TRAFFIC LIGHTS OPTIMIZATION IN THE CONDITIONS OF SMART CITY BASED ON CHOSEN CROSSROAD

Nathan REGASA[1], Mariusz KMIECIK[2*]

[1] Student at Silesian University of Technology, Zabrze; nathanbeyene8@gmail.com
[2] Silesian University of Technology, Zabrze, mariusz.kmiecik@polsl.pl; identyfikator ORCID: 0000-0003-2015-1132
* Corespondence: Mariusz.kmiecik@polsl.pl; Tel.: +48 32 277 74 07

Abstract: Smart cities integrate both data analytics and digital technology to improve life quality and sustainability. Among all the key ingredients of a successful smart city, transportation and supply of goods, public transportation services, and traffic flow all play important roles in the design of the city layout, business applications, and infrastructures. Due to high population density and inadequate transportation infrastructure, large urban agglomerations face a variety of logistical challenges. City logistics entails the efficient distribution of freight transport in urban areas, as well as approaches to reducing environmental impacts and traffic congestion. Optimization of traffic signal timing plans is one of the most cost-effective ways to improve urban mobility. Inappropriate signal timing can cause driver inconvenience as well as increased emissions and fuel consumption. Thus, it is critical to investigate signal optimization practices to ensure that new timing plans improve system performance. The goal of this research is to optimize the average time that vehicles spend in the system. First, real-time traffic data (vehicle arrival and turning movements, for example) is gathered from the Addis Ababa Atlas Mebrat crossroad. The Arena Simulation Software is then used to create a simulation model. The developed model's most important feature is the replacement of an existing pre-timed traffic signal timing plan with the new optimized pre-timed traffic signal timing plan. Following model validation, several alternative scenario analyses for traffic signal timing plans are considered, and the one with the shortest average time spent, shortest queue length, and highest utilization in the system is chosen.

Keywords: Smart City, traffic lights, City Logistcs, simulation.

OPTYMALIZACJA ŚWIATEŁ ULICZNYCH W PERSPEKTYWIE SMART CITY NA PRZYKŁADZIE WYBRANEGO SKRZYŻOWANIA DROGOWEGO

Streszczenie: Inteligentne miasta integrują zarówno analizę danych, jak i technologię cyfrową, aby poprawić jakość życia i zrównoważony rozwój. Wśród wszystkich kluczowych składników udanego inteligentnego miasta transport i dostawa towarów, usługi transportu publicznego i przepływ ruchu odgrywają ważną rolę w projektowaniu układu miasta, zastosowaniach biznesowych i infrastrukturze. Ze względu na dużą gęstość zaludnienia i nieodpowiednią infrastrukturę transportową duże aglomeracje miejskie stoją przed różnymi wyzwaniami logistycznymi. Logistyka miejska obejmuje wydajną dystrybucję na obszarach miejskich, a także podejścia do zmniejszania wpływu na środowisko i zatorów komunikacyjnych. Optymalizacja planów czasowych sygnalizacji świetlnej jest jednym z najbardziej opłacalnych sposobów poprawy mobilności w mieście. Niewłaściwa synchronizacja może powodować niedogodności dla kierowcy, a także zwiększone emisje i zużycie paliwa. Dlatego bardzo ważne jest zbadanie praktyk optymalizacji świateł, aby zapewnić, że nowe plany czasowe poprawią wydajność systemu. Celem tego badania jest optymalizacja średniego czasu, jaki pojazdy spędzają w systemie. Po pierwsze, dane o ruchu drogowym w czasie rzeczywistym (na przykład przyjazd pojazdów) są gromadzone ze skrzyżowania Addis Abeba Atlas Mebrat. Oprogramowanie do symulacji Arena służy do tworzenia modelu symulacyjnego. Najważniejszą cechą opracowanego modelu jest zastąpienie istniejącego planu czasowego sygnalizacji świetlnej z wcześniej ustalonym czasem nowym, zoptymalizowanym planem czasowym sygnalizacji świetlnej z ustalonym czasem. Po walidacji modelu rozważanych jest kilka alternatywnych analiz scenariuszy dla planów czasowych sygnalizacji ruchu i wybierana jest ta z najkrótszym średnim czasem spędzonym, najkrótszą długością kolejki i największym wykorzystaniem w systemie.

Słowa kluczowe: Smart City, światła uliczne, logistyka miasta, symulacje

1. Introduction

The term "smart city" and its roots must be followed by the smart growth movement, and it is emerged in the late 1980s and early 1990s and supported new urban planning policies. (Shafaatio et al., 2022) According to the smart growth approach, development decisions affect everything from personal lives to communities and nations. To mitigate the negative effects of development, intelligent growth strategies can help to maintain and develop health, safety, and more comfortable and appealing urban environments. (Jha et al., 2020) The term "smart city" was coined in Brisbane, Australia, and Blacksburg, Virginia, where ICT promotes social participation by closing the digital divide and improving access to services and information. Smart cities have emerged as a tool for visualizing urban texture. After the 1990s, they evolved slowly, but quickly since the early 2000s. (Zanella et al., 2014) According to a United Nations

(UN) report published in 2014, the global population has grown significantly in recent decades, as has the expectation of higher living standards. By 2050, it is expected that around 70% of the world's population will be living in cities. Cities currently consume 75% of the world's resources and energy, resulting in the production of 80% of greenhouse gases. As a result, the environment may suffer severe consequences in the coming decades. This necessitates the concept of smart cities. The creation of smart cities is a natural strategy for addressing the issues that have arisen as a result of rapid urbanization and population growth. Despite the costs, smart cities can reduce energy consumption, water consumption, carbon emissions, transportation requirements, and municipal waste once implemented. (Benjelloun et al., 2010) There are many components that make up a smart city, and this paper covers eight of them. Smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart technology, smart governance, smart education, and smart citizens are all components of smart cities. (Mohanty et al. 2016) Depending on their focus, different smart cities have different levels of these smart components. The major tasks involved in this research were field data collection. The data required to develop the model is as follows:

- Field data collection.
- Intersection geometry.
- Vehicle arrival counts.
- Turning movement counts.

The data for the current state of traffic was gathered on the spot. This data was used to assess the current and future state of the research area. The information was gathered at the Atlas-Mebrat crossroads. For data collection, a stop watch was used to keep track of time. All the field data collection took place in one month in 2022

2. Theoretical background

2.1 Smart infrastructure in the conditions of Smart City

One of this kind of components is smart infrastructure, the other ones are smart buildings, smart transportation, smart energy, smart healthcare and smart technology. Physical, information and communication technology (ICT), and service infrastructure are all part of the smart city's infrastructure. In a traditional sense, a city's infrastructure refers to any physical component of the city, such as roads, buildings, and bridges, that enables the city and its residents to function. In the context of smart cities, however, any physical, electrical, or digital infrastructure that serves as the backbone of the smart city can be considered infrastructure. It could be distinguished the three elements: physical infrastructure, service infrastructure and information and communication technologies infrastructure. Physical infrastructure is the smart city's actual physical or structural entity, which includes buildings, roads, railway tracks, power lines, and water supply. The non-smart component of smart cities is typically the physical infrastructure. Rapid transit systems, waste management systems, road networks, railway networks, communication systems, traffic light systems, street light systems, office space, water supply systems, gas supply systems, power supply systems, firefighting systems, hospital systems, bridges, apartment homes, hotels, digital libraries, law enforcement, and economic systems are just a few examples. Physical infrastructure underpins service infrastructure, which may include some ICT components. Smart grids and mass rapid transit systems are examples of service components. Communication infrastructures, such as fibber optics, Wi-Fi networks, and wireless hotspots, as well as service-oriented information systems, are all part of the ICT infrastructure. When compared to traditional infrastructure, smart infrastructure is more efficient, safe, secure, and fault-tolerant. information and communication technologies infrastructure is the smart city's core smart component that connects all other components, essentially acting as the smart city's centre.

The world is experiencing unprecedented urbanization. This rapid urban population growth rate is not a fascinating statistic, but it does call for long-term development and a better quality of life. In the 18th century, only about 5% of the world's population lived in cities. According to a United Nations report on the prospects of urbanization released in 2008, 2008 is the year in which more than half of the world's population lives in cities. This trend is accelerating, and by 2050 it is expected to account for more than 70% of the world's population. In Europe, 75% of the population now lives in cities. (Alawadhi et al., 2012) The effects of cities on the environment are the second issue in moving towards intelligence with regard to population growth in cities and their central role in economic and social dimensions around the world. Since the Industrial Revolution, human development has had a significant impact on the environment, and we now live in a time when these changes are largely attributed to widespread and destructive human behaviour. (Steffen et al., 2011) They do, however, have 2% of the world's drought and consume about 75% of the world's energy. Cities are the engine of economic growth, accounting for 80 percent of global GDP. Today, the majority of resources are consumed in cities around the world that are both economically and environmentally unfriendly. Cities account for roughly 70% of greenhouse gas emissions, making them a significant contributor to climate change. Global carbon dioxide emissions increased by 45 percent between 1990 and 2010, owing primarily to urbanization. (Zanella et al., 2014) As a result, many smart city projects focus on environmental issues and the need to develop sustainable cities. In Europe, smart cities are primarily concerned with energy and environmental issues. These issues have been identified as critical to maintaining a high standard of living in cities. This unprecedented rate of urbanization necessitates the development of novel approaches and solutions to address the challenges. Smart cities are concerned about environmental issues, and one of the pillars of the smart city is the use of technology to improve sustainability and natural resource management. By utilizing the potential of information and communication technology, the urban model of the twenty-first century can be understood. ICT advancements, according to Taffler, have ushered in a third wave in the evolution of cities. Citizens, businesses, and organizations are all connected to the nervous system by communication systems. Thanks to technology and Internet connectivity, citizens can receive services without regard to time or space. The flow of information between different parts of a city and between cities is cut off if broadband infrastructure is not invested in. This will stifle economic activity and have an impact on financial services. (Jha et al., 2020) As a result, connecting is an important aspect of city life that has become possible thanks to technological advancements

2.2 City logistics issues

Global population growth and the positive trend of urbanization, all forecasts for city trends show that there will always be more people living in cities in the future. This is what figure above shows, in which the UN DESA (United Nations Department of Economic and Social Affairs) gathered data to compute urbanization from 1950 to 2015 and forecast future values until 2050. The figure 1 shows a clear positive trend; the current urbanization rate is around 53.90 percent, and it is expected to reach 68.40 percent in 2050. (Morganti and Browne, 2018) For this reason, it is becoming necessary to figure out new logistics solutions to optimize the shipments in these environments, always more crowded and complex.

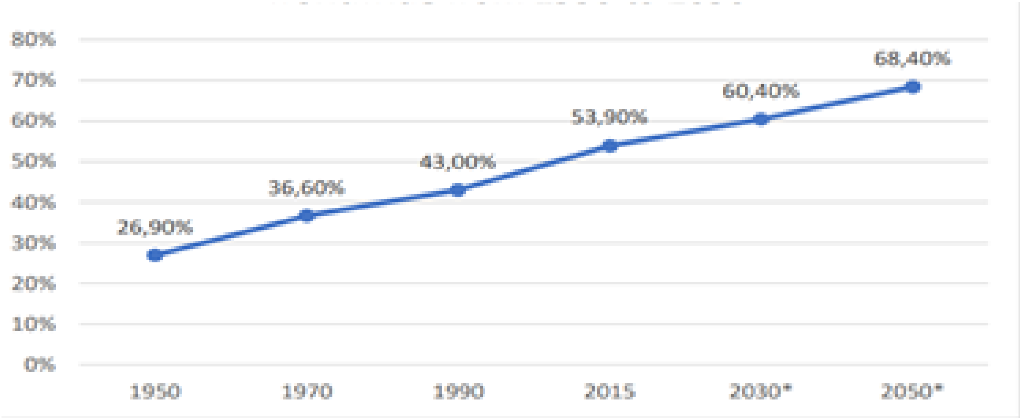

Figure 1. Percentage of the population living in urban are worldwide from 1950 to 2050

The Internet paved the way for e-commerce, which allows customers to purchase goods and services without having to go to a store. This phenomenon has resulted in a significant shift in society as well as new challenges for logistics providers. Goods are delivered directly to final customers in the traditional e-commerce setting. The traditional method of parcel delivery is by van, which means that drivers must take far more breaks for the downloading process than in traditional retail, because in the latter, customers must go to stores to make purchases, whereas vans must only download parcels at a few points. An increase in e-commerce leads (figure 2) to an increase in these operations in the city, as well as all of the problems associated with city logistics, necessitating better freight transportation management in urban areas. (Pession, 2020)

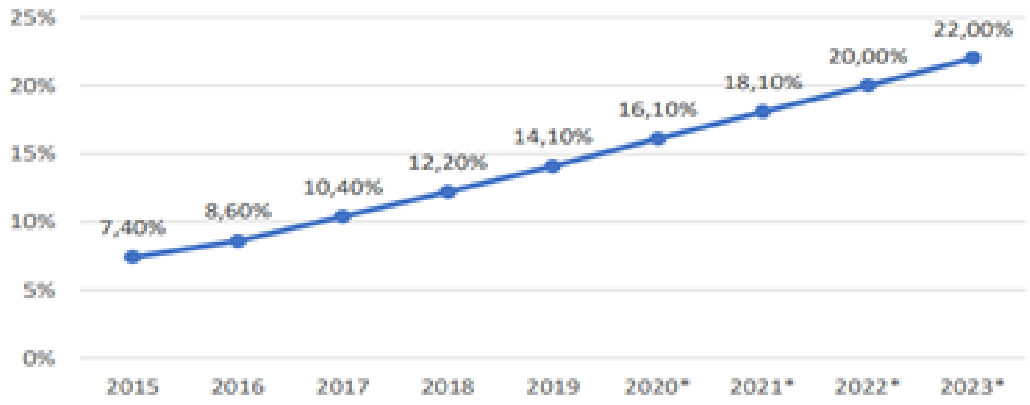

Figure 2. E-commerce share of total global retail sales from 2015 to 2023

The majority of people nowadays are aware of climate change. In recent years, society has attempted to choose more environmentally sustainable solutions in order to reduce gas emissions and improve air quality in order to improve human living conditions. As will be shown later, the European Union has made a significant contribution to promoting initiatives aimed at creating a more sustainable urban environment by funding numerous European projects. (Boysen et al., 2020) The effort to shift to a more sustainable business is led not only by the public sector, which provides incentives, new regulations, and new operational strategies, but also by the private sector, which is actively involved. In some cases, private companies try to choose environmentally friendly solutions even if they end up being worse in their current state. In this case, they want to be industry leaders, and they want to target a specific demand segment made up of people who are interested in these topics. Sustainable solutions can be an effective marketing tool for logistics companies to use in order to run their operations, even in cities, and improve their brand image. When it comes to purchasing decisions, a large segment of consumers in some markets is conscious of sustainability. Those working in the city logistics industry must take these factors into account by attempting to improve environmental conditions. (Benjelloun et al., 2010)

2.3 Solutions adopted for reducing city logistics externalities

First solution is a night deliveries. Running city logistics operations during off-peak hours is what night deliveries entail. There are numerous advantages to doing so, including the absence of traffic congestion on the roads, which allows deliveries to be completed faster and with larger vehicles. Because traffic-related acceleration and stops are minimized, assets will be used more efficiently, resulting in the need for fewer drivers, fewer vehicles, higher vehicle utilization, and a better driving style. The availability of workers could be a problem. (Boysen et al., 2020)

Second solution is combining forward and reverse logistics. Some city logistics initiatives are attempting to combine forward and reverse logistics in order to reduce the number of vehicles traveling through cities. After the driver has downloaded the goods from the van, rather than traveling with a light load, he can transport the goods that the customer needs to send to a recovery or disposal point, eliminating the need for a separate shipment for the disposal of goods. Instead, the two processes can be managed with one vehicle. The CITYLAB projects in Rome, which combined postal deliveries with the collection of recyclable plastic, are an example of how forward and reverse logistics can be combined. (Lebeau et al., 2016)

Third solution is combining passenger and freight transport. This solution has the potential to reduce pollution, noise, traffic congestion, and accidents, and it is based on the business model proposed by Pimentel et al. (2018). Because the demand for passenger transportation varies significantly throughout the day, modern cities have a valid network for passenger transportation in urban areas, which is characterized by hours of high intensity and hours of low intensity. As a result, the excess capacity of passenger transportation must be used for other purposes, such as the transportation of goods in urban areas, in order to maximize resource utilization. (Lebeau et al., 2016) Buses, trams, metros, private cars, and taxis make up the passenger transportation network. Because some of them follow a set route, the passenger network can be used to transport goods that need to be delivered in the city to a location as close to their final destinations as possible. Then, if the service wants to achieve environmental sustainability, it must identify a solution capable of ensuring last-mile deliveries, and the vehicles chosen must be environmentally friendly. (Benjelloun et al., 2010)

3. Methods

The primary goal was to use simulation analysis to develop an optimized traffic signal timing plan for the Addis Ababa Atlas-Mebrat crossroad. Field data collection, simulation model development, simulation model validation, the development of an optimized timing plan, and the analysis of an existing timing plan were all major tasks in the study (figure 3).

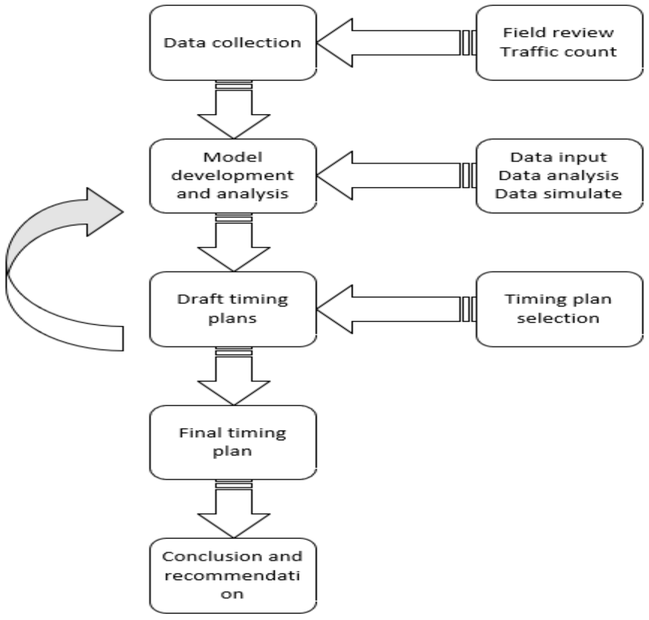

Figure 3. Methodology design flow chart

A site survey should be conducted to record relevant geometric and traffic control data. The number of lanes and lane width are among the information provided. A condition in the figure is a good way to keep track of this information.To further illustrate, in Figure below, two roads merge vehicles into an intersection with unique names like 2000 Habesha Hotel, Yoli Hotel, Washington Hotel, and Bilo's Cake. Naturally, any vehicle approaching the intersection has the option of proceeding straight or turning to one of the two sides of the road. The intersection then employs a three-phase policy, with green, yellow, and red light coding (figure 4). When the light turns green, a waiting vehicle has the option of driving straight ahead or turning right or left, depending on the driver's choice.

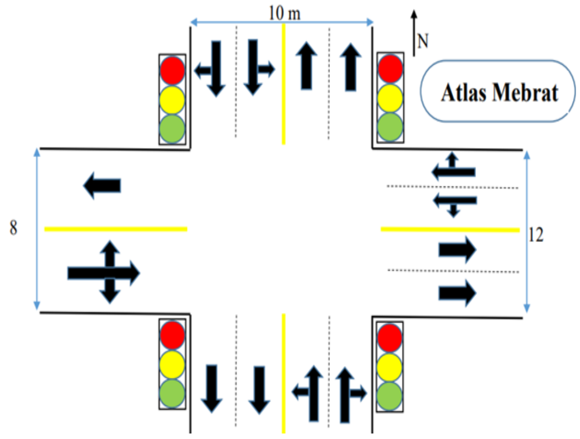

Figure 4. Intersection geometry

Arrival of vehicles at each approach—data gathered through observation. The time it took for each vehicle to arrive was recorded. Due to the length of the queue, it was difficult to take the time only after the vehicle came to a complete stop behind another vehicle. Each vehicle's arrival time was recorded when it passed a certain reference point. For one weekday, all data was collected at 12-hour intervals. The data was collected over a seven-day period in order to reduce the effects of day-to-day variations in traffic flow behaviour. We also used video to compare and validate our manual data by recording peak-hour traffic for 30 minutes. Turning movement counts were collected on Friday, April 26, 2019 between the hours of 7:45 AM to 08:30 AM which is representative of traffic peak period the case study intersections is called Atlas Mebrat crossroad.

The basic operation of vehicular movement through a signalized intersection is depicted in Figure below. The signal display is on the horizontal axis, and the instantaneous vehicle flow is on the vertical axis. During the time when the movement is receiving a red indicator and there is no flow, vehicles arrive and form a queue. After receiving a green indication, it takes a few seconds for the driver of the first vehicle to recognize that the signal has turned green and to get the vehicle moving. The next few vehicles also take a long time to accelerate. During the time when the movement is receiving a red indicator and there is no flow, vehicles arrive and form a queue. After receiving a green indication, it takes a few seconds for the driver of the first vehicle to recognize that the signal has turned green and to get the vehicle moving. The next few vehicles also take a long time to accelerate The start-up delay, also known as the start-up loss time, is commonly estimated to be around 2 seconds. Around the fourth vehicle in the queue, the flow rate tends to stabilize at the maximum flow rate that the conditions will allow, known as the saturation flow rate. This is usually maintained until the last car in the line has passed through the intersection. When the green signal is turned off, some vehicles pass through the intersection during the yellow change interval, known as the "yellow extension." The amount of green time that can be used between the end of the start-up delay and the end of the yellow extension is known as "effective green time" for the movement. The unused portion of the yellow change interval and red clearance interval is known as clearance lost time. (Mosannenzadeh and Vettorato, 2014).

The saturation flow rate is the maximum hourly volume that can pass through an intersection, from a given lane or group of lanes, if that lane (or lanes) were allocated constant green over the course of an hour. Saturation flow rate is given by (Mannering and Washburn, 2020)

$$S=360/h \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

S = saturation flow rate in vehicle/h

h = saturation headway in s/vehicle,

3600 = number of seconds per hour.

The total length of the cycle is equal to the sum of the individual phase lengths. Cycle lengths are typically kept as short as possible in practice, ranging between 60 and 75 seconds. Complex intersections with five or more phases, on the other hand, can have cycle times of 120 seconds or more. Webster (1958) devised a practical equation for calculating cycle length with the goal of minimizing vehicle delay. The formula for Webster's optimum cycle length is (Mannering and Washburn, 2020)

$$\mathrm{Copt} = \frac{1.5 * \mathrm{L} + 5}{1 - \sum_{\mathrm{i}=1}^{\mathrm{n}} \left(\frac{\mathrm{v}}{\mathrm{s}} \right)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where

Copt = cycle length to minimize delay in seconds

L = total lost time for cycle in seconds (v/s)

I= flow ratio for critical lane group

n = number of critical lane groups

Traffic streams are constantly started and stopped as a result of the traffic signal's function of continuously alternating the right-of-way between conflicting movements. Every time this happens, a portion of the cycle length isn't fully utilized, resulting in wasted The total lost time is the sum of the start-up and clearance times. Drivers in the queue do not immediately begin moving at the saturation flow rate when a signal indication changes from red to green; there is an initial lag due to drivers reacting to the change in signal indication. As a result of the start-up delay, a portion of the green time for that movement is not fully utilized. This lost time during start-up is usually around 2 seconds.

$$tl=tsl+tcl\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where

tL= total lost time for a movement during a cycle in seconds

tsl= start-up lost time in seconds

tcl= clearance lost time in seconds.

Time is also lost when a traffic jam comes to a halt. When the signal indicator changes from green to yellow, traffic generally does not use the latter half of the yellow interval. if there is an all-red interval, traffic does not typically use this time period. Clearance lost time refers to the time during the change and clearance intervals that is not effectively utilized by traffic (Mannering and Washburn, 2020).

4. Results

The first step in the data analysis process was to import manually collected vehicle arrival data in order to calculate the inter-arrival of each approaching vehicle. The data for the case study area was collected for a week between 7 a.m. and 7 p.m The data collected was divided into 15 minutes time intervals. The analysis of daytime 7 day data MS Excel distributions show that there is peak hour in Kasanchis Urael and Bole Bras approach at morning and evening time and constant low traffic flow at Bole Rwanda and 22 Wuha Limat approach through a day. For similar hourly traffic count almost the same average number of arrival were observed for seven day time. The figure below shows that the average number of arrival of vehicles for each four approaches in 7 day in the one example of Kasanchis Urael (figure 5).

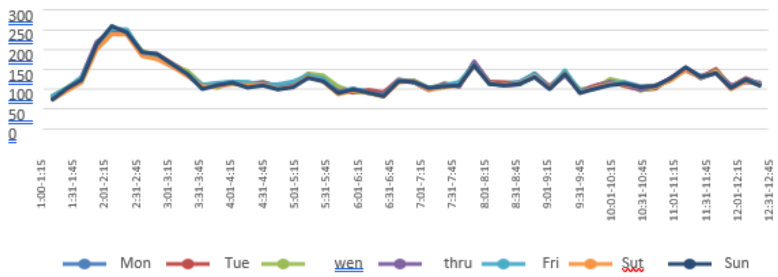

Figure 5. Arrival rate of Kasanchis Urael Approach

Phase sequence, minimum green, red, and yellow, and cycle length are all important aspects of existing signal timing. The existing signal timing helps the user understand what currently exists in the field and provides a baseline for improvement.

Because they are most likely different, the time during a cycle that is effectively (or not effectively) utilized by traffic must be used instead of the time for which green, yellow, and red signal indications are actually displayed for analysis purposes. These findings are interesting in two ways: the effective green time and the effective red time (table 1).

Table 1.

Currently used traffic signal time duration for each signal indication

Approaches / Indications	Kasanchis Bound	Bole Bras Bound	22 Wuha L. Bound	Bole Rwanda Bound
Red	90	90	110	120
Yellow	5	5	5	5
Green	20	20	15	10

The distributions of the inter arrival time of vehicle for each approach were fitted using schedule based on the collected data and MS Excel measurements. The distributions and the parameters are given as follows (figures 6,7,8,9).

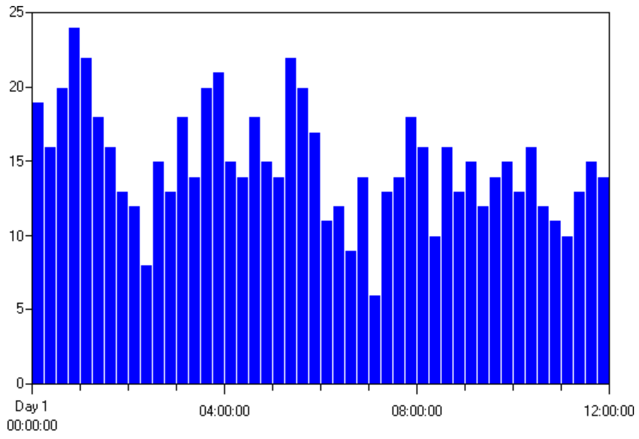

Figure 6. Kasanchis Urael Approach inter arrival of vehicle

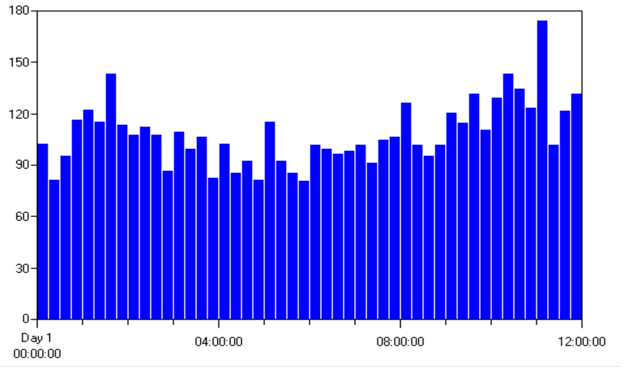

Figure 7. Bole Bras Approach road inter arrival of vehicle rate

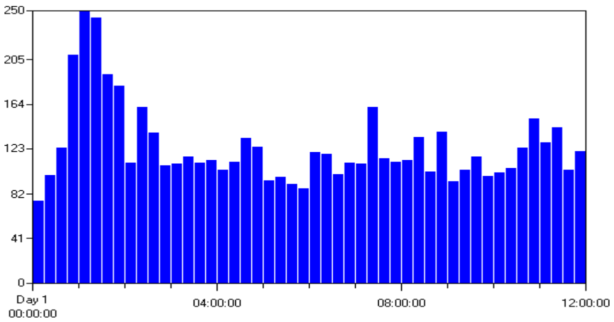

Figure 8. Wuha Limat approach inter arrival rate

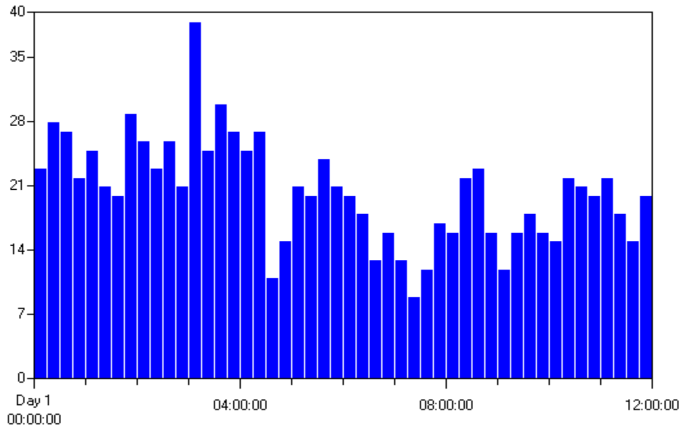

Figure 9. Bole Rwanda inter arrival rate

The Average waiting times of vehicles in queues are as shown in Table below. The table identifies vehicles from Kasanchis Urael that have to wait an average of 16 seconds before they are given clearance, while waiting time is 21 seconds for vehicles on Bole Bras approach (figure 10).

Category Overview

Traffic Signal Analysis

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Hold on horizontal road 2.Queue	70.2069	5.39202	0.00	194.58
Hold on horizontal road one.Queue	0.00	(Insufficient)	0.00	0.00
Hold on the horizontal road r.Queue	0.00	(Insufficient)	0.00	0.00
Hold on the Vertical road r.Queue	0.00	(Insufficient)	0.00	0.00
Hold on the vertical road.Queue	16.4120	0.320868886	0.00	53.9931
Horizontal Light1.Queue	21.6663	(Correlated)	0.00	61.9998
Horizontal Light2.Queue	33.6637	2.78921	0.00	73.9459
Vertical Light1.Queue	31.1704	2.17227	0.00	77.0000
Vertical Light2.Queue	0.00	(Insufficient)	0.00	0.00

Figure 10. Existing intersection Waiting time Condition

The largest number represents process 75 and 68 which is associated with Kasanchis Urael and Bole Bras approach thus it can be considered as the bottle neck of the traffic system (figure 11).

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Hold on horizontal road 2.Queue	0.00	(Insufficient)	0.00	0.00
Hold on horizontal road one.Queue	0.8494	0.016571492	0.00	9.0000
Hold on the horizontal road r.Queue	0.00	(Insufficient)	0.00	0.00
Hold on the Vertical road r.Queue	18.5306	0.071780592	0.00	66.0000
Hold on the vertical road.Queue	0.00	(Insufficient)	0.00	0.00
Horizontal Light1.Queue	22.7270	0.067258773	0.00	76.0000
Horizontal Light2.Queue	1.0603	0.027038684	0.00	9.0000
Vertical Light1.Queue	0.00	(Insufficient)	0.00	0.00
Vertical Light2.Queue	0.00	(Insufficient)	0.00	0.00

Figure 11. Existing intersection Waiting time Condition (Arena simulation)

This data is crucial to collect at the subject intersections because it is used to develop an existing analysis model. Phase sequence, minimum green, red, and yellow, and cycle length are all important aspects of existing signal timing. The existing signal timing provides a baseline for improvement and helps the user understand what is currently available in the field. The Arena Process Analyzer was now used to compare scenarios and evaluate the performance of the traffic signal system and the traffic flow associated with it, as well as a system analysis for various control policies. The different scenarios in this study were defined based on observations of the system in real-world settings. The system behaves differently in each scenario. If the timing policy number 1 is used, the average waiting time in the Kasanchis approach is 18 seconds, while it is only 1 for the 22-wuha limat approach. Average queue length and waiting time over the different periods are calculated for each scenario model (from scenario 1 up to 30) in order to assess the performance of each scenario and compare the obtained results. Figure 12 and 13 show the general average queue length and waiting time for each simulation scenarios

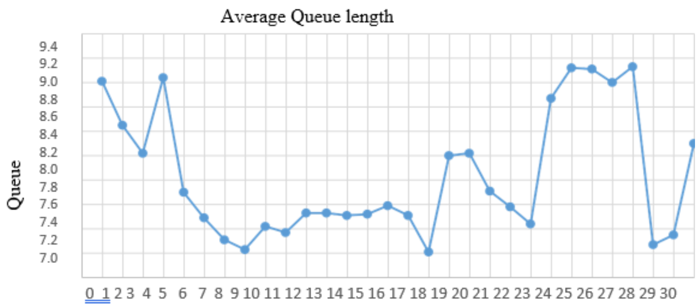

Figure 12. Average Queue length of the system

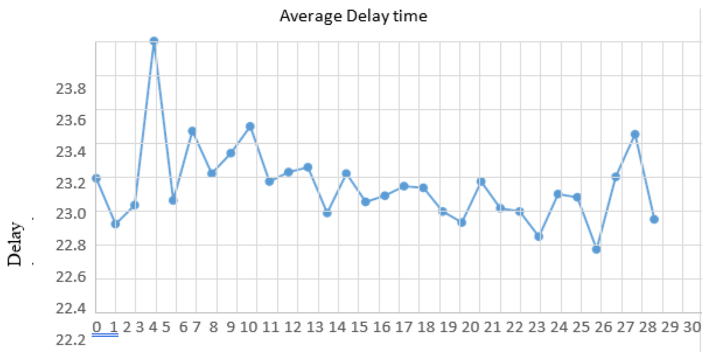

Figure 13. Average Queue length of the system

Average queue length and waiting time over the different periods are calculated for each scenario model (from scenario 1 up to 30) in order to assess the performance of each scenario and compare the obtained results. Figure 14 and 15 show the general average queue length and waiting time for each simulation scenarios

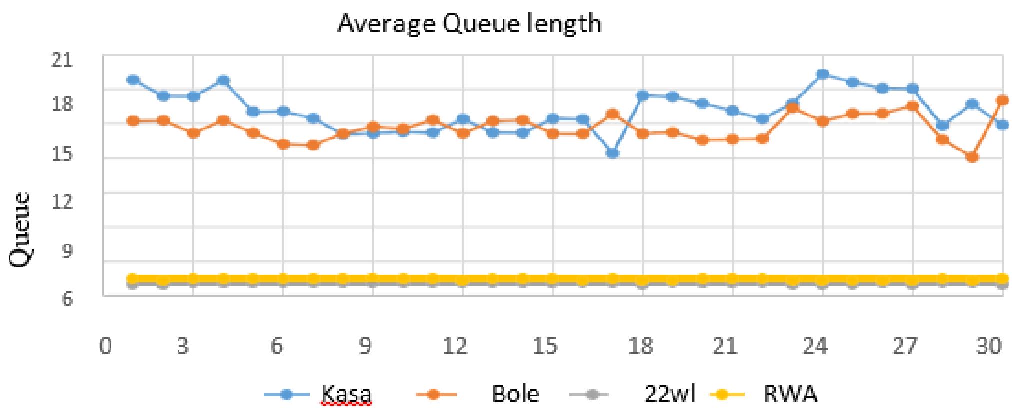

Figure 14. Average Queue length of the intersection

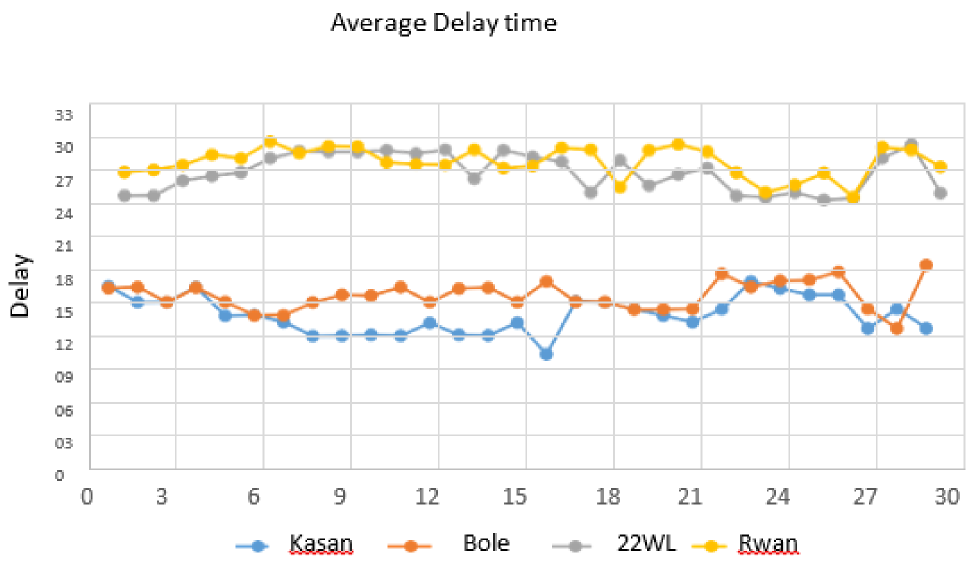

Figure 15. Average delay of the intersection

From the scenario analysis we realize that the system has a generally better performance if the timing policy 17 is applied. That is, the length of queue and delay in the whole system reaches the lowest value. After applying the proposed solution the total number of entities that will be served on this intersection will be =10,007 This shows 44.74% improvement will come on the traffic signal system when we apply the simulation techniques.

5. Discussion

The absence of an effective timing plan is the main motives of this study. The traffic light system in Road Addis Ababa Atlas Mebrat Intersection Is very poor and the time distribution is inappropriate. The time distribution for traffic light system is not based on simulation rather is it based assumption(try and error). The most significant finding of this thesis was that optimized the signal timing plan using existing resource and arena simulation software . A general signal optimization model is formulated to optimize the timing plan. The developed simulation model is able to determine realistic and reasonable approximations of strategies of optimum control in intersection Solving this issue will improve the traffic system in Addis Ababa.

Ethiopia is one of the fastest growing country toward the smart city. But due to same facture the(in my case trafficking system) the growth rate is not that much fruitful. Improving trafficking system in Addis Ababa is accelerate its growth. The city logistics are poor and disorder. The city has no low number of road. One measurement of smart city is the transportation system. Improving this problem will lead Ethiopia toward smart city. Generally this paper solve indirectly peoples problems other than transportation system.

Comparing with my hypothesis, the simulation result is above expected. As we remember in my hypothesis the planed over all improvement was 65 percent. Reduce overall delaying time at the intersection was 30 percent and reduce queue length by 10 percent. In this study I use the collected data from 7am to 7pm in order to simulate and a variety of scenarios on traffic signal timing for intersection of Atlas Mebrat. The best signal timings were determined for rush hours by comparing the results of these scenarios. According to this, the duration of green light, that is now 23, 23, 18 and 10 seconds in Kasanchis Urael Appropach, Bole Bras, 22 Wuha Limat and Bole Rwanda approach respectively, should be 35, 24, 10, and 10 seconds respectively. Therefore, average queue length and average delay at signal could be decreased from 10.78 vehicle to 7.61 vehicle and 25.71 seconds to 22.7 seconds respectively. 30 and 11 percent improvement could be ensured for average queue length and average delay. In addition, 45 and 25 percent improvement could be ensured for average queue length and average delay for Kasanchis Urael approach that has longest queue length at traffic signal. Number out of Existing system = 5,605 After applying the proposed solution the total number of entities that will be served on this intersection will be =10,007 This shows 85% improvement will come on the traffic signal system when we apply the simulation techniques.

Based upon the results of this study and observations in case study the following recommendations are made:

- To create facilitated traffic flow we recommend the concerned body to use this study result that is the optimized timing plan.
- During this study we observed that they try to adjust the timing plan using try and error method. So we recommend implementing this kind of software based studies.
- In traffic law it is prohibited to stop a vehicle with a radius of 60 m when it is a traffic signal. But in this intersection drivers have experience of parking a car and especially in 2000 Habesha Hotel area taxi drivers use the traffic signal area as station. So they must take a remedy action to expedite the traffic flow.
- In this study, the proposed simulation calibration and validation procedure used only a week of field data. It is recommended that further research that uses multiple weeks of field data in order to account for better performance.

From this we can see that the over all improvement is 85 percent but in my hypotjesis the planed improvement was 65 percent. Which is greater than expected by 20 percent. the planned over all queue delay at the intersection improvement was 25 percent but after simulation we get up to 40 percent improvements. and finally the over all delay in queue is up to 45 percent which is above I planed by 20 percent. Additional problem that solved in this thesis is city logistic problem. City transportation system is the very crowded during the day time. Because of the road quality, low number of road and high number of car compering with road number. To solve this problem it is better to use night deliveries. During the night the road is free. Combining Forward and reverse logistics and Combining passenger and freight transport are the way to improve city logistics

References

1. Alawadhi, S., Aldama-Nalda, A., Chourabi, H., Gil-Garcia, J. R., Leung, S., Mellouli, S., & Walker, S. (2012). Building understanding of smart city initiatives. In International conference on electronic government (pp. 40-53). Springer, Berlin, Heidelberg.
2. Benjelloun, A., Crainic, T. G., & Bigras, Y. (2010). Towards a taxonomy of City Logistics projects. Procedia-Social and Behavioral Sciences, 2(3), 6217-6228.
3. Boysen, N., Schwerdfeger, S., & Weidinger, F. (2018). Scheduling last-mile deliveries with truck-based autonomous robots. European Journal of Operational Research, 271(3), 1085-1099.
4. Jha, S., Nkenyereye, L., Joshi, G. P., & Yang, E. (2020). Mitigating and monitoring smart city using internet of things. Computers, Materials & Continua, 65(2), 1059-1079.
5. Lebeau, P., Macharis, C., & Van Mierlo, J. (2016). Exploring the choice of battery electric vehicles in city logistics: A conjoint-based choice analysis. Transportation Research Part E: Logistics and Transportation Review, 91, 245-258.
6. Mannering, F. L., & Washburn, S. S. (2020). Principles of highway engineering and traffic analysis. John Wiley & Sons.
7. Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Everything you wanted to know about smart cities: The internet of things is the backbone. IEEE Consumer Electronics Magazine, 5(3), 60-70.
8. Morganti, E., & Browne, M. (2018). Technical and operational obstacles to the adoption of electric vans in France and the UK: An operator perspective. Transport Policy, 63, 90-97.
9. Mosannenzadeh, F., & Vettorato, D. (2014). Defining smart city. A conceptual framework based on keyword analysis. TeMA-Journal of Land Use, Mobility and Environment.
10. Pession, J. (2020). Analysing the impacts of technology in City Logistics projects (Doctoral dissertation, Politecnico di Torino).
11. Shafaati, A., Valizade, R., Rahimi, A., & Panahi, A. (2022). The Role of Smart Urban Development in the Development of the Dilapidated Areas of Tabriz City: A Case Study of 8th District of Tabriz. Geography and Environmental Planning, 33(1), 113-132.
12. Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011). The Anthropocene: conceptual and historical perspectives. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 369(1938), 842-867.
13. Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of things for smart cities. IEEE Internet of Things journal, 1(1), 22-32.