Comparative Analysis of 4G Network Internet Data Connectivity Based on Quality of Service (QoS) Method (Case Study West Bandung Regency Tourism Area)

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Abstract. The aim of this study is to determine the quality of 4G network connectivity in a case study in the tourism area of West Bandung Regency. The research methodology used is descriptive quantitative method and survey method. The analysis was conduct by comparing 2 (two) X and Y providers, which are internet service providers that are widely used by tourists in 11 tourist areas based on a survey conducted by the author team. The test parameters used 3 (three) QoS parameters namely delay, jitter, and packet loss. The tools used in the analysis are Wireshark, Speedtest by Ookla, nPerf, and Cell Tower Locator. Test results show that the distance of the Base Transceiver Station (BTS) to the tourist site does not affect the quality of the network. Provider X network excels at the delay (average 652 ms) and jitter (average 34.77 ms) parameters, while provider Y excels only at packet loss parameters (average 0.26%). Based on the QoS parameters test can be concluded that provider X is the best provider because it excels at 2 (two) parameters.

1. Introduction
The number of tourist visits to attractions in West Bandung Regency based on data from the Badan Pusat Statistik (BPS) in 2016 reached 1,567,684 people [1]. This number has an impact on increasing the per capita income of the West Bandung Regency Government from the tourism sector. The various efforts and strategies are needed to increase the number of tourists, such as providing various facilities needed by tourists when visiting. One of them is the availability of the internet to access information in real-time when in a tourist spot.

The report of the Asosiasi Penyelenggara Jasa Internet Indonesia (APJII) in 2018 showed that internet users significantly increased to 171.17 million people (64.8%) in 2018 out of Indonesia's total population of 264.16 million people, percent of user growth/year 10.12%. The development of internet access using smartphones in 2018 according to APJII reached 93.9% [2]. Smartphone market share in Indonesia reaches 55.72%, the use of smartphones has become an important requirement for almost everyone [3]. The development of 4G technology has an effect on cellular market competition between operators, 4G supports high speed internet services that is 100-200Mbps [4]. 4G technology based on IP technology which is a previous technology solution that is based on voice telephony so that network costs become cheaper [5].

Efforts to achieve the optimal needs of 4G network connectivity cannot be separated from the improvement of Quality of Service (QoS). QoS refers to the ability of networks to provide better services on certain network traffic through different technologies [6]. QoS parameters are used to
assess the quality level of service providers and networks (such as telecommunications operators), it is important to understand by customers to compare quality between service providers [7].

The author made observations to obtain data related to the quality of 4G technology in 16 (Sixteen) appropriate tours in the district of West Bandung. Based on the observations by the author on the day 10 March 2019 obtained data that 9 tourist attractions are not available to free internet facilities (free wifi). The results of the survey through questionnaires to respondents (tourist visitors) with a range of ages 19 to 24 years (student status) obtained data that 38% of respondents (out of a total of 50 respondents) used providers X and Y. The argument for the use of both providers is the fulfillment of data access needs with a relatively affordable cost for students, although the connection has not optimal. The results of the QoS analysis have expected to be made recommendations for adding services to a network. The best service to customers important for communication service providers (providers), this will impact positive competition between providers.

Provider X has established in 2007. 90% of X's customers are young smartphone users. X operates a national network licensed by 2G, 3G/WCDMA, and 4G LTE GSM. 4G LTE technology covers 7,900 villages and sub-districts, 4.5G in 7,400 villages and sub-districts in Sumatra, Kalimantan, Sulawesi, Java, Bali and Lombok, and 16,000 km of optical fiber [8]. Provider Y was founded in 1967, X was a leading provider of telecommunications and information services and/or convergence technology services in Indonesia. In 2018, the entire national network of provider Y has equipped with 4G LTE capabilities with 58.0 million customers (4G subscribers increased from 45% to 80%), the total BTS 74,926 (4G BTS increased from 7,179 at the end of 2017 to 17,050 at the end of 2018). Y launched a seamless 4G network in 2018. The end of 2017 regulates the 4G spectrum, an additional 5 MHz in the 2100 MHz spectrum, the use of the 4G spectrum increased by 73% [9].

Several studies related to 4G network internet data connectivity have conducted. [10] conducted a strength analysis of 4G-based networks (Telkomsel, XL and Indosat operators) based on QoS in a case study on the UIN Sunan Kalijaga campus in Yogyakarta, the proceeds of the study indicated that Telkomsel operators were better than other operators although the results were not significant. The other study was conducted by [11] analyzed 3G and 4G network internet data connectivity in a case study in Malioboro, the results of the research showed that the needs of customers (chat, voice conversation and voice messaging) internet customers in the Malioboro area have fulfilled. Another study conducted [12] is analyzing and testing 3G and 4G networks in Quality of Service (QoS) services, the results of the study indicate that 4G networks have a value of throughput, latency, jitter, and packet loss twice as large as 3G networks. Research conducted by [13] analyzed Telkomsel 4G using QoS parameters in the Soreang area, [14] study performance 4G/LTE using 5 (Five) categories of Third Generation Partnership Project (3GPP) standard.

This paper has divided into five sections: Section 1 gives a brief overview of the background of research, the second section described the research method. The result and discussion have examined in section 3. The last section has outlined conclusions. The aim of this study is to determine the quality of 4G network connectivity in a case study in the tourism area of West Bandung Regency. The paper analysis of performance 4G based on QoS method, the test parameters used 3 (three) QoS parameters namely delay, jitter, and packet loss. The analysis was conduct by comparing 2 (two) X and Y providers, which are internet service providers that are widely used by tourists in 11 tourist areas.

2. Method
The method used in this research has a descriptive quantitative method and survey method. The descriptive quantitative method has research that clearly describes a phenomenon based on staying in the form of numbers and processed with statistical calculations. The research method had chosen because the authors sought exact data that could be used to answer statements about how good the quality of the Internet Service Provider (ISP) is in the tourist area. The chronology of quantitative research consisted of 6 (six) grooves, as shown in Figure 1 as follows [15].
Figure 1. Stages of Quantitative Research [15]

The first stage is the formulation of the problem, formulated based on the background of the problem obtained from the literature review related to the research topic studied and data/information from observations made by the author at the case study site. The second stage of the theoretical foundation, namely the material and data sources has obtained from various literature is carried out with content analysis techniques. The formulation of the hypothesis in the third stage is a temporary answer to the problems that still require empirical evidence through verification testing [16] at this stage the authors analyze the observational data in the field, obtained a hypothesis that is provider X and Y claimed as less provider good internet connectivity. The fourth stage has carried out before and during the study, data collection using three instruments, namely interviews, questionnaires, and observation. In the next stage, data analysis based on the results of observational data. The data analyzed are 3 (Three) parameters from QoS, namely delay, jitter and packet loss, the provider analyzed is provider X and Y. Tools used by the author in analyzing data are Wireshark, Speedtest, nPerf, and Cell Tower Locator. In the final stage, the conclusion is the answer to the hypothesis based on the results of the analysis.

To obtain complete and valid data, the authors conducted observation that began on March 10, 2019, until March 21, 2019, and located in 16 (Sixteen) tourist attractions in the district West Bandung (Table 1).

### Table 1. Bandung Regency Tourist Area

| Day/Date Observation | Tourist Area       | Location   |
|----------------------|--------------------|------------|
| 1                    | Sunday, March 10, 2019 | Farm House | Lembang |
| 2                    | Sunday, March 10, 2019 | Curug Malela | Rongga |
| 3                    | Sunday, March 10, 2019 | D’Ranch   | Lembang |
| 4                    | Tuesday, March 12, 2019 | Gunung Hawu | Padalarang |
| 5                    | Wednesday, March 13, 2019 | Venue Gantole | Cililin |
| 6                    | Wednesday, March 13, 2019 | Stone Garden | Cipatat |
| 7                    | Thursday, March 14, 2019 | Puspa Iptek | Padalarang |
| 8                    | Thursday, March 14, 2019 | Danau Wakadobol | Batujajar |
| 9                    | Monday, March 18, 2019 | Dusun Bambu | Cisarua |
| 10                   | Monday, March 18, 2019 | Jendela Alam | Parongpong |
| 11                   | Tuesday, 19 March 2019 | Observatorium Bosscha | Lembang |
| 12                   | Tuesday, 19 March 2019 | Kota Mini | Lembang |
| 13                   | Tuesday, 19 March 2019 | Floating Market | Lembang |
| 14                   | Tuesday, 19 March 2019 | The Lodge Maribaya | Lembang |
| 15                   | Wednesday, 20 March 2019 | Maribaya Natural Hot Spring | Lembang |
| 16                   | Thursday, 21 March 2019 | Wisata Grafika | Lembang |

### 3. Results and Discussion

The first stage is carried out by examining provider X and continued with provider Y. The next step is to calculate and analyze the results of the study based on QoS parameters. The QoS parameters tested in Table 2.
Table 2. QoS Parameters

| QoS Parameters | Metric       | Explanation                                                                 |
|----------------|--------------|------------------------------------------------------------------------------|
| Delay          | Milisecond (ms) | Packet delay time from source to destination which includes transmission, propagation, queue and process delays [17] |
| Packet Loss    | Percentage (%) | The parameter for the number of packets from source to destination is missing or not arriving [17] |
| Jitter         | Milisecond (ms) | Variations in queue length, data processing time, and recompilation time of packets at the end of jitter travel [18]. |

Delay can be affected by distance, physical media, congestion or also long processing time. Jitter is commonly called a variation of delay, related to latency [18]. Categories, quantities and indexes of the three QoS parameters detailed in Table 3.

Table 3. Categories, Quantities and Indexes [18]

| Categories | Delay | Packet Loss | Jitter       | Index |
|------------|-------|-------------|--------------|-------|
| Very good  | <150 ms | 0-2 | 0 ms | 4 |
| Good       | 150 ms s/d 300ms | 3-14 | 1 ms s/d 75 ms | 3 |
| Moderate   | 300 ms s/d 450ms | 15-24 | 76 ms s/d 125 ms | 2 |
| Bad        | >450 ms | >25 | 126 ms s/d 225 ms | 1 |

The tools for measurement in this study used 3 (Three) types of software, details in Table 4

Table 4. The tools used in the analysis

| Software     | Version | Function                                                                 |
|--------------|---------|--------------------------------------------------------------------------|
| 1 Wireshark  | Win 64 2.6.1 | Analyze and measure network traffic [19], data can be captured directly and analyzed offline [20] |
| 2 Cell Tower Locator | 1.31 | Measure the distance between the device used and the BTS tower and measure the signal strength and GPS location [21] |
| 3 nPerf      | 2.4.7   | Measuring speed tests (bitrate speed and latency), browsing tests, and streaming tests [21] |
| 4 Speedtest  | 4.3.3.51120 | Measure 4G network speed [22], measure the delay parameter [23] |

This research was conducted to determine the quality of the network in the tourism area of West Bandung Regency. The sample in this study amounted to 16 tourist area and data collection was carried out for 2 hours in each tourist area. From a total of 16 tourist areas found in all areas examined by the author, there are 5 (Five) tourist areas that cannot be retrieved due to several factors:

- No permission has been given by the management of the tourist area
- There is no internet connection
- There is no 4G network in one of the providers tested

Therefore, the authors only describe the results of QoS from several tourist areas where data has been successfully retrieved (11 tourist attractions). Tests are carried out on provider X and Y on the same day with different periods. The limitation of this study is that the researcher cannot retrieve the data of both providers simultaneously due to device limitations. Tables 5 and 6 show the results of the X and Y provider network quality tests.
Table 5. Internet Network Quality Test Results (Provider X)

| Period (Time) | QoS Parameter | BTS distance (m) | Explanation |
|---------------|---------------|------------------|-------------|
|               | Delay (ms)    | Packet Loss (%)  | Jitter (ms) |
| 1 Dusun Bambu | -             | -                | -           |
| 2 Floating Market | 09:55 – 10:55 | 106              | 9.1         | 19         | 178         | Data cannot be obtained, 4G network is unstable, changed to 3G |
| 3 Gunung Hawu | 10:45 – 11:45 | 280              | 0.6         | 23         | 523         | -           |
| 4 Jendela Alam | 13:12 – 14:12 | 2610             | 0.3         | 12         | 337         | -           |
| 5 Kota Mini | 09:55 – 10:55 | 106              | 9.1         | 19         | 178         | -           |
| 6 Maribaya Natural Hot Spring | -             | -                | -           |
| 7 Observatorium Bosscha | 13:05 – 14:20 | 649.3           | 0.0         | 92.4       | 1115        | -           |
| 8 Puspa Iptek | 10:30 – 11:23 | 800              | 1.3         | 61         | -           | Unable to detect BTS location |
| 9 Stone Garden | -             | -                | -           |
| 10 Venue Gantole | -             | -                | -           |
| 11 Wisata Grafika | 13:21 – 15:23 | 14              | 0.3         | 17         | -           | -           |
| Average       |               | 652.67           | 34.77       | 3.23       | -           |

*1s = 1000 ms

Table 6. Internet Network Quality Test Results (Provider Y)

| Period (Time) | QoS Parameter | BTS distance (m) | Explanation |
|---------------|---------------|------------------|-------------|
|               | Delay (ms)    | Packet Loss (%)  | Jitter (ms) |
| 1 Dusun Bambu | 10:00 – 11:00 | 2430             | 0.1         | 22         | 200         | -           |
| 2 Floating Market | 10:56 – 11:43 | 2802             | 0.3         | 20         | 531         | -           |
| 3 Gunung Hawu | 11:47 – 12:47 | 1949             | 0.3         | 25         | 366         | -           |
| 4 Jendela Alam | 12:30 – 13:10 | 189              | 0.2         | 18         | 1425        | -           |
| 5 Kota Mini | 10:56 – 11:43 | 2802             | 0.3         | 20         | 531         | -           |
| 6 Maribaya Natural Hot Spring | 14:32 – 15:32 | 2536             | 0.3         | 132        | 1180        | -           |
| 7 Observatorium Bosscha | 12:33 – 13:03 | 1035             | 0.2         | 17         | 704         | -           |
| 8 Puspa Iptek | 11:25 – 12:25 | 2200             | 0.2         | 87         | -           | Unable to detect BTS location |
| 9 Stone Garden | 14:04 – 15:04 | 660              | 0.5         | 51         | 7296        | -           |
| 10 Venue Gantole | 13:46 – 14:46 | 1840             | 0.3         | 126        | -           | Unable to detect BTS location |
| 11 Wisata Grafika | 13:21 – 14:21 | 3040             | 0.2         | 16         | 678         | -           |
| Average       |               | 1953             | 48.55       | 0.26       | -           |

The smallest value is the best value for the three QoS parameters (delay, packet loss and jitter). Based on the tourist area, the best test results for provider X are the delay parameters (14 ms) located in the Wisata Grafika (Lembang), jitter (12 ms) in the Jendela Alam tourist area (Parongpong) and the packet loss value (0.0%,) located in the tourist area of Observatorium Bosscha (Lembang). While the best results for provider Y are the delay parameters (189 ms) in the Jendela Alam tourist area (Parongpong), jitter (16 ms) in the Wisata Grafika area (Lembang) and packet loss (0.1 ms) in the tourism area of the Dusun Bambu (Cisarua). Results a test based on the type of provider shows that provider X is superior to all QoS parameters (Figures 2 and 3).
Based on the results of the test, data has been assessing that the distance from the BTS to the tourist area does not affect the value of delay, jitter, and packet loss. For example, the nearest distance of BTS Provider X to the Floating Market and Kota Mini tourist areas is 178 m, has the same jitter value (19 ms), while the Jendela Alam tourist area is 337 m to BTS has a smaller jitter value (12 ms) compared to the Floating Market and Kota Mini tourist areas. Likewise, with Provider Y, the distance of the BTS to the tourist area of Dusun Bambu is 22 m (jitter 22 ms), while Wisata Grafika distance of 678 m to BTS has a smaller jitter value (16 ms) compared to Dusun Bambu.

The average test results based on the type of provider as a whole in 11 (Eleven) tourist areas in West Bandung Regency showed that provider X excels in 2 (Two) QoS parameters namely delay (average 625 ms) and jitter (average 34.77 ms), while provider Y excels only in packet loss parameters (an average of 0.26%). The graph in Figure 4 and 5.

Based on our experiment, the test result shows the possibility of repeated experiments will produce different test data:

- Test results of packet loss have influenced by external factors such as weather conditions that affect 4G connectivity. The test be following the study [24] that packet loss has influenced by geographical conditions such as fog, rain, radio frequency interference, cell handoff during roaming, and interference such as trees, buildings, and mountains. Also the study [25] explained that the weather contributes to network instability
- The test results indicate that the distance of the BTS does not significantly influence the QoS parameters. The results of this study were in line with previous studies [26] and [27] that the position of BTS has influenced by the topography of a region. Earth curvature factor and BTS antenna height are variables that will affect the signal transmission process.

Figure 2. Delay and Jitter Testing Result based on tourist area

Figure 3. Packet Loss Testing Result based on tourist area
4. Conclusion
This paper analyzes 4G network internet data connectivity based on the QoS method. The case study was conducted in 11 tourist areas in West Bandung Regency. 4G network quality based on the "Very Good" category has obtained by provider X (delay parameter) and the "Good" category (jitter parameter), while the "Good" category for provider Y (packet loss parameter). The results of tests conducted by the authors on provider X and Y for the 3 (Three) QoS parameters that provider X excels at delay parameters (average 652 ms) and jitter (average 34.77 ms), while provider Y only excels at packet loss parameters (average 0.26%). Therefore it can be concluded in this study that provider X is the best provider because it excels in 2 (Two) parameters. 4G network connections for provider X have not been stable in 4 (Four) tourist areas (Dusun Bambu, Maribaya Natural Hot Spring, Stone Garden, Venue Gentole). Further studies are needed to calculate the earth's curvature of the BTS position and additional QoS parameters for testing such as throughput.

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