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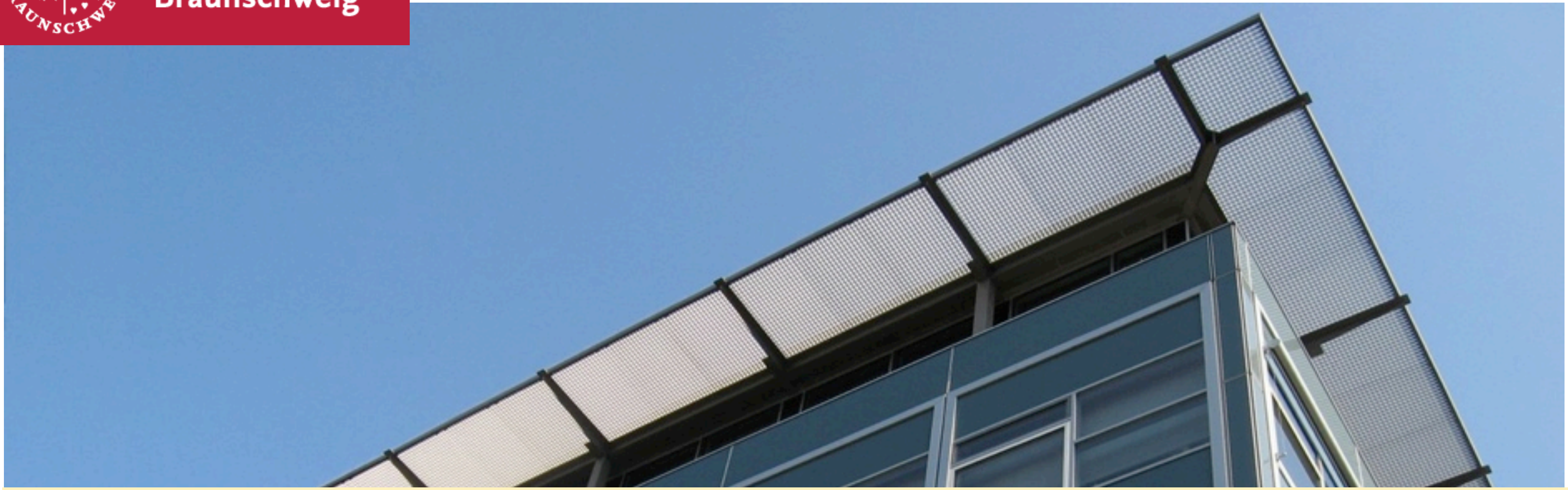

Detecting Blackhole and Greyhole Attacks in Vehicular Delay Tolerant Networks

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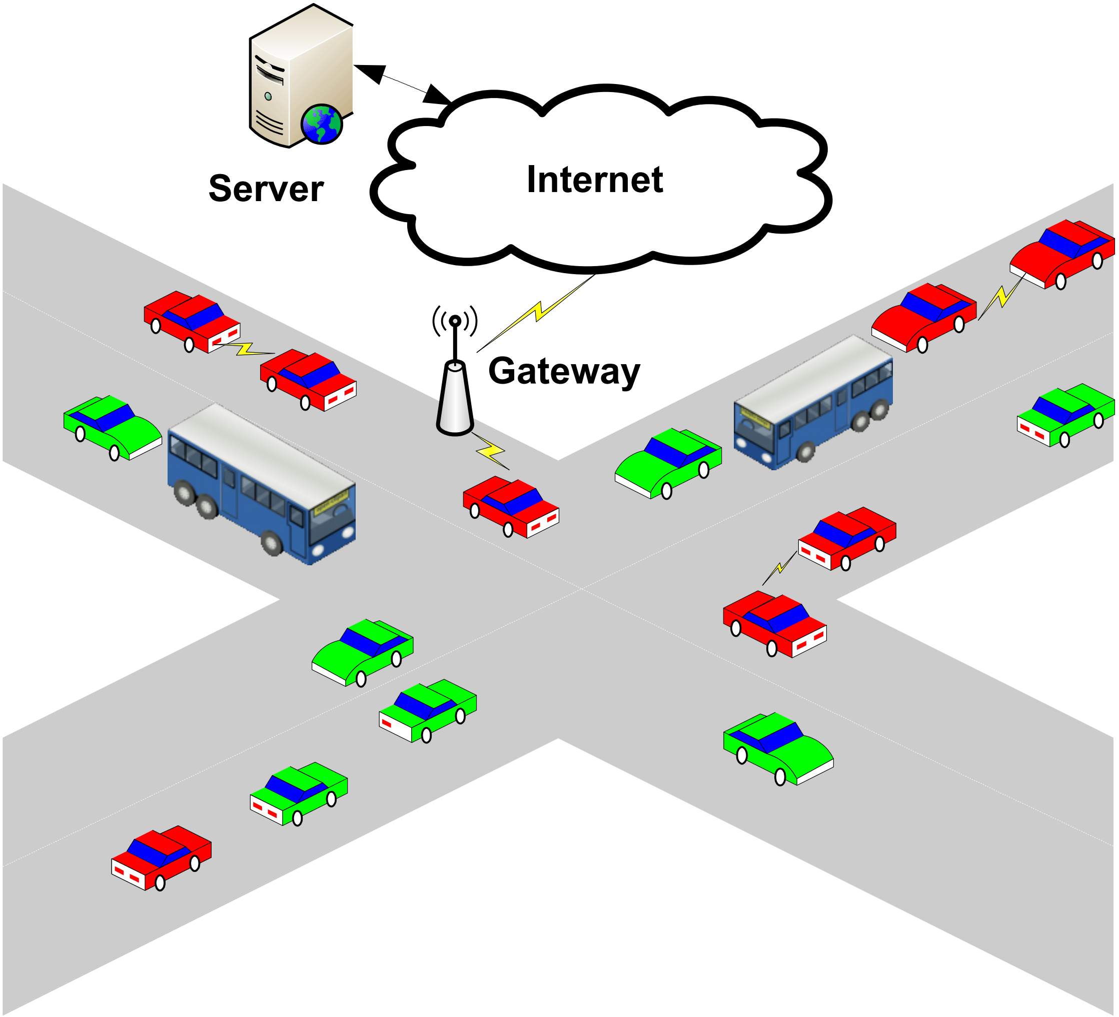
COMSNETS 2013, Bangalore

Vehicular Delay Tolerant Networks (VDTNs)



Only small penetration for first deployments

Backend/Internet Connection not always available

Centralistic backend based approach not suitable for all applications

🟥 VANET/VDTN enabled vehicle

🟩 legacy vehicle

Why Misbehavior Detection?

Open systems

- Future VANET Vision: Ubiquitous deployment of VANET/VDTN capable systems from different vendors
- Can not centralize security infrastructure

Big attack surface (even for closed systems)

- Proposed systems mostly realized using widely available commodity hard- and software
  - WiFi Technology
  - Off-the-shelf operating systems and hardware platforms

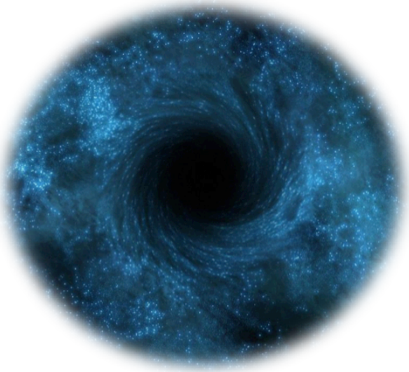
Misbehaviors can be the result of attacks or caused by hard- or software errors

Blackhole and Grayhole Attacks

A greyhole attacker drops a certain percentage of all messages it should send (Blackhole: 100%)

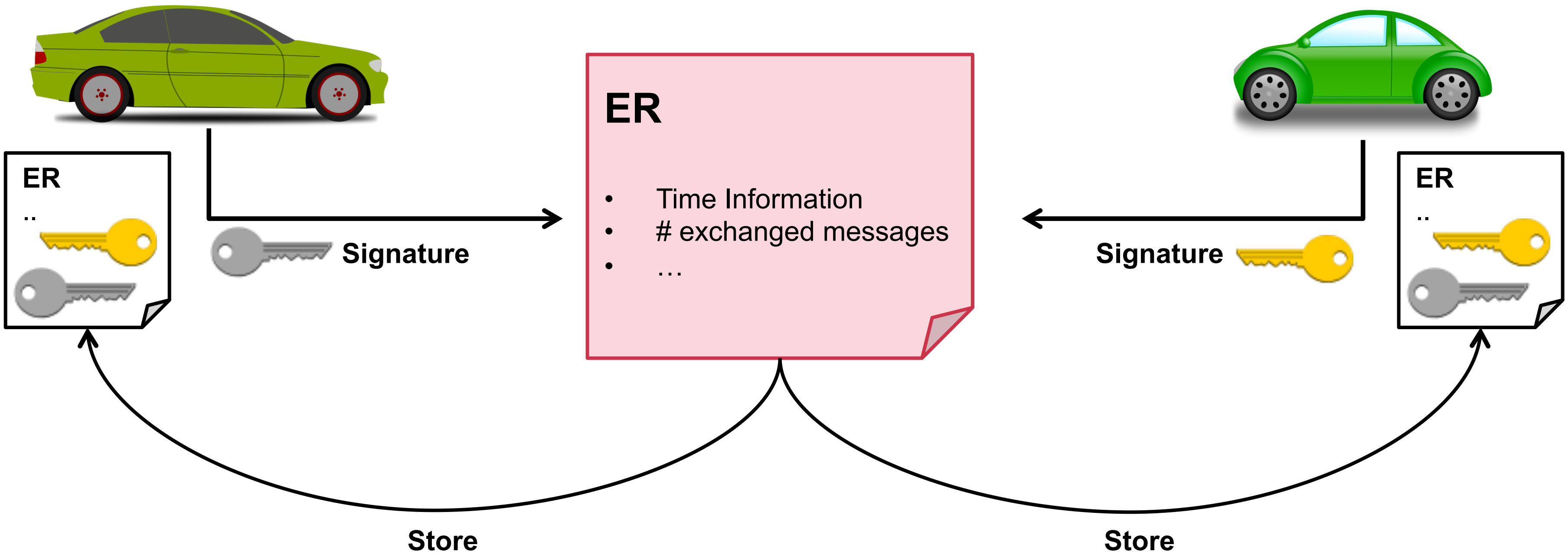
- A baseline attack to disrupt the network
- Hard- or software errors often manifest themselves in lost messages
- Can also be a symptom of more complex attack schemes such as certain attacks on the employed routing scheme

A good general property to measure network health



Encounter Records

Our system is based on Encounter Records*



* F. Li, J. Wu, and A. Srinivasan. Thwarting blackhole attacks in disruption-tolerant networks using encounter tickets. In INFOCOM 2009, IEEE, pages 2428–2436, Rio de Janeiro, Brazil, Apr. 2009.

Exchanged Encounter Records (ERs)

$$ER_i = ID_i, ID_j, sn_i, sn_j, t, Re_{i\rightarrow j}, Re_{j\rightarrow i}$$

$$Re_{i\rightarrow j} = \{(msg_{id}, msg_{src} | i \quad send \quad msg \quad to \quad j)\}$$

$$Re_{j\rightarrow i} = \{(msg_{id}, msg_{src} | j \quad send \quad msg \quad to \quad i)\}$$

$$sig_i = E_{RK_i}\{H(ER_i)\}$$

$$sig_j = E_{RK_j}\{H(ER_i)\}$$

$$ER_i^* = ER_i, sig_i, sig_j$$

Rules

- Consistency of sequence numbers and timestamps
  - $s_{n1} < s_{n2}$ implies $t_1 < t_2$
  - Last known valid s/t combination for a node stored in the Meeting List (ML)
  - If a node violates constraints it is put into the blacklist immediately

- Ratios regarding sent and received messages
  - Reputation System: Good behavior will be encouraged
  - Bad behavior leads to lower trust levels and ultimately to (temporary) inclusion into the blacklist

Ratios

Upon contact nodes exchange up to *w* of their newest Ers

Violations of thresholds lead to decreased trust level, compliance to the rules increases trust.

$$\theta = \frac{\sum_{m=0}^{m<w} N_{send}^{ER_m}}{\sum_{m=0}^{m<w} N_{recv}^{ER_m}}$$

Amount of send messages compared to received messages

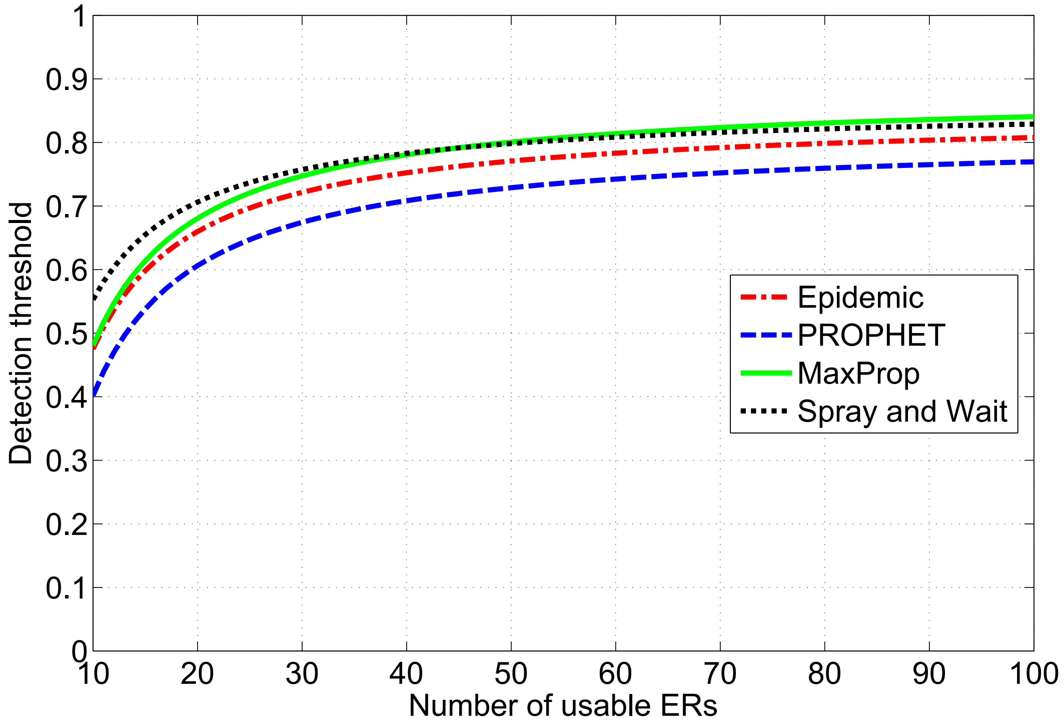
$$\psi = \frac{\sum_{m=0}^{m<w} N_{send}^{jER_m}}{\sum_{m=0}^{m<w} N_{send}^{ER_m}}$$

Sent messages, which are generated by a node itself, compared to sent messages generated by a third party

Detection Thresholds

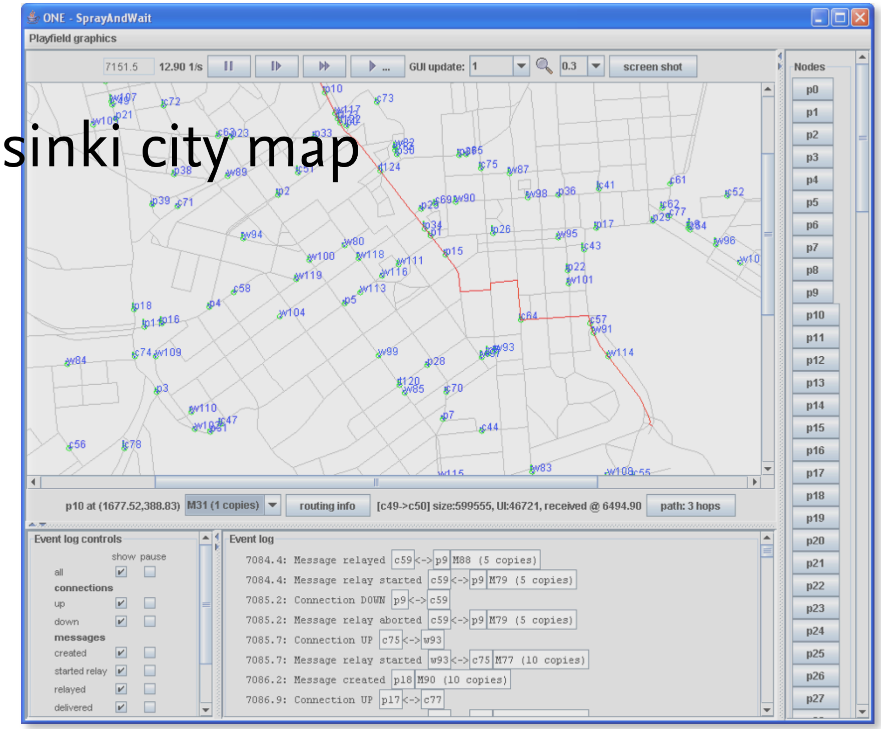
Strict thresholds when more ERs are available increase detection rate

Relaxed thresholds when little information is available decrease false positives



Simulations

- Used The ONE DTN simulator
- Routing: Epidemic, Spray and Wait, MaxProp, and PROPHET
- 40 vehicular nodes
- Transmission radius 100 m
- Map-based movement, Helsinki city map
- Area 4500 m × 3400 m
- 12 h simulation time



7151.5 12.90 1/s GUI update: 1 0.3

p10 at (1677.52,388.83) M31 (1 copies) [c49->c50] size:599555, UI:46721, received @ 6494.90 path: 3 hops

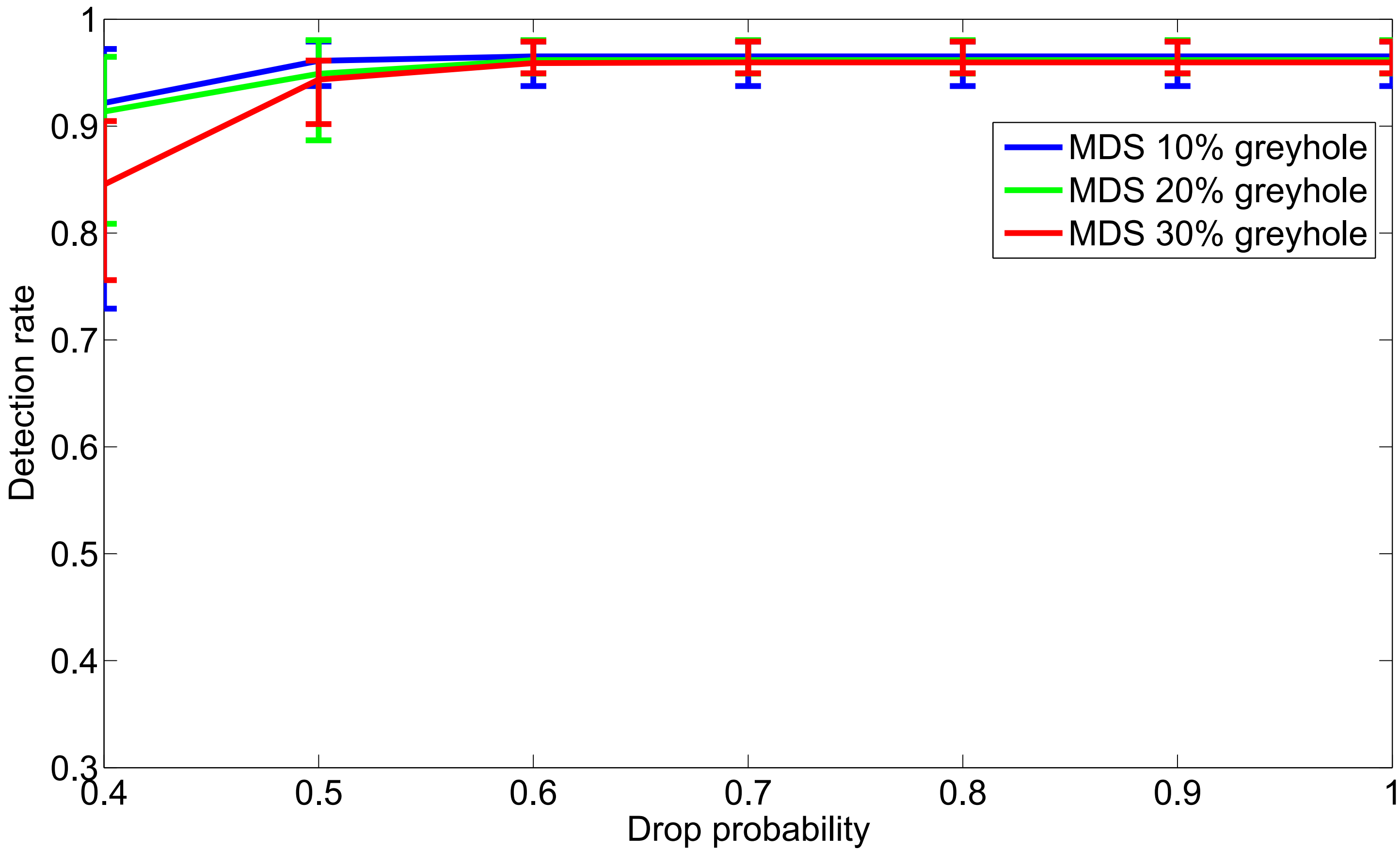
Event log controls

	show	pause
all	☑	□
connections		
up	☑	□
down	☑	□
messages		
created	☑	□
started relay	☑	□
relayed	☑	□
delivered	☑	□

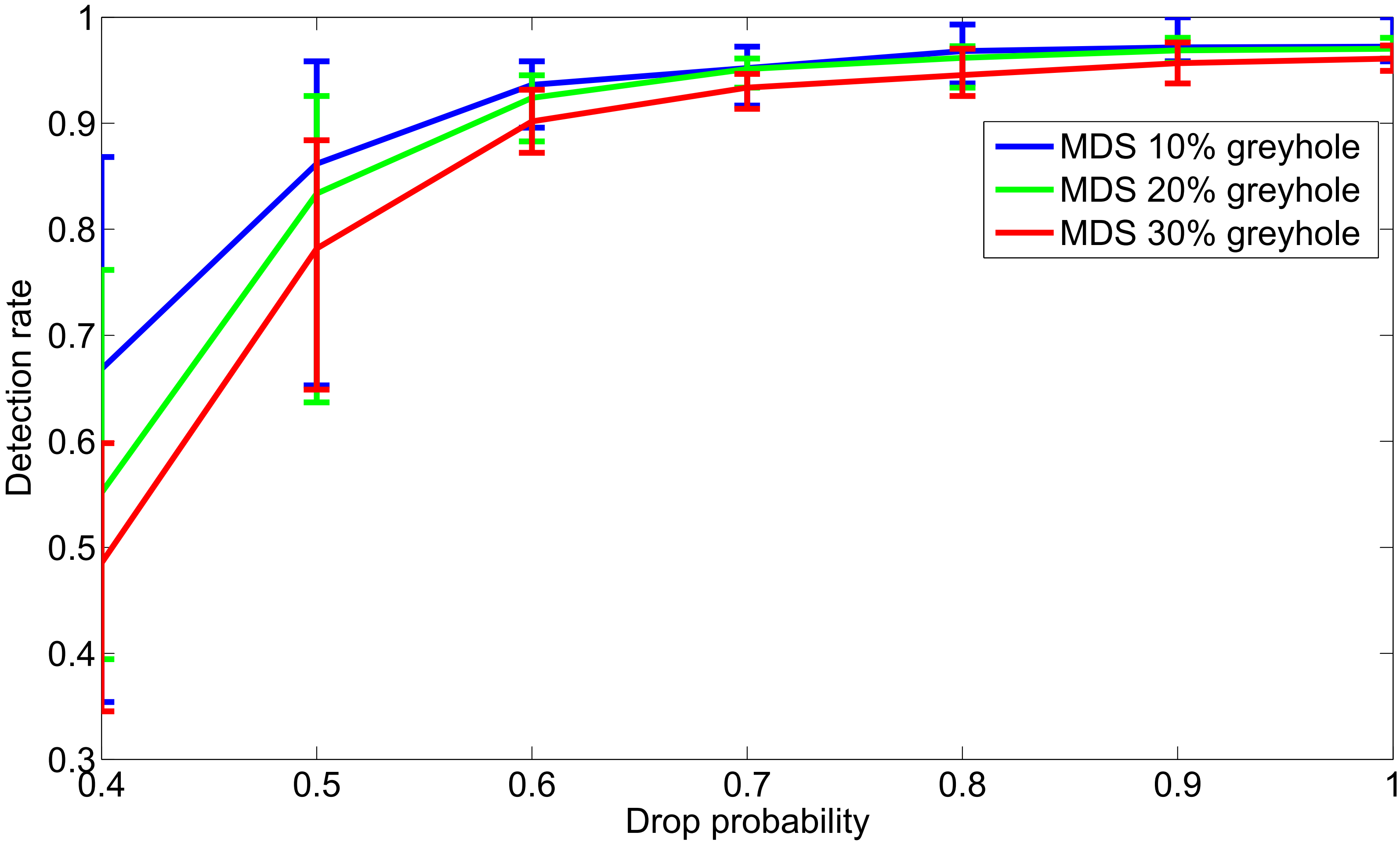
Event log

```
7084.4: Message relayed c59<->p9 M88 (5 copies)
7084.4: Message relay started c59<->p9 M79 (5 copies)
7085.2: Connection DOWN p9<->c59
7085.2: Message relay aborted c59<->p9 M79 (5 copies)
7085.7: Connection UP c75<->w93
7085.7: Message relay started w93<->c75 M77 (10 copies)
7086.2: Message created p18 M90 (10 copies)
7086.9: Connection UP p17<->c77
```

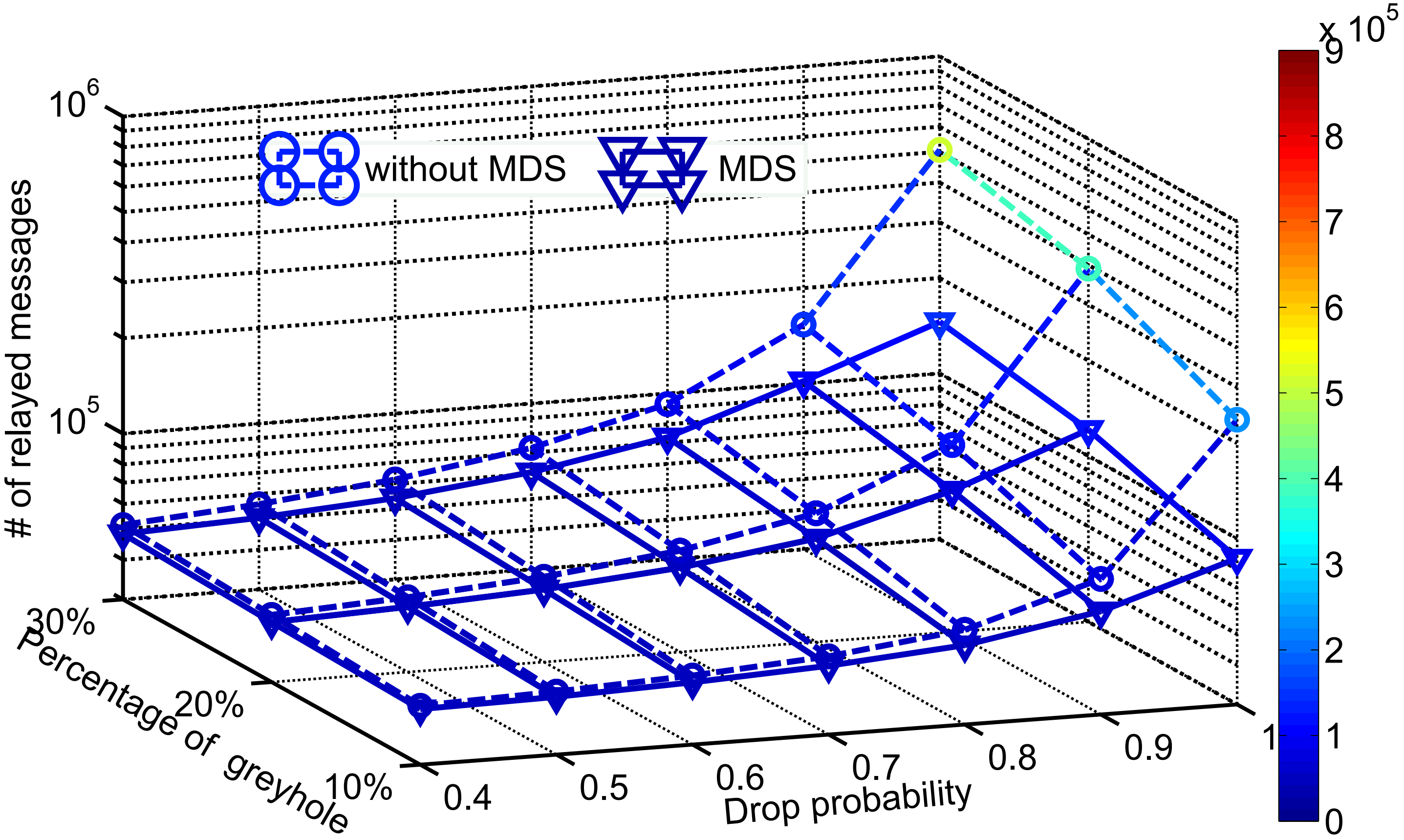
Detection Rate, Epidemic Routing



Detection Rate, Spray & Wait

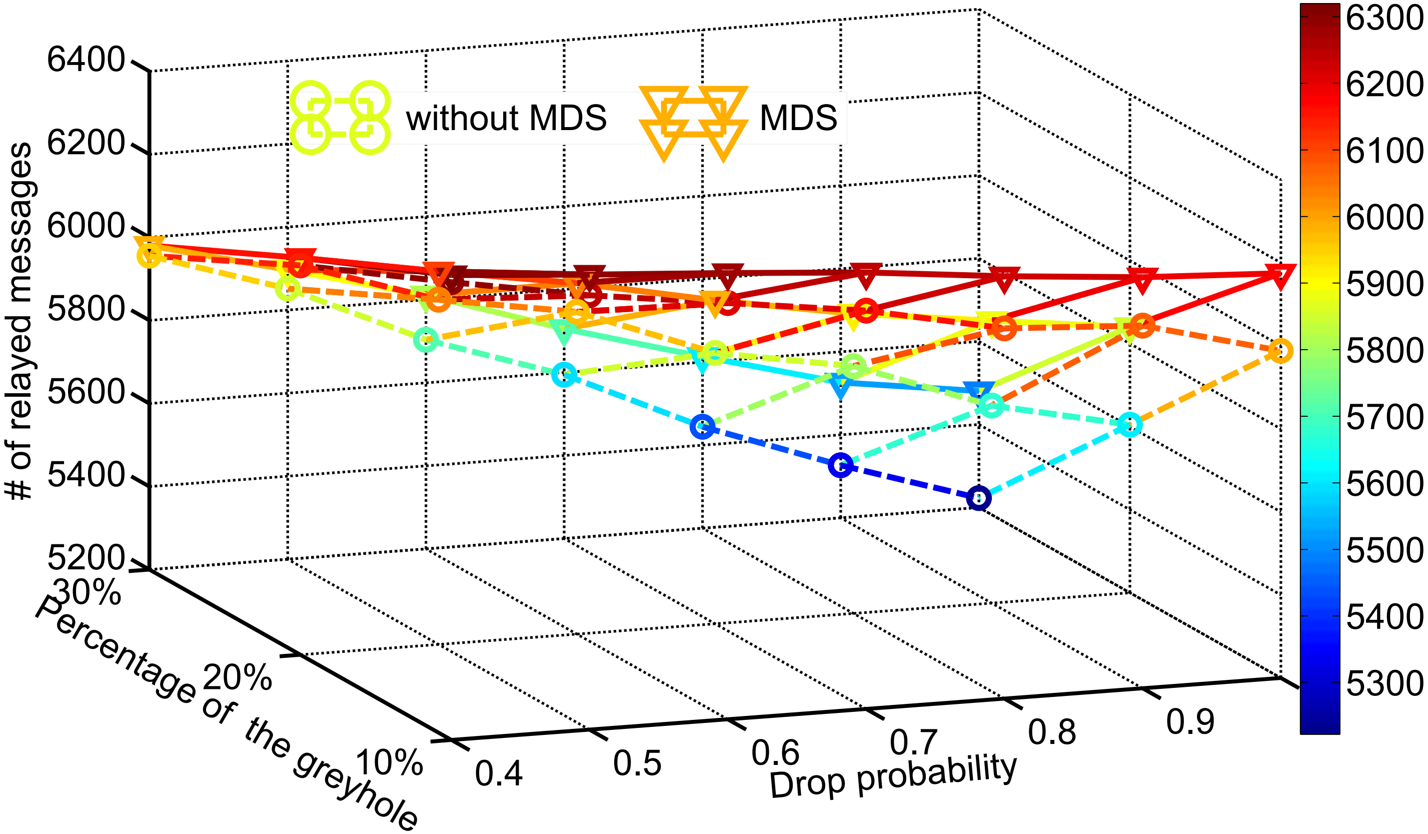


Energy Consumption, Epidemic Routing



MDS reduces useless transmissions

Energy Consumption, Spray & Wait



MDS protects limited replications, increases delivery rate

Conclusion

- Future VANETs will have a DTN structure
- Misbehavior detection is needed to exclude non-conforming nodes and keep the system healthy
- The proposed system
  - detects blackhole and greyhole behaviors
  - has a high detection rate
  - significantly reduces energy usage for routing protocols with unlimited replication
  - increases delivery rate for routing protocols with limited replication

Thank you! Questions?

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