Simplified Multicast Forwarding for MANET

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MANET IETF 61

Work Item Goals

- Provide a basic multicast forwarding function
- Simple baseline (all nodes receive)
- Target native IP multi-hop forwarding
  - IPv4 and IPv6
- Include dynamic optimized relay set function (e.g., MPRs, CDS)
- Internet connectivity and interoperability
- Minimize per packet processing
- Avoid encumbered protocol mechanisms in baseline
- Extensible where sensible
  - Future Enhancements and Optimizations

WG Approach

- Build from existing knowledge and work
  - Optimized MANET Flooding/Broadcast experience
  - Ideas from MPR-F and other RFCs, IDs looked at in the past
- Form a design team to develop a specification targeting initial EXP RFC
  - Progress work to STD track if positive experience using this protocol is gained

Key Design/Implementaiton Issues

- Duplicate Packet Detection Mechanism
- Forwarding Engine
- Maintenance of any applied optimized flooding algorithms
  - Neighborhood knowledge/ relay set election
  - Previous-hop vs no dependencies

“Proof-of-Concept” implementation and some test experience

This is not the WG DESIGN but an example of an early working implementation with similar goal functionality

See paper in IEEE MILCOM 04
(Joe Macker, William Chao, Justin Dean)

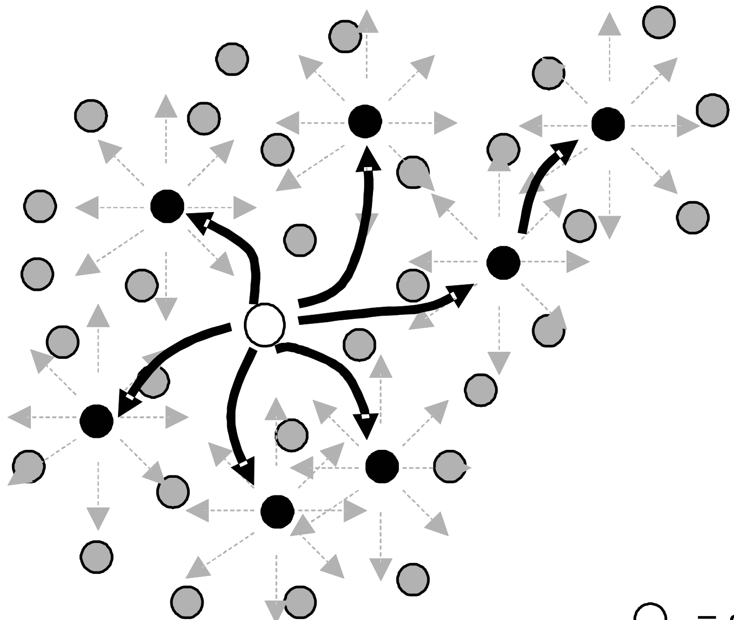
Running Code Prototype

- "Proof-of-concept" simplified MANET multicast forwarding engine implemented in 2003
  - Independent implementation from unicast routing, but borrows existing OLSR maintained relay set information for convenience (API method)
  - Similar in concepts to parts of the MPR-F ID

- Mechanisms Prototyped
  - Duplicate Packet Detection Mechanism
  - Simplified Multicast Forwarding Decision
    - Classical flooding
    - MPR-based forwarding and a simple non source-dependent MPR flooding method tested
    - Other relay set algorithms can be examined as well, this is not an exhaustive study in that sense

- Empirical results are IPv4-based; An IPv6 implementation is underway. We have also demonstrated native multicast application sessions (e.g., VoIP) supported over this

MPR Flooding Optimization Example



○ = source

● = flooding agent

● = passive receiving node

<u>"REDUCE RETRANSMISSIONS REQUIRED TO REACH ALL NODES"</u>

Duplicate Packet Detection

- Multi-hop broadcast wireless needs to forward out the upstream interface (MANET type interface)
- We desired to preserve native IP forwarding capability over hop-by-hop encapsulation
  - IPv4 – id field adapted for use in detecting duplicate packets
    - Implemented this working technique across multiple OS systems
  - IPv6 – header option with robust sequence number –Work ongoing
  - Investigated hashing methods for passive duplicate detection as mentioned in MPR-F
    - Possible, but deemed not sufficiently robust
    - Number of false positives vary depending on type of traffic and other factors
- If sequence-based detection mechanisms fail, the ttl field can still limit traffic forwarding

Classical Flooding (CF)

- Every node retransmits every packet heard once and only once
- Duplicate packet detection is performed and is the critical feature used to avoid additional retransmissions
- Suffers from poor scalability even in small networks tested
- Simple and no maintenance overhead or state dependencies (e.g., HELLOs)

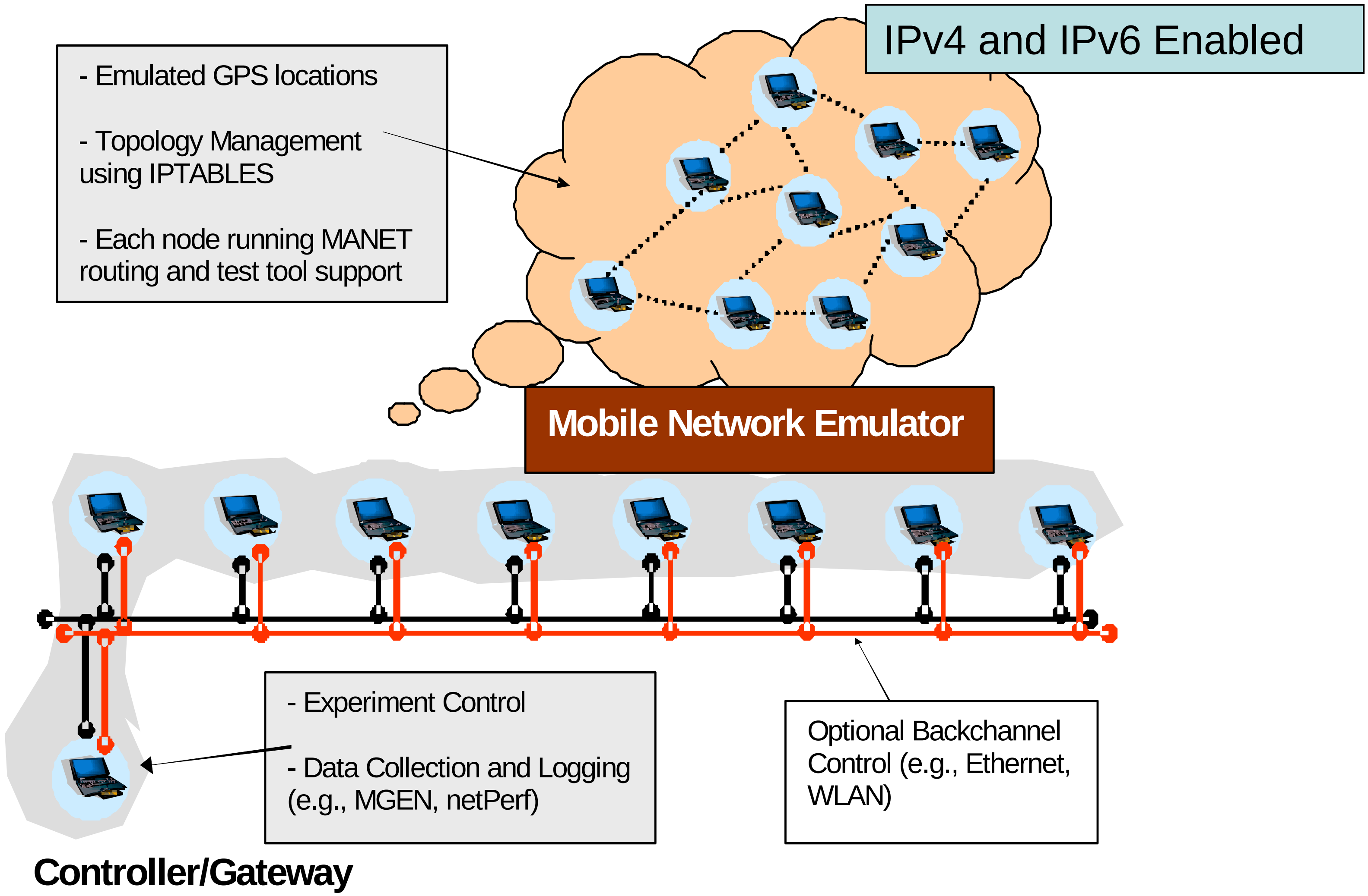
Source Specific MPR (S-MPR) Flooding

- Multi-point Relay (MPR) sets well understood and used in practice (e.g., OLSR spec)
- As a form of CDS algorithm, it can applied for simplified multicasting
- Issues
  - Previous hop dependency
  - MPR election and maintenance

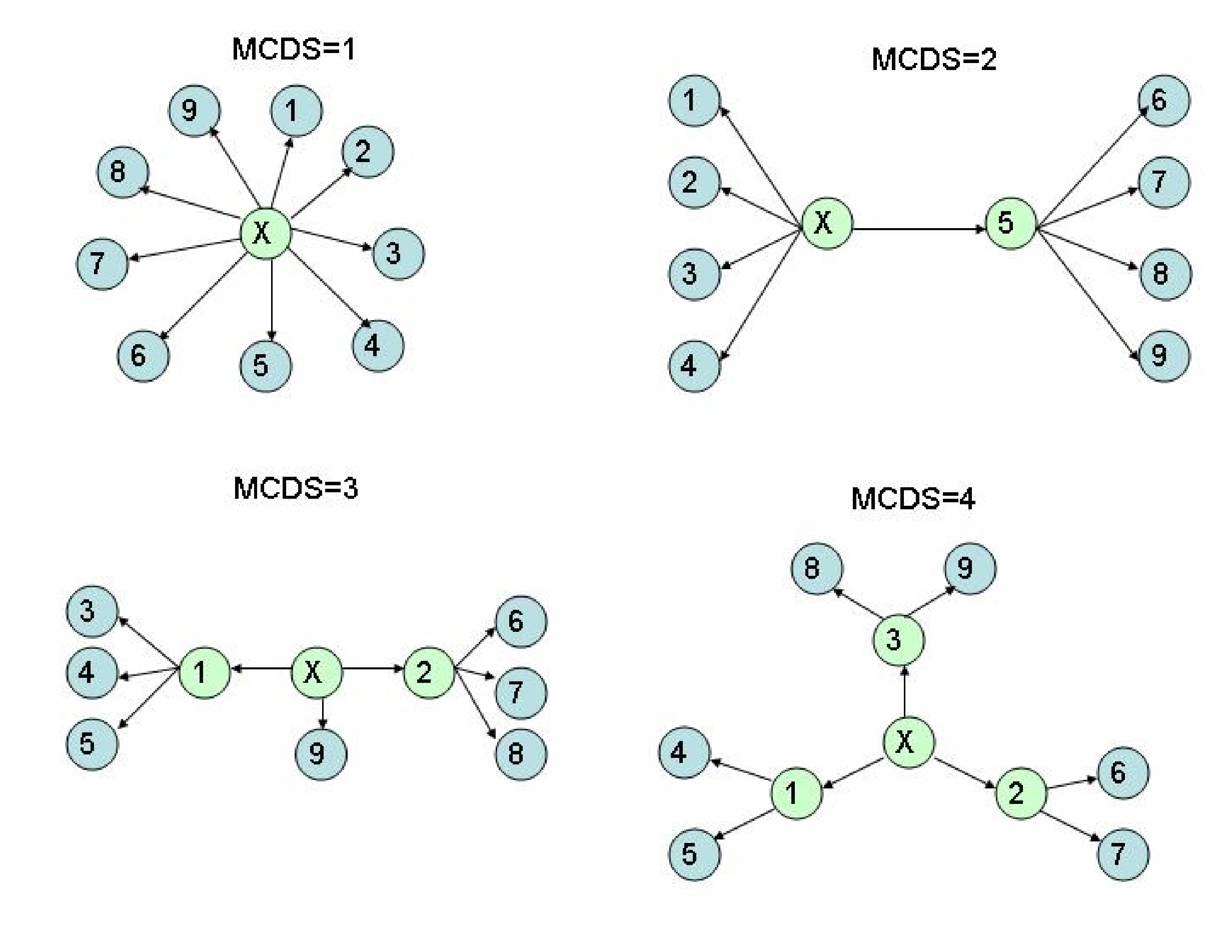
Non-source specific MPR (NS-MPR) Flooding

- Removes previous hop dependency of S-MPR, simplifies per packet forwarding
- IDEA: Combine local source-dependent relay set into a single shared set of forwarders
- <= forwarders in CF (but how much less?)
- Other issues: traffic concentration, more optimized shared set algorithms

Mobile Network Emulation Used



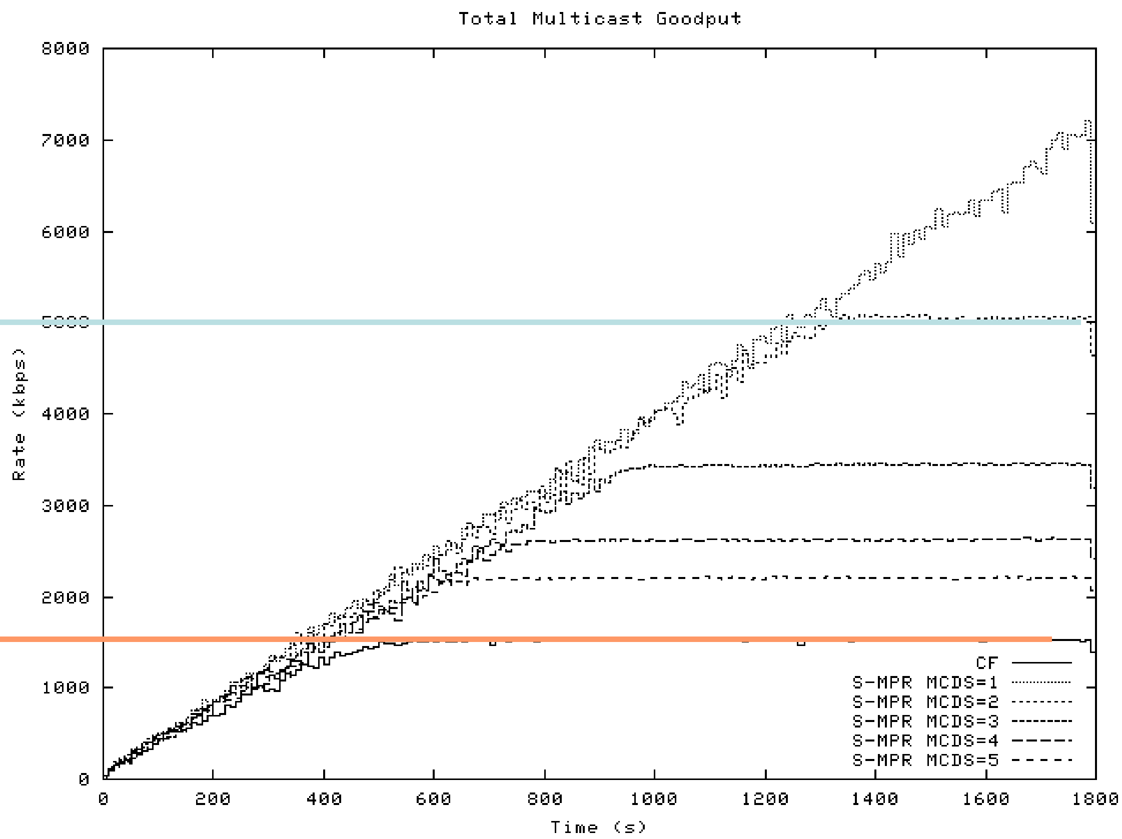
Topologies for Simple Static Emulation



Maximum Observed Goodput vs. Flooding Technique and Density in Small Wireless Network

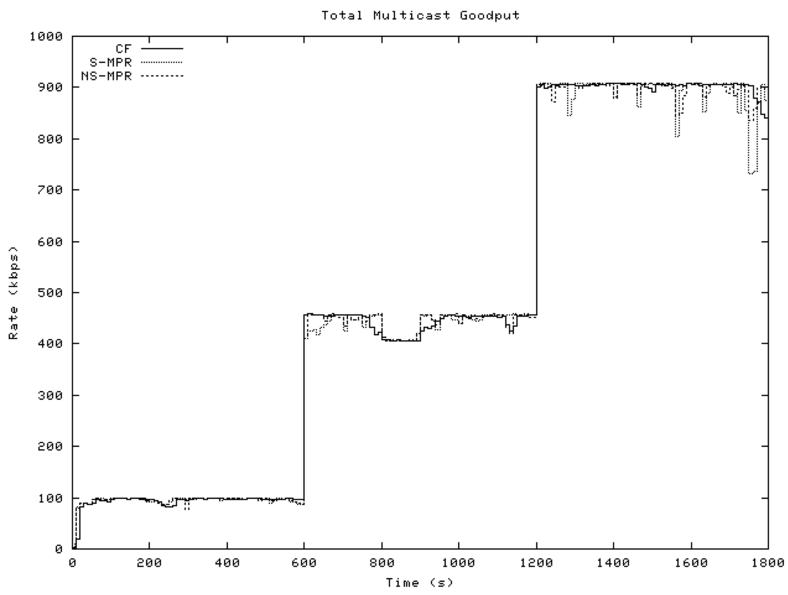
Max traffic S-MPR (MCDS-2): 5 Mbps

Max traffic CF (all topologies): 1.5 Mbps

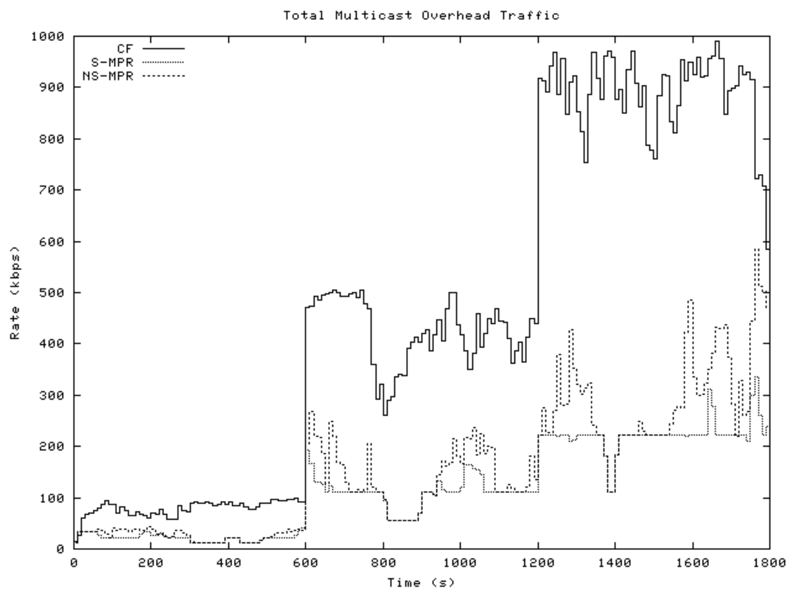


10 Node Mobility Scenario with MANET Multicasting

Total Network Goodput



Total Network Traffic

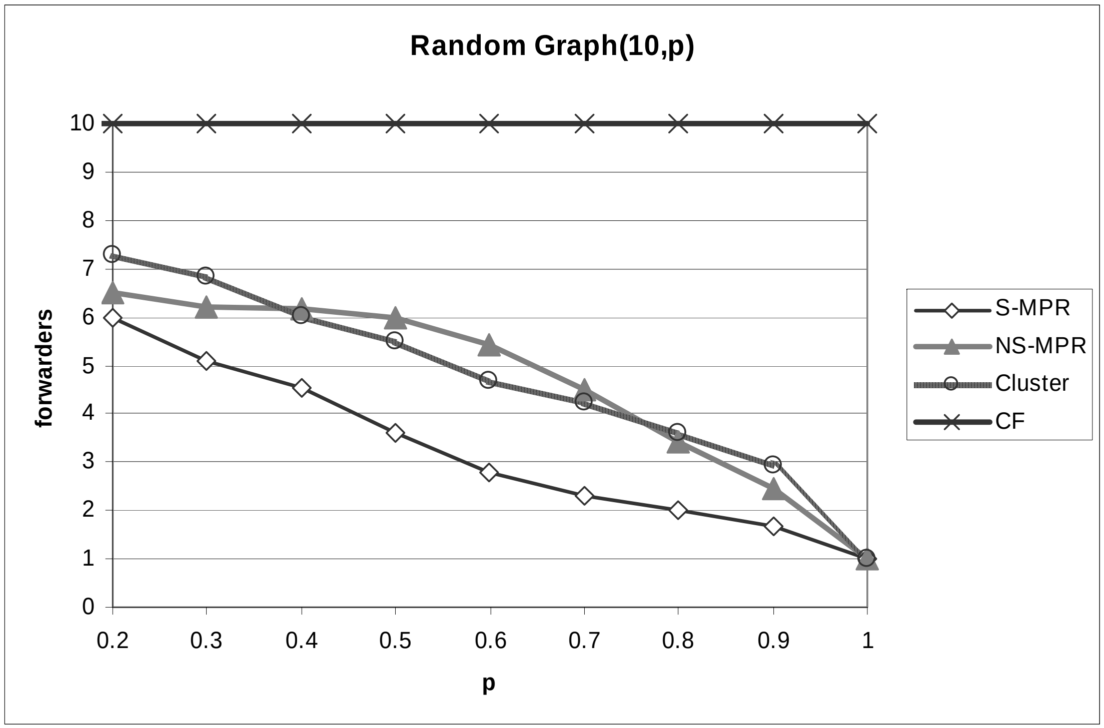


Tests with Mobility to Examine Delivery Robustness and Overhead:
Non-congested condition for all algorithms to compare robustness

Analytical Relay Set Size Trends

- Developed an analytical model to estimate number of multicast forwarders needed by various techniques
  - Random Graph (n,p)
    - Randomly connected n nodes with probability p
  - Random Unit Graph (n,L)
    - N randomly placed nodes in L by L square
    - Nodes connected if distance between them is <1
- Various flooding methods analyzed
  - Classical Flooding (CF)
  - S-MPR
  - NS-MPR
  - Clustering Method (a non-optimal global clustering algorithm)

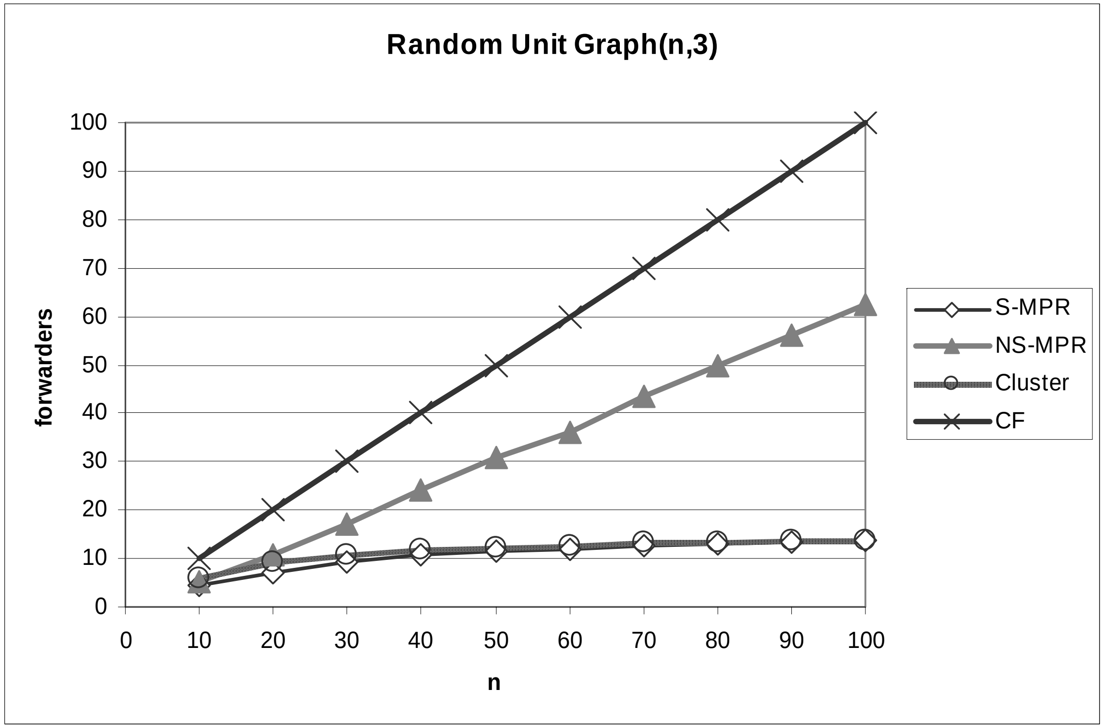
Analytical Results in Random Graph vs. Density



Shows expected forwarders as density increases for small fixed 10 node scenario: CF always 10

Example Expected Forwarders vs. Network Size in Fixed Area

For small sparse networks
NS-MPR does well



NS-MPR does not scale as density increases

For S-MPR we count the expected number of forwarders per source packet not the total number, since not ALL MPRs are used

Shows expected forwarders as number of nodes increases with a fixed area