A Vision for a Cognitive Campus Network of Universities: The Learnscapes of Poveglia Island

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ABSTRACT

In recent years, refurbishment of existing buildings as well as reuse of abandoned areas has become the central issue of strategies and funding programs. The focus of this research is Poveglia, Italy: an abandoned island in the lagoon of Venice. The underpinning idea is to refurbish Poveglia as a zero energy Cognitive University Campus, connected to other educational institutions in the lagoon. It aims at the reuse of abandoned islands by combining architecture with digital networks. The goal is to demonstrate the potential of new technologies for the transformation of existing structures into adequate and innovative locations for learning activities. Poveglia case study, exemplifies the implementation of suitable systems and tools. The island works as part of the 'smart city, smart campus network'. In such scenario, Poveglia is understood as part of a bigger context, which requires both strategies for historical preservation as well as for energy efficiency.

KEYWORDS

Cognitive campus, responsive building; behavioural design, zero energy building, retrofit strategies, digital networks.

INTRODUCTION

This research elaborates the idea of developing an educational network in the Lagoon of Venice, which is based on cognitive principles. It aims at the reuse of abandoned islands by combining architecture with digital networks. The goal is to show the potential of new

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technologies within the transformation of existing structures into adequate and innovative locations for contemporary learning activities.
The island of Poveglia has been hereby chosen as case study to exemplify the implementation of suitable systems and tools. It represents not only a proposal for the refurbishment of Poveglia but also an opportunity [1] for the application of similar strategies in the entire lagoon of Venice, Italy [2]. Poveglia works as part of the 'smart city, smart campus network'. In such scenario, Poveglia is understood as part of a bigger context, which requires both strategies for historical preservation as well as for energy efficiency. On the island scale, users and architecture are placed into a constant dialogue by integrating 'cognitive agents' and mediating by smartphone applications [3, 4].
The first part of the paper is looking at the general implications of Inofrmation Technologies (IT) networks as well as the notion of 'cognitive' while the second part focuses more in detail on the project of Poveglia island. In the final third part major critical aspects of data exchange are discussed such as the value of user data and its role as contemporary commodity.

Venice – a "senior city"?

Located in a vast lagoon, Venice is caught between the contrast of memory and modernity. On the one side, there are historical buildings and canals, whereas on the other side we have modern mobility and mass tourism. Hence, Venice (together with its direct environment) is subject to strong prejudices, which affect incentives for future developments. One crucial prejudice, which impedes many investments, is that of being a "senior city", i.e. it is incompatible to keep up with the contemporary world. The question arises if that is really the case? And if not, how the compatibility can be demonstrated with pioneering projects?
The divergence between memory and modernity has been always an important file rouge in the history of Venice. The most radical example is the futurists who argued in favour of a complete abolishment of the old. "Let's burn the gondolas, rocking easychairs for idiots, and erect the imposing geometry of metallic bridges and factories pluming with smoke to the sky, to abolish the falling curves of old architectures. Let the reign of divine Electric Light come to liberate Venice from its venal moonlight of bedrooms for rent" [5]. Quite the opposite was the case. The radical shift did not happen, the historical stayed and bedrooms for rent skyrocket more than ever. Platforms like Airbnb, for example, have grown to major players in the commercial sector and start influencing the dynamics of the whole city.
With the ascent of the Internet, we find increasing evidence that digital networks start playing an important role in reshaping the city. It is, therefore, important to ask whether these networks are able to become not only a tool for commercial activities but also for urban transformation. The Lagoon of Venice is an excellent example to study networks since it is by nature a setting where physical isolation (islands, archipelago) is present in a rather extreme way. Abandoned islands such as Poveglia are hereby potential nodes to (re)create a strong network for the future.

Network essentials - Essential networks

The notion of "network" can be defined in very different ways, which depends on whether it is taken in a more specific or a wider sense. Catalan sociologist Manuel Castells suggests that "networks matter because they are the underlying structure of our lives", without their influence contemporary life would not happen. They can be described as systems where elements and nodes are connected with each other exchanging information in short periods [6]. His definition comprises not only sociological but also technological matters. Elements and nodes can be represented by many things: individuals in a social context as well as components in a high-tech product. One node can be part of one or many networks at once. In

more specific definitions we encounter "networks" distinguished in IT networks or divided into natural/social phenomena.
The evolution of IT networks has seen, until now, five major steps forward; each driven by an enhancement of the network's level of smartness.
Thinking of a pre-Internet era the network was limited to fixed and mobile telephony, faxes and text messages through the Short Message Service (SMS). The first step ahead was the World Wide Web (WWW), enabled by adding smartness to the network, which primary focus was the sharing of contents (Google 1998).Adding smartness to IT platforms and services the WWW has evolved in the WEB 2.0 in which the focus was provide services through the network. In the early 2000s the smartness in phones and applications raises and the focus of the network moved to allow people to be connected through the social media (Facebook 2004, Twitter 2006, iPhone 2007).
The evolution step that we face today is caused by the rise of smartness inside devices. The focus now is mainly directed to a machine-to-machine level of communication (identification, tracking, monitoring, metering) commonly addressed as the Internet of Things (IoT). The huge amount of data collected by IoT systems enables the pervasive use of Machine Learning Algorithms.
The consequent integration of Artificial Intelligence (AI) systems into the network, will allow data evaluation on a big scale [7].
We intend to benefit from the described technological progress and apply it to the abandoned island of Poveglia. The aim is to turn Poveglia Island into a node within a broader university network that has an impact both on the digital as well as on the physical as "Cognitive Campus" (Figure 1).

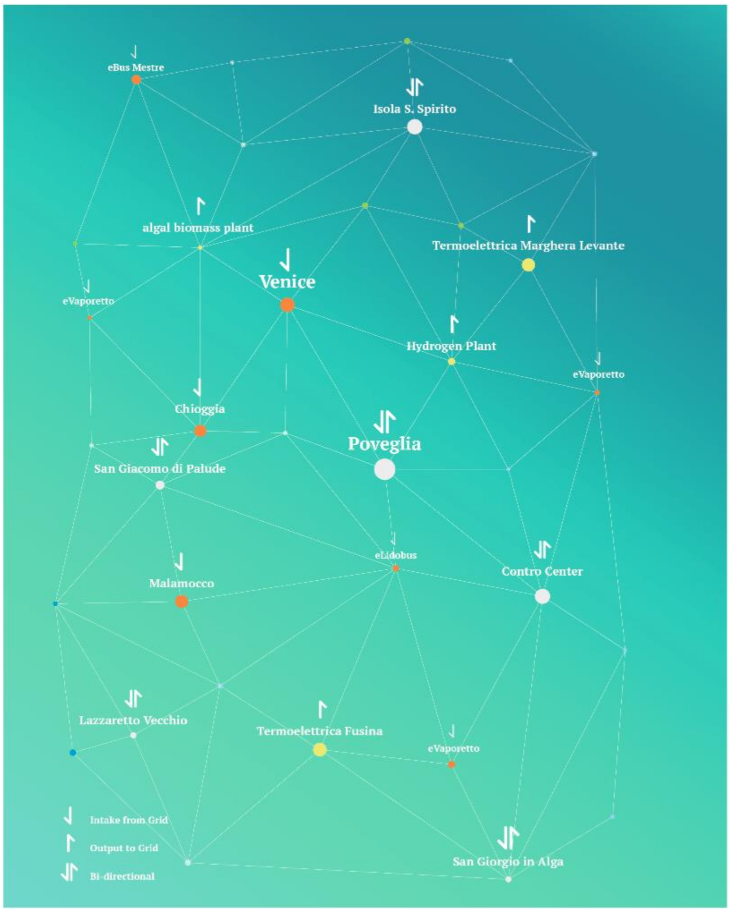

Figure 1. Vision of a Cognitive Campus with Poveglia as node of network

Cognitive principle – IoT and artificial intelligence

"Cognitive Buildings" respond to changes imposed by external and internal factors such as climate or user behaviour. They optimise processes that influence the overall performance of the building considering the impact on the environment and issues of comfort. The idea of "Cognitive Campus" goes one step beyond and envisions the combination of several cognitive buildings into a network in which IoT technologies are combined with AI agents to achieve a dialogue between buildings and end-users as well as between one building and another.

The term "Cognitive" is related to the noun "cognition" which means "the use of conscious mental processes" i.e. thinking [8]. The key elements of a cognition process involve understanding, reasoning and learning. Computers are nowadays able to take large volumes of structured and unstructured data, analyse it and generate outputs that are "conscious" of the evolutions of the problem. One of the most advanced example of such an AI system is currently coming from researchers of IBM who have developed a cognitive agent called "Watson" [9], which is able to process big amount of data.

The research programme of eLux of the University of Brescia, deal with the idea to integrate Watson as part of the cognitive concept for a smart campus. This has been an important stimulus to develop the project for Poveglia Island, entitled "Maritime Oasis". In Maritime Oasis, Watson acts as "brain" to analyse the gathered information (data) from both the built environment and end-users. The idea is to use AI systems to analyse measures and feedbacks to select the suitable commands that alter the buildings to react towards users. The aim is to integrate users and their behaviour into an overall self- managing system, similar to the functioning of the human body: stimulus from the surrounding world are detected by senses and translated into purposive information. Latter is passing through an appropriate infrastructure up to the computation centre that organizes and evaluates the incoming data. Subsequently, the computation centre triggers the actuators e.g. muscles that breathe air into the lungs.

Applied to architecture this would translate into smart buildings that aggregate into a common network. The ubiquitous computing agent which analyses all the data collected from various sensors maximizes their potentials. All the users involved in this network will be able to send their feedback directly to Watson. Such feedback is taken into consideration for the building automation, whereas the system can deduce certain patterns of behaviours. Throughout forecasts the system can predict the necessary changes for the performance of the building and consider external factors such as weather conditions. Either in real time or in a programmed time period, the actuators that control part of the buildings will be activated under commands of the AI agent.

NZEB CONCEPT AND BUILDING MANAGEMET SYSTEM IN POVEGLIA

The planning process was accompanied by an extensive Building Energy Model (BEM) study, based on dynamic calculation which consisted mainly in optimising building envelopes and implementing smart scheduling schemes. Various methodologies have been applied in order to obtain an overall reading of the energy performance of the campus in Poveglia.

Calculations have been made in order to define the suitable building envelope to achieve good energy performance in terms of a balance between transmittance and solar heat gain. Since the retrofit intervention includes three architectural typologies, it's necessary to have a precise definition on the exact material used in the project. Thanks to the BEM study, we could define the energy consumption of each building in the campus, based on their characteristics (i.e. orientation, volume, building envelope and scheduling schemes). In addition, photovoltaic systems are adapted on the roofs of one architectural typology (the "tent shelter" with the largest flat roof surface).

In Figure 2 it is possible to compare the energy production and the relevant energy consumption of the built environment. The results are positive as to say we're able to create a new campus on an abandoned island applying a NZEB concept providing a new life to the buildings and changing the nature of the node which becomes attractive for people and active into producing energy.

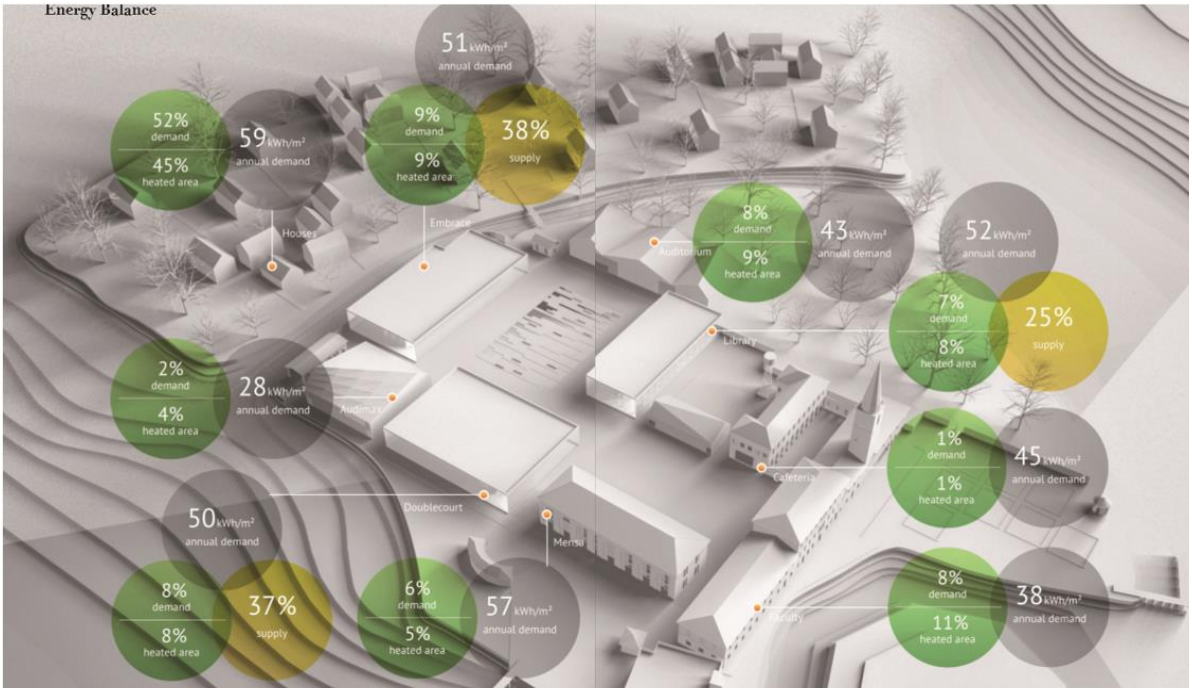

Figure 2. Energy balance of the University Campus in Poveglia

The project 'Maritime Oasis' [2] creates a scenario in which the described cognitive principle is applied to Poveglia. The maritime environment suggests principles that cover a larger rehabilitation circle than on the mainland especially because of the heavily decayed buildings. In the early phase of the design process, the condition of either the buildings or the islands has to be taken into consideration in order to find the right retrofitting intervention.

The main framework for the project of Poveglia consists in the implementation of IoT and Artificial Intelligence. As for the supply of sufficient input data, we envisioned two main systems. On the one side we planned to insert a series of "Sensors & Actuators", whereas on the other side we will have a "Mobile Application".

Figure 3 shows in a simple way how different participants are wired up in the Cognitive network. We can see that the core of the system is the Cognitive Agent (IBM Watson), which it interacts with both the "Sensors & Actuators" (Environment and Architecture) and the "Mobile Application" (Users). The sensors will translate environmental conditions into data and deliver to Watson. After analysing the data, Watson will give commands to trigger direct actions from the actuators. E.g. as soon as sensors installed in classrooms detect a poor quality of air, Watson will trigger a higher ventilation rate in order to improve the air quality in short response time. In another scenario, where too much people are waiting in an underground station, the access systems and signals could be reconfigured to manage the temporary peak of affluence maintaining a suitable level of service.

Figure 3. Data collection and concept app for Poveglia Smart Campus

Users can exploit the mobile application to interact in real-time with both the information from Watson (translated into a user interface that has been designed according to rules for a better user experience) and each other (an integrated inter-com service and social networking).

They can see the energy performance of the buildings they're interested in, they can check up in advance the room comfort or occupancy of the classrooms they intend to go to, or even they can benefit from shared services provided by different university structures (canteen, library or even the equivalent services from other universities in the lagoon area).

The sensors applied in the project (Figure 3) are monitoring temperature, humidity, natural light condition, noise level, air quality and occupancy: all aspects concerning the room comfort. Additionally, sensors connected to weather forecast will be able to allow Watson to monitor severe weather changes ahead. Internet traffic will be also monitored as part of the sensors applied in the project. As corresponding actions commanded by Watson, the actuators will regulate heating and cooling, activate humidifier or dehumidifier, open or close the jalousies, increase or decrease ventilation rate and also give alerts to users that their focused rooms are heavily occupied. When it comes to weather change as thunderstorm or high water, Watson will open up the jalousies in order to prevent damage from wind or water, it will also give alert to facility management so that they can do adequate adjustments. As mentioned before, if any user is detected with high data traffic demand, his/her bandwidth will be reduced in order to provide other users with good connection.

The role of the sensors and actuators on Poveglia Island is to empower the vision of a greater network of "smart city, smart campus" in the lagoon area. By implementing them in the design phase we can easily depict a fluent response system in later use of the buildings. The connectivity and networking of both the facilities and the academic services will be shared within the greater network.

All resources and information will be shared within the network. It's somehow helping rejuvenating Venice and breaks the stereotype of being a "Senior City". A vivid and vibrant public institution is definitely a good example for reutilisation project of abandoned islands in the lagoon area. Poveglia is the perfect place for testing a cognitive system that connects various spots in the Venetian Lagoon and reinforces the historical bond between the islands. Devices can be integrated in the course of time. Installed actuators will respond in real time with incoming commands, which have been deduced, from sensors, user preferences and external data [10]. Virtual reality devices will help to simulate architectural interventions and help to facilitate maintenance.

As long as the buildings are operating, a smartphone application will be designed according the user experience principles (UX design) to facilitate the communication between users and the AI agent. The cognitive system needs to communicate to the users, as generally speaking, over 90% of the data generated by Internet of Things network are unstructured and impossible for users to understand.

Since the buildings are designed with high energy efficiency standard, one of the Interface's aims is to (with the help of an AI agent) translate the unstructured data and withdraw meanings from the data, in order to provide the users with comprehensive infographics, useful for understanding the functioning of the built environment, especially in terms of energy performances.

Various academic institutions have been involved in the "smart campus" network. The university campus we imagined for Poveglia is encompassed in the scenario of an extension of Ca' Foscari University, which could access the resources present on Poveglia Island. For the pan-lagoon area, we have designed an interface to visualise the application for different universities (VIU, Accademia and other Ca' Foscari campuses) (Figure 4)

What we try to achieve in this project is to verify the possibility of a combination of preservation and new construction on a historical abandoned island. Abandoned island is not equivalent to discomfort. Visual, thermal even usage comfort can be realised through a good study during the design phase. Even dealing with buildings in poor conditions can be optimised majorly in terms of energy performance.

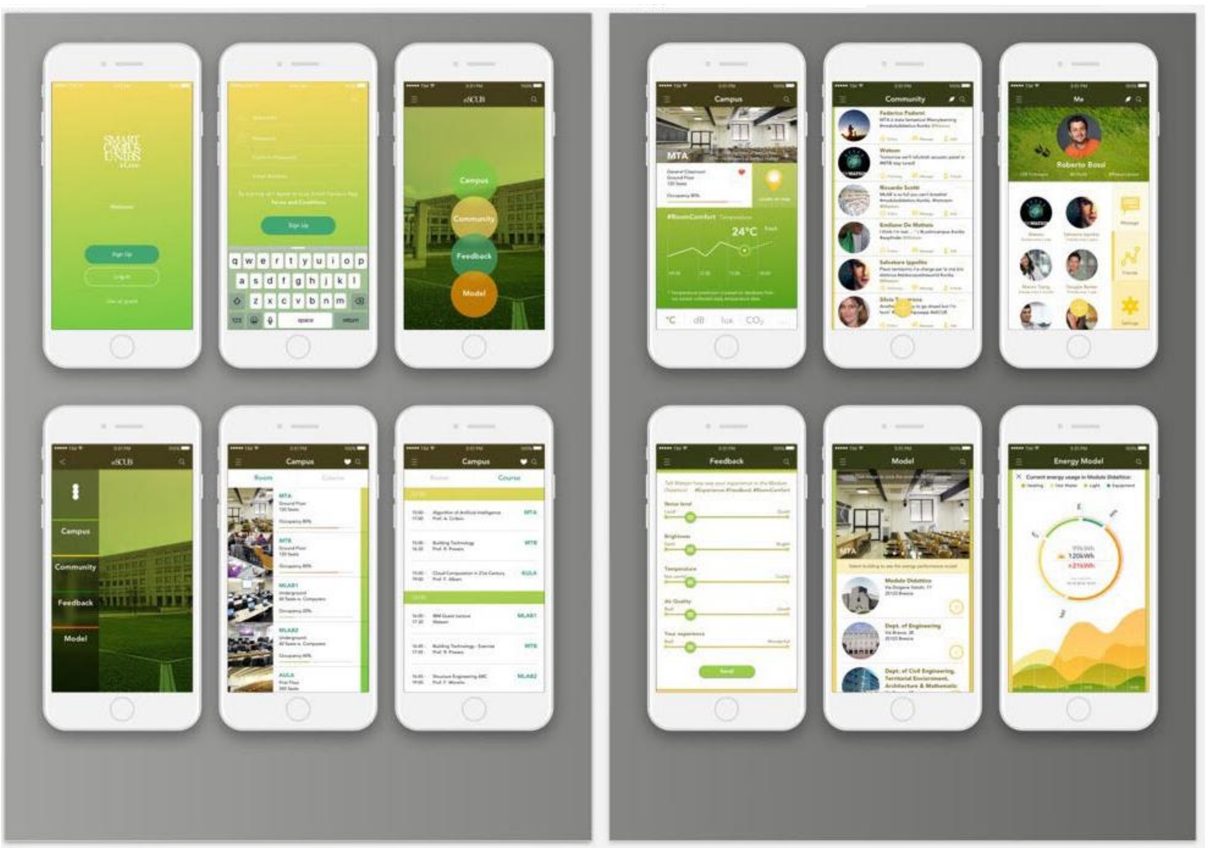

Figure 4. Bi-directional App at the University of Brescia Smart Campus to collect and analyze the users' feedback and provide information about building energy amangement

PRIVACY CONCERNS AND OPEN ISSUES

As we could see above, user data is essential for digital networks. In the case of the "Cognitive campus" users are constantly producing data during daily campus life. This raises the question of what the implications of this process are. It can be argued that by choosing and reacting to the environment, the act of living turns itself into an involuntary critique. Surely there has always been a certain degree of such critique. The main difference is that the critique is nowadays accessible throughout endless data flows. The data is coming directly from users who are monitored in their movement and behaviour. In such an "Internet of Living Things" [10] accepting the "Terms of Conditions" and agreeing to data exposure becomes a major concern. How could we assess the value of data in our contemporary networks?

As the digital networks grow, both in dimension and in potential, we are witnessing a process of "commodification". It can be regarded as equivalent to what happens in economic networks of Capitalism as described by Karl Marx. For Marx both the commodities (capital and labour) are exchanged within the network of participants in the industrial production process. [11] However in the contemporary example of the digital network we can argue that the main commodities are resources of network owners and data of the users. Users give their personal data (sometimes rather unconsciously) to service providers in exchange for services (sometimes claimed as "free"). If we consider data as commodity with a definable "value", we see three main possible scenarios:

The first considers data as part of the "Gift Economy principle" [12]: French socio-anthropologist Marcel Mauss stated that a "gift" is never for free, it creates a strong social bond between two participants. One party gives away goods as a gift, the social bond will lead to the receiver giving back something in return, no matter if it is a favour or goods as well. In the case of digital network, users by accepting the terms and conditions accessing free online service for instance (Wi-Fi hotspot, social networking, or cookies when they browse online content) consent to objectification of their personal data because in a gift economy, nothing is for free.

The second scenario sees data as an exchange product within the framework of a commercial contract. The economic act ends with the exchange of "goods" is executed. This implies that as soon as users give away their data, there could be some sort of "reward" that indicate a defined value. In the university environment, students could be rewarded with educational coupons for courses but also for services such as cloud storage etc. or with cryptocurrencies as well.

The third scenario sees a strong role of public institution and the affirmation of the open-data paradigm in which data are shared, free of charge, through standard interfaces and formats. This behaviour will be mandatory for data generated by public services, as they have already been paid by taxes, but their integration form private sources will generate a prosperous ecosystem that will stimulate the development of innovative solutions.

CONCLUSION

The study promotes and describe the structure of a node of University Campus included into a wider network because the cultural environment of educational point and Universities is a field of development for communication and cognitive technologies. The framework includes the need of cyber security to protect the network and the users' data [13].

The educational use given to an abandoned place with environmental potential and value incudes a layered stratification of benefits. As first it is possible introduce new solutions to define new spaces and "learnspaces" for students and users of a wider community. Secondly it is possible promote virtuous behaviours and organise a reduced impact community by means of new technologies and architectural heritage. As third point it is possible to enhance the users' experience with the added cyberspace.

The Universities network introduces the issues and potentials of the smart city into the educational environment and can promote virtuous behaviours to increase the value of learning with new business models based on knowledge rewards. However also strategies to involve the users and gamification systems to implement data exchange and training/learning experience should be tested and refined during a first phase. The eLUX lab experience at the University of Brescia [14] is the first test of the transposition of the cognitive campus in Italy and the idea is to extend the network [15] at international level [16].

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REFERENCES

1. Bélissent, J., Making Leaders Successful Every Day Getting Clever About Smart Cities: New Opportunities Require New Business Models for Vendor Strategy Professionals. Available at: http://193.40.244.77/iot/wp-

content/uploads/2014/02/getting_clever_about_smart_cities_new_opportunities.pdf [Accessed February 28, 2018], 2010.
2. Bittenbinder, F. & Liu, C., Maritime Oasis. Available at: http://www.poveglia.info/ [Accessed February 28, 2018], 2017.
3. Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., Oliveira, A., Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation, in *Future internet assembly*, vol. 6656, no. 31, pp. 431-446, 2011.
4. Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J.R., Mellouli, S., Nahon, K., Scholl, H. J. Understanding smart cities: An integrative framework, in *Proc. of IEEE International Conference on System Science (HICSS)*, Hawaii, USA, pp. 2289-2297, 2012.
5. Scappettone, J., Killing the Moonlight: Modernism in Venice“, Columbia University Press, p. 138, 2016.
6. Castells, M., Why Network Matters in McCarthy, H., et al. *Network Logic: Who Governs in an Interconnected World?*, Demos, p. 217, 2004.
7. Elloumi, O., Scarrone, E., SmartM2M/oneM2M architecture and principle overview, *DG Connect/ETSI Smart Appliances Workshop*, Brussels 27-28 May, 2014.
8. Cambridge University Press, 2018. Cambridge Dictionary. Available at: https://dictionary.cambridge.org/it/dizionario/inglese/ [Accessed February 28, 2018].
9. George P. Johnson, George P. Johnson Experience Marketing Agency | Global Event Marketing & Entertainment Marketing. Available at: https://www.gpj.com/ [Accessed February 28, 2018].
10. Bellagente, P., Ferrari, P., Flammini, A., Rinaldi, S., Adopting IoT framework for Energy Management of Smart Building: A real testcase, in *Proc. of International Forum on IEEE Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI)*, Italy, pp. 138- 143, 2015.
11. K. Marx, “Capital: a Critique of Political Economy”, Charles H. Kerr and Co., Chicago, 1867.
12. Mauss, M., *The Gift: Forms and Functions of Exchange in Archaic Societies*, HardPress Publishing, 2014.
13. Zanella, A., Bui, N., Castellani, A., Vangelista, L., Zorzi, M., Internet of things for smart cities, *Internet of Things Journal*, IEEE,vol .1, no.1, pp. 22-32, 2014.
14. Bittenbinder, F., Liu, C., Rinaldi S., Bellagente, P., Ciribini, A.LC., Tagliabue, L.C., Bi-Directional Interactions between Users and Cognitive Buildings by means of Smartphone App, *IEEE Second International Smart Cities Conference (ISC2 2016), Improving the citizens quality of life*, 12-15 September 2016, Trento, Italy, .
15. Viani, F., Robol, A., Polo, P., Rocca, G., Massa, O.A., Wireless Architectures for Heterogeneous Sensing in Smart Home Applications: Concepts and Real Implementation, in *Proceedings of the IEEE,* vol. 101, no. 11, pp. 2381-2396, 2013.
16. Perera, C., Zaslavsky, A., Christen, P., Georgakopoulos, D., Sensing as a service model for smart cities supported by internet of things, *Transactions on Emerging Telecommunications Technologies*, vol. 25, no. 1, pp. 81-93, 2014.