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Privacy and Robustness for Data Aggregation in Wireless Sensor Networks

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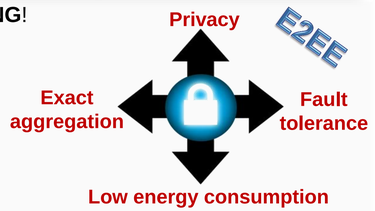
Introduction/Goals

- Sensors: limited **EVERYTHING**!
  - Bandwidth
  - Storage
  - Power
  - Computation
- Challenges:
  - Data Confidentiality
  - Fault Tolerance



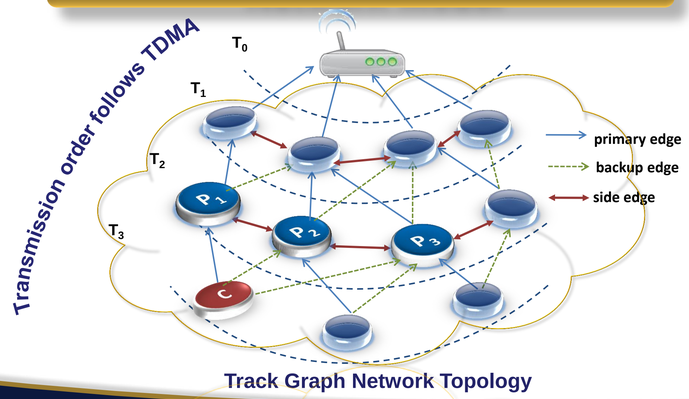
Building Blocks:

Privacy Preservation	Additively homomorphic stream cipher [1]
Robustness	Cascaded Ridesharing [2]

Applications

Collaborative sensing over shared infrastructure

Network Model



Track Graph Network Topology

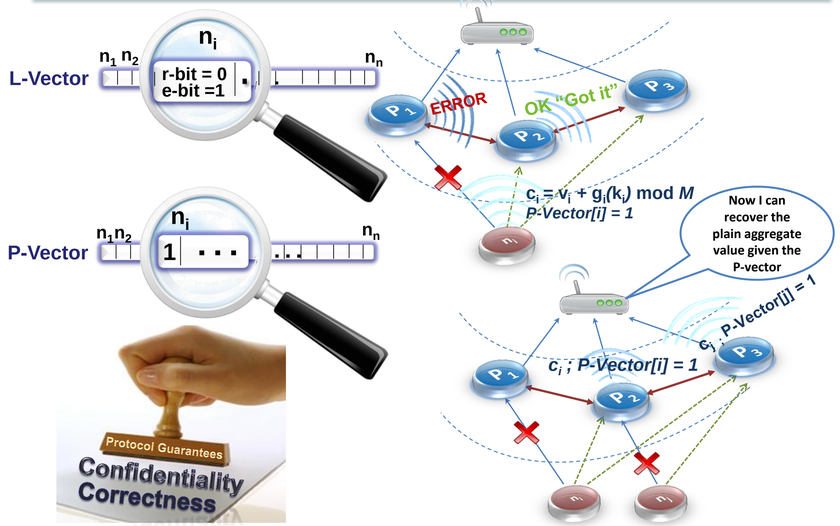
Attack Model

HONEST-BUT-CURIOUS
correctly aggregate, but eavesdrop

QUIET INFILTRATORS
stealthily infiltrate the network to eavesdrop

Protocol

1. Each sensor n_i encrypts its value v_i *as* $c_i = v_i + g_i(k_i) \bmod M$, and sets its corresponding bit in the *P*-Vector.
2. The resulting c_i values are aggregated using the Cascaded RideSharing protocol, which results in the sink receiving the value $C = \sum_i c_i \bmod M$.
3. The sink computes the aggregate key value $K = \sum_i g_i(k_i) \bmod M$ *for each* $i \in$ *P-Vector.*
4. The sink extracts the final aggregate value $V = \sum_i v_i = C - K \bmod M$.



Evaluation

Comparison of four protocols using the CSIM simulator [3]:

1. Spanning-tree: no fault tolerance, but efficient for power!
2. Cascaded RideSharing
3. Our confidentiality-preserving fault-tolerant aggregation protocol
4. Our protocol with state compression

Results

Comparison metrics :

1. Average relative RMS error in aggregated results
2. Average energy consumed per node per epoch
3. Average message size transmitted per node per epoch

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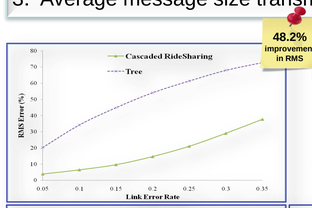
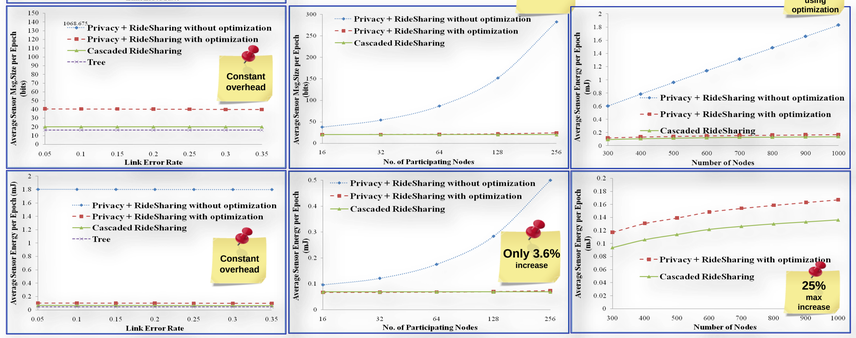


Simulation Parameters

Parameter	Value Ranges
Total number of nodes	300, 400, 500, . . . ,1000
Link error rate	0.05, 0.10, . . . , 0.35
Number of primary + backup parents	max(3)
Participation level (% of nodes reporting values)	1.5%, 2.5%, 5%, . . . , 25%



1- Effect of Link Error Rate | *2- Effect of Participation Level* | *3- Effect of Network Density*

Conclusions

- New privacy-preserving and fault tolerant in-network data aggregation protocol.
- Improvement of 48.2% in the root mean square (RMS) error of the final aggregate result over the spanning tree schemes (error rate up to 35%).
- Only 7.1% and 3.6% increases in the average message size and average power consumption over the RideSharing scheme.
- Maximum incurred power consumption overhead was 25% (with 100% node participation).

References

[1] C. Castelluccia, A. Chan, E. Mykletun, and G. Tsudik, "Efficient and provably secure aggregation of encrypted data in wireless sensor networks", ACM Transactions on Sensor Networks, Vol. 5, No. 3, Article 20, May 2009.
[2] S. Gobriel, S. Khattab, D. Moss´e , J. Brustoloni, and R. Melhem, "RideSharing: Fault tolerant aggregation in sensor networks using corrective actions", IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks,in SECON, 2006.
[3] "CSIM Simulator", http://www.mesquite.com/.

Appeared in 17th ACM Conference on Computer and Communications Security, CCS 2010