The Dear Leader

The Parliament

CONSENSUS

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propose →  → decide

- **Validity** – If a process decides v, then v was proposed by some process
- **Agreement** – No two correct process decide differently
- **Integrity** – No correct process decides twice
- **Termination** – Every correct process eventually decides some value

A simple Consensus algorithm

Process p_i

Initially $V = \{v_i\}$

To execute propose(v_i)

1: send $\{v_i\}$ to all

decide(x) occurs as follows:

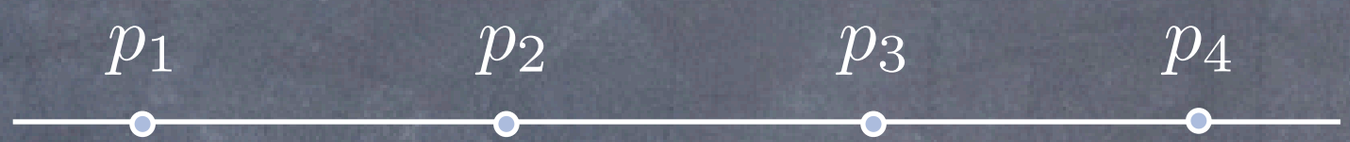
2: for all j, $0 \leq j \leq n-1$, $j \neq i$ do

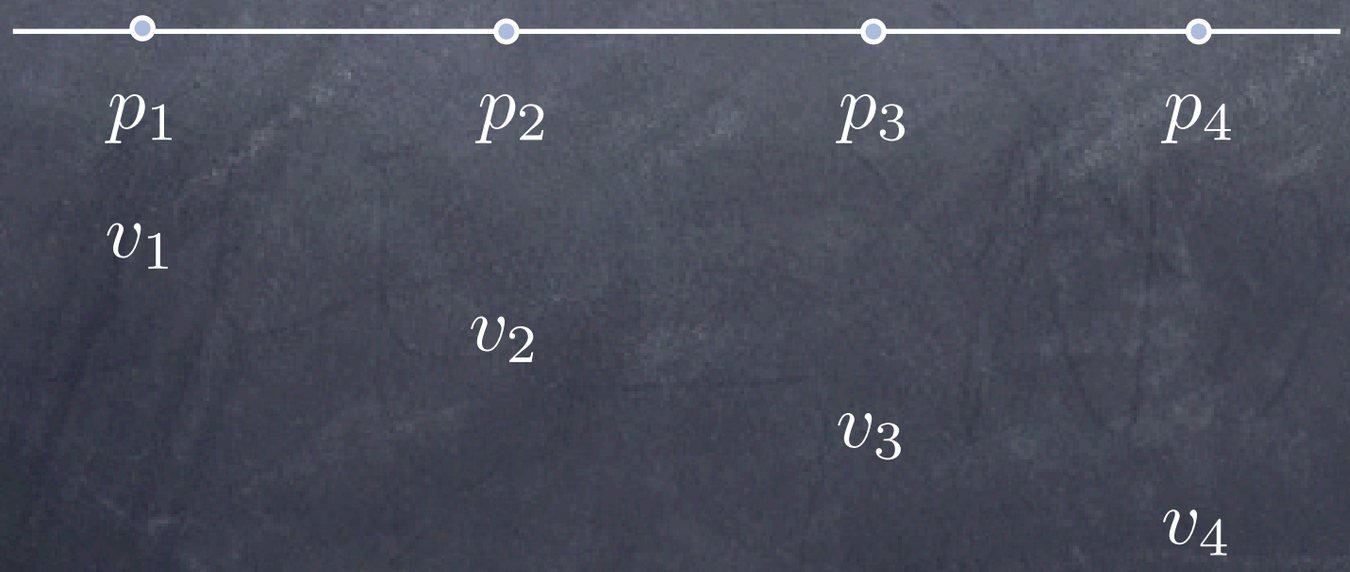
3: receive S_j from p_j

4: $V := V \cup S_j$

5: decide min(V)

An execution





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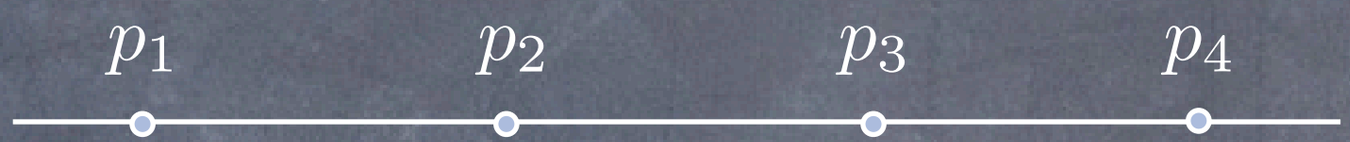
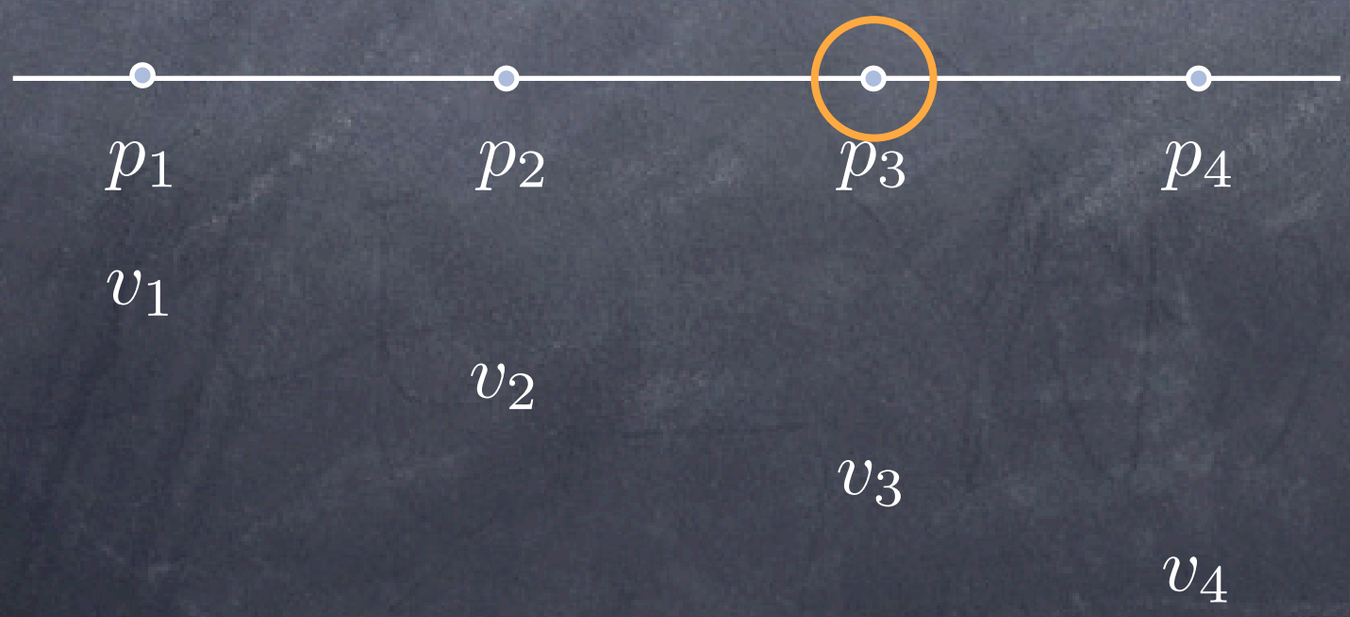
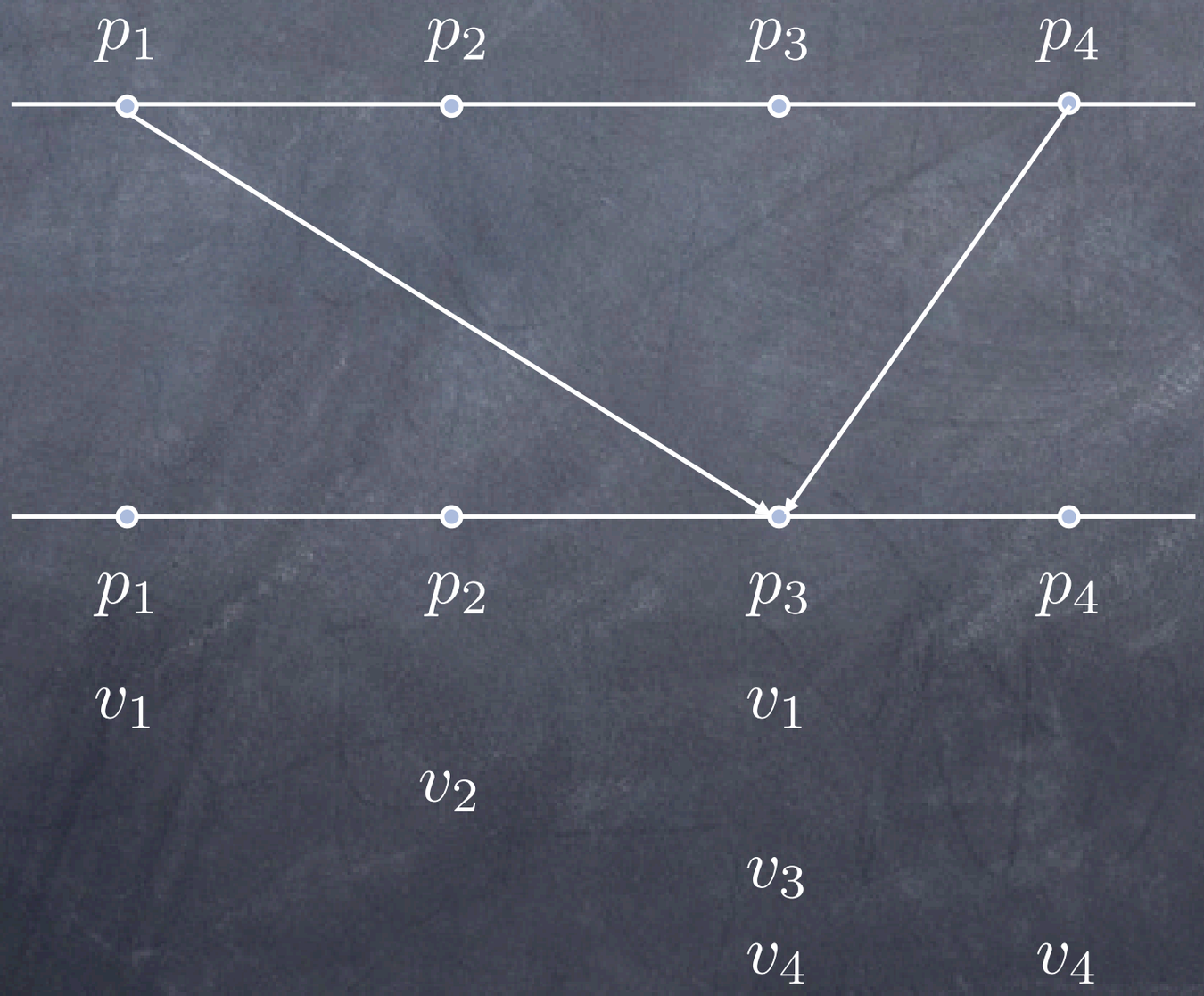




An execution

Suppose $v_1 = v_3 = v_4$ at the end of round 1

Can p_3 decide?



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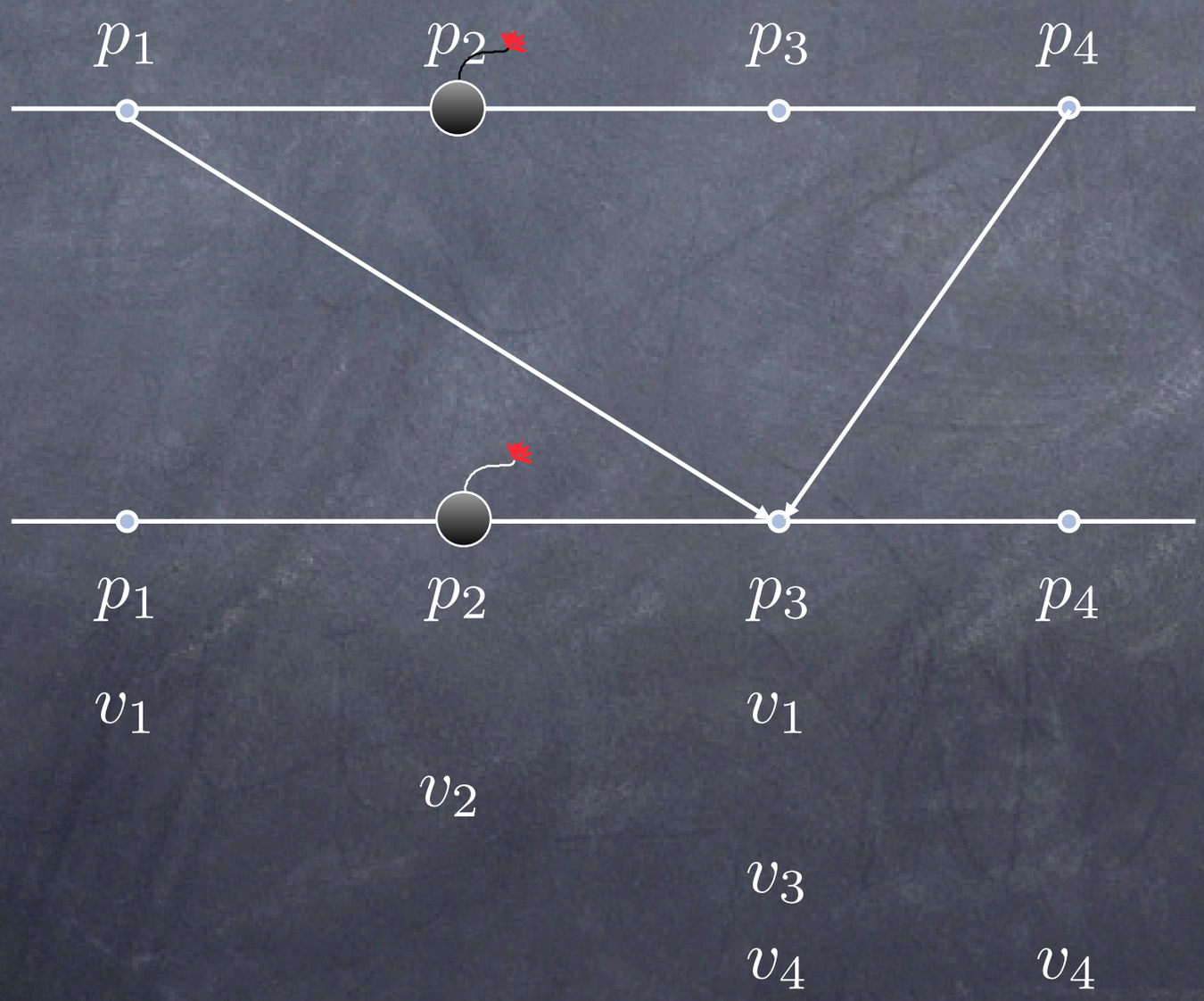

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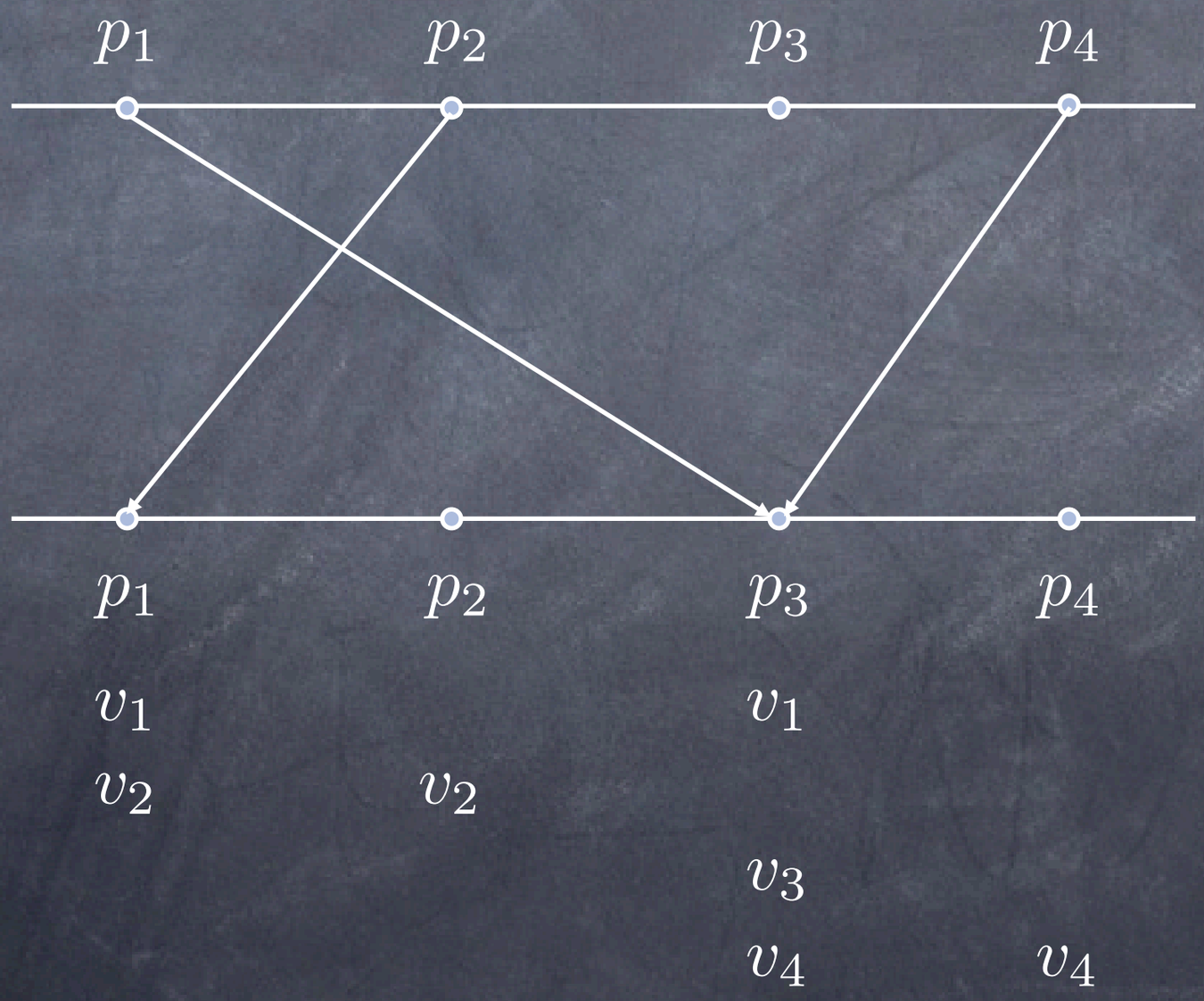

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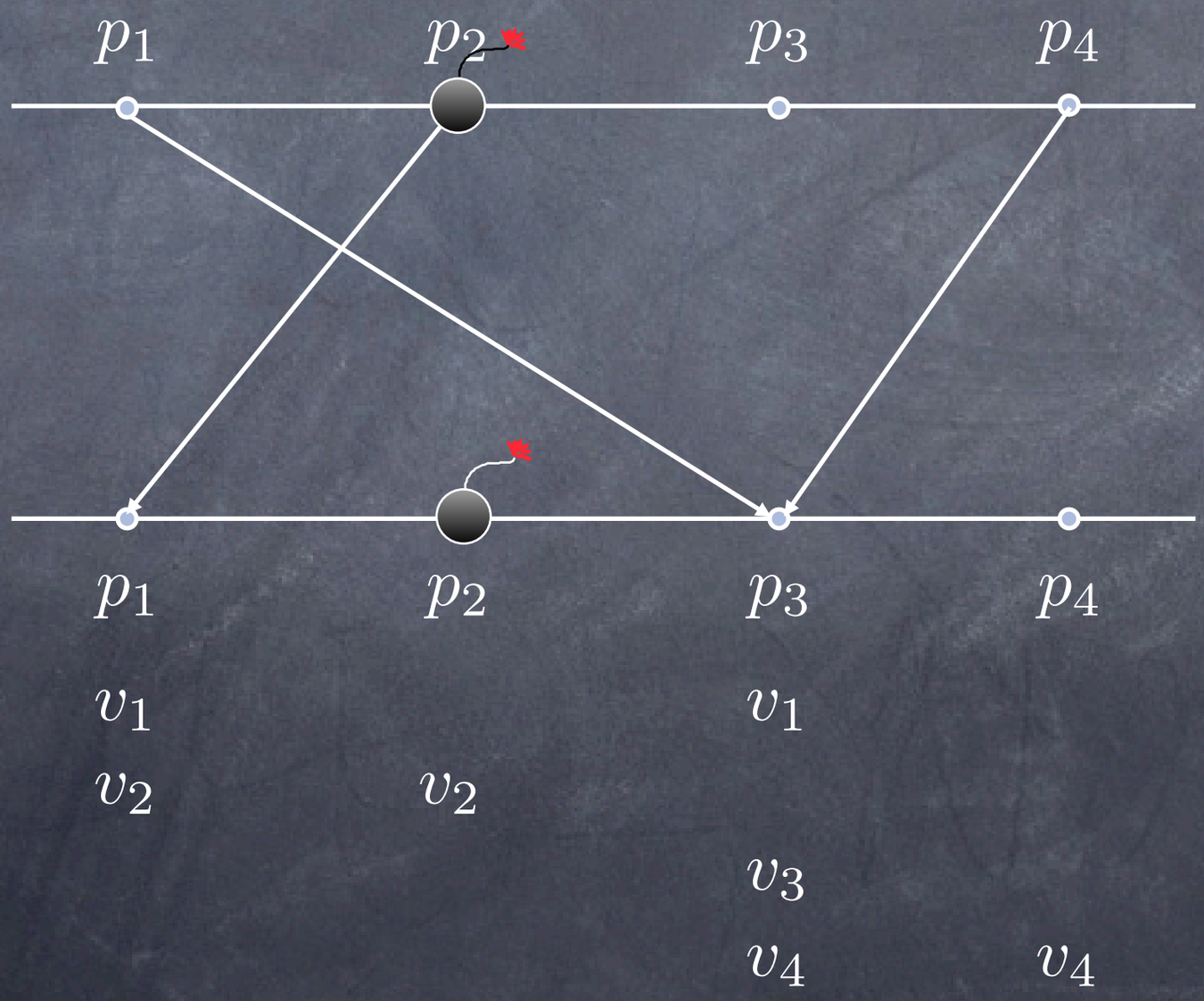

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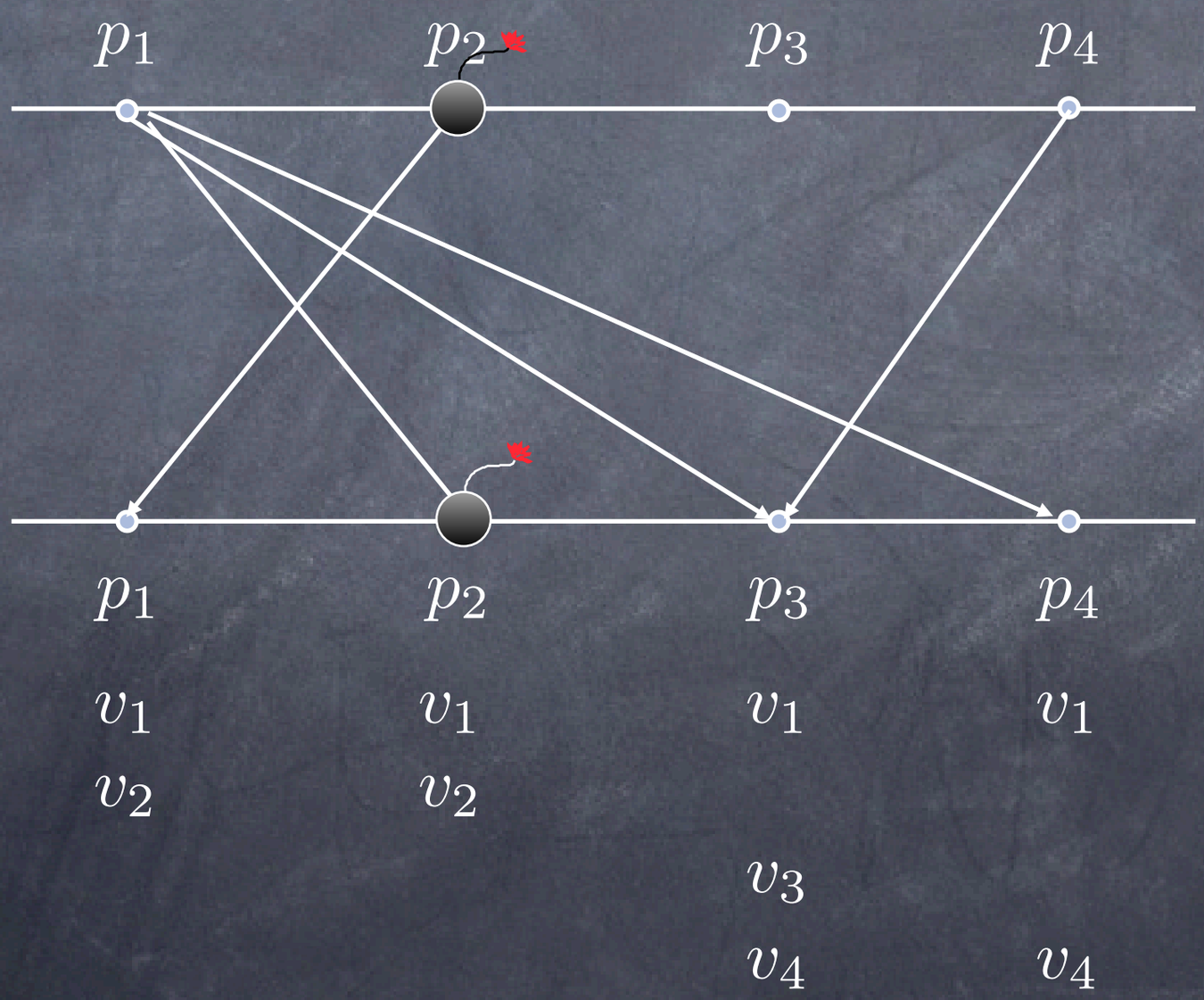

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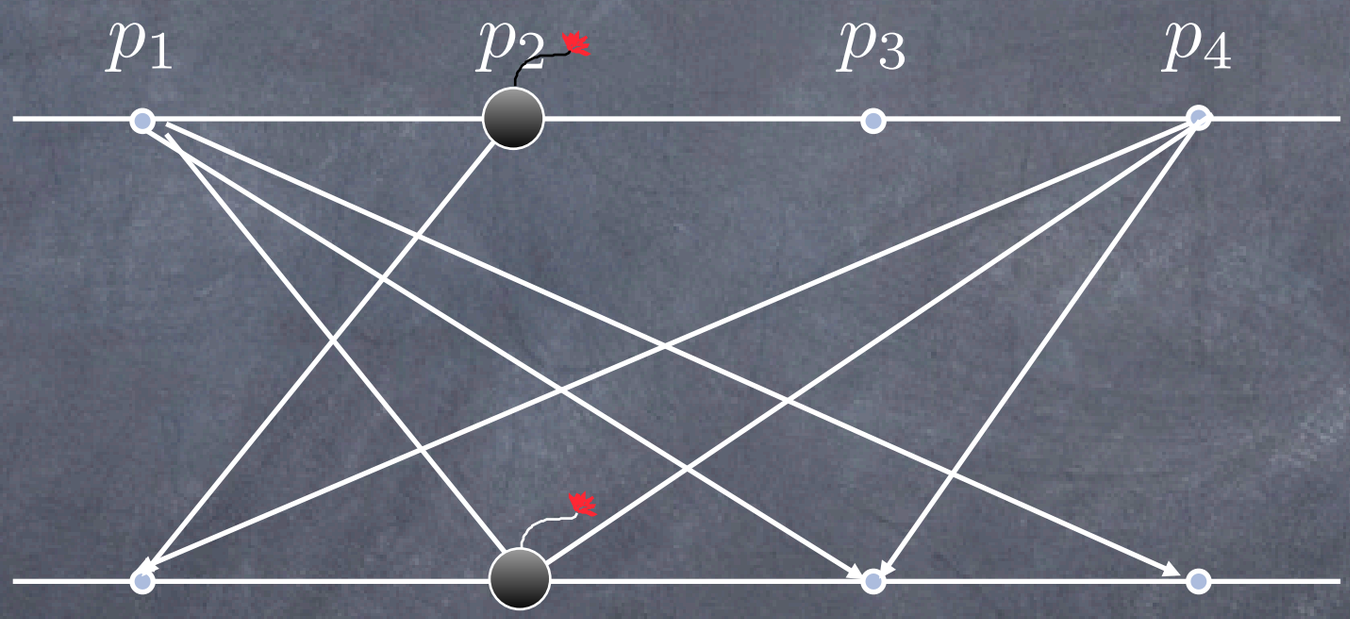

p_1	p_2	p_3	p_4
v_1	v_1	v_1	v_1
v_2	v_2		
		v_3	
v_4		v_4	v_4

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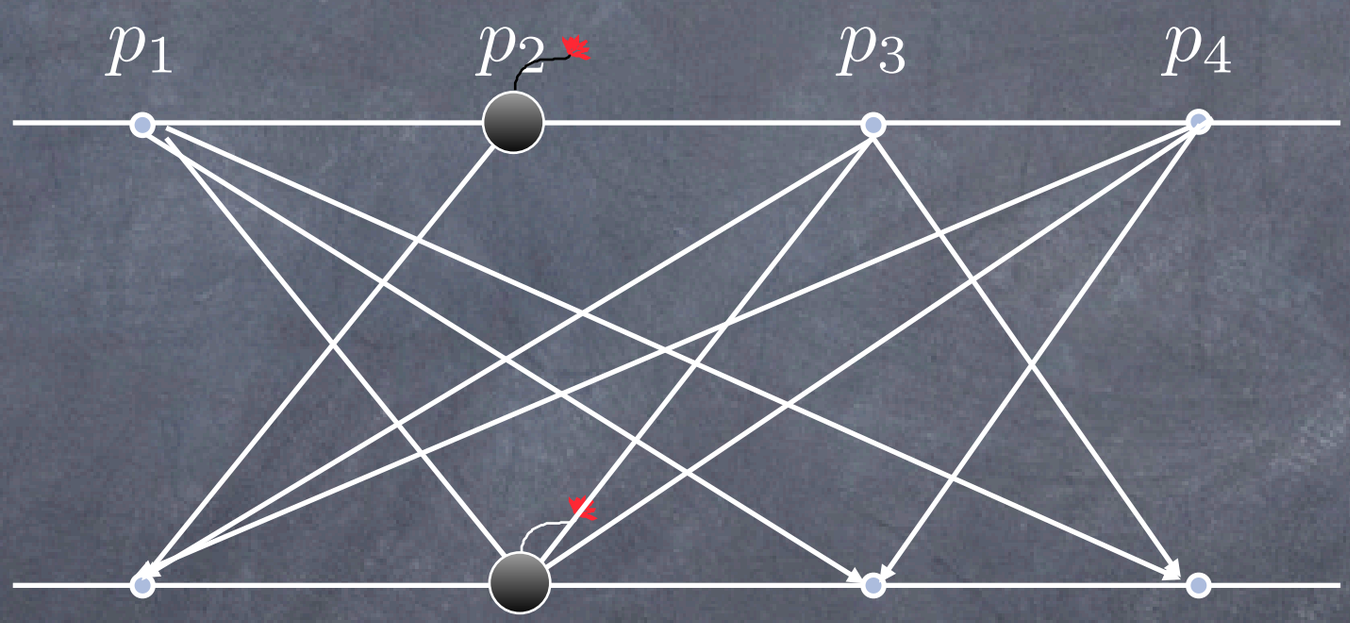

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v_1	v_1	v_1	v_1
v_2	v_2		
v_3		v_3	v_3
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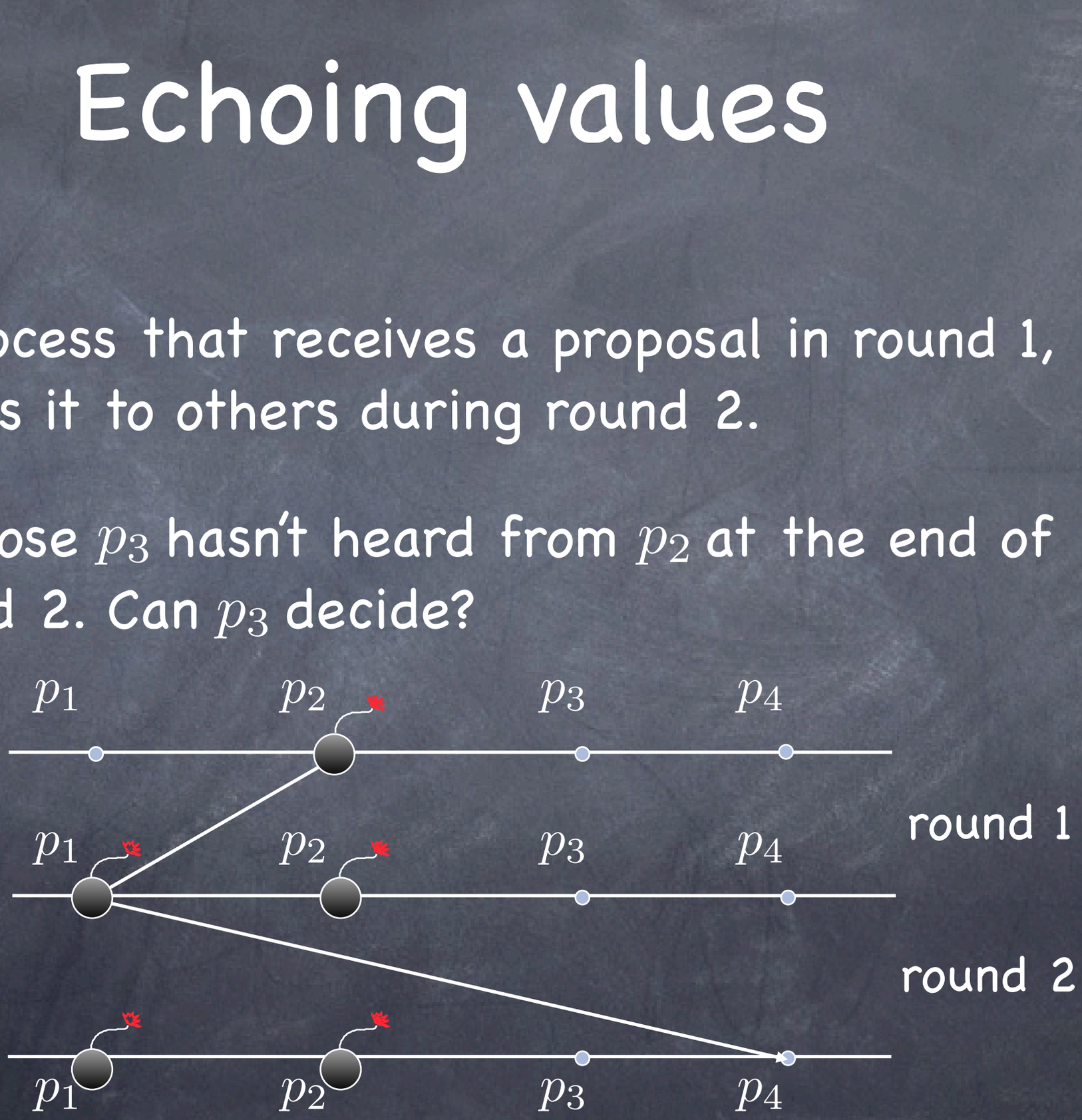


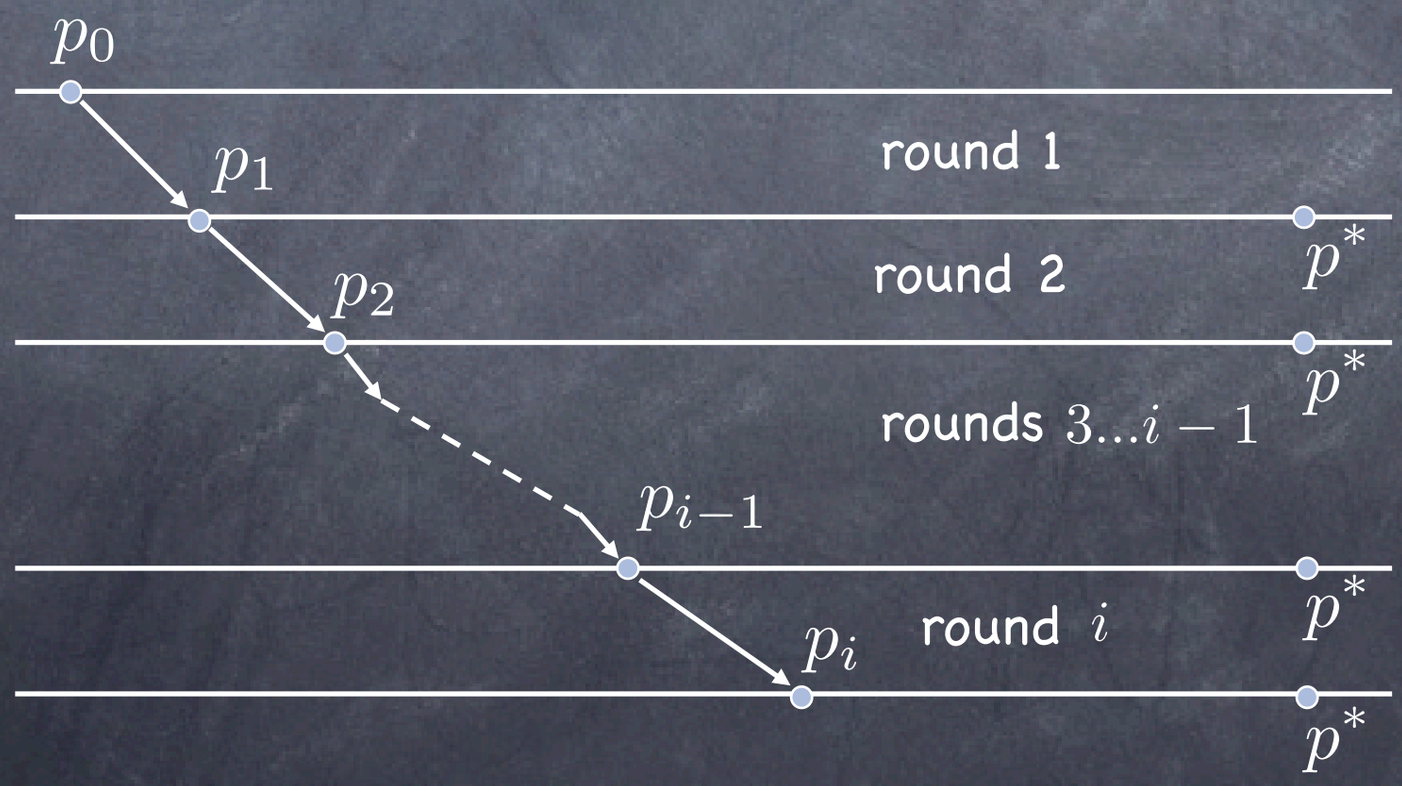
What is going on

- A correct process p^* has not received all proposals by the end of round i. Can p^* decide?
- Another process may have received the missing proposal at the end of round i and be ready to relay it in round $i+1$

Dangerous Chains

Dangerous chain

The last process in the chain is correct, all others are faulty



Living dangerously

How many rounds can a dangerous chain span?

- f faulty processes
- at most $f+1$ nodes in the chain
- spans at most f rounds

It is safe to decide by the end of round $f+1$!

Easy enough, right?

MESSAGES TAKE TIME

Does it matter how much?

OF COURSE!

AND YET...

Should it matter for CORRECTNESS?

Assumptions are vulnerabilities!

ASYNCHRONOUS SYSTEMS

NO centralized clock

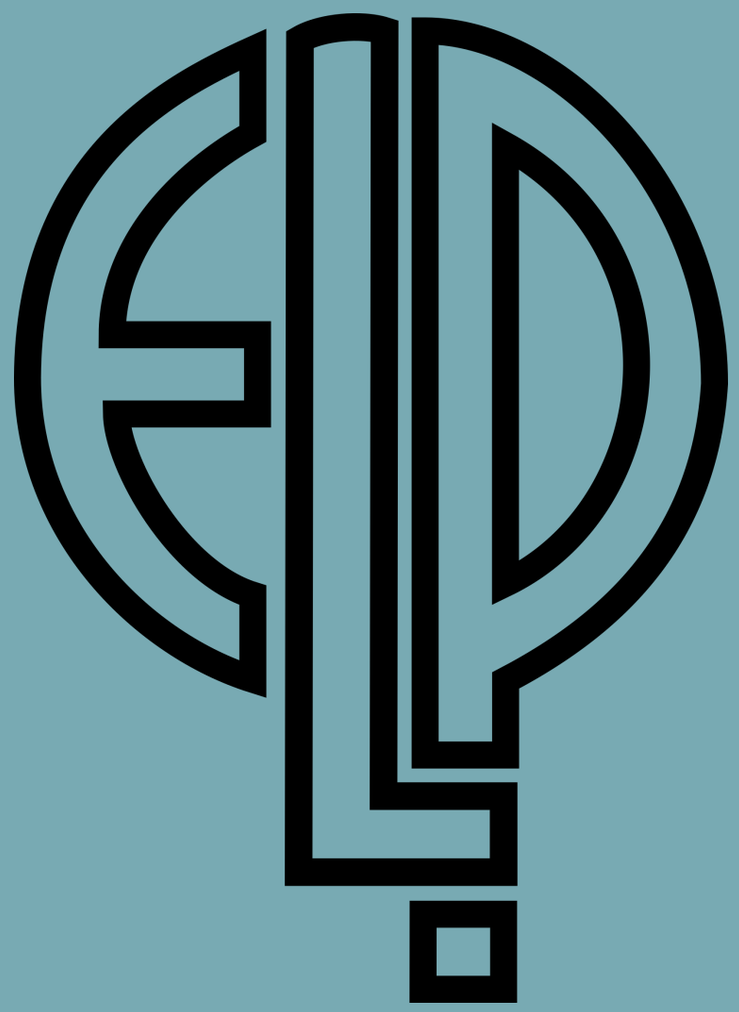
NO upper bound on the relative speed of processes

NO upper bound on message delivery time

CONSENSUS† IS IMPOSSIBLE IN AN ASYNCHRONOUS SYSTEM*

†deterministic

*in the presence of failures



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