xDash : RAPID-PROTOTYPING OF CYBER-PHYSICAL SYSTEMS IN WEB BROWSER

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14th MODPROD Workshop 2020; Linköping; Sweden

OUTLINE

- Context and motivations
- xDash : principles and features (+ demo)
- Some use-cases
- Conclusions and perspectives

CONTEXT : IFPEN RESEARCH ON CONNECTED MOBILITY

- Eco-driving coaching (for truck fleet fuel reduction)
- Energy management (for hybrid or electric vehicle optimal battery use)
- CO2 footprint and Total Cost of Ownership (TCO) of a car based on usage questionnaire (for helping new car purchase decision)
- Cycle road network qualification using crowdsensing (for bike GPS app development)
- Pollutant emissions estimation (how driving style impacts real-driving emissions)

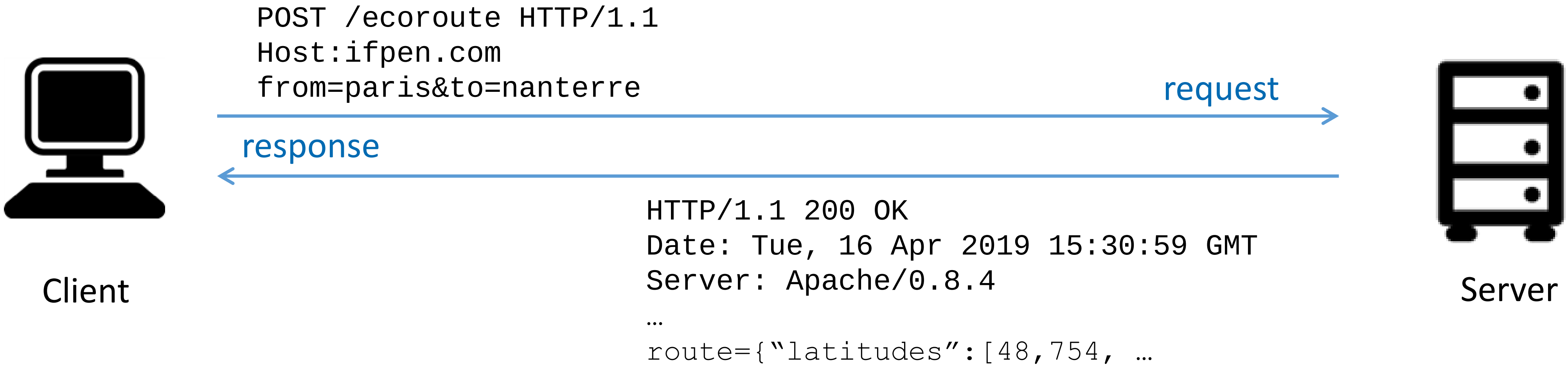
→ **Algorithms deployed as web-services**

GENERAL CONTEXT : CONNECTED MOBILITY & WEB-SERVICES

- Connected vehicle : typical example of Cyber-physical system
- In our context, from a software engineering point of view
  - Vehicle-to-infrastructure (V2I) communications rely on web-services (over HTTP protocol)
  - Web-services follow microservices architectural principles (Service Oriented Architecture)
- Web-services bring new optimization parameters
  - At design phase
    - Open, community or company data access or query as web-service
    - Examples : road accidentology or pollution measures history, public bike stations, public transport theoretical fares …
  - At operation phase
    - Live information about weather, traffic, routes, pollution is available from web-services …
    - Use by real-time control algorithms (EMS, BMS, ECU) or on on-board display for driver …
- Mobility as a Service paradigm shift

WHAT IS A WEB-SERVICE ? (IN CONNECTED MOBILITY CONTEXT)

- It is a (stateless) function (in the sense of compute science) running on a server
- Software interface is based on HTTP protocol over TCP/IP (core Internet Technology)
- Can be extended to run simulation as a web-service (adding state for long runs)



```
POST /ecoroute HTTP/1.1
Host:ifpen.com
from=paris&to=nanterre
```

```
HTTP/1.1 200 OK
Date: Tue, 16 Apr 2019 15:30:59 GMT
Server: Apache/0.8.4
…
route={“latitudes”:[48,754, …
```

STATE-OF-THE ART

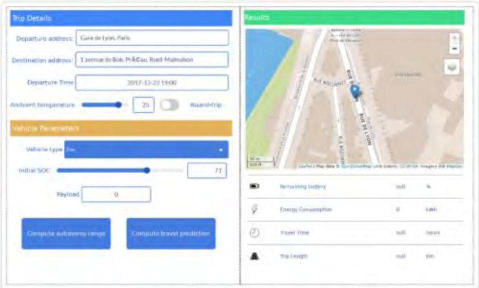
- Most programming languages or frameworks have libraries for calling web-services
- Many tools exist for the unit testing of web-services, such as Postman or SoapUI, but purely from software engineering point of view
- To the best of our knowledge, no cyber-physical system level tool exist for testing aggregation of web-services
    - With scientific or technologic oriented data interaction and visualization
    - With connection to simulation & scientific computation (Python)
    - With real-time execution capabilities
    - Closest tool was freeboard.io

⇒ **Need for a cyber-physical systems-level web-services aggregation and dashboarding tool**

CONCEPT

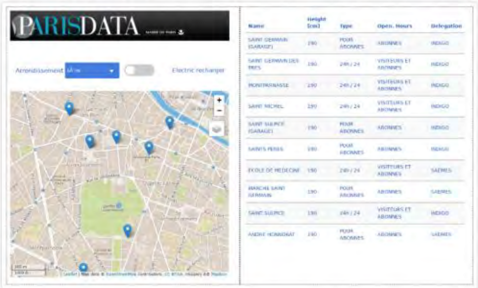
- xDash allows technicians, scientists or engineers, not specialists in web technologies, to build their own web applications to answer these questions autonomously

Electrical mobility range



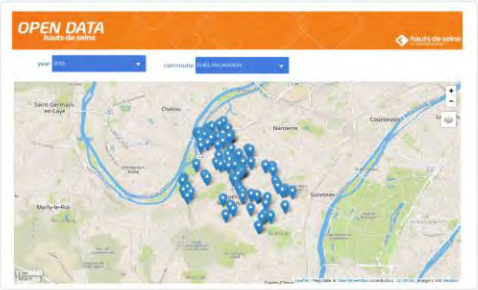
Select your departure address, your electric vehicle brand, your departure date, the weather conditions, your battery state of charge and eventually your extra load. Get average and conservative estimation of your electrical mobility range. Get the energetic characteristics of your trip

Parkings in Paris



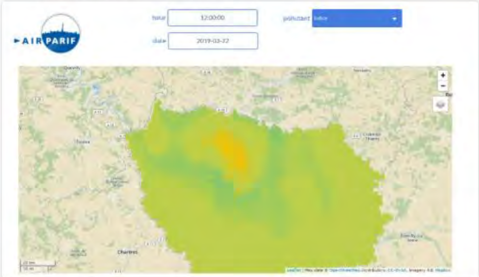
Select the Paris "arrondissement", whether electric recharger is needed. Paris open data about parkings is illustrated

Accidents in Hauts-de-Seine (92)



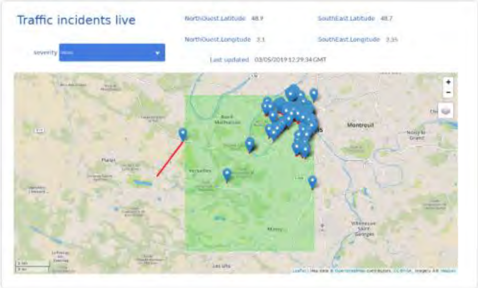
Location and description of road accidents in the Hauts-de-Seine (92) department from 2014 to 2016

Airparif map real-time



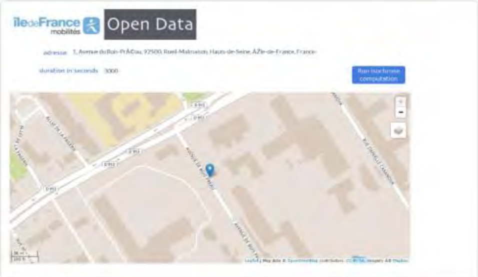
Select the date and the hour, and get pollution map of the Ile-de-France region (pollution index, NO2, O3, PM10 and PM25)

Traffic incidents live



Select a latitude/longitude box, and criticality value, to get updated about traffic incidents in that area

STIF isochrones



Fill an address, and a maximal trip duration. STIF webservices will compute the isochrones around that position

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INSTITUT CARNOT
IFPEN Transports Energie

BASE CONCEPTS

- JSON variable

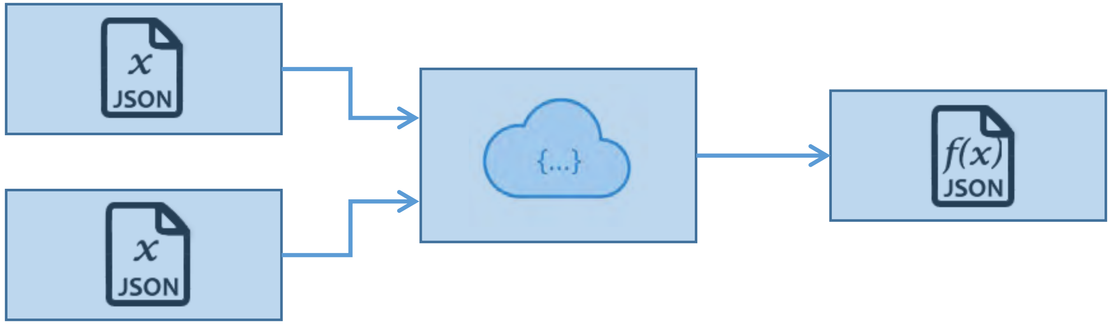
```
{
    "x": [0, 1, 2, 3 ,4],
    "y": [0, 1, 4, 9 , 16],
    "rectangle" : {
        "longueur": 1.23,
        "largeur": 5.5
    },
    "message": "Success"
}
```

- *datasources* keyword in scripts
  - Specifies a data dependency
  - Specifies an execution order dependency

- Datasources (operations)
  - Are stateless
  - May have input, always have one output
  - Have a status
    - None : never executed
    - Pending : is being executed
    - OK : successful execution
    - Error : error reported when executed
  - May have an execution period
- xDash keeps truck of a workspace of JSON variables corresponding to latest datasources successful evalution

EXECUTION ENGINE

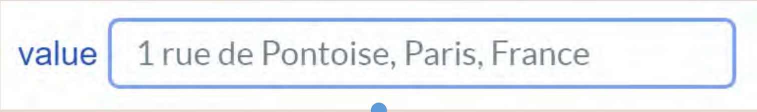
- Synchronous-reactive language
- Direct acyclic graph
  - Vertices : operations
  - Edges : data dependencies
- Data flows are JSON variables



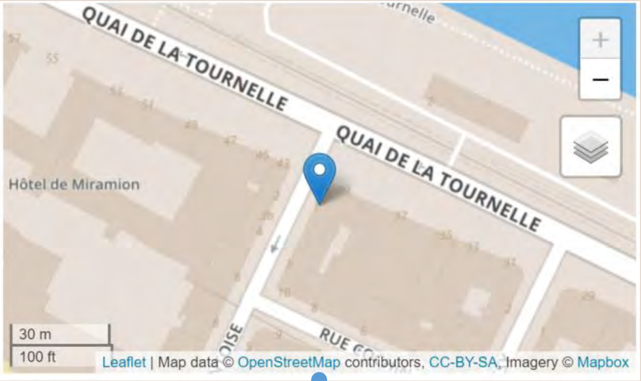
- Execution rules
  - Datasource is executed if and only if all its predecessors completed their execution with status *OK*
  - Every time a datasource is successfully computed (status "OK"), it triggers the execution of all its successors
  - Graph execution is interrupted at datasources with status *Error* : their successors are not executed
- Similar concept as Simulink or Synchronous Modelica, but runs on a web-browser

SIMPLE EXAMPLE : GEOCODING VISUALIZATION

Widgets



value 1 rue de Pontoise, Paris, France

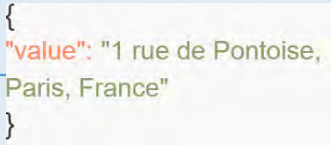


Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

address

Type : JSON variable

Category : datasource

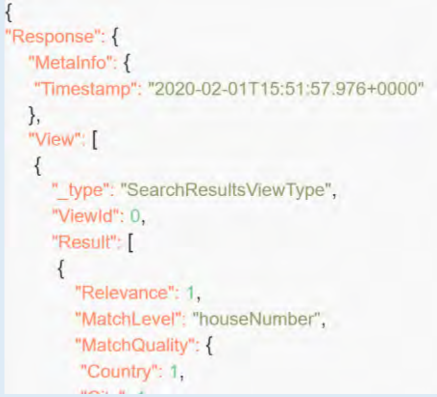


```
{
"value": "1 rue de Pontoise,
Paris, France"
}
```

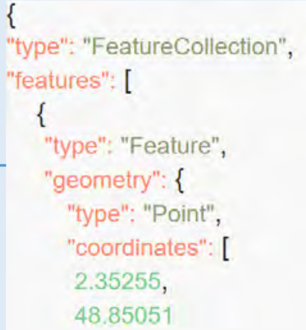
geocode

Type : REST Web-service

Category : datasource



```
{
"Response": {
   "MetaInfo": {
    "Timestamp": "2020-02-01T15:51:57.976+0000"
   },
   "View": [
    {
      "_type": "SearchResultsViewType",
      "ViewId": 0,
      "Result": [
       {
         "Relevance": 1,
         "MatchLevel": "houseNumber",
         "MatchQuality": {
          "Country": 1,
```



```
{
"type": "FeatureCollection",
"features": [
   {
    "type": "Feature",
    "geometry": {
      "type": "Point",
      "coordinates": [
       2.35255,
       48.85051
```

to GeoJSON

Type : JS Script

Category : datasource

datasources

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DATASOURCE CATEGORIES

Base functions

- JSON Variable
- Web-service REST
- Python Script
- JS Script

Mobility

- Map-matching
- Trip conversion

IoT & real-time

- Clock
- MQTT
- Websockets
- Geolocation

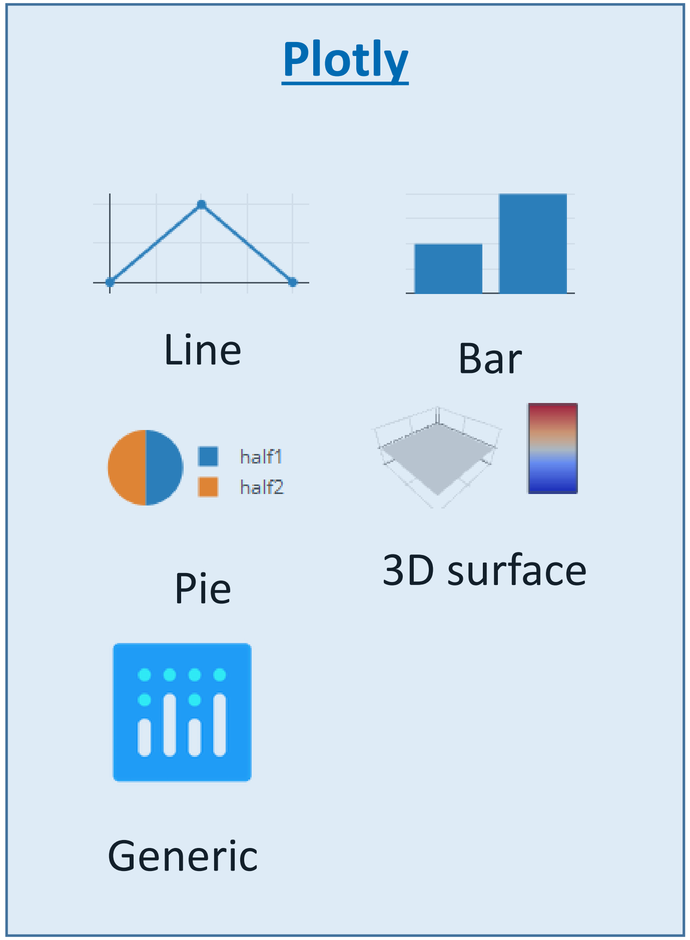
Transversal

- FMI simulation

Files

- CSV Reader
- CSV Player
- Generic reader

WIDGETS



Plotly

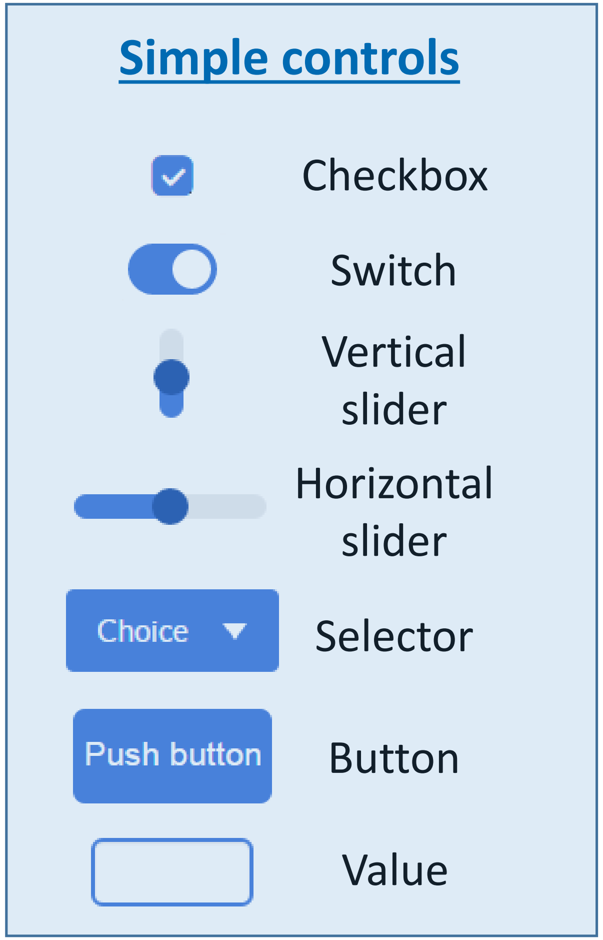
Line

Bar

Pie

3D surface

Generic



Simple controls

Checkbox

Switch

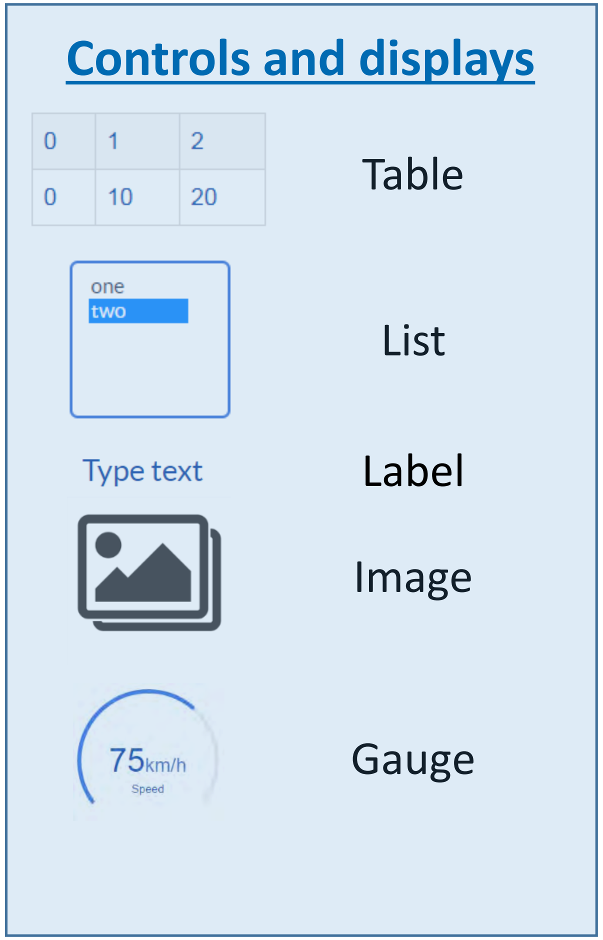
Vertical slider

Horizontal slider

Selector

Button

Value



Controls and displays

0	1	2
0	10	20

Table

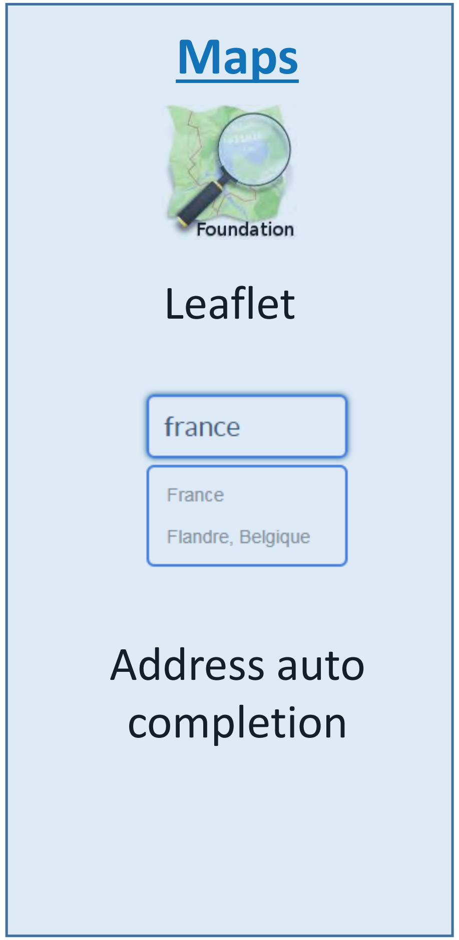
List

Type text

Label

Image

Gauge



Maps

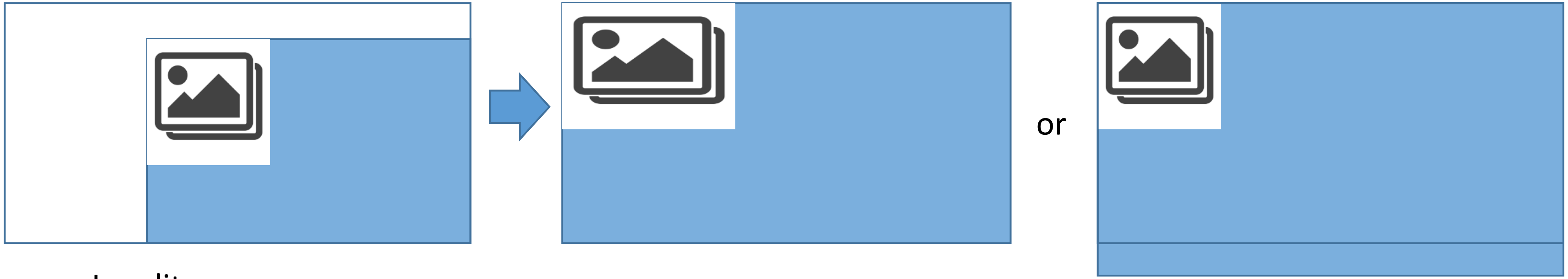
Leaflet

Address auto completion

RESPONSIVE DASHBOARDS

- « Bootstrap » rows and columns

- Scaling methods



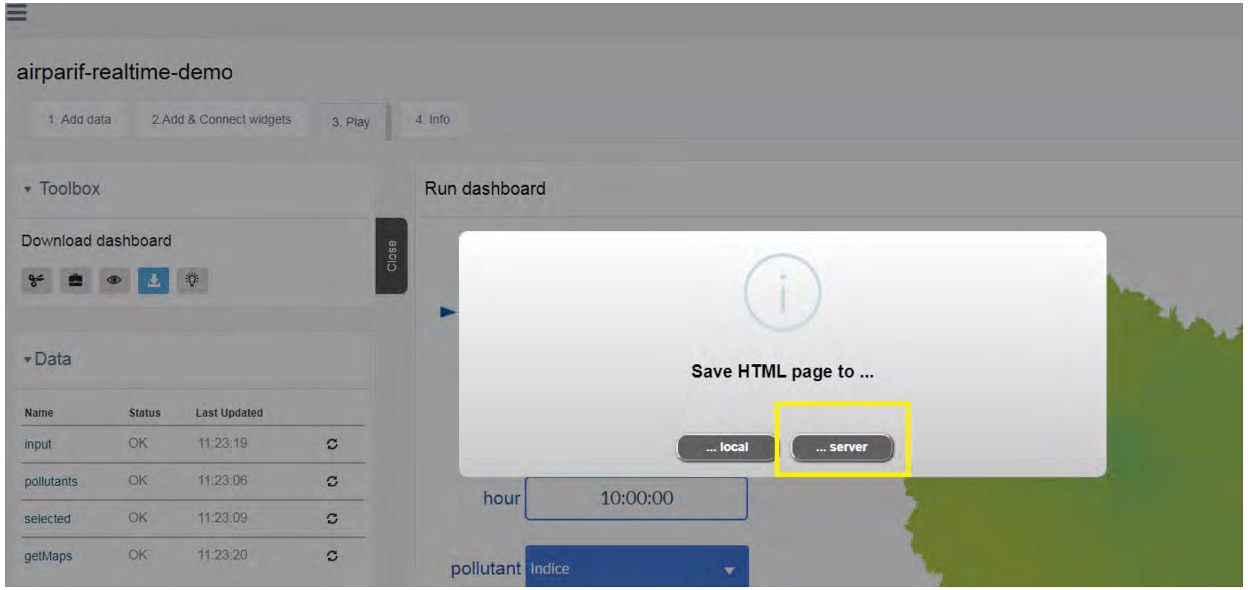
In editor

or

Projection

Keep proportions

SHARING APPLICATIONS

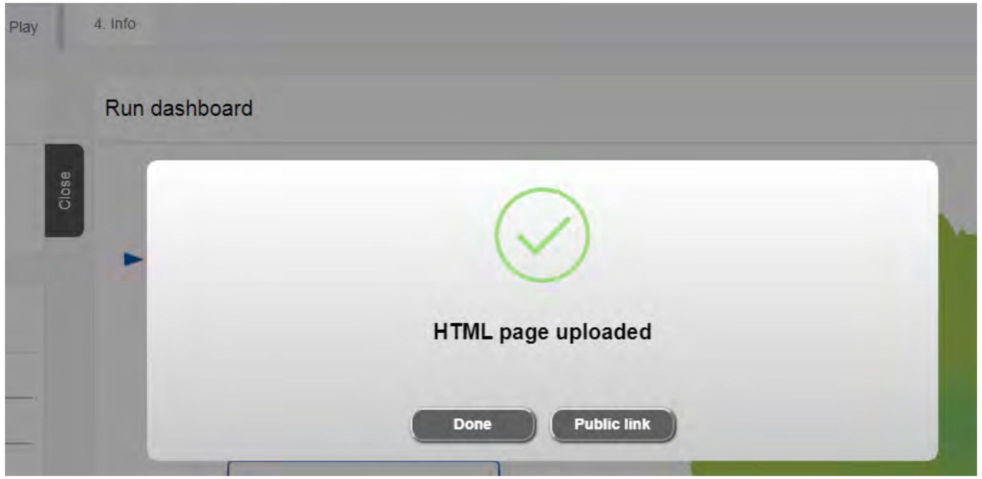


Save HTML page to ...

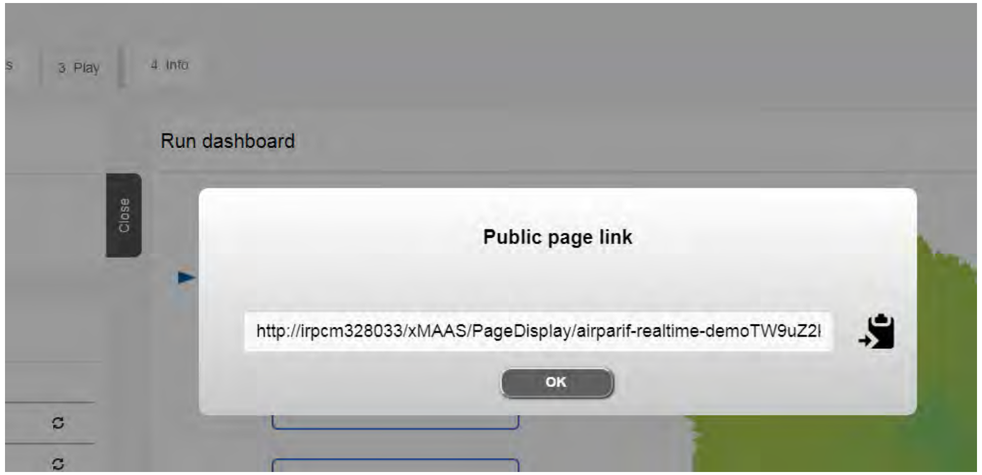
Name	Status	Last Updated
input	OK	11:23:19
pollutants	OK	11:23:06
selected	OK	11:23:09
getMaps	OK	11:23:20

hour 10:00:00

pollutant Indice



HTML page uploaded



Public page link

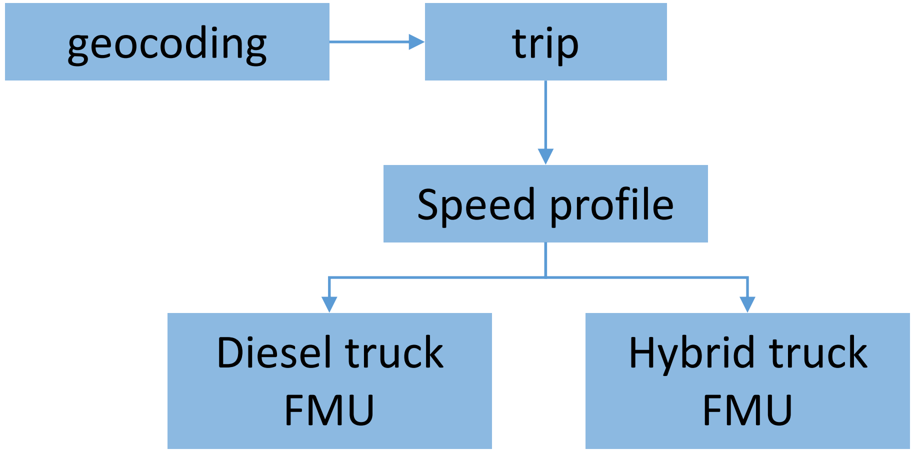
http://irpcm328033/xMAAS/PageDisplay/airparif-realtime-demoTW9uZ2l

Sharing a dashboard in 3 clicks

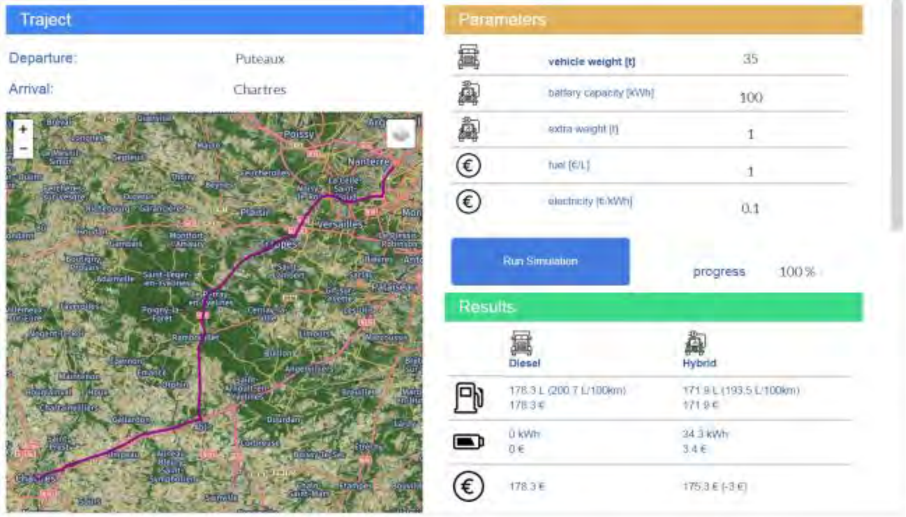
TRUCK HYBRIDIZATION STUDY

- Main inputs : start and destination address, truck parameters, fuel & electricity prices …
- Main outputs : cost of trip of conventional truck vs. hybrid truck
- Truck dynamic simulation models are FMUs generated from Amesim models

Aggregated web-services



Rapid prototype in xDash



Departure: Puteaux
Arrival: Chartres

Parameters

	vehicle weight [t]	35
	battery capacity [kWh]	100
	extra weight [t]	1
€	fuel [€/L]	1
€	electricity [€/kWh]	0.1

progress 100 %

Results

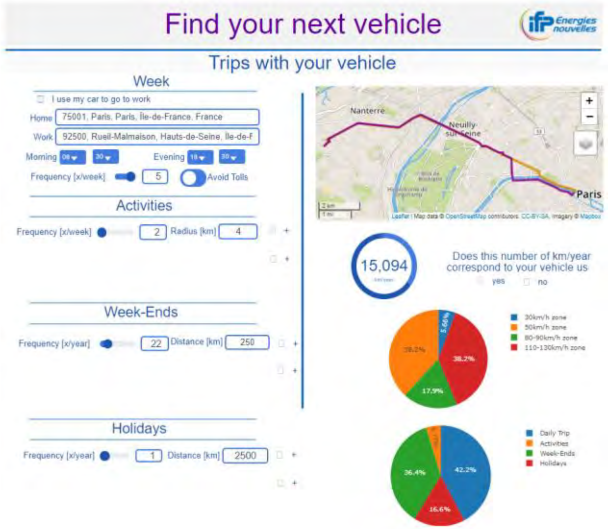
	Diesel	Hybrid
⛽	178.3 L (200.7 L/100km) 178.3 €	171.9 L (193.5 L/100km) 171.9 €
🔋	0 kWh 0 €	34.3 kWh 3.4 €
€	178.3 €	175.3 € (-3 €)

TCO & CO2 ESTIMATION FOR CAR PURCHASE ADVISE

- Main inputs : home &work addresses, other usages, ownership duration, desired segment …
- Main outputs TCO (€) and CO2 footprint (kg) …

Rapid prototype in xDash

General public site : https://jechangemavoiture.gouv.fr/


Find your next vehicle

Trips with your vehicle

Week

□ I use my car to go to work

Home: 75001, Paris, Paris, Île-de-France, France

Work: 92500, Rueil-Malmaison, Hauts-de-Seine, Île-de-F

Morning 08 30 Evening 18 30

Frequency [x/week] 5 Avoid Tolls

Activities

Frequency [x/week] 2 Radius [km] 4

Week-Ends

Frequency [x/year] 22 Distance [km] 250

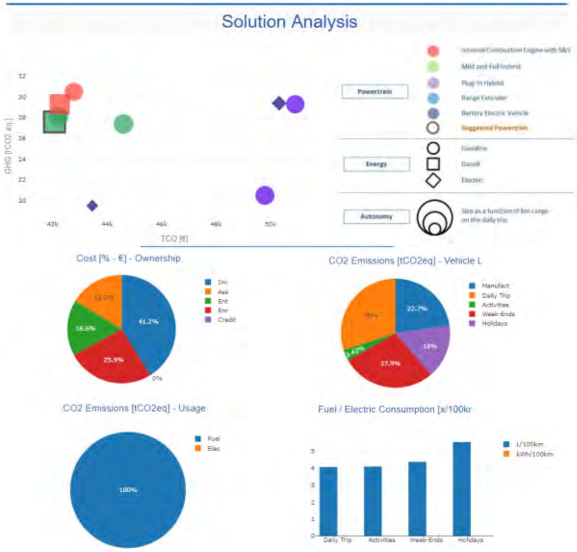
Holidays

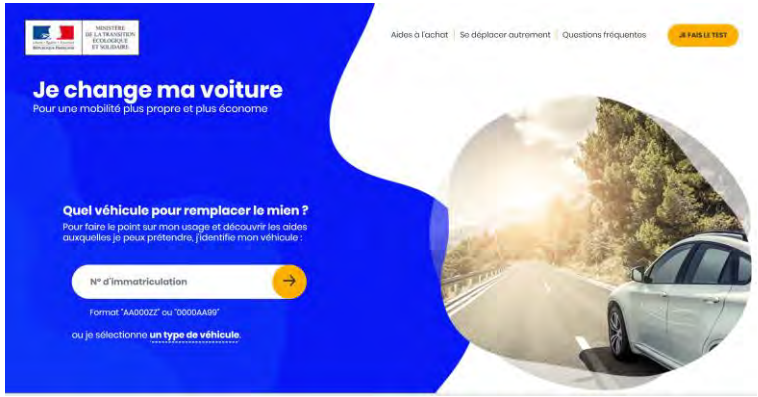
Frequency [x/year] 1 Distance [km] 2500

15,094

Does this number of km/year correspond to your vehicle us

yes □ no


Solution Analysis


Aides à l'achat | Se déplacer autrement | Questions fréquentes

JE FAIS LE TEST

Je change ma voiture

Pour une mobilité plus propre et plus économe

Quel véhicule pour remplacer le mien ?

Pour faire le point sur mon usage et découvrir les aides auxquelles je peux prétendre, j'identifie mon véhicule :

N° d'immatriculation

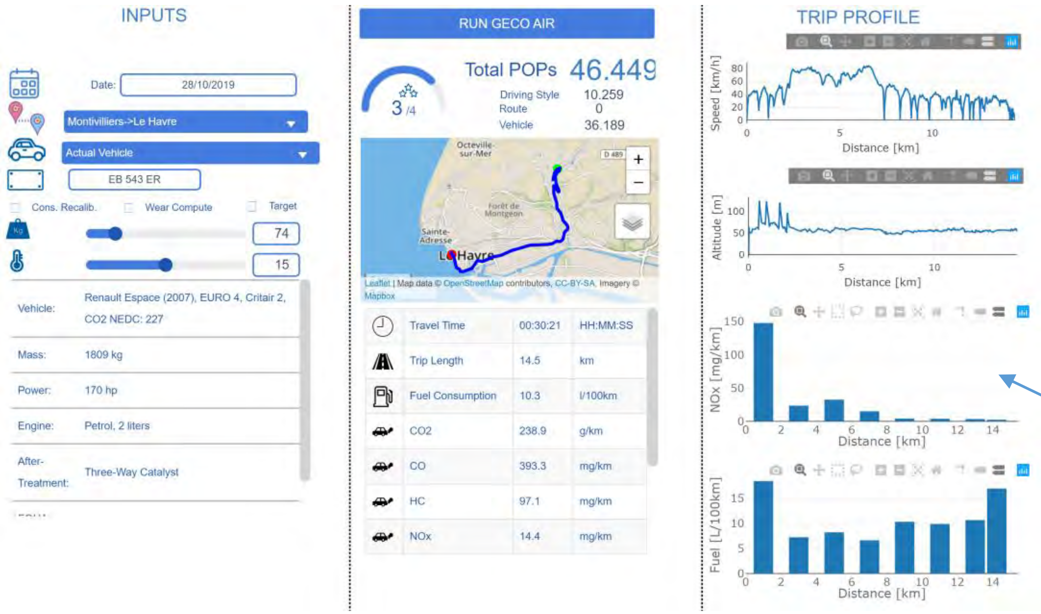
Format "AA000ZZ" ou "0000AA99"

ou je sélectionne **un type de véhicule**.

POLLUTING EMISSIONS ESTIMATION WEB-SERVICE

- Main inputs : vehicle parameters, trip, road conditions from test database …
- Main outputs : fuel consumption, CO2, CO, HC, NOx, PM, PM tires, PM brakes …

Rapid prototype in xDash



INPUTS

Date: 28/10/2019

Montivilliers->Le Havre

Actual Vehicle

EB 543 ER

□ Cons. Recalib. □ Wear Compute □ Target

74

15

Vehicle:	Renault Espace (2007), EURO 4, Critair 2, CO2 NEDC: 227
Mass:	1809 kg
Power:	170 hp
Engine:	Petrol, 2 liters
After-Treatment:	Three-Way Catalyst

RUN GECO AIR

3 /4

Total POPs 46.449

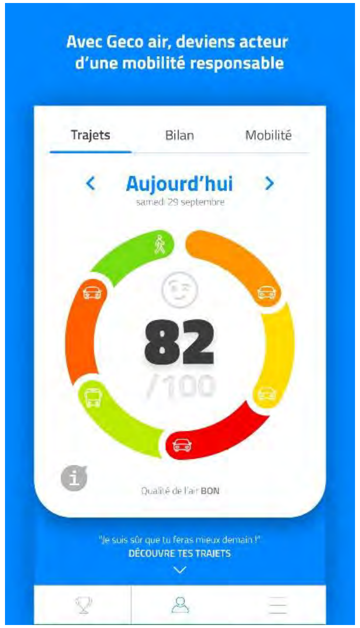
Driving Style	10.259
Route	0
Vehicle	36.189

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Travel Time	00:30:21	HH:MM:SS
Trip Length	14.5	km
Fuel Consumption	10.3	l/100km
CO2	238.9	g/km
CO	393.3	mg/km
HC	97.1	mg/km
NOx	14.4	mg/km

Digital twin debugging

Gecoair app



Avec Geco air, deviens acteur d'une mobilité responsable

Trajets Bilan Mobilité

Aujourd'hui

samedi 29 septembre

82 /100

Qualité de l'air BON

"Je suis sûr que tu feras mieux demain !"

DÉCOUVRE TES TRAJETS

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CONCLUSIONS & PERSPECTIVES

- Conclusions
  - xDash for
    - rapid-prototyping of CPS
    - demonstration
    - sharing, collaboration
  - Web technologies have the potential of bringing “social” and “collaborative” features to scientific computing
  - xDash supports both on cloud or on-premises deployments
  - We are looking for beta-testers!
- Perspectives
  - xDash for AI & crowdsensing
  - xDash will be publicly available soon for free use