Demo: Large Scale Wireless Network Simulations with TSCH-Sim

Atis Elsts
Institute of Electronics and Computer Science (EDI)
Riga, Latvia
atis.elsts@edi.lv

Abstract

Simulators capable of handling large networks are increasingly necessary. To this end, this demo abstract presents TSCH-Sim, a scalable simulator for TSCH and 6TiSCH networks. The experimental results presented in this demo abstract include both performance of the simulated networks, as well as the speed of the simulator itself. The results demonstrate the benefits from developing new, custom solutions for networks above a certain size.

1 Introduction

The attraction of the research community is increasingly focused on large-scale and high-density low-power wireless networks. Even though the TSCH protocol is standardized on top of the IEEE 802.15.4 PHY, recent work has also demonstrated its operation on top of the LoRa protocol, which allows to build very large networks. This has increased the need for simulators capable on handling networks with hundreds and thousands of nodes.

2 TSCH-Sim

TSCH-Sim[1] is a scalable simulator for TSCH and 6TiSCH networks [2]. TSCH-Sim is implemented in JavaScript to facilitate fast experimentation and prototyping. It includes support for the TSCH protocol from the IEEE 802.15.4-2020 standard [1], as well as elements of the 6TiSCH standards [3], including integration with IPv6 and RPL. In terms of schedulers, the Orchestra scheduler is available from the Contiki OS, as well as the 6TiSCH minimal, and a leaf-forwarder scheduler for hierarchical networks. Multiple link models, mobility models, and control over the low-level details of simulations are available to the user. TSCH-Sim is usable both from the command line and a web GUI (Fig. 1).

[1] Available at `https://github.com/edi-riga/tsch-sim`

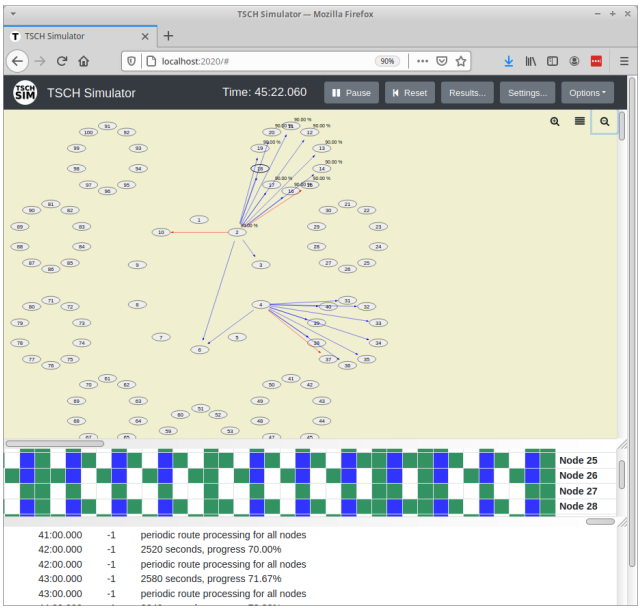


Figure 1. TSCH-Sim web user interface. From the top: control panel; network view; schedule view; log view.

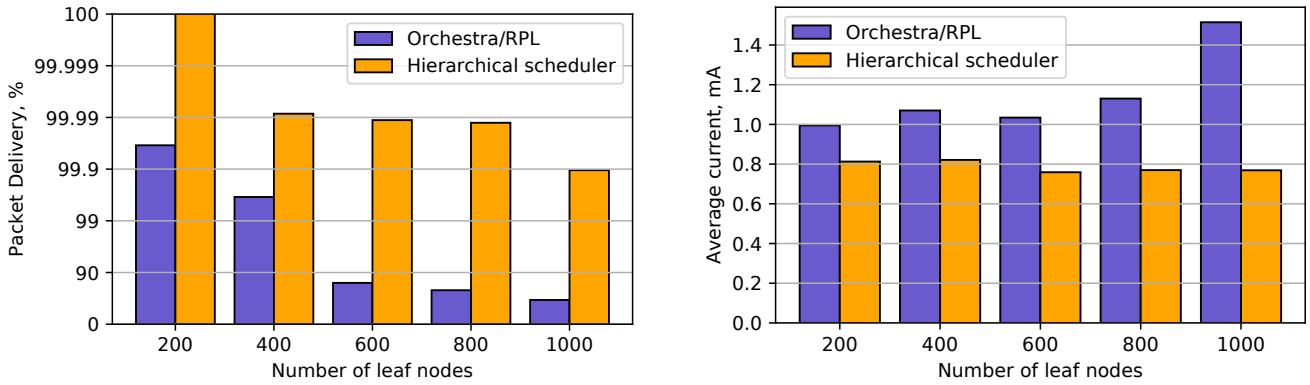
3 Experiments

This demo abstract presents simulations of networks up to >10 000 nodes, for a data collection application, with data packets flowing from leaf nodes to the root. In these experiments, several hierarchical networks are generated. The networks consist of a root, multiple forwarders, and a number of leaf nodes (Table 1). The root node and forwarders use a full-mesh connectivity matrix. The leaf nodes are divided in connectivity groups; each group is connected to a single forwarder, as well as has full-mesh connectivity between themselves (Fig. 1). The networks are constructed to emulate realistic, but challenging (for the simulator) settings where large number of potential communication links are present. All experiments are executed on a laptop with Intel i7-10710U CPU and Ubuntu 20.04 OS.

3.1 Comparison Experiments

First, the experiments compare the default TSCH network stack (standard RPL protocol and the Orchestra scheduler) with a simpler version for hierarchical leaf-and-forwarder (LF) networks. The hierarchical (LF) routing module as-

International Conference on Embedded Wireless Systems and Networks (EWSN) 2021
17–19 February, Delft, The Netherlands
ISBN: 978-0-9949886-5-2



(a) Reliability

(b) Current consumption

Figure 2. Network performance comparison in hierarchical network simulations.

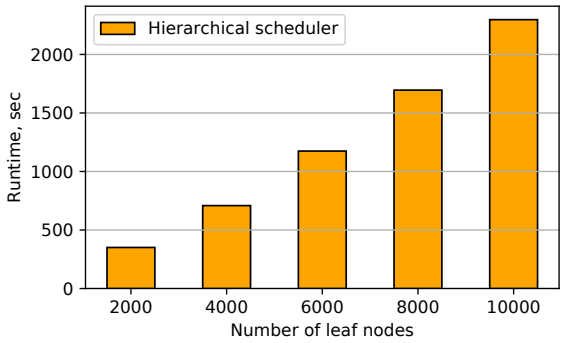


Figure 3. TSCH-Sim speed in large hierarchical networks.

Table 1. Experimental settings.

Parameter	Value
All experiments	
Total duration	60 min
Packet generation duration	30 min
Link quality	90 %
Number of root nodes	1
Comparison experiments	
Number of leaf nodes	200–1000
Number of forwarders	10
Routing	RPL and LF routing
Schedulers	Orchestra and LF
Orchestra common period	11
Orchestra unicast period	3
LF schedule period	7
Data packet interval	60 sec
Large network experiments	
Number of leaf nodes	2000–10 000
Number of forwarders	100
Routing	LF routing
Scheduler	LF
LF schedule period	7
Data packet interval	600 sec

sumes that the root node is directly reachable from any forwarder. The hierarchical (LF) scheduler assumes that the root and forwarders are not highly energy restricted and can keep the radio always on, while the leaf nodes only get one active cell per slotframe to save energy.

The results (Fig. 2) show that the RPL/Orchestra network stack breaks down in larger hierarchical networks even when a very short slotframe is used (higher average current consumption than for the hierarchical scheduler). In contrast, the hierachical scheduler achieves good reliability even in 1000-leaf-node networks.

3.2 Large Network Experiments

In order to scale the simulations even further, the packet generation period is increased to 600 sec and the number of forwarders increased from 10 to 100 (Table 1). This allows networks with up to 10 000 leaf nodes with high reliability; PDR is $> 99.8\%$ in all simulations.

The results (Fig. 3) show that TSCH-Sim achieves faster-than-real-time simulations of networks with more than 10 000 nodes and more than 500 000 links.

4 Conclusion

The results show that: (1) TSCH-Sim is capable of simulating large scale networks in real time or faster; (2) above a certain network size, commonly used protocol stacks such as RPL/Orchestra become unusable. The results demonstrate the importance of developing new, custom solutions for large and dense networks.

5 Acknowledgments

This work was supported by the ERDF Activity 1.1.1.2 “Post-doctoral Research Aid” (No. 1.1.1.2/VIAA/2/18/282).

6 References

[1] IEEE Standard for Local and metropolitan area networks—Part 15.4. IEEE Std 802.15.4-2020, 2020.

[2] A. Elsts. TSCH-Sim: Scaling Up Simulations of TSCH and 6TiSCH Networks. *Sensors*, 20(19):5663, 2020.

[3] X. Vilajosana, K. Pister, and T. Watteyne. Minimal IPv6 over the TSCH Mode of IEEE 802.15.4e (6TiSCH) Configuration. *IETF, RFC 8180*, 2017.