High fidelity simulation of large wireless networks

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Extended Abstract

The worldwide proliferation of wireless connected devices continues to accelerate. There are 10s of billons of wireless links across the planet with an additional explosion of new wireless usage anticipated as the Internet of Things (IoT) develops. This makes the understanding of many network protocols important for large wireless networks. Numerous studies have been done on wireless networks via simulations to characterize performance of popular routing protocols like OLSR and AODV as well as standard application and transport layer protocols like UDP, HTTP, and TCP, but these studies have been limited to small networks (less than a thousand nodes).

Wireless networks are generally characterized by mobility and proximity-based communications. Together, these aspects make it less predictable and more computationally expensive to simulate in a discrete event simulator. The well-accepted and published DES network simulators like ns-3 and OPNET provide a plethora of source codes to simulate many wireless network simulators with high fidelity. However, practical simulations are generally restricted to less than a thousand nodes in sequential simulations due to prohibitive wall clock times. A usual suggestion is to consider parallel implementation of DES, also known as PDES. PDES delivers an advantage over sequential DES by increasing the size of network that can be simulated as well as reducing the wall clock time, but at the expense of synchronization to maintain causality of simulated events. The improvement of simulations with PDES has been demonstrated by Prof. George Riley et al in ns-3 [1]. In their work, Prof. Riley demonstrated regions of trade-offs between the conservative synchronization approaches available in ns-3 as well as alluded to the future implementation of optimistic (time warping) synchronization in ns-3.

Although PDES provides significant advantages, it will most likely require clever design principles for wireless network simulations to scale appropriately. This is because, unlike their wired network counterpart where large scalability has been demonstrated [3], the pattern of event flow is mostly unknown without executing the actual simulation. The less predictability nature of wireless networks is due to the frequent mobility and associated proximity-based data communication and interference prevalent in it. This is a nontrivial challenge and as of ns-3.25 (released March 2016), PDES is currently limited to point-to-point net devices and is not enabled for general wireless simulations. In OPNET, simulations that we conducted indicate no advantage when using the PDES engine for simulating wireless network with AODV routing.

In this work, we have started the development of a simulation framework for enabling order of magnitude improvement in the size of full-featured wireless nodes that can be simulated in ns-3. Our approach relies on (i) the ability to significantly improve the simulation of proximity-based communication, which is prevalent in wireless network simulations, and (ii) the ability to efficiently load-balance workload across multiple processors in PDES as mobility is anticipated to occasionally cause uneven distribution of simulated event on processors. Although some recent contributions have been made in the ns-3 community for simulating large wireless network simulations, these efforts are limited in handling the general wireless net device. In [2], Kevin Jeffay and his group made important contributions in ns-3 to simulate large-scale airborne networks, but the advance was limited to less than a thousand nodes and relied on point-to-point wireless connectivity. In their work with airborne networks, interference was also ignored as it was most appropriate for this type of wireless communication.

General wireless network simulations tend to consume significantly more compute time than wired network simulations. For example, we recently showed that a simulation of a general who-is application developed in ns-3

with mobile wireless node showed that after around a 100 simulated nodes, the amount of time taken to run the simulation becomes greater than the simulated time (see Figure 1).

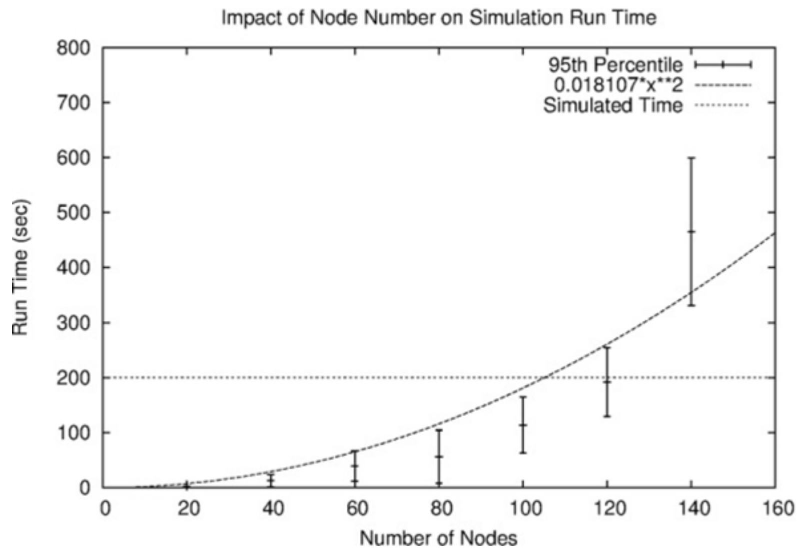

Figure 1: Basic simulation of a “who-is” application in ns-3 with mobile nodes following the random waypoint model.

In the simulation of general wireless networks, mobility causes changing communication patterns. This translates to proximity computations in the simulation engine. Fortunately, there are techniques for significantly improving proximity calculations and we have demonstrated orders of magnitude improvement in our framework over exhaustive (brute force) techniques used in most DES simulation. In our presentation, we intend to discuss the advances that we have made towards large scale wireless simulation, the current challenges, and the proposed ideas for further advancement and incorporation into the ns-3 simulator.

References:

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