

THE SMART CITY AS AN EVOLUTIONARY NETWORK  
PROMOTING CULTURAL COMMONS: THE OR.C.HE.S.T.R.A.  
PROJECT AND NAPLES ANTIQUE CENTER CASE STUDY

1. INTRODUCTION

The purpose of this paper is to analyze how the smart city paradigm can be used to valorize cultural heritage of a community and, in particular, how the Or.C.He.S.T.R.A. project meets this goal<sup>1</sup>. Indeed, in a general vision that prefigures ideal cities, through technology mediated cooperation between material and immaterial resources in order to overall improve citizens' life quality, this project integrates tourism and cultural heritage knowledge with information related to other sectors of the smart city paradigm: smart mobility, smart health, smart education, smart energy, etc. (CANTONE, MARRELLI, MOTTA c.s.).

To show how smart cities are able to promote and valorize Cultural Heritage we have to start from the concept of Cultural Commons. This is defined as «environments for developing and distributing cultural and scientific knowledge through institutions that support pooling and sharing that knowledge in a managed way» (MADISON *et al.* 2010; for a discussion OSTROM 1990, 2002, 2009; HESS, OSTROM 2007; SOLUM 2010; HESS 2012).

Cultural Commons on the one hand create the right environment and the minimum group size and cohesion to produce positive externalities in Cultural Heritage fruition, on the other, being, as we shall see, the result of *evolutionary behavior*, they can have the important role of *educational mechanism* and therefore, increase the number of individuals who valorize Cultural Heritage.

In what follows we will briefly outline how Cultural Commons are formed and how the Or.C.He.S.T.R.A. project (an application of the smart city paradigm) can help in their development.

<sup>1</sup> OR.C.HE.S.T.R.A. (ORganization of Cultural HERitage and Smart Tourism and Real-time Accessibility) is a project financed in Programma Operativo Nazionale Ricerca e Competitività 2007-2013, Smart Cities and Communities and Social Innovation, Asse II - Azioni integrate per lo sviluppo sostenibile, Ambito: Smart Culture e Turismo with a partnership among Università degli Studi di Napoli Federico II (Centro Interdipartimentale di Ricerca LUPT, Dipartimento di Fisica, Dipartimento di Economia, Management e Istituzioni, Dipartimento di Studi Umanistici), CNR (IRAT, Istituto di Ricerche sulle Attività Terziarie; ICTP, Istituto di Chimica e Tecnologia dei Polimeri, IMCB, Istituto per i Materiali Compositi e Biomedici, ICAR, Istituto di Calcolo e Reti ad Alte Prestazioni), IBM Italia, Autostrade Tech, Lauro.it.

## 2. THE SMART CITY AS AN EVOLUTIONARY NETWORK PROMOTING CULTURAL COMMONS

*Cultural traits* (or cultural elements) have been used as basic analysis units in a long and intense debate on culture and cultural transmission, but the possibility of achieving an unanimous and sound definition has been somehow undermined by the lack of a theoretically based acknowledgement (LYMAN, O'BRIEN 2003; O'BRIEN *et al.* 2010; PANEBIANCO, SERRELLI 2014). An open, broad definition has been taken as a starting point for a multidisciplinary study among cultural anthropology, linguistics, psychology, archaeology, musicology: «any trait whose production in individuals depends, to some extent, on social learning» (PANEBIANCO, SERRELLI 2014). In this sense it will be used in this study, mainly to represent a wide interdisciplinary debate still ongoing, and taking into account the possible weaknesses related to issues such as complexity, scale, patterns, configuration and considering the importance of categories of time and space for their analysis.

However, a subset of *cultural traits* can be selected to identify *cultural types*, i.e. aggregations of *cultural traits* related to values, traditions, social living, affecting entertainment and leisure time activities choices. *Cultural traits* can be identified in a very high number; therefore it becomes relevant to select a limited number of salient ones which characterize a *cultural type*. Table 1 represents the set of *traits* (where the number indicates ordinal weights) identifying a *cultural type*. Since not all individuals have the same ordinal ranking of *cultural traits* we define belonging to a *cultural type* those individuals whose correlation  $R_{i,j}$  among the rankings is higher or equal to a threshold level.  $R_{i,j}$  is the correlation coefficient between orders of individual  $i$  and those of individual  $j$ . The height of the threshold level has to be set according to the purposes of the model and in particular the higher the need to differentiate finely between types within the model, the higher the threshold level to be set.

Therefore a *cultural type* is characterized by a set of *cultural traits* and by an ordering on these. Each *cultural type* will probably show individual priorities and preferences, a willingness/effort to reach them and this will have an influence on observable behaviors. However, the identification of *cultural type* goals is a fuzzy one, since we can observe different weights even for the same ranking of *cultural traits* among individuals. The extreme variability of rankings and values is determined by the plastic and changeable nature of cultural choices, and by the blended dynamics of mixing processes among other *types* happening in space and time.

According to this approach, in any community there exists a set of *cultural types*. Different individuals/agents belong to each *type*, every one of

Cultural traits	Rank
Religious beliefs	1
Intellectual interests	2
Appreciation of comfort	3
Sociality	4
Emotions appreciation	5

Tab. 1 – *Cultural traits* for a hypothetical type.

$$c = \sum_{i=1}^n \sum_{j=1}^n \frac{R_{i,j}}{n \times n}$$

Fig. 1 – Network cohesion measure.

them characterized by different (but similarly ranking) *cultural traits*<sup>2</sup>. *Cultural types* interact and as such they can be considered as *nodes* in a network. The essence of such a network is its dynamics; networks evolve in time and space with observable changes in the number of individuals belonging to a *type* and in the relations between the different *types* (BORGAT *et al.* 2008). To better define the dynamics taking place in the network, we remind studies on networks economies, that explain that positive externalities for the agents grow according to density and cohesion values of the nodes in the network (ECONOMIDES 1996), where the density of a graph is the ratio between the number of bonds observed and the number of all the possible links between the nodes (WASSERMAN, FAUST 1994). The network density describes the general level of ties among the points in a graph (the more numerous the nodes directly connected to each other, the denser the graph); while the cohesion measure is identified as the correlation degree among individual ordering relative to the different goals (BERTACCHINI *et al.* 2012), such measure formalizes task commitment individuated by Beal (BEAL *et al.* 2003) (Fig. 1).

In a few words, such an evolutionary model assumes that, according to the characteristics of the network, each individual belonging to a *cultural type* faces a probability of experiencing other *cultural types* behaviors and, by confronting the satisfaction that derives from the experience he/she can decide whether or not to “change” his/her *type*. The final result on which *types* will have evolutionary success will depend on the degree of satisfaction which

<sup>2</sup> In this paper we do not tackle the problem of how *cultural types* evolve in time, nor we analyze the internal dynamics of the subset *cultural type*.

individuals of each *type* experience, and this in turn depends on cohesion and density of each sub-group. Indeed the proposed approach contributes to building up a multidisciplinary information environment, which aims at facilitating *cultural types* in observing different behaviors, and at evaluating the outcomes deriving from their adoption.

### 3. CULTURAL HERITAGE, CULTURAL IDENTITY AND ARCHAEOLOGY VALORIZATION IN THE SMART CITY: THE OR.C.HE.S.T.R.A. PROJECT APPROACH

An extensive speculative activity recently led to outline many different definitions of the concept of Smart City, developing methodologies and technologies to implement this paradigm, identifying sets of indicators and designing models of evaluation, and to provide policy makers with decision support tools (CARAGLIU *et al.* 2009; HARRISON, DONELLI 2011; CHOURABI *et al.* 2012; ALBINO *et al.* 2013). In such emergent rich debate cultural aspects are mainly considered as factors able to improve life quality and to facilitate creativity and knowledge circulation (NAM, PARDO 2011; ALBINO *et al.* 2013).

Existing approaches fulfill partially the representation requirements of complex cultural systems, such as the Or.C.He.S.T.R.A. project case study, Naples antique center, where “cultural facilities” correspond to an interconnected network of cultural heritage evidences and activities, not only collected in museums (archaeological, historical, artistic, archivist, demo-ethno-anthropological, crafts, traditions), and of (material and immaterial) expressions of cultural identity, spread on the territory with a high density and strong pervasivity. Accordingly it can be observed that mapping and assessing the value of such crucial sectors as cultural heritage, cultural landscapes and cultural identity in the smart city may be not immediate and various improvements are expected and estimated by means of further studies on these themes.

On the other hand, Cultural Heritage disciplines lack a widespread critical awareness of the potential deriving from exploring, customizing and specifically applying the smart city paradigm to the cultural heritage fields of interest. Nevertheless, an analysis of main emerging trends in digital archaeology highlights a progressive delineation of various lines of research convergent with issues raised by the smart city scientific literature. They range from collaborative and social approaches, promoting archaeological and cultural heritage knowledge sharing and collaborative construction, to a stronger interconnection between anthropic and natural elements in the interpretation and reconstruction of the ancient landscape, to the frequent and multiple interdisciplinary interactions, both in archaeological research and didactics, to the need for strategies for territorial planning and archaeological potential information management.

SMART CITY	DIGITAL ARCHAEOLOGY
Focus on user	Archaeology 2.0
People/place synergy	Cultural landscapes; nature/culture interconnections
Holistic approach	Holistic approach; contextual approach
Interdisciplinarity	Virtual archaeology; digital archaeology; archaeometry; archaeozoology; archaeobotanics
Open approaches in information circulation; open innovation	Archeology and open science; open archaeology; open archaeological data; open software in archaeology
Sustainable urban planning and development	Archaeological potential; archaeological excavations planning; archaeological risk map
CARAGLIU <i>et al.</i> 2009; HARRISON, DONELLI 2011; CHORABI <i>et al.</i> 2012; ALBINO <i>et al.</i> 2013.	LOCK 2003; CANTONE 2005, 2012b, c; RYAN <i>et al.</i> 2005; FELICIATI NATALE 2009; CHIANESE <i>et al.</i> 2010; KANSA <i>et al.</i> 2011; ANICHINI <i>et al.</i> 2012; BONACINI 2012; MOSCATI 2012; TORTORA 2012; CANTONE, DE TOMMASI in press

Tab. 2 – Mapping main smart city and digital archaeology issues.

Such issues may find a distinctive point of view in the smart city studies, where collaborative approaches are a starting point for building up participated environments of people and places, and where planning and managing sustainable territorial development is made possible by a deep investigation and recognition of uniqueness and distinctive elements of the places history (Tab. 2).

Such preliminary considerations about the complexity of archaeological scientific trends that find new stimulus in the smart city approaches induce to consider the possibility of an enhanced study and representation of the cultural framework in the smart cities paradigm, thus improving the possibility to better analyze the territorial potential and the impacts of the application of the model on it (CANTONE, MARRELLI, MOTTA in press)<sup>3</sup>.

Therefore it is reasonable to state that the Or.C.He.S.T.R.A. project intercepts an area of scientific knowledge that seems still obscure by multiple points of view, since the value of the cultural context in the paradigm of Smart City and in assessing its performance is still widely disregarded. This way the research suggests investigating also the opportunity of a recalibration of the value attributed to the cultural framework in the smart city paradigm, and to identify an appropriate evaluation model to be adopted for the analysis of the performance of the complex outcomes expected (GIFFINGER, GUDRUM 2010; ALBINO *et al.* 2013) (Fig. 2).

<sup>3</sup> In the European Smart City Ranking model (Smart City Index: <http://www.smart-cities.eu/>), for example, cultural heritage is mainly represented by the Smart Living Session-“cultural facilities” indicators (1: Cinema attendance per inhabitant; 2: Museums visits per inhabitant; 3: Theatre attendance per inhabitant). Furthermore it has to be considered that many cultural heritage features can be compatible with other indicators used in the same model to characterize Smart Living, such as Education Facilities and Touristic Attractivity, or other smart city sectors, such as Creativity (in the Smart Living section), Attractivity of natural conditions (in the Smart Environment section). Likewise, in other models aspects related to cultural heritage are not listed clearly, but generally entailed in other aspects (for instance <http://www.smartcitycouncil.eu/>).

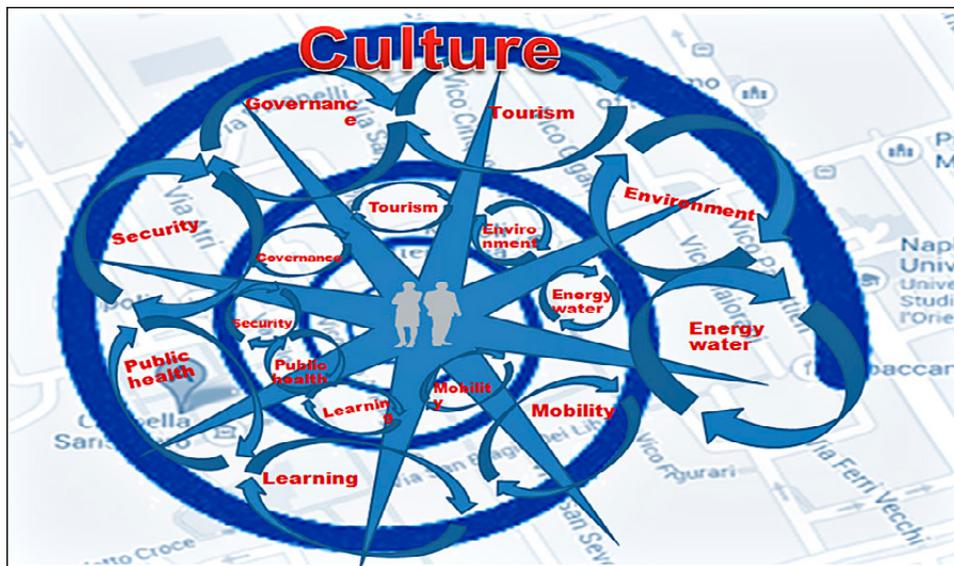


Fig. 2 – Napoli Smart City and the Cultural Framework (Authors' elaboration).

#### 4. FIRST EXPERIMENTATIONS AND SCENARIOS

The model approach that is defined as part of the Or.C.He.S.T.R.A. project is refined foreshadowing different case-studies, that will be further investigated by the ongoing project activities. The following hypotheses use stereotypes to identify application scenarios: the project activities, with a precise identification of user profiles of the technological platform in development, will specify the research hypotheses and verify the validity of the methodological assumptions on which they are formulated.

##### 4.1 Archaeological tourism

A tourist plans to visit Naples, registers to the Or.C.He.S.T.R.A. on line platform and he/she is identified in his/her cultural preferences and mobility supports and logistical requirements in the city visit (Fig. 3). In this work this can be achieved by the activity of users profiling, that allows offering cultural contents in different ways to match different profiles needs. This way on the one hand a *cultural type* is facilitated in meeting and experiencing other *types* behaviors, on the other the variety in cultural contents structuration increases the possibility of making cultural experiences appealing for different *types*.



Fig. 3 – Or.C.He.S.T.R.A. Cultural information base: diachronic stratification at Sant’Antoniello (Or.C.He.S.T.R.A. website).



Fig. 4 – Or.C.He.S.T.R.A. Cultural tourism services: Augmented Reality at Sant’Antoniello (Or.C.He.S.T.R.A. website).

The tourist arrives at the Port of Naples and downloads one of the available Or.C.He.S.T.R.A. mobile apps, the Multimodal Navigator, which, fitting the visitor cultural interests for archaeology, suggests visiting the Greek walls remains inside the Sant’Antoniello monumental complex in Piazza Bellini, proposing customized multimedia information about Naples history (VALE-

RIO, PINTO 2009). The recommendation is planned by harmonizing cultural *desiderata* with constraints and opportunities related to mobility, timing and budget aspects, furthermore making the Or.C.He.S.T.R.A. platform data interact with real-time information about expected travel time, integration of the various transport systems available, recommendations and reviews by other visitors and citizens. This way the user-centered decision-support aims at facilitating a more tailored touristic experience, making it easy to manage the environmental impact of touristic flows on the territory, and furthermore promoting interactions among tourists/citizens/territory. Again, in proposing various ways to reach a place or to plan a visit, the Or.C.He.S.T.R.A. system supports meeting and adopting different behaviors, thus increasing the desirability of the territorial experience; furthermore the improved control on sustainability of visitors impact contributes to making the Cultural Heritage fruition more attractive.

When in Sant'Antoniello, the visit is technologically enhanced by a bouquet of Or.C.He.S.T.R.A. technological mediated systems, such as, for example, augmented reality applications semi-automatically managed by the tourist behavior (CALANDRA *et al.* 2013; CALANDRA, CUTUGNO 2014) or 3D sound guides (DI MAURO, CUTUGNO 2013). The aim is to increase the immersion in an information-rich, emotional, multisensorial, social, personalized environment that supports the exploration of the monument, its history, its semantics. The interaction with the Or.C.He.S.T.R.A. community goes on also after the staying, by means of tailored tools supporting multimedia memories, comments, reviews, recommendations sharing among visitors (Fig. 4).

The archaeological information, in such a dense and multi-dimensional knowledge environment, thus becomes the framework for planning, living and remembering a more satisfactory visit experience, increasing the attractiveness and the reputation of Naples destination (MORVILLO 2012; DEL CHIAPPA *et al.* 2013; MICERA *et al.* 2013). Tourists/visitors become an active part in the knowledge construction process, their preferences, requests, experiences, emotional and experiential feedback, purchasing activities in the area, are acquired, stored and integrated into the Or.C.He.S.T.R.A. system, increasing the informative value over time and allowing a progressively more tailored service.

Furthermore, according to the evolutionary scheme of the communities above mentioned, this approach increases the payoff of innovation, facilitating the choice of adopting desired *cultural traits* (archaeological visit) and helping to spread its adoption.

#### 4.2 Participated Cultural Heritage governance

The Municipality of Naples uses the platform to optimize resources for acquiring, analyzing and managing archaeological information and its



Fig. 5 – Naples Smart City logo.

valorization for touristic activities. The Or.C.He.S.T.R.A. platform allows re-orienting tourists flows avoiding irrational distributions and congestions, managing information about emergencies such as temporary occlusions in the territory (strikes, unexpected unavailability of roads or areas collapsed for heavy rains, roadworks, etc.), the temporary unavailability of sites and monuments for restoration or conservation activities. The increased capacity of territorial control is supported in an interactive, participated way, reducing the necessary resources, thus rationalizing the costs and impacting positively on the perception of efficiency of public services.

Citizens and tourists participate to cultural heritage sustainable management and cultural identity construction, for instance by uploading pictures documenting in real time critical situations (damages, risks), proposing ideas, sharing comments and opinions about their experience and about the Points Of Interest (POIs) they visit. Furthermore citizens and tourists participation supports also mechanisms of identification and appropriation, contributing to re-socialize the value of archaeology and to reconnect people to their history and cultural identity (Fig. 5).

#### *4.3 Cultural identity, cultural heritage, traditional handicrafts*

A luthier owns his own workshop near San Gregorio Armeno street and enters his artisan activities information in the Or.C.He.S.T.R.A. platform (PINTO *et al.* 2013). Thus his production is not an isolated monad anymore, he joins the cultural knowledge network by participating actively to the shared information construction process; the musical instruments products become a hub in an articulated connection of information on local museums, theaters, conservatories, music programs; the craft production information is related to the integrated visit of the area, contextualized in its cultural matrix, the accessibility of information increases the visibility of handicraft product, enhances the commercial attractiveness and desirability, by identifying an idiosyncratic production (DE CARO, MARRELLI, SANTAGATA 2008).

Similarly, a new start-up company that wants to develop a new business by focusing it on a music production technology is attracted by the Neapolitan territory since its dense informative and intelligent substrate, supported by the Or.C.He.S.T.R.A. platform, can interact with the new information entered from the start-up, facilitating the integration of new information and multiplying its value.

#### 4.4 *Academic didactics and cultural heritage ICT-enhanced valorization*

In the Smart City context there are many transformations in the need of knowledge in the processes of information acquiring, creating, circulating, and sharing. Accordingly, the academic and learning models change in the emerging paradigm, in which the complexity vision supports a progressive interdisciplinary blurring and merging among disciplines. In the last years Napoli University Federico II developed an experimentation on didactic technologies and methodologies particularly focused on interactions between ICT and Humanities, Cultural Heritage, Archaeology disciplines (CANTONE *et al.* 2010, 2012a; CANTONE, DE TOMMASI *in press*).

In the methodological context of the Or.C.He.S.T.R.A. project an experimentation of interdisciplinary cooperative didactics, named “Smart Cities and Cultural Identity” merged two different academic courses, Audiovisual laboratory (Bachelor Degree Course in Digital and Communication Cultures) and Man/Machine Interaction (Bachelor Degree Course in Informatics) at Napoli University Federico II, in collaboration with the IRAT-CNR Institute for the aspects related to innovation transfer in the territory and bridging research and academic fields (ETZKOWITZ, LEYDESDORFF 2000; CARAYANNIS BARTH CAMPBELL 2012; the approach is further analyzed in CANTONE, DE TOMMASI *in press*)<sup>4</sup>. Students were directed in the process of selecting a case study and constructing a shared course by mixing competencies of the two sectors.

The theme selected was the valorization of cultural identity of the territory surrounding the Social Sciences Department, vico Monte di Pietà (in the Naples Antique Center), focused in its historical, artistic, social and cultural aspects, and in the crafts and arts that characterize the area. Smartphone apps were designed in order to valorize local identities and to support cultural tourism in the smart city methodological context.

So students learned a multimedia pipeline, mainly based on open source software, created a shared content repository, and four smartphone apps:

– Naples Antique Center Emotions Map, which allows people, tourists/citizens to share the emotions raised by their visit to the territory in real time,

<sup>4</sup> Academic Year 2012-2013: Francesca Cantone and Emanuela Motta (CNR-IRAT), and Franco Cutugno (Dipartimento di Ingegneria elettrica e tecnologie dell'informazione, Università degli Studi di Napoli Federico II).

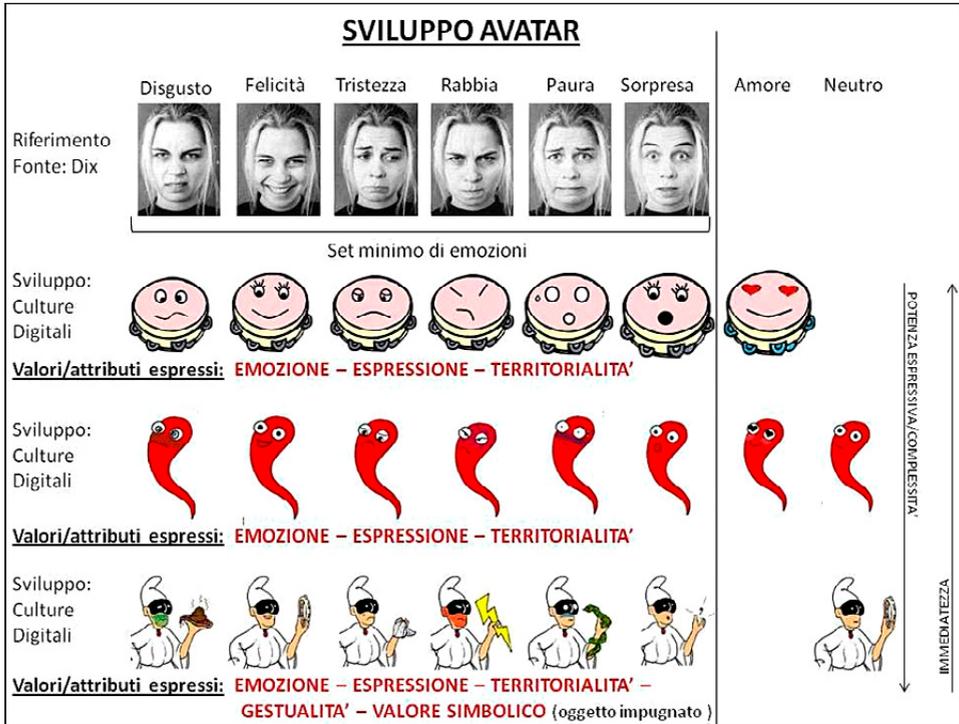


Fig. 6 – Naples emotional chat.

creating an happiness map, with variations through time, and allowing also to track, for instance, the emotional impact of particular events such as concerts or strikes impacting positively or negatively on the average happiness perceived in a place).

- Naples Antique Center Sounds Map, which allows people to share typical sounds representing the identity of different places in the territory.
- Emotional Chat, to support people interaction and emotional status sharing, by means of emoticons representing aspects of cultural Neapolitan traditions, by exploring, for example, the possibility of representing Neapolitan gestures as described in DE JORIO 2002.
- Services and Mobility App, to support a Car Pooling service for students and tourists moving across the territory.

All the applications are supported by a centralized Multimedia Editorial Staff, that manages the multimedia contents (texts, pictures, drawings, video, sounds), that give information on a series of POIs (churches, monuments, sites, historical-cultural evidences, commercial and craft activities, typical restaurants,



Fig. 7 – Naples emotional map.

Smart city and cultural identity apps	Smart city trends
Emotion Chat	Emotional and experiential cultural tourism
Emotion Map	Networks density and cohesion representation in space and time
Naplesquare Portal	Holistic approach; context, network density
Services and Mobility App Car Pooling	Mobility; social participation

Tab. 3 – Matching “Smart city and cultural identity prototypes” and Smart City trends.

entertainment activities). All the mobile services are collected by a web portal, named “Naplesquare”, and by a Social Media Editorial Staff, diffusing information about the project by means of the web 2.0 channels. This way students become a crucial point in creating a local network among university, research, commercial and craft activities in the local development perspective and territorial valorization (Figs. 6-7). The prototypes have their methodological context in the emerging themes in the smart city literature (Tab. 3).

For instance, the representation of emotions of people by clusters evolving in time and space supports density and cohesion in networks by showing places where people are happier: this way the app contributes to make a place more appealing in a specific moment (for instance during a cultural event or activity), for different types, and therefore it contributes to creating cohesion in the network. Indeed such emotional and multisensorial approaches support aggregation on cultural contents, by means of attracting people for their emotional and qualitative value.

## 5. CONCLUDING REMARKS, EXPECTED RESULTS, PERSPECTIVES

This research proposes to evaluate the Smart City approach as an evolutionary network promoting cultural commons and this way it suggests

a reconsideration of the rule of the cultural framework in the Smart City paradigm. The Or.C.He.S.T.R.A. project aims at building up a multidisciplinary technological informative environment for the Naples Antique Center, impacting on the density and cohesion of the network and supporting the territorial valorization for tourists and citizens and sustainable development.

In this context the described activities are to be integrated in the first experimentations of the approaches outlined, ranging from archaeological tourism support technologies, to the participated cultural heritage management strategies, to the didactics innovation. However, the model outlined can give rise to different possible results. Depending on the distribution function of the *types* in the community the evolutionary advantage can go in either direction; the *cultural type* which is able to attribute value to cultural heritage can prevail, but it can also constitute a case of “tragedy of commons”, i.e. the tendency to disappear for continued lack of new cultural inputs (BERTACCHINI *et al.* 2012). This of course calls for policy interventions.

Facilitated by the models and strategies described above, the Or.C.He.S.T.R.A. network aims at increasing automatically and, therefore, over time, to improve its sustainability, attracting further information according to the logic of social and participatory construction of knowledge, thus contributing to prevent the appearance of the “tragedy of cultural commons”.

FRANCESCA CANTONE, EMANUELA MOTTA  
Istituto di Ricerche sulle Attività Terziarie  
CNR - Napoli

MASSIMO MARRELLI  
Dipartimento di Scienze Economiche e Statistiche  
Università degli Studi di Napoli “Federico II”

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## ABSTRACT

The paper investigates the perspectives of applying the “smart city” paradigm in the Archaeology and Cultural Heritage field, thus outlining the emerging concept of *Smart Cultural Heritage* and *Smart Archaeology* and proposing an integrated approach, in which the fundamental value of the cultural framework is acknowledged in the complexity of the “smart” paradigm. The theory of Cultural Commons, moreover, is invoked as a basis for the study of the advantages of sharing common resources (such as cultural heritage and the related digital information) within the Communities, identified in their inclination to innovation by means of the Evolving Networks model. In this context, the Or.C.He.S.T.R.A. project proposes a participatory and cooperative complex system of heterogeneous information on the ancient center of Naples as a case study, ranging from mobility, to health, energy, and cultural heritage, to support the “smart” exploitation of the tangible and intangible cultural heritage, for citizens, visitors and tourists while fulfilling the requirements of sustainability and eco-friendliness. The first experimentations of this methodological approach are presented, with focus ranging from archaeological exploitation to participated management of cultural heritage, to educational innovation. The integration of these aspects multiplies their potential, and influences the value of cohesion and density of networks of shared goods and services in the area, supporting the spread of innovation in the community, and creating value in the territory, thus impacting the possibility of the appearance of the “tragedy of cultural commons”.