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High Fidelity Simulations of Large-Scale Wireless Networks

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Outline

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- Background
- Wireless network Discrete Event Simulation (DES)
  - Usefulness
  - Limitations
- Efficient, scalable wireless network simulations
  - Proximity-based communication
  - Dynamic load balancing
- Future work

Background

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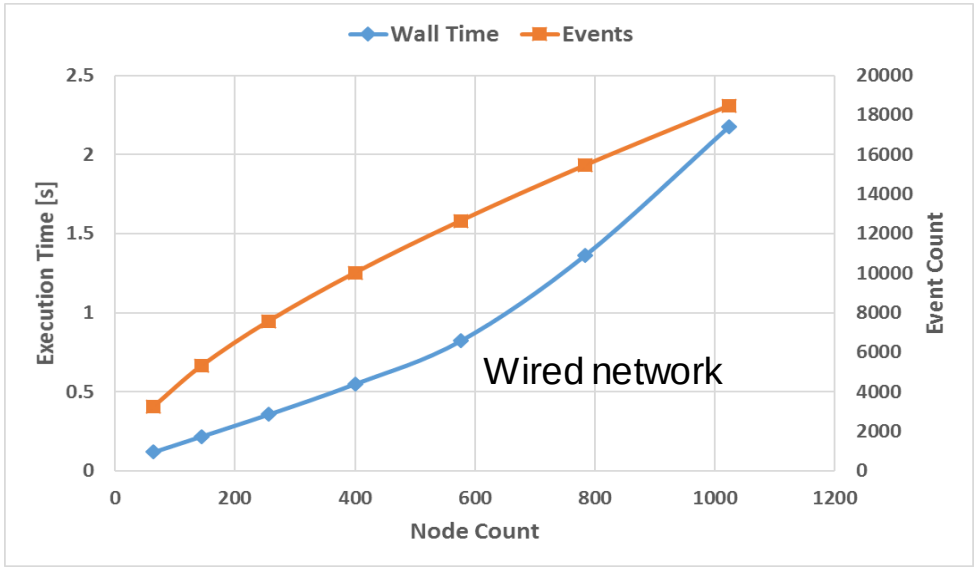
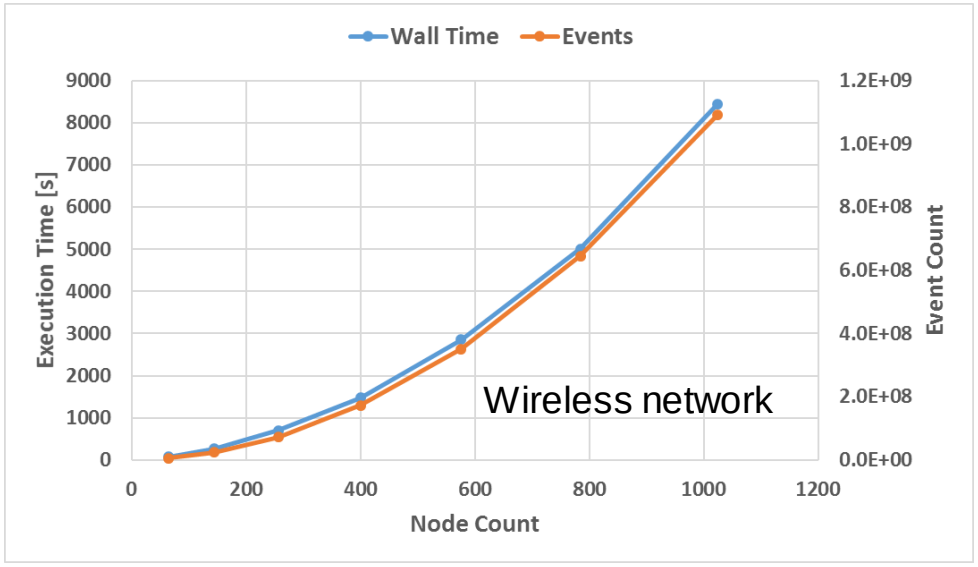
- Large-scale studies of wireless networks are becoming increasingly important with ubiquity of wireless systems.
- Wireless networks are often characterized by mobility and proximity-based communications, which are inadequately handled in today's DES simulators (ns-3, OPNET).
- High fidelity simulation of large-scale wireless networks (order of thousands of nodes) is usually prohibitively long.

Background:

Comparing simulations of pure wired vs wireless networks





- Simulation setup
  - Nodes fixed at vertices of simple regular square grid
  - Source at NW corner of grid region, while destination is at opposite corner (SE corner)
  - Total simulated time = 1000s and constant traffic every 10s.
- Wireless network simulations requirements for events and wall clock time are more than three orders of magnitude greater than for the comparable wired network.

Wireless Network DES

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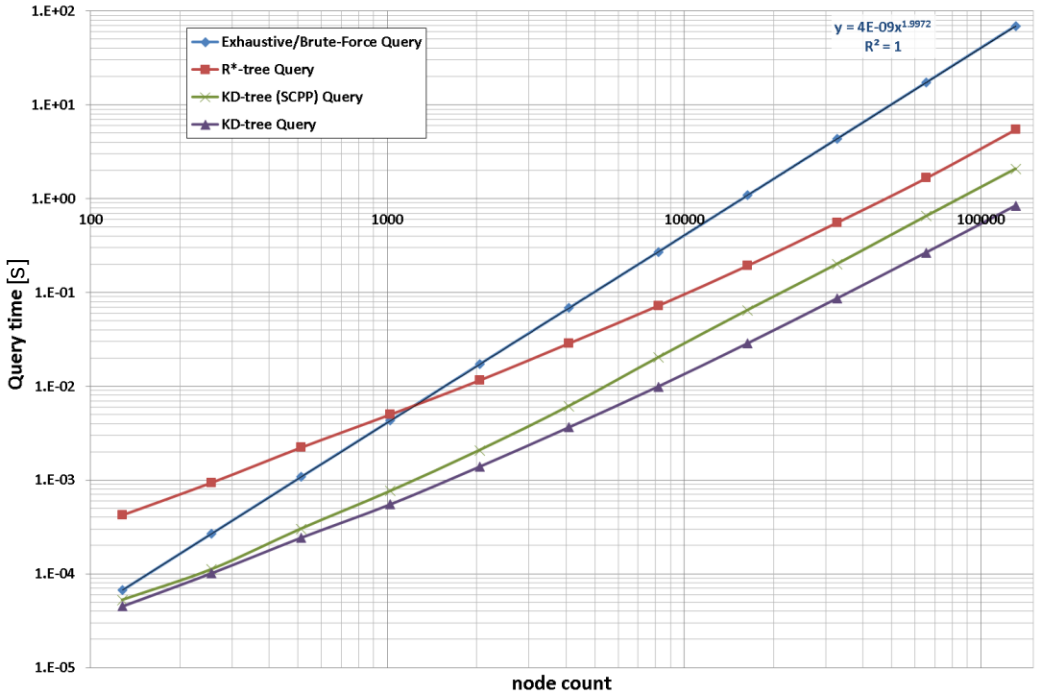
- High-fidelity discrete-event simulators (DES)
  - ns-3
  - OPNET
  - …
- Usefulness
  - Protocol characterization
  - Cost-effective performance evaluation
- Limitations
  - Prohibitive (time) cost for moderate size (>1000 nodes)
  - Difficult to parallelize (using parallel discrete-event simulation engine)
  - Verification and validation

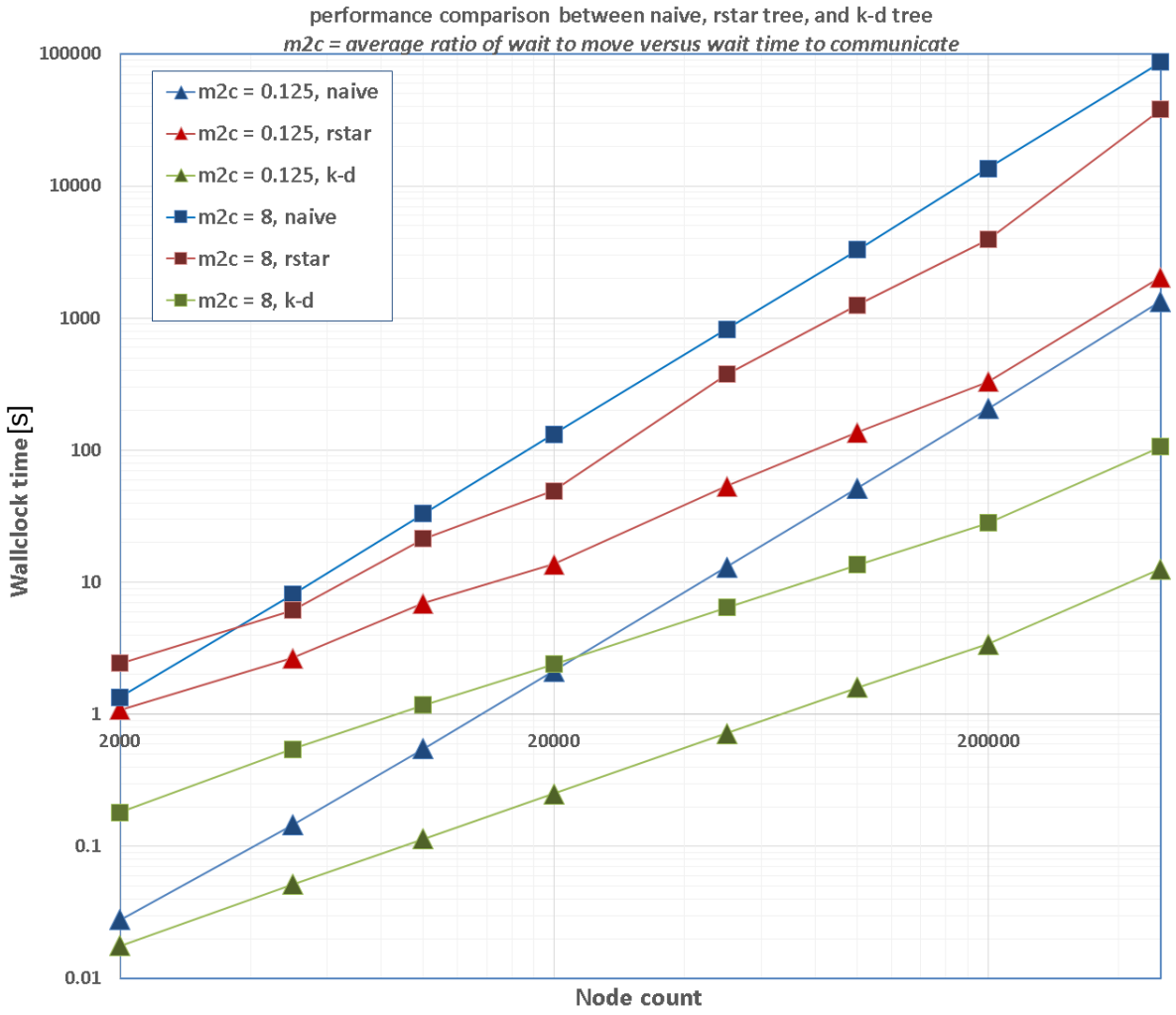
Proximity-based Communication Events



- Computing platform: *Intel Xeon CPU E5-2697 @2.7 GHz.*
- Spatial indexing (R* and k-d trees) gives hundredfold speedup over the often-used naïve calculations.

R* tree implementation (libspatialindex: http://libspatialindex.github.com)
SCPP = Spatial C++ Library (http://sourceforge.net/projects/spatial)

Mobility and Proximity-based Communication Events



Attained up to 800X improvement in skeletal simulation of mobility and wireless communication events.

Dynamic Load Balancing in PDES

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- Goal
  - Attain equal work load distribution across all processors.
  - Adapt to dynamically changing connectivity graph.
  - Minimize physical inter-process communication among nodes.
- Considerations
  - Equal simulated node count per physical core.
  - Clustering according to geographic regions and assign to processes.
  - Monitor resource usage per simulation process and adapt to equal work load.

Future Work

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- Incorporate framework for improving mobility and communication event handling into ns-3.
- Develop solutions to dynamic load balancing suitable for large-scale wireless network simulations.
- Verify and validate findings with other collaborators.

QUESTIONS