SenseSIM: Sensor Network Simulator

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Abstract—In spite of the increasing demand for Wireless Sensor Network based simulators, we are still lacking a clear understanding of analytical and computational techniques, as well as best practices, to design resource allocation schemes, communication protocols, and self-organization algorithms for wireless sensor networks that will deliver, in a predictable and quantifiable fashion, the quality of service required for a given computational lifetime. There is an urgent need to develop simulation platforms that are useful to explore data mining approaches with a stack supporting both the networking issues and the distributed computing aspects of wireless sensor networks.
This research summary presents my cross-level simulation approach and discusses ongoing work in terms of optimizing query scalability, computation aspects of cross-layer power-aware protocol.

I. Research Methods

The purpose of my PhD thesis lies in developing Lifetime models for methods in §**Computational aspects for Wireless Sensor Networks & Protocols**. Results on the performance of network layer†, medium access control schemes‡ have been simulated for power-aware routing algorithms. These simulators where initially implemented in VC++ and then ported into standard discrete event engines such as GlomoSIM to calculated the power consumption losses due to *collisions* at single/multi hop for CSMA/B-MAC. In the new framework we study end-to-end *scalability* issues§ of the simulators for cross-layer analysis using Directed Diffusion MAC. *Throughput* is calculated by overloading test-bed parameters which are used by proactive table driven algorithm in routing decisions. [1]

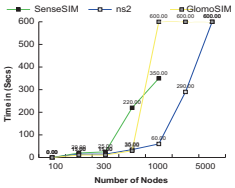
II. Computational Aspects

A. Computational Aspects at the MAC Layers

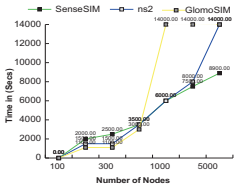
When the percentage of the sensors fail due to power drain the simulator calculates the average computational lifetime in terms energy consumed by the routing layer, IEEE MAC states of Tx, Rx & Idle and number of reliable quarries successfully completed by the algorithm. The complexity of depletion of energy per node for dense deployment follows the $PowerLaw = f(d) = kd^2 + o(d)^2$.

B. Computational Aspects at the Network Layers

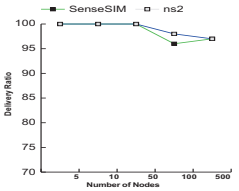
A routing protocol is considered scalable with respect to sensor network nodes, if the size of the necessary routing table on each node grows at a rate of $O(\log N)$, where N is the number of nodes in the network. SenseSIM routing implements LEACH, SPEED and Directed Diffusion which are scalable (*see Benchmark-table*) in terms of fixed resources. The work in-progress results are shown in Fig 1, plots (a,b), in which it performs twice as fast compared to ns2. Plot (c) (*see Throughput-table*) shows the SenseSIM MAC throughput is as scalable as in ns2's Directed Diffusion.



(a) Execution time-10 queries



(b) Execution time- 100 queries



(c) Directed Diffusion data throughput

Benchmarking

Target Test-bed Resources	ns2	SenseSIM	GlomoSIM	TOSSIM
1. Data structures§	Pre-defined-scalable	Can define all	Pre-defined	Objects
2. STACK Size	Upto tools	Upto tools	Upto tools	X-bow limits
3. CPU Util	90%	40-50%	90%	90%
4. Memory Util§	500 nodes	1,000 nodes	100 nodes	100 nodes
5. Clock	μsecs	μsecs	ηsecs	μsecs
6. Net/MAC routing	Loadable	Loadable NED	Loadable	Fixed
7. Kernel	-	PC Portable	PC Portable	-
8. Algorithm Animation§	Trace	Full-GUI with steps	Trace	GUI-plugin
9. Battery Model	-	Crossbow	Crossbow	Crossbow

Protocol Computation

Routing	Lower Bound Errors	Upper Bound Errors	CSMA-MAC	B-MAC
LEACH -Network†	$27.0\%^*$	41.0%	-	-
LEACH-Single-hop‡	$10.0\%^*$	15.0%	$320rnd^*$	$300rnd$
LEACH-Multi-hop‡	$15.0\%^*$	70.0%	$8rnd$	$32rnd^*$

Throughput Computation

Discrete Event Simulators	Directed Diffusion (50 nodes)	(5,000 nodes)	No. of nodes	Traffic
SENSESIM§	100%	96%	WSN Scalable	Adaptive
NS-2	100%	–	-	Adaptive

Fig. 1. **Benchmarking SenseSIM applications-** The optimized performance for cross-layer performance*.

III. Very Large Scale Deployment - Results

Use of network layer clustering further enhances reliability as shown in LEACH simulations. Upper-bound (*see Protocol -table*) for power-aware routing including lower layer synchronization and idle processing is achieved using B-MAC state scheduling for Tx, Rx and Idle periods.

[1]†Third International Conference on Sensing Technology, Tainin, Taiwan. V.Iyer, ¶G.R.Murthy, ¶M.B. Srinivas and Bertrand Hochet and ‡FARMS:IEEE Sensors Applications Symposium, 2009, New Orleans, Louisiana, USA. V.Iyer, S.S. Iyengar, V. Phoha, N. Balakrishnan, M.B. Srinivas. §PhD Thesis Preliminary results using SenseSIM. ¶IIIT-H Advisors