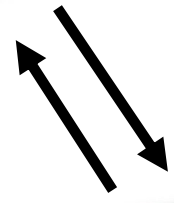
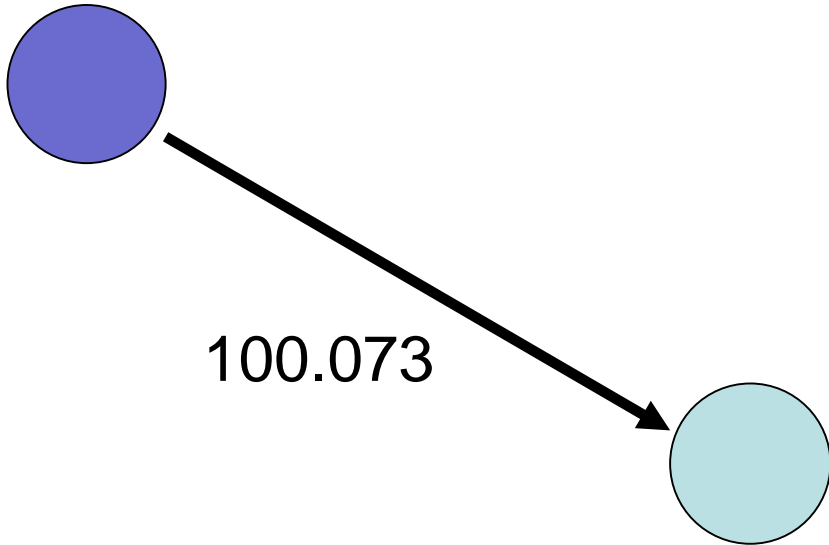


Byzantine Agreement with Median Validity

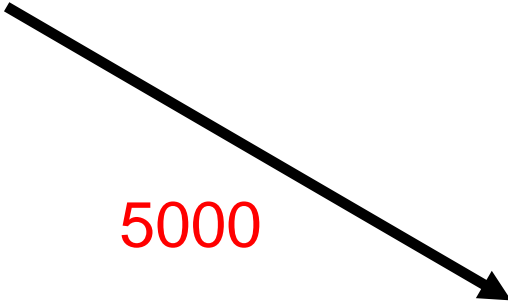
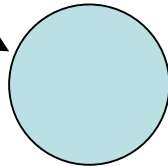
David Stolz and Roger Wattenhofer

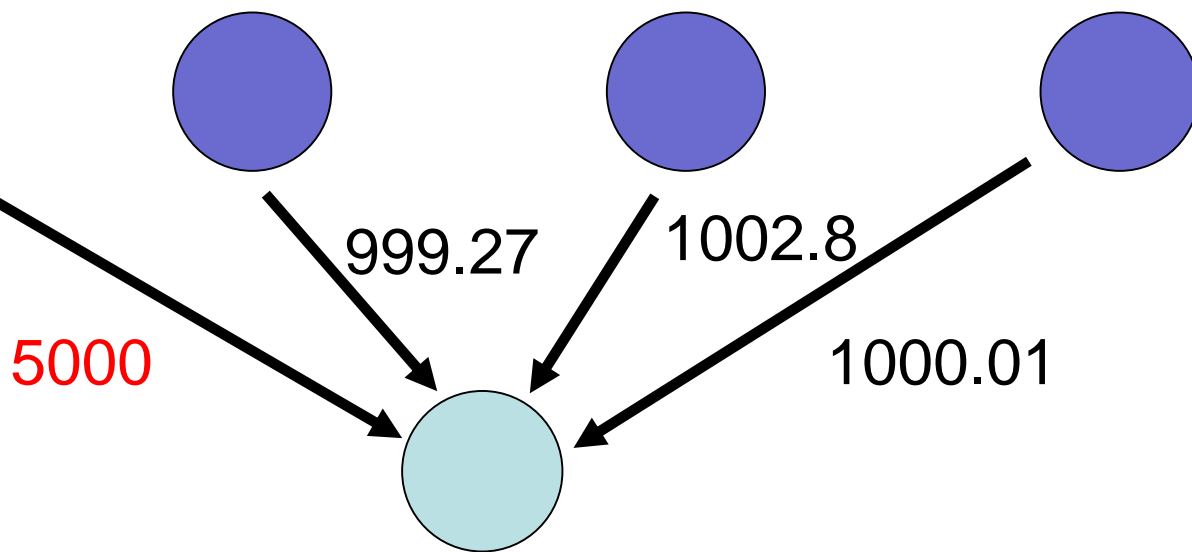


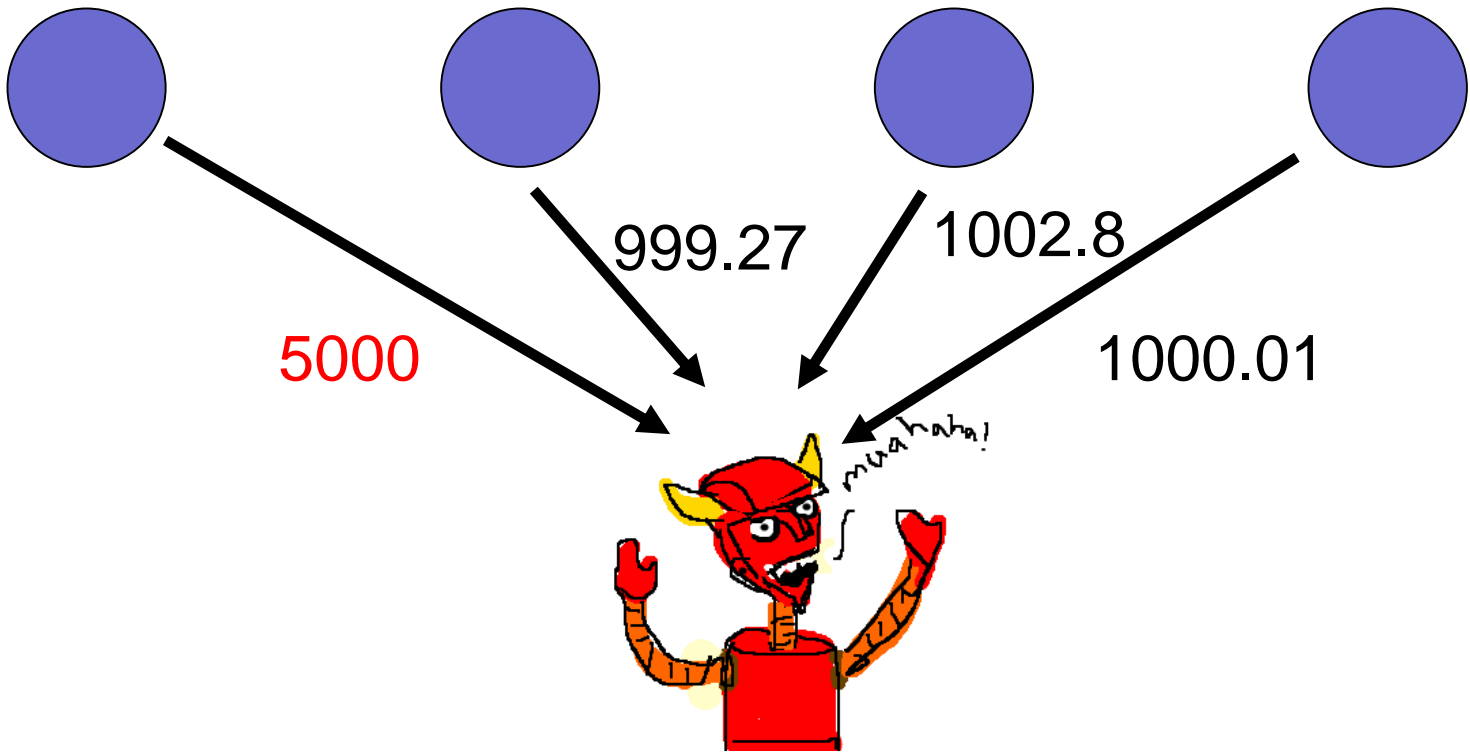


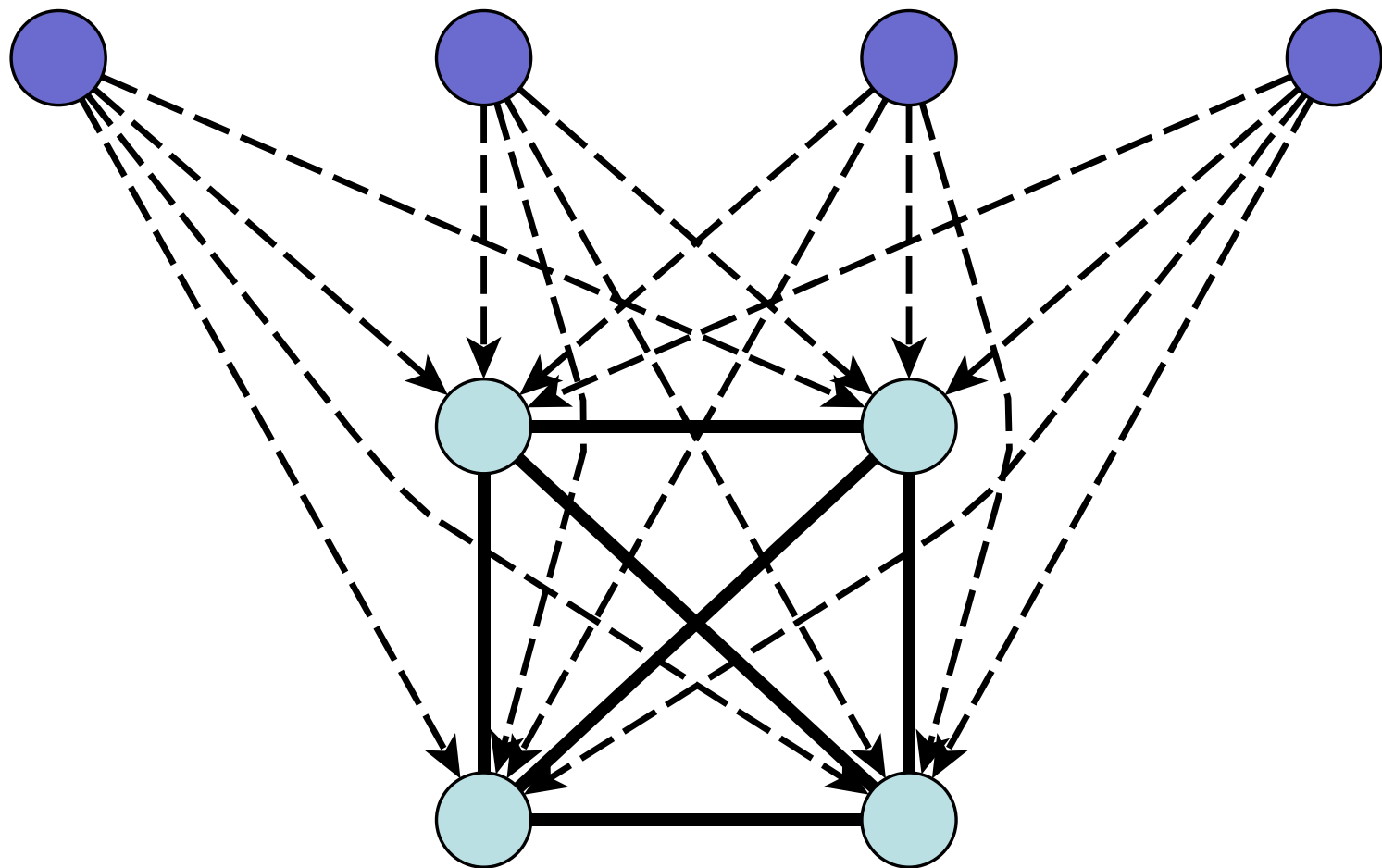


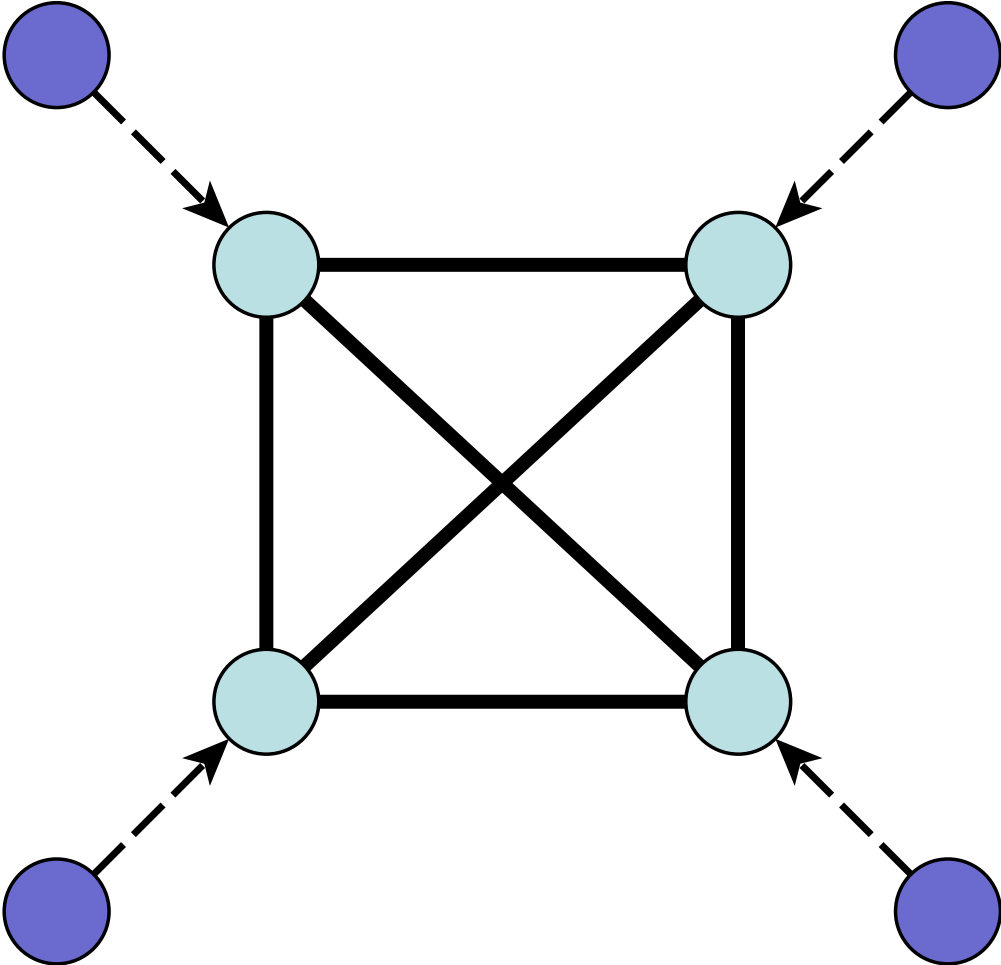
5000











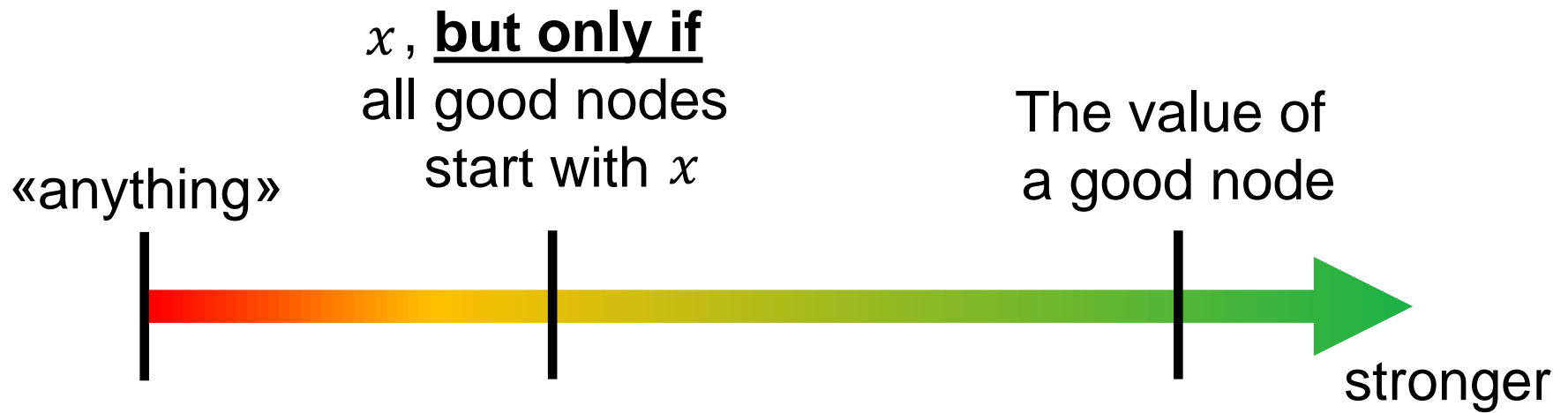
Byzantine Agreement

1. Agreement

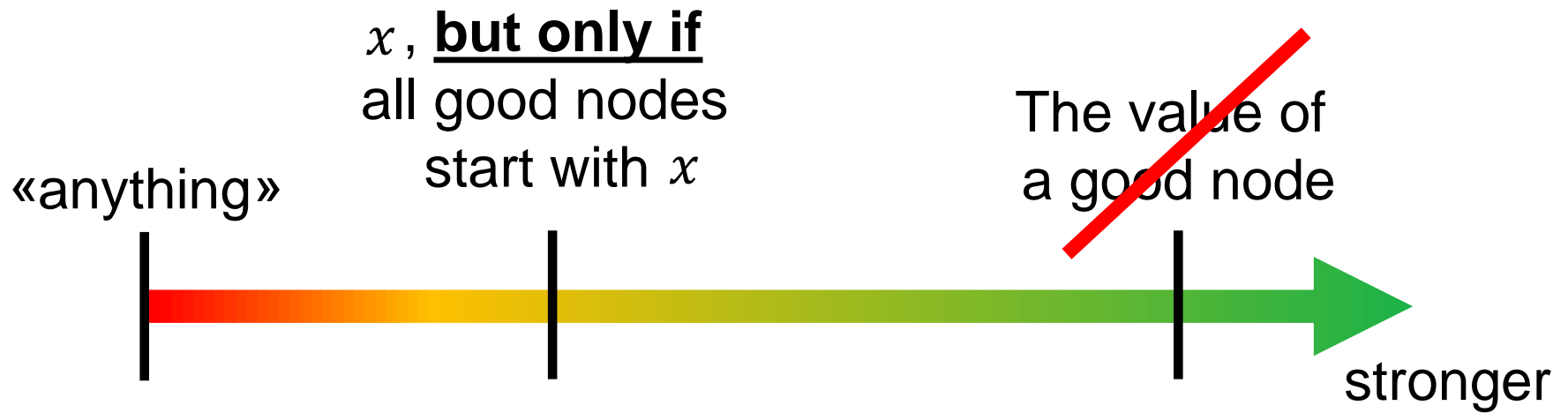
2. Termination

3. Validity

Different Validity Properties

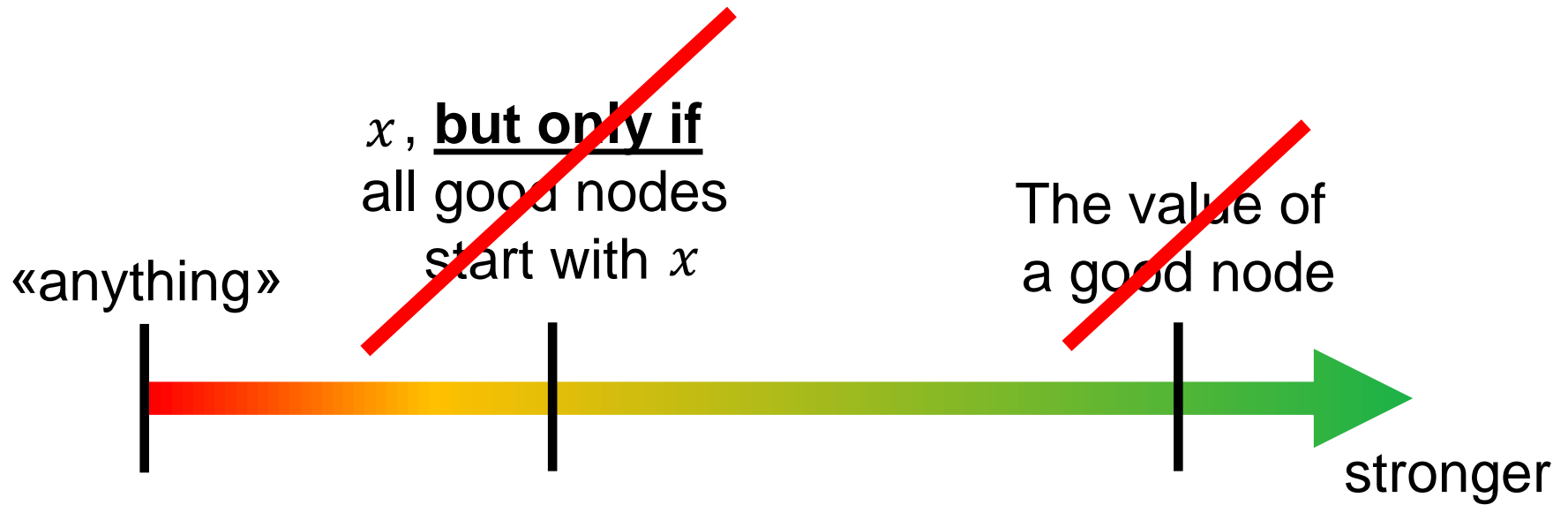


Different Validity Properties for values in \mathbb{R}



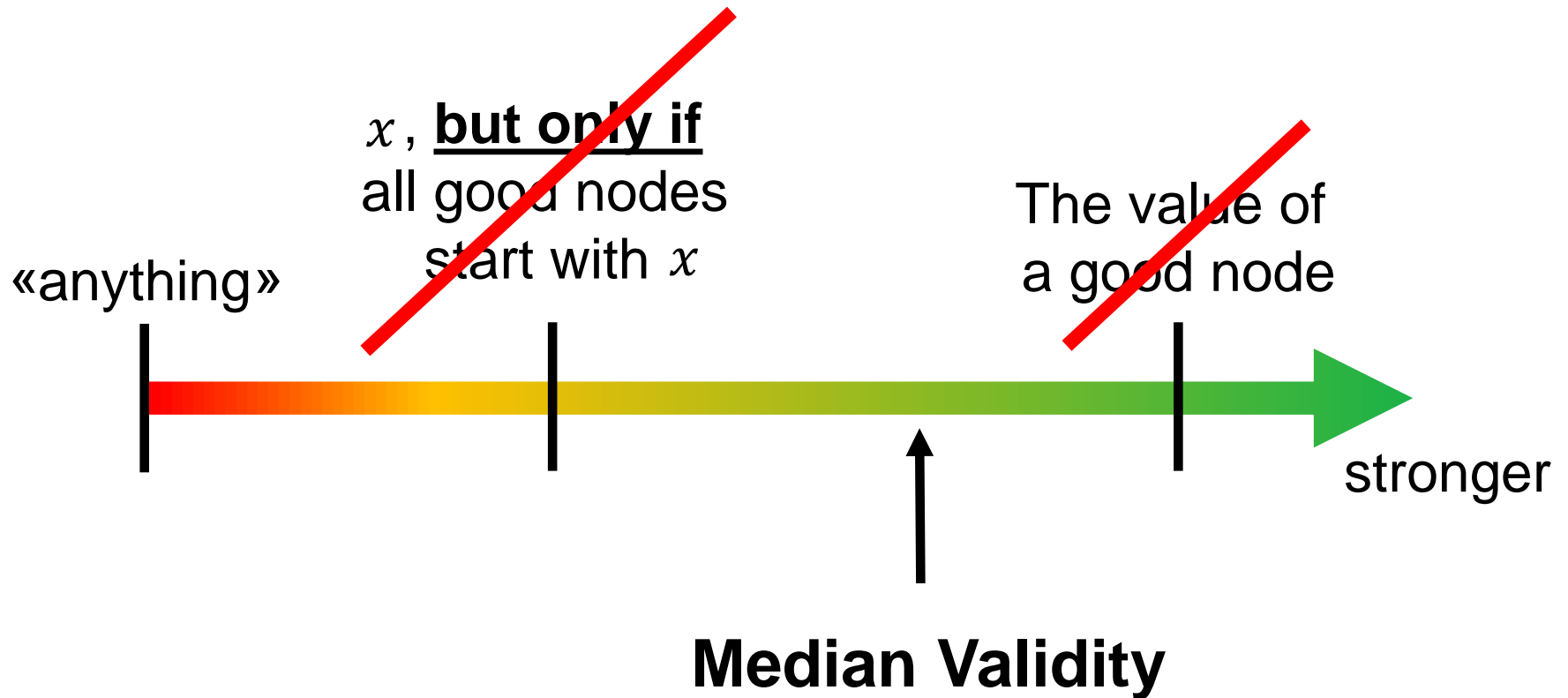
$D \geq 3\mathbb{R}$
[Neiger 94]

Different Validity Properties for values in \mathbb{R}



$D \geq 3\mathbb{R}$
[Neiger 94]

Different Validity Properties for values in \mathbb{R}



Related Work

- Distributed Average Consensus

➡ no byzantine failures

- Byzantine Multi-Agent Optimization: Part I

➡ optimization of cost functions

[Su, Vaidya 15]

Model

- n nodes
- $f \leq t$ byzantine nodes
- synchronous time

996

998

999

1000

1001

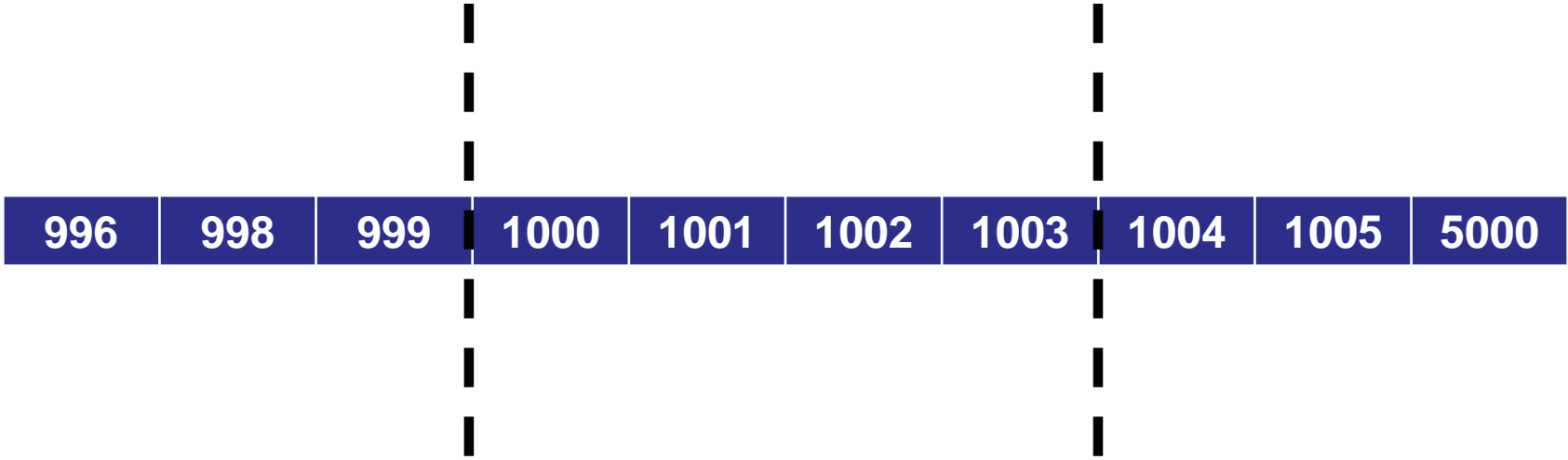
1002

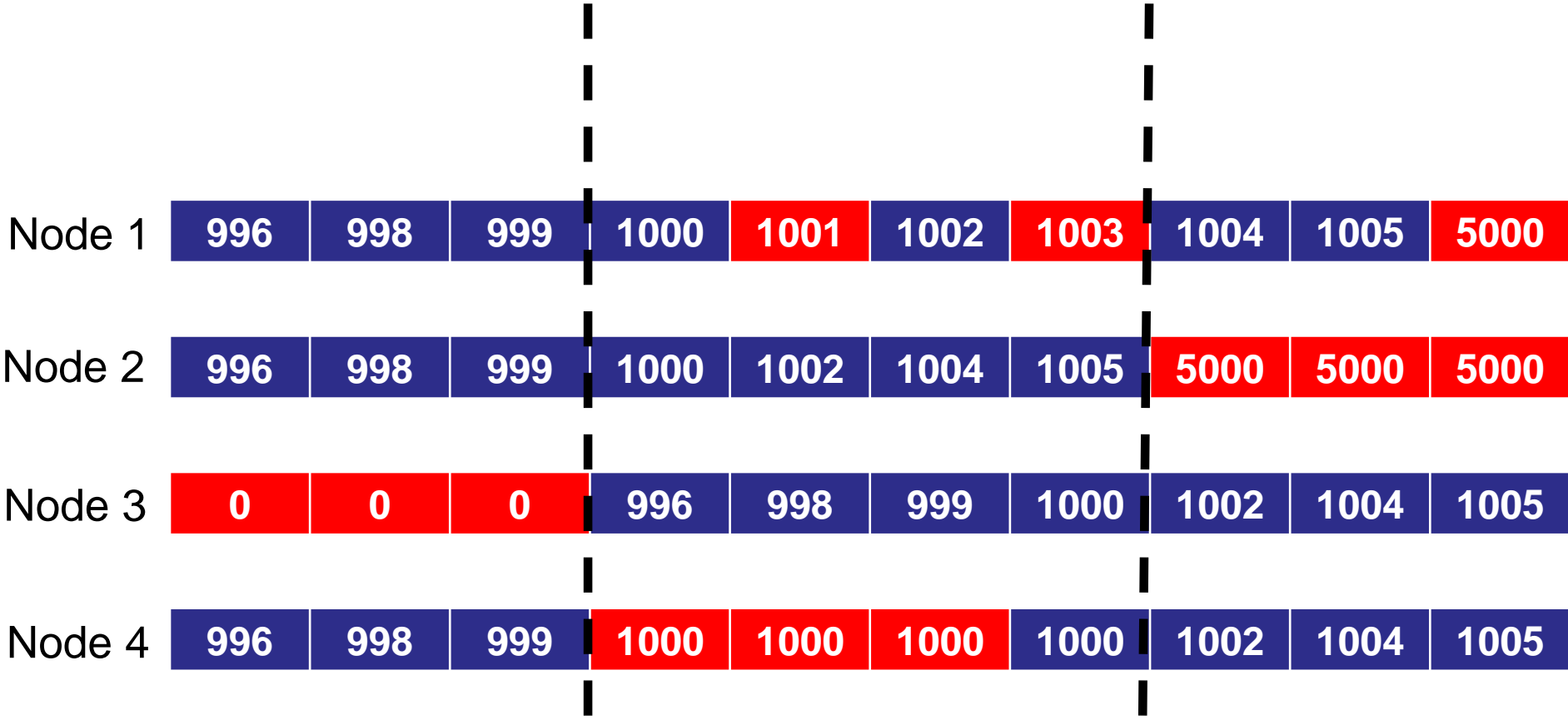
1003

1004

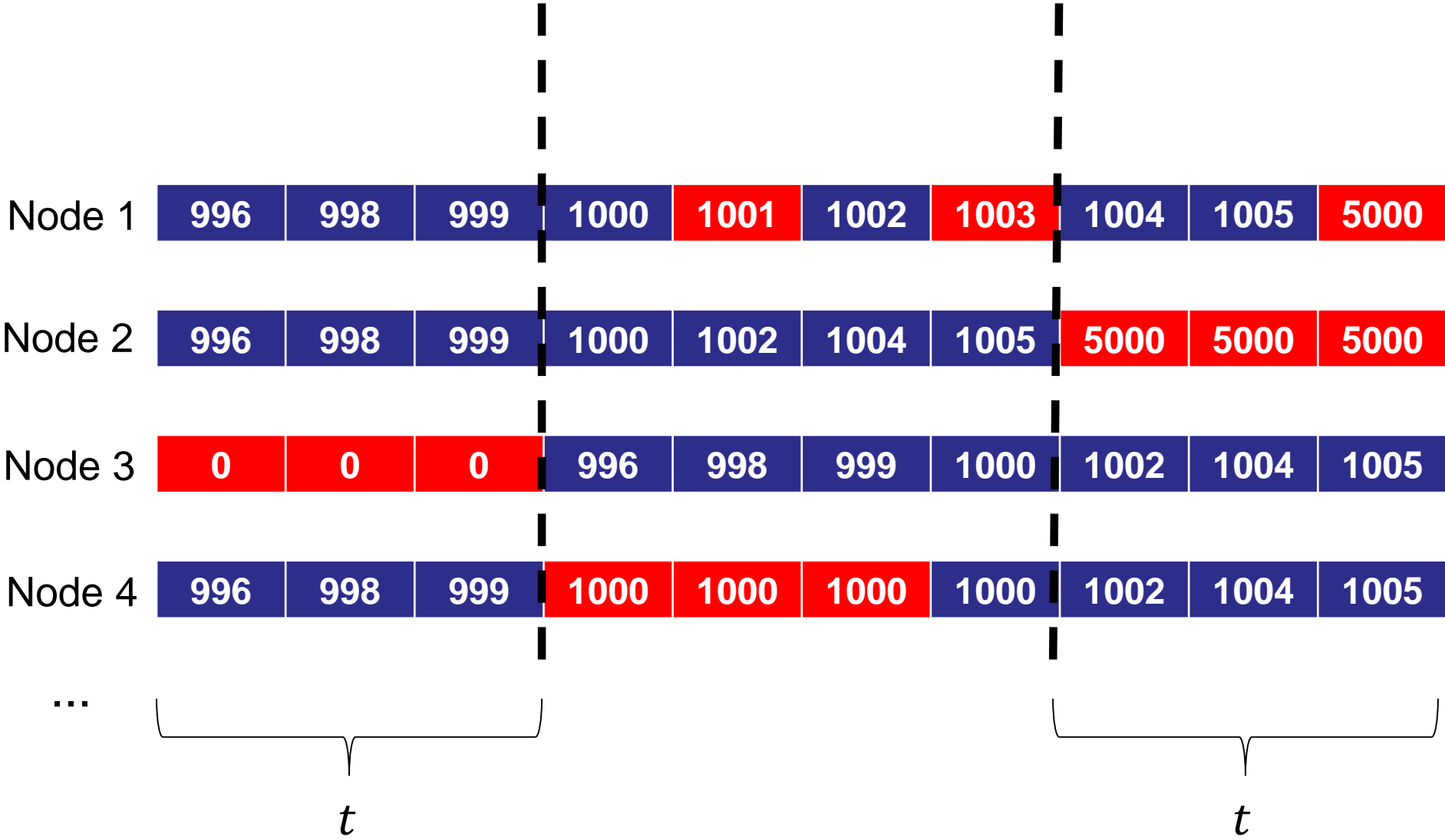
1005

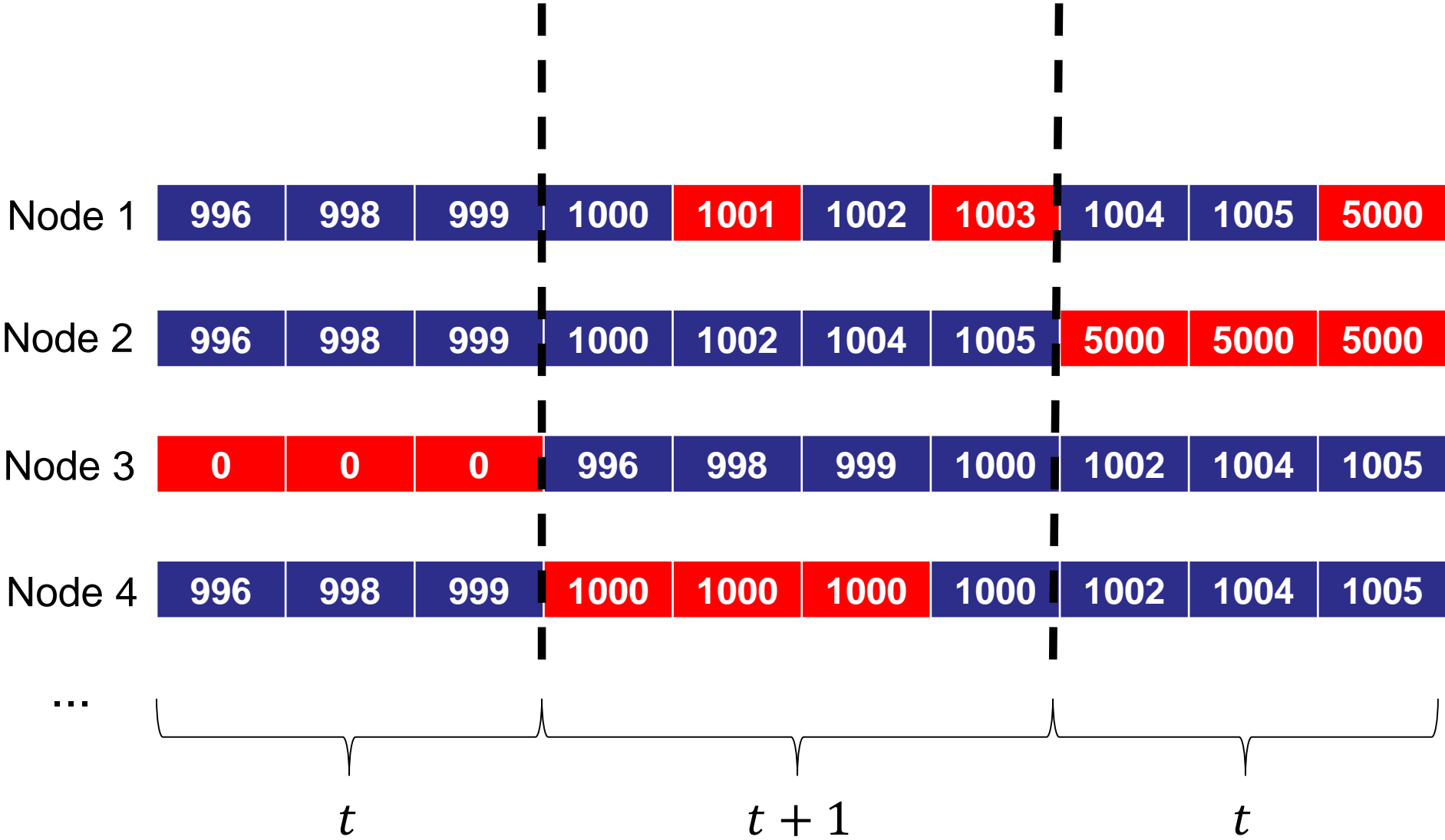
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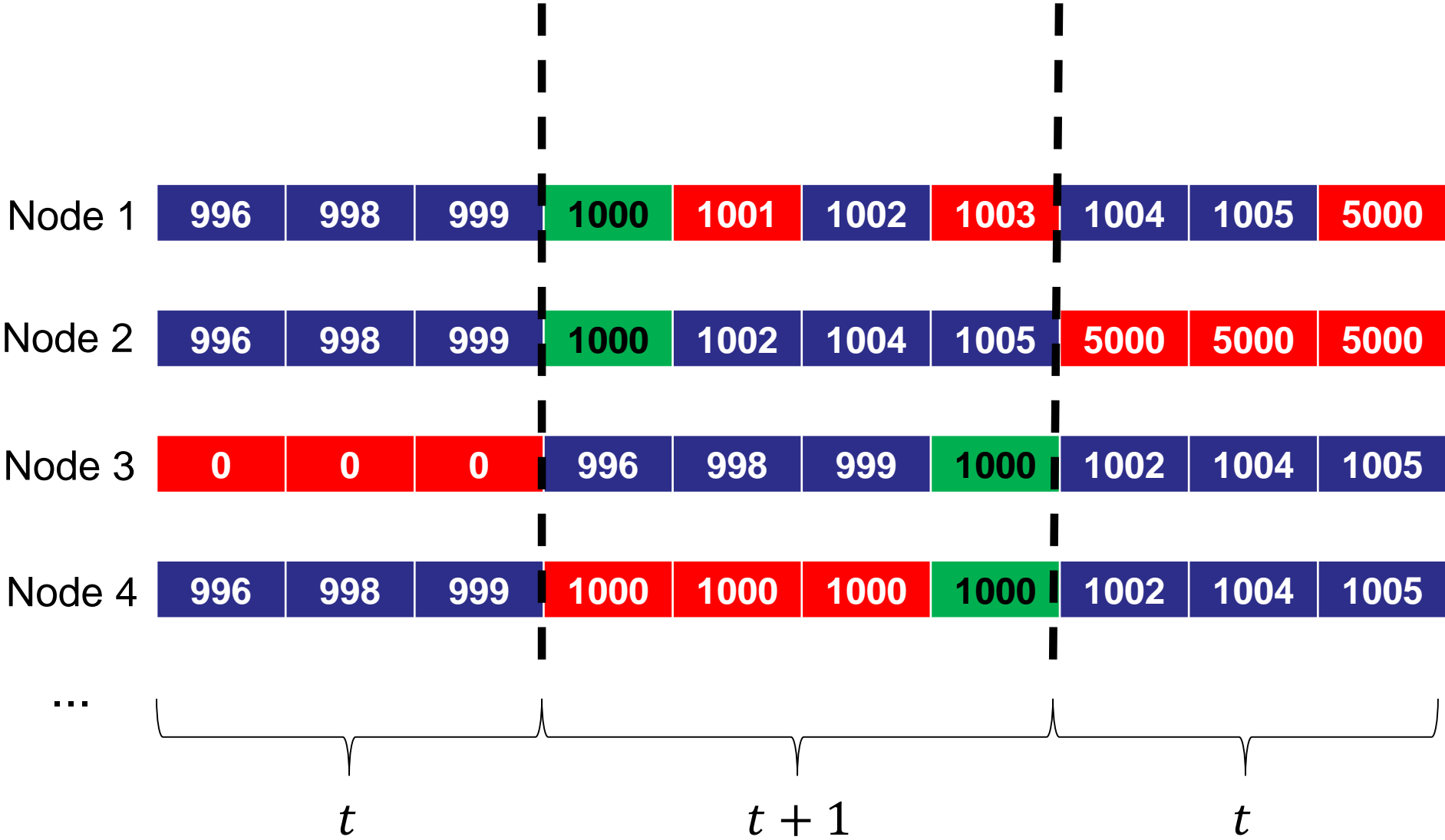




...





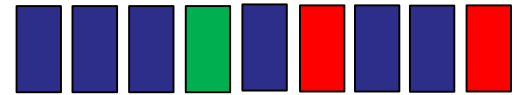




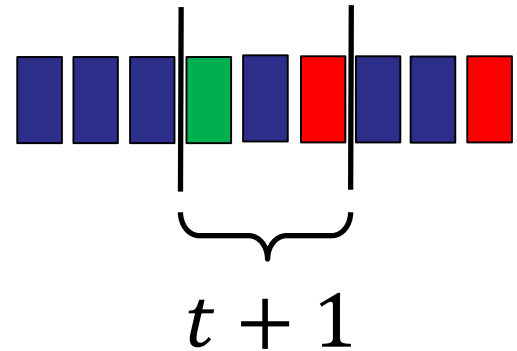


Setup Stage

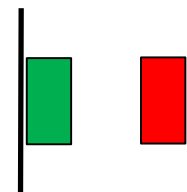
- Broadcast & Gather all values



- Remove potential outliers



- Broadcast & Gather all bounds



Search Stage ($f + 1$ phases)

- Broadcast current value
 - ➔ if agreement already, don't change
- If no agreement, let jack suggest a value
 - ➔ support the suggestion, if in own interval
- Adapt jack suggestion, if enough support

Node 1

1

Node 2

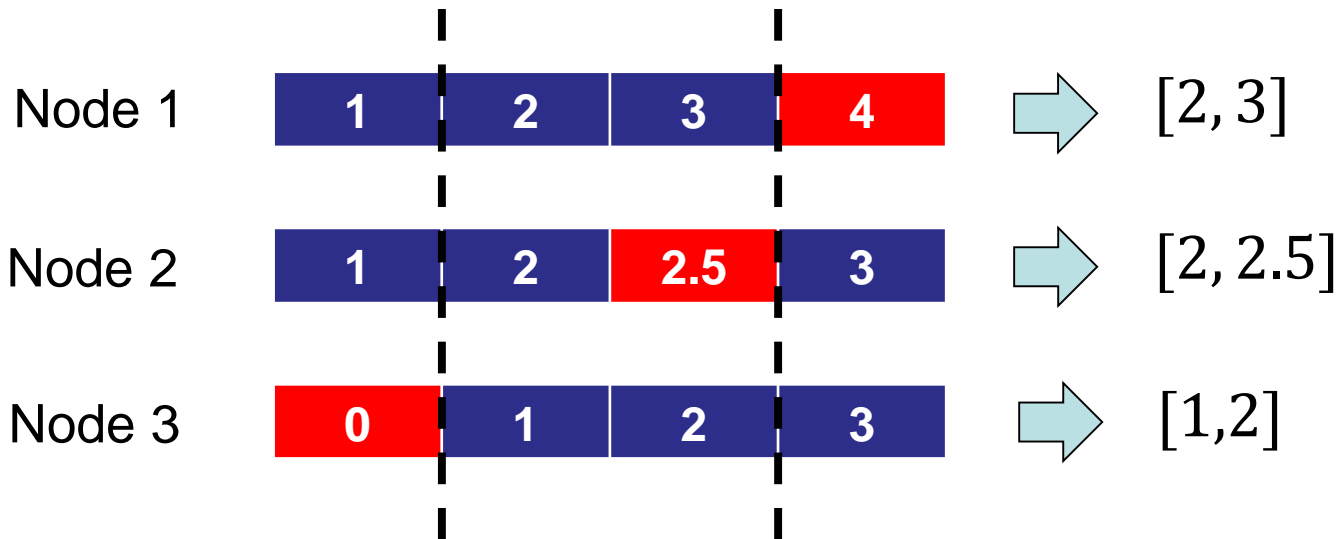
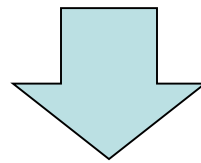
2

Node 3

3

Byzantine Node

?



1. Phase

Step 1

Is there already
Agreement?

1

3

2

?

1. Phase

Step 1

Is there already
Agreement?

1

2

3

?

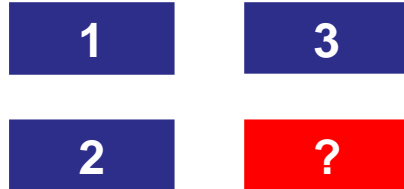
Step 2

Byzantine Jack

999

1. Phase

Step 1
Is there already
Agreement?



Step 2
Byzantine Jack

999

Step 3
Support Jack?

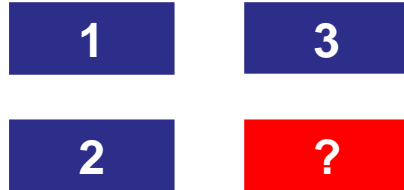
[2, 2.5]

[2, 3] [1,2]

➡ **No!**

1. Phase

Step 1
Is there already
Agreement?



Step 2
Byzantine Jack

999

Step 3
Support Jack?

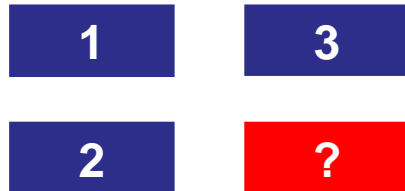
[2, 2.5]

[2, 3] [1,2]

➡ **No!**

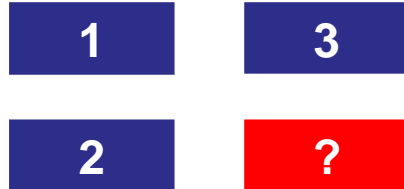
2. Phase

Step 1
Is there already
Agreement?



1. Phase

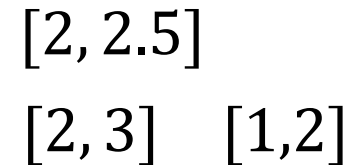
Step 1
Is there already Agreement?



Step 2
Byzantine Jack



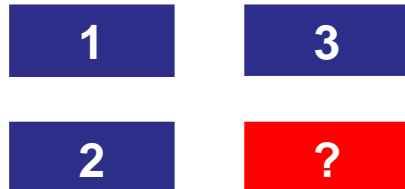
Step 3
Support Jack?



➡ **No!**

2. Phase

Step 1
Is there already Agreement?



Step 2
Good Jack



1. Phase

Step 1
Is there already Agreement?

1	3
2	?

Step 2
Byzantine Jack

999

Step 3
Support Jack?

[2, 2.5]
[2, 3] [1,2]

➡ **No!**

2. Phase

Step 1
Is there already Agreement?

1	3
2	?

Step 2
Good Jack

2

Step 3
Support Jack?

[2, 2.5]
[2, 3] [1,2]

➡ **Yes!**

Only good values



Median Validity

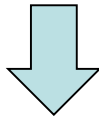


Lower bound
(tight)

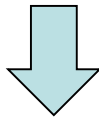


Conclusion

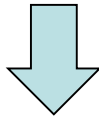
Validity property is essential



Median Validity



Efficiently achievable



Good quality

Optimal* time	$O(t + 1)$ rounds
Optimal resilience	$n > 3t$
Small messages	1 value / message

* if $f = t$

2-Approximation in index distance
Always in the range of the good values