Queue Length Estimation for Adaptive Traffic Signal Control Based on Traffic Information Collected from GPS Probe Data

(AYRF 15-056)

Napon Srisakda

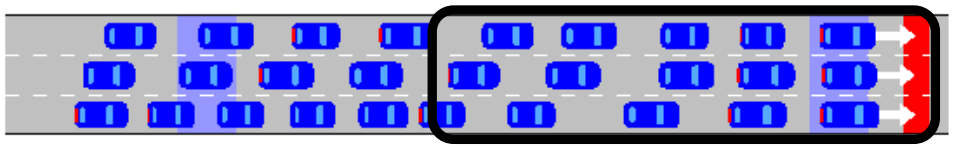
Prof. Atsushi Fukuda

Assoc. Prof. Tetsuhiro Ishizaka

College of Science and Technology
Nihon University

Introduction

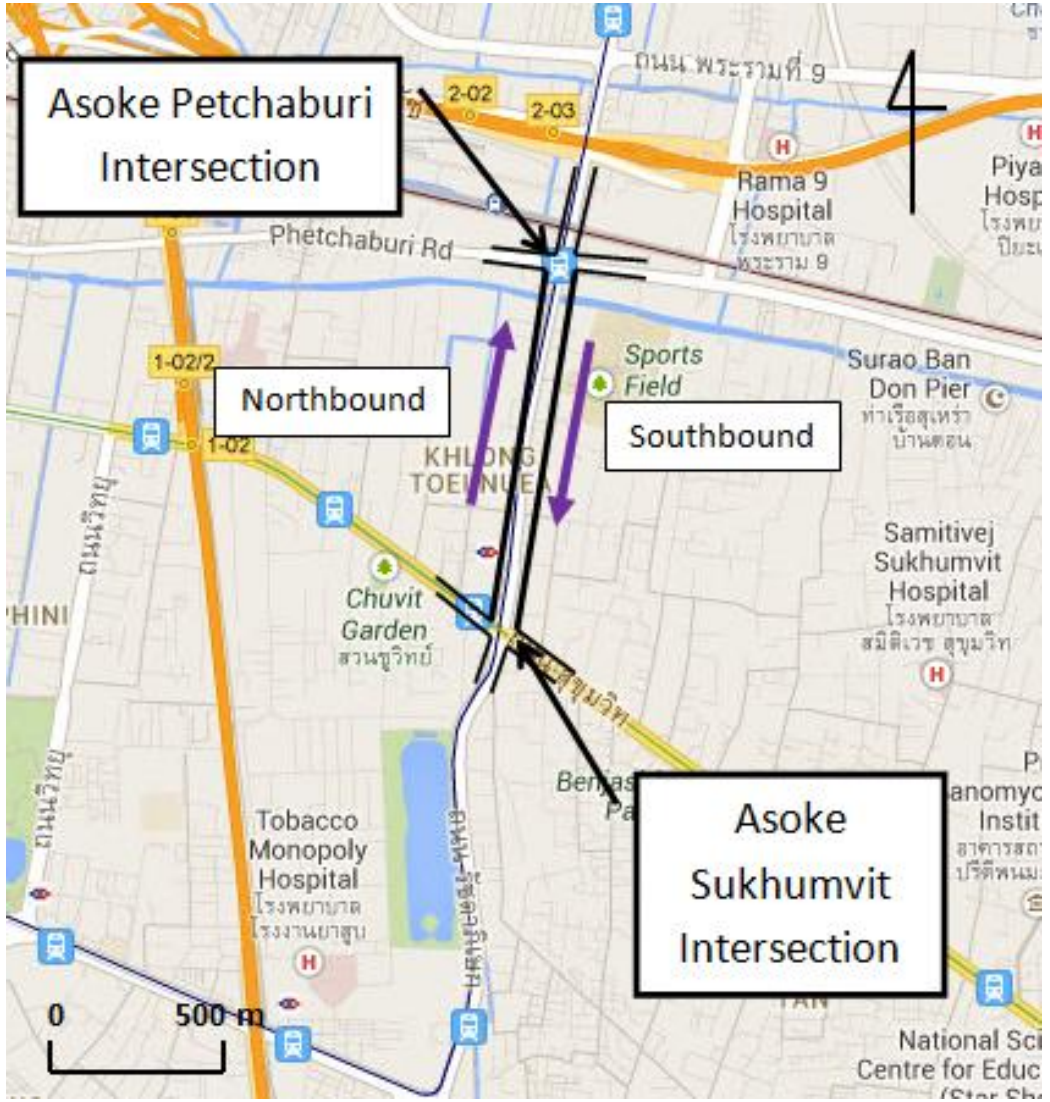
- Queue length
  - The performance measures for traffic signal control
  - Can be estimated using traffic data from detectors
  - However, they can not cover the actual queue length by limitation of amount of detectors and traffic congestion
- For better adaptive signal control, queue length estimation and reliability of its data are necessary
- Therefore, queue length estimation based on GPS probe data collected from taxis instead of traffic detectors is proposed in this study



Loop Detector

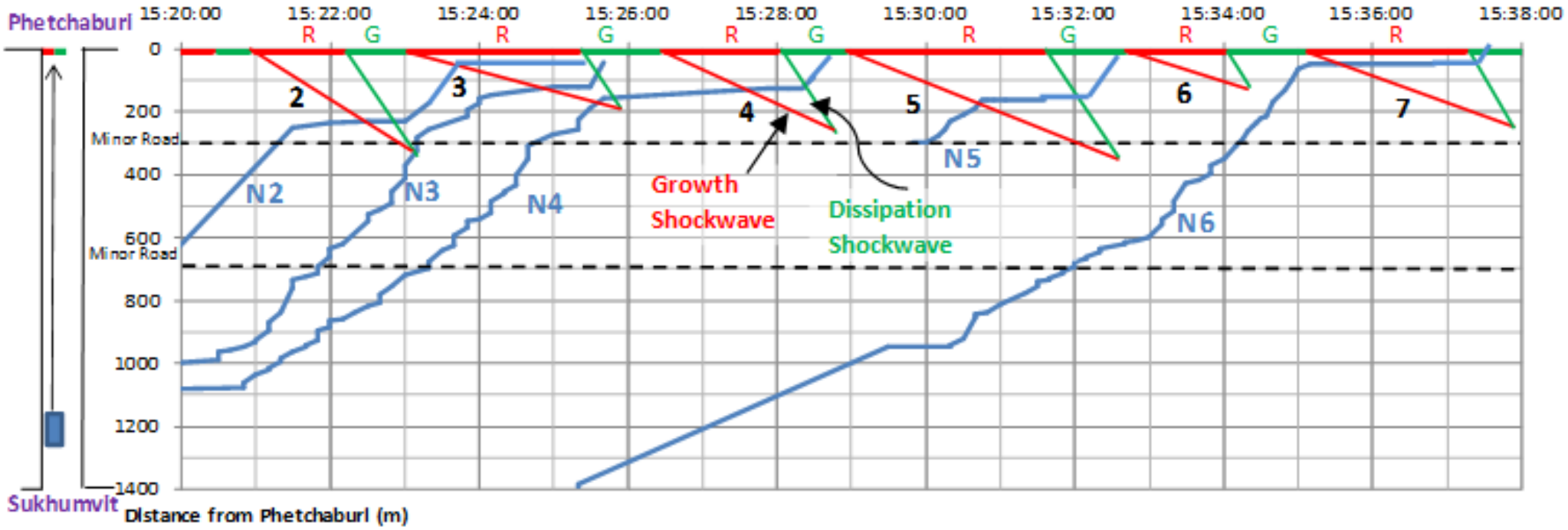
Data Collection

- Probe Data
  - Obtained from taxis in Bangkok area
  - Can Identify the ID numbers, positions, and speeds every 5 seconds
  - Probe trajectories can be plotted into time-space diagram from each point of data
- For observed traffic data
  - The growth of actual queue was determined based on shockwaves phenomenon in order to compare with probe trajectories
  - Traffic signal timing data was also collected to identify shockwave position
- Asoke Montri section was selected as the study site during 3-4 p.m.



Time-space diagram

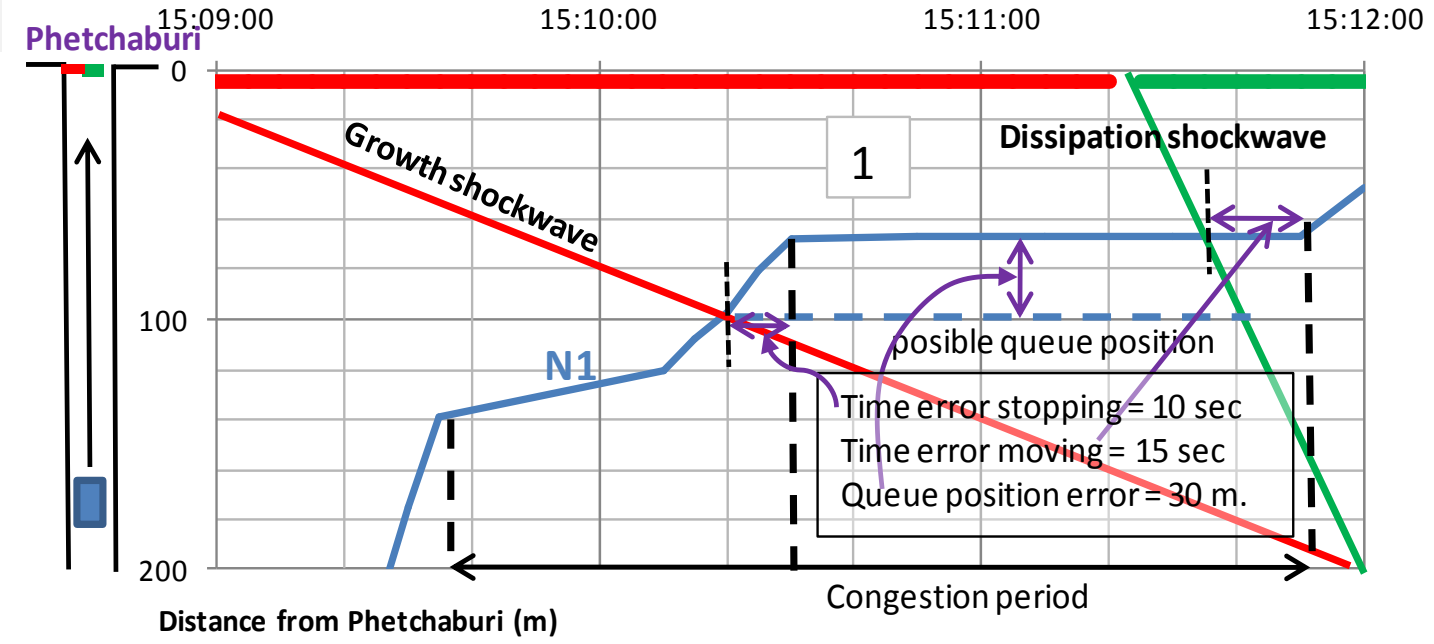
- Probe trajectories could stop at the queue and move out from the intersection depending on the shockwave lines
- However, detail of probe movement when stopping at the queue could not be readily seen, and queue length estimation was not focused upon



Reliability of Probe Trajectories

- Growth of actual queues was compared with queues predicted by probe trajectories in each cycle time by error identification
- Verification methods included

1) Time error when probe trajectories stopped at the queue
2) Time error when probe trajectories moved out from the queue
3) Error from stopping position of them compared with possible queue length position



- To prove reliability, average values of these errors from all cycle times could not be judged and explained that these results were close to the observation

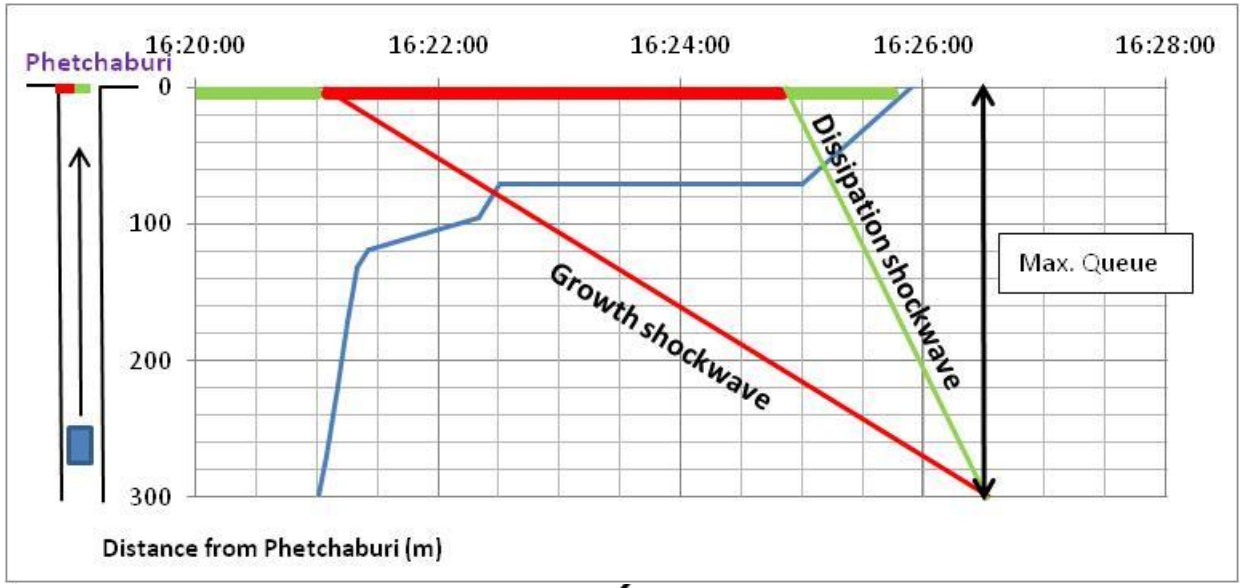
Reliability of Probe Trajectories

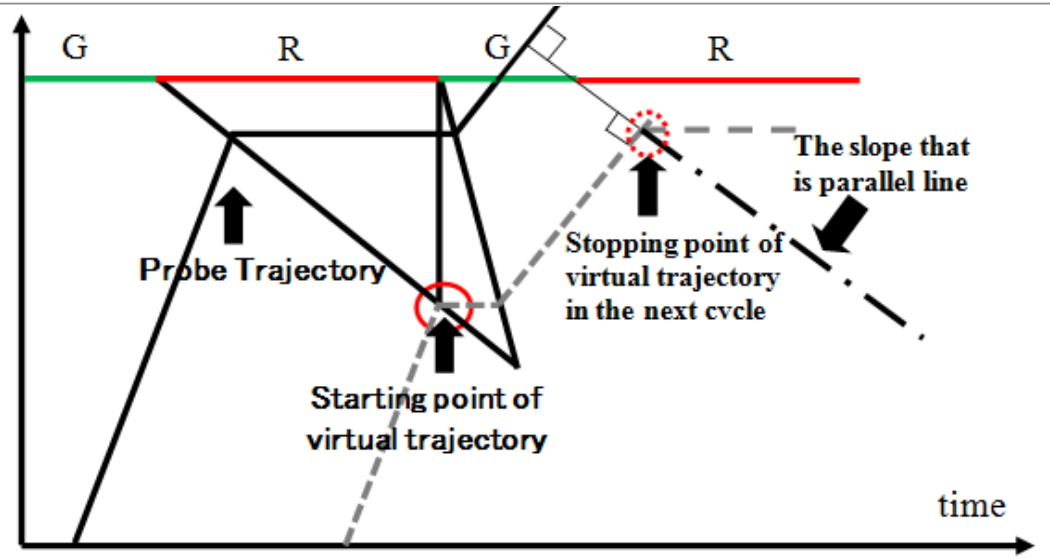
- So, non-parametric statistic was used for reliability judgment by using **Wilcoxon Signed-Rank Test**
- The difference between error and expected median (equal to 0) was calculated
- Ordered by using absolute value
- Separated into the group of positive and negative values
- The minimum summary of order in 2 groups was selected to compare with the critical value at 95% confidence

Tested Data (Amount of data)	The Minimum Summary of order	Critical Value at 95% Confidence	Significant difference
Time error stopping at the queue (14)	52.5	21	No
Time error moving from the queue (15)	32.5	25	No
Average error of stopping position (14)	24.5	21	No

Maximum Queue Length Estimation

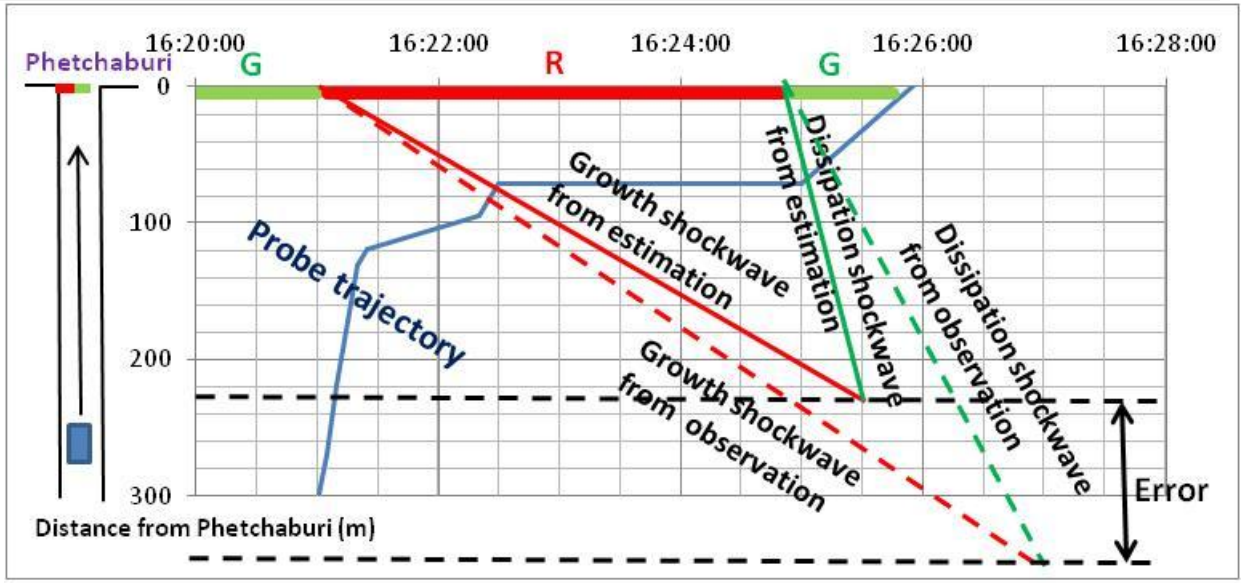
- For how to estimate the maximum queue length in each cycle time
- This study proposed a method for estimating queue length without probe vehicle detection based on previous probe trajectory
- This method can be explained by traffic flow theory that all vehicles travel with the same speed, and maintain the same constant spacing





Maximum Queue Length Estimation

- The estimation was compared with actual queue length in all cycle time results by MAPE
- As a results, MAPE both in 2 directions equaled to 18.6 which could be observed in this study



Direction	Cycle Time	Queue Length (meters)		% Error	Amount of Probes
		Probe Data	Observation		
Northbound	1	120	200	40.0	1
Northbound	2	130	150	13.3	0
Northbound	3	420	330	27.3	0
Northbound	4	150	240	27.5	1
Northbound	5	170	170	0.0	2
Southbound	1	375	300	25.0	1
Southbound	2	370	420	11.9	1
Southbound	3	230	275	16.4	2
Southbound	4	210	180	16.7	1
Southbound	5	240	200	20.0	0
			MAPE (NB)	19.5	
			MAPE (SB)	16.8	
			MAPE (ALL)	18.6	

Conclusion

- Probe data could well reflect the trajectory according to traffic flow theory
- By using Wilcoxon Signed-Rank Test, time error of probe trajectories in all cases provided satisfactory results from error examinations in all cycle times
- For maximum queue length estimation, MAPE both in northbound and southbound of this study site equaled to 18.6, which could be observed
- For better adaptive signal control, methodology for queue length estimation without signal timing information should be considered for further study

Thank you for your attention