Use of Multi-Master PTP to Mitigate Faulty Masters Reporting as Healthy

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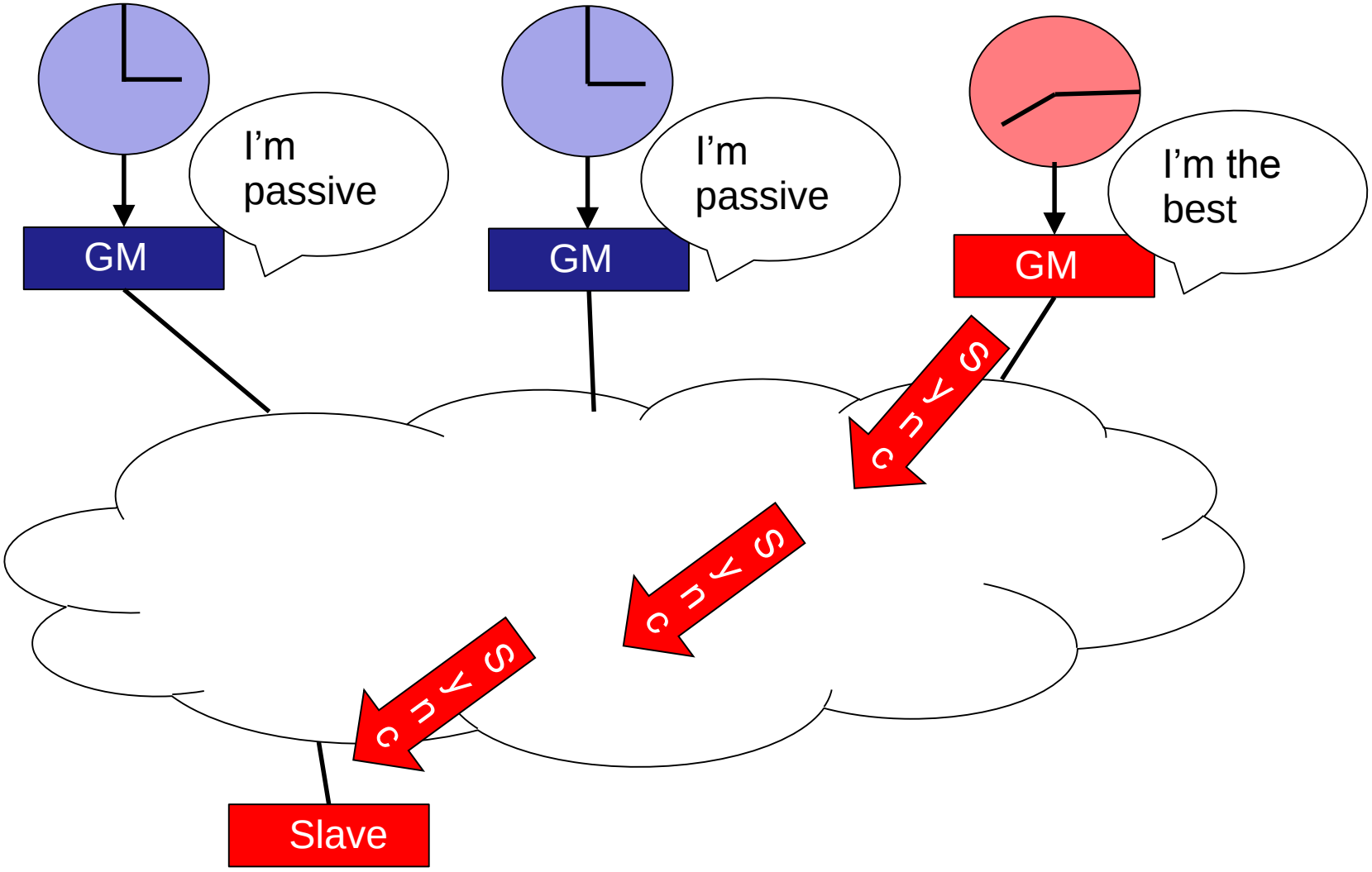
Agenda

1. A weakness with PTP
2. Proposed solution for PTP: multi-master PTP
3. Voting algorithms
4. Simulations results
5. Conclusions

Single Point of Failure!



Solutions From Other Technologies

General approach

- Compare multiple sources of time and remove any which are “different” from the rest
- Bad time sources can be identified if they make up less than half of the number available sources

GPS Timing receivers

- TRAIM
- In timing mode (using fixed position)

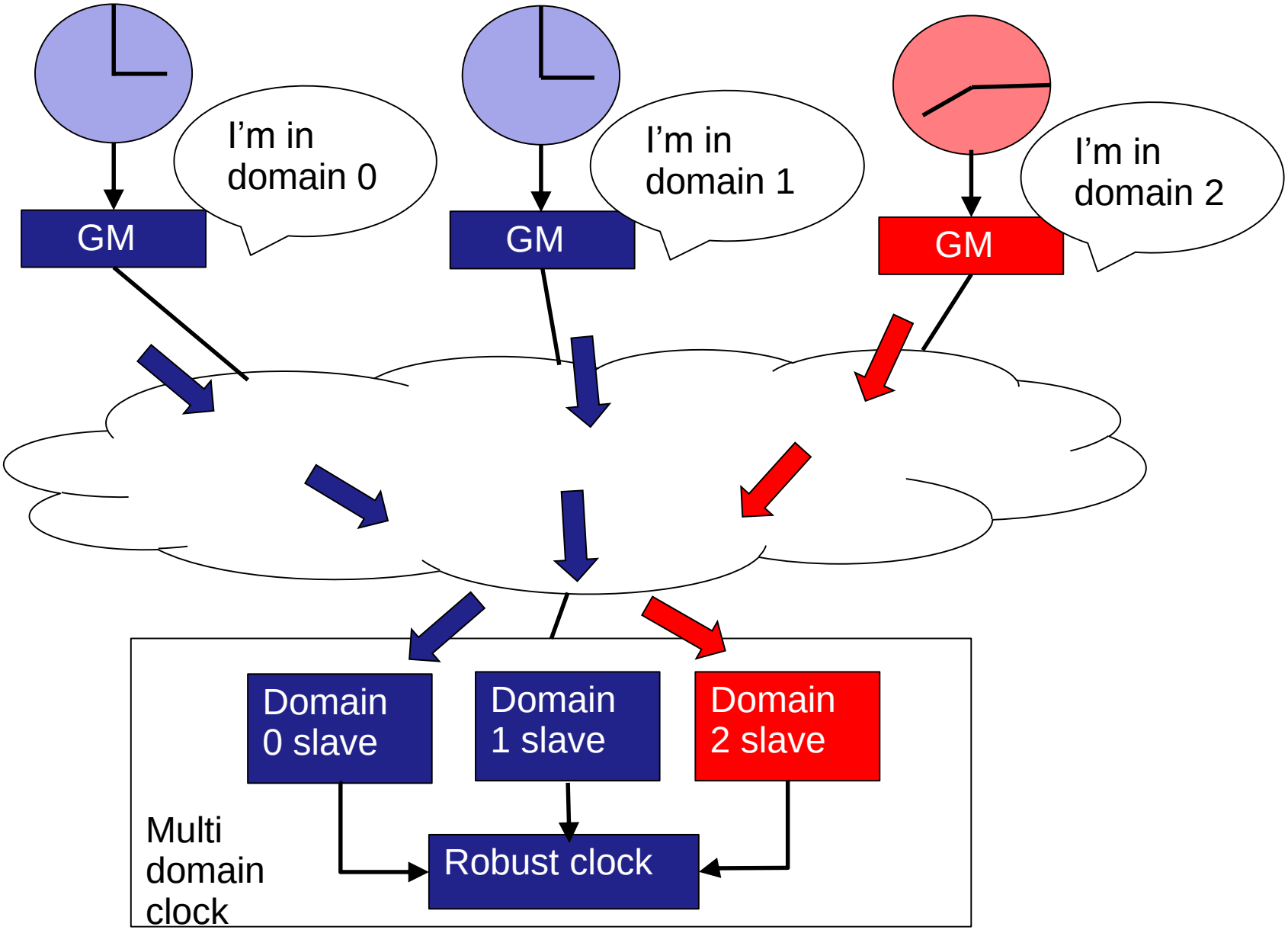
NTP

- False tickers identification algorithm

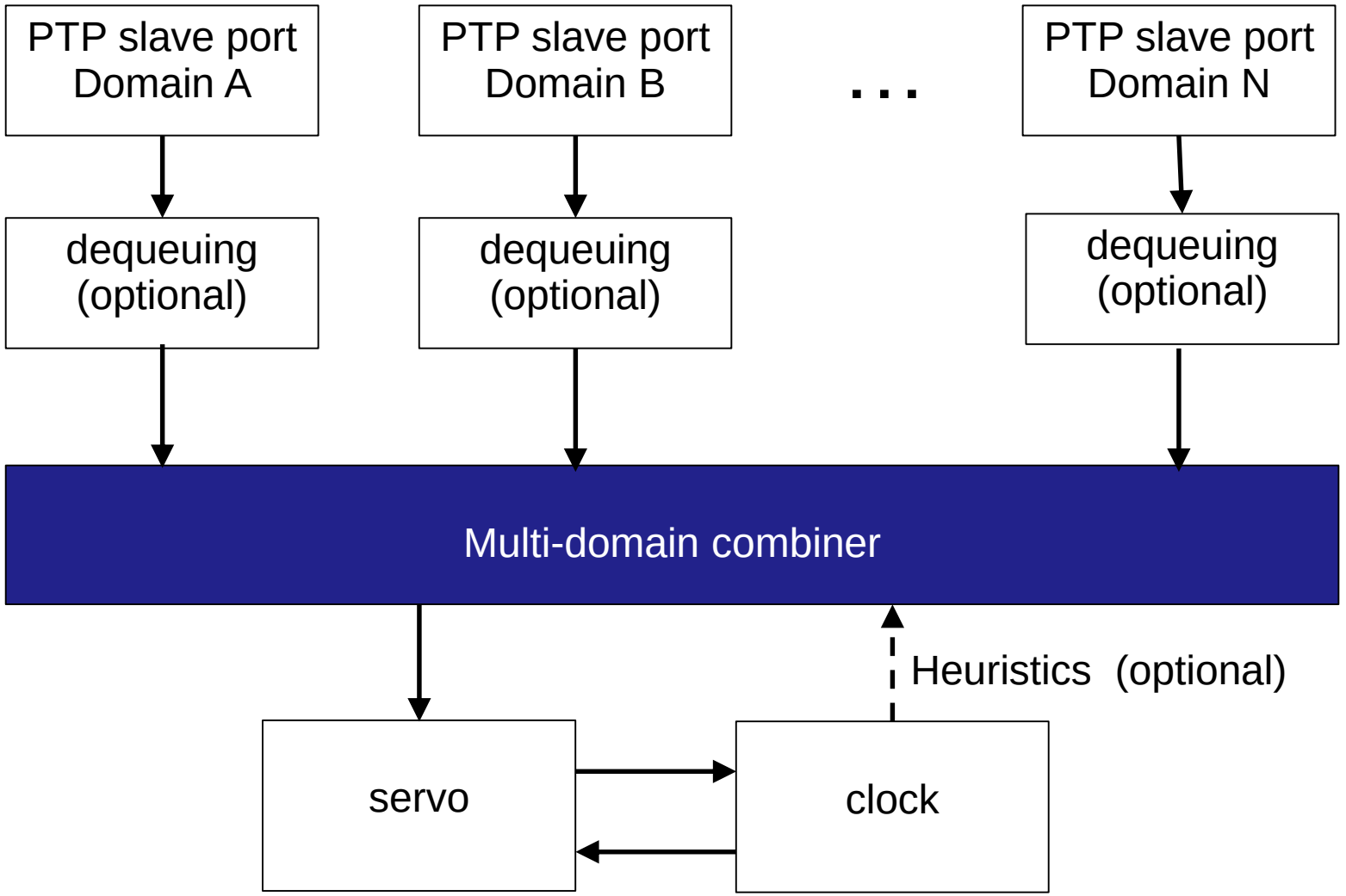
From robust statistics

- Use median value from population
- Insensitive to outliers, even with very large errors

Proposal in IEEE 1588 Working Group



Robust Clock



Timing Receiver Autonomous Integrity Monitoring

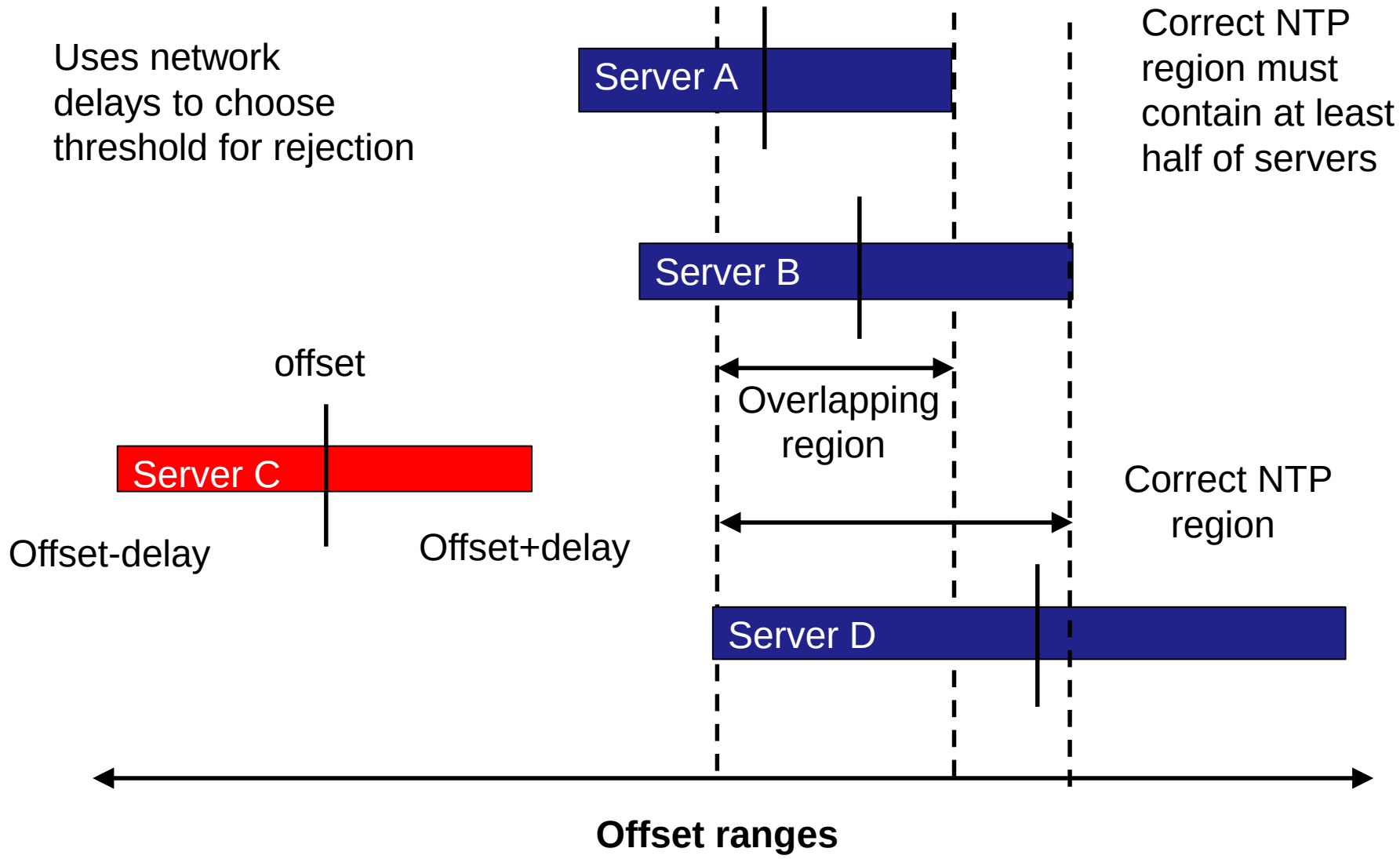
Described at ION-GPS 1996-1998 by Motorola
Looks at clock offsets only, not propagation delay
Threshold offset for bad satellite identification (user configured)

Recursive Algorithm

0. GPS receiver in timing mode with a known position
1. Obtain local clock offset with respect to each satellite
2. Compute the mean_offset
3. If |Offset(i) – mean_offset| > max_offset_deviation
   - Remove satellite(i) from calculation
   - Goto step 1
4. Stop when all offsets are within the max_offset_deviation of the mean
5. Or when the number of satellites < 3
6. Use mean_offset with bad satellites removed

PTP: Satellite = domain

NTP False Ticker Identification



Comparison of Approaches

When to exclude time sources

- Median: always exclude all but median
- TRAIM : up to half +1 if they are over threshold from average
- NTP: only when majority of clocks agree with each other

Threshold for exclusion

- TRAIM: manually set and fixed
  - OK for GPS where noise properties are relatively constant
- NTP: determined by network delay
  - Good worst case error for NTP dominated by raw queuing noise
  - Automatically changes with different network delays

Adapting NTP algorithm to PTP

- Need different criteria for determining offset ranges
  - Range of offsets in a window?
  - Standard deviation from recent data?

Simulations

Focus on source selection

- Ignore dequeuing filters
- Ignore servo-loop filters

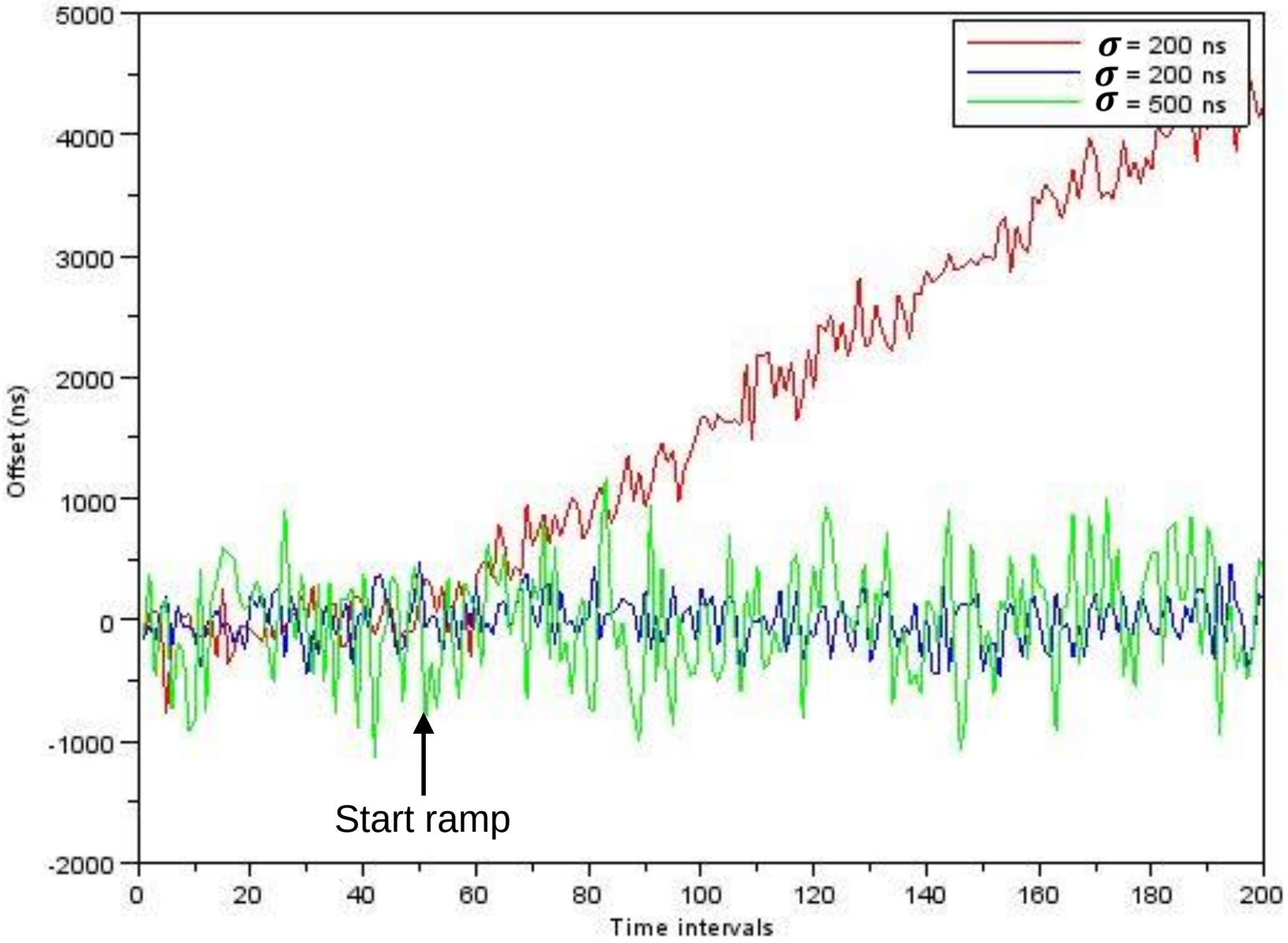
Source selection type

- TRAIM like
- NTP false ticker identification
- Simple median

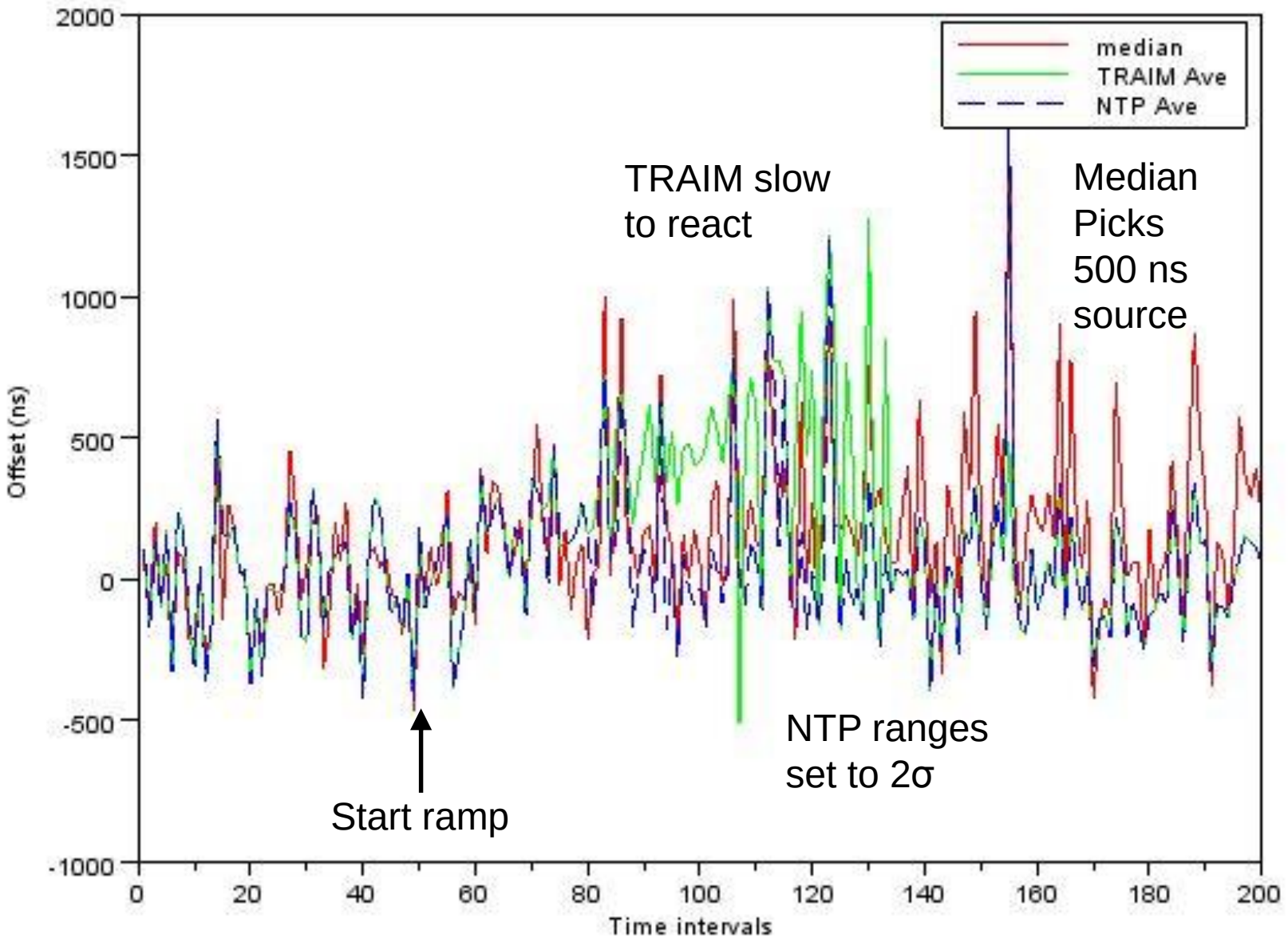
3 Time Sources

- Normal random time transfer errors
  - Dequeued delays and offsets from unicast networks
  - Boundary clock networks
- False ticker
  - Ramp error

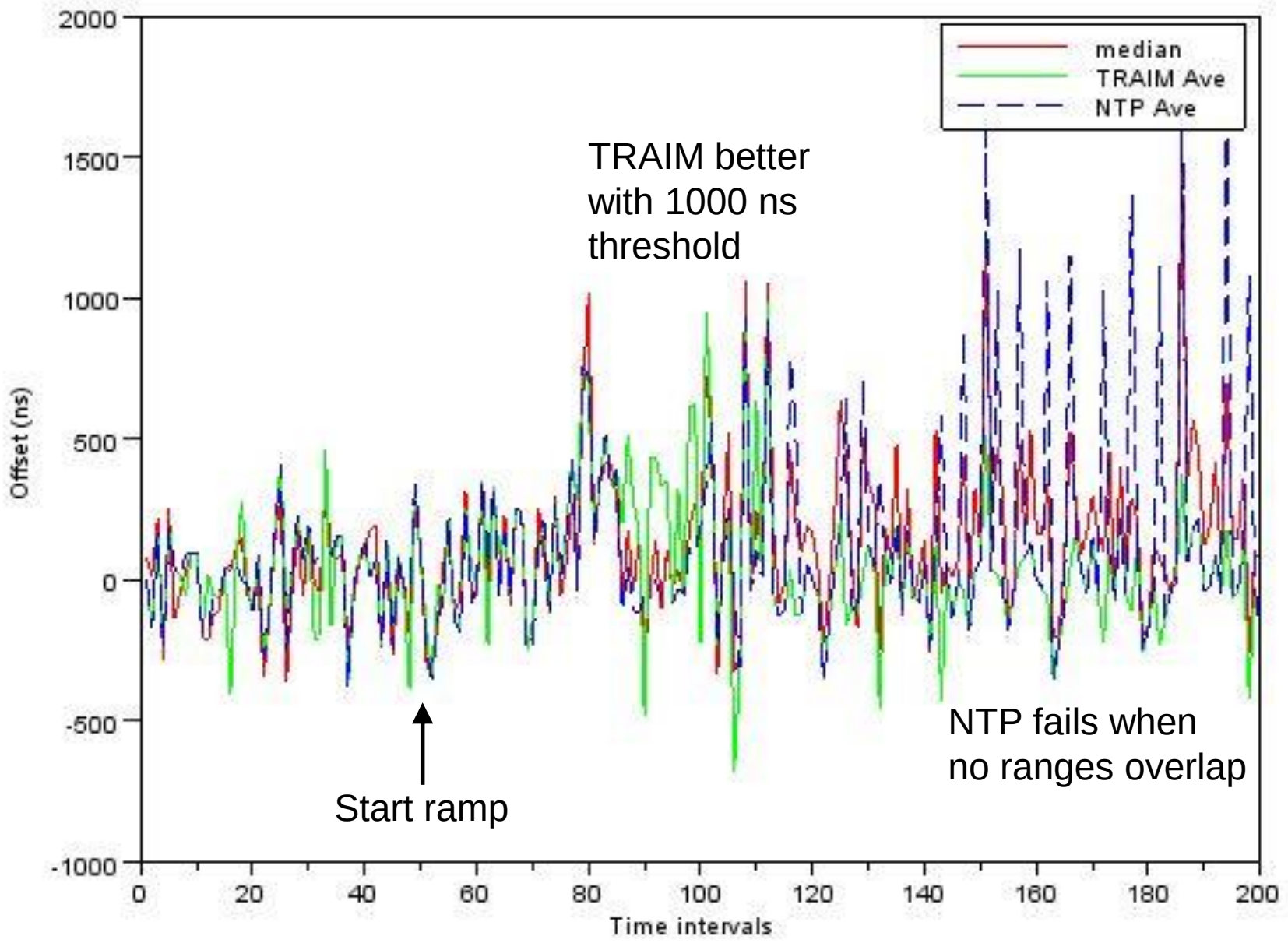
Simulated Time Sources



Filtered offsets with 1500 ns TRAIM threshold



Filtered Offsets with 1σ NTP offset ranges



False Positives

20000 time intervals, ramp starts at 5000

TRAIM threshold	NTP offset ranges	False Positives	Correct Rejections
500 ns		838	11942
1000 ns		19	9971
1500 ns		0	7538
	1σ	1015	10046
	2σ	32	10470
	3σ	0	8757

Conclusions

PTP vulnerable to a faulty best master reporting healthy

Multiple simultaneous masters

- Combine time from multiple domains
- Proposed in IEEE 1588 Working Group

Outlier rejection filters

- Median filters
- TRAIM like filters
- NTP like filters

Outlier filters need to be tuned for network

- Trade off between outlier identification aggressiveness and false positives
- Tuning needs to adapt to variable network characteristics

Thank you for your attention

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