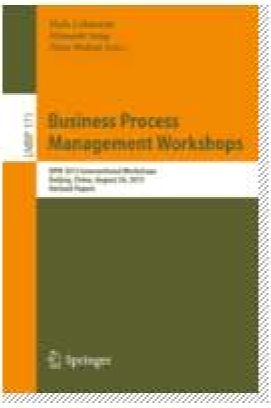

Business Process Management Workshops

BPM 2013 International Workshops, Beijing, China, August 26, 2013, Revised Papers
Series: » Lecture Notes in Business Information Processing, Vol. 171

Lohmann, Niels, **Song**, Minseok, **Wohed**, Petia (Eds.)

2014, XXXIX, 564 p. 205 illus.

Available Formats:

eBook

Softcover
(gross) price for Algeria

72,00 €

Get it now

- ISBN 978-3-319-06256-3
- free shipping for individuals worldwide
- Due: June 30, 2014

» add to marked items

Like 0 Tweet 0 +1 0

ABOUT THIS BOOK

This book constitutes the refereed proceedings of nine international workshops held in Beijing, China, in conjunction with the 11th International Conference on Business Process Management, BPM 2013, in August 2013.

The nine workshops comprised Business Process Intelligence (BPI 2013), Business Process Management and Social Software (BPMS2 2013), Data- and Artifact-Centric BPM (DAB 2013), Decision Mining and Modeling for Business Processes (DeMiMoP 2013), Emerging Topics in Business Process Management (ETBPM 2013), Process-Aware Logistics Systems (PALS 2013), Process Model Collections: Management and Reuse (PMC-MR 2013), Security in Business Processes (SBP 2013), and Theory and Applications of Process Visualization (TAProViz 2013). The 38 revised full papers presented were carefully reviewed and selected from 74 submissions.

Content Level » Research

Keywords » SCM - business analytics - business intelligence - business process management - event processing - event-driven architectures - information visualization - logistics systems - process mining - process modeling - process monitoring - process patterns - process security - process visualization - social software - supply chain management - workflow management

Related subjects » Business Information Systems - Database Management & Information Retrieval - Information Systems and Applications - Production & Logistics

TABLE OF CONTENTS

Discovering and Navigating a Collection of Process Models using Multiple Quality Dimensions.- Discovering Stochastic Petri Nets with Arbitrary Delay Distributions From Event Logs.- Discovering Unbounded Synchronization Conditions in Artifact-Centric Process Models.- Uncovering the Relationship between Event Log Characteristics and Process Discovery Techniques.- Process remaining time prediction using query catalogs.- Discovering Block-Structured Process Models From Event Logs Containing Infrequent Behaviour.- Business Process Intelligence Challenge 2013.- Enabling Workflow Composition within a Social Network Environment.- Towards A Meta-Model for Goal-Based Social BPM.- An experiment on the capture of business processes from knowledge workers.- ISEAsy: a social business process management platform.- Towards a Reference Implementation for Data Centric Dynamic Systems.- Synthesizing Object-Centric Models from Business Process Models.- Activity-centric and Artifact-centric Process Model Round trip.- Automatic Generation of Business Process Models based on Attribute Relationship Diagrams.- Enriching Business Process Models with Decision Rules.- Validating and Enhancing Declarative Business Process Models Based on Allowed and Non-Occurring Past Behavior.- Constructing Decision Trees from Process Logs for Performer Recommendation.- An Exploratory Approach for Understanding Customer Behavior Processes Based on Clustering and Sequence Mining.- The Design of a Workflow Recommendation System for Workflow as a Service in the Cloud.- Business Process Assignment and Execution from Cloud to Mobile.- Monitoring of Business Processes with Complex Event Processing.- Bringing Semantics to Aspect-Oriented Business Process Management.- Towards the Enhancement of Business Process Monitoring for Complex Logistics Chains.- Investigating Service Behavior Variance in Port Logistics from a Process Perspective.- A Petri Net Approach for Green Supply Chain Network Modeling and Performance Analysis.- Towards a DSL-based approach for specifying and monitoring home care plans.- Urban Congestion: Arrangement of Aamriw intersection in Bejaia's city.- Supply Chain Uncertainty under ARIMA Demand Process.- Methods for Evaluating Process Model Search.- Decomposition and Hierarchization of EPCs: A Case Study.- Process Model Fragmentization, Clustering and Merging: An Empirical Study.- Towards Measuring Process Model Granularity via Natural Language Analysis.- Automatic Extraction of Process Categories from Process Model Collections.- The Process Model Matching Contest 2013.- Keynote: Specification and Conflict Detection for GTRBAC in Multi-domain Environment.- Multi-dimensional Secure Service Orchestration.- Explication of Termination Semantics as a Security-Relevant Feature in Business Process Modeling Languages.- Supporting Domain Experts to Select and Configure Precise Compliance Rules.- A Framework for the Privacy Access Control Model.- Role-based Access Control for Securing Dynamically Created Documents.- Towards Enhancing Business Process Monitoring with Sonification.- A Navigation Metaphor to Support Mobile Workflow Systems.- Evaluating KIPN for Modeling KIP.

Urban Congestion: Arrangement Aamriw Intersection in Bejaia's City

N. Guerrouahane, S. Bouzouzou, L. Bouallouche-Medjkoune, and D. Aissani(✉)

Laboratory of Modeling and Optimization of Systems (LAMOS)
Department of Operational Research, University of Bejaia, Bejaia, Algeria
djamil_aissani@hotmail.com

Abstract. This study analyzes the traffic characteristics and management within Bejaia metropolis (Algeria). Large scale spatial and temporal land-use data were used to investigate the dynamics of land-use change in this area. In this paper, we considered the case of the intersection of Aamriw (Bejaia's city), using discrete event simulation. This allowed us to calculate the main performance of the system with traffic lights and with the construction of a hopper. We present simulation results that show the validity of the queueing models in the computation of average travel times. These results allowed us to make a comparison between different versions, with traffic lights or with hopper.

Keywords: Modeling and verification of processes in logistics-based systems · Urban congestion · Intersection · Traffic lights · Queueing Theory

1 Introduction

With the rapid increase in the transport demand in this last decade, congestion has become a mostly problem and frequently for the human mobility [18]. An effective policy of the transport is necessary to struggle against the urban congestion. Building infrastructure is one of the most important accompanying measure to reduce a road congestion. A question has been asked: the construction of the infrastructure should it be continue, or the growing demand for mobility should it be deplaced into public transport. Optimizing of the waiting time in the intersection have advantages: save time for drivers, reducing pollution and fuel use as well as through reducing congestion and improve the road safety [10,17]. The problem of congestion in an intersection persists and the construction of a new infrastructure was envisaged in this work. For this reasons we propose a study with the new situation. In this paper, we want to measure the traffic flow at the intersection of Aamriw in the Bejaia's city, using discrete event simulation. This allowed use to calculate the main performance of the system with traffic lights and with the construction of a hopper. Bejaia is one of the major towns of Algeria, located in the north to 180 km east of the capital Algiers, in edge Mediterranean sea. The density of Bejaia is a 481 inhabitants/km^2 in

N. Lohmann et al. (Eds.): BPM 2013 Workshops, LNBIP 171, pp. 355–364, 2014.
DOI: 10.1007/978-3-319-06257-0_28,

2010, or in 1999 it was 276 inhabitants/km^2. This evolution that exceeds 80 % in this last decade reflect the society by any problems in particularly the urban congestion. The city have an international commercial port, whose principal activity is the transport of hydrocarbon. Moreover, for this year 2012, the port of Bejaia has become the first wearing of Algeria in term of transported goods. This city is one of the largest industrial centers due to its geographical location and most dynamic in Algeria; that is why a proper transport policy is necessary to struggle against the urban congestion and to answer at the request of displacement.

The intersection of Aamriw situated in north west of the Bejaia's city, is an important point of exchange and distribution at the center. This intersection is dense to traffic during the year, but the flows are different during the summer and the rest of the year, for this reasons we are interested in the arrangement to this intersection. The reasons of congestion in this intersection are:

- It is an important point to access at areas of Bejaia's city, center of city, OPOW stadium, Iheddaden's area and national road toward Boulimat,
- It is the transit point toward neighbor communes, and toward cities,
- Not conformity of existing indication,
- Insufficiency of the markings horizontal and vertical,
- The presence of anarchistic bus stops at the exit of the crossroads.

In order to cure the problem of urban congestion at this intersection, we used the modelilisation of the road traffic by queues, of which the goal is to calculate the average waiting time of a vehicle during a cycle. In practice, several solutions can be considered like the improvement of the system of road signs, construction of new roads, hoppers, etc. Because of the complexity of this problem, one solution is not effective but a combination of these alternatives allows us to minimize the problems of congestion. For this reason, we considered an arrangement of this intersection by a static control system which is the traffic lights and by construction of a hopper.

Fig. 1. Aamriw intersection

The remainder of this paper is organized as follows. In Sect. 2, we first present a brief review of the existing work on stochastic queueing models and the modeling of the traffic flow at signalized intersections. In this regards, we present the methodology to calculate the average waiting time at signalized intersections. The main performance of the system with signals timed and with the construction of a hopper is presented in Sects. 3 and 4. Finally, Sect. 5 gives the conclusion and future work of this paper.

2 Literature Review

Congestion leads to delays, decreasing flow rate, higher fuel consumption and thus has negative environmental effects. The issue of urban traffic control came with the exponential growth in the number of vehicles on the roads, and intersections are the points where traffic is dense [17,18]. Modeling the traffic flow at signalized and unsignalized intersections has been discussed in many works [3,5,7]. The arrival process in roadway traffic is modeled as singly arriving Poisson process [8,14] and as platoons to represent the behavior of the vehicles moving between traffic signals [1,7,9]. Daganzo [1] presented a cell transmission model, representing the traffic on a highway with a single entrance and exit, which can be used to predict the evolution of traffic over time and space. Deschutter and Demoor [3] minimized the waiting time in a continuous manner. Ahadar et al. [4] reduced the control system to a state of non-saturation while minimizing an optimality criterion (the sum of the queues, the quadratic form queues, etc). Cheah and Smith [12] explored the generality and usefulness of state-dependent M/G/c/c queueing models for modeling pedestrian traffic flows. Jain and Smith [13] used M/G/c/c state-dependent queueing models for modeling and analyzing vehicular traffic flow on a roadway segment which can accommodate a finite number of vehicles. Each vehicle space corresponds to a server, thus, the maximum number of vehicles that can be accommodated on the link provides the number of servers, c, in the queueing model. Heidemann [5,6] studied the signalized intersections, and presents an unifying approach to both signalized and unsignalized intersections. Vandaele et al. [16] used $M/M/1$, $M/G/1$ and $GI/G/1$ queues with or without state-dependent rates to model traffic flow. Van Woensel et al. [15] compared the queueing approach with other approaches and its potential benefits are described and quantified. Raheja [11] proposed an analytical model of uninterrupted single-lane traffic, using queuing analysis.

Olaleye et al. [19] examined the traffic characteristics and management within Abeokuta metropolis (Nigeria). Markov chain and descriptive analysis were used to analyse the traffic characteristic of the Lafenwa and Ibara intersections, and also to predict the short and long term daily traffic situation for the incoming and outgoing traffics. The results predicted that provision of terminal facilities, parking lots instead of on-street parking and adequate terminal facilities around the intersections are suggested traffic management options to reduce traffic congestion noticed at these intersections. Yonggang and Kyungyong [20] modeled the traffic at the intersection of Archer RD and SW 34 ST in Gainesville during busy hours by using $M/G/1$ model. Based on the collected data they proposed two approaches to make the system Ergodic, by increasing number of lanes or by adjusting green light time for each direction. From the results, they saw that increase of the number of lanes by 2 is optimal and increasing the green light duration is easy to implement but not feasible in the traffic of SW 34 ST. In our work, we examined the traffic characteristics and management within Bejaia metropolis (Algeria). We modeled the traffic at the intersection of Aamriw using discrete event simulation, and show the validity of the queueing models in the computation of average travel times. Because of the complexity of this problem, one solution is not effective. In this case we proposed a combination of two approaches to minimize the problems of congestion, by traffic lights and by the construction of a hopper. The results obtained from the simulation we make it clear that the traffic lights will not solve the congestion problems at the intersection of Aamriw and the construction of a hopper is necessary to cure this problem.

3 Methodology

It is more reasonable, before looking at extending the network to use wisely the existing infrastructure. As the use of road infrastructure controlled by a signaling system, the question is how to exploit the best control of the system to improve traffic flow. Modeling the traffic flow at signalized intersections has been discussed in many works [3,6–8].

The real situation is complicated compared to the classical model of queues [15,16]. The fact that during the red light, no departure is permitted and vehicles do not go necessarily in order of their arrival except in the case of the intersection that consists of a single road corridor. The establishment of a system of lights at an intersection makes a separation in time of admission to different schools of vehicles. We concerned with random variables:

- The average waiting time for a vehicle during a cycle,
- The average number of vehicles in the queue.

3.1 The Average Waiting Time in a Cycle

The average waiting time in a cycle can be found in Morris et al. [8] and is given by:

$$E[W_c] = E[W_R] + E[W_V], \tag{1}$$

where

$$E(W_R) = E[\int_0^R (N(0) + A(t))dt] = R.E[N(0)] + \frac{\lambda R^2}{2}, \tag{2}$$

and

$$E(W_V) = E[\int_R^C N(t)dt] = \frac{\lambda p R}{2(1-\lambda p)^2} + \frac{p(2\lambda R.E[N(0)] + (\lambda R)^2 + \lambda R)}{2(1-\lambda p)}. \tag{3}$$

in which $A(t)$ is the number of vehicles reaching the system at [0, t], this interval starts at the red light. $N(0)$ is the length of queue at t = 0. W_R is the waiting time of any vehicle during the red light (R). W_V is the waiting time of any vehicle during the green light (V). W_c is the waiting time of any vehicle during a cycle (C = R + V). $N(t)$ is the number of vehicles in the queue at "t", p is the necessary period for a driver to cross the intersection (time service) and λ is the average number of arrivals per hour.

Remark 1. The necessary and sufficient condition for the queue is in equilibrium is that the average number of arrivals at cycle is less than the number of departures during the green. This means:

$$\lambda C < \frac{V}{p} \Rightarrow \lambda p < 1 - \frac{R}{C} \Rightarrow \quad \rho = \lambda p < 1 - \frac{R}{C}. \tag{4}$$

with the relations (1) and (2), the average waiting time during a cycle for any vehicle is:

$$E[W_c] = \frac{\lambda R}{2(1-\lambda p)}(R + \frac{2E[N(0)]}{\lambda} + p(1 + \frac{1}{1-\lambda p})). \tag{5}$$

Using Little's formula, we obtain the average waiting time during a cycle for one vehicle as:

$$E[d] = \frac{E[W_c]}{\lambda C} = \frac{\lambda R}{2C(1-\rho)}(R + \frac{2E[N(0)]}{\lambda} + p(1 + \frac{1}{1-\rho})). \tag{6}$$

Remark 2. If the traffic is fluid, $E[N(0)]$ *can be negligible. Otherwise, calculate the value of* $E[N(0)]$*. Morris et al. [8] calculated the probability generating function of the initial size of the queue* $(N(0))$*.*

3.2 The Directional Flow Analysis

According to the public works management 2010 [2], empirical observations of the road traffic at the intersection of Aamriw are referred to Fig. 1.

- **The channel 1** represents the flow from **Wilaya** on a global traffic of nearly 24 890 vehicles: 39 % for OPOW stadium, 35 % for Iheddaden and 26 % for Boulimat,
- **The channel 2** represents the flow from **Ihaddaden** on a global traffic of nearly 9950 vehicles: 56 % for Wilaya, 32 %for Boulimat and 12 % for OPOW stadium,
- **The channel 3** represents the flow from the **OPOW Stadium** on a global traffic of nearly 6170 vehicles: 65 % for Wilaya, 28 % for Iheddaden and 7 % for Boulimat,
- **The channel 4** represents the flow from **Boulimat** on a global traffic of nearly 3980 vehicles: 59 % for Iheddaden, 22 % for Wilaya and 19 % for OPOW stadium.

3.3 Statistical Analysis of Data

The adjustment of the probability laws of arrivals by theoretical laws was done with the statistical software R. This software allows us to test adjustments by different probability laws, discretes or continuous. Tests of Chi-square and Kolmogoriv-Smirnov are used in order to adjust the law of the arrivals. For that, each test is calculated in order to compare it with theoretical values and then decide the rejection or acceptance of the hypothesis (H) of the model of queues: H_0: "Arrivals$_i$ $\longrightarrow$ Poisson (λ_i)" ons H_1: "Arrivals$_i$ $\longrightarrow$ Not Poisson (λ_i)".

After trying several possibilities, the arrivals are Poisson at the crossroads for each destination of each channel. Indeed, the values of the Kolmogorov-Smirnov statistics (or Chi-square) calculated for the different destinations are all below the tabular value at a confidence level of 1 %. This allows us to accept the hypothesis H_0.

For each destination of each channel, the arrival rates, λ_i, are estimated and given in Table 1.

Table 1. Arrival rate

Channel i	1	2	3	4
λ_i (veh/sec)	0.54	0.23	0.15	0.073

3.4 Discrete Event Simulation

The data from the whole year of 2010 was used in the MATLAB (MATrix Laboratory) to determine the performance of our system. MATLAB is an environment of calculation equipped with a language of very high level with an interactive interface and to apply in the fields of applied mathematics such as : numerical calculation and mathematical modeling, programming of the mathematical algorithms, etc. Simulation by discrete events indicates the modeling of a real system such as it evolves in time, by a representation in which the sizes characterizing the system change only into one finished or countable number of points isolated in time. These points are the moments when the events occur. The simulation queues allows us to calculate performances of our system (queue length, waiting time, etc.). The principle of a queueing system is, when a costumer arrives, it joins the queue if the server is busy, otherwise it immediately begins to be served. The events of a phenomenon waiting are:

1. The arrival of a customer in the system,
2. The customer access server (the start of service),
3. The output of a customer in the system (the end of service).

4 Comparison of Analytical Results with Signals Timed and with the Hopper

4.1 With Signals Timed and Without the Hopper

We consider a fixed cycle with 90 s, the green light is placed on the channels (1) and (3) and the necessary period for a driver to cross the intersection when the green light is on, is $p = 3$ s. The average waiting time when decreasing the green light period for the channels (1) and (3) (So the red light period for the channels (2) and (4) is also decreased) are shown in the Table 2.

Table 2. The average waiting time for motorist at each channel

Cycle (V, R)	Channel 1		Channel 2	
⇓	Analytical	Simulate	Analytical	Simulate
(70,20)	Congested	-	Congested	-
(60,30)	Congested	-	Congested	-
(50,40)	Congested	-	Congested	-
(45,45)	Congested	-	Congested	-
(40,50)	Congested	-	Congested	-
(30,60)	Congested	-	Congested	-
(20,70)	Congested	-	61.8	75.23
Cycle (V, R)	Channel 3		Channel 4	
⇓	Analytical	Simulate	Analytical	Simulate
(70,20)	30	33.9	20	29.03
(60,30)	46	29.34	26	39.56
(50,40)	50	57.61	28	22.50
(45,45)	70	85.09	30	15.64
(40,50)	90	107.61	28	22.50
(30,60)	Congested	-	26	39.56
(20,70)	Congested	-	25	29.03

Interpretation of Results
For channels 1 and 2 (resp.Wilaya, Ihedadden) the stability condition (3) is not checked for considered cycle, which means that both channels are congested. Note that for channel 2 (Ihedadden), the system will be stable if the red period for this channel is less than 27 s (according to (3)). But this will cause congestion of the channel 3 (OPOW Stadium). For channel 1, so that it is not congested it is necessary that the red period tends to zero and the service time is minimal. This clearly justifies the development of a new road.

4.2 With Signals Timed and With the Hopper

The governments has addressed the problem of congestion of the intersection of Aamriw. One of the solutions suggested in urgency is the construction of a

Table 3. Comparison of wait times for each variant of hopper and without hopper

Cycle (V, R)	Variante 1 (Y)		Variante 2 (arc)		Without hopper	
Channel 1	Analytical	Simulate	Analytical	Simulate	Analytical	Simulate
(70,20)	Fluid	Fluid	26.32	28	Congested	-
(60,30)	Fluid	Fluid	20	18.12	Congested	-
(50,40)	Fluid	Fluid	Congested	-	Congested	-
(45,45)	Fluid	Fluid	Congested	-	Congested	-
(40,50)	Fluid	Fluid	Congested	-	Congested	-
(30,60)	Fluid	Fluid	Congested	-	Congested	-
(20,70)	Fluid	Fluid	Congested	-	Congested	-
Channel 2	Analytical	Simulate	Analytical	Simulate	Analytical	Simulate
(70,20)	Congested	-	Congested	-	Congested	-
(60,30)	Congested	-	Congested	-	Congested	-
(50,40)	35	33.83	Congested	-	Congested	-
(45,45)	23.15	29.25	Congested	-	Congested	-
(40,50)	26	28.45	Congested	-	Congested	-
(30,60)	20	25	Congested	-	Congested	-
(20,70)	11	10.22	62	75.23	61.8	75.23
Channel 3	Analytical	Simulate	Analytical	Simulate	Analytical	Simulate
(70,20)	20	18.51	30	33.9	30	33.9
(60,30)	40	35.98	46	39.34	46	29.34
(50,40)	48	50	48	50	50	57.61
(45,45)	33	38.05	33	40	70	85.09
(40,50)	58	61.82	58	61.82	90	107.61
(30,60)	Congested	-	Congested	-	Congested	-
(20,70)	Congested	-	Congested	-	Congested	-
Channel 4	Analytical	Simulate	Analytical	Simulate	Analytical	Simulate
(70,20)	40	47.64	40	47.64	20	29.03
(60,30)	38	45.77	38	45.77	26	39.56
(50,40)	30	30	30	30	28	22.50
(45,45)	28	28	28	28	30	15.64
(40,50)	28	30.40	28	30.40	28	22.50
(30,60)	20	26	20	26	26	39.56
(20,70)	15	11.18	15	11.18	25	29.03

hopper in order to increase the number of lanes (what reduces the arrival rate which pass by this intersection). Two variants are currently being discussed.

The first variant is a hopper ‘Y’, for the arrivals of channel 1 (Wilaya) towards channels 2 and 3 (resp. Ihedadden, OPOW Stadium), and the arrivals of channel 2(Ihedadden) towards channel 1 (Wilaya) (will have to go through the hopper). As for other locations, these drivers will go through the intersection (Arrivals channels 3 and 4 respectively, OPOW Stadium and Boulimat, will not change their habits). Hopper ‘Y’ increases the lane number by 2.

The second variant is a hopper ‘arc’, for the arrivals of channel 1 (Wilaya) towards the channel 2 (Ihedadden). Hopper ‘arc’ increases the lane number by 1.

In what follows, we will simulate the state of the intersection after the construction of the hopper, to determine the average waiting time for motorists entering the intersection. After an interpretation of the results, we will compare the two versions in terms of average waiting time.

The comparison of the average waiting time for each variant of hopper and without hopper is represented in Table 3.

Interpretation of Results

According to the simulation results of the two variants of the hopper, it is noted that with the second variant (arc), the congestion will not be eliminated, for channel 1 (Wilaya), traffic will be smooth for some cycles ((70,20), (60,30)) and congested for others, but the channel 2 (Ihedadden) will remain congested for some cycles (except the cycle (20,70)), so this hopper is not efficient in terms of waiting times for motorists from channels 1 and 2 (resp. Wilaya, Ihedadden). For the others channels 3 and 4 (resp. Boulimat, OPOW Stadium) there will be no improvement.

With the first variant (Y) traffic for channel 1 (Wilaya) will be fluid. For channel 2 (Ihedadden) traffic will remain congested only for two cycles (70,20) and (60,30). We can then conclude that the first variante (Y) is more appropriate to reduce congestion at the intersection of Aamriw.

5 Conclusion and Future Work

In this paper, we measured the traffic flow at the intersection of Aamriw (town of Bejaia, Algeria). We used discrete event simulation to calculate the main performance of the system with traffic lights and with the construction of a hopper. The results obtained from the simulation make it clear that the draft hopper is necessary to remedy of the congestion problems at this intersection, the traffic lights will not solve this problem.

Comparing the average waiting time, with both types of hopper : 'Y' and 'arc', it appears that the hopper 'Y' would be more beneficial to motorists in terms of saving time.

Our future work will include the extension of the current consideration with application of a dynamic control systems at signalized intersections which certainly captures more dynamics of traffic flow. At the same time, congestion level will be differentiated by peak, non-peak hour, and accidents to categorize the dynamics within different time periods.

Acknowledgments. The authors wish to thank the anonymous reviewers whose constructive suggestions helped improve the paper. The authors are especially thankful to Public Works Management of the town of Bejaia for providing accessibility to their vehicle data at the study intersection.

References

1. Daganzo, C.F.: The cell transmission model: a dynamic representation of highway traffic consistent with the hydrodynamic theory. Transp. Res. Part B **28**(4), 269–287 (1994)
2. Data on the road traffic on the level of the intersection of Aamriw, Public Works Management of the town of Bejaia (2010)
3. Demoor, B., Deschutter, B.: Optimal traffic light control for a single intersection. Eur. J. Control **4**(3), 260–276 (1998)
4. Elmoudni, R., Ahadar, Y.: R. Laboratoire SeT-Université de Technologie Belfort-Montbéliard UTBM, Bouyekh. Minimisation des files d'attente d'une intersection isolée (2003)
5. Heidemann, D.: Queueing at unsignalized intersections. Transp. Res. Part B **31**(3), 239–263 (1997)
6. Heidemann, D.: A queueing theory model of nonstationary traffic flow. Transp. Sci. **35**(4), 405–412 (2001)
7. Lehoczky, P.: Traffic intersection control and zero-switch queues. J. Appl. Probab. **9**(2), 382–395 (1972)
8. Morris, R.W., Darroch, J.N., Newell, G.F.: Queues for vehicle-actuated traffic light. Oper. Res. **12**(6), 882–895 (1964)
9. Neuts, M.F.: Modeling vehicular traffic using the discrete time Markovian arrival process. Transp. Sci. **29**(2), 109–117 (1999)
10. Pandian, S., Gokhale, S., Ghoshal, A.K.: Evaluating effects of traffic and vehicle characteristics on vehicular emissions near traffic intersections. Transp. Res. Part D **14**(3), 180–196 (2009)
11. Raheja, T.: Modelling traffic congestion using queuing networks. Indian Acad. Sci. Part 4 **35**, 427–431 (2010)
12. Smith, J.M., Cheah, J.Y.: Generalized M/G/C/C state dependent queuing models and pedestrian traffic flows. Queueing Syst. **15**, 365–385 (1994)
13. Smith, J.M., Jain, R.: Modeling vehicular traffic flow using M/G/C/C state dependent queueing models. Transp. Sci. **31**(4), 324–336 (1997)
14. Tanner, J.C.: A problem of interface between two queues. Biometrica **40**, 58–69 (1953)
15. Van Woensel, T., Kerbache, L., Peremans, H., Vandaele, N.: Vehicle routing with dynamic travel times: a queueing approach. Eur. J. Oper. Res. **186**(3), 990–1007 (2008)
16. Verbruggen, N., Vandaele, N., Van Woensel, T.: A queueing based traffic flow model. Transp. Environ. Transp. Res. Part D **5**(2), 121–135 (2000)
17. Wang, H., Rudy, K., Li, J., Ni, D.: Calculation of traffic flow breakdown probability to optimize link throughput. Appl. Math. Model. **34**, 3376–3389 (2010)
18. Wua, X., Liu, H.X.: A shockwave profile model for traffic flow on congested urban arterials. Transp. Res. Part B **45**, 1768–1786 (2011)
19. Olaleye, O.T., et al.: A Markov chain approach to the dynamics of vehicular traffic characteristics in Abeokuta metropolis. Res. J. Appl. Sci. Eng. Technol. **1**(3), 160–166 (2009)
20. Yonggang, L., Kyungyong, L.: Modeling Signalized Intersection Using Queueing Theory (2010)