

XS-WSNet

Extreme Scale Wireless Network Simulator

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May 15, 2009

Outline

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- Issues in WSNs.
- Simulators.
- WorldSens Environment.
- XS-WSNet (Design, Implementation, Key Features).
- Application Epidemic Protocol.
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- Questions/Comments.

Introduction to Wireless Sensor Networks

- Smart devices with multiple **sensors** connected through **wireless** links and internet.
- Diverse applications like defense, security, traffic control, video surveillance, environment monitoring, etc.
- Overlaps with technologies from different fields e.g. sensing, computing, communication.
- Sensors, processors, communication devices getting **smaller** and **smarter**.
- Reduction in size and price made possible **large size** networks.

Issues in WSNs

- **Limited** storage, computing and communication capacity.
- **Unpredictable** medium.
- **Unreliable** wireless links.
- Sensor nodes prone to **failures**.
- Testing protocols and applications **difficult**.

Simulators (low level)

- Also called **emulators** or **platform simulators** e.g. WSim, TOSSIM, ATEMU, etc.
- Provides more details at **hardware** level and node **internals**.
- Run the **actual** application code.
- Very **limited** network scalability.

Simulators (high level)

- High level or network simulators e.g. ns-2, GloMoSim, GTSNets, OMNet++, etc.
- Provides more details at network and protocol levels.
- Differs in design choices, implementation languages, underlying operating systems.
- Limited scalability due to limited resources.
- Only a few use [parallelism](#) e.g. GloMoSim.

WorldSens Environment

- Two simulators **WSNet**(network simulator), **WSim**(sensor node simulator).
- WSNet features: **event driven**, **modular** design, **extensible**.
- **Various** models for different layers like application, MAC, radio, antenna, energy, etc.
- **Choice** to configure the simulation environment.
- Simulation configuration: in the form of **XML** file.

Example WSNets Simulation Configuration

- Here is the small portion of an xml configuration file.

```
<!-- == Worldsens ===== -->
<simulation nodes="10000" x="200" y="200" z="0"/>
<!-- == Entities ===== -->
<!-- == PROPAGATION, INTERFERENCES and MODULATION ===== -->
<entity name="range" library="propagation_range" >
  <init range="5"/>
</entity>

<entity name="interf" library="interferences_orthogonal">
</entity>

<entity name="none" library="modulation_none">
</entity>

<!-- == Environment ===== -->
<environment>
<propagation entity="range" range="5"/>
<interferences entity="interf"/>
<modulation entity="none"/>
</environment>

</worldsens>
```


XS-WSNet Design Features

- Basic idea to use **parallelism** using multiple machines.
- Node/network **partitioning** scheme: divide **nodes** on number of **machines** with **full** area on each machine.
- Communication module: **developed** and **embedded** with WSNet.
- Changes in WSNet: made necessary changes in WSNet to work in **distributed** environment.

XS-WSNet Architecture

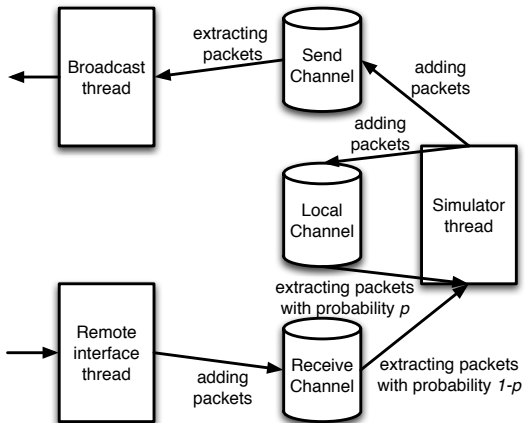


Figure: The *XS-WSNet* simulator on each machine

Application: Epidemic Protocol

- Nodes distributed **randomly** in simulation area.
- **One** source node: **emits** a message.
- Sensor nodes receive and forwards the message with certain **probability**. Do not forward the same message twice.
- Communication mode: **local broadcast**.
- Comparison criterias for single and multiple machine simulations:
 - Number of receiving nodes.
 - Average path length from source to sensor node.

Comparison: Number of Receiving Nodes

wsnet comparison of total number of receive nodes for approximately 10000

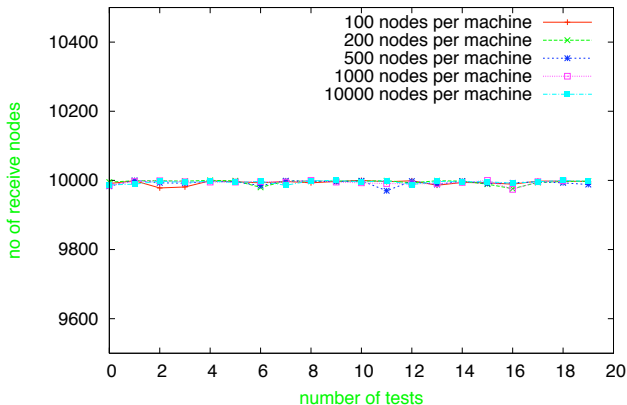


Figure: Number of receiving nodes when simulated on different number of machines.

Comparison of Average Number of Hops

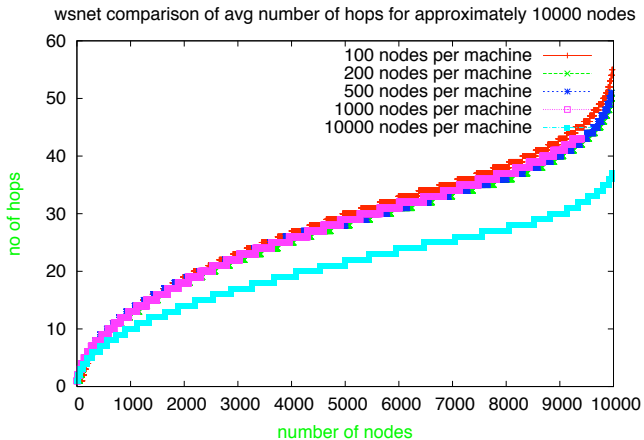


Figure: Average number of hops from source node to sensor node.

Example Asynchronicity in XS-WSNet

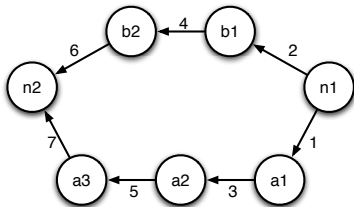


Figure: All nodes on same machine.

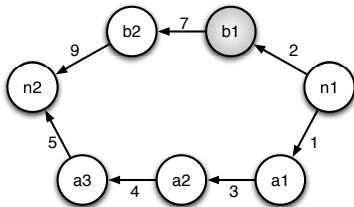


Figure: Node b1 on different machine.

Network Scalability

- **Network size**: number of nodes.
- **Simulation time**: difference of message receiving time of last node and emitting time of source node.
- **Node density**: local node density, global node density.
- **Scale up options**: increasing nodes on each machine or increasing number of machines.

Time comparison: single vs five machines

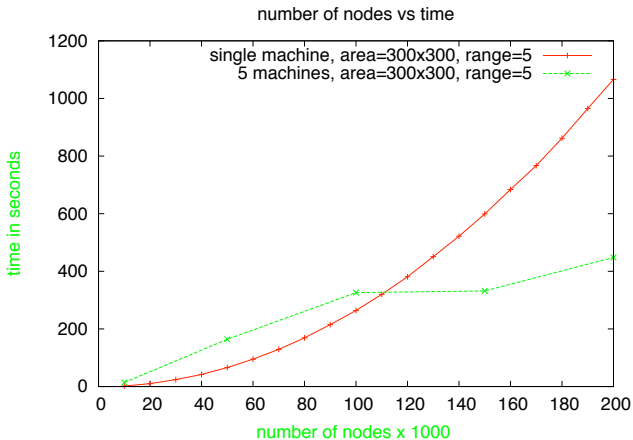


Figure: Simulation times up to 200,000 nodes.

Scalability with increasing node density

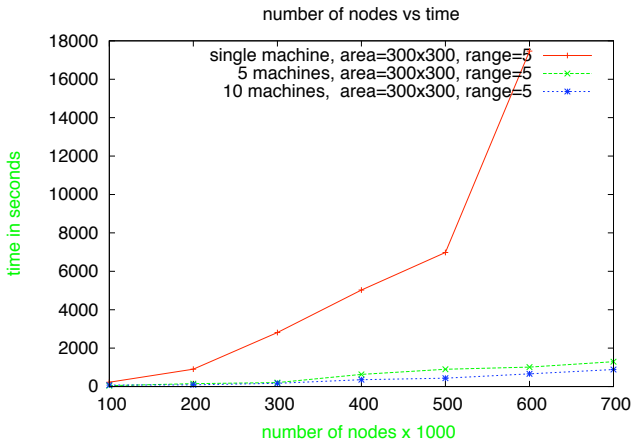


Figure: Simulation times up to 700,000 nodes.

Scalability with increasing node density

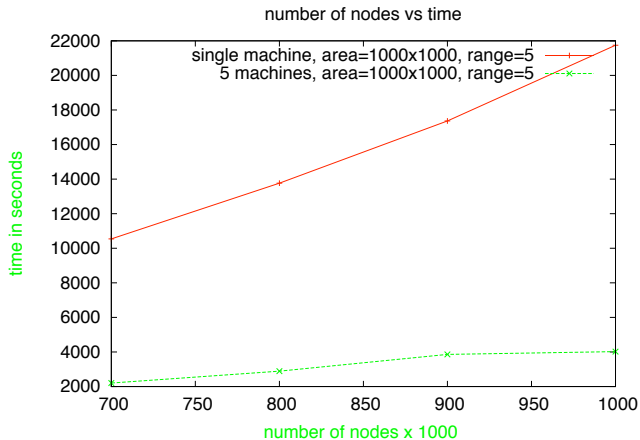


Figure: Simulation times from 700,000 to one million nodes.

Scalability with constant node density

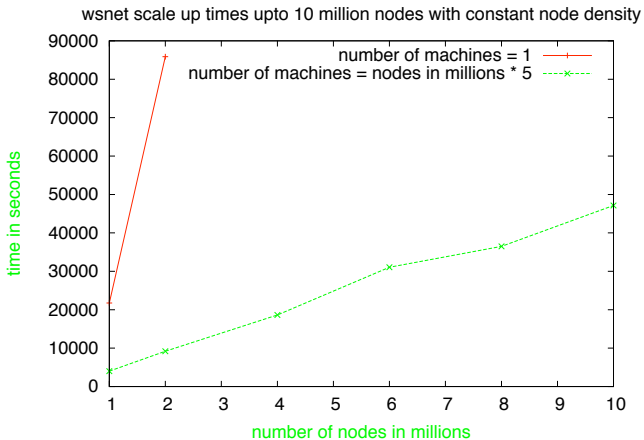


Figure: Simulation times from one million up to 10 million nodes.

Conclusions

- Proposed, implemented and tested a distributed version of WSNNet simulator with scalability as prime objective.
- XS-WSNet provides scale up and speed up even with small number of machines.
- Scalability is linear with number of participating machines.
- Provides asynchronous environment for simulation.

Any Questions/Comments

Thanks.
Any **questions** please.