

VANET via Named Data Networking

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Name Oriented Mobility, 2014

V-NDN: VANET via Named Data Networking

- We designed and implemented a prototype of Name Data Networking
- V-NDN utilizes the strengths of the NDN paradigm and extend the model to adapt to VANET scenario

Outline

1 Introduction

- VANET
- NDN

2 V-NDN

- Why NDN
- Realization

3 Experiments

- Experiments on the field
- Simulations

4 Conclusions

- Future work

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- Vehicular networking is an area of significant importance in the connected and mobile world where we live
- Vehicles are everywhere, they have a penetration rate of about 70% in most developed countries
- Cars manufacturers are starting to equip vehicles with network interfaces such as WiFi, 3G ...

Car are the ideal candidates to become nodes of a pervasive wireless mobile network

- Consumer
- Producer
- Forwarder

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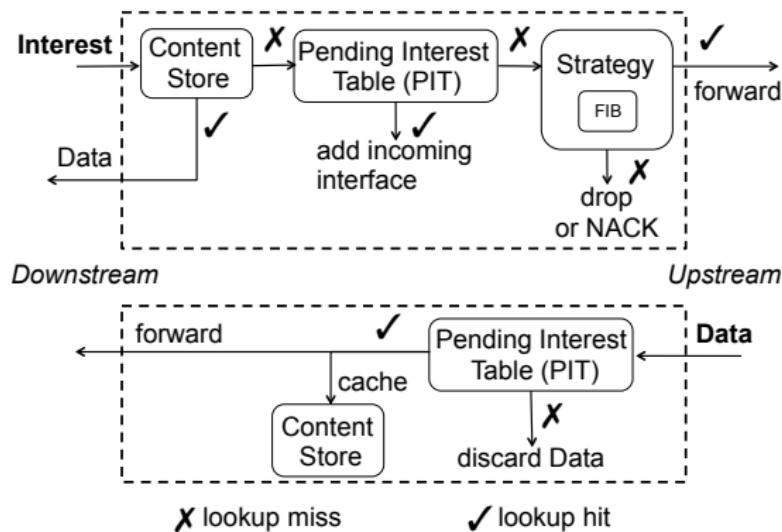
NDN - the best fit for VANET

NDN puts **contents** at the center of its communication model

- IP is host centric: it has difficulties coping with mobility and multihoming
- Naming data decouples communication from specific interfaces and endpoints.
- NDN naturally supports multihoming and mobility.
- Each application names the data it wants to fetch or provide
- The network directly uses these names to process the packets

NDN - the best fit for VANET

- The network directly uses these names to process the packets
 - Interest goes through CS, PIT and FIB
 - Content follows the Interest breadcrumbs left in the PIT



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VANET nowadays

- We should be able to fully utilize all the network interfaces a car will be equipped with
- IP based approaches don't facilitate multihoming and mobility
 - IP puts addresses and hosts at the center of its communication model
 - The communication is tied to the network interface, to its IP address

NDN - the best fit for VANET

NDN puts **contents** at the center of its communication model

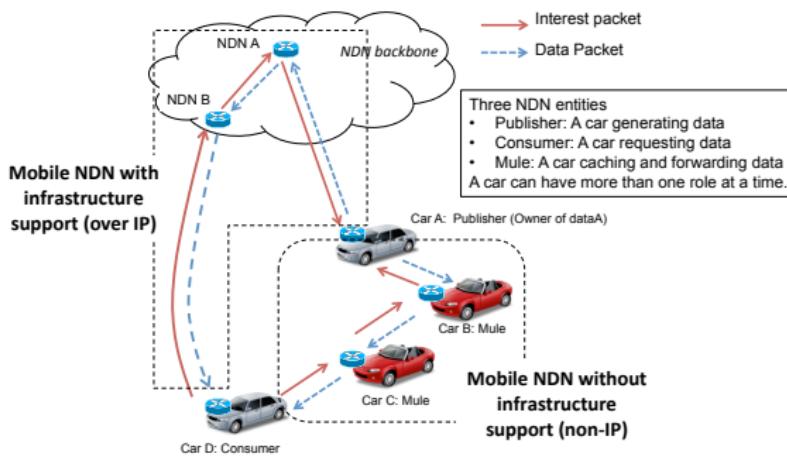
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- Each application names the data it wants to fetch or provide
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 - Interest goes through CS, PIT and FIB
 - Content follows the Interest breadcrumbs left in the PIT
- NDN naturally supports multihoming and mobility.

Cars roles in V-NDN

In V-NDN cars can play all the 4 roles in NDN architecture:

- **Consumer** of traffic status information, music entertainment ...
- **Producer** of data provided by sensors car for accident alerts ...
- **Forwarder**: A car actively participates to the communication forwarding packets

- **Mule**: storing received contents in the CS, a car can move them from a place to another even while it doesn't have any connectivity



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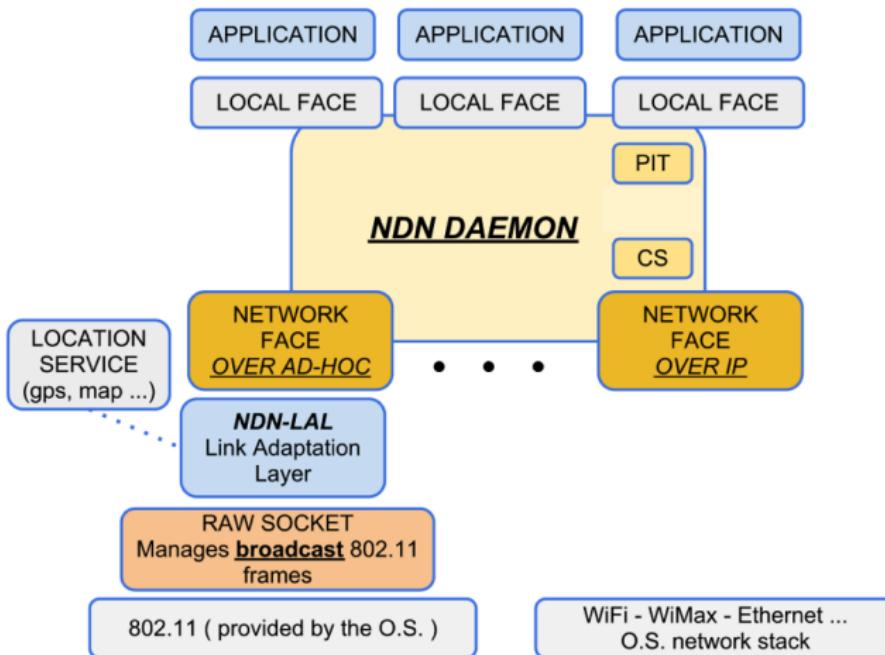
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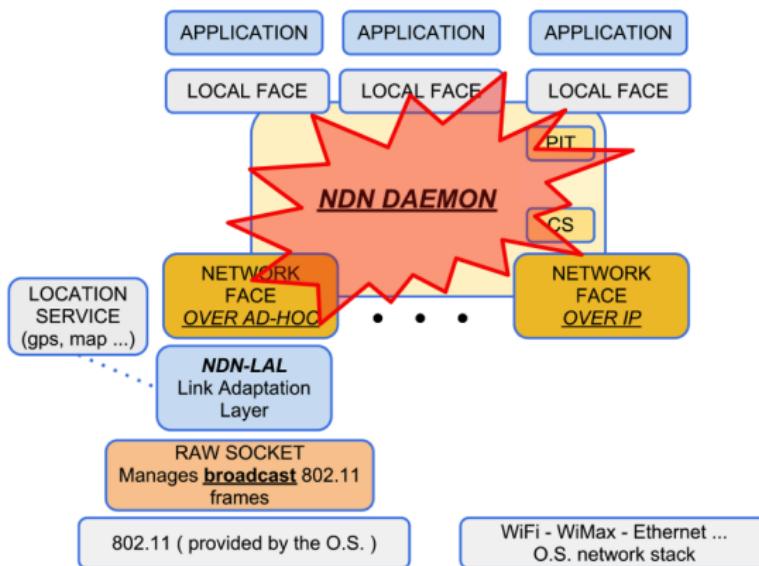
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V-NDN: Realization



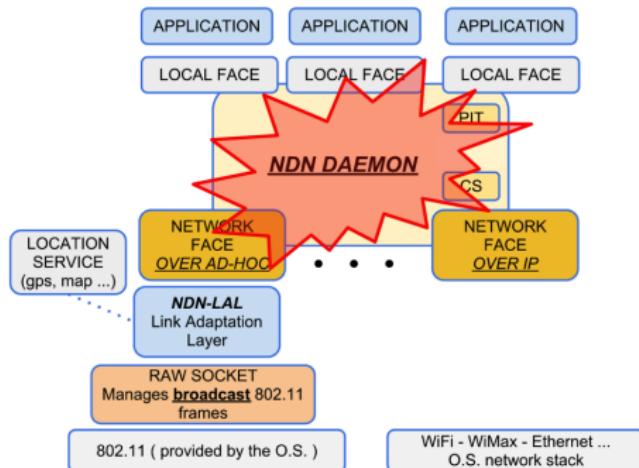
Realization - NDN Daemon

It provides the core NDN capabilities by maintaining the key data structures of CS and PIT and taking care of name prefix-matching and packet forwarding decisions.



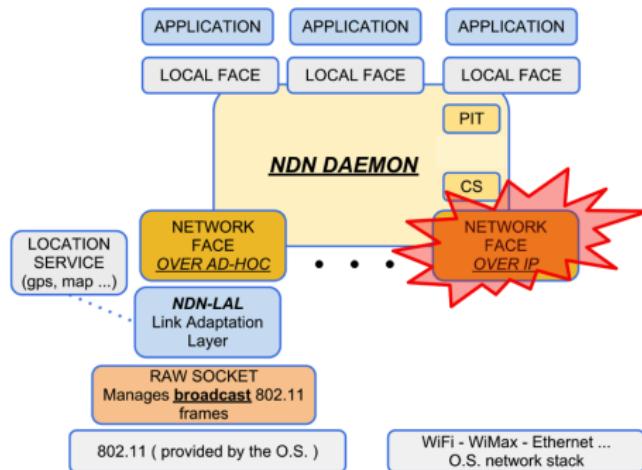
Realization - Forwarding Interests

Controlled flooding: The V-NDN Daemon takes a simple approach of forwarding each Interest to all the interfaces that are available at the time



Realization - Network Faces

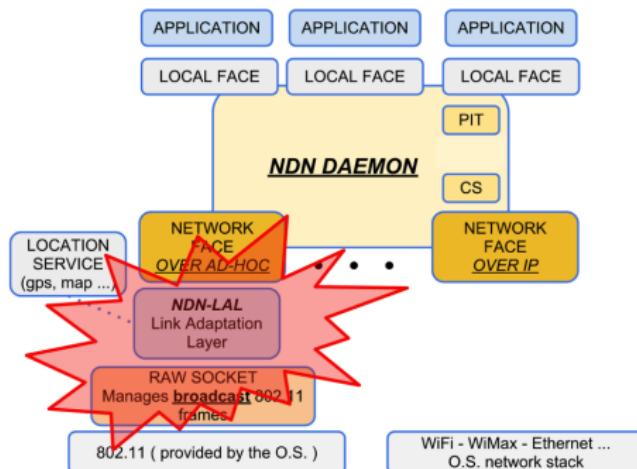
- **V2I communication:** the face uses IP connectivity to reach NDN nodes in the core network
- **V2V communication:** a 2.5 layer has been designed, the Link Adaptation Layer



Realization - Link Adaptation Layer

Link Adaptation Layer as 2.5 layer

- The LAL is designed specifically for 802.11 broadcast communication.
- It provides reliability services (retransmission, acknowledgment) not supported by 802.11 (broadcast)



V2V communications

- When you are looking for something, all your neighbors can help
- "One to one" communications limit your chances in finding the information you want.
- Broadcast communication, instead, allows all the cars around you to collaborate

V-NDN takes full advantage from the broadcast nature of the wireless channel, by directly communicate using 802.11 broadcast frame

- 802.11 broadcast communication has a limit: the communication is more **vulnerable**
 - lack of collision detection/avoidance mechanism, retransmission, acknowledgment, RTS/CTS

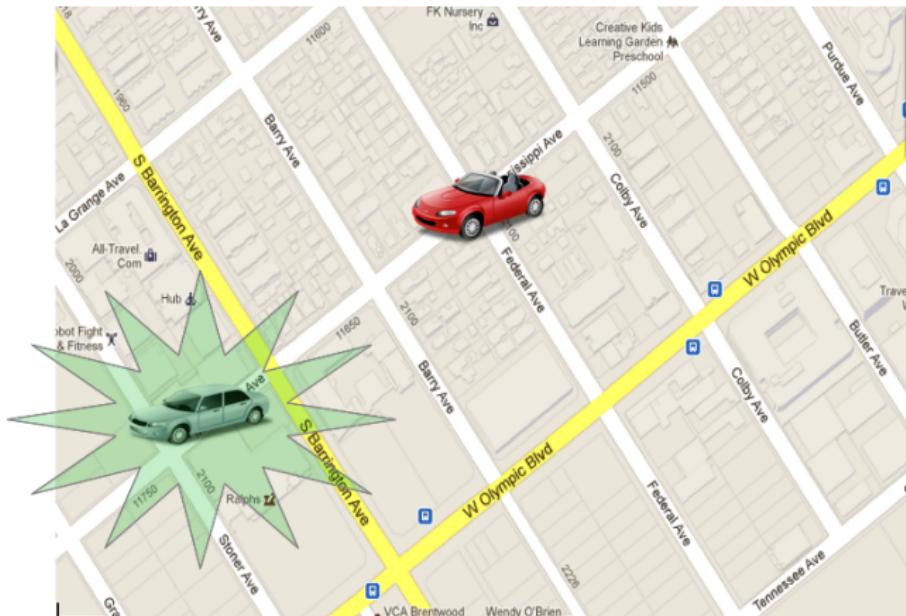
Implicit acknowledgement

The Link Adaptation Layer introduces an acknowledgement - retransmission process

- When a car forwards a packet, transmission of the same packet by neighbors are considered as implicit acknowledgment
- Implicit acknowledgments from each of the streets stemming from where the car is located acknowledge the packet
- Packet not acknowledged will be retransmitted
- After “n” unsuccessful attempts, the packet is dropped

LAL: broadcast support

The red car receives a packet from the grey car



LAL: broadcast support

The red car forwards the packet



LAL: broadcast support

The red car will wait for an implicit ack for each of the streets stemming from where the car is located, except the street where the grey car is situated



LAL: broadcast support

The red car overhears the retransmission from another car: it's the first implicit acknowledgment



LAL: broadcast support

The red car overhears the retransmission from another car: it's the second implicit acknowledgment



LAL: broadcast support

The retransmission timer is expired and the packet has not been acknowledged yet. The red car will retransmit



LAL: broadcast support

The red car overhears the retransmission from the last street stem: the packet has been acknowledged



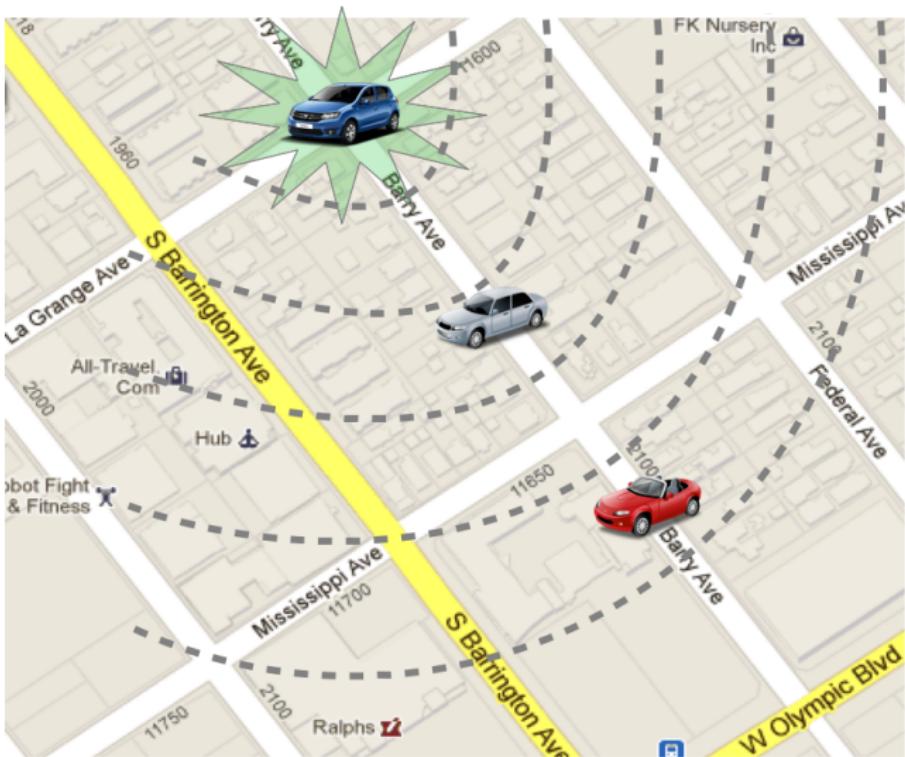
LAL: avoiding the broadcast storm

If everybody talk, nobody hears

- If all the cars forward the same packet at the same time, the communication will stop
- Solution: prioritize the transmission based on the position of the cars, on the distance among the cars and the previous hop
- Cars farther from the previous hop will forward the packet first

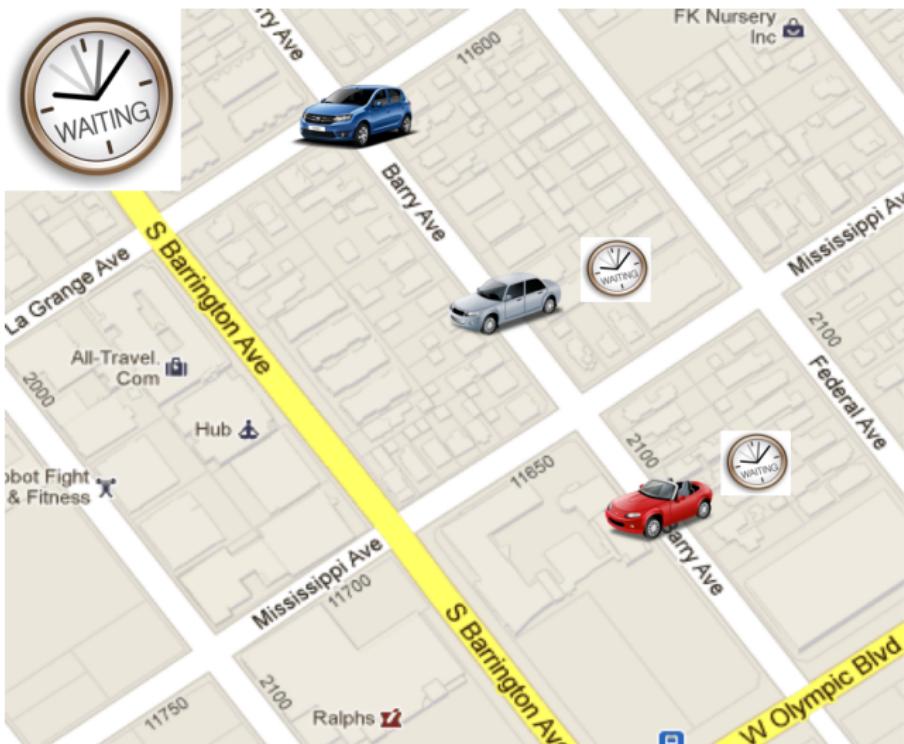
LAL: avoiding the broadcast storm

Two cars (red and grey) receive the same packet



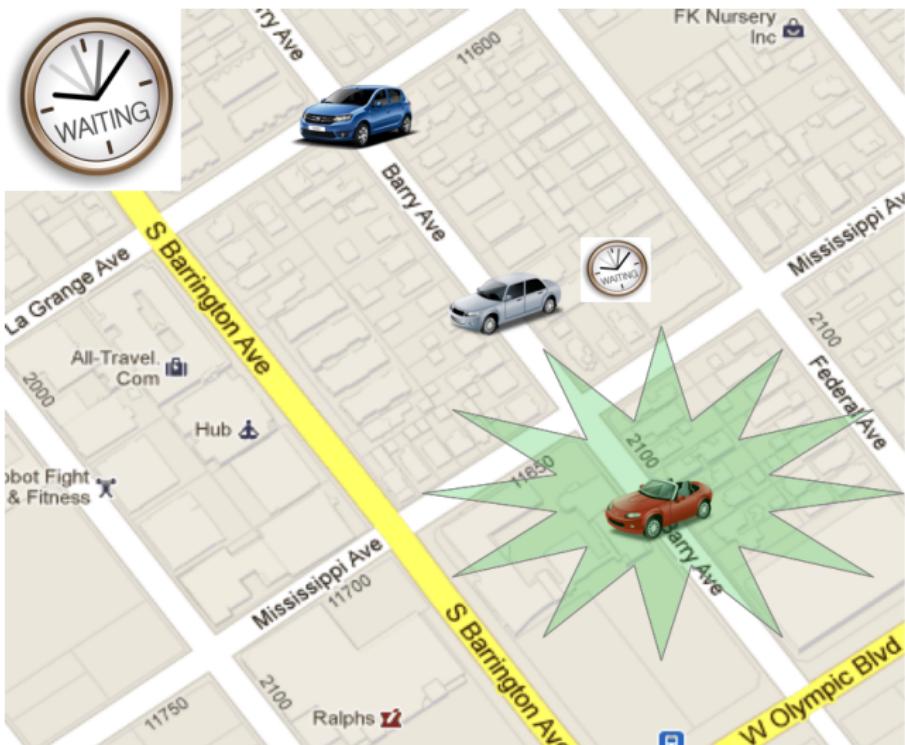
LAL: avoiding the broadcast storm

Both cars will calculate the Waiting Timer based on the distance among them and the previous hop



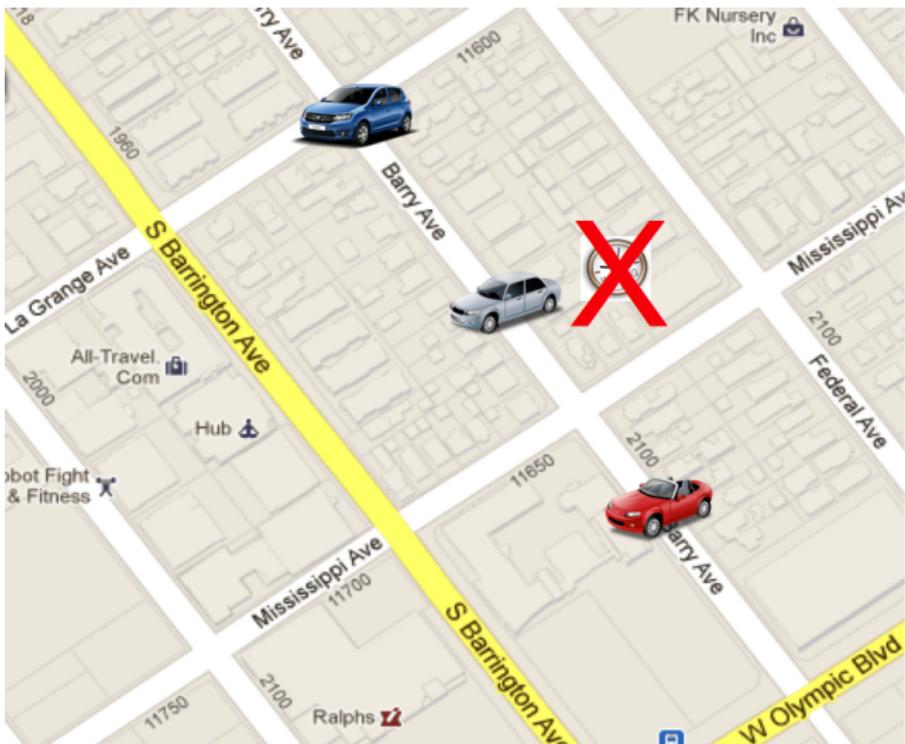
LAL: avoiding the broadcast storm

The red car is farther, than its Waiting Timer will be smaller



LAL: avoiding the broadcast storm

The grey car overhears the packet transmitted by the red car and it will cancel its transmission of the same packet



LAL: avoiding the broadcast storm

- A waiting Timer based only on distance is not enough: cars with similar distance to the previous hop will transmit at “the same time”
- Solution: adding a small **random component** to the Waiting Timer



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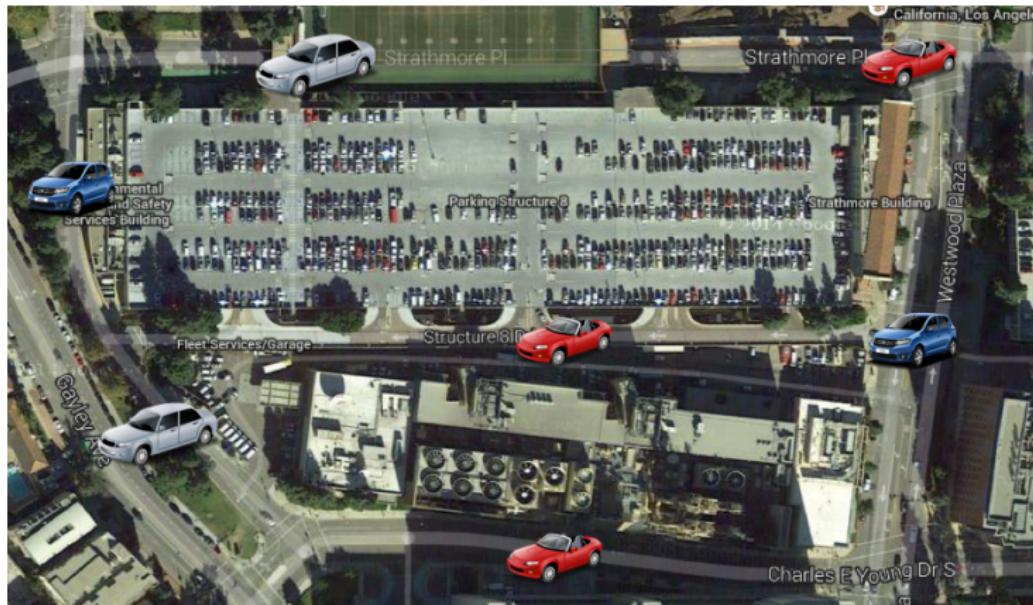
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Experiments on the field

As proof of concept, we performed a number of field experiments with 10 cars around the UCLA campus



Experiments on the field

Two application were running: Info-Traffic application and Photo application



All the cars were equipped with WiFi Ad-Hoc interfaces.

A subset of them was equipped with an additional network interface (WiMax or WiFi in Infrastructure Mode)

Results: Data survives Producer

Data is decoupled from its container - producer

Once a piece of data has been spread in the network, its availability becomes independent from the connectivity to its producer.

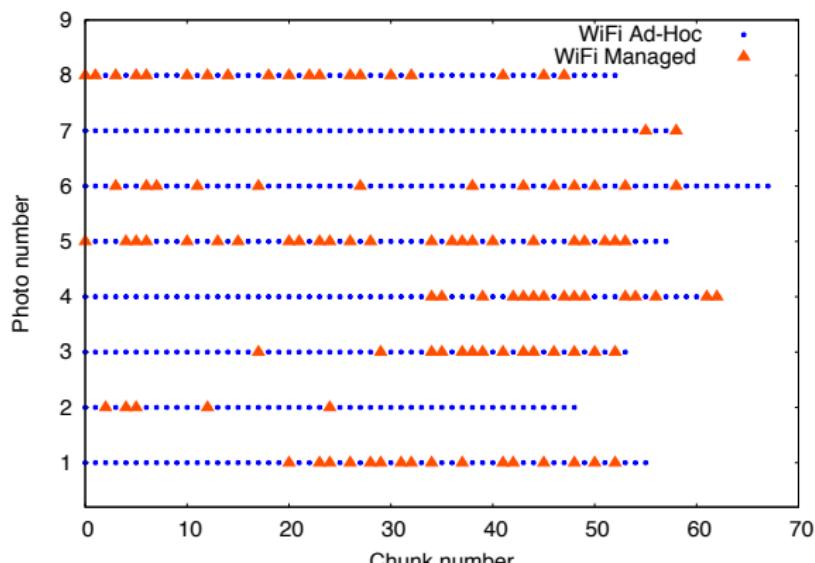
As proof of concept, we design the following test:

- Only one producer is running
- After answering to the first consumer request, the producer is turned off
- Later, a second consumer asks for the same content
- As expected, the second consumer was able to get the desired content from other cars (consumer or mules)

Results: Multihoming

Fetching data by name enables multihoming

V-NDN possesses the innate ability of utilizing node multihoming to communicate with other cars via Ad-Hoc WiFi on the Internet via 3G/4G/WiFi connectivity simultaneously.



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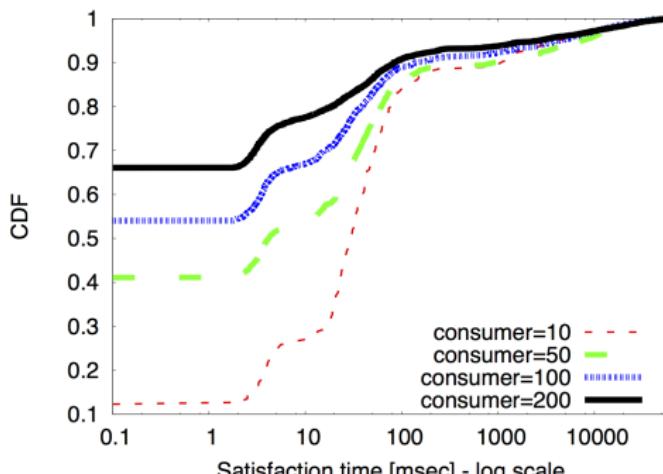
Simulations

- The experiments on the field are limited in scale
- We used simulation to explored the scalability of V-NDN approach for Ad-Hoc communication
- In a urban scenario (a residential area of Los Angeles) with dense traffic (695 cars) we analyzed the behavior of V-NDN:
 - The satisfaction time for the Info-Traffic application
 - The overhead to get the desired content

Simulations: Satisfaction Time

In a system where the same information can be helpful to multiple users, V-NDN can bring great benefits

By letting all cars caching overheard information, they become data mules. Not only a car can help forward a content that it has just received, but it can also carry the content and answer Interests for the same content in the future.



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Remaining challenges

- **Forwarding strategies** able to direct the Interest toward the location where the content is, instead of use controlled flooding of the network
- **Names design:** How can names help the forwarding process?
Encoding geolocation into names for location-based data can help.
But what about the other content?
- **Security and privacy:** how to provide consumers with authenticated data but without the exposure of producers identity

Summary

- V-NDN exploits NDN strengths and extend the NDN paradigm to adapt to VANET scenario
- By naming data rather than hosts:
 - Can fully **utilize all the available network interfaces** as soon as they are available.
 - The **communication can start spontaneously**, IP assignment process for V2V communication is no longer required
 - The communication is **resilient to connectivity disruptions**: mules overcome interruptions in the communication among consumer and producer

That's all

Thank you for your attention

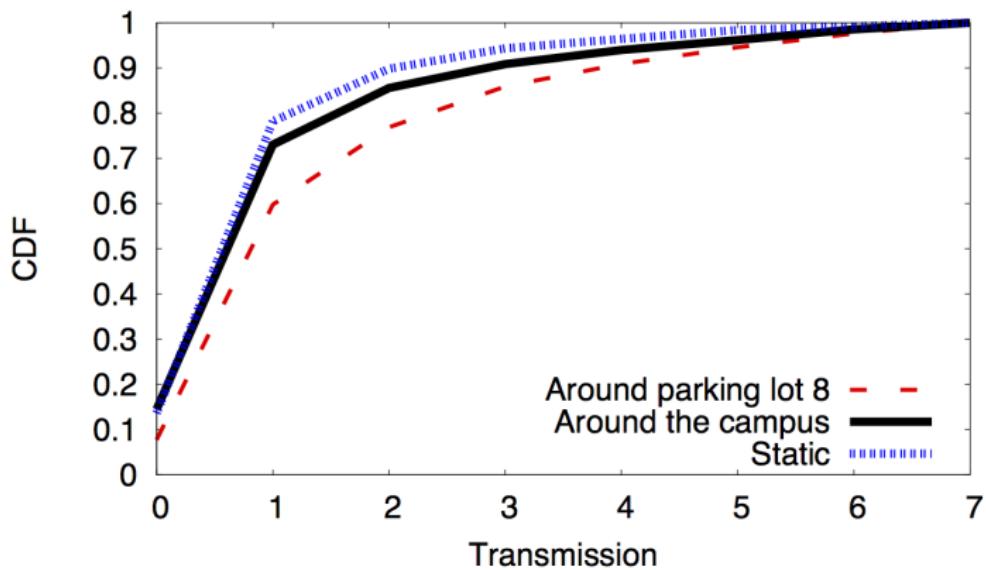


Questions?

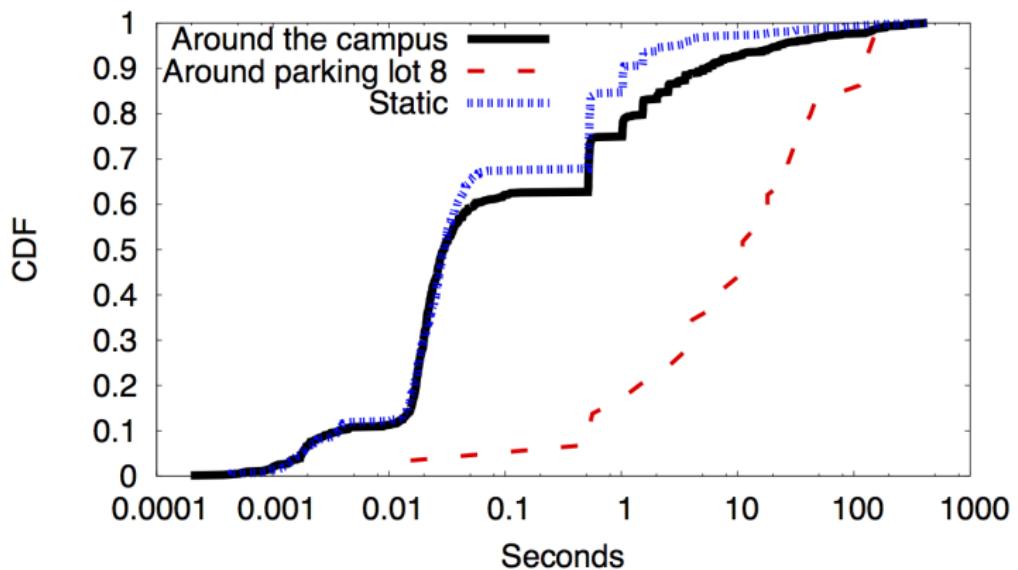
giulio.grassig@lip6.fr

You want to try V-NDN ... the code is available online and it will be soon integrated with the NFD project

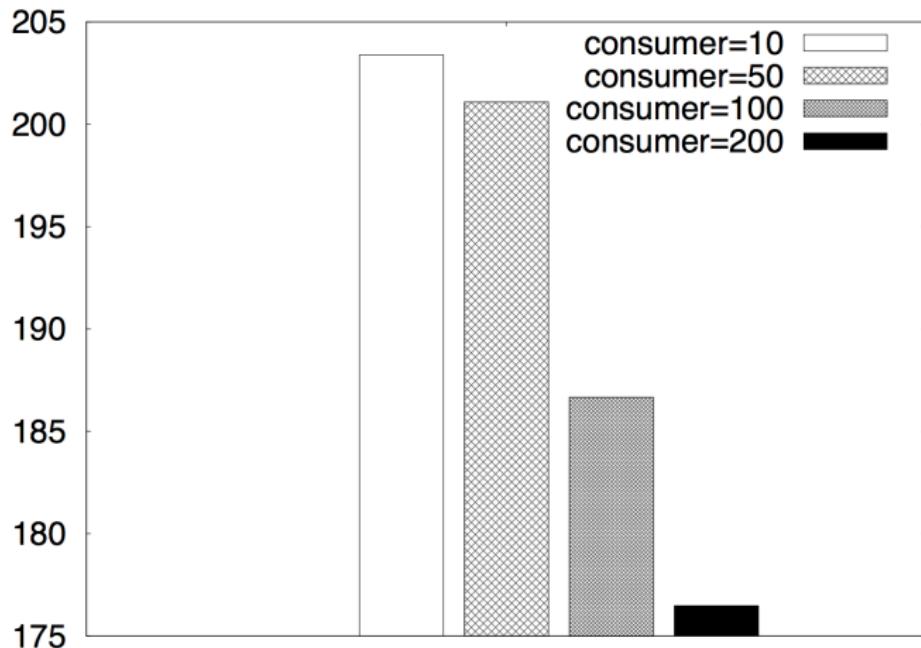
Experiments on the field results: LAL retransmission process



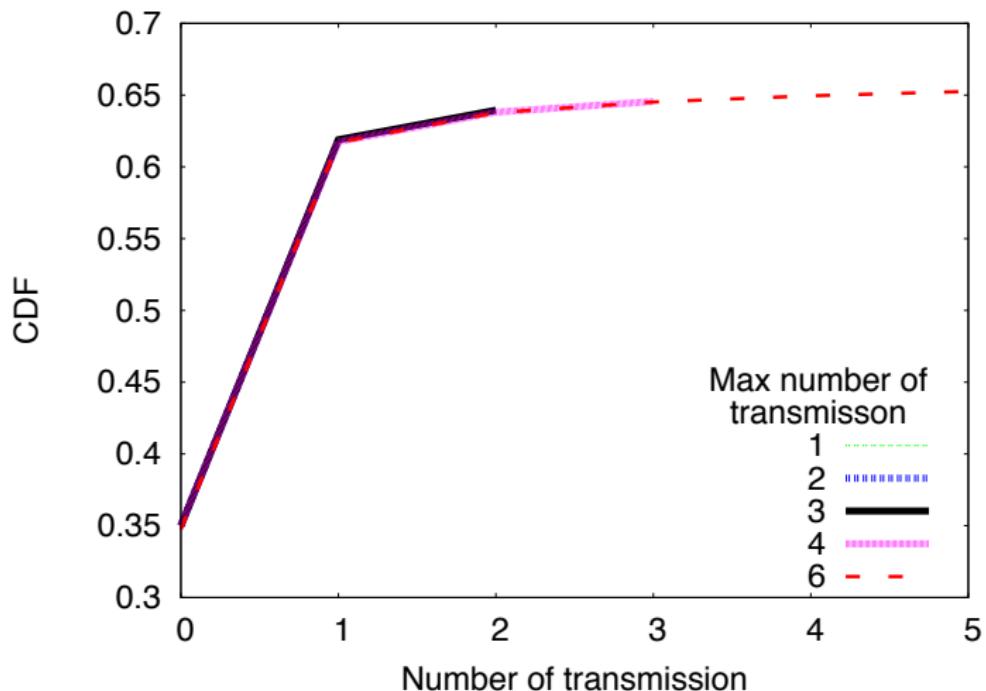
Experiments on the field results: Satisfaction time



Simulation results: Overhead



Simulation results: LAL retransmission process



Simulation results: Satisfaction time

