Virtual traffic simulation for minimizing average of vehicle queue length in Serang city Indonesia

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Abstract. Almost the big cities in the world has the traffic jam problem. Serang City as the capital city of Banten-Indonesia has the same traffic problem, without a good integrated public transport, makes the problem of traffic transportation in Serang City becomes heavier. Virtual traffic simulation is known as powerful tool for generating alternative solution to minimize the traffic problems. This research use PTV Vissim as virtual traffic simulation software to minimize the traffic problems in Serang City. Serang City has 6 sub-district area, there are Cipocok, Curug, Kasemen, Serang, Taktakan, and Walantaka. This research focus on vehicles traffic only in area of sub-district Serang with 5 main traffic lights crossroad. PTV Vissim uses to simulate the 5 of the main crossroads and find the average of the existing vehicles queue length in rush hour. Trial and error operations such as traffic lights timing and routing modification use to generate alternative solutions for minimizing vehicles queue length as traffic performance in this research. The result of this research has found the rush hour in Serang City occured at 06.00-10.00 and 14.01-18.00 (UTC +07:00), and the routing modification in Kebon Jahe can reduce the average of queue length for 53%.

1. Introduction
Traffic jam is a situation or state of stagnation or even cessation of traffic caused by the large number of vehicles exceeding road capacity. Traffic jam problems often occur in the Serang City, generally occurring during rush hour during morning and evening. This traffic jam problem can cause other problems such as stress, wasteful time, even increasing air pollution and noise pollution in Serang City. This traffic jam problem can be assessed through a simulation method, where simulation is a technique that mimics the operations or processes that occur in a system based on certain assumptions so that the system can be studied scientifically. Simulation can be used to describe and analyse the behaviour of a system, ask questions about "what if" about a real system, and help in the process of design of real systems. Simulation refers to a broad collection of methods and applications of real-life behaviour imaging. Simulation models are the right alternative in describing a complex system, especially when analytical mathematical models are difficult. In general, if viewed in terms of its functional application, the simulation occupies a role as a substitute or supplement from the actual experiment [2, 5].

Simulations can take place more safely in a relatively short time with the precision of the results of data processing which is also relatively high, when using computer-based programs or software [4]. One software that is often used to perform virtual traffic simulation is PTV Vissim. PTV Vissim is a microscopic simulation tools (software) based on time and behavior developed for urban traffic models. This program can be used to analyse traffic operations under the boundaries of road line configuration, traffic composition, stops etc. So that makes this software is useful for evaluating various types of
alternative transportation engineering and the most effective level of planning [1,3]. Some example can be found when simulation software used to find the best place for new facilities and reduce the street congestion inside the port [4].

The Problems discussed in this research is knowing the volume of vehicles passing on the road in Serang District (Serang City), knowing when the rush hour that occurs, build existing traffic simulation and make proposed traffic simulation in the Serang City with PTV Vissim software.

2. Methodology
2.1. Data Collection
The Data of the number of vehicles is collected by 24-hour camera on five traffic-light spots in Serang City (Pisang Mas, Kepandean, Kebon Jahe, Sumur Pecung, and Ciceri). The interview was conducted with the Head of the Serang City Transportation Agency to find out the best location for this research. We divide 24-hours to 6 zone of time, there are 06:01-10:00, 10:01-14:00, etc. The volume of vehicles is counting based on each zone of time and it is classified when is the rush hour zone of time in Serang City. The speed of the vehicles is assumed to 50 km/hr.

2.2. Method
The existing virtual traffic simulations is created on 5 main traffic lights crossroad by PTV Vissim with the average queue length (Q-LEN) becomes the performance indicator in this research. The alternative solutions are generated by Trial and error traffic lights timing modification and routing modification using the One Direction System (ODS).

3. Results and Discussion
The results and discussion in this study derive from the observation of the number of composition and volume of vehicles, the existing and proposed virtual traffic simulation.

3.1. Observation of the number of composition and volume of vehicles
This is a sample table of composition and volume of vehicles passing at five traffic light points in Serang Subdistrict, which are divided into 6 time zones, is every 4 hours a day.

| Vehicle Type                           | Jl. Ahmad Yani (East Lane) = Pisang Mas |
|----------------------------------------|----------------------------------------|
|                                        | Number of Vehicles (Units)             | Percentage of Vehicles |
|                                        | Left  | Middle | Right | Total | Left  | Middle | Right | Total |
| Public Transportation                  | 33    | 47     | 24    | 104   | 31.73 | 45.19  | 23.08 | 100   |
| Private Car                           | 231   | 374    | 292   | 897   | 25.75 | 41.69  | 32.55 | 100   |
| Motorcycle                             | 272   | 1146   | 469   | 1887  | 14.41 | 60.73  | 24.85 | 100   |
| Bus & Truck                           | 13    | 10     | 3     | 26    | 50.00 | 38.46  | 11.54 | 100   |
| Total of Motorized Vehicles           | 549   | 1577   | 788   | 2914  | 18.84 | 54.12  | 27.04 | 100   |

| Table 2. Grand total vehicle          |
|---------------------------------------|
| No | Time Zone (UTC +07:00) | Grand Total Vehicle Volume | No | Time Zone (UTC +07:00) | Grand Total Vehicle Volume |
|----|------------------------|----------------------------|----|------------------------|----------------------------|
| 1  | 06.00-10.00            | 22,313                     | 4  | 18.01-22.00            | 16,975                     |
| 2  | 10.01-14.00            | 19,928                     | 5  | 22.01-02.00            | 12,243                     |
| 3  | 14.01-18.00            | 22,222                     | 6  | 02.01-06.00            | 5,701                      |
Based on the grand total vehicle volume table, we can see that rush hour in Serang City is occurred at 06.00-10.00 and 14.01-18.00 which will be the inputs of simulation at the two time zones.

3.2. Existing Simulation with PTV Vissim 9 Software
The existing simulation is based on rush hour to find out the road performance parameters, which is Q-LEN (average queue) at 5 crossroad traffic light points. Figure 1 is a sample of existing simulation layout in Pisang Mas by PTV Vissim.

The signal controller on figure 1, it can be seen that at this 5 main crossroad traffic light point the cycle time of the traffic light is 112 seconds. Where at each red light on each side has 4 seconds allowance before the red light (Amber time), 4 seconds yellow light, 20 seconds green light and 84 seconds red light.

3.3. Existing Simulation Output
The existing simulation output is shown on Figure 1 and Table 3 below. On Figure 1, there is simulation layout and the traffic signal controller in PTV Vissim.

![Figure 1. Existing virtual traffic simulation in pisang mas: (a) Layout, (b) Traffic signal controller](image)

Table 3. Existing simulation output in rush hour

| Traffic Light Point | Q-LEN (m) at 06:00-10:00 (UTC +07:00) | Q-LEN (m) at 14:01-18:00 (UTC +07:00) |
|---------------------|-------------------------------------|--------------------------------------|
| Pisang Mas          | 46.39                               | 46.5                                 |
| Sumur Pecung        | 13.67                               | 13.86                                |
| Kebon Jahe          | 19.65                               | 19.71                                |
| Kepandean           | 3.83                                | 4.61                                 |
| Ciceri              | 20.64                               | 21.25                                |

3.4. Proposed Simulation with Modification of Traffic Lights Time
This proposed method is based on the addition of the green light time on the protocol road (the side of the road that has a large volume of vehicles). The idea was made to make the green light time on the protocol road becomes 30 seconds, and the time for the green light on the road other than the protocol is 12 seconds. By still using the amber time for 4 seconds, the proposed traffic light has a cycle time of 116 seconds. This modification tries to minimize the Q-LEN on the protocol road which has more vehicle on its.

On Table 4 below, show the result of proposed method with modification of traffic lights time that compare with the existing method for the Q-LEN in Meters unit.

![Table 4](image)
Table 4. Comparison between q-len existing and proposed by traffic light time modification

| Area       | Time          | Q-LEN Existing (m) | Q-LEN Proposed (m) |
|------------|---------------|--------------------|--------------------|
|            | 06:01 - 10:00 |                   |                    |
| Kepandean  | 3.83          | 3.78               | 4.61               | 4.42               |
| Pisang Mas | 46.39         | 45.67              | 46.5               | 45.91              |
| Sumur Pecung | 13.67       | 13.57              | 13.86              | 13.66              |
| MCD-Carefour | 20.64        | 20.28              | 21.25              | 20.98              |
| Kebon Jahe | 19.65         | 19.41              | 19.71              | 19.42              |

The proposed simulation using the modification of the traffic lights time, it is known that the results obtained are not significant, this is because the volume of vehicles which passing at the rush hour is not too significantly different. Therefore, we did the other way changing the system of road flows by implementing a one-way system.

3.5. Proposed Simulation with Modification of Vehicle Route by One Direction System (ODS)
On the proposed simulation that has been made, the simulation is made based on the point to be made in a one-way system, namely on Jl. Ahmad Yani (Pisang Mas) and Jl. Raya Serang - Pandeglang (Kebon Jahe).

Table 5. Vehicles composition and volume at jl. ahmad yani (pisang mas-ods) - west lane

| Vehicle Type          | Number of Vehicles (Units) | Percentage of Vehicles |
|-----------------------|----------------------------|------------------------|
|                       | Left | Middle | Right | Total | Left  | Middle | Right |
| Public Transportation | 33   | 71     |       | 104   | 6.63% | 3.32%  |
| Private Car           | 208  | 600    |       | 808   | 41.79%| 28.09% |
| Motorcycle            | 245  | 1453   |       | 1698  | 49.23%| 68.03% |
| Bus & Truck           | 12   | 12     |       | 23    | 2.35% | 0.55%  |
| Total                 | 498  | 2136   |       | 2633  | 100%  | 100%   |

Table 6. Vehicles composition and volume at jl. ahmad yani (pisang mas-ods) - north lane

| Vehicle Type          | Number of Vehicles (Units) | Percentage of Vehicles |
|-----------------------|----------------------------|------------------------|
|                       | Left | Middle | Right | Total | Left | Middle | Right |
| Public Transportation | 0    | 0      |       | 0     | 0%   | 0%     |
| Private Car           | 90   | 90     |       | 180   | 32%  | 32%    |
| Motorcycle            | 189  | 189    |       | 378   | 67%  | 67%    |
| Bus & Truck           | 3    | 3      |       | 6     | 1%   | 1%     |
| Total                 | 281  | 281    |       | 562   | 100% | 100%   |
Table 7. Vehicles composition and volume at jl. ahmad yani (pisang mas-ods) - south lane

| Vehicle Type      | Number of Vehicles (Units) | Percentage of Vehicles |
|-------------------|----------------------------|------------------------|
|                   | Left | Middle | Right | Total | Left | Middle | Right |
| Public Transportation | 43   | 0      | 43    | 6%    | 0%   |
| Private Car        | 283  | 21.2   | 305   | 39%   | 35%  |
| Motorcycle         | 387  | 38.9   | 426   | 53%   | 64%  |
| Bus & Truck        | 14   | 1      | 15    | 2%    | 2%   |
| **Total**          | 727  | 61.1   | 788   | 100%  | 100% |

Table 8. Vehicles composition and volume at jl. raya serang – pandeglang (kebon jahe-ods) –east lane

| Vehicle Type      | Number of Vehicles (Units) | Percentage of Vehicles |
|-------------------|----------------------------|------------------------|
|                   | Left | Middle | Right | Total | Left | Middle | Right |
| Public Transportation | 46   | 0      | 0     | 46    | 3%   | 0%     | 0%   |
| Private Car        | 350  | 35     | 20    | 405   | 23%  | 26%    | 36%  |
| Motorcycle         | 1096 | 99     | 35    | 1230  | 73%  | 73%    | 63%  |
| Bus & Truck        | 9    | 2      | 1     | 12    | 1%   | 1%     | 2%   |
| **Total**          | 1501 | 136    | 56    | 1693  | 100% | 100%   | 100% |

Table 9. Vehicles composition and volume at jl. raya serang – pandeglang (kebon jahe-ods) –west lane

| Vehicle Type      | Number of Vehicles (Units) | Percentage of Vehicles |
|-------------------|----------------------------|------------------------|
|                   | Left | Middle | Right | Total | Left | Middle | Right |
| Public Transportation | 0    | 0      | 0     | 0     | 0%   | 0%     | 0%   |
| Private Car        | 52   | 15     | 67    | 124   | 26%  | 24%    | 4%   |
| Motorcycle         | 147  | 49     | 196   | 352   | 73%  | 75%    | 8%   |
| Bus & Truck        | 3    | 1      | 3     | 7     | 1%   | 1%     | 1%   |
| **Total**          | 202  | 65     | 267   | 534   | 100% | 100%   | 100% |

Table 10. Vehicles composition and volume at jl. raya serang – pandeglang (kebon jahe-ods) south lane

| Vehicle Type      | Number of Vehicles (Units) | Percentage of Vehicles |
|-------------------|----------------------------|------------------------|
|                   | Left | Middle | Right | Total | Left | Middle | Right |
| Public Transportation | 20   | 78     | 98    | 196   | 5%   | 4%     | 4%   |
| Private Car        | 107  | 494    | 601   | 1202  | 28%  | 27%    | 27%  |
| Motorcycle         | 243  | 1204   | 1447  | 1814  | 64%  | 67%    | 67%  |
| Bus & Truck        | 12   | 24     | 36    | 72    | 3%   | 1%     | 1%   |
| **Total**          | 382  | 1801   | 100%  | 100%  | 100% | 100%   | 100% |
Below is the ODS simulation layout with parameter for the signal controller.

![Image of ODS simulation layout](a) (b)

**Figure 2.** ODS simulation layout: (a) Jl Ahmad Yani (Pisang Mas), (b) Jl Raya Serang – Pandeglang (Kebon Jahe)

On the signal controller above, it can be seen that at this 5 main crossroad traffic light point the cycle time of the traffic light is 84 seconds. Where at each red light on each side has 4 seconds allowance before the red light (Amber time), 4 seconds yellow light, 20 seconds green light and 84 seconds red light. For Jl. Ahmad Yani there is no traffic light with this one-way system implementation on this area.

For the second proposed with using ODS, the result is Q-LEN for Jl. Ahmad Yani (Pisang Mas) is 0 m because there is no the traffic signal again and in Jl. Raya Serang – Pandeglang (Kebon Jahe), the Q-LEN becomes 9.25 m (reduce 53% existing Q-LEN). Shown on table 7.

**Table 7.** Q-len proposed by modification of vehicle route by one direction system (ods) at jl. raya serang-pandeglang = kebon jahe (06.00 – 10.00 (UTC +07:00))

| Lane | Queueu Length (m) |
|------|-------------------|
| 1-1: Jl. Kh Abdul Hadi (Right)4.8-12: Jl. Yusuf Martadilaga (Right)85.0 | 0 |
| 1-2: Jl. Kh Abdul Hadi (Middle)5.1-8: Jl. Letkol Tb Suwandi (Middle)94.5 | 4.42 |
| 1-3: Jl. Kh Abdul Hadi (Left)5.5-6: Jl. Raya Pandeglang (Right)79.3 | 0 |
| 1-4: Jl. Raya Pandeglang (Left)12.9-7: Jl. Letkol Tb Suwandi (Right)94.6 | 0 |
Lane | Queueu Length (m) |
--- | --- |
1-5: Jl. Raya Pandeglang (Middle) | 9.8 |
9-11: Jl. Yusuf Martadilaga (Middle) | 84.8 |
1-9: Jl. Letkol Tb Suwandi (Left) | 5.5 |
10: Jl. Yusuf Martadilaga (Left) | 85.4 |
1-14: Jl. Letkol Tb Suwandi (3)4.6-13: Jl. Raya Pandeglang (4) | 76.2 |
Average | 9.25 |

4. Conclusion
The simulation was made using PTV VISSIM software, we found Q-LEN or the average queue length based on existing simulation as follow: at 06.00 – 10.00 Q-LEN for Jl. Ahmad Yani (Pisang Mas) point is 46.39 m, Jl. Jend Sudirman (Sumur Pecung) point is 13.67 m, Jl. Raya Serang – Pandeglang (Kebon Jahe) point is 19.65 m, Jl. Raya Cilegon (Kepandean) point is 3.83 m, Jl. Jend Sudirman (Perempatan Mcd Carrefour) is 20.64 m. And at 14.01 – 18.00, Q-LEN for Jl. Ahmad Yani (Pisang Mas) point is 46.5 m, Jl. Jend Sudirman (Sumur Pecung) point is 13.86 m, Jl. Raya Serang – Pandeglang (Kebon Jahe) point is 19.71 m, Jl. Raya Cilegon (Kepandean) point is 4.61 m, Jl. Jend Sudirman (Perempatan Mcd Carrefour) is 21.25 m. The volume of vehicles passing on the road in Serang City are 22313 vehicles at 06.00 – 10.00, 19928 vehicles at 10.01 – 14.00, 22222 vehicles at 14.01 – 18.00, 16975 vehicles at 18.01 – 22.00, 12243 vehicles at 22.01 – 02.00 and 5701 vehicles at 02.01 – 06.00 (UTC +07:00). Based on the biggest grand total vehicle volume, we can see that rush hour in Serang Subdistrict is at 06.00-10.00 and 14.01-18.00 (UTC +07:00).

There are 2 proposed simulations in this research. First proposed is make a new scenario for traffic light on 5-point area and second proposed is make a one-way system/ one direction system (ODS) for 2 areas. In the first proposed, the result of Q-LEN on 5-point area at 06.00 – 10.00 is Q-LEN for Jl. Ahmad Yani (Pisang Mas) point is 45.67 m, Jl. Jend Sudirman (Sumur Pecung) point is 13.57 m, Jl. Raya Serang – Pandeglang (Kebon Jahe) point is 19.41 m, Jl. Raya Cilegon (Kepandean) point is 3.78 m, Jl. Jend Sudirman (Perempatan Mcd Carrefour) is 20.28 m. And at 14.01 – 18.00, Q-LEN for Jl. Ahmad Yani (Pisang Mas) point is 45.91 m, Jl. Jend Sudirman (Sumur Pecung) point is 13.66 m, Jl. Raya Serang – Pandeglang (Kebon Jahe) point is 19.42 m, Jl. Raya Cilegon (Kepandean) point is 4.42 m, Jl. Jend Sudirman (Perempatan Mcd Carrefour) is 20.98 m. For the second proposed with using ODS, the result is Q-LEN for Jl. Ahmad Yani (Pisang Mas) is 0 m and Jl. Raya Serang – Pandeglang (Kebon Jahe) is 9.25 m (reduce 53% existing Q-LEN).

5. References
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