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The Role of Internet of Things to Support Cultural Heritage Inventory in Urban Resiliency Approach: Tradisional House in Bandar Lampung Case

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Abstract—This paper views Internet of Things (IoT) as a tool to support architectural and urban heritage protection and preservation. It bases its understanding on the premise that urban resiliency act as an agent of cultural heritage inventory which are completed by building category, facade, typology, structure, social cultural and human behavior. This research proposes the first step of an innovative methodological approach to develop an information system, and to stimulate identification of “flag” all traditional houses in database’s management. Moreover, we deliver opportunity and challenge to implement IoT in cultural heritage inventory. Collectively view these possibility to adapt, protect, and preserve local community knowledge, traditional technique and traditional houses that as part cultural identity in the future. As a case study, we present three layer inventory which integrates IoT for sustainable cultural heritage, especially traditional houses in Bandar Lampung, Indonesia.

Keywords—Internet of Things, Architecture, Urban Resiliency, Traditional Houses, Bandar Lampung.

I. INTRODUCTION

In context of urban resilient, building existence, inventory and management activities perform a fundamental role. Inventory should be considered an important factor for identify characteristic, productivity and condition of traditional houses, however this aspect can still be studied in deep and improved. Traditional houses as a part of cultural heritage is an intangible asset and as a main role of cultural diversity to develop community resilient. As a result, traditional houses would provide high impact to identify resilience strategy in research field. Therefore, it is necessary to realize various solution which are attractive and sustainable with used user experience and local knowledge in cultural site.

Sadly, in the recent years and decade, traditional houses and cultural diversity has been forgotten by local community. More of new building was made by concrete or inferior technology, without meet the requirement of the surroundings. Today, human not much cared about building construction or settlement structure are laid out, unlike the last 100 years, traditional houses and building structure has built to adapt natural hazards, raid of rivalling tribes or assault of hostile power.

Due to the uniqueness and originality of traditional houses deserved to be preserved and preservation. By identifying various benefit trough analysing traditional houses potential will present not only cultural heritage preservation and disaster management, but also to crate innovation for building technologies and to implement of building partnership [21]. All Form of traditional houses has

constructed by local need, community values, social-economy, and local cultural. Caused that traditional houses was built and utilized by climate adaptation, material and living cultures [18][19]. Accordingly, to understand risk interpretation and problem solving of cultural heritage preservation, it is essential to own any strategy for disaster and risk management from human and natural include hazard such as war that could have contribution in resilience.

In the field cultural heritage preservation, traditional houses draw from a theory based in living system, developing strategies both for adopting to those impact and mitigating those threats by sustaining building and natural environment. Their main characteristic is that they consist of heterogeneous object, which usually are describe by variety of metadata scheme. These inventories need to contain information on various building attributes such as geographic location (longitude and latitude), height or number of stories, footprint area, total square footage, structural class (construction type), usage or occupancy of buildings, age or year of construction, plan and elevation irregularities (re-entrant corners, setbacks and etc.), cladding type, roof shape, roof type and etc. Several of these attributes can directly be extracted from remotely sensed data -such as the data collected by aerial photography or satellite imagery. Height, footprint and other geometric features of buildings are among this group of attributes. There is however another set of attributes -that cannot directly be derived from remotely sensed data- which can be inferred using engineering or statistical rules that is named building typology. Structural type, occupancy type and age of structures are among the attributes of this group [20][23].

In this perspective, technology has an important role in creating a system to monitor traditional houses by using data to prevent incident. The Internet of Things (IoT) paradigm, many of the object that surround us will be on the network in one form or another can support cultural heritage – traditional houses protection and preservation in now days. It is smart technology architecture that have integrate between a sensor network from smart device, WIFI and Bluetooth to identify location, characteristic and condition of traditional houses. Radio Frequency Identification (RFID) and sensor will rise to meet this new challenges, in which information and communication system are invisibly embedded in the environment around us [12].

IoT technology offers, for sustainable price and with significant, flexibility, a wide range of different possibilities, fitting different circumstance, from inventory, monitoring the building to sensing structural change in a historical building and protecting vulnerable artifacts. IoT bring formerly inert object into dynamic world of information technology that

can be monitor environmental condition toward real-time data driven management across. If implemented properly, the role of IoT in heritage inventory can enhance sustainability of traditional houses through real-time data collection and monitoring. Thereby, the mediation to connect between people, objects and space could be made by IoT, thus creating new social, economic and cultural opportunities.

II. MOTIVATING AND STATE OF THE ART

In order to understand motivation behind the role of the proposed IoT architecture supporting the development of cultural heritage inventory, it is most important to understand the vulnerability of traditional houses to reliable assessed future impact and monitoring cultural heritage in urban changing. Policy maker, public and private institution, and citizens has highly important responsibility to preserve and protect traditional houses. Cultural heritage preservation are related to historical event and depict the customs of human society. Knowledge of cultural heritage preservation can provide guidance on the building design and construction policy that aim to increase the capacity of social-ecological system to respond and to adapt environmental and socio-economic stressors [8][10]. Cultural heritage is considered as a complex asset that develop and prosper community life, as well as cultural identity and is a good resources for economic and political interests [3][5]. So, to imagine original condition of traditional houses, we need a smart device that can detect and monitor the existence of traditional houses. Phase detection is done through sensor installation in inside and near traditional houses, and then, transferred to data system by IoT (internet). Once such traditional house has been detected, the object begin to talk about itself, its story and its status by means of multimedia content and facilities.

The research is intended to increase public awareness for sustainability and usability cultural heritage, to encourage the cooperation among multiple parties, such as: the citizens (heritage movements)/ governmental agencies/ universities and other institutional organizations through a traditional houses inventory. In this paper, researcher present the role of IoT technology that be supporting and established a network between parties to construct inventory format that has agreed by the whole of parties.

III. URBAN RESILIENCY

A. *The Role of Traditional Architecture in Urban Resiliency*

In context of finding suitable approach for understanding of The Role of Traditional Architecture in Urban Resiliency, it is important to learn local knowledge and local cultural in particular understanding of how local communities interact with their environment. This research will critically observe, identify and analyse the conception of spatial transformation, which is driven by culture of dwelling, socio economy condition, and community development. In morphological study, interpretive historical research is an important qualitative method to analyze and collecting all of architectural forms evidence and meanings of the indigenous culture of dwelling and its domestic setting of settlements [17]. This can be done by searching for, collecting, evaluating and establishing a narrative construction of any evidence that a holistic and reliable. The entire process is a key to interpreted and developed correlations and causal

explanations among those historical evidences. As an architectural analysis approach, the study of structural change and variation, a typical component of the architectural approach, should be included much more frequently in in-depth study of traditional houses.

B. *Urban Resilience as a Concept for Co-Creating Architectural Houses in Future*

Local communities condition that are affected by global change, climate, social and cultural change, natural and industrial disasters and economic shocks, could be addressed through resilience as part of strategic in human settlement (urban and rural) [2]. The sign in the sea, the skies and wildlife to predict hazard used as guide by local communities. Local knowledge is obtained by direct experience during the disaster on location, time frequency, intensity, predictability and possible behaviour of the hazard link to these events. Traditional houses as part of cultural heritage is a research field that has intangible and tangible value, and important capacity to evolve and adapt itself to the changing external condition in global changes cycles [11].

A constant process of transformation has two fundamental principles of resilient architecture such as “flexibility” and “adaptability” was acquired by dynamic architecture of resilient settlements which considering all the surrounding conditions. In order to reduce the negative impacts of the abovementioned changes and increase the safety of the cities, local communities need resilience concept implementation [27][33]. In this case, Traditional Houses existences can be approved as “resilient that is influenced by dynamic factors such as “macro climate”, “environmental materials” and “living cultures”. Therefore, local technologies and construction practice often reflect adaptation to the environmental conditions.

Traditional Houses is at the center of a web of customs, social relations, traditional laws, taboos, myths and religions that bind the villagers together. Man activities of residents has been focused by family and it community in traditional houses. Traditional houses was designed and constructed by local community under the direction of master builder, and/or a carpenter that have local resources and knowledge [1][24].

Beside, traditional houses is well adapted to climate and natural hazard i.e. floods, hurricanes, and earthquake where Indonesian’s region topography have lying at the Eurasian junction, Indo-Australian and Philippine Sea tectonic plates poses an actively deforming area with high seismicity. The fast motion of plate are accommodated 49 mm/year of oblique convergence at Sumatera seduction zone. The large damaging earthquake was caused by lateral displacement e.g Mw 7.6 in 1943 where Sumatera has high vulnerability and Malaysian peninsula has low moderate hazard showed by probabilistic hazard analysis [15][33].

The outstanding example of environmental condition adaptation is traditional houses in Nias and Lombok Island. A Tsunami have been caused by a major earthquake in Indian Ocean Region on December 26th 2004 through lay off shore the Sumatera Island as an epicentre of the quake that is closed to Nias Island. Then, another series of earthquake was hit Nias on three months later and causing thousands people death. Therefore, the earthquake was not only caused human tragedy, but also natural disaster and traditional houses

showed as outstanding resilience meanwhile 80 percent of modern style houses collapsed, few old buildings were damaged, causing less harm to the inhabitants. Traditional houses also provide excellent shelter from hot and humid tropical climate which was constructed to withstand the common unstable ground conditions and earthquakes in local area [10].

In the other hand, traditional houses also help understanding building construction technology in modern day practice. The combination between modern engineering technique and traditional architectural methods i.e. local craftsmen knowledge and traditional material characteristic to stabilize building maintenance and battle the effect of climate change [30]. So, both of traditional knowledge and modern technologies offer valuable technique for reducing disaster risk that can creates innovation technology, and enhance local ownership and local acceptance for initiative of new risk reduction. Consequently, resilience's strategy was identified by traditional houses characteristic and cultural diversity to build communities resilient. Both of physical and social factors are shape resilience component in both of people and natural environment [29][30][32]. With this research, we aim to develop greater resistance for effect of natural hazard with use resilience's strength and local diversity as a new urban strategies in the future.

IV. HERITAGE INVENTORY

A. Building Typology as a Scheme of Traditional Architecture Inventory

The existence of identity and the meaning of place can be obtained through clarity. One of the most important aspect in the appearance of this meaning is the visual clarity of urban elements. To achieve the visual clarity, needed a way or method to find out the visual potential of heritage building in given area that can be referred as typology approach. In architecture, understanding the context of typology have been refers to the original myth of the first building. On this concept, a building essentially can be classified based on object with the similarities of characteristic of nature and structure [15]. It can be conclude that building typology does not refer to the age but to the place which borders and opposites melt together into an intellectual universe [1].

Traditional House of Lampung have motif on home elements that are call as ornament. Ornament is an important element in architecture and has significance psychological emotional (perception) in human life, dimensional and as a hallmark of cultural identity [25][26]. As part of architecture, the existence of ornament have been disclosure from creativity, idea and mirror of function. Ornament can meet the physic and religious needed, as well as quality and quantity of building aesthetics and social level. Space of Traditional houses is open and easily accessible by guest and was influenced by family tradition or a value between family member and relatives.



Fig. 1. Traditional House's Space

In general, traditional houses of Lampung have successfully put the inhabitants humanely, both as individually or social environmental where reflect the spirit of openness, strength, comfort, beauty and a hierarchy of space. Building typology scheme was identified by physical and spatial criteria that are related to building construction and urban design into urban structure type. Urban structure type and building type of traditional houses was generated by specific typology. Based on this typology, the total scenarios for traditional houses in Bandar Lampung were drafted by spatial and physical element of urban sub system and characteristics of each type environmental visualization.

In early step, inventory scenarios for the project were performed identification of traditional houses characteristic in Rajabasa, Bandar Lampung with use building characteristic parameter. The results shows that was found 13 buildings which was the traditional house of Lampung category. Rajabasa is sub urban areas with high development intensity where its people tend to not care about the existence of traditional houses. The municipal planning, engineering, transportation, construction and building infrastructure have been identified and lagged by heritage resources i.e. Properties, and site. So, building permit, rezoning application, demolition permit, etc are being processed all parties involved will be aware of heritage significance of any property affected [4].

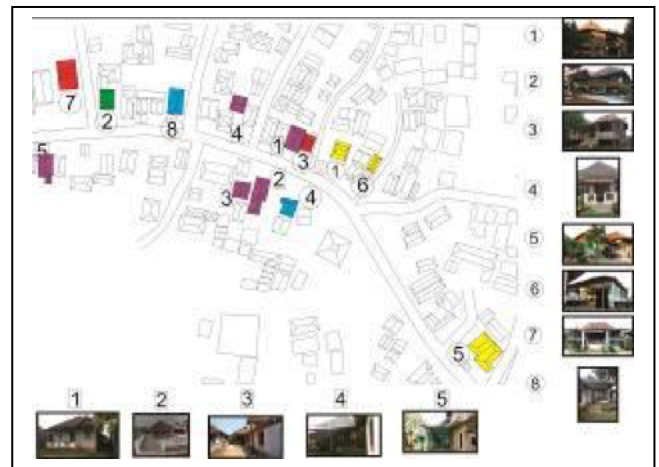


Fig. 2. Building Inventory Map

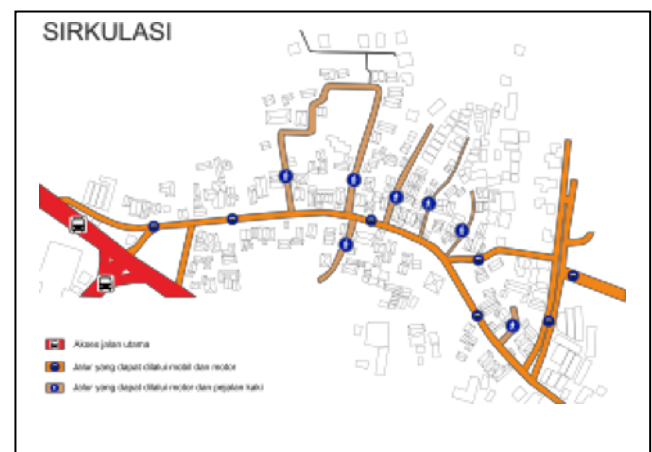










Fig. 3. Urban Circulation

In next step, the general typology analysis on traditional houses was broken down to the level of building authenticity, both building function and physical visualization. From this point of view it become clear, that building category will able to absorb percentage of building authenticity where in this research found 8 of 13 traditional houses have a function and original physical condition. As the complete explanation can be seen in the table below.

TABLE I. TRADITIONAL HOUSES IN BANDAR LAMPUNG

No	Picture	Location	Status
1		Indra Bangsawan St. 70, Rajabasa	House has function and original physical condition
2		Indra Bangsawan St. 62 nd , Rajabasa	<ul style="list-style-type: none"> • original physical condition • function change • change pattern of space
3		Indra Bangsawan St., Rajabasa Raya District	<ul style="list-style-type: none"> • original physical condition • function change • empty
4		Indra Bangsawan St., Rajabasa Raya District	<ul style="list-style-type: none"> • original building function • lower construction change
5		Indra Bangsawan St., 38 th , Rajabasa	<ul style="list-style-type: none"> • original building function • lower construction change
6		Indra Bangsawan St., 20, Rajabasa	<ul style="list-style-type: none"> • original building function • add wall material
7		Indra Bangsawan St., 64 th , Rajabasa	<ul style="list-style-type: none"> • original building function • lower construction change
8		Indra Bangsawan St., 21 st , Rajabasa	<ul style="list-style-type: none"> • all structure and function change • original Window material and ornament

B. Internet of Things Framework to Support Heritage Building Inventory

In this section, the IoT architecture has a central importance in preserving heritage building. It is a newly method to improve building management and monitoring through building system. The Internet of Things (IoT) paradigm can support cultural heritage – traditional houses protection and preservation now days. Protection and preservation of traditional houses is one of the important responsibilities for policy makers, public and private institutions and citizens themselves. Implementation of IoT as tool of inventory could improve the liveability, revitalization, and sustainability of Heritage Building. IoT technology could providing innovative, new services and expand economic opportunities in the future managements. The vision of IoT technology for traditional houses inventory is to remember the past, live in present and plan for the future [28].

The functional IoT architecture for the purpose of heritage building inventory involves three different layers, i.e.: sensing layer, networking layer, and data application layer [6] [22] [28].

1. Sensing layer: aimed to transform heritage buildings into smart objects. The layer includes all kind of building characteristics and building operations, connected to the internet with various smart devices, with the main function to perform diagnostics function on the building and transferring data across different networks and applications. The following is the diagnosis performed in three methods:

- Location of traditional houses, represented by compilation of Registry tabs, proposed by Department of Bandar Lampung civil housing and GPS sensor through Google map.
- Visual survey of the building, represented by building structure, building typology and building condition.
- Function of the building, represented by a change in the state of the building itself or the surrounding environment.

All of the collected data will be transmitted to the networking layer with specific format, which will allow the stakeholders to make a response accordingly.

2. Networking layer provides connection for the system, which aimed to transmit data and information by the implementation of appropriate communication technology.
3. Data application layer is the core layer of building heritage inventory, where the IoT applications are deployed together with middleware functionalities. This layer acts as an interface between IoT intelligent system and end user in the case of building managers (stakeholder). All of the data analysis is performed by providing different scores to quantify each component of the traditional houses. The indicators, which will be scored according to the conditions, are namely:

- Traditional houses' condition rating
- Traditional houses' function rating
- Traditional houses' management rating

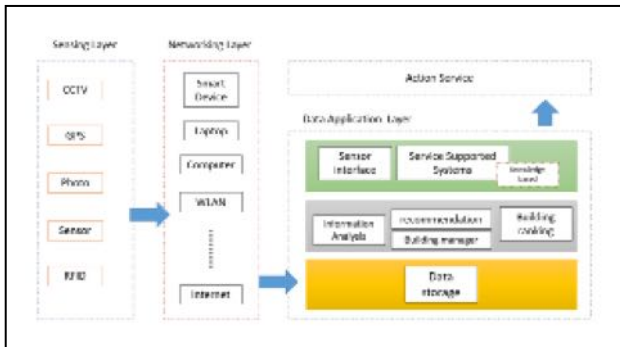


Fig. 4. Architecture of IoT for Heritage Building Inventory

With the support of IoT and Smart Technologies, all heritage building belonged to the inventory can be connected to the current Internet. It is expected that the smart devices with the purpose to continuously monitor the buildings, connected to the internet, can update information about the inventoried buildings automatically. The users of the system are able to access any device connected to internet and obtain analysis results related to the condition of the building.

V. CONCLUSION

Based on the research conducted, it can be assumed that the existence of IoT in Heritage Building inventory could help stakeholder to find out the condition and building typology of the existing condition both in traditional houses and cultural heritage. According to the architecture of the IoT for heritage building inventory, enabling technologies include sensing, data technologies, and connecting system. This has prompted various sensing data and help in mapping traditional houses location, so that it can be developed some recommendations and plans toward traditional houses revitalization through influence of technology including IoT in everyday life. Meanwhile, this paper not provide deeper analysis related implementation of IoT, because most of analysis aim to a general role and architecture of IoT in cultural heritage inventory. There are many challenges in data technologies, including storage, organization, management and analytic.

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