The cellular voice traffic profiling spatial urban land use for South Jakarta

H M Taki1, B M Djaja2, T Nurlambang3, M Z Lubis4 and R H Koestoer5
1Department of Urban and Regional Planning, Faculty of Environmental Design, King Abdulaziz University, Jeddah, Saudi Arabia
2Department of Archaeology, Faculty of Humanities, Universitas Indonesia, Depok 16424, Indonesia
3Department of Geography, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
4Department of Geomatics Engineering, Batam State Polytechnic, Batam 29461, Indonesia
5Study Program of Environmental Sciences, Universitas Indonesia. 10430, Indonesia
Corresponding author’s email: triarko@sci.ui.ac.id

Abstract. Cellular traffic in the literature can be classified into voice, SMS, and data. Along with the rapid development of internet technology, a cellular operator is required to have spatial-based customer behavior information as the primary data in making business policy. The use of cell phone in Jakarta is remarkably recorded, while competitors among cell phone providers unavoidably follow the customer's behaviors. Combined methods are applied such as statistical analysis of ANOVA and multiple comparison tests supplemented by the spatial techniques using Geographic Information System (GIS) to review the time and area differences of the voice traffic changes. A cellular provider name Indosat is chosen as a case of voice traffic model data. Simple land-use types of residential classifications are set up and isolated rings of Von Thunen are reconstructed to explain more on the relationship between voice traffic of cell phone and land use distribution. The result of research indicates that the voice traffic highly varies among residential strata and commercial areas. In addition, voice traffics vary between weekdays and weekends depending on the accumulated users.

Keywords: Voice traffic, spatial dynamic, cellular operator, land use, customer behavior

1. Introduction
Sandy defines the geography as the study of a variety of symptoms in the earth's surface in the space point of view [1]. In this case, Sandy wants to emphasize that any symptom can be a field of geography study if reviewed from the standpoint of spatial. Geography of communication has a concern about the influence of spatial human behavior in general [2-4] and more specifically devotes his attention on locations of human activity, the flow, the spread of information and communication through space [5], [6], as well as the effect of communication behavior towards the environment [7-9]. The presence of communication in space brings influence to the development of physical and mental changes and its
inhabitants [10-12]. Communication geography is the study of symptoms and problems geography, a more dynamic study in comparison with other geographic studies [13, 14].

The cellular telecommunication is one of the communication geographies which progresses rapidly [15, 16]. It is characterized by increasing the amount of income and customers from year to year, as well as the development of infrastructure network technology [17, 18]. There are three types of traffic in cellular telecommunication (i.e. data, SMS and voice) [19]. Nowadays, the development of traffic experiences a convergence because of the rapid impact of internet technology [20]. This development indicates a change of paradigm from voice-centric to data-centric [21].

The change of the paradigm from voice to data-centric caused some negative impact at the telecommunication business. The cellular operators who have been voice-based need to adjust the customer behavior data regarding its spatial distribution which needs an appropriate action of business policy [22]. In order to respect it, this research aims to study the spatial dynamics of cellular voice traffic on urban land use [22-24]. The traffic observation in this study performs each Base Transceiver Station (BTS) by associating the time difference [25-27]. The study subject is PT. Indosat (as the cellular provider service) in South Jakarta, Indonesia.

2. Methodology

2.1. Study case
This study was carried out in South Jakarta as the largest sales area of Indosat in terms of the customer’s number and sales product.

2.2. Data collection
The required data of this study consisted of two types of data, namely, spatial and cell data. Spatial data were obtained from BAPPEDA Jakarta Selatan. The data were displayed as low-cost residential, high-cost residential, and commercial areas [28]. The cellular data of voice traffic in Erlang units were retrieved from PT. Indosat during the period of January 2012. The data were regularly recorded every 24 hours on each BTS.

2.3. Data processing
The required data of this study consist of two types of data, namely, spatial and cell data. Spatial data were then divided into these categories:

- **First**, the low-cost residential areas are the type of residential land use, valued at < IDR. 2,000,000/m².
- **Second**, the high-cost residential areas are the types of residential land use, valued at > IDR. 2,000,000/m².
- **Third**, the commercial areas are the type of land assigned for industries, fisheries, markets, warehouses, workshops, service industries, and other regular offices.

Processing traffic data was began with some stages:

- **First**, determining the duration of the pick hours in the morning and night within 24 hours. It was conducted by measuring the difference of traffic based on an area at the same time using data of BTS. It was expected to represent overall customer activity within a single day and night.
- **Second**, calculating the average of voice traffic (Erlang unit) on each BTS within a single month:
  - Working days from Monday to Friday
  - The weekend includes Saturday and Sunday
  - The national holiday is Chinese New Year’s Day
- **Third**, calculating traffic capacity (equation 1) which compares the traffic to design capacity by adopting the method of spatial clustering [29].

\[
\text{Traffic capacity} = \frac{\text{Traffic (Erlang Unit)}}{\text{Design capacity}} \times 100
\] (1)
• Fourth, performing traffic capacity performance classification with the degree as follows:
  o 0–20 % = Low
  o 21–80 % = Normal
  o 81–100 % = High
  o > 100 % = Congested

2.4. Data analysis
Statistical analysis is the process of collecting and reading data to describe past behavior and characteristics. The statistical analysis in this study used SPSS software to see the normality of the data as well as the significance of differences in the data. While the spatial analysis involves geographic data that is applied to structures at the human level scale. The spatial analysis in this study used GIS software to obtain the relationship between traffic pattern and its land use.

2.5. Research framework
Research method followed framework steps as shown in figure 1.

3. Results and discussion

3.1. Statistical analysis
The first step was performing the normality test of the traffic capacity per-BTS by the type of land use. The variance equality test was conducted to determine the proper statistical method. The result was normally distributed and has a common variant. The method of analysis used a mixture of two variables, independent variables (traffic capacity) and the variable of land use types. The method was carried out to determine whether there are significant differences or not and whether those significant differences were influenced by both variables.

3.2. The test toward model assumptions.
Based on the similarity test variants in figure 2, it was indicated that the average voice traffic capacity of each station was normally distributed and the capacity of voice traffic was within the intended result.

Figure 1. Research framework
3.3. Normality data test
Based on the results of the Kolmogorov-Smirnov, the test showed no significant results (at the 5% significance level) and (0.471 > 0.05). Thus, the decision Ho was not rejected. Therefore, the conclusions of the data distribution were within acceptance.

3.4. ANOVA
The test results point out that the significant variables of differentiating average traffic per-BTS were the type of land use variable. It can be seen from the significance of 0.002 (< 0.05); it showed a significant difference in the average capacity of voice traffic per the land use. Hence, the type of land use affected the average traffic capacity of each BTS. The variable did not affect the average traffic per-BTS. It can be seen from the significance of value 0.937 (> 0.5). Then the average differences that exist between working days, Saturday-Sunday, and National holidays were not so noticeably affected by the traffic capacity on each BTS.

3.5. Traffic capacity by type of land use
The average traffic capacity on the low-cost residential (52%) was higher than the high-cost residential (40%) and the commercial areas (30%).

3.6. Multiple comparison tests
Multiple comparison tests showed a significant difference between voice traffic capacity of the low cost residential and others (high cost residential or commercial areas), while the high cost residential and commercial areas did not show a significant difference.

4. Spatial analysis

4.1. Working days

4.1.1. The capacity fluctuation of voice traffic per hour. Figure 3 indicates the capacity of voice traffic on working days tend to rise starting at 05.00 am. Then, it increases steadily between 08.00 am until 10.00 am. Later on, it tends to decrease by 06:00 pm. Then, it rises back between 08:00 pm to 09:00 pm.

![Figure 2. Similarity variant test](image-url)
4.1.2. The profile of voice traffic capacity on land use at working days of afternoon. The dynamic of voice traffic capacity on a working days afternoon based on land use can be explained by figure 4 where the voice traffic capacity is high in low cost residential, but normal in the high cost residential and commercial areas.

4.1.3. The profile of evening voice traffic capacity on land use on working days. Figure 5 below shows that the traffic is solid only in low-cost residential areas. However, voice traffic per-BTS is surprisingly low in high cost residential and commercial areas.

4.1.4. The spatial dynamic of voice traffic capacity on land use at working days. Table 1 shows the spatial dynamics of voice traffic on working days which occurred at 10–11 am and at 8–9 pm. Table 1 indicates the traffic capacity of the voice’s customer of the high cost residential is not always high in category for both morning and night. It has a normal level in the afternoon and low traffic at night.
4.2. Fluctuations of voice traffic per hour in the weekend

Figure 6 indicates voice traffic on Saturday and Sunday tends to rise at 4 to 6 am. In accordance with the activities of customers on the morning of the weekend. Then it tends to decrease by 4 pm. This shows a decrease in the activity of customers when it comes the time for them to return to their home.
After that, the traffic capacity voice is starting to increase again between 5–6 pm and reached a high level at 7–8 pm.

4.3. The voice traffic capacity on land use at the weekend afternoon

Figure 7 is the dynamics of capacity traffic voice on Saturday and Sunday afternoon based on land use and it explains the voice traffic capacity tends to be dense on the low cost residential but low on a high cost residential and commercial areas. The profile of voice traffic capacity profile on land use at weekend night is shown in figure 8.

4.4. The spatial dynamic of voice traffic capacity on land use on weekends

Table 2 below shows the spatial dynamics of voice traffic on Saturday which occurred at about 10.00–11.00 am and 08.00–09.00 pm.
Based on table 2, the traffic voice of customers with different types of land use in a low cost residential always shows high level in both times of day and night. Traffic voice of customers in the commercial areas has a low level at the day and keep low at night. Likewise, the voice traffic that occurs among customers in commercial areas is quite similar to the high cost residential, which is low during day and night.

4.5. The capacity fluctuation of hourly voice traffic on national holiday

The voice traffic capacity within 24 hours on national holiday showed the fluctuation as shown in figure 9 below. It shows the fluctuation of voice traffic capacity based on land use for 24 hours. The voice traffic capacity on national holiday tend to rise, starting at 06.00 am until 08.00 am. Then at 10.00 am, it begins to stabilize until 03:00 pm. This indicates an increase in the activity of communication at that given time period, and later on in the evening. Voice traffic capacity starts to rise again at 08.00 pm.

4.6. The voice traffic capacity on land use at national holiday afternoon

Figure 10 below indicates the dynamics of voice traffic capacity on a national holiday based on land use. It indicates the voice traffic capacity tends to decrease towards the southwest, otherwise getting up towards the northeast.

4.7. The profile of voice traffic capacity on land use at national holiday night

Figure 11 is the dynamic of voice traffic capacity at holidays night based on land use. Based on it below seen that a voice traffic capacity classes from the Southwest toward the Northeast tends to decrease into a low level.

| Table 2. The spatial dynamic of voice traffic capacity on land use at weekends |
|--------------------------------|-----------------|-----------------|
| Land use                      | Working days    |                |
|                               | Afternoon (10–11 AM) | Night (8–9 PM) |
| Low cost residential          | High            | High           |
| High cost residential         | Low             | Low            |
| Commercial areas              | Low             | Low            |

Figure 9. Voice traffic capacity on a national holiday
4.8. The spatial dynamic of voice traffic capacity on land use at the national holiday

The following table 3 is shown the capacity of voice traffic that occurs in its entirety in a national holiday in both day or evening.

Based on table 3, it is seen that voice traffic capacity of customers with different types of land use in low cost residential always showed a high level of traffic both day and night. The traffic capacity of voice customers in high cost residential has a low level at the time of the day and stays low at night. Voice traffic capacity that occurs among customers in commercial areas is quite similar to the high cost residential, which is low during both day and night.

Figure 10. The traffic capacity on a national holiday afternoon

Figure 11. The traffic capacity on a national holiday night
Table 3. The spatial dynamic of voice traffic capacity on land use at national holiday

| Land use          | National holiday |   |   |
|-------------------|------------------|---|---|
|                   | Afternoon (10–11 AM) | Night (8–9 PM) |
| Low cost residential | High             | High |
| High cost residential | Low             | Low  |
| Commercial areas   | Low              | Low  |

Table 4. Traffic capacity level based on all the time difference and the type of land use

| Land use         | Afternoon (10–11 AM) | Night (8–9 PM) |
|------------------|-----------------------|----------------|
|                  | Working days | Weekend | National holiday | Working days | Weekend | National holiday |
| Low cost residential | High         | High    | High             | High        | High    |
| High cost residential | Normal       | Low     | Low              | Low         | Low     |
| Commercial areas | Normal       | Low     | Low              | Low         | Low     |

4.9. The spatial pattern dynamic of voice traffic capacity on land use in South Jakarta

Based on table 4 below shows that the spatial dynamics that occur between 10:00 am to 11:00 am shows that the voice traffic capacity of the low cost residential always in the high category. It shows on working days, weekends, and a national holiday (Chinese New Year). The voice traffic capacity of a high cost residential and commercial areas is within normal level during working days and low on the weekends and that national holiday.

The dynamics of voice traffic capacity between 08:00 pm to 09:00 pm shows that the capacity of voice traffic in the low-cost residential always high during working days, weekend, even on national holiday; while customers in the high cost residential and commercial areas always low both on working days, weekend and the Chinese New Year.

5. Conclusion

There are differences in voice traffic based on the type of areas (i.e. high-cost residential areas, low-cost residential areas, and commercial areas). There are significant differences in traffic voice occurred between the low-cost residential areas and the high-cost residential areas or commercial areas. While the differences in traffic voice between the high-cost residential areas and commercial areas are no significant.

The differences in voice traffic based on both afternoon and in the evening on working days, weekend and national holiday do not significantly affect the dynamics of the overall voice traffic. Dynamics of the voice traffic on the low-cost residential areas tend to have a high traffic pattern both in the afternoon and in the evening on working days, weekend and national holiday. Thus, it is not affected by differences in the time of occurrence, while the capacity of voice traffic in the high cost residential and commercial areas tend to be lower than normal during the working days.

References

[1] Sandy I M 1960 A Preliminary Statistical Investigation on the Rainfall of Java Ph.D. Thesis (Massachusetts: Clark University)

[2] Sui D and Goodchild M 2011 Int. J. Geogr. Inf. Sci. 25 1737-48
[3] Downs R M and Stea D 2011 *Cognitive Maps and Spatial Behaviour: Process and Products* (New York: John Wiley & Sons)

[4] Walmsley D J and Lewis G J 1993 *People and Environment* (London: Routledge)

[5] Castells M 2000 *The Rise of The Network Society* (New York: John Wiley & Sons)

[6] Taki H M, Maatouk M M H, and Qurnfulah E M 2017 *J. Appl. Geospatial Inf.* 1 26-35

[7] Taki H M and Lubis M Z 2017 *J. Appl. Geospatial Inf.* 1 36-43

[8] Graham M and Shelton T 2013 *Dialogues Hum. Geogr.* 3 255-61

[9] Madanipour A and Hull A 2017 *The Governance of Place* (New York: Routledge)

[10] McMichael P 2011 *Development and Social Change* (United States: SAGE Publications, Inc)

[11] Maher S P, Kramer A M, Pulliam J T, Zokan M A, Bowden S E, Barton H D, Magori K and Drake J M 2012 *Nat. Commun.* 3 1-8

[12] Taki H M 2017 *J. Geomatics Plan.* 2 69-81

[13] Blaut J M 2012 *The Colonizer’s Model of the World* (New York: Guilford Press)

[14] Knox P and Pinch S 2010 *Urban Social Geography* (England: Pearson Education Ltd)

[15] Roche S, Propeck-Zimmermann and Mericskay B 2011 *GeoJournal* 78 1-20

[16] Porter G 2012 *Geogr. Compass* 6 241-59

[17] Hennessy J L and Petterson D A *Computer Architecture* (United States: Morgan Kaufmann)

[18] Zott C, Amit R, and Massa I 2011 *J. Manag.* 37 1019-42

[19] Boase J and Ling R 2013 *J. Comput. Mediat. Commun.* 18 508-19

[20] Vermesan O and Friess P 2013 *Internet of Things* (Denmark: River Publisher)

[21] Adams N P, Little H A and Kirkup M G 2011 U.S. patent 20100242086A1

[22] Calabrese F, Ferrari L and Blondel V D 2015 *ACM Comput. Surv.* 47 1-20

[23] Becker R A, Caceres R, Hanson K and Loh J M 2011 *IEEE Pervasive Comput.* 10 18-26

[24] Taki H M, Maatouk M M H, Qurnfulah E M and Aljoufie M 2017 *J. Geoscience Eng. Environ. Technol.* 2 84-94

[25] Shafiq M Z, Ji L, Liu A X and Wang J 2011 *ACM SIGMETRICS Performance Evaluation Review* 39 305-16

[26] Iqbal M S, Choudhury C F, Wang P and Gonzalez M C 2014 *Transp. Res. Part C Emerg.* 40 63-74

[27] Sobolevsky S, Liu Y and Ratti C 2013 *Proc. of the 2nd ACM SIGKDD Int. Workshop on Urban Computing* (Chicago) (New York: ACM)

[28] Schliephake K H 2016 *Transport Costs in a Shrinking World: the Spatial Approach of Geographers* (Pennsylvania: IGI Global)

[29] Diggle P J 2013 *Statistical Analysis of Spatial and Spatio-Temporal Point Patterns* (United States of America: CRC Press)