# Analysis of Multi-Hop Emergency Message Propagation in Vehicular Ad Hoc Networks

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# Outline

- Overview
- Motivation
- Models
- Dissemination Algorithms
- Evaluation
- Discussion
- Questions

# Overview

- Analysis of message propagation in VANETs
  - Simplified probabilistic wireless model
  - Simplified representation of a VANET scenario

# Motivation

- Safety applications require *fast* and *reliable* message delivery to all vehicles to provide guarantees of performance
- Unknown how strategies to prioritize emergency messages (MAC retransmits, transmit power) affect overall performance
- What are the performance tradeoffs between emergency message protocols and other network applications?

# Radio Model

- rT = radius from transmitter within which a node can receive
- rI = radius from transmitter within which a node can be blocked from receiving closer transmissions
- p = probability of message reception within rT

# VANET Model

- Line of cars in one direction as a series of bits
  - 1-node: has token (message)
  - 0-node: no token
- Least significant bit starts with token and propagates to the left, most significant bit
- Cars are equally spaced, with distance determined by traffic conditions

# Idealized Dissemination Model

- May not be possible for all configurations
- All internal 0-nodes changed to 1-nodes according to p at every round
- All 0-nodes within rT of left-most 1-node changed to 1-nodes according to p at every round

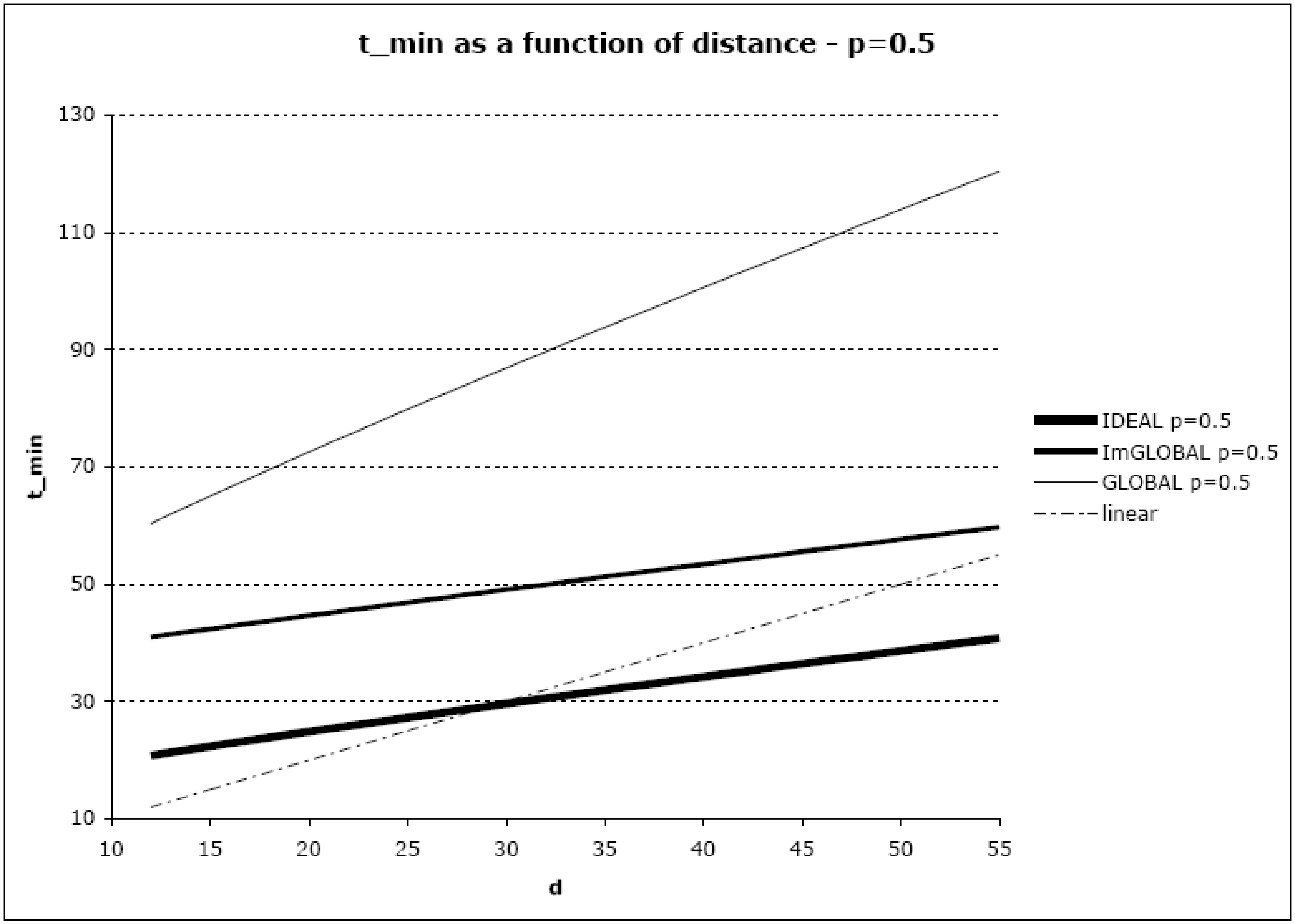
# Global Dissemination Model

- Centralized, requires global knowledge: who is the left-most node
- Greedy algorithm to select optimal transmitters
- Problem: left-most 1-node may not be selected every round, increasing time to propagate message

# ImGlobal Dissemination Model

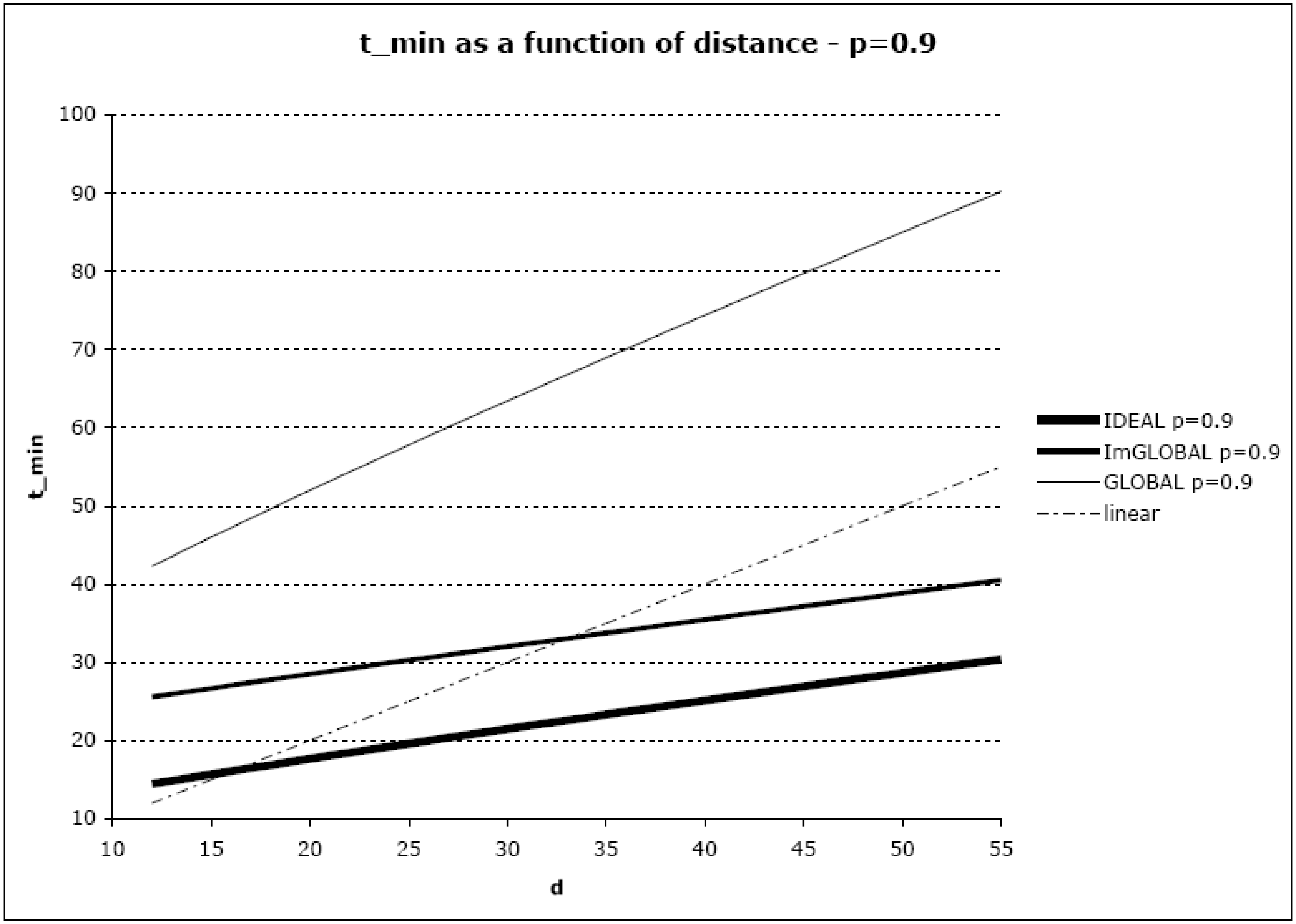
- Focuses on fast backwards propagation of message at expense of in-network propagation to internal 0-nodes
- Left-most 1-node is always scheduled for transmission at every round

# Evaluation



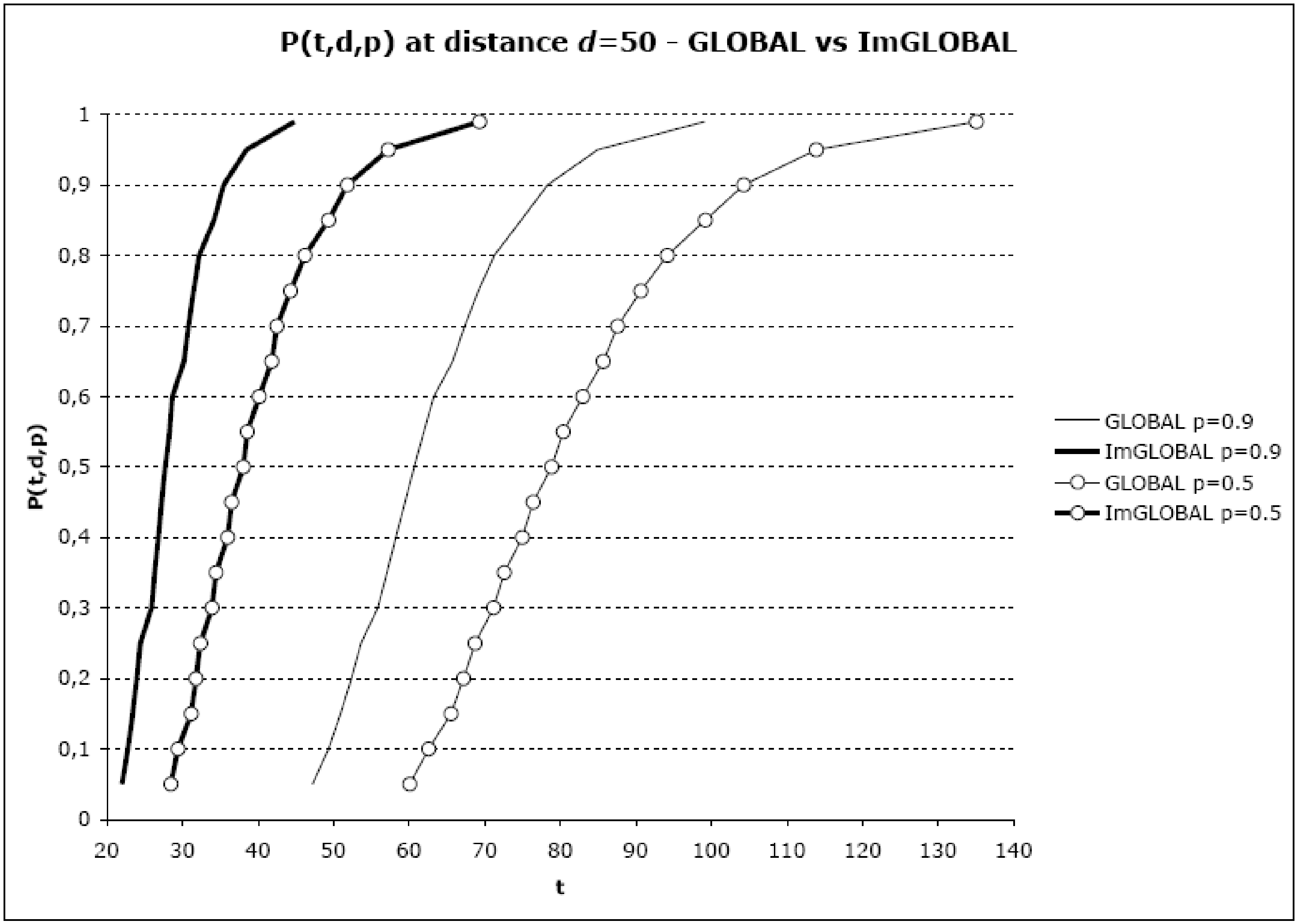
t_min as a function of distance - p=0.5
130
110
90
70
50
30
10
t_min
10
15
20
25
30
35
40
45
50
55
d
IDEAL p=0.5
ImGLOBAL p=0.5
GLOBAL p=0.5
linear

# Evaluation



t_min as a function of distance - p=0.9
100
90
80
70
60
50
40
30
20
10
t_min
10
15
20
25
30
35
40
45
50
55
d
IDEAL p=0.9
ImGLOBAL p=0.9
GLOBAL p=0.9
linear

# Evaluation

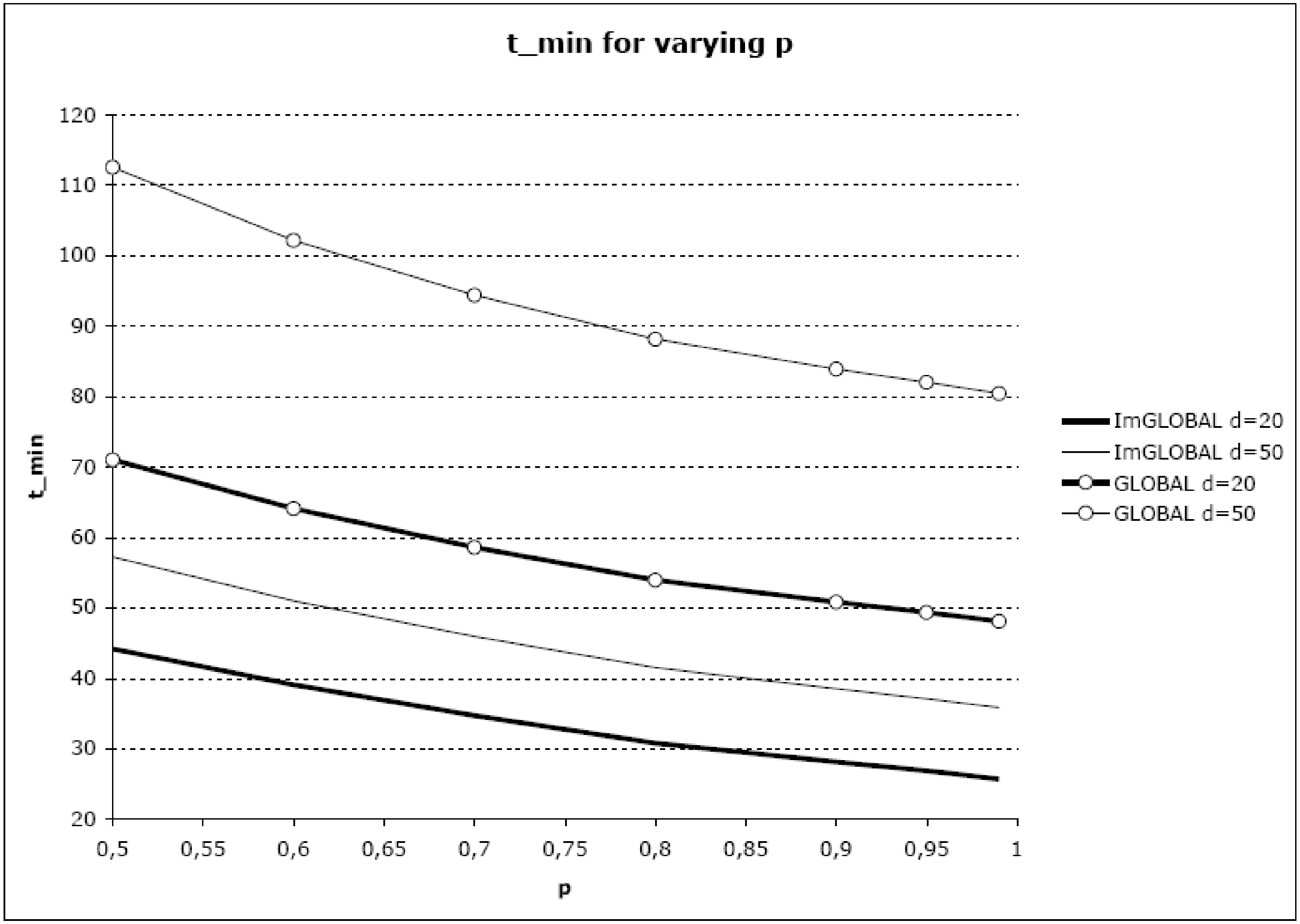


P(t,d,p) at distance d=50 - GLOBAL vs ImGLOBAL
P(t,d,p)
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
20
30
40
50
60
70
80
90
100
110
120
130
140
t
GLOBAL p=0.9
ImGLOBAL p=0.9
GLOBAL p=0.5
ImGLOBAL p=0.5

# Evaluation

| | distance | $t_{min},\ p = 0.5$ | $t_{min},\ p = 0.9$ | $\%reduction$ |
|---|---|---|---|---|
| Heavy traffic | $600m$ | $411,4ms$ | $280,43ms$ | $31,8\%$ |
| | $1500m$ | $525,61ms$ | $382,76ms$ | $27,2\%$ |
| Medium traffic | $600m$ | $441,93ms$ | $281,19ms$ | $36,4\%$ |
| | $1500m$ | $572,23ms$ | $385ms$ | $32,7\%$ |
| Light traffic | $600m$ | $502,39ms$ | $283,77ms$ | $43,5\%$ |
| | $1500m$ | $662,69ms$ | $390,77ms$ | $41\%$ |

# Evaluation



t_min for varying p
120
110
100
90
80
70
60
50
40
30
20
t_min
0,5
0,55
0,6
0,65
0,7
0,75
0,8
0,85
0,9
0,95
1
p
ImGLOBAL d=20
ImGLOBAL d=50
GLOBAL d=20
GLOBAL d=50

# Discussion

- tmin is the minimum time required to reach a probability of 0.95 propagation at distance d
- 10ms transmit window (round time) is adequate for fast propagation (1.5 Km in 700 ms)
- Increasing 1-hop reliability gives more improvement in light traffic conditions versus denser traffic conditions
- Increased 1-hop reliability benefit decreases as distance from transmitter increases
- Dissemination strategy has large impact on multi-hop performance

# Questions?

- Is the radio or vehicle model too simplistic?
- How can message prioritization be realized?
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