COSMOS

Cultivate resilient smart Objects for Sustainable city application

Grant Agreement Nº 609043

D7.5.1 –

Smart events and protocols for smartpublic transport
(Year 1 Functionality)

WP7: Use cases Adaptation, Integration and Experimentation

Version: 0.7
Due Date: 31/10/2014
Delivery Date: 15/03/2015
Nature: Report
Dissemination Level: Public

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The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° 609043

Version Control:

Version	Date	Author	Author's Organization	Changes
0.1	19/01/2015	Sergio Fernández Andrés Recio	EMT	Initial version
0.2	20/01/2015	Juan Sancho	ATOS	Internal Review
0.3	17/02/2015	Sergio Fernández Andrés Recio	EMT	Reworked version from internal review
0.4	18/02/2015	Juan Sancho	ATOS	Internal Review
0.5	22/02/2015	Sergio Fernández Andrés Recio	EMT	Reworked version from final delivery
0.6	24/02/2015	Mónica Aguirre	ATOS	Internal Review
0.7	13/03/2015	Sergio Fernández Andrés Recio	EMT	Final additions

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Acronyms

Acronym	Meaning
ICT	Information and Communications Technology
ITS	Intelligent Transportation Systems
NoSQL	Not only SQL[1][2]
RDF	Resource Description Framework
JSON	JavaScript Object Notation
JSON-LD	JavaScript Object Notation Linked
AENOR	Spanish Association for Standardisation and Certification
UNE	A Spanish Standard
VEProt	Virtual Entity Process for Reactive and Ontological Things
DDP	Distributed Data Protocol.
UDP	User Datagram Protocol
TCP	Transmission Control Protocol
PYTHON	ComedianMonty Python.

1   Introduction

The development of intelligent systems oriented to Smart Cities requires coordination and the sum of synergies which, slowly, could lead to the expected changes. A clear example is the development of specialized sensors by companies and industries that have emerged in the wake of the niche market. This would not have been possible without setting up intelligent elements that offer business opportunities for those companies. In the meantime, these mechanisms and sensors have enabled smart cities to have physical and virtual elements on which to rely. Thus, the slow and constant work on this regard has meant to a mutual enrichment for sides, public and private sectors.

To achieved this, it has been important the investment in R&D of many entrepreneurs and managers who are anticipating the future, but also the work of theoretical researchers, docents and universities which have established guidelines and protocols for the virtualization of cities avoiding becoming chaotic. In addition to that, the role of cities, becoming city labs where to test and incorporate real projects has made possible the knowledge of the requested infrastructure to keep on working on this field.

As aforementioned before, within the objectives of COSMOSthe aim is to follow the same approach, which equivalence will be expressed in D7.5.2 and D7.5.3 deliverables. This development model will start from classical systems for integrating transport data events towards a model of virtualization of such events, following guidelines for standardization, orchestrationof services and public open data policies, designing protocols to be used in the exchange of information by citizens, businesses and institutions, even beyond the model of public transportation. That will be the contribution of COSMOS within the research field of SmartCities and, more specifically, within the concept of smarttransport.The transport oriented protocols which are being defined under the framework of COSMOS are the basement of the system predictive models that will deployed between Y2 and Y3.

2   Smart Labs and research projects

Multiple projects worldwide are serving for the development of information technologies aimed at creating ecosystems that allow learning how to use ICT and ITSto make smarter and more sustainable cities. The R&D efforts focus on several strategies, including:

1. Sensing systems: there are new business opportunities under multiple pathways thanks to new adapted microcontrollers oriented to signal acquisition and actuators as well as thanks to the expansion of reduced cost sensors together by an increased supply promoted by an industry in full expansion. It is therefore essential to have laboratories that can quantify and qualify the different technologies that are appearing. In Spain, scenarios such as Malaga, Zaragoza and Santander, to give some examples, provide unique opportunities for research in the field of intelligent sensing and intelligent control of objects, mainly within the fields of energy and communication. In these cities, large companies have deployed laboratories in large areas of the city including data acquisition and control of different types of elements of the city, always talking under the framework of smart labs.

2. Event management and information systems in real time: the construction of platforms oriented to the analysis of events such as queue managers and other information models based on the observation of changes, provide trained technologies for the exchange of status information among sensors. Currently, multiple commercial technologies enable the deployment of event-driven systems.

3. Storage capacity and Big Data: new storage systems, based on schemas and objects, known as No-SQLdatabases, are allowing scaling data solutions covering cloud infrastructures, from which status can be stored in order to apply methods of learning and experience through the use of data and the relationship between them.

4. Definition of schemes and digital information entities: multiple standards allow machines to know about entities and objects, by its ontology and semantics, providing structured repositories and methods of consultation and access to information enabling intelligent definition methods of any element of the city, especially affecting sensors and actuators.

All these elements together and in combination are being experimented in different city labs, producing a paradigm shift in the new world that is being built, which is a combination between the classic concept of a city and the integration of elements that improve its energy efficiency, mobility and accessibility, among others. In summary, Smart Cities are emerging thanks to technology and the construction of living labs in cities.

3   The commercial approach in the Smart Cities environment

One aspect to consider in the current deployment of Smart Cities is the possibility that large companies and corporations literally take technological control of cities. This is mainly due totheir privileged position in industry and research sectors, which can involve, in many cases, the deployment of various components (sensors, devices, event management systems, etc.) based on proprietary protocols and proprietary encryption systems that prevent a democratic growth approach of infrastructure. The risk is particularly high in models of municipal concessions, in which the exploitation and management of the various systems and resources of the city are delivered during a certain number of years by companies that are responsible for its management. These companies can, in turn, install sensing and control systems based on closed protocols and infrastructure, aimed basically to control their range of management and to ensure that the operation is performed in the best economic and energy efficiency conditions.

However, although the purpose for these action plans is legitimate and belongs to the normal operating field, its design has several disadvantages and risks, including:

- Prevents the constant technological adaptation: as it is based on a closed model and usually supported only in the field of the deployed system itself.
- Produces opacity phenomena in the information: as citizens and other companies have not the means to interact with the smart city infrastructure.
- It blocks business models based on local industry: as local industry might have a lack of integration possibilities for expanded uses of the network of sensors or actuators.

4   SmartTransport in the field of Smart Cities

One of the objectives pursued when advancing in the implementation of models of Smart Cities is an optimized transport from both the functional and economic point of view, including (especially when talking about public sector):

- Energy efficiency for cost savings. More energy efficient vehicles pose a significant reduction in costs, since fuel and energy is one of the biggest expenses in a public transport company. Vehicles with improved aerodynamics and propulsion systems with higher performance are part of the core of the research activities of vehicle manufacturers.
- Reducing emissions to achieve cleaner cities. Using cleaner fossil fuels and new technologies (catalysts, electric vehicles, hybrid vehicles with self-production energy, etc.)
- Optimization of routes and services. Inefficient or costly routes, obstacles on public roads, delays by blockages or slow traffic are causes of poor or inefficient service level. Better services can be achieved through optimization algorithms and processes, as well as applying greater control over the regulation of the fleet. Applying new regulatory measures and policies, such as dedicated lanes for public transport, increase the efficiency of the service.
- Quick resolution of incidents to avoid possible downtime. The public transport is subject to various endogenous and exogenous factors that will prevent planning to be accomplished. The affectation of an incident will largely depend on the knowledge of the events by the managers and the ability of a quick decision making transfer.
- Management of smart ticketing, with the aim of improving co and inter-modality. One factor that highly affects the efficient use of public transport is the creation of integrated tariff systems. Furthermore, the creation of registration systems for selling and accessing to public transport guarantee the control of demand, promoting management and spending management policies based on real data. The use of large areas of multimodal exchange stations and the analysis of origin-destination matrices coupled with fast access systems and contactless technologies for accessing or paying ensure comfortable and economical use of public transport.
- Instant detection of incidences. The use of sensors and alarms (detectors) in public transport vehicles ensure the anticipation of an event with major consequences. To this end, industrial sector is increasingly introducing elements for early detection.
- Integration with other systems of the city. Public transport is not an isolated element of the city, and its optimum performance largely depends on its links with other city infrastructures. Therefore it is necessary to foster joining relations between different infrastructures and systems creating supra-intelligent mechanisms. Some examples are the prioritization for buses at traffic lights or the coordination with security and emergency systems.
- Customer Information Systems. Ensuring that the public transport user has reliable information that allows instantaneous trip planning or, to take instantaneous decisions if the usual trip option is failing.
- Accessibility. Public transport should not be effective only with a majority of citizens but to all citizens. For this reason, it must provide means of access and service knowledge using channels and mechanisms accessible for all.

To achieve the aforementioned objectives, technologies and information systems pose one of the greatest challenges and, in turn, one of the main tools in the field of transportation, and

ITS and ICT initiatives must be efficient and be based in technological models that guarantee the points described above.

5 Smart Cities Public models vs. Private models

SmartCities offer a new range of niches in which private exploitation system models of transportation, energy and other sensorial elements are not the only viable infrastructure, as are not either those exclusively municipal or public. On the contrary, mixed and juxtaposed models between private and public systems can be a way to ensure continuity, scaling and co-participation in building virtual cities.

The proposed COSMOS model is intended to provide a possible architecture equivalent to those which have been the classical ones that have come to be the benchmark in the construction of cities, that is: public bodies concerned and in charge of ensuring the transmission and exchange of information from which any organism, company or citizen can create their business models or research activities. The proposed model is based on standardization, certification and co-participation of systems emulating the traditional functioning of cities, since this model is adapting naturally to the ecosystem of human societies.

6 COSMOS within the Smart Public Transport infrastructure. Standardization and protocols proposal

6.1 Virtual Entities associated or connected with public transport: schema and ontology definition

The definition of an intelligent transport model involves designing proper ontology. Transport COSMOS model schemas and contents are being built on RDF and JSON-LD models. The definitions are proposed under European standards through the Spanish Association for Standardization and Certification, AENOR (CTN 178 AENOR group as defined in UNE 178301). The datagram message headers are being defined under schemes of context (@context) according the proposed standard by the JSON-LD community.

The Virtual Entities which are being defined under semantic schemes are:

- Line: Each journey trip made by the public transport service (bus line).
- Bus: Each of the transport units serving in a line (bus).
- Driver: Driver performing each specific service on the bus.
- Traveller: Bus user connected or integrated into the COSMOS infrastructure.
- Electronic Panel: Information device providing useful information to travellers about the service or incidents.
- Sensor: reading device or actuator connected to the transport infrastructure (bus or informative electronic panel).
- Event: Each of the messages containing information related to transportation. An event can be one bus stop, a traveller getting on the bus, a engine temperature alarm and, in general, any information generated in the system which gets integrated into the COSMOS infrastructure.

The semantic definition of virtual entities, once finalized, will be available in opendata format in the server repository http://openbus.emtmadrid.es

6.2 Transport oriented events server

The city information should flow through systems and nodal connections capable to ensure the exchange of useful information for citizens and businesses. Communication architecture should be based on open standards and be public infrastructure through which data can be consumed and reused openly (or at least, those data that are capable of being shared). Thus, the information could be exchanged in multiple modes, that is, from citizens and private sectors to municipal systems and vice versa.

In order to share this information within the COSMOS system, Madrid proposes a Local Cloud based on an event server that would act as the only point of connection and exchange of mobility oriented events. This event server must be:

- Adaptive: allowing the addition of new layers of information quickly and dynamically, compatible with dynamic information models based in objects or virtual entities
- Reactive: allowing subscription to objects or entities by clients and multiple systems.
- Safe: supporting models based on public information and private data.

The nodal server systems should be, undoubtedly, municipally controlled considering the approach of Smart Cities, and orchestration of services should correspond to infrastructures under the rule of public sector, beside the fact that private contents compliant with the protocol and standardization standards of the city could pass through it or be exchanged through it.

COSMOS proposed model for the intelligent management of public transport event, is based on JavaScript Meteor architecture, supported by Node.js. This infrastructure allows real-time client subscriptions to exchange standardized events information. The management of change for publishing queue results towards subscribers would be made by observing changes in a Mongo DBdatabase.

6.3   Smart Events integration client

In order to provide systems that enable rapid integration of events within the transportation environment, COSMOS proposes the development of a specific piece of software that allows the exchange of information between different transport entities. This system, called VEProt(Virtual Entity Process for Reactive and Ontological Things),is a software client that will be released under an Open Source model on Githubin order to ease the exchange of events and to consume/send information about transportation as well as any other useful data using the events server of the city.

6.3.1. VEProt description

VEProtis a logical system for the exchange of information between the different processes that can interact within an open scheme with proprietary or third parties systems. Its purpose is to provide a means of transportation and normalized information flow by which two systems or devices can communicate.

VEProt uses JSON as the exchange protocol handshaking and its functionalities are implemented through listening ports; these ports are configurable according to each subsystem model. Thus, it is possible to develop variable and adaptable configurations to each device according to port availability. VEProt sends data frames from IP ports towards the devices or subsystems which are message recipients and, in turn, can listen and receive responses via another port.

The VEProt system, designed globally, is the set of processes and protocols that allow a low-level object within the paradigm of IoT, to communicate status and data and to connect sensors and react instantly to changing events. This system, originally designed to work within different devices in the field of smart city mobility, can be moved naturally to any platform or system which requires interoperability and reactivity, especially in city environments, providing a unified mechanism for both communication and processing of various existing elements and also for instant sharing information with the public.

VEProt is based on a message scheme containing the rules, format and information needed so the different message subsystems know the attributes, relationships and the information to be exchanged among VEs.

VEProt can communicate remote Virtual Entities (not visible to each other) through reactive mechanisms by using DDP (into Event Server of Municipality of Madrid) or, can communicate local VE through UDP / TCP Standard protocols.

VEProt is defined in two ways, depending on its behaviour. The first definition is in terms of the set of processes that enables a device, sensor or system to operate autonomously. These

processes are developed through a multi-platform programming language (Python) and they are located within a local area or ecosystem, to which sensors or devices are connected.

In summary, the transformation of a sensor or device into a VE requires:

1. A manufacturer driver or a low-level routine resident in the system that has the device connected.
2. A communication interface with VEProt, consisting of the transformation process of the different actions, status and characteristics of the device into those of a VE by defining a datagram.
3. Installing VEProt software that allows two-way communication among the device or sensor with other systems or with other VE, as well as performing autonomous actions.

Conversion processes of events from devices/sensors to virtual entities are performed at the far end of the communication, that is, at those points where the information can be processed (generally a computer) and which have contact with the device information at a low level (communication with the driver, access to the communication port, access to the interruption, etc.).

Communication frames (datagram) are defined by a common language, through which they can indicate:

- Who is it?
- What kind of Virtual Entity is it?
- What characteristics and qualities does it have?
- What actions does it want to perform on another system?
- How can it communicate?
- What does it want to communicate?

6.4   Transport events exchange protocol

The exchange of events information within a Smart City has to be based on business rules and structures of dynamic information, but known in advance.

Currently, there are models of information in a very early stage or which are not fully developed to allow open communication of events that permit co-management participation and exchange of public-private information. Therefore, COSMOS aims to provide a new vision that guarantees the possibility of exchanging any information.

This structure must ensure the inclusion of multiple sensors and data in the system, while different observers can subscribe to get the information that is of interest to them using the event server.

The proposed datagram contains the following structure:

6.4.1. Header context

The virtual entities included in the message manifest themselves through this structure that defines the context elements. Further details about the implementation of the elements of the dictionary definition can be found inhttp://www.w3.org/TR/json-ld/

Example:

"VE:prot":

[

 {

   "@context": "http://cosmos.org/contexts/cities",

"city": "Madrid",

   "homepage": "http://www.emtmadrid.es/",

"domain": "http://cosmos.org/contexts/domain#transport",

        "layer": "transport.emt.bus.cpucore"

        "VE": "source",

        "@type": "bus"

 },

 {

   "@context": "http://cosmos.org/contexts/cities",

   "city": "Madrid",

   "homepage": "http://www.madrid.org/",

"domain": "http://cosmos.org/contexts/domain#sensor",

        "layer": "transport.emt.bus.sensor"

        "VE": "target",

        "@type": "co2sensor",

 }

]

6.4.2. Control Header

The header contains general information of the message frame.

- VE:header. Unique identifying label indicating that the text below is a header.
- VE:version. Contains the VEPROT version used for communication.
- VE:id.Allows the introduction of a unique identifying value for the entity.
- VE:datetime.Date and time of the request or generated message.
- VE:dateexpir.Message expiration date and time.
- VE:coordinateX.Geographic longitude coordinate in which the message is generated.Format must be WGS84.
- VE:coordinateY. Geographic latitude coordinate in which the message is generated.Format must be WGS84.

- VE:coordinateZ. Altitude in meters in which the message is generated.
- VE:size. Message size (for check of integrity).

Example:

```
"VE:header": {

    "VE:version": "1.00",

    "VE:id": "8CDA1667-C31B-4723-8154-90B8992EDA2A",

    "VE:datetime": "2014-04-20 13:23:05.01234 UTC",

    "VE:dateexpir": "2014-04-20 14:00:05.01234 UTC",

    "VE:coordinatey": "40.6719856",

    "VE:coordinatex": "-4.089738",

    "VE:coordinatez": "853",

"VE:size": "243"

}
```

6.4.3. Virtual Entity Identifier or Request Original System

It allows that the message's addressed or the message's intermediate manager knows about the message sender. The data included is:

- VE:source. Fixed label that indicates that the structure contains the identification of the source system of the message.
- VE:id. Unique identifier of that object within its data layer.
- VE:systemsource.System/Entity code that generates the information. The receiver system must recognize that code as it allows the segmentation and analysis of the message contents.
- VE:subsystemsource.Information origin subsystem. It will allow the segmentation of the information of a virtual entity in multiple schemes, depending on the specialization.
- VE:versionsource.Identifier of the version of the generated information by the system source,regarding the general diagram.
- VE:functionsource. Function that emits the message.
- VE:modelistening. Listening mode for the answers.
- VE:port. Listening port
- VE:address. Listening address for the message answer.

Example:

```
 "VE:source": {

        "VE:id": "1234",

         "VE:systemsource": "EMTBUS",

        "VE:subsystemsource": "CORECPU",

          "VE:functionsource": "INTEGRATOR",
```

"VE:versionsource": "3.02.76",

"VE:modelistening": "SKT",

"VE:address": "82.45.133.2",

"VE:port": "1424"

}

6.4.4. Identifiers of the target system

It contains relevant information about who is the final addressee of the data frame. This way, segmentations can be done in the subscription mechanisms by receiver system, so only the systems that need that frame will be the consumers of that information.

It defines the system to which VEPROT must send the information. It contains the following tags within its structure:

- EV:target. Unique label that identifies this block.
- EV:systemtarget.Identifier of the destination system. This is an identifier for the subscriber through which the subscriber who is the message addressee.
- VE:subsystemtarget. Identifier of the destination subsystem. A subscriber can identify its message and recognize where it will be redirected within its system.
- VE:functiontarget. Invoking function at the addressee system. It indicates the function type that must be invoked in the destiny subsystem.

Example:

```
 "VE:target": {

  "VE:systemtarget": "VALUE",

  "VE:subsystemtarget": "VALUESENSOR",

  "VE:functiontarget": "READ"

 }
```

6.4.5. Identifiers of instructions and data

They define the structure of the virtual entity that contains the data from the message body (on array type structures).It contains the following values:

- VE:message. Unique label of the object. Message information exchanged between two virtual entities. Several of such structures may exist within the message to be exchanged.
- VE:id. Unique identifier of the data section within the overall message. It may simply be a sequential value.
- VE:confirmreq. Indicator response requirement. Value 0 = No requirement 1.- requirement.
- VE:timeout.Information or content validity time in milliseconds.
- VE:mode.Execution mode indicator. Value 0=Asynchronous (VEPROT generates the call through one of its threads and continues with the execution of other processes or functions). Value 1= Synchronous (VECore stops the execution of its threads until response or timeout requested) call.
- VE:fiability.Reliability of the message; it will contain a percentage value whose maximum will be 100.
- VE:type.Defines the data type within the message.
- EV:subtype.It contains the data subtype within the type category. Some examples may be: XLS, MP3, TXT, EXE, etc.
- VE:encrypt. Encryption type (if there is any).

- VE:user.User that will be required to connect to the destiny resource.
- VE:passw.Password that will be required to connect to the destiny resource.
- VE:publickey. Public key that will be used for the encryption (coding-decoding) of the communication (if there is any).
- VE:data. Data set to be communicated by the virtual entity. The content will depend on each frame type.

Example:

```
"VE:message": [
  {
"VE:id": "9DBC2368DA1E-56A1-895F-143A56BC87DF",
    "VE:confirmreq": "1",
"VE:timeout": "1000",
    "VE:fiability": "100%",
"VE:type": "BIN",
    "VE:subtype": "B64",
    "VE:encrypt": "none",
    "VE:user": "any",
    "VE:passw": "any",
    "VE:publickey": "any",
    "VE:data": {
     "port": "COM4",
     "PARITY": "true",
     "velocity": "9600"    }
  }
 ]
```

6.4.6. Response indicators

In the area of response data the invoked subsystems will return the achieved result data either as a return message or as the required data frame, provided that a response has been requested.

The content is defined as indicated below:

- VE:returntosender. Unique defining label indicating that the object is the one informing about the result of the operation. The object contains the following values:
  - VE:errorcode: Return code about the result of the request.
  - VE:errordescription. Request result description.
  - VE:datetime. Date and time of the result of the request according to the invoked system
  - VE:response. It will be an added object to each message sent within the array

- o VE:response.Array with the content of the returned data
  - • VE:id. Identifier of the individual frame of the message.
  - • VE:data. Values of the message.

<u>Example:</u>

```
{
        "VE:returntosender": {
        "VE:,errorcode": "000",
        "VE:errordescription": "INFO:decoded ok, datagrame allowing",
        "VE:datetime": "2014-04-20 13:23:05.06543 UTC",
        "VE:response":      [
        { "VE:id":"9DBC2368DA1E-56A1-895F-143A56BC87DF",
            "VE:data": {
             "valuelevel": "18",
             "temperature": "5º"
        } }
         ]
}
```

7   COSMOS opportunities under the Smart Transport context

There are multiple circumstances and needs within a mobility oriented city system that depends on systems or subsystems whose development and implementation is beyond the specific context of transport or the establishment of protocols and standards for the exchange of information within a city. Among the main ones, we could find the security elements to ensure that certain content can be transferred between ends with the highest guarantee and confidentiality. On this regard, COSMOS could provide a secure way to encrypt a message segment that can travel through a public infrastructure and within an open protocol.

Information such as personal data, images, health data, etc. could use the Hardware Security Board developed under the framework of COSMOS as an encryption mechanism "extreme to extreme". Those client systems requiring encryption of a VEPROT datagram segment can perform the encryption operation and then be translated only by authorized recipients. It also lets information storage through Storlets within the Cloud with segments of encrypted messages and be recovered afterwards with total security.

Another important element for Smart Transport environment is the Complex Event Processor (CEP), which allows you to manage and anticipate situations where a special event somewhere in the city can affect very significantly to the overall mobility or specific mobility of a citizen. Such events, by analyzing patterns of previously processed data through the CEP can provide predictions that can help efficiency in traffic and, ultimately, to the overall mobility of the city.

Therefore, analyzing the course and passing of buses, the density of traffic and traffic light phases provides useful data for planning special situations or prevent changes to a value of a pre-established series. Thus, connecting a predictive events analysis system to the transportation infrastructure provides added value for the management and planning of public transport and traffic.

For this, the mobility systems of the city must provide those events to the CEP, and through its analysis, getting automatically outlier data to take the appropriate decisions. And all in real time.

A clear example or use case is when the expected arrival time of a bus, which carries a person with special needs, should be analyzed in a particular place and this bus does not arrive within its forecast; or undergoes a change on the bus route; or the person with special needs gets off the bus at a wrong bus stop; or does not realize that he/she has arrived to his/her destination, etc. all the aforementioned situations that could alert a supervisor or caregiver. To this end, transport events and contextual data need to be sent to bigdata storage systems such as those designed in the context of COSMOS. The purpose of Madrid, as a Smart Mobility City is to analyze how COSMOS, from the point of view of a permanent events analysing system can be used to solve complex problems of the city.

In summary, efficient communication of a uniform and open data flow, integrating connectors and processes within urban public platforms, interoperating with a system like COSMOS provides the ability to dynamically compose information flows for solutions adaptable to multiple situations.

8   Conclusions

The final conclusion of the study leads us to believe that the integration of the various systems of public transport within the paradigm of IoT passes through the right combination of public infrastructure and private systems, within which the public component plays the following roles:

- Supplier of a unified event information exchange protocol.
- Provider of public service infrastructure, especially server architectures able to understand, integrate and connect different systems, information providers and customers under a unified architecture.
- Coordinating and managing body for the approval and of smart devices in order to ensure the adaptability of different mechanisms and virtual organizations in the city.

On the contrary, the private component (businesses, citizens, research centres),will use thepublic infrastructure used for the purposes that their model or task is required, either for collaborative purposes or for direct consumption of information.
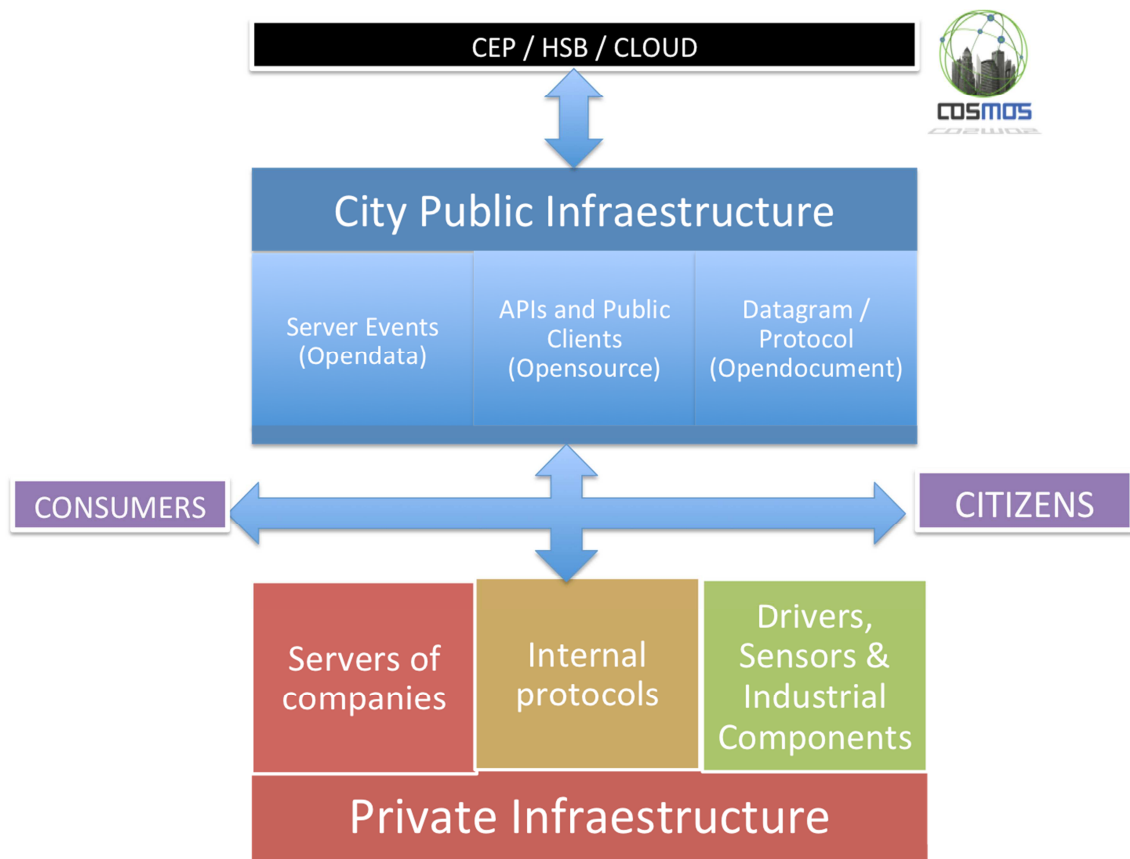

Figure 1: Public and private cooperation schema

9 Recommendations for Y2

Among the recommendations for this first Y1 results, we would like to highlight the following to ensure the success of the project. We suggest establishing a <u>multi-discipline working group</u> aimed at creating a model definition, communication and management of objects, systems and sensors for the city of Madrid. This working group will be responsible for the specification, development and implementation of a Smart City Labin Madrid. In principle, the focus field may be more related to transportation, but with an open scope.

The main aim is to constitute a group wide enough to allow the participation of the four major groups of actors potentially involved in the development of the VEPROT system. This group will be the project management committee and the "seed" for the implementation of the lab infrastructure.
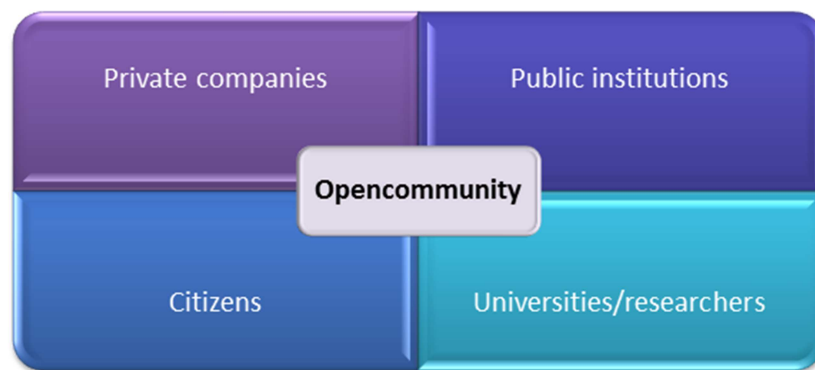

Figure 2: Proposed local working group for Y2

The aforementioned community could be structured as follows:

- <u>Project ManagementCommittee</u>: management function will be at a high level throughout the life cycle of the project and presentation, distribution and publication of the progress and results achieved over time.
- <u>Audit and Oversight Committee</u>: their role will be to establish the guarantees to ensure that the tasks that are planned are carried out with maximum quality as well as to verify that the repositories of code and documentation and new versions of VEProthave the highest reliability and warranty. This committee will also analyze the bug and the feedback from any source, establishing mechanisms for the evolution of the system.
- <u>Coordination of code development</u>: It shall arrange the analysis and specification of the source code to develop. It will also have the function to document and upload to the public repository the code developed.
- <u>Developers</u>: Those responsible for conducting the development of source code, using public repositories (GitHub, etc.)
- <u>Specification-ontology and semantic entities</u>: is responsible for defining the data model of virtual organizations in the city, as well as to maintain the information and the definition of the entities in public repositories. This function will be performed by specialists.
- <u>Repositories, diagrams, web-semantics</u>: the schemes will be used under any standardized specification for defining objects in public and accessible repositories.
- <u>Protocol specification data</u>: VEProt requires a standardized data exchange, to be defined, nurtured and developed by specialists and updated in a public repository.

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