A Review of MATSim: A Pilot Study of Chatuchak, Bangkok THAILAND

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***Abstract*— Transportation is one of the basic infrastructures that has become an important factor for urban planning and development. Studying on the transportation system can lead to a better understanding of transport facilities, the traffic system, current situation and its behavior, is necessary. However, to reveal every object and its dynamic that happens in the traffic system is impossible without a tool and techniques. MATSim is a simulation model software used to assign the traffic between origins and destinations. Most of MATSim applications have been used for developed countries. Nevertheless, Bangkok is one of several cities challenging on the over-saturated situation on road traffic. To check the situation, the simulation can be used to explore highly concentrated traffic flow. Thus, the objective of this study is to examine the applicability of the Multi-Agents Transportation Simulation (MATSim) framework to Bangkok situation. For the travel demand forecasting, it commonly referred to as the four-step model. And, MATSim framework is one model for the fourth step of the model which is traffic assignment or route assignment. Therefore, this study explored MATSim by experimenting with two plans of agents represented by people travelling from home to work and work to home over Chatuchak district, Bangkok. The sample size of agents using in the simulation are 10, 100, and 500 agents. The results show the traffic flow differently because of the volume of agent effect on the traffic flow.**

***Index Terms*— Agent-based modeling, Transportation, Road transportation.**

I. Introduction

A simulation model is essential as one of the analytic tools used to display characteristics or situations of the real-world situation. Hence, the simulation models are also a helpful technique that can be used to estimate or evaluate the performance of several development plans as well as decision making. The Multi-Agent Transportation Simulation [1], [2] (MATSim) framework, one of the simulation models, is an efficient tool used to represent the real-world traffic and its behavior. In Thailand, many problems remain in the basic infrastructure [3], such as the modes of transport which have not been modified to be more efficient and meet performance targets even in Bangkok, the capital city of Thailand as mentioned by Office of the National Economic and Social Development Board Office of the Prime Minister Bangkok in 2017. As the history of travel demand modelling [4], studying on demand modelling referred to the four-step model consisting of trip generation, trip distribution, mode choice, and route assignment. The last step of the model, that utilized the traffic assignment to estimate the route and departure time as a choice of agents for whole day traffic or even for a certain time.

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Commonly, transportation models can be classified into several models such as the microscopic model, mesoscopic model, macroscopic model, and megascopic model. MATSim is one of the microsimulation models that used to track individual movement objects which can be the vehicle, people, mobile, etc. The microsimulation relies on random numbers to generate agents and select routing decisions. However, this paper introduces a review of MATSim basic simulation by applying in Chatuchak area in Bangkok, Thailand. Thus, to understand how the traffic flow as well as studying on the present traffic situation, MATSim can be used to apply for the pilot simulation around Chatuchak area, one of the famous tourist destinations in Bangkok.

MATSim has been used for modeling transportation studies and relevant applications such as modeling bicycle traffic transportation for cycling decision that cyclists take [5], traffic incident analysis on the transport system and its impacts [6], the public transportation simulation using the origin-destination matrices from mobile phone data and smart card transaction data [7], urban mobility using traffic simulation [8], travel mode choice modeling using the agent-based microsimulation in MATSim [9], etc., As per past studies on traffic simulation, there are many challenges for simulating traffic system in Bangkok due to the requirement of updated and actual data including the efficient model which can support huge data in the simulation. Therefore, the study has applied MATSim in Chatuchak case study for introducing the overall framework of the model. The required data for a basic simulation contains network and sample routes with a different number of agents or vehicles.

In addition, several applications have been studied and MATSim can be used to support the analysis as well as the simulation. For example, urban mobility pattern and spatial and temporal correlation prediction from personal travel information. There is similar research that studies on mobility pattern prediction with bicycle. This research is analyzing human mobility data in an urban area using the number of available bikes in the stations of the community bicycle program in Barcelona [10]. MATSim can be used for demand model simulation, especially for traffic demand simulation. According to this research on estimating the demand volume of transportation[11], transport planning and management tasks require an origin-destination (OD) matrix to represent the travel pattern. Also, the model of transport demand has been used for many years to synthesize OD matrices. So, OD data can be used for estimation the demand for transportation. Furthermore, for understanding the taxi service pattern and taxis' passenger usage pattern, MATSim can be used to simulate the travel pattern in both views of taxi drivers and passengers. As per the research of [12], the travel pattern refers to a travel flow of a passenger moving from a starting point to a destination. Therefore, the origin and destination of taxi service can also represent their service pattern.

II. PROCEDURE FOR RUNNING MATSIM

A. Review of MATSim Framework

MATSim is an agent-based simulation which requires individual agent plans. The model framework is designed to model a one-day travel based on activities during the day or activity-based models. MATSim is running based on the co-evolutionary principle. Every agent repeatedly optimizes its daily activity schedule on the transportation infrastructure [9]. Minimally, MATSim is configured in network and population files. Although, population file and network file might get quite large. So, MATSim supports reading and writing data in a compressed format to save the space in working memory.

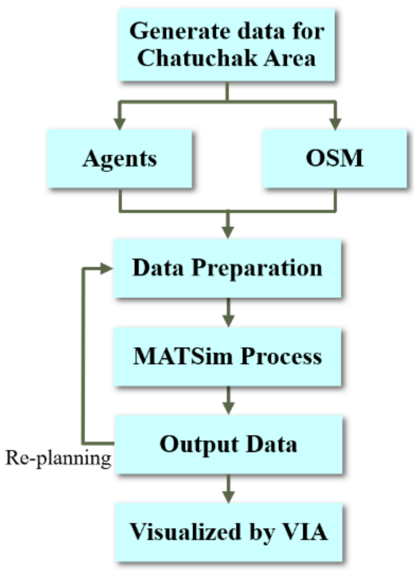

Fig. 1. The overall procedure for running MATSim, a case study of Chatuchak area in Bangkok.

Overall procedure, the study is focusing on exploring MATSim framework and data preparation requiring for simulations as in the Fig. 1. The first step is generating data for Chatuchak, Bangkok where the study area is located. After that, two main elements are defined; the OpenStreetMap (OSM) and agent's plan. The second step is preparing required data as the defined format in MATSim; all input data are prepared in .xml file format. MATSim is configured in the config file, containing a settings list that influences how the simulation behaves. After running MATSim, the output will be generated in the defined path file folder. Several files are created consisting of the log file, mode stats, score stats, stopwatch, travel distance stats, and the details of each iteration that has been set for repeating loop.

As MATSim takes the activity chain and schedule given from the initial demand generation process to generate a population with one initial demand, coordinates in the population need to be consistent with coordinates in the network; coordinates mentioned in the population file need to be in the same range as coordinates mentioned in the network.

During the iterations, this initial demand is also optimized individually by each agent. Every agent possesses a memory containing a fixed number of day plans, where each plan is composed of a daily activity chain and an associated score. In fact, one agent might have several plans, each plan contains several activity chains and each activity chain consists of several activities. Frankly, every single activity must be clearly defined for each individual agent as shown in Fig. 2

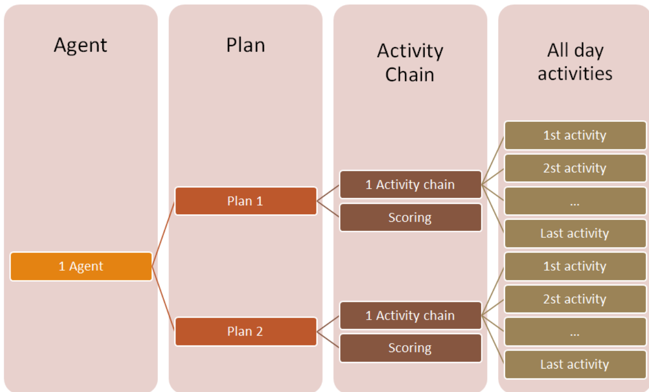

Fig. 2. The initial demands diagram of a full day plan and agent's activities.

B. Chatuchak Area, Bangkok

Chatuchak area, Bangkok is selected as the study area for the simulations; Paholyothin road, Vibhavadi road and some small roads are covered as shown in Fig. 3. According to the OpenStreetMap (OSM), the road network data over Chatuchak district, Bangkok was extracted and created using QGIS software.

Network file consists of two main elements called nodes and links. Nodes consist of the information of id, x and y defined for latitude and longitude. Links consist of the information of id, from and to connected to nodes, length, free speed, capacity, perm lanes, volume, category, type, and mode. In this case study, all links of the network are set for car mode with the same speed, capacity and volume.

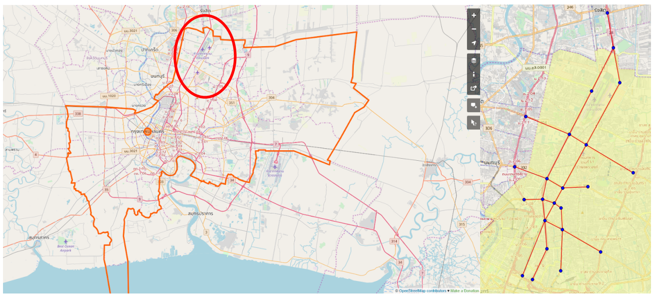

Fig. 3. Road network proving by the OpenStreetMap (OSM). This study, network is extracted for Chatuchak area, Bangkok.

III. Case Study

A. The Simulation Cases

Agents' plan consists of the information of id, activities type and its location, departure time, travel mode, and route. The route defined in this file refers to the node id that agents travel through. As shown in Fig. 4., there are two routes for agents. The first route is from home (id2) to workplace (id6). Another route is from home (id16) to workplace (id26).

As MATSim running as a loop which can be called as iterations. Furthermore, controller of iteration processing is defined in the configuration file. For example, the first iteration is 0 and the last iteration is 10. So, the simulation will start from zero and it will repeat the process for 10 times until the completion of the last iteration mentioned in the configuration file. For this study, simulations have been set with 10 iterations.

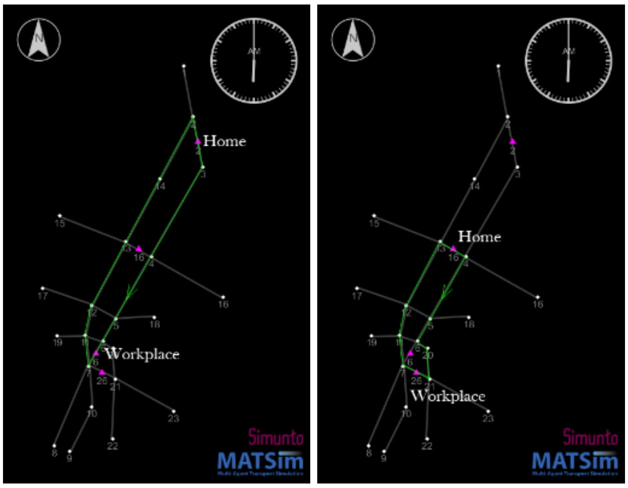

Fig. 4. Agents' plans for a one-day simulation, the case study over Chatuchak area, Bangkok.

B. The Different Number of Simulated Agents

The number of simulated agents can be set and planned before running the simulation. In this study, the number of experimental agents was 10 agents, 100 agents, and 500 agents. The first half of the agents run on the first plan, the longer route, And the second half of the agents run on the second plan, the shorter route as shown in Fig. 4. Finally, the results of all experiment will be compared and shown in the result section.

IV. Results

Agents represented by rectangle labels; green colors mean that traffic is flowing freely. Yellow colors mean that traffic is flowing slower or starting a traffic jam, and red colors mean that traffic is flowing with difficulty. According to Fig. 5., it presents the traffic flow simulation from homes to workplaces among the different number of agents in the simulation; 10, 100, and 500 agents. Via visualization program is used to present the results from MATSim. Via can support to work with large, spatio-temporal datasets like the results of agent-based simulations or collected GPS trajectories including visualizing and analyzing MATSim data.

The results showed that a greater number of agents created more traffic on the road network. For 10 agents, the traffic can flow freely and starting to speed down when simulated with 100 agents. Moreover, the traffic flows with difficulty or jam with 500 agents in the simulation. However, these results can explain that the number of vehicles affects the traffic flow on the road network. Furthermore, some links are shared for all agent such as the Paholyothin road that agents travel through this route to their workplace as shown in Fig. 5. and Fig. 6. Especially for 500 agents, it is shown continuously as green lines. It shows heavy traffic on that links due to the large number of agents sharing route among themselves. However, agents travel from their workplaces to their homes using the Vibhavadi road that is a shared route too.

Additionally, the simulation results show the traffic jam situation for running 500 agents on the route from workplace to home, as shown in the Fig. 6. Since, there is another home location which is set as the top of the study area, agents seem stuck and one junction is for letting agents flow to another home location. Therefore, other agents whose home location set at the top cannot move, because the lane capacity set for one lane means that agents can flow as first come first serve. In the real world, this kind of situation happens in Bangkok such as the car blocked at one junction, where most of the cars prefer to go left or right. On the other hand, cars which want to go straight line up on the queue but not able to go.

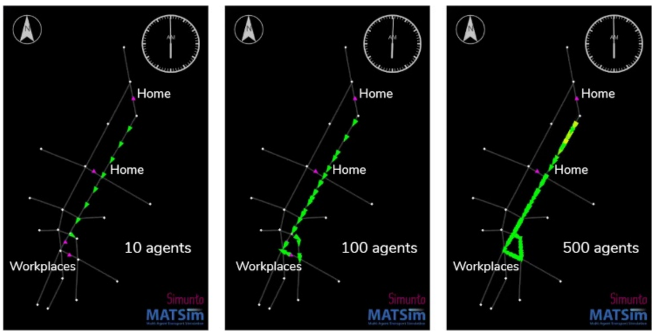

Fig. 5. The traffic flow simulation results from MATSim, for homes to workplaces trips among the different number of agents; 10, 100, and 500 agents visualized by VIA.

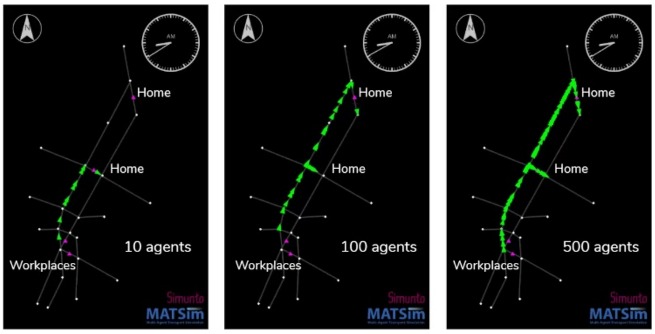

Fig. 6. The traffic flow simulation results from MATSim, for workplaces to homes trips among the different number of agents; 10, 100, and 500 agents visualized by VIA.

Moreover, MATSim also generates results such as score statistics, travel distance statistics, travel time histogram, and running performance. In every iteration, a leg histogram is plotted. A leg histogram depicts the number of agents arriving, departing or ending the route, per time unit. Histograms are created for each transport mode and for the sum of all transport modes. Each file starts with the iteration number and ends with the transport mode. As the result in Fig. 7., the travel time histograms show different arrival time among the different number of agents in the simulation. For 10 agents, it starts departure at the same time, but it arrives at the destination at a different time (single minute different). For 100 agents and 500 agents, the result shows clearly that agents arrive at their destination in different time (an hour different) because of the larger number of agent effect on their travel time that leads to late arrival time.

The score statistics show the average best, worst, executed and overall average of all agents' plans for every iteration. Also, plans are scored after the simulation step and, based on the score, agents adapt their plans in response to conditions that arose during the simulation. In this study, the results show the different score for running three cases of the simulation as the example illustrator shown in Fig. 8. For first iteration, it shows the low score at the first running iteration and gradually increase until finishing running at the last iteration. Higher round or higher iteration, the results present a higher average of the average travel distance per plan.

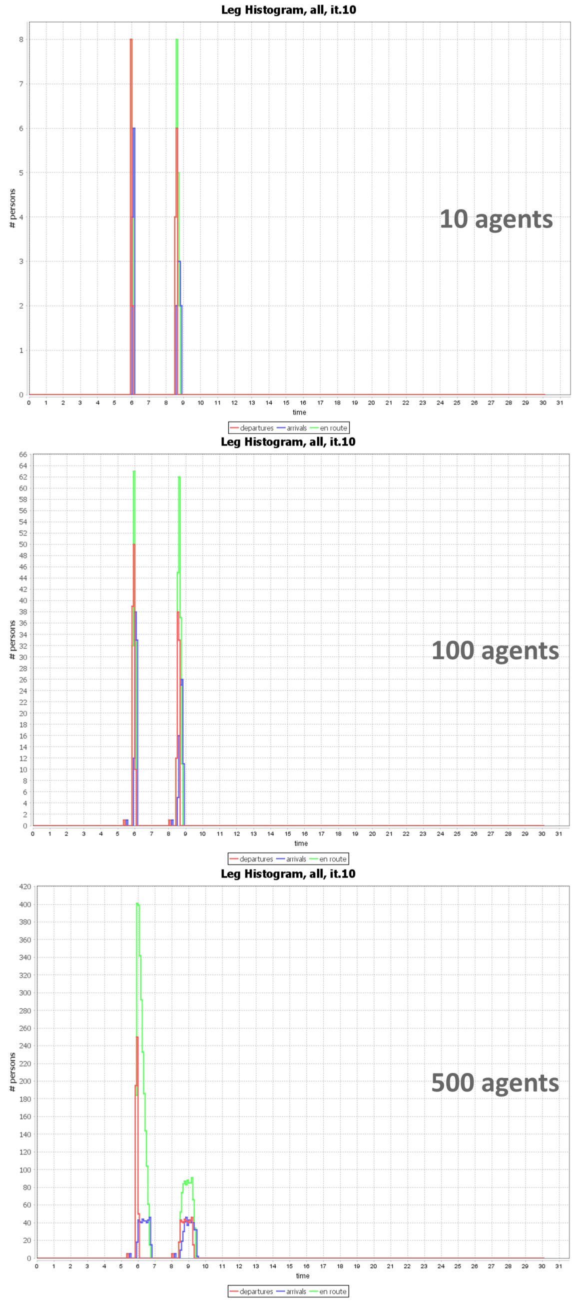

Fig. 7. The travel time histogram results among different number of agents; 10, 100, and 500 agents.

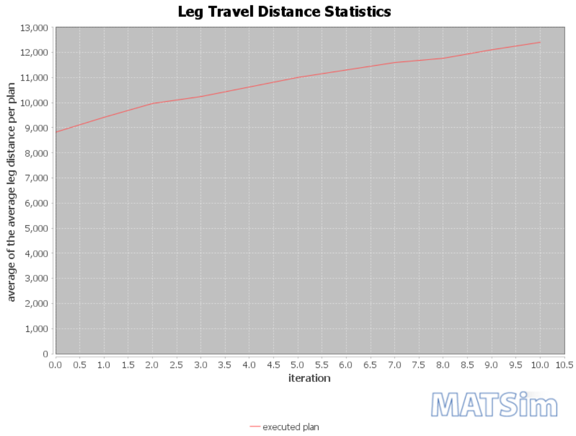

Fig. 8. The example of the score statistics results from running 500 agents with 10 iterations.

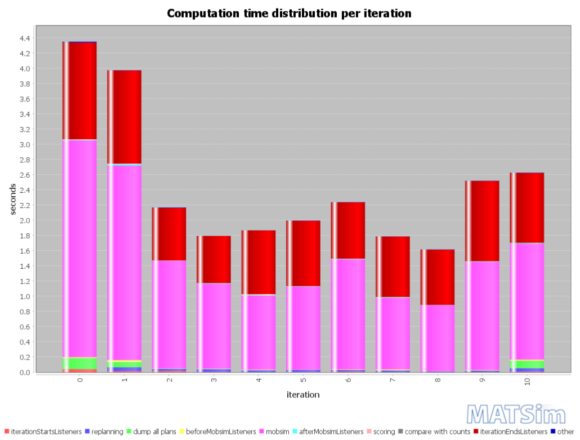

Fig. 9. Example of the stopwatch results from running 10 agents with 500 iterations.

The stopwatch file contains the computer time of actions like re-planning or the execution of the mobsim, a simulation in MATSim framework for every iteration. This data is helpful for computational performance analyses, e.g., how long does re-planning take compared to the mobility simulation. As the results in Fig. 9., at the first and second iteration, it took more time for execution plan and processing. Moreover, most of the processing time spend for mobsim and iteration of end listener (writing the output file).

MATSim framework file size is approximately 157 MB (Megabyte). In this case, 512 MB of memory is typically enough to run the small simulation as examples. For larger scenarios might need more memory, that allows Java to use up to 3 GB (Gigabyte) of RAM. In this study, processor Intel Core i7-6500U CPU, 2.59 GHz and RAM (Random Access Memory) 8.00 GB (7.59 GB usable) are used for processing. Therefore, about 50-60% of CPU is used for running MATSim and the physical memory usage including file size of input and output data are shown in Table 1. According to the results in part of physical memory usage, the large number of agents used the most memory for processing because it read all plans from every single agent that is related to file size of input data

V. Discussion

For data requirement for running MATSim, two main required inputs are network and agent's plan because the model is simulated based on agent's plan and its travel route. So, for new users, they can skip this facility file and only prepare for network data and agent's plan file. For initial demands of a full day plan and activities, based on the results, a full day plan and activities affect the traffic flow because one agent consists of several plans in a day. Some plans are needed for them to share the route for travelling.

For the traffic flow simulation using MATSim for the different number of agents, the number of agents is the primary cause of different traffic flow because the more agent contains in the link, the more it presents heavily traffic flow. One important variable that affects the simulation is the travel demand between zones or areas. It can simulate the flow of study area based on how much each area or zone attraction people. However, there are other influencing and related variables which can be included in the simulation such as travel mode, population demographics, and employment data, etc. These data can be added for more realistic simulation.

TABLE I
File Size And Physical Usage

Number of Agents	10 agents	100 agents	500 agents
Configuration file size	3 KB	3 KB	3 KB
Network file size	5 KB	5 KB	5 KB
Agent's plan file size	4 KB	39 KB	195 KB
Computing time	21 seconds	23 seconds	29 seconds
Physical memory usage	227.85 MB	235.44 MB	260.60 MB
Output file size	1.07 MB	1.38 MB	1.88 MB

VI. Conclusion And Future Work

A. Conclusion

In conclusion, MATSim framework can be used to simulate traffic flows based on the given data. Especially, the route assignment can be estimated by using MATSim as route assignment model. Also, MATSim can simulate many agents such as 10-100 million agents which is moving objects. The moving objects such as bicycles, motorbikes, people, cars, buses, taxis, etc. can be used for simulation considering as agents. However, MATSim cannot support the specific free speed for the different time of a day.

According to the pilot study, network and agents' activity plans are mainly required for input data in MATSim framework. Facilities data is also important in order to set a location type such as homes, workplaces, hospitals, schools, etc. Also, because MATSim model executes based on individual agent plans, initial demands are needed to define before running MATSim. A full day plan and activity can be performed based on historical data or OD data. Moreover, according to the different number of agents, the traffic simulation results are given differently. The larger number of agents are presented with more congestion of traffic rather than a smaller number of agents. Lastly, about physical memory usage, MATSim is quite a small program and produces a small size of output file. Moreover, the output file size is increased by the number of agents. More agent contains more physical space of memory.

B. Future Works

As discussed in the previous sections, many challenges remain and MATSim can apply as a simulation tool. In case of Bangkok, morning peak hour and evening peak hour always has high congestion, especially on weekdays. Also, some special events or occasions such as rainy days, pay days, Friday at the ends of month, etc., the traffic jam also occurs on all of these example events. In order to understand the traffic flow situation during the day or comparing the day within the week, MATSim can be used to simulate the flow of the vehicle on the network. Moreover, MATSim also supports multi-mode choices for travelling, and other transport modes can be combined in the simulation for modeling the situation of the transportation in Bangkok.

In the future, other areas related to transportation can be included in the simulation, for example; land use planning and policy making, integrated land-use and transport models or infrastructure planning for the future. Moreover, there are some similar traffic problems from other Southeast Asia countries which has not yet been studied using MATSim framework such as in Philippine, Vietnam, or Indonesia, where the model can be applied for studying on the traffic situation and transport systems.

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