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Multi-Domain Master Spatial Information Management for Open SDI in Indonesian Smart Cities

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Abstract

Spatial Information Infrastructure (SDI) has great potential to support smart city by providing framework dataset and real-time information services in urban informational infrastructure, the social infrastructure and citizen's participation practices. Bandung City and Jakarta City are maintaining their SDI for various kinds of decision-making at different domain within their jurisdiction. In smart cities, it is crucial to have a data management systems which allow more stakeholders to participate in collecting, updating, maintaining, evaluating and utilizing urban information. A smart city should open their data to its citizen following Open Government Data (OGD) principles through SDI. As a member of Open Government Partnership, Indonesia is in the beginning phase of extending its SDI systems not only to serve government entities but also to citizens, academia, and private sectors. In reality, smart cities cannot rely on government entities only in producing spatial information. Heterogeneity of spatial information quality produced by citizens, academia, and private sectors create some difficulties in urban data management. However, most of the smart cities in Indonesia, namely Bandung City and Jakarta City, have not yet connected their SDI to their Smart City system due uncoordinated policies and technical limitation. Specification of Multi-domain Master Spatial Information Management (MSIM) will be the key factor for improving SDI in Indonesian Smart Cities to able to accommodate citizens, academia, and private sectors to enrich urban information. This paper proposes master data management solution for a multi-domain environment and Open SDI in a smart city.

Keywords: Spatial Information Infrastructure, Smart City, Master Data Management, Open Government Data, Spatial Information

1 Introduction

Urban information produced by public sectors are extraordinary in quantity and vital for decision-making, policy development, and public service delivery. In a smart city, these data are also valuable to citizens for making personal decisions, academia for doing researches and businesses for creating innovative services and competitive products. Batty et al. (2012) defined a smart city as a city in which ICT is merged with traditional infrastructures, coordinated and integrated using new digital technologies. Spatial information can support the development of the smart city by enhancing the digital city dimension and in particular the urban informational infrastructure and the social infrastructure and community spatial engagement practices (Roche, 2014). Urban information from urban planning monitoring and evaluation can help the smart city to extract relevant information from the past and ongoing activities that will be used as the basis for optimization, adjustments and better future planning.

To comply with national policy on spatial planning, Bandung City and Jakarta City have conducted awareness programs for their citizens, including the notion that urban planning implementation is essential for the well-being and can shape their future (Kamil, 2015). These programs were collecting more information to measure quantifiable aspects of quality of life, efficiency, equity, and economy from their citizens. Gil-Garcia et al., (2013); and; O'Grady & O'Hare (2012) associated that smart cities consider on the primacy of citizens in communication and information systems supported by technology for urban innovation processes through open procedures. The 'smart citizens' can act as active sensors (Goodchild, 2007a) and if allowed to contribute information to the spatial intelligence of a smart city. In contrary, Bandung and Jakarta primarily use the 'one size fits all' approach in developing their smart cities initiatives which are dominated by the use of technology. This approach hinders the integration and utilization of quality spatial information from many sources, such as SDIs and crowdsourced information (include participatory mapping and VGI). Roche (2014) noted these approaches mainly dominated by the functionalities of the Internet of Things (IoT), potentially reducing the urban model to a coherent and indivisible whole, with little prospect to facilitate multi-scalar projects. Such an approach considers citizens only as passive sensors, to stage their personal spaces or land and to share their spatiality as smart citizens and potentially marginalized people who do not have access to ICT infrastructure.

Roche and Rajabifard (2012) proposed spatial referencing to make SDI the heart of the technology platforms of smart cities. The principal objective of SDI is to facilitate access to the geographic information assets that are held by a wide range of stakeholders with a view to maximizing their overall usage (Masser, 2011). In order to allow the smart city to be able to manage data from any source, SDI should be improved by implementing Open Government Data (OGD) principles and developing a 'two-way' capability which enabling all stakeholder to update spatial information with adequate data quality management and metadata management. In contrary, SDI in Bandung and Jakarta is still in its initial phase and have not yet connected their Smart City infrastructure. Moreover, SDI solely for government entities by not accepting citizens, academia, and private sectors as equal stakeholders as national policy suggested.

It is mandated by the Indonesian Geospatial Information (GI) Law that all shall follow the "One Map Policy", including government entities, academia, citizen and private sectors. The idea of One (version) Map for Indonesia was initiated in December 2010, in a cabinet meeting that followed with the President instructing Ministries and Agencies to use official basic geospatial information (topographic map) as a national geospatial data reference. In April 2011, the Parliament enacted Indonesian GI Law to give guidance for improvements and to cultivate the momentum for coordination of geospatial activities. To have a geospatial data reference means that all sectoral (thematic) maps will be reviewed and produced according to one unified base map. Somehow similar to the Authentic Registry in the Netherlands, The Indonesian Geospatial Law mandating the National Geospatial Information Authority (www.big.go.id) to produce a unified base map in scale 1:1,000 to 1:1000,0000. Indonesian base map containing coastline, hypsography, water bodies, toponym, administrative boundary, transportation and utility, building and public facilities, and land cover. Implementation of the Indonesian Geospatial Law creates complexities to other ministries, national agencies, and local government to fulfill their responsibilities in producing and utilizing various thematic maps. Many of these activities also derived from other laws and/or regulations, for example: Ministry of Agrarian and Spatial Planning (www.bpn.go.id) for generating land use map; Meteorological, Climatological, and Geophysical Agency (http://www.bmkg.go.id) for weather maps; and local government may produce other maps to fulfil their needs, such as Land Value map and Urban Planning map.

In a Smart City environment, it is inevitable that SDI stakeholders are increasingly becoming more connected in many ways. As the degree of separation narrowed and the cost of advanced geospatial technology getting accessible, the amount of spatial information will be exploded in various qualities and formats. To be able to accommodate smart city needs, a smart city is urged to improve existing spatial information management. Master Data Management (MDM) approach for spatial information should be able to minimize confusion, including data redundancy and gaps in urban information datasets. This approach provides both data governance and technical guidance for the urban planning and management. An MDM implements the policies, procedures, services, and infrastructure to support the capture, integration, and shared use of accurate, timely, consistent, and complete master data (Loshin, 2010). As a way to produce single working data reference from many stakeholders, MDM covers management of quality, integration, use, integration, and synchronization to optimize the utilization of information to meet the city's operational and strategic business objectives. For this paper, we propose MDM terminology in SDIs as Master Spatial Information Management (MSIM).

The focus of this study specification design for MISM for Open SDI which suitable to be implemented in Indonesian Smart Cities. This literature study describes the proposed design of MSIM built on Open SDI framework in cities regenerating themselves as a smart city by developing new urban intelligence functions to allow citizen participation, such as participatory urban planning monitoring. Furthermore, this paper will outline three proposed elements which we believe will support the study:

- Open Government Data in Smart City
- Open SDI for Indonesian Smart City
- MSIM in an Open SDI in a Smart City

2 Open Government Data in Smart Cities

Since the past decades, there is increasing trend of opening up government's data to enable citizens to learn about the activities of their government, to hold their government accountable for its actions and spending and to participate in the political process (Janssen, 2011). Ubaldi (2013) defines Open Government Data (OGD), which should be applied in smart cities, as any data and information produced or commissioned by public bodies that can be freely used, re-used and redistributed by anyone - subject only, at most, the requirement to attribute and share-alike.

Indonesia was co-founder and active member of the Open Government Partnership (OGP). OGP provides a platform to develop reforms that promote transparency, empower citizens, fight corruption and harness new technologies to strengthen governance (Timmins et al. 2016). Gonzalez-Zapata & Heeks (2015) studied key elements of open government data derived from its foundation, which are Government-data, Open-data, and Open-government (see Figure 1). OGD implementation in a smart city, local government not only urged to adopt its principles to allow citizens to have access to reference spatial information about government operations and decision-making, but also enabling them to updates master data whenever meet standards, maintaining privacy, confidentiality, security and compliance with all relevant laws. Bandung City opens its 409 datasets which contains demography and employments; economy and finance; educations; health; environment; social; tourism and culture; transportation and disaster management. Office of Communication performs data management independently (Kamil, 2016). They manage their databases independently which requires all offices to update their data according to each domain and disconnected to national and provincial data infrastructure. At High-level Symposium on Sustainable Cities 2015, Kamil (2015), major of Bandung, presented three categories for data utilization in Bandung Smart City which are Control, Observe, and Connect. "Control" mainly for smart government purposes, such as e-controlling, Tax tracking, e-contract, energy management, e-planning, e-budgeting, e-permit, e-reporting, and e-admission. In "Observe", Smart City infrastructure were developed to capture real-time data (e.g. news, weather, traffic, GPS tracking, internet data, publc safety, and social media. While "Connect" functioned as open data, service and open communication. Bandung Smart City can be good example on how City government in developing countries take effort to manage urban information to monitor, controlling, and evaluating urban planning implementation and project management. This challenge prompts local government to institute a framework for ensuring the quality and integrity of the spatial information asset for all of its purposes.

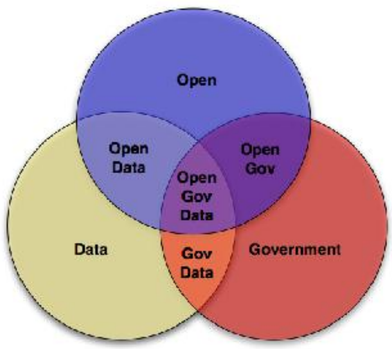

Fig. 1. Foundations of open government data
Source: Gonzalez-Zapata & Heeks, (2015)

Urban information assets should be managed in consolidated datasets which sourced from different applications into a master data environment. By this notion, city government needs to have effective programs to govern spatial data and performing spatial data management functions which require regulation, indicators, guidance and units that play specific roles and tasks. These roles and tasks may also be considered data governance. Nedovic-Budic & Pinto (1999) mentioned that organizational settings and inter-organizational relations influence open government spatial data implementation and to determine the benefits of the joint database development and sharing, such as efficiency, more use, and better quality. Further, to accommodate transformation of citizens from passive recipient to the producers; advancement of ICT providing social networks among citizens is needed; making a good case to reconceptualize the role of data producer (Budhathoki & Nedovic-Budic, 2008); and to update current data governance to have sustainable SDI and improving its use. Based on Ladley (2012), we define open spatial data governance as the exercise of authority, control, and shared decision-making (planning, monitoring, evaluation, and enforcement) over the management of spatial data assets. The purpose of open data governance is to ensure that the spatial data meets the expectations of all the business goals. This definition works in the context of data stewardship, ownership, compliance, privacy, security, data risks, data sensitivity, metadata management, and master spatial data management which include government, private sectors, data providers, and citizens/communities.

Indonesian Geospatial Information Authority has developed MSIM based on ISO standards in their activity for its organization transformation and to fulfil Presidential Regulation No. 27 of 2014 on National Geospatial Information Network (JIGN). The implementation MSIM has been conducted collaboratively, orderly, measurable, integrated, sustainable, efficient and accommodating public contribution to improve spatial data quality (Indonesian Geospatial Information Authority, 2017).

Based on study literature and experience in National Mapping Agency, this paper argues that the three key factors of the open spatial data governance mentioned by Ladley to be applied to a typical smart city are: (1) Business model. A smart city should not only comply with open government data principles, higher (national) regulation and reference information but also able to accommodate spatial information from the citizens and private sectors; (2) Content being governed. There are many types of spatial information managed in a city database, but there are much more data needed in a smart city to work properly. The enormous quantity of data is captured and managed in a smart city on the hourly basis. If a smart city is decided to accept non-standardized (and non-structured) data, such as crowd-sourced data, then the city spatial database system should be prepared for variation of data definition and data quality. MSIM will be essential to manage urban information with high in heterogeneity. The third key factor is (3) Degree of federation. The federation of a data governance program is a definition of where and how standards will be applied across various layers and segments of an organization.

The SDI concept has shifted emphasis (Williamson et al., 2006; Van Loenen et al., 2009) and has an evolving concept about facilitating and coordinating the exchange and sharing of spatial data and services between stakeholders from different levels in the spatial data community (Hjelmager et al., 2008). Adapting to technological advances and bottom-up approach, an SDI should be able to manage spatial information from crowdsourcing, Volunteered Geographic Information (VGI) and standards for collecting and sharing geographic information (Goodchild, 2007b).

In a smart city, an SDI should accommodate not only government entities, but also to academia, private sectors, and citizens. To achieve this, Indonesian SDI follows federated data governance model. Federated data governance is a structure that supports decisions, policies, standards, and information sharing between multiple semi-autonomous entities, such as data domains, committees, business and IT functions, and projects. A federated model will usually have a steering committee that oversees the governance process and addresses issues or needs that can’t be addressed at the domain level (Figure 2) which is almost similar to INSPIRE.

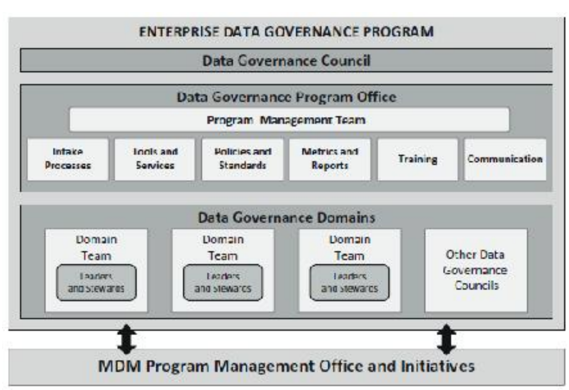

Fig 2: Federated data governance model
(Source: Allen & Cervo, 2015)

3 Open SDI for Indonesian Smart Cities

An early definition of SDI has been proposed by Hoffmann (1999). He suggests an SDI should be the spatial integration component of an information society system, which is the major interoperable element of a future information society. Since then, many countries and cities throughout the world are developing SDI in administrative-wise leveling, from local to state/provincial, national, regional, and global levels (Figure 3). The nature of the SDI is both dynamic and complex (Rajabifard et al., 2000); it covers institutional arrangement, policies, technologies, standards, and human resources for the effective collection, process, management, communication and usage of spatial information. In Figure 3, Rajabifard et al. (2000) noted that SDI characteristics would depend to its administrative leveling, in such way that its stakeholders, level of data resolution and spatial planning coverage. In practice, most of the SDIs dominated by government entities, while other parties such as academia, private sectors, and citizens are not part of SDI agenda.

While Roche (2012) noted that user-generated geographic content and geo-crowdsourcing are two major characteristics of a spatially enabled society, as well as a smart city. Smart citizens in a smart city have transformed from spatial information users to both producers and consumers of with the help of technology, particularly web-based and mobile technology, to voluntarily contribute and provide local information and share place-based knowledge on their social networks with real-time information about their spatial experiences. The concept of “citizens as sensors” (Goodchild, 2007a) is also an important issue for SDI which considered as a dynamic source of information (Craglia, 2007) as well as the monitoring system of smart cities.

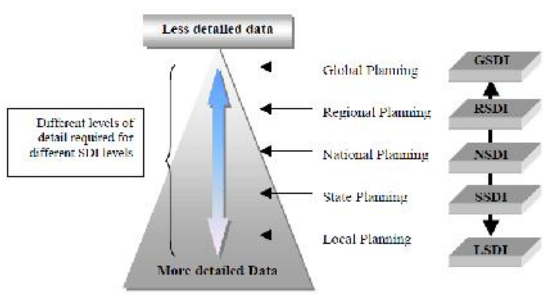

Fig. 3: Relationship between Data and different level of SDIs (Source: Rajabifard, 2000).

Based on Onsrud (2007) and Hendriks et al. (2012) works, an Open SDI as a network-based solution to provide easy, consistent, geographic information database and services to improve decision-making in the real world in which we live and interact which facilitate government, private sectors, and citizens as equal stakeholders. This paper proposed all parties have equal right to access and contributing spatial information through the user interface in Open SDI platform. While geoportal can be used as a tool to help stakeholders to search and discover spatial information access in the master spatial database (Figure 4).

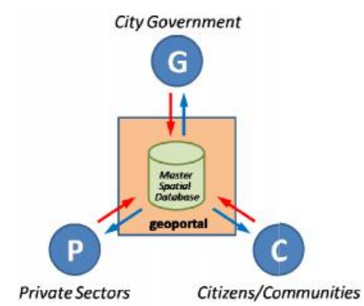

Fig. 4: Schematic between Stakeholders of Open SDIs. Blue arrow means access to spatial information and red arrow means contribute spatial information.

Due to millions of social media users and the variety of free mobile geolocation applications available, Indonesian smart cities have the potential to take advantage of citizens as a sensor. ClickZ.com (2016) stated that there are 66 million Indonesian as active mobile social numbers and 88 million (and predicted as much as 110 million in 2019) as active social media users. Furthermore, Jakarta was stated as the social media capital of the world due to its 11 million Facebook users, 254. 3 million tweets each day (Socialmemo, 2013). Jakarta City has been participated Indonesian SDI and utilized spatial information for flood disaster and implementation of President of Republic Indonesia Regulation No. 85 Year 2007 on National Spatial Data Network (Sukmayadi & Indrajit, 2012). In 2017, Jakarta City plan to integrate their SDI and its smart city infrastructure to comply to President of Republic Indonesia Regulation No. 27 Year 2014 on National Geospatial Data Network.

4 MSIM for Open SDI

Spatial information is as vital assets and being used since the very beginning of the city development and should be maintained through the time. O’Looney (2001) reported that approximately 80% of local government activities have spatial components. Urban management in many cities is getting more dependent to access of spatial information, especially in land administration and urban planning. Data management in SDI are not designed to serve specific projects or narrowed communities, and the focus is shifting to the challenges associated with integrating these systems into a society perspective and enabling good governance.

Hjelmager et al, (2007) noted that SDI has evolving concept in facilitating and coordinating the exchange and sharing of spatial data between stakeholders from different levels in the spatial data community. It has long proclaimed the benefits to be gained by the implementation of SDI (Grus, 2008). European Commission stated its directive to develop SDI which is called INSPIRE, across its members In order to support the formulation, implementation, monitoring activities and evaluation of Community policies and activities that may have a direct or indirect impact on the environment at various levels of public authority, European, national and local

(INSPIRE, 2007). SDI was also developed to support national social, economic and environment development and also functioned as a backbone for e-governments (Kok & Crompvoets, 2010). Furthermore Van Loenen (2006) noted that the level of development of a country's SDI can be seen as an indicator for the economic performance.

Rajabifard et al., (2006) noted that local government SDI should maintain core and authoritative spatial information which are national & local control networks, topographic features, cadastral map, natural hazards, the position of national & local projects. These core datasets are often called fundamental datasets. Nevertheless, many other spatial data should be provided to fulfill smart city needs such as aerial photos, ortho imageries from satellite, urban planning, GPS Correction Services, utility networks, transportation, and public facilities. In his book, Loshin (2010) noted this important spatial information as master data objects that reflect core business objects used in the different applications across the organization, along with their associated metadata, attributes, definitions, roles, connections, and taxonomies.

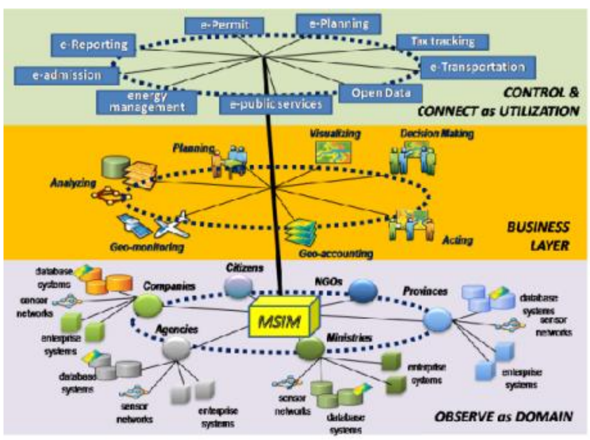

Fig. 5: Proposed MSIM at the centre of Open SDI in Indonesian Smart Cities

MSIM as a collection of best spatial data management practices that orchestrate key stakeholders, participants, and business clients in incorporating the business applications, information management methods, and data management tools (see Figure 5). The master spatial data management environment presents an enterprise resource integrated with the business application architecture through a collection of provided services. Loshin (2010) stated that an MDM solution consists of Architecture; Governance; Management; identification; Integration; and Business Process Management.

A city should have a flexible and fluid dynamic between its activity produced data domain and ICT to address huge spatial information that emerges over the years as city grow and are subject to increasing requirements regarding activities, government regulations, public services and legal compliance

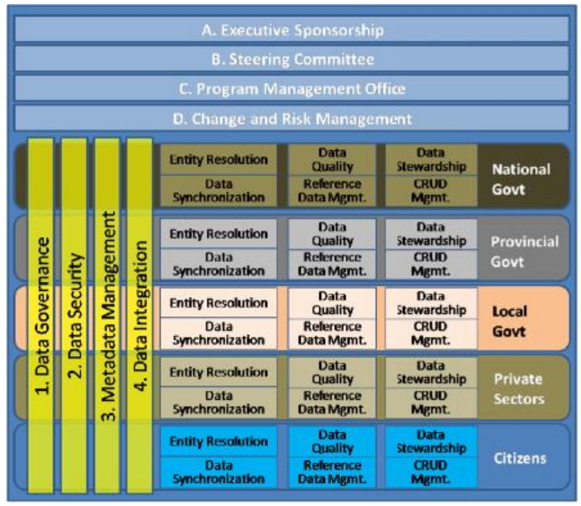

Fig. 6: Multi-domain MSIM — A cross-domain model Based on Allen, M. & Cervo, D. (2015) work on Multi-domain MDM

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When SDI accessed for Flood disaster in 2014, there were redundancies and gaps in road network layers at large scale accessed from two different sources, Ministry of Public Works and Indonesian Geospatial Information Authority. Learned from this, a new President Regulation on National Geospatial Information Network enacted in 2014 to prevent redundancy and gaps in all layers; increasing collaboration; and to accommodate private sectors and citizens as new source of information. This regulation also founded a committee and Program Management Office (PMO) at national level to develop guideline and prototype for change and risk management (see Figure 6). Steering committee constructed national action plan and strategy to be organized by PMO for data governance, data security (and licensing), metadata management, and data integration.

A data domain reflects the organization of key city entity areas such as infrastructure, health, economy, taxes, services, and security. Therefore, we analyze the potential of cross multi-domain MSIM approach to be implemented in Open SDI in a smart city to create collaborative data management roles and responsibilities over urban management and ICT functions. In a smart city application, a cross-domain model of MSIM require management organization functions, which consist of Executive Sponsorship, Steering Committee (SC), Program Management Office (PMO), and Change and Risk Management (CRM). Each node (national government, local government, private sectors, and citizens) of SDI has entity resolution; data quality; data stewardship; data synchronization; reference data management; and Create-Read-Update-Delete (CRUD) management. Throughout each node, there will be generic process by various types of stakeholders, which are: Data Governance, Data Security, Metadata Management, and Data Integration. Implementation of MSIM could minimize confusion during utilization of spatial information services from SDI.

5 Discussion

Based on Indonesian Geospatial Information Authority (2017) experience in implementing MSIM, there is a need for a comprehensive study of the development of MSIM in an Open SDI in a smart city. This kind of study should explain how to implement open government data principles in a smart cities and define enabling factors to accommodate "two-ways" data sharing from citizen and private sectors participation. This research should cover (1) Policy aspects, such as regulation and data governance for Open SDI; (2) Technical aspects which consider on the working specification of Open SDI and master spatial data management to allow four dimensions, (three spatial dimensions and time dimension). Whenever MSIM is applied across more domains in a smart city, these functions and their associated tools and processes should become more reusable or adaptable. Similar to SDI development, an MSIM program will require executive sponsorship and collaboration between urban management unit and ICT unit.

A guidance on how to integrate Open SDI and smart city infrastructure will contribute to geomatics science and will simplify data governance. At the same time allowing citizens contribution in enriching information for urban management activities such as urban planning monitoring, reporting, and verification. Addressing these issues with a proposal for a new approach have both academic and public advantage and will have considerable impact for next generation smart city and next generation SDI.

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