Convergence Guarantees Between Network Models

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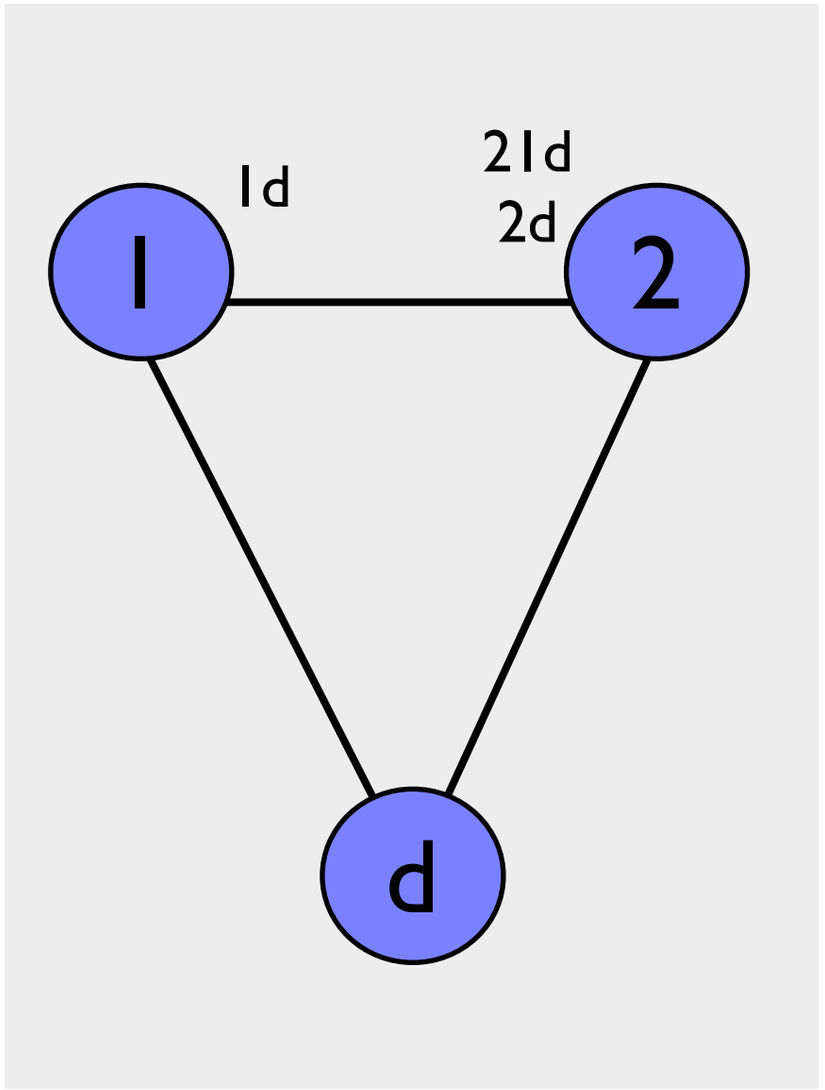
Background Information

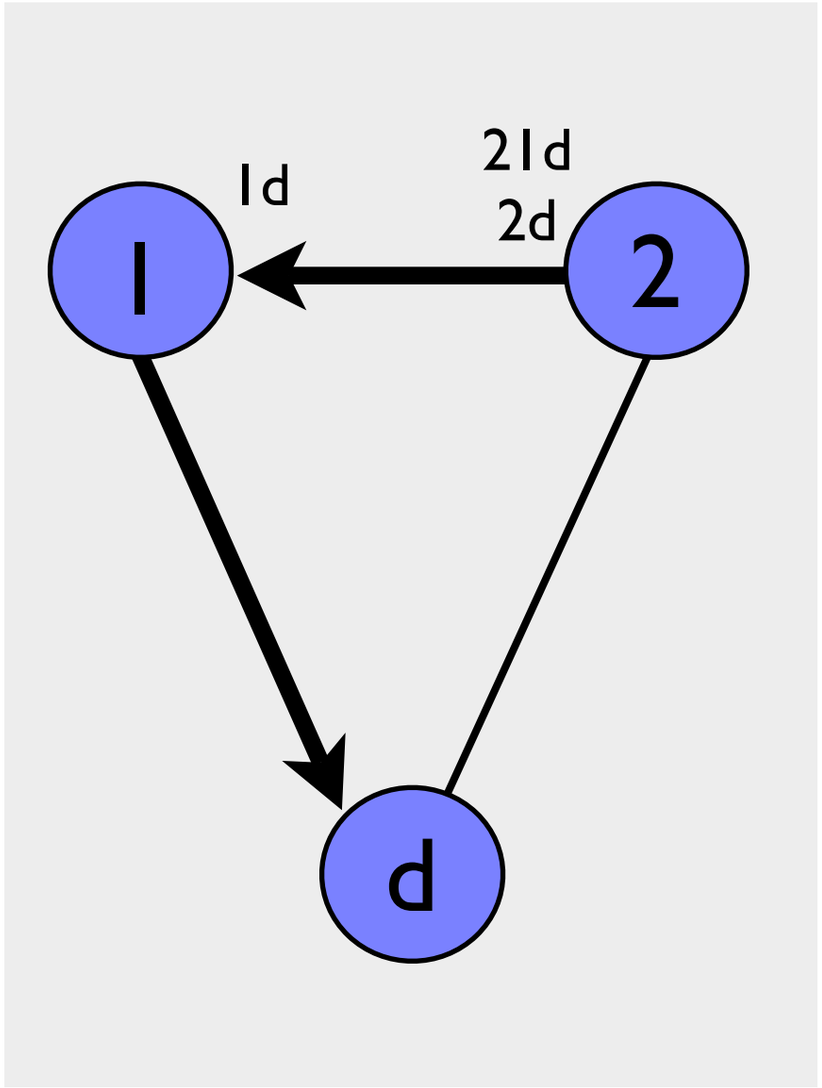
- A network is a set of nodes connected by edges
  - All nodes want to reach a destination d
- Each node has a preference ordering on its permitted routes to d
- We want a consistent, stable routing solution (a solution which does not oscillate)



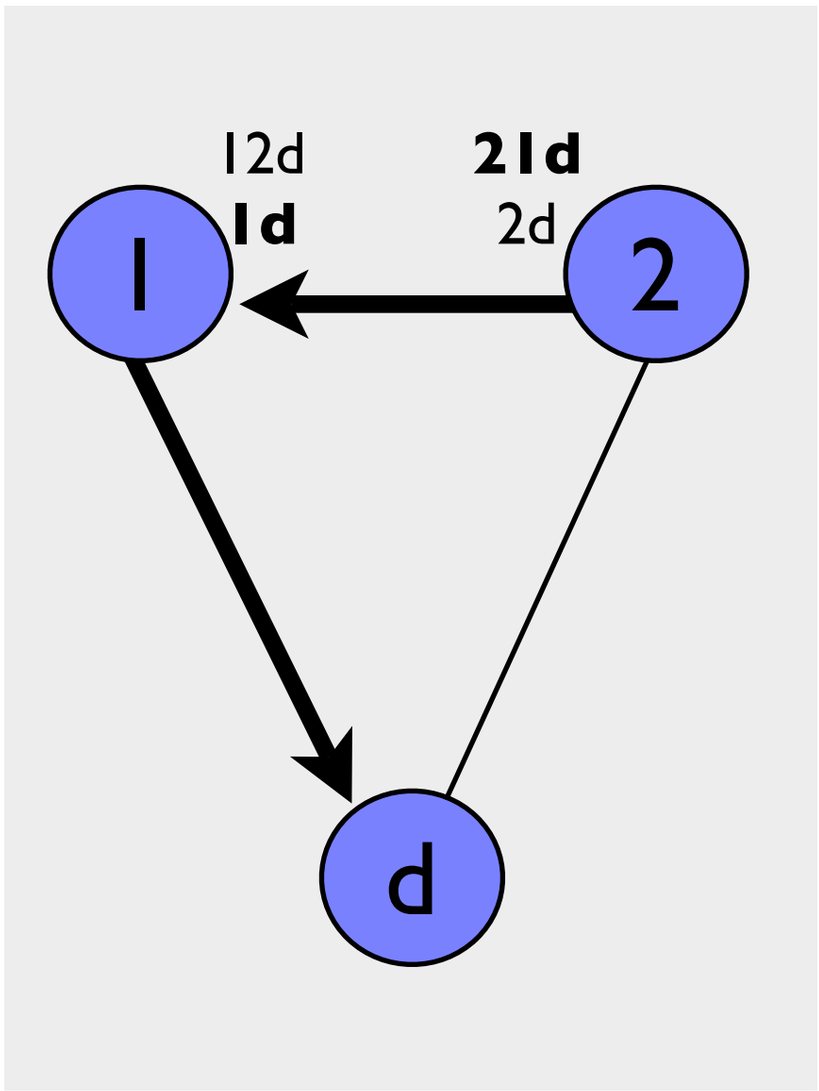
Background cont.

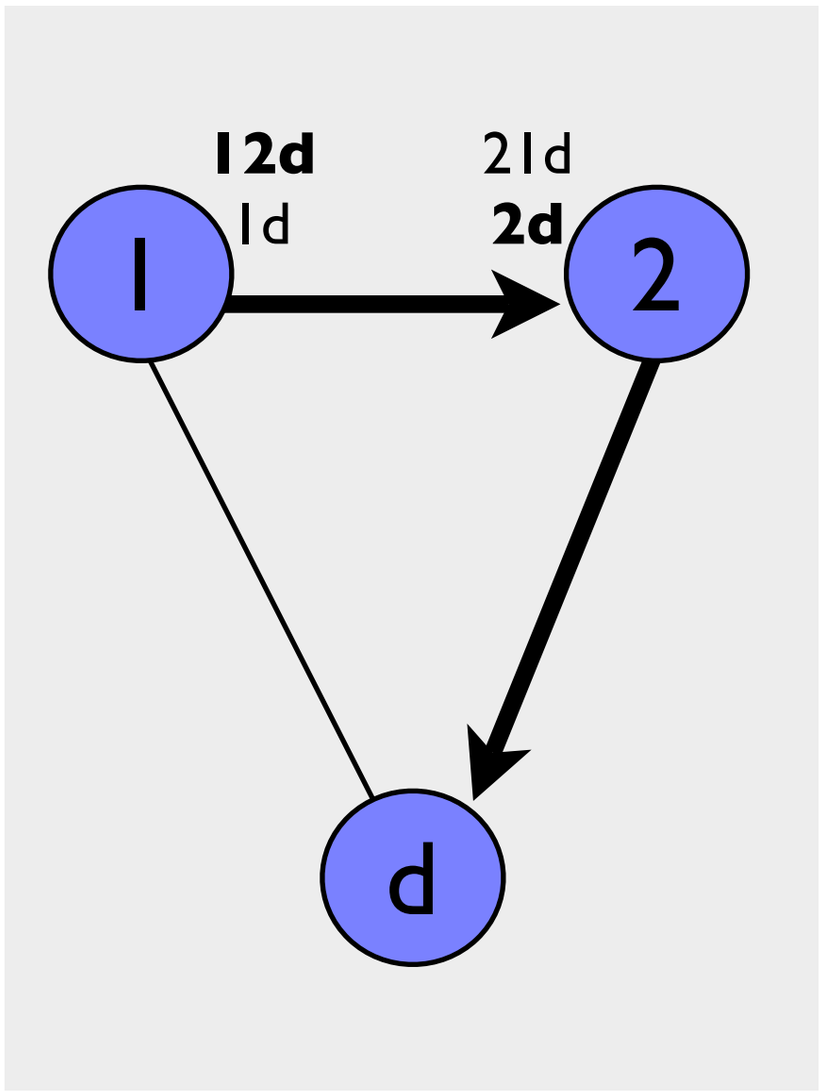
- Each node is assigned its most preferred path with respect to its neighbors' assigned paths

- Question: If a network does not oscillate under one set of communication assumptions, does that necessarily guarantee it will converge under another set of communication assumptions?



Two Solutions of DISAGREE



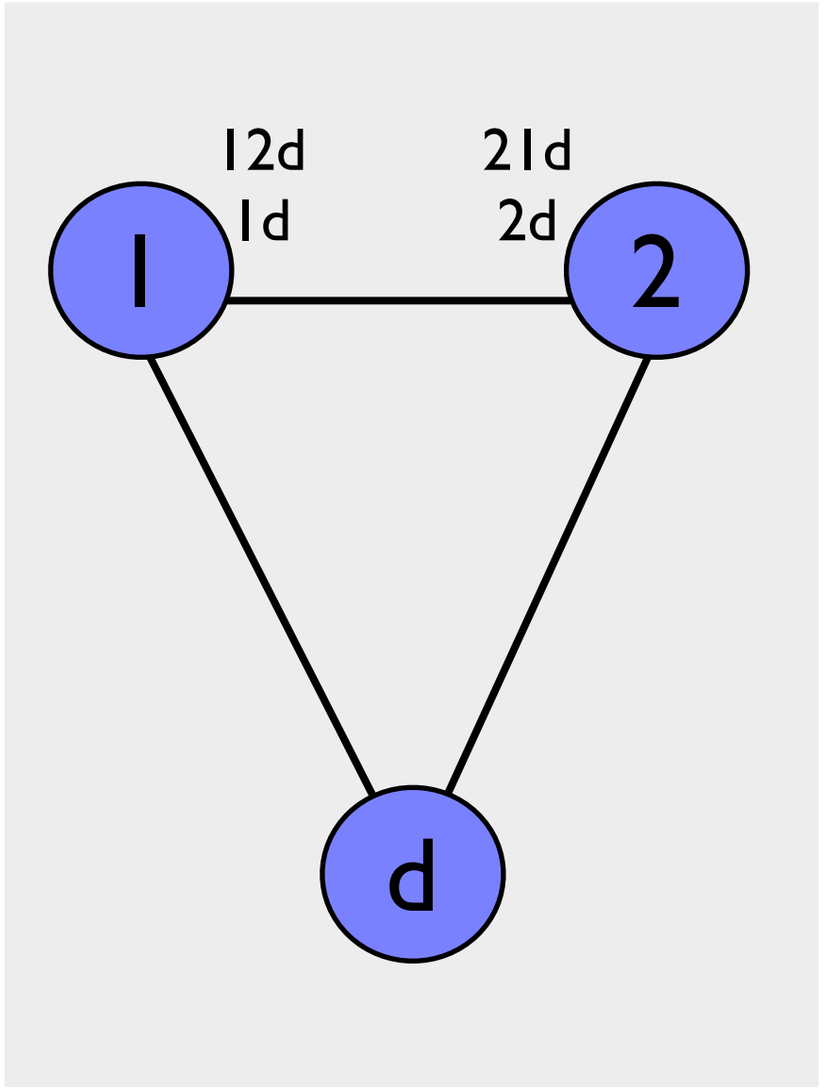


Oscillation Depends on the Model

- DISAGREE example from Griffin, Shepherd, and Wilfong

- It will oscillate in R1O (when a node is activated, it processes messages from exactly **1** of its neighbors and **O**ne message from each of its neighbors' channels)

- It will not oscillate in REO, REA, or RMA

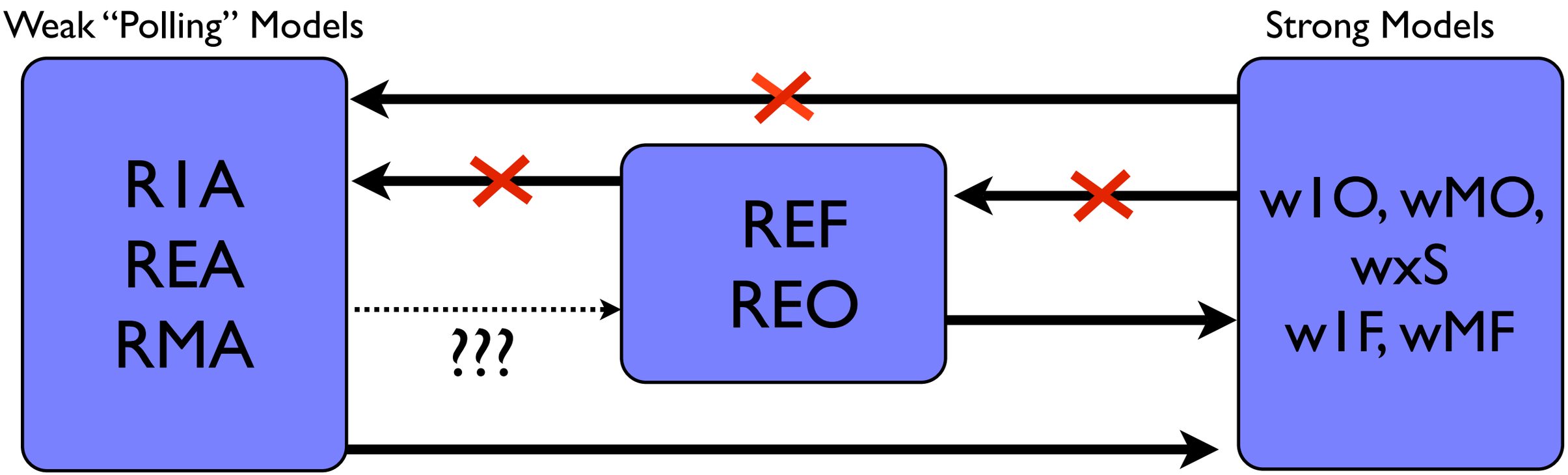


The Space of Communication Models

- Channel Reliability
- Number of neighbors processed
- Number of messages processed per channel
- Number of nodes updating

- **R**eliable (all messages processed)
- Updating from **E**very neighbor or updating from **M**ultiple number (including 0) of its neighbors
- Each node processes **A**ll messages, or exactly **O**ne message from each channel
- We assume exactly one node updates in each step

Previously Known Relationships



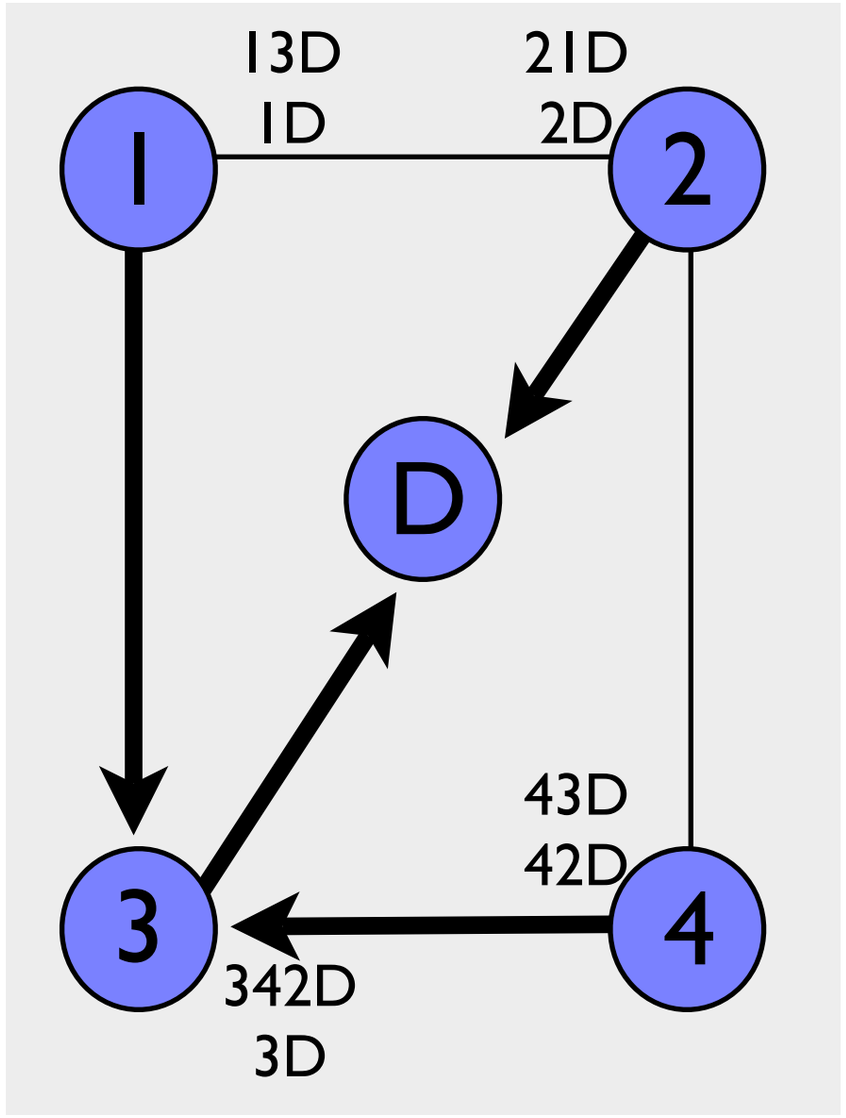
- Arrows denote preservation of oscillation
- Crossed-out arrows indicate models on the right that can oscillate in ways the models in the middle and left cannot

Main Results

- NAUGHTY GADGET example from Griffin, Shepherd, and Wilfong

- This network graph does have a stable solution, but it may oscillate when we examine different network models

- This example helped show new relationships between network models

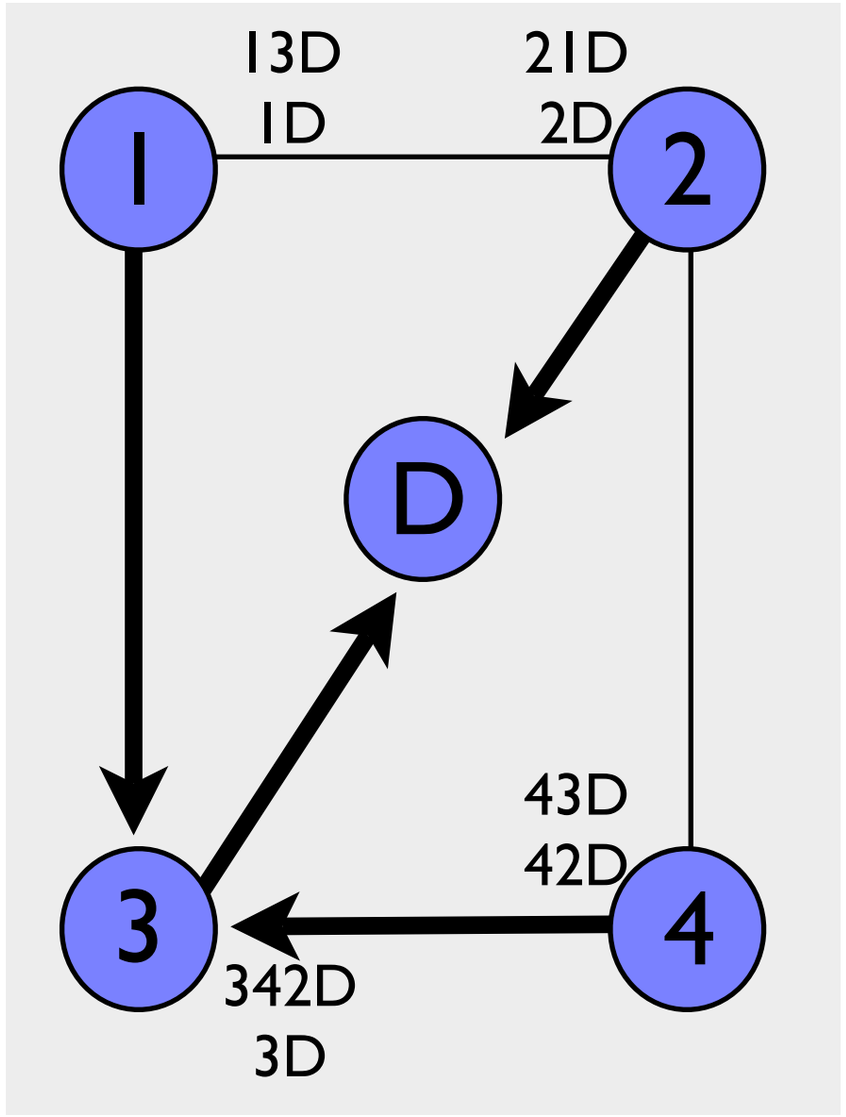


Naughty Gadget cannot oscillate in REA

- REA: **R**eliable, updating from **E**very neighbor, each node processes **A**ll messages in the channel

- Once node 4 chooses path 43D, the network will drop into the stable solution

- If node 4 chooses 42D, it will eventually drop into a stable solution

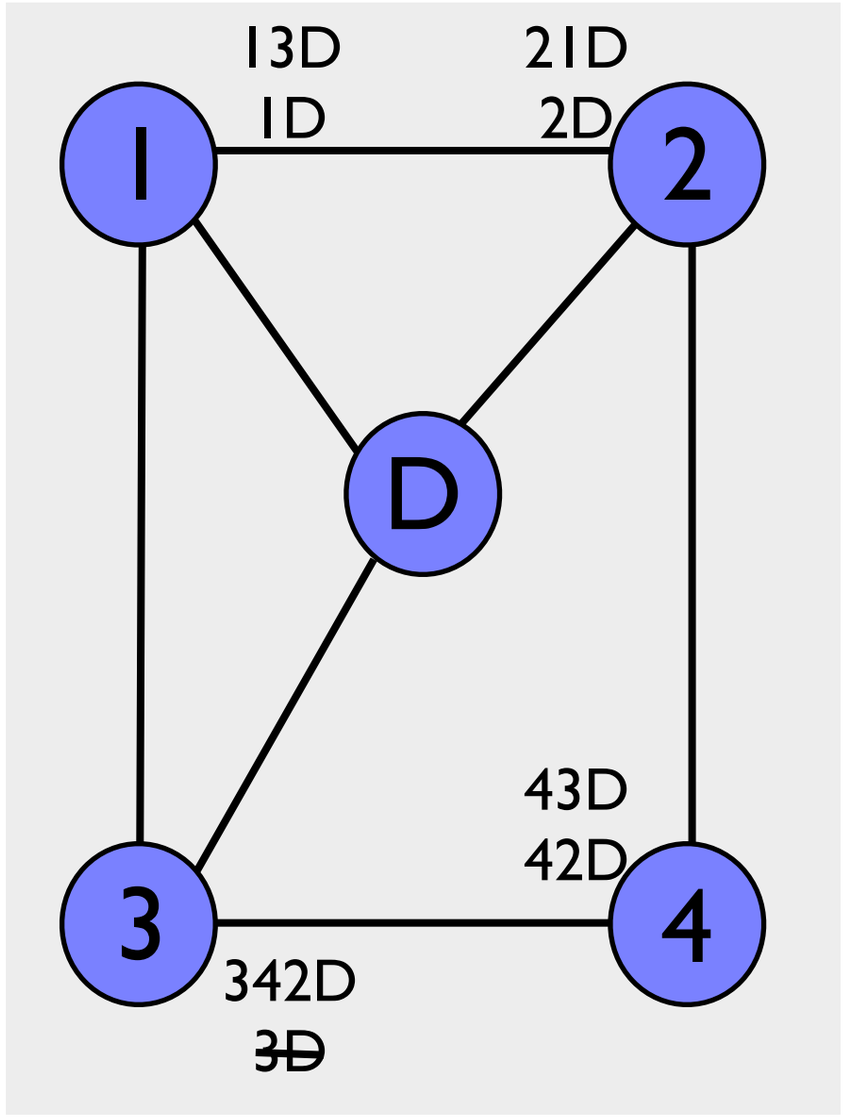


Naughty Gadget can oscillate in RMA

- REA: **R**eliable, updating from **M**ultiple number (including 0) of its neighbors, each node processes **A**ll messages in the channel

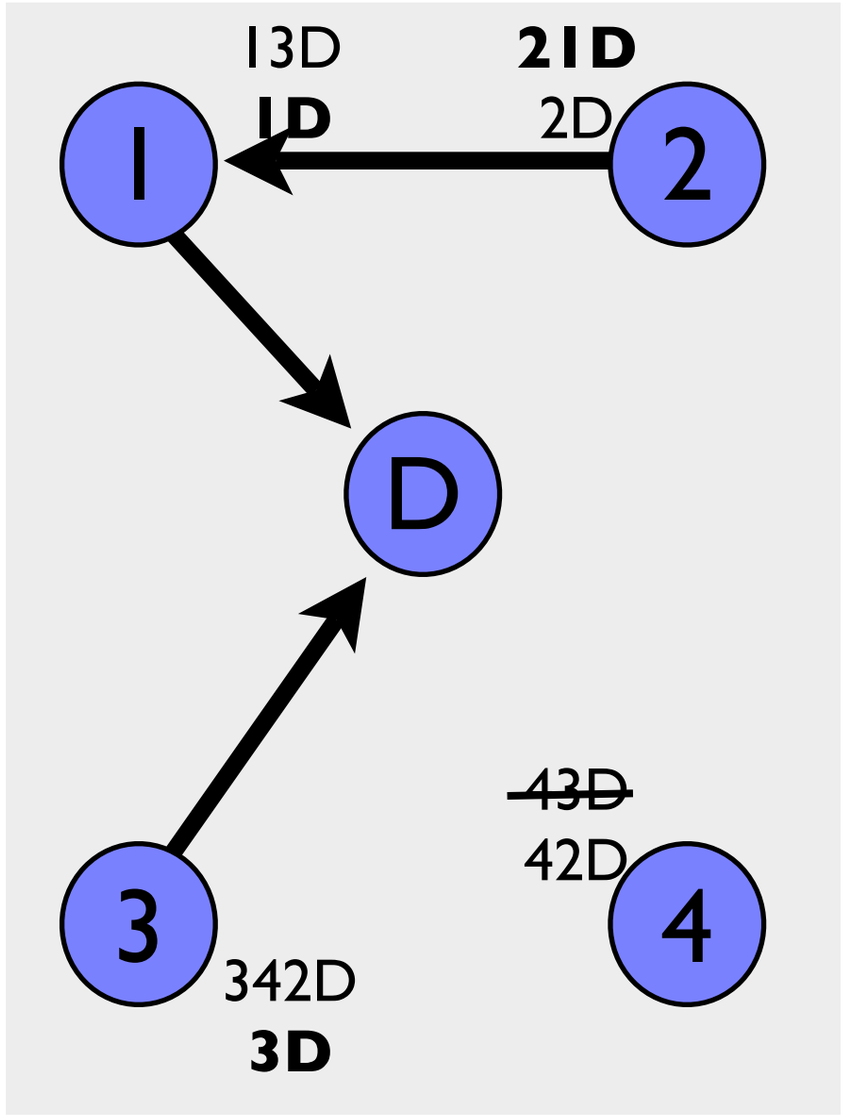
- Limit Node 4 to only process message 342D from 3 (so 4 can never choose path 43D)

- This ensures that RMA can oscillate in Naughty Gadget



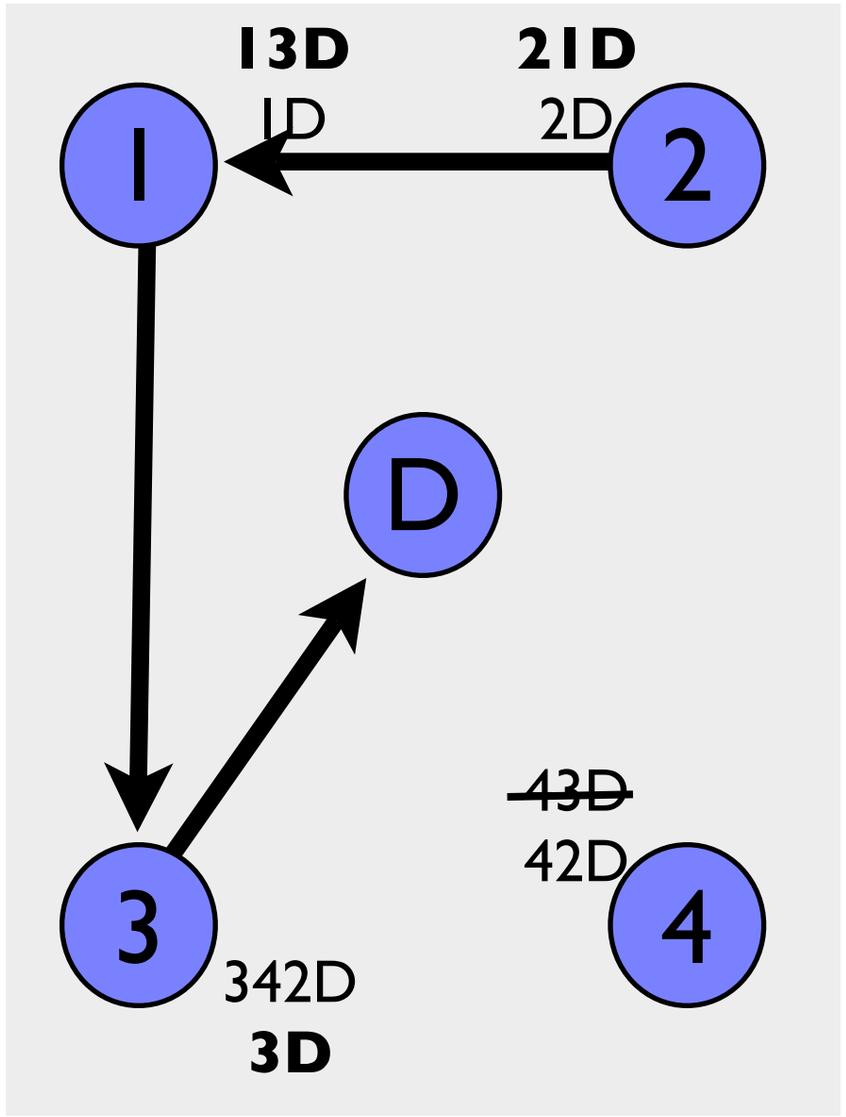
An Oscillation Sequence

- Start the sequence so that 1 is activated, then 2 is activated then 3 is activated



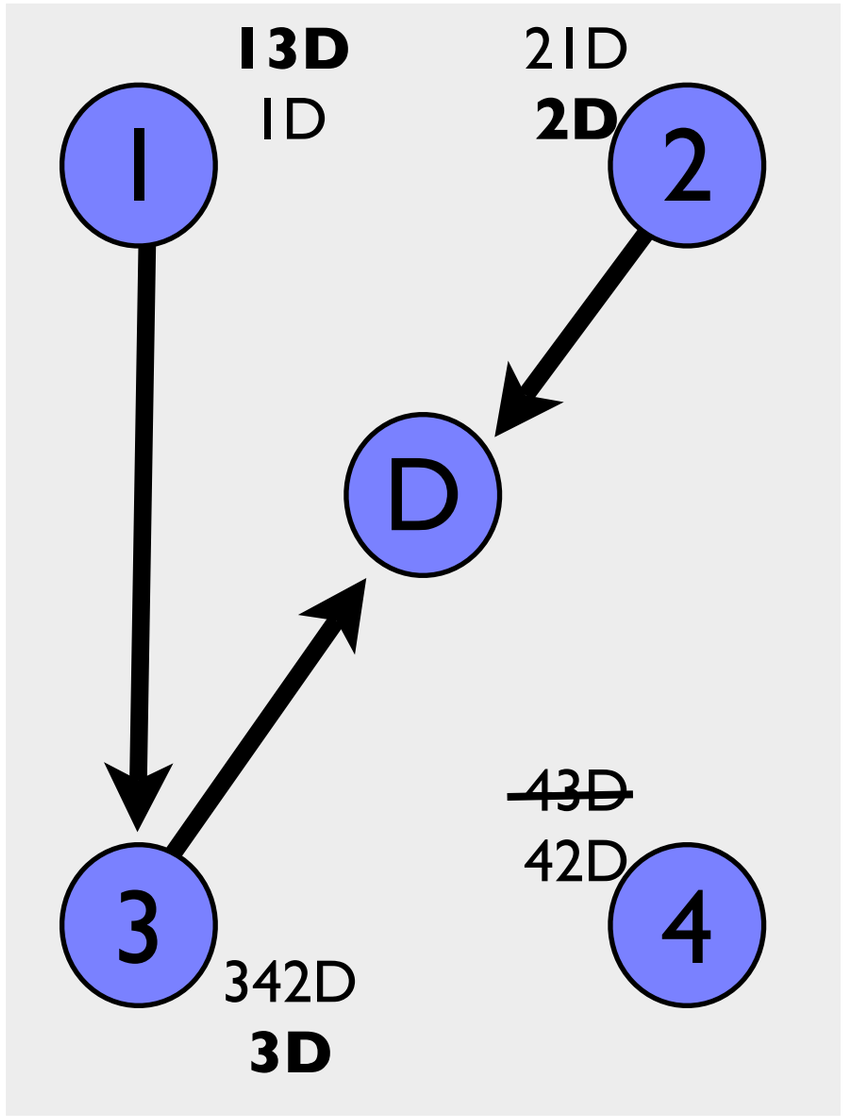
An Oscillation Sequence

- Now activate 1 again



An Oscillation Sequence

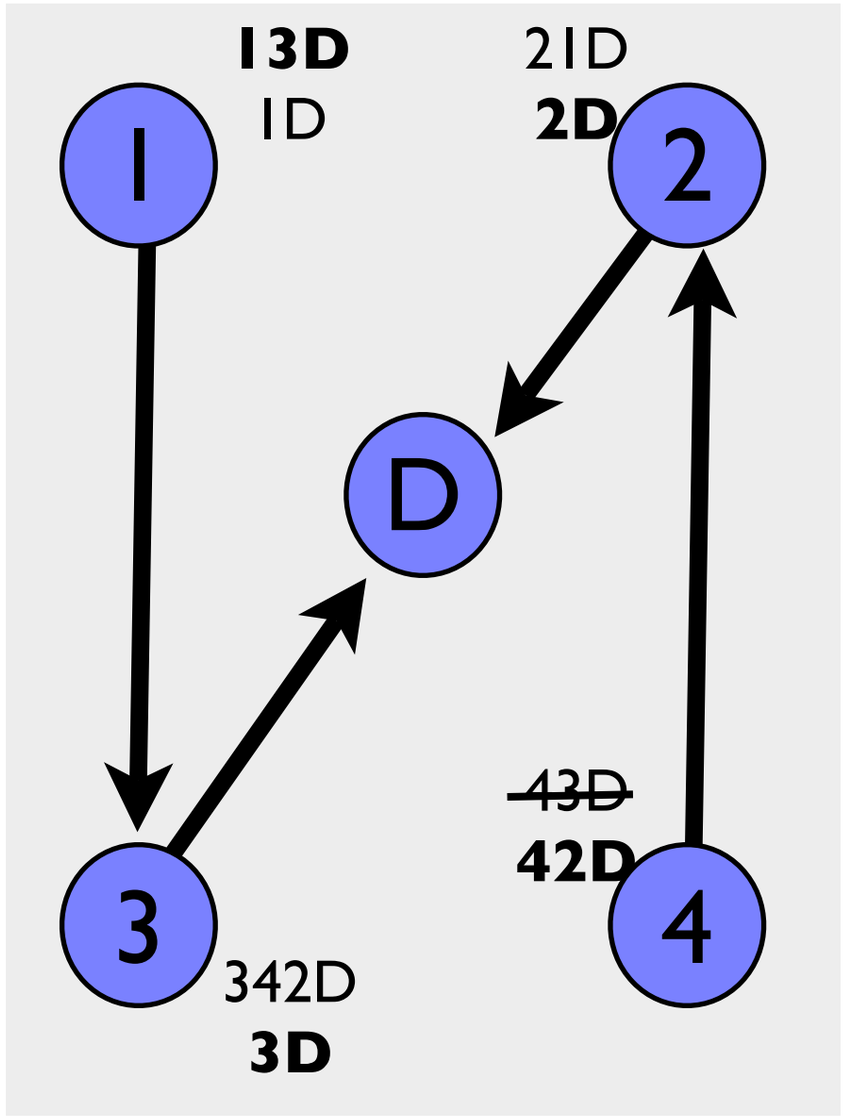
- Now activate 2



An Oscillation Sequence

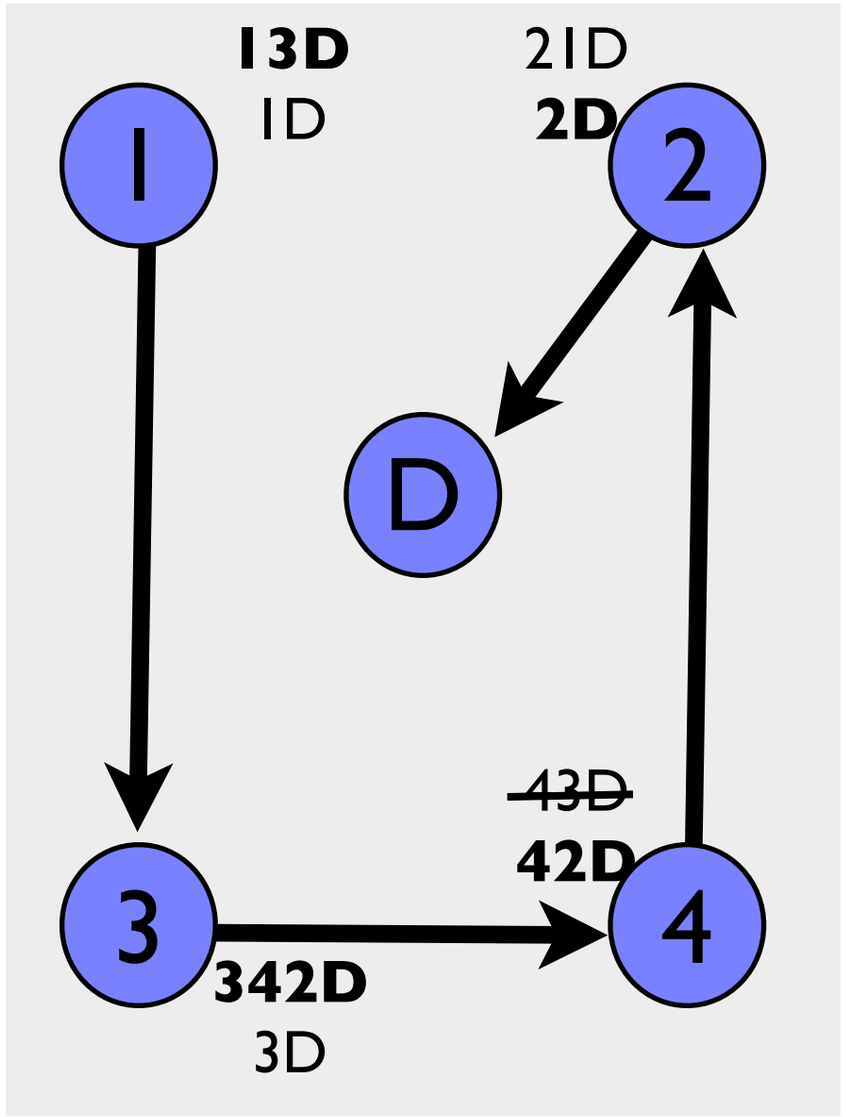
- Now activate 4

- 4 has to choose 42D, since it does not see the update of 3D from 3



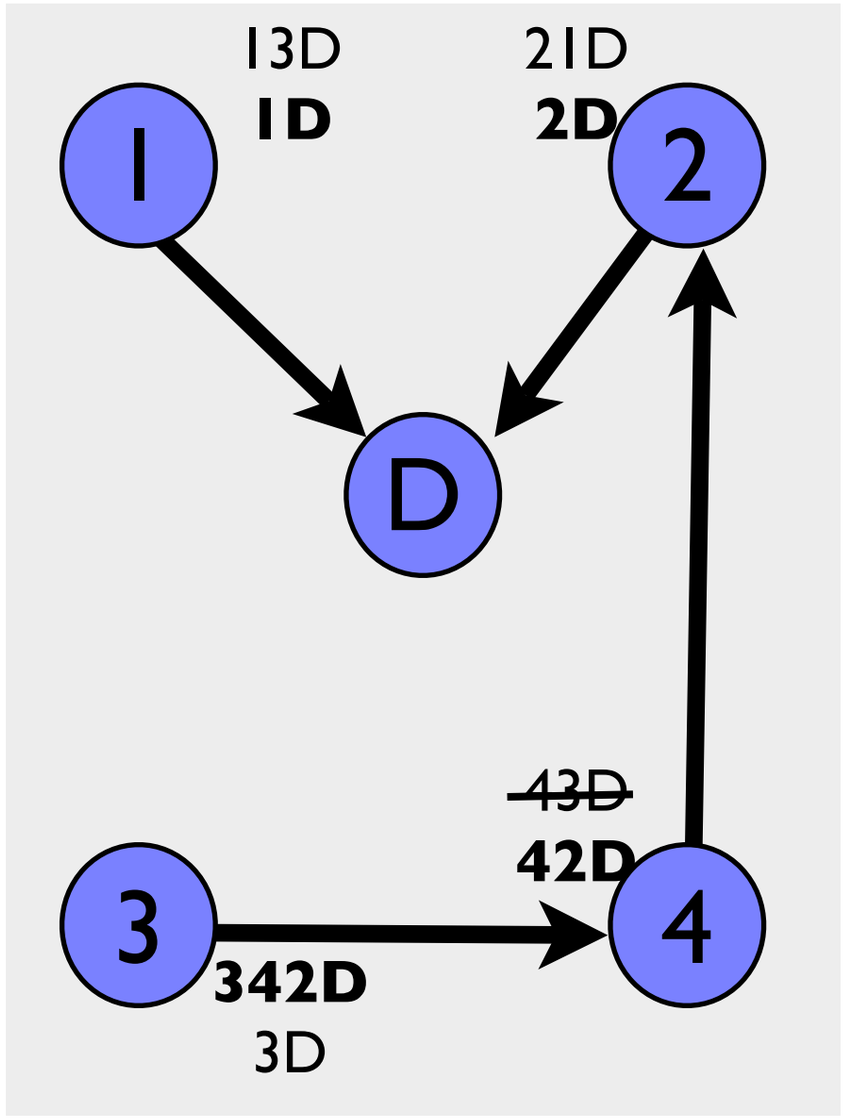
An Oscillation Sequence

- Now activate 3



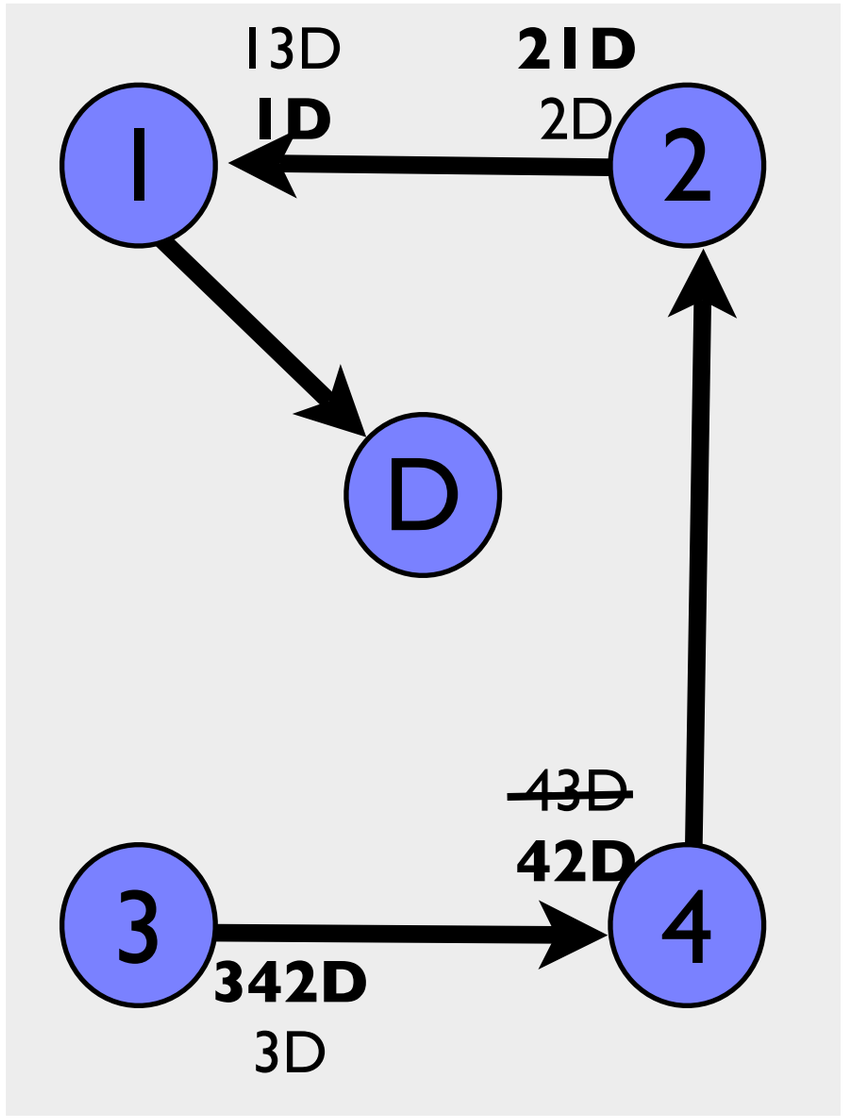
An Oscillation Sequence

- Now activate 1



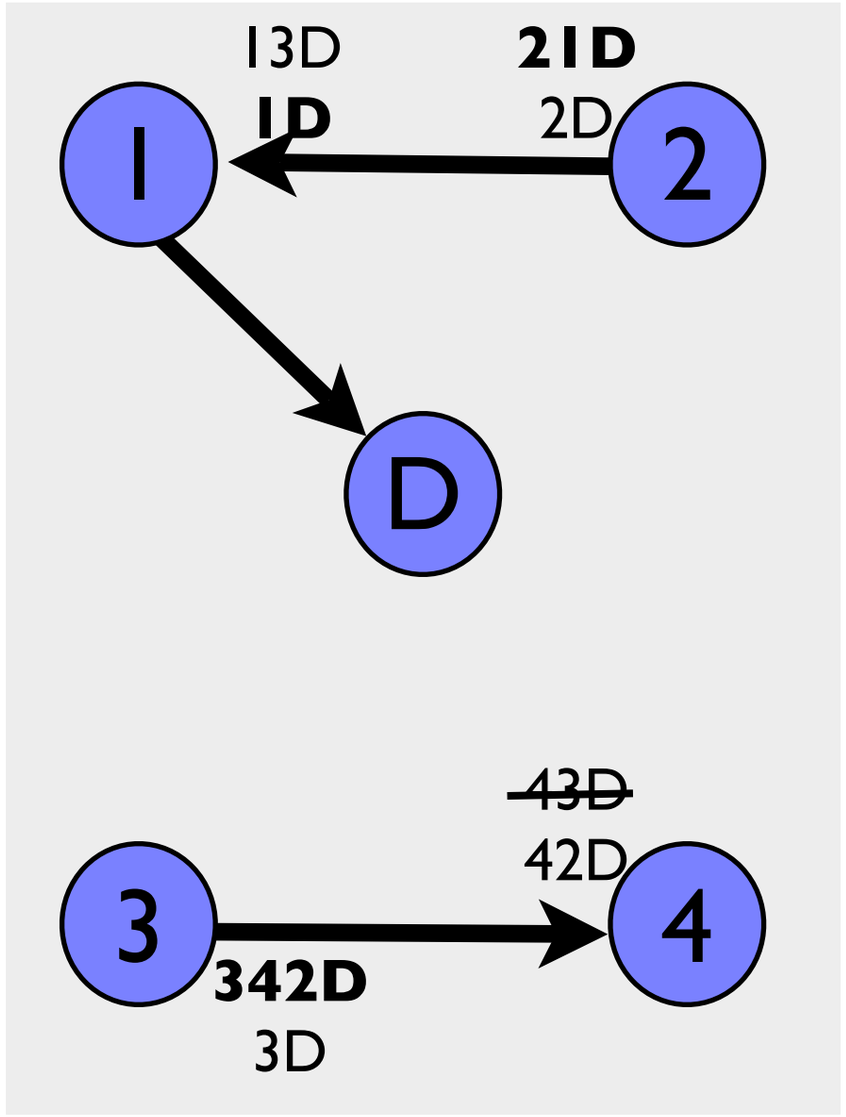
An Oscillation Sequence

- Now activate 2



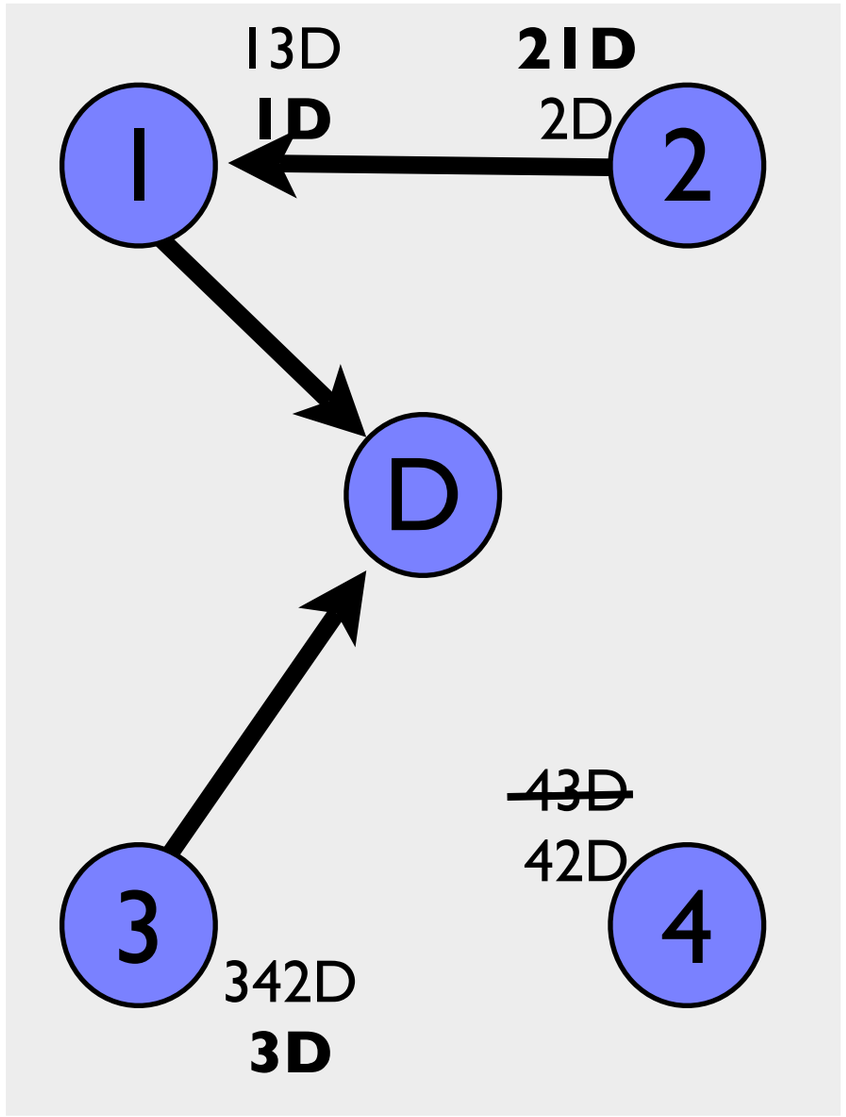
An Oscillation Sequence

- Now activate 4
- 4 will choose no path since its conflicted by its neighbors' path assignments



An Oscillation Sequence

- Now activate 3
- The network is back in the beginning stage, and executing this activation sequence will ensure oscillation

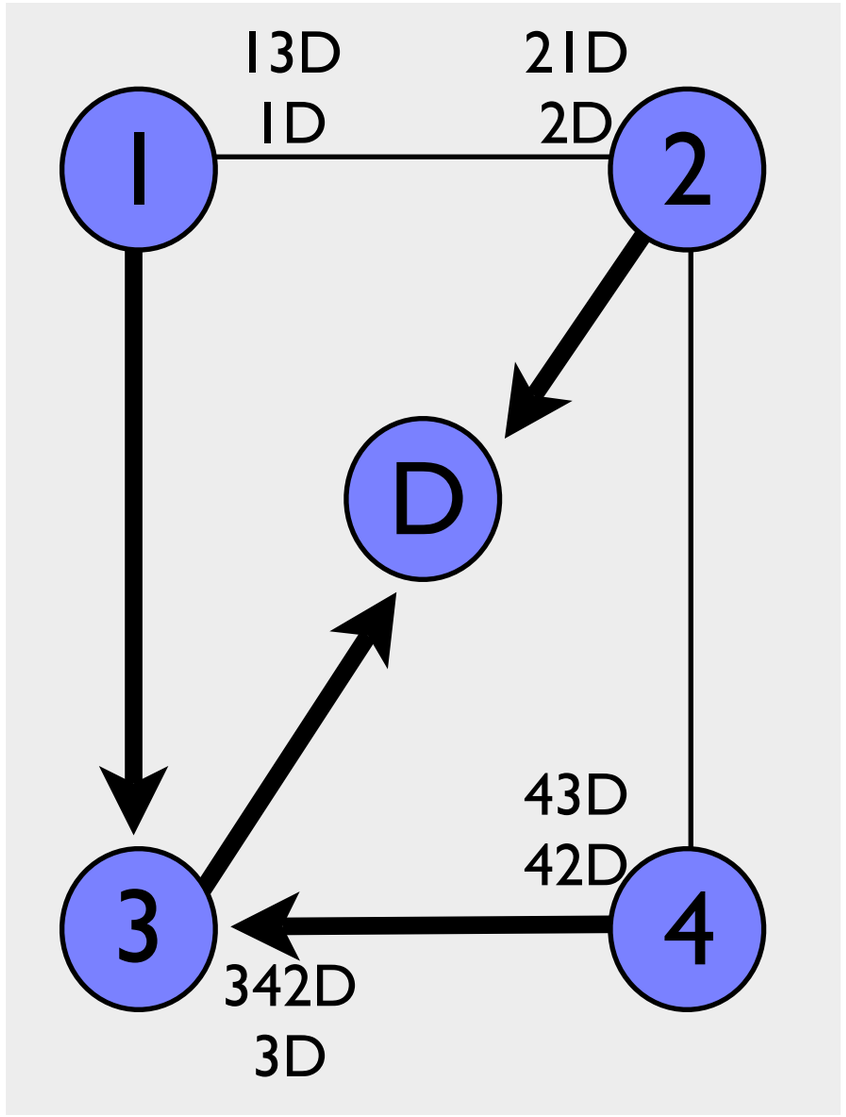


Naughty Gadget cannot oscillate in REO

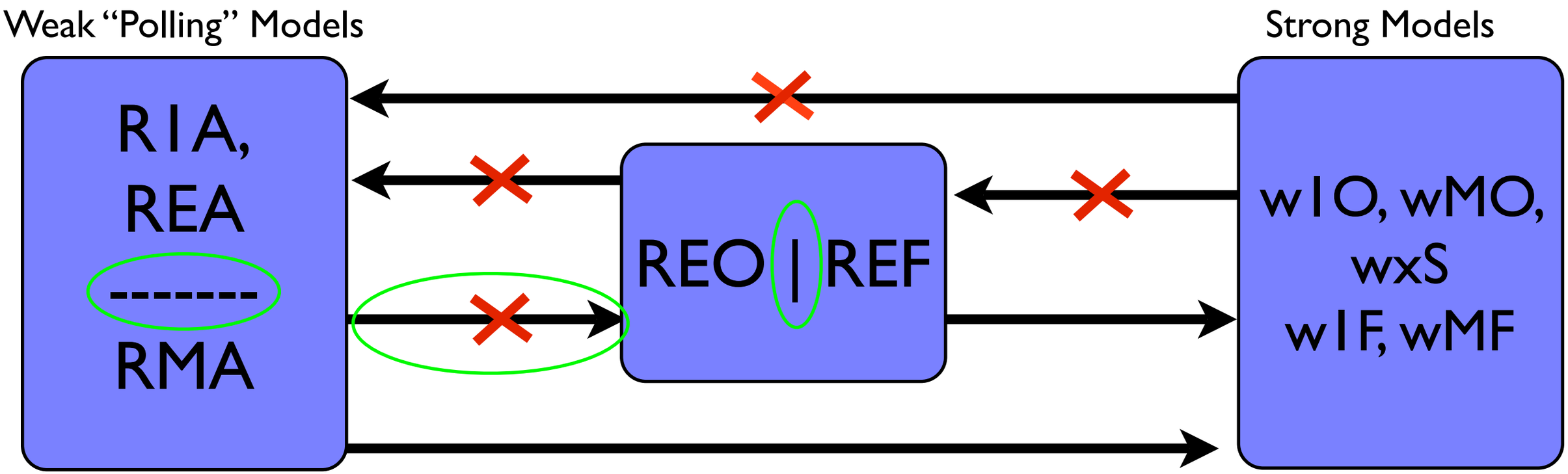
- REO: **R**eliable, updating from **E**very neighbor, each node processes exactly **O**ne message from each channel

- Once node 4 chooses path 43D, the network will drop into the stable solution (much like the proof that REA will not oscillate)

- If node 4 chooses 42D, examine the first time 4 chooses this path, and show it drops into the stable solution



Results



- Arrows denote preservation of oscillation.
- Crossed-out arrows indicate models on the right that can oscillate in ways the models in the middle and left cannot.
- Green circles designate my new contributions.

Future Work

- I hope to continue this research throughout my fall quarter at UC San Diego and look at different models and network examples.
- I want to start looking at Unreliable channels (where messages placed in the channels might not be processed), and if we can generate the same results.

References

T. G. Griffin, F. B. Shepherd, and G. Wilfong. The Stable Paths Problem and Interdomain Routing. *IEEE/ACM Transactions on Networking*, Vol. 10, No. 2, April 2002.

Aaron D. Jaggard, Vijay Ramachandran, and Rebecca N. Wright, "The Impact of Communication Models on Routing-Algorithm Convergence" Proceedings of ICDCS 2009, pp. 58--67

Thank You!

- A special thanks to my mentors: Aaron Jaggard, Vijay Ramachandran, and Rebecca N. Wright