

# Application of Metric Dimensions to Minimize the Installation of Fire Sensors on The Rectorate Building of Pasifik Morotai University

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**Abstract.** The metric dimension of the connected graph  $G$  for each  $v \in V(G)$  to the set  $W$  is  $r(v|W) = (d(v, w_1), d(v, w_2), \dots, d(v, w_k))$ .  $W$  is called the resolving set if every vertex  $u, v$  in  $G$ , if  $u \neq v$ , then  $r(u|W) \neq r(v|W)$ . Then the resolving set with the minimum cardinality can be called the minimum resolving set. The cardinality is called the metric dimension of  $G$  and is denoted by  $\dim(G)$ . This study aims to study and apply the concept of metric dimensions to minimize the installation of fire sensors in a building and focus on saving procurement costs and monitoring security against fire hazards. The Rectorate Building of the Pasifik Morotai University is under study, which consists of 3 floors with 55 rooms. From the results of the study, it was obtained that the fire sensors needed on the first floor were three, and on the second floor, three. There were three fire sensors on the third floor, so the number of fire sensors that will be installed in the Morotai University Pacific Rectorate Building is nine, regardless of the relationship between the floors.

**Keywords.** Minimum resolving set, Metric dimensions, Fire sensor

## 1 Introduction

Graph theory has a variety of discussion topics that can be applied in everyday life. One of the interesting ones is related to metric dimensions. Harary and Melter first proposed metric dimensions in graph theory in 1976 [1]. The metric dimension is the set that has at least one connection from the resolving set. Until now, Gary Chartrand, a mathematician from America, is still studying and developing metric dimensions. Also, the one developed by Chartrand shows that the graph is connected  $G$  with order  $n > 3$  so that  $\dim(G)=1$  if and only if  $G$  is path [2]. The resolving set with the minimum cardinality is called the minimum resolving set, and the cardinality is called the metric dimension of  $G$  denoted by  $\dim(G)$ .

One application of metric dimensions in everyday life relates to the system of fire sensor installation in high-rise buildings [3]. The installation of a fire sensor is essential in a building, especially for high-rise buildings, where this tool is designed to detect the location or room that is the source of fire or smoke. Fire sensors can also prevent the rapid spread of fire to other rooms. However, in the installation of fire sensors, we must be careful because in the installation of fire sensors, if there are too few, it will be challenging to detect fires. However, if there are too many, the fire

sensor installers will experience a significant cost loss in procurement. The optimal installation of fire sensors is perfect for high-rise buildings, especially the building to be studied, the Morotai Pacific University Rectorate Building, which consists of the 1st floor, 2nd floor, and 3rd floor. The installation of fire sensors will focus on optimizing procurement cost savings and security monitoring against fire hazards that might happen.

Previously Suhud Wahyudi's research in analyzing the metric dimensions of a graph in general, whether it can be applied in a building with 12 rooms. In his invention, only three fire sensors had to be installed in the building [3]. Furthermore, Maria M. E. Sulistiawati's research shows that the number of fire sensors without considering the relationship between floors is only 14. In contrast, if we pay attention to the relationship between floors, only 13 fire sensors are needed [4]. Asmiati et al. research in their research only focused on the concept of determining the placement of fire sensors in a minimum two-story building, then making an application for determining the placement of fire sensors using the C++ programming language [5]. Unlike previous studies, which minimize the use of fire sensors, it is assisted by the SketchUp application to facilitate the understanding of graphing in the Geogebra application. The graph under study focuses on connected, simple,

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and finite graphs. All terminology, notations, and definitions use [6].

## 2 Research Methods

This is a literature and observation research with detailed stages described as follows.

- The first step that the researcher took in this research was a literature study on relevant topics to get the research's novelty. At this stage, a literature study is carried out by studying books, journals, or other research references that use metric dimensions.
- Collecting data by observing the relevant agencies and conducting direct interviews.
- Make a 3D floor plan of the Morotai Pacific University Rectorate Building for easy understanding using the SketchUp application. Data Processing From the floor plan made to be easy to understand, we use the SketchUp application to make it easier to understand, then represent it to the Geogebra application so that it can be converted into graph form.
- Determine the minimum resolving set of the Morotai Pacific University Rectorate Room in order to facilitate the installation of the fire sensor to a minimum
- Determine the number of fire detection equipment needed to install fire sensors at the Morotai Pacific University Rectorate Building using the minimum possible metric dimensions.

## 3 Result and Discussion

### 3.1 Representation of the Pasifik Morotai University building plan in a graph for first floor

On the first floor, there are several rooms, including the warehouse, toilets for women and men, prayer room, the Bureau of Personnel, the Student Affairs Bureau, the Administration and General Staff room, the General Bureau Headroom, the Finance Bureau room, the Treasurer room, the generator room, and pantry. The rooms are interconnected and can be represented in 3D using SketchUp and then graphing using GeoGebra to make it easier to understand and determine the minimum resolving set and the following representation.

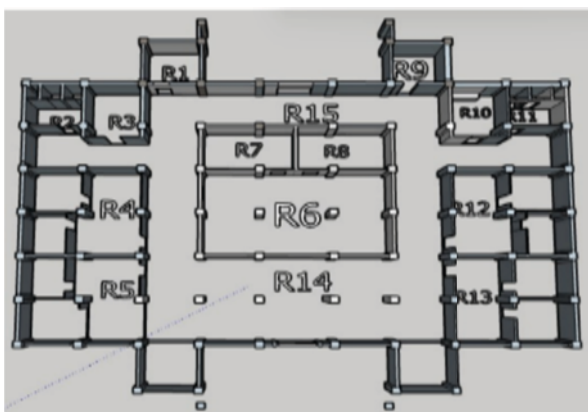


Fig 1. First floor

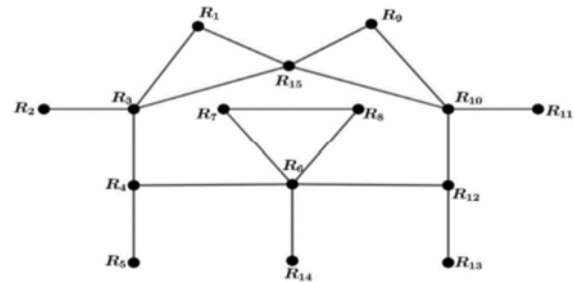


Fig 2. Representation graph of first floor

For  $W_3 = \{R_3, R_7, R_{10}\}$  we get  $r(R_1|W_3) = (1,4,2)$ ,  $r(R_2|W_3) = (1,4,3)$ ,  $r(R_3|W_3) = (0,3,2)$ ,  $r(R_4|W_3) = (1,2,3)$ ,  $r(R_5|W_3) = (2,3,4)$ ,  $r(R_6|W_3) = (2,1,3)$ ,  $r(R_7|W_3) = (3,0,3)$ ,  $r(R_8|W_3) = (3,1,3)$ ,  $r(R_9|W_3) = (2,4,1)$ ,  $r(R_{10}|W_3) = (2,3,0)$ ,  $r(R_{11}|W_3) = (3,4,1)$ ,  $r(R_{12}|W_3) = (3,2,1)$ ,  $r(R_{13}|W_3) = (4,3,2)$ ,  $r(R_{14}|W_3) = (3,2,3)$ ,  $r(R_{15}|W_3) = (1,4,1)$ , therefore  $W_2 = \{R_3, R_7, R_{10}\}$  is the minimum resolving set. So that fire sensors can be installed in Men's Toilet, Head of General Bureau, and Ministerial Room. So, the minimum resolving set in the picture above is three, so three fire sensors will be installed.

### 3.2 Representation of the Pasifik Morotai University building plan in a graph for second floor

The rooms on the second floor are the core rooms of the rectorate building. The second-floor room consists of a prayer room, the head of the foundation's room, the rector's room, the vice rector I room, the vice rector II room, the vice rector III, the foundation staff room, the dean's room, the senate meeting room, the foundation meeting room, the men's and women's restrooms, and the ministers.

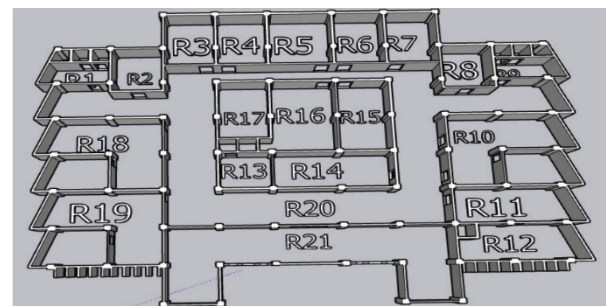
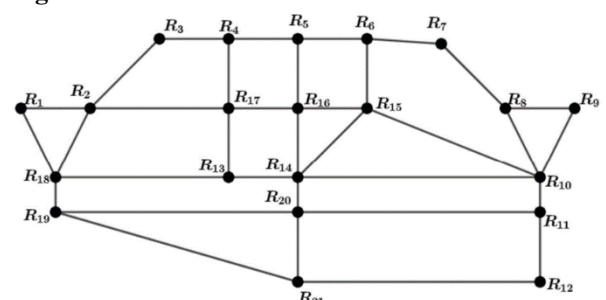


Fig 3. Second-floor

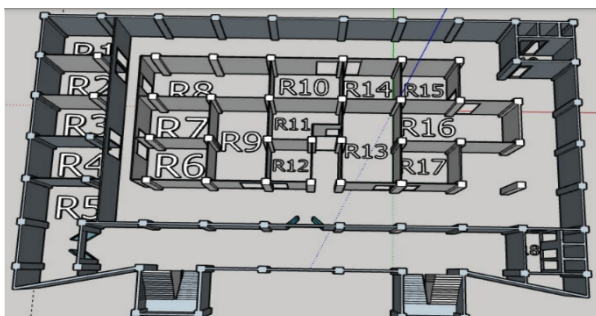


**Fig 4.** Representation graph of second-floor

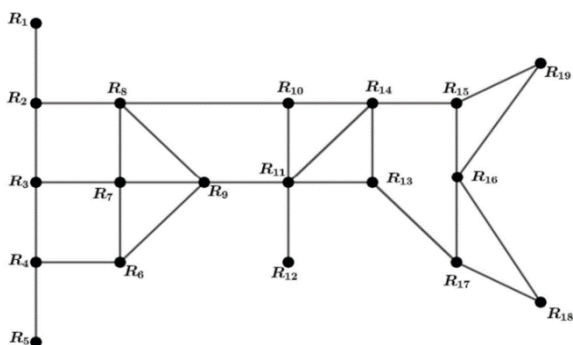
For  $W_3 = \{R_3, R_7, R_{14}\}$  we get  $r(R_1|W_3) = (2,6,3)$ ,  $r(R_2|W_3) = (1,5,3)$ ,  $r(R_3|W_3) = (0,4,4)$ ,  $r(R_4|W_3) = (1,3,3)$ ,  $r(R_5|W_3) = (2,2,2)$ ,  $r(R_6|W_3) = (3,1,2)$ ,  $r(R_7|W_3) = (6,0,3)$ ,  $r(R_8|W_3) = (5,1,2)$ ,  $r(R_9|W_3) = (6,2,2)$ ,  $r(R_{10}|W_3) = (5,2,1)$ ,  $r(R_{11}|W_3) = (5,3,2)$ ,  $r(R_{12}|W_3) = (5,4,3)$ ,  $r(R_{13}|W_3) = (3,4,1)$ ,  $r(R_{14}|W_3) = (4,3,0)$ ,  $r(R_{15}|W_3) = (4,2,1)$ ,  $r(R_{16}|W_3) = (3,3,1)$ ,  $r(R_{17}|W_3) = (2,4,2)$ ,  $r(R_{18}|W_3) = (2,5,2)$ ,  $r(R_{19}|W_3) = (3,5,2)$ ,  $r(R_{20}|W_3) = (4,4,1)$ ,  $r(R_{21}|W_3) = (4,5,2)$ . Thus  $W_3 = \{R_3, R_7, R_{14}\}$  is the minimum resolving set of the second-floor graph so that fire sensors can be installed in Dean's Room for Engineering, Dean's Room FPIK, and Foundation Staff Room.

**3.3 Representation of the Pasifik Morotai University building plan in a graph for third-floor**

On the third floor, study program rooms include Industrial Engineering, Informatics Engineering, Civil Engineering, Environmental Engineering, Mathematics, Accounting, State Administration, Marine Science, Fishery Products Technology, PGSD, English, and meeting rooms for each study program and toilets.



**Fig 5.** Third floor



**Fig 6.** Representation graph of third floor

For  $W_3 = \{R_3, R_{10}, R_{17}\}$  we get  $r(R_1|W_3) = (2, 3, 6)$ ,  $r(R_2|W_3) = (1, 2, 5)$ ,  $r(R_3|W_3) = (0, 3, 5)$ ,  $r(R_4|W_3) = (1, 4, 6)$ ,  $r(R_5|W_3) = (2, 5, 6)$ ,  $r(R_6|W_3) = (2, 3, 4)$ ,  $r(R_7|W_3) = (1, 2, 4)$ ,  $r(R_8|W_3) = (2, 1, 4)$ ,  $r(R_9|W_3) = (2, 2, 3)$ ,  $r(R_{10}|W_3) = (3, 0, 3)$ ,  $r(R_{11}|W_3) = (3, 1, 2)$ ,  $r(R_{12}|W_3) = (4, 4, 6)$ ,  $r(R_{13}|W_3) = (4, 2, 1)$

$r(R_{14}|W_3) = (4, 1, 2)$ ,  $r(R_{15}|W_3) = (5, 2, 2)$ ,  $r(R_{16}|W_3) = (6, 3, 1)$ ,  $r(R_{17}|W_3) = (5, 3, 0)$ ,  $r(R_{18}|W_3) = (6, 4, 1)$ . Thus  $W_3 = \{R_3, R_{10}, R_{17}\}$  is the minimum resolving set of the third-floor graph so that fire sensors can be installed in Civil Engineering Study Program, Mathematics Meeting Room, and State Administration Study Program room. Then the minimum resolving set in the picture above is three, so three fire sensors will be installed.

**4 Conclusion**

Determination of the location and the minimum number of fire sensors from each floor that can be installed in the Pasifik Morotai University Rectorate building, there are nine fire sensors. Among them, on the first floor, three fire sensors are installed in the Men's Toilet, Head of General Bureau, and Ministerial Room. On the second floor, there are three fire sensors: Dean's Room for Engineering, Dean's Room FPIK, and Foundation Staff Room. Furthermore, on the third floor, three fire sensors are installed in the Civil Engineering Study Program, Mathematics Meeting Room, and State Administration Study Program room.

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