

Design and Experimentation of a Data Collection Protocol for Vehicular Ad-Hoc Networks

Y. Dieudonné¹, B. Ducourthial¹, S.-M. Senouci²
contact: Bertrand.Ducourthial AT utc.fr

¹ Lab. Heudiasyc (UMR UTC-CNRS 6599)
Université de Technologie de Compiègne

² Orange Labs
Lannion

CFIP 2011, 10-13 juin 2011,
Sainte Maxime, France



B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



① Context

② Data collection

③ Distributed algorithm

④ Experiments

⑤ Conclusion



B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion

1 Context

Intelligent Transport Systems
Scientific issues
Team
Contribution

2 Data collection

3 Distributed algorithm

4 Experiments

5 Conclusion



Intelligent Transport Systems

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Literature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



• ITS motivations

- Improving transportation in terms of safety, mobility, productivity, environmental impact...
- **main goals** : reduce road fatalities, improve infrastructure management, offer new on-board services

• ITS applications

- Infrastructure oriented applications for optimizing the infrastructure management (transit, freeway, freight, emergency organization...)
- Vehicle oriented applications for increasing the road safety (crash prevention, alerts, visibility distance...)
- Driver oriented applications for improving the road usage (traffic jam, road work information, payment...)
- Passenger oriented applications for offering new services on board (Internet access, distributed games, tourist info...)



Scientific issues

Highly dynamic ad hoc networks

Context
ITS
Scientific issues

Team
Contribution

Data
collection

Taxonomy
Literature
Proposed
architecture

Distributed
algorithm

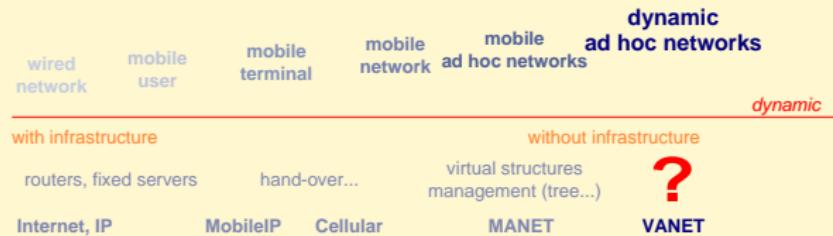
Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion

- Next step in networking and distributed alg.



- Impact of the dynamic

- impact on network layers
link (2), network (3), transport (4)
- impact on distributed algorithms
fault tolerance, data sharing...
- impact on trusty and security
who believe? what information is reliable?
- algorithms necessary embedded
context-aware optimization, adaption...

~ Strong problems, new solutions expected



B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Litterature
Proposed
architecture

Distributed
algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



- 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
 Automatic, Computer Science, Networking, Knowledge...
<http://www.hds.utc.fr>

Equipex Robotex, Labex MS2T

- Intelligent vehicles team
 several equipped cars
- Vehicular networks team



Some of the team projects

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Litterature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



HEUDIASYC



- **Road anticipating**
Regional grant DIVA, Heudiasyc - CREA 2004-2007
- **Network services for com. between mobiles objects**
Industrial grant FTR&D 2004-2008
- **Co-operative Systems for Road Safety**
"Smart Vehicles on Smart Roads"
IP SafeSPOT, 6th PCRD / IST / eSafety 2006-2010
- **Distributed applications for dynamic networks**
Regional grant Heudiasyc - LaRIA 2007-2010
- **Data gathering from VANET to infrastructure**
Industrial grant FTR&D 2008-2010
- **Distributed system for vehicle dynamic evaluation**
Regional grant Heudiasyc - MIS 2008-2011
- **Inter-vehicles cooperative perception for road safety**
National project ANR JC, (Heudiasyc) 2008-2011



Some of the team contributions

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection

Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



- Performances in a convoy of vehicles [VTC 2011]
- Vehicular networks emulation [ICCCN 2010]
- Distributed dynamic group service [SPAA 2010]
- V2I architecture [Mobiwac 2010]
- Simulation of vehicular networks [VTC 2010]
- Road experiments [VTC 2009]
- Messages forwarding conditional transmissions [IEEE TVT 2007]
- IEEE 802.11 fairness [MedHocNet 2006]
- Capacity of vehicular networks [VTC 2005]

How to validate the contributions

- By proofs
 - for distributed algorithms
 - require com. and synchronization models
- By simulations ↗ Airplug-ns
 - for networking protocols
 - require propagation and MAC model,
packets traffic and node mobility model
- By experiments ↗ Airplug-live
 - for proof of concept and perf. measuring *in situ*
 - require equipments and logistic
- By emulation ↗ Airplug-emu
 - between analytical studies and experiments
 - require valid emulation of low layers
- **The Airplug Software Suite**
 - Programs and libraries for comprehensive studies
 - Many prototypes for protocols and applications

<http://www.hds.utc.fr/airplug>



Contribution in this paper

Data
collection in
Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Summary

Data
collection in
Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results
Conclusion

1 Context

2 Data collection

Taxonomy

Litterature

Proposed architecture

3 Distributed algorithm

4 Experiments

5 Conclusion



Problem

Data
collection in
Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



- Motivations

- Many data produced by vehicles
Produced by embedded sensors and calculators
- Could feed intelligent applications
 - infrastructure
 - vehicle-oriented, driver oriented

- Problem to solve

- Large amount of data
- Limited network ressources

- Kind of collect

- Data production
local, time/geographic aggregation...
- Data sending
a single, some, all vehicles...
- Starting
Push-based, pull-based...
- Ending ?



Taxonomy

Data collection in Vanet

B. Ducourthial

Context

ITS

Scientific issues

Team

Contribution

Data collection

Taxonomy

Litterature

Proposed

architecture

Distributed algorithm

Local views

Algorithm

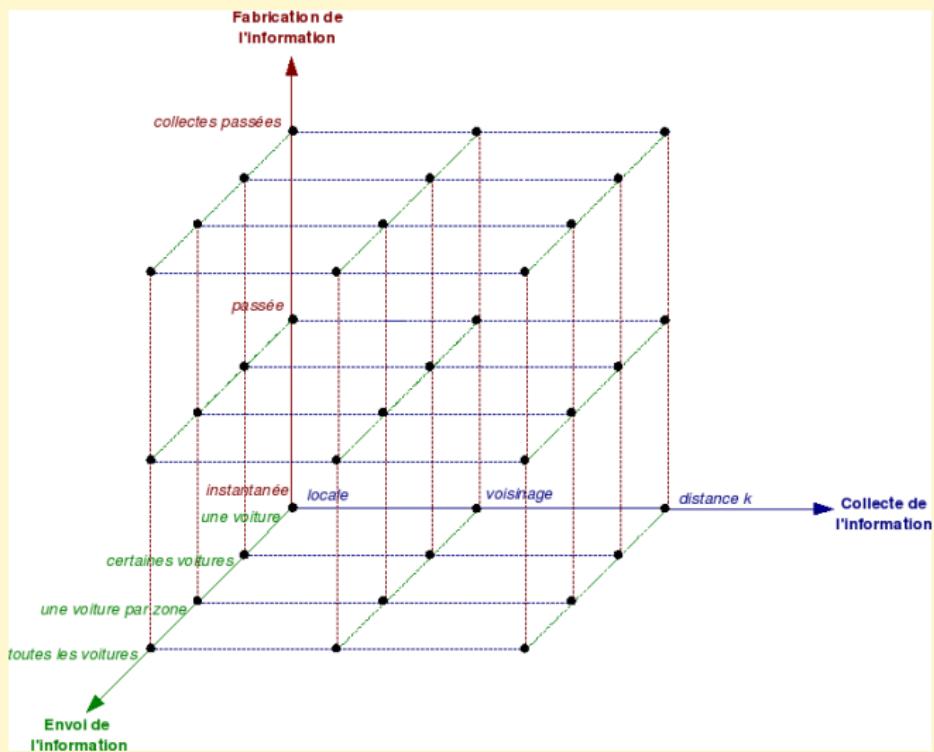
Experiments

Plateform

Experiments

Results

Conclusion



Litterature : a summary

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection

Taxonomy
Literature
Proposed
architecture

Distributed
algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



- Disseminations
 - Opportunistic, geographic, peer-to-peer, cluster-based... [WU04,LEE06,BON07]
 - Kind of data to be sent ?
 - When to send data ?
- Request-based
 - Propagation of Information with Feedback [SEG83]
For fixed networks
 - Wave for manets [CHE02]
For networks without partitioning



Litterature : PIF

Data collection in Vanet

B. Ducourthial

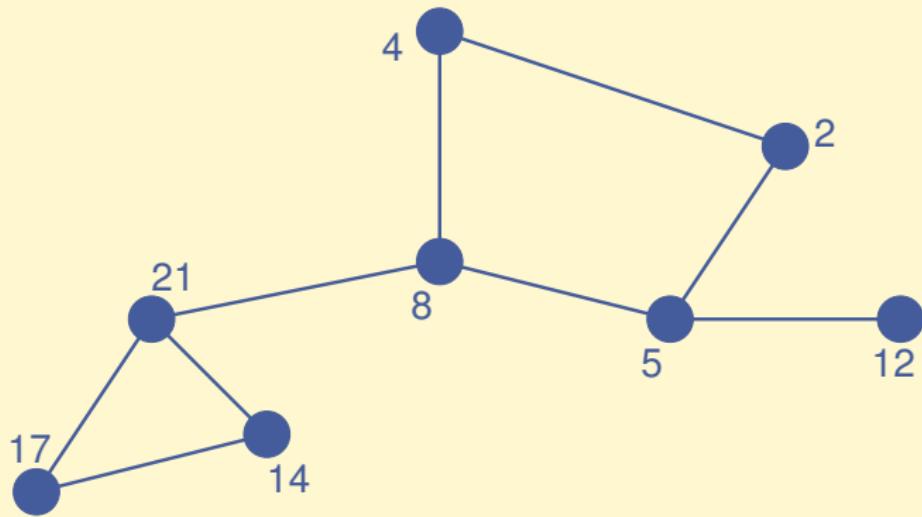
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

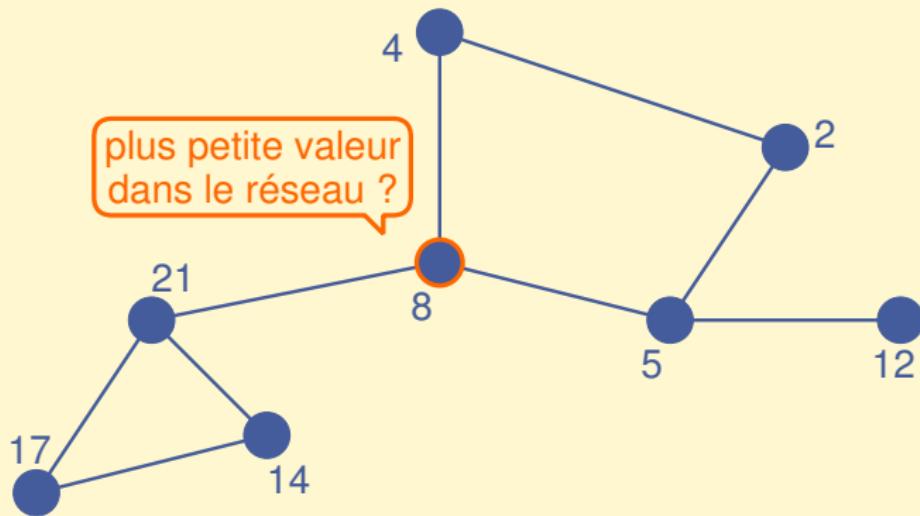
Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm

Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

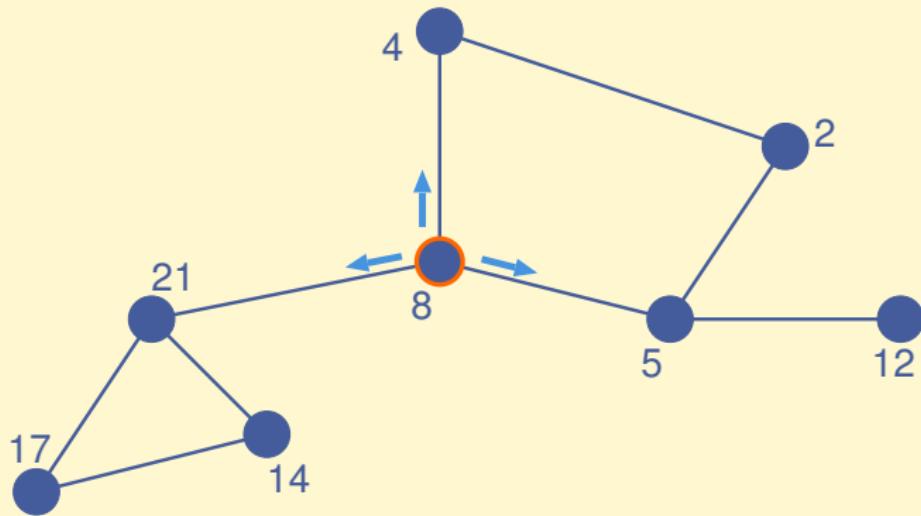
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

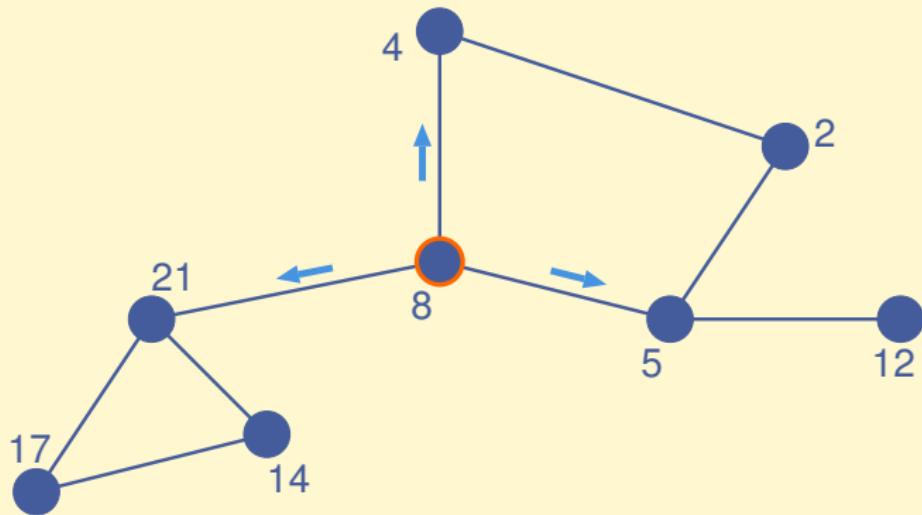
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

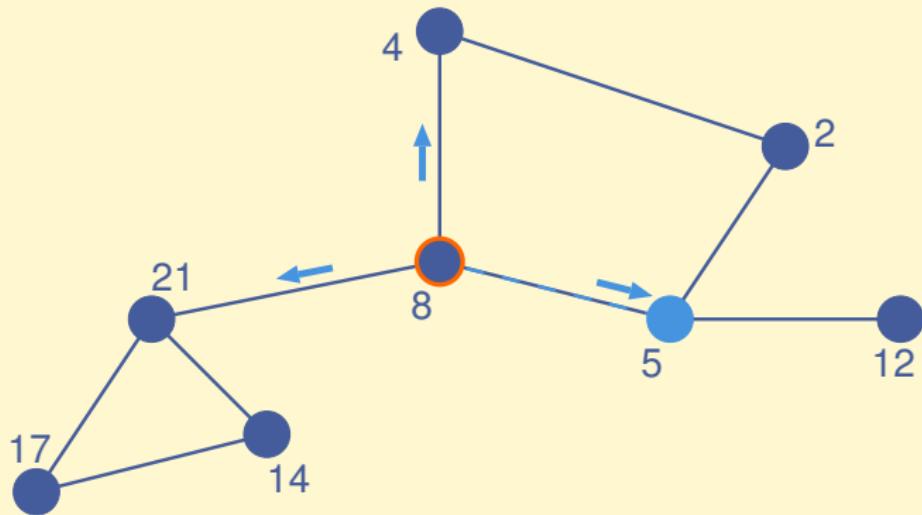
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

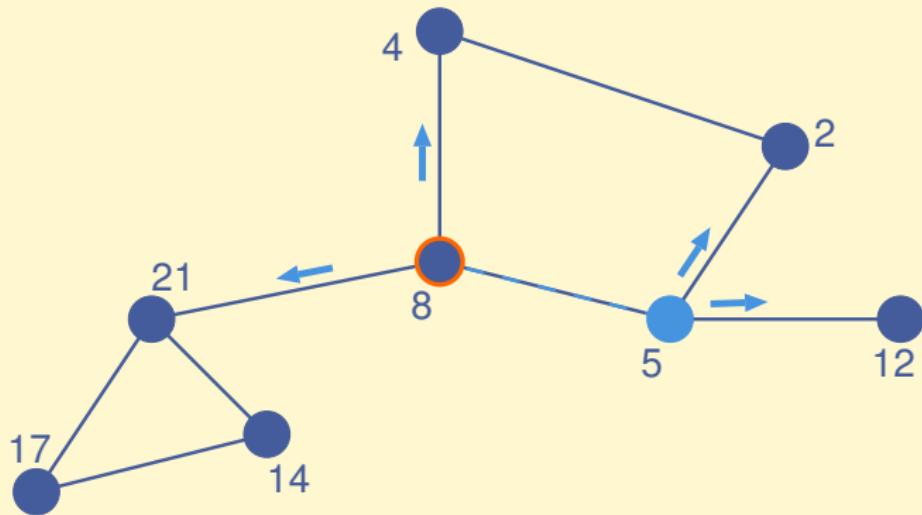
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

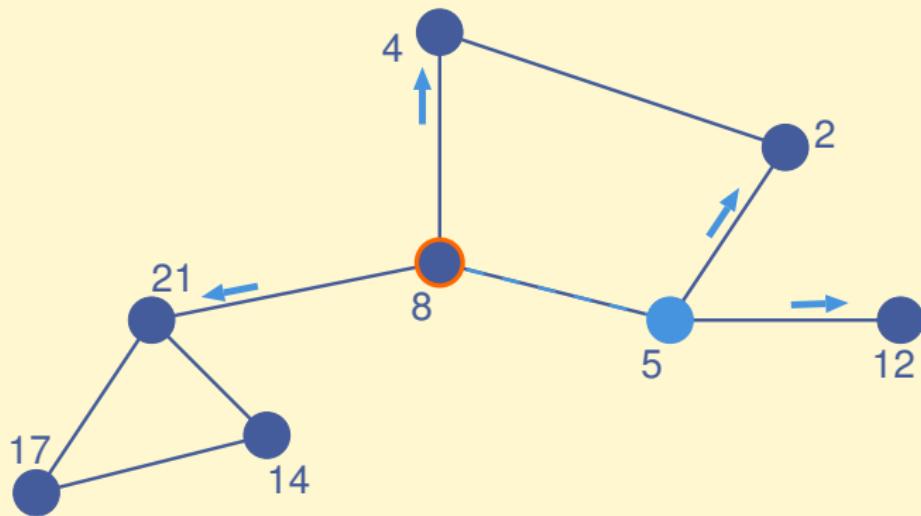
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

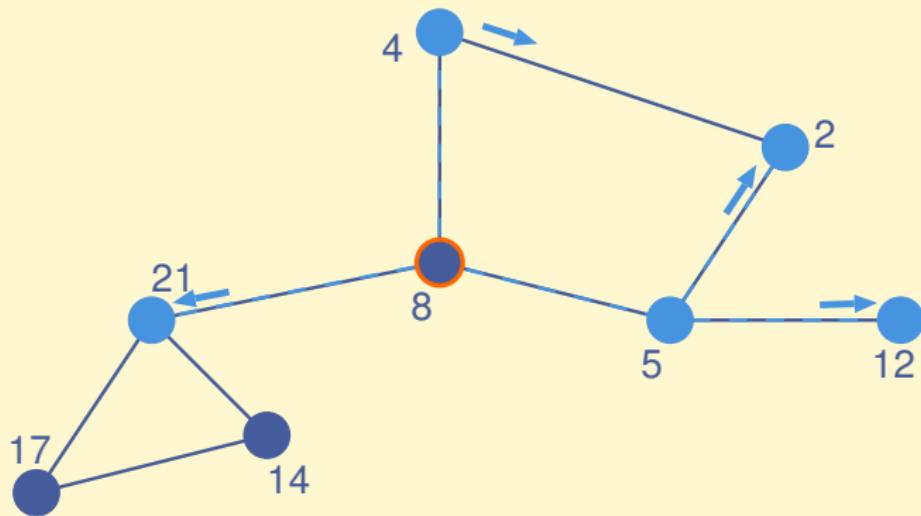
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

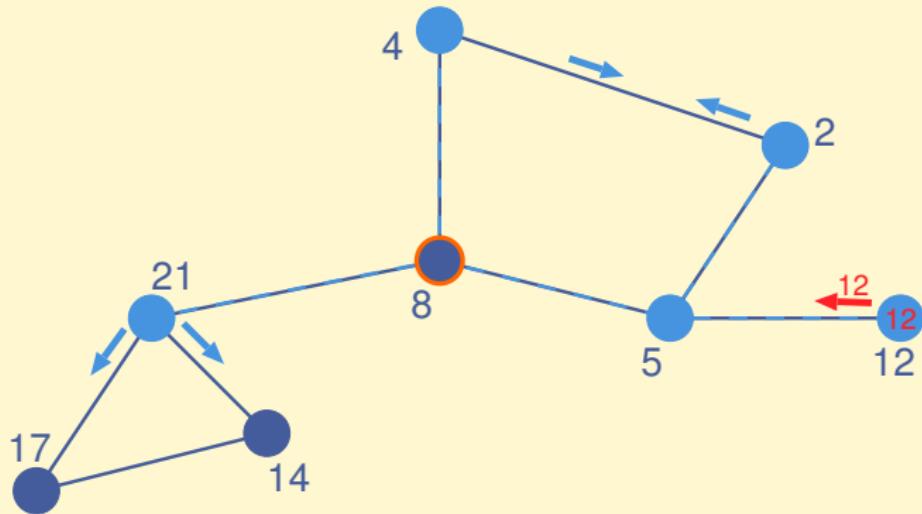
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

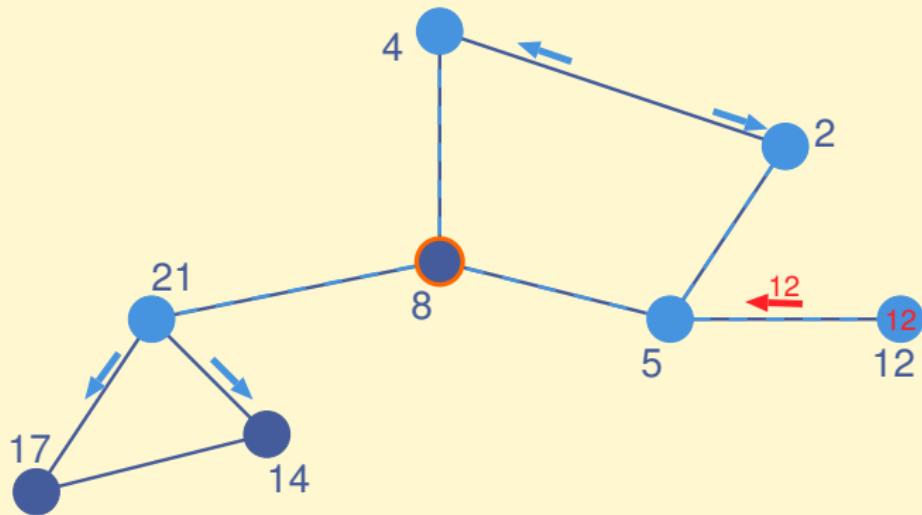
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

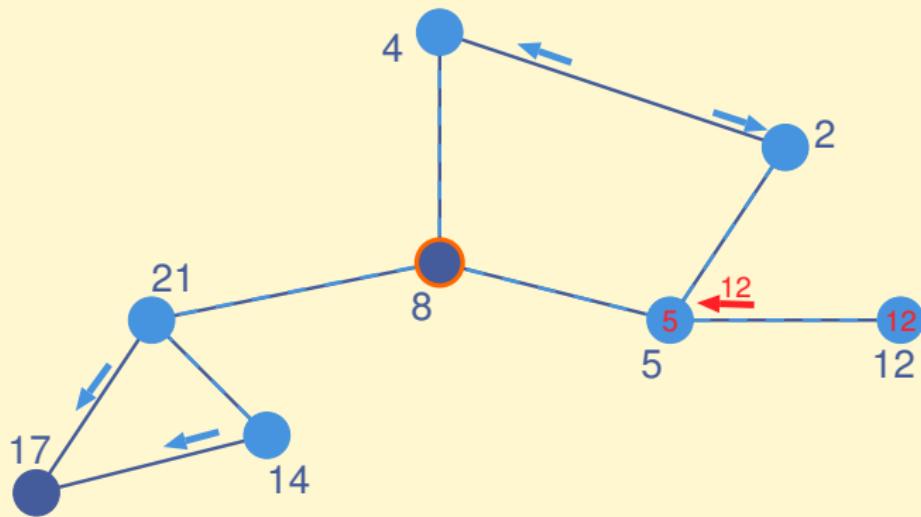
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

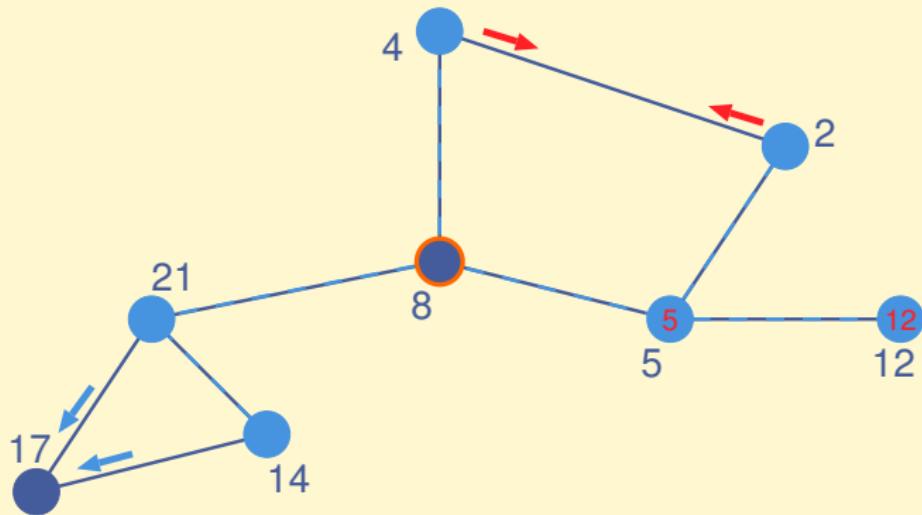
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

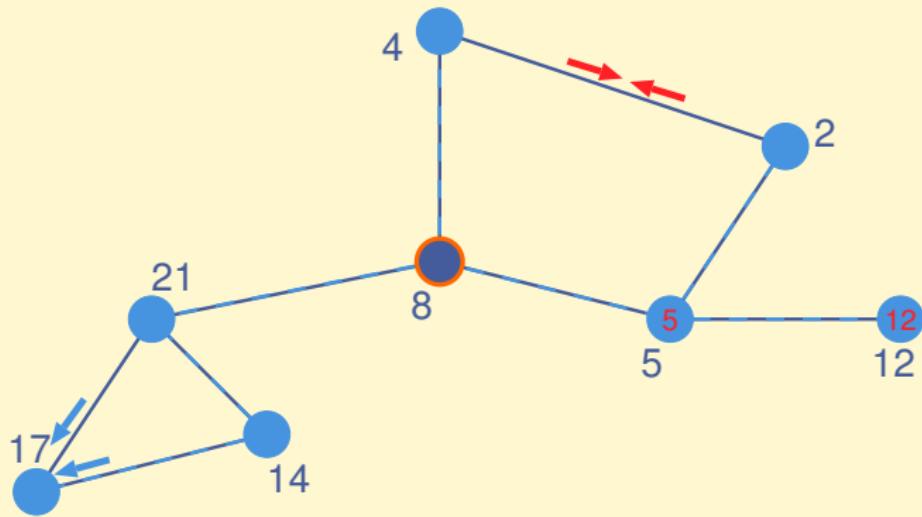
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context

ITS

Scientific issues

Team

Contribution

Data collection

Taxonomy
Litterature

Proposed
architecture

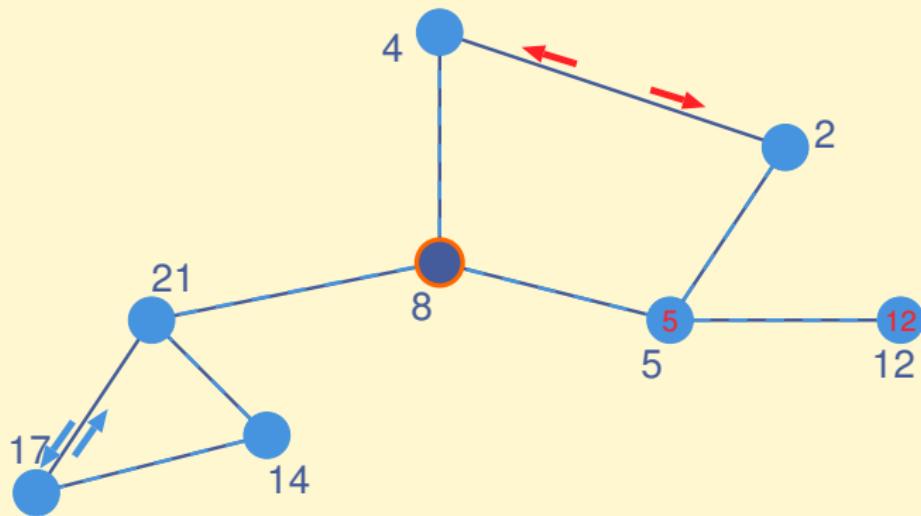
Distributed
algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

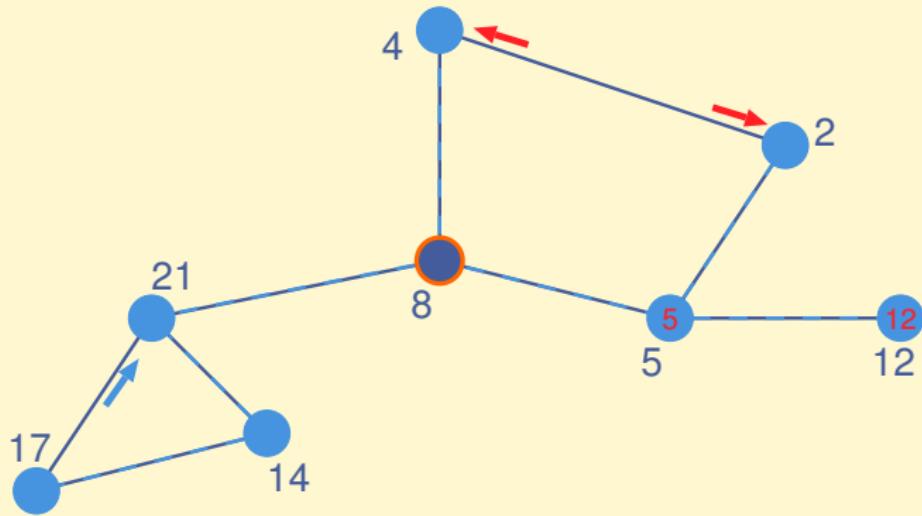
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

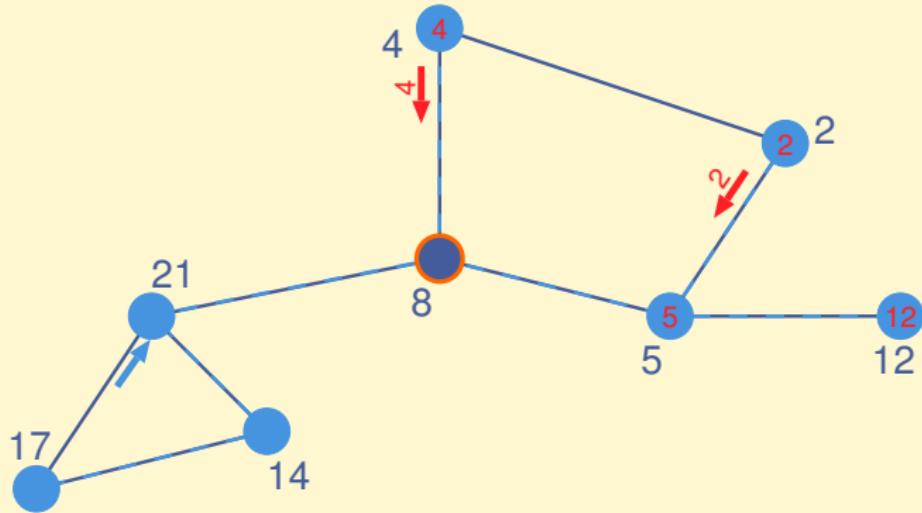
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

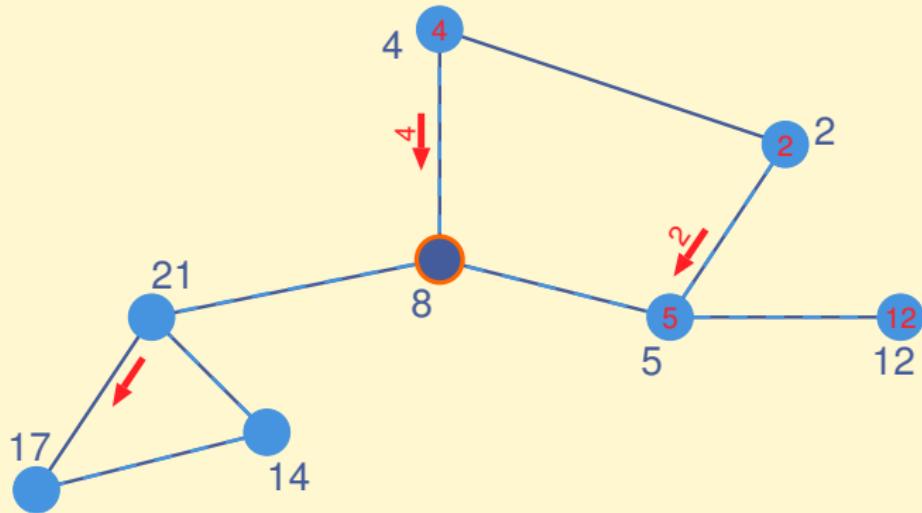
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

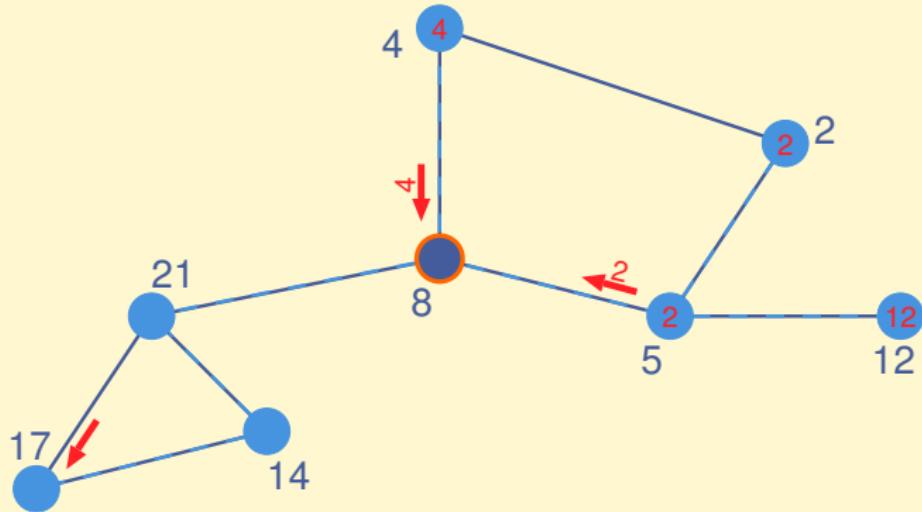
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

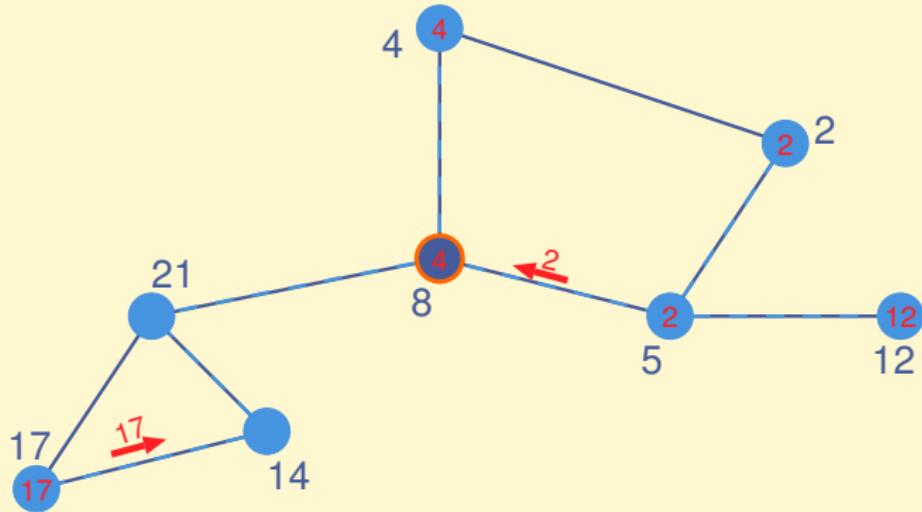
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

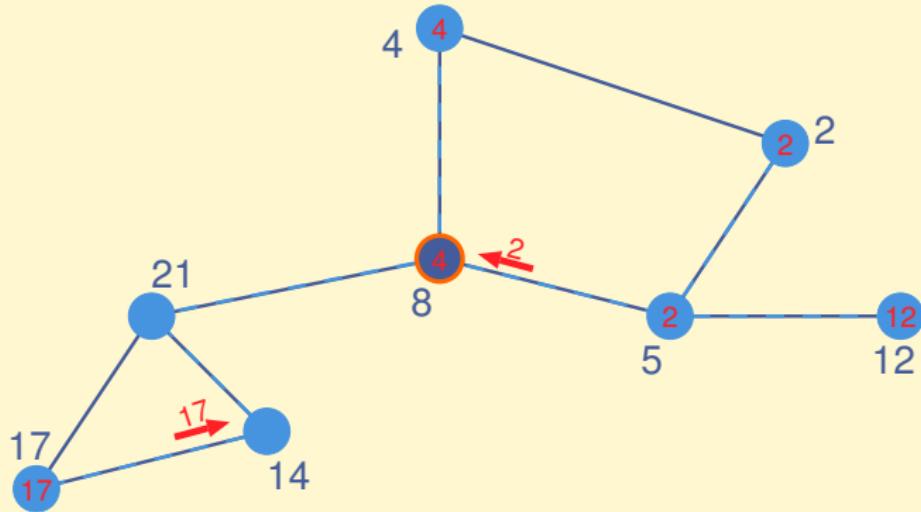
Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

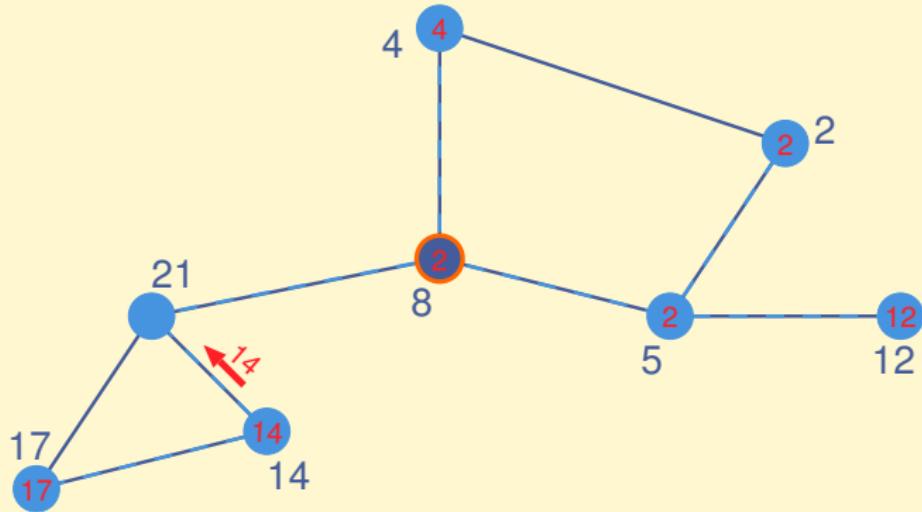
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

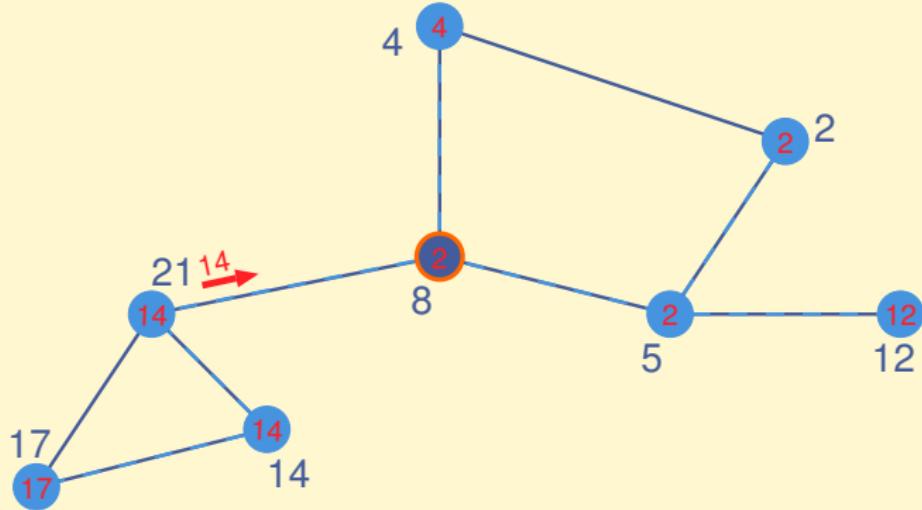
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

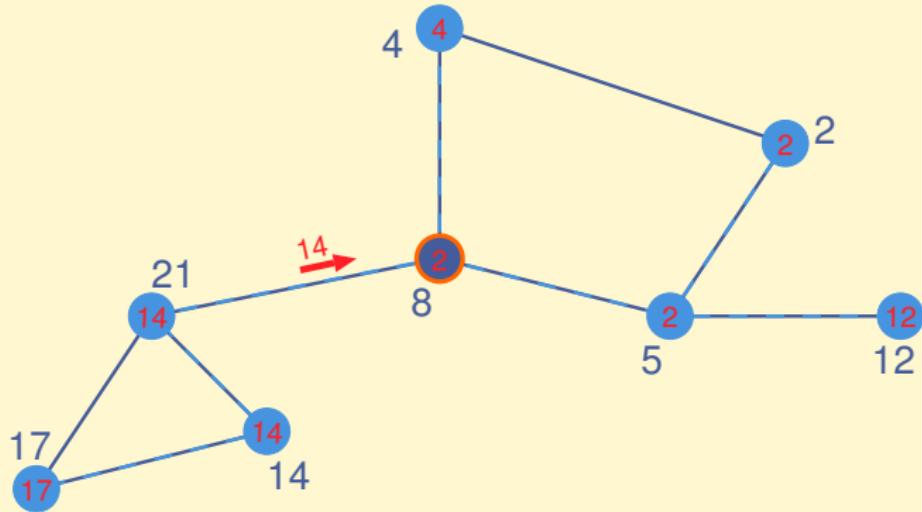
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

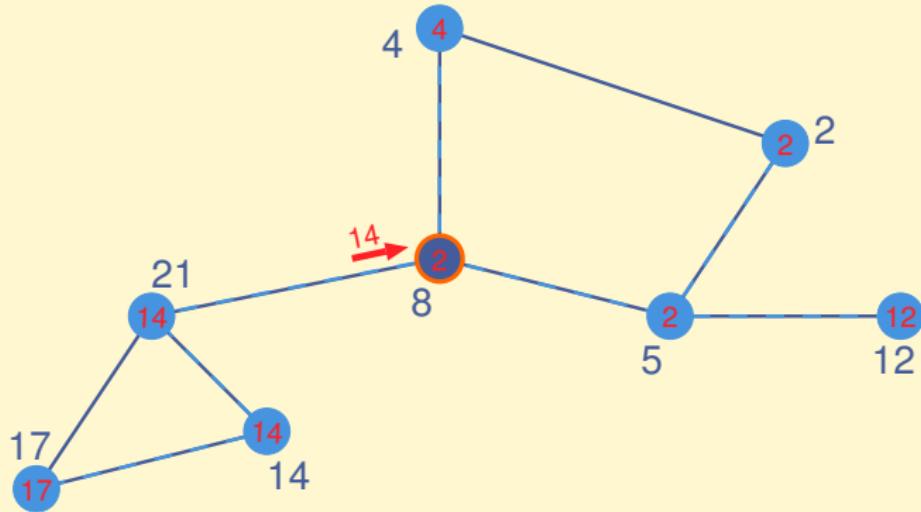
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Litterature : PIF

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

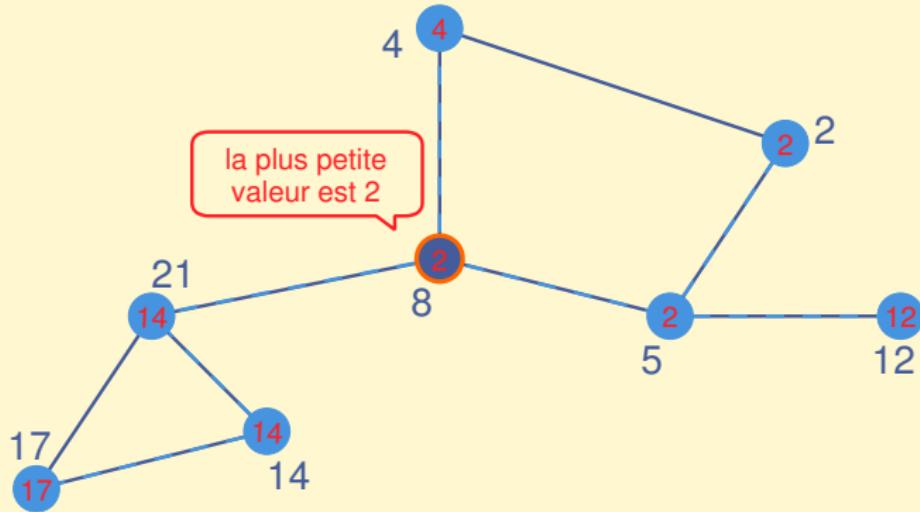
Distributed algorithm

Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Proposed architecture

- Start on some *initiators*
 - Any vehicle
Periodically, or on request (local/infrastructure)
 - Service vehicles
 - Road side unit
- Collect
 - Data in vehicles up to a given distance
 - Update of dynamic data
- Termination
 - Maximal duration
 - Stability of the result
- Result
 - Ordered by the distance to the initiator
 - Allow aggregation before exploitation
 - Local exploitation
 - Dissemination in the close neighborhood
 - Sending to the infrastructure...



Summary

1 Context

2 Data collection

3 Distributed algorithm

Local views

Algorithm

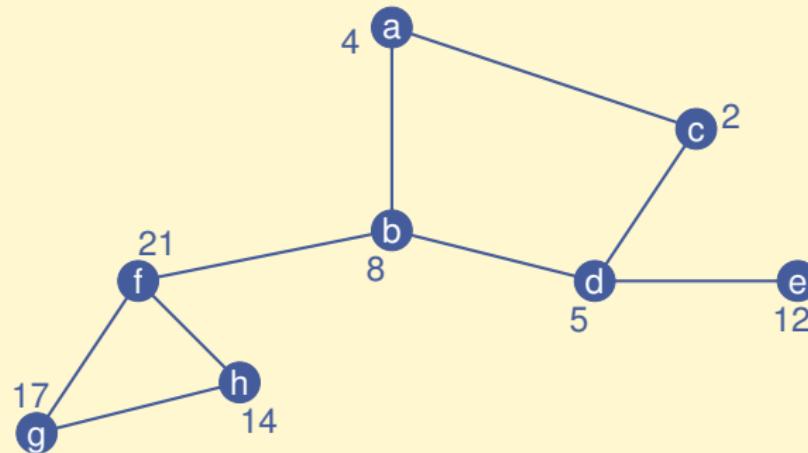
4 Experiments

5 Conclusion



Local view : definition

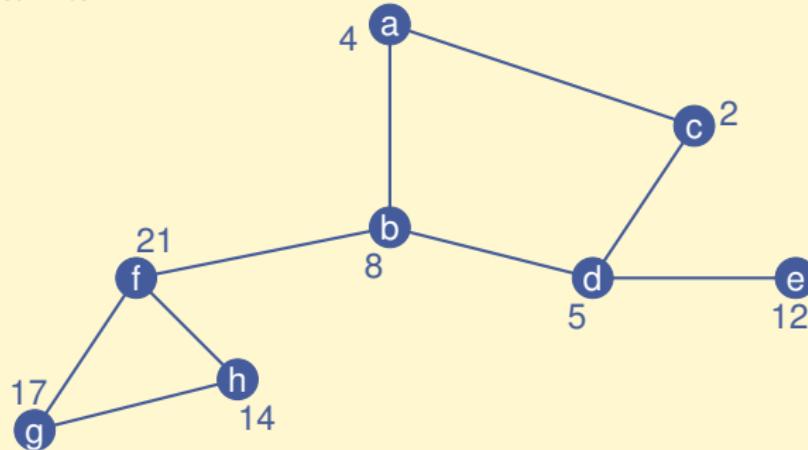
- Local view of a node :
lists of (node_id, local_data) ordered by the distance to the node



Local view : definition

- Local view of a node :
lists of (node_id, local_data) ordered by the distance to the node

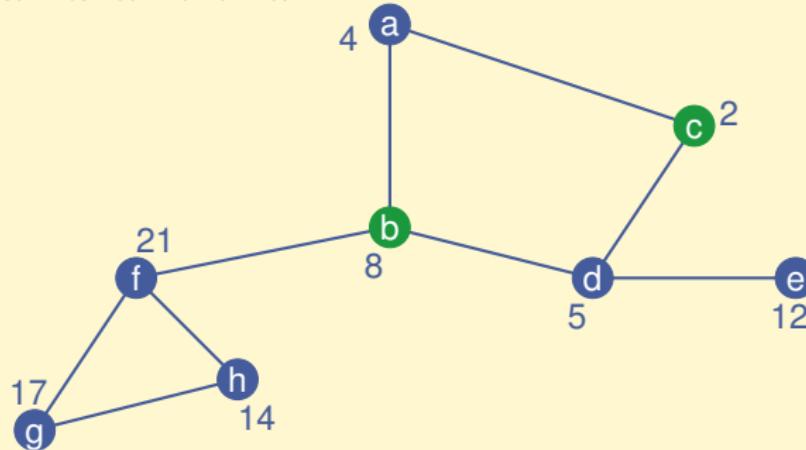
$\{(a,4)\}$



Local view : definition

- Local view of a node :
lists of (node_id, local_data) ordered by the distance to the node

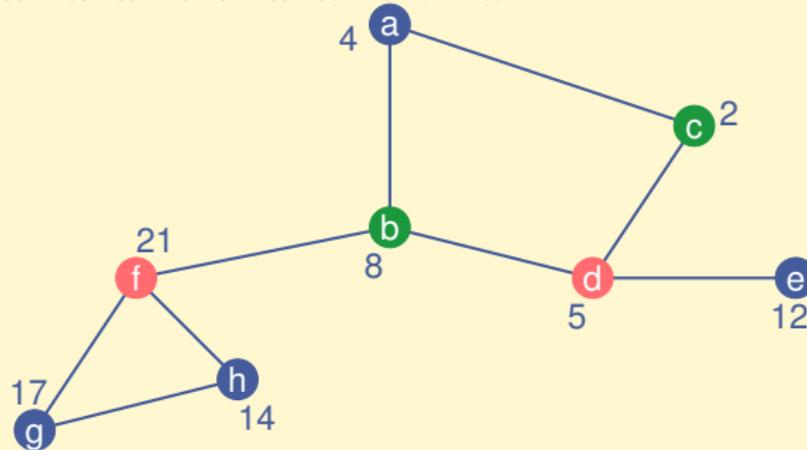
$\{(a,4)\}, \{(b,8), (c,2)\}$



Local view : definition

- Local view of a node :
lists of (node_id, local_data) ordered by the distance to the node

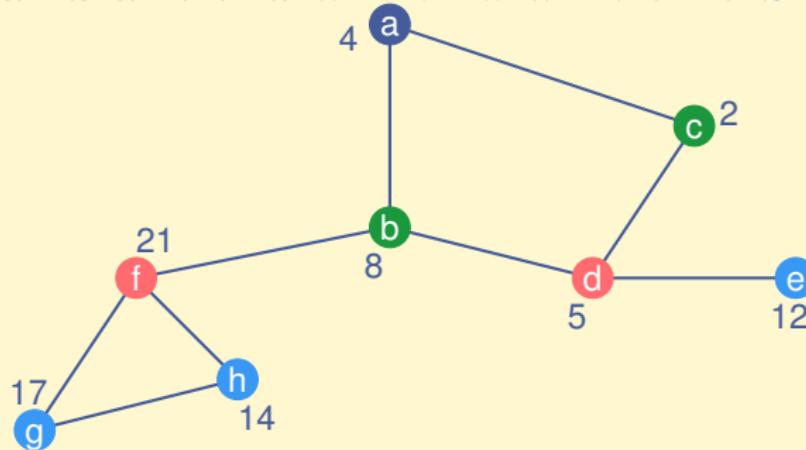
$\{(a,4)\}, \{(b,8), (c,2)\}, \{(d,5), (f,21)\}$



Local view : definition

- Local view of a node :
lists of (node_id, local_data) ordered by the distance to the node

$\{(a,4)\}, \{(b,8), (c,2)\}, \{(d,5), (f,21)\}, \{(e,12), (h,14), (g,17)\}$



Local view : operator ant

Data collection in Vanet

B. Ducourthial

Context

ITS
Scientific issues
Team
Contribution

Data collection

Taxonomy
Literature
Proposed architecture

Distributed algorithm

Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



- Views \mathcal{V}_1 and \mathcal{V}_2 :

$$\mathcal{V}_1 = \{(a, 4)\}, \{(b, 8)\}, \{(d, 5), (f, 21)\}$$

$$\mathcal{V}_2 = \{(c, 2)\}, \{(d, 5)\}, \{(b, 8), (e, 12)\}$$

- Shifting

$$\mathcal{V}_1 = \{(a, 4)\}, \{(b, 8)\}, \{(d, 5), (f, 21)\}$$

$$r(\mathcal{V}_2) = \{\}, \quad \{(c, 2)\}, \{(d, 5)\}, \quad \{(b, 8), (e, 12)\}$$

- Merging

$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8), (c, 2)\}, \{(d, 5), (f, 21)\}, \{(b, 8), (e, 12)\}$$

$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8), (c, 2)\}, \{(d, 5), (f, 21)\}, \{(e, 12)\}$$

- r -operator ant :

$$\text{ant}(\mathcal{V}_1, \mathcal{V}_2) = \mathcal{V}_1 \oplus r(\mathcal{V}_2)$$

↗ self-stabilizing distributed algorithm



Local view : example

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm

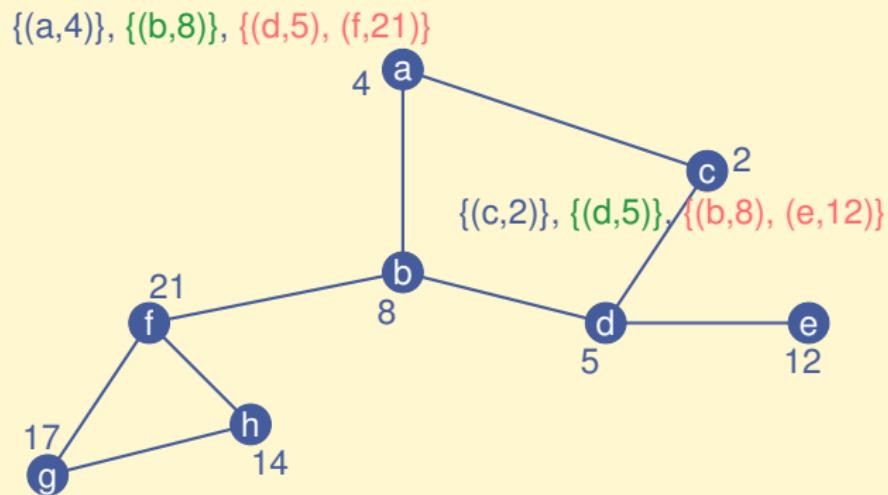
Local views
Algorithm

Experiments
Plateform Experiments
Results

Conclusion



$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8)\}, \{(c, 2)\}, \{(d, 5)\}, \{(f, 21)\}, \{(e, 12)\}$$



Local view : example

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

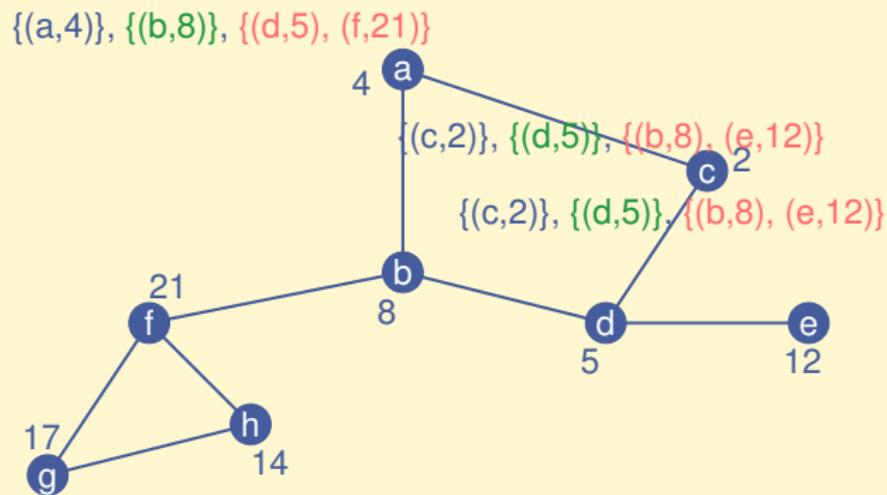
Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion

$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8), (c, 2)\}, \{(d, 5), (f, 21)\}, \{(e, 12)\}$$



Local view : example

Data collection in Vanet

B. Ducourthial

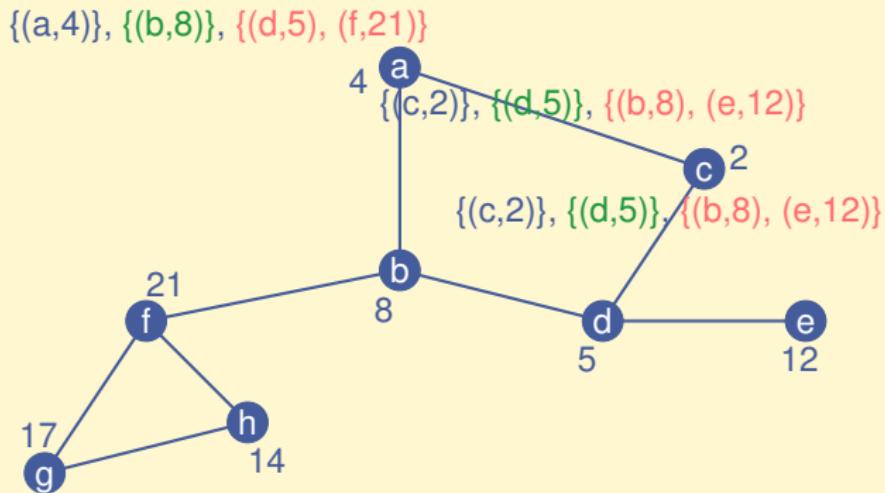
Context
ITS
Scientific issues
Team Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments
Plateform Experiments
Results
Conclusion

$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8)\}, \{(c, 2)\}, \{(d, 5)\}, \{(f, 21)\}, \{(e, 12)\}$$



Local view : example

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

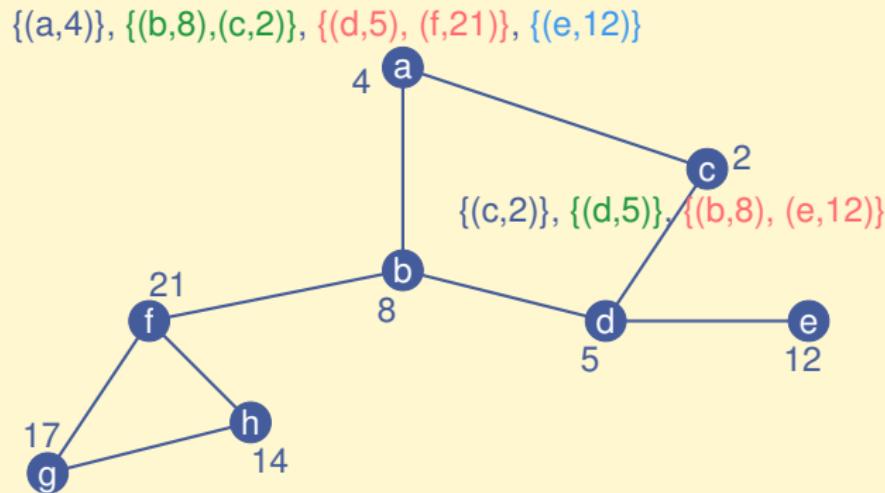
Distributed algorithm

Local views
Algorithm

Experiments
Plateform Experiments Results

Conclusion

$$\mathcal{V}_1 \oplus r(\mathcal{V}_2) = \{(a, 4)\}, \{(b, 8), (c, 2)\}, \{(d, 5), (f, 21)\}, \{(e, 12)\}$$



Algorithm : receptions

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results
Conclusion



Algorithm for message reception

receive(parameters, view)

if no current collect **then**

 Reset variables ; store the parameters

 Set the lifetime of the sender to maxloss

 Store the view of the sender

 Set the timer

else if message for current collect

 Set the lifetime of the sender to maxloss

 Store the view of the sender

else

 Drop the message

end if



Algorithm : timer expiration

Algorithm for timer expiration

Decremente the lifetime of each known neighbor

Reset any data of neighbors with lifetime=0

Update local_view with local data

for each view previously stored **do**

local_view \leftarrow ant(local_view, view)

end for

Truncate local_view to maxdst first elements

if local terminaison is false **then**

set the timer

send(parameters, local_view **)**

end if



Algorithm : terminaison

Data
collection in
Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Litterature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion



Algorithm for Local terminaison detection

```

if initiator  $\notin$  local_view then return true
count_dur  $\leftarrow$  count_dur + 1
if count_dur == maxdur then return true
if old_local_view  $\equiv$  local_view then
    count_stb  $\leftarrow$  count_stb + 1
else
    count_stb  $\leftarrow$  0
end if
if count_stb == maxstb then return true
return false

```



Summary

Data
collection in
Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data
collection
Taxonomy
Literature
Proposed
architecture

Distributed
algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results
Conclusion



1 Context

2 Data collection

3 Distributed algorithm

4 Experiments

Plateform

Experiments

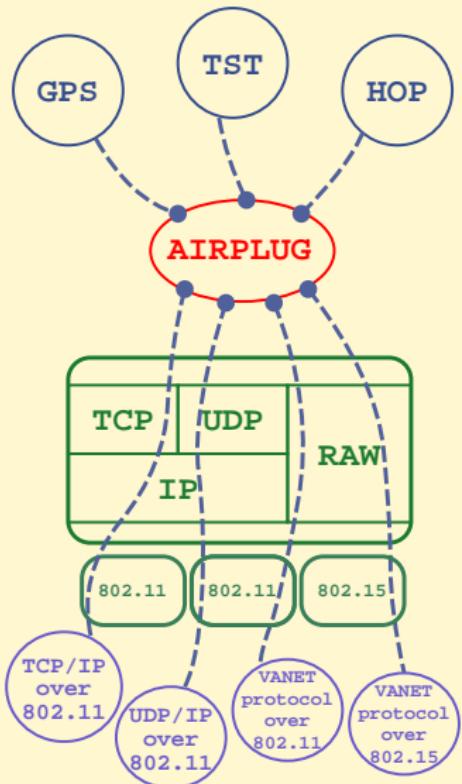
Results

5 Conclusion



Airplug architecture

Process-based architecture



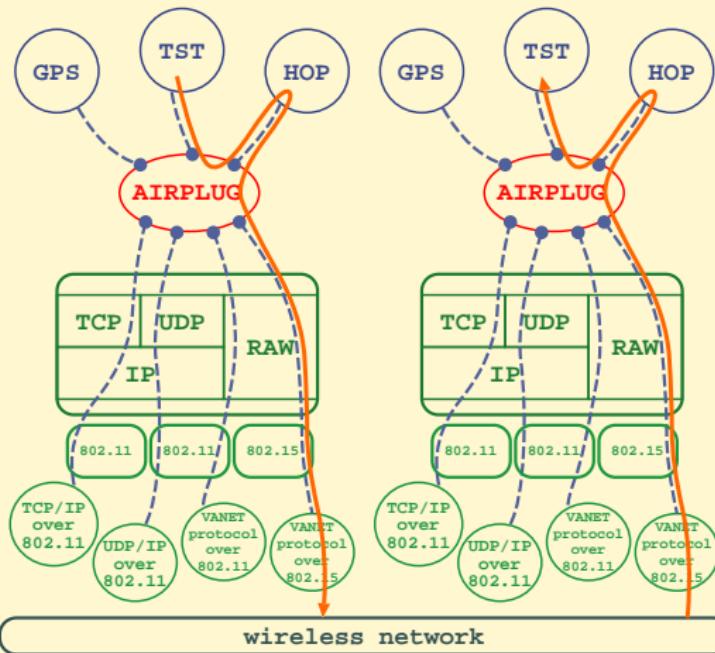
- Posix OS
- core program
 - user-space process
 - networking
- applications
 - user-space process
 - read on stdin
 - write on stdout
 - API close to IEEE WSMP
- ensure tasks and OS independence for robustness
- open to any programming language



Airplug architecture

Facilities for developing new protocols

- New protocols developed in user space processes
 - open to new networking solutions
 - cross-layer solutions facilitated



Complete research platform

- On the road : airplug-road [VTC 2009]
 - in Compiègne, France
 - in Michelin circuit, France
 - test-bed with 6 cars with France Telecom R&D
 - test-bed with 7 cars with France Telecom R&D
 - [see movie on-line
 - <http://www.hds.utc.fr/airplug>



Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
 - GPS position replaying
 - new trajectories derived \leadsto convoys
 - out of range messages filtered (soon)



Complete research platform

Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team
Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

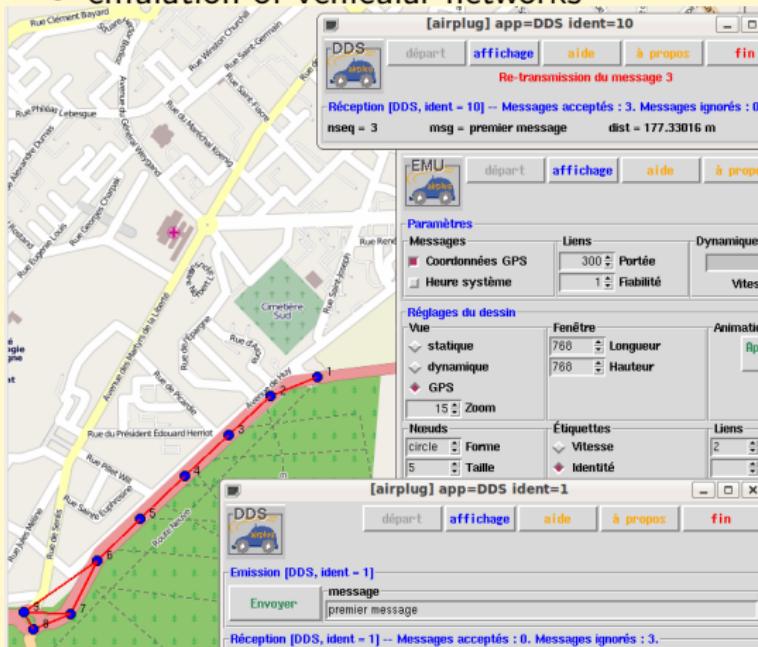
Distributed algorithm
Local views
Algorithm

Experiments
Plateform
Experiments
Results

Conclusion

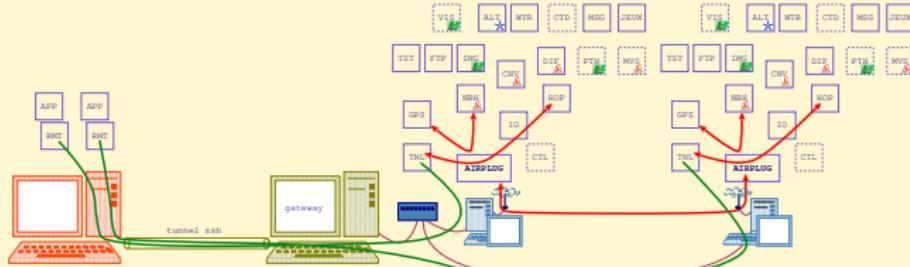


- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu
 - using shell facilities
 - emulation of vehicular networks



Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
- Remotely : airplug-rmt
 - a specific application controls remote access from external applications
 - portability of the applications transparent usage stand-alone / remotely / locally
 - heterogeneous vehicular networks emulation



Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

Data collection

Taxonomy
Litterature
Proposed architecture

Distributed algorithm

Local views
Algorithm

Experiments

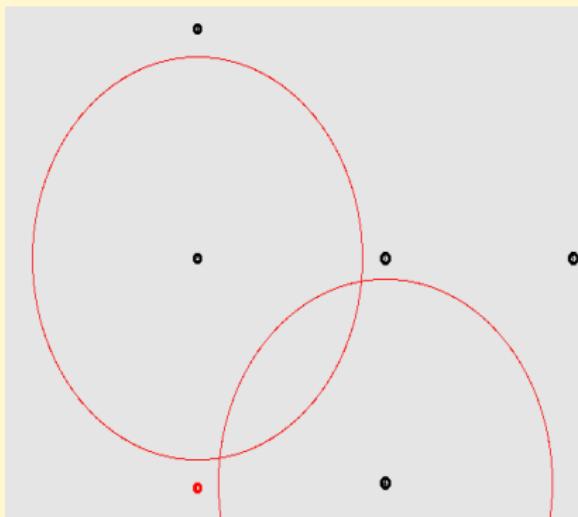
Plateform
Experiments
Results

Conclusion



Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
- Remotely : airplug-rmt
- In Network Simulator : airplug-ns [VTC 2010]



Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

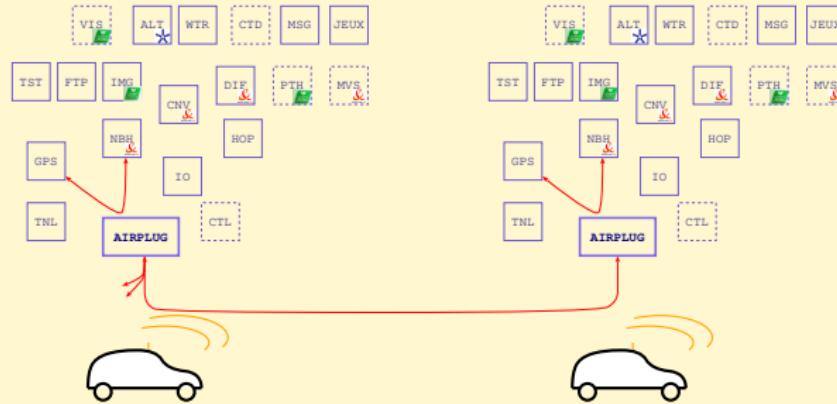
Experiments
Plateform
Experiments
Results

Conclusion



Complete research platform

- On the road : airplug-road [VTC 2009]
- In the laboratory : airplug-lab
- In a computer : airplug-emu [ICCCN 2010]
- Remotely : airplug-rmt
- In Network Simulator : airplug-ns [VTC 2010]
- In all these usages, the same codes are used



Data collection in Vanet

B. Ducourthial

Context
ITS
Scientific issues
Team Contribution

Data collection
Taxonomy
Litterature
Proposed architecture

Distributed algorithm
Local views
Algorithm

Experiments

Plateform
Experiments
Results

Conclusion



Experiments

- On the road

- 5 vehicles with Dell mini-9, Wifi devices and roof antenna
- Ubuntu 8.04, Airplug, GPS and COL programs embedded
- [see movie on-line
<http://www.hds.utc.fr/airplug>]

- By emulations

- 13 vehicles, series of 50 experiments
- Variations of the timer duration, the links robustness and the life duration of a neighbor





Results

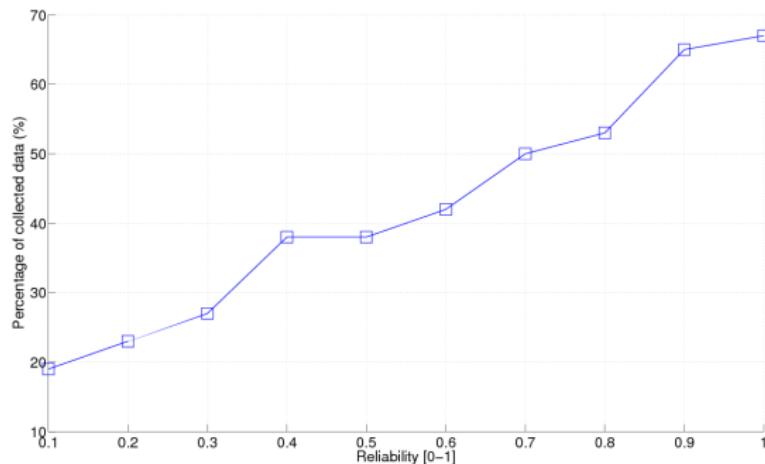
Summary

- Qualitative result
 - Success of the proof of concept
 - Support the network partitionning
- Quantitative results
 - ↗ link reliability \Rightarrow % collected data ↗
 - few influence of the timer duration
 - lifetime duration versus dynamic of the data and the network



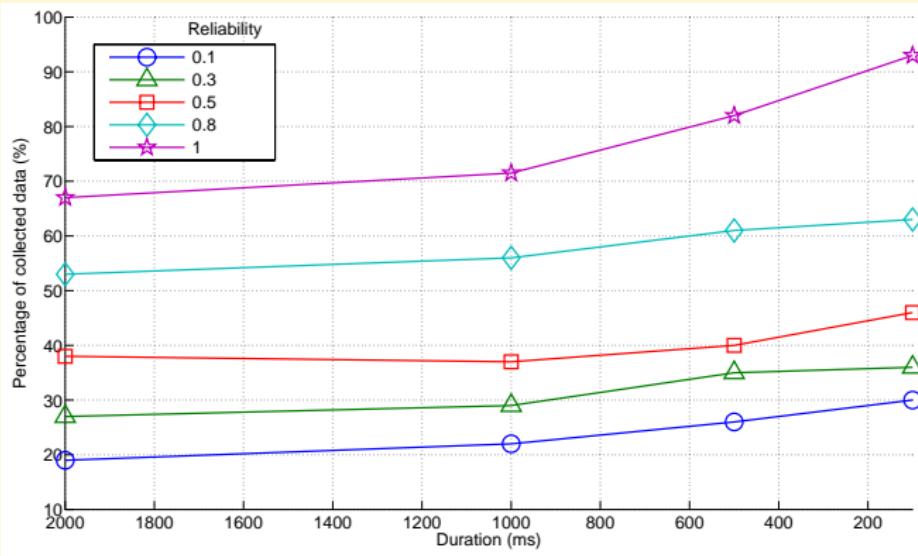
Results

Percentage of received data versus Link reliability



Results

Percentage of received data versus timer duration



Summary



Context



Data collection



Distributed algorithm



Experiments



Conclusion



Conclusion

- Problem

- Many data produced by vehicles
- Could lead to intelligent applications
- How to collect them ?

- Contribution

- Distributed algorithm COL
- Take into account of the bandwidth limitation
- Support the network dynamic
- Robust (self-stabilizing)

- Evaluation

- Implementation for Airplug
- Experiments on the road and by emulation
- Study of the parameters
- Interesting results obtained

[more on-line <http://www.hds.utc.fr/airplug>]

