Spatial analysis for calculating closest distance of operators’ location to Base Transceiver Station (BTS) in Banda Aceh city

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Abstract. Base Transceiver Station (BTS) is used to generate auxiliary signal for cellular uses. BTS will support all the activities regarding data exchange such as messaging and web browsing. The spatial data plays important role to support BTS’s signal coverage area. The spatial data also can be used for designing of new cellular networks and construction new BTS. This research purpose is to help operator manager find the distance of BTS distribution that will be used to make group of BTS position for the operators. In this research Geographic Information Systems (GIS) has been utilized to analyse the nearest distance and to create group of BTS. Spatial network analyst uses network data path to find out the nearest distance from operators’ location to all of BTS in Banda Aceh by using tools closest facility, and to analyse the operators’ location grouping based on the mean value BTS distance by using buffer method. The result of this research has calculated the average distance from the operators’ location to all BTS is 6.2 Kilometres. Based on the average distance the first team will manage 7 BTS and the second team will manage 14 BTS.

1. Introduction
Base Transceiver Station (BTS) as an auxiliary signal generator is used for cellular purposes. Every activity for data exchange such as web browsing and others cannot be separated from the role of BTS. To support the smooth communication of data through BTS to be more optimal, the role of spatial data is needed. With spatial data, cellular network development such as new BTS development can be considered and plotted. The position of a BTS has been calculated based on the range of the transmitted signal. The number of base stations in urban areas is greater than in rural areas because each operator wants full signal coverage so that it can attract consumers to use the operator [1].

Base Transceiver Station (BTS) as an additional signal generator is commonly used for cellular purposes. Every activity for data exchange for example web browsing and others cannot be separated from the role of BTS.

Geographic Information System (GIS) as a computer-based system is used to collect, store, organize, transform, manipulate and analyse geographic data [2]. The GIS capability is expected to help provide complete and easy information for BTS operators in Banda Aceh. A geographic
information system is utilized for displaying data on the distribution of BTS locations and for providing the complete information of BTS. It also can be used by operator manager to easily find the distance and distribution of BTS. The results of the distance search are also used to make groups of BTS positions. These groups will be used for managing the BTS’s operator.

Network analyst is a method of spatial analysis used to analyse the movement of a resource from one location to another and to find the closest distance to that location. Network analysts utilize segment or line features in conducting analysis. Network analyst application in determining the shortest path from one object to another is processed through the arithmetic process of connecting lines that have attributes [3]. In network analysis, one of the line features that can be used is road feature [4]. This study will find the closest distance from the operators’ location to the BTS using the road feature.

2. Research Method
2.1. Geographic Information System (GIS)
Geographic Information System (GIS) is a computer-based system to collect, store, organize, transform, manipulate, and analyse geographical data [2]. GIS can be defined as a combination of computer hardware and software that allows to manage, analyse, map spatial information and attribute data with cartographic accuracy [5]. GIS is all types of manual and computer-based procedures for storing and manipulating geo-referenced data [6]. GIS uses spatial data as input in doing its work. Spatial data is data that refers to the position, objects, and relationships between them in the earth's space. Spatial data is one item of information, in which there is information about the earth including the surface of the earth, below the surface of the earth, and under the atmosphere [7].

2.2. Building a Topology
The initial stage before conducting network analysis is to check the road data used by the building topology. Topology is used to find out the relationship between one object with another object. In GIS topology there are data characteristics such as lines, polygons and points. Each data characteristic has certain rules, these rules have been provided by ArcGIS software [8]. The topology has been created to easily find out the lines that are not connected to each other, the lines that exceeded the limit and others. This topology will be included in the Banda Aceh City road map to find out which roads have been cut off. The rules used in this topology are “Must not have dangles”, which has several functions including: “a). Extend: to connect the dangle at the end of a line segment to the feature in front of it, as long as the spanning distance is met.”, “b). Trim: to remove line features if the dangle point at the end of the intersection line falls within the specified spanning distance tolerance.”, “c). Snap: to unite the dangle line to the nearest line that falls within the spanning distance tolerance.”. So that there will be no more topological error for all road features that will be used in network analysis.

2.3. Creating a Dataset Network
A road network has rules about how an object passes through it. For example, a road network is a combination of one-way and two-way roads. The rules used in the network dataset include: a). At mileage use kilometres. b). One-way streets are regulated with separate columns added to the attribute table named "ONeway" with the following rules as shown in Table 1.

According to the table, the rules of a unidirectional or bi-directional road are very much determined by digitizing road line elements. Especially roads that can only be traversed in one direction can be seen from the digitization of certain road line elements. If in the same direction, the FT (From-To) value is the opposite if it is given the TF (To-From) value [9]. Based on the network dataset rules, the Banda Aceh City road network determines the direction and location of the destination by identifying and verifying the location of the BTS and the operators’ location house on the map. Each road segment is given rules, for example for two-way roads are coded TF or FT, so the Banda Aceh City road network can be used at a later stage to conduct network analysists [8].
Table 1. Types of road rules, modified from [8].

| Types of road rules                                      | Value                  |
|---------------------------------------------------------|------------------------|
| The trip can only be made from the starting line to the finish line, which is the same as the direction at which the line was digitized | FT                     |
| The trip can only be made from the finish line to the starting line, which is the opposite direction at the time the line is digitized | TF                     |
| Travel can be done Other values in both directions | Value does not need to be filled |

2.4. Network Analyst
Spatial analysis is utilized to perform analytical functions using GIS. Spatial analysis leads to many kinds of operations and concepts including simple calculation, classification, structuring, and cartographic modelling [4]. According to Cromley et al. [10] one of spatial analysis is network analysis that refers to the analysis of spatial data points or lines as an inseparable network. The network analysis tools used in this study is an extension “closest facility” to find the closest facility. Banda Aceh city road feature has been utilized as input data. This analysis finds the closest distance between the location of the operator’s house with all BTS in Banda Aceh city. There are four parameters, which are facilities, location, barriers and routes. Facilities location consists of initial facilities to start the trip and the destination location. The barriers are something that blocks route between two directions. The route is the result of the final route. The results of the closest facility produced the mileage attribute from the operator house to all existing BTS in Banda Aceh city.

2.5. Buffer
The results of the distance using the network analyst was obtained from the process of finding the average value of the BTS distance. After the result is put into a buffer including the average values, then the a BTS grouping is formed.

3. Result and Discussion
The network analyst applying the closest facility tool using the Banda Aceh city road network has found the closest distance from the location of the operator house to all BTS. In this study there are two operator houses that manage all BTS in Banda Aceh City. The following analysis has produced the closest distance from each home operators’ location to each BTS.

3.1. Analysis of the Closest Distance of the First Team
There are 21 BTS that spread throughout the Banda Aceh City. The search results for the closest distance from the location of the first operator's house in Darussalam area to all BTS in the city of Banda Aceh has produced the shortest distance to the BTS at Lhok Bangka Darussalam area by 0.9 km and the farthest distance to the BTS at Surien Empeerom area with a distance of 12.2 km. After getting the mileage results to all BTS in Banda Aceh city, the average value of the mileage was searched. The first team's average score is 7.9 Km.

3.2. Analysis of the Closest Distance of the Second Team
The search results for the closest distance from the location of the second operator's house in Geuceu Complex area to all BTS in the city of Banda Aceh has produced the shortest distance to the BTS at Banda Raya 2 area by 0.7 km and the farthest distance to BTS at the Lhok Bangka Darussalam with the distance of 10.7 km. After getting the mileage results to all BTS in Banda Aceh city, the average
The value of the mileage was searched. The second team average score is 4.9 Km. The following network analysis map for the first and the second team can be seen in Figure 1.

![Network Analysis Map](image)

**Figure 1.** Spatial network analysis and buffer for the first and the second team.

### 3.3. Average Distance of the Two Teams

Based on the optimal path results, the first team had an average value of 7.9 km, while the second team had an average value of 4.5 km. So, we can conclude that the results of the two teams' travel paths have an average value of 6.2 km, then the average results will be entered into the buffer method. Table 2 shows the average scores of the two teams.

| Operator     | Minimum (km) | Maximum (km) | Mean (km) |
|--------------|--------------|--------------|-----------|
| First Team   | 0,9          | 12,2         | 7,9       |
| Second Team  | 1            | 10,7         | 4,5       |
| Average (km) | 6,2          |              |           |

### 3.4. First Team Buffer

The results of the network analysis process obtained an average value from both teams, then the buffering process is based on the average value of the two teams. Based on the results of the first team buffer with a range of 6.2 kilometres. As the result the first team will manage 7 BTS. At 1 kilometre range there is 1 BTS, namely Lhok Bangka Darussalam BTS, at 2 kilometres there is no BTS, at 3 kilometres range there are 2 BTS namely Ulee Kareng BTS and Prada BTS, while at 4 kilometres
range there are 4 BTS namely Meuraxa BTS, Berawe BTS, Ilie BTS and Alue Naga BTS and range 5, 6 and 6.2 kilometres have no BTS.

3.5. Second Team Buffer

Based on the results of the first team buffer with a range of 6.2 kilometres. As the result the first team will manage 14 BTS. At 1 kilometre range there is 1 BTS, namely Ketapang MC BTS, at 2 kilometres there are 5 BTS, namely SC 03 BTS, Ketapang BTS, Ketapang 4 BTS, Banda Raya BTS and RS Fakinah BTS, at 3 kilometres range there are 6 BTS namely Surien Emperom BTS, Stadion Lampenerut BTS, Aceh Rayeuk BTS, Perlak BTS, Panglima Polem BTS, and Ulee Lheue, while at 4 kilometres range there are 2 BTS namely Kuta Raja BTS and Lampulo Keudah BTS and range 5, 6 and 6.2 kilometres have no BTS.

3.6. Results of Both Team Buffer

The results of grouping the two teams using the buffer method can be seen in Figure 2. The buffer can only be inputted with the range of distance, it cannot be inputted with the number of points that is wanted to group. The grouping of operators’ locations is based on the mean value of the distance which is 6.2 km in this research. The result of the blue colour is 1 km range, green is 2 km range, pink is 3 km range, red is 4 km range, purple is 5 km range, black is 6 km range and green are 6.2 km range. From the grouping of the two teams, the results obtained are the first team will manage 7 BTS while the second team will manage 14 BTS.

![Figure 2](image-url)  
**Figure 2.** The results of grouping the two teams using the buffer method.
The results of network analysis for group 1 will take route around 19,964 meter or 20 km from tower no. 1 to tower no. 9 and group 2 will take route around 28,869 m or 28 km from tower no. 1 to tower no 15 as shown in Figure 3.

4. Conclusion
The results of the first team's travel path have an average value of 7.9 km while the second team has an average value of 4.5 km, and the results of the average value of the two teams is 6.2 km. Based on the grouping using the buffer method, the results is obtained, the first team will manage 7 BTS located in Syiah Kuala sub-District, Darul Imaarah sub-District and Kuta Alam sub-District. While the second team will manage 14 BTS located in Kuta Raja sub-District, Banda Raya sub-District, Meuraxa sub-District, Lueng Bata sub-District, Jaya Baru sub-District and Baiturrahman sub-District.

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References
[1] Hakim F, Anggraeni W and Pribadi A 2012 Optimasi perencanaan jumlah Base Transceiver Station (BTS) dan kapasitas trafil BTS menggunakan pendekatan goal programming pada sistem 44 telekomunikasi seluler berbasis GSM, Fakultas Teknologi Informasi (ITS),
Surabaya http://download.portalgaruda.org/article.php?article=54057&val=4186 accessed 01 June 2019.

[2] Yousman, Y. 2004. Sistem Informasi Geografis dengan MapInfo Professional. Dani, Yogyakarta.

[3] Nizamuddin, Aldika W A, Ardiansyah, Hizir and Muzailin 2019 WEBGIS Application for Planning the Tsunami Evacuation Route IOP Conference Series: Earth and Environmental Science 273 012051

[4] Demers M N 1997 *Fundamentals of Geographic Information Systems* (New York: Jhon Wiley & Sons.)

[5] Prahasta E 2005 *Sistem Informasi Geografis* (Bandung: Informatika)

[6] Aronoff S 1989 *Geographic Information System: A Management Perspective* (Ottawa: WDL Publication)

[7] Rajabidvard A dan Williamson I P 2000 *Spatial Data Infrastructures: Concept, SDI Hierarchy and Future Directions* Melbourne, Victoria: 45 Spatial Data Research Group, Department of Geomatics, The University of Melbourne.

[8] Sudomo O 2011 *Membangun Geodatabase* (Jakarta: PT. Duta Informatika)

[9] Puntodewo A, Dewi S, dan Tarigan J 2003 *Sistem Informasi Geografis untuk pengelolaan sumber daya alam* Bogor Barat: Center for International Forestry Research.

[10] Cromley, Ellen, K, McLafferty, Sara, L 2002 *GIS dan public health* (New York:The Guilford Press)