CLASS

COORDINATING EDGE AND CLOUD FOR BIG DATA ANALYTICS

CLASS Analytics Fabric

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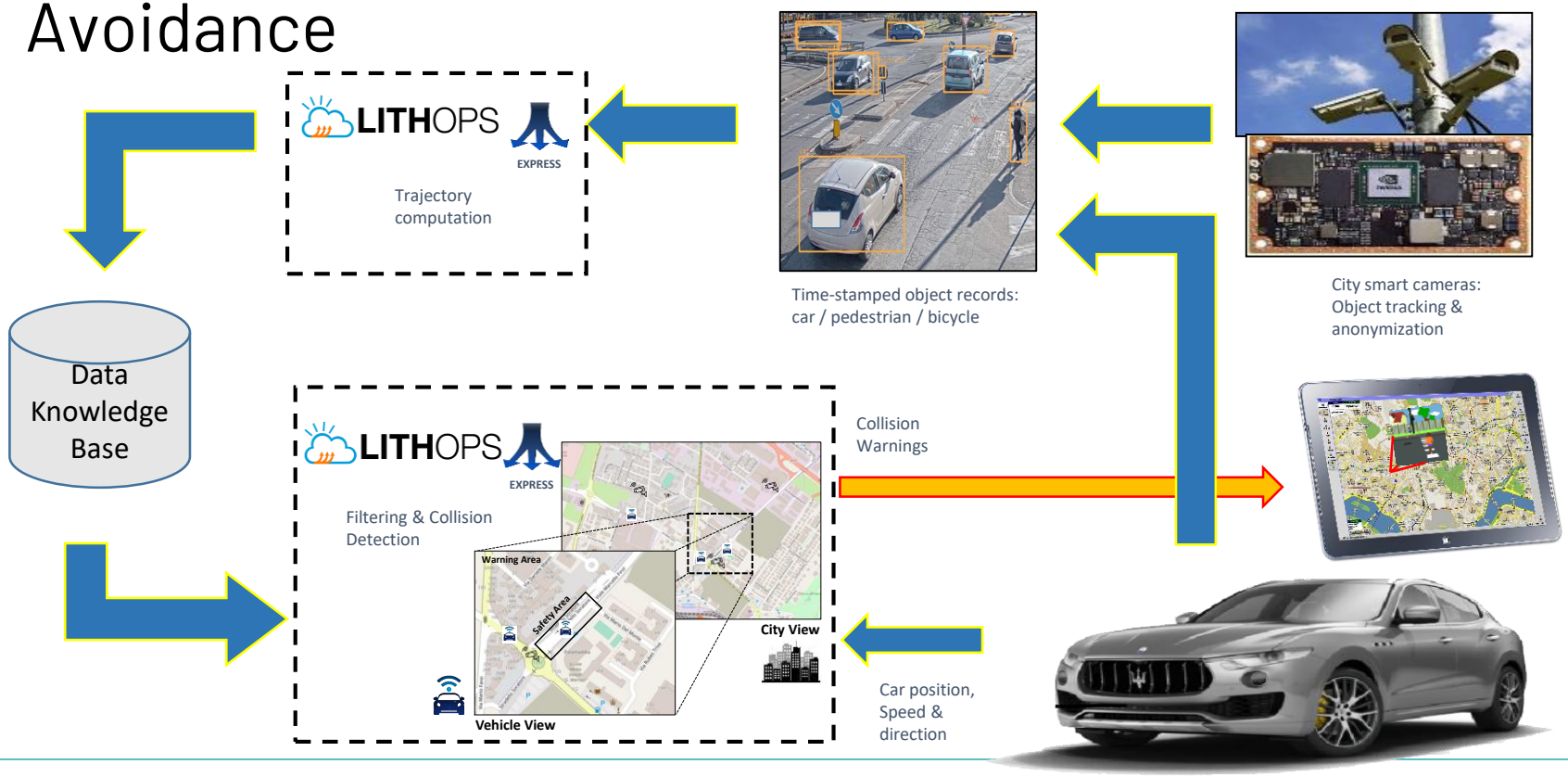
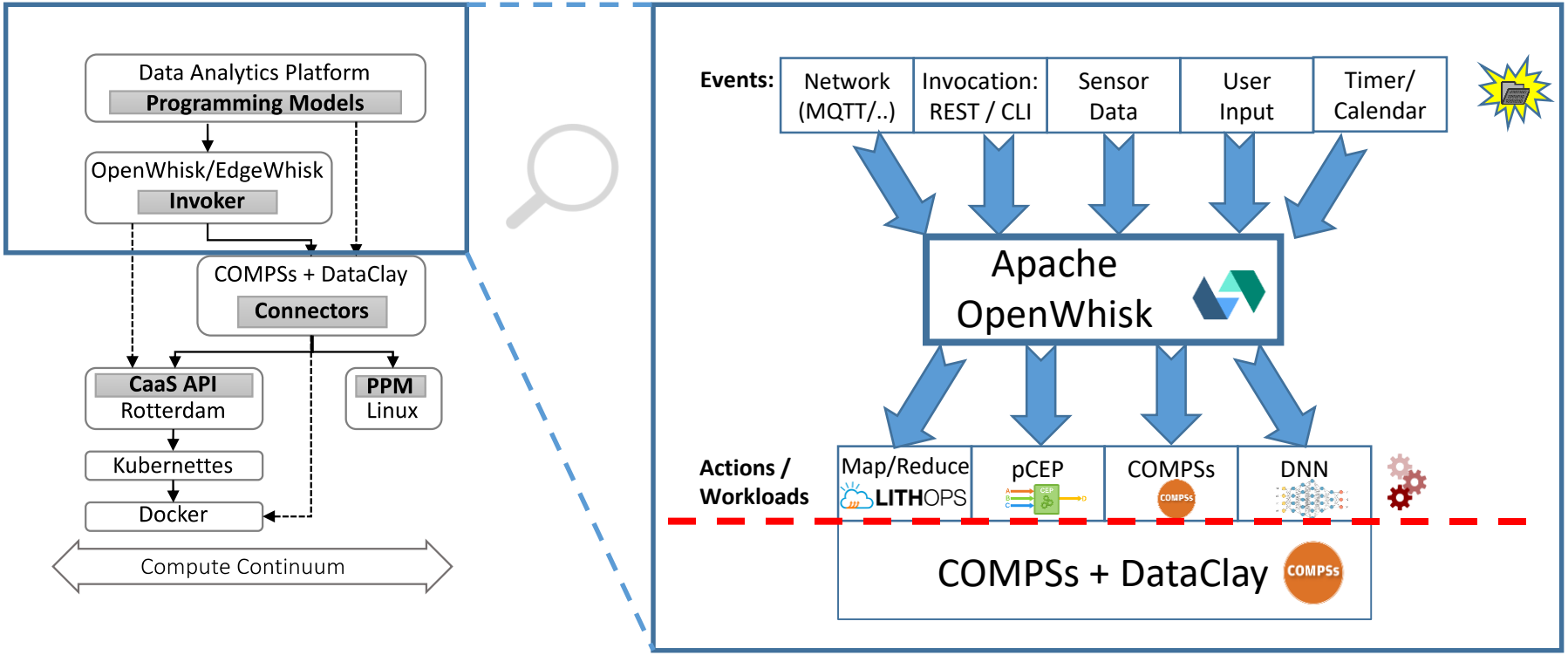
The CLASS project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 780622

CLASS V2X Application: Collision Avoidance



CLASS Analytics Fabric - Overview



Serverless Example - OpenWhisk

1. Write a code function

hello.js:

```
/** * Hello world as an OpenWhisk action. */
function main(params) {
      var name = params.name || 'World';
      return {payload: 'Hello, ' + name + '!'};
}
```

2. Deploy the code function as a serverless function ("action"):

```
$ wsk action create hello hello.js
```

3. The serverless function can be invoked directly:

```
$ wsk action invoke hello –blocking –result
{
    "payload": "Hello, World!"
}
```

4. Create an event trigger:

```
$ wsk trigger create myTrigger
```

[the event can be triggered via REST API by e.g., network message feed, sensor data, timers, etc]

5. Bind the serverless function to the event using a rule:

```
$ wsk rule create rule myRule myTrigger hello
```

6. Every time the event is triggered, the function will compute using parameters from event payload – and the result will show up in OW logs
   - Auto-scaling!

```
{
    "payload": "Hello, OpenWhisk!"
}
```

Serverless Foundation in CLASS Analytics - Discussion

- Advantages:
  - Event-driven + direct invocation
  - Auto-scaling of function instances
  - Isolation when using shared infrastructure (e.g., cloud)
  - Lightweight - fit edge & cloud
  - Polyglot - use different programming languages and frameworks in the same application
  - Rapid prototyping

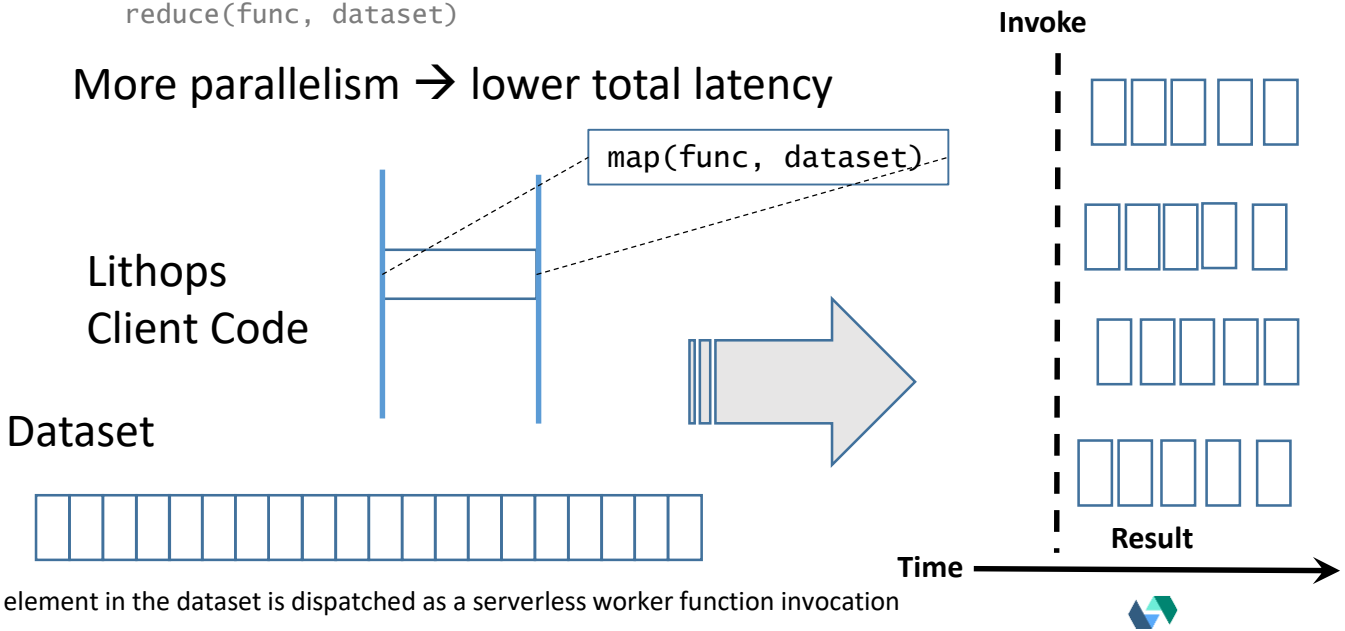
- Issues:
  - Stateless-ness
    - Mitigation – state retrieved from parameters and dataClay (CLASS data backbone)
  - Initialization / finalization overhead
    - Mitigation - warm start, async execution
  - Lack of scheduling / scale control
    - Mitigation – [manual] tuning

Low-latency Map/Reduce in Lithops

https://lithops-cloud.github.io/

- A Python library for parallel computation on various backends incl. serverless
- map applies func to every element of dataset, yielding a new dataset:
  map(func, dataset)
- reduce applies func to all elements of dataset with an accumulator, yielding a single result:
  reduce(func, dataset)

More parallelism → lower total latency



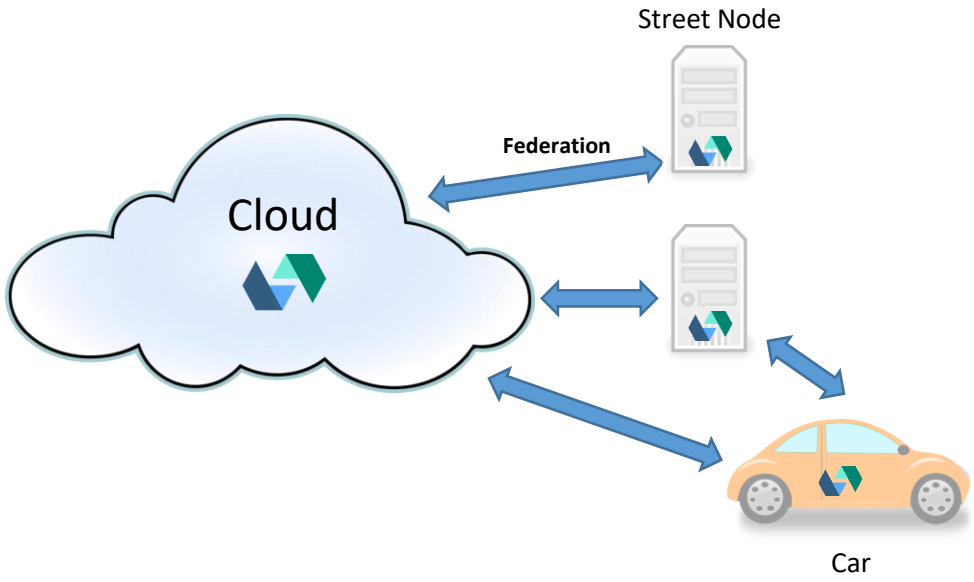
Each element in the dataset is dispatched as a serverless worker function invocation

Speedup: ~4000 msec → 350 msec
X11.5 times!

- Faster data preparation
- Faster worker launch (less I/O)
- Leverage warm start better
  - Session connection in-mem
- Persist map func in worker image
- Faster result/finish protocol
  - Object storage → MQ
- Chunking elements to mitigate worker re-init cost

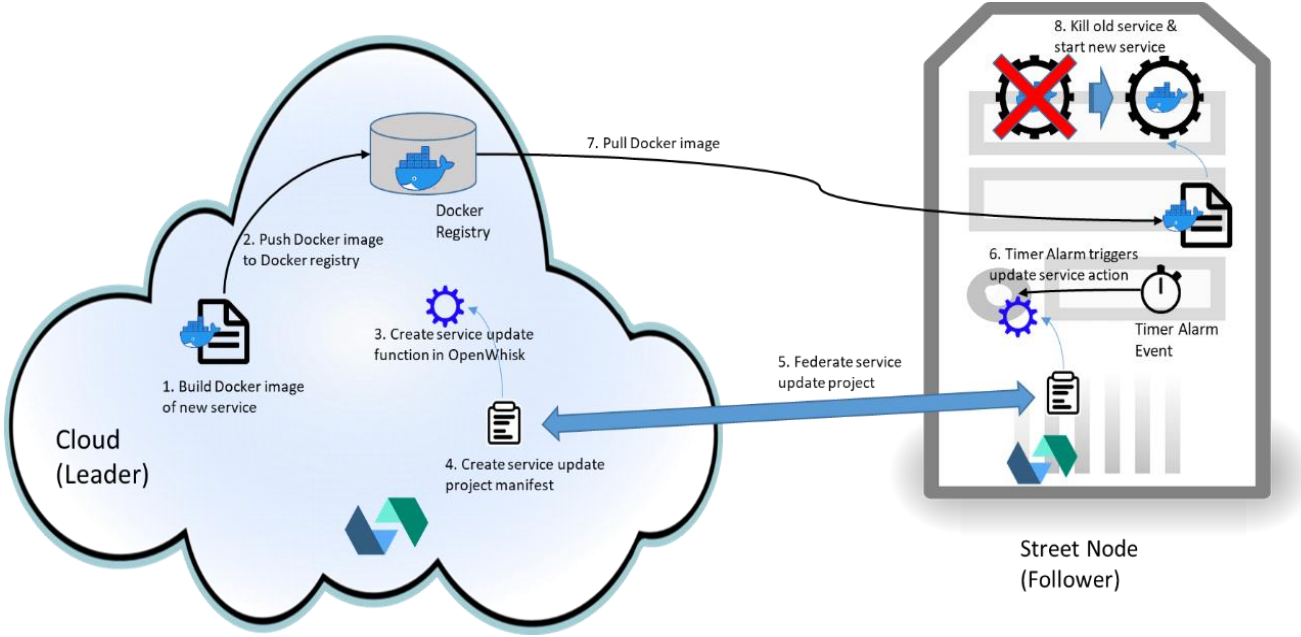
Edge Analytics Agent

- **Federation** allows propagating software assets from one **Leader** OW to multiple **Follower** OW-s
  - Leader and Followers can be **any** OW instances
- Each Follower OW is a *programmable agent* of the Leader OW
- *Eventual consistency* of propagated assets (but typically very quick)
- Used for scenarios of deploying/updating software
  - Deploy/update software at all street nodes, or all cars
  - Update neural network at cars



Federation Example – CLASS Detector

- Detector is a long-running stateful docker service for edge nodes
- Federation is used to propagate an updated *project manifest* to edge nodes
- A periodical OW action in the edge detects the updated manifest and handles image pull and service update



CLASS Analytics Fabric - Summary

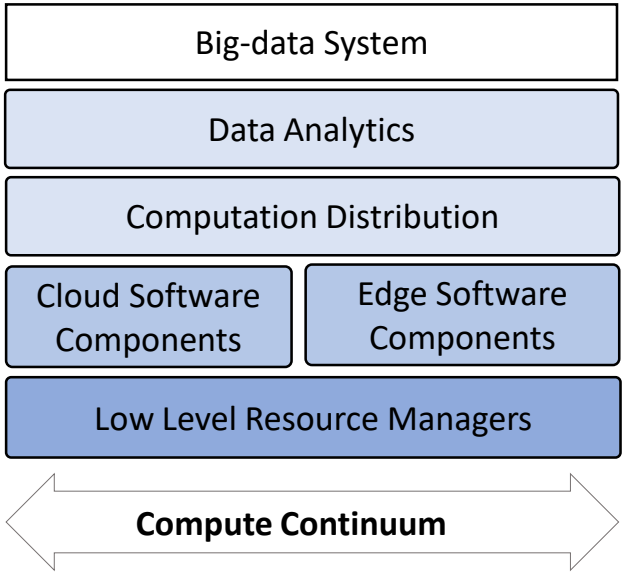
- Event-driven serverless infrastructure
  - Polyglot
  - Autoscaling
  - Simple + productive
  - Mitigations for CLASS: stateless-ness and init/fin overhead
- Leverage parallelism to reduce latency for independent computations
  - Trajectory Prediction and Collision Detection in Lithops
  - Concurrent computation in COMPSs
- Span cloud and edge via federation

CLASS

www.class-project.eu
Twitter: @EU_CLASS

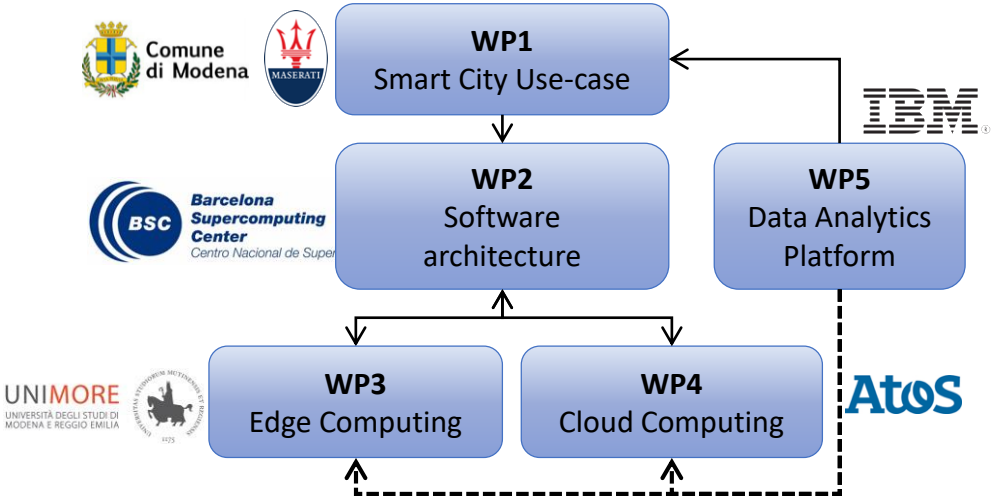
Backup

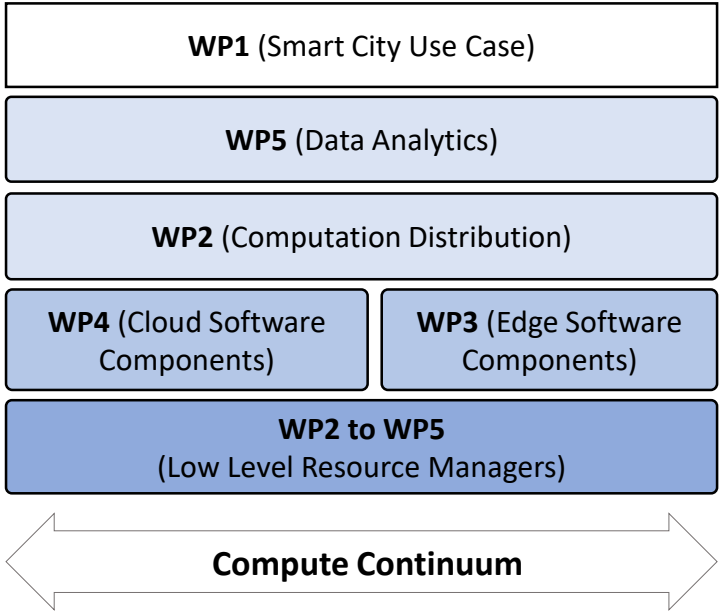
CLASS Goals & Architecture



- Provide the **right level of abstraction** to facilitate the development of distributed big-data systems
- Increase **data throughput speed-up and analytics accuracy** by efficiently combining data-in-motion and data-at-rest analysis, while providing the required **real-time capabilities**
- Apply current open **initiatives, standards** and **industrial practices** with special interest on those adopted in the smart city

Project Structure





CLASS Smart City Use-Case – Intelligent Traffic Management

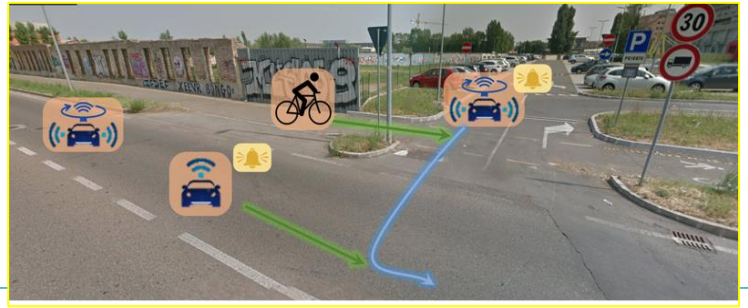
- 2021+ Connected Vehicles - Cooperative, Predictive, Sub-second
- Connected cars V2V, V2C, V2I
- **Collision avoidance** computations at the edge+cloud using FaaS (safety)

CLASS: https://class-project.eu/

Collision Avoidance Test Scenarios (from C-ASS)

- MASA – Modena Automotive Smart Area

Car emerging from side street behind tree corner

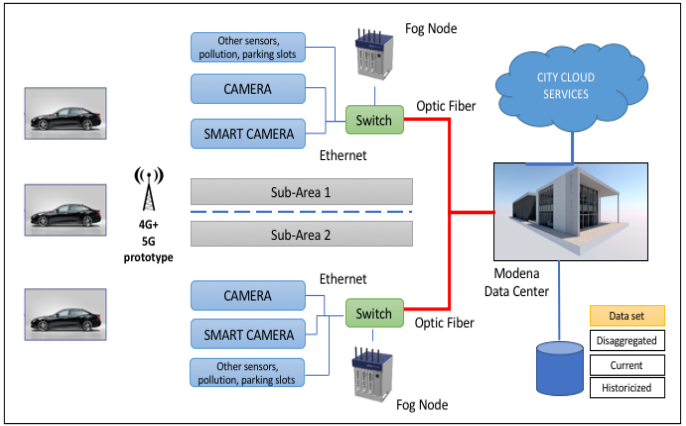


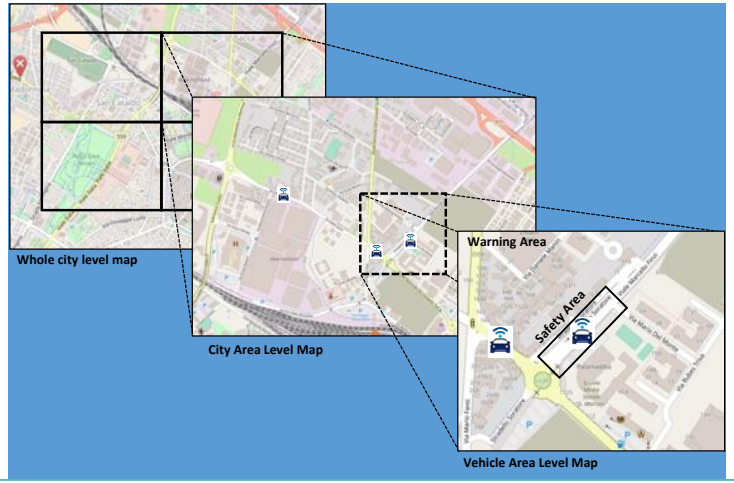
Cyclist jumps to street behind fence. NO CITY CAMERAS.

Child crossing behind parked truck

CLASS Project
https://class-project.eu/

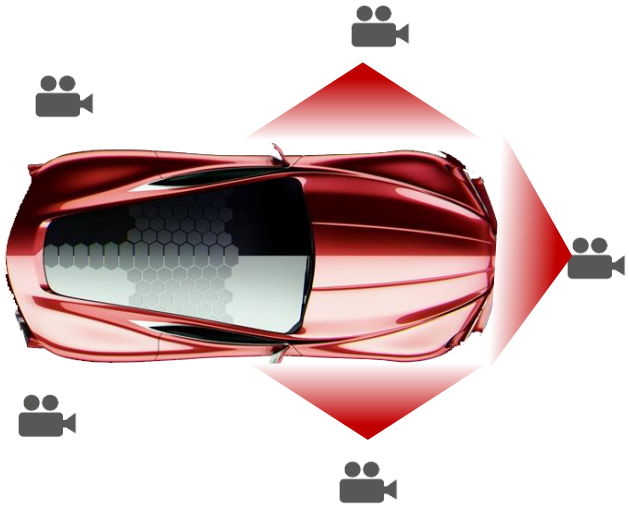
- Big-Data Analytics Across Cloud and Edge
- Edge = Car, Street cell, Smart Camera
- 2 main use-cases:
  - **Obstacle detection** – extend car awareness beyond sensors – around corners, beyond parked cars, etc
    - *Safety* area vs. *warning* area
  - Air pollution simulation crossed with real-time traffic data

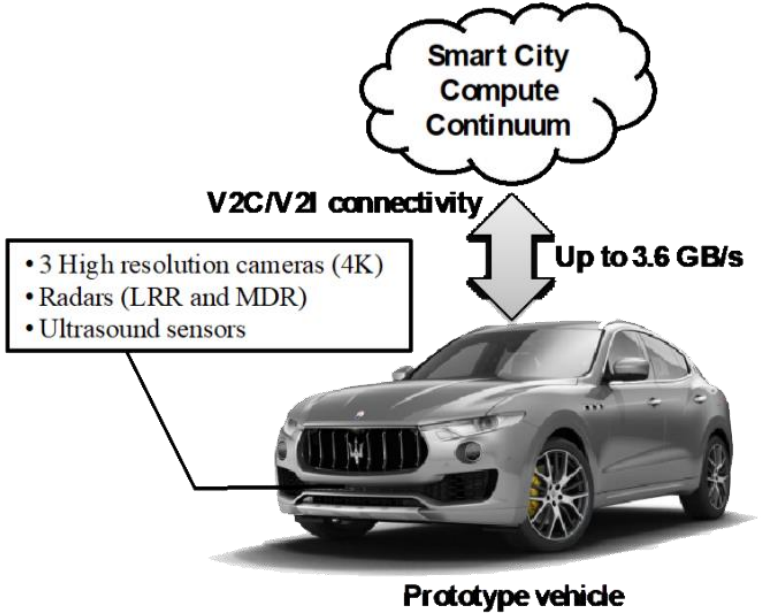




Smart Prototype Car

Highly-connected cars: V2I connectivity tailored to the specific **use-case** and **application scenario**



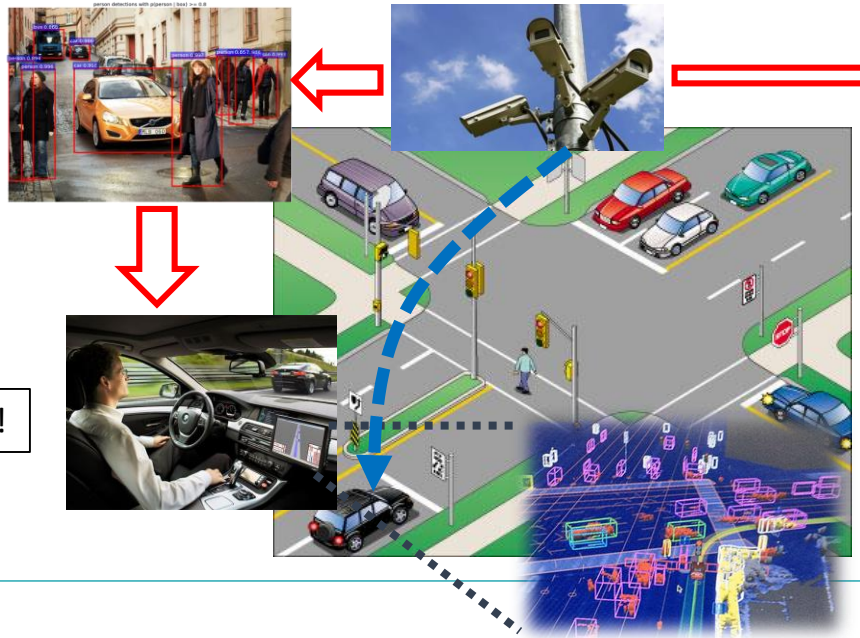


- Multiple cameras @4K resolution
- LRR
- MRR
- Ultrasound sensors for short range detection

Advanced module for Vehicle-To-Cloud (V2C)
V2I communication through a 4G and 5G connectivity

Edge-side: Real-time road user detection

- Multiple infrastructure cameras detect road users and obstacles
  - vehicles, buses, trucks, pedestrians, bicycles, etc.
- A consistent representation of RU's is sent to L3/L4 vehicles (V2I) in <u>real-time</u>



To cloud infrastructure

Camera-to-car < 100ms !

- V2I sensing system for harsh urban environment
- Redundant and robust perception
- Safer obstacle detection

Obstacle Detection At The Car

Conceptual Illustration

- **Cameras** recognize & determine the hazard level of the obstacle/pedestrian.
- In case of danger a warning is send to the **vehicles** placed in the limited area directly into the car.
- Connected vehicles communicate the hazard to **other traffic participants**, avoiding accidents.

MASA Computing/Communication Infrastructure