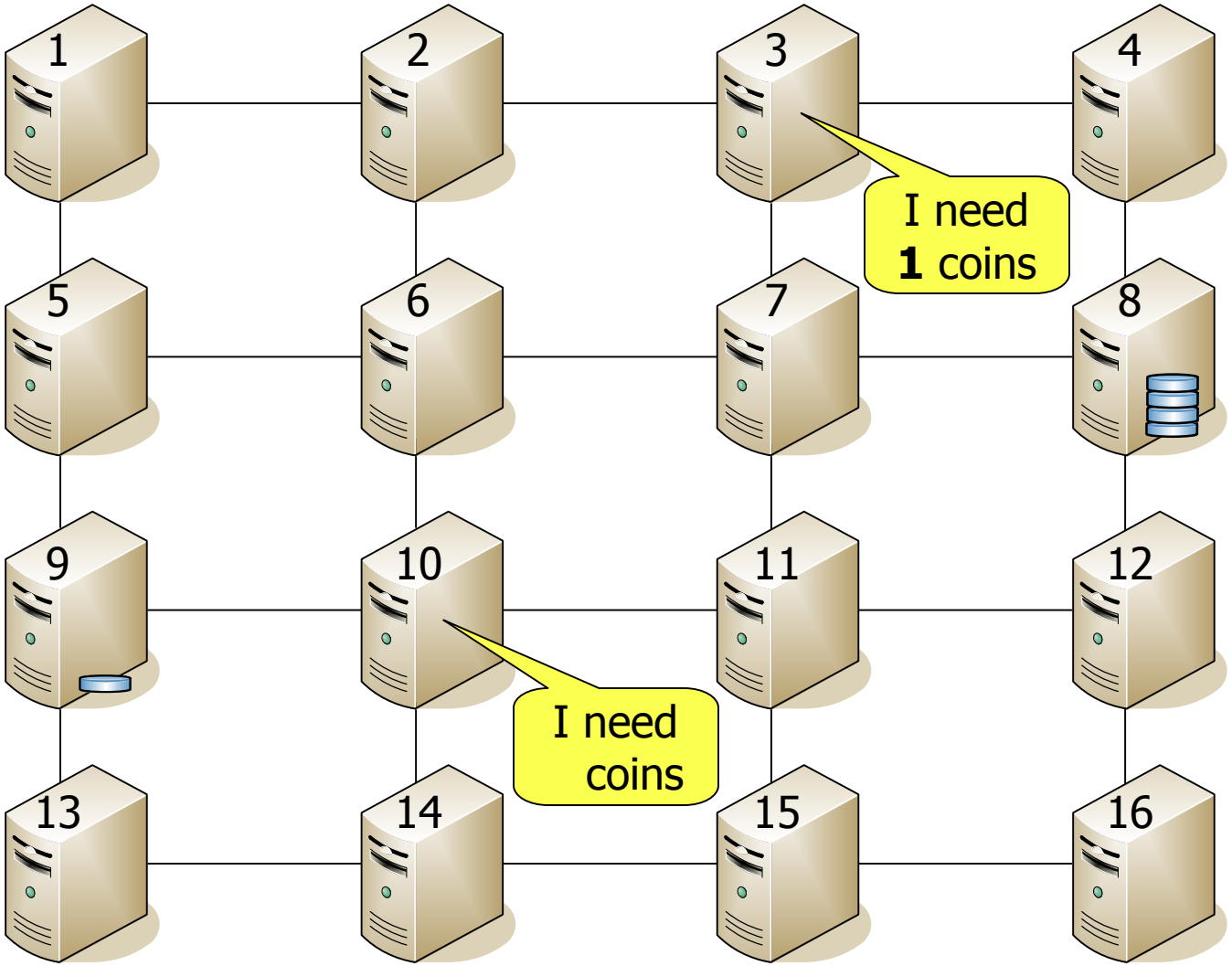


GWiQ-P – Spanning Forest

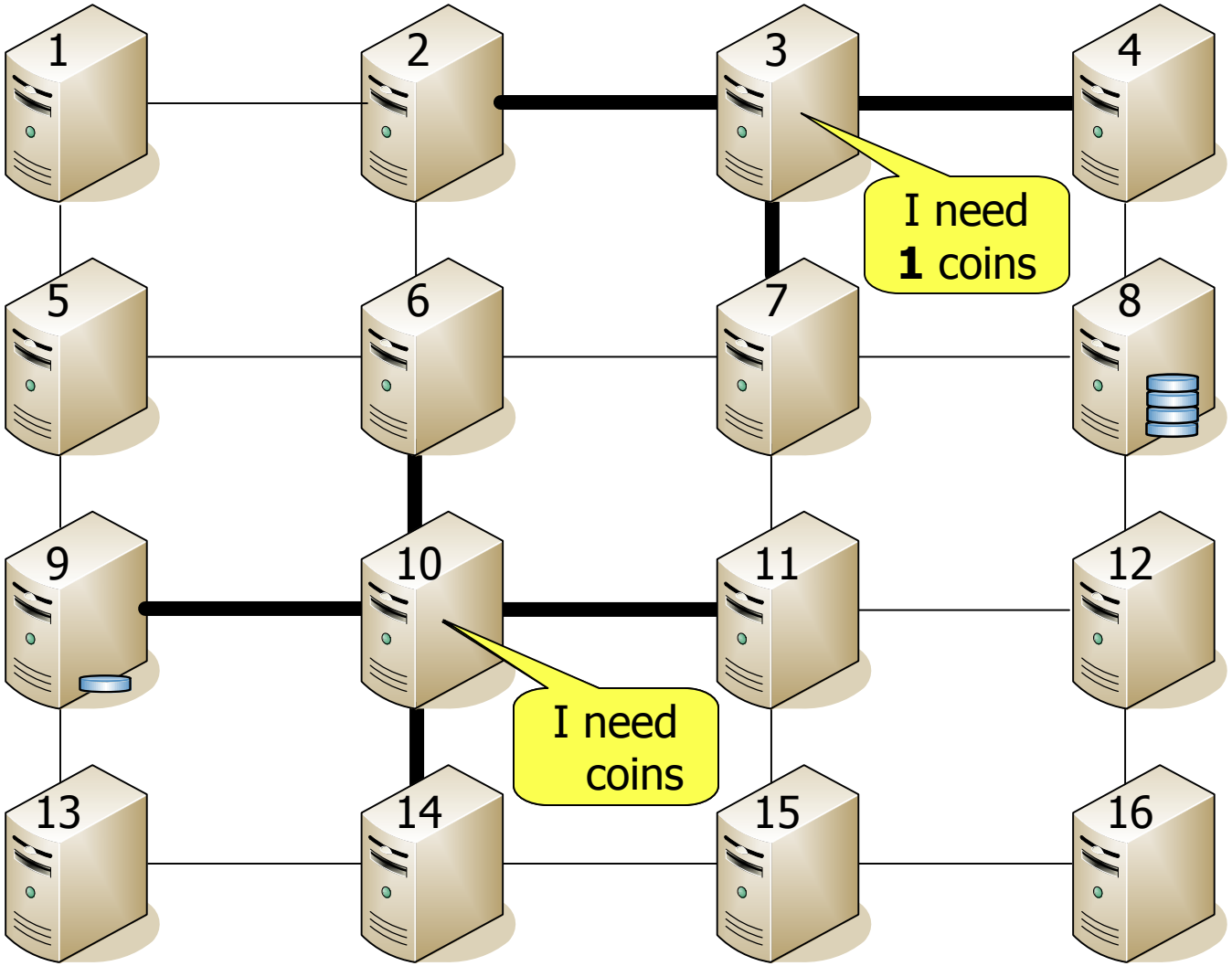
- Using a BF-based alg we build a spanning forest.
- A sandbox hosting a needy job will start forming a tree around itself.
- At all times, each neighbor will join the tree to which it is closest to its root.
  - Member of one tree at a time.
- Surplus coins will be transferred to the root.



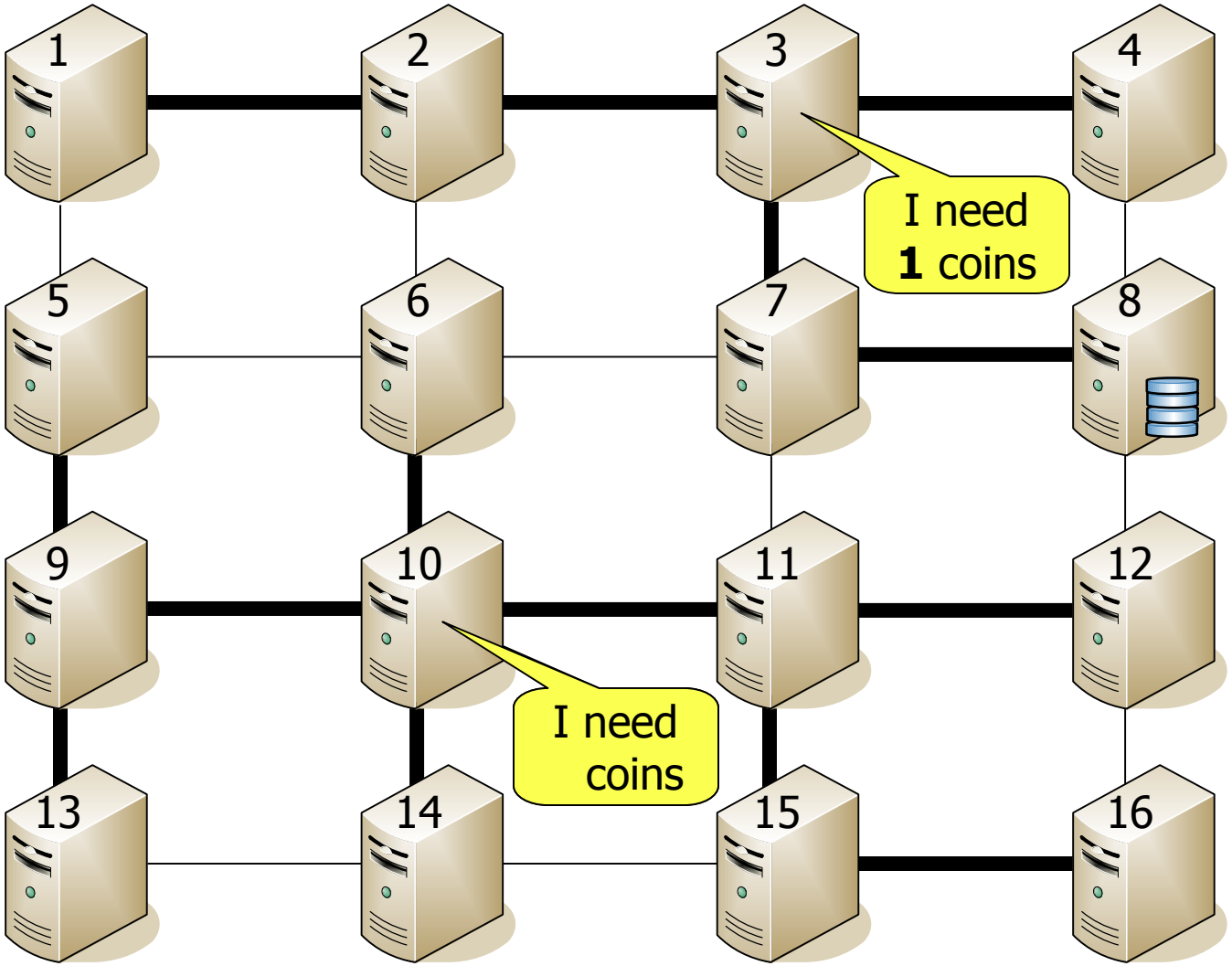
GWiQ-P : In action 1/5



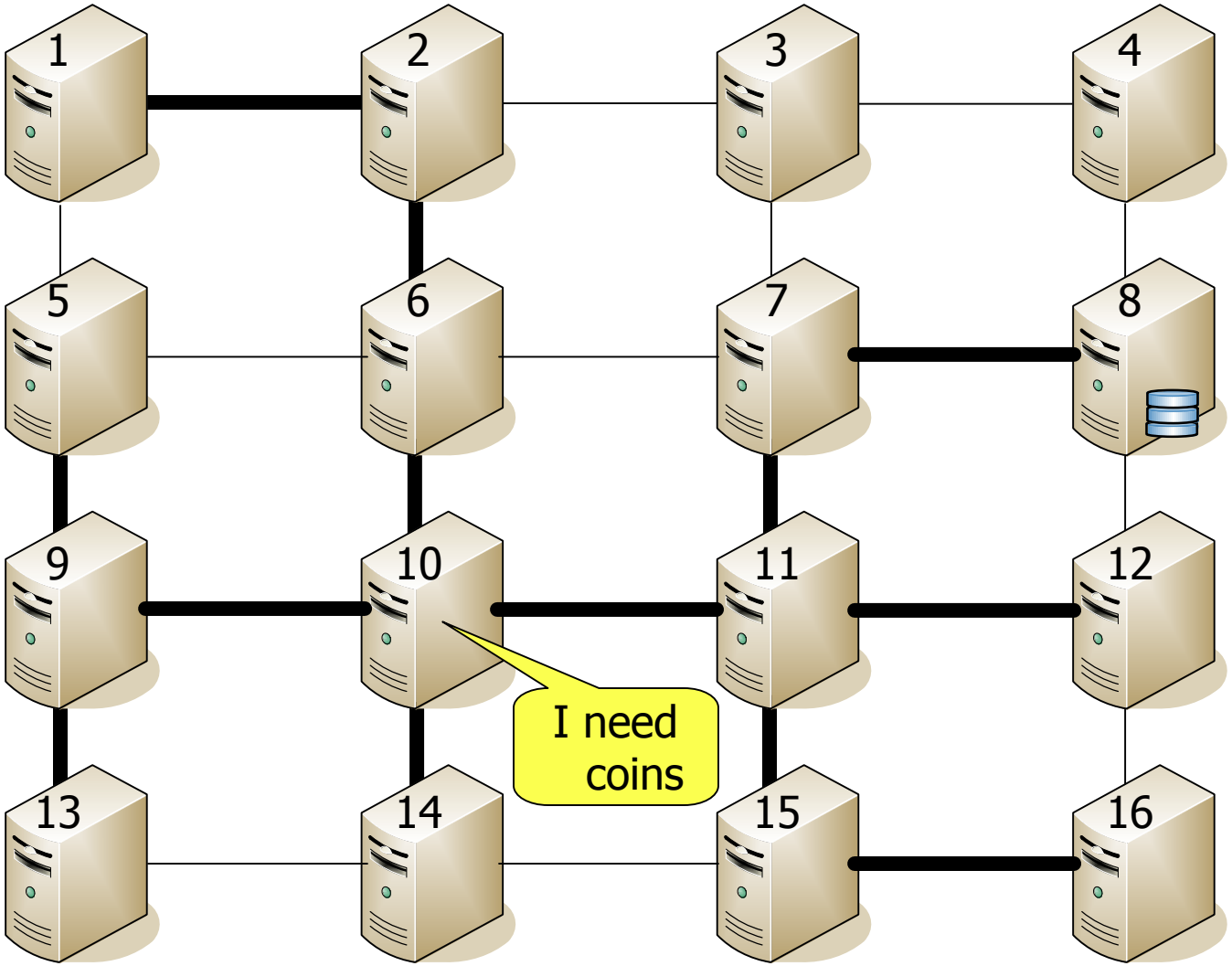
GWiQ-P : In action 2/5



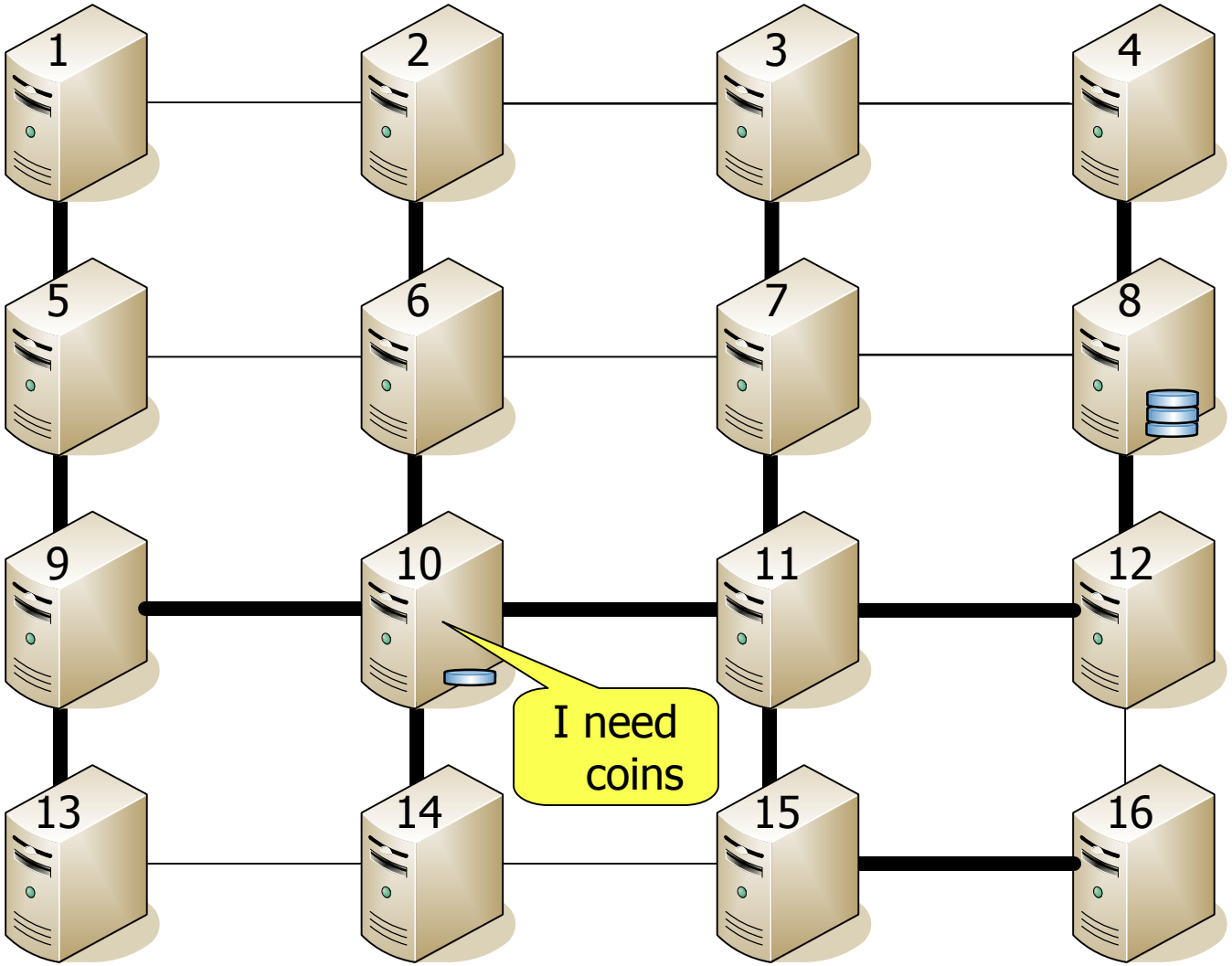
GWiQ-P : In action 3/5



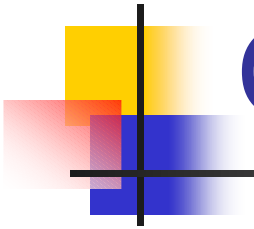
GWiQ-P : In action 4/5



GWiQ-P : In action 5/5

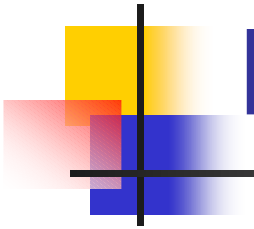


GWiQ-P: Fault Intolerance



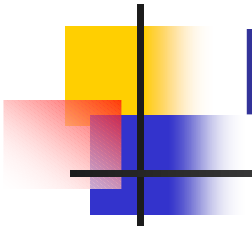
- Links and nodes may crash
  - Link crash ➔ Passing coins are lost
  - Node crash ➔ Local coins are lost
- Lost coins ⇔ Unfair GWiQ reduction
- Can’t be sure how many coins are on the wire
  - Did my neighbor send something?
  - Have the coins I sent reached already?
- How do we restore unknown lost coins???

FT Solution1: Transactional



- Coin transfers are done in Transactions
- Pros
  - Coins never lost on transfer
- Cons
  - Slowdown
  - Needs persistent storage
  - Node failure (temporarily?) reduces GWiQ by local quota

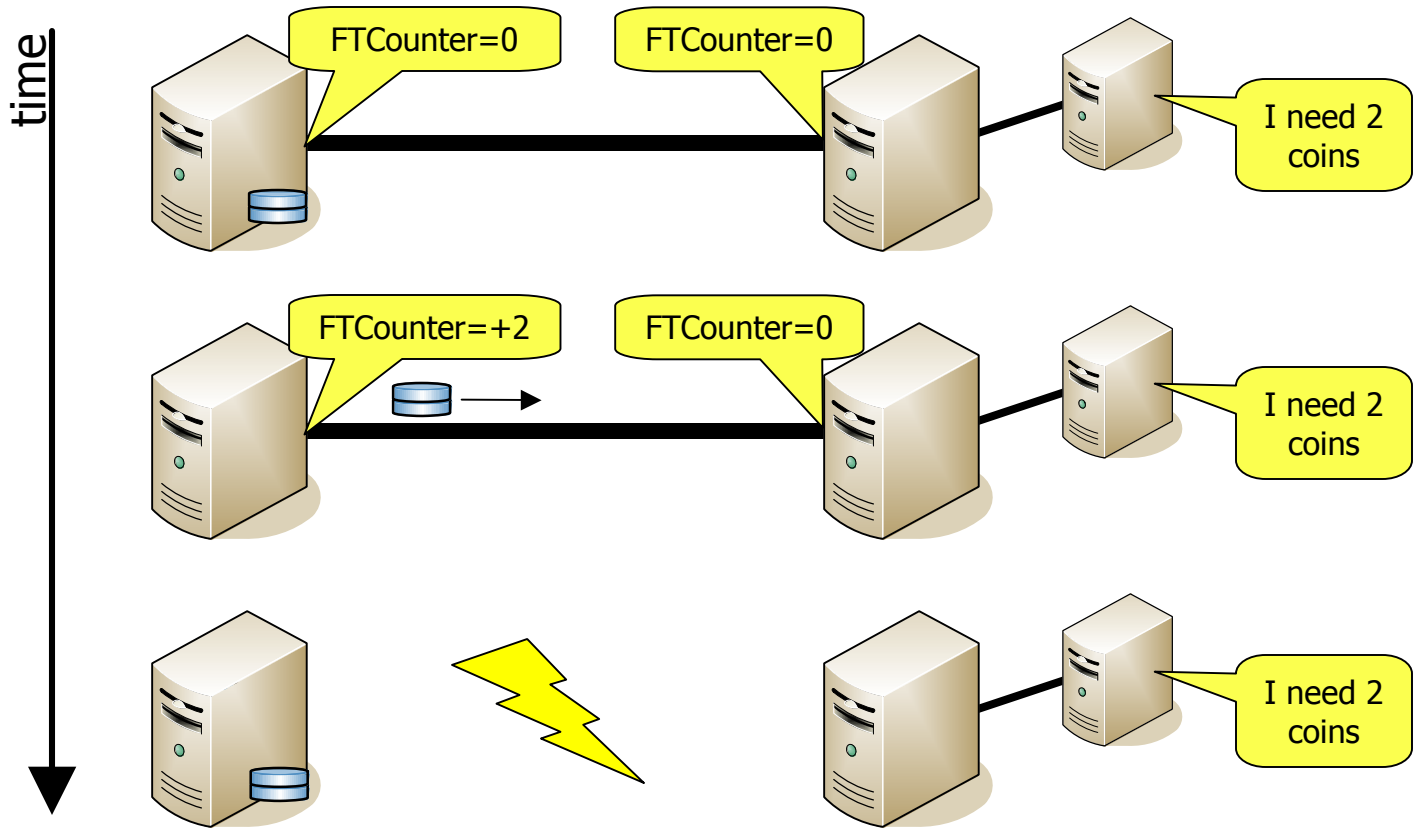
FT Solution2: Light Weight 1/6



- Machine down ⇔ All of its links are down
- Each node holds a counter for every link.
  - FTCounter = Sent coins – Received coins
  - FTCounter = Net number of transferred coins
- When a link goes down:
  - If FTCounter < 0
    - Create a fictive demand for |FTCounter| coins
  - Else
    - |FTCounter| coins are added to the node's surplus

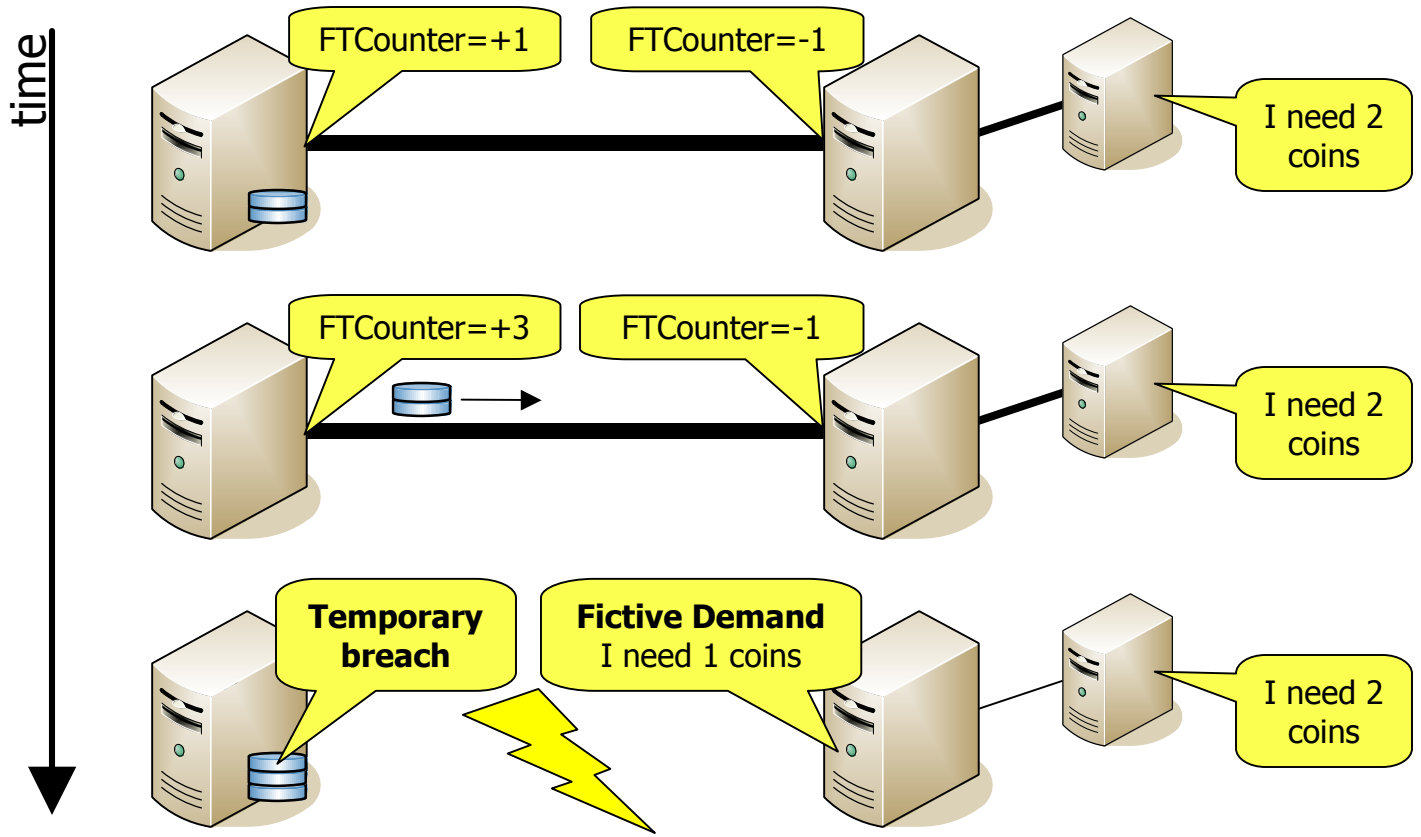
FT Solution2: Light Weight 2/6

- Example 1:



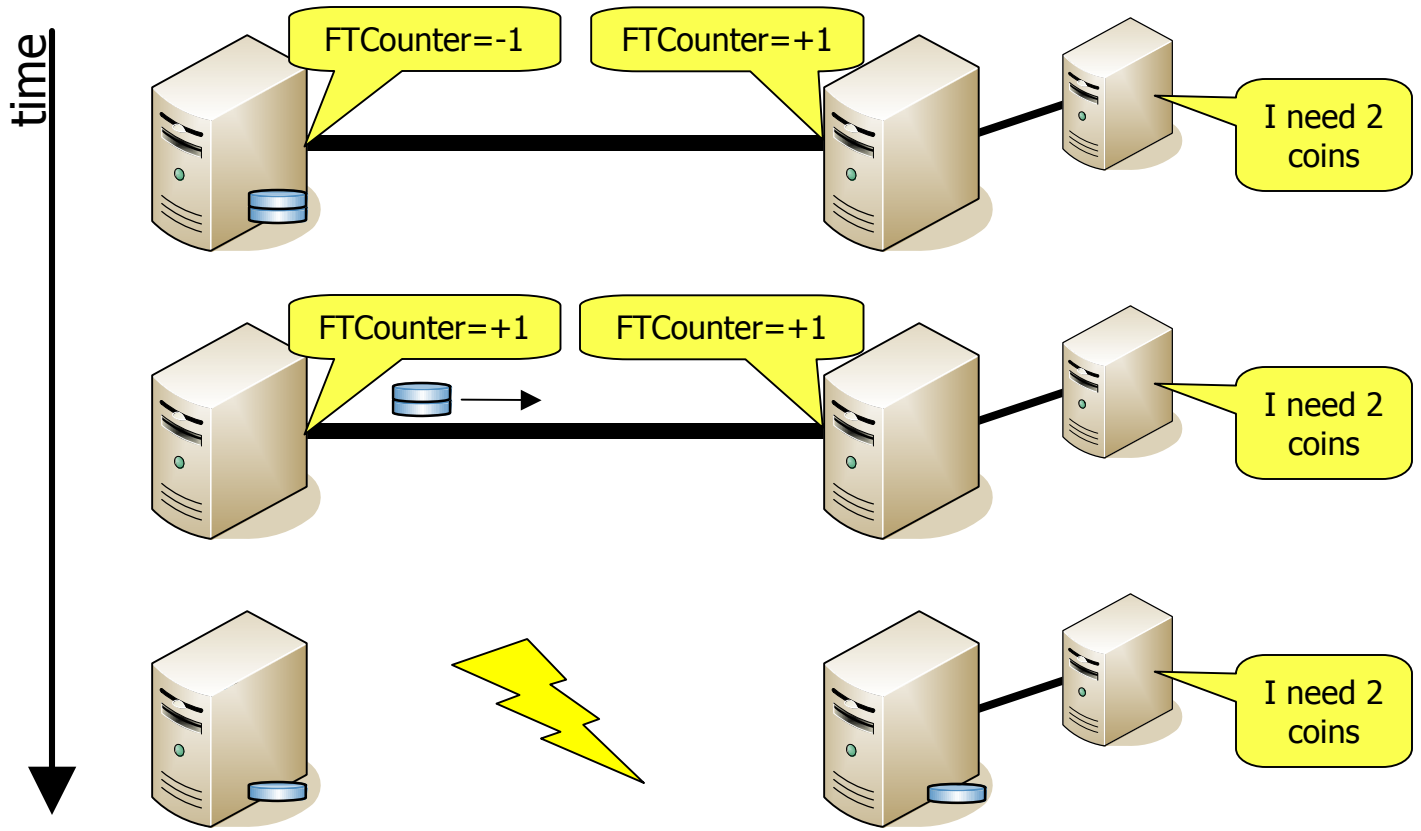
FT Solution2: Light Weight 3/6

- Example 2:



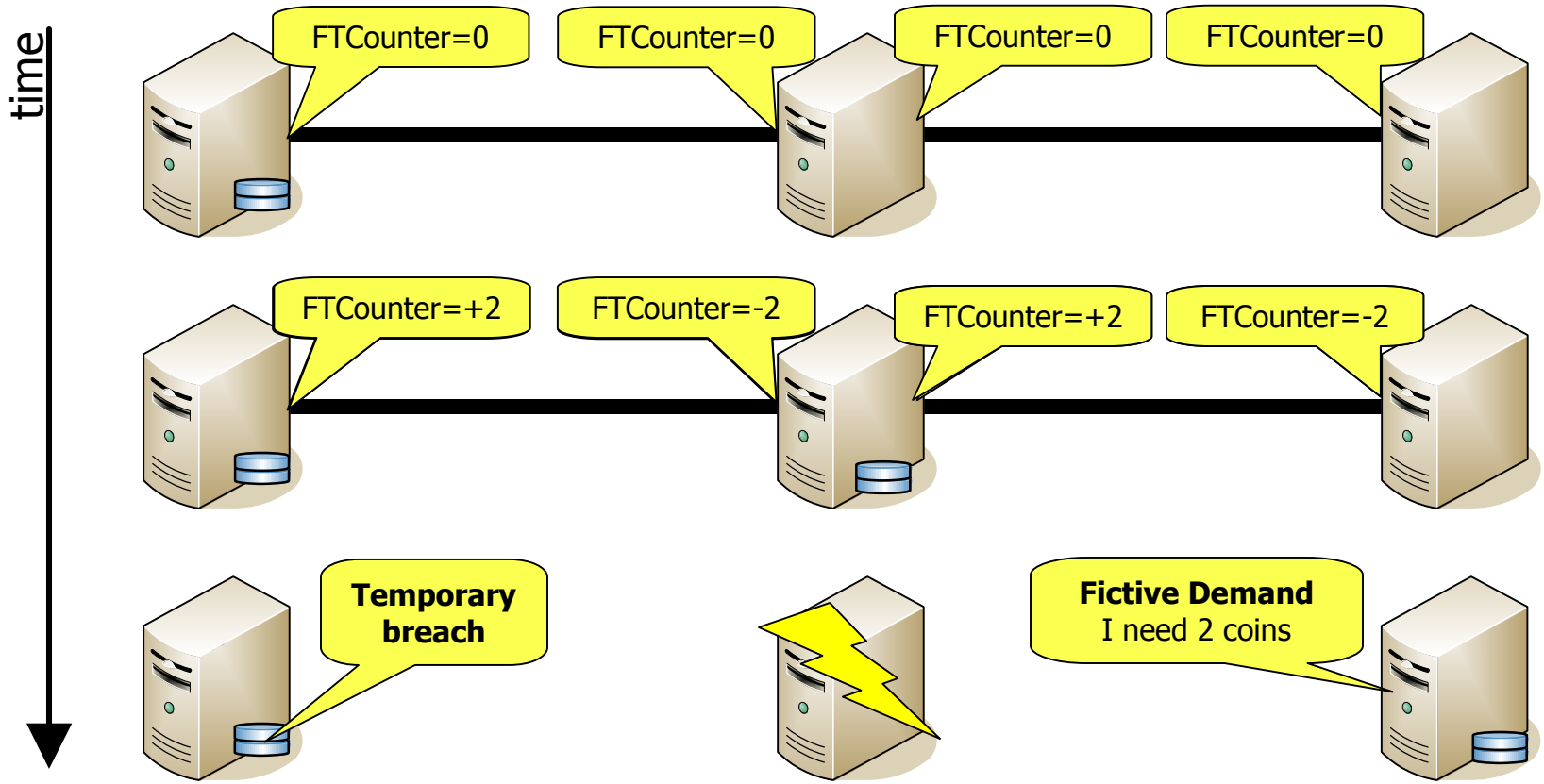
FT Solution2: Light Weight 4/6

- Example 3:

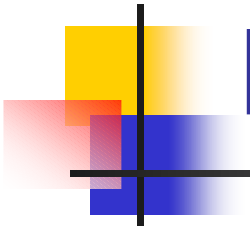


FT Solution2: Light Weight 5/6

- Example 4:

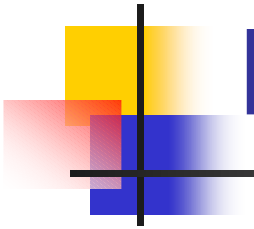


FT Solution2: Light Weight 6/6



- Pro
  - No latency
  - No need for persistent storage
  - GWiQ never unfairly reduced
- Con
  - May introduce temporary GWiQ breaches

FT Solution3: Hybrid 1/2



- Use the Light-Weight solution regularly
- Only con to deal with: GWiQ breaches
  - Caused by loaded FTCounters
- Issue FTCounter balancing Transactions
  - If $|FTCounter_{i,j}| > Threshold$
    - Disallow link usage. Start transaction.
    - $FTCounter_{i,j} = FTCounter_{j,i} = 0$
    - End transaction. Resume link usage.
  - Or, issue periodically.

FT Solution3: Hybrid 2/2

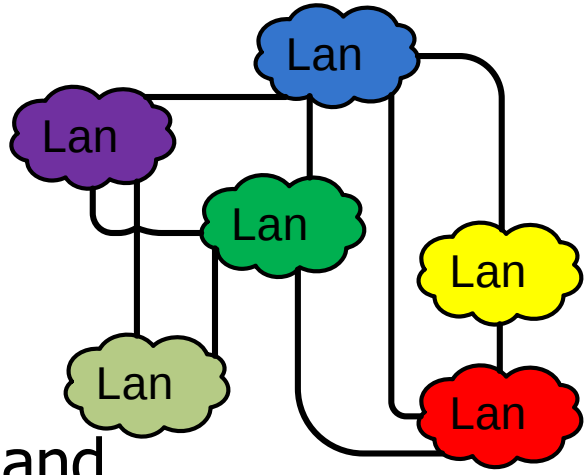
- Pro
  - Due to Transactions:
    - Reduce breaches' size
  - Due to Light Weight:
    - No slowdowns (mostly)
    - No persistence storage (mostly)
    - Node crash fully remedied immediately also
- Con
  - See other side of the 'Pro'-coin ;)
- Play with the tradeoff using parameterization

GWiQ-P: Properties

- Small trees form around demand
  - Requests are remedied locally
- Coins are drawn towards 'hot' areas
  - Auto-Adaptable
- Fully distributed
  - No hot-spots & single points of failure
  - Low latency
  - No Congestion
  - Infinitely Scalable
- Fault Tolerant

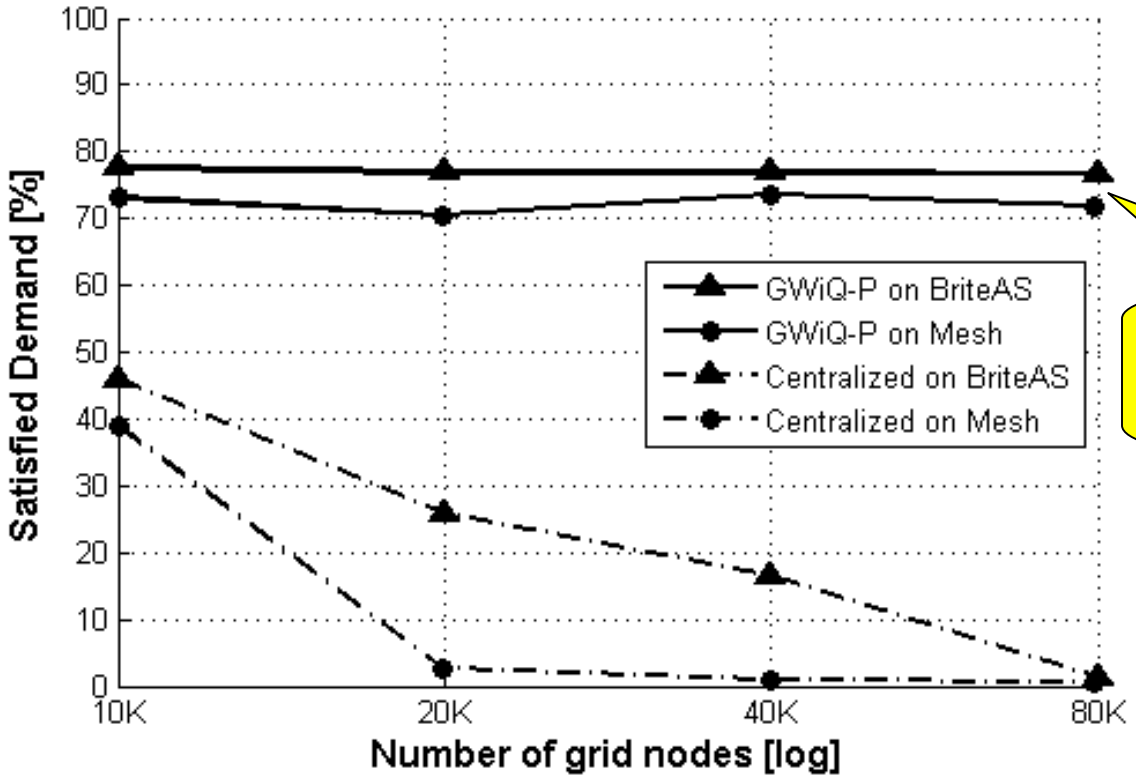
Simulations' (default) Properties

- Toplogy = BriteAS
  - Fast LANs, slower intercon/
- NetSize = 10K
- Q/D=1
  - Q for GWiQ; D for Overall demand
- Change Rate = 1%*D/E[EdgeDelay]
- Demanders = 1%*NetSize
- Fail Rate = 1%*Edges/E[EdgeDelay]
  - Applicable for FT scenarios



Simulations 1/6

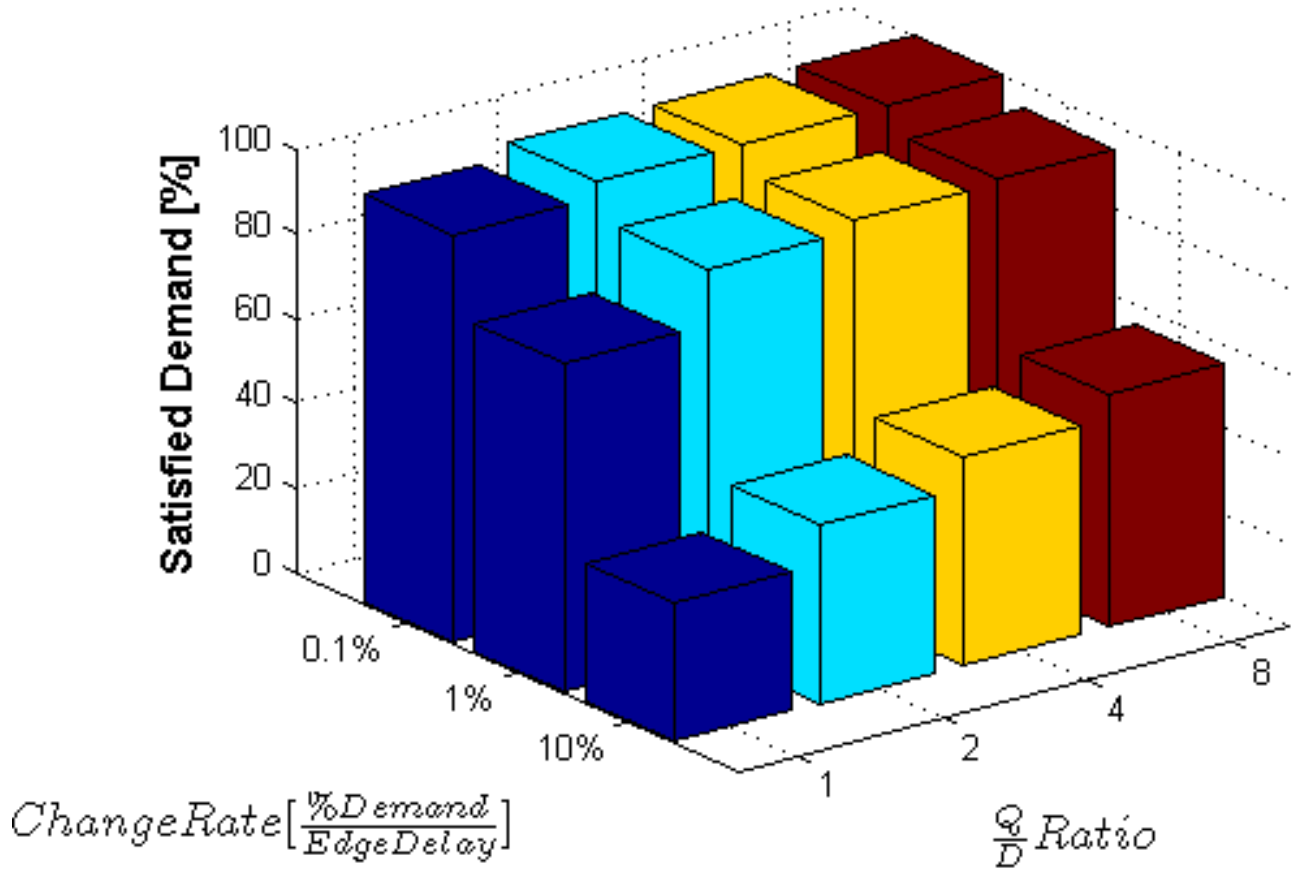
- Topology: BriteAS
- Change rate: 1%*D/E[EdgeDelay]
- Q/D=1
- Demanders: 1%



GWiQ-P scalability due to locality

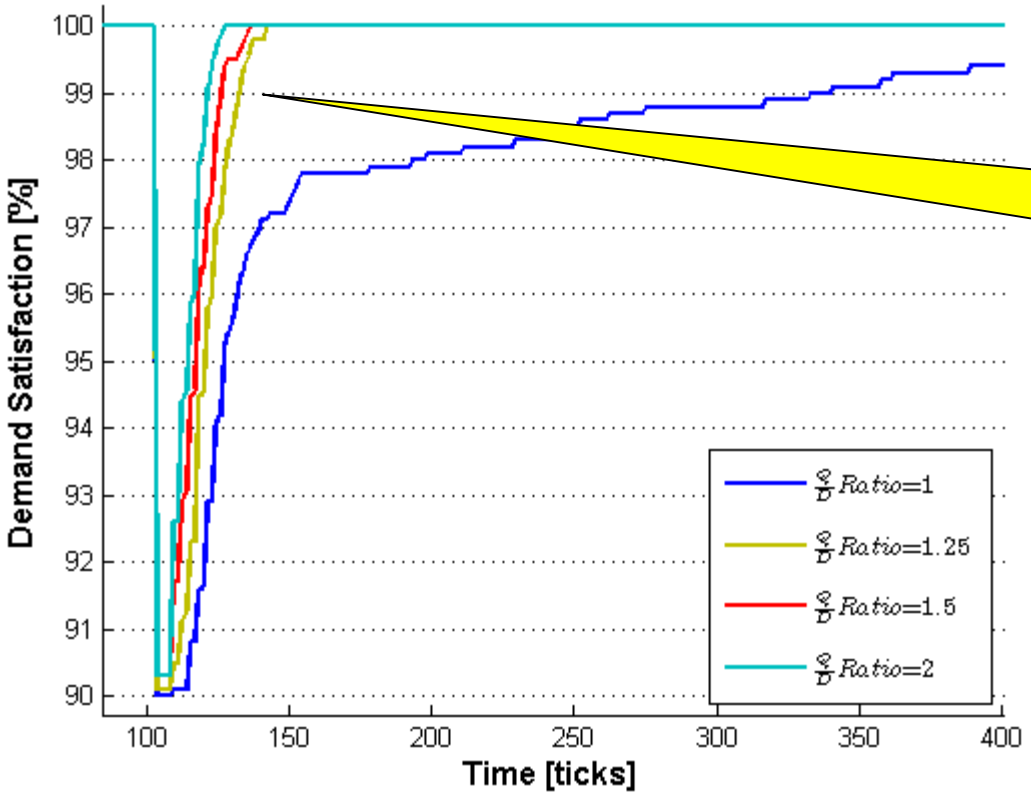
Simulations 2/6

- Topology: 10K BriteAS
- Demanders: 1%



Simulations 3/6

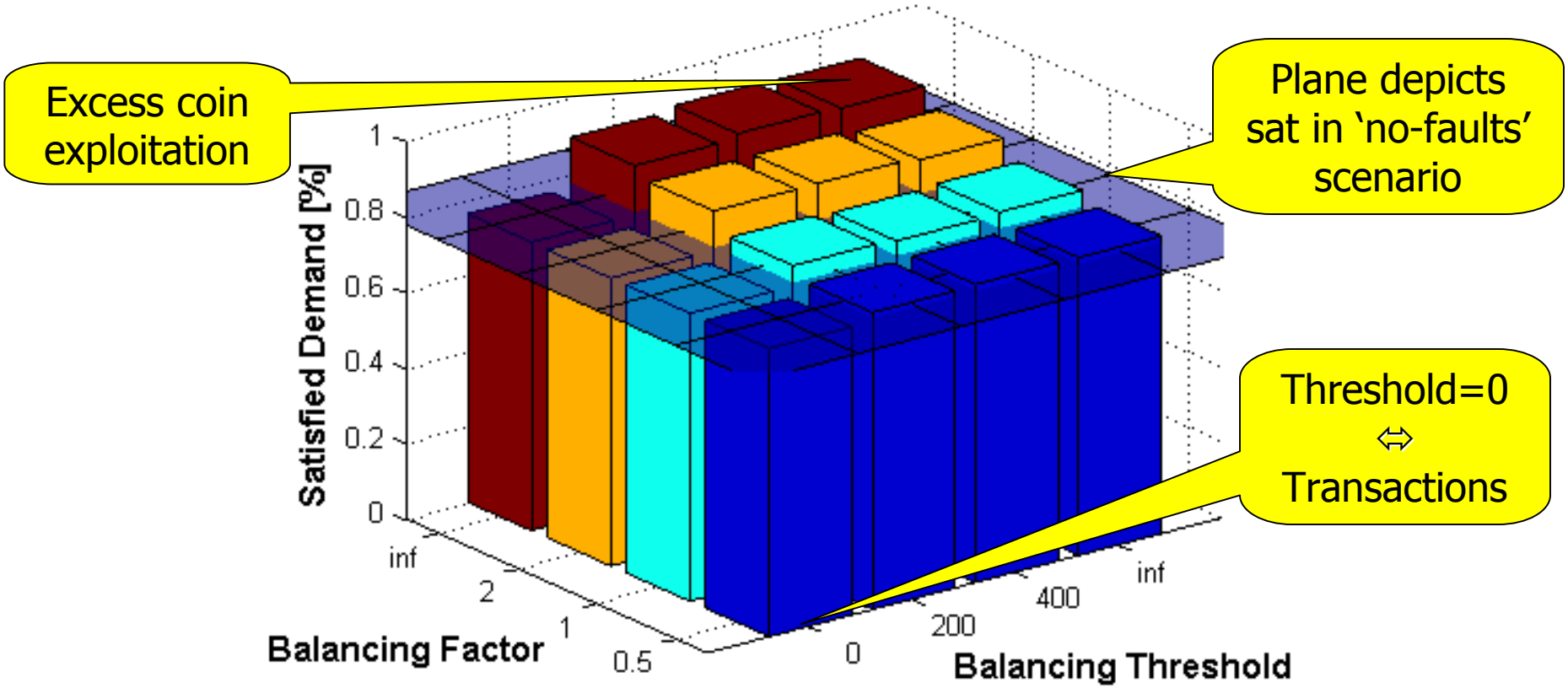
- Topology: 10K BriteAS
- E[EdgeDelay] ~= 3 ms
- Change rate: One Time 1%*D
- Demanders: 1%



Return to 99% sat after =~ 30ms

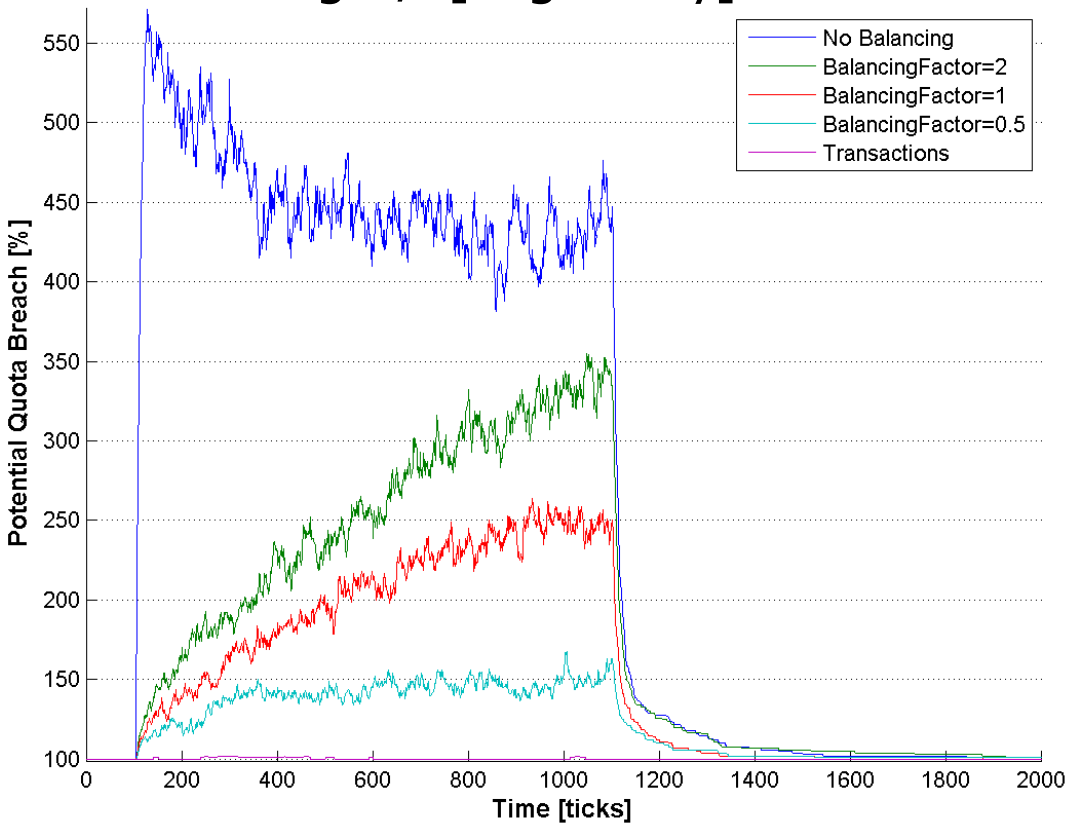
Simulations 4/6

- Topology: 10K BriteAS
- Change rate: 1%*D/E[EdgeDelay]
- Fail rate: 1%*Edges/E[EdgeDelay]
- Q/D=1
- Demanders: 1%



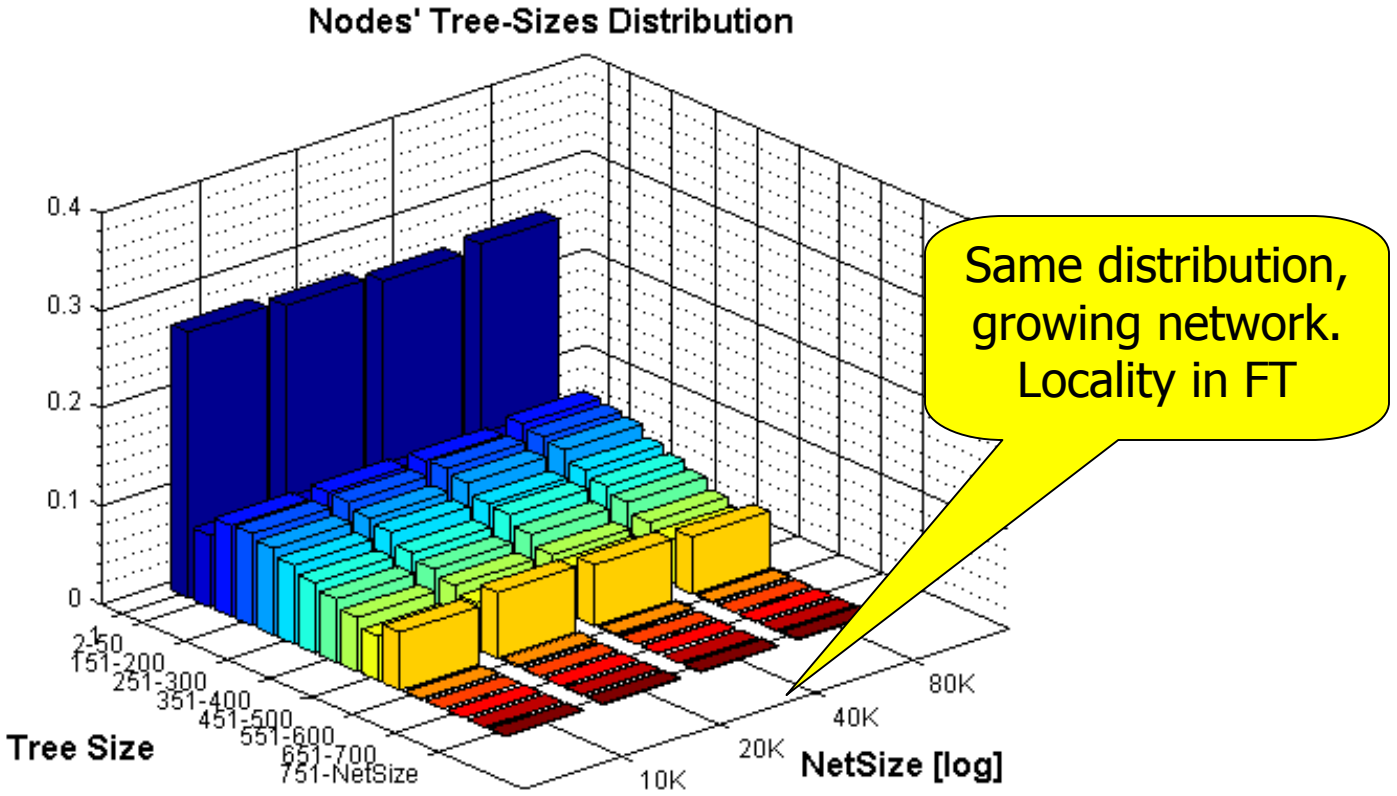
Simulations 5/6

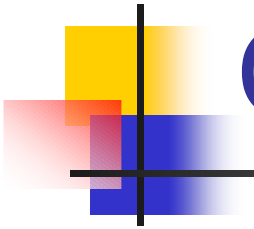
- Topology: 10K BriteAS
- Change rate: 1%*D/E[EdgeDelay]
- Fail rate: 1%*Edges/E[EdgeDelay]
- Q/D=0.5
- Demanders: 1%



Simulations 6/6

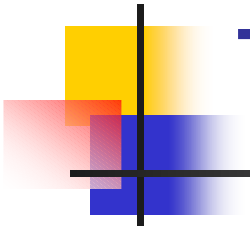
- Topology: BriteAS
- Change rate: 1%*D/E[EdgeDelay]
- Fail rate: 1%*Edges/E[EdgeDelay]
- Q/D=1
- Demanders: 1%





Conclusion

- We displayed GWiQ-P, a Grid Wide Quota enforcement Protocol
- GWiQ-P is infinitely **scalable**
- GWiQ-P is fully **distributed**
- GWiQ-P is **local** hence very efficient
- GWiQ-P is **fault tolerant**



Thank You!

Q&A

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