A Realtime Dynamic Traffic Control System Based on Wireless Sensor Network

International Conference on Parallel Processing Workshops, 2005

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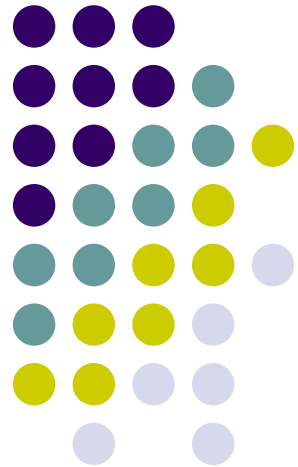
2007/05/31



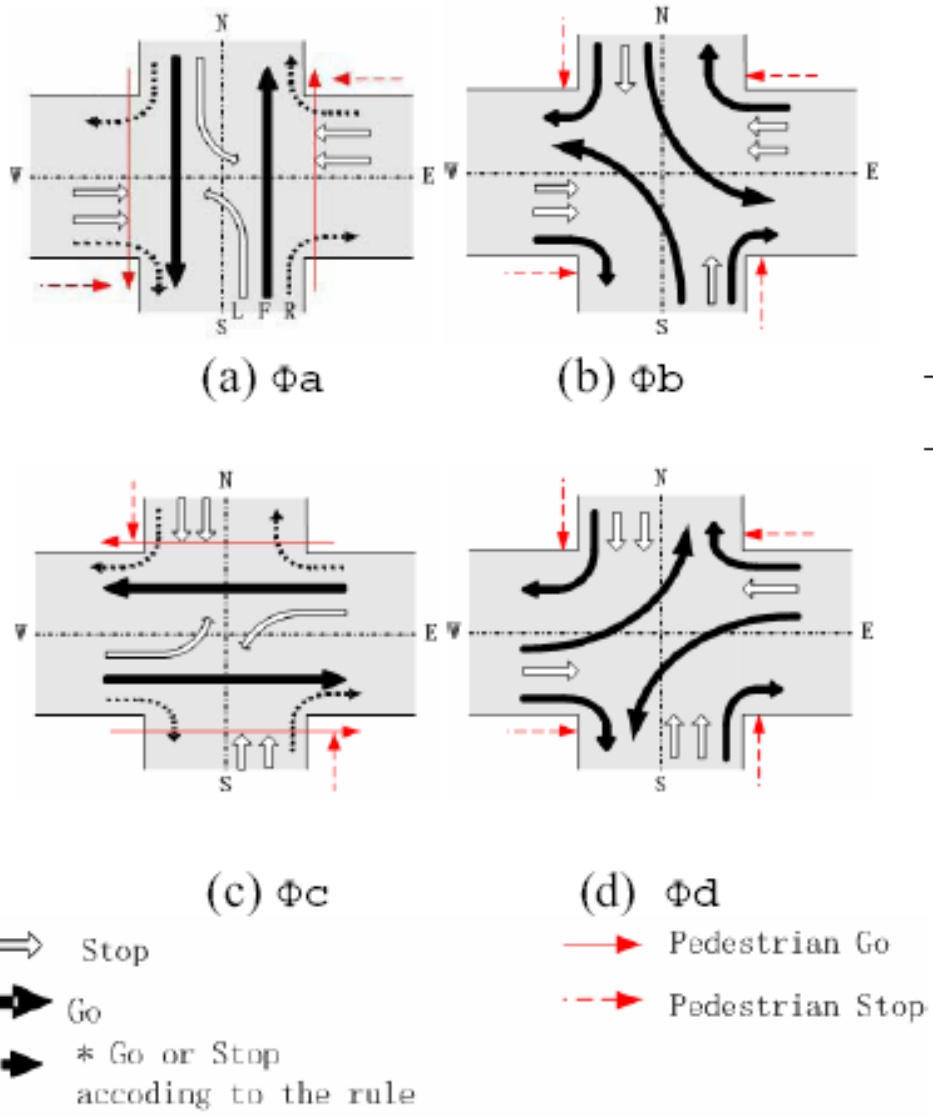
Outline

- Introduction
- Model of intersection
- Algorithm
- System model
- Simulation
- Conclusion

Introduction

- Traffic signal control :
  Preset or Wireless Sensor-based.
- Gather the traffic information and control the traffic flow.
- How to forecast the incoming vehicles in an intersection?

Model of intersection



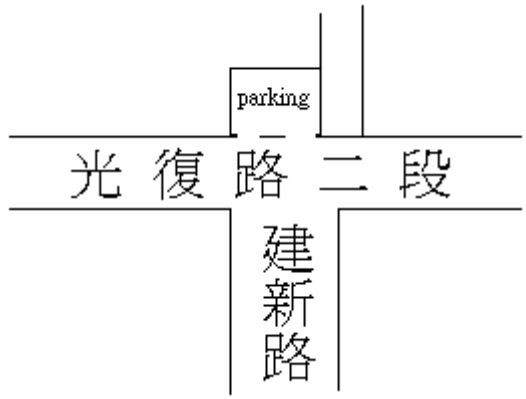


Figure 1. Four phases of signal light

Model of intersection

- Assume the right turn is always permitted.
- In each direction, there are two waiting queues including parking and running vehicles.
- The goal is to gather the information of incoming vehicles via WSN, and set phase time dynamically.

Algorithm

- The key idea of the algorithm is to set Expectant Phase Time equal Queue Passing Time
- Phase time $\leqq$ 90 seconds.
- If there is no vehicle in the waiting queues, the phase will be passed through.

System model

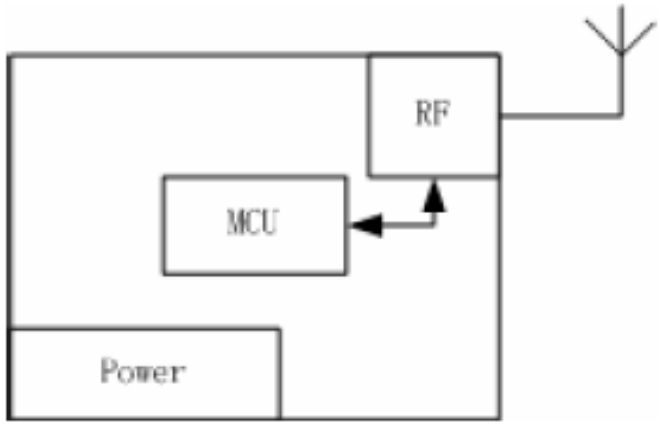
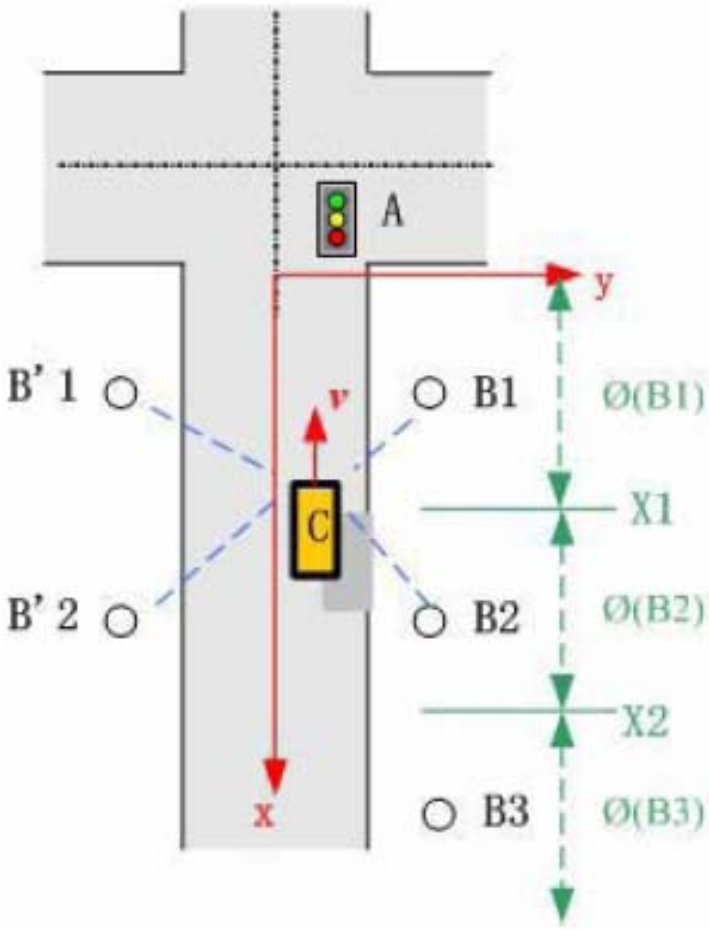


Figure 2. Module structure of a WSN node used in this paper

- Radio Frequency.
- 8-bit Micro Control Unit.
- Solar cell or rechargeable battery.

System model

- A – Control Node
- B – Detector Node
- C – Vehicle Node



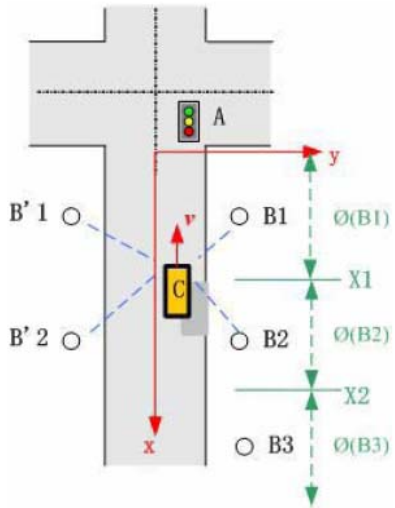
System model

- There are three steps to get Queue Passing Time:
  1. Vehicles detecting and locating.
  2. Data synthesizing and relaying.
  3. Summarizing and executing.

System model

(1) Vehicles detecting and locating

- Vehicle node receives more than three detector nodes' broadcast, and it can calculate its location **(x,y)** and velocity **v**.
- Then, vehicle node sends **(x,y,v)** to the detector node nearby.



System model

(2) Data synthesizing and relaying

- Detector nodes receive **(x,y,v)** and will know the vehicle status is :
  1) It has reached the intersection.
  2) It will reach the intersection before the current phase expired.
  3) It will not reach the intersection in time.

System model

- The expectant queue passing time can be calculated dynamically by detector nodes.
- If the traffic condition changes, a new expectant queue passing time will be re-calculated and sent to the control node.
- In order to reduce the transmitting data, detector nodes will merge the data received from their neighbor.
- Detector nodes relay the data every second.

System model

(3) Summarizing and executing

- Control node receives the Queue Passing Time of each phase and uses the algorithm to determine the phase time.

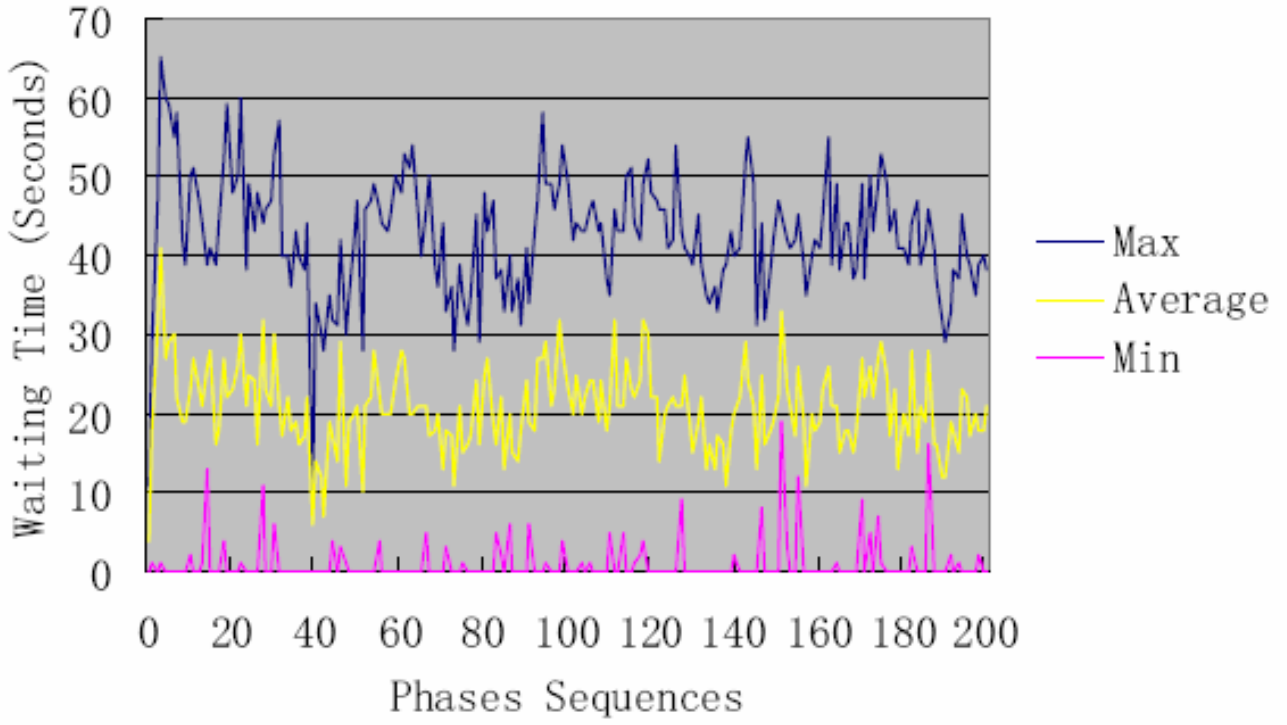
Simulation

- Assume that it takes a vehicle 1 second to pass a vehicle.
- It takes the first vehicle in queue 5 seconds to cross the intersection forward, and 7 seconds to turn left.
- The evaluation is based on the waiting time of vehicles.

Simulation

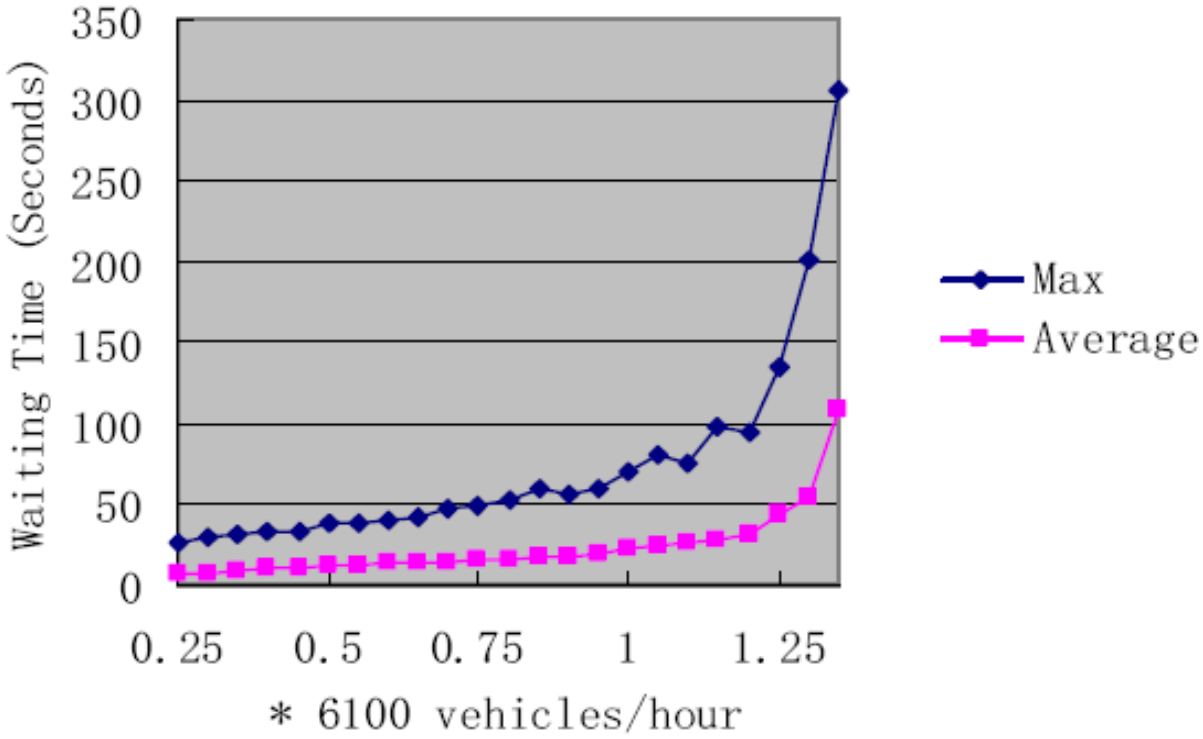
Approach	Incoming Vehicles (vehicles/hour)			Initial Queue Length (Vehicles)		
	L	F	R	L	F	R
E	251	779	242	5	12	4
W	346	896	430	5	10	6
S	410	944	275	6	10	5
N	430	854	243	6	12	4

Simulation



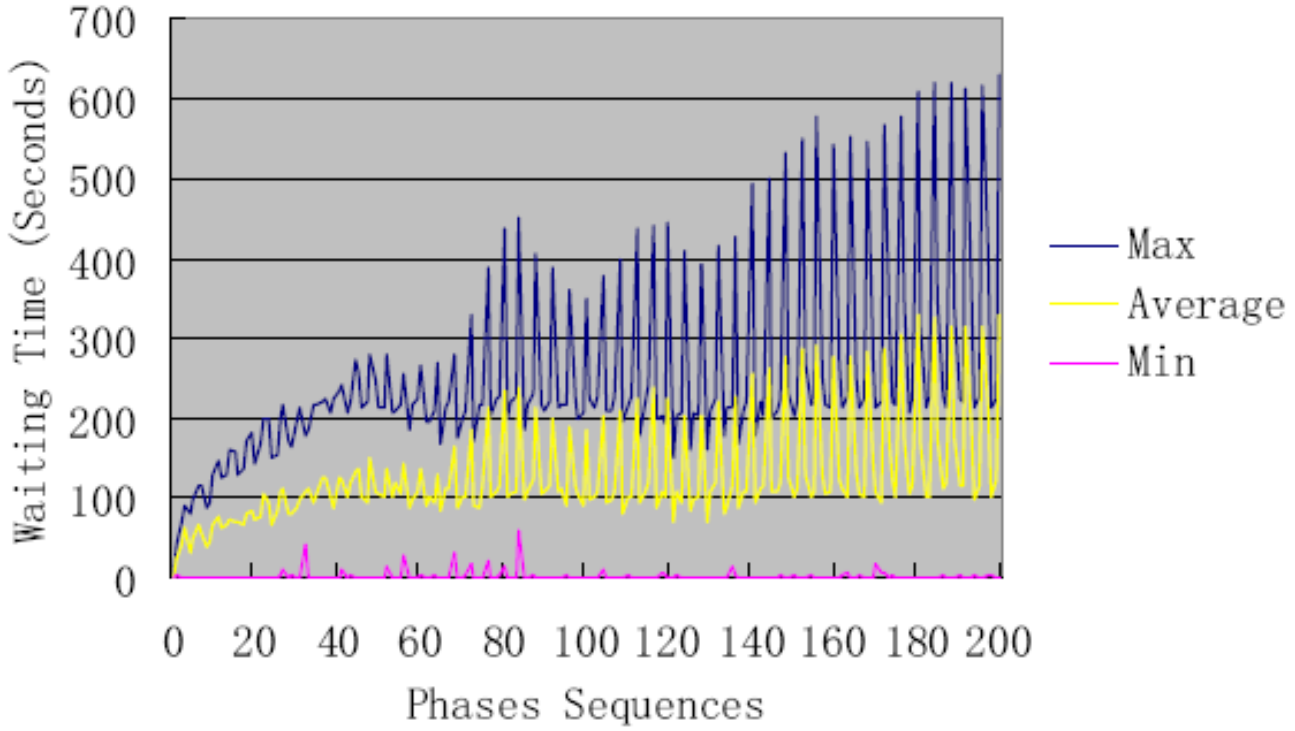
(a) Maximal, minimal and average waiting time in 200 phases when traffic load = 6100 v/h

Simulation



(b) Maximal and average waiting time in terms of different traffic load

Simulation



(c) Maximal, minimal and average waiting time in 200 phases when traffic load=6100*1.4 v/h

Conclusion

- The authors propose a method based on wireless sensor network, controlling the traffic signal light time dynamically.
- The simulation shows that the average waiting time is about 20 seconds when the traffic load is 6100 vehicles/ hour.
- However, if the traffic load is over 8500 vehicles / hour, this method will fail.