EXTEND THE SAFETY SHIELD – AN EARLY WARNING SYSTEM FOR VEHICLES

Prof. Michael Tsai
Department of Computer Science and Information Engineering and
Intel-NTU Connected Context Computing Center
National Taiwan University

Introduction to M2M course

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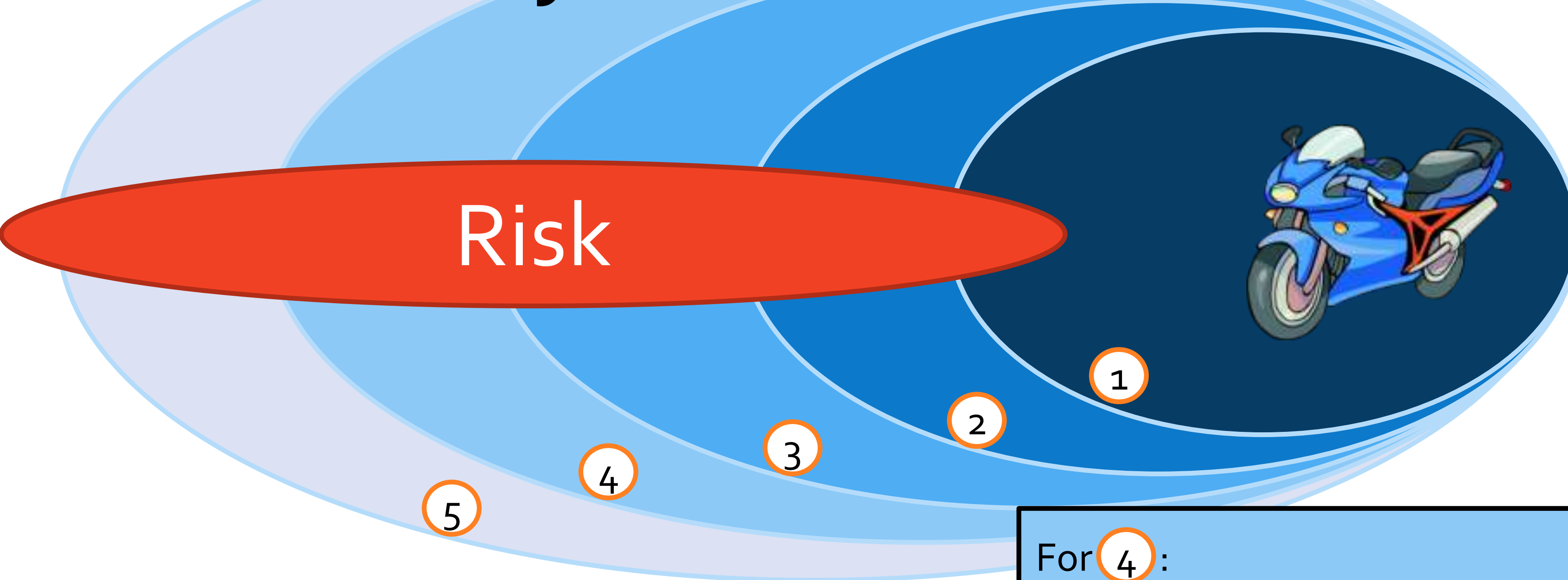
The “Safety Shield”



1 Crash – post crash

2 Crash is unavoidable

3 Crash may occur

4 Risk has appeared

Larger Shield is SAFER!

For 4:
- Blind Spot Information System (BLIS)
- Adaptive Cruise Control (ACC)
- Forward collision warning
- Pedestrian detection
- Lane departure warning

We are here.

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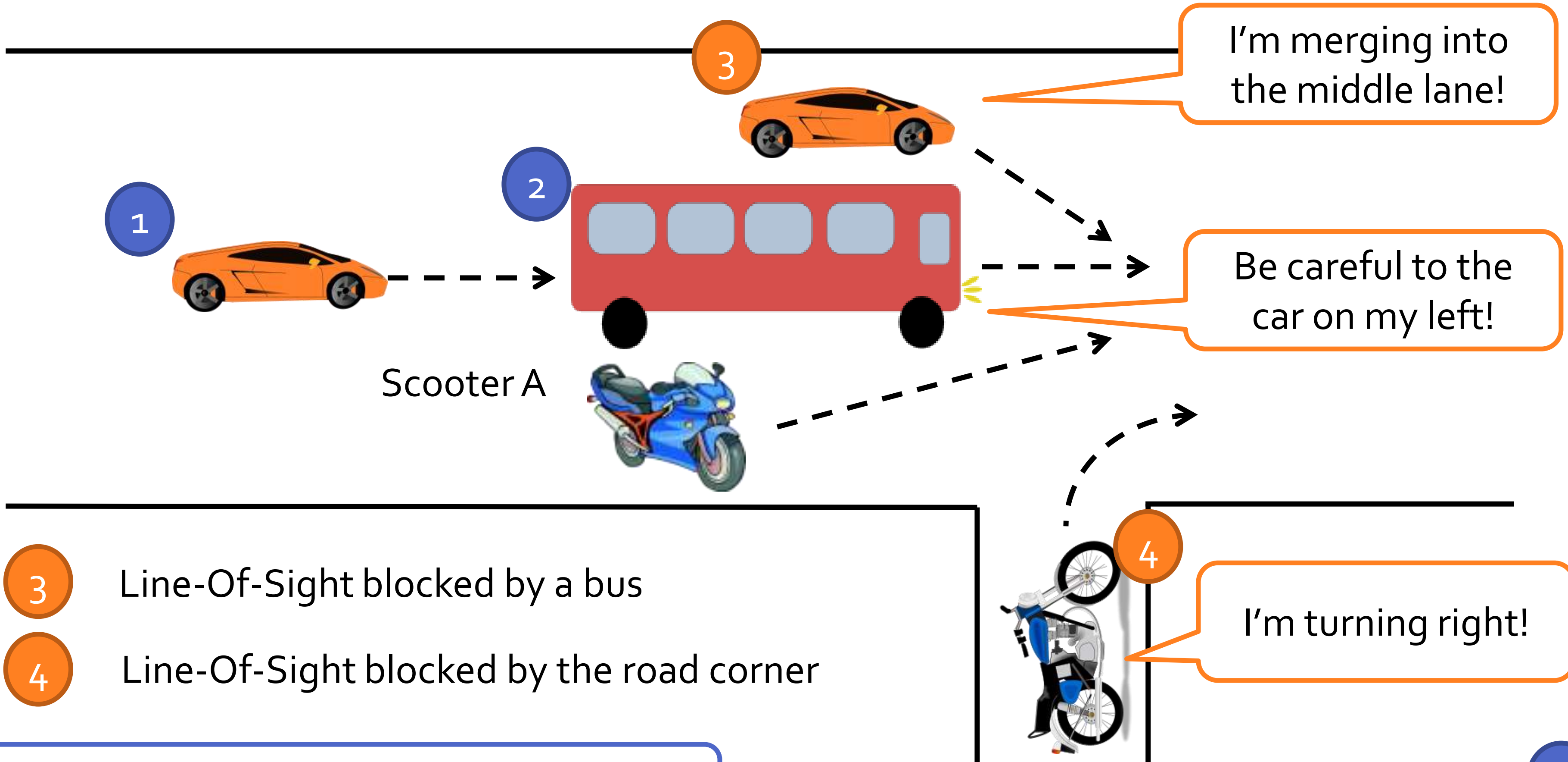
5 Risk has not yet appeared

What can we do here?

Communication-Assisted Approach



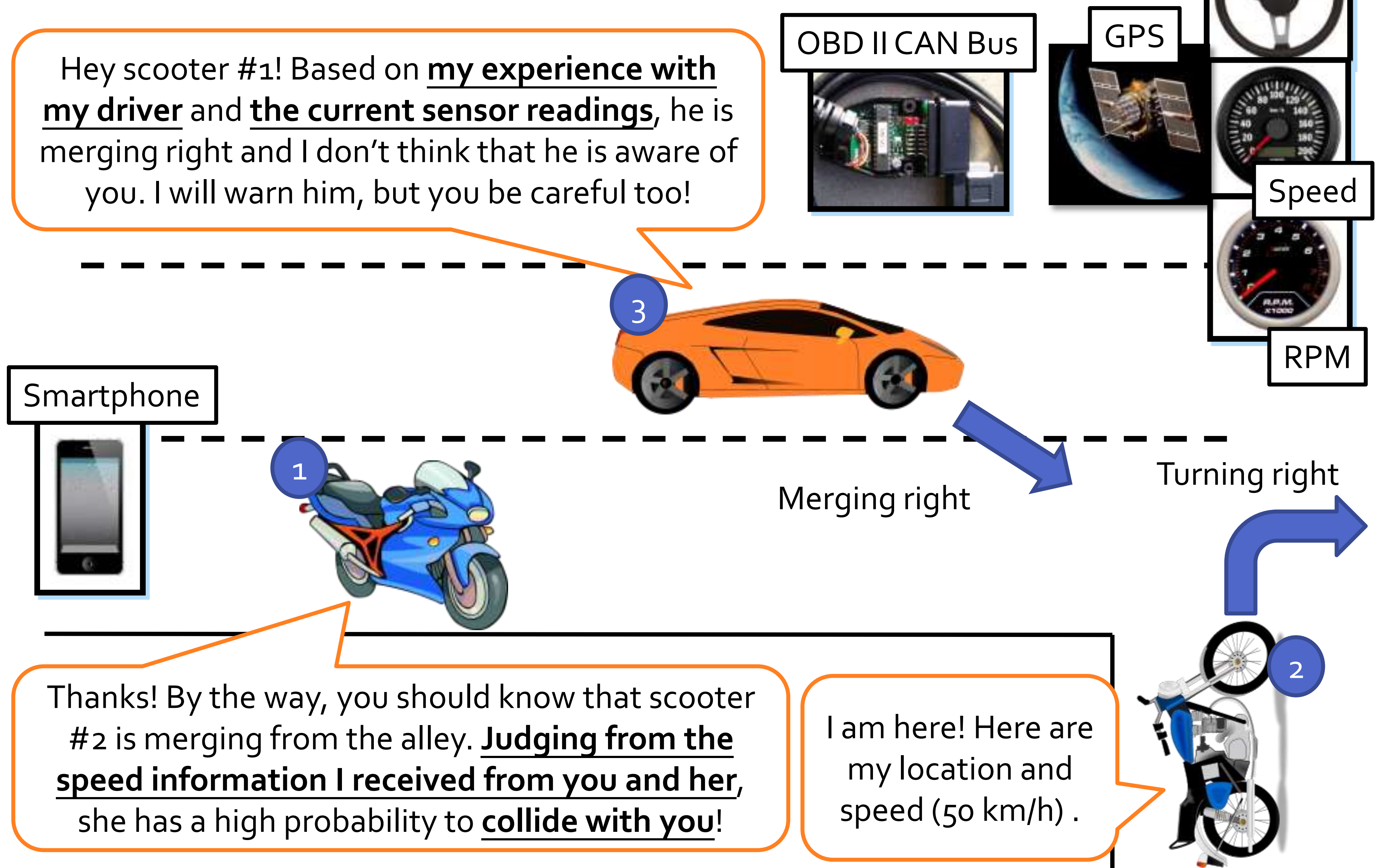
3 Line-Of-Sight blocked by a bus

4 Line-Of-Sight blocked by the road corner

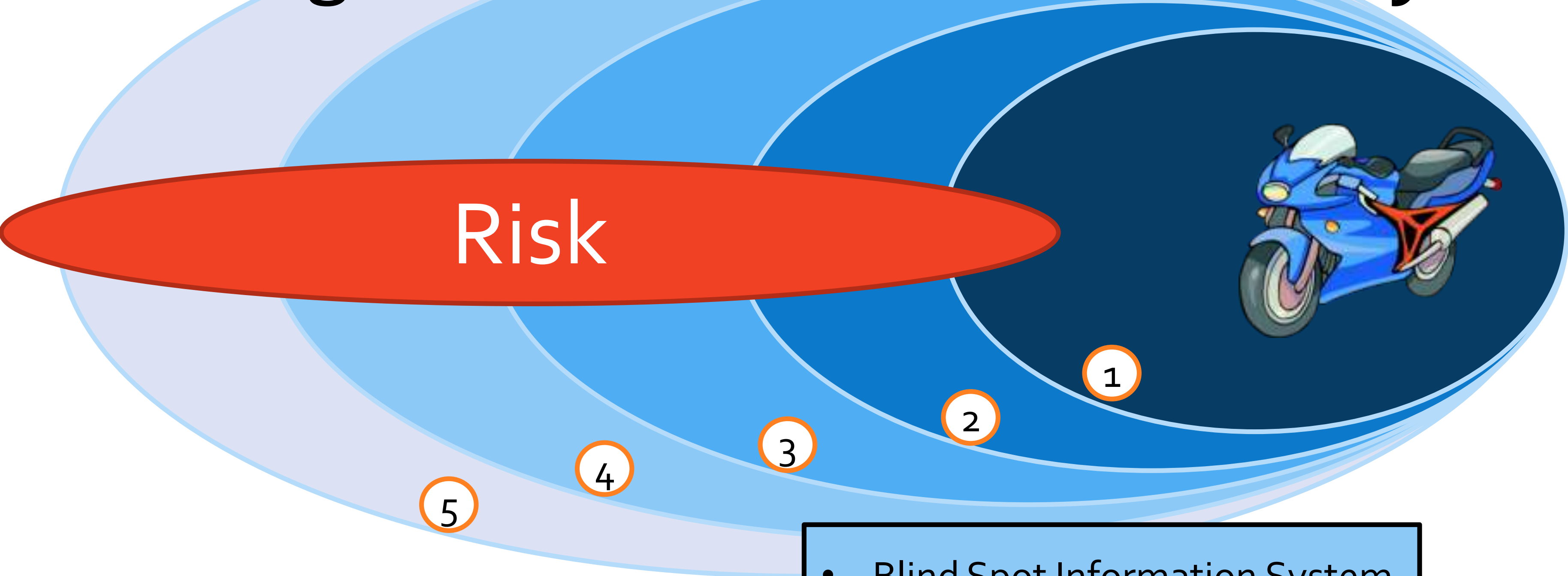
Conventional Approach: Video camera and/or radar only (1, 2)
Detects only risks with a LOS path

Communication-assisted approach: Sensors + Communications (1, 2, 3, 4)
Detects also risks via multi-hop comm./ nLOS path

Vehicle Behavior Prediction



Next-generation Vehicle Safety



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- Blind Spot Information System (BLIS)
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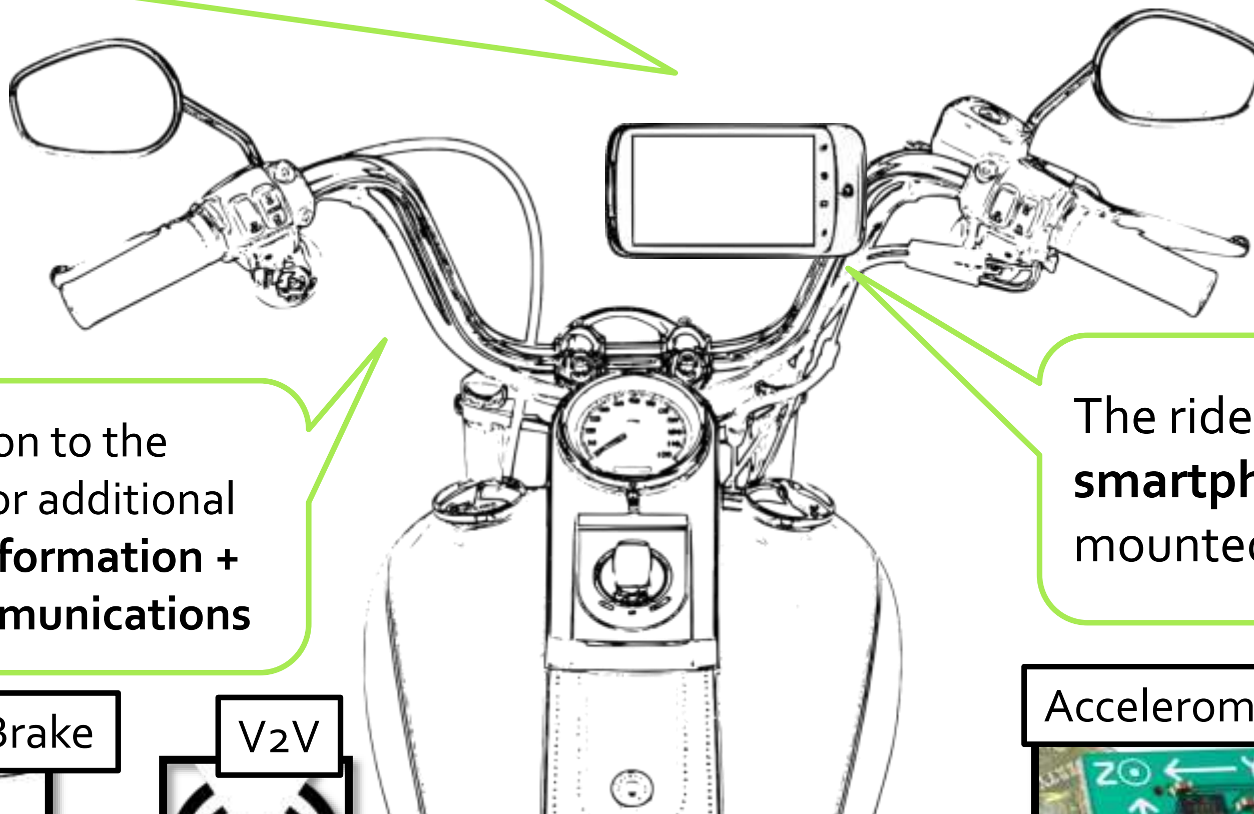
M2M (V2V) technologies eliminate the "gap", and make these solutions applicable to 5 as well!

An Early Warning System for Vehicles

Concept:

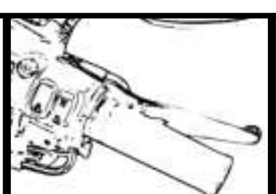
A new “**magic mirror**” for you to check for potential risks.



Connection to the scooter for additional **sensor information + V2V communications**

The rider’s **smartphone** is mounted on a holder.

Throttle & Brake



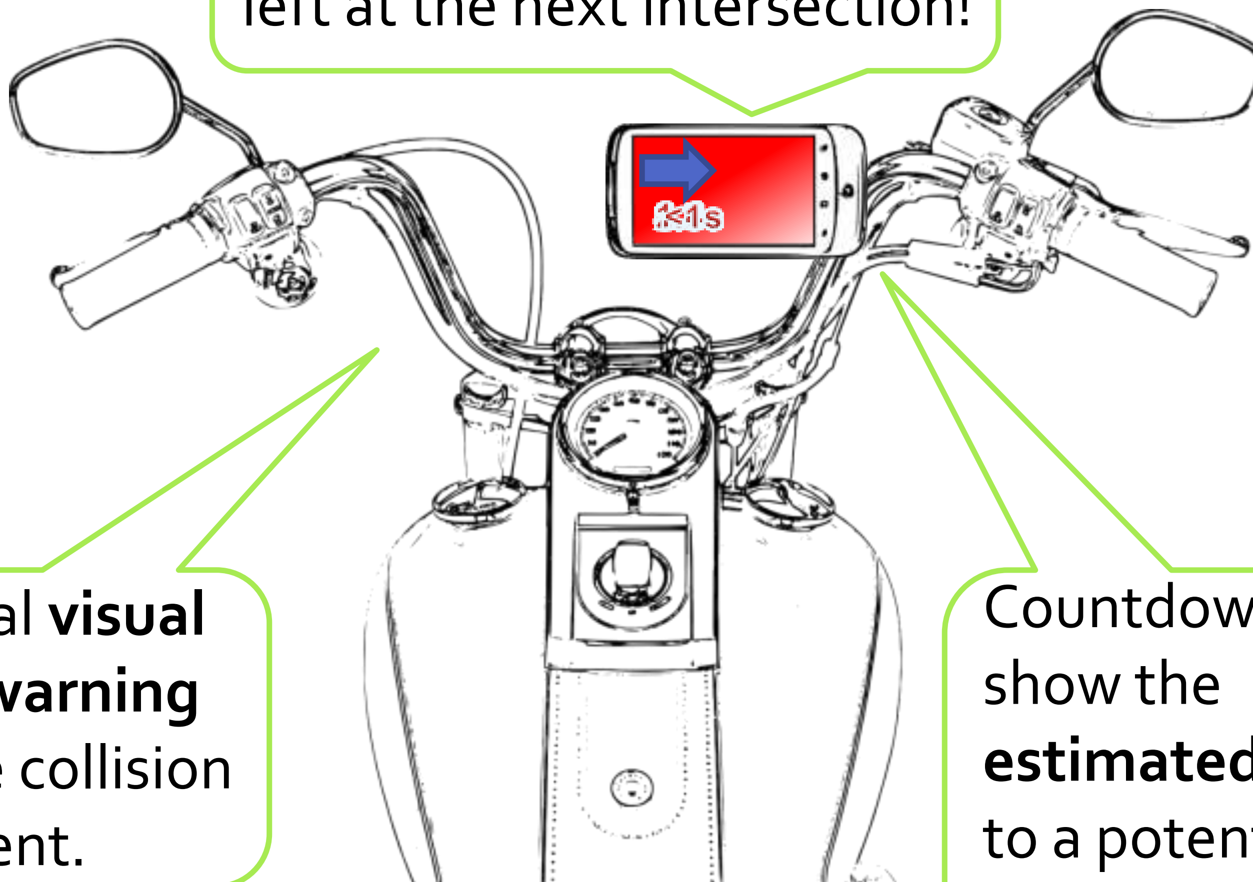
V2V

Accelerometer

GPS

An Early Warning System for Vehicles

Vehicle coming from the left at the next intersection!

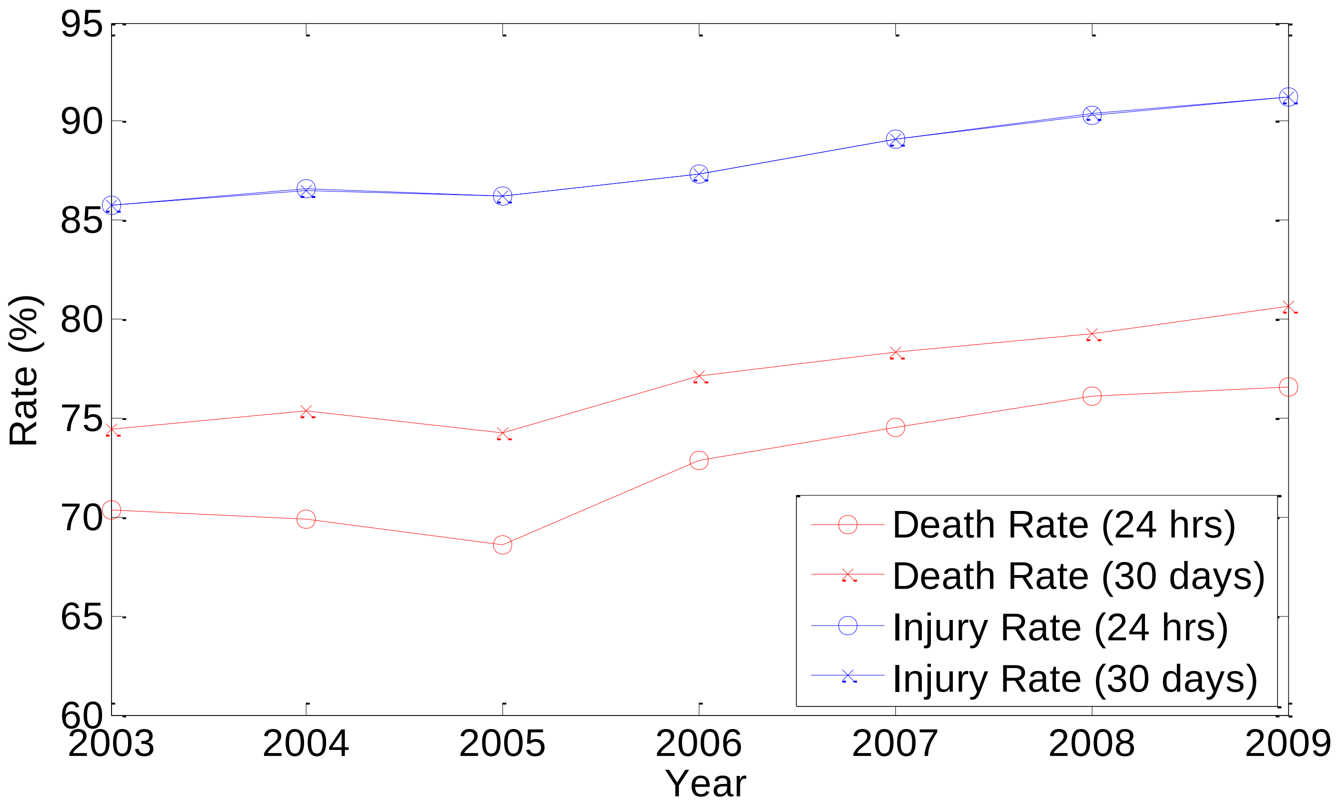


Additional **visual + audio warning** when the collision is imminent.

Countdown to show the **estimated time** to a potential collision.

Scooter Safety

- **68.34%** of registered vehicles are scooters
- Accidents involving **scooters/motorcycle** account for most of fatalities/injuries (**and rising!**)



Off-the-Shelf Product Features

	Cars 	Scooters 
Active Safety Feature	1. Anti-lock Breaking System (ABS) 2. Electronic Brake-Force Distribution (EBD) 3. Electronic Stability Control (ESC) / Traction Control System (TCS)	1. Anti-lock Breaking System (ABS) 2. Traction Control System (TCS) 3. Power mode map Not common!
Passive Safety Feature	1. Seat belts 2. Body frame 3. Head restraints 4. Front air bags (driver & passenger) 5. Side & curtain air bags	1. Full-face helmet 2. Leather suit (jacket, gloves, pants) 3. Boots Open-face helmet only Not much development!

A Common Platform: Smartphone

High initial market penetration rate

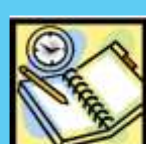
- Lower effect cost for users
- 2010 smartphone market share:

 **27%**  **31%**

- Existing Supporting Infrastructure

Good user experience

- Already familiar with the smartphone's HCI
- Know about the user behaviors in other context as well



Useful Components

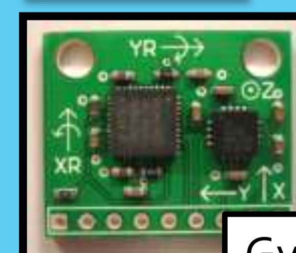
Multi-touch Screen

Powerful CPU

Useful Sensors:

Accelerometer

GPS



Gyro

V2V

CAN

Smartphone

Next-Generation Vehicle Safety: An Early-Warning System

Scooter

Reliable V2V Communications

Vehicle Behavior Model

Research Challenge 1

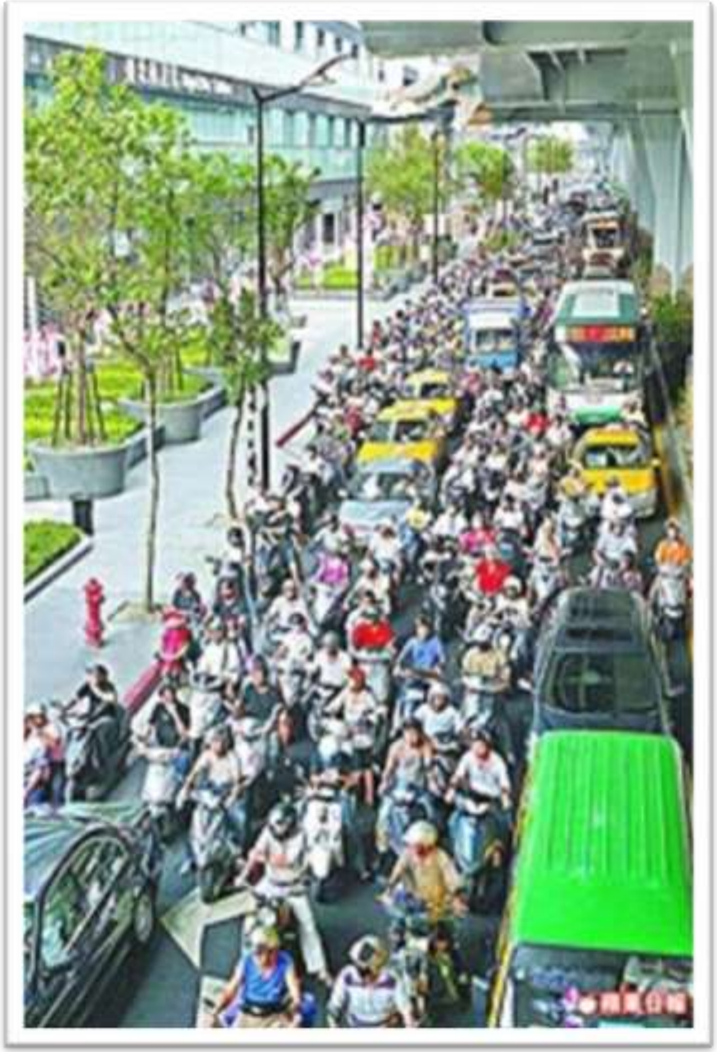
- Can the system work in **this condition**?
  - Urban area, high density scenario

- Delivery Ratio
- Delay
- Bandwidth

Reliability

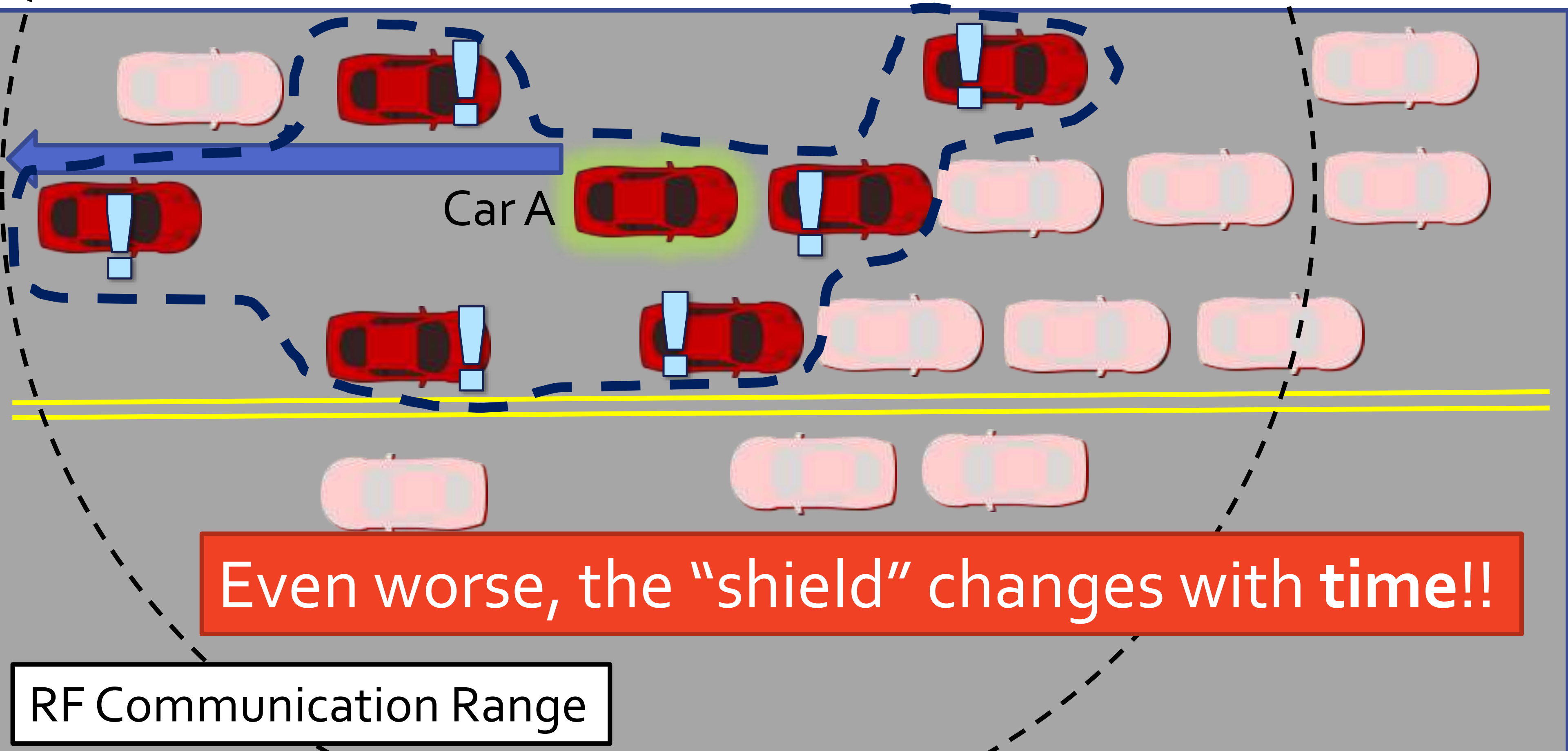
all limited by the **number of vehicles in the range**.

- Density == Performance



A **Mismatch** between the “Safety Shield” & Communication Coverage

“Safety Shield”: contains vehicles which could be risks

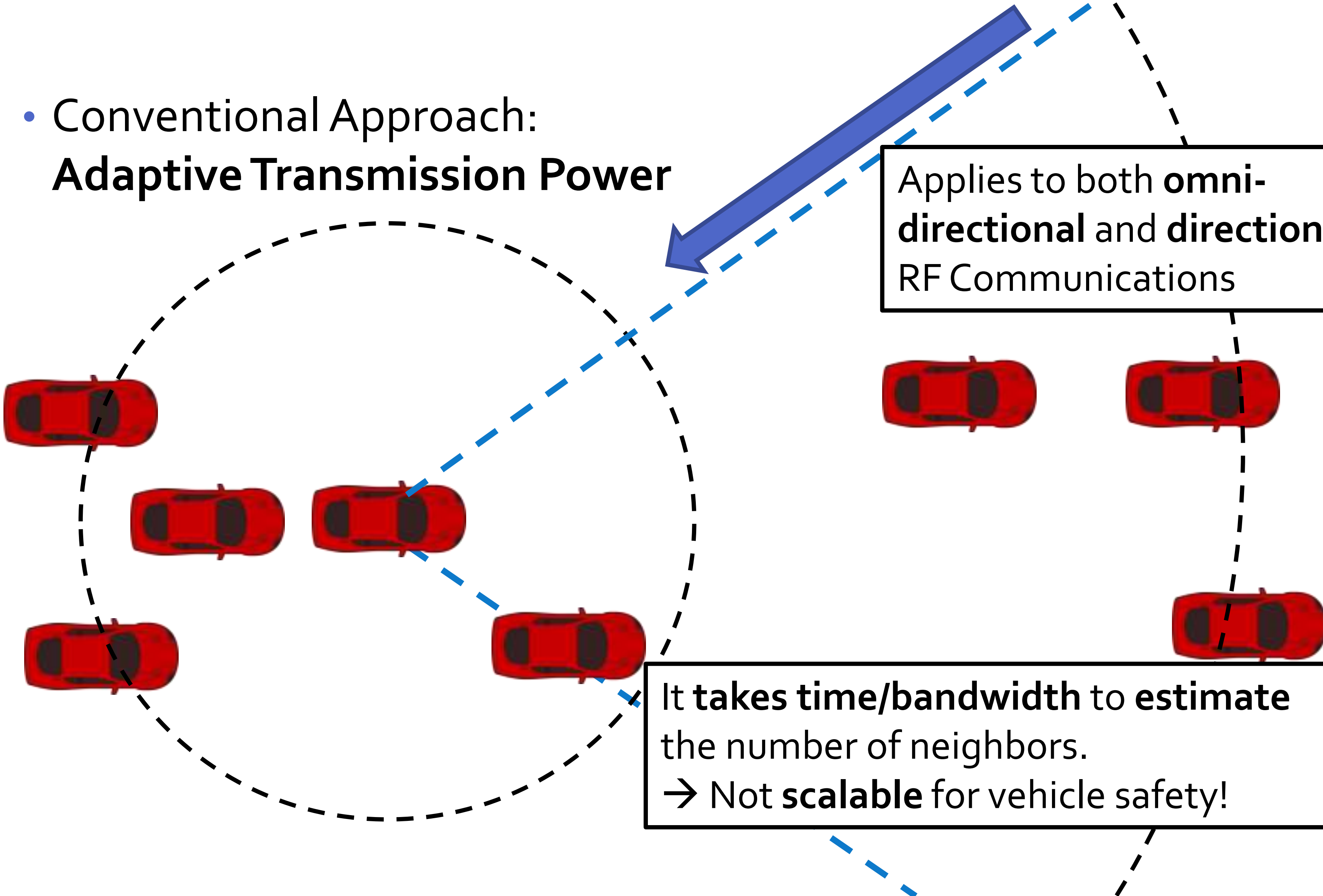


Even worse, the “shield” changes with **time**!!

How do we control the coverage (scale)?

- Conventional Approach:
  Adaptive Transmission Power

Applies to both **omni-directional** and **direction** RF Communications



It **takes time/bandwidth** to **estimate** the number of neighbors.
→ Not **scalable** for vehicle safety!

- Some slides regarding the solution for this problem is removed as the research is still in early stage and highly confidential.

Research Challenge 2

How do we know
whether the nLoS communication is **reliable or not**?

The behavior of nLoS wireless channel/link in vehicular settings is

1. Very hard to be **theoretically** modeled (realistically).
2. Highly dependent on **"scenarios"**.

"Scenarios" mean:

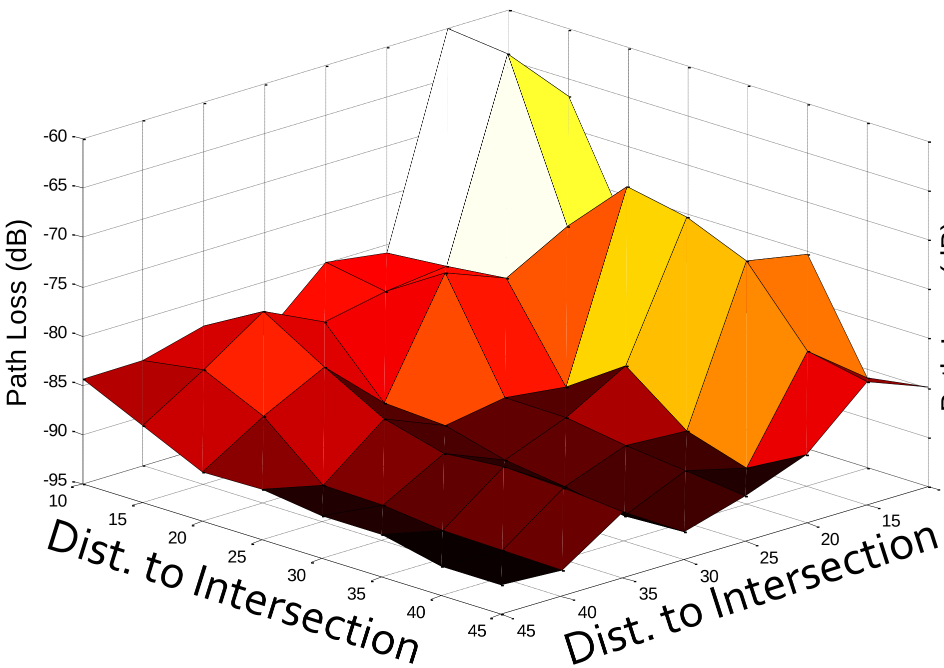
1. The surrounding static objects (buildings, parked vehicles)
2. The surrounding moving objects (human body, other moving vehicles)
3. The speed, location, orientation of the transmitting and receiving vehicles

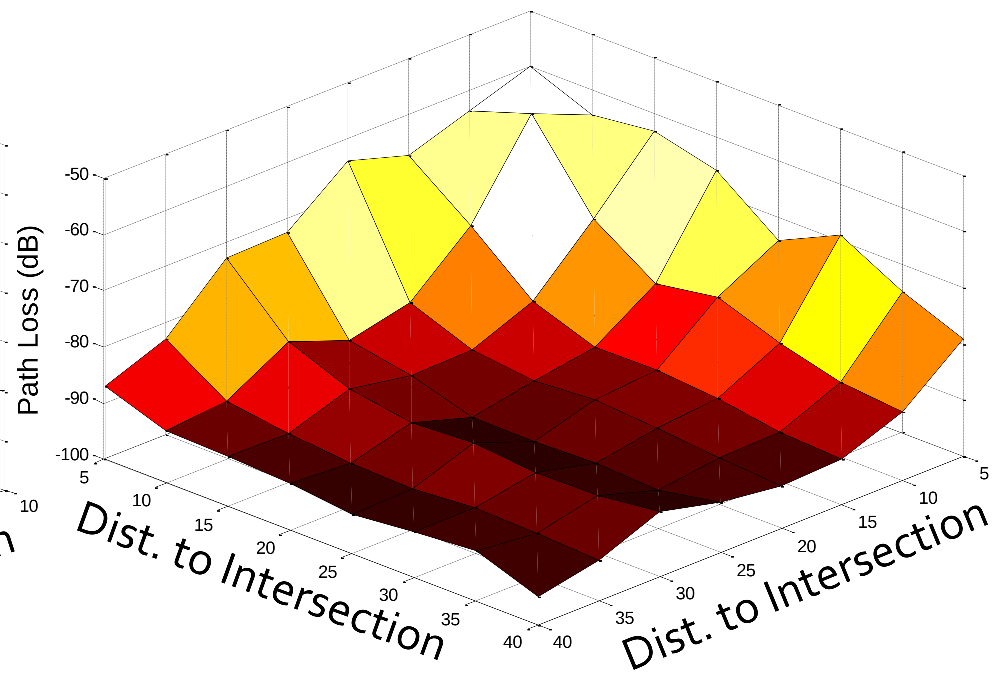
Corner Building as Obstacles

Radio: Chipcon CC2420
IEEE 802.15.4, 2.4 GHz
TX pwr: 0 dBm

8 dBi peak gain omni-directional antenna

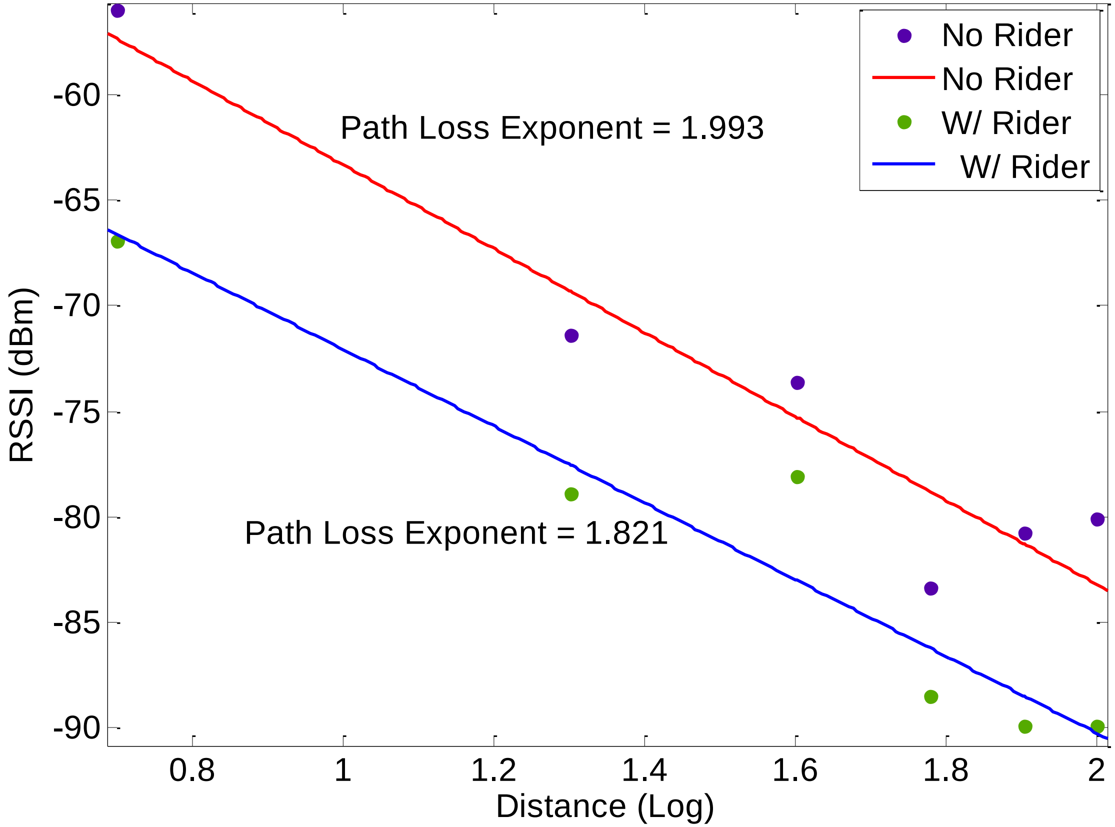
Corner Building as Obstacles





- nLoS links through the corner buildings often **neglected**
- Fairly usable! At (30m,30m), path loss ~ 85 dB!
- Path loss exponent ~ 4.2-4.5
- At 50 km/s, 30m = 2.16 seconds → Sufficient for some reactions!

Human Body as Obstacles



- Human Body creates an **additional 14-20 dB of attenuation** in a 2.4 GHz Scooter-to-Scooter channel

Required Communication Paradigms

RF Communications

None-Line-Of-Sight Communications

Communication to vehicles blocked by objects, other vehicles, or buildings.

VLC Communications

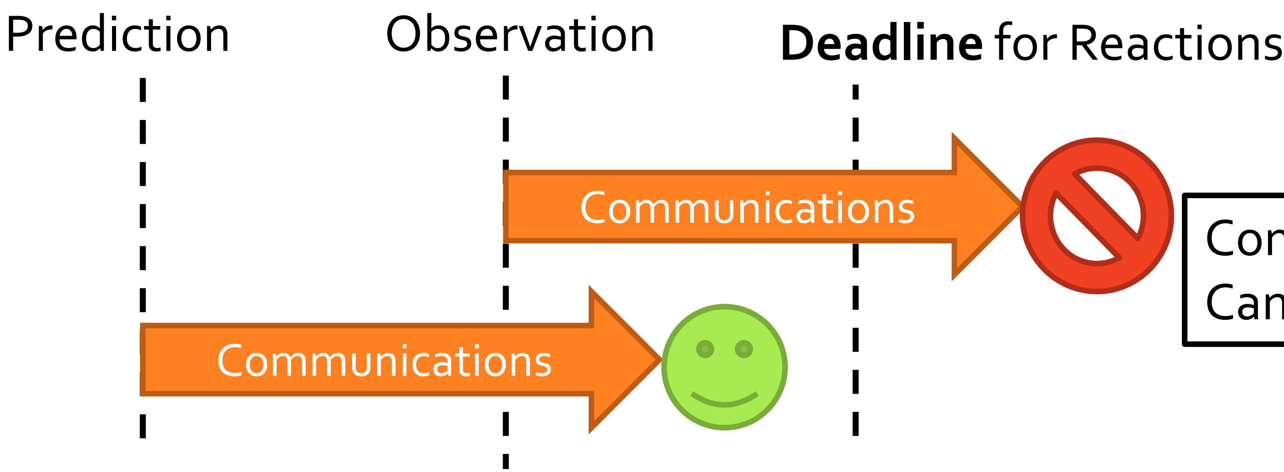
Line-Of-Sight Communications

Communication to immediate neighbor vehicles.

V2V Communications for Vehicle Safety

Total Awareness of the Neighborhood

Research Challenge 3



Communications take time.
Can we react **in time**?

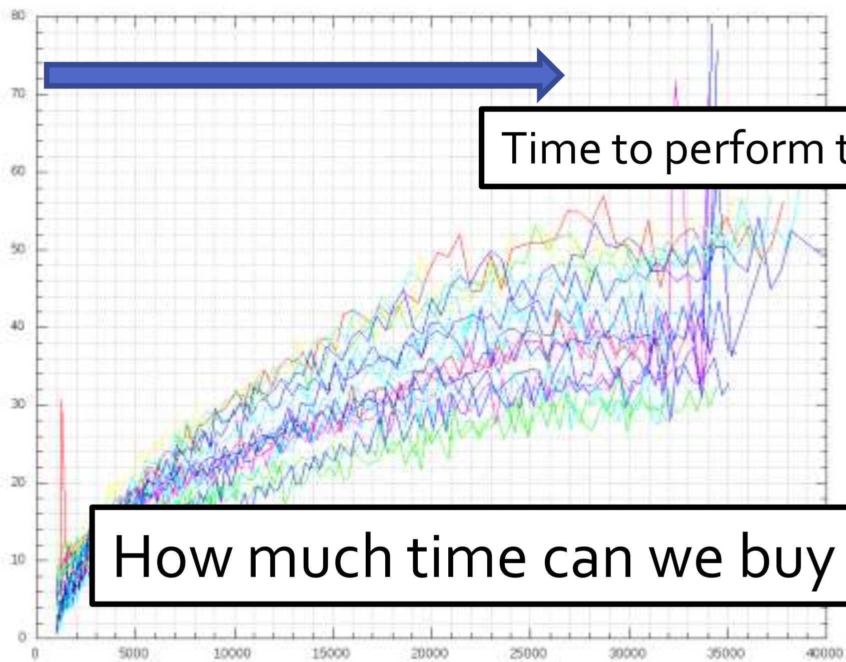
The goal of the model:
To **predict** the vehicle behavior (from the sensor data), not just **observe.**

The catch:
Observation: **100%** accuracy (The event already happens)
Prediction: **??? accuracy** (The event hasn't happen)

Example – Red-Light Runner

Non Red-light runner

Speed(km/hr)

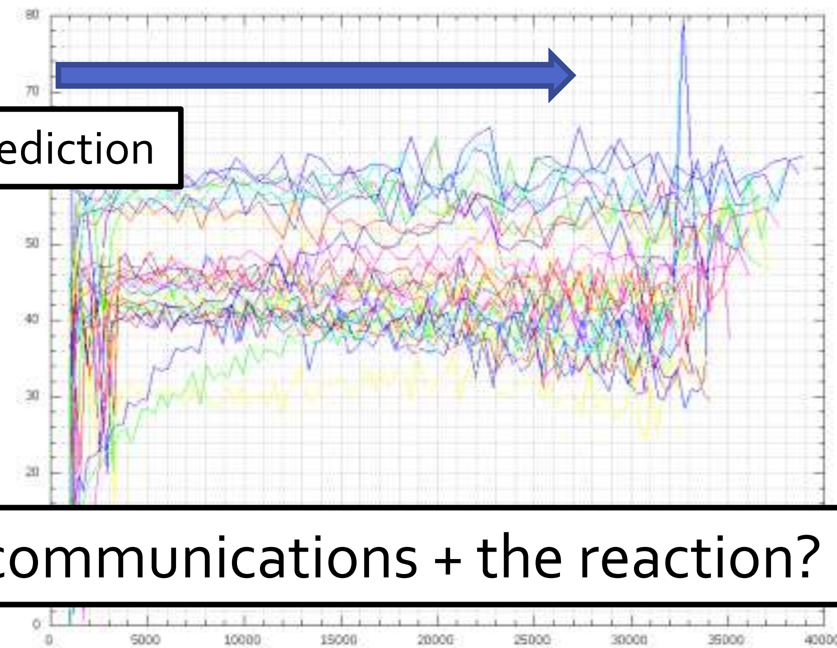


Distance to the intersection (mm)

Closer to the intersection

Red-light runner

Speed(km/hr)



Distance to the intersection (mm)

Closer to the intersection

Time to perform the prediction

How much time can we buy for communications + the reaction?

Smartphone

Recap: Next-Generation Vehicle Safety An Early Warning System

Scooter

Reliable V2V Communications

LoS V2V Links:

- VLC Communications is naturally **scalable** for vehicle safety

NLoS V2V Links:

- Extensive RF link measurements enable the protocol to:
  - Estimate the link quality
  - Adjust the parameter based on the sensor information

Vehicle Behavior Model

- Prediction model for certain vehicle events
  - Red-light runner,
  - Lane switching, and
  - More…
- A vehicle mobility model (cellular automata)
  - Estimate vehicle future locations

(In the Demo session)

Both help each other to improve their accuracy!

Our Team

PI

Prof. 蔡欣穆

Co-PI

Prof. 逄愛君

Champion

Dr. 郭新鋼

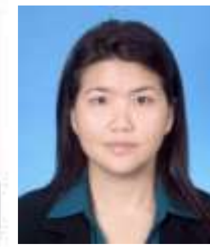
System/Protocol Design

Ph.D.
林浩民

Visible Light Communications

Master
游舜翔

Postdoc
Dr. 張世豪



Visiting Scholar
Dr. Nawaporn Wisitpongphan

Vehicle Mobility Model

Senior
石浩安

Senior
許永健

Master
龍晶

Senior
歐志先

RF Link Measurement

Master
邱柏睿

Vehicle Behavior Model System Prototyping

Senior
李蕙宇

Master
黃光世