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Active RFID Technology for Asset Tracking and Management System

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Abstrak

Aset merupakan salah satu benda berharga dalam industri atau lembaga, kehilangan aset menjadikan permasalahan pada sistem manajemen aset. Keuntungan dari teknologi identifikasi frekuensi radio (RFID) telah membuat teknologi ini berguna untuk sistem pengelolaan dan pelacakan aset. Penggunaan teknologi RFID aktif untuk pelacakan aset adalah dengan melampirkan tag pada aset atau item dengan diberi ID yang unik untuk identifikasi. Beberapa pembaca RFID aktif diletakan pada titik-titik atau lokasi strategis untuk melacak pergerakan aset dan mengumpulkan informasi ketika setiap item diluluskan di daerah cakupan pembaca. Pembaca mengumpulkan informasi pada jangkauan pembacaan dan mengirim ke sistem backend. Integrasi setiap sistem tunggal dilakukan dengan menggunakan kabel atau metode nirkabel untuk menjaga sentralisasi sistem pengolahan data. Pesan peringatan akan dikirim ke departemen terkait untuk memberikan peringatan. Sistem pelacakan dan manajemen aset yang menggunakan tipe teknologi RFID aktif bekerja pada pita frekuensi ISM 433 MHz. Sistem backend terdiri dari perangkat lunak aplikasi, middleware dan database. Semua informasi yang telah dikirim dari setiap sistem tunggal dicatat dalam satu basisdata pusat.

Kata kunci: *RFID, tag aktif, database*

Abstract

Asset is one of valuable item in the industry or institution, missing or lose of asset may have problem in asset management system. The advantages of Radio Frequency Identification (RFID) technology have made this technology useful for asset management and tracking system. The use of active RFID technology for asset tracking is by attaching the tag at the asset or item with assigned a unique ID for identification. A few of active RFID readers install at strategic points or location to track asset movement and collect information when anyone of item pass by in reader coverage area, reader collect information with in reading range and send to backend system. Integration every single system by using wires or wireless methods to keep centralize data processing system. Alert message will be send to representative department to give warning. This asset tracking and management system that use active type of RFID technology is working at ISM band frequency of 433 MHz. The backend systems consist of application software, middleware and database. All the information have been sent from every single system recorded in one central database.

Keywords*: RFID, active tag, database*

1. Introduction

Radio frequency identification (RFID) is used to describe various technologies that use radio waves to automatically identify human or objects. RFID technology concept is similar to the bar code identification systems concept as we seen in retail stores every day, however one big difference between RFID and bar code technology is that RFID does not required line of sight reading as bar code scanning requires line of sight reading. The component of radio frequency identification (RFID) system consists of tag, readers and backend system (computing system) for processing the information received by the readers. The simplest passive tags with no batteries attached for transmitters. RFID tag consists of a semiconductor chip, an antenna, and the packaging that holds them together. The tag stored a unique identification number in their memory [1].

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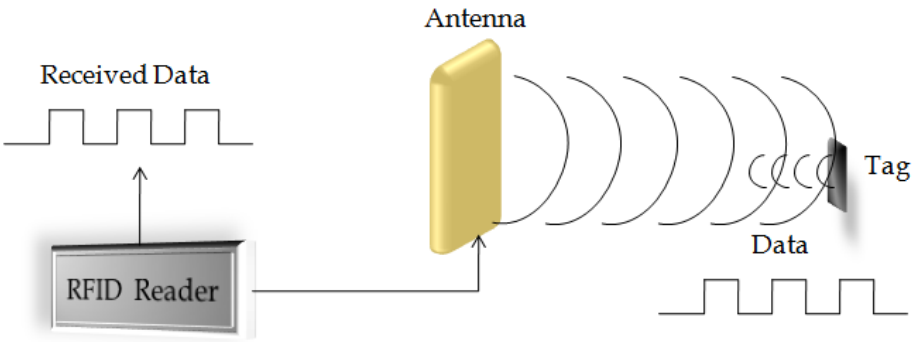

Figure1. Basic concept of RFID

Current EPC gen 2 tags use a 96-bit ID code, which could be expanded if necessary. Market prices of passive tags are currently priced in the cent for large quantities ordered. The chips consist of microcontroller and memory unit in the tags derive their power from the radio field from antenna of the reader. Interrogating the tags to the reader by reflecting and modulating a signal returned to the reader. Tags may have provisions for extended read/write memory. Every tag has a unique ID, the reader may be able to recognize many tags in its field virtually simultaneously, and up to about 1000 tags per second depend on type of reader [2].

Figure 1 shows basic concept of RFID system and how antenna exposes electromagnetic wave and received by tag than tag data transmit back to reader thru antenna. In RFID systems, the tag that stored the information or data can be categories into two different types. Passive tags use the radio frequency from the reader to transmit their signals, passive tags will generally have their data permanently burned into the tag when it is made, although some can be rewritten. Active tags are much more powerful in reading distance because they have on board battery for power to transmit their data signal over a longer distance and be able to stored more data with a random access memory (RAM) in circuit giving them the ability to store up to 128kB of data. Normally for active tag reading range up to 100 meters or more will depend on power of tag and reader, major issue in active RFID system is tag battery lifetime, typically the battery can last up to a few years based on setting of beacon rate [3].

Similar like tuning into your favorite radio station, RFID tags and readers also must be tuned into the same frequency band to enable communications both of equipment. RFID systems can use a variety of frequencies to communicate, because radio waves work and act differently at different frequencies as standardization, basically frequency band of RFID system categories into LF, HF, UHF and Microwave. A frequency for a specific RFID system is often dependant on its application. UHF (Ultra High Frequency) RFID systems 860 MHz to 960 MHz, currently most people uses this band for passive system and 433 MHz or 2.4 GHz for active system [4].

2. Active RFID Technology

An RFID tag is called active tag when it is powered by a battery that can be used as a partial or complete source of power for the tag's circuitry and antenna. Some active tag battery capable for replaceable of several years of use, and some others are sealed unit that difficult to replaceable and prepare for one cycle use. Figure 2 shows basic concept of an active RFID tag that consist component such as transceiver, microcontroller for controlling data transaction, a battery for power supply and antenna as media to convert to electromagnetic wave.

Active RFID system as shown in Figure 3 consists of active tag, reader, power supply, antenna and microcontroller for backend system. A single active RFID reader can be able to read the information and collect the data from the tag more than one hundred of tag, also be able to read the tag in speed up to 100 kilometers/hour. Active tags memory have much larger data storage and transmit or receive capacities, and also able to equipped by others sensor such as temperature, humidity, vibration, and pressure.

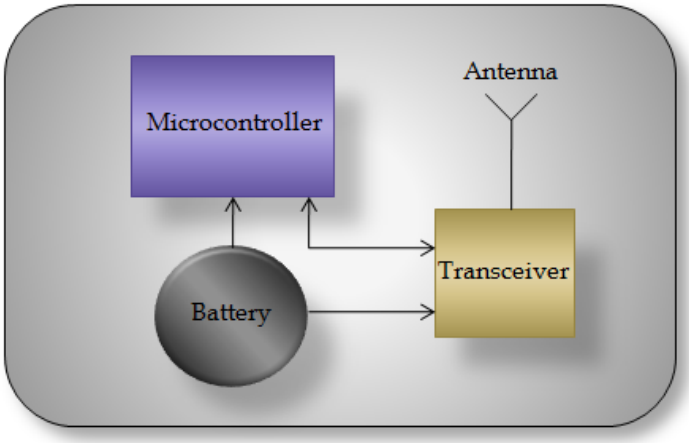

Figure 2. An active RFID tag

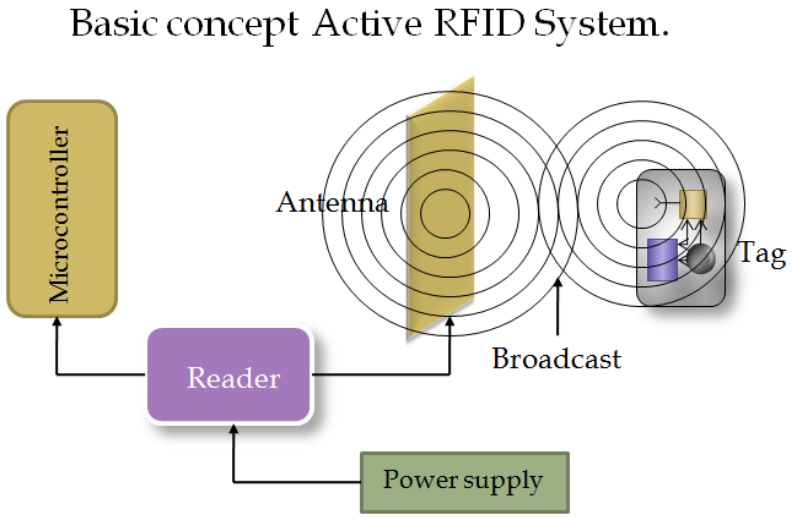

Figure 3. Basic concept active RFID system

3. Active RFID for Asset Tracking and Management System

RFID can be used to tract assets in a company or manufacturer. It is a diverse application that can have different meanings to different company or organizations. Some companies or organizations view asset tracking as the physical items means to count the non-sellable assets within offices, factories, or labs. Others organizations definite asset tracking is when items or assets are moving from one facility to others facility, either expecting them to return or move from one balance sheet to another. RFID asset tracking is non-vertical in nature, many different industries such as university, healthcare, manufacturing, insurance, banking, government and even law offices are using RFID technology in a slightly different environment and application [5].

The tag system in an active RFID greatly depends on how you can trigger a read, when the reading is important, and exact location resolution is required for the application. Complexity of system and cost may rise up depending on the type of tag and reader that chosen for your application and requirement. When deciding on which type of RFID tag is correct for your application, users must identify the type of assets, location, reading coverage, frequency of reads, and necessity to be able to pinpoint a location of reader for that asset. Because of active tag with the flexibility that comes with their larger data storage and data transmit capabilities, less re-engineering of business processes is required to implement in an active tracking system. Standardization for active RFID system is in ISO 18000-7:2004 Information technology - Radio

frequency identification for item management Part 7: Parameters for active air interface communications at 433 MHz [6].

3.1. Basic Concept

Development of an active RFID system for asset tracking is illustrated from active RFID technology, the concept is based on active system where every valuable items or asset of organization will be with an active tag that assigned a unique ID. Figure 4 shows how an active tag with data and a unique ID send the information to reader through RFID antenna, all the information processing by the reader with embedded microcontroller. Backend system consists of application software, middleware and database verified information from the reader to send back signal. An alarm system connected to reader to alert system when unauthorized item pass through or reader captured information from the tag [7].

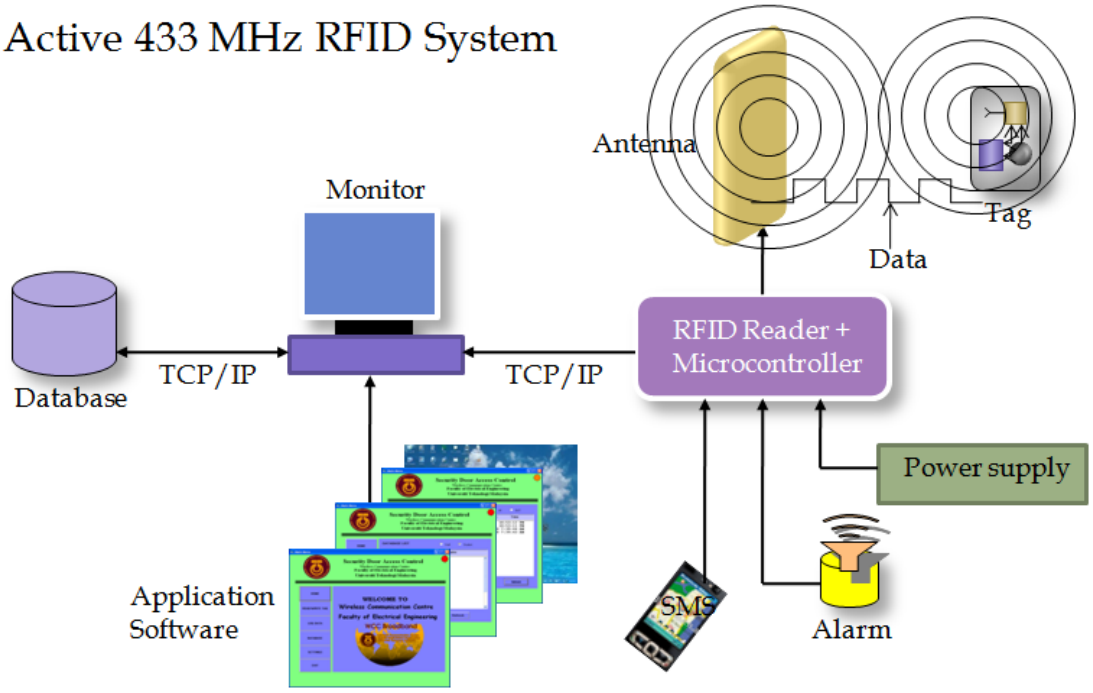

Figure 4. Basic concept active RFID for asset tracking

3.2. Tracking Management System Design

In this design of RFID system for asset tracking, it consists of three major part, indoor tracking system, outdoor tracking system and checkpoint tracking system. Every system has different scenario but all the information will be sent to same backend system. The data from each single system will send information to the server via Ethernet LAN for indoor system, radio link for outdoor system and WiFi and LAN for checkpoint system.

Figure 5 shows the architecture of RFID asset tracking system for every tracking location and how the information sends back to the backend system. RFID middleware and application software are used to verify the information and send back to alarm system.

3.2.1. Indoor Tracking System

Indoor tracking system uses exit door location as scanning area, by installing RFID reader at that place so when items with tag pass through reading area, reader will capture tag ID and send to backend system by using local network. Figure 6 shows active RFID tag used in this tracking system.

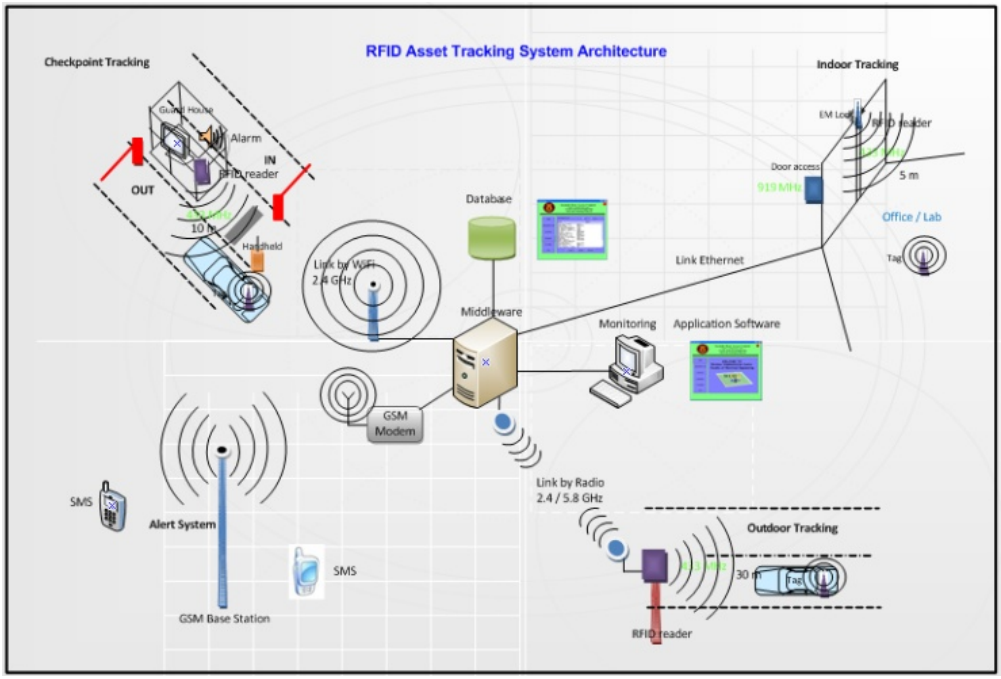

Figure 5. Architecture diagram of RFID asset tracking

Figure 6. Active RFID tag

Figure 7 shows the proposed active RFID reader used in indoor tracking system. The reader is powered by Dc 12 V. A battery is attached as a backup power supply. Backup power supply is added to give continuous power to reader.

3.2.2. Outdoor Tracking System

Another part of this tracking system is outdoor system, where a reader is installed at strategic point to capture information from tag when items pass through the area. All the information scanned by reader will be send to backend database system using point to point communication system. Application software will verify the information received to make alert to respective person or department. With the maximum transmit power set to the reader, reading coverage can be achieved up to 100 meters radius. With this power setting can track equipments inside vehicle. Figure 8 shows a reader which is used for outdoor tracking system and checkpoint tracking system. By install outdoor reader at a few points it can provide more accurate and detail information for tracking management system.

Figure 7. Active RFID reader for indoor system

3.2.3. Checkpoint Tracking System

Checkpoint tracking system use the same concept as explained in precious section, the only different is the antenna part; in this case directional antenna is used. The reader used for checkpoint system is set with maximum transmits power and directional antenna are used, direction of antenna facing to way of vehicle going out checkpoint. With directional antenna reading range of reader can reach up to 100 meters and items or assets in vehicle are still be able to be detected. Reading distance or coverage area of reader can be adjusted depend on requirement, in this application setting distance is 30 meters, with this setting items inside vehicle still can be detected also in various types of vehicle [7].

Figure 8. Active RFID reader for checkpoint system

Figure 8 shows an active RFID reader for checkpoint tracking system, additional feature adds on such as alarm system, interface to monitoring system. The reader powered by 12 VDC with built in backup power supply, battery embedded in the reader unit as backup power supply to reader for continuously reading and tracking system. At the checkpoint tracking system officer can monitor every single items pass through detected by reader, this to help officer to identify equipment ID and asset series no. Application software also is able to show asset picture at monitoring system when items is detected by reader.

3.3. Data Management System Flow

This asset tracking and management system consist of a few readers as scanner to detect asset movement, all the information go to one central processing system and require data management (middleware) to control data flow. Figure 9 shows how data flowchart, start from reader scanning the tags and every reader send data to backend system using those media as mention early, the last step of data processing flow is send message (alert) to respective department.

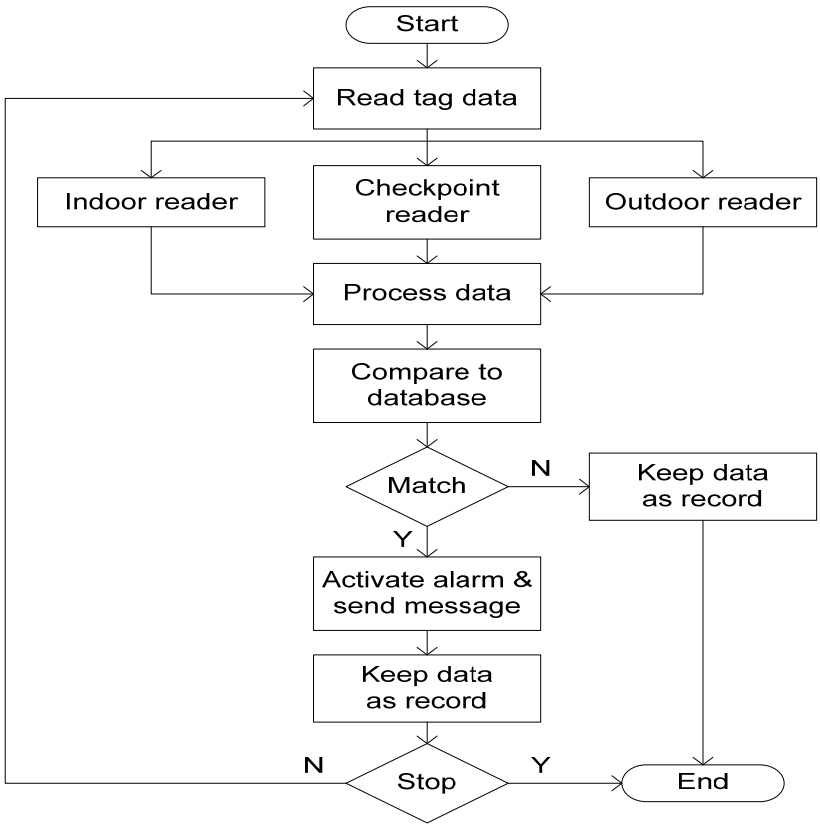

Figure 9. Data management flowchart

Middleware are used for buffer between readers to application software, with some data filtering to avoid unnecessary data processed. Unnecessary data may slower down the system. Application software communicate to server database to keep update every transaction of data and recorded. Figure 10 shows RFID application software used for this asset tracking system and middleware system as buffer between readers to application system. Application software also shows equipment identity from which reader information captured [7].

4. Results and Analysis

Some testing was conducted to check reader reading range, coverage area, response time and performance in various fields of system and scenarios. This asset tracking have three systems and every system used different type of antenna depend on environment. Figure 11 shows the reading distance versus radio signal strength indicator (RSSI) of radio, the reader sensitivity is up to -120 dBi. At this point the tag still can be detected by the reader with distance up to 100 meters for indoor environment and for others as shown in the graph.

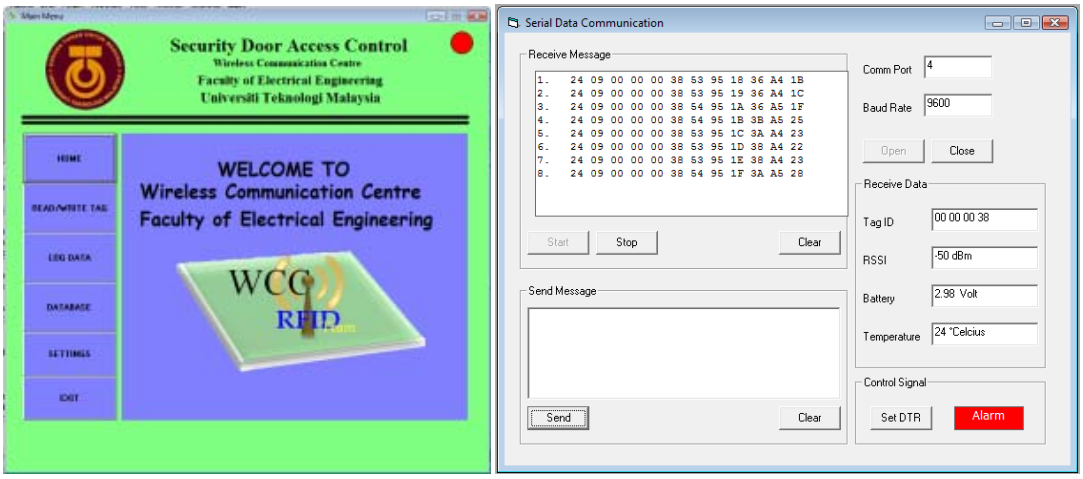

Figure10. Application software and RFID middleware

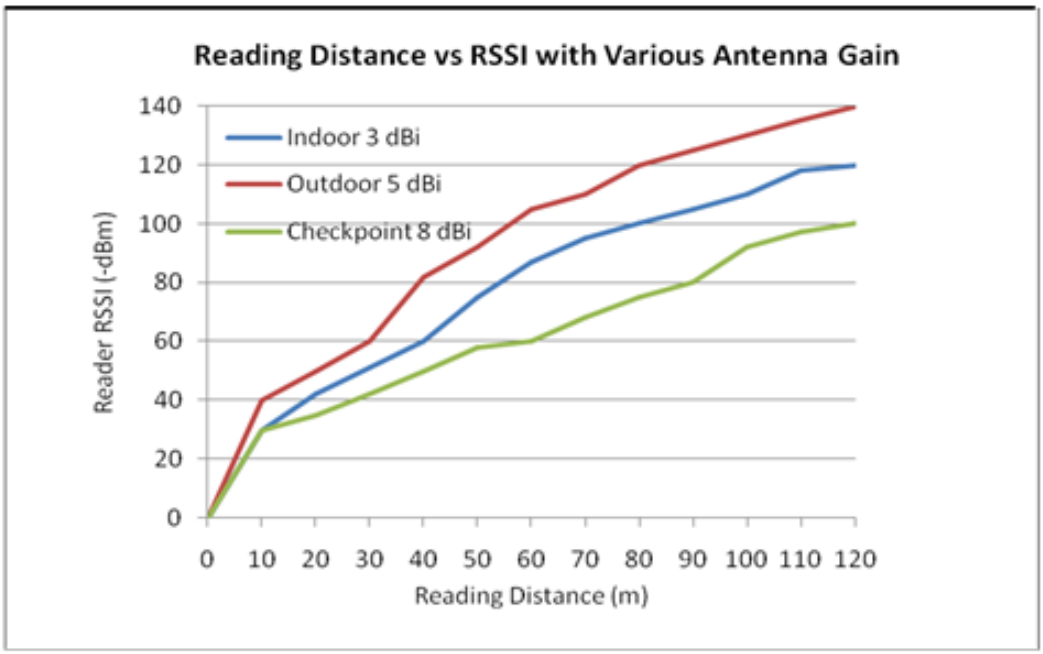

Figure 11. Graph reader reading distance vs RSSI

Experiment was successful tested by using spectrum analyzer to collect data of receive signal strength from the tag. Equipment setups and setting such as antenna gain, power transmits and distance based on system configuration. Result shows different response for each system, this due to environment factor and propagation effect.

Simple Frii's Equation :

$$r_{max} = \frac{\lambda}{4\pi}\sqrt{\frac{P_r\, G_r\, G_t\, \tau}{P_{th}}}$$

$$\tau = \frac{4Rc\, Ra}{|Zc+Za|^2}, \quad 0 \le \tau \le 1 \qquad (1)$$

where

r_{max} : Maximum reading range
λ : Free space wavelength
P_r : Power of RFID reader
G_r : Gain of RFID reader antenna
G_t : Gain of tag antenna
P_{th} : Threshold power of RFID chip
τ : Matching coefficient of tag and antenna
Rc : Real value of impedance chip
Ra : Real value of impedance antenna
Zc : Impedance of chip
Za : Impedance of antenna

The Frii's free space transmission formula is first expressed in terms of wireless power calculation. Receive power by reader can simply calculate using Frii's free space formula as equation (1), where Pr is receive power in dBm, Pt is transmit power of reader in dBm, Gt is reader antenna gain in dBi, Gr tag antenna gain in dBi and R is distance between reader to the tag in meter. In this experiment reader and tag power transmits is fix also for antenna gain and propagation factor, so variable factor is distance between reader to tag. In the testing a few scenarios of distance between tag to reader tested and data collected as shows in graph fig. 11 above.

Measurement result indicate with red color line in the graph is indoor tracking system with 3 dBi antenna gain, reading distance up to 100 meters as shows in the graph with RSSI -130 dBm. Second result is for outdoor systems that indicate in blue color line shows reading distance up to 100 meters with 5 dBi antenna gain, in this case shows RSSI -110 dBm. Lastly for checkpoint systems as indicate in graph green color line shows good response, for the 100 meters reading distance shows RSSI -90 dBm and for 120 meters reading distance from reader shows -100 dBm. All the results used different type of antenna and antenna gain.

Radio signal strength indicator (RSSI) in each system as mention before are used for reference alarm indicator, alarm system to alert to the officer or staff that unauthorized item passing through or away from the home of location. Result of RSSI as shown in fig. 10 is not linier between signal to distance but it is enough for indicator reference. Since this system does not require precision input reference. At the same time when alarm is triggered, on the monitoring display shows the picture of the items captured, all the information keeps in one central database. Centralize database choose because to provide one source and centralize record. By using GSM module that connected to central server, a message will send to representative person use them mobile phone to give alert and information when unauthorized items or asset pass thru checkpoint that belong respective department. This system used to give faster response to the officer.

5. Conclusion

Asset tracking and management system using active RFID technology successfully test and working, the system is separate by three major systems, namely indoor tracking system, outdoor tracking system and checkpoint tracking system. All the information captured by respective tracking system send to one central backend system, application software will process the information receive by refer to item information that keep in the central database. If the item captured is unauthorized to bring out than alarm will alert staff or officer, respected item displayed on screen to know actual item detected, also message are send to respective person to alert to the owner. All the information and transaction recorded in a database for checking and documentation purpose.

Alarm system input trigger by using RSSI signal received, using RSSI system as reference indicator, system can determine distance or radius of detected items, alarm triggered zone for alarm system can be adjust depend on location and environment required. The use of RSSI signal as alarm reference indicator because of parameter have easy to set, also in this system does not required high accuracy in distance measurement, as the main objective this system is to detect asset movement and tracking system.

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