Smart City Planning and Heritage – An IoT based toolkit framework

The aim of this paper is to review and assess national and international developments in smart cities and their contribution in preserving the cultural heritage, thus facilitating the policy makers to embrace the concept of Smart Heritage. Smart city planning majorly focuses on IoT, ICT, big data, real time data and monitoring. This gives an opportunity to the policy makers to adopt the dynamic concept of IoT for heritage and integrate past and future through policy intervention, while managing the challenges faced by heritage and minimizing or negating the damage or decay of heritage assets of a city. The focus of this paper is upon integration of Smart Heritage in Smart City embracing a bottom-up approach from local level to national level. The objective encompassed herein is to explore the use of IoT in providing End-to-End (E2E) Solution using various smart tools, in a form of standard toolkit, which could be modified on a case by case basis. This toolkit will help enabling the capabilities of local bodies in monitoring and maintenance of heritage assets, thus assisting them to incorporate the smart heritage concept as a part of smart city planning.

Keywords: *Smart City, Smart Heritage, IoT, Policy intervention*

Introduction

There are several definitions of a "smart city" across the globe, either community/citizen-focused or data driven, based on the context and level of development along with willingness and aspiration of government and community.

Some of the broadly used definitions and approach are as below:

The British Standards Institute (BSI) defines the term as "the effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future for its citizens".[1]

IBM defines a smart city as "one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources".[2]

In the approach of the Smart Cities Mission in India, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.[3]

[1]BSI (2014), *Smart cities framework – Guide to establishing strategies for smart cities and communities*, PAS 181:2014

[2]Cosgrove M & al, (2011), Smart Cities series: introducing the IBM city operations and management solutions. IBM.

[3]Official website of Ministry of Housing and Urban Affairs, Govt. of India, available on http://mohua.gov.in/cms/smart-cities.php

Cisco defines smart cities as those who adopt "scalable solutions that take advantage of information and communications technology (ICT) to increase efficiencies, reduce costs, and enhance quality of life".[4]

According to the Manchester Digital Development agency, "a 'smart city' means 'smart citizens' – where citizens have all the information they need to make informed choices about their lifestyle, work and travel options".[5]

Cultural heritage is the combination of tangible and intangible assets, which hold cultural, artistic or architectural significance that include monuments, artistic expressions, landscapes, and even traditions, languages, and dances (UNESCO, 1972). Safeguarding of the urban heritage and landscapes is not only a need but also a necessary financial investment to progress towards the creation of inclusive and sustainable cities as they are crucial resources for sustainable development, economic growth and employment (Fusco Girard, L. 2013 and Girard et al. 2017). Also, the deterioration or destruction of artworks is a serious loss/damage that cannot be recovered in many cases (Fernando et al. 2017).

The paper attempts to explore the possibilities of use of IoT, ICT, big data, real time data and monitoring for managing the challenges faced by heritage and minimizing or negating the damage or decay of heritage assets of a city. This gives an approach and a system to provide End-to-End (E2E) Solution using various smart tools, in a form of standard toolkit, which could be modified on a case by case basis. This toolkit will help enabling the capabilities of local bodies in monitoring and maintenance of heritage assets, thus assisting them to incorporate the smart heritage concept as a part of smart city planning.

The structure of the paper is as follows: first, the concept of 'Smart Heritage'; second, various systems, techniques, tools discussed together with the approach needed to assess, maintain and monitor the value of heritage; third, an elementary suggestive toolkit for heritage management within the context of smart cities.

Smart Cultural Heritage

The concept of "smart cultural heritage," according to researchers of the EU funded DATABENC (Distretto ad Alta Tecnologia per i Beni Culturali) initiative, is about digitally connecting institutions, visitors, and objects in dialogue. Smart heritage focuses on adopting more participatory and collaborative approaches, making cultural data freely available (open), and consequently increasing the opportunities for interpretation, digital curation, and innovation. This offers potential and unprecedented access to cultural artefacts and experiences across distances, in which cultural consumers are no longer passive recipients (Angelaccio, M. et al. 2012).

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[4]Falconer G & Mitchell Sh (2012), Smart City Framework A Systematic Process for Enabling Smart+Connected Communities

[5]MDDA website http://www.manchesterdda.com/smartcity/

In 2014, at the International Biennial of Art Restoration and Heritage Management (AR&PA) in Valladolid, Spain on the theme of 'India-Spain Co-operation in the field of Heritage Conservation and Management', a roundtable was organised on the future of heritage in the context of Smart City (MEA Report 2014).

The Internet of Things (Zanella et al. 2012) is changing our life style and our connection with the world. The recent development in technologies may influence the development of a new framework adept to support heritage-led policymaking in smart cities, as *smart heritage* agenda. Information technologies can be helpful in promoting inclusive, comprehensive and participative governance to support heritage centred sustainable urban development and economic growth.

Methodology/Research Design

The methodology adopted for this paper is 'cross-case analysis', whereby selected information is collected across selected cases and then analysed comparatively in order to identify underlying trends, patterns and relationships, allowing for the extraction of theoretical propositions (Eisenhardt, K., 1989). In this paper, the author has examined several systems, techniques and tools to understand how the cultural heritage of cities has been incorporated in existing smart city strategies so far. Thus, proposing an elementary suggestive toolkit, for monitoring and maintenance of heritage assets, which could be modified on a case by case basis.

Valuation of Heritage

The preservation of cultural heritage implies a valuation process. Labelling something as heritage constitutes a value judgment, distinguishing a specific object/event from others; it is a conscious act of belonging to a group, a city, a nation and the outcome of an important cultural journey (Riganti, P. 2010). A property as having Outstanding Universal Value should fulfil the criteria of Operational Guidelines for the Implementation of the World Heritage Convention. These criteria were formerly presented as two separate sets of criteria - criteria (i) - (vi) for cultural heritage and (i) - (iv) for natural heritage. The 6th extraordinary session of the World Heritage Committee decided to merge the ten criteria (Decision 6 EXT.COM 5.1). Protection and management of World Heritage properties should ensure that their Outstanding Universal Value, including the conditions of integrity and/or authenticity at the time of inscription, are sustained or enhanced over time (UNESCO 2017).

The bottom-up approach emphasises the use of new technologies (for example, social media, websites, mobile applications or censoring technologies) and new data (becoming available through open data platforms or censors) as a means to enable citizens to devise solutions, acquire new skills through online learning and improve their interaction with decision makers.

ICT/IoT for Smart Cities and Smart Heritage

There are couple of applications, which have been developed for smart cities through Information and Communication Technologies (ICT). These have been categorised as per application type. Some of them are Smart lighting, Smart parking, Smart buildings, Energy consumption, Traffic control, Centralized and integrated system control, Structural health of buildings.

General Architecture of IoT

General architecture of IoT that interconnects data and information through devices and internet involves various elements creating a cycle of information flow. These are: (i) User, (ii) Devices, (iii) Technologies, (iv) Storage, (v) Processing and Classification, (vi) Applications' sectors

ICT/IoT can serve dual purpose, one for the users (i.e. visitors/ tourists) and second for the decision makers (i.e. government/ local bodies). Here, the role of big data comes into picture, which is very crucial as it has greater influence on administration and dissemination of information. Proper management of big data is utmost important as it generates value in information, in absence of that platforms lack of velocity to process data, coverage to hold great value of information, and ability of classification of data according to their variety (José, et al. 2016).

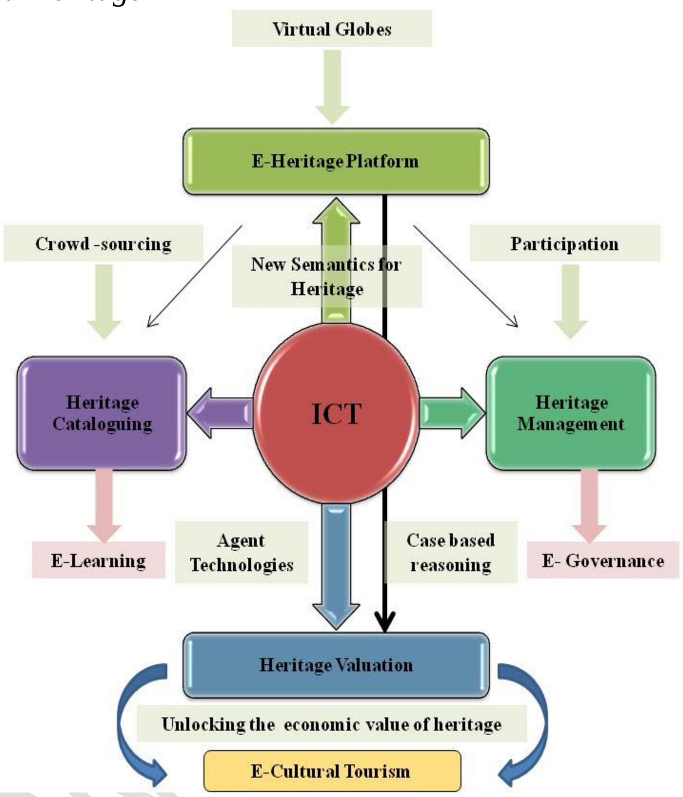
Vattano (2014) asserts that the integration of a city's historical elements into its modern reality is a significant factor towards the advancement of its urban intelligence. The specific benefits of including cultural heritage in a smart city initiative derive from big data management and augmented reality (AR).

ICT can serve the users through various systems which comprise of state-of-art technologies. Some of them are as below:

Enabling Technologies: Internet of Things (IoT), Cloud computing, Wireless Sensor Network (WSN), Wireless Sensor Network (WSN), Short range wireless
Visualisation Technologies: 3D visualization, Geovisualisation, Augmented Reality (AR)

For decision makers, an integrated platform is required, which should have the potential to combine the demand-supply assessment of heritage assets with the management strategies, hence providing a national and regional database for the preservation and management of heritage. A system which incorporates multimodal data analysis, and content-based augmented data retrieval with the aim of assisting preservation endeavours. This integrated platform has three main components: an ICT architecture, based on the use of advanced information techniques such as agent technologies; which would be linked to a 3D GIS relational database/virtual globe containing all the relevant information on the site and its cultural heritage. Finally, the combination of these two components would be supplemented by a number of users driven software/apps, providing e-services to enhance the access and appreciation of cultural destinations and their heritage, as well as software for online valuation of public preferences for the way such heritage is presented/managed/used (see Figure 1). The final product should be flexible to accommodate future improvements (Riganti, P., 2017)

Figure 1. *Intelligent Environment (IE) for valuation and management of cultural heritage*



Source: adapted from Riganti, 2017

Proposed elementary suggestive toolkit for Smart Heritage

The proposed elementary suggestive toolkit will form a system which will utilise contemporary tools in natural language processing, image processing, semantic classification and dissemination.

It will work under three major categories:

Research: identify the ways for improved use of spatial and physical analysis to further identify risks and opportunities; improving knowledge and awareness towards digital archiving and dissemination.

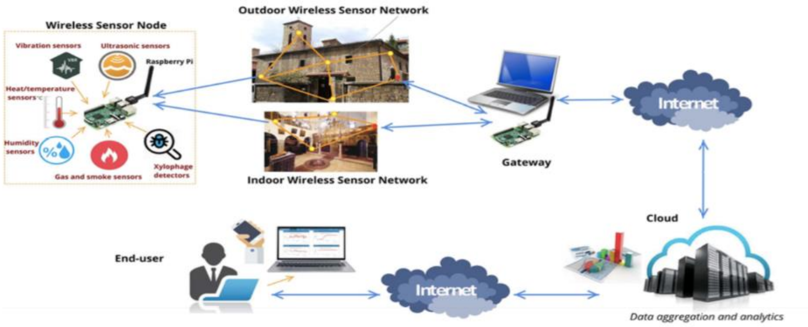
Engagement: showcasing the value of heritage with assumptions and counter-assumptions; transfer and sharing of sensitive heritage data; citizen engagement through social awareness of impacts of heritage on society as they are vital for sustainable development, economic growth and employment.

Presentation/Promotion: improving data sharing capability; identifying type of metadata which is more accessible.

Components of Toolkit

The proposed approach enables 24/7 monitoring of a variety of parameters, generates accurate and specific alerts, hence enabling real-time insights into heritage conditions and timely interventions. This solution is modular and can be tailored to the specific use-case scenario by adding the extra components and services (see Figure 2).

Figure 2. *The overall structure of the IoT based monitoring system*



Source: Marijana. 2019

General structure and main design principles using the six-layer IoT architecture (see Figure 3 and Figure 4)

The Source Logic Layer: Lowest layer which consists of online and offline data derived from various IoT devices such as sensors, and human and social network. The raw data is sent to cloud infrastructure to be stored and extracting the relevant data.

The Data Logic Layer: Contains functional modules to gather and process the data collected from various sources (offline, human and social). Pre-processed data are validated and elaborated using data validation, processing, classification and enhancement techniques to produce useful information.

The Information Logic Layer: Information processing and fusion modules dealing with the processing of useful information, produced by the data analysis modules, to extract classified events.

The Event Logic Layer: Set of modules to analyse and process the classified events, application of Complex Event Processing techniques, elaborating the Threat analysis and Risk assessment for a valid Decision Support Mechanism.

The Service Logic Layer: Contains various service categories to prevent, manage and mitigate risk associated with the natural hazards in the cultural heritage domain.

<u>The Application Logic Layer</u>: This layer allows users/experts to interact with the services and tools using web applications technologies, mobile apps, GIS services, crowdsourcing etc. In this layer, GUI functionalities are implemented to have an easy and intuitive access using a simple browser to the operational and collaborative working environment for making decisions and sharing the cultural heritage knowledge.

Figure 3. *Platform's logical architecture*

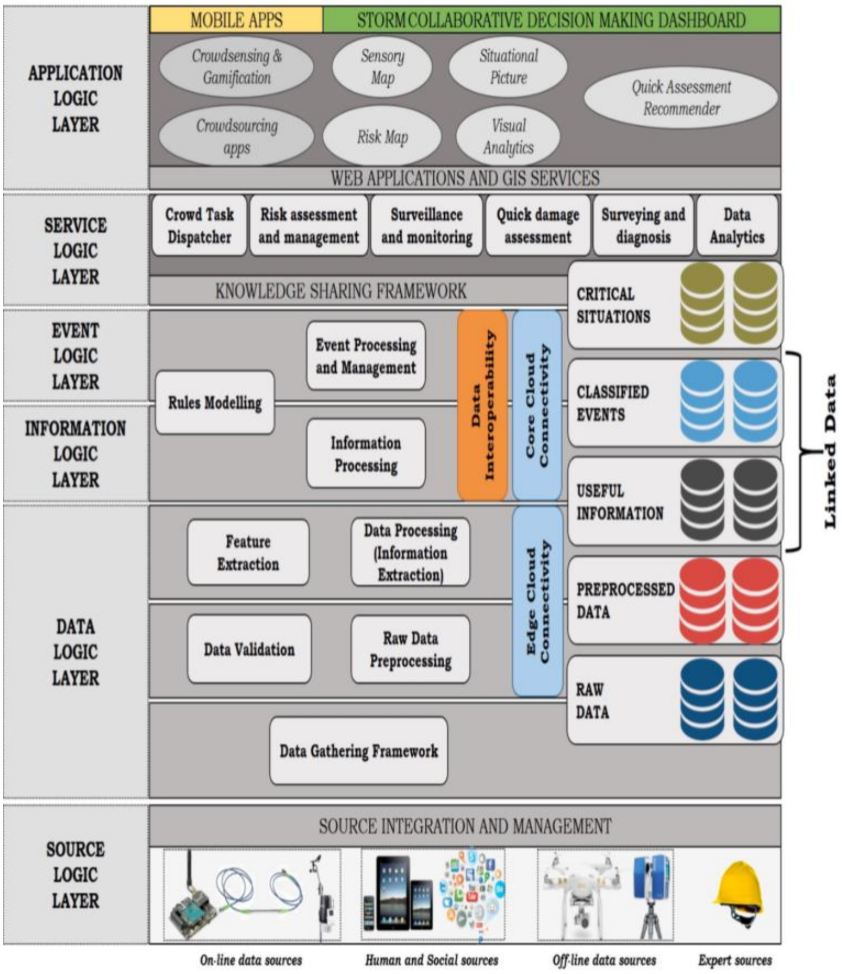
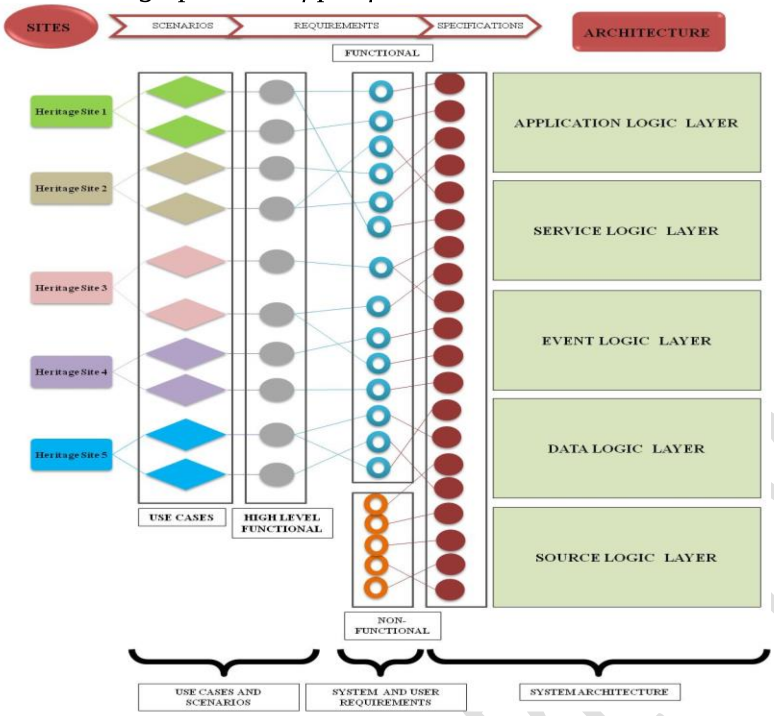


Figure 4. *Design process of platform architecture*



Source: Joao. et al. 2019

Components of this suggestive toolkit should be modified on a case by case basis such as indoor and outdoor (building/ statue). (see Table 1)

Table 1. *Components of the suggestive toolkit*

Design Component	Analysis/ Monitoring	Technique/ Tools	Dataset
Node	Surveillance and Monitoring Microclimatic monitoring Quick Damage assessment RF performance evaluation	Electronic sensing techniques RFID (Radio Frequency Identification), Bluetooth, Wi-Fi Wireless sensor networks	Temperature, Humidity, Equilibrium Moisture Content (EMC) measurement, Termite/pest detection
Gateway	Energy requirements evaluation	Web applications Mobile applications	
Cloud Infrastructure	Risk Assessment and Management	GIS Crowdsourcing	HDFS and NoSQL databases
User Interface	Data Analysis		

The components of this toolkit be improved with further research and case studies.

Conclusion

A smart heritage agenda is a heritage management/ governance tool for smart cities. Prima-facie, such an agenda could consist of a policy framework, but eventually would need to be developed into a proper tool based on ICT intelligent environment to support policy making related to the various risks that heritage faces. An intelligent environment, based on an open data approach, would be an ideal support for policy makers. For the recognition of proposed concept, multiple options need to be explored amongst variety of available sensors, cleaning and processing methods for collected data, techniques for setting alerts, storing of the generated data and approaches of accessing the processed data, in order to select the appropriate contender for each of the application fields. IoT architecture can be optimized with focus on cost efficiency and energy efficient solutions.

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