ANALYSIS OF PASSENGER QUEUES TOWARD THE IMPROVEMENT OF PUBLIC TRANSPORT SERVICE IN KIGALI CITY

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In many developing countries, buses play a crucial role in providing affordable and accessible public transportation. However, the capacity constraints of buses often result in long passenger queues and severe congestion at bus terminals, leading to poor service quality and discouraging ridership. This study aims to analyze the passenger queues and congestion issues in Kigali city, Rwanda, and propose strategies for improving public transport. This study first describes qualitatively the situation in developing countries and in Kigali city particularly and then quantitively describes the congestion using data of Kigali as a case study. The analysis reveals that the congestion is severe, with queues exceeding 120 passengers on some routes and waiting times of more than 30 minutes, and sometimes even over 50 minutes, at the terminals. This waiting time is longer than the bus travel time from the origin to the destination bus terminal, which highlights the severity of the congestion. The study proposes a range of strategies to mitigate the congestion, such as increasing the frequency and capacity of buses, providing real-time information about bus arrivals, and improving traffic flow through bus priority measures such as dedicated bus-only lanes and signal prioritization. In addition, the congestion and long passenger queues should be incorporated into the planning stage to ensure efficient and effective transport services.

Key Words: *public transport service, developing countries, passenger queues, capacity constraint*

1. INTRODUCTION

Over the last decade, developed and developing countries have experienced rapid population growth and urbanization. This has led to a rapidly growing demand for travel. Due to this increase in mobility, the use of cars has increased, and therefore the design of the public transportation network should be promoted to address the problems associated with the excessive use of cars. Buses are the most widely used public transportation today because they are easily accessible and cheaper than other forms of public transportation. The demand for passengers using the bus network is higher because it is cheaper and covers more area.

Bus ridership is affected by the quality of the bus service. Level of Service (LOS) and bus headways are among the key factors for the quality of bus service. Cost, freedom, travel time, comfort, availability, and reliability were reported as the influencing factors for public bus ridership (De Luca, 2014[1)]; Imre & Çelebi, 2017[2)]; Jain et al. 2014[3)]; Olojede et al. 2017[4)]; Simons et al. 2014[5)]; Tilahun et al. 2016[6)]). Among these factors, reliability plays the most important role as bus delays proved to be the main factor that discourages road users from using public transport (Fonzone et al. 2015[7)]; Ishaq & Cats, 2020[8)]). Irregularities in bus arrival times increase the gap (headway) between two consecutive buses and lead to extra dwell time, thus delaying the bus arrival time (Bellei et al. 2010[9)]; Ruan et al. 2009[10)]). Bus delays are mentioned as one of the factors for the inconsistency of bus arrival times (Wahab et al. 2017[11)]). If a delay occurs, the buses will try to catch up with the schedule and it will cause a bunching event. Therefore, the rest of the schedule will be disrupted. This increases the waiting time for bus passengers until the next bus arrives.

Due to the costs associated with data collection, only a few studies have analyzed revealed preferences and almost all of these have focussed on car traffic. Shelat et al. 2022[12)] made empirical studies of bus travel time reliability using smart card data of the Hague, the third largest city in the Netherlands. They found that during the off-peak hours at origin stops, for both, trams and buses, 1 min of waiting time is about 1.55 in-vehicle minutes in the respective modes.

Most studies have focused on comfort, in-vehicle time, waiting time, and the number of transfers as utility attributes in the modeling route choice behavior of bus passengers, To the best of our knowledge, none has analyzed passenger queues in a real-world bus network of a city in developing countries to assess the impact of travel time in public transport networks. In most developing countries, particularly in African cities, the use of low-capacity minibuses and so-called midi-buses which are a larger form of the minibus is much more prevalent than large buses reflecting the capacity constraints of the bus network. As a result, long queues for public transport passengers have become common sights during peak hours.

To depict how serious passenger queuing is and to point out the need to study mitigation methods for this issue, this study presents a basic statistical analysis of passenger queues observed at bus terminals in the City of Kigali, Rwanda, using the actual survey data. The bus transport network in the City of Kigali is characterized by unscheduled services with high demand and capacity constraints. The general situation of public transport systems (mostly bus services) in developing countries and Kigali are also explained as background for this study.

This paper consists of four sections, including this introductory section. Section 2 explains the general situation of public transport systems in developing countries and in the city of Kigali. Section 3 presents a quantitative analysis of queuing in Kigali using read data. Section 4 summarises the results and shows future directions.

2. BUS NETWORKS IN DEVELOPING COUNTRIES

(1) General Situations

Africa's cities are growing rapidly. In 2000, one in three Africans lived in a city; by 2030, one in two will do so(Kumar and Barrett, 2008 [13)]). This growing urban population is inadequately served by the transport system characterized by the declining standard of public transport services, massive growth in the use of minibus services, growing dependence on private transport (cars and motorcycles), inadequate and deteriorating transport infrastructure, and poor facilities for non-motorized transport (walking and cycling). In most cities, there are thousands of minibuses compared to only a few hundred larger buses. Minibus operators raise fares as demand increases and change routes at will. During off-peak, Vehicles wait at the terminal until they are fully loaded. This means that passengers who want to board at other stops along the route often cannot do so. Many walk long distances to the terminal to secure a seat on the bus.

Most cities have 30–60 bus seats per thousand residents, mostly in minibuses. Even in some cities, the indicator falls to no more than 10 per thousand. The average number of large-bus seats in most cities is only 6 per thousand. As a point of comparison, the average number of large-bus seats per thousand urban residents in the middle-income countries of Latin America, Asia, the Middle East, and Eastern Europe is 30 to 40 (Kumar and Barrett, 2008 [13)]). Fares are also high in relation to the purchasing power of the typical family in the cities, and bus usage is correspondingly low. The average family cannot afford more than one daily round-trip bus ride, while for the poorest households, even this basic level of mobility is unattainable. But even this low rate of use translates into peak demand for around 200 seats per thousand residents, about five times higher than the supply available in many cities.

Minibuses, which carry roughly 8 to 25 passengers, and So-called midi-buses which are a larger form of the minibus, with a passenger capacity ranging from around 30 to about 50 (with standees), are much more prevalent than large buses except in some cities, reflecting the difficulty of operating large buses profitably (Kumar and Barrett, 2008 [13)]). Overall, about twice as many trips are taken by minibus than by large bus. As a result, long queues for public transport have become common sights during peak hours. In the hot sun or heavy rain, people wait impatiently for the next bus. Frustrated and eager to reach their destination, some passengers storm out of the line to try to see if walking might be a faster alternative, even if unsafe and inconvenient.

(2) Kigali City Bus Network

The current population of Kigali stands at 1.7 million(NISR,2022 [Note 1)])and is expected to grow to between 4 to 5 million in the next twenty-five to thirty years. Traffic and congestion in the city have grown significantly due to recent economic growth and increasing vehicle ownership levels. The number of vehicles in Kigali has risen by almost 75% over the past 5 years, from approximately 98 000 to 180 000 (CoK,2019 [Note 2)]). This unsustainable rise in traffic volumes will continue to grow with a persistent increase in private car ownership, despite more investment in road widening projects.

As far as bus transport is concerned, the service was operated randomly before 1994. After 1994, the city of Kigali was still in the reconstruction phase and the buses were still running without clear instructions: There was no precise schedule for bus transportation, and the buses had to wait until they were full before leaving the terminals, and then to pick up and leave passengers frequently along the way. Buses previously used in the city of Kigali were mainly minibuses defined as cars capable of carrying 15 to 20 people and the routes operated were defined by the bus operators themselves. Over the years, minibuses have been supplemented by the introduction of coasters defined as cars that can carry from 20 to 35 people, and by the introduction of buses defined as cars that can carry more than 35 people (RURA, 2013 [Note 3)]). As time goes the demand for public transport has increased with a number of population and thus the travel demand growth is linked to the growth of the population. According to the Census of 2012 [Note 4)], only 7% of private households owned vehicles in the City of Kigali (CoK) and this shows that the demand for public transport is at a high level. The demand for access to reliable public transport visibly manifests in long waiting lines at bus stops and public transport interchanges as well as the growth in the number of moto-taxis. The national fleet of motorcycles is estimated by the Rwanda National Police at around 80,000 in 2017 [Note 5)]. This should be compared with previous estimates of around 58,000 in 2012,38,500 in 2010 and 6,700 in 2004 .

Due to this high demand for public transport, in 2013 a public transport system reform was carried out whereby the city of Kigali was divided into four (4) main trajectories each of which was assigned to a transport company to carry the passengers through competitive bidding and five-year contracts were awarded to the three companies namely Kigali Bus Service (KBS), Rwanda Federation of Transport Cooperatives (RFTC) and Royal Express in order to enhance the quantities and needed quality of service in Kigali where the passengers had high waiting time and very long queue being at bus stations or at bus stops. These contracts contributed to accelerating the transition from small minibus taxis to larger state-of-the-art buses with a carrying capacity of 70 passengers. During the 5-years contract, the private companies purchased new buses that increased the capacity of the public transport network. The development of new bus parks, the implementation of an Electronic Ticketing System (Tap & Go), and the generalization of automated fare collection contributed also to modernising the public transport network.

Public transport routes were redesigned in 2013, to reduce the distances which are walked by travelers to the nearest bus stop within the City of Kigali. Some of the suburbs and neighborhoods which were not previously linked to the public transport network have now been connected. The network is organized around four zones, each structured around a Bus Park with inter-zone routes and local routes. The main bus parks are the following: Nyabogogo; CBD; Kimirinko; Remera; Nyanza; Kabuga. The number of urban bus route services operating has evolved over time, with operators introducing changes to the services, either removing or adjusting routes. According to the information published by RURA [Note 3)], originally 81 routes were included in the four awarded contracts. Subsequently, a number of bus routes were suspended, either permanently or temporarily, resulting in a decline in the number of operated services. The bus network covers only 24% of the whole City area; nonetheless, the service is accessible within 400m by more than half of the population (55%). Overlapping of several routes potentially creates redundancy for cost-effective routes. Fare is charged per single route, regardless of the length of the trip. No time-based fares are in place, and hourly, daily, monthly, and annual passes are not available. Social passes are also not available. In Rwanda's context, particularly in the City of Kigali, the bus is the main mode of public transportation. Buses do not run on a dedicated lane but share the route with other traffic.

Despite improvements in the City of Kigali's public transport services, several challenges have emerged for passengers related to long waiting times, overcrowded buses, noncompliance to schedules, and no passenger information - routes or timetables. The current bus service in Kigali offers non-scheduled services. This structural condition resulted in inefficiencies in the public transport system manifesting in significant latent demand and long queues of passengers during peak hours. The visible latent demand in the form of large numbers of pedestrians, moto-taxis, and private car users, indicates that the public transport system is far from optimal and requires significant further improvement. Passenger complaints about overcrowding on buses and being compelled to stand for long periods also raise questions about fleet size, vehicle types, and the fleet mix.

Due to very long queues of passengers as a result of denied boarding or low frequency of buses at bus stations or at bus stops waiting for the bus to arrive as well as the lack of information on bus time and headways where passengers don't know when the waited buses will arrive, 2 scenarios occur: First, some passengers choose to join a queue first, but gradually lose their patience, and eventually leave the queue before boarding the bus due to intolerable waiting hence the word Reneging. second, some other passengers choose not to join a queue upon their arrival, normally because of too long a queue ahead hence the word Balking. In both scenarios, the passengers choose alternative modes such as walking, Moto-taxis, or taxis which are generally more expensive than bus transport. The above problems also, to some extent, make transportation more expensive for passengers and, on the other hand, prevent transportation agencies from gaining a certain number of passengers due to the utilization of alternative modes.

3. QUEUE LENGTH ANALYSIS

(1) Data and Methodology

a) Explanation of the Data Set

The data used in this study was collected in 2017 by an international consulting company hired by the City of Kigali with the purpose to be used in the feasibility study of BRT for the City. The data collection was carried out with the support of local staff under the supervision of international consultants and the core team of experts.

The survey sample included two bus routes in each of the 6 City Terminals (**Fig. 1**) during morning and evening peak hours. **Table 1** lists sampled routes at terminals where queues were observed. The two routes have been identified as those where long passenger queues usually occur at each terminal, based on the local knowledge of the city's public transport system. The surveyors counted passengers standing in a queue at specific bus platforms/stops within the terminal.

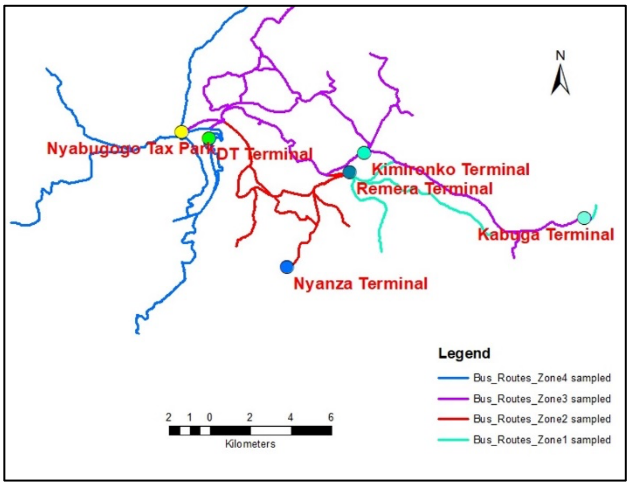

Fig.1 Main bus routes with the bus terminals

Table1 Terminals with sampled routes

Terminal	Morning Peak	Evening Peak
Downtown	CBD-Kimihurura-ChezLando-Kimironko**(302)** CDB-Kacyiru**(304)**	CDB-Gakinjiro-Batsinda**(303)** CBD-Kimihurura-ChezLando-Kimironko**(302)**
Remera	Remera-Kicukiro-Nyanza**(108)** Remera-Kacyiru - Nyabugogo **(105)**	Kimironko-Rwandex-Bwerankori **(215)** Remera-Kanombe **(114)**
Kimironko	Kimironko-Kicukiro **(213)** CBD-Kimihurura-ChezLando - Kimironko **(302)**	Kimironko-Kinyinya**(309)** Kimironko-Bumbogo **(316)**
Nyabugogo	Nyabugogo-Kimironko**(305)** Nyanza-Zion-Nyabugogo **(204)**	Nyabugogo-Jali **(409)** Nyabugogo-Gakinjiro - Batsinda **(310)**
Nyanza	Nyanza-Zion-Nyabugogo**(204)** KCentre-Stade-Kimironko **(213)**	Kicukiro Centre - Kimironko**(213)** Nyanza-Gatenga-Nyabugogo **(214)**
Kabuga	Nyabugogo - Kabuga**(314)** Remera - Kabuga **(111)**	Nyabugogo - Kabuga**(314)** Remera - Kabuga **(111)**

b) Methodology

We assume that there exist three factors that affect the change in a queue length, as follows:

1. passengers joining the queue
2. passengers boarding a bus
3. passengers leave the queue as they give up waiting for their turn to board the bus.

In the same way as in the analysis of bottlenecks on roads, let $A(t)$ and $D(t)$ denote the cumulative numbers of joining passengers and boarding passengers between time 0 and t, respectively. Similarly, let $L(t)$ denote the cumulative numbers of leaving passengers between time 0 and t.

We also assume that

1. passengers joining the queue earlier board the bus earlier than those joining the queue later, i.e. first-in-first-out (FIFO) discipline is assumed.
2. passengers joining the queue later leave the queue earlier than those joining the queue earlier, i.e. last-in-first-out (LIFO) discipline is assumed.

FIFO is a typical assumption in the bottleneck model, which is satisfied when no one overtakes others in the queue. On the other hand, for the LIFO discipline to hold, it must be assumed that the passenger leaving the queue is always the one at the tail end of the queue. This assumption is strong but is not unrealistic because those who expect longer waiting times would be more likely to give up boarding the buses than those expecting shorter waiting times.

Considering the FIFO and LIFO disciplines, the waiting time in the queue can be graphically calculated as shown in **Fig. 2**. Owing to the FIFO and LIFO, $A(t)-L(t)$ is equivalent to the order of entry to the queue and $D(t)$ is equivalent to the order of boarding the bus. Therefore the horizontal gap between the cumulative curves of $A(t)-L(t)$ and $D(t)$ indicates waiting time in the queue.

The actual observation is made only for the queue length, whereas $A(t)$, $L(t)$, and $D(t)$ are not directly observed. Let $q(t)$ denote the queue length at time t, then we have

$$q(t) = A(t)-L(t)-D(t). \quad (1)$$

We then assume q(t) decreases rapidly only when a bus arrives and picks up passengers from the queue, while q(t) decreases slowly only when passengers leave the queue. Using this assumption, we calculate A(t) −L(t) and D(t) by the following formulas:

$$q(t_{i+1})-q(t_i) = \{A(t_{i+1})-L(t_{i+1})\}-\{A(t_i)-L(t_i)\} \quad \text{if } \Delta q/\Delta t > -q_{th} \quad (2)$$

$$q(t_{i+1})-q(t_i) = D(t_{i+1})-D(t_i) \text{ if } \Delta q/\Delta t < -q_{th}, \quad (3)$$

where $\Delta q/\Delta t = \{q(t_{i+1})-q(t_i)\} / (t_{i+1}-t_i)$ and $q_{th}>0$ is a threshold distinguishing the two cases. Note that we assume that $A(t)$ and $L(t)$ do not change in the latter case for simplicity. We use the histogram of the $\Delta q/\Delta t$ to estimate an appropriate q_{th}.

The proposed methodology is applicable only when the queue length is positive. If no queue exists, both $A(t)$ and $D(t)$ become zero. Note the waiting time is zero in this case.

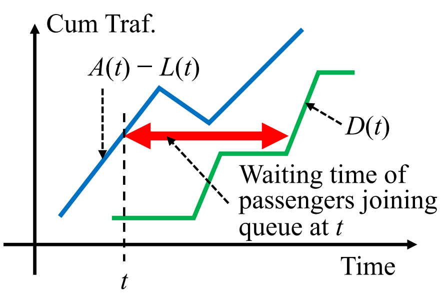

Fig. 2 Cumulative curves and waiting time

(2) Result

Table 2 shows the maximum queue length (i.e. the maximum number of passengers in the queue). The numbers vary and can be up to over 100 passengers. We have selected five key cases, whose maximum queue length is up to the top fifth, for the detailed analysis. They are highlighted in red bold letters in **Table 2**.

Figs. 3-7 depict queue lengths in the five key cases. Their profiles vary depending on the cases. In the evening cases, they tend to monotonical increase with respect to time, while such a trend is not found in the morning cases.

Fig. 8 is the histogram of $\Delta q/\Delta t$, i.e. the changes in queue per minute. The figure includes the negative domain only as it is necessary to determine the threshold q_{th} appearing in Eqns. (2) and (3). Based on the histogram, we determined $q_{th} = -5$ for further analysis as we can see a trough at this point, as marked in **Fig. 8**. Note that, although we can also find another trough around $q_{th} = -14$, we did not adopt this threshold because this setting caused too small a departure rate and consequently too long waiting time.

Figs. 9-13 are the cumulative curves calculated from the queue lengths using Eqns. (1) – (3). We can observe that the horizontal gaps between two curves are sometimes more that 30 minutes. The $A(t)-L(t)$ curves are not always monotonically increasing, impying that passengers giving up boarding the buses exist.

Figs. 14-18 are the estimated waiting time profiles of the five key cases. We can observe that the waiting time can be up to 20 minutes in all cases and exceeds 50 minutes in the two evening severer cases.

Table 2 Maximum queue lengths at terminals
(Queues ≥ 120 passengers are shown in red bold letters)

Terminal / Route No.	Date	Morning	Evening
Downtown 302	21-Jun	11	**164**
Downtown 304	21-Jun	4	114
Kabuga 111	23-Jun	8	20
Kabuga 314	23-Jun	22	23
Kimironko 213	21-Jun	90	92
Kimironko 302	27-Jun	**157**	86
Kimironko 322	21-Jun	8	80
Nyabugogo 204-214	22-Jun	76	**126**
Nyabugogo 305	22-Jun	**138**	**123**
Nyanza 204 - 214	23-Jun	62	66
Nyanza 213	23-Jun	32	86
Remera 105	22-Jun	88	22
Remera 108	22-Jun	65	59

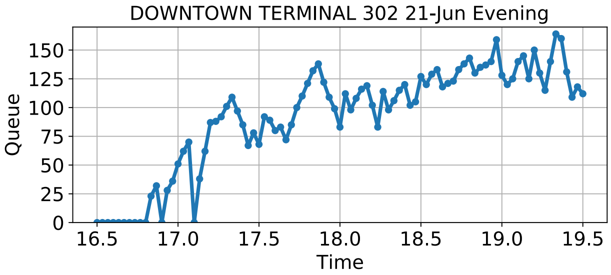

Fig. 3 Queue length (Downtown 302 / Evening)

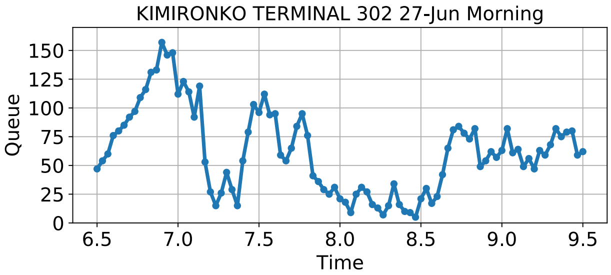

Fig. 4 Queue length (Kimironko 302 / Morning)

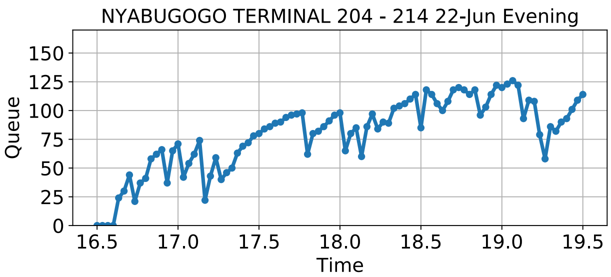

Fig. 5 Queue length (Nyabugogo 204-214 / Evening)

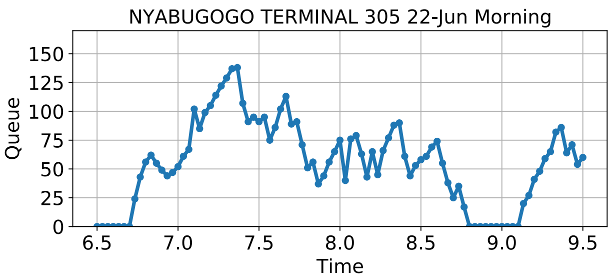

Fig. 6 Queue length (Nyabugogo 305 / Morning)

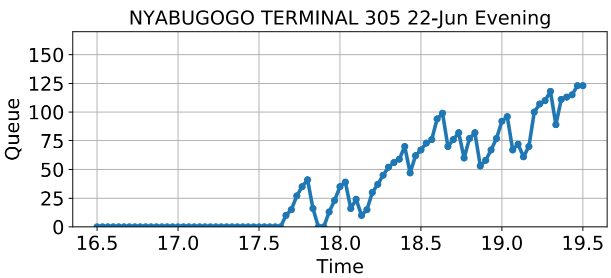

Fig.7 Queue length (Nyabugogo 305 / Evening)

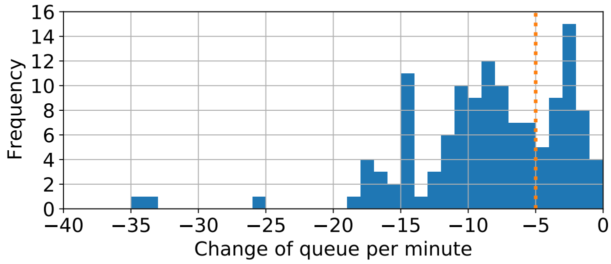

Fig. 8 Histogram of $\Delta q/\Delta t$ (negative domain only)

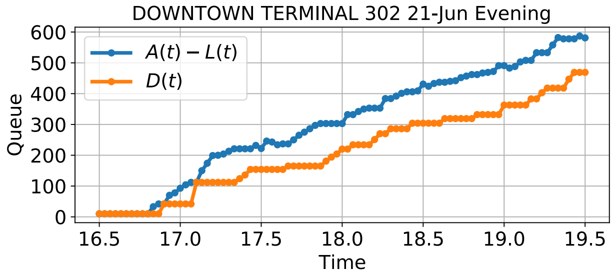

Fig. 9 Cumulative curves (Downtown 302 / Evening)

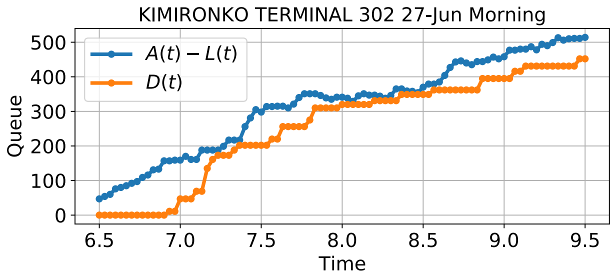

Fig. 10 Cumulative curves (Kimironko 302 / Morning)

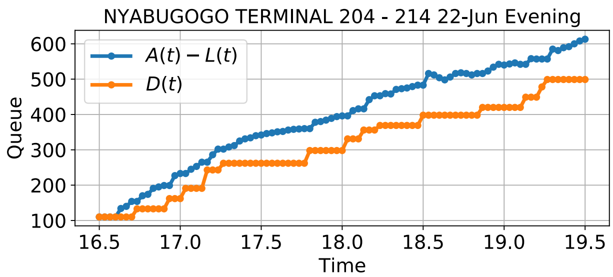

Fig. 11 Cumulative curves (Nyabugogo 204-214 / Evening)

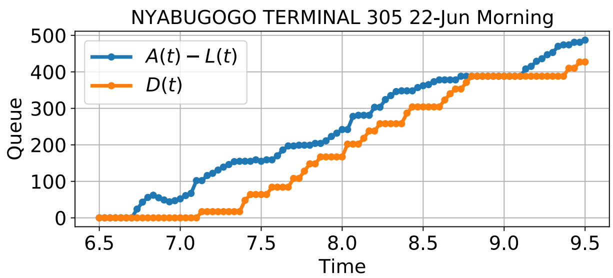

Fig.12 Cumulative curves (Nyabugogo 305 / Morning)

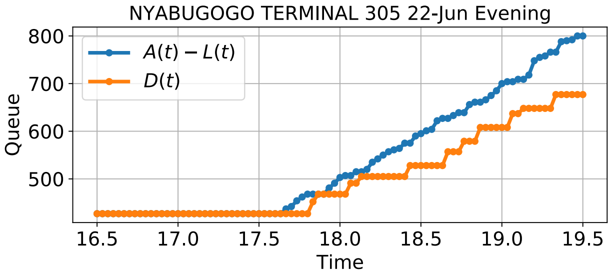

Fig. 13 Cumulative curves (Nyabugogo 305 / Evening)

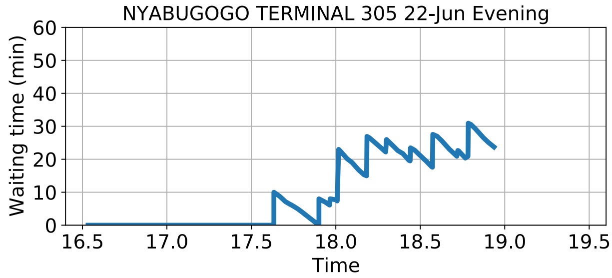

Fig. 18 Waiting time (Nyabugogo 305 / Evening)

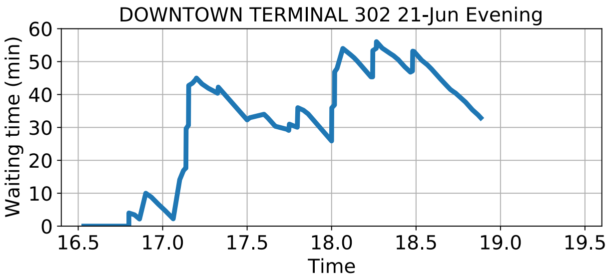

Fig. 14 Waiting time (Downtown 302 / Evening)

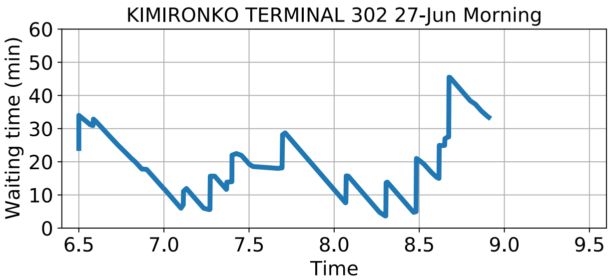

Fig. 15 Waiting time (Kimironko 302 / Morning)

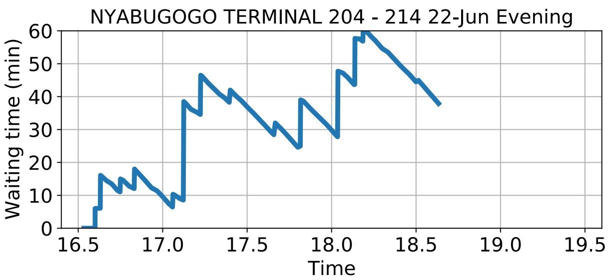

Fig. 16 Waiting time (Nyabugogo 204-214 / Evening)

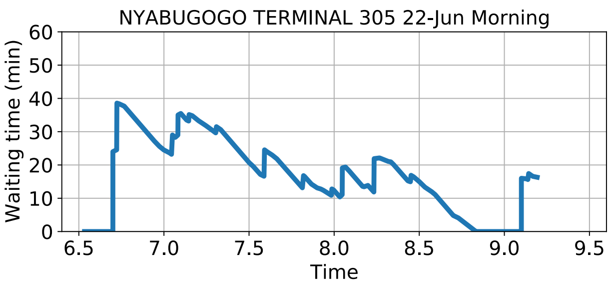

Fig. 17 Waiting time (Nyabugogo 305 / Morning)

4. DISCUSSION

From the results above, it is generally observed that long queues at terminals occur mainly in the evening hours than in the morning hours, probably due to the following two reasons:

1. As buses in Kigali City run in mixed traffic, there is more traffic congestion during the evening rush hour since many people are driving home at the same time, leading to a higher volume of traffic on the roads which in turn leads to delays for buses, which can cause longer headways (the time between buses). Longer headways mean that buses arrive less frequently, which can result in longer wait times for passengers and longer queues at bus terminals. In contrast, during the morning rush hour, there may be less traffic congestion because many people leave their homes at different times in the morning to get to work, school, or other activities (some leave earlier, some later, depending on their travel purpose to avoid congestion). This results in a more spread-out flow of traffic, reducing the likelihood of traffic jams and bottlenecks and allowing buses to maintain a more regular schedule and shorter headways. This means that buses arrive more frequently, reducing the waiting time for passengers and resulting in shorter queues. This suggests the importance of considering adjustments to the time of day when leaving work in conjunction with the bus schedule.
2. In the morning, people are often time-constrained and may prioritize getting to work or school on time rather than waiting in a long line for a bus. Therefore, they may choose alternative modes of transport, such as cars, motorcycle taxis (which are prevalent in Kigali) or cabs, to avoid queues and ensure they arrive at their destination on time. In contrast, during the evening rush hour, people may be more willing to wait in long queues for a bus as they are less likely to have time constraints or urgency to get to their destination, which is usually their home. If the time value of leaving work

is a factor, there may be potential to reduce congestion by introducing time-dependent bus fares.

There is a long queue on line 305 at the Nyabugogo bus terminal, which goes to Kimironko, both in the morning and in the afternoon, as this terminal is used by both city and intercity buses. When intercity buses arrive at the terminal, additional demand is created for this bus route, as passengers arriving on intercity buses may need to transfer to this bus route to reach their destination. Since this route has low capacity and cannot handle this increased demand, this results in long queues at this bus terminal. The morning queue is longer than the evening queue, probably because this route passes through places with many business centers such as offices, hotels, stores, and markets, and there are many passengers who live outside of Kigali and may work or do business in the area where this route operates.

Route 302 from Kimironko bus station which goes to the downtown bus station (located in the CBD) has a long queue in the morning because Kimironko and surrounding areas are heavily built-up residential areas and according to the structure of the city of Kigali, many activities are concentrated in the CBD which is often a major destination for commuters, shoppers. This leads to high demand for public transport services, especially during peak hours. Considering the low capacity of this route, therefore, this high demand leads to long queues at Kimironko terminals, especially on this route to downtown.

Long queues at the terminals with more than 120 passengers counted waiting at the platforms were observed on routes 302, 204-214, and 305. This is because most of the buses operating on these routes have a carrying capacity ranging from 20 to 35 people and less frequency. when a bus arrives carries a limited number of passengers, which means that fewer people are only transported on each trip. This leads to longer waiting times for passengers at terminals, as they must wait for multiple buses to arrive before they can board. In some cases, a person can wait up to 4/5 buses departing from the platform before he can board, with a waiting time that can reach 30 minutes or more, depending on the size of the bus and the frequency of the service.

Also routes 302, 204-214, and 305 have long passenger queues both in the morning and afternoon because, in addition to their low capacity, frequency, and their long length, they pass through bottleneck junctions causing delays of buses as they are unable to pass through bottleneck junctions quickly, therefore this can reduce the frequency of bus services at the bus terminal which leads to longer wait times(in some cases, it may be greater than 50 minutes) and long queues for passengers, as well as overcrowding on buses. This increases the overall travel time for passengers and makes it more difficult for them to plan their journeys and increases the uncertainty around bus travel.

On route 302 at the Downtown terminal and route 204-214 at Nyabugogo bus terminal in the evening peak hours, Some passengers wait for the bus for more than 30 minutes, and sometimes even over 50 minutes. This waiting time is longer than the bus travel time from the origin to the destination bus terminal, which highlights the severity of the congestion. Longer waiting times can also result in overcrowding and congestion at the terminals, which can lead to safety concerns and discomfort for passengers. In addition, if passengers are consistently experiencing long waiting times, it can negatively impact their perception of the bus system's reliability and efficiency, making them less likely to use it in the future.

Fig. 8 shows that in some cases, the queues move slowly which means that passengers waiting for a long time in a queue may become frustrated and impatient since there is no clear indication of the arrival time of the buses. Some passengers may feel like their time is being wasted, causing them to lose interest in waiting and leave the queue. Also, standing in a long queue for an extended period can be physically uncomfortable, especially during extreme weather conditions such as rain or heat. This discomfort may prompt some passengers to leave the queue before boarding the bus. This may lead to passengers seeking alternative modes of transportation.

4.CONCLUSION AND RECOMANDATION

Based on our analysis, it is clear that there is severe congestion at the bus terminals in Kigali City which manifests itself in long queues where on some routes, the length of the queue is more than 120 passengers and passengers may wait for the bus at the terminal for more than 30 minutes and in some cases waiting time may be longer than 50 minutes which is longer than the bus travel time from the origin bus terminal to the destination bus terminal. It was found that the length of passenger queues at bus terminals is a complex issue that is influenced by a variety of factors, including the vehicle capacity of buses, bottleneck junctions along the bus route as buses in Kigali City run in mixed traffic, and activities in high-density areas such as the Central Business District (CBD) and high residential areas. Standing in a long queue for an extended period of time can lead to frustration, discomfort, and safety concerns for the waiting passengers. To address these challenges, it is necessary to implement a combination of measures that improve the frequency and capacity of buses, provide real-time information about bus arrivals, and improve traffic flow through bus priority measures such as dedicated bus-only lanes and signal prioritization to help reduce congestion and improve travel times. By addressing these challenges, transport authorities can enhance the attractiveness of public transport, reduce car use, and promote sustainable mobility in urban areas.

NOTES

Note 1) National Institute of Statistics Rwanda (2022), Fifth Population and Housing Census 2022.
Note 2) City of Kigali (2019), Business Model for Public Transport Services in the City of Kigali 2019.
Note 3) Rwanda Utilities Regulatory Authority (2013), Annual Report 2013.
Note 4) National Institute of Statistics Rwanda (2012), Fourth Population and Housing Census 2012.
Note 5) Rwanda National Police (2017), Annual Report 2017.

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