Jamming-Resistant Multi-path Routing for Reliable Intruder Detection in Underwater Networks

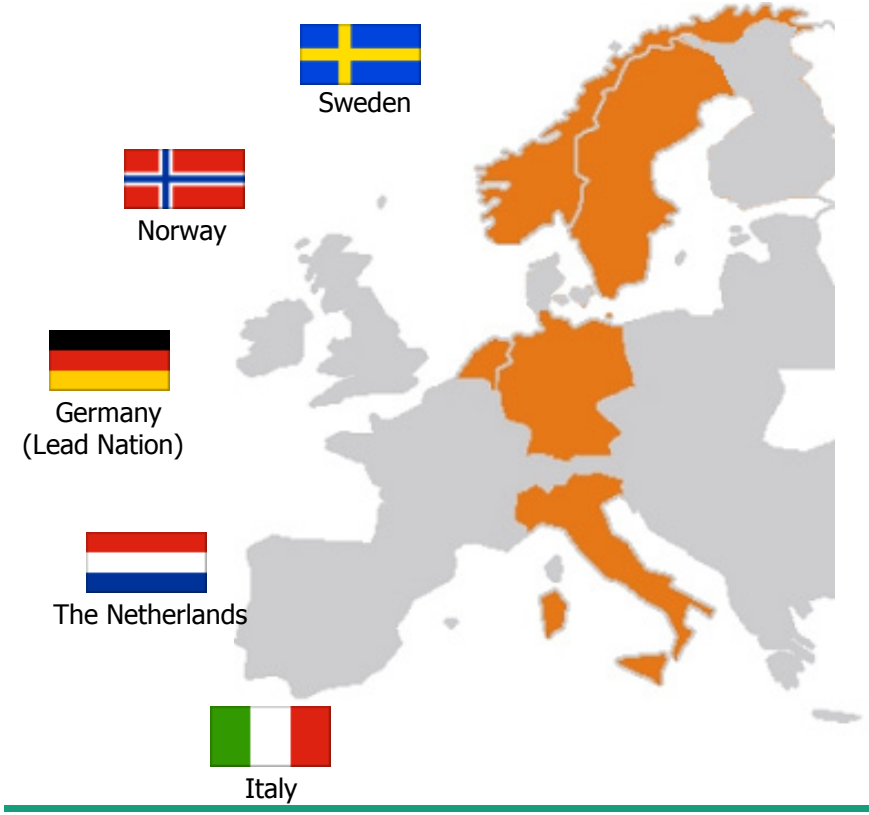
Michael Goetz, Saiful Azad, Paolo Casari, Ivor Nissen, Michele Zorzi

© Fraunhofer FKIE

Fraunhofer
FKIE

Robust Acoustic Communications in Underwater Networks (RACUN)

RACUN is a european military R&D project under the European Defence Agency



RACUN

EDA

European Defence Agency

© Fraunhofer FKIE

Fraunhofer FKIE

Goals of RACUN

Develop and demonstrate an underwater acoustic network until 2014

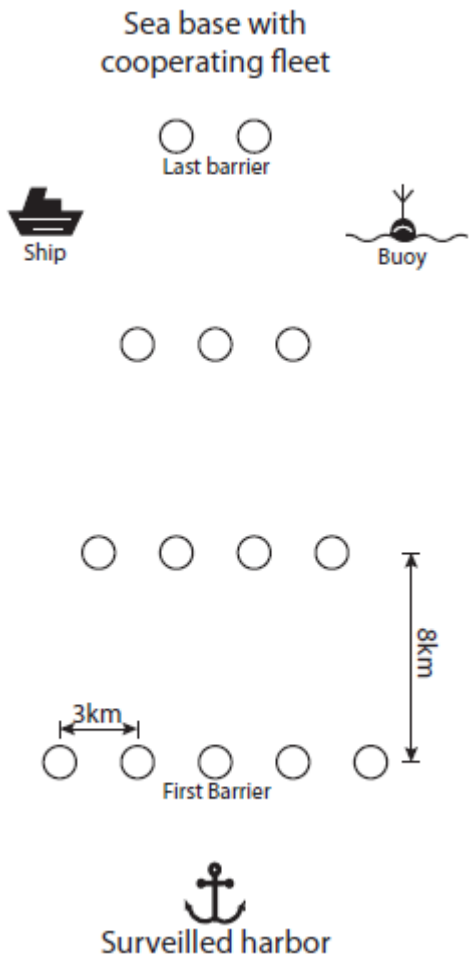
Features:

- Robustness → any ocean / all weather conditions
- Ad-Hoc → self-configuring
- Long Range → ~ 10 kilometers (4 - 8kHz)
- With stationary and mobile nodes

© Fraunhofer FKIE

Scenario – Intruder Detection

- 14 bottom sensor nodes in 4 barriers
- 2 sinks (ship and buoy)



Goal:

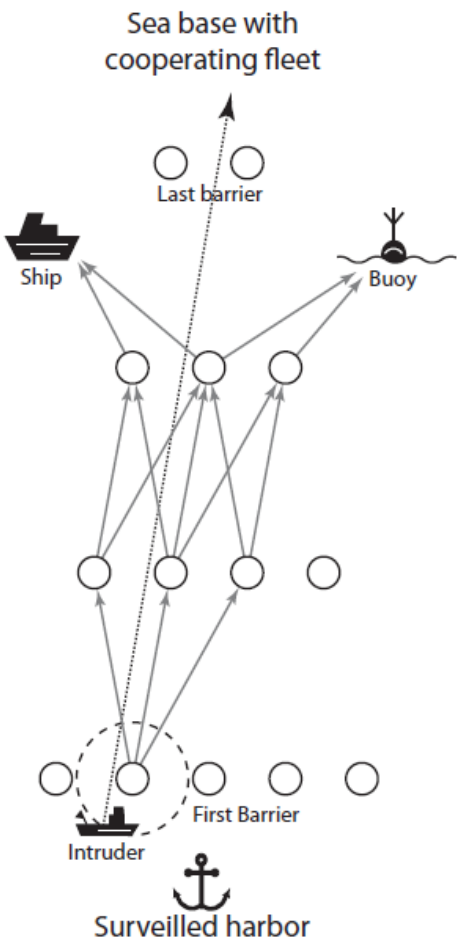
Monitor and report all movements

Detection Range: 2km

© Fraunhofer FKIE

Scenario – Intruder Detection

1. Intruder leaves harbor
2. Sensor node detects and tracks intruder
3. Forward detection report of 128bit to cooperating fleet



© Fraunhofer FKIE

Fraunhofer FKIE

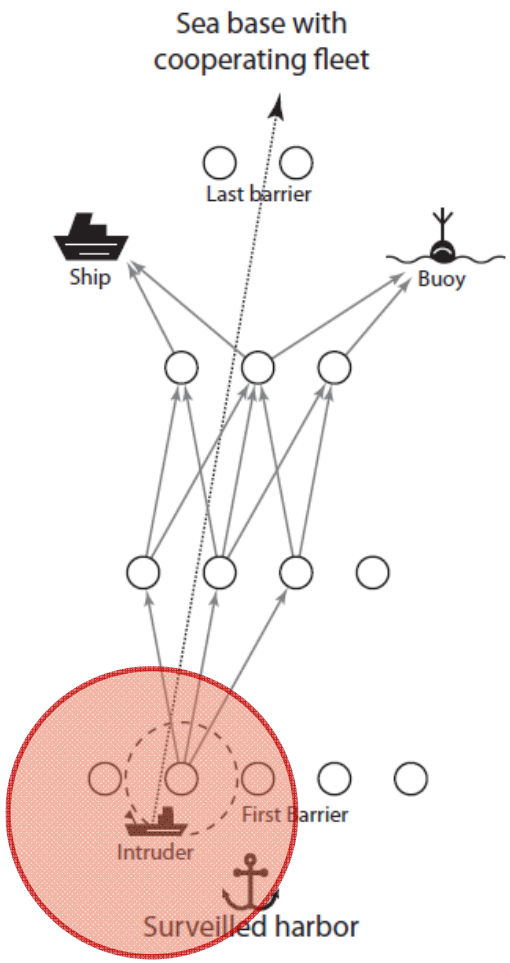
Intruder Jamming

Engines of the intruder creates noise.

Spectrum of noise is largely superimposed to that used for communications.

Intruder acts as a jammer.

Multi-path strategies as a countermeasure.



© Fraunhofer FKIE

Fraunhofer
FKIE

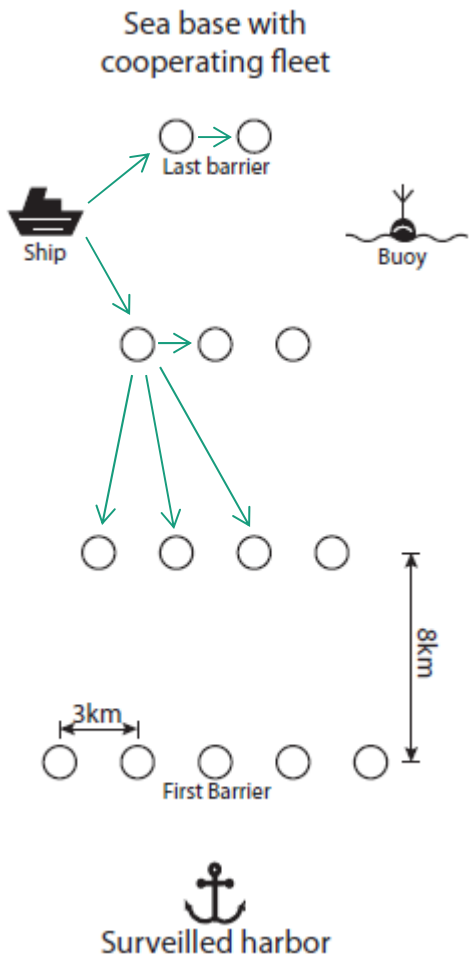
Route establishment

Proactive Routing:

Each sink floods a control message every 5 minutes including:

- Source ID
- Sequence Number
- Hop Count
- Last Hop

Each node forwards only once but stores <u>all</u> received messages to have route alternatives available if route breaks down / gets obsolete.



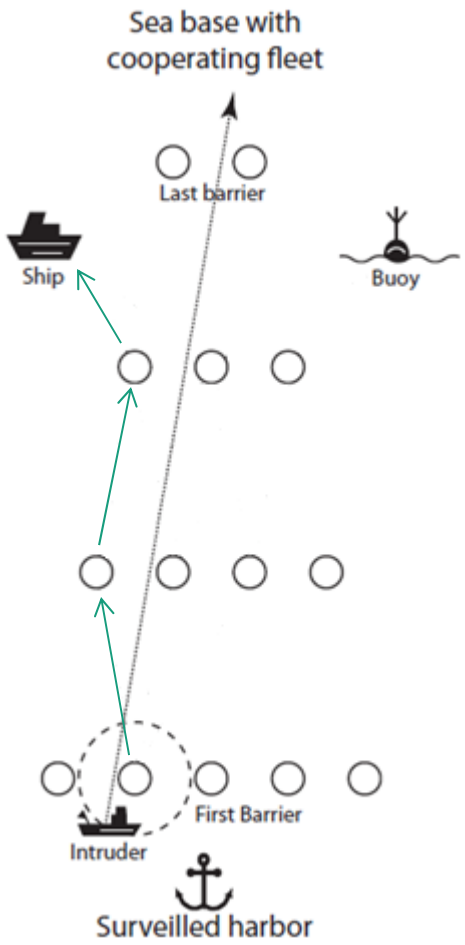
© Fraunhofer FKIE

Routing strategies

Simple-path Routing (SP)

1. Searching closest sink in routing table
2. Define next hop in data packet
3. Only next hop forwards data packet

High vulnerability to jamming!



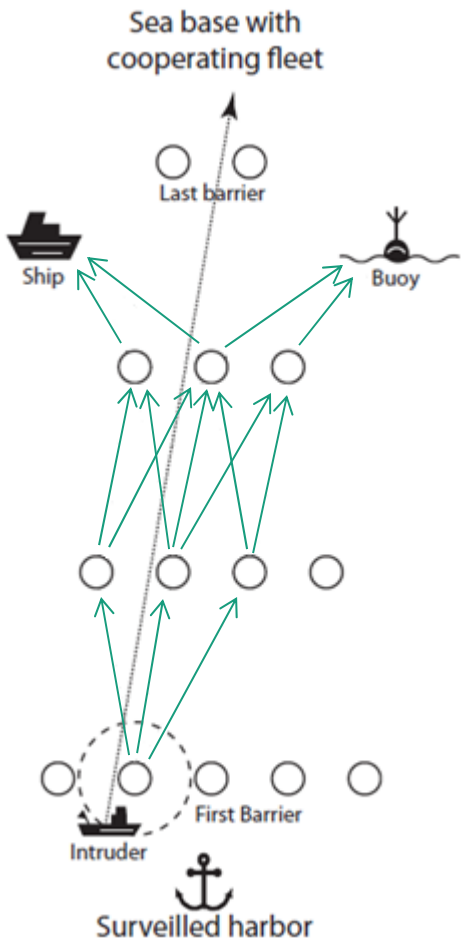
© Fraunhofer FKIE

Routing strategies

Restricted Flooding (RF)

1. Searching closest sink in routing table
2. Define TTL = shortest hop distance in data packet
3. All nodes with dist < TTL forward data

High overhead! More collisions?



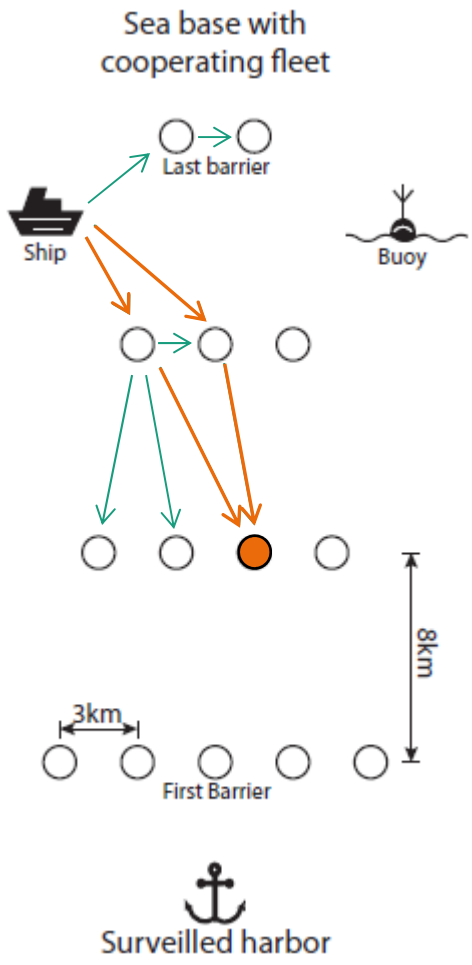
© Fraunhofer FKIE

Routing strategies

Multi-sink routing protocol (MSRP)

1. Searching distinct routes to each sink
2. Define routes (source routing) to all sinks in data packets
3. Only nodes on route list forward data

Less packets but more overhead in control and data packets.



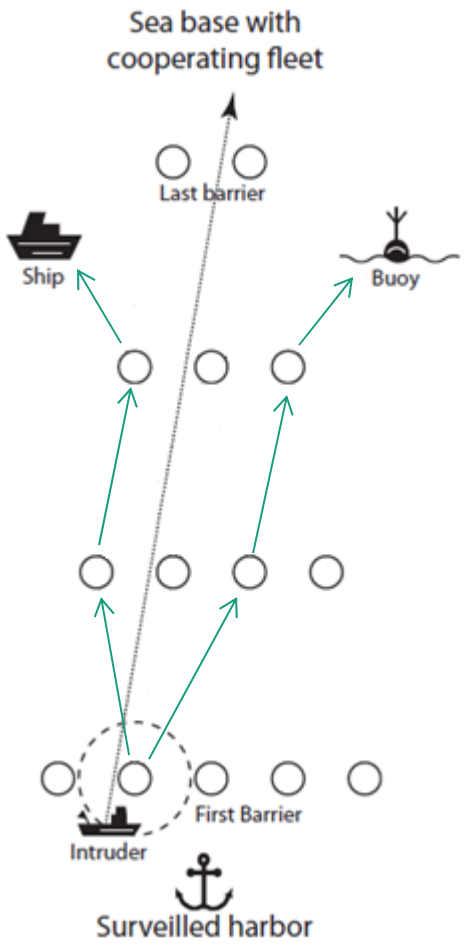
© Fraunhofer FKIE

Routing strategies

Multi-sink routing protocol (MSRP)

1. Searching distinct routes to each sink
2. Define routes (source routing) to all sinks in data packets
3. Only nodes on route list forward data

Less packets but more overhead in control and data packets.



© Fraunhofer FKIE

Simulation

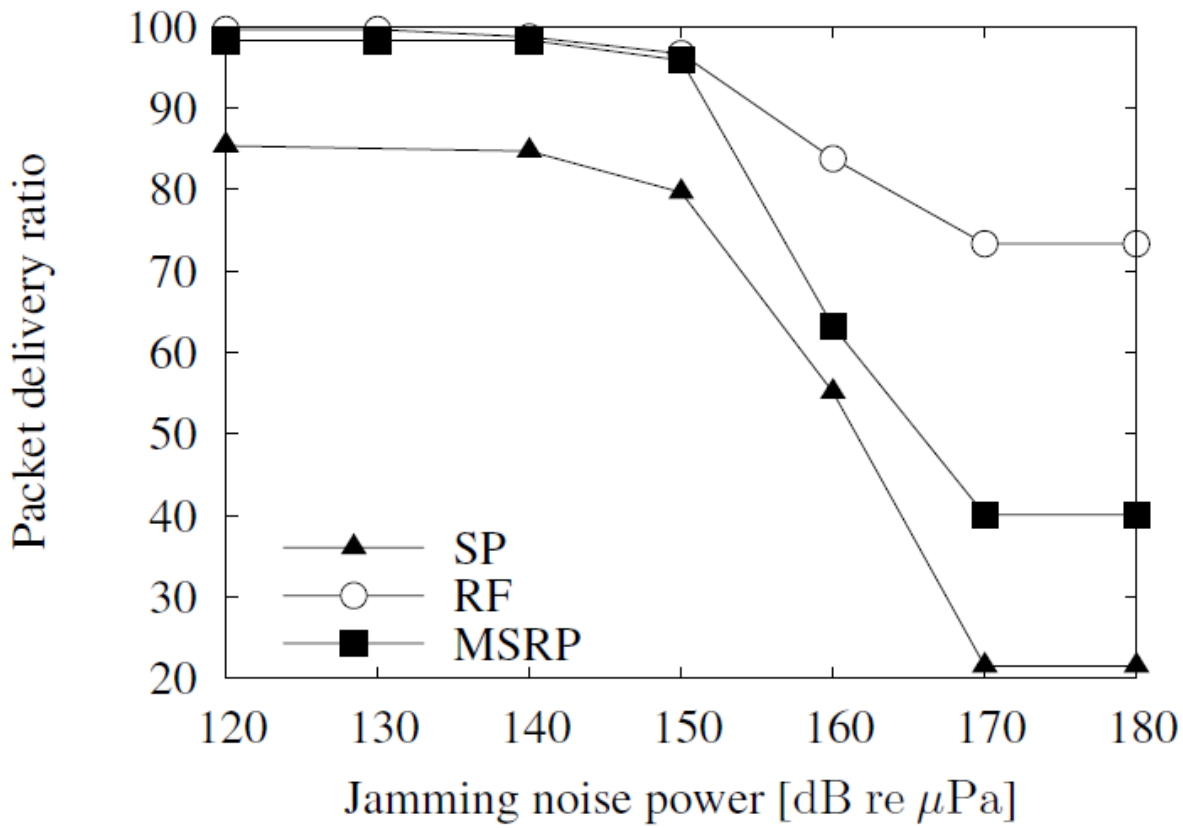
Simulator: World Ocean Simulation System (WOSS) based on ns-2 from University of Padova

Parameter: Different intruder trajectories
Jamming noise power (120 – 180 [dB re µPa])
Data generation rate (1 – 6 [pkt/min])

Metrics: Packet delivery ratio
Delay
Hop Count
Overhead

© Fraunhofer FKIE

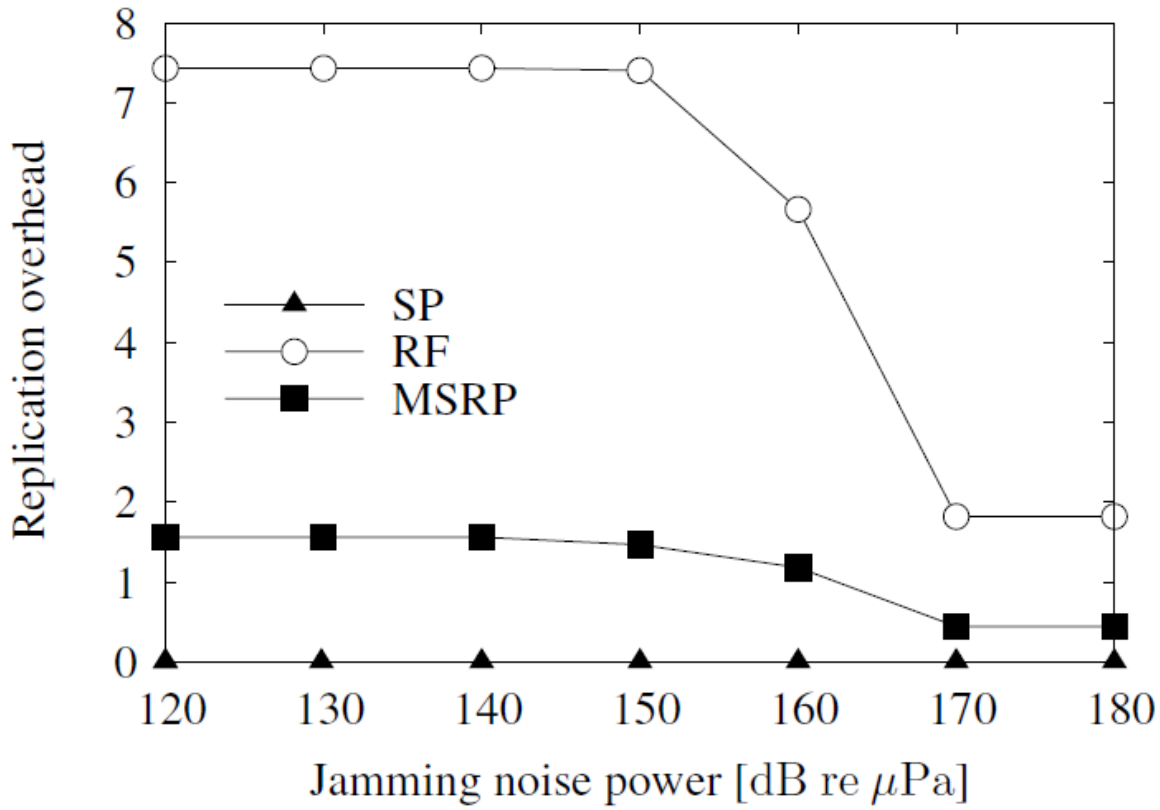
Results – Packet Delivery Ratio



© Fraunhofer FKIE

Fraunhofer FKIE

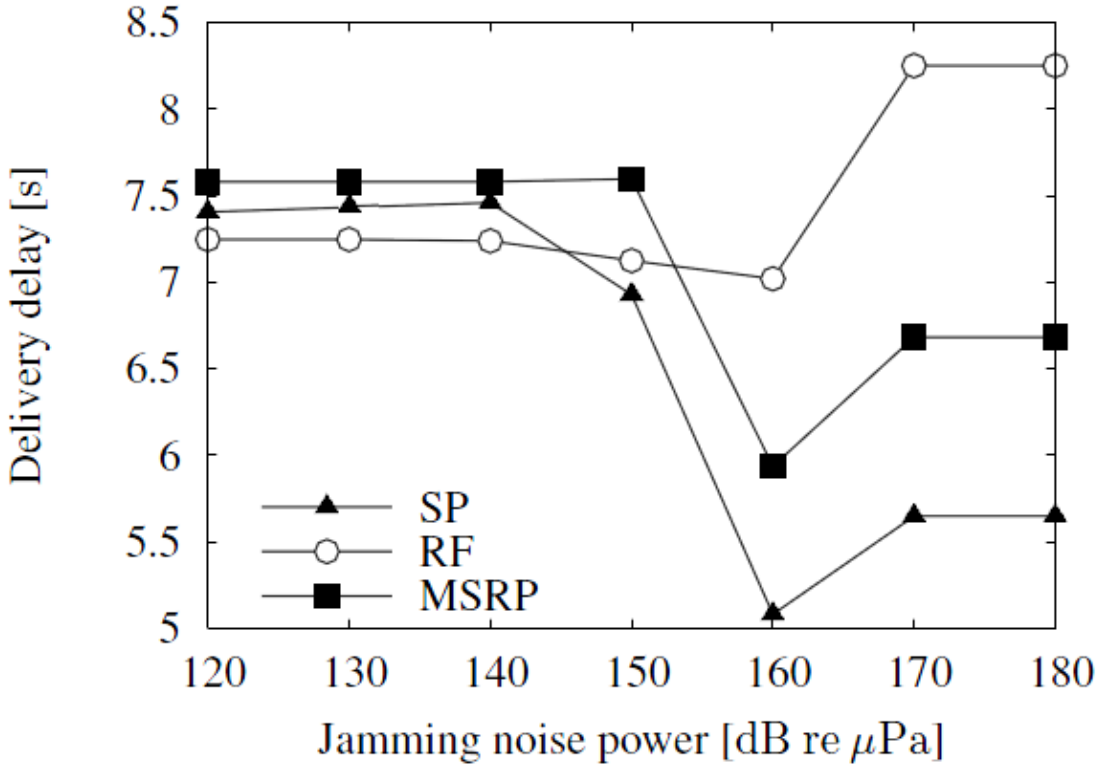
Results – Replication Overhead



© Fraunhofer FKIE

Fraunhofer FKIE

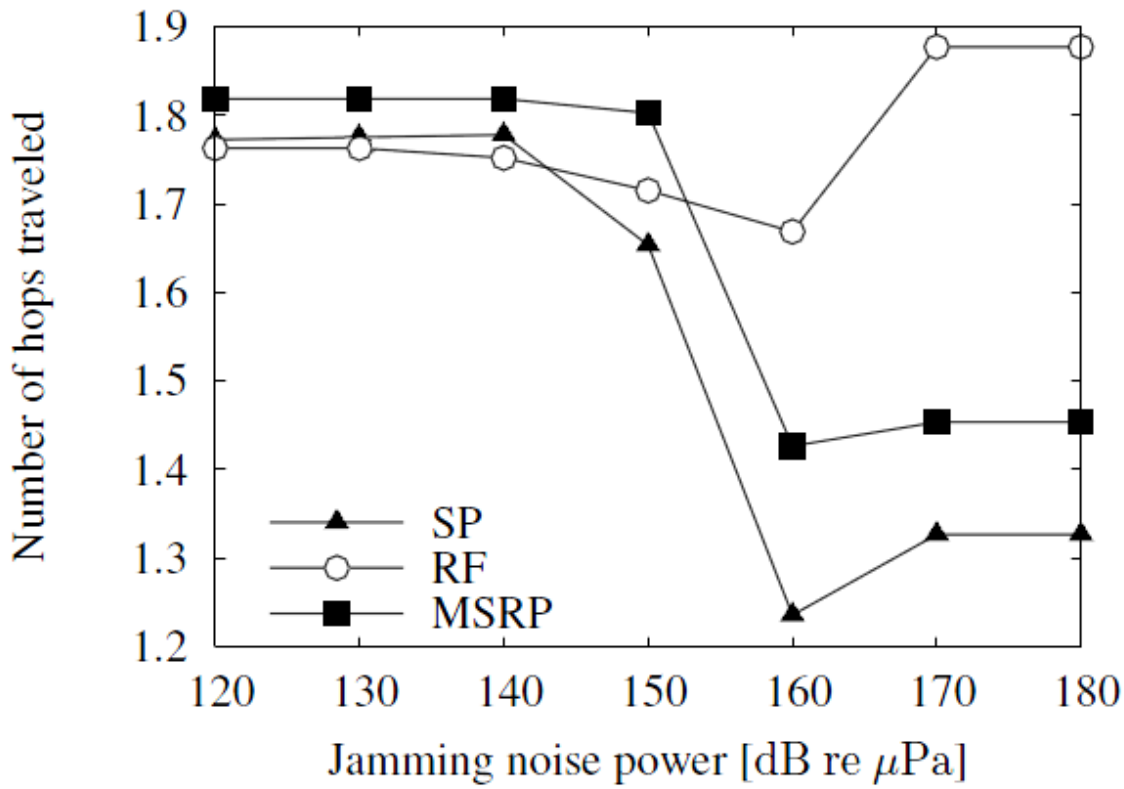
Results – Delivery Delay



© Fraunhofer FKIE

Fraunhofer FKIE

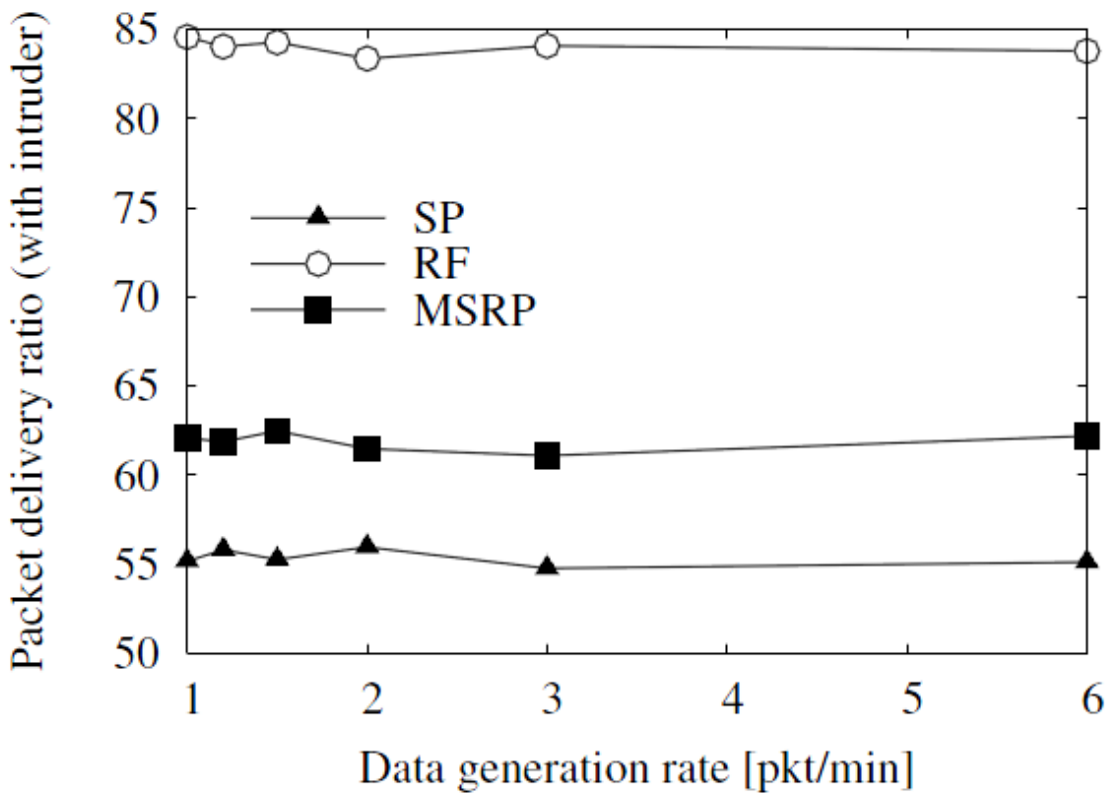
Results – Number of Hops



© Fraunhofer FKIE

Fraunhofer FKIE

Results – PDR with high Traffic



© Fraunhofer FKIE

Fraunhofer FKIE

Conclusion

- Multi-path is a good countermeasure against jamming

- Simple-path has minimum overhead but low PDR
- Restricted Flooding has best PDR but very high overhead
- MSRP is a tradeoff between overhead and PDR

© Fraunhofer FKIE

Jamming-Resistant Multi-path Routing for Reliable Intruder Detection in Underwater Networks

Thank You!

Michael Goetz, Saiful Azad, Paolo Casari, Ivor Nissen, Michele Zorzi

© Fraunhofer FKIE

Fraunhofer FKIE