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

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Motivation

- Road safety may be the top application for many groups, auto makers, governments, (insurance companies?)
- Differentiated packet forwarding services may be needed for different levels of criticality.
  - Dynamic road map
  - Accident reporting, warning

Motivation

- Emergency messages may need to reach cars following as fast as possible
  - Accidents are often a matter of sub-seconds
- If a vehicle V has received an emergency message, it should be very likely that the vehicles between V and the originator have received the message.
  - Accidents are often caused by a single vehicle which is not situation-aware of

In other words

- By when can a vehicle V at D distance away from the originator receive an emergency message?
- When V receives an emergency message, how much percentage of the vehicles in between have probably received the message already?

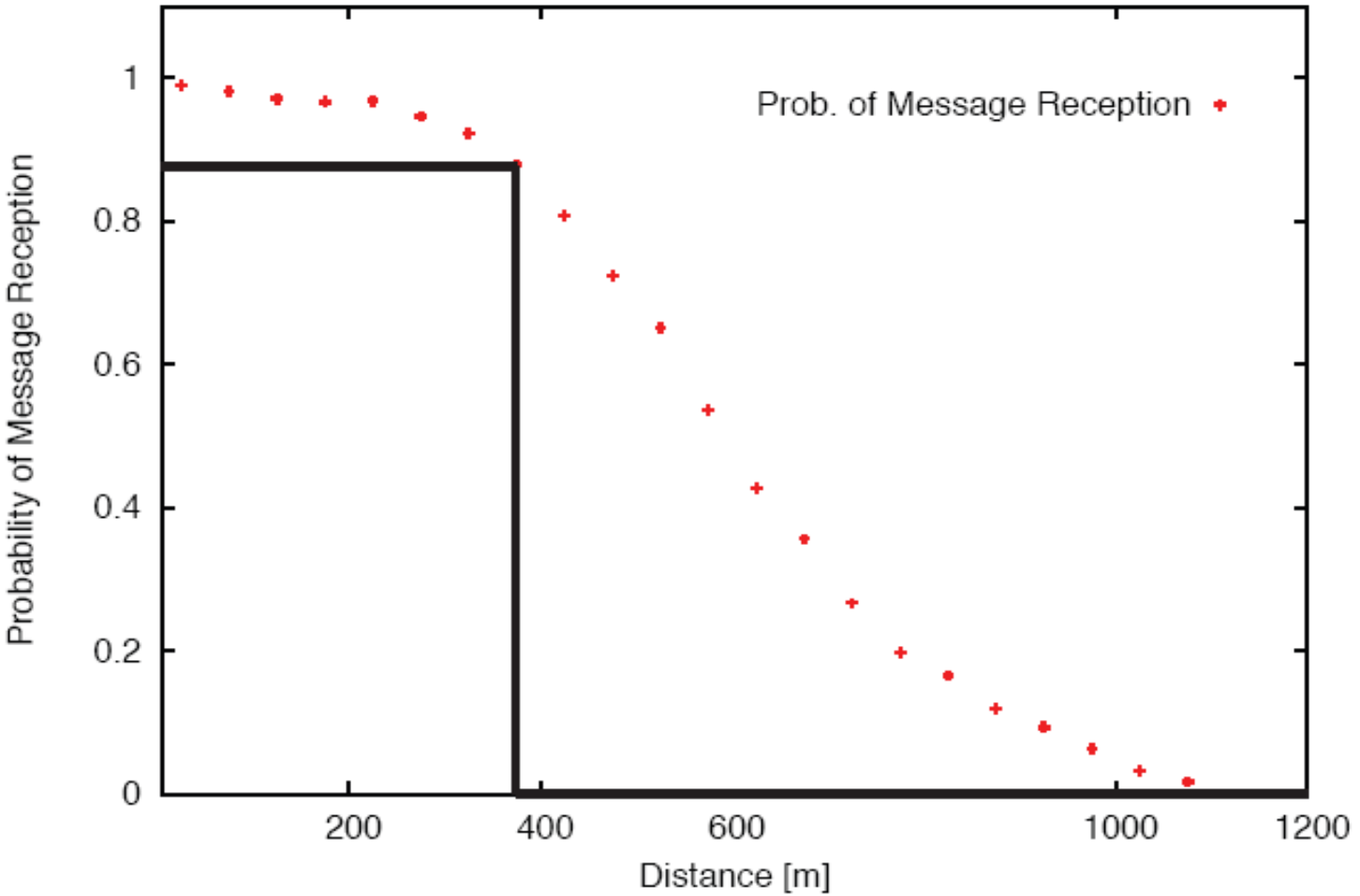
Two dominant factors

- 1-hop reliability
  - Adjustable by the levels of radio transmission power
- Smart dissemination protocol?
- Third?
- Which factor do we need to focus to realize the two goals; fast dissemination, high coverage

Simplified models

- Cars are equally spaced
- Emergency messages are broadcast
- Protocol round
- Interference model: only one speaker within a transmission range
- Channel model?

Channel model



Problem formulation

$$P(\bar{d}, \bar{t}, \bar{p})$$

Analytical model

- 000011001100111
- Three strategies
  - GLOBAL
  - IDEALIZED
  - IMGLOBAL

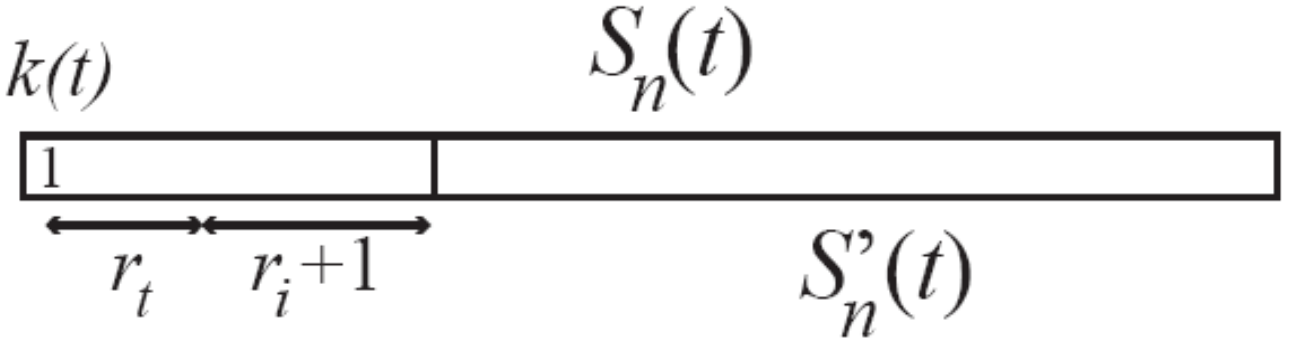
GLOBAL

- Centralized algorithm
- Needs global knowledge
- Input: Sn(t)
- Output: a set of transmitters for next rounds in a way that interference is minimized

IDEALIZED

- The leftmost 1-node transmits next, always, to reach cars following as fast as possible
- 0-nodes in between turn to a 1-node with probability p

IMGLOBAL



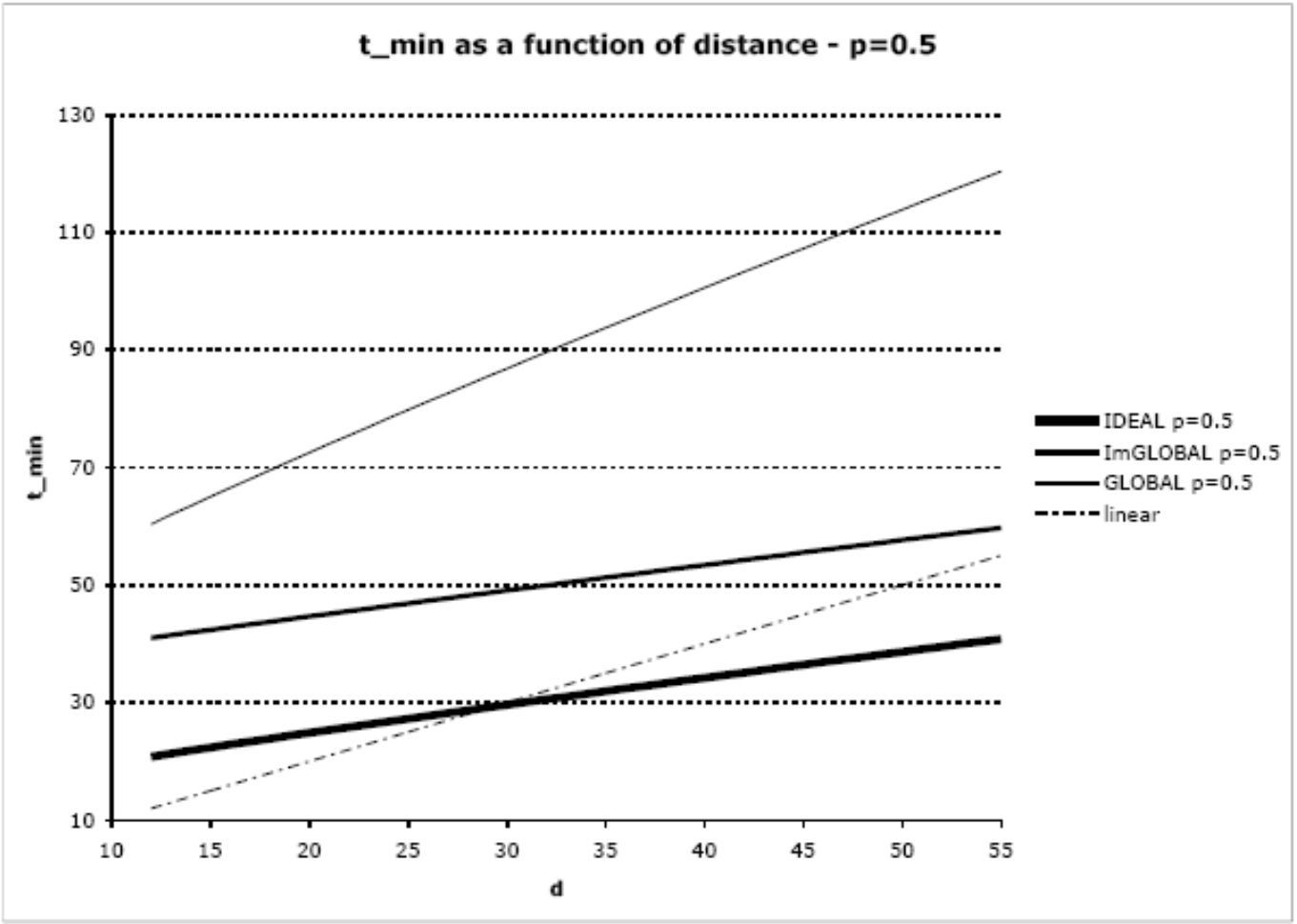
Discussion

- Three traffic scenarios, inter-vehicle diatance
  - Light: 60m
  - Medium: 30m
  - Heavy: 15m
- Transmission range: 125m
- Interference range: 250m

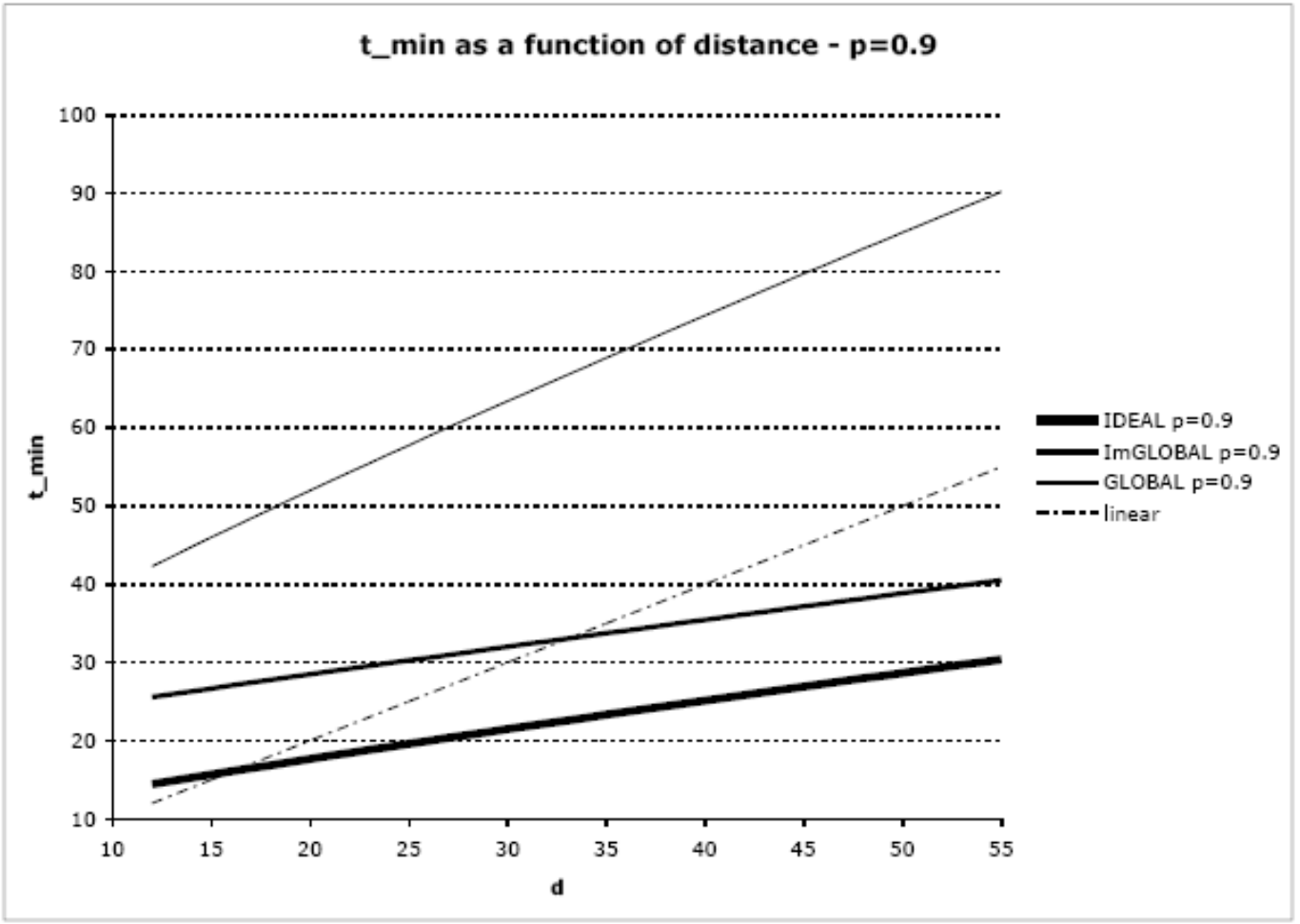
Decomposition of T

- A node V needs to be within a transmission range of another node to receive a message with a probability p.
- Until then, the probability of V to be a 1-node remains 0
- Once V is within a transmission range of another node, a process begins at the node with a probability p’ < p
- Tmin is the time V needs to be in the transmission range of another node

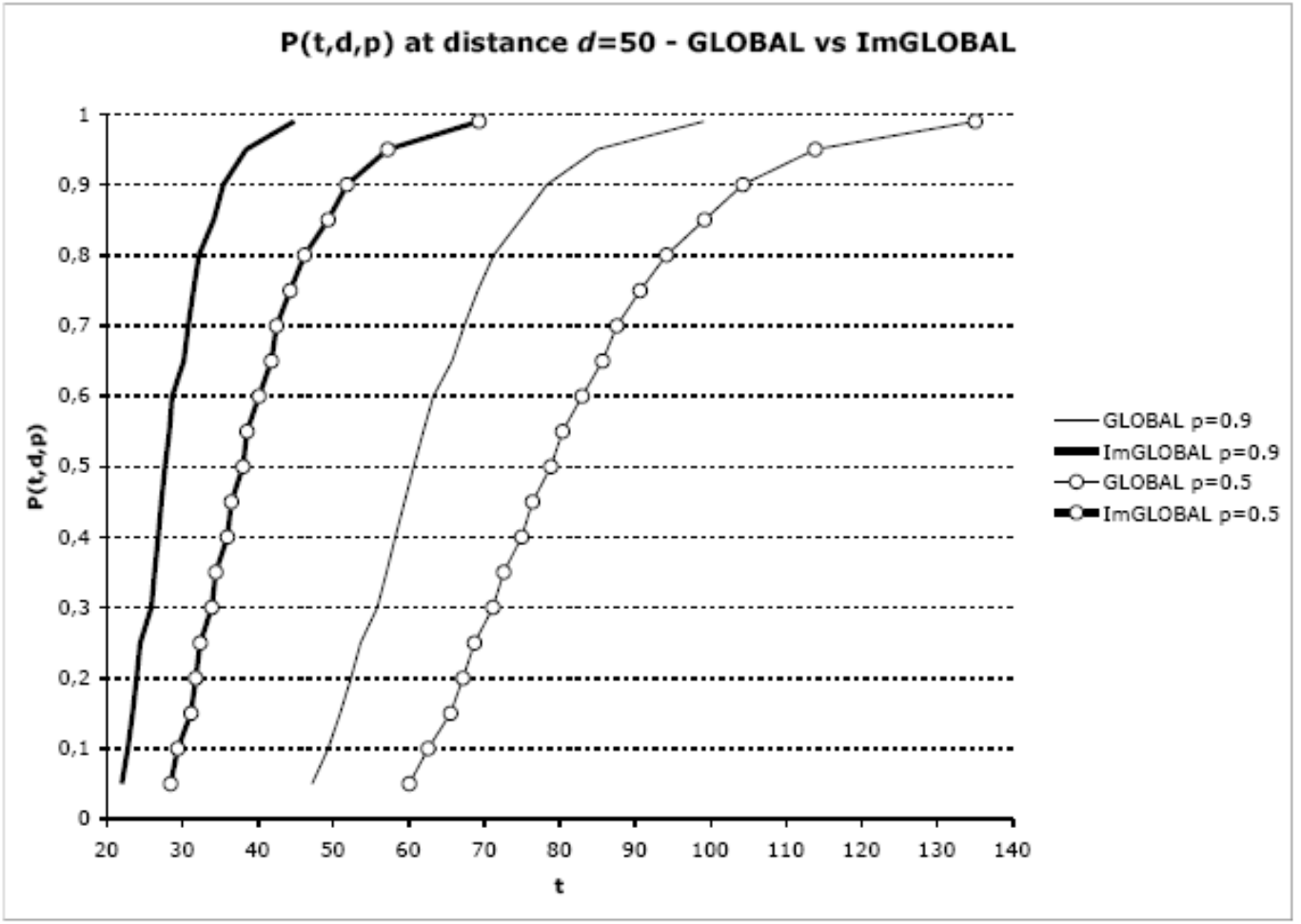
Dependence on distance



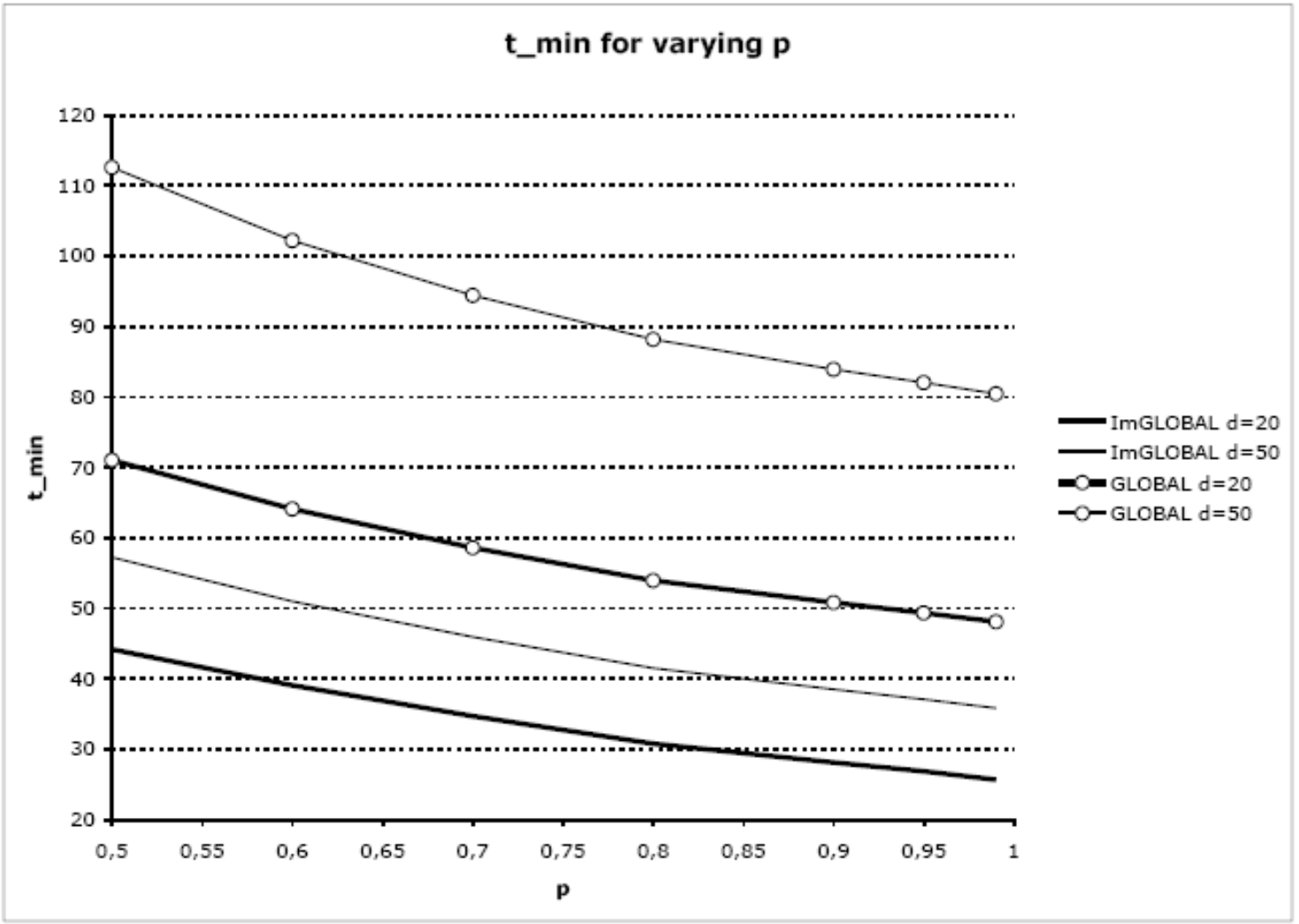
Dependence on distance



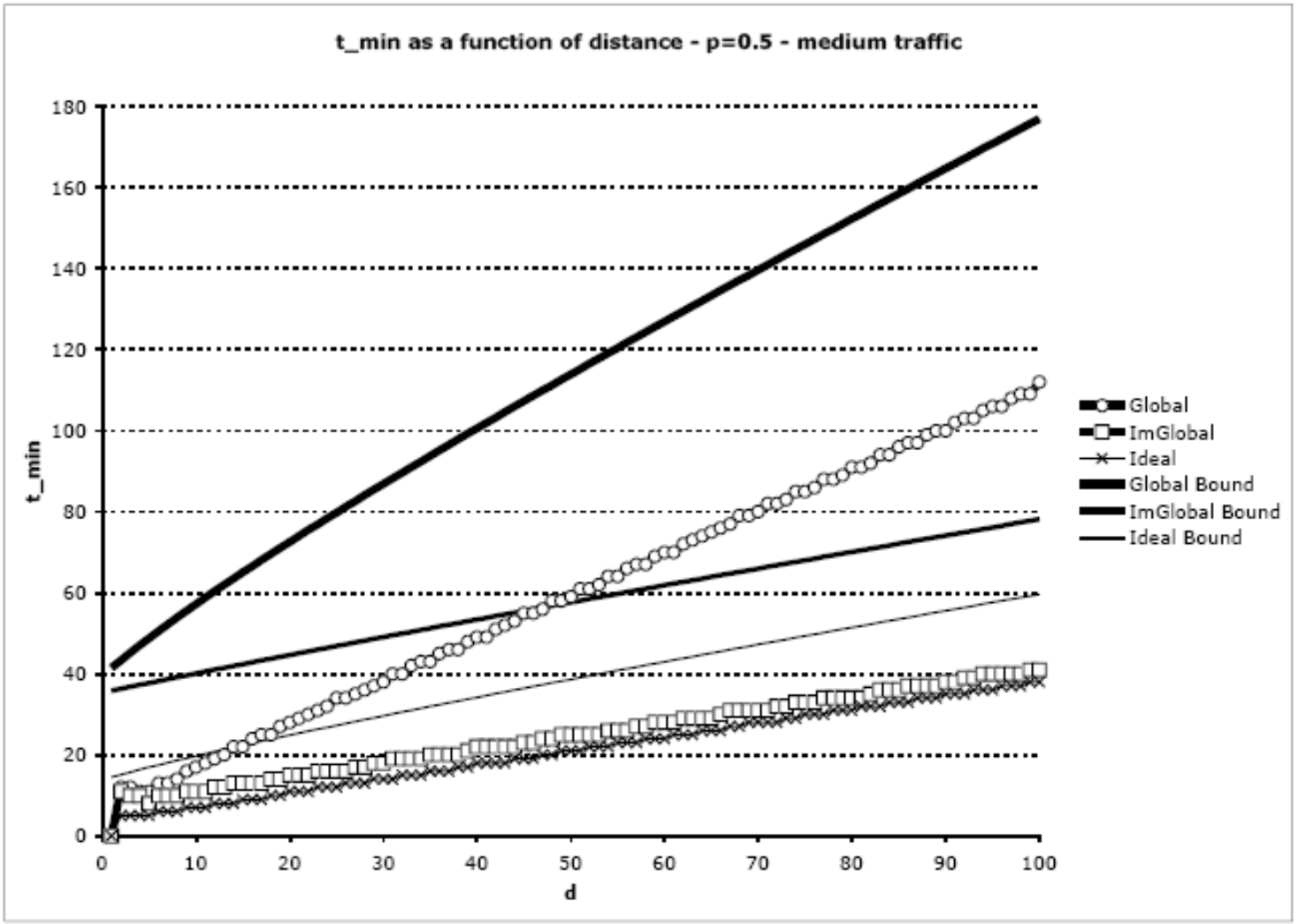
Dependence on time



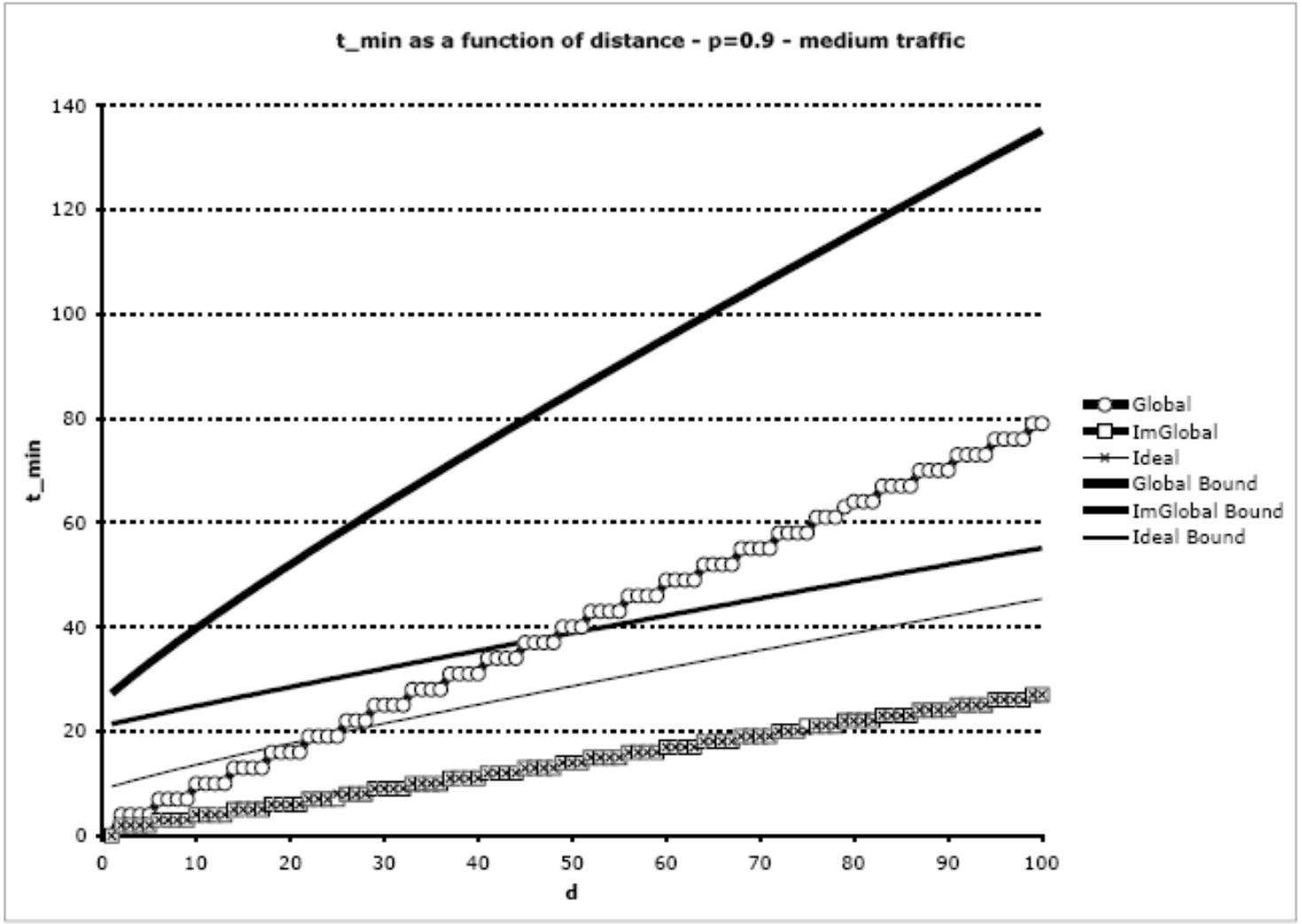
Dependence on channel reliability



Simulation


t_min as a function of distance - p=0.5 - medium traffic
t_min
d
0
20
40
60
80
100
120
140
160
180
0
10
20
30
40
50
60
70
80
90
100
Global
ImGlobal
Ideal
Global Bound
ImGlobal Bound
Ideal Bound

Simulation


t_min as a function of distance - p=0.9 - medium traffic
t_min
d
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90
100
Global
ImGlobal
Ideal
Global Bound
ImGlobal Bound
Ideal Bound