Control System for Public Lighting

DECEMBER 2016 – Rev.1

Technical Brochure

1. Preface

AEC Smart System is an innovative platform able to manage public lighting and at the same time is suitable to join the most advanced capability to manage every city's parameter (energy, maintenance, pollution, traffic, waste, connectivity, digital signage etc.) using a powerful technology of WSN (Wireless Sensor Network) able to cover IoT needs. This integrated built-in multi service technology permits to the AEC Smart System platform to become a flexible, modular and sustainable solution to manage the modern Smart Cities.

To have a true smart city services, both for old plants or new project, AEC Smart System is the unique solution to upgrade each application step by step and cover every citizen needs, thinking a modern city where is possible to manage in real time alarm, planning and sensors performing the so called "Internet of Things" paradigm and "smart city" services.

In the following pages will be described the solution architecture, the hardware devices and the software with all the services that it is possible to enable.

2. System Architecture

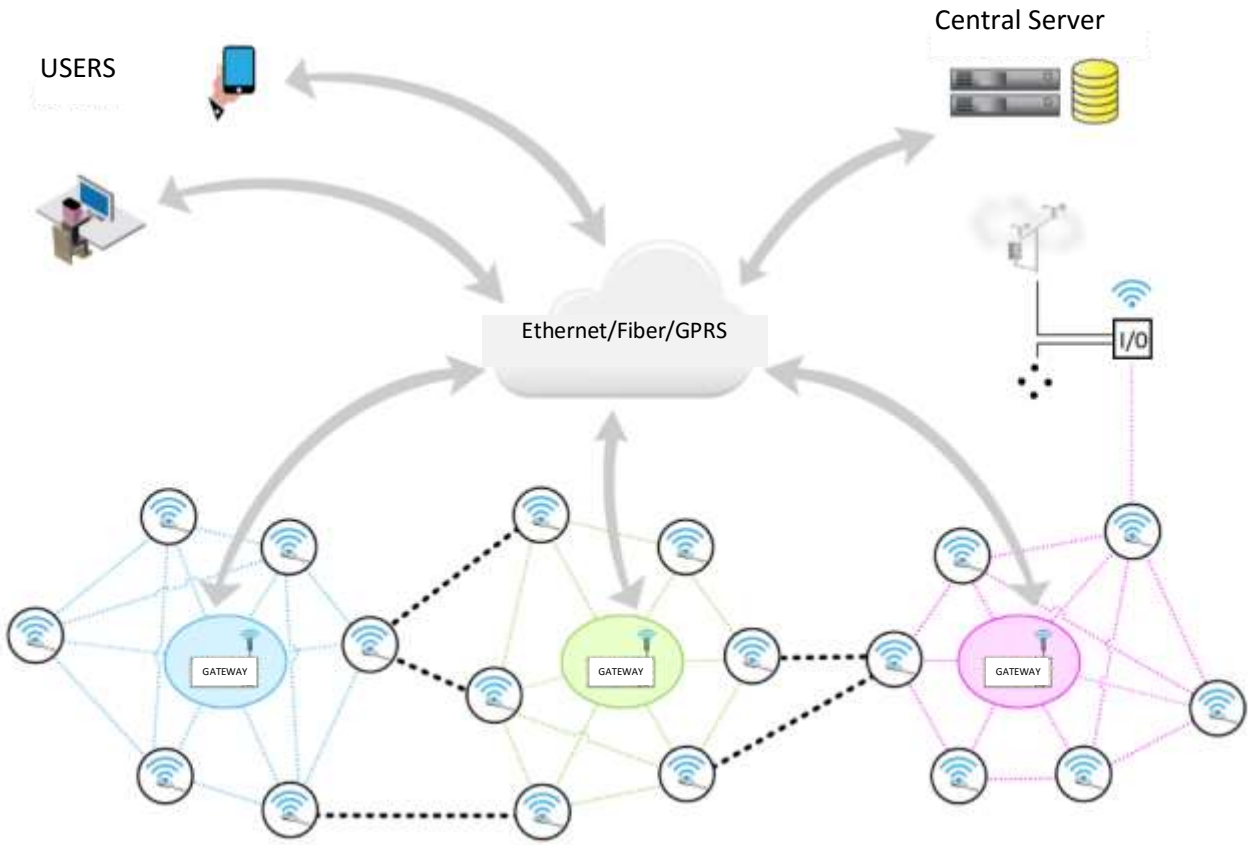

Figure 1: General Architecture

Gateway & node coordinator

wireless node (luminaire) and light controller

Environmental sensor (option)

Local I/O device (optionally)

User Control Station

Service mobile user able to connect to SmartSystem Network

Figure 1 describes Smart System wireless network and each part of the system, each one coupled to a corresponding a gateway. All the sub network are logically divided from the main network. Each node, during the installation time, is therefore associated to one sub network. This assignment could be changed dinamically during the time.

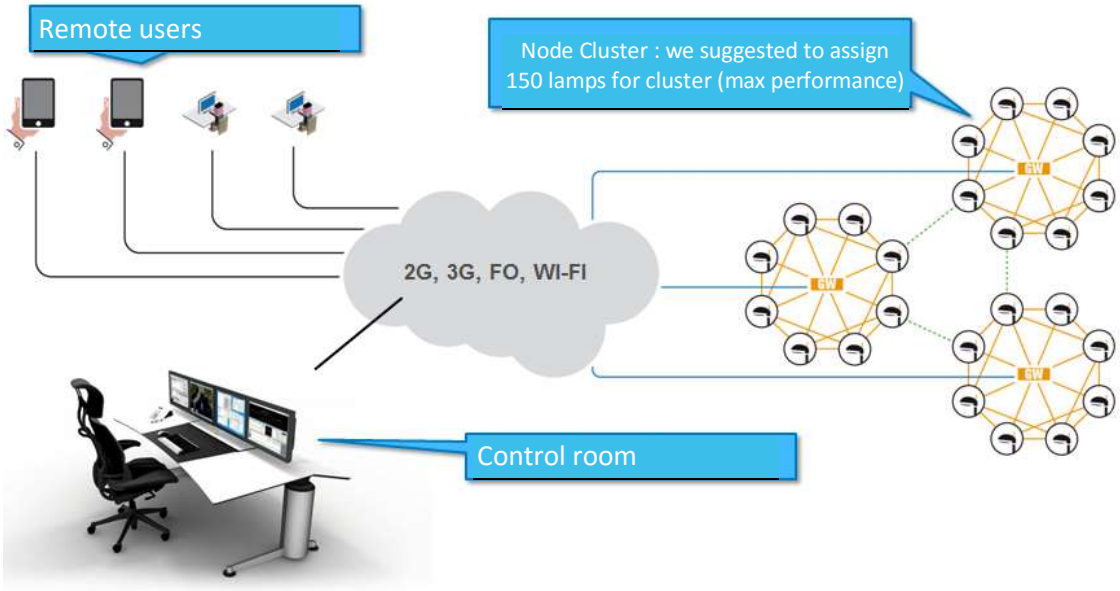

Figure 2: Up level architecture with each group for each gateway

A gateway permits to connect the wireless network nodes with an IP network to guarantee the data exchange between nodes and server.

On the main server will be installed the remote supervision system; in this way all the nodes will be managed according to the scenario and the programmed configuration.

3. Smart System Network

Actually the IoT scenario became day by day part of City Life. Due to innovation technology and higher sensibility in energy saving, environmental issue, integration and efficiency in urban services, smart city solutions are fast increasing according to citizens needs and requirements. This scenario impose to provide and adopt a big variety of electronic sensors able to work in a distributed and cooperating way, using a shared information channel. These devices creates widespread wireless communication therefore is necessary to have a suitable architecture to manage all these data and the corresponding services.

The innovation technology closely related to this particular network, permits to produce smaller electronic device with great performance, increasing efficiency, reducing energy consumption and improving cost effectiveness. The result is a higher level integration of these devices in many cities. Typically there is the need to create a network to share information between sensors and a control center to manage in a supervised way the functionalities of the end devices and smart city services. A possible approach is to configure end devices as network nodes: using the shared wireless communication channel each node can interoperate with the others performing specific services (energy, waste, traffic etc) under the supervison of a central control room.

The disadvantage of this approach is that the sensors usually work on battery basis, therefore the network capabilities are drastically limited (or not feasible) due to power consumption. AEC Smart System provides an innovative solution based on the usage of the lighting fitting as primary network node interacting with second sensors layer to perform at the same time smart lighting remote and Smart City services.

Smart System platform, using the public lighting, permits to have a unique IoT infrastructure composed by a huge amount of nodes widespread over the city to manage smart lighting and Smart City services through a remote control approach. Public lighting is definitely suitable for supporting a Wireless Sensor Network (WSN) for a wide range of applications and requirements.

The wireless network provided by AEC works on free 2.4 GHz frequency and supports the IEEE standard 802.15.4 at physical level. Like ZigBee, all Smart System devices are able to connect other nodes using multi-hop connections. Using the capillarity of public lighting network (Figure 3), Smart System platform enables a low power and low bit rate WSN with huge coverage over urban areas, and uses sensors (installed on board or connected in the same wireless network) to perform Smart City activities.

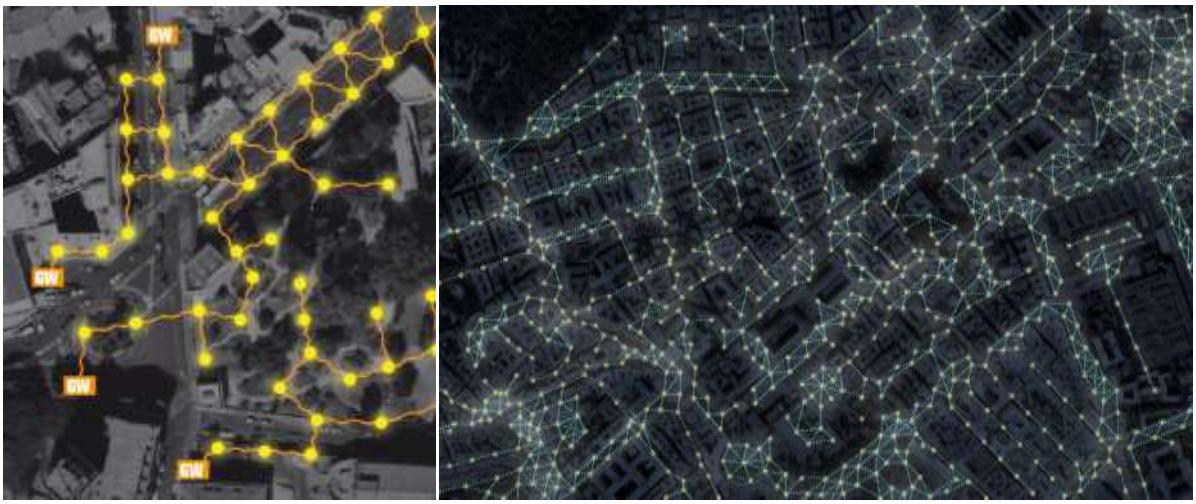

Figure 3: Capillarity of Smart System solution.

The nodes network can be divided in sub-net, each one typically assigned to a gateway to convey information to/from the control center. Every sub-net can correspond to a specific area of the city or may convey specific functionalities. Network segmentation makes easier the data radio transmission avoiding congestion increasing efficiency and resilience and simplifies the infrastructure communication management. In case of gateway break down or communication failures within the nodes of the network, the multi hop architecture and multiple gateways may ensure continuity of service (in particular the closest gateway may take charge of the isolated subnet if there is link connection between subnets and there is a congruous number of network elements).

Furthermore, thanks to the network organization, the control room is able to manage the smart lighting in broadcast (**Figure 4**), multicast or unicast (**Figure 5**) approach, to exploit at best the lighting management capabilities.

In case of wrong connectivity toward the control room and devices, Smart System nodes work in stand alone off-line mode, driving the lamps on local approach using built-in astronomical timer or dimming phases regulation stored in its memory (that can be remotely configured). (**Figure 6**)

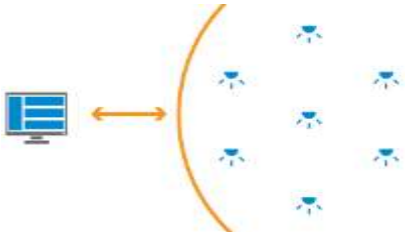

Figure 4: Cluster management

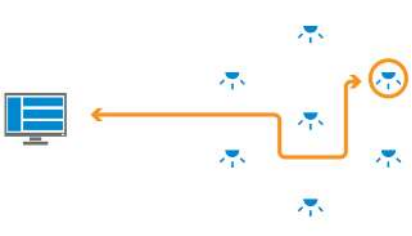

Figure 5: point management

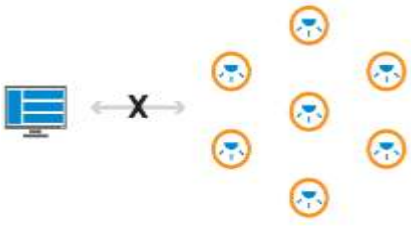

Figure 6: off-line working

4. Hardware system components

AEC Smart System consists basically in two devices that create the WSN (Wireless Sensor Network). The combination of these elements allows to manage the public lighting infrastructure and to receive all the information coming from the different elements of the WSN (nodes, sensors, end devices) collecting information, forwarding data, and providing Smart City services.

- **Concentrator** (**Figure 7**). This device is the communication gateway and a nodes WSN coordinator installed on the lighting point.
- **Luminaire node** (**Figure 8**). Installed on the lighting point, is either the lamp commander/controller either the WSN node.

Figure 7: Concentrator with radio module.

Figure 8: Internal Radio Node.

In a standard application the concentrator usually interacts with a power meter to acquire electrical line measurements included power savings.

The node device is installed on the luminaire through the NEMA SOCKET from which it is powered and through which is connected to the DALI port of the led driver.

The concentrator provides network gateway functions. It is typically installed inside the main cabinet coupled with a power meter device. The gateway provides also data logger function to collect the power meter information. In this way is possible to have on the same device gateway functionality coupled with a data logger function. Very easy installation for a wide variety of functionalities.

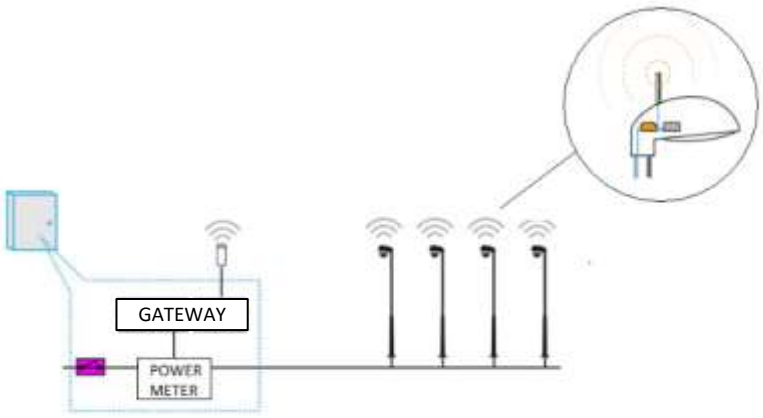

Figure 9: Cabinet + line + smart lighting communication

Gateway & network coordinator

The concentrator is a general purpose programmable device, easy to upgrade – expand and with a great versatility. It is equipped with analog and digital I/O, two serial port and one Ethernet connection. It permits to interface other device, like sensor, power, breakers, etc. Internal memory allows to memorize the data collected, useful to send to the control room. It is possible to connect the device in network using the LAN port. Optionally is possible to have a modem 2G or 3G on board for mobile connection and radio communication with the control center.

Radio Node

The Radio Node permits to manage the public lighting, using the DALI interface for ON/OFF/DIMMING and for each information of faulty.

The device represent a network node and creates the Wireless Sensor Network enabling multi hop communication between the close nodes between a range of approximately 100 m.

It can retrieve specific information thanks to the sensors mount on board as temperature and inclination of the pole (thanks to the 3 axes accelerometer); moreover diagnostic information as ballast operation, DALI connectivity and WSN radio communication are available.

The communication with the central control room is supported by the network nodes. The multi-hop network approach, allows the control room to communicate to a specific node using the connectivity towards the gateway module and the network routes of the nodes. In particular the coordinator module is responsible of collecting and forwarding data and information of the network to the control center (and to forward commands and instructions of the remote control room to the network).

The node includes a Real Time Clock useful for the internal astronomical clock. In fact, in case of wrong connectivity therefore in off-line mode the system work anyway with the timer and program on board.

The device is available also compatible to the standard ANSI NEMA C136.41 (“NEMA SOCKET”) at 7-pin, which determines the node to be installed outside on the appropriate NEMA SOCKET of the light fitting (when prepared).

The NEMA standard uses three cables: neutral, line and load + DALI to control the ballast of the lamp (i.e. the illuminance level). This approach has the advantage to be more effective from the operational point of view.

Figure 10: Nema Socket

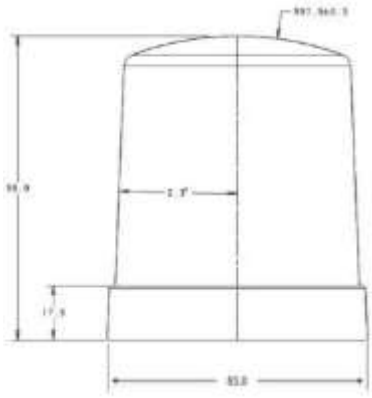

Figure 11: NEMA case

5. Software management platform

AEC Smart System CMS is a web-oriented application installed on a server (own byb the customer or in the cloud) that permits to each user (username & password for each level – guest/admin) to manage smart lighting and specific Smart City services (pollution measurement, power consumption acquisition, waste application, parking detection) through a standard internet browser.

The software is composed of two parts: one suited for remote control (supervision, management, alarm notification, diagnostic, data collection and analysis) and the other part suited for public lighting scenarios (dimming operation, information storage, synoptical browsing).

Map view or tree view are available to view data, information and resources related to each device and equipment installed. The software allows the capability of easily modify the functionalities, the configuration system and implement new features accessing the appropriate parameters. The dashboard and the modules of the software platform are implemented in a straight-forward and user-friendly way to exploit at best the functionalities of the software in an easy way. Moreover the graphical architecture and software panel simplify data access and system elements exploration. The CMS ensures high level of security and reliability enabling stable monitoring, strong control over end devices and related services, asset management, smart data acquisition, black box features and alarm notifications in case of failures or critical situations.

Figure 12: Example of user web interface (remote control section)

The second parts of the CMS performs an integrated management of public lighting through remote control and in situ node intelligence. In particular lighting behavior can be driven from remote defining a set of dimming phases and rules of working exploiting the interaction with different information sources (weather forecast, astronomical clock, specific occurrences, traffic detection) to set the lighting level in the most efficient. Following this approach smart lighting increases service efficiency and reduces operational costs. A cartographic map allows to have a city view and a time precise status of the whole system according to services provided, information acquired, operational status and alert levels.

Different lighting programming can be associated to different groups of lamps (belonging to different sub-net or logically independent groups) to perform specific dimming depending on local requirements. Groups can be configured directly by the users on the GIS-based editor while dimming rules can be managed through a user friendly inteface (like Outlook/Google calendar) in a very quickly and simply way.

Figure 13: Editor GIS-based for lighting points placement and configuration

Gestione regole illuminazione

Regole e gruppi

Applica

Gruppi regolati				Ricorr. att./tot.	Eventi att./tot.	Azioni	Il gruppo condivide PL con:
ID	*Denominazione*	*PL*	*Attivato*				
G00	Gruppo di default	468	☑	1/1	0/0		
G01	Martignano	97	☑	1/1	0/0		G12
G10	Universiadi piazza e laterali	22	☑	0/0	3/3		G11 G07 G02 G05 G08
G09	Portici Piazza Duomo Universiadi	17	☑	0/0	3/3		G03
G13	Garibaldi Universiadi	3	☑	0/0	1/1		nessuno
G11	~~scaletta dimmer test~~	2	☐	1/1	0/0		G10 G08
G07	luci architettoniche (?)	51	☑	3/3	0/0		G10 G02 G05 G08
G03	Portici (?)	16	☑	1/1	0/0		G09
G04	PL 14087	1	☑	1/1	0/0		nessuno
G06	Piazza Dante	107	☑	1/1	0/0		nessuno
G02	~~proiettori torre civica~~	2	☐	0/0	0/0		G10 G07
G05	~~pareti torre civica~~	5	☐	0/0	0/0		G10 G07
G08	~~Proiettori NA Piazza Duomo~~	9	☐	0/0	0/0		G10 G11 G07
G12	~~test lux via del forte42 14628~~	1	☐	1/1	0/0		G01

Figure14: group configuration and management

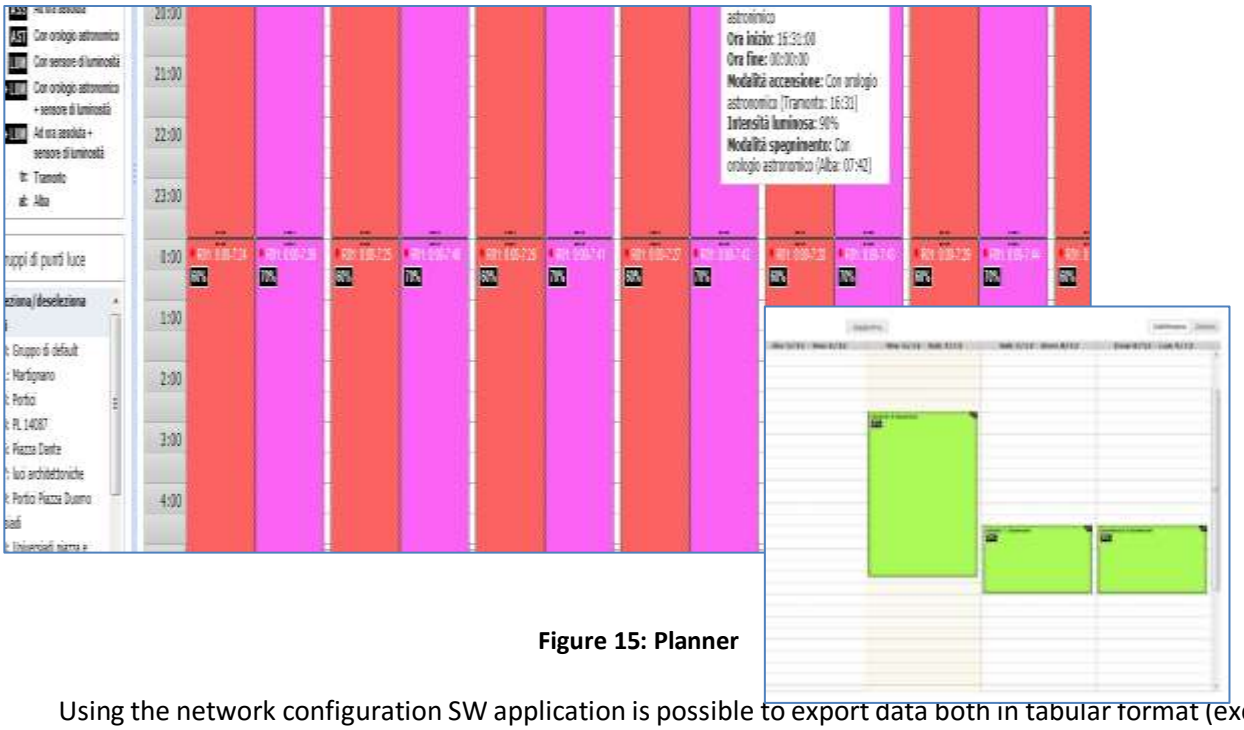

Figure 15: Planner

Using the network configuration SW application is possible to export data both in tabular format (excel etc) and graphic format, according to the needs, to analyze data and value information collected from network nodes, sensors and end devices.

Figure 16: Report Module

6. Interoperability

AEC SmartSystem CMS is a modular, scalable, efficient solution that enables to control, supervise and manage the smart lighting and Smart City services. The aim of the software is to interact with existed platform to achieve the highest level of efficiency and operational effectiveness. The CMS is not designed to be a stand alone smart lighting and service management solution but is suitable for integration with third part units and application services.

The interoperability is possible through Web Services and XML/JSON based interfaces. The external platform can retrieve information from the network, communicating with the network nodes and access resources and services typically accessed by the CMS software. Any remote management features like remote control, supervision, remote reading, remote data access and resources analysis can be transferred to an external platform.

Each concentrator is provided with an Open Protocol-Gateway. The external platform can interact directly with the filed gateways and independently by the use of AEC CMS.

The connectivity between the gateways and the Server can be leaded in different ways, both on cabled mode (Internet, Intranet) both on mobile mode (2G/3G/UMTS).

A wide range of open protocols is available on request: i.e. ALIS, TALQ, OSC.

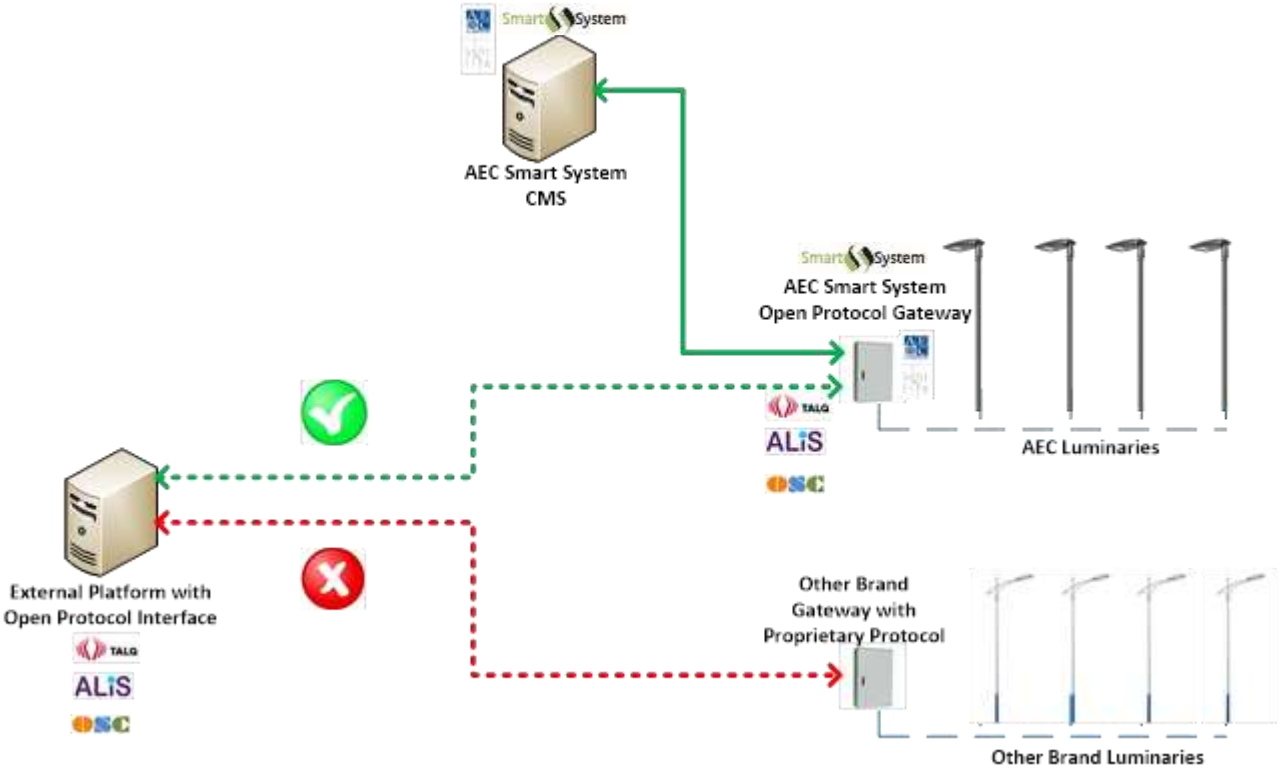

Figure 17: Open Protocol Interoperability

7. Smart City & IoT Services (some examples)

Using AEC SmartSystem is possible to manage using the same network a lot of Smart City & IoT services.

Sustainable Mobility

The network permits to connect low power sensor. The sensors powered by a long life battery, placed in park spots, permit to identify a car presence.

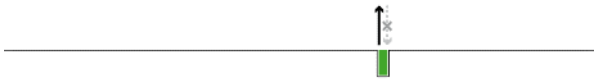

Figure 18: Parking free

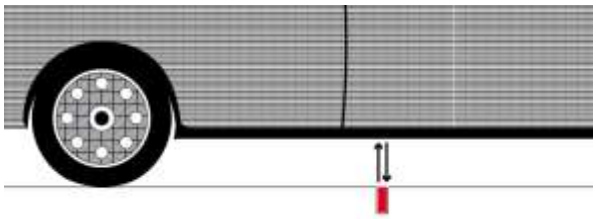

Figure 19: Parking busy

The platform can be used not only for smart lighting management but also for parking management service. Furthermore, the possibility to know on Digital Panel the parking available, reduce the not necessary traffic in the city for parking searching, to guarantee to the citizen a clear overview of parking free.

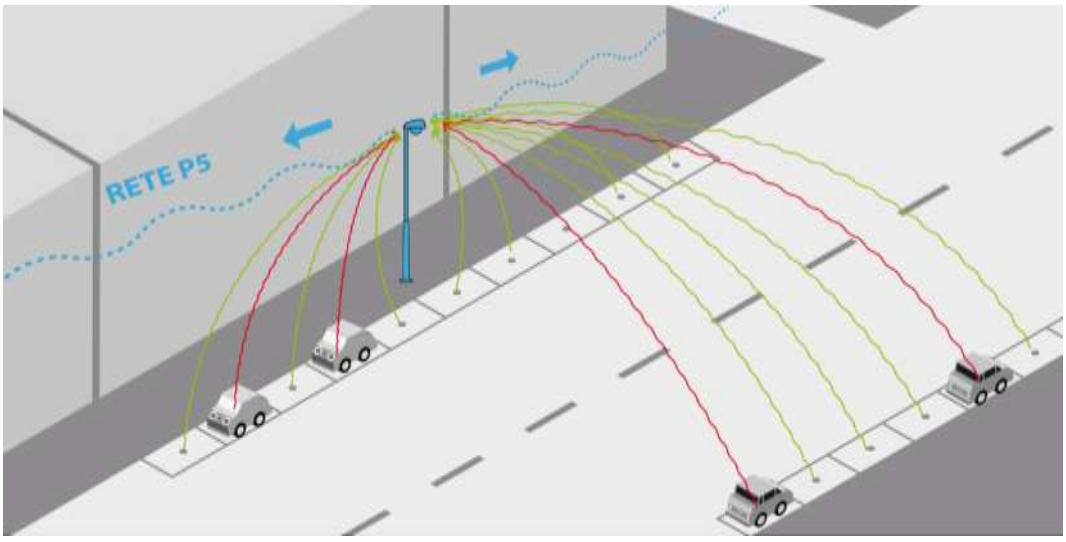

Figure 20: Communication between different nodes

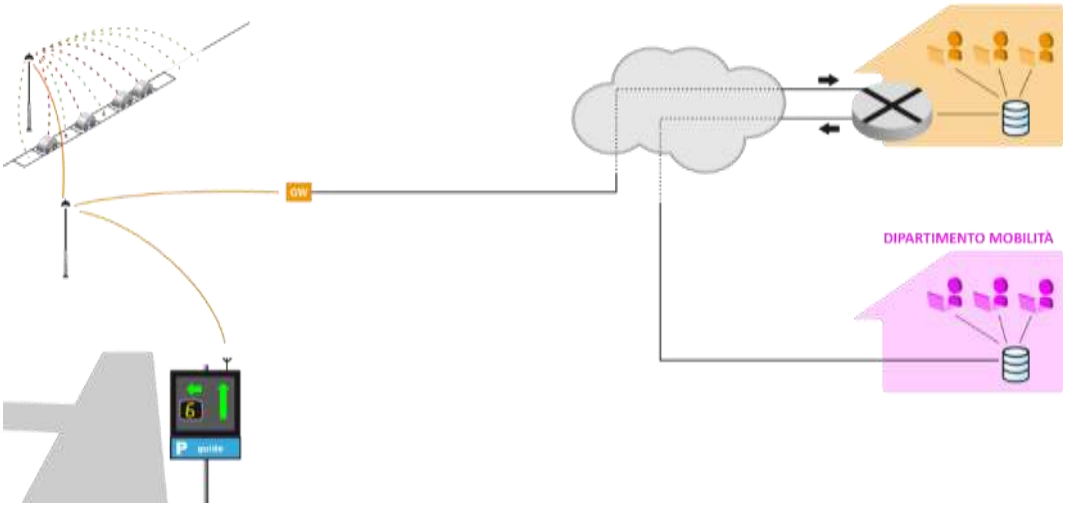

Figure 21: Node communication to show the status of parking in real time on a Digital Panel

Green public irrigation

An interesting application permits to manage the green public irrigation using the same network. Some device can interoperate with the irrigation system (irrigation valves) to open and close the water according to the user settings. Data la capillarità dell'illuminazione pubblica, sarebbe facile collocare tali dispositivi in un'area di copertura della rete wireless.

A single web interface (map panel) permits to manage either lighting or. Furthermore collecting data from a weather provider information will be possible to stop automatically the irrigation in case of shower. An example of a lot of combination possible using the same network.

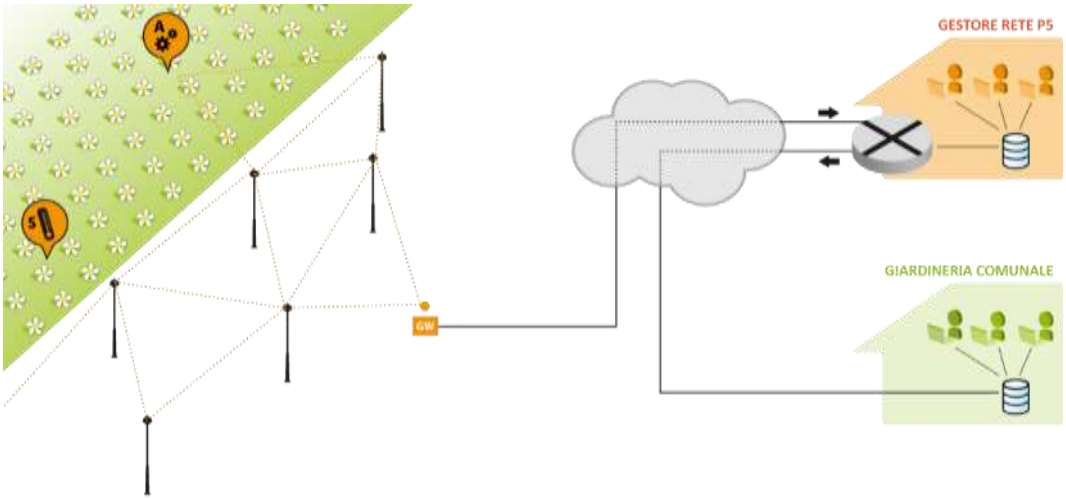

Figure 22: Green public management

Waste management interoperation system

Garbage bins could be equipped with special tag RFID to detect the waste status (full bins). The node collect these information and send the data to the supervisor. In this case is possible detect the presence of the bins and their status using the same node infrastructure.

The information will be sent to the Utility service company for the management planning also in real time. Time and money savings, efficiency and on need waste requests are achievable.

Figure 23: Waste management integration.

Presence Sensor

It is possible to integrate presence sensors in the network in order to set different lighting scenario according to the status of the sensor.

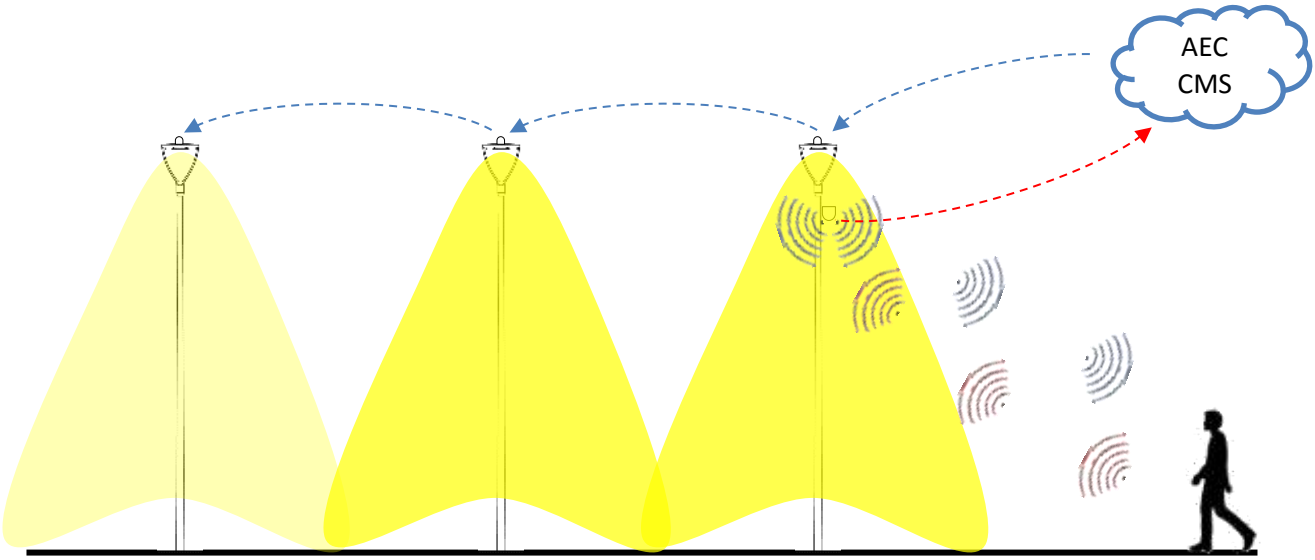

Figure 24 Presence Sensor

Traffic Sensor

Throight video processing digital camera, it is possible to provide information about the vehicular traffic status and regulate consequently the street lighting level.

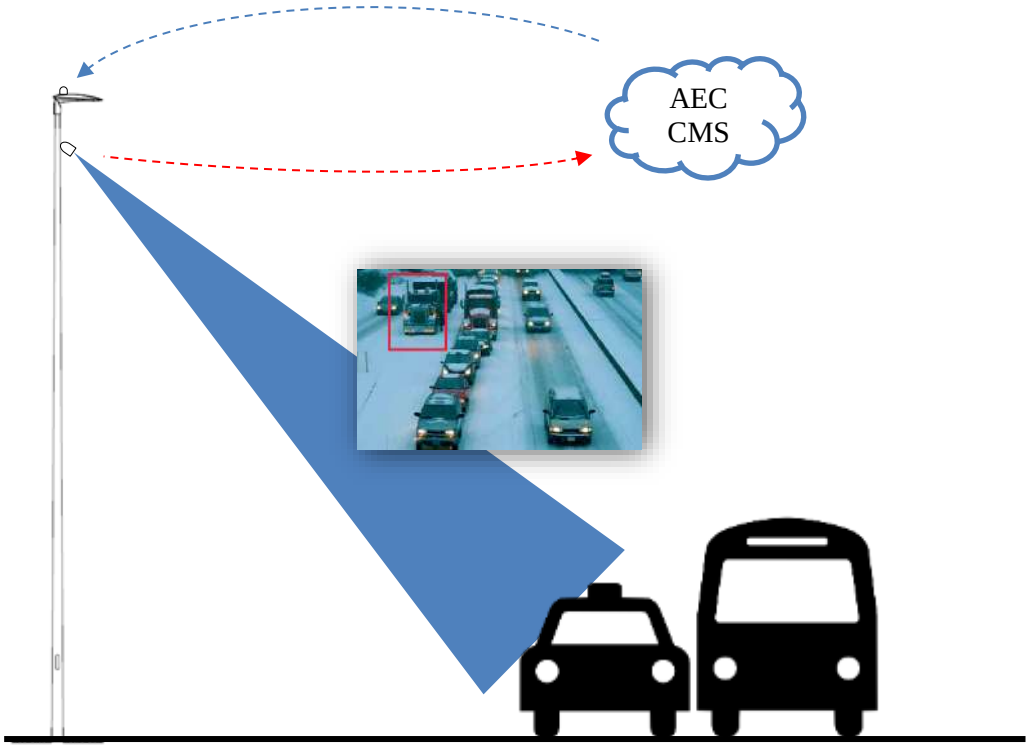

Figure 25: Traffic Sensor

8. Conclusion

The wireless node network is an innovative, effective solution for smart lighting that enables Smart City applications exploiting street lights infrastructure. The devices installed in the lighting point, the concentrator placed possibly in the main electric cabinet, and the CMS management software allow to realize an efficient, resilient, sustainable, cost effective Wireless Sensor Network and a TRUE SMART city platform. AEC Smart System is in conclusion a powerful tool for remote control, supervision and management of public lighting and IoT infrastructure for Smart City services.

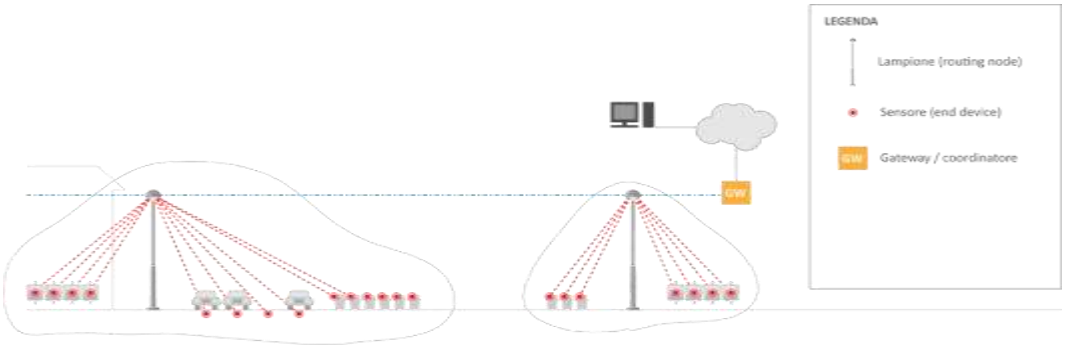

Figure 26: Example of different multi services sub systems management

Figure 27: Different "Smart" features possible