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Advanced Indoor Location Measurement Architecture for Emergency Situations

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Abstract

According to the increasing of modern people's life time in indoor places, the importance of indoor LBS has been continuously gotten higher attention. This phenomenon is one of the inevitable IT trends which caused by the evolved computing paradigm, mobile and wireless communication technologies, and Internet of Things. In addition, there are other hot topics in these trends, big data and cloud. The trends are like a blackhole which strongly pulls the whole technology. That is, it has same ripple effects in the indoor location service and technology. Although there are still several problems which related to the accuracy and precision in the indoor location service, it will be certainly overcome in the near future. However, the practical uses of indoor LBS are applied in some limited fields such as marketing, finance, and so on until now. This is one of the reasons why we propose the advanced indoor location measuring architecture, which is very suitable for emergency situations. Moreover, the proposed architecture can improve the accuracy and precision, when it measures an indoor location, because we need high accuracy and precision in emergency situations than common situations. In the proposed architecture, it utilizes various information and big data to measure an exact indoor position, and it operates with various IoT devices. Based on these schemes, the proposed architecture can provide high accuracy and precision than the existing methods. In this paper, we verified the superiority of architecture than others in various aspects.

Keywords: Big Data, Cloud, Emergency, IoT, Indoor Location

1. Introduction

Nowadays, IT technology is one of the leading technology to change our lifestyle in many fields. The changing of lifestyle based on rapid prevalence of smartphones has been one of the representative instances, because it has a lot of functionalities which can be used in various circumstances. In addition, these technologies are not only one of the most important key technology for the next generation IT world, but also one of the leading technology for the Internet of Things (IoT). According to the market and technology research & advisory companies such as Gartner, IDC, and etc., IoT technologies will be a key technology within a few years, and it will dramatically change the computing paradigm. Besides, it has been already occurred in various fields of the world. That is, there is no doubt that we will live in more convenient environments based on these technologies.o doubt that we will live in more convenient environments based on these technologies.

As previously mentioned in the above paragraph, IoT technology will be a driving force to change our lifestyle. It will have almost the same ripple effects like as the smartphone technology has been done. However, the effect of IoT will be limited, if it will be converged to the simple applications and ideas. So, we should consider some IoT technologies to apply to the various fields. It will be a good business field such as marketing, finance, healthcare, etc. to adopt the IoT technologies.

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Generally, the applicable fields of IoT are based on the LBS (Location Based Service) to provide converged services. During the past few years, the accuracy of LBS has been astonishingly improved, and the LBS have been adopted in various fields. Although the accuracy and precision will be continuously improved to provide well-defined services, it is not the main subject of controversy anymore in the outdoor services, because the service levels have been already reached to acceptable level. On the other hand, the indoor LBS aren't the applicable services yet, since there are a lot of things that should be improved to the accuracy and precision of the indoor positions. This is the main reason why the indoor LBS can't use accurate GPS (Global Positioning System) signals. Nonetheless, due to the fact that modern people's lifetime in indoor spaces have been continuously expanded more and more, the indoor LBS technology has been one of the key IT technology. However, there are still remaining problems we have to solve. It means that we should have to improve the accuracy and precision of indoor position in location measuring system[1].

On the one hand, most of people are forecasting that IoT technology will generate tremendous data than the legacy Internet world, and the generated data will be accumulated to the big data, which will be stored in the cloud. These technical flows or trends will be an inevitable computing paradigm. In the same manner, it will also be influenced to the indoor location services. Nevertheless, these interworking scheme or architecture didn't develop yet, because IoT, big data, and cloud technologies are still evolving now by themselves. Although we can make a lot of benefits based on these interworking architecture, there are some deficiencies in the research fields.

Actually, the indoor LBS is very important service in modern life, since most of people spend their time in the indoor spaces.Although the indoor LBS has been usually applied to a business field until now, there are various fields which can be adopted.Among these fields, a representative field is safety and disaster field. If there are some calamities in indoor space, the indoor LBS can be one of the best solution which can effectively handle this situation. However, the indoor LBS should have to provide more exact location information in emergency situations, because an inexact information might occur to other accidents.To avoid these situations and improve accuracy & precision, we propose an advanced indoor location measurement architecture[1,2].

Basically, the advanced indoor location measurement architecture (A-ILMA), we proposed, consists of IoT devices with various sensors, big data base cloud center, smartphones which is embedded various sensors, and GIS (Geographic Information System) server which has the indoor information of building or place. Based on these elements, the proposed A-ILMA can search an exact indoor location of users. In addition, the proposed A-ILMA uses big data techniques to measure an exact indoor location.

The rest of this paper is organized as follows. Section 2 describes the related works such as indoor locations measurement technologies and standardizations, and Section 3 discusses the proposed indoor measurement architecture and its performance evaluations. Finally, we offer a conclusion in Section 4.

2. Indoor Location Measurement Technologies

Generally, the indoor location measurement technologies are categorized to various things by accuracy of required location, available service coverage, applicable service and sensor, and so on. Although there are many indoor location measurement technologies, we will focus on some highlighted technologies and standardizations in this paper.

2.1 Indoor Location Measurement Techniques

- Indoor Location Measurement Technology based on Wi-Fi: Generally, there are 3 categories in the Wi-Fi based indoor location measurement technologies, Cell ID, Fingerprinting, and Multilateration (MLAT). The detailed each technology is as followings.
- Cell ID: This technique determines a location of node by measuring a signal strength. The node's location will be set to a Wi-Fi connection point where the node establishes a connection. It is usually used in wireless & mobile communications technologies, and it is very simple technique to measure an indoor location. However, it has high error tolerance than other techniques.
- Fingerprinting: This technique is comprised of 2 steps. In first step, it makes a radiomap or heatmap. The map is made by pre-collected signal strength information at specific points. In second step, the

received signal strength compares with the measured signal strength in the radiomap or heatmap. Based on these results, it assigns the signal strength weights and then it re-calculates the final indoor location by using the values. It doesn't matter where the Wi-Fi connection point is, and it has advantages that can be reflected the signal features in the place. However, it might be increasing the cost to collect a signal strength, and the map should be changed or modified whenever the indoor environments be changed. Nonetheless, this technique will be continuously evolving, because it is one of the most usable technique in this field.

- MLAT: This technique is basically measuring the difference in distance between 2 nodes by using a broadcasting signal. To measure a distance, the technique uses a received signal strength, time of arrival (TOA) or time difference of arrival (TDOA), and round trip time (RTT).
- Indoor Location Measurement Technology based on Beacon: This technology has been highlighted after success of auto check-in service of the Shop kick which is based on low frequency sound. However, the beacon technology based on BLE (Bluetooth Low Energy) is now main stream, since the Bluetooth 4.0 was established. To measure with BLE, a BLE device send advertising packet to un-prescribed devices in near place. The advertising packet includes various information such as device ID, service place, transmitted signal strength, and so on. The device calculates their location by using a Cell ID technology or MLAT technology when it received the packet. Although the technology has several advantages, it can be not only measure itself without other measurement technology, but also interwork with other measurement technology to make a strong synergy effect.
- Indoor Location Measurement Technology based on Sensor: The mass production and low cost of MEMS (Micro-Electro-Mechanical System) sensors has been enabled this technology. The representative example is a rapid and widespread deployment of smart phone with various embedded sensors, since this technology has to need various sensors. In indoor location

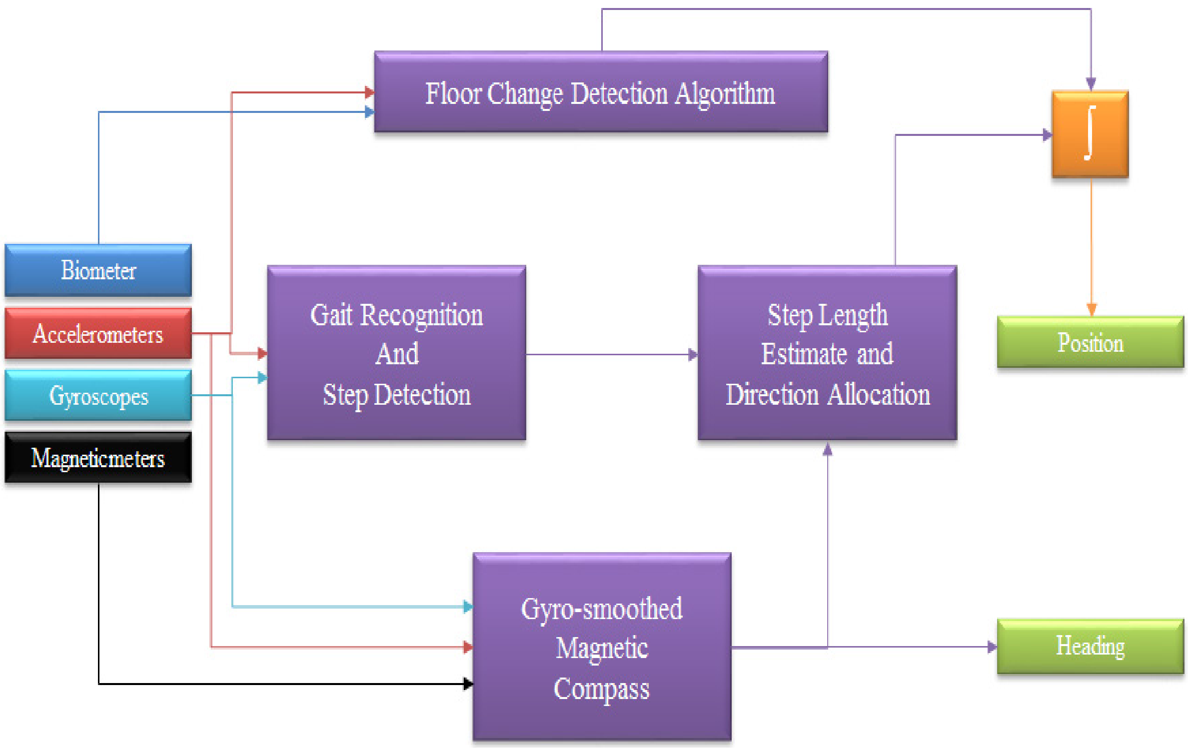

Figure 1. Working flows of pedestrian dead reckoning.

services, the technology based on the sensors is a PDR (Pedestrian Dead Reckoning), representatively, as shown in Figure 1. It has some advantages than comparing with Wi-Fi measurement technologies. The most important things are independent measurement and high accuracy & precision. However, this technology has to interwork with other things such as GNSS, Wi-Fi, magnetometer, beacon, etc., to compensate an accumulation of gradual errors.

- Indoor Location Measurement Technology based on Opportunistic Signal: This technology uses all signals which don't have a location measurement purpose such as Wi-Fi, base station, broadcasting, FM, GNSS, light and so on. That is, although the various signals are already supposed to achieve their own purposes, the measurement technology utilizes the proper signals to measure a location among these signals.In the measurement processes, if there are already fingerprint map, which are based on the pre-collected information, it is operating very similar to the existing fingerprinting technology. However, if there is no pre-collected information or changes the indoor environments, the measurement technology will make a new fingerprint map automatically. It is possible to use a SLAM (Simultaneous Localization and Mapping), etc

2.2 Indoor Location Measurement Standardizations

- OMA Location WG Standardizations: The LOCation WG in OMA (Open Mobile Alliance) is discussing the standards about MLS (Mobile Location Service), SUPL (Secure User Plane Location), LPPe (LTE Positioning Protocol extension), etc.Among these standardization items, LPPe has a high correlation in indoor location measurement and performance. The LPPe is a kind of expanded measurement protocol from the 3GPP LPP standards.The LPPe is a kind of expanded measurement protocol from the 3GPP LPP standards. Until now, the standardization process is in the making a draft, and the OMA is discussing the LPPe 2.0 in the WG, the detail things are as followings.
  - » Frequency property information propagations
  - » Context cognition methods based on video
  - » Measurement method based on dead reckoning for a pedestrian
  - » Supporting mobility sub-state based on device assistance
  - » Crowdsourcing for node position and measurement inforamtion
  - » Supporting indoor/outdoor transit area information
  - » Supporting radio map data
  - » Supporting enhanced WLAN location measurement information
- ILA (In-Location Alliance) Standardizations: It was founded by the mobile industry to accelerate the adoption of indoor position solutions that will enhance the mobile experience. This organization is discussing an interface standard with other standardization organizations for implementing applicable instances. The mainly discussing items in the organization are Bluetooth 4.0 and Wi-Fi. In this organization, it consists of the Use case WG, Pilot WG, System Architecture WG and so on, it is the reference architecture, as shown in Figure 2[3-9].

3. Advanced Indoor Location Measurement Architecture

As previously mentioned Section 1 and Section 2, indoor location measurement technology has been consistently evolved during a past decade, and it is still ongoing process. However, there are still remaining problem in indoor location measurement. In addition, the technology will be evolved to converge various services, and it is certainly true, because if the indoor positioning service (IPS) can be a base technology to create a blue ocean. To fulfill these goals, there have been a lot of efforts in these days. It is actually to interwork with IoT, Big Data, Cloud, and so on.

In fact, the higher accuracy and precision can be provide a better fundamental thing to some convergence services, which have the indoor location measurement scheme. Although low accuracy and precision can be suitable in some services, it can't be a sufficient condition in some cases. For example, high accuracy and precision can be a prerequisite condition in some cases, especially in emergency situations, because we have to save people's life based on the information. This is why we propose the advanced indoor location measurement architecture which can be a very useful solution in that case.

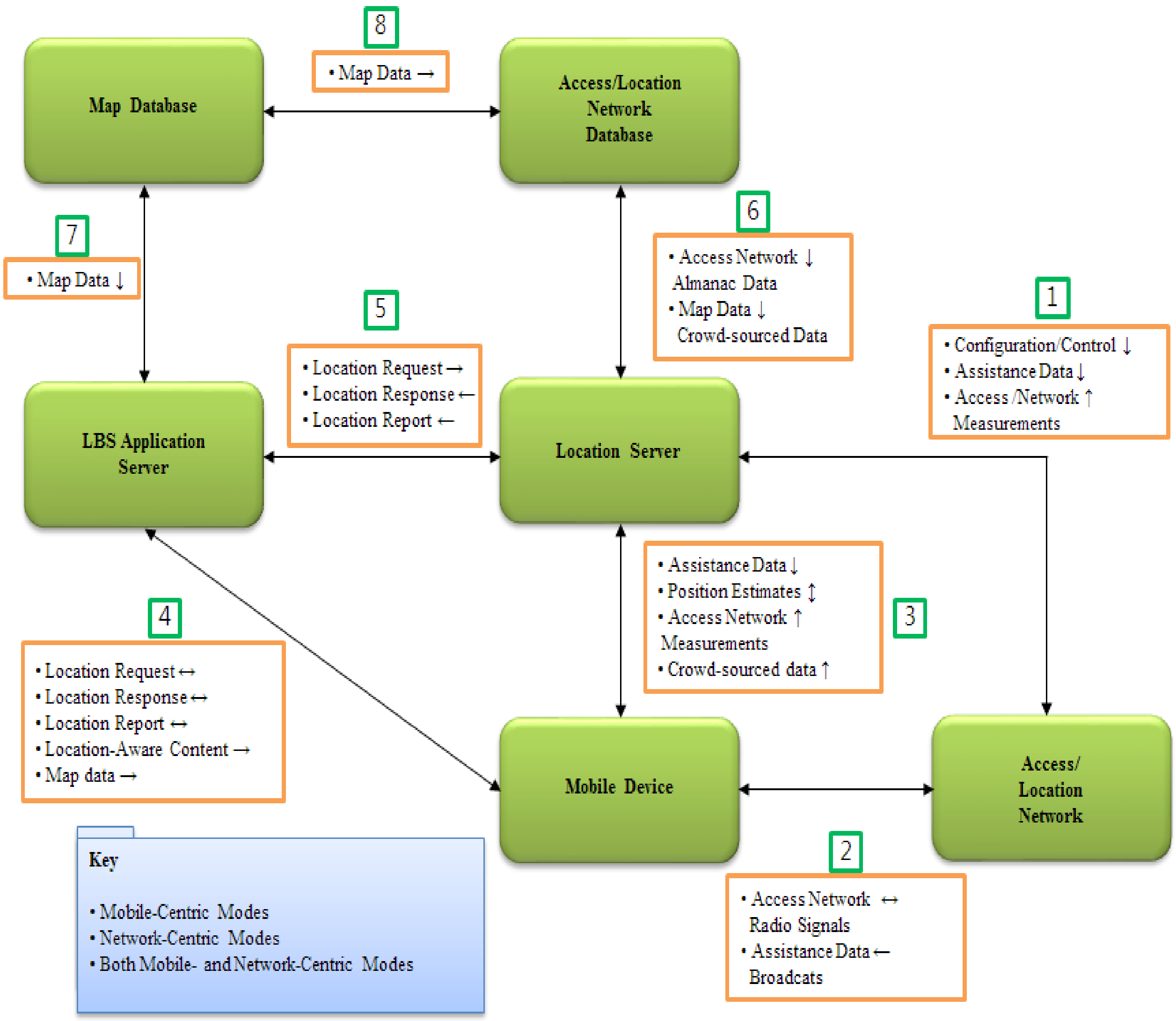

Figure 2. In-Location Alliance (ILA) architecture.

As shown in Figure 3, the proposed A-ILMA works with various IoT devices and Cloud data centers, which can handle Big Data. To improve accuracy and precision of indoor location measurement, the proposed A-ILMA uses big data and indoor spatial information to construct an exact radiomap. Due to the fact that the proposed A-ILMA utilizes various IoT devices to build an exact radiomap, it can be a kind of the indoor measurement technology based on opportunistic signal. However, there are definite differences between the proposed A-ILMA and opportunistic signal method. First of all, the proposed A-ILMA uses not only some installed device's signals, but also end device's signals. Secondly, the proposed A-ILMA is focused on the big data analyzing and processing. Based on this scheme, the proposed A-ILMA can make an exact radiomap than other technologies. Finally, the radiomap is made by the A-ILMA, is stored in the Cloud. Since the proposed A-ILMA can actively cope with changing indoor environments. The detail construction steps are as followings.

- Environment Sensing Step: In this step, the proposed A-ILMA gathers the environmental signal information in the indoor spaces. If there are pre-constructed radiomap for the indoor space, the A-ILMA checks the changed points about the indoor spaces. This step will consistently repeat to get a changing environment in the A-ILMA, the IoT devices in the indoor spaces will be used to detect various signals. And then, the

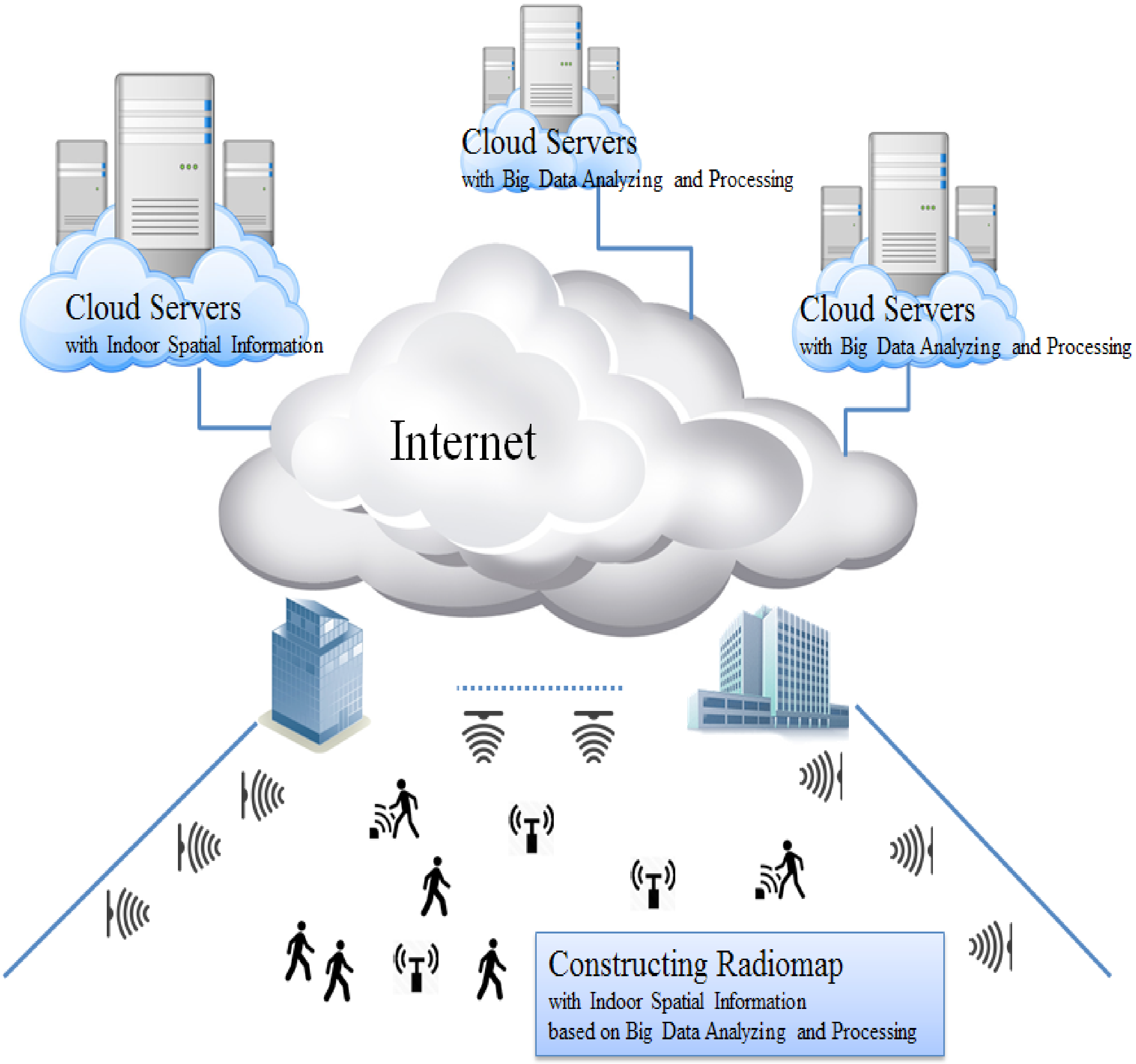

Figure 3. The proposed A-ILMA.

collected environmental signal information will be a fundamental information to analyze and process big data. In addition, the information will transmit to the Cloud servers to implement an upgraded radiomap.

- Radiomap Constructing Step: This step makes a radiomap based on the collected information, which is transmitted to the Cloud servers in the environment sensing step.To increase accuracy and precision of constructed radiomap, the proposed A-ILMA utilizes various Big Data analyzing and processing techniques such as cluster analysis, hadoop, and so on[10-15]. In addition, the A-ILMA uses various indoor spatial information and moving pattern analysis to build an exact radiomap. Based on these process, the A-ILMA can construct a detail radiomap with having a high accuracy and precision. Moreover, the A-ILMA can easily adapt to environmental changes, because the A-ILMA always gathers a sensing data whenever the indoor spaces are changed.
- Indoor Location Measurement Information Utilizing Step: In this step, the A-ILMA can provide an exact indoor location information to users. As previously mentioned in above steps, the A-ILMA can be measuring not only an exact indoor location, but also constructing an upgraded radiomap with the indoor spatial information.Based on these scheme,

the A-ILMA can support an exact indoor location information to users when they encounter some emergency situations such as accident, fire, sudden health problem, and so on. That is, both victim and rescuer can utilize the exact indoor location information in their space through the A-ILMA.

To verify the performance of A-ILMA, we have performed computer simulations. In these computer simulations, the proposed A-ILMA outperformed 16.7% than other scheme in error tolerance aspects. Although it isn't incredible results, we verified that the more there are accumulated data, the more the accuracy and precision is upgraded.

4. Conclusions

In modern life, the importance of indoor spaces will be increased more and more, because the most of modern people predominantly spend their time in the indoor spaces. Due to the fact that the indoor location measurement technology has been consistently highlighted. Although there has been a lot of efforts to measure the exact location in an indoor spaces, it isn't still making an enough results until now. To solve this problem, we propose the advanced indoor location measurement architecture. The proposed A-ILMA consists of 3 steps, and it uses various Big Data techniques and IoT devices. Based on these schemes, the proposed A-ILMA can exactly measure indoor location in some indoor spaces. Although the A-ILMA shows outperformance than legacy schemes in the computer simulations, the A-ILMA has still something which we have to upgrade. However, as we described in the previous sections, if there are tremendous data to construct a radiomap with indoor spatial information, the accuracy and precision will be dramatically increased, that are already verified in the computer simulations. Nonetheless, we can't be sure adjustable point about amount of Big Data, and correlations between accuracy & precision and Big Data yet. These are one of our future works.

Based on this paper, it will be a part to upgrade an indoor LBS, and it will be a very useful solution, especially in an emergency situations. Due to the fact that the indoor LBS is helpful technology in emergency situations, if it can be properly used to the cases. The proposed A-ILMA will be a priming and trigger to save our life.

5. Acknowledgement

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