

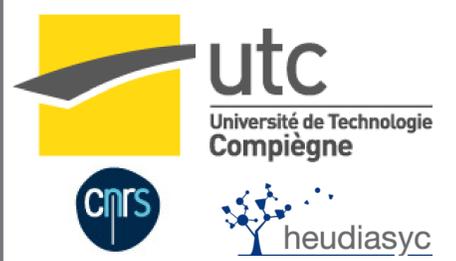
COL: a Data Collection Protocol for VANET

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Introduction

- ▶ Motivations
 - ▷ Many data produced in vehicles by embedded sensors, calculators...
 - ▷ Could feed intelligent transport applications
 - ▶ infrastructure, vehicle, driver oriented
 - ▶ **need to collect vehicles data**
- ▶ Problem to solve
 - ▷ Large amount of data
 - ▷ Limited network resources
- ▶ Contribution
 - ▷ Study of data collection in vehicular networks
 - ▷ Self-stabilizing distributed protocol (formal proof)
 - ▷ Implementation, tests and evaluation (proof of concept and perf.)

Literature

- ▶ Dissemination
 - ▷ 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 **for fixed networks** [SEG83]
 - ▷ Wave for MANET **for networks without partitioning** [CHE02]

Solutions for collecting data

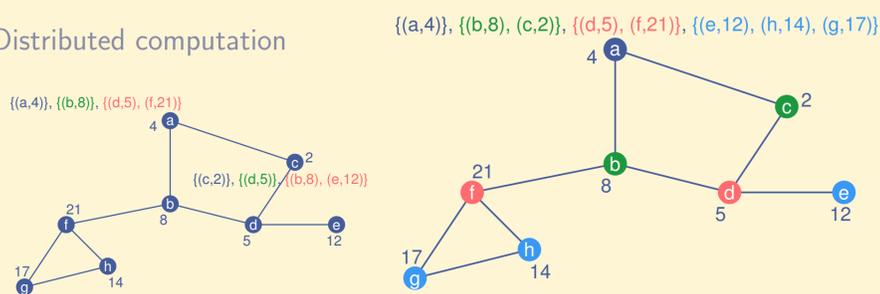
- ▶ Data production: local, time/geographic aggregation...
- ▶ Data sending: a single, some, all vehicles...
- ▶ Starting: push-based, pull-based...
- ▶ Ending?

Proposed architecture

- ▶ Start on some **initiators**
 - ▷ Any vehicle, periodically, or on request from the vehicle or the 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 view of a node

- ▶ Distributed computation



Example:

a owns {(a, 4)}, {(b, 8)}, {(d, 5), (f, 21)}

b sends {(c, 2)}, {(d, 5)}, {(b, 8), (e, 12)}

on a: shifting {}, {(c, 2)}, {(d, 5)}, {(b, 8), (e, 12)}

merging {(a, 4)}, {(b, 8), (c, 2)}, {(d, 5), (f, 21)}, {(b, 8), (e, 12)}

result {(a, 4)}, {(b, 8), (c, 2)}, {(d, 5), (f, 21)}, {(e, 12)}

- ▶ Conflict operator on the received data in case of collecting varying data such as speed
- ▶ **Self-stabilizing distributed algorithm**
 - ▷ Tolerate transient faults
 - ▷ Tolerate network reconfiguration (dynamic network)

The Airplug Software Distribution

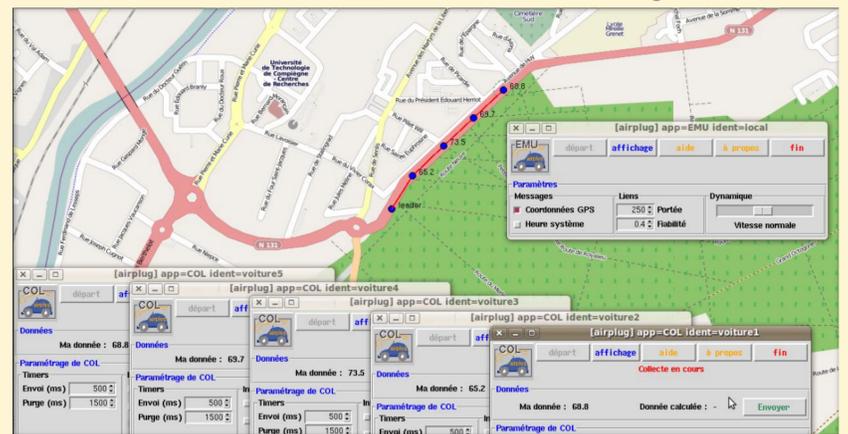
- ▶ Complete development environment for vehicular networks
 - ▷ Prototyping facilities using Airplug-term [ACM WIN-ITS 2007]
 - ▷ Vehicular network emulator using Airplug-emu [IEEE ICCCN 2010]
 - ▷ Road testbed using Airplug-live [IEEE VTC2009]
 - ▷ Remote access using Airplug-rmt
 - ▷ Embedded target computers using Airplug-notk
 - ▷ Network Simulator ns-2 compatibility using Airplug-ns [IEEE VTC2010]
- ~> **A single code used in many different situations, from the desk to the road**
- ▶ Architecture
 - ▷ Process-based architecture on top of POSIX OS
 - ▷ Core program named Airplug for the Airplug-live mode (road testbeds)
 - ▷ User-space process reading on stdin and writing on stdout
 - ▷ Specific or OS-supported networking facilities; cross layer facilities
 - ▷ Message passing API, close to IEEE 1609.3 WAVE WSMP
 - ▷ A Lego of more than thirty applications and protocols
- ~> Ensure tasks and OS independence for robustness
- ~> Open to any programming language

Experiments

- ▶ On the road A movie is available on-line <http://www.hds.utc.fr/airplug>
 - ▷ 5 vehicles with Dell mini-9, Wifi devices and roof antenna
 - ▷ Ubuntu 8.04, Airplug core, GPS and COL Airplug applications embedded

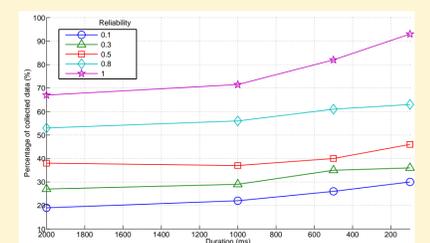
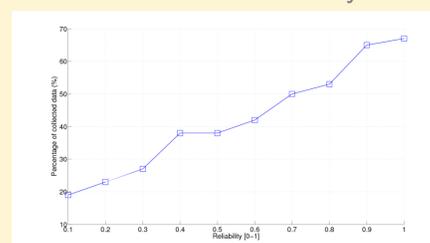


- ▶ By emulation A screenshot movie is available on-line <http://www.hds.utc.fr/airplug>
 - ▷ 13 vehicles, series of 50 experiments
 - ▷ Variations of timer duration, links robustness and neighbor life duration



Results

- ▶ Qualitative result
 - ▷ Success of the proof of concept, **support the network partitioning**
- ▶ Quantitative results
 - ▷ ↗ link reliability ⇒ % collected data ↗
 - ▷ Few influence of the timer duration
 - ▷ Lifetime duration versus dynamic of the data and the network



Conclusion

- ▶ Design, proof, test and study of a new self-stabilizing data collect protocol
- ▶ Fully operational solution, combined with an Internet gateway discovery protocol to upload aggregated data up to a server [ACM MobiWac 2010]