Remote data collecting for water meter (automatic meter reading) in high-rise building construction

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Abstract. Managing water demand is a question that always concerns apartment management boards especially the number of meter readings, which faces many problems in terms of labor investment costs, time spent on manual reading is too long and not really effective. Currently the remote reading solution based on the principle of broadcasting and receiving radio waves is a trend in Ho Chi Minh City. This study aims to determine the performance of remote reading systems when applied on high-rise buildings. The objective of the study is to find out the scope of the activity or the best range of reading of radio waves in high-rise buildings. Methods of empirical survey and statistical data were collected in May, 2019. The results showed that the radius of the broadcasting range is about 16m-25m.

1 Introduction

Ho Chi Minh City is one of Vietnam's largest cities with a densely populated and concentrated population. Demand for clean water is always one of the top concerns. Since then, the management of clean water requires more flexibility and efficiency than before. The shortcomings in the process of managing the clean water production of the people are what should be discussed. One of the shortcomings is the investment cost for reading and recording the water meter index. Reading the clock number is always a boring and time-consuming task. For common conventional reading method, the digital reader must directly read the water meter readings to calculate the user's cost of water consumption. In the naked eye, the digital reader will record the value displayed on the water meter, subtracting a previous month's numerical value from the recorded value and giving the user a report invoice [1].

The process of reading this meter has a drawback in that it requires a large amount of manpower, which lead to increased costs. In addition, readers may incorrectly write the numerical values of the meter, in many cases where no one is present in the apartments to be checked or some individuals may
refuse the request to read the meter inside the property. Moreover, meter reading centers require a large amount of human resources to process digital data recorded by the readers through computers, which results in a lot of additional costs [2].

In order to solve the problem of shortcomings from this traditional reading method, the remote meter reading method was born with the support of advanced technology devices. The remote meter reading system has been developed from communication via wire signal [3] to wireless (radio) signals [4]. Only with the support of a regular transport vehicle (truck or motorbike) can we set up an automatic and time-saving digital reading journey [5]. Moreover, the remote reading system can send a warning of clean water leakage, which not only protects the quality of domestic water for the local citizen but also saves clean water resources [6], of which recently, the United Nations World Development Report stated that by 2050 up to a quarter of the population will possibly live in areas of clean water scarcity [7]. The importance of in-house wireless communication systems is increasingly confirmed when in the United States there have been more than 40 million automatic meter readings installed over the past several decades (reading water meters by radio waves is also part of the radio information system) [8].

However, when studying the ability of remote reading devices to see that the radii of radio transmitters are impaired, the properties of construction materials are important factors to predict the precise wave propagation in indoor environment, in which research has suggested that when dividing waves prevention levels from low to high, walls and floors are at a high level and the degree of decline of radio waves has a tendency to increase if it goes through many layers of components that constitute a high-rise housing project [9] [10]. In addition, equipment maker Izar Radio Receiver (research object) stated that the radio reception range of 434MHz can reach up to 500m [11] but in fact, from the results of the study, it shows that the coverage radius is only 16m-25m.

The research will explain this problem with the goal of determining the optimal position for the meter data reader to obtain all the meter signals in the building or the location to install fixed radio receivers.

2 Materials and Methods

2.1. Theoretical basis

Currently, many studies have been successfully developed when applying radio signals in the field of automation, of which researches on AMR (Automatic meter reading) in clean water management are outstanding. Studies on AMR are called automatic water meter readings based on the principle of radio frequency transceiver of 868MHz or 434MHz and read these wave signals in the form of numbers equivalent to the number displayed on the water meter. However, when applying this technology to high-rise buildings, somethings should be considered such as the followings:

Radio wave is a form of electromagnetic radiation that has a longer spectrum than infrared light, the frequency from 3 kHz to 300 GHz. Radio waves transmit at the speed of light and in nature, it comes from lightning.

We know that the propagation of electromagnetic waves in the environment has a very complex interaction with building structures. The impact of external and internal walls, floors, ceilings and windows on electromagnetic waves changes the amplitude and phase of the propagating signal [2].

In order to assess whether these external elements are or are not related to the radius of the water meter reading in a high-rise building, the study is based on the results of the actual reading work to find the concentrating intervals of the data (25, 75 percentile) and from there evaluate the most accurate coverage radius.
2.2. Research model

2.2.1. Research object

The specific research object in this study is a German 15mm diameter Auriga water meter, which incorporates an Izar Radio transmitter - after every 8 seconds they will emit a radio frequency signal of 434MHz. At the moment, if the Izar receiver wave receiver is in Izar Radio's coverage area, the water consumption data and some warnings if any will be sent to the display immediately (smart phone or handheld device). From the display set, data is sent to Izar @ Net2 software to produce the final product, which is the list of water users.

![Figure 1. Remote water meter reading cycle](image)

2.2.2. Research range

The meters are read and the data collected is determined at the same time. The study time was in May 2019 in Go Vap District, Ho Chi Minh City.

The study is based on a signal survey of 220 water meter samples of the same size and technical standards in Cityland-CH3 condominium in Go Vap District, Ho Chi Minh City. Auriga watch model, 15mm diameter, signal reading method via the Izar @ Net software are installed on smartphones and the Izar Receiver BT radio receivers. The meters of the apartments are put together in each technical room of each floor. Each technical room of the building contains 20 meters, 20 of them represent 20 apartments of that floor. There are 11 technical rooms corresponding to 11 floors of the building, and the location of these 11 technical rooms is the same on each floor (Figure 2). The measuring position is within a 0.5m radius in front of the main technical room door. Since the distance measured horizontally is not large, the study ignores this distance and only takes into account vertical distance.
The study focused on finding the signal catchment area of the remote digital reader (smartphone) so the survey focused on collecting data related to distance, signal, and quantity. The distance is calculated from the measurement position or the location of the meter to the same position but on different levels. For example, if the location is measured within a radius of 0.5m near the meters located on the 2nd floor, the distance received will be calculated by $3.5m \pm 1m$; $3.5m$ is the distance calculated from the position of the meter on any floor to the meter position located on the adjacent floor (upper or lower floor), $1m$ is the distance calculated from the display set or the hand-held measuring set (smartphone) to the floor or to the meter position. The measured signal is divided into 2 groups, received group and not received group.

To collect data from the 1st floor, 2nd floor, and the remaining floors, proceed to the technical room location where the meter is located. Then turn on the radio receiver and display unit (smartphone) at the same time, the data collected to the display unit will be transferred to the computer for statistical analysis. Time for each measurement on each floor is 5 minutes to ensure that no object is missed because the radio signal from Izar Radio does not emit continuous waves, only once every 8 seconds, and 5 minutes is the time from when the measuring device is turned on to the moment it stops receiving data about the display. Repeat this task for the remaining floors.

**Figure 2.** Typical floor plan of the CH3 apartment

**Figure 3.** Measuring tools and methods of measuring samples
2.2.3. Research method
Statistical methods and data were collected from the number reading process in turn and separated from floor 1 to 11 of high-rise building CH3. The software for charting support used for research is the R software version 3.5.2.

3 Results
The number of meters measured at each floor is not the same, as shown in Figure 4. The upper part of the chart of Figure 4 shows the number of non-measurable meters and the lower part shows the number of measured meters. Corresponding to each floor is a separate measurement.

![Figure 4. The number of meters measured across the floors of the CH3 building](image)

However, to explain more about the ability to receive signals from the clock, we will look into Figure 5. Figure 5 explains the relationship between measuring distance of reading and measuring signal.
Figure 5. Signal distribution chart based on distance

Table 1. Scope of vertical broadcasting in 11-storey apartment building.

|                | Minimum average distance | Maximum average distance | Maximum distance | Minimum distance |
|----------------|--------------------------|--------------------------|------------------|-----------------|
| Signal         | 1m                       | 36m                      | 25.08m           | -               |
| No Signal      | 9.5m                     | 37.5m                    | -                | 16.08m          |

The horizontal axis values are F.0, F.1, F.2, etc ... and Fl11 corresponds to the values of the G floor, the 1st floor, the 2nd floor, etc ... and the 11th floor. The value on the vertical axis represents the interval How from the clock to the measuring position (Figure 5). The 25% percentile explained that at most 25% of the measured meters, the distance below the value is displayed perpendicular to the vertical axis, similar to the 75% percentile that explains that there is at most 75% of the meter measured has a distance below the value that it represents respectively on the vertical axis. (eg, in Figure 5 column F.0, the value at 25% percentile says that at most 25% of the meters have a similar distance of less than 6m, at most 75% of the measured meters have a distance below 16.5m, and the
50% median explains that 50% of the meters have a distance above 9.5m, 50% of meters have a distance below 9.5m). The peripheral object, also known as the exception object, is the jamming value caused by many random factors, which are often valued beyond the focus interval of the data.

4 Discussion

It is easier to recognize the number of meters read from the 5th, 6th, and 7th floors than the rest (Figure 4), meaning that the receiving area in these locations is the widest. Based on the measured results, the average distance that radio signals are transmitted in high-rise buildings, the material layers are 25.08m for the cases of receiving waves, and 16.08m for the case of not receiving wave.

For the periphery, Figure 5 shows that the presence of these objects is relatively small, accounting for only about 2% -3% of the 220 observed objects (water meters), causes can be derived from random factors and these factors are not in the scope of the study so it is recommended to eliminate these objects to avoid the possibility that they can affect the accuracy when we study the real distance that radio waves 434MHz can transmit in high-rise buildings. In this case, the research shows that the best reception distance in a high-rise building which has the same factor as the CH3 apartment building, most water meters should be in the range of 16.08m and should not exceed 25.08m. This method of research can be applied to find the most appropriate distance for a digital reading process at equivalent high-rise buildings using automatic digital radio reading, not just the CH3 condominium. However, if this method is applied in other high-rise buildings, please be noted that in the data synthesis and analysis process, the distance from the measurement position to the position of each meter should be recalculated to achieve the results corresponding to the conditions of that project.

5 Conclusions

In order to find out the true distance that 434MHz frequency radio transmits in high-rise buildings, the study has achieved the expected results that the best range of reception should be within the range of 16m and should not be exceeded. 25m. Along with that, the application of this analytical method for high-rise buildings is feasible and can be used to make prediction for high-rise buildings located in different locations, environments with different internal structure. The method will produce different results but still ensure that these results will best reflect and explain the nature of the building most accurately.

References

[1] Das, Vinu. (2009). Wireless Communication System for Energy Meter Reading.
[2] HAN, Myoung. System and method for wireless automatic meter reading. U.S. Patent Application No 10/148,896, 2003.
[3] Zaballos, Agustin & Vallejo, Alex & Majoral, Marta & Selga, JM. (2009). Survey and Performance Comparison of AMR Over PLC Standards. Power Delivery.
[4] DeWeerd, A. W., May, C. J., & Tilka, S. C. (2002). U.S. Patent No. 6,351,223. Washington, DC: U.S. Patent and Trademark Office.
[5] Brennan Jr, W. J. (1995). U.S. Patent No. 5,451,938. Washington, DC: U.S. Patent and Trademark Office.
[6] Bragalli, C., Neri, M., & Toth, E. (2019). Effectiveness of smart meter-based urban water loss assessment in a real network with synchronous and incomplete readings. Environmental Modelling & Software, 112, 128-142.
[7] Parmar, Akshay. (2019). Smart Water Management Market Reached US$ 11.62 Bn In 2017.
[8] ROUF, Istiiaq, et al. Neighborhood watch: Security and privacy analysis of automatic meter reading systems. In: Proceedings of the 2012 ACM conference on Computer and communications security. ACM, 2012. p. 462-473.
[9] Anthony C. Caputo, in Digital Video Surveillance and Security (Second Edition), 2014
[10] D. E. Bassey, R. C. Okoro, B. E. Okon, Modeling of Radio Waves Transmission in Buildings Located Around Niger Delta Urban Microcell Environment Using “Ray Tracing Techniques”, Volume 5 Issue 2, February 2016

[11] https://www.diehl.com/metering/en/portfolio/software-system-components/software-system-components-products/software-system-components-product/izar-receiver-bt/64022/