Parametrization of Terrestrial Ad-Hoc Routing Protocols for Tactical Underwater Networks

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Outline

- Introduction & Motivation
- Ad-hoc Routing Protocols
- Performance Evaluation
- Conclusion

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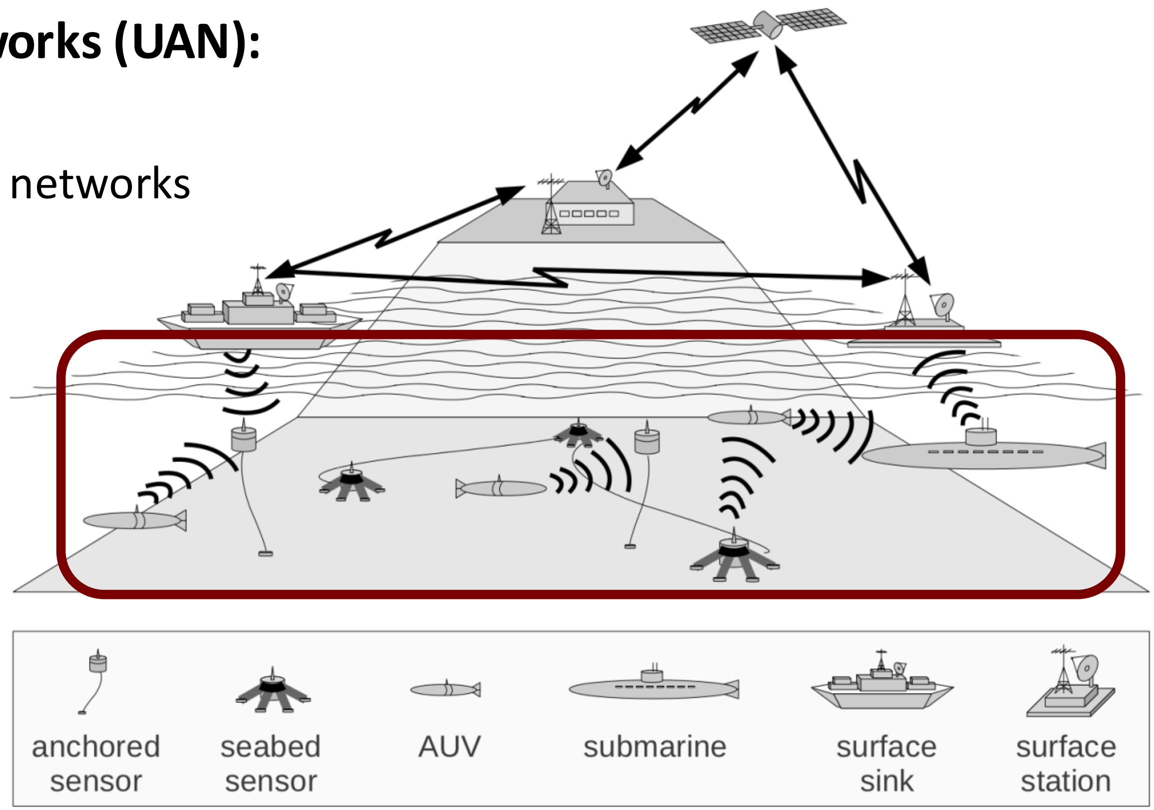
Underwater Acoustic Networks (UAN):

- acoustic communication
- sparse and heterogeneous networks
- multi-hop links



→ novel applications (enabled by ad-hoc routing protocols)

- environment /equipment monitoring
- underwater exploration
- military operations

Characteristics and Challenges of UANs:

- high transmission range
- **slow and varying signal propagation**
  → high communication delay
- high bit error rates
- low data rates

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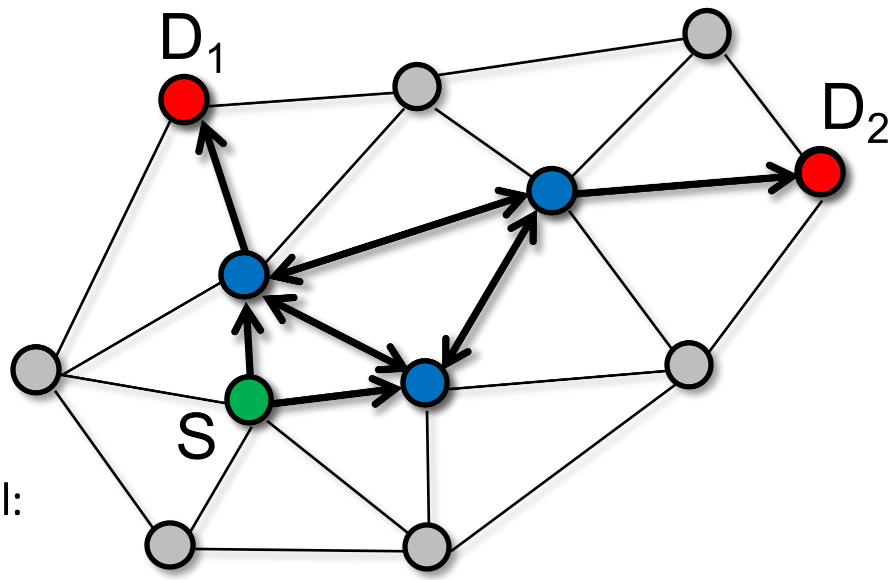
- **selection of two representatives of ad-hoc routing protocols**
  - developed for terrestrial (wifi) networks / MANETS
  - uni- & **multicast** capability (enable multiple sink data transmission)
- **comparison against Simple Flooding**

On-Demand Multicast Routing-Protocol (ODMRP)

- **reactive**
- route discovery (exchange of query and reply messages)
- mesh structure (**forwarding group**)

→ **scoped flooding**



protocol timer:

- route refresh interval:

  1000 s
- forwarding group timeout interval:

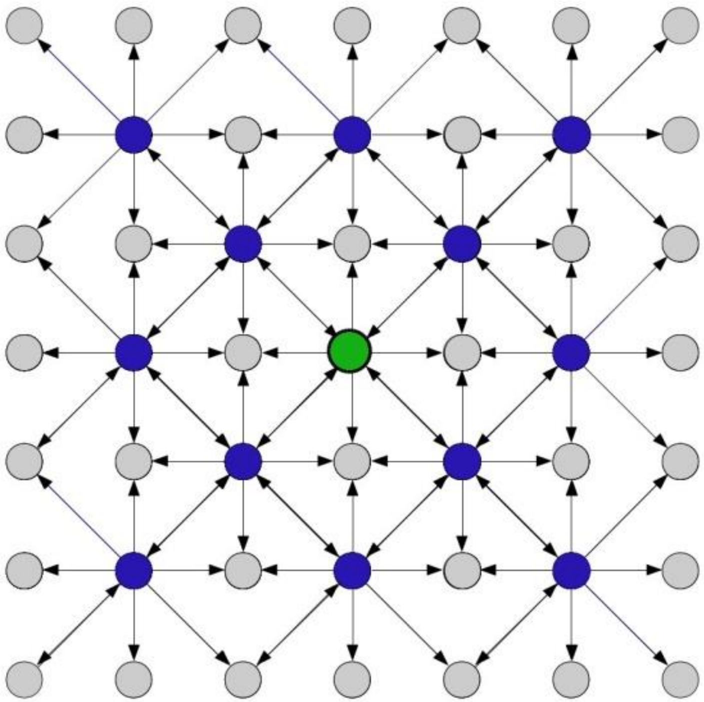
  1500 s

Simplified Multicast Forwarding (SMF) Protocol

with **source-based multipoint relay** (S-MPR) forwarding

- **proactive**
- neighborhood information (exchange of hello messages)
- **relay set** (covering each node's 2-hop neighborhood)

→ **reduced and efficient network-wide flooding strategy**



protocol timer:

- hello interval:

  250 s
- neighbor hold time:

  1500 s

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Simulation

- **ns-2** [2] with **UnderWaterMiracle** [3]
- **signal propagation model** (parametrization of SSP, noise, attenuation)

- **protocols**: ALOHA, (lightweight) IP, UDP
- **traffic**: periodic (constant bit rate)
- **packet size**: 32 byte
- **header optimization**: 8 byte
- **assumption**: negligible bit errors

- **configuration of underwater modem**:

distance (km)	freq./band.(kHz)	nom. data rate (kbit/s)	delay (s)
5	8.5/11	5.5	3.37
10	5.9/7.8	3.9	6.74

- number of replications: 10

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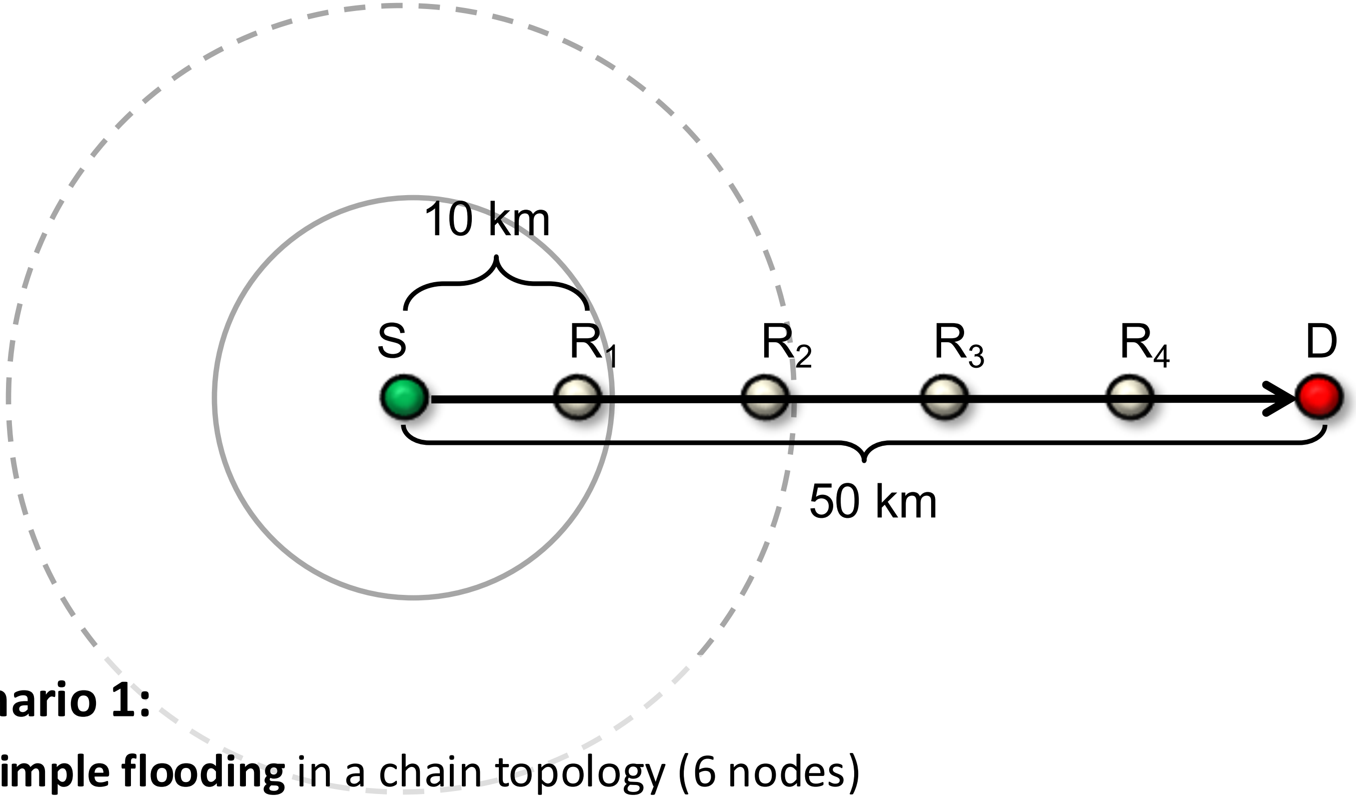

Scenario 1:

- **simple flooding** in a chain topology (6 nodes)
- chain length: 50 km
- transmission range: 10 km (with low loss probability)
- simulations series (transmission period: 1 – 15 s)
- simulation duration: 1000 s / run

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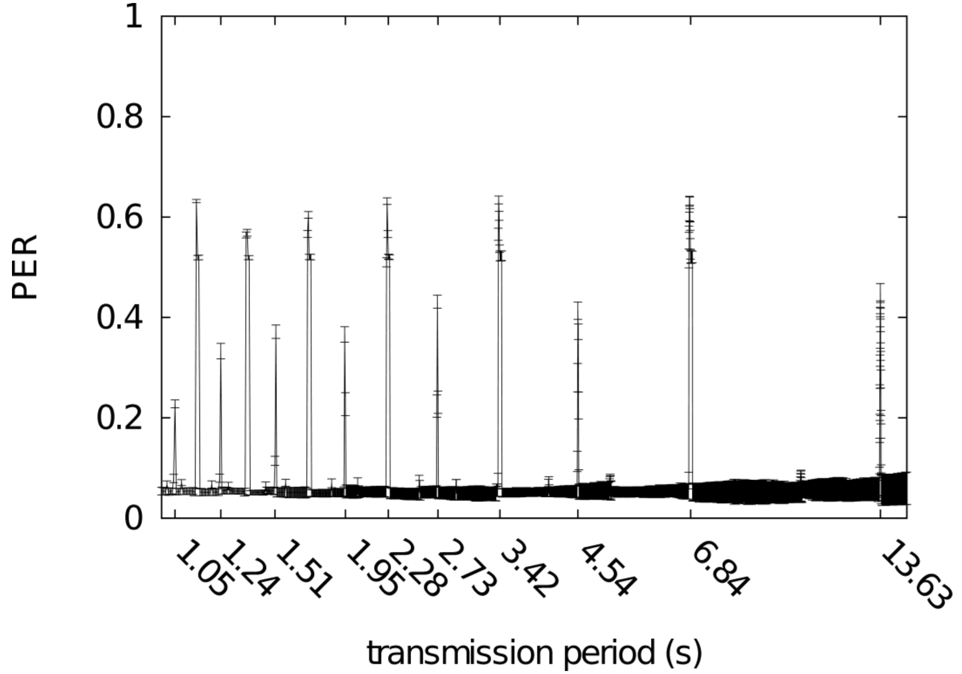
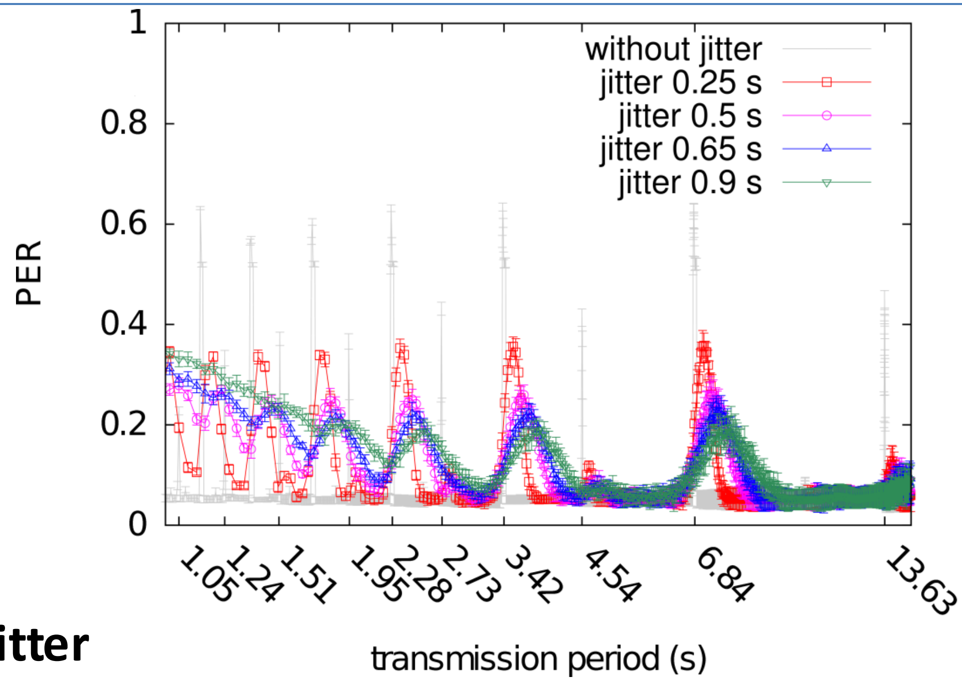


peaks in Packet Error Rate (PER) graph (caused by insufficient collision avoidance)



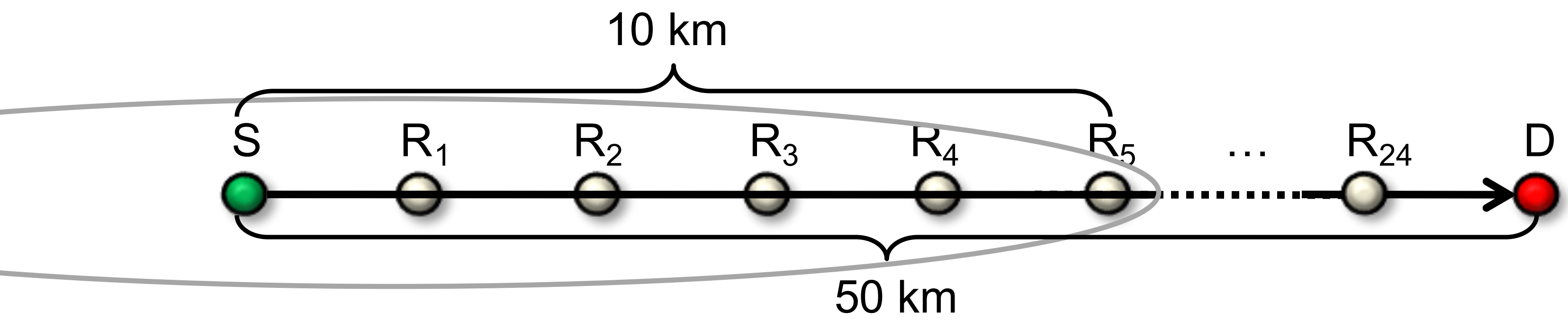
probabilistic jitter

- larger jitter interval → more intensive mitigation of peaks
- **disadvantages of jitter:**
  - additional end-to-end delay
  - higher probability of packet order permutation

  → jitter length should be minimal

- appropriate jitter interval with length: **14-times of transmission time**

  → **5 km: 650 ms** and **10 km: 900 ms**



Scenario 2:

- chain topology with **26 nodes**
  - increased density
  - multiple alternative paths allowed

- chain length: 50 km
- transmission range: 10 km (with low loss probability)
- **jitter interval:** **900 ms**
- simulation time: 2 h

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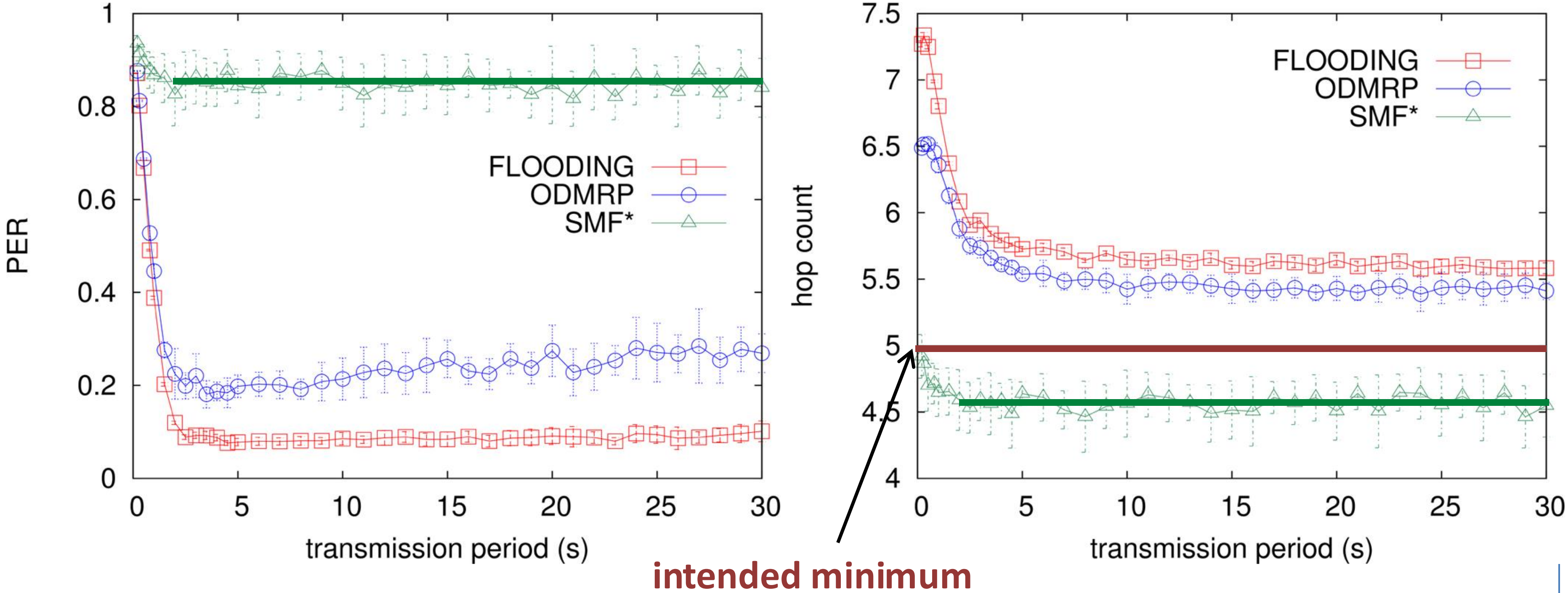

- **SMF:** very **high PER**
  - hello packets from 12 km afar nodes are received
  - SMF prefers node with highest connectivity (farthest nodes)
    → **low loss transmission is not guaranteed**
  - packets are forwarded along lossy paths

possible **solution**: cross layer approach with link quality measurement

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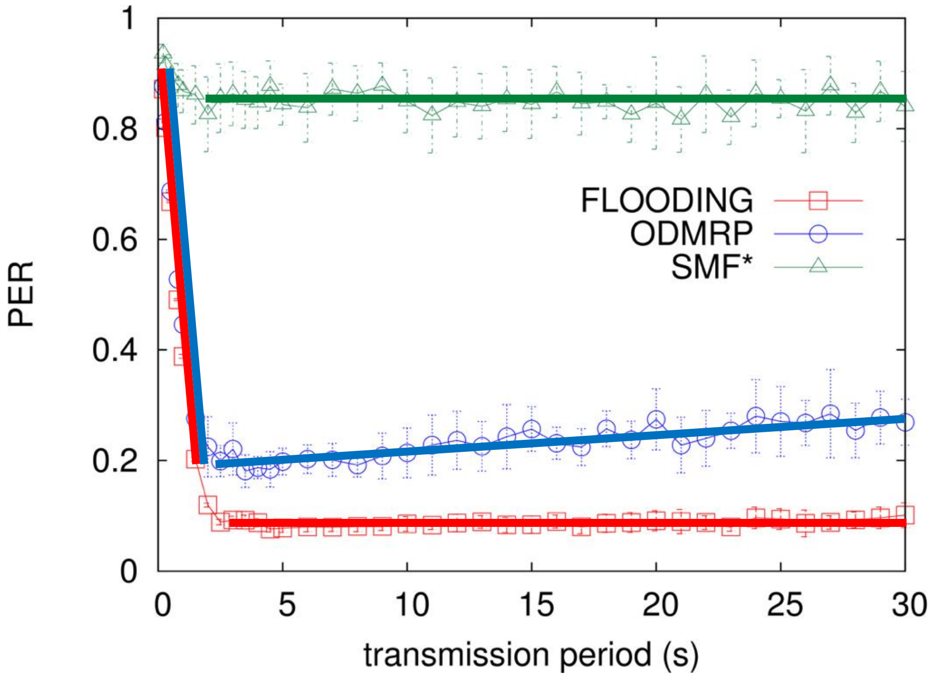
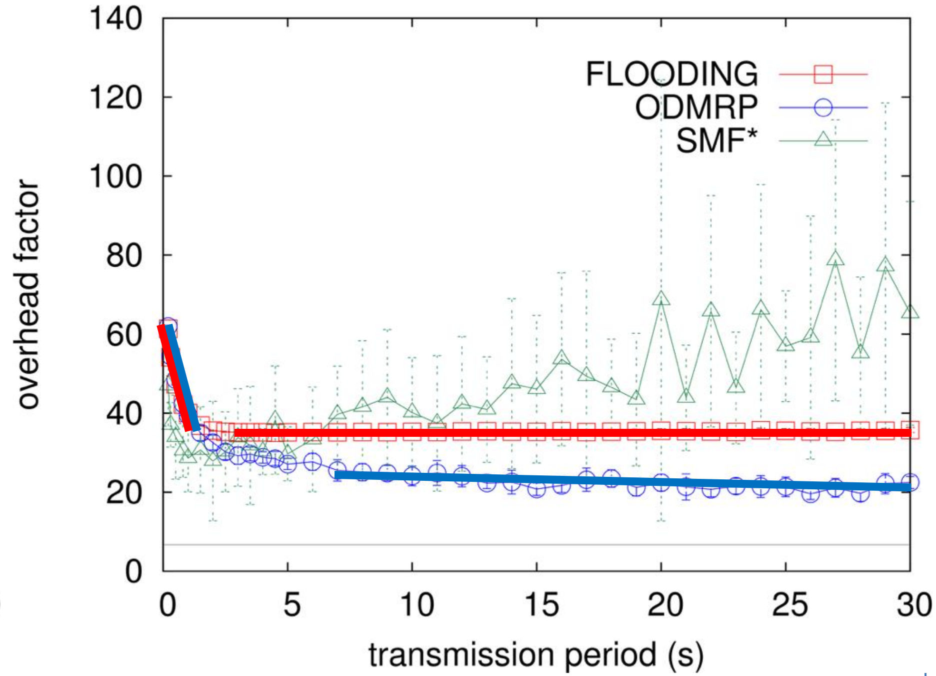
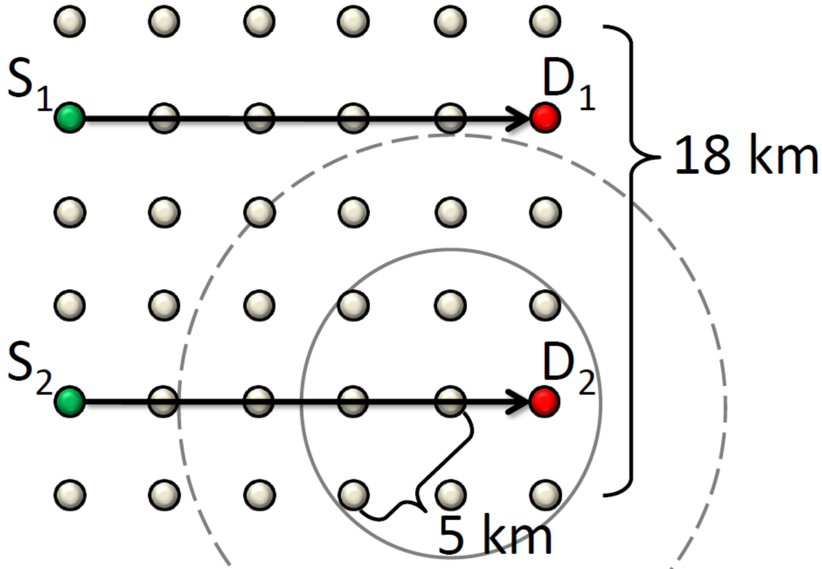




- **FLOODING:** lowest **PER**
  but: massive redundancy

$$overhead\ factor := \frac{\sum bits\ transmitted}{\sum bits\ used\ on\ app-layer}$$

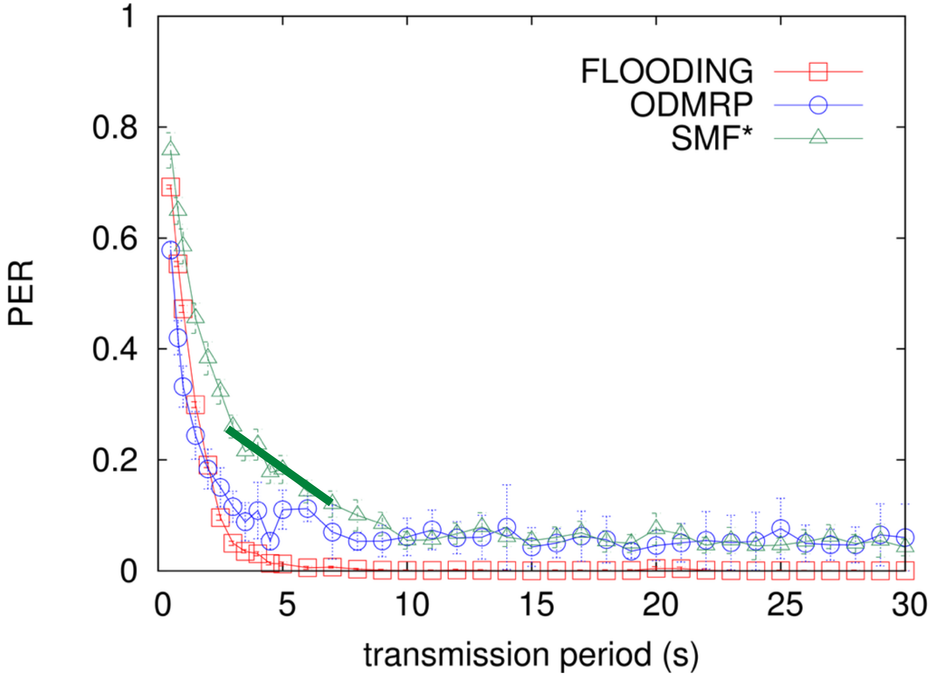
- **ODMRP**: tolerable **PER** and up to 40% **overhead reduction**
  but: comparable to flooding in presence of congestion

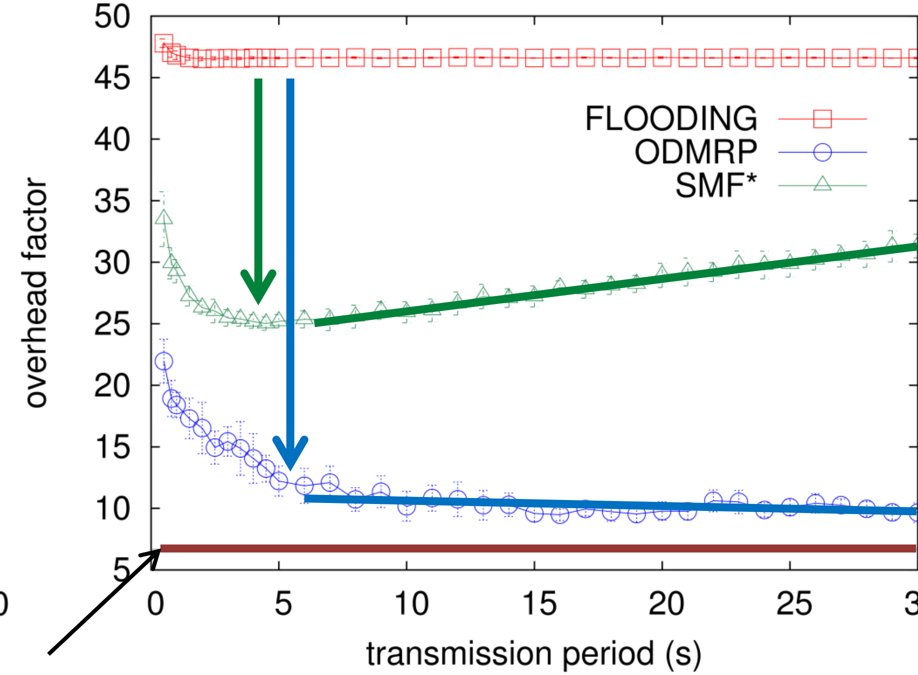


Scenario 3:

- 36 nodes in grid topology
- grid area: 18 km²
- transmission range: 5 km (with low loss probability)
- **2 flows** (geographically separated paths)

- **jitter interval: 650 ms**
- simulation time: 2 h





optimum

- **SMF:** network-wide packet propagation
  - → collisions in presence of high load (transmission period < 6s)
  - → higher overhead compared to ODMRP
- **SMF** and **ODMRP:** significant **overhead reduction**
- **ODMRP:**
  - separates both flows
  - close to optimal overhead factor

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Conclusion:

- **Parametrization** of two representatives of terrestrial ah-hoc routing protocols
  - reactive ODMRP
  - proactive SMF
- Introduction of **probabilistic jitter**
- **Performance Evaluation**:
  - **ODMRP**: best performance due **to scoped flooding**
    & significant **overhead reduction**

Future Work:

- dynamic scenarios
- variance of signal propagation
- bit error rates

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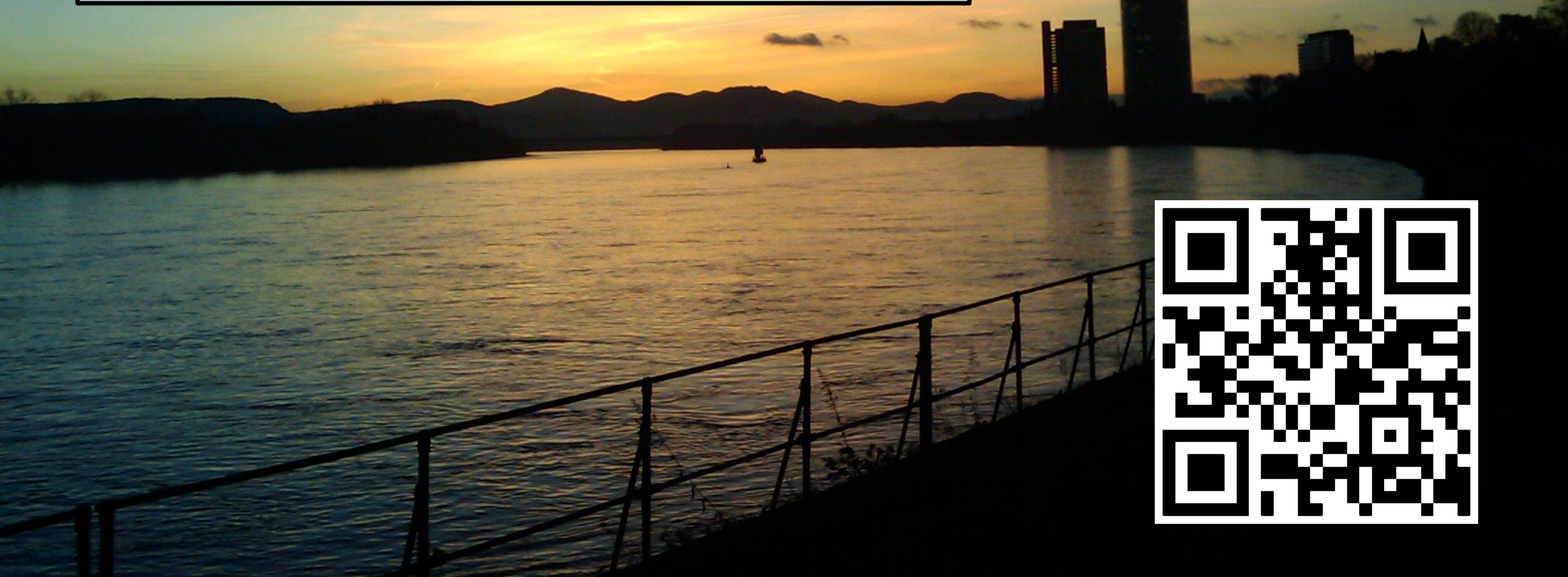

Picture by Nils Aschenbruck