UNIVERSITÀ
DEGLI STUDI
DI PADOVA

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Game Theoretic Analysis of Road User Safety Scenarios Involving Autonomous Vehicles

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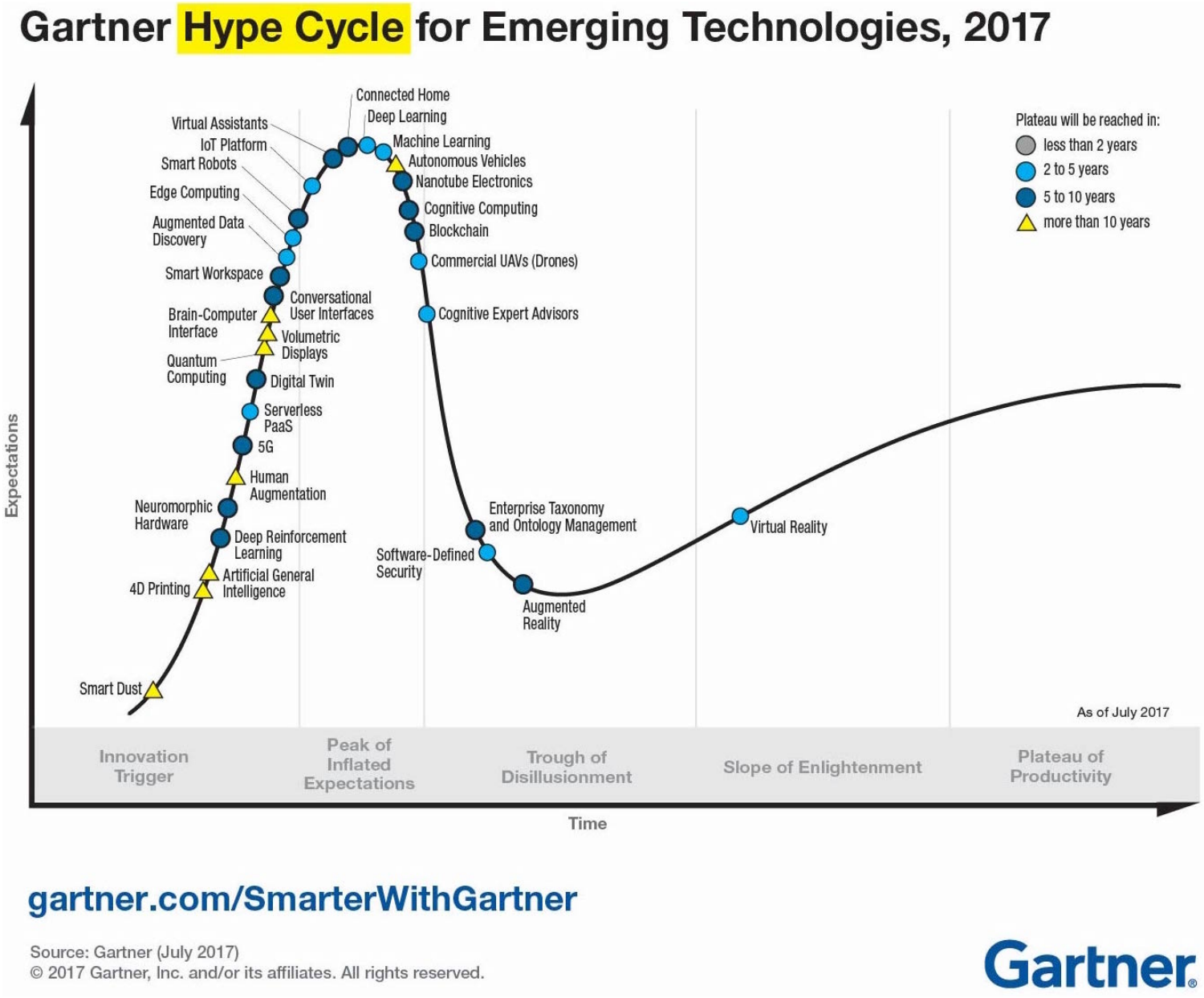
Rise of Autonomous Vehicles (AVs)



gartner.com/SmarterWithGartner

Source: Gartner (July 2017)

Gartner

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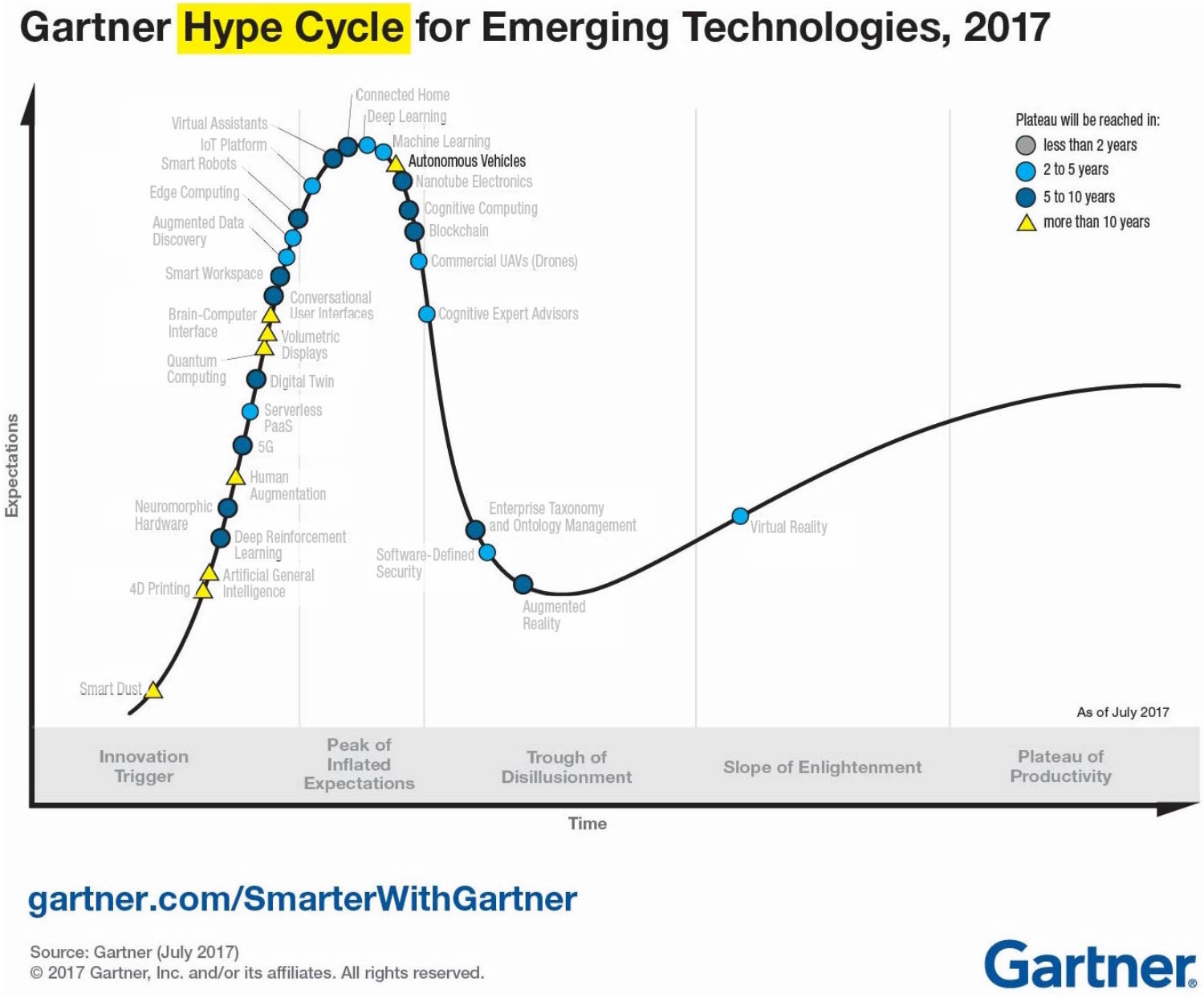

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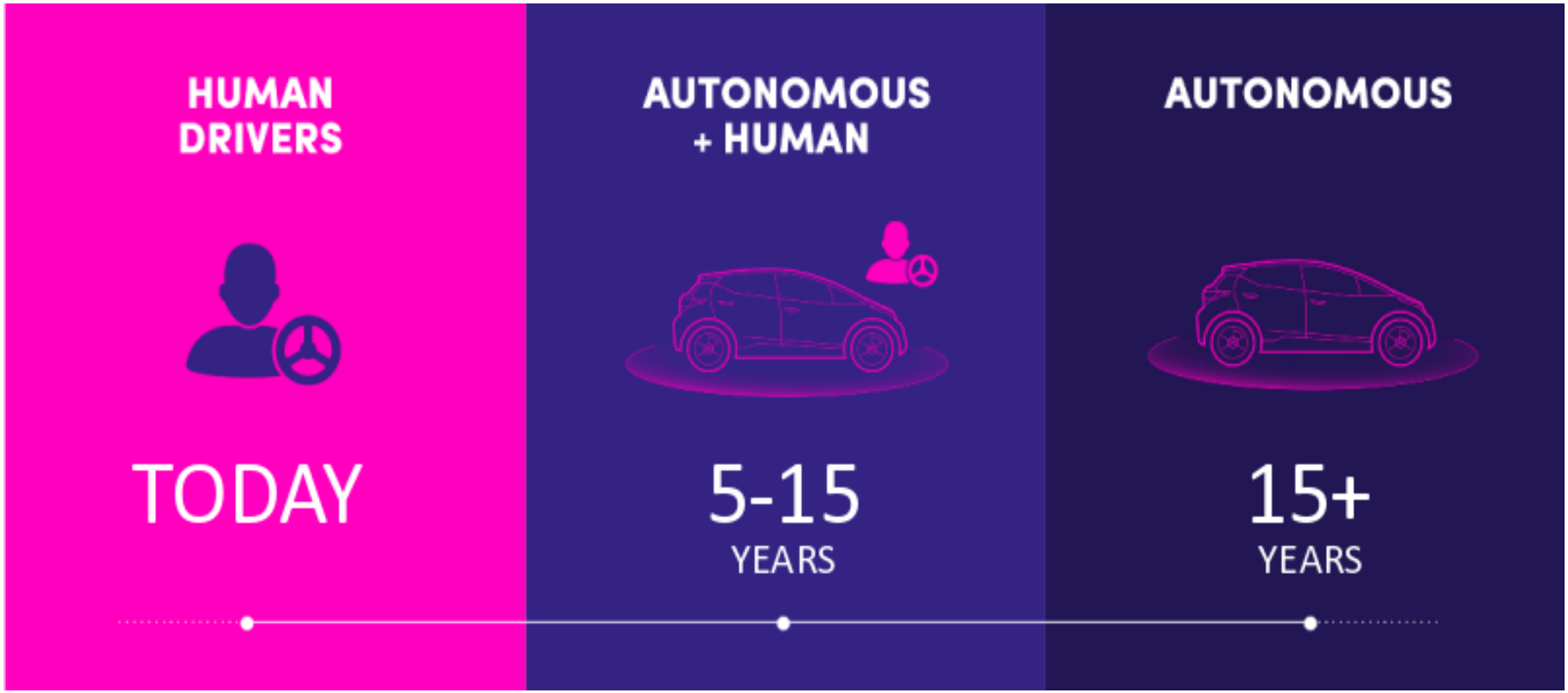
Transition to AVs



Smooth transition

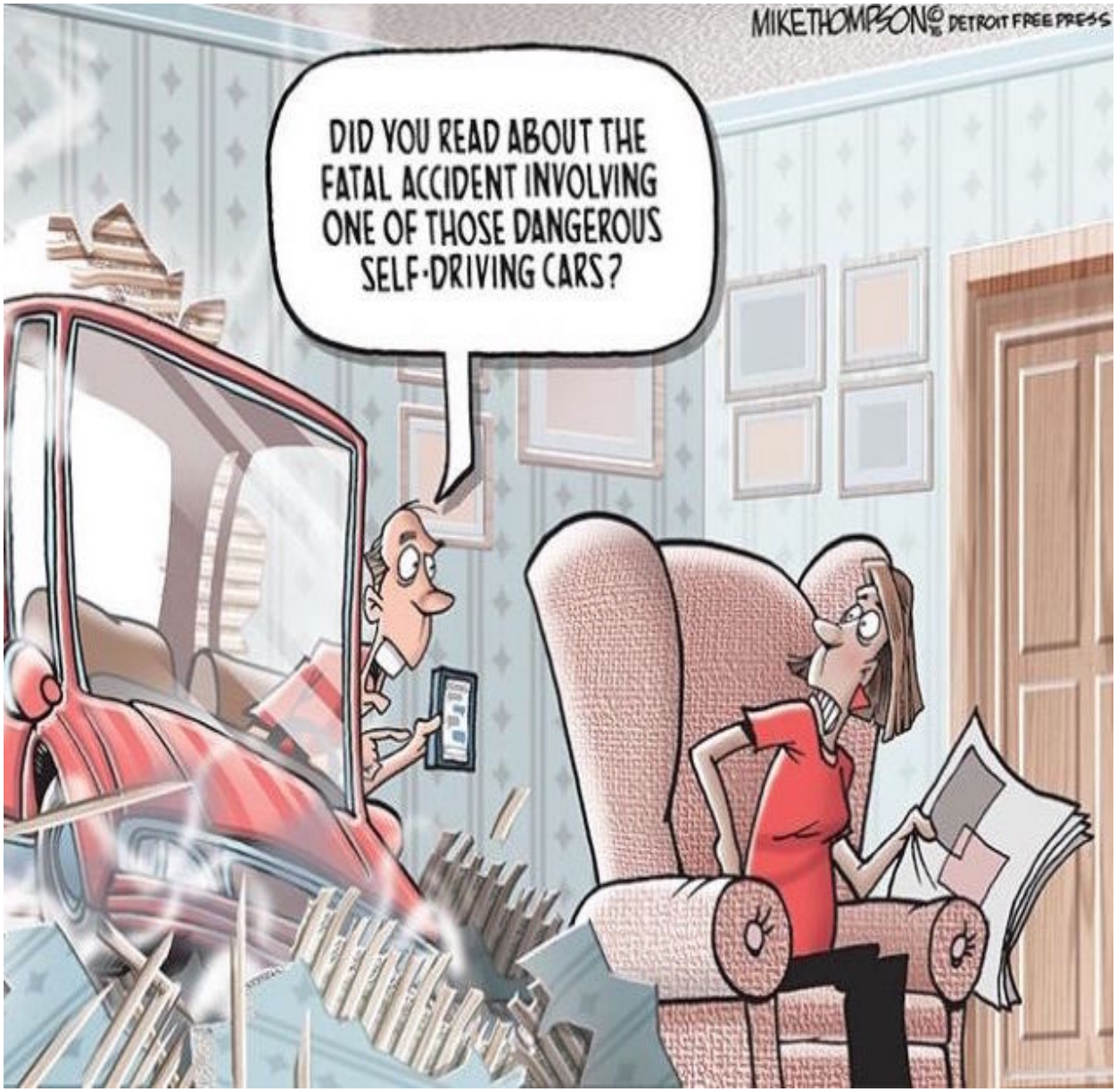
Need to overcome many conflicts

PRO

1. Accidents ↓
2. Less stressful time
3. Less road congestion
4. Decreased emissions
5. Eventually faster than human-drivers

CONS

1. Social acceptance



CONS

1. Social acceptance

2. Technological issues
   - snow/rain
   - yellow-lights
   - partial occlusion

MOORE'S LAW

3. Interactions w/ humans
   - road regulations
   - AVs are cautious

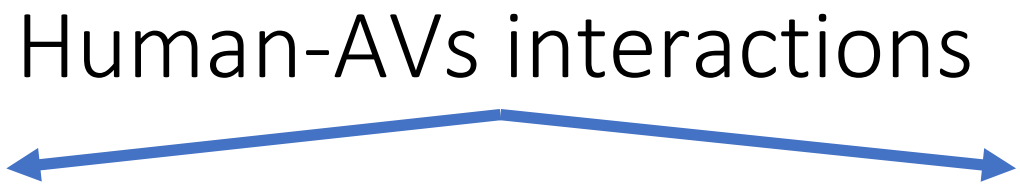
RISK AVERSE

Our Approach

Expected Conclusions:

- Game Theory extensions
- Accidents ↓ as share of AVs ↑
- Need for new traffic regulations
- Need for communication systems

Modeling



- *Players* have different *utilities*
- Distinguishable *set of actions*
- Statistical generality

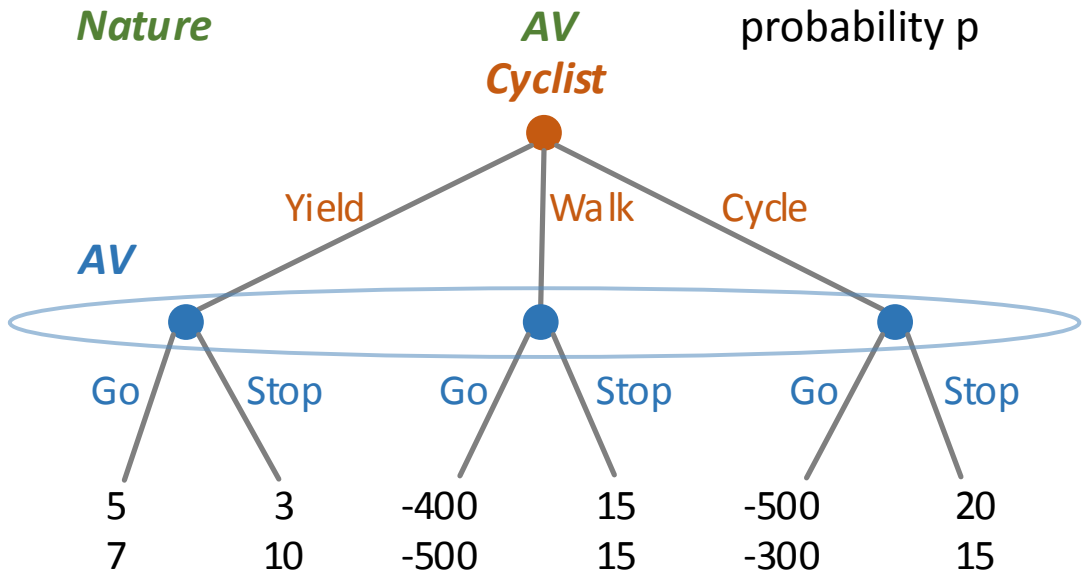
Proposed models: 1. Cyclist vs. Vehicle on Zebra Crossing

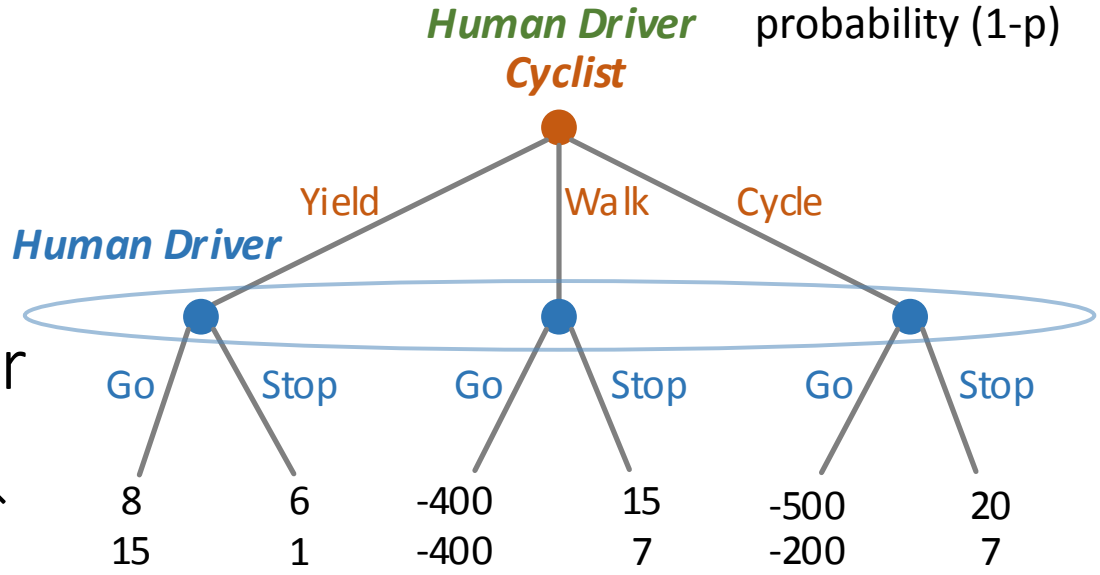
2. Pedestrian vs. Vehicle

1. Cyclist vs. Vehicle on Zebra Crossing

→ SIMULTANEOUS BAYESIAN GAME

COMMON KNOWLEDGE & FULL RATIONALITY





AIMS:

Cyclist vs. AV or human driver

Accident rate curve as AVs ↑

1. Cyclist vs. Vehicle on Zebra Crossing

TWO PURE NEs

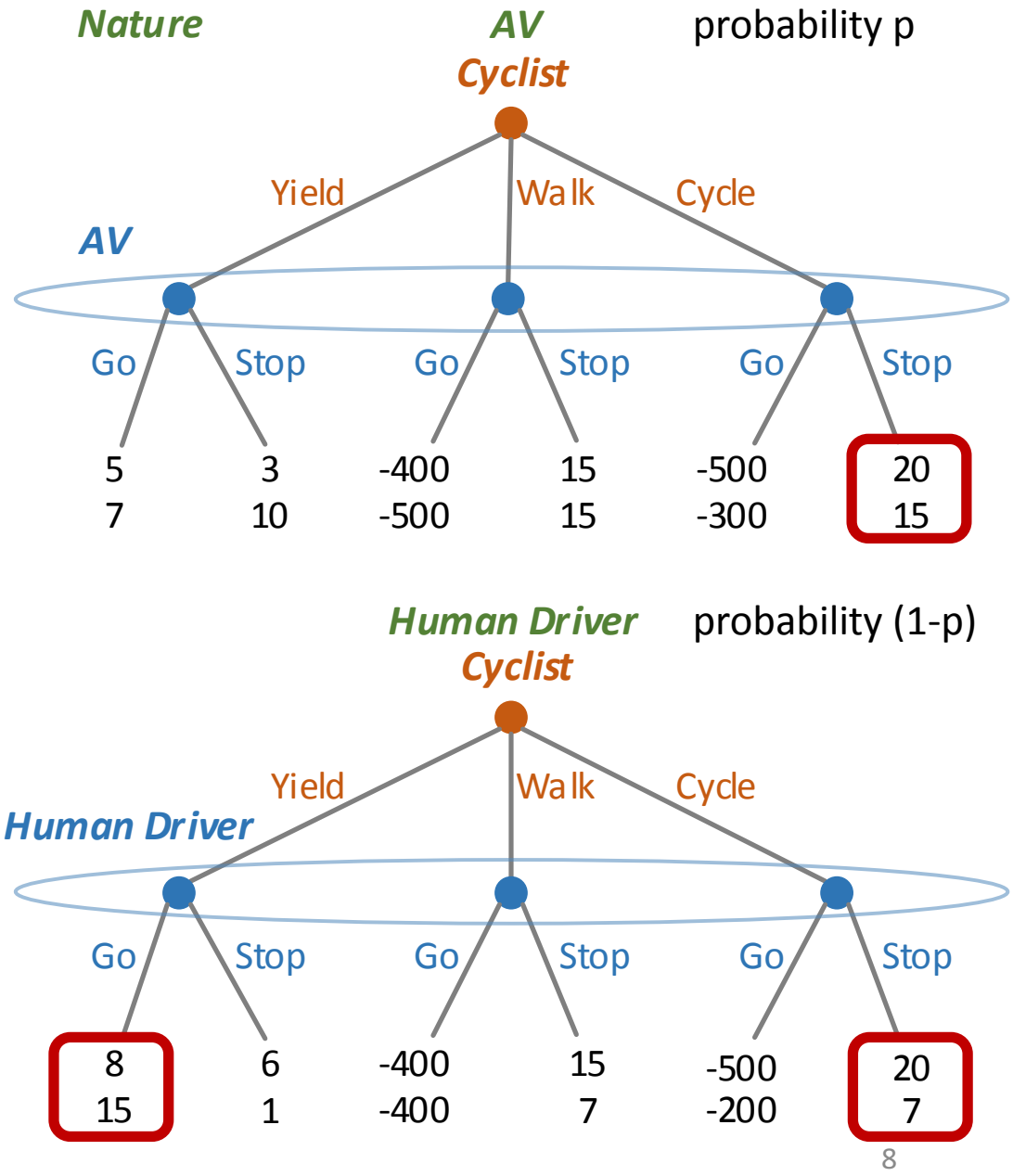
1. (CY, SG)
2. (CC, SS)

ONE MIXED NE

If AV: (C,S)

If human: yield (p_1) or cycle ($1-p_1$), go (p_2) or stop ($1-p_2$)

p1=93.7% p2=2.7%



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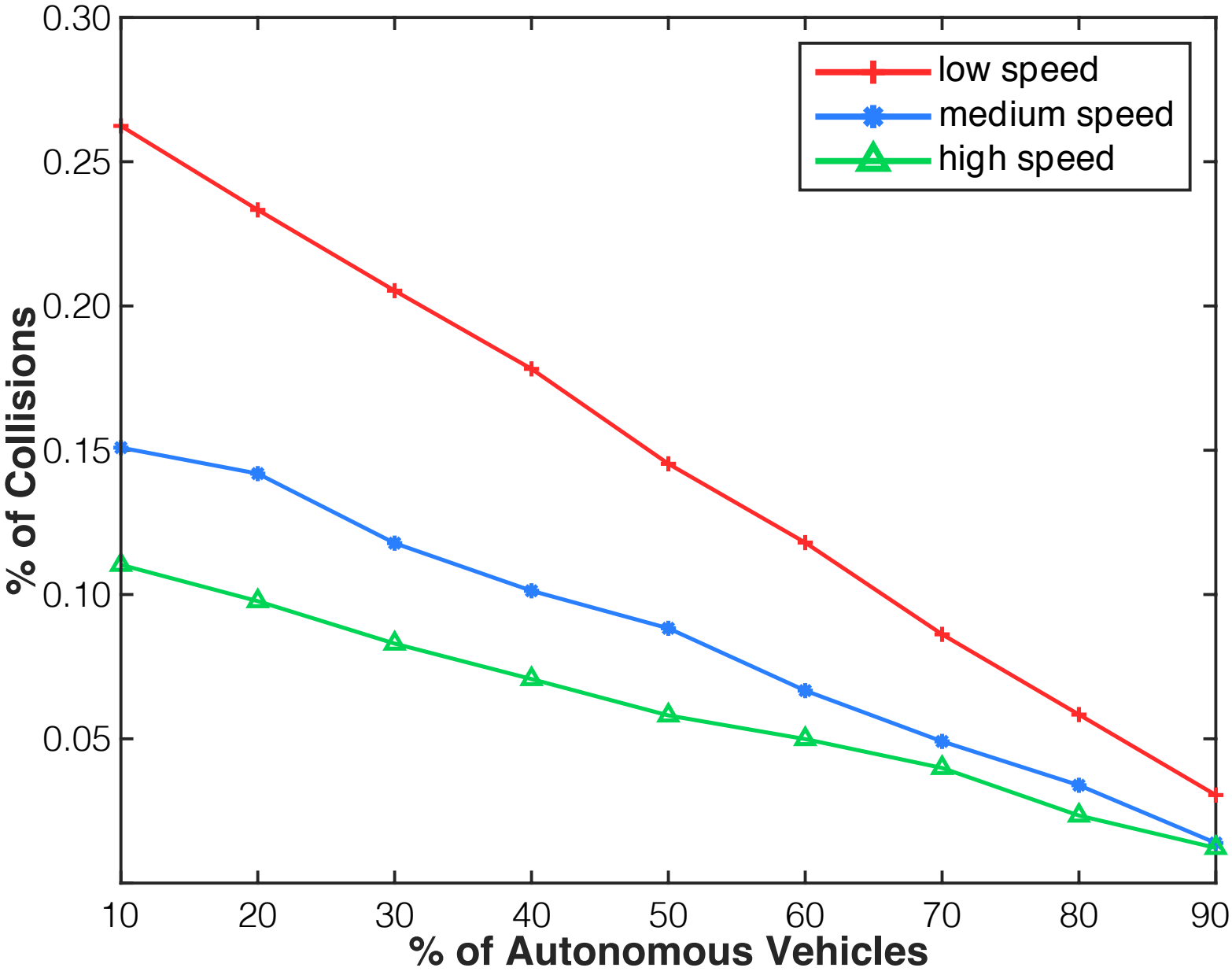

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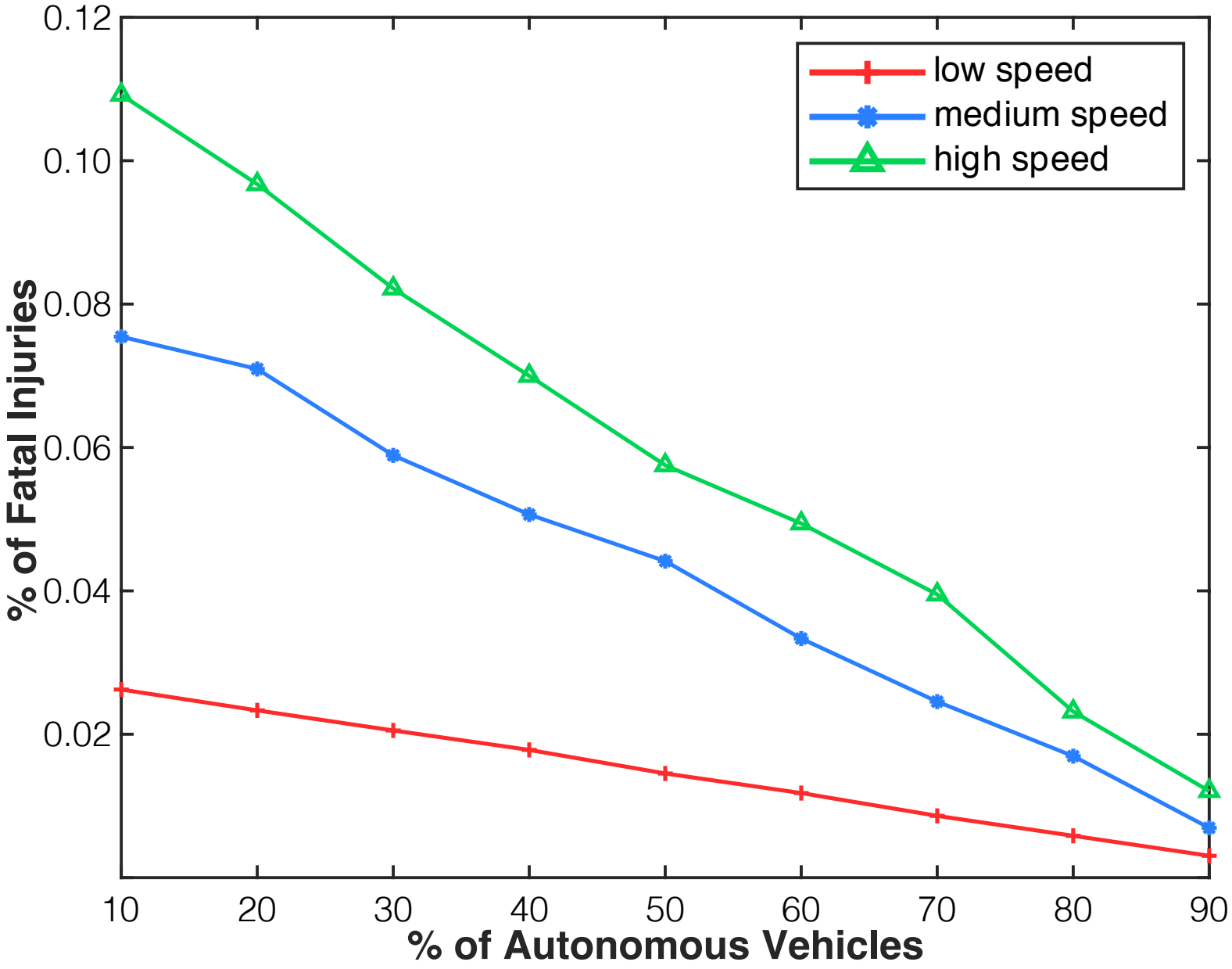
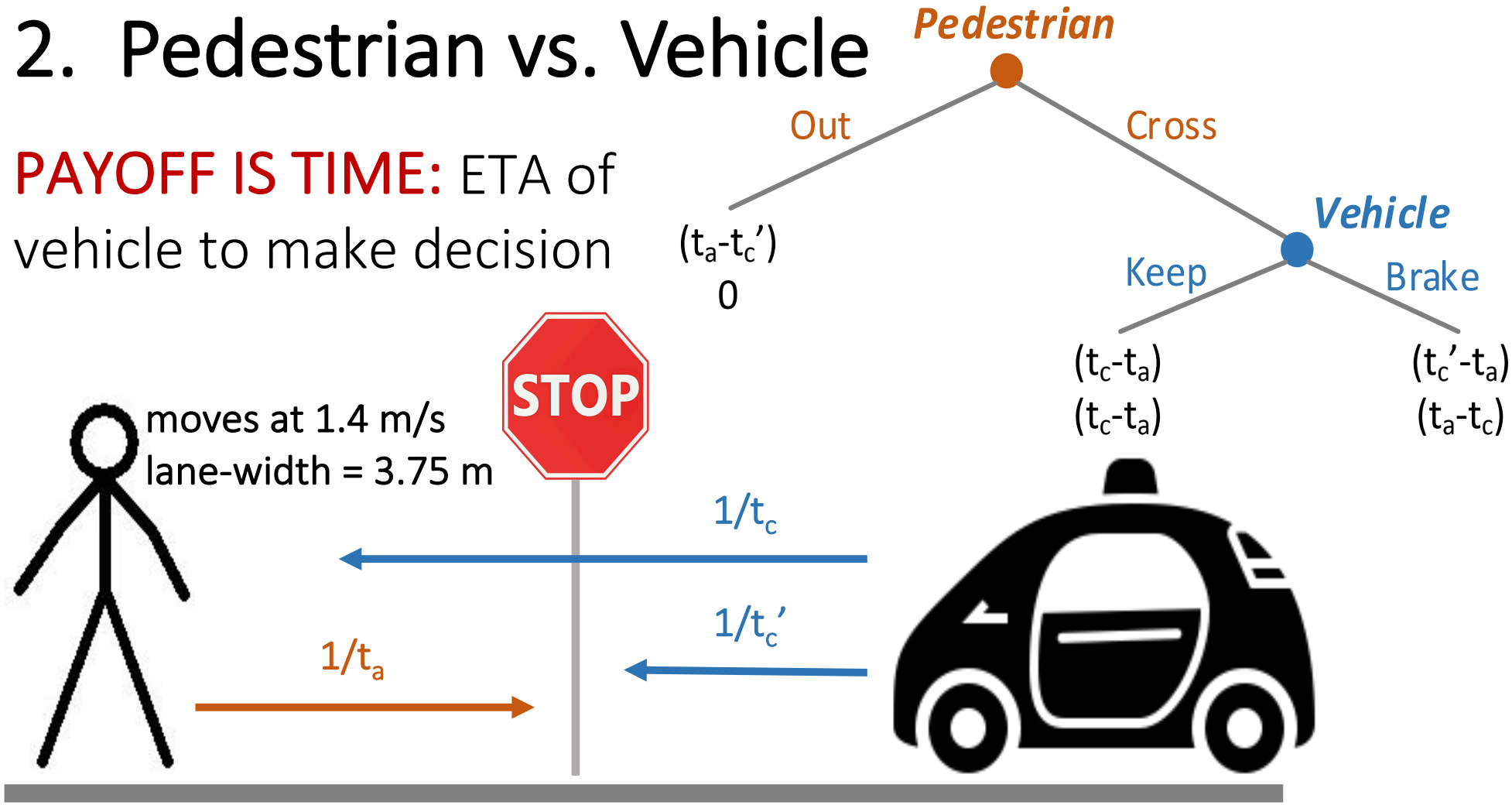


2. Pedestrian vs. Vehicle

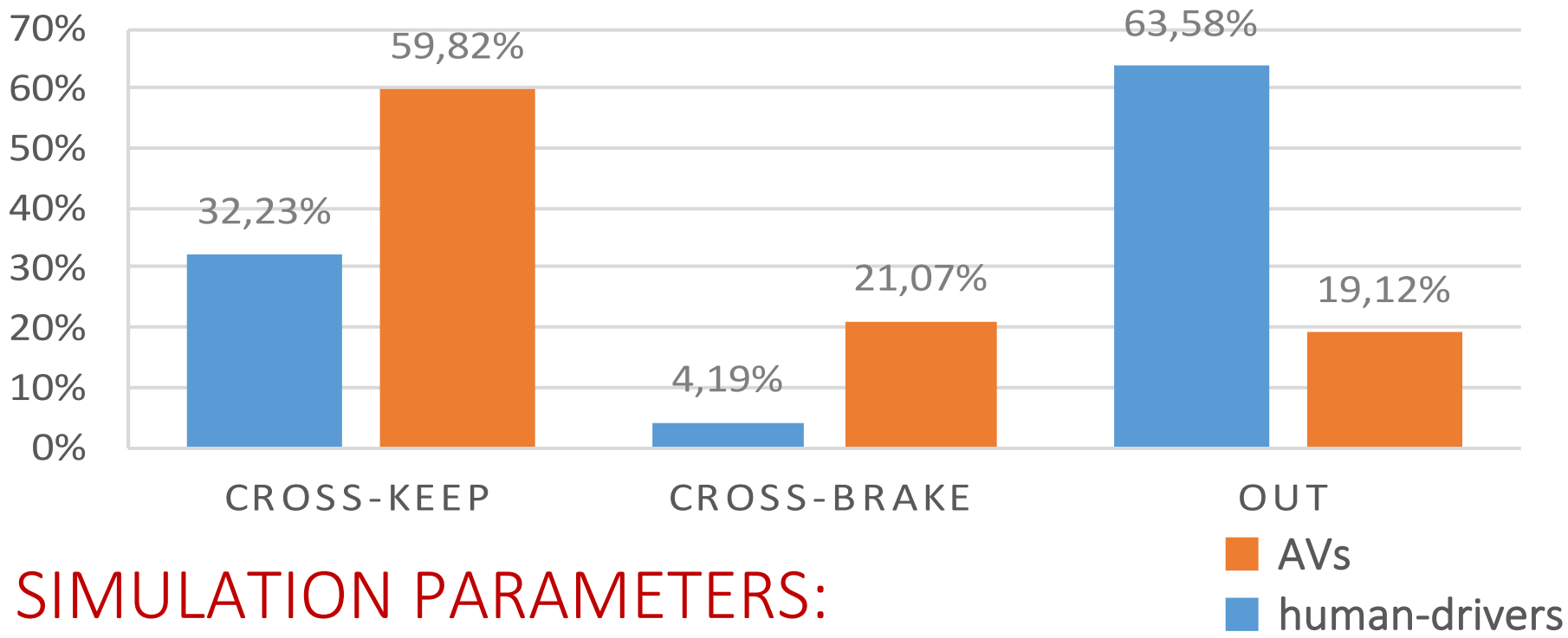
PAYOFF IS TIME: ETA of vehicle to make decision



NE shifts:

$t_a < t_c$	$t_c < t_a < t_c'$	$t_a > t_c'$
CK	CB	O

2. Pedestrian vs. Vehicle



SIMULATION PARAMETERS:

v ~ max($\mathcal{N}$(30,10), 0) km/h

a = 2.5 m/s

d ~ $\mathcal{U}$(10,50) m

reaction time t_r = 1.5 s → t_c' higher than AVs

v ~ max($\mathcal{N}$(50,10), 0) km/h

} AVs

} human drivers

Conclusions → Future Work

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- Game theory useful for human-AV interactions

  → improve realism

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- Models are lightweight

  → embedding into communication systems and traffic simulators

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- Game theory useful for human-AV interactions

  → improve realism

- Models are lightweight

  → embedding into communication systems and traffic simulators

- Accident rate ↓, dominance of pedestrians

  → new regulations needed, then new game analysis

Thank you for the attention!

Questions?