



UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

Cognitive Mobility

MEC Internet of Vehicles (IoV) Architecture



droidcon MEC Hackathon - November 2020
Final Presentation

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- Centralised, cloud-centric solutions are **sub-optimal**
 - high latency
 - privacy concerns
 - do not exploit efficiently the **geo-localised nature** of the problem

- **Mobility issues** affect all major cities worldwide
 - congestion at intersections
 - pathfinding complicated by contingencies (e.g. road work, collisions)
 - parking by trial-and-error
 - unprepared for electric and connected vehicle revolution
- **Socio-economic cost** for public administrators and citizens

Coordination of Autonomous Vehicles: Taxonomy and Survey

STEFANO MARIANI, GIACOMO CABRI, and FRANCO ZAMBONELLI, Università degli Studi di Modena e Reggio Emilia

In the near future, our streets will be populated by myriads of autonomous self-driving vehicles to serve our diverse mobility needs. This will raise the need to coordinate their movements in order to properly handle both access to shared resources (e.g., intersections and parking slots) and the execution of mobility tasks (e.g., platooning and ramp merging). The aim of this paper is to provide a global view of the coordination issues and the related solutions in the field of autonomous vehicles. To this end, we firstly introduce the general problems associated with coordination of autonomous vehicles, by identifying and framing the key classes of coordination problems. Then, we overview the different approaches that can be adopted to deal with such problems, by classifying them in terms of the degree of autonomy in decision making that is left to autonomous vehicles during the coordination process. Finally, we overview some further research challenges to address before autonomous coordinated vehicles can safely hit our streets.

ACM Computing Surveys

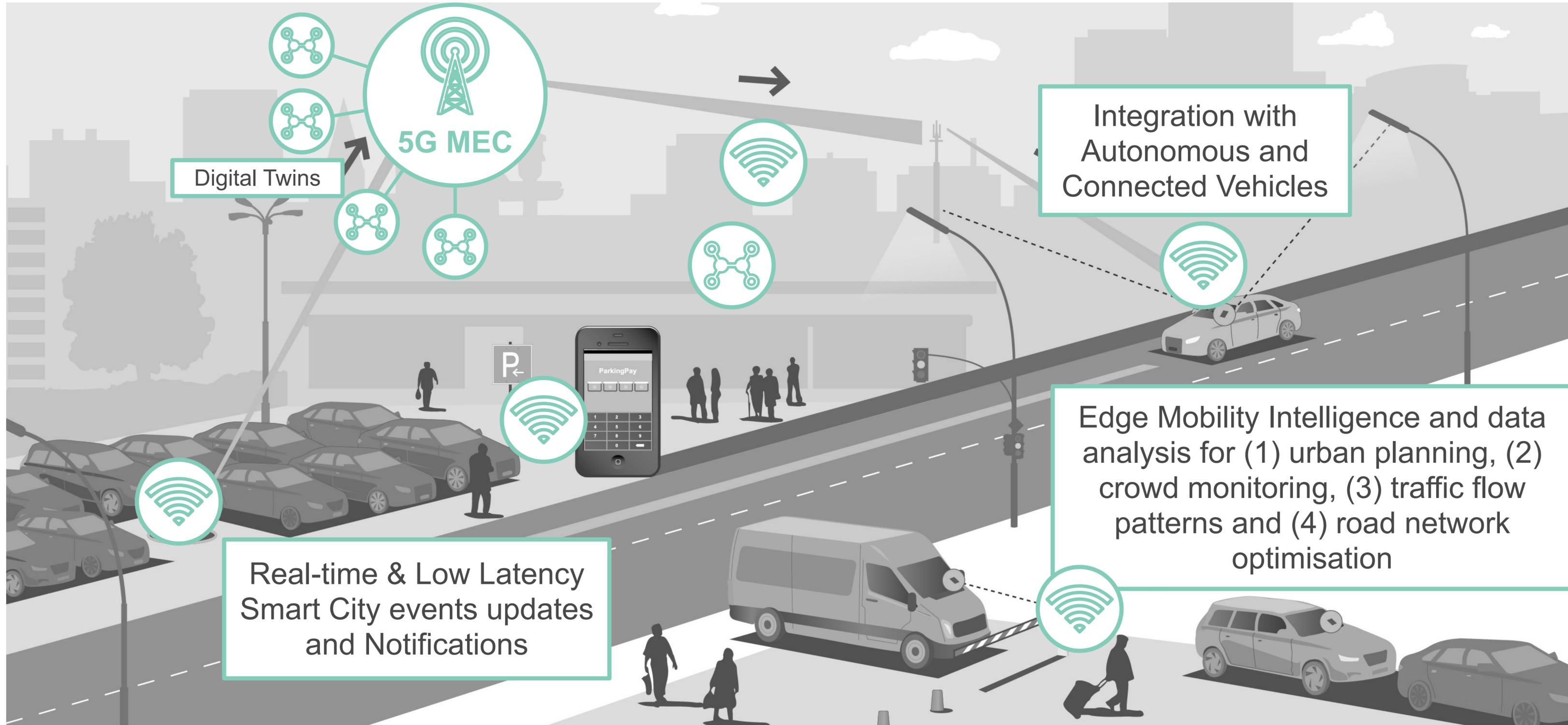


Intelligent Systems Reference Library

Springer Link

Marco Picone
Stefano Busanelli
Michele Amoretti
Francesco Zanichelli
Gianluigi Ferrari

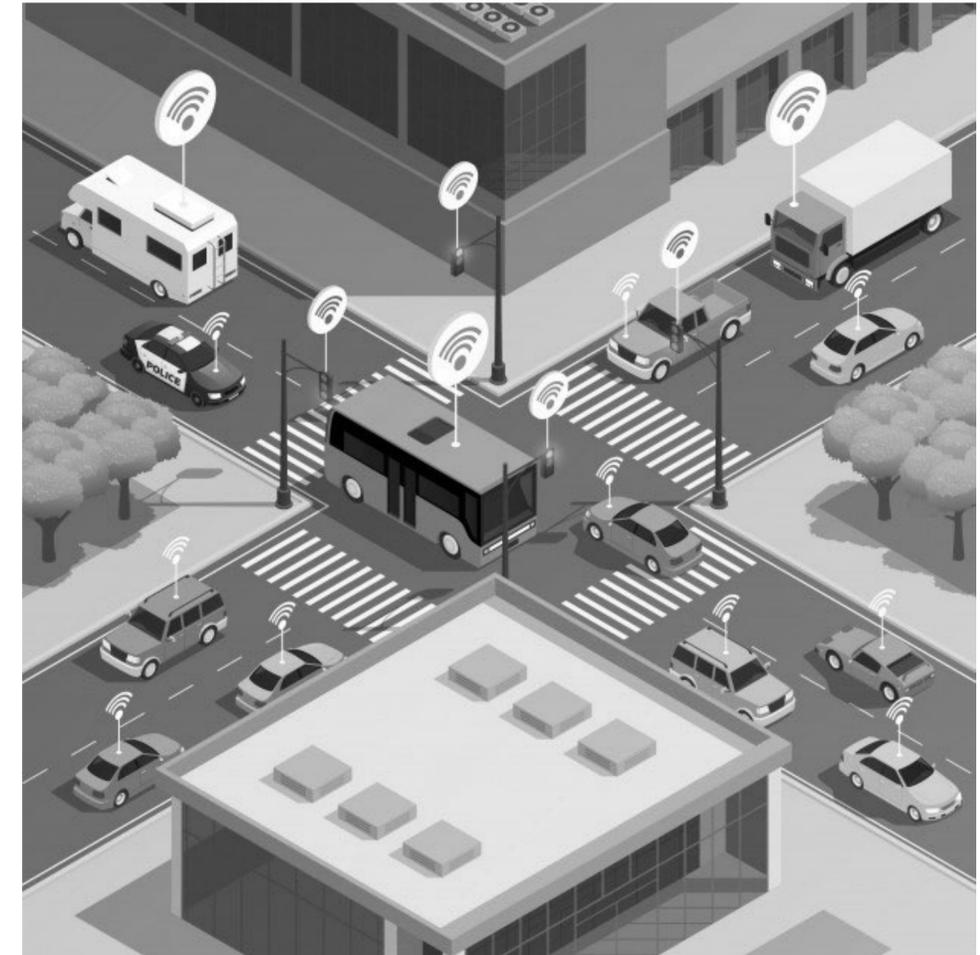
Advanced Technologies
for Intelligent
Transportation Systems

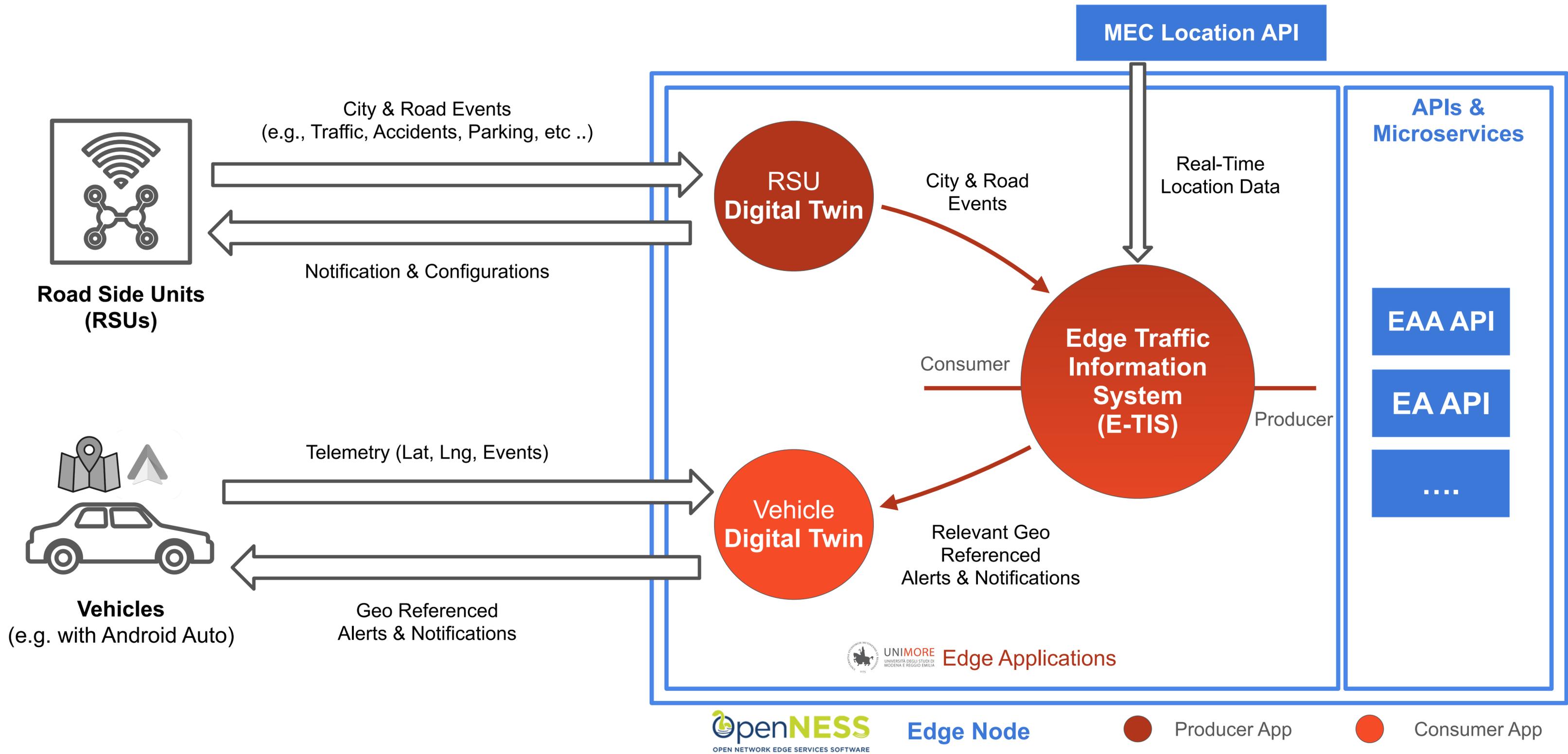


- **Cognitive mobility**

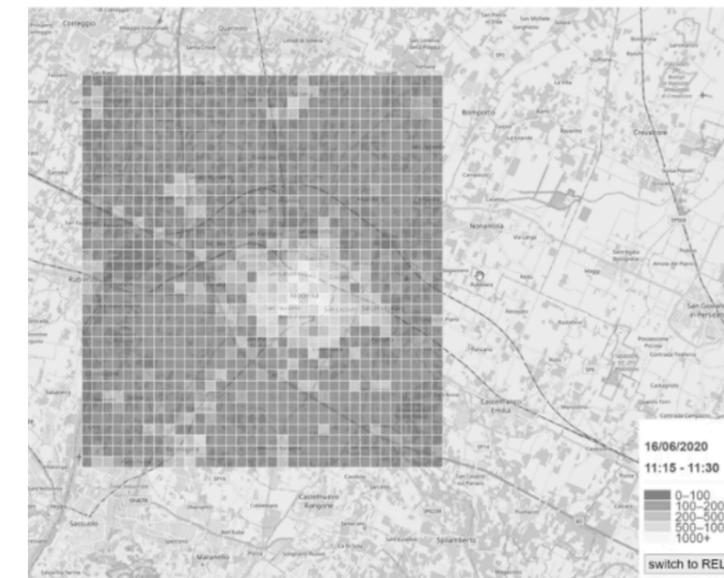
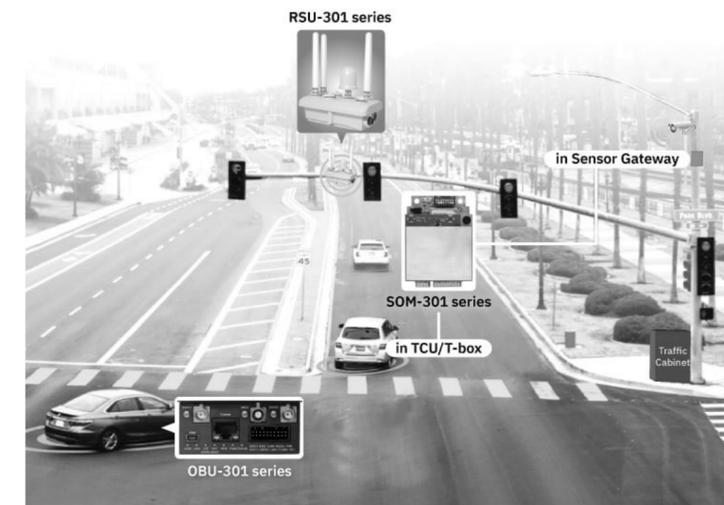
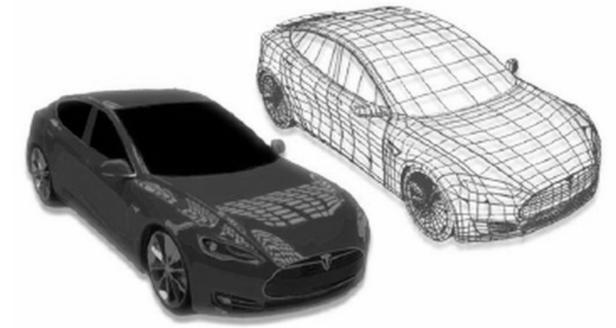
- let people get **notifications** about road network state
 - real-time
 - location-relevant
 - *can also be applied directly to vehicles themselves if (semi-)autonomous!*

- let administrators focus on mobility data **analysis** and urban planning
 - crowd monitoring
 - traffic flow patterns
 - road network optimisation





- The application is designed to provide two types of Edge services on top of the MEC infrastructure:
 - **Vehicle Digital Twin (VDT) and Road Side Unit Digital Twin (RSU-DT):**
 - Create a uniformed abstraction layer handling the heterogeneity of physical devices
 - Maintain a secure communication channel between physical and digital counterparts
 - Extend the features of the physical device moving integration responsibility and complexity to the digital replica (e.g., connectors, protocols, data structure etc ...)
 - **Mobility Intelligence:** Extend MEC Location API through an Intelligent Edge Layer able to provide:
 - Data classification in order to understand through mobility patterns if a device is a traditional vehicle, a pedestrian or a micro-mobility user
 - Mobility flows estimation and anomaly detection related to traffic congestion or unexpected gathering of people in public places, parking areas or other Point of Interest (PoI)



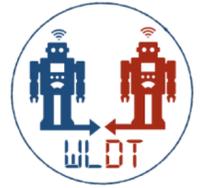


<https://github.com/openness-4-java>

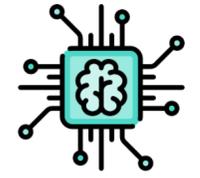
  
[NEW] OpenNess Connector Library
Edge Application API
Edge Application Authentication API
Location API

1

5G Digital Twin
(Vehicles, Parking Areas, Traffic Monitoring etc ...)
White Label Digital Twin Library
<https://github.com/wldt>



2

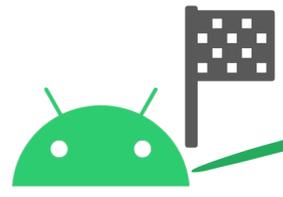


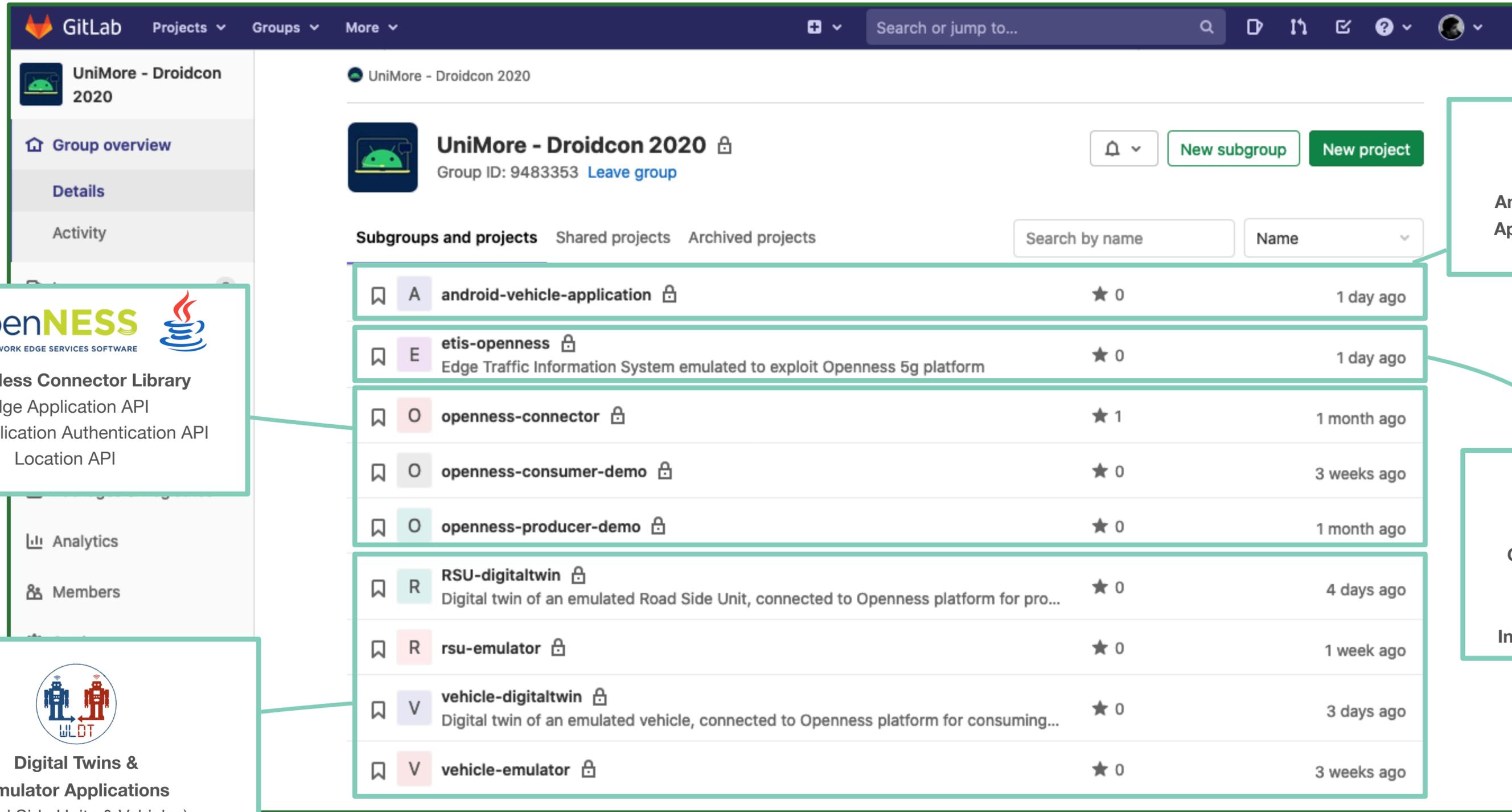
Cognitive Mobility Engine

3

Connected Vehicle

4





UniMore - Droidcon 2020

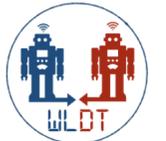
Group ID: 9483353

Subgroups and projects	Shared projects	Archived projects
A android-vehicle-application		
E etis-openness Edge Traffic Information System emulated to exploit Openness 5g platform		
O openness-connector		
O openness-consumer-demo		
O openness-producer-demo		
R RSU-digitaltwin Digital twin of an emulated Road Side Unit, connected to Openness platform for pro...		
R rsu-emulator		
V vehicle-digitaltwin Digital twin of an emulated vehicle, connected to Openness platform for consuming...		
V vehicle-emulator		



OpenNESS
OPEN NETWORK EDGE SERVICES SOFTWARE

OpenNess Connector Library
Edge Application API
Edge Application Authentication API
Location API



Digital Twins & Emulator Applications
(Road Side Units & Vehicles)



Android Vehicular Application Demo



Cognitive Mobility Engine
(Edge Traffic Information System)

Expected Benefits



Technical perspective

- **real-time** & low latency **communications**
- **service migration** close to things and vehicles (“follow-me”)
- **localised services** provided only where/when relevant
- support **integration** and **interoperability** among services, things and people
- **easy development and deployment** (automatic digital twin creation)
- security & privacy between physical and digital counterparts
- **Edge data analysis and forecasting**



Socio-economical perspective

- **reduce** traffic **congestions**, speed up parking management and **optimize** public electric charging stations
- relief drivers from cognitive overhead and “too-much-information”
- help municipalities for:
 - urban **planning**
 - crowd **monitoring**
 - traffic & parking flow patterns
 - road network **optimisation**



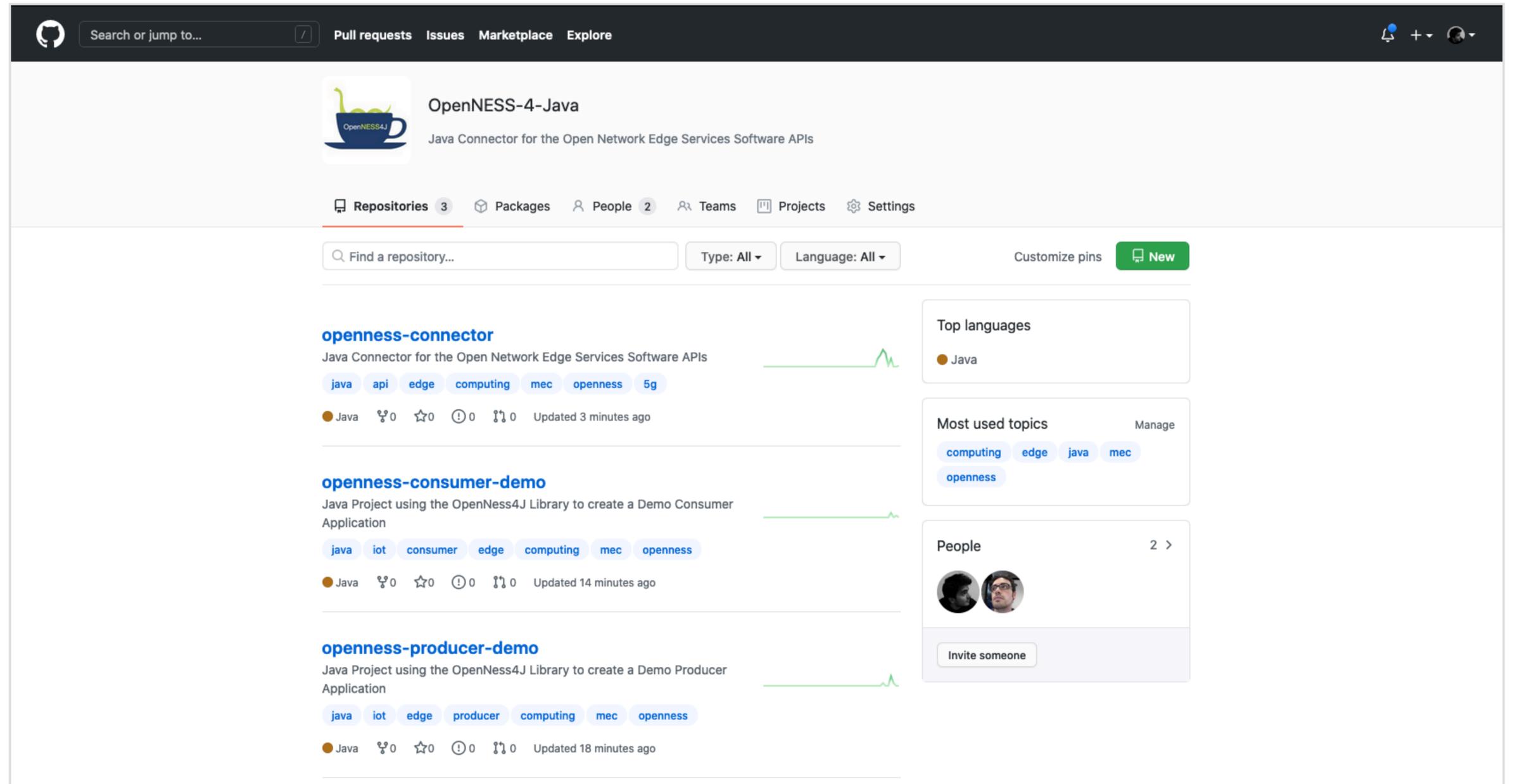


OpenNess Connector Library MEC OpenNESS Deployment Demo Android Application

A short video has been shared to show the deployment, running applications and library usage



<https://github.com/openness-4-java>



The screenshot shows the GitHub repository page for 'OpenNESS-4-Java'. The repository is described as a 'Java Connector for the Open Network Edge Services Software APIs'. It features three sub-repositories: 'openness-connector', 'openness-consumer-demo', and 'openness-producer-demo'. The 'openness-connector' repository is the most prominent, showing it is a Java project with 5g size and various tags like 'api', 'edge', 'computing', 'mec', and 'openness'. The 'openness-consumer-demo' and 'openness-producer-demo' are also Java projects, with the former being a consumer application and the latter a producer application. The page includes navigation links for Pull requests, Issues, Marketplace, and Explore, as well as a search bar and filters for repository type and language.



Alpha Version Released Today !

MEC OpenNESS Edge Node



```
or(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=19, freeParkingLotNumber=11))
14:53:53.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - it.unimore.dipi.rsu.com:iot:it.unimore.dipi.rsu.0f4d0b7e-efa9-4807-84d0-6f976cf3ec99/telemetry/resource/parking: TelemetryMessage(timestamp=1606402433232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=21, freeParkingLotNumber=9))
14:53:53.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - Posting event to notification service...
14:53:53.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Notification - Target Url: https://eaa.openness/notifications
14:53:53.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402433232, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file"}, "parkingLotLimit":30, "occupiedParkingLotNumber":21, "freeParkingLotNumber":9}}}
14:53:53.270 [Timer-0] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Notifications Response Code: 202
14:53:53.270 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - ... notification posted -> Notification(name='parking', version='0.0.1', payload=TelemetryMessage(timestamp=1606402433232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=21, freeParkingLotNumber=9)))
14:54:03.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - it.unimore.dipi.rsu.com:iot:it.unimore.dipi.rsu.0f4d0b7e-efa9-4807-84d0-6f976cf3ec99/telemetry/resource/parking: TelemetryMessage(timestamp=1606402443232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=22, freeParkingLotNumber=8))
14:54:03.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - Posting event to notification service...
14:54:03.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Notification - Target Url: https://eaa.openness/notifications
14:54:03.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402443232, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file"}, "parkingLotLimit":30, "occupiedParkingLotNumber":22, "freeParkingLotNumber":8}}}
14:54:03.267 [Timer-0] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Notifications Response Code: 202
14:54:03.267 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - ... notification posted -> Notification(name='parking', version='0.0.1', payload=TelemetryMessage(timestamp=1606402443232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=22, freeParkingLotNumber=8)))
14:54:13.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - it.unimore.dipi.rsu.com:iot:it.unimore.dipi.rsu.0f4d0b7e-efa9-4807-84d0-6f976cf3ec99/telemetry/resource/parking: TelemetryMessage(timestamp=1606402453232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=23, freeParkingLotNumber=7))
14:54:13.232 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - Posting event to notification service...
14:54:13.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Notification - Target Url: https://eaa.openness/notifications
14:54:13.232 [Timer-0] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402453232, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file"}, "parkingLotLimit":30, "occupiedParkingLotNumber":23, "freeParkingLotNumber":7}}}
14:54:13.268 [Timer-0] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Notifications Response Code: 202
14:54:13.268 [Timer-0] INFO i.u.d.rsu.device.RsuMqttSmartObject - ... notification posted -> Notification(name='parking', version='0.0.1', payload=TelemetryMessage(timestamp=1606402453232, type='iot:sensor:parkingarea', dataValue=ParkingAreaStatusDescriptor(gpsLocationDescriptor=LocationDescriptor(latitude=44.7935344666667, longitude=10.3132929666667, altitude=0.0, provider='location_provider_file', parkingLotLimit=30, occupiedParkingLotNumber=23, freeParkingLotNumber=7)))
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14:56:43.269 [HttpClient@77d67cf3-57] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Service - Target Url: https://eaa.openness/services
14:56:43.269 [HttpClient@77d67cf3-57] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"uzn":{"id":"etis-openness-demo", "namespace":"etis-openness"}, "description":"ETIS service", "endpoint_uri":"http://eaa.openness:7070/api/etis/event/", "status":"ready", "notifications":{"name":"parking", "version":"0.0.1", "description":"rsu-digitaltwin-demo:rsu-digitaltwin"}, "info":""}
14:56:43.305 [HttpClient@77d67cf3-57] INFO i.u.d.e.p.RsuNotificationsHandle - incoming 'parking' from 'EdgeApplicationServiceUrn{id='rsu-digitaltwin-demo', namespace='rsu-digitaltwin'} (0.0.1) -> {"timestamp":1606402603234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":13, "freeParkingLotNumber":17}}
14:56:43.305 [HttpClient@77d67cf3-57] INFO i.u.d.e.p.RsuNotificationsHandle - forwarding 'parking' to subscribers...
14:56:43.305 [HttpClient@77d67cf3-57] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Notification - Target Url: https://eaa.openness/notifications
14:56:43.305 [HttpClient@77d67cf3-57] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402603234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file"}, "parkingLotLimit":30, "occupiedParkingLotNumber":13, "freeParkingLotNumber":17}}
14:56:43.342 [HttpClient@77d67cf3-57] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Notifications Response Code: 202
14:56:43.342 [HttpClient@77d67cf3-57] INFO i.u.d.e.p.RsuNotificationsHandle - ... parking forwarded -> {"timestamp":1606402603234, "type":"iot:sens or:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":13, "freeParkingLotNumber":17}}
14:56:53.269 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - Message got: {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402613234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file"}, "parkingLotLimit":30, "occupiedParkingLotNumber":14, "freeParkingLotNumber":16}}, "producer":{"id":"rsu-digit altwin-demo", "namespace":"rsu-digitaltwin"}}
14:56:53.269 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - publishing ETIS service descriptors: EdgeApplicationServiceDescriptor{serviceUrn=EdgeApplicationServiceUrn{id='etis-openness-demo', namespace='etis-openness'}, description=ETIS service, endpointUri='http://eaa.openness:7070/api/etis/event/', status='ready', notificationDescriptorList=[EdgeApplicationServiceNotificationDescriptor{name='parking', version='0.0.1', description='rsu-digitaltwin-demo:rsu-digitaltwin'}], info:''}...
14:56:53.269 [HttpClient@77d67cf3-53] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Service - Target Url: https://eaa.openness/services
14:56:53.269 [HttpClient@77d67cf3-53] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"uzn":{"id":"etis-openness-demo", "namespace":"etis-openness"}, "description":"ETIS service", "endpoint_uri":"http://eaa.openness:7070/api/etis/event/", "status":"ready", "notifications":{"name":"parking", "version":"0.0.1", "description":"rsu-digitaltwin-demo:rsu-digitaltwin"}, "info":""}
14:56:53.306 [HttpClient@77d67cf3-53] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Service Response Code: 200
14:56:53.306 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - incoming 'parking' from 'EdgeApplicationServiceUrn{id='rsu-digitaltwin-demo', namespace='rsu-digitaltwin'} (0.0.1) -> {"timestamp":1606402613234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":14, "freeParkingLotNumber":16}}
14:56:53.306 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - forwarding 'parking' to subscribers...
14:56:53.306 [HttpClient@77d67cf3-53] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - Post Notification - Target Url: https://eaa.openness/notifications
14:56:53.306 [HttpClient@77d67cf3-53] DEBUG i.u.d.i.o.c.EdgeApplicationConnector - {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402613234, "type":"iot:sens or:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":14, "freeParkingLotNumber":16}}
14:56:53.342 [HttpClient@77d67cf3-53] INFO i.u.d.i.o.c.EdgeApplicationConnector - Posting Notifications Response Code: 202
14:56:53.342 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - ... parking forwarded -> {"timestamp":1606402613234, "type":"iot:sens or:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":14, "freeParkingLotNumber":16}}
14:56:53.342 [HttpClient@77d67cf3-53] INFO i.u.d.e.p.RsuNotificationsHandle - publishing ETIS service descriptors: EdgeApplicationServiceDescriptor{serviceUrn=EdgeApplicationServiceUrn{id='etis-openness-demo', namespace='etis-openness'}, description=ETIS service, endpointUri='http://eaa.openness:7070/api/etis/event/', status='ready', notificationDescriptorList=[EdgeApplicationServiceNotificationDescriptor{name='parking', version='0.0.1', description='rsu-digitaltwin-demo:rsu-digitaltwin'}], info:''}...
```

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.28445434570312 m]
14:57:58.543 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402678543, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.7852568333334, longitude=10.2947711666667, altitude=85.28445434570312, provider='location_provider_file'))
14:57:59.542 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.7851651666667, Lng: 10.2947561166667, Altitude: Optional[85.28445434570312 m]
14:57:59.542 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402679542, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.7851651666667, longitude=10.2947561166667, altitude=85.28445434570312, provider='location_provider_file'))
14:58:00.584 [Timer-1] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/battery: TelemetryMessage(timestamp=1606402680504, type='iot:sensor:battery', dataValue=1598.9494344683026)
14:58:00.542 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.785046183333334, Lng: 10.2947202, Altitude: Optional[85.284420134277 m]
14:58:00.542 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402680542, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.785046183333334, longitude=10.2947202, altitude=85.284420134277, provider='location_provider_file'))
14:58:01.542 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.784987416666667, Lng: 10.294702383333333, Altitude: Optional[85.28440475463867 m]
14:58:01.542 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402681542, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.784987416666667, longitude=10.294702383333333, altitude=85.28440475463867, provider='location_provider_file'))
14:58:02.542 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.784928133333333, Lng: 10.294684533333333, Altitude: Optional[85.2843856815234 m]
14:58:02.542 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402682542, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.784928133333333, longitude=10.294684533333333, altitude=85.2843856815234, provider='location_provider_file'))
14:58:03.269 [HttpClient@47db5fa5-53] INFO i.u.d.v.p.EtisNotificationsHandle - Message got: {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402683234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":12, "freeParkingLotNumber":18}}, "producer":{"id":"rsu-digit altwin-demo", "namespace":"rsu-digitaltwin"}}
14:58:03.343 [HttpClient@47db5fa5-56] INFO i.u.d.v.p.EtisNotificationsHandle - Message got: {"name":"parking", "version":"0.0.1", "payload":{"timestamp":1606402683234, "type":"iot:sensor:parkingarea", "data":{"gpsLocationDescriptor":{"latitude":44.7935344666667, "longitude":10.3132929666667, "altitude":0.0, "provider":"location_provider_file", "parkingLotLimit":30, "occupiedParkingLotNumber":12, "freeParkingLotNumber":18}}, "producer":{"id":"etis-openness-demo", "namespace":"etis-openness"}}
14:58:03.542 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.784809733333333, Lng: 10.294643316666667, Altitude: Optional[85.2843516357422 m]
14:58:03.542 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402683542, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.784809733333333, longitude=10.2946433166667, altitude=85.2843516357422, provider='location_provider_file'))
14:58:04.543 [Timer-0] INFO i.u.d.v.r.GpsGpxSensorResource - iot:sensor:gps -> Lat: 44.7847983, Lng: 10.294462116666667, Altitude: Optional[85.28417205810547 m]
14:58:04.543 [Timer-0] INFO i.u.d.v.d.VehicleMqttSmartObject - fleet/vehicle/com:iot:vehicle:vehicle0081/telemetry/gps: TelemetryMessage(timestamp=1606402684543, type='iot:sensor:gps', dataValue=LocationDescriptor(latitude=44.7847983, longitude=10.2944621166667, altitude=85.28417205810547, provider='location_provider_file'))
```

Road Side Unit (RSU)
Digital Twin Container

Edge Traffic Information System
Container

Vehicle
Digital Twin Container

External Connected Development Machine

Road Side Unit (RSU)
Emulator

```
//ADD LISTENER FOR AVAILABLE RESOURCES
if(resourceEntry.getValue().getType().equals(ParkingAreaSensorResource.RESOURCE_TYPE)){
    ParkingAreaSensorResource parkingAreaSensorResource = (ParkingAreaSensorResource)resourceEntry.getValue();
    parkingAreaSensorResource.addDataListener(new ResourceDataListener(ParkingAreaStatusDescriptor){
        @Override
        public void onDataChanged(SmartObjectResource<ParkingAreaStatusDescriptor> resource, ParkingAreaStatusDescriptor updatedValue) {
            try {
                publishTelemetryData(String.format("%s/%s/%s", deviceBasicTopic, TELEMETRY_TOPIC, resourceEntry.getValue().getTopic()), new TelemetryMessage(ParkingAreaStatusDescriptor(parkingAreaSensorResource.getType(), updatedValue)));
            } catch (MqttException | JSONException e) {
                e.printStackTrace();
            }
        }
    });
}
```

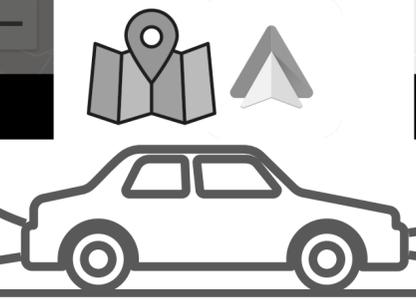
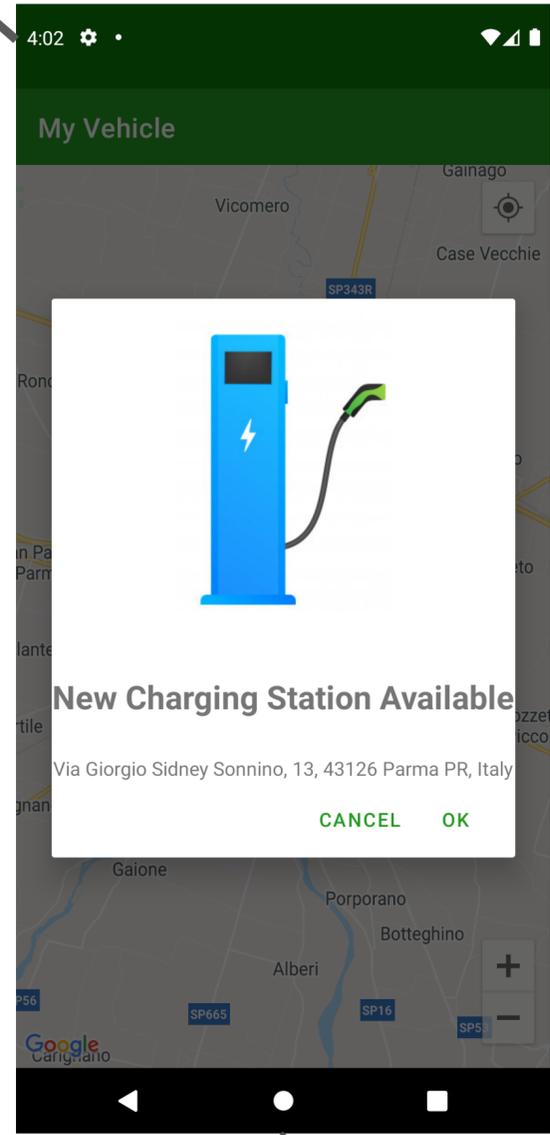
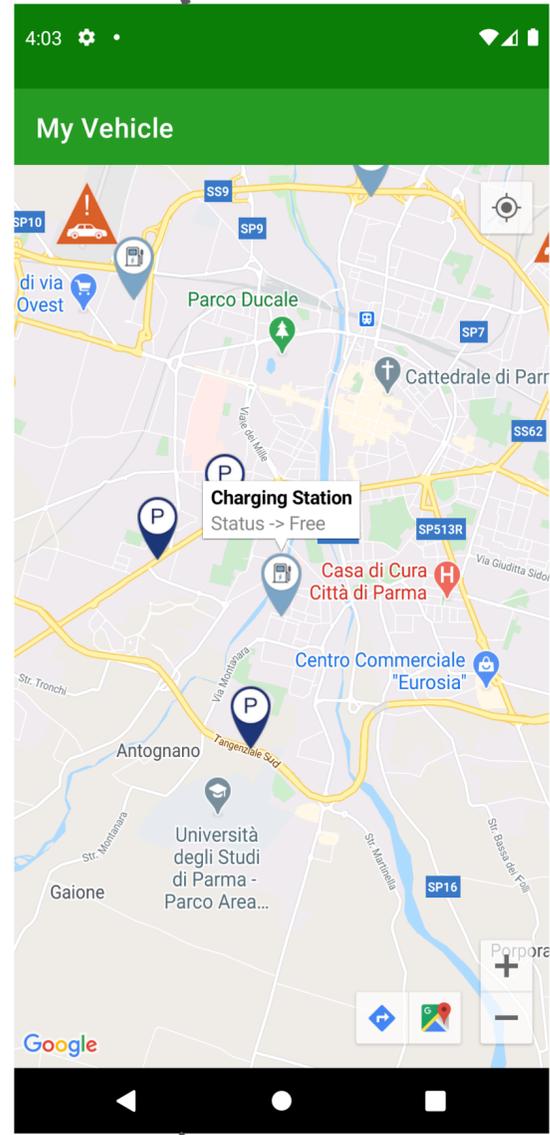
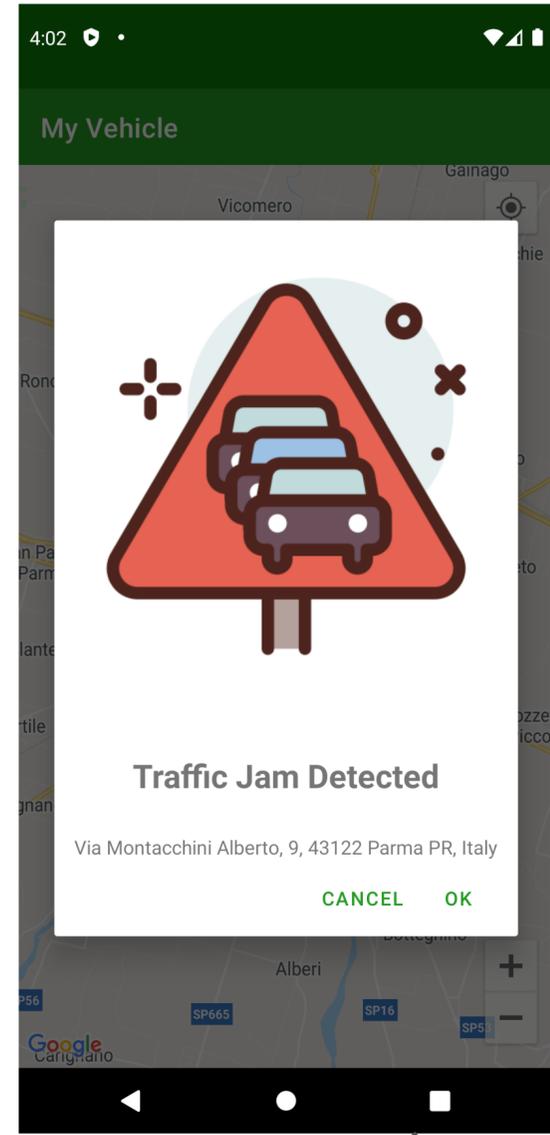
```
if(resourceEntry != null){
    //ADD LISTENER FOR GPS AND BATTERY RESOURCES
    if(resourceEntry.getValue().getType().equals(GpsGpxSensorResource.RESOURCE_TYPE) || resourceEntry.getValue().getType().equals(BatterySensorResource.RESOURCE_TYPE)){
        resourceEntry.addDataListener(new ResourceDataListener(){
            @Override
            public void onDataChanged(SmartObjectResource<GpsGpxSensorResource> smartObjectResource, Object updatedValue) {
                try {
                    publishTelemetryData(String.format("%s/%s/%s", deviceBasicTopic, TELEMETRY_TOPIC, resourceEntry.getValue().getTopic()), new TelemetryMessage(smartObjectResource.getType(), updatedValue));
                } catch (MqttException | JSONException e) {
                    logger.error("Error Sending Location Update: {} ", e.getLocalizedMessage());
                }
            }
        });
    }
}
```

Vehicle
Emulator

 **openNESS**
OPEN NETWORK EDGE SERVICES SOFTWARE

MEC - Edge Traffic Information System & Vehicle Digital Twin

 UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA



“Connected” Emulated Android Vehicle

Research

Extend Experiments
& Write Paper

Digital Twin Distributed
Coordination & Orchestration

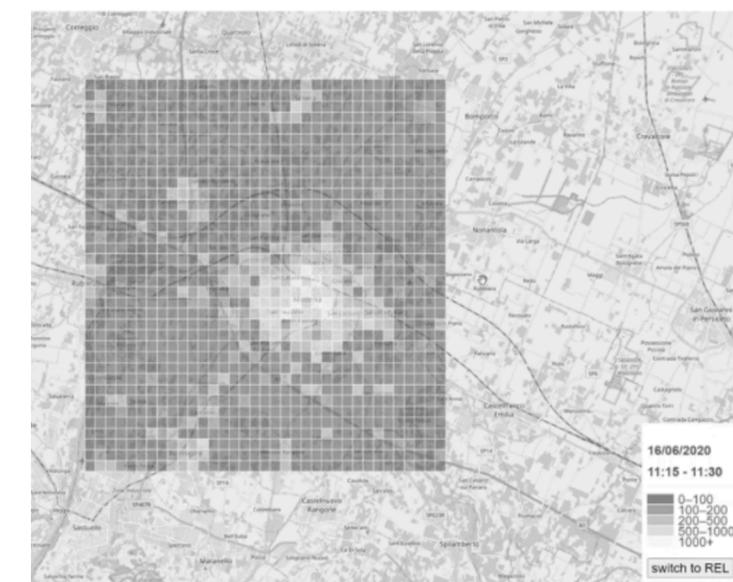
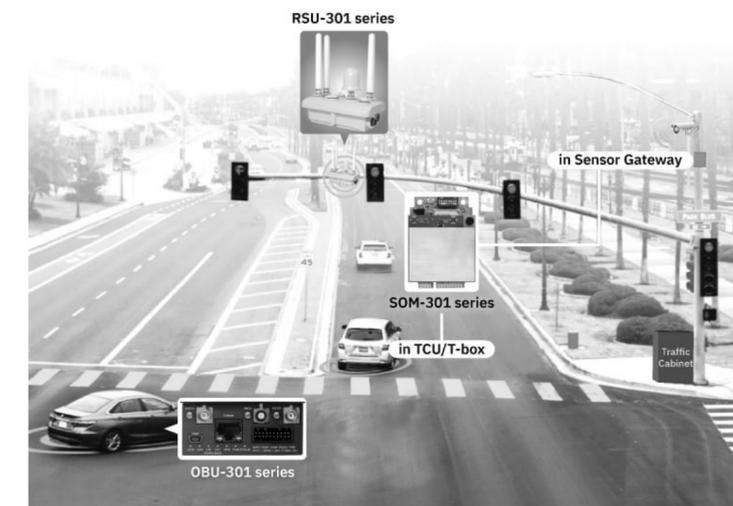
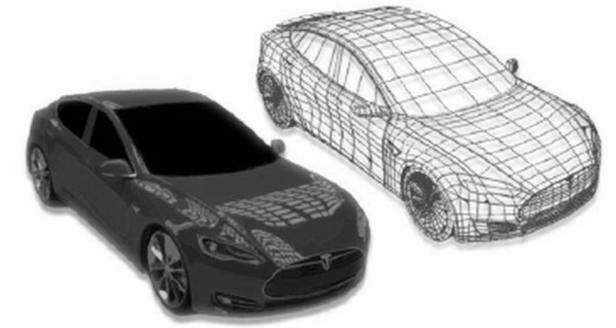
Development

Library OpenSource Release
+ Examples (Producer, Consumer) 

Congestion forecasting

Alternative routes suggestion

Forecasting and mobility patterns recognition
on cellular data (location & CDR)



Smart City Platforms Integration & Experiments

5G MEC IoT Digital Twin Large Scale Use Cases

Real Experiments and Integrations with
intelligent & connected vehicles

- Here (virtually)

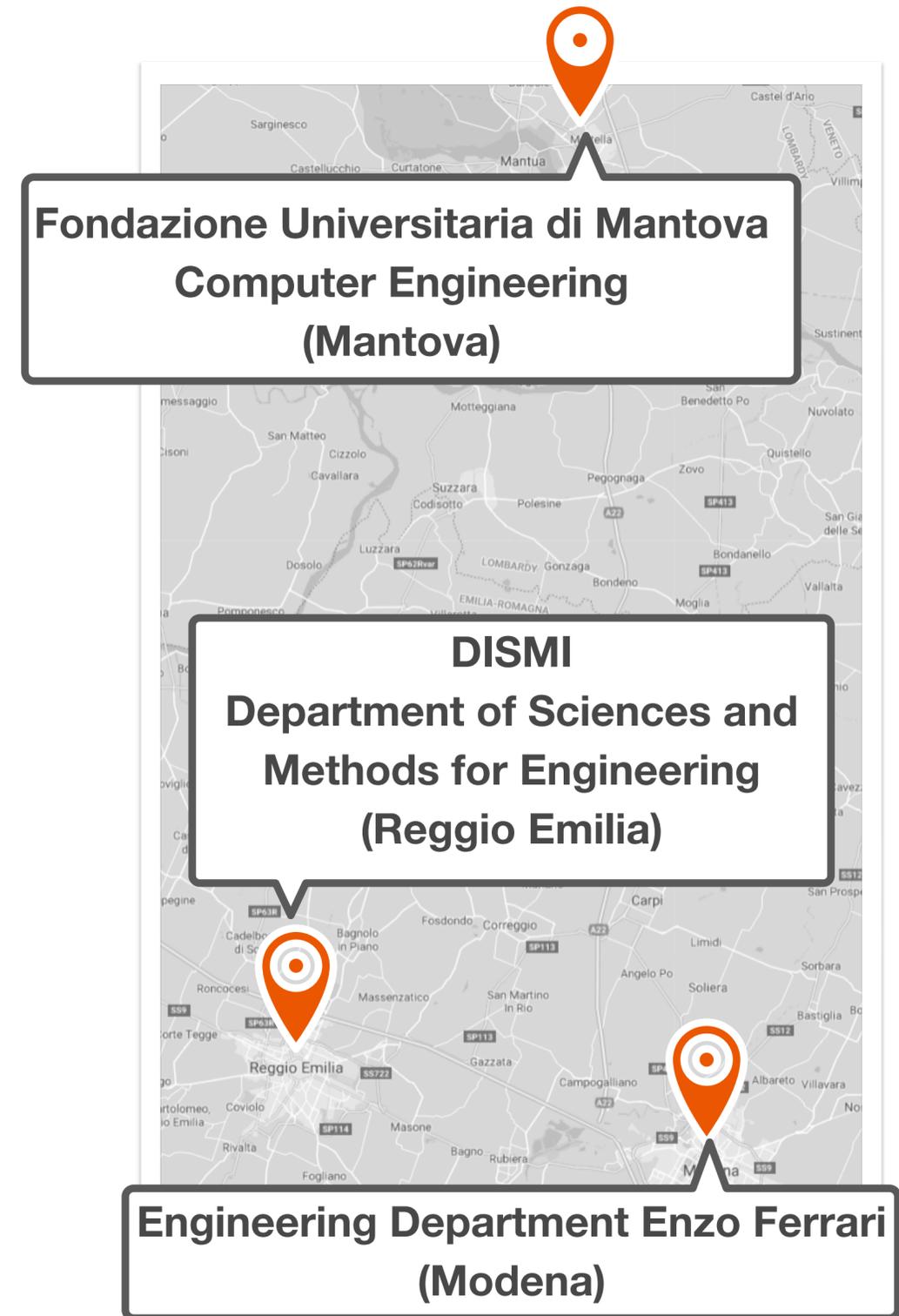
- Marco Picone, PhD
<https://www.marcopicone.net>



- Stefano Mariani, PhD
<https://smarianimore.github.io>



- Distributed and Pervasive Intelligence Group
(<http://dipi.unimore.it>)
 - 3 professors
 - 3 post-doc
 - 2 phd students
 - many MSc Students
- EU and National Projects
- Industrial Collaborations





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Cognitive Mobility

MEC Internet of Vehicles (IoV) Architecture



droidcon MEC Hackathon - November 2020
Final Presentation

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