

provlae...-case bonus

contention among  $g(i)$  messages  
2V SC messages exchanged in  $T_i$   
 $\tau$

$$= K_{g(1)} + \delta g(1) + (f+n_i-1) \tau$$

$$T_2 = K_{g(2)} + \delta g(2)$$

$$T_3 = K_{g(3)} + \delta g(3) + f \tau$$

$$T_1 = T_2 = T_3 = \dots$$





On the Power of Cohorts – Multipoint Protocols for  
Fast and Reliable Safety-Critical Communications in  
Intelligent Vehicular Networks

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*Intelligent Vehicular Networks (IVNs):  
platforms, VANETs, clusters, ... comprising fully automated  
cooperative vehicles*







Cyber gloves in the news...

It is possible...

Technology available: **Microsoft Kinect**

It is possible to capture the movement of a hand and use it to control a computer screen. This is done by using a camera and sensors to track the hand's position and movement.

Qualita 12

Cyber-physics on the move...

40 minutes

Introducing connectivity, network mobility, and mobility...



... enables complex cyber communication flows, that can be adaptive and dynamic, allowing for physical and cyber communication flows to be dynamically re-routed...



## Cyber-physics on the move...

### SC scenarios

Steep breaking, overtaking, on-ramp merging, **lane change**, ...



A SC scenario comprises **cyber (communication) phases**, which serve to achieve inter-vehicular agreement, followed by **physical (perception) phases/maneuvers**. Communication modes in a cyber phase are 1-to-many or many-to-1, denoted Xcast. In the sequel,

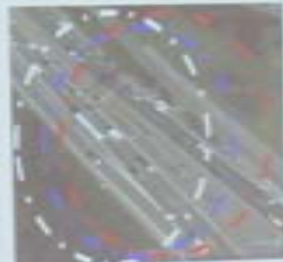




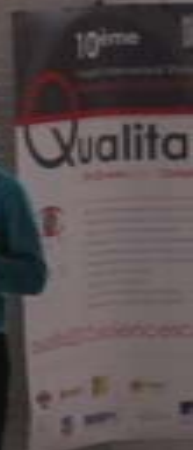
## Cyber-physics on the move...

### SC scenarios

Stop breaking, overtaking, on-ramp merging, **lane change**, ...



A SC scenario comprises **cyber (communication) phases**, which serve to achieve inter-vehicular agreement, followed by **physical (perception) phases/maneuvers**. Communication modes in a cyber phase are 1-to-many or many-to-1, denoted  $X_{cast}$  in the sequel.



### Questions and observations

- When  $n$  is unknown, how to decide « at least  $f$  ack still missing »?
- Acks may be lost as well. NPAR protocols waste time and bandwidth, due to useless retransmissions.
- Inefficient whenever real  $f$  is smaller than estimated worst-case value (retransmission timers are set according to worst-case value), and dangerous in the opposite case.
- How to prove, for any given suite of Xcast  
probability of experiencing more than  $f$  omissions per hour  $< 10^{-9}$
- Existing acknowledgment-free Beast or Geocast? How to know
  - There has been no MAC level collision,
  - Message has been delivered to every intended recipient?



## Questions and observations

- When  $n$  is unknown, how to decide « at least I ack still missing »?
- Acks may be lost as well. NPAR protocols waste time and bandwidth, due to useless retransmissions.
- Inefficient whenever real  $f$  is smaller than estimated worst-case value (retransmission timers are set according to worst-case value), and dangerous in the opposite case.
- How to prove, for any given suite of Xcast:
  - probability of experiencing more than  $f$  emissions per hour  $< 10^{-4}$
- Existing acknowledgment-free Bcast or Gocast? How to know:
  - There has been no MAC level collision.
  - Message has been delivered to every intended recipient?

QUESTIONS:



A man in a teal sweater and black pants is walking across the stage, pointing towards the projected image. He appears to be a lecturer or presenter.

The foreground shows the backs of several audience members sitting at wooden desks, indicating a lecture hall or classroom setting.

# ANALYTICAL RESULTS

cannot provide worst-case bounds

on time

resolving contention among  $g(i)$  messages

number of V2V SC messages exchanged in  $T$

$$T_1 + T_2 + T_3$$

$T_1 = K_{g,1} + \delta g(1) + (f+n_v-1) \tau$
$T_2 = K_{g,2} + \delta g(2)$
$T_3 = K_{g,3} + \delta g(3) + f\tau$
$T_1 = T_2 = T_3 = x$





e transmission time  
 el delay for resolving contention among  $g(i)$  messages  
 $n_i$  = total number of V2V SC messages exchanged in  $T_i$   
 $T = T_1 + T_2 + T_3$

er phase 1	$T_1 = K_{g,1} + \delta g(1) + (f+n_1-1) \tau$
er phase 2	$T_2 = K_{g,2} + \delta g(2)$
er phase 3	$T_3 = K_{g,3} + \delta g(3) + f\tau$
R protocols	$T_1 = T_2 = T_3 = \tau$

