DATA-DRIVEN MODELS OF HUMAN BEHAVIOR IN TRANSPORTATION SYSTEMS

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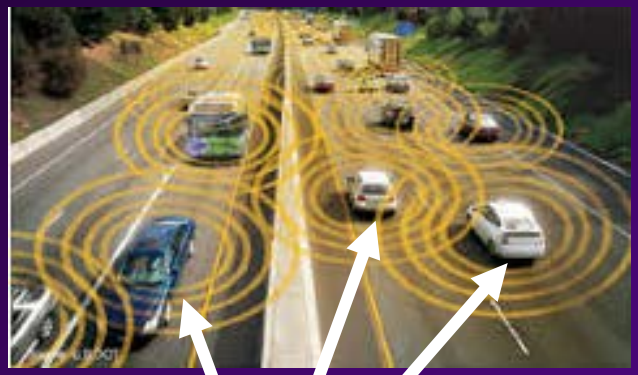
GAME-CHANGING OPPORTUNITY:
CONNECTED AUTONOMOUS VEHICLES (CAVs)



CAVs

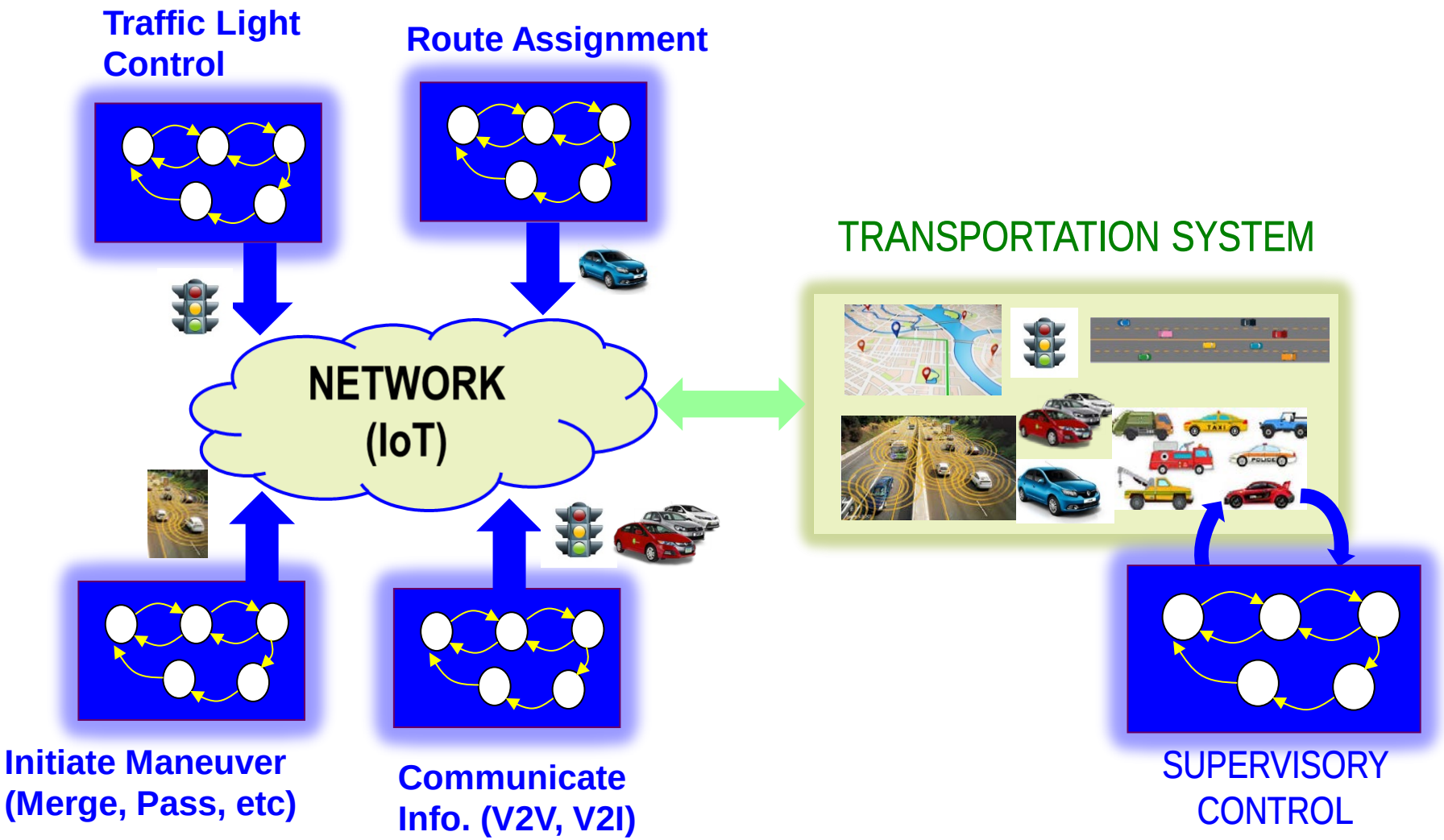
FROM (SELFISH) "DRIVER OPTIMAL"
TO (SOCIAL) "SYSTEM OPTIMAL"
TRAFFIC CONTROL

ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS)

NO TRAFFIC LIGHTS, NEVER STOP…

THE "INTERNET OF CARS"

AUTOMATING DRIVER DECISIONS



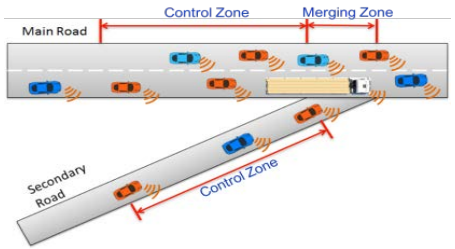
AUTOMATING DRIVER DECISIONS

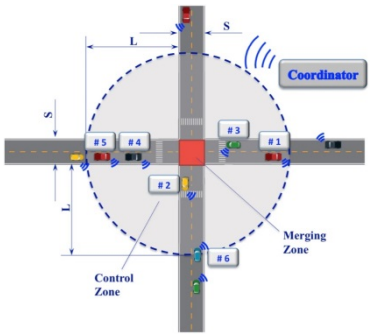
TRANSPORTATION SYSTEM

Learn driver behavior

...and take into account in controllers

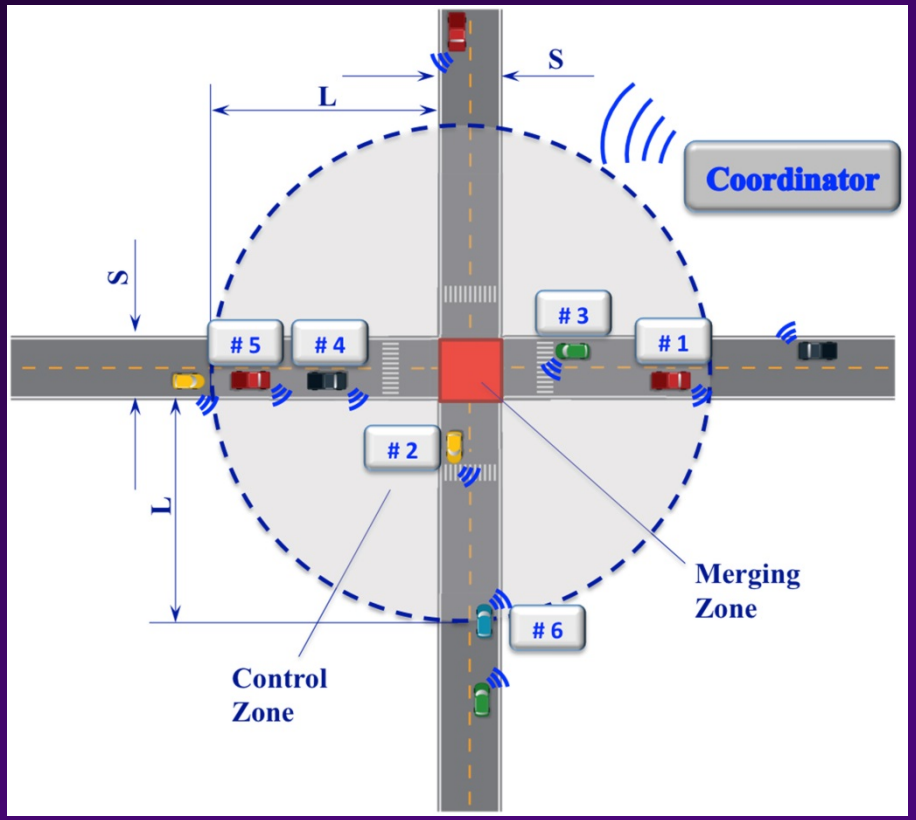
Initiate Maneuver (Merge, Pass, etc)





EXAMPLE:
OPTIMAL CONTROL OF CAVs AT SIGNAL-FREE INTERSECTIONS

THE MODEL



CAV dynamics:

$$\dot{p}_i = v_i(t)$$
$$\dot{v}_i = u_i(t)$$
$$t \in [t_i^0, t_i^f]$$

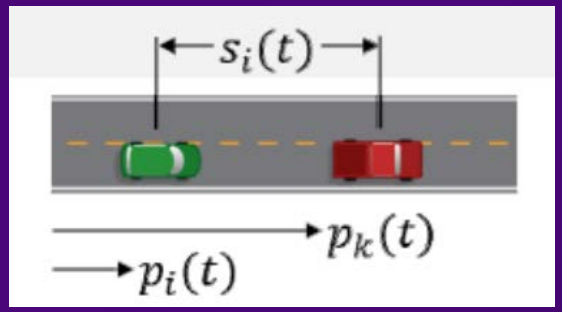
Speed, Acceleration constraints:

$$u_{\min} \le u_i(t) \le u_{\max}$$
$$0 \le v_{\min} \le v_i(t) \le v_{\max}$$

SAFETY CONSTRAINTS

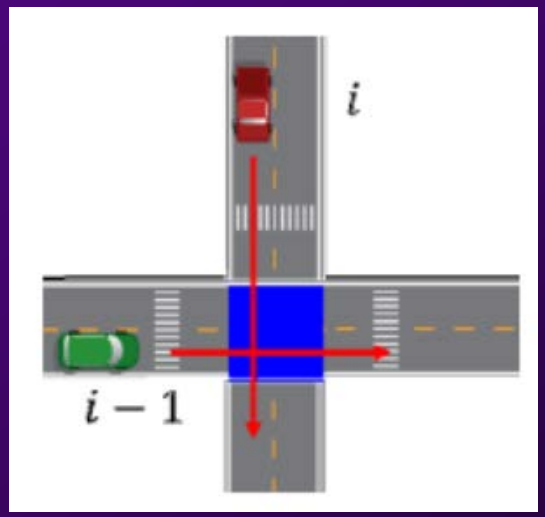
- Rear end safety constraint:

$$s_i(t) = p_k(t) - p_i(t) \geq \delta, \quad t \in [t_i^0, t_i^f]$$



- Lateral collision avoidance constraint:

$$\Gamma_i = \{t : t \in [t_i^m, t_i^f]\}$$
$$\Gamma_i \cap \Gamma_j = \varnothing, \; t \in [t_i^m, t_i^f], \quad j \in C_i(t)$$



TYPICAL OPTIMIZATION PROBLEM

Minimize ENERGY

Minimize TIME

Maximize COMFORT

$$\min_{u_i(t)} J_i(u_i(t)) = \frac{C_E}{2}\int_{t_i^0}^{t_i^f} u_i^2(t)dt + \frac{C_T}{2}(t_i^f - t_i^0)^2 + \frac{C_{comfort}}{2}\int_{t_i^0}^{t_i^f} \dot{u}_i^2(t)dt$$

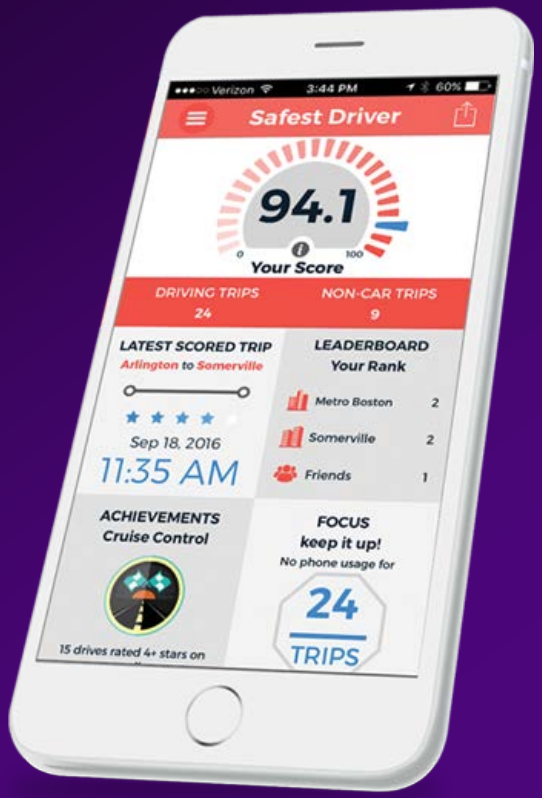
subject to :

1. Vehicle dynamics
2. Speed/Acceleration constraints
3. Collision and Safety constraints

Adapt control (acceleration, speed) to match driver behavior, “comfort”

LEARNING DRIVER BEHAVIOR FROM DATA

"SAFEST DRIVER IN BOSTON" APP



CAMBRIDGE MOBILE TELEMATICS

DRIVING FEATURES:

- Speeding
- Harsh acceleration
- Harsh deceleration (breaking)
- Harsh cornering/turning
- Distraction

  (phone shows data activity)

LEARNING DRIVER BEHAVIOR FROM DATA