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Automatic System For Carpooling Proof Computation And Delivery

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Title	“Automatic system for carpooling proof computation and delivery”
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Description of the technical solution:

1) Background:

In the context of the “Mobility Orientation Law” edited by the French Government (http://www.assemblee-nationale.fr/dyn/15/dossiers/loi_orientation_mobilites), it will be possible for employer to support the travelling cost of their employees who use carpooling. To do so, they must rely on a mobility operator who can edit and provide a car pooling proof for these employees. This document aims at providing a solution to edit this carpooling proof.

This solution aims at providing a fully integrated solution avoiding at maximum any manual action and the use of GPS interface which is power consuming and may not be accurate enough in case of low battery or non-synchronization with satellites.

In addition, this solution relies on a non-deterministic algorithm which allows to estimate the likelihood of the occurrence of a carpooling transaction without the need of deterministic data such as the accurate location.

A carpooling proof for a mobility operator editing Class C proofs shall respect the following conditions:

L’opérateur certifie la mise en relation, les trajets des occupants du véhicule et une identité distincte des occupants.	Horodatage conducteur ET passager(s) Collecte identifiant device conducteur ET passager(s) Collecte position point A (conducteur) ET A’ (passager(s)) Collecte position point B (conducteur) ET B’ (passager(s))
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(Original requirement in French)

The operator certifies the linking, the journeys of the vehicle occupants and a distinct identity of the occupants	Timestamping driver AND traveler(s) collect identifiers of driver AND traveler devices collect A point position (driver) and A’ (traveler(s)) collect B point position (driver) and B’ (traveler(s))
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(English translation of the original requirement)

The purpose of this solution is to gather sufficient information from either the travelers, the wireless infrastructure and open data database so as to edit this proof without the use of the GPS location system. The basic principle is to consider two steps in the solution. For the first step, the solution

uses GPS technology for fine location tracking. Once the journey is recorded, it will calculate the likelihood a driver and her traveler will do the same journey based on “Cell Id” gathering and the proof they both driver and traveler move inside the same transportation mean. The embodiment below depicts the different element of the solutions and how they interact in a timely manner.

2) Detailed description of the solution:

➤ Users onboarding:

The solution provides a digital platform that enables the travelers to register all information necessary to perform the carpooling proof calculation.

Driver D1 registers her car C1 in the application, her address (HAD1) and the address of the place she works (WAD1). D1 also registers her mobile phone number PND1.

The platform calculates the different journeys J_i to link HAD1 and WAD1 and the mean duration to go from one point to the other. When registering the car, the mobility operator creates an entry in its database to record the car registration number. It associates an identifier, IdC1 which is the identifier that will be broadcasted by a BTLE (Bluetooth Low Energy) beacon made available to the driver. Hence the database associates the following information together: The car registration number C1, the driver and her home address and working address (D1, HAD1, WAD1) and the Beacon Identifier IdC1. Several solutions are supported:

1. The mobility operator programs the Beacon and sends it to D1. It is up to the driver to put it in her car C1. In case the driver has several cars or if in the informal carpooling agreement between driver and traveler both carpoolers use alternatively their own cars, it is possible to keep using the same beacon thanks to the following procedure.
 - Driver D1 and traveler T1 have means either on a platform portal or through the mobile application executing the system to declare a new vehicle with its registration number.
 - When creating a new vehicle entry on the platform, the driver indicates the serial number of the Beacon. The backend will then make the new association between IdC1 and the new registration number.
 - When creating the new vehicle with the mobile application, this latter uses the smartphone Bluetooth interface to read through the RF (Radio Frequency) protocol the IdC1 and sends automatically the identifier to the backend together with the new registration number.
 - The active association between IdC1 and the real car during a carpooling instantiation is made either manually or automatically.
 - i. If there is only one car registered per carpooler, the car associated to the Beacon is the one owned by the first carpooler entering the car, i.e. whose mobile application read the Beacon identifier and reports this reading to the backend.
 - ii. If there are several cars registered for the first carpooler entering the vehicle or if this is the manual procedure which is chosen by travelers to be always

performed, the mobile application will ask the driver to select the car used among the list of declared vehicles.

2. An alternative solution is to avoid the use of a hardware device as Bluetooth Beacon and to use the Bluetooth capability of the driver smartphone. When entering the driver's car C1, the mobile application of traveler T1 reads the identifier of the beacon mimics by the driver's mobile application and reports it to the backend. The driver's mobile application had previously reported this identifier, enabling the backend platform to validate the proximity between both mobile phones.
3. If the car has Bluetooth capability, the car will act as a beacon and the mobile application, once the mobile phone connected to the car Bluetooth endpoint, will read the car Bluetooth identifier IdC1 and requests the driver to manually confirm the association of the vehicle registration number/Beacon identifier/Driver identity triplet
4. In case it becomes possible in the mid-term to access remotely to the vehicle Bluetooth equipment through open API (Application Program Identifier) published by the car manufacturers, the mobility operator will then be able to read remotely the identifier of the Bluetooth system of the driver car.

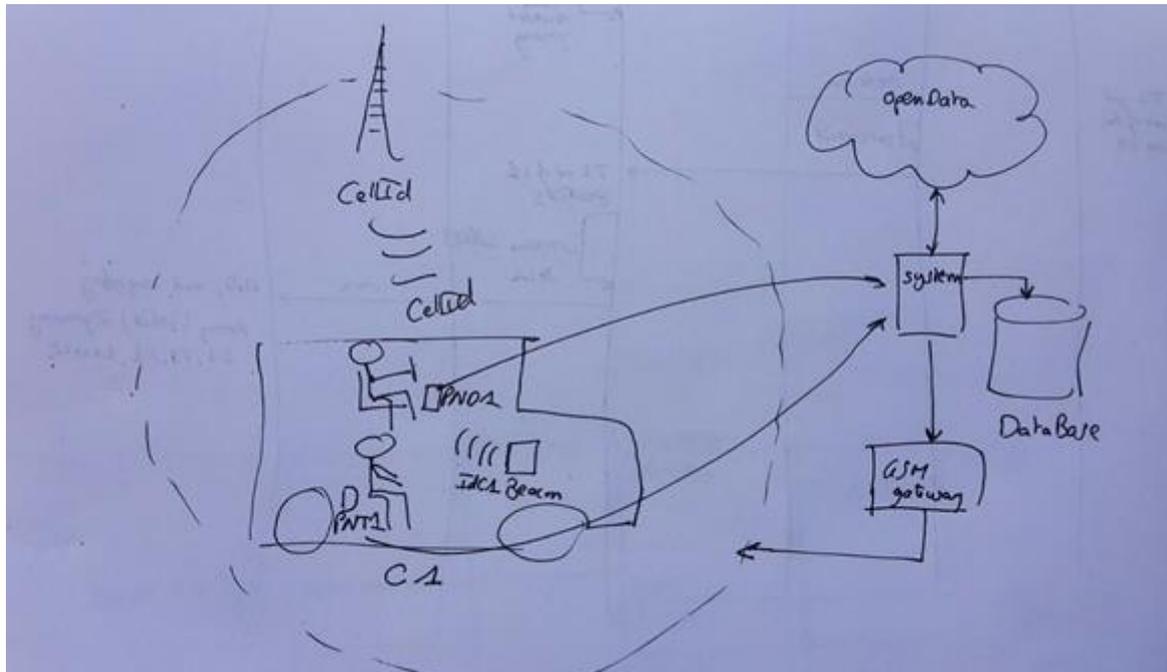
Traveler T1 registers also her address HAT1 and her work address WAT1 as well as her mobile phone number PNT1.

The objective of the solution is to calculate a carpooling evidence which is a proof that D1 and T1 used the same car C1 at the same time to go from one geographical location situated between HAD1 and HAT1 and WAD1 and WAT1.

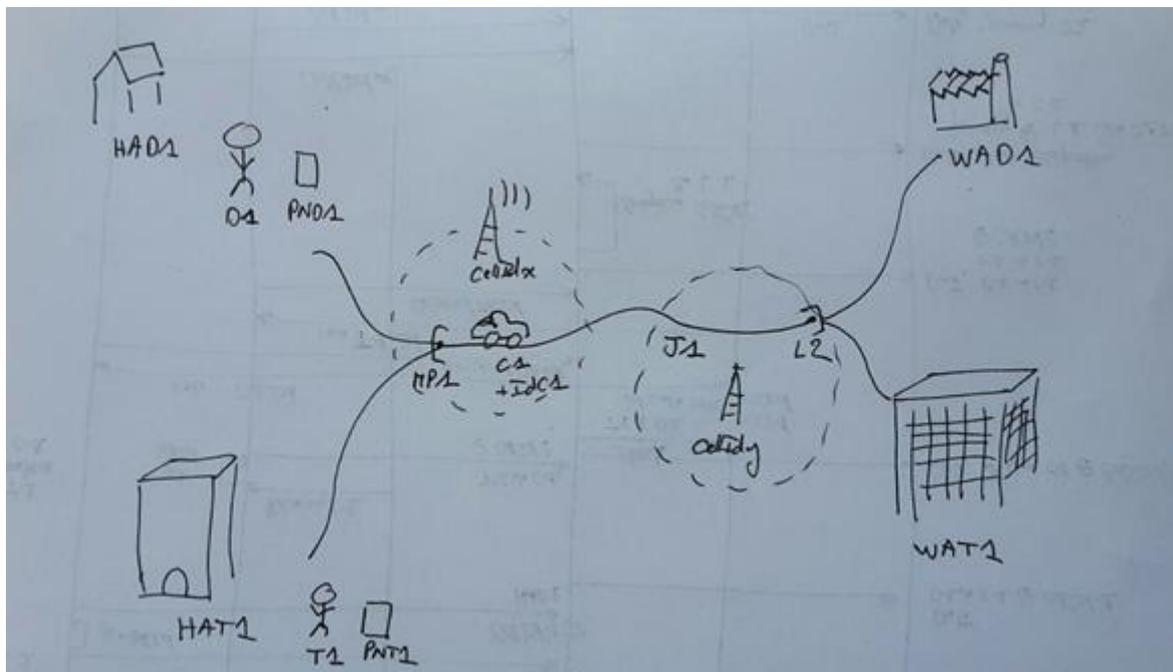
The proof is validated if the following hypothesis are true.

- D1 and T1 are in the same car C1 at a time T_s considered as the start of the journey
- D1 and T1 are in the same car C1 at a time T_e considered as the end of the journey
- The place L1 where the car C1 is located at time T_s is on one of the possible way J_i linking addresses HAD1, HAT1, WAD1, WAT1.
- The place L2 where the car C1 is located at time T_e is on one of the possible way J_i linking addresses HAD1, HAD2, WAD1, WAD2.
- D1 and T1 are in the same car during the whole journey between L1 and L2.

➤ **Description of the overall system:**



Embodiment description:



Scenario 1:

D1 get out of her house at HAD1. She enters her car and drive at point MP1 where she meets T1. T1 enters in car D1. They both indicate a beginning of a carpooling journey. The system records MP1 as L1. The system verifies that D1 et T1 are in a car heading to their work places.

☞ **First Question:** How to verify that D1 and T1 are in a car moving towards their workplace?

- The car detects the presence of D1 and T1 through a short-range radio interaction between one device attached to the car and two devices owned respectively by D1 and T1. As D1, T1 and C1 are able to communicate within this small area, that means they are at the same place. It does not prove that they are on their way to their workplace. Alternative solutions are also described above when depicting the registration procedure to associate beacon identifier, car registration number and user identity.
- D1 and T1 are located at the same place thanks to an overall positioning infrastructure such as GPS. Their position is on a route between HAD1/HAT1 and WAD1/WAT1.
- Having the position of a device does not mean having the position of a person. To check if the identity of both travelers, one can imagine having a SMS (Short Message Service) gateway sending a well-tailored message to both devices when signaling their carpooling start. The content of the message is extracted by an app on the device and forwarded to an identity controller that will check the match between the identity of the phone owner the mobile device running the app.

They drive a certain amount of time depending on the traffic on one of the itinerary consistent to reach WAD1 and WAT1. T1 and D1 split at L2, indicating the end of the carpooling journey. L2 could be equal to WAD1 and WAT1 in case WAD1 and WAT1 coincide. The system records the journey (J1) = Time duration T1, route R1, travelers, car identifier. The route R1 is recorded in an array of locations measured thanks to GPS coordinates. Hence the route R1 array could be formatted like this:

Route R1 = Array[Lx] where Lx = (dateX, GPS coordinate (latitudeX, longitudeX), CellIdX) where

- DateX is the absolute date at which D1 and T1 have been located at latitude/longitude
- GPS Coordinates are captured by D1 or T1 mobile phone regularly (configurable period depending on the journey duration) and uploaded to the system once measured.
- CellIdX is the identifier of the cellular cell recorded by D1 and/or T1 mobile phone at the same time of the GPS coordinates and uploaded embedded in the Lx data toward the system.

A correlation could be done between the cellular zone identified, the routes crossing these zones and the itinerary calculated between HAD1 and WAD1 and HAT1 and WAT1.

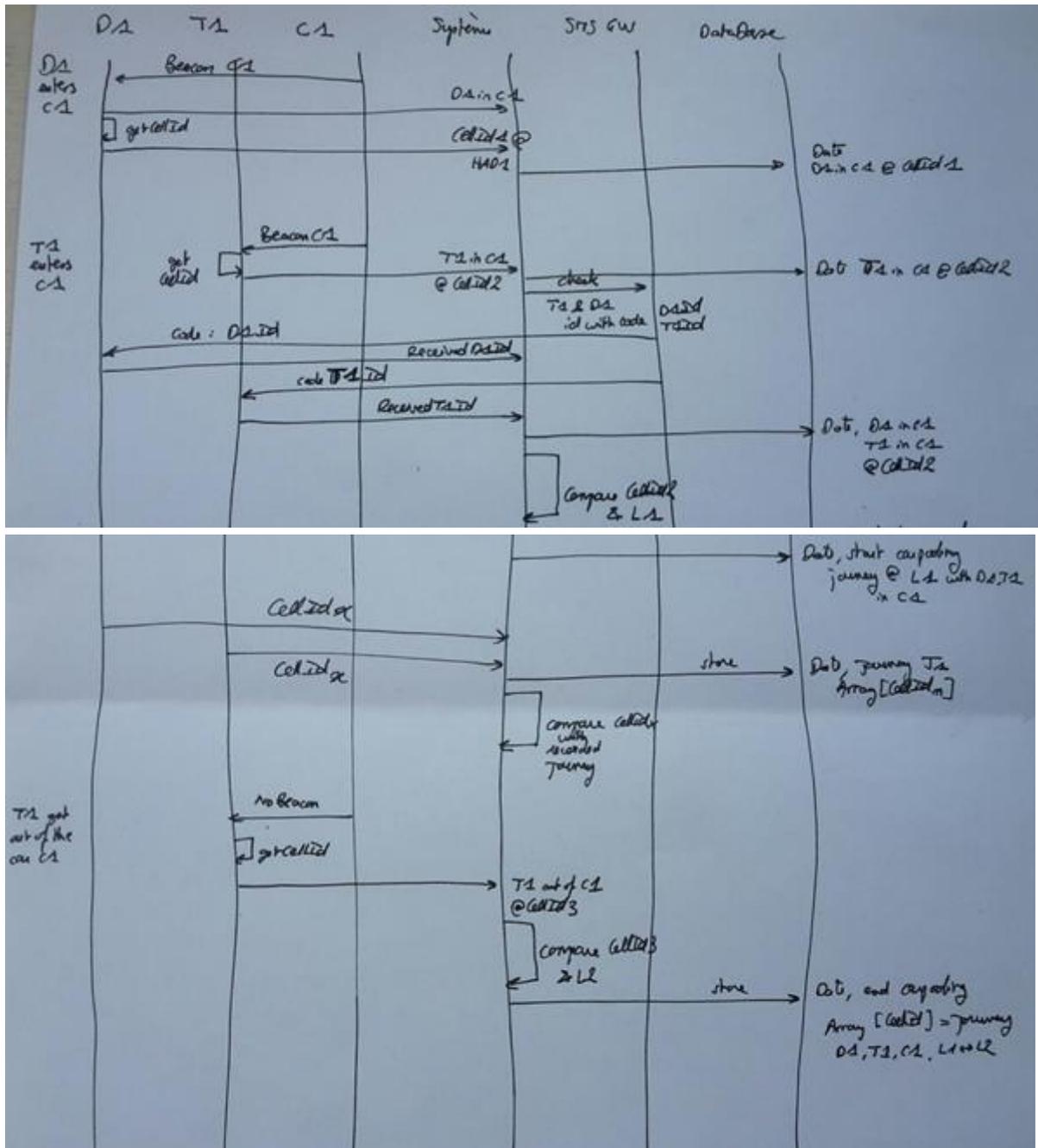
☞ **Second Question:** How to check that D1 and T1 have split at that point L2?

- D1 and T1 work at the same place. When D1 and T1 split, they enter the workplace building and the access management record their entering. Both travelers have to check-in the same day to validate a carpooling transaction. At least only one of the traveler has to check-in within a reasonable delay after the split.

Scenario 2:

Journey J1 is known by the system. D1 and T1 meet at L1. When entering the car, each of application of D1 and T1 detects the beacon in the car. The status is sent and stored in the system with the value "In the car" or "Out of the car". When both travelers D1 and T1 are detected as "In the car", that triggers a location check, each application being controlled such as measuring its rough location using recording of the cell identifier. It is not necessary to do a correlation between the cell identifier and the actual location as the checking will be done between the cell identifiers detected and the cell identifier stored during the recording of J1 in array R1.

Sequence diagram for scenario 2:



Additional data of interest:

The underlying principle of the solution is to use an aggregation of various data to estimate the carpooling likelihood. We describe here a list of this relevant data and how they could be processed:

- Time at which the data is collected
- Mean journey duration
- Cellular relay where the phone is connected to
- Open Data giving location of the cellular relay
- Public/private Wi-Fi (Wireless Fidelity) network that the phone is detecting

- Accelerometer used to estimate speed and directions
- Image recognition
- Synchronization of separate actions performed by two different users

Processing:

The cellular relay identifier gives hints about the zone where the traveler mobile device is. This zone has to be consistent with the calculated route between home and work addresses.

The cellular identifiers collected by mobile phone of travelers have to be consistent at a given time once the journey has started. Either it is the same identifier or the cellular relays are located in the same area. This will be controlled by accessing to open database.

The use of both accelerometers of mobile phone travelers must show consistent measurements (acceleration and deceleration at the same time). In addition, the duration of the journey could be estimated by this mean and compared to the duration calculated on the itinerary and traffic condition basis.

End of Document