

NETWORK PROGRAMMING · ALTERNATE ASSESSMENT · 2026-27

SMART EMERGENCY ALERT BROADCASTING

in Vehicular Ad Hoc Networks using ns-3

[Name 1] · [Name 2] · [Name 3] · [Name 4]

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Why every millisecond matters

At 108 km/h, a car covers 3 metres every 100 ms.



One hop $\approx$ 300 m

An IEEE 802.11p radio reaches only a few hundred metres.



Cars must relay it

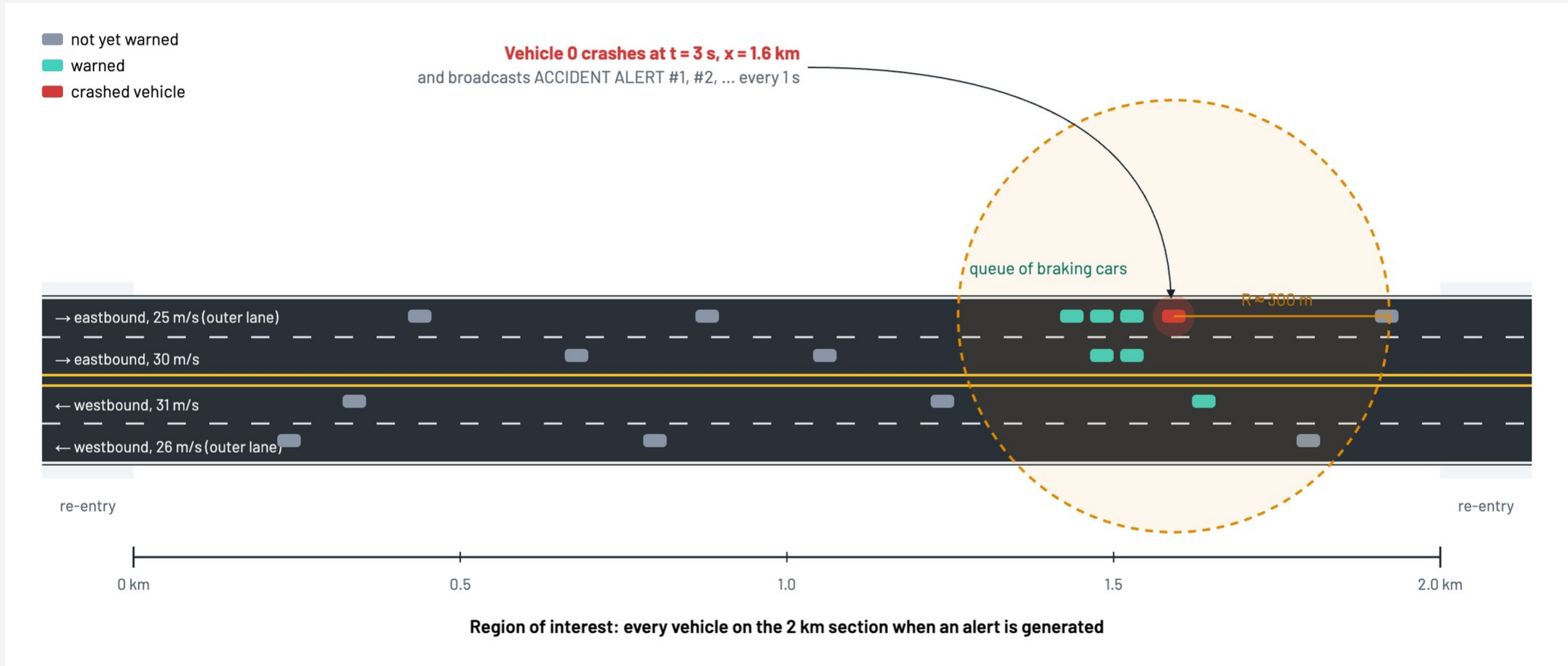
The drivers who need the warning can be a kilometre or more behind the crash.



Who relays, and when?

That one decision sets how fast and how far the warning spreads. It is the focus of this project.

The scenario: one crash on a 2 km highway



Traffic keeps left, so eastbound lanes are the upper half · 20–120 vehicles · the alert repeats every second

Blind flooding starts a broadcast storm

If every car re-sends the alert the moment it hears it, dozens of cars transmit at once on one shared channel.

29 %

of 20 simultaneous relays
avoid a collision: $(15/16)^{19}$
with 16 back-off slots.

41 %

average new area a relay
adds, because most of its
range overlaps the sender's
(Ni et al., 1999).

0 ACKs

Broadcast frames are never
acknowledged or
retransmitted, so a collided
alert is simply lost.

16 papers, four families of solutions



[1] [2]

Storm suppression

Slotted and weighted persistence: farther receivers get earlier slots.

Gap: Distance only; never cancels after a farther relay.



[3]–[6] [13] [15]

Contention relays

UMB, Smart Broadcast, DV-CAST, time barriers: the farthest car forwards.

Gap: Need handshakes, black-bursts or beacons.



[7] [8]

Gossip

Forward with probability p ; $p = 0.6$ – 0.8 saves up to 35 % of messages.

Gap: All-or-nothing; dies out on thin roads.



[9]–[12] [14] [16]

Channel and platforms

802.11p, fading studies, surveys and ns-3 frameworks such as ms-van3t.

Gap: Fading cuts reception; schemes rarely compared under it.

Research gap and problem statement

No simple relay rule that works on a standard 802.11p stack

None combines distance-based contention with direction-aware cancellation over plain UDP broadcast, tested under fading, beacon load and repeated alerts.



PROBLEM STATEMENT

Design, implement and evaluate in ns-3, using UDP socket programming, an accident-alert application whose application-layer Smart Relay reaches at least as many vehicles as flooding, with fewer transmissions and collisions, and keeps delay far below the 100 ms safety budget.

Smart Relay: two rules applied by every car

- 1 The farther you are, the sooner you relay

```
slot = ⌊ N · (1 - d / R) ⌋  
wait = slot · τ + jitter
```

$N = 5$ slots, $\tau = 2$ ms, $R = 300$ m. The car that adds the most new road relays first.

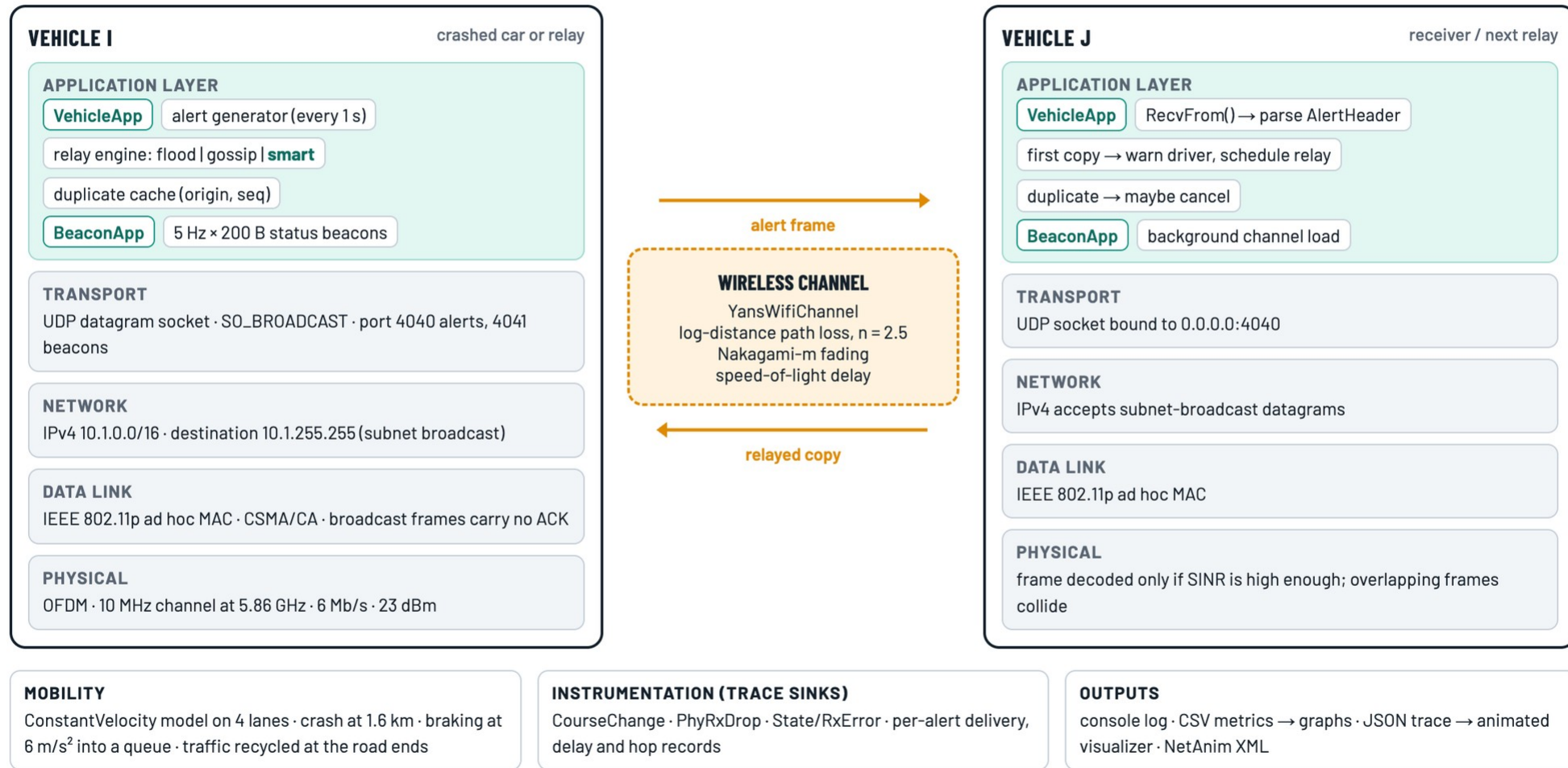
- 2 Someone ahead relayed? Stand down.

```
cancel if  
(x_sender - x_me) · dir ≥ 0
```

A duplicate from a car further along the alert's path means our relay would add nothing.

No handshakes, no MAC changes. Only the sender's position, carried in a 40-byte header.

System architecture: one protocol stack per vehicle

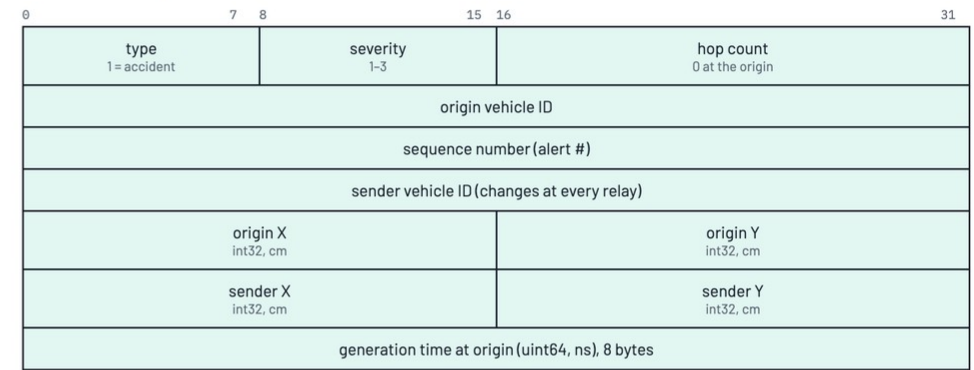


The socket code behind every alert

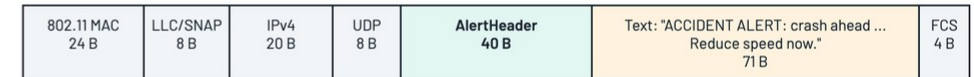
```
// create, enable broadcast, bind
s = Socket::CreateSocket(GetNode(),
    UdpSocketFactory::GetTypeId());
s->SetAllowBroadcast(true);
s->Bind(InetSocketAddress(
    Ipv4Address::GetAny(), 4040));
s->SetRecvCallback(MakeCallback(
    &VehicleApp::HandleRead, this));

// send one alert to every car in range
p->AddHeader(alertHeader);
s->SendTo(p, 0, InetSocketAddress(
    "10.1.255.255", 4040));
```

ALERTHEADER (40 BYTES, NETWORK BYTE ORDER)



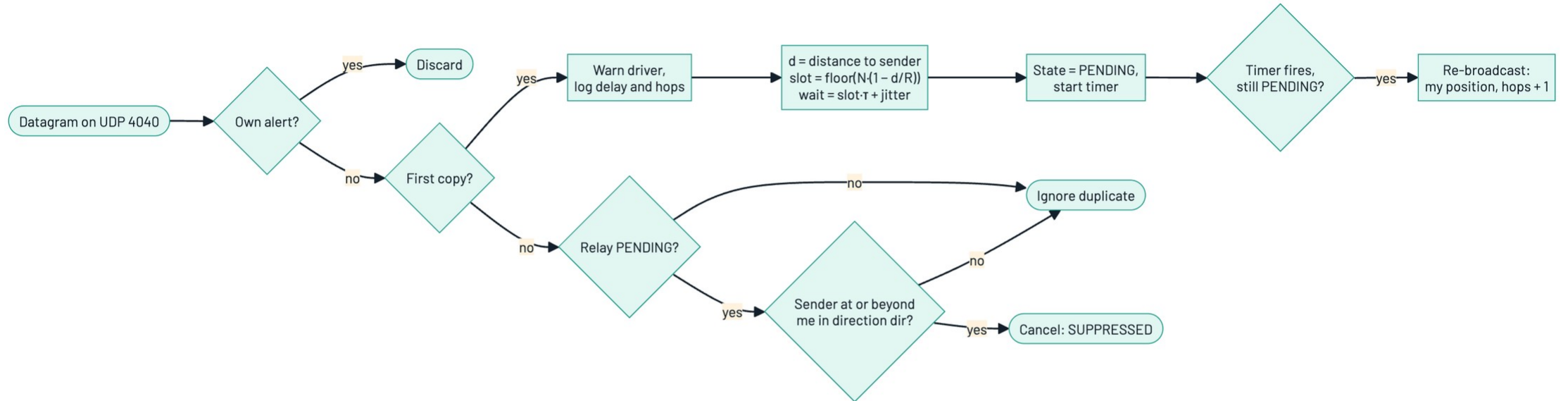
Positions are 32-bit words each; they are drawn two per row to keep the figure compact. (origin, sequence) identifies an alert for duplicate detection; sender X/Y drives Smart Relay's distance and direction test.



Encapsulation of one alert frame on air (175 bytes).

A 40-byte AlertHeader in network byte order: (origin, seq) detects duplicates, and the sender's X/Y drives Smart Relay.

What a car does when an alert arrives



Flooding baseline: Relay at once on the first copy. Same socket code; no waiting, no cancelling.

Gossip baseline: Relay at once with probability 0.6, otherwise drop the alert.

Experimental set-up

Parameter	Value
Radio	IEEE 802.11p ad hoc · 10 MHz · 6 Mb/s · 23 dBm
Channel	Log-distance ($n = 2.5$) + Nakagami fading
Transport	UDP broadcast to 10.1.255.255:4040
Traffic	20–120 cars, 4 lanes, 25–31 m/s
Crash and alerts	$t = 3$ s at 1.6 km · 1 alert/s · 17 per run
Background load	5 beacons/s × 200 B per car
Smart Relay	$R = 300$ m · $N = 5$ · $\tau = 2$ ms
Gossip	$p = 0.6$



180

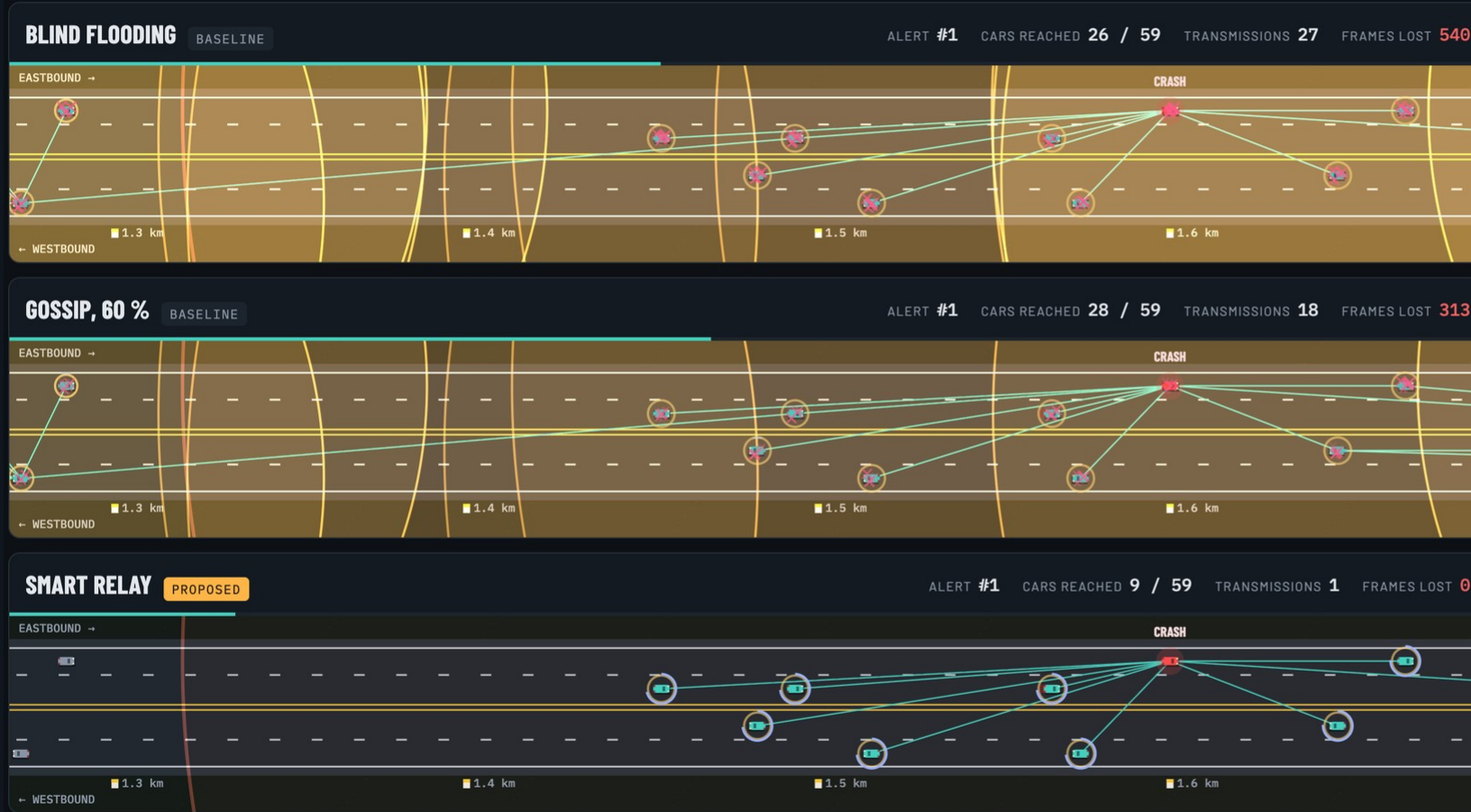
runs: 6 densities × 3 schemes × 10 seeds

1:41

minutes for the whole sweep on 8 cores

Same seed = same cars, same movement and same fading for all three schemes.

1.5 ms after the crash



- Flooding**
27 transmissions
540 frames lost
- Gossip**
18 transmissions
313 frames lost
- Smart Relay**
1 transmission
0 frames lost

Frame from our replay of the ns-3 trace · 60 vehicles, seed 1 · zoomed on the crash site

30 ms later, on the whole 2 km road



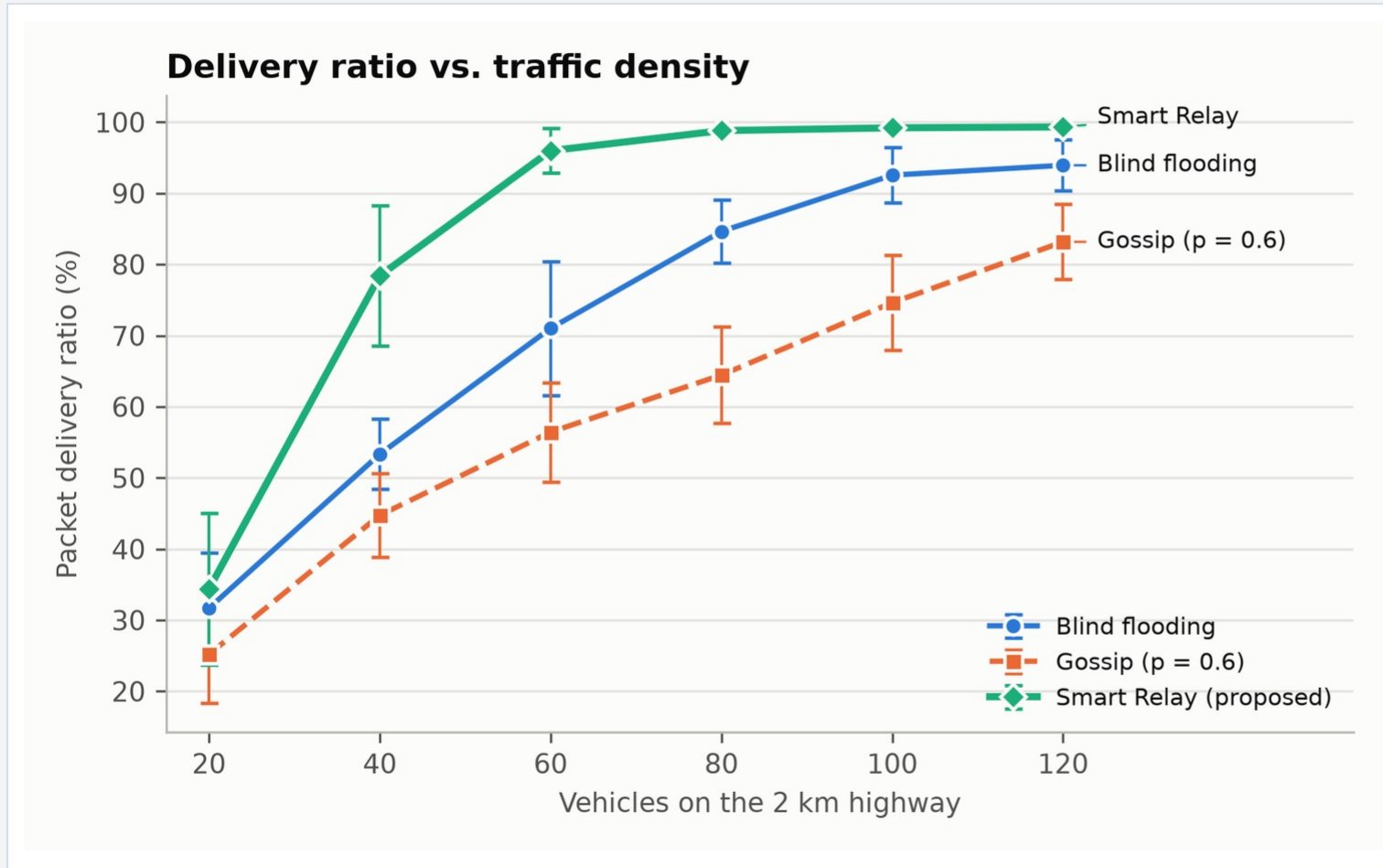
Flooding
56 of 59 cars
57 sent · 1,132 lost

Gossip
28 of 59 cars
died out mid-road

Smart Relay
55 of 59 cars
21 sent · 22 lost

Teal cars have the warning · lines show which car each vehicle heard it from

Smart Relay delivers more alerts at every density



60 VEHICLES

96.0 %

vs 71.0 % flooding, 56.4 % gossip

120 VEHICLES

99.3 %

vs 93.9 % flooding, 83.2 % gossip

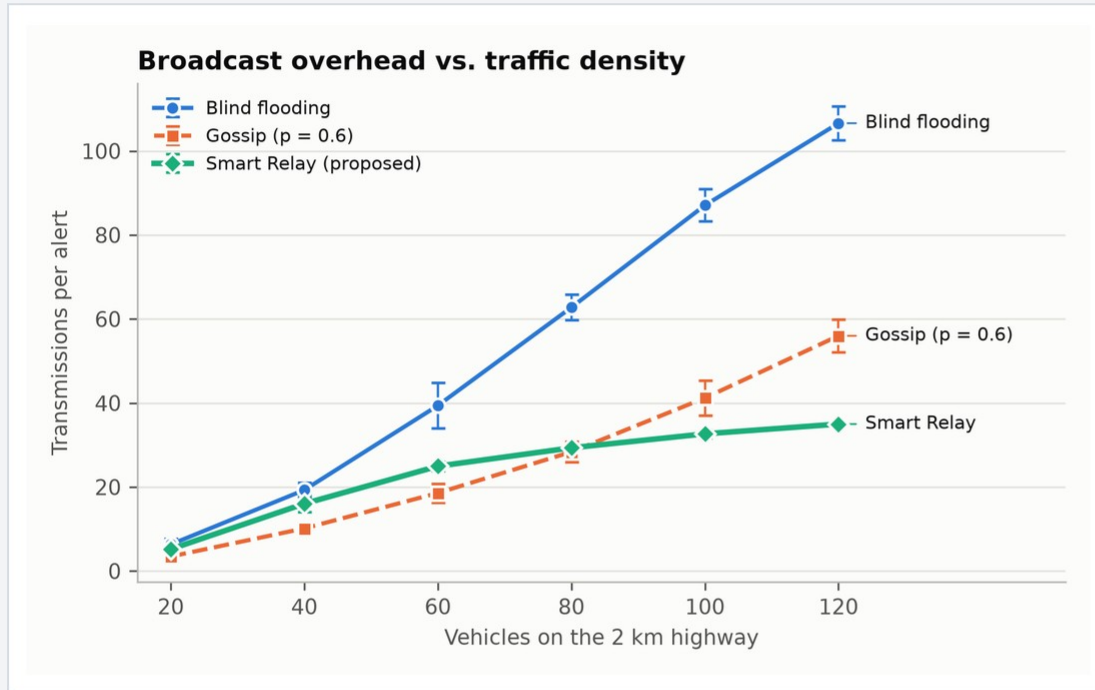
20 VEHICLES

25–34 %

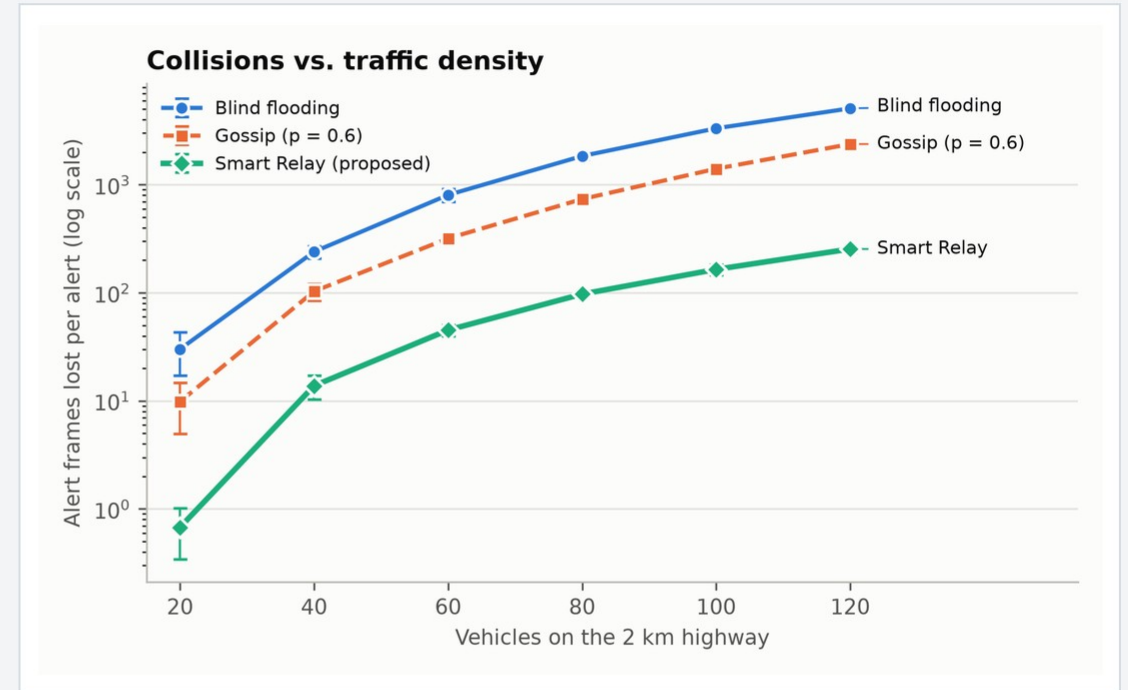
road too sparse for any scheme

Mean of 10 seeds per point · at 20 vehicles there is one car every 400 m per lane, so the road is disconnected

Fewer packets, about 95 % fewer collisions

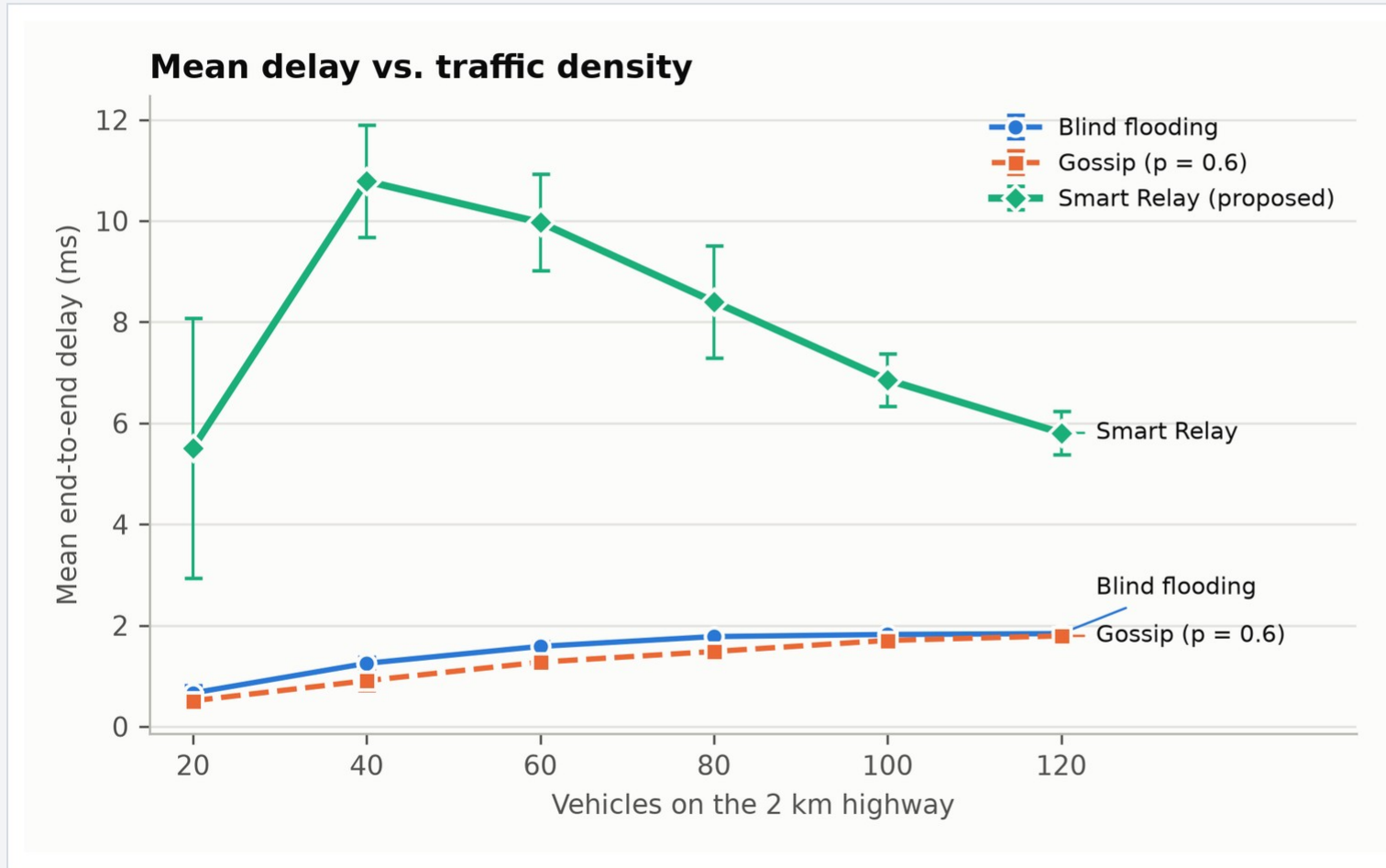


Transmissions per alert: 35 vs 107 for flooding at 120 cars, 67 % fewer.



Frames lost to collisions: 254 vs 5,084 per alert at 120 cars, 95 % fewer.

The cost: a few milliseconds of waiting



95th-percentile delay 15–30 ms · jitter 2.3–5.2 ms

SMART RELAY MEAN

5.5–10.8 ms

flooding and gossip: about 0.5–2 ms

SAFETY BUDGET

100 ms

still about 10× headroom

TREND

Falls

as traffic grows: more cars near the range edge win slot 0

More drivers warned, on a quieter channel

SMART RELAY VS BLIND FLOODING · 80 VEHICLES · MEAN OF 10 SEEDS

98.8 %

alerts delivered, up
from 84.6 %

−53 %

transmissions: 29
per alert instead of
63

−95 %

frames lost: 97 per
alert instead of
1,841

8.4 ms

mean delay
(flooding 1.8 ms),
far under 100 ms

Conclusion



What we built

- A UDP broadcast alert app in ns-3.45
- A 40-byte application header
- Three relay schemes, one codebase
- 180-run study and an animated replay



What we found

- 96–99.3 % delivery from 60 cars up
- Up to 67 % fewer packets
- About 95 % fewer collisions
- 5.5–10.8 ms mean delay



What comes next

- Density-adaptive slot length
- Store-carry-forward for sparse roads
- SUMO city maps and traffic
- Signed alerts against forgery

A relay rule that needs only the sender's position removes most of the broadcast storm on a standard 802.11p stack.

Limitations: straight highway, scripted braking, exact GPS positions, fixed R, N and τ .

LOADING

ALERT #1

CARS REACHED 56 / 59

TRANSMISSIONS 57

FRAMES LOST 1132

THANK YOU

Questions?

Live demo: the animated replay of all three schemes on the same traffic, generated from the ns-3 trace.

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