ISE SRA
Institute of Systems Engineering
System and Computer Architecture
Prof. Dr.-Ing. C. Müller-Schloer

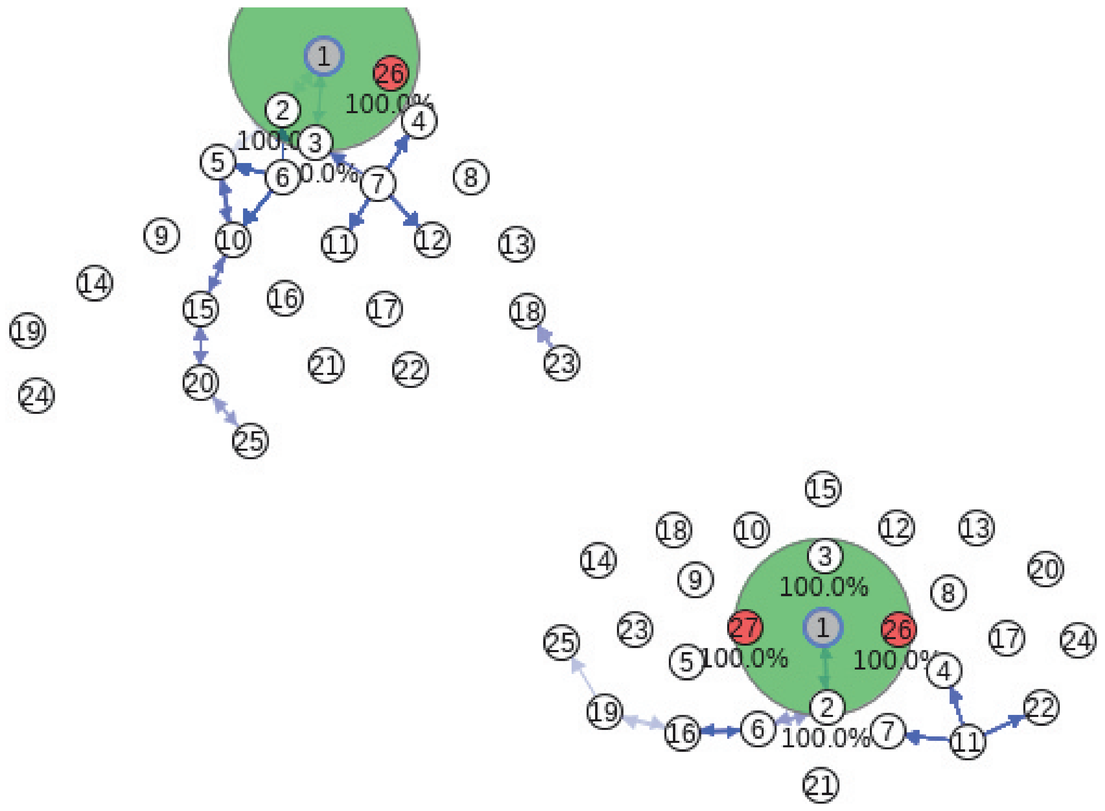
Leibniz Universität Hannover

Norm-based System Control in Distributed Low-Power Sensor Networks

Jan Kantert, Sarah Edenhofer, Sven Tomforde, Jörg Hähner, Christian Müller-Schloer

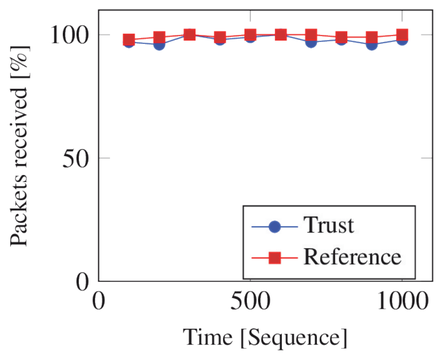
Distributed Low-Power Sensor Networks

- Routing Protocol for Low power and Lossy Networks (RPL)
- Destination-Oriented Directed Acyclic Graph (DODAG)
- One root per DODAG (ID=1 in example)
- Nodes choose a rank (root has 0)
  - Discover neighbours
  - Choose greater rank than neighbours initially
  - All nodes with smaller rank become parents
- Nodes can adapt rank during runtime
  - When new neighbours enter
  - When parents increase their rank
- Nodes broadcast their rank using DODAG Information Objects (DIOs)
  - Send periodically using Tickle Algorithm
  - Send on change
- Nodes do not know if their packets reach root
  - We introduced end-to-end trust to change that
  - Nodes send sequence numbers with packets
  - Root records missing sequences
  - Root embedds a signed record containing those sequences in each DIO
  - Nodes forward this in their DIOs
  - A node can eventually find out if its packets reached root
  - Malicious parents can be removed/ignored

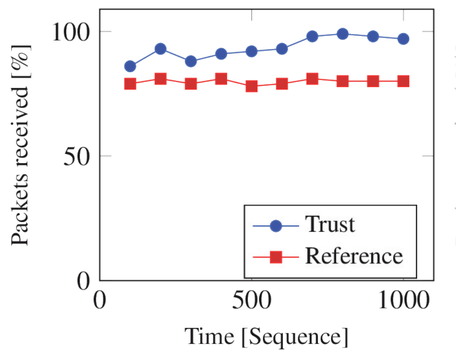


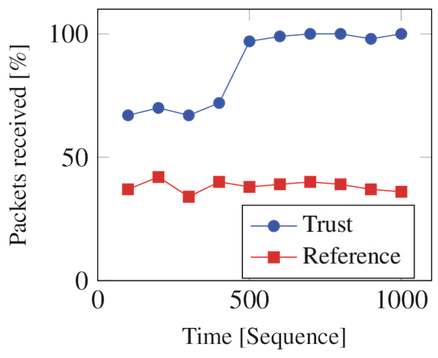
	Trust	Reference	Δ
ROM	48796 B	47520 B	1276 B
RAM	9516 B	7834 B	1682 B
Metric Container	65 B	0 B	65 B

(a) Additional Memory Usage



(b) Undisturbed system





Using Trust in Distributed Low-Power Sensor Networks

- Impact of Trust in RPL
  - Delivery rate improves when attack happens
  - Nodes start to ignore malicious parents
  - Some nodes increase their rank to regain a sufficient number of parents
  - Networks return to stable state
  - Size of DIOs increases
  - Slightly higher network contention
  - Delivery rate without attack does not change significantly
- Root gains insight into network
  - Coarse network topology
  - Where delivery fails in network
  - Currently feedback is given to nodes via DIOs only
- Can root use gathered informations?
  - Root has a lot more resources than nodes
  - Root is typically not power constrained
  - Root can do graph analysis on data
  - Detect if problems happen at all
  - Detect in which part problems happen
  - May be which kinds of problems

Higher-Level Observer in Sensor Networks

- Higher-Level Norm Manager (NM)
  - Inside root
  - Observer detects situation
  - Controller issues norms
  - System under Observation and Control (SuOC) represents Sensor Network
- How can root influence the network?
  - It cannot directly influence nodes
  - Communication embedded in DIOs
  - Information cryptographically signed
  - Enable security measurements
  - Disable security measurements
  - Change trust metric parameters
  - Trigger optimisation
- Nodes are autonomous
  - They can ignore all of this
  - However, they may use the information to save energy
  - Makes network more robust
  - Can trigger passive sniffing
  - Additional optimisations possible