Densité de Trafic Emergente pour des Véhicules Intelligents Communiquants Guidés par Heuristique

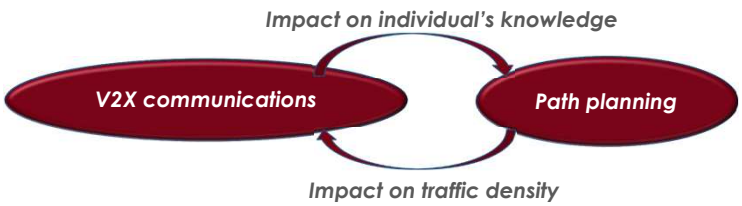
Density of Emergent Traffic of Heuristically-Driven Intelligent and Communicating Vehicles

Philippe Morignot
Oyunchimeg Shagdar
Fawzi Nashashibi

Research motivation

--- Path planning of Intelligent vehicles in urban roads ---

- V2X communication
  - Research on the domain of wireless communications
  - Limited study about the impact of communication on the traffic behavior
- Path planning
  - Research on the domains of AI, robotics
  - Assumption of perfect communication



Research Objective

Studying the collective behavior of vehicles, which individually plan their path based on V2V information exchange.

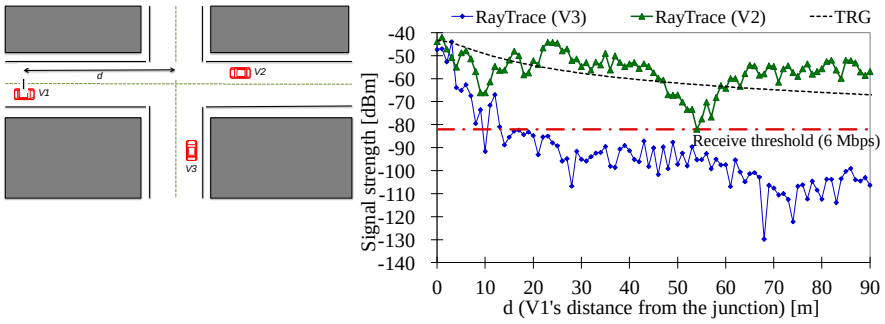
Intelligent vehicle: Finite state automaton

1. Initial state:
   Randomly assigned position and goal (destination)
2. If the vehicle is on a straight road
   accelerate (**speed limit**) or decelerate (**collision avoidance, or red traffic light**).
3. If the vehicle reaches an intersection
   choose the exit (N/E/S/W) of the intersection based on information obtained from the **V2V communication** and **the path-planning heuristics.**
4. If the vehicle reaches its goal location, randomly assign a new goal.

V2V Communications -- Channel model--

- Two-ray ground ground reflection model (TRG)

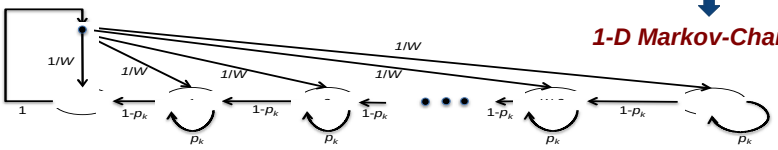
$$Ltrg[dB] = \begin{cases} Lfs = 20\log_{10}\left(4\pi\frac{d}{\lambda}\right), d \le d \\ Lfs = 20\log_{10}\left(4\pi\frac{d^2}{h_t h_r}\right), otherwise \end{cases}$$



- TRG can be used for signal estimation for vehicles on the same road
- It is difficult to expect communications between vehicles on crossing roads

V2V Communications – MAC Model --

- IEEE 802.11p MAC: same as IEEE 802.11e
  - Prioritized channel access for different access categories
- Transmission of CAMs
  - A single AC
  - Broadcast: no retransmission



1-D Markov-Chain

Channel access probability (saturated channel)

$$\tau_s = b(0) = \left[1 + \frac{W-1}{2(1-p_k)}\right]^{-1}$$

Channel access probability

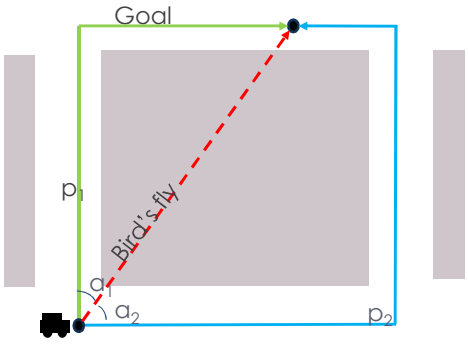
$$\tau = \left(1 - \exp\left(-\lambda Y_s\right)\right) \times \tau_s$$

Comm. success probability

$$P_s = \left(1-\tau\right)^{N-1}$$

Path-planning heuristics

- Compass: Take **the shortest path** to the goal without considering vehicle density
- Ant: Take the **more popular road**, which leads to the goal.
- No-ant: Take **the less congested road,** which leads to the goal.

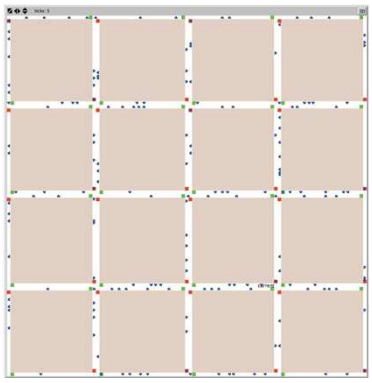


$a_1 < a_2$

Compass : a_1		(p_1 *is always chosen*)
Ant	: max(#Cars(a_1), #Cars(a_2))	(p_1 *or* p_2)
No-Ant	: min(#Cars(a_1), #Cars(a_2))	(p_1 *or* p_2)

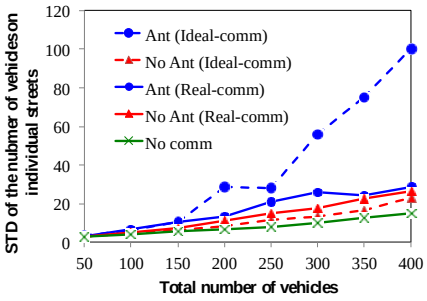
Experiments: NetLogo multi-agent simulator

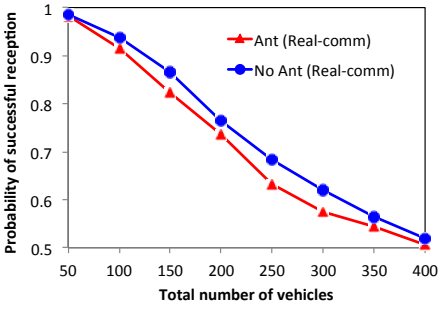
- Scenario: Manhattan streets, traffic lights, traffic regulations, up to 400 vehicles



- Communications:
  - **No communications**.
  - **Ideal communications**: no communications error
  - **Realistic communications**: message delivery probability for a given transmitted CAM is calculated based on propagation/MAC models
- Path planning
  - **Compass**: No communications
  - **Ant**: with/without communication
  - **No-Ant**: with/without communications

Communications impact

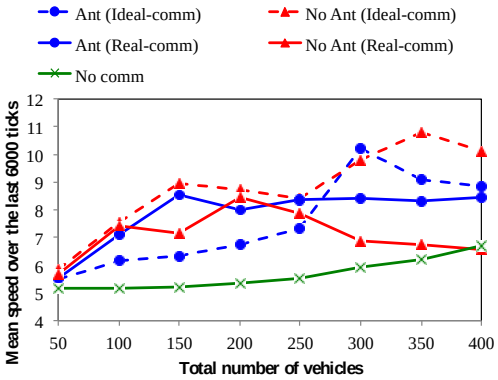




Conclusion

- Ant/No-ant strategies show their expected behavior when comm. is ideal
- And/no-ant strategies fail to show their expected behavior when comm. is realistic.
- Communications failure → Strategy failure

Emergent behaviors



Conclusion

- Communications has a great impact on the collective behavior
- Ideal communications: No-ant behavior provides faster velocity (better to have an information)
- Realistic communications: the difference between ant and no-ant behaviors is small

Thank you!

Oyunchimeg SHAGDAR
oyunchimeg.shagdar@inria.fr

Path-planning for Intelligent Vehicles

- Grid-based with a search algorithm (e.g., A*).
  - The finer the grid, the longer the search.
- Potential fields : attracted to goal, repulsed from obstacles.
  - Might be trapped in local minima.
- Paving-based search. Generate 2 sub-pavings such that $X^- \subset C_{free} \subset X^+$
- Sampling algorithms : sample N configurations and retain those in C_{free}. If there is a path between 2 samples, retain it ; otherwise, re-sample.
  - Works well for high dimensional problems.