

Cooperative alert generation and propagation in vehicular networks Cooperative Mobility for the Service of the Future

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> > Decembre 2016







Agenda

Lancian de la constitución

Comosef French pilo

Team Pilot

Aim Archited

Framewo Hardwar

Fusio

Example Distributed a

Coommun

Strategy V2V

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1 Introduction

2 Pilot in Compiègne

3 Distributed data fusion

4 Cooperative communication architecture

6 Conclusion











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Introduction





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1 Introduction

Comosef French pilot Team

2 Pilot in Compiègne

- Oistributed data fusion



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1 Introduction

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Comosef project

Cooperative Mobility for the Service of the Future

Comosef Erench pi

Pilot

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Data fusio

Distributed Properties

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V2V

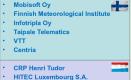
Conclusio





European Celtic Plus project

- Coordinator: Pekka Eloranta
- 9 million euros, 94 person-years
- 7 countries, 21 partners
 - 11 pilots



- HITEC Luxembourg S.A.
 Entreprise des Postes et Telecommunications Luxembourg
- Technical University of Cluj-Napoca
- AROBS Transilvania Software







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French consortium

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French pi

Pilot

Architectu Framework

Fusio

Data fusion Example Distributed all Properties

Coommuni

V2V

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- Viveris Technologies
 CAN bus decoding, embedded architecture
- Thales Communication and Security Optimizing data diffusion from RSU, network coding
- Université de Technologie de Compiègne CNRS Heudiasyc 7253 Cooperative alert generation and propagation in VANET



Compiègne









Technologies









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1 Introduction

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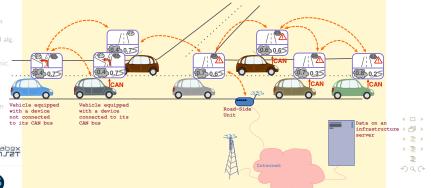
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Conclusion

- Inputs from CAN bus of vehicles
- Distributed data fusion
- Alert propagation to vehicles/infrastructure







Team



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1 Introduction

French pilot

Team







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Université de Technologie de Compiègne
 ~4500 students, master degree (engineer diploma), PhD

http://www.utc.fr

- One of the first French engineering school for computer science
- Close to Paris and Charles de Gaulle airport
- Heudiasyc lab from the UTC & CNRS Equipex Robotex, Labex MS2T



 Dynamic networks team https://airplug.hds.utc.fr



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Team approach

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• Dynamic networks are differents

Very short communication timer

Unknown neighbors

• Example:

Confidence in the information

Security

Data sharing, data collect

Messages routing

Impact

Protocol design

Modeling and proofs

Embedded architecture

Evaluation methodology

• Our tools:

Airplug Software Distribution

Communicating embedded disposals

https://www.hds.utc.fr/airplug







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Research projects

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 Collecting water meters data using vehicles Grant Aceda with Amiens city

 Cooperative architecture for smart cities Agreement with Compiègne city

 Cooperation in a fleet of drones FUI Airmès (I. Fantoni)

 Modeling and proofs in dynamic networks Regional grant Toredy

• European Celtic-Plus project Comosef (2013-2016)

 Cooperative perception for road safety ANR Percoive (A. Victorino)

 Co-operative Systems for Road Safety European project SafeSPOT (M. Shawky)

 Data gathering from VANET to infrastructure Industrial grant FTR&D
 Distributed applications for dynamic networks

Regional grant Toredy 2007-2010

Network services for com. between mobiles objects
Industrial grant Orange lab 2004-2008

les 2016-2017

2015-

2015-2018

2015-2018

2008-2011

2006-2010

2008-2010





UTC/CNRS Heudiasyc

Scientific contributions

Team



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Dynamic p-graphs	[Ad Hoc Networks 2016]
Detecting icy roads	[IEEE ITS 2016]
Adaptive inter-messages delay	[WiMob 2016]
Robustness of distributed data f	usion [SRDS 2016]
Mobile measure of the pollution	[IWCMC 2015]
Cooperative approach near RSU	[IWCMC 2014]
Keepalive service in VANET	[WCNC 2014]
	Dynamic p-graphs Detecting icy roads Adaptive inter-messages delay Robustness of distributed data for Mobile measure of the pollution Cooperative approach near RSU Keepalive service in VANET

Vehicular networks emulation

Distributed data fusion

Data collect on the road

Distributed dynamic group service

Performances in a convoy of vehicles

V2L architecture Simulation of vehicular networks

Road experiments

Messages forwarding

[Mobiwac 2010] [VTC 2010]

[SSS 2012] [IV 2012]

[VTC 2011]

[ICCCN 2010] [SPAA 2010]

[IEEE TVT 2007]

[VTC 2009]



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2 Pilot in Compiègne Aim

Architecture

Airplug framework

Hardware



4 Cooperative communication architecture



Conclusion



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Architecture Airplug framework







Aim













Vehicular network































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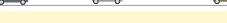




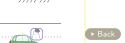


Pilot in Compiègne





- Vehicular network
- Detecting potential danger















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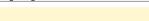
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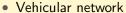




Pilot in Compiègne







- Detecting potential danger
- Warning only concerned vehicles















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Architecture



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2 Pilot in Compiègne

Architecture

Airplug framework



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Pilot in Compiègne Architecture: vehicle as a source

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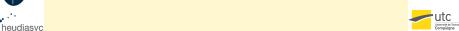












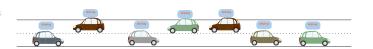
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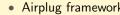
Pilot in Compiègne

Architecture: vehicle as a source



Vehicle as a source of information

Airplug framework



















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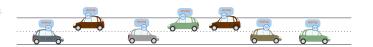
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Architecture



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Pilot in Compiègne Architecture: vehicle as a source





- Airplug framework
- GPS device and app















Pilot in Compiègne

Architecture: vehicle as a source

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Architecture





- Vehicle as a source of information
 - Airplug framework
 - GPS device and app
 - MAP app

















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Pilot Aim

Architecture Framework

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- Airplug framework
- GPS device and app
- MAP app
- CAN app

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Pilot in Compiègne

Architecture: vehicle as a source









Architecture







Pilot in Compiègne

Architecture: vehicle as a source



Vehicle as a source of information

- Airplug framework
- GPS device and app
- MAP app
- CAN app
- CTM app: local confidence in the danger













Viveris & Heudiasyc





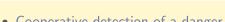
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Architecture: cooperative detection of danger

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Architecture: cooperative detection of danger

Architecture







Cooperative detection of a danger

MET app: robust distributed data fusion

















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Pilot in Compiègne

Architecture: cooperative detection of danger



• Cooperative detection of a danger

MET app: robust distributed data fusion

















Architecture





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Architecture: cooperative detection of danger



Cooperative detection of a danger

MET app: robust distributed data fusion

















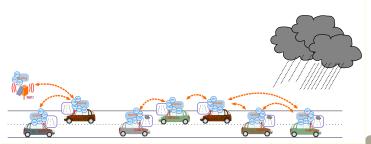
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Pilot in Compiègne

Architecture: cooperative detection of danger



- Cooperative detection of a danger
 - MET app: robust distributed data fusion
 - Updating the local confidence Reading the windscreen wipers speed on the CAN bus

▶ Back















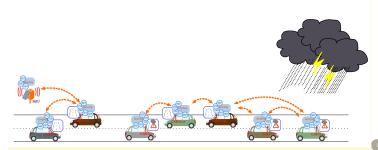
Architecture





Pilot in Compiègne

Architecture: cooperative detection of danger



Cooperative detection of a danger

- MET app: robust distributed data fusion
- Updating the local confidence Reading the windscreen wipers speed on the CAN bus
- Detecting a danger Computed distributed confidence larger than a threshold











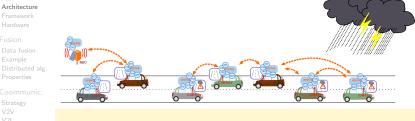






Pilot in Compiègne Ducourthial Architecture: cooperative propagation of an alert

• Cooperative propagation of the danger

















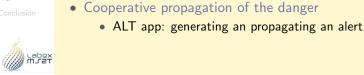


Pilot in Compiègne Architecture: cooperative propagation of an alert

Architecture



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Data fusion Example Distributed a Properties

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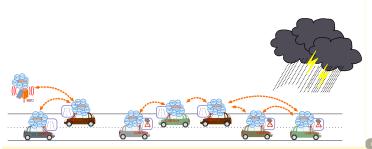






Pilot in Compiègne

Architecture: cooperative propagation of an alert



Cooperative propagation of the danger

- ALT app: generating an propagating an alert
- HOP app: smart conditionnal retransmission

















Architecture

Pilot in Compiègne

Architecture: cooperative propagation of an alert

Cooperative propagation of the danger

ALT app: generating an propagating an alert

• HOP app: smart conditionnal retransmission

• GTW app: searching for Internet gateway







Pilot in Compiègne Architecture: cooperative propagation of an alert

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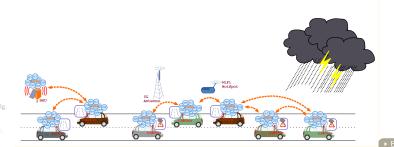
Strategy

V2I

Conclusion







- Cooperative propagation of the danger
 - ALT app: generating an propagating an alert
 - HOP app: smart conditionnal retransmission
 - GTW app: searching for Internet gateway



Pilot in Compiègne

Architecture: cooperative propagation of an alert

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Cooperative propagation of the danger

- ALT app: generating an propagating an alert
- HOP app: smart conditionnal retransmission
- GTW app: searching for Internet gateway















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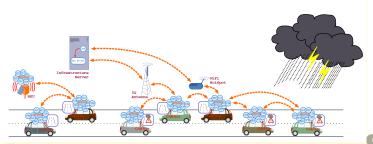
Pilot in Compiègne

Architecture: cooperative propagation of an alert

Architecture







Cooperative propagation of the danger

ALT app: generating an propagating an alert

HOP app: smart conditionnal retransmission

GTW app: searching for Internet gateway

Web app: warning web clients











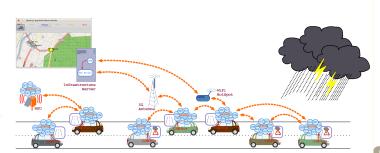




Architecture

Pilot in Compiègne

Architecture: cooperative propagation of an alert





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Cooperative propagation of the danger

ALT app: generating an propagating an alert

HOP app: smart conditionnal retransmission

GTW app: searching for Internet gateway

Web app: warning web clients

Web clients warned













Pilot in Compiègne

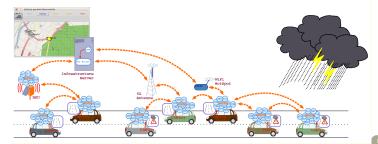
Architecture: cooperative propagation of an alert

Architecture





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Cooperative propagation of the danger

ALT app: generating an propagating an alert

HOP app: smart conditionnal retransmission

GTW app: searching for Internet gateway

Web app: warning web clients

Web clients warned











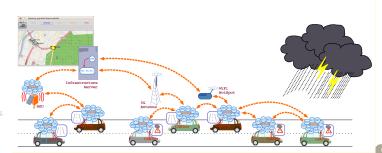






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Architecture: cooperative propagation of an alert



Cooperative propagation of the danger

ALT app: generating an propagating an alert

- HOP app: smart conditionnal retransmission
- GTW app: searching for Internet gateway
- Web app: warning web clients
- Web clients warned





















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Architecture: cooperative propagation of an alert

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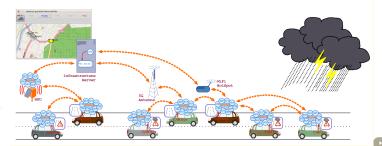
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- Cooperative propagation of the danger
 - ALT app: generating an propagating an alert
 - HOP app: smart conditionnal retransmissionGTW app: searching for Internet gateway
 - Web app: warning web clients
 - Web clients warned
 - Far vehicles warned using road side units

Back















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Sommaire

Framework



2 Pilot in Compiègne

Airplug framework



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Airplug framework 1

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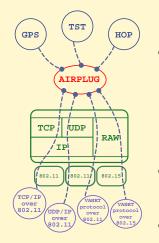
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V2V

Conclusio







- Core program
 - User-space process
 - Networking
- Applications
 - User-space process
 - Any language
 - · Read on stdin
 - Write on stdout
 - API close to IEEE WSMP
- Robustness
 - Tasks and OS independence
- Portability
 - GNU/Linux











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Airplug framework 2

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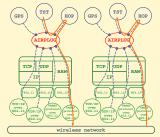
V2V V2I

Conclusio





- Designing new protocols
 - Developed in user space processes
 - Cross-layer solutions facilitated



- Airplug software distribution
 - LEGO: many applications that can be combined
 - Tools to ease packaging, prototyping and studies

https://www.hds.utc.fr/airplug



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Pilot in Compiègne Airplug framework 3

- Airplug-term → rapid prototyping
- Airplug-emu → study by emulation
- Airplug-live → real experiments (vehicles, UAV)

+ remote, notk...





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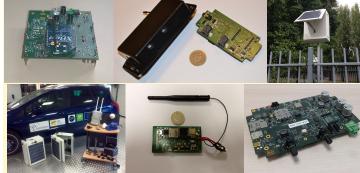
Hardware





Research plateform

Road tests













Properties

Data fusion introduction

Fusion







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Example of Basic Belief Assignment Distributed data fusion algorithm



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3 Distributed data fusion

Data fusion introduction

Example of Basic Belief Assignment Distributed data fusion algorithm



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- Several sources of information
 - How to deal with?
 - Could disagree
 - Take benefit of all of them
- Imperfect measures
 - Can we trust data?
 - Imprecision
 - Uncertainty
 - Ambiguity











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Distributed data fusion

Data fusion introduction

Comosef French pi

• How to deal with imprecise and uncertain data?

Pilot Aim Architecture

Set Membership Approach

Imprecision :

uncertainty?

• Aleatory uncertainty :

Probability theory imprecision?

 Theory of Belief Function: generalizes both Also known as Dempster-Shafer Theory of Evidence

Coommuni

Data fusion

• Belief Function Framework

Coommuni

Information modeling

Conclusio

Combination rules

ation rules

[Dempster 1968, Shafer 1976, Smets 1990s]









Data fusion introduction

Data fusion

- Data X with value in Ω
- Representation of X
 - (value, confidence)
 - value: subset of \(\infty \)
 - confidence: indication on the reliability of the item of information
- Interest:
 - Imprecision of X → value
 - Uncertainty of X → confidence

[Dubois, Prade 1988]

Sh.			Confidence	
M.S.L			certain	uncertain
Carc	le	precise	20	probably 20
chrs	=	imprecise	between 15 and 25	probably between
8. O	>			15 and 25





Data fusion introduction

Data fusion





- Frame of discernment: set \(\infty \)
- Basic belief assignment
 - Mass function
 - $m^{\Omega}: \mathcal{P}(\Omega) \rightarrow [0,1]$

•
$$\sum_{X \subset \Omega} m^{\Omega}(X) = 1$$

- Our algorithm: vector of weights
- Dempster operator
 - Emphases the agreement of reliable and independent sources [Smets 1990, Shafer 1976] $m_{1 \bigcirc 2}(A) = \sum_{B \cap C = A} m_1(B) \cdot m_2(C)$
 - Spread the conflict over other sets [Dempster]
- Cautious operator

[Denoeux 2008]

- Do not assume independent sources
- Least commitment principle
- Avoid the data incest











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3 Distributed data fusion

Data fusion introduction

Example of Basic Belief Assignment

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Distributed data fusion

Example of Basic Belief Assignment 1/3

• Pressure measurement



- Weather forecast
 - Compare current measure with the last one















Example of Basic Belief Assignment 2/3

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Example

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Barometer?







Measure:

- Pressure measurement: interval / $\subset \mathbb{R}^+$
- Pressure gradient: interval △/ ⊂ ℝ
- Simple mass function:
 - Only two subsets: ΔI and \mathbb{R}
 - R: lack of knowledge
 - $m^{\mathbb{R}}(\Delta I) = 1 \alpha$
 - $m^{\mathbb{R}}(\mathbb{R}) = \alpha$
 - α: uncertainty of the barometer



Example of Basic Belief Assignment 3/3

Example





Coarsening

Finite frame of discernment instead of △/ ⊂ ℝ

Example: $\Omega = \{wet, cloud, sun\}$

Mass function:



{wet}

 $\Delta I < 0$

{wet, cloud}



{wet, cloud, sun}



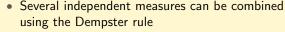


{cloud, sun}



 $\Delta I >> 0$

Combination



Decision

 From mass to pignistic probability $P(A) = \sum_{\emptyset \neq B \subset \Omega} m(B) \frac{|A \cap B|}{|B|}$







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Distributed data fusion algorithm

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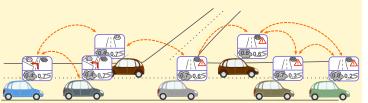


Distributed data fusion

Distributed algorithm: motivation

• Distributed approach for data fusion

- Direct confidence (regularly) produced locally Using an external uncertain device
- Node's confidence computed using other values
- Avoiding data collection
- Locality
 - One result per node
 - Depends on its position in the network



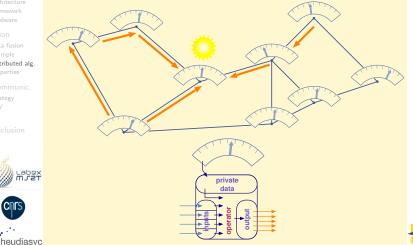


Distributed algorithm: example

Distributed alg.



 Result on any node v now depends on all other nodes, not only its neighbors.





Distributed algorithm: characteristics

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- Our distributed data fusion algorithm [SSS2012]
 - Combine all direct confidences of the system
 - Relies on local periodic broadcast
 - Discount received information
 - → confidence decreases according to the distance
- Characteristics
 - Finite data set
 Discretization + adapted operators
 - Asynchronous and anonymous system
 - Unreliable message passing system
 - Intermittent faults on memories/messages
 - Crash faults on nodes









Distributed algorithm: details

private

Distributed alg.





Upon (local) timer expiration

 $PRIV_{\nu} \leftarrow current direct confidence$ $OUT_{\nu} \leftarrow PRIV_{\nu}$ **for each** entry u in IN_v **do** $OUT_v \leftarrow OUT_v \oslash r(IN_v[u])$ end for push(OUT_v) Reset IN

Restart the timer



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3 Distributed data fusion

Data fusion introduction Example of Basic Belief Assignment Distributed data fusion algorithm

Properties



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Properties: locality

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Discounting r

• Local computation: $OUT_v \leftarrow OUT_v \oslash r(IN_v[u])$

O: cautious operator defined on weights

• r : discounting function

Decreases the information

Application-dependent

Without discounting

A single result per connected component

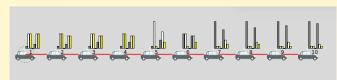
• With discounting

· Limited influence of a node

Locality of the result



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Properties: robustness

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Self-stabilization

[SSS2005, SSS2007]

- : r-operator defined by x y = x r(y)
- Condition 1: endomorphism
 r(w₁ ⊗ w₂) = r(w₁) ⊗ r(w₂)
- Condition 2: expansion
 w ≺_∅ r(w)
- Without discounting
 - No convergence after a fault In a message, in a memory or in the input device
- With discounting
 - Convergence in finite time after the transient failure ceases



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Properties: complexity

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Stabilization time

supposing a synchronous system

- O(k+D)
- k: defined by r^k (smallest value) = largest value
- D: diameter of the stabilized topology





Summary

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1 Introduction

2 Pilot in Compiègne

Distributed data fusion

4 Cooperative communication architecture Strategy for dynamic networks One-to-many communication (V2V)

Vehicle to Infrastructure communication (V2I)

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4 Cooperative communication architecture Strategy for dynamic networks

One-to-many communication (V2V)

Vehicle to Infrastructure communication (V2I)





Cooperative communication architecture

Strategy for dynamic networks 1/2

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- Dynamic network: topology? address?
- One-to-one communication (V2-1V)
 - Known receiver? → fix or already encountered
 - Maintaining a path
- One-to-many communication (V2-nV)
 - Sending a message without knowing the receiver ...and without trying to know it
 - Sending to receiver(s) defined by conditions
- Vehicle-to-infrastructure communication (V2I)
 - Sharing the gateways toward Internet
 - Enlarging their range
 - Cooperative approach
 - First try by yourself (waiting for a gateway)
 - Else request help from others









Cooperative communication architecture

Strategy for dynamic networks 2/2

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- Choosing the next hop
 - Neighborhood is unstable
 - Learning from the neighborhood is costly
- Sender-side
 - Exchange messages to learn about the neighbors
 - Select a neighbor
 - Send the message to the selected neighbor
 - Consume bandwidth
 - The neighborhood may have change
- Receiver-side
 - Send the message to all neighbors
 - Each neighbor decides whether it is concerned or not

Solutions to avoid several retransmission if required



V2V



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4 Cooperative communication architecture

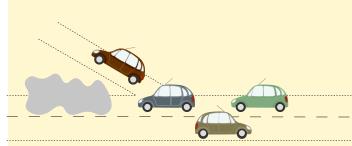
Strategy for dynamic networks

One-to-many communication (V2V)



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One-to-many communication (V2V)





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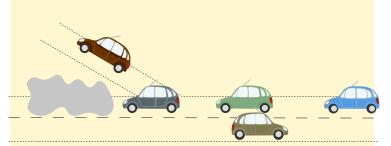
- Conditions instead of addresses
 More adapted to dynamic networks
 - CUP: upward condition → applications
 - CFW: forward condition → local broadcast.
- Conditions
 - Identity, address, GPS cf. geocast
 - Distance, duration, trajectory correlation... Eg. being back to the sender



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One-to-many communication (V2V)





V2V V2I

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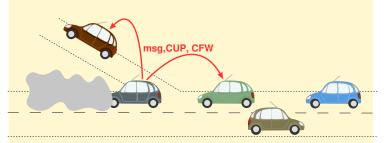
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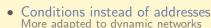
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One-to-many communication (V2V)





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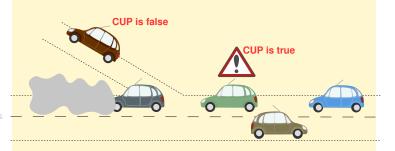
Conclusio





Cooperative communication architecture

One-to-many communication (V2V)



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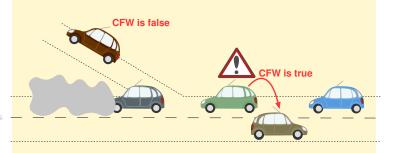
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Cooperative communication architecture

One-to-many communication (V2V)



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One-to-many communication (V2V)



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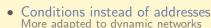


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One-to-many communication (V2V)





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One-to-many communication (V2V)

CUP is true



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One-to-many communication (V2V)



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V2I

Strategy for dynamic networks

Vehicle to Infrastructure communication (V2I)

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Vehicle to Infrastructure (V2I)

V2I





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- Cooperative strategy
 - Relies on conditional transmissions New condition: gateway discovered
 - Messages contains:
 - Lifetime
 - Number of attempt for robustness
 - Delay before forwarding to other nodes

















Vehicle to Infrastructure (V2I)

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- Cooperative strategyRelies on conditional transmissions
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Cooperative communication architecture

Vehicle to Infrastructure (V2I)

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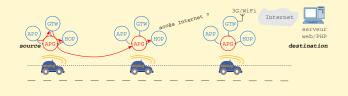
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- Cooperative strategy
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Vehicle to Infrastructure (V2I)

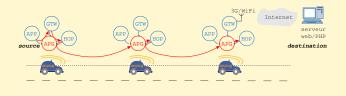
V2I







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- Cooperative strategy
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Conclusion

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Conclusion





Cooperative alert generation and propagation in vehicular networks

- Distributed data fusion
 - Avoiding the data collection phase
 - One result per node depending on its position
 - Robust algorithm
- Cooperative communication architecture
 - Adapted to dynamic networks
 - V2V and V2I
- CoMoSeF project
 - From theory to practice
 - Special thanks to:
 - Pekka Eloranta
 - the Celtic-Plus Office and the DGE
 - and all the Heudiasyc team!





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Strategy V2V





- Distributed data fusion
 - Enforce confidences in the rain event
- Decision phase
 - Pignistic probability > threshold → alert
- Alert propagation
 - Message forwarding based on conditions

