



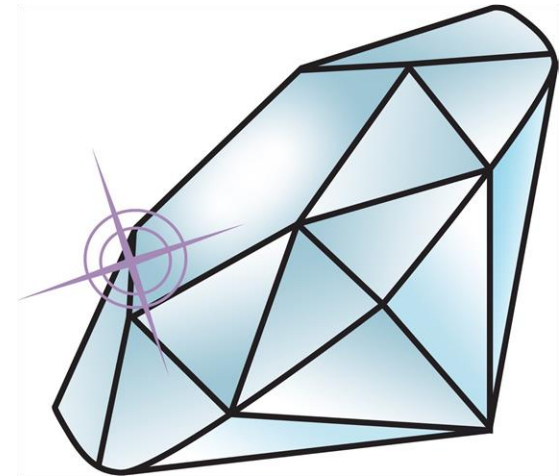
UNIVERSITY
OF TRENTO



CRYSTAL CLEAR

MAKING INTERFERENCE TRANSPARENT

Matteo Trobinger, Timofei Istomin,
Amy L. Murphy, Gian Pietro Picco



EWSN'18 Dependability Competition, 15 February 2018

ORIGINAL DESIGN GOALS

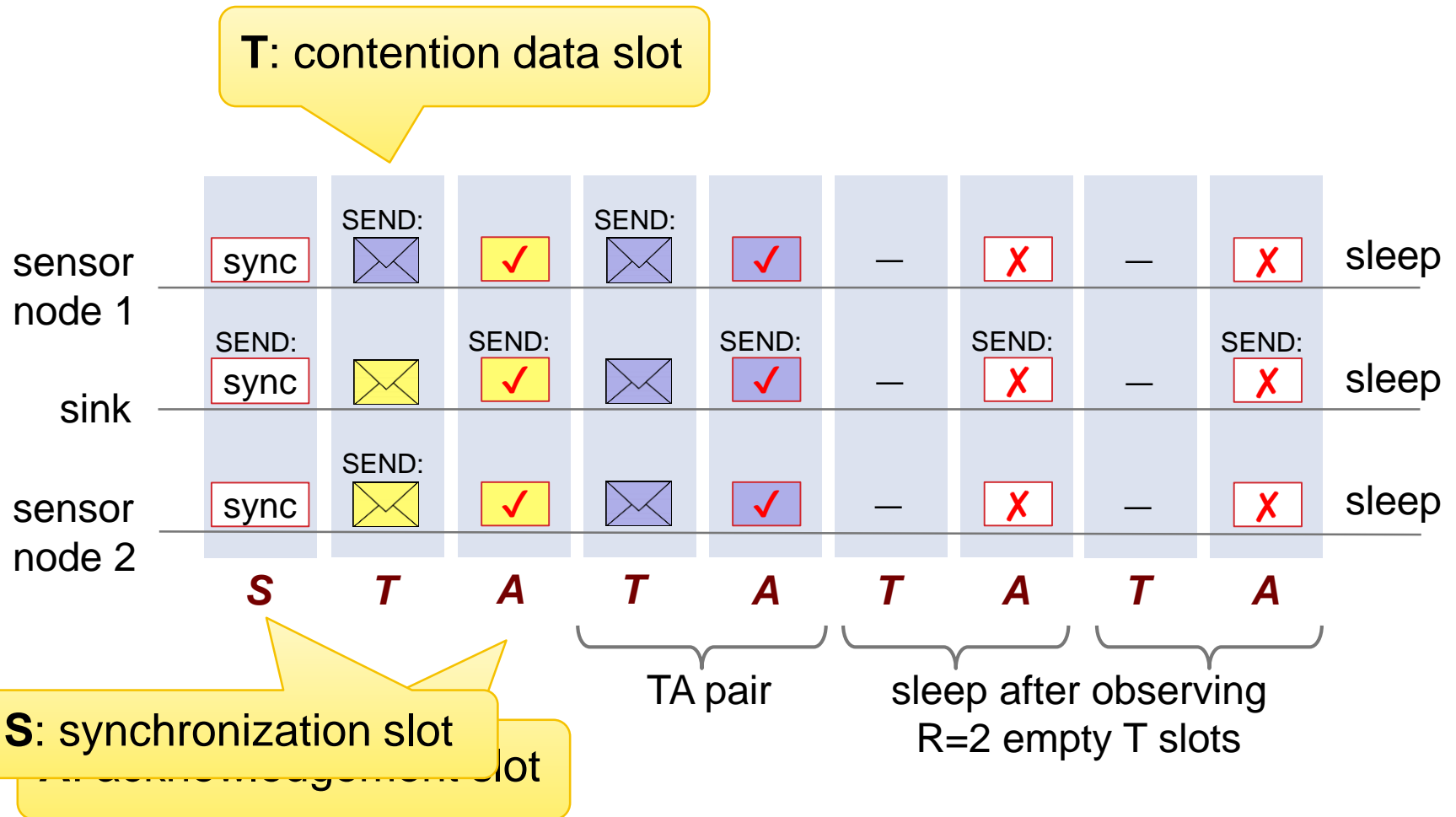
Crystal was designed for aperiodic unpredictable data collection traffic

- Little overhead when the traffic is sparse
 - per-mille radio duty cycle in some real-world applications [SenSys'16]
- Low latency at delivering data bursts
- "5 nines" reliability under Wi-Fi interference of an office building [IPSN'18]

Q ■ Can Crystal be used (almost) unmodified in the challenging competition setting?

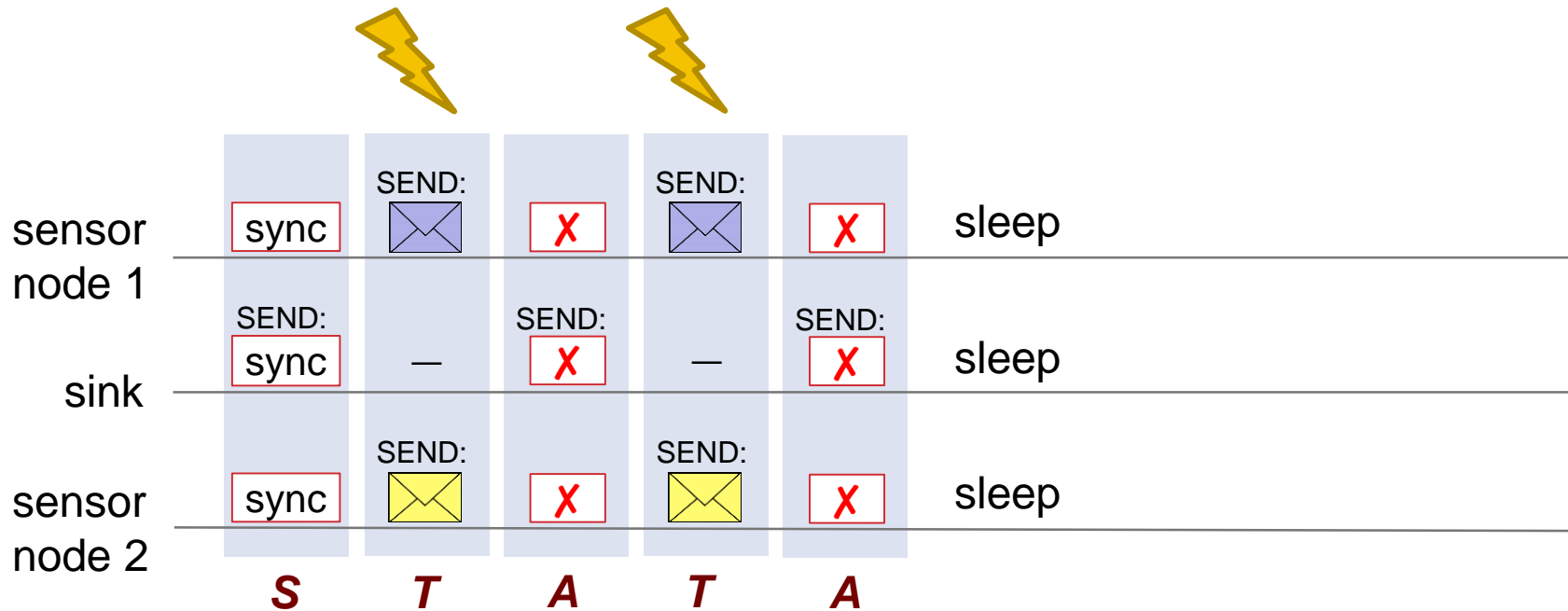
CRYSTAL IN A NUTSHELL

Each Crystal timeslot is a Glossy flood



CRYSTAL UNDER NOISE

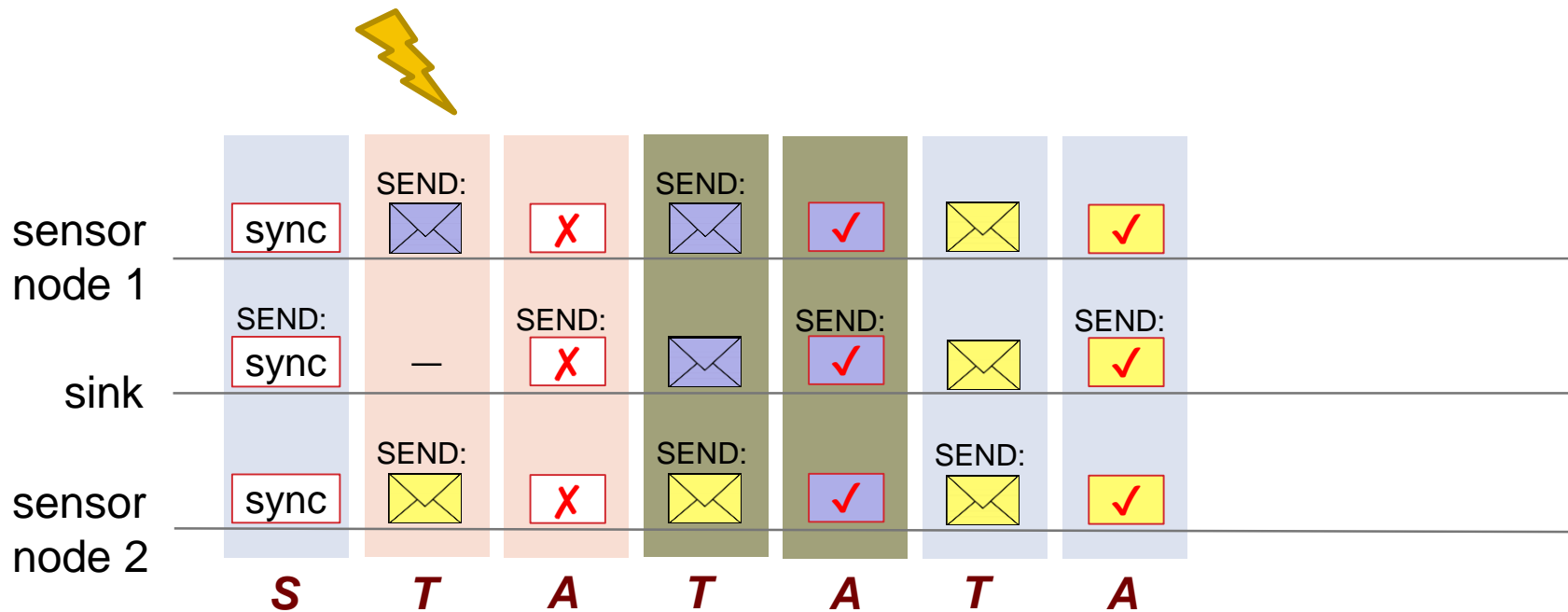
Data packet loss can cause premature termination



The messages will be delayed till the next epoch

TIME SLOT CHANNEL HOPPING

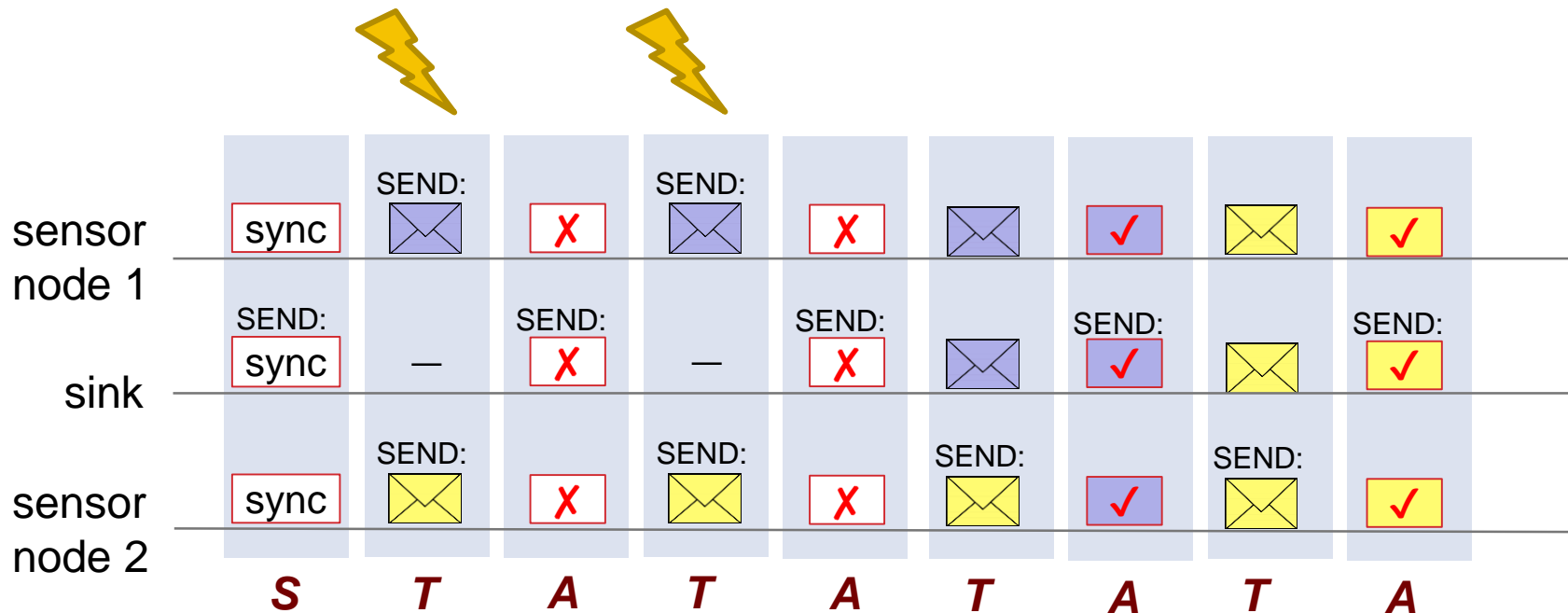
Try to escape noise: change the channel every TA pair



We set Crystal to hop over all 16 IEEE 802.15.4 channels

NOISE DETECTION

Defer going to sleep if there is strong noise in the channel



Strong noise: CCA is above -60 dBm during T or A slots

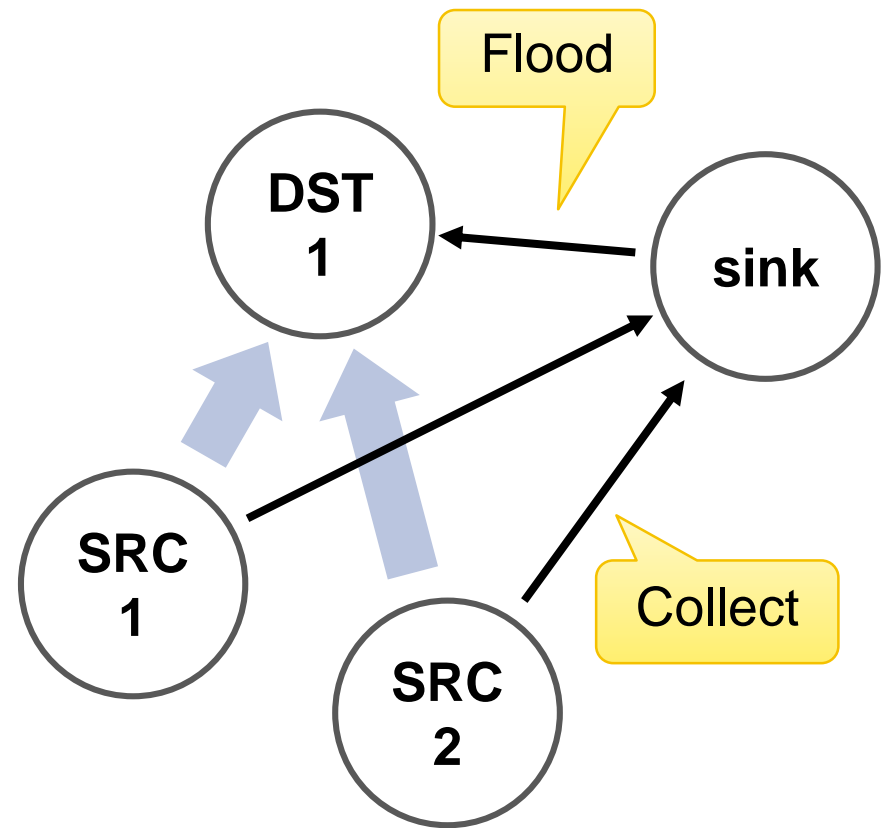
FROM DATA COLLECTION TO COMPETITION TRAFFIC PATTERNS

1. Collect sensor readings to a dedicated sink node

- unmodified Crystal (T slots)
- 1-2 bits per message

2. Flood the network with the global sensor state

- piggyback on Crystal control messages (S & A)
- 11 bits



PROBLEMS WE FACED

Could we go decentralized? We tried...

- Allowing the actuators react on the information received directly from sensors in T slots
- That resulted in superfluous events under noise

Concurrent events

- Packet reordering causes superfluous/missed events

Topology and noise

- Isolated nodes on some channels even without noise
- Noise Level 3 almost blocks our Glossy floods: difficulties in bootstrapping and data delivery

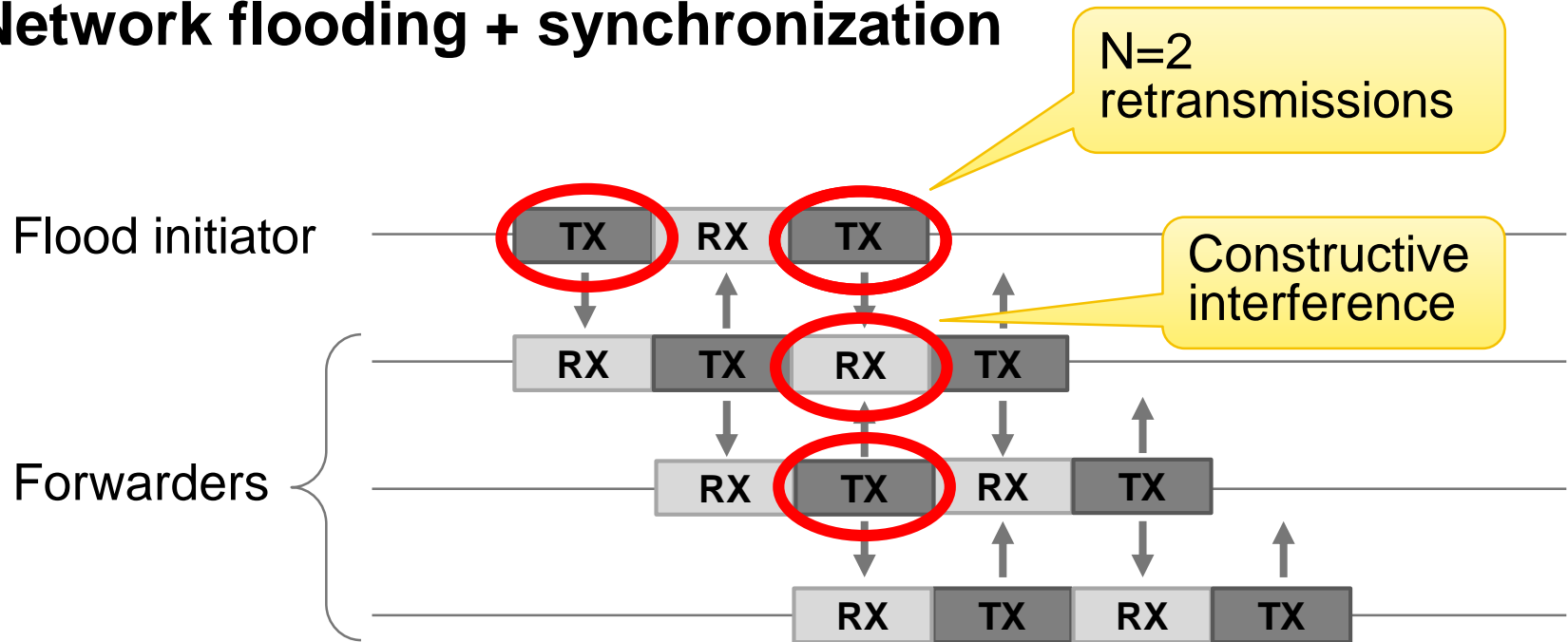
Further modifications would make a new protocol while the goal was to test the original Crystal

THANK YOU! QUESTIONS?

Crystal is Open Source: github.com/d3s-trento/crystal

GLOSSY IN A NUTSHELL

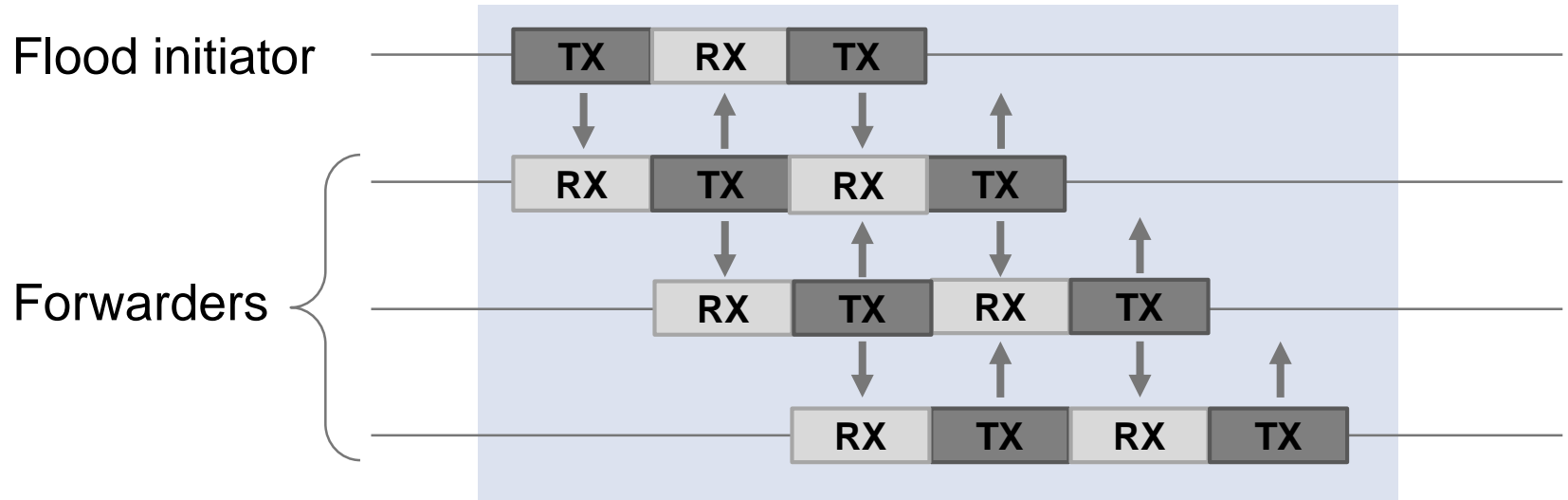
Network flooding + synchronization



- Fastest possible propagation by design
- Very reliable

GLOSSY IN A NUTSHELL

Network flooding + synchronization



- Fastest possible propagation by design
- Very reliable