Internet of Things with Wireless Sensor Network Potential Business Possibility

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Abstract
Wireless Sensor Network is an exciting part of the Internet of Things to study because of its versatility in various types of industries. The existence of wireless sensor networks is believed to develop similar to the evolution of computer network systems when they were first connected and eventually became what we call today the Internet (World Wide Web). The source of information from the wireless sensor network will be more precious than the current internet information source, and this will change the World Wide Web to what is called the World Wide Sensor Network (WWSN). This paper focuses on the impact of this transformation process, the parties involved, the operational and business models possibility.

***Keywords**:* Wireless Sensor Network; World Wide Wireless Sensor Network; Business Models; Market Opportunities

Abstrak
Jaringan sensor nirkabel (*Wireless Sensor Network*) sebagai bagian dari Internet of Things menarik perhatian dari berbagai jenis industri dan diyakini akan berkembang dengan cara yang mirip dengan evolusi sistem jaringan komputer pertama yang dapat saling terhubung dan menjadi apa yang kita sebut hari ini sebagai Internet (*World Wide Web*). Infrastruktur pendukung jaringan sensor nirkabel akan muncul sebagai sumber informasi yang lebih kaya, dibandingkan sumber informasi internet saat ini dan akan mengubah *World Wide Web* menjadi apa yang disebut *World Wide Sensor Network* (WWSN). Makalah ini menitikberatkan pada dampak dari proses transformasi ini, para pihak yang terlibat, model operasional dan bisnis yang terkait dengannya.

***Kata kunci**:* Jaringan Sensor Nirkabel; World Wide Wireless Sensor Network; Model Bisnis; Peluang Pasar

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1. INTRODUCTION

The existence of sensor network infrastructure installed on a large scale will provide opportunities for increasing the amount and quality of information that can be obtained from the existence of such sensor network infrastructure. Opportunities will arise to utilize this wealth of information for specific purposes from just monitoring and tracking of a living habitat, to an integrated urban information system to improve the quality and scalability of information browsing. The existence of a large-scale sensor network infrastructure allows a change from what is currently referred to as the World Wide Web (WWW) to the World Wide Sensor Network (WWSN). Although this transition will be evolutionary, the progress offered will have an impact on individual and social activities. A simple example of its use is from just looking for weather information in real-time to accessing integrated health services between human habitation and the desired hospital [1].

The wireless sensor network literature today has been found in many studies. The type of information that can be obtained is also quite complete, starting from technical issues such as transmission, network topology, device control mechanisms, addressing and network routing, to application support, including security features. But something is missing in the development of technology and wireless sensor network-based applications, namely the types of services and application scenarios such as what will be used by users? Business models such as what is expected to develop, and how this service can generate revenue for infrastructure providers and vice versa can provide the best benefits for its users.

In this paper, the author tries to identify trends in the use of wireless sensor network technology by examining and providing examples of services that are relevant to the conditions of prospective users in Indonesia and consider several categories of users according to their needs. The user categories that come to mind by the author are of three types, namely premium users, users of authority (government), and ordinary users.

The economic growth of IoT WSN-based services is also considerable for businesses. Healthcare and manufacturing applications are projected to form the most noticeable economic impact. Healthcare applications and related IoT WSN-based services enable medical wellness, prevention, diagnosis, treatment, and monitoring services to be delivered efficiently through electronic media are expected to create about $1.1–$2.5 trillion in growth annually by the global economy by 2025. The whole annual economic impact caused by the IoT is estimated to be in a range of $2.7 trillion to $6.2 trillion by 2025 [2]. Table 1. shows the projected market share of dominant IoT applications.

Table 1. Projected Market Share of IoT Applications 2025 [2]

Implementation Area	Market Share (%)
Health care	41
Manufacturing	33
Electricity	7
Urban Infrastructure	4
Security	4
Resource Extraction	4
Agriculture	4
Vehicles	2
Retail	1

This paper is generally divided into several sections, where the first part explained the condition of the development of wireless sensor networks in general. In the second part, a typical wireless sensor network architecture and the basic wireless sensor network interactions will be explained briefly. In the third part, the writer goes on to review the impact of the development of the current network infrastructure, seen from the way individual and industry users use the current Internet infrastructure services (World Wide Web). Then proceed with consideration of the impact of the development of wireless sensor networks into the World Wide Sensor Network (WWSN) for individual users and industry players. WWSN can be considered as a space consisting of smart objects supported by contemporary wireless and internet network technology, resulting in the application of new services that go beyond the scope and reach of current internet information [3]. At the end of the third part, we will explain the role of the parties in the wireless sensor network (business chain wireless sensor network) in the form of a business model and the potential sources of revenue from these new services.

2. MATERIAL AND METHOD

2.1. WSN Architecture and Interaction between Its Components

The technology of wireless sensor networks has been frequently discussed in various papers scientific ([1], [4]), and articles of other technologies (comprehensive survey can be found in [5]. Still, no one has discussed the type of service based on wireless sensor network. To determine representative service delivery models, wireless sensor network architectures, and their interaction models need to be analyzed first.

Wireless sensor networks, has the ability to detect the environment using its sensors [6], can perform simple communication wirelessly, can process data, and store data autonomously for long periods of time (sense, reason, communicate and act, in whatever order). The wireless sensor network is able to detect the environment in the form of temperature, fire [7], [8], tracking object [9], vehicle density [10], light, vibration, sound, radiation, to its ability to detect the condition of the human body [11], [12]. The main limitations in implementing wireless sensor networks are electrical resources and lack of flexibility in operations [13, 14, 15]. This is because when a node sensor has been set to detect one or more sensory data, it will be difficult to change the

sensor function or the positioning position of the sensor (because there will be new costs or changes in dimensions needed).

In general, the application of wireless sensor networks is referred to as "nodes," and some are referred to as "sinks" [16] [17]. Nodes are sensors that function to detect the environment and produce data, which is then sent to the sink. The sink is a gateway to the main network, which can be either an internet network or a network private (intranet). Generally, one sink can handle multiple nodes according to their grouping zones, as shown in Figure 1. So that the wireless sensor network consists of two processes as follows:

1. Retrieval of data by one node sensor can be in the form of temperature, pressure, vibration, noise, humidity, and others. Each sensor takes different data.
2. Data from various sensors are combined into one or several sinks. *The* sink sends data to the server, the data center for further processing, according to the needs of the service user. The pattern of interaction between the nodes sensor network and their sinks can be seen in Figure 1.

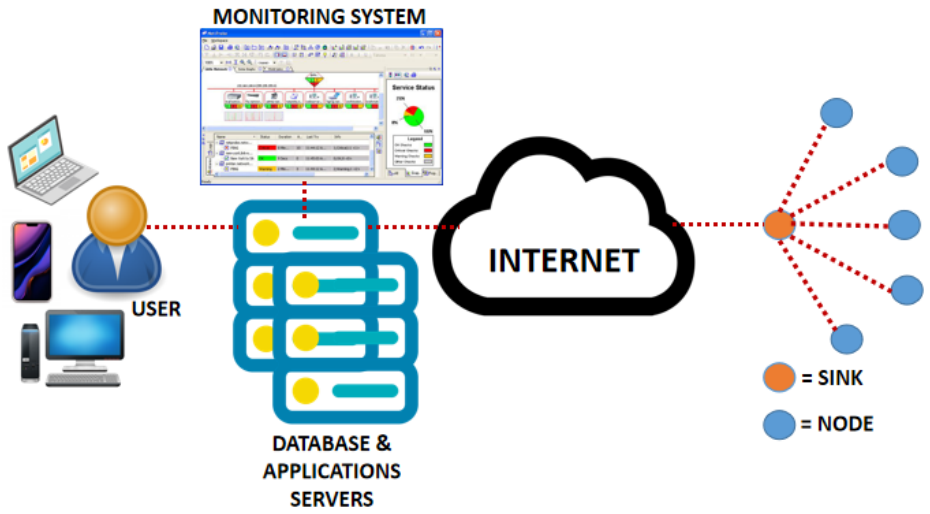


Figure 1. Implementation of a wireless sensor network

a. Detection of events: a node or more (adjacent to its location) will be able to detect events (can be changed in temperature, humidity, light intensity, sound, etc.), then report these events to a sink that has been designated as a gateway of nodes these.
b. Classification of events: Classification occurs based on simple computation by a node or by computational results performed on the same object by nodes neighboring.
c. Periodic measurements: Sensors report measurements periodically with several conditions. First, the measurement reporting schedule is determined by programming (hardcoded, *for* example, every 5 minutes). Second, reporting is carried out when triggered by an event (e.g., a rise in temperature at a particular scale). Third, reporting is based on a combination of the first and second provisions above.

d. Estimated functions: Sampling of the sensor network is chosen to estimate the function of space and or time (for example, to make a temperature map at a certain location, it is necessary to sample nodes temperature sensor only in the desired area and within a specific period).
e. Edge detection: set the boundary in a function (generally to determine the location or shape of the object to be detected).
f. Tracking: tracking and reporting the position of an object being observed (for example, nodes sensor on a mountain that detects all climbers around the mountain).

3. Data generated must ultimately be used by systems outside the wireless sensor network, so the system gateway needs to be introduced. Between nodes on a wireless sensor network generally operates in accordance with the internal protocols of nodes these. However, these nodes also function as endpoints in the communication architecture with external systems (servers data center and wireless sensor network service users).
4. The interactions mentioned above aim to:
   a. So that the data sender and receiver do not need to know in detail the information that is not required from their partners, and
   b. the network response does not have to be directly triggered by questions from service users so that it can be referred to as asynchronous communication.

2.2. Use of WSN Services

To connect wireless sensor networks with external communication networks (global internet infrastructure) or integration between different communication protocols is required. Based on the authors in [18] have identified the scenario of using wireless sensor networks as follows and shown in Figure 2.

- A wireless sensor network is used for the needs of one type of application (application-specific per-wireless sensor network). This is an example of a commonly applied scenario.
- One application uses more than one wireless sensor network of the same type. This application is responsible for handling the heterogeneity of the data generated.
- Different applications use several types of wireless sensor networks whose use is integrated through platform middleware.

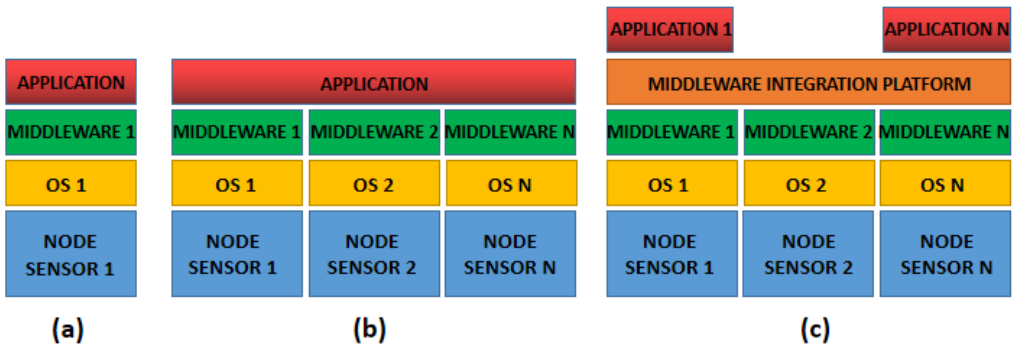


Figure 2. Model of using wireless sensor networks (adopted from [6])

2.3. Wireless Sensor Network Data Provision Model

Based on the type of application and wireless sensor network usage model presented earlier, it can be seen that there are at least four data supply models based on how to process the information. The data supply models are (1) Publish Model, which is a subscription to specific data, the main idea is that the node sends data based on one particular name (according to the names of users who subscribe). This model is made possible by the software bus (middleware) that stores user data, and publishes data according to the user's needs, uses the user's name as a filter, and can ensure that the user will get information about the value of the desired data change as illustrated in Figure 3. For example, users who subscribe to congestion level data at a location. (2) Pull Model, namely the provision of data begins with a request from a service user, for example, a user who wants to know the soil moisture from a sensor installed in his garden). (3) Push Model, namely the provision of data-driven by events (for example breeders who want to be notified if their cattle shed doors are open without any conditions), and (4) Hybrid Models, namely the provision of data-driven by the Grade of Service (GoS) approach, which is applied to specific applications. In this model, the wireless sensor network needs to report information according to the minimum requirements that arise from the Service Level Agreement, for example, users who want information on the level of water level in a river near their home at night with frequent notifications every hour.

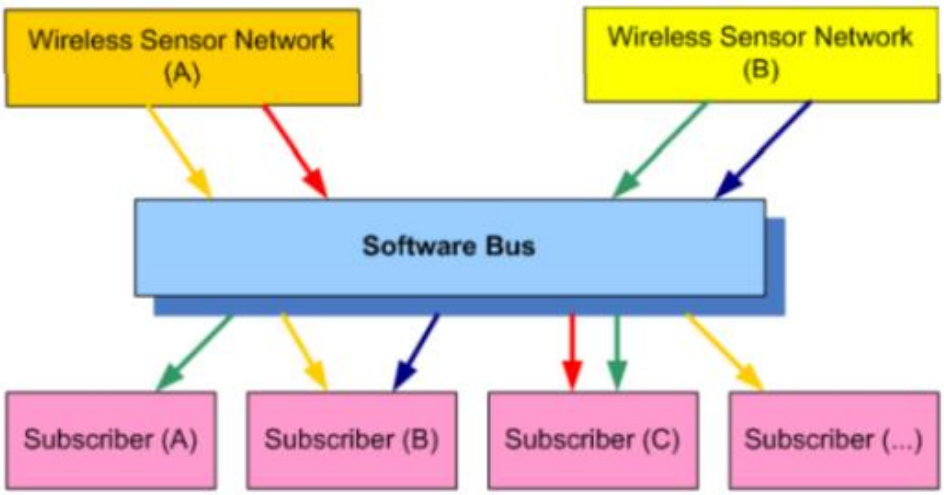


Figure 3. Data Supply Service Model (Subscription)

The differences especially between the push model and pull model are apparent, but in terms of business, the main limitation of wireless sensor networks is that the source of electricity is limited, the choice of push models (initiated by the system) is a model that will be cheaper than the pull model (user-initiated). The existence of these differences can be interpreted that request data subscription model Pull and Hybrid would be a kind of "premium" when compared to the "standard" or "free" will only give the result data collected by the system of nodes attached.

2.4. SERVICE AND VALUE CHAIN WWSN

The enrichment of updated internet information is more specific based on its geographical location, obtained from various wireless sensor networks used throughout the world so that it will lead to the transformation of the type of information used the more detail according to the needs of its users. This wealth of data can be obtained from existing gadgets to the latest models of devices in the future so that user awareness of the environment will increase. This transformation can be referred to as from the World Wide Web (WWW) to the World Wide Sensor Network (WWSN). The last few decades can be felt that information is a resource and will, in turn, become a high-value product for the majority of its users, so the impact on its acquisition costs (information) will be assessed based on the resources used, their rarity, accuracy, and speed of time. This information can be directly generated by a sensor, but can also be obtained from the results of a production chain that connects various parties to add value to the information received. Value Chain WWSN consists of several entities with the following roles:

1. Owner of the wireless sensor network (Infrastructure): This entity has one or more sensor networks that are used, which provide essential data for the specific needs of business activity. Data collected by the wireless sensor network can be directly presented to users either through certain content providers and services.
2. Content Providers - Aggregators and providers Middleware: This entity is a mediator between real data obtained from sensors and end-users. Content providers have the role of collecting and/or combining data collected by various sensors, to be provided to service providers and end-users. Data obtained from Content Providers can be in the form of raw data (according to information from sensors) or new data types from the results of raw data processing.
3. Service Providers (Cellular Operators, Web Portal Owners, Data Publishers): This entity stands at Value Chain the highest. This entity provides information to service users sourced from content compiled by content providers. Service providers have the ability to present content through different channels (fixed access, cellular or wireless communication systems, including GSM/GPRS/3G, 4G or WiFi) and in different formats (HTTP, Application Push Notifications or only in the form of SMS messages) according to user requirements.
4. Third Parties (trusted): They are members of the value chain that have direct access to information sources, in order to make a regulation, so as to ensure health in business competition and legally this entity has the right to access to that information (for example the government or other institutions that serve the public and have been appointed by the government).
5. Users: users are consumers of all types of information, ranging from raw data to information and services that have been processed by content providers and service providers.

Other entities/roles may exist, not only as mentioned above. This paper only lists the roles mentioned above, adjusting to the generality of the wireless sensor network usage model. In addition, this paper also limits its classification to add value to the service supply chain, so that the Infrastructure Equipment Vendor is not included as

the entity mentioned above because its role is only to provide the equipment needed by the wireless sensor network infrastructure owner.

In Figure 4, it can see the wireless sensor network content flow diagram. It can be observed in the figure. There is a relationship from one entity to multiple entities or from multiple entities to other multi entities.

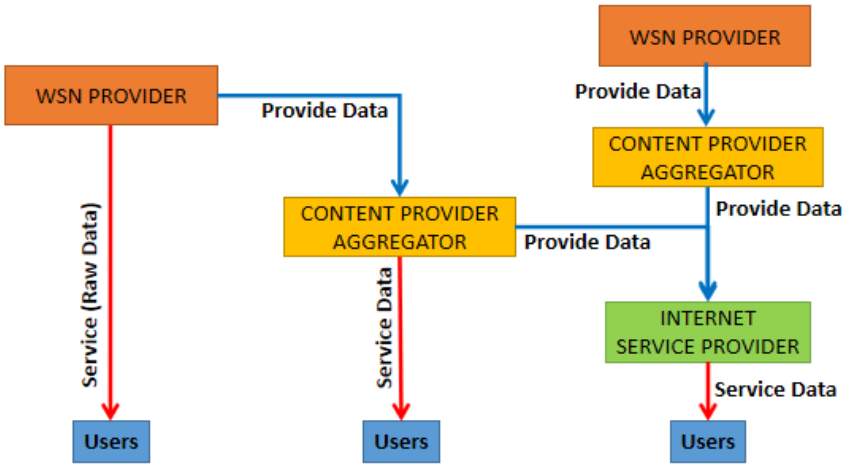


Figure 4. Wireless Sensor Network Content Flow Chart

3. BUSINESS MODELS AND MARKET OPPORTUNITIES WSN

3.1. Business Models for Wireless Sensor Networks

Based on the uniqueness of the wireless sensor network, this WWSN application is expected to easily spread quickly throughout the business domain. In the most primitive business model, the company is an exclusive producer who is also the owner of the infrastructure. A relevant example (from Supply Chain Management) is a case where a company uses several wireless sensor infrastructures to monitor conditions throughout the product cycle, from the time of production, to when the product is consumed and even used to monitor the product recycling process. Although this type of scenario does not produce much value for WWSN users, it can demonstrate the efficiency offered by wireless sensor networks to increase operational effectiveness.

The following are three business models that are currently representative:

1. Asset Management Business Model. In this model, a company or organization uses the company's sensor infrastructure to obtain information that is real-time or near real-time and allows other parties (trusted third parties) to access all or part of the data obtained. This model generally occurs in the agricultural business model, where soil temperature and humidity are monitored by the farm owner (for example plants that are sensitive to changes in temperature and soil moisture), and all or part of the results of temperature and humidity measurements can also be seen by local government offices aims to gather overall information (on a small scale) about the condition of soil temperature in the area.

2. Knowledge Management Business Model. In this model, content is obtained from various sensor measurement information sites (both free and paid) and then processed to produce other information that is different from the source of information. Content aggregators do not need to have the infrastructure and only needs to know the reliability of the measurement results of sensors (owned by other parties). The number of applications included in this category is still small at the moment. Still, the increase in sensors that are increasingly installed in the world is expected within a decade [19], [20] to create opportunities for "content collectors" to obtain valuable information, which is relevant to the trends in consumer needs at that time. This model represents the best correlation between wireless sensor networks and existing WWW-based services.
3. Public Service Business Model. Public entities will build their infrastructure or get access to content produced by infrastructure built by private organizations.

This latter practice can occur when the state subsidizes investment in infrastructure. Part or all of the content obtained will be processed by public authorities and will be available both for the benefit of the general public and to stimulate the growth of other services from the private sector.

Service and content providers are expected to be able to make service classifications based on the costs required to provide this information to end-users.

1. Content and services available free of charge to individuals (home users and other non-company users). This type of information can be accessed using applications that are connected to servers and wireless sensor networks. Still, there are no minimum requirements Grade of Service (for example, on-time, real-time or not, not a big issue because of the free nature of the service). This scenario will be encountered more and more in the future. For example, individuals can search for information about traffic conditions to the shopping area, identify parking availability at the shopping location, and at the same time, find out the selling price of the product they want to buy before the individual leaves their home. The tourists can search for information about tourist destinations based on the density of visitors to a tourist attraction on another continent, the climatic conditions in the area, and the density of traffic lanes from the hotel to the tourist location.
2. Service providers can offer premium services to professional users. The service will provide guarantee level Grade of Service (determination of this level is defined by parameters that include accuracy, latency, whether the speed of information in real-time or not). An example of its application is when a professional or a company is looking for agricultural land for a particular crop. The professional or company can search for land according to their needs based on weather information obtained by sensors installed at various nearby agricultural locations.

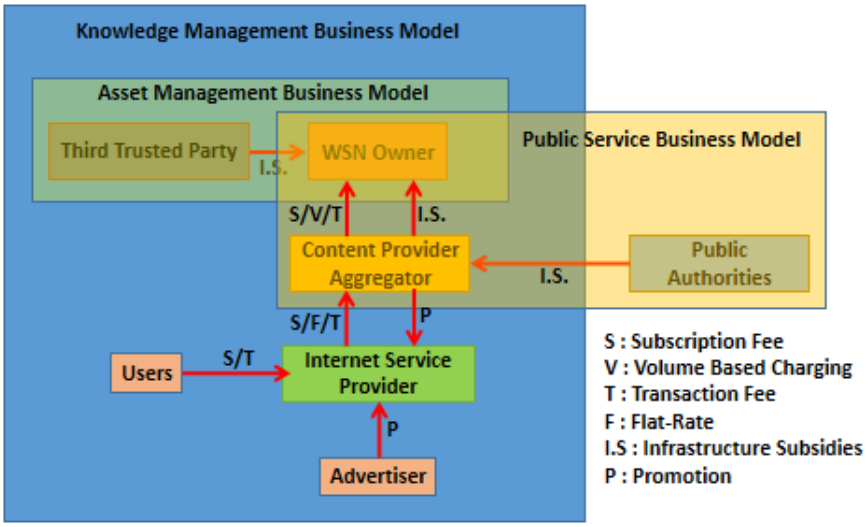
3.2. Revenue Flow and WWSN Service Billing Model

Several revenue flow scenarios from WWSN services include:

1. Direct Income. This income is expected to come from Premium Services that can be used by Users and can also be used by other entities from the value chain wireless sensor network. The following are several billing models that might be used:

a. Flat rate, i.e., users are charged the same fee, regardless of the number of services used and the volume of network resources required.
b. Volume-based, i.e., users are charged a fee based on the volume of information exchanged (this model fits the case of the wireless sensor network infrastructure owner who may charge for each transaction that consumes his sensor energy)
c. Subscription, i.e., the user subscribes to a service or application and therefore are charged periodically (monthly / yearly). The type of subscription can be adjusted to the level of service that is relevant to the user's needs.
d. Transactions, i.e., users will be charged once for a particular activity in a short time (for example: only want to know the current traffic density real-time but do not want to know about it continuously).

2. Indirect income, i.e., other income that can finance service provider entities other than the type of premium service. The main source of income for this type is the income from all types of promotions (advertisers pay fees to promote their products, while content aggregators pay fees to be chosen as exclusive content providers).



Picture. 5. WWSN Business Model Revenue Flow

4. CONCLUSION

Based on the WWSN Business Model Revenue Flow above, a comparison can be made between services that use the basis of the World Wide Web (WWW) compared to new services that use the World Wide Sensor Network (WWSN). The fast development of wireless sensor networks will make a condition where new opportunities and business models will emerge. Changes to this business model will bring new entities such as wireless sensor network local providers, various content providers, and observers, and new policymakers in addition to internet service providers and end-users that currently exist. End users will have the option to subscribe, both free and premium, according to their needs. End users will have more choices in finding information accurately from local wireless sensor providers and content

providers who currently only depend on internet service providers and internet content providers through the world wide web. So, it will be possible changes in human procedures in obtaining information that is abundant and interconnected with one another and can be referred to as the World Wide Sensor Network (WWSN). To achieve this, opportunities and business models need to be matured using pilot projects in areas that are considered to have good business potential.

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