ENSC 427: Communication Networks Spring 2019

Mobile Wireless Sensor Network Simulation

Team 10

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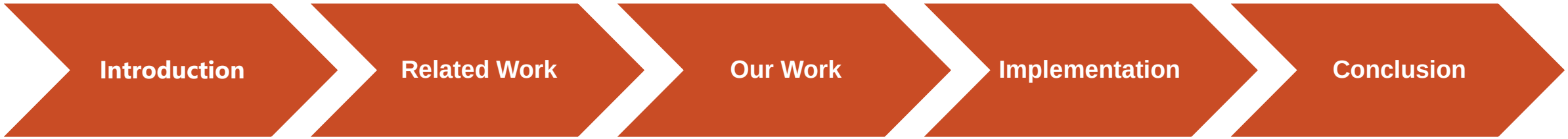
Project URL: https://loshau.wixsite.com/team-10

Presentation Overview



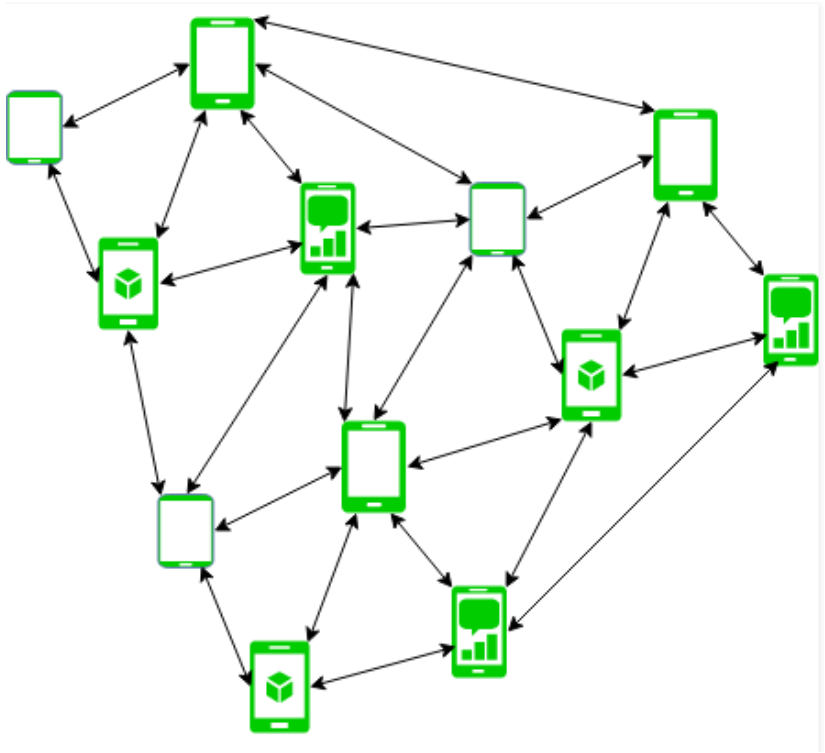
Introduction

- What are Wireless Ad-Hoc networks?
  - Decentralized/pseudo-decentralized network
  - Peer to peer connections
  - Self-organizing and flexible
- Applications
  - Military Applications
    - Area monitoring
  - Industrial/Manufacturing
    - Health of machinery
  - Autonomous Mobile Systems
    - Drones, Cars

http://surflextechnology.in/2017/04/05/design-and-implementation-of-path-establishment-and-maintenance-technique-for-manets/

3 Main Types of Wireless Ad Hoc Networks

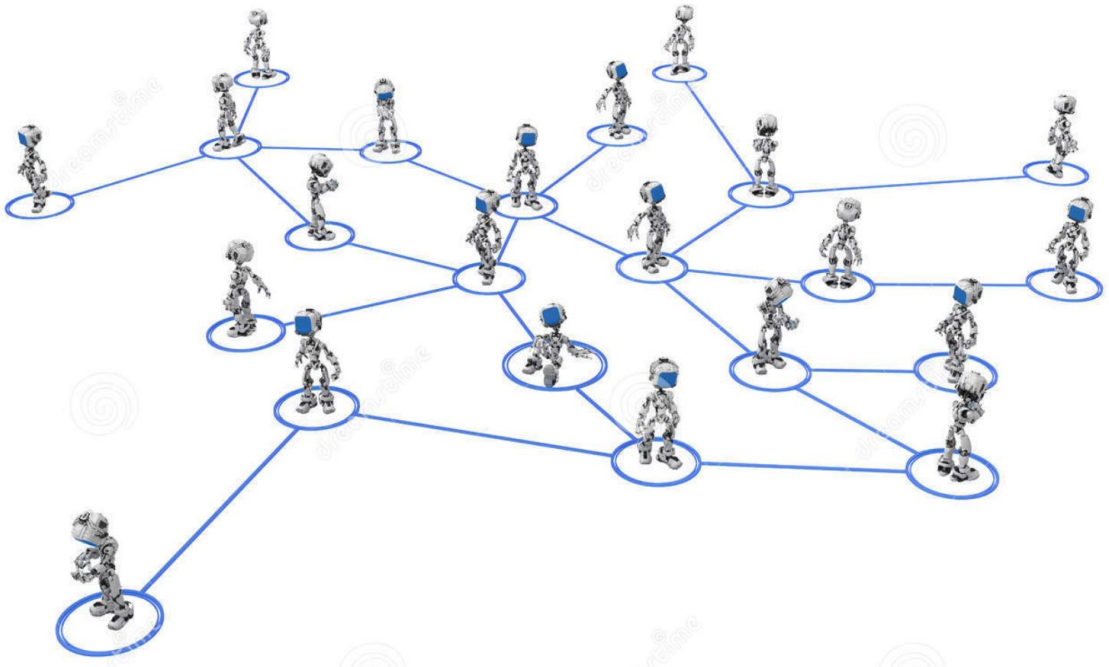
- Mobile Ad hoc Networks (MANETs)
- Wireless Mesh Networks (WMN)
- Mobile Wireless Sensor Networks (MWSN)



https://www.geeksforgeeks.org/manet-mobile-ad-hoc-network/

Mobile Wireless Sensor Networks

- Subset of Mobile Wireless Ad-Hoc Networks
- Ad-Hoc network consisting of many mobile devices with few Base Stations
- Mobility unpredictable but globally constrained
- Predictable and relatively consistent network traffic
  - Mobile Sensor <--> Base Station generally transmit data at a known constant rate (analogous of a sampling rate)



https://www.dreamstime.com/stock-photography-blue-screen-robot-line-link-network-image14987992

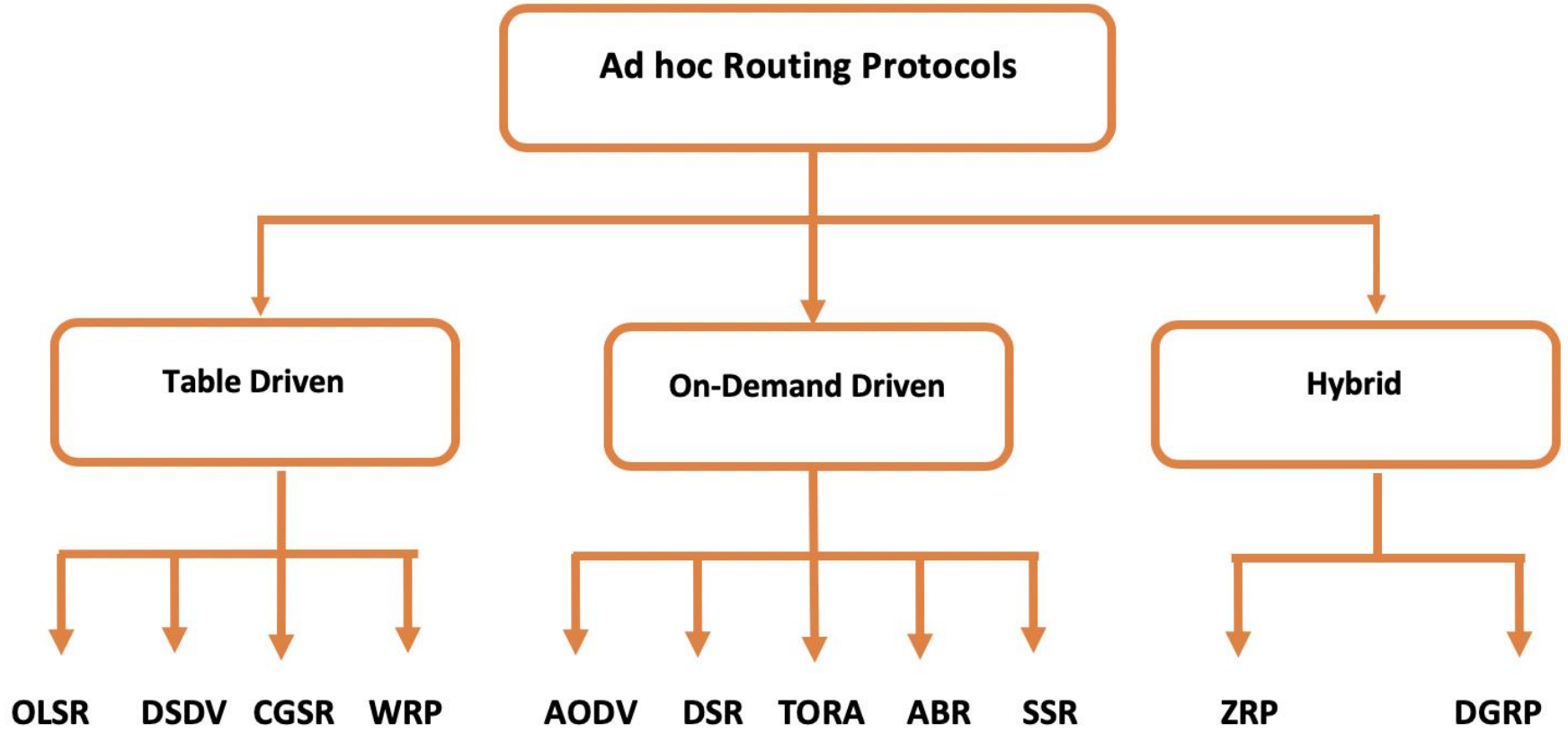
Main MWSN Design Problems

- MWSN nodes are generally battery powered embedded devices
  - Desire low transmission power
  - Desire minimal transmissions (optimal routing)
- Packets must be routed quickly and efficiently
  - Some applications have inherent real time constraints
- Mobility of nodes is locally unpredictable

https://www.mobile-industrial-robots.com/en/products/mir100/

Design problems all revolve around efficient + flexible routing!!!

Ad hoc Routing Protocols



OLSR Routing Protocol

- **Periodically update link state at each node**

Optimized Link State Routing	
Advantage	**Disadvantage**
Use hello and topology control messages	**Overhead increases when nodes increase**
Reduce control traffic overhead	**Long time to find broken link**
Small end-to-end delay	**Large processing power to find alternate transmission path**

DSDV Routing Protocol

- **Modified version of Bellman-Ford Algorithm**

Destination Sequence Distance Vector	
Advantage	**Disadvantage**
Guarantee loop-free path	Excessive delays as nodes increase
Short path set-up process time	Large power consumption due to frequent routing table update
optimal for network with few nodes	

DSR Routing Protocol

- Use source routing
- Route Discover and Route maintenance to find routes from source to destination

Dynamic Source Routing	
Advantage	**Disadvantage**
Self-organizing without network infrastructure	Poor performance when nodes movements increase
No need for up-to-date routing information	Not scalable

AODV Routing Protocol

- Reactive routing protocol
- Calculate distance vector on demand for packet transmission

Ad hoc On Demand Distance Vector	
Advantage	Disadvantage
Unicast and multicast transmission	High processing demand
Flexible with nodes' movements	Transmission delay due to expired route
Reduction of stale router	Lengthy time to build routing table
Smaller bandwidth for path advertisements	

Related Work

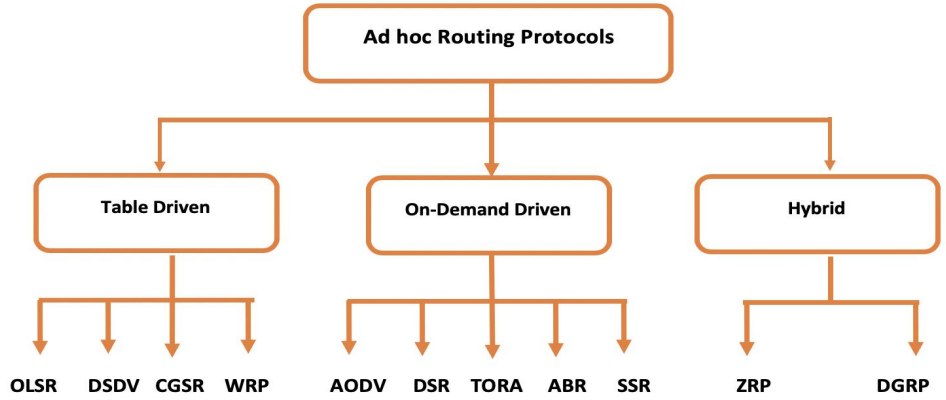
- V. Jayalakshmi, T. Razak study on two types of routing protocols in MANET
  - Table-driven Routing
    - Attempt to maintain up to date information from each node to every other node
      - **DSDV, OLSR**
  - On-Demand driven Routing
    - Establish routes only when needed by flooding network with router request packets
      - **AODV, DSR**
- S. Lally, L. Trajković performance analysis of routing protocols for Wireless MANETs
  - Simulated in OPNET with UDP and TCP traffic

Summary of Our Work

- Simulated Mobile Wireless Sensor Networks (MWSN) Scenarios in ns-3
  - Compared throughput of ad-hoc routing algorithms under varying parameters
    - Algorithms:
      - AODV, OLSR, DSR, DVSR
    - Parameters:
      - Physical Network Area
      - Number of Mobile Devices
      - Transmission Power
      - Traffic Levels
      - Varying Physical Network Area with Low Transmission Power

Goal

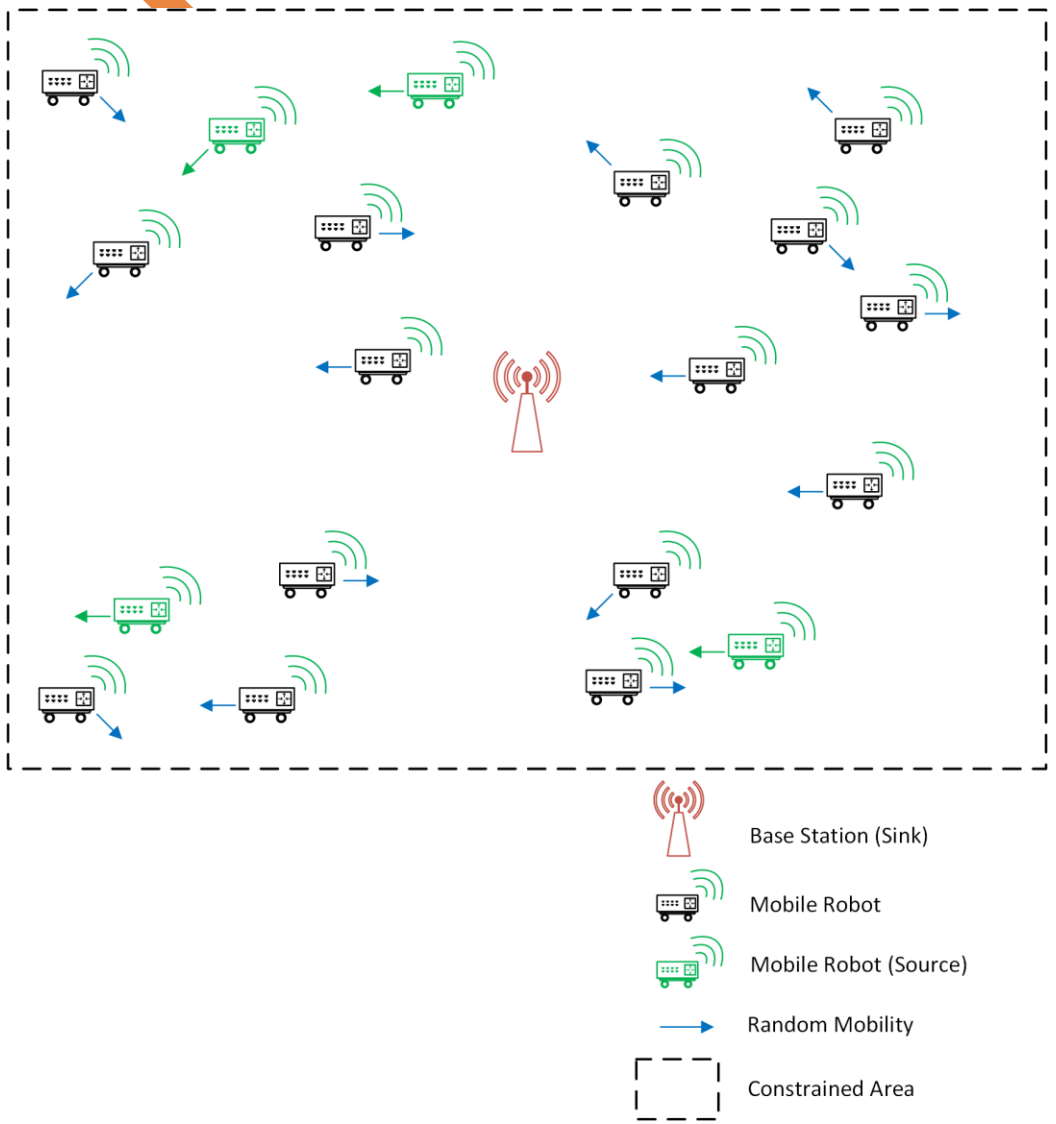
- Understand the effects of:
  - Area
  - Transmission power
  - Number of nodes
  - Traffic rates



- Determine the best routing algorithm for MWSN between OLSR, AODV, DVSR, and DSR routing protocols
- Contribute re-useable code to the network simulation community

Base Scenario

- Base Scenario Motivation:
  Industrial warehouse with many worker robots
- Mobile Robots in a constrained area
  - N Mobile Robots
    - M Data-Generating Robots (Sources)
    - N – M Non-Data-Generating Robots
  - 1 Base Station (Sink)
  - Data-Generating Robots constantly send packets addressed to Base Station (at R bps)
  - Routing algorithms attempt to find optimal global packet routes



Implementation

- Adapted open-source ns-3 "manet-routing-compare.cc" written by Justin Rohrer <rohrej@ittc.ku.edu> to reflect our MWSN scenario
  - Added a base station node
  - Adjusted number of sinks/sources
  - Added parameters for adjusting area, Tx power, traffic, and number of nodes
  - Added command line arguments for these parameters
- Created simulation environment using Python to batch over 200 large individual ns-3 simulations (each requiring over 10min) and used NumPy for improved data manipulation of ns-3's csv output files
- Computed and graphed average packets received by Base Station in order to compare AODV, OLSR, DVSR, and DSR under varying system parameters

Implementation

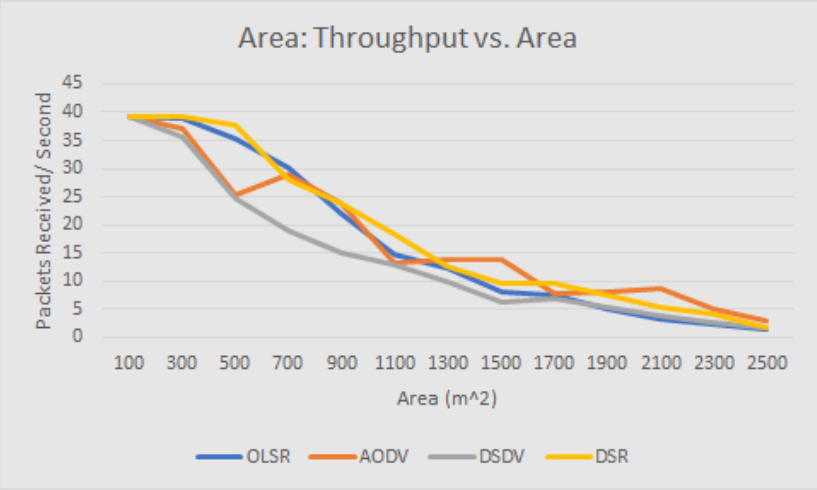
- Took advantage of ns-3's vast open source code base:
  - Routing Algorithm Helpers: AODV, OLSR, DSDV, DSR
  - Wifi Helper
  - Mobility Model: Ad Hoc
  - Internet Stack Helper
  - IPV4 Routing Helper

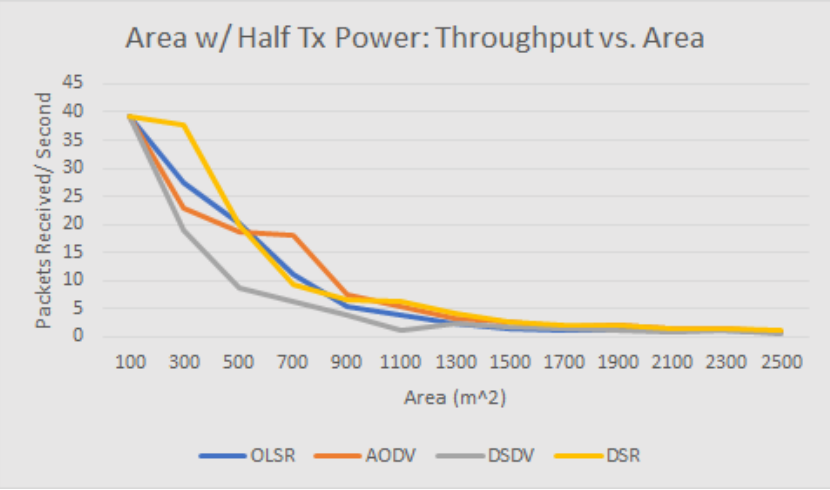
```
#include "ns3/mobility-module.h"
#include "ns3/aodv-module.h"
#include "ns3/olsr-module.h"
#include "ns3/dsdv-module.h"
#include "ns3/dsr-module.h"
#include "ns3/applications-module.h"
#include "ns3/yans-wifi-helper.h"
```

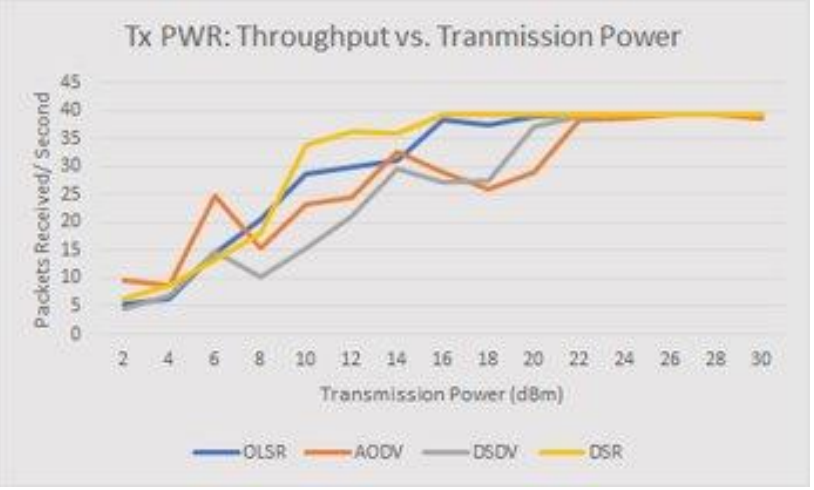
```
mobilityAdhoc.SetMobilityModel ("ns3::RandomWaypointMobilityModel",
                                "Speed", StringValue (ssSpeed.str ()),
                                "Pause", StringValue (ssPause.str ()),
                                "PositionAllocator", PointerValue (taPositionAlloc
```

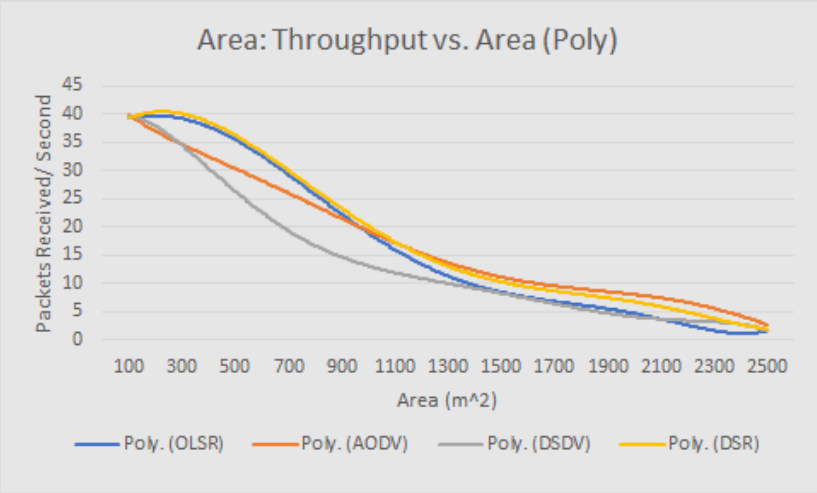
```
cmd.AddValue ("protocol", "1=OLSR;2=AODV;3=DSDV;4=DSR", m_protocol);
cmd.AddValue ("nodes", "The number of nodes", m_nodes);
cmd.AddValue ("max_width", "The maximum spatial width for mobile nodes", m_max_width);
cmd.AddValue ("max_height", "The maximum spatial height for mobile nodes", m_max_height);
cmd.AddValue ("txp", "Wifi transmission power", m_txp);
cmd.AddValue ("source_drate", "source's transmission rate", m_rate);
```

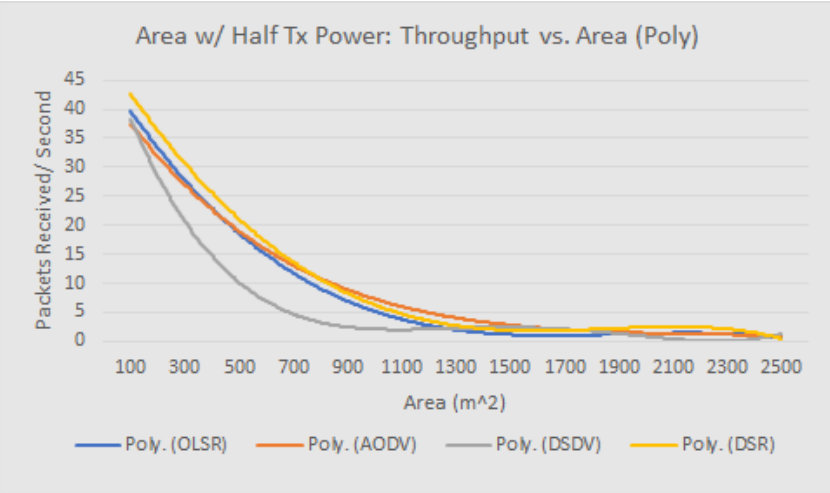
Results: Tx Power vs Area

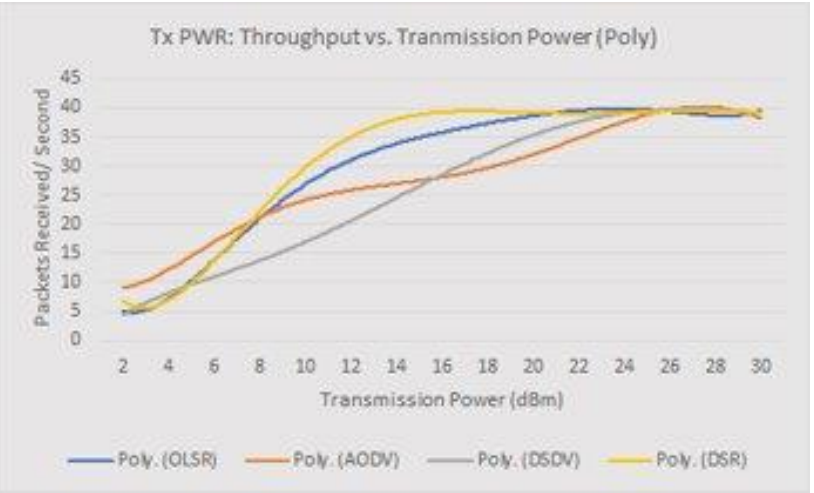






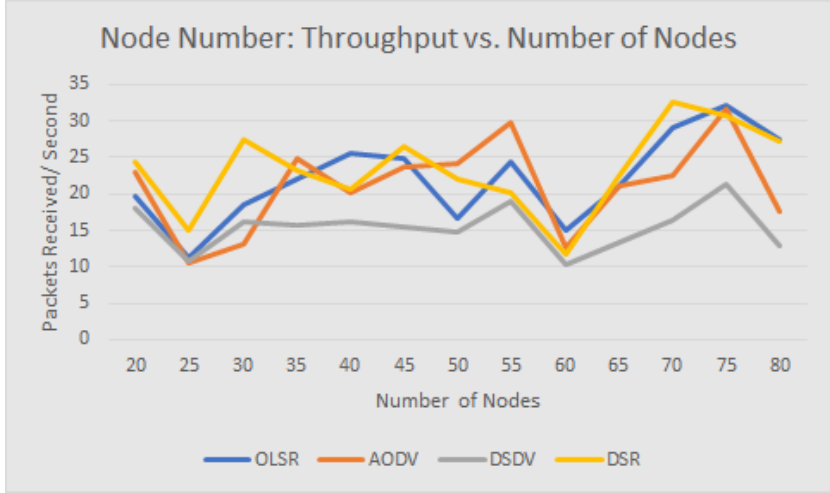


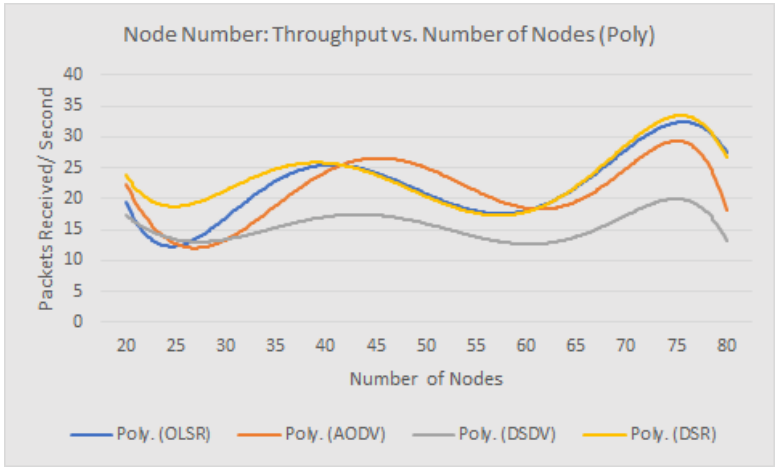


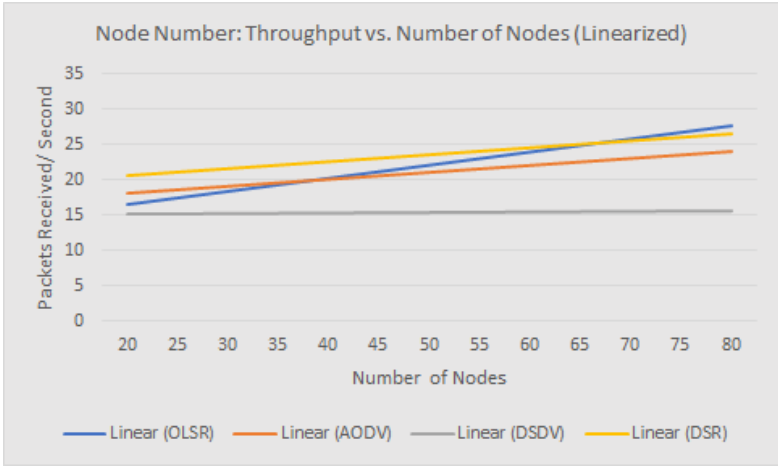


Results: Number of Nodes

- Can overcome traffic requirements by introducing more non-sourcing nodes
- Algorithms appear to have local maxima which can be taken advantage of by system designer (e.g. 45 nodes < 50 nodes < 55 nodes)
  - Density vs. Overhead

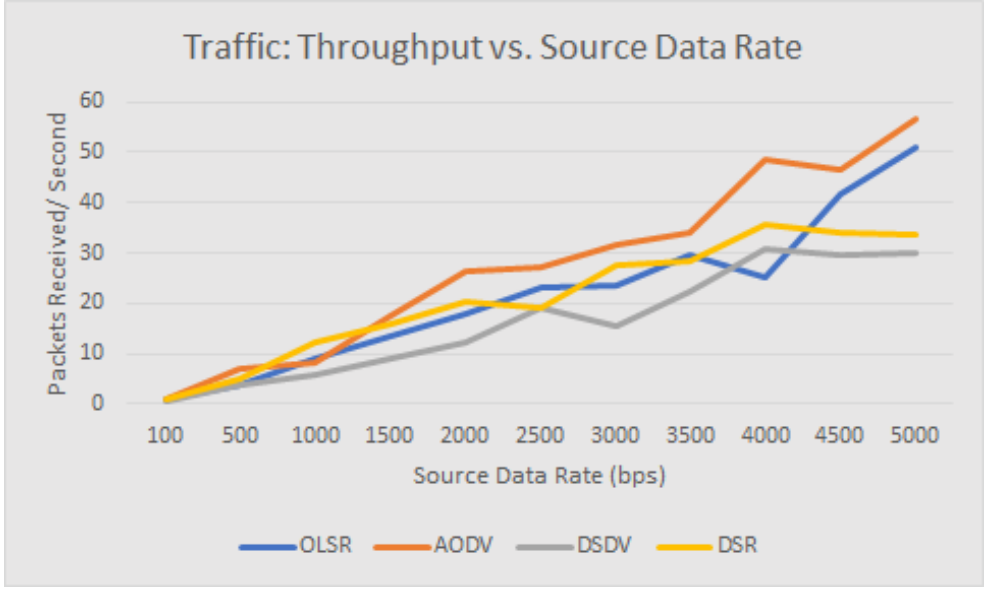


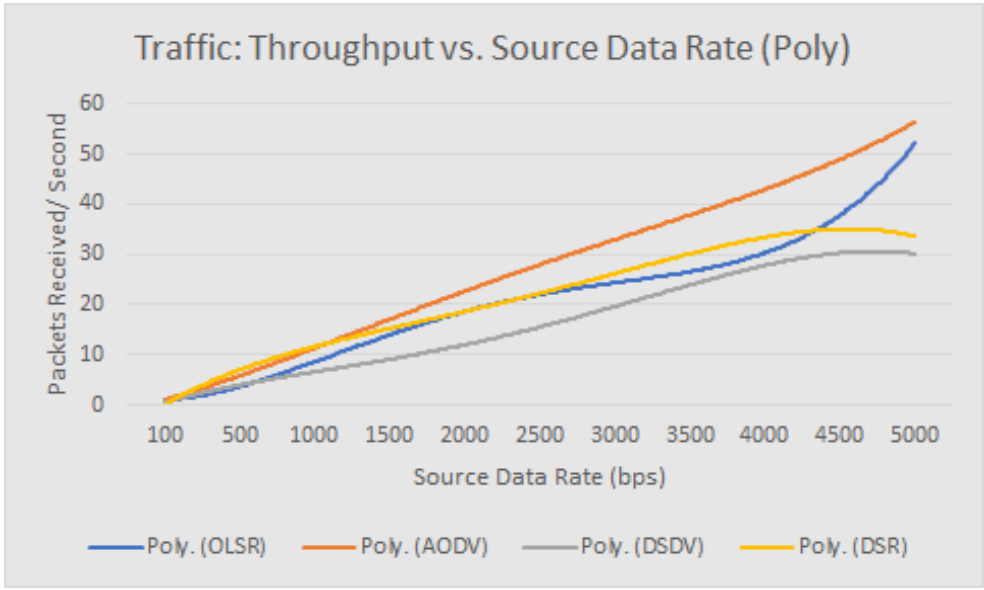




Results: Traffic

- AODV and OLSR adapt to high traffic
- DSR and DSDV had obvious knee point
- Additional simulations of higher traffic required





Conclusion

- Less differences between OLSR, DSR, and AODV than expected
- Notable Results
  - Protocol Comparisons
    - DSDV overall worst performance, particularly poor in high traffic, high node conditions
    - AODV & OLSR excelled in high traffic, high node conditions
    - DSR performed well with high node conditions, could not handle high traffic, saw relative boost from Tx power increase
  - General MWSN findings
    - Increasing transmission power to overcome large area
    - Transmission power shows clear knee point
    - Number of nodes was relatively unpredictable, must be analyzed for each network
- Challenges
  - Taking advantage of ns-3 capabilities
  - Processing power with virtual machines
  - Limiting scope, lots of parameters and interesting scenarios to tweak

Possible Future Work

- Changing the type of traffic UDP --> TCP
- Further investigation into Table vs. Demand Driven protocols
  - Time-varying data rates
  - Changing speed of mobile nodes
  - Time-varying number of nodes
- Changing the number of sources sending data to base station
- Measuring the average packet delay
- Add a hybrid ad-hoc routing algorithm

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Questions?