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

RSU (Roadside Unit)

Road Blocked

1~10km
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
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**
    \[
    \text{Reliability} = \frac{\text{Number of nodes who received EWM pkt}}{\text{Total number of nodes in the network}}
    \]
  - **Efficiency**
    \[
    \text{Efficiency} = \frac{\text{Number of nodes received EWM pkt}}{\text{Number of the nodes broadcasted EWM pkt}}
    \]

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

![Graph showing the number of message reception and transmission per node with adaptive suppression and basic controlled flooding.]
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

Mini ITX-based SSF PC w/ 2x 802.11a/b/g
Antennas
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
    - Autonomous operation
  - **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
  - \( \frac{20 \text{msec}}{360} = 0.056 \text{msec} = 56 \mu \text{sec} \)

- **Internal processing delay**
  - Assume 1msec
  - \( \frac{1 \text{msec}}{56 \mu \text{sec}} = 17.8 \)

- **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