Smart City Dashboard for Integrating Various Data of Sensor Networks

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***Abstract*— Urban growth may lead to various problems. The increasing number of citizens at urban areas may lead the increasing of demand such as new residential, public health, public transport. A city require basic infrastructure such as educational facilities, housing, clean water, sanitation, solid waste, electricity, telecommunications and so on. In the socio-economic level the increasing of city residents must be supplied with availability of jobs. A city must be managed and planned well to handle problems such as traffic congestion, air quality, water quality, water supply, energy supplies, and public health quality and so on. At this paper, we proposed tool using information technology and communication (ICT) to help local government to monitoring what currently happened in the city. We proposed application for monitoring city in single dashboard to help summarize the current condition of city. The architecture system use network sensor consisting of sensor nodes that has function to capture city condition like temperature, air pollution, water pollution, traffic situation. Also we can add another information socio-economic situation like public health service, economic indicator, energy supplies, etc. We have successfully developed the prototype of the smart city dashboard the give more accurate information of Bandung City, one of big cities in Indonesia.**

Keywords—network sensor, monitoring, smart city, internet

I. INTRODUCTION

The increasing numbers of population in urban or city areas create high demand and cause new problems [1]. The problem like difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestions, and inadequate, deteriorating and aging infrastructures are among the more basic technical, physical, and material problems [1].Urban areas always needs basic infrastructure such as educational facilities, housing, clean water, sanitation, solid waste, electricity and telecommunications and so on.

Some of the problems occurred mostly in the cities such as:

- The complexity of urban transport and congestion problems
- Health care issues
- Waste management, especially in big cities
- Environment issues such as air quality, water supply and quality, etc.
- Disaster may occur in urban area such as floods, landslides, etc. Some disasters such as floods can be caused by poor city planning.

Problems caused from cities always related with multiple and diverse stakeholders [1]. So, Information technology and communication (ICT can be empowered to help to manage the city. ICT can be empowered to monitor and record what happens at some specific city area to be reported and acted upon. With ICT assistance, some problems can be recorded quickly and find the solutions as soon as possible. Thus, the city situation will be more easily to monitor, manage and create some decisions. The stakeholder of this system is not only for the local government but also urban community can also monitor and participate at what happening in a city. Some studies associated it with *smart city*.

In some perspective, smart city relies on a collection of smart computing technologies applied to ICT infrastructure [2]. Smart computing can reflect technology of integrated hardware, software, and network with real-time awareness of the real world. From the results, it can be evaluated by advanced analytics to help stakeholder decide more intelligent decisions and do some actions that will optimize business function. [2].

Smart City could be defined as city that can predict and accommodate the citizens need. Implementation of ICT technology to make the city smarter could be done in areas such as transport, health and other public services. Smart City concept can be supported at the highest levels of city government and has contributed to the daily needs of citizens [3]. For a smart city, all activities related to public services can be managed by developing a platform (dashboard) for monitoring all relevant data. Visualization of data can result a variety of indicators, where stakeholders can make decision in the city planning or city managing [3],[4].

Monitoring the city conditions can be done with sensor networks. Sensors can be placed at certain places to capture important data. Wireless Sensor Networking (WSN) solutions for Smart Cities are being driven by standards such as IEEE 802.15.4 and ZigBe and other standards.

From previous work, we have developed part of smart city concept consist of to monitor environmental and disaster early

warning system [5]. In this paper, we extend the research for all basic need monitoring visualized on single dashboard.

II. RELATED RESEARCH

System with the Information and communication technology (ICT) can help provide accurate and precise information about city situation. The problems such as: transportation, congestion, health, education, environment (waste, water, air quality) and disaster could be identified earlier. The concept of smart city usually integrated with use of information and communication technology (ICT) infrastructure especially for monitoring, management and decision making tool [4].

The implementation of smart city may various depend on the need on each city. Some big cities in the world has started to implement Smart City Project such as Amsterdam[6], Lyon[7], Santader[8], Endesas[9], Aarhus[10] and many others. Amsterdam is one of big city that has successfully implemented smart city like in Fig. 1.

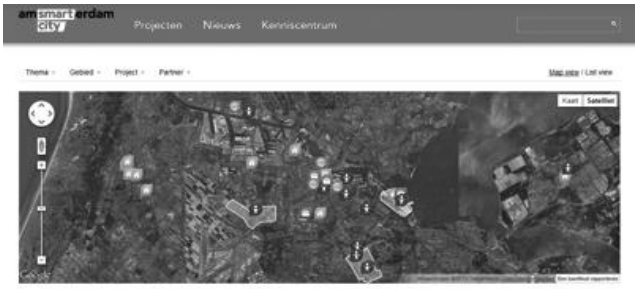

Fig. 1 Amsterdam Smart City [6]

Some of important information of city could be summarized into dashboard like in Fig. 2 [11]. Information about weather, forecasting, air pollution, river level, economic indicator such as stock, station, traffic condition are displayed in single dashboard [11]. This useful information could be used for stakeholders to get information more accurately, faster and then make some decisions.

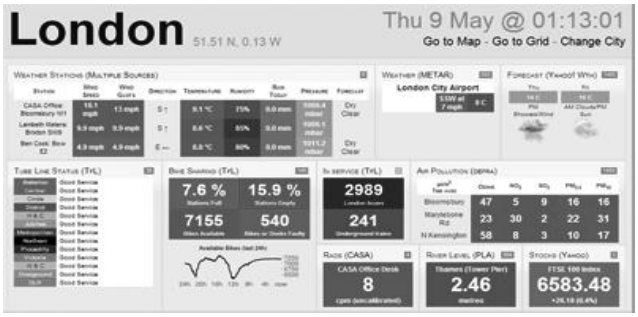

Fig. 2 Sample of City Dashboard [11]

III. SYSTEM DESIGN

At this section, we describe about the system design. We begin with an overview of system architecture. We also describe about the integration network sensor into TCP/IP network with certain communication protocol.

A. Architecture

The architecture for monitoring city could be seen at Fig. 3. The system consists of network sensors, server and internet network. Network sensors are collection of sensors placed in certain place for specific purpose. The sensors have main function for data collecting. The data from sensor are sent to server via Remote Terminal Unit (RTU). Server can be equipped with a database or GIS (Geographical Information System) features. The connection between network sensor and server use internet or TCP/IP network. In the server side, it can use cloud computing infrastructure.

The data transmission can be done using gateway or using Telecommunication network such as GPRS. Some researches also successfully developed radio transmitting to send data using GPRS radio [12]-[18].

B. Integrating Network Sensor into internet

To interconnect between network sensor with the server and the users, it can be used internet. Internet can be used as basic network underlying because mostly network hardware support with IP-Based.

C. Communication Protocol

As previous work, we have proposed communication protocol to integrating network sensor into internet [19][7], [20]. Based on our basic design, the sensors must report periodically to the server via network. The commonly network used are internet or TCP/IP network based. From previous work, we have already defined the basis of Finite Time Response (FTR) Protocol as follow [20]:

$$P_{i+1} = \begin{cases} 1 & if\ (\Delta r_i < MaxTR) \\ 0 & if\ (\Delta r_i \geq MaxTR) \end{cases}$$

P_{i+1} = Next mode at next duty cycle period (i+1)
It has only 2 values consist of 0 or 1.

- 0 indicates that at the next duty cycle period node must be entering on sleep mode *(force sleep*). It means that node isn't allowed to send data at some period.
- 1 indicates that at the next duty cycle period node allowed to transmit data to server.

Δr_i = Response time at duty cycle period-i (second)

$MaxTR$ = Parameter of maximum response time allowed (second)

Note that we defined *force sleep* as a period when a node entering phase of postpone to send data for several time. At this paper, we defined the duration of force sleep not only single duty cycle period only, but we can define as follow:

$$T^{FS} = K.\Delta T$$

T^{FS} = Duration for force sleep period (second)

K = Constant multiplier to indicate duration of force sleep

ΔT = Duration for single duty cycle time (second)

The duration of sleep (*force sleep)* is K times of duty cycle. Note that we use parameter K as control parameter to achieve level of performance. We can describe that parameter K can control the average performance like average response time.

The basic function of this method is to maintain performance always on the certain value. We need to balance between the performance like average response time (end-to-end delay), energy efficiency and also periodic updating to server.

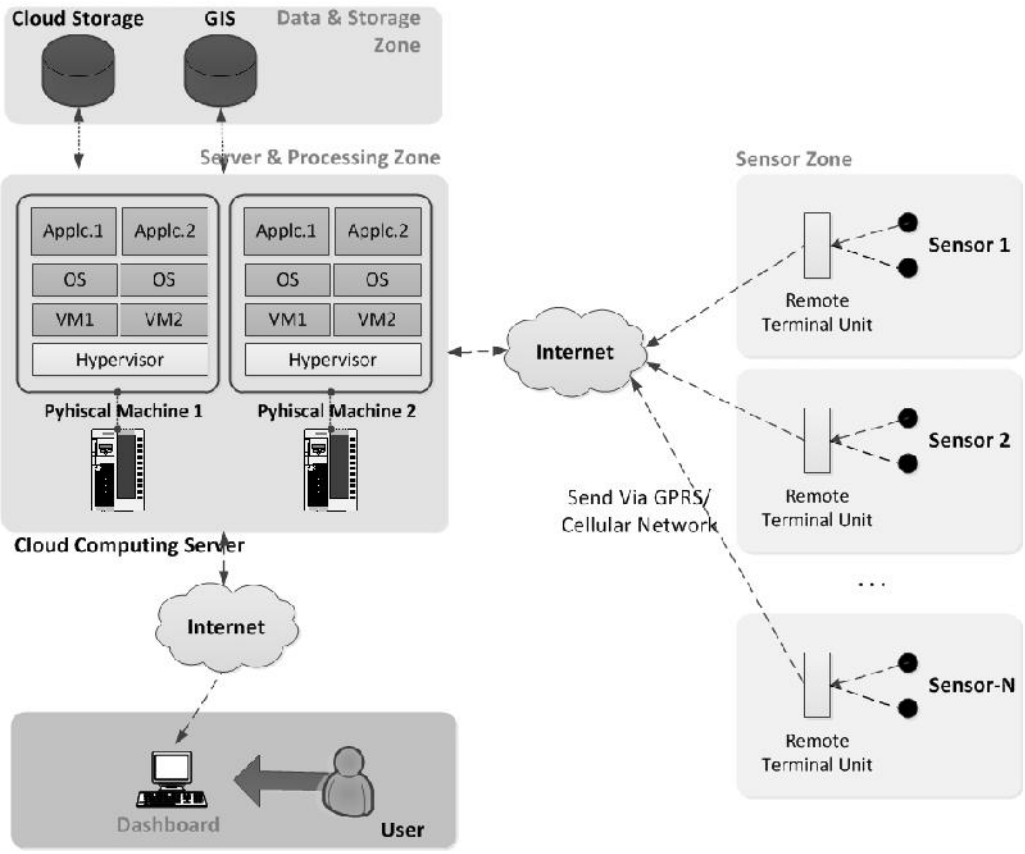

Fig. 3 Architecture of Network Sensor to monitor city situation and condition

D. User Application

The system provides application for the users. The summaries of city could be displayed on single dashboard. Data from various sensors are collected and recorded in databases. Then, the last value can be displayed in dashboard. Users can find information about current condition of the city from this dashboard application. The results from sensor reading also can be displayed on dashboard application.

IV. RESULT AND DISCUSSION

The application of sensor network applications for city monitoring has implemented into city dashboard application like in Fig. 4. The project was implemented on Bandung, one of big city in Indonesia. As a big city, Bandung has grown very fast. Bandung has many problems and many situations that need to be monitor or controlling. The number of citizen, the number of vehicle, the number of housing and industry must be controlled and monitored. Users of application can monitor the condition of the city such as temperature, humidity, traffic situation, current public service status.

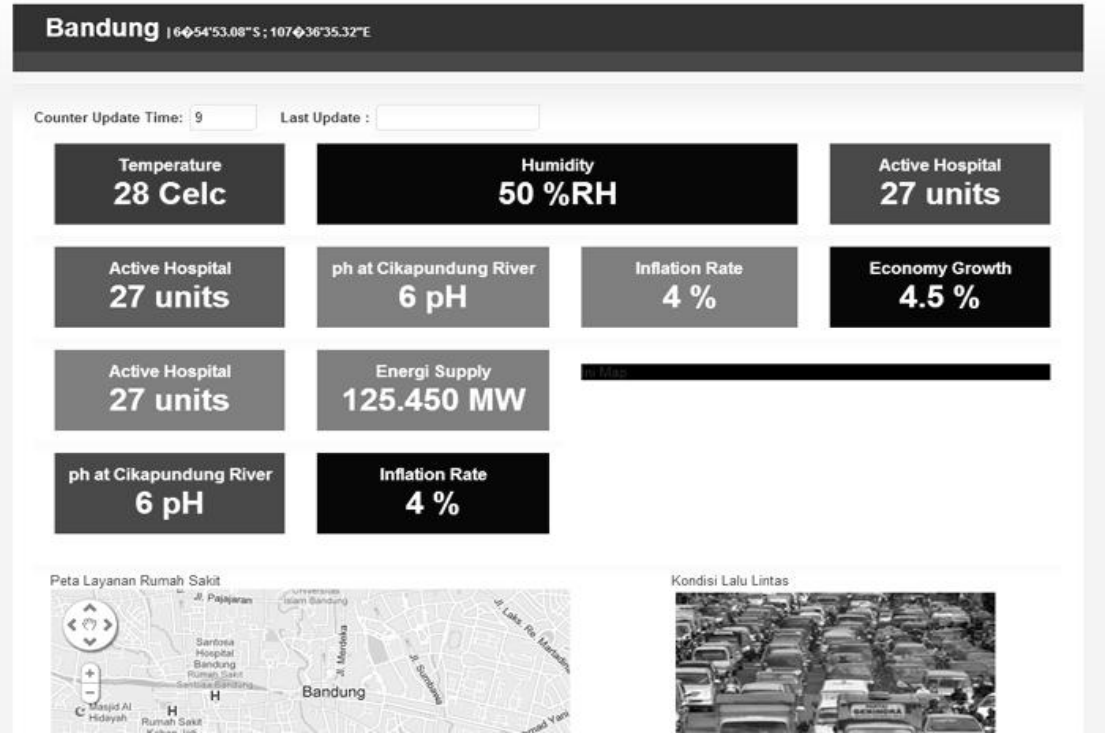

Fig. 4 Sample of Smart City Dashboard Application

It is prototype project with small number of sensor. In this pilot project, we set that our system can implement with any kind type of sensor. It done well with configuration of Remote Terminal Unit when only receive signal in voltage only. At the future, we can place the sensors like temperature and humidity sensors at certain points in the city to get actual value from the fields. We can also place environmental sensors at the place with very high pollution.

The users of system can also add or view additional information of the city such as public health infrastructure, environment state, energy supplies, economic indicator, etc. Other information such as traffic conditions or maps of public services can also be displayed.

V. CONCLUSION AND FUTURE WORK

This study has implemented prototype system of smart city dashboard at Bandung. It consists of network sensor, server, application and also communication protocol which is used for city monitoring. The summary information of city can be displayed in single view to help people watching, analyzing and action to what being happen to city.

In the future, we can add more analytical tool or business intelligence to get more precise evaluation like prediction or decision system support (DSS) tool.

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