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USE OF MULTIPLE AGENTS FOR MAKING THE SMART CITY

Prof. Jayesh N. Rathod[1], Archita Zaveri[2]

[1,2]*Department of Information Technology, Atmiya Institute of Technology and Science, Rajkot , Yogidham Gurukul, Kalawad Road, Rajkot*

Abstract. *The current economic crisis, combined with growing citizen expectations, is placing increasing pressure on European cities to provide better and more efficient infrastructures and services, often for less cost. This trend has contributed to the growing popularity and use of the term 'Smart City' [1]. The Smart City, represent a new way of thinking about urban space by shaping a model that integrates Green Energy Sources and Systems (GESSs), energy efficiency, sustainable mobility, protection of the environment and economic sustainability, that represent the goals for future developments. Smart cities are made by a high level of Information and Communication Technology–ICT-structures able to transmit energy, information flows multidirectional and connect a different sector that include mobility, energy, social, economy. Into Smart Cities transport systems are sustainable, smart grids are enhanced to ensure greater integration capabilities of production plants from renewable sources, public lighting is efficient, the buildings are equipped with sensors and devices aimed at rationalizing consumption energy and create greater awareness on the part of citizens, with the aim of improving the quality of life of people through a new governance of public administration capable of managing this innovation and cultural change. However, while wishing the transformation of cities in smart systems, have not defined models infrastructure, that allow different subsets to communicate and interact, in order to make the concrete realization of a smart city. The objective of this paper is to discuss a model of Smart City with a multi-agent systems and Internet of things that provides intelligence to a city, as basic infrastructure for a definition of a model repeatable and exportable, so as advocated by the European Community that is allocating considerable funds (Horizon 2020) for the creation of Smart City.*

Keywords: *Smart city, ICT, multi-agent systems, grid.*

1 INTRODUCTION

The Smart City (SC) refers to that place and territorial context, where use of planned and wise of the human and natural resources, properly managed and integrated through the various ICT technologies already available, allows for the creation of an ecosystem that can be used of resources and to provide integrated and more intelligent systems [2]. The SC through ICT appropriately integrated with a network of fixed and mobile telecommunications, it can ensure a real improvement in the quality of life, job creation, and urbanization understood as the sum of the environmental and social sustainability, development and cost savings. The SC must take into account the fundamental dimension of information management in an environment of inclusiveness and territorial cohesion of open government, sustainability and opportunities for cooperation and development between public administrations, business, finance and citizens. Among the main players who can take concrete steps in the development of this system, are over the PA, those responsible for the supply, distribution and energy management, cultural associations, citizens, organizations operating in the context of health, voluntary associations, universities and schools, cultural institutions, local facilities, the public security forces. In order to build intelligent places it is necessary a multidisciplinary and integrated approach that starts from the needs of the city and the objectives to be pursued, identifying digital innovation as a tool and not as a purpose of change, involving a variety of systems (remote monitoring systems, decision support and planning systems, communication systems, etc.). already available on the market and involving the various subnets of a SC as:

a) Mobility , Transport and Logistics

Around the world, cities are facing an increase in travel demand and an inability to achieve sufficient infrastructure to meet that demand. Transport systems "smart" may result for citizens easy moving, an innovative public transport and merchandise, regulating access to town centers, a reduction of externalities of public transport, reduced congestion, accidents and pollution of air and noise. Advanced solutions for mobility management can return to the people, in real time, useful data traffic on routes to take to reach destinations of interest, and trade with neighboring areas, and that they can manage and make the most of the infrastructure (roads, parking , etc..) and equipment and means (public vehicles, bicycles, cars in car sharing, car pooling, electric charging points, etc.), including through user friendly app by smart phones and tablets.

b) Energy and Smart Building:

The context of this area includes different smart systems for cities, as well as the implementation of smart grid:

- Smart Street that with the remote control of the sources of public lighting, enables the optimization of consumption, up to 30 percent
- Smart Home defines a new way of thinking about the home energy management through the installation of smart meters, that lets smart appliances through, among them interoperable and can be controlled remotely, to manage sustainable energy consumption;
- Smart Building that enable integrated control of different systems (security, heating, elevators, sensors, etc..) and processes (maintenance, access control, etc..), in order to optimize energy consumption and level of service to users and in communication Two-way town infrastructure;
- “Micro Smart Grid" which consist of interconnected areas (hospitals, campuses, shopping centers, etc.) for the production and consumption of energy.

c) Public Safety Urban

Public safety is a key element: urban crime, disasters and emergencies, terrorism to the infrastructure, to the people and to the safety of transport, require a systems of "Urban Safety" with the real-time control of these events, so as to achieve the rehabilitation of entire city districts.

d) Environment and Natural Resources

It is necessary to optimize the management of natural resources according to principles of equity and sustainability through the development of technologies and business models for the management, treatment and upgrading of natural resources and the protection of biodiversity.

e) Tourism and culture

The system of tourism, cultural and artistic heritage, can be made innovative through the development of solutions for diagnostics, restoration, preservation, and digitization of cultural heritage materials and or intangible, defining useful models to digitize and make more competitive tourist sector, with an adequate information and communication that use specific applications and adopt the telecommunications network as a vector.

f) Health and assistance

The development of Health, which may be partially managed "at a distance", it will be to able to innovate the health care system, allowing to increase the level of service felt by the user and at the same time to decrease costs.

g) E-education

This field will allow the school innovation through educational technology in e-learning.

h) Public spaces and social aggregation

This context include the set of services and technologies that will be able, for example, to identify such barriers, possibly by proposing alternative routes for people with disabilities or the elderly.

i) E-government

A new innovation in services to the public through the digitization of back-end processes of Public Administration (PA), through the development of "cloud computing" and the spread of new tools, including open source, to the use and sharing of data (open data) in digital format, input and output with the PA.

j) Smart Economy

Invest for the future in an intelligent way developing a new "ideology" commercial, the ethics of environmental sustainability and inclusion civil. Indeed the white-green economy is driving the job market in environmental spheres, going against the trends in the current economic context.

The definition of SC through its indicators, is already several definitions and debates [3]. There is no still a model, a physical structure that identifies what could be the type of system to be used to operate a SC. Currently data and information flows of the different sectors of society are stored and used in systems typically "vertical" heterogeneous, not associated with each other, making it very difficult for city administrators to coordinate fully and effectively all the forces and activities. The objective of this work is to analyze, design, implement and evaluate an approach that simulates a dynamic infrastructure within the broader context of the envisioned Smart City, that integrates these areas in a model "horizontal", with the aim of optimizing energy resources, reduce emissions, improve the quality of life, which is replicable, expandable and able to "communicate" with each type of user. One key goal is to have this infrastructure created as close as possible to a real-world model, in order to evaluate different scenarios.

II. TECHNOLOGY FOR A SMART CITY GRID

The smart city increases connectivity, automation and coordination between providers, consumers and network to make the most of the work of transmission and distribution data. The whole system connects equipment and devices, is more correct to refer to networks of processing and consumption on a large scale, as it is not identifiable as a single entity, but consists of an interconnection of subsystems. The smart city are also aimed at making more balanced integration number of subnets. The traditional control and communication system needs to be improved to accommodate for a high penetration of data. To perform demand response in a most efficient way, the system operation conditions need to be known. For example smart meters and two- way communication technologies are can provide consumers and operators the information for decision making. [3]

The smart city grid infrastructure envisioned is highly dynamic, and by being able to tap to the information generated by its discrete items i.e. generating and consuming devices in real-time, new possibilities are emerging towards real-time adaptation, optimization and prediction. Advances in the areas of embedded systems, computing, and networking are leading us to an infrastructure composed of millions of devices. These devices will not simply convey information but compute on it, network, and form advanced collaborations. To provide characteristic of a Smart City Grid, have been identified a different categories of technologies and management:

- information and communication technology- ICT

- communications infrastructure
- analysis of “big data”
- technology Services
- models of decision support
- sensors and actuators
- systems reduction of energy consumption
- systems of energy production and distribution
- new materials and solutions for sustainable construction
- new hybrid and electric vehicles
- sustainable Organizational Models
- models of urban planning and decision support
- management of the waste cycle: models of collection, treatment and recovery

- models for Social Inclusion

SCADA (Supervisory Control And Data Acquisition) deal instead of fielding the hardware monitoring and control protocols, and also signals necessary to exchange state information and control systems. Now this technology is used almost exclusively to manage the power system, but it need human intervention to perform many operations, unlike the multi-agent systems [4].

- **Distributed Intelligent agents**, which are designed to act on the system performing the task assigned to pursue a common goal, which is to always keep the network operational and quality standards of the highest possible service. A grid, must surely be: Intelligent, e.g. performs demand side, management based on price signals; Distributed: how natural resources are distributed, even in network devices communicate Internet. Autonomous: must remain active in the autonomous electric system in case of outage. The agents technology can make the system more flexible, allowing for example, redefine the boundaries of the autonomous system dynamically.

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- **"Internet of Things"** infrastructure will be strongly integrated with the surrounding environment, and additionally it will closely interact with the enterprise systems. The last will lead not only to further blur the line between the busine ss and real world, but will change the way we design, deploy and use services. New opportunities will emerge for businesses, which can now closely collaborate with the real world [4].

The conceptual model proposal of the Smart City consists of several domains, each of which contains many applications and actors are shown in Fig. 1. The bidirectional lines represent the secure communication interface.

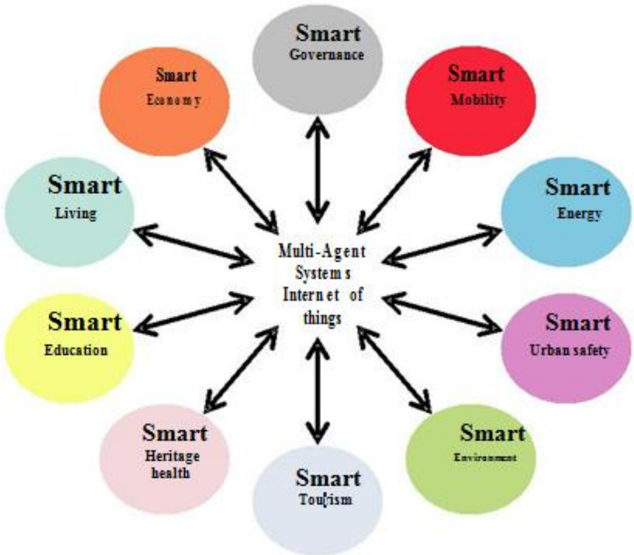


Figure 1. Conceptual model of SC

In this infrastructure the devices, of all domains, will be no more considered as black-boxes, but will also get interconnected, and will be represented by its own intelligent software agent that communicates information on operating status and needs, collects information, and responds in ways that most benefit its owners and the grid. Constant interactions and transactions of millions of smart agents will move the grid beyond central control to a collaborative network of almost biological complexity [5]. It is also expected that they will provide their functionality as a service and be able to consume online services (Internet of things) in order to better address their internal goals. This does not represent the final architecture of the Smart City Grid; rather it is a tool for describing, discussing, and developing that architecture. The conceptual model provides a context for analysis of interoperation and standards, both for the rest of this document, and for the development of the architectures of the Smart City Grid.

III. INTELLIGENT DISTRIBUTED AUTONOMOUS SMART CITY

In recent years more and more often we hear about Smart City in government circles. The main focus seems to be the strategic role played by ICT infrastructure for the development of cities, but in fact many studies identify the enablers of urban growth, meaning the ability to progress, with increasing attention to the environment, improving the levels of education and the centrality of human resources, as well as the social and relationship capital. As yet is no single definition of SC: the term is used with different meanings and especially to highlight specific aspects of a city and very varied. Often the term refers to the use by the Public Administration (PA) of the new communication channels to interact with citizens, focusing on e-Governance and e -democracy. Very often indicates a strong appeal to the use of computer technology in everyday life of a city in terms of transport systems, infrastructure, logistics and systems for energy efficiency. In other cases the term Smart City will emphasize the softer factors such as urban development best practices of participation, high levels of security and enhancement of cultural heritage.

The concept of SC is the meeting point of an ideal path that joins the new economy of the century with the green economy of the present day, in which the thread is represented that the uninterrupted development of ICT, as a tool to revive the economy of knowledge becomes engine of sustainable development of cities. This process is achieved through the implementation of a variety of policies and strategies to ensure a smoother transition by a dissipative system of natural resources to a more efficient, dynamic, circular, can pursue growth and well-being of citizens, focusing on capacitating and social relationships.

The smart approach is also able to equip cities with tools to track and manage their emissions in advance, reducing the cost of energy supply. A greater availability of information on the infrastructure and the activities of a city also facilitates the identification and management of risks. For example, real-time data related to flows of commuters - provided by the transport systems and mobile devices - can help to optimize the allocation of the security services during emergencies [4]. To this interpretation comes to the possibility of cities full of technology but careful about human dimension, both individual and collective, built on sensor networks, platforms, touch screen, digital panel, led light wear, portable devices connected to the Web, where the electronic component tends to become invisible (disappearing computer) or to be integrated into the structures (room ware, such as offices with walls and tables digital) and objects (such as refrigerators have intelligence that interact with the surrounding environment).

In the middle of a SC are the people who live in environments, real and virtual, and can obtain and exchange information at any place and time, as well as by any means, thanks to the spread of broadband, mobile technologies and opportunities offered by the Internet of things [5].

To obtain a SC necessary to establish a telemetric platform that is able to use existing systems (e.g. smart grid, smart mobility ...), to collect and normalize information sourced from these systems and make them available to the application layer, where to create value-added services oriented business operators, the PA and citizens.

The project's objectives and scenarios presuppose the following technological issues:

Use new technologies, integrated or supporting existing ones give value to the services to the community;

Integrating existing technologies to acquisition, normalize and correlate heterogeneous data;

Create functionality, algorithms, and shared services with the end user.

IV. INFRASTRUCTURE AND ARCHITECTURE OF MULTI-AGENT SYSTEM FOR A MODEL OF SMART CITY

Virtually all new energy technologies come with embedded electronic intelligence that controls their operations and enables them to link with other devices, buildings and the overall grid where Information and Communication Technology (ICT) represents the "backbone" [5]. Realization of the Intelligent Distributed Autonomous Smart City (IDASC) requires meeting the ever increasing reliability challenges by harnessing modern communication and information technologies to enable an ICT infrastructure that provides grid-wide coordinated monitoring and control capabilities. Such ICT infrastructure should be capable of providing fail proof and nearly instantaneous bidirectional communications among all devices ranging to the grid -wide control centers including all important equipment at the distribution and transmission levels. This involves processing vast number of data transactions for analysis and automation. This requires a high performance infrastructure capable of providing fast intelligent local sub-second responses coordinated with a higher level global analysis in order to prevent or contain rapidly evolving adverse events. Centralized systems are too slow for this purpose. A distributed architectural framework can enable the high performance infrastructure with local intelligent sub-second response using modern technologies.

The Agents facilitate more ubiquitous use of local controls coordinated by global analysis, real-time tuning of control parameters, automatic arming and disarming of control actions in real-time, as well as functional coordination in the hierarchy, and in multiple timescales. The virtual architecture allows seamless integration of intelligence at all levels so that the locations of specific services and data are virtualized and transparent throughout the infrastructure subject to cyber security. Such modular, flexible and scalable infrastructure meets the global operational needs and allows for evolutionary implementation on a continental scale. It can respond to actual steady-state and transient operating conditions in real-time more effectively than conventional solutions that depend on off-line analyses.

The Agents operate at different timescales ranging from milliseconds to hours. Their actions are organized by execution cycles. An execution cycle refers to a set of related functional tasks performed in a temporally coordinated manner. The specific periods and activities of the cycles are configurable according to the operating concerns, physical phenomena, control response times, computational burden, and engineering practices. In each cycle, at each hierarchical level, an agent is responsible for a specific function and for a specific portion of the grid. [6]

Autonomous Intelligent Agents are deployed, as needed, on a grid-wide computing network throughout the infrastructure to provide services necessary for the execution of functional tasks in the areas of:

- Data Acquisition and Model Management
- System Monitoring
- Performance Enhancement
- Control

The IDASC will have to use a two-way communication, able to make the SC infrastructure dynamic and interactive, capable of exploiting architecture plug-and-play open, such as to create a secure environment to allow the passage of resources between the various networks, and allows both real and virtual operators to communicate and interact with each other.

Analogies between distributed networks and telecommunications networks peer-to-peer protocols suggest to inherit already studied in the field of ICT and design them so as to make up for the new challenges related to the creation of a distributed network for the control of smart subsystems that will be among their integrated and interacting. For the implementation of the chosen architecture, among many of the numerous open source platforms to existing agents, the most valuable is ZEUS, a framework that uses Java based communication ACL Agent Communication Language KQML Knowledge Query and Manipulation Language has some features oriented security and a GUI Graphic User Interface quite advanced and compatible with the standard FIPA, Foundation for Intelligent Physical agents, to ensure interoperability between systems to heterogeneous agents, as showed in Table I.

TABLE I. ZEUS FEATURES

Free and open source
FIPA compliance
Java Based
ACL and KQML
Some security capabilities
User friendly GUI

ZEUS reflects the need to have methodologies and toolkits to solve problems, rather than specific solutions to specific problems. To do this, it provides a library of components based on agents and an environment that supports them. It can be considered as a synthesis of ZEUS agents already established technologies, combined with some innovative solutions to develop applications quickly and integrated [4]. ZEUS offers implementations, software, already functioning for communication, reasoning and cooperation, leaving only the definition of the Agents necessary for the application, which is accomplished by writing the code necessary to give the agent the specific capabilities of the application domain.

Each agent is then divided into three levels, as shown in Fig. 2:

- Definition, to determine which agent has the ability to reason, its goals, resources, skills, beliefs, preferences.

- Organizational, specifies relationships with his fellow agent.

- Coordination, modeling the agent so that it can negotiate and coordinate with other agents.

The functions of the Name Server, which maps agent names to network addresses, and Facilitator, which provides the names of possible agents capable of a certain capacity, utilities are provided by the agents [7], [8]. The implementation of an agent system consists of:

1. Specification of the Agents,

2. Analysis of the application, which is achieved through a *Collaborative Agent diagram* (as shown in Fig. 3):

a) Control agent puts forth responsibilities that include monitoring system to detect contingency situations or grid failures, and sending signals to the main circuit breaker to isolate the IDASC from the utility when an upstream outage is detected.

b) DER agent is responsible for storing associated DER information, as monitoring and controlling DER power levels and its connect/disconnect status. DER information to be stored may include DER identification number, type (solar cells, micro turbines, fuel cells, etc), power rating (kW), local fuel availability, cost function or price at which users agree to sell, as well as DER availability, i.e. planned maintenance schedule.

c) User agent acts as a customer gateway that makes features of an IDASC accessible to users. It includes responsibility of providing users with real-time information of entities residing in the IDASC system. A user agent also allows users to control the status of loads based on priority predefined by a user [10].

3. Application design, through modeling of the knowledge of each agent.

4. Realization of the application, create, trough a graphical interface of the frame work, the agents.

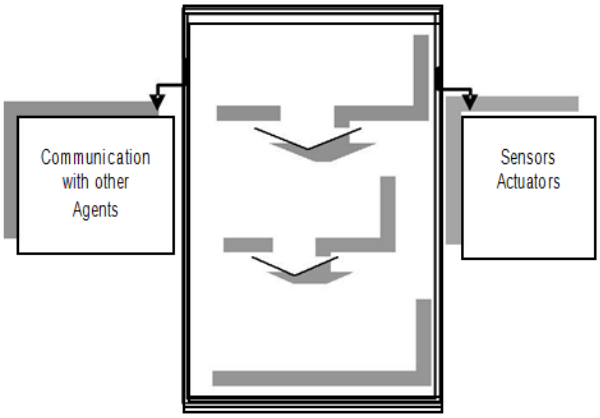
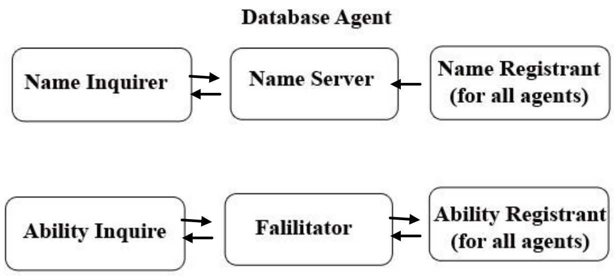


Figure 2. Stage of development of Agent ZEUS



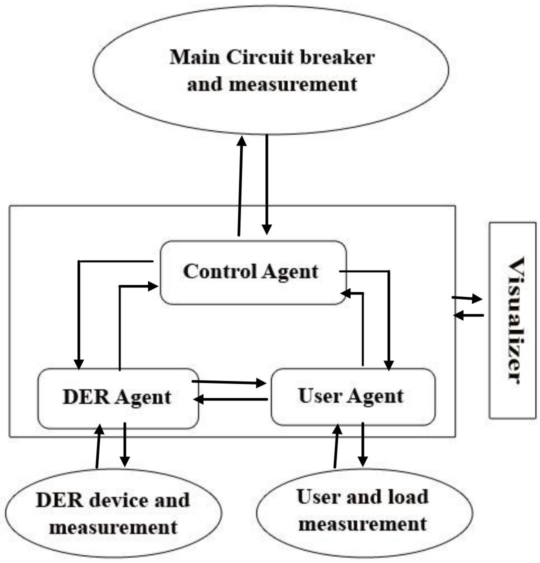


Figure 3. The Multi-agent systems Collaborative diagram

Finally once generated codes agent the application process is complete. All messaging exchanges among agents are established via the Transmission Control Protocol/Internet Protocol or TCP/IP.

The idea behind any multi-agent system is to break down a complex problem handled by a single entity – a centralized system – into smaller simpler problems handled by several entities – a distributed system. The multi-agent system has become an increasingly powerful tool in developing complex systems that take advantages of agent properties: autonomy, sociality, reactivity and pro-activity [9]. The multi-agent system is autonomous in that they operate without human interventions. The multi-agent system is social-able in that they interact with other agents via some kind of agent communication language. The agents also perceive and react to their environment. Lastly, the multi agent system is proactive in that they are able to exhibit goal oriented behavior by taking initiatives. The proposed architecture of IDASC provides a generalized framework that facilitates the design and development of various components of the ICT infrastructure and emergence of necessary standards and protocols needed for the SC.

The technical feasibility of the architecture relies on recent advances in the areas of sensors, telecommunications, computing, internet technology, power equipment, and power system analysis [6].

V. SMART CITY CONCEPTUAL MODEL

The IDASC is a system of systems that embraces diversity of technology, operators, and connection. The composition of these systems will change as technology evolves, generating new businesses and new interactions. To support this generative quality, the systems of the Smart City must not demand great intimacy with each other—they must interact with each other using minimum amounts of mutual information. The Smart City Conceptual Model is a set of views (diagrams, as in fig.4) and descriptions that are the basis for discussing the characteristics, uses, behavior, interfaces, requirements and standards of the Smart City.

The Conceptual Model provides a context for analysis of interoperation and standards, for the development of the architectures of the Smart City. It is important to note that the conceptual model of the Smart City is not limited to a single domain, see Table II, or a single application or use case. The scope also includes cross cutting requirements including cyber security, network management, data management, and application integration [2].

For each model domain of SC, for each individual device, it will associate an Agents, with the characteristics illustrated above, so as to obtain the previously described IDASC. The key is the algorithm that is the heart of the operation of IDASC and that will be determined, by following the guidelines provided by the governance (policymakers), according to environmental, social, economic, etc. goals.

Smart software agents can be programmed to seek power from the Green source. Agents representing each generating source can report current air emissions. Power customers interested in reducing their environmental impacts could order their agents to buy the cleanest power available within their budgets.

TABLE II. DOMAIN AND ACTORS OF SC MODEL

DOMAIN	ACTORS IN DOMAIN
Operations	Alghoritms of Smart City Strategy Governance's
Service Provider	Customer management , Account Management, installation and maintenance, Internet of things
Business Needs	Trading, Market, A Ancillary, Customer satisfaction, Smart commerce
Smart Grid	Generation, Transmission, Distribution, Control measurement, Power Quality, Reliability, Energy efficiency, distributed resources
Devices	Electric vehicles, Smart Building, Lightning, Customer

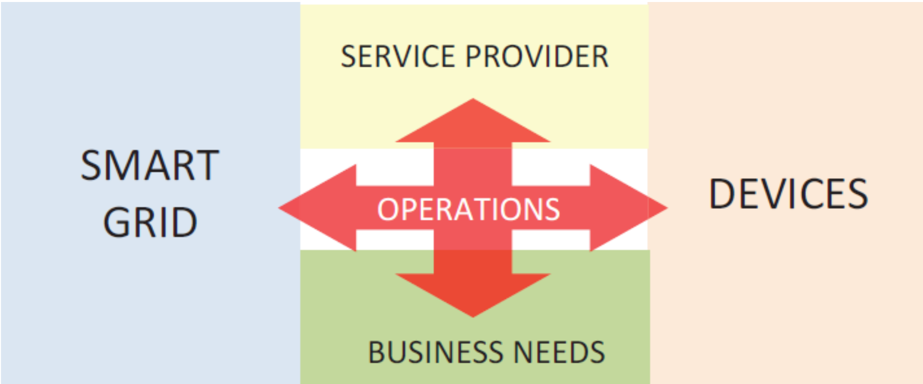


Figure 4. The diagram of Domain of Smart City Grid

Smart networks respond collaboratively during smog alerts.

VI. CONCLUSION

Several positive externalities is able to generate a Smart City:

Stimulus to the economy;
Service innovation;
Involvement of citizens;
Reduction of carbon dioxide emissions;
Increase public safety;
Protection of health.

The concept of smart city appears to be fundamental in the redefinition of urban systems, where for the first time also takes into account the human and social aspects for the establishment of an urban structure. Essential to enabling the realization of a model give clear and objective to define the key elements constituting and implemented by SC in order to make it replicable.

This paper discusses the design and implementation of a multi-agent systems in the context of Intelligent Distributed Autonomous Smart City (IDASC), a model outlining the subsystems, manufacturing technologies, operating systems, application of Multi-agents systems making concrete that the project of a smart city, so as to give a clear overview and user friendly to policy makers.

The originator of the first great electrical revolution knew that innovative devices are important, but the key is creating systems that make them useful [5]. By distributing decision making to virtually everyone systems, it will create a smart network that supplies clean, secure, reliable and economical energy to meet the emerging needs of economy. The more comprehensively the potentials of SC are addressed and developed, the more quickly and fully we will realize its many opportunities and benefits.

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