Location-Based Flooding Techniques for Vehicular Emergency Messaging

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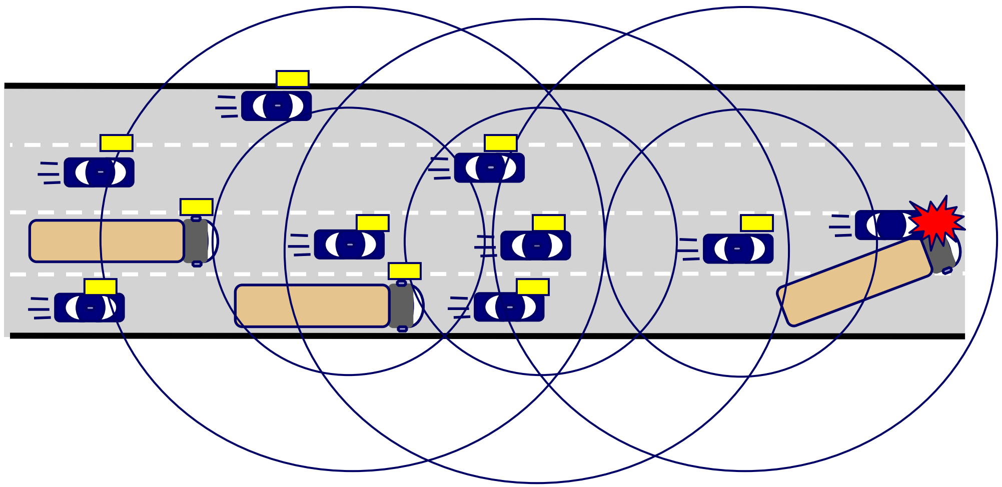
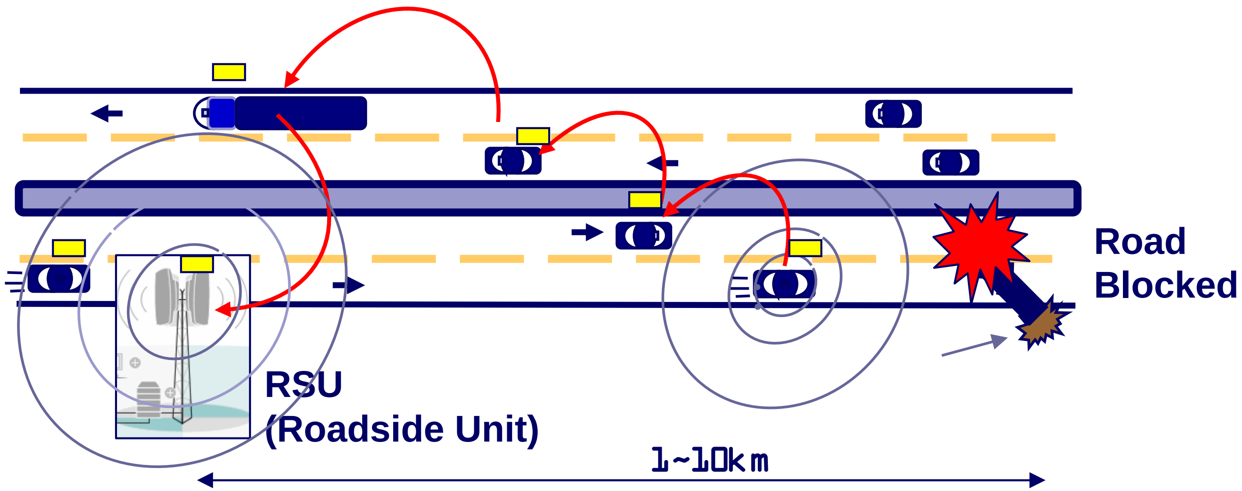
Emergency Warning Message (EWM)

- Purpose
  - Avoidance of collision
  - Inform drivers of possible dangers on the road



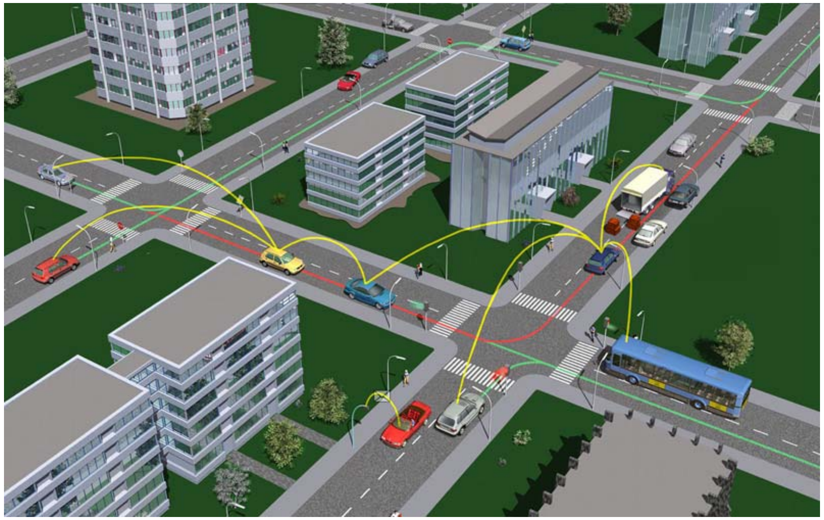
Requirement for EWM

- Broadcast of message
- with small delay and high reliability
- Delivery of message some km away from the event



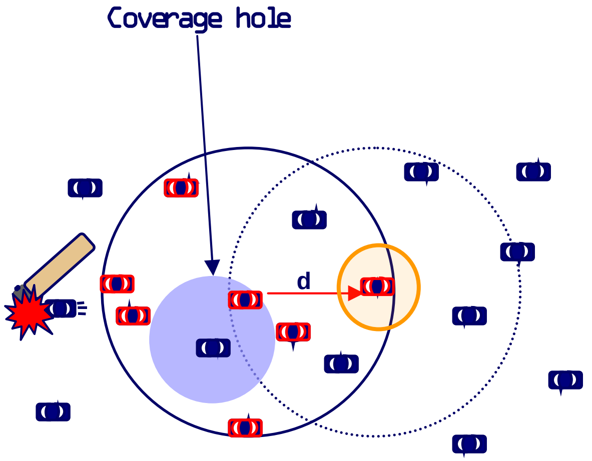
Issues in V2V communication

- Communication channel is unreliable
  - Higher frequency band at 5.9Ghz spectrum
  - Unfavorable channel condition due to moving vehicles
- Solutions
  - Multi-hop communication is a kind of spatial diversity
  - Use flooding for broadcasting
    - Simple to implement
    - Low delay
    - Generate redundancy
    - While increasing reliability

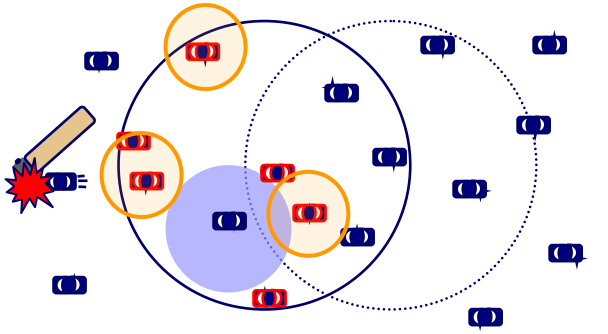


Flooding

- Simple Flooding vs. Controlled Flooding
  - Simple flooding cause “Broadcasting Storm”
  - In controlled flooding, the next hop forwarding node will be selected
- Location based Controlled Flooding
  - Use location information in deciding the next hop forwarder
  - Deterministic method
- Probability based Controlled Flooding
  - Make a probabilistic choice for the next hop forwarder
  - More reliable with the increased redundancy.
  - Counter based method is an example



Location based controlled flooding



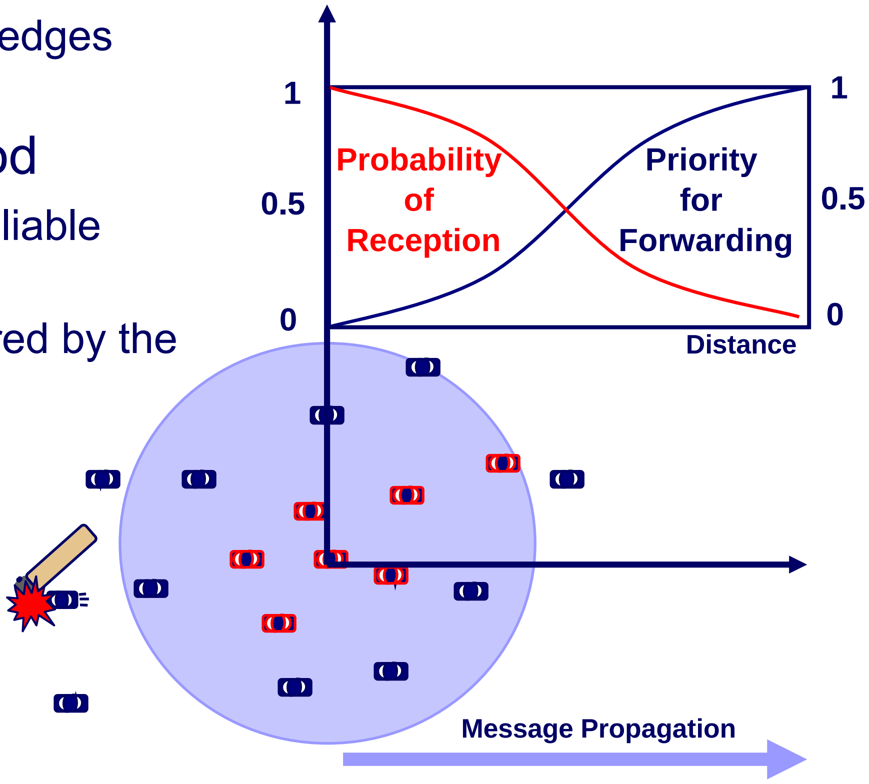
Probability based controlled flooding

Hybrid Scheme

Key idea I

Utilize both Probability based method & Location based method

- Prioritize forwarders depending on the node location,
  - Give higher probability of forwarding to edges nodes
- Use opportunistic forwarding method
  - Deterministic is not appropriate for unreliable wireless communications
  - Make sure the coverage holes be covered by the forwarding process.

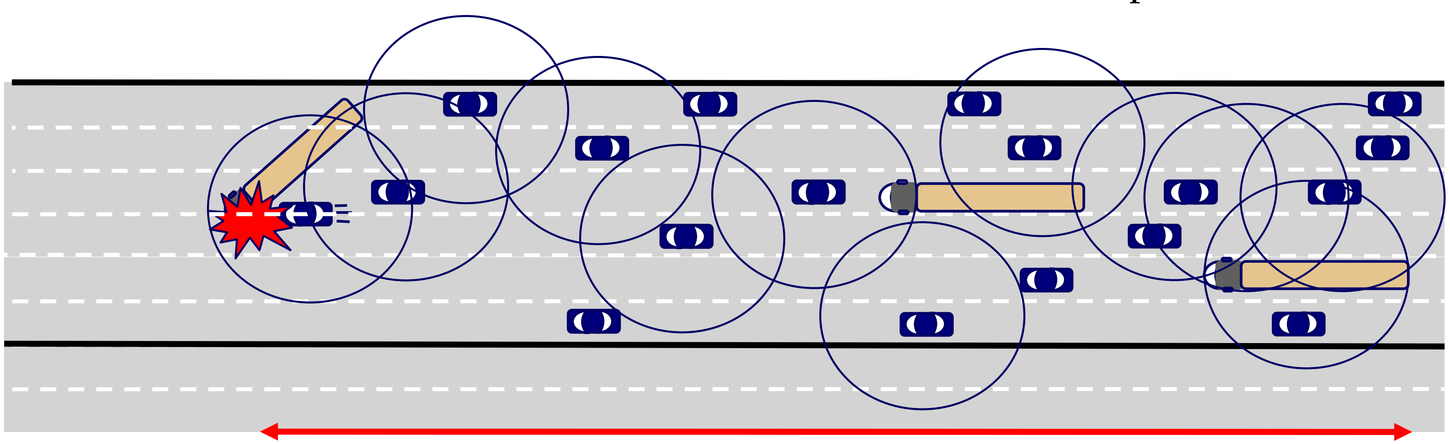


Key idea II

Normalize the probability of forwarding

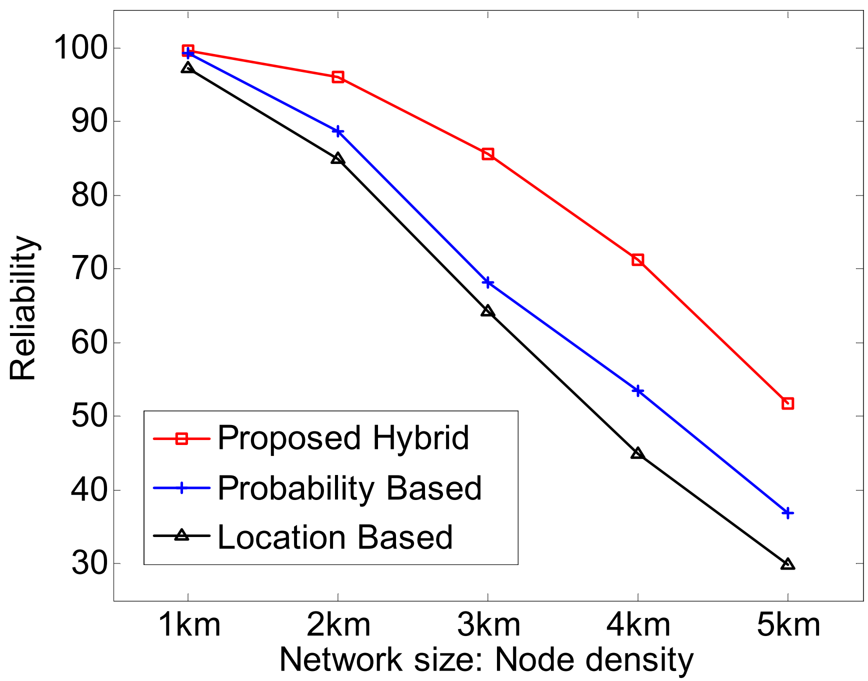
Simulation Setup

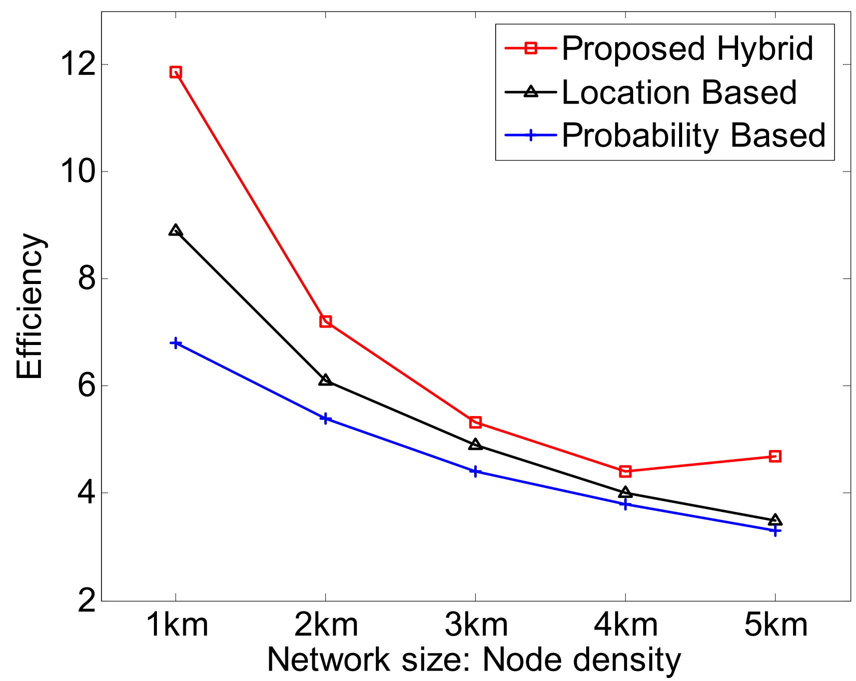
- Simulator: NS-2
  - Channel fading: Rayleigh
  - Number of nodes: 200 Nodes
  - Node density: Change the network size from 1Km to 5Km
- Measurement
  - Reliability $= \dfrac{\text{Number of nodes who received EWM pkt}}{\text{Total number of nodes in the network}}$
  - Efficiency $= \dfrac{\text{Number of nodes received EWM pkt}}{\text{Number of the nodes broadcasted EWM pkt}}$



Length of Network (road size)

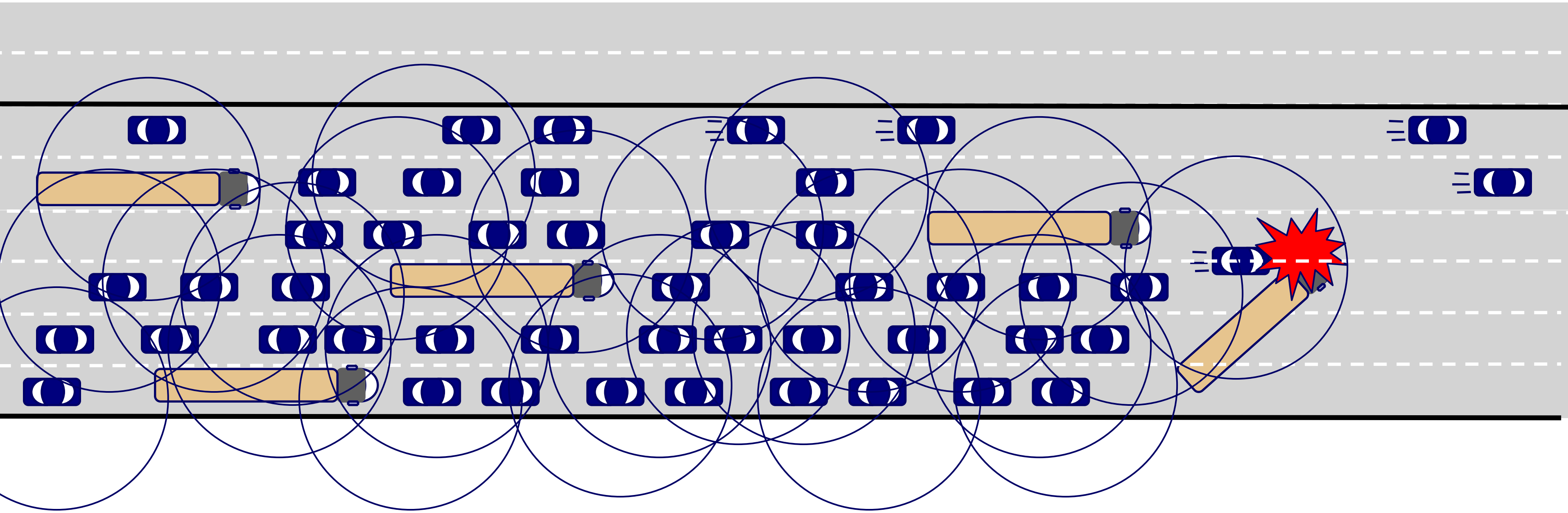
Simulation Results





- Reliability
  - 40% gain in 5km road
- Network efficiency
  - 41% gain in 1km road

Extremely Congested Network Scenario

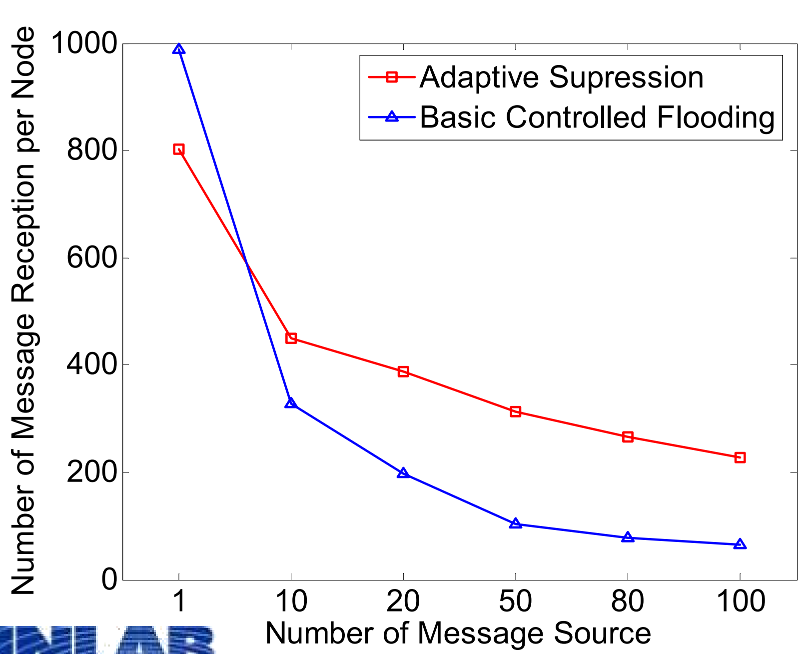


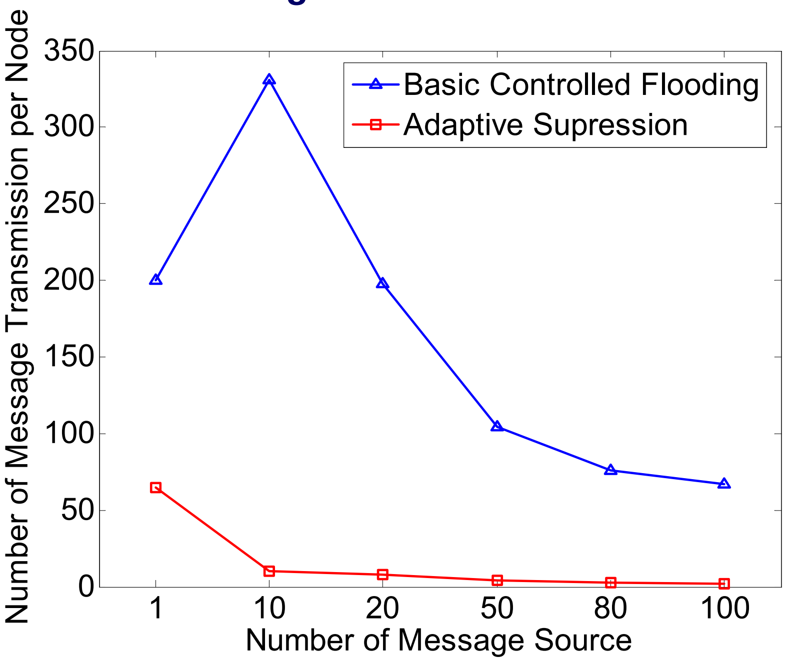
- Scenarios
  - Rush hour in 12 lane, 5m inter vehicle distance, 300m range
  - Multiple number of EWM sources transmitting similar events
  - 6 lanes x 60 = 360 vehicles in the communication range

Alleviation of the Network Congestion

- Controlled flooding may not sufficiently suppress the redundant message forwarding
  - Too many nodes are in the communication range
  - Multiple number of Emergency message source
- It needs to give additional back-off delay
  - Adaptive to the network congestion status

Number of Node in one hop communication range : 100





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Conclusions

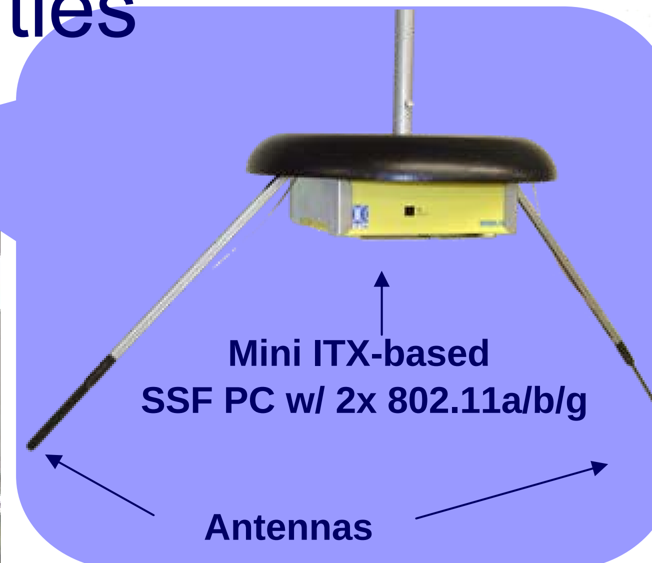
- Using location information for forwarder selection in flooding techniques
  - More efficiency & reliability
- These techniques can be implemented on top of
  - 802.11a MAC
  - 802.11p MAC
- In extremely congested network scenarios,
  - Density-based adaptation of the probability of forwarding in each node
  - Power/rate adaptation to use spectrum utilization
  - Data aggregation

Future Work

- Need to make a more precise consideration for end to end delay
- The channel is V2V communication
  - Impact on the reliability of Emergency message dissemination
  - Heavily affects the simulations results
- Through more realistic channel modeling
  - Accurate simulation result
  - More reliable protocol design

Future Work: Evaluation on ORBIT Experimental Facilities

400 Node High-Density Controlled Indoor Testbed



10-Node Vehicular Testbed

Thank You !!

- Additional Slide I
- Additional Slide II

Controlled Flooding Methods

- Counter based method
  - Count overheard forwarding packets for RAD(Random Access Delay) time and suppress its transmission when the number exceeds a certain threshold (*Max_count*)
  - Pro: Generally performs well in overall network environments
    - Reliable and convenient
    - Autonomously operate
  - Con: Inefficient, because edge nodes may not have chance to broadcast
- Location based method
  - Use its location information in deciding its forwardings. Nodes farther than a certain distance will forward the received packet.
  - Pro: Optimal for fast routing
  - Con: A kind of deterministic method, so nodes close to the source will never have chance to broadcast
- Neighbor knowledge based method
  - Using neighbor list, decide its forwarding
  - Pro: Minimize the number of transmission
  - Con: require exchange of hello messages, cannot applicable to high mobility condition and to scenarios that has tight delay requirements

Weakness of Counter-based Method

- Average interval between the RAD values in each node
  - 360 vehicles
  - 20msec/360 = 0.056msec = 56 µsec
- Internal processing delay
  - Assume 1msec
  - 1msec / 56 µsec = 17.8
- 18 RAD timers expire before the first forwarded packet really appears in the channel,
  - They will initiate their transmission processes in the application layer
  - Before they transmit the packet, they will sense the channel
  - If the channel is busy, they will go to back-off process and try to access the channel in the next available channel slot
  - Result in collisions or further congestions