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Using Intelligent Transport Systems as Tools to Develop the Efficiency of The Public Transport System in Jordan

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Abstract

The problem of the study lies in the need for smart cities to adopt new methods of transportation, especially public transportation, in light of this rapidly changing world and intense competition.It has become necessary forcities to adopt new methods, especially in public transport, because of their advantages. These include raising the level of road safety,traffic control and emergency incident management on the roads,increasing the power and operational efficiency of the transmission network,managing the demand for transport services, improving movement levels and mobility for recipients of transportation services,reducing the effects of the use of vehicles on the environment,and using electronic simulation systems to evaluate engineering plans and changes before implementing the design in the field and thus having a holistic view before implementation and reducing the construction costs of the transport network infrastructure.

Keywords: *intelligent transportation, smart cities*

Introduction

The transportation sector isone of the main pillars of the Jordanian national economy.With its various activities, this sector represents a basic pillar of progress, as it is impossible to achieve balanced growth between the sectors of the national economy of any country without securing the needs of those sectors in terms of transportation. It is also the most important indicatorofthe level of development and urbanisationin countries (Jordan, 2001) with the provision of transport services of quality, efficiency and reliability to citizens. The continued growth and development in Jordanian citieshas led to a significant increase in the volume of demand for public transportation services.Moreover,with increasing population and labor in Jordanian urban areas (Richter, 2020) and the problems facing the Middle East likewars and the refugees problem, new and advanced transportation systems will be needed (Abu Al-Nasr, 2014).Traffic management in modern roads is the most important responsibilities and challenges facing the development of the

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intelligenttransport system (Cui, 2019), especially after the emergence of wireless networks and technologies and the scarcity of radio spectrum (Raya, 2007; Ghoneim, 2019). To address this problem, a new smart traffic monitoring system was devised using free spectrum technology (Alsarhan et al., 2018). This technology allows drivers to rent free spectrum and spread the spectrum to build a short-range and cost-effective wireless network to monitor traffic and enable drivers to exchange warning messages, thus enhancing road safety and reducing the possibility of collisions using wireless networks. There is aconsiderablegrowth in the number of vehicles around the world, which has led to an increase in traffic congestion on public roads.

Therefore, Smart City Paradigm initiatives (Alsarhan et al., 2018; Sadiq, 2013) emergedto encourage the use of information and communication technologies in all services provided by cities (Petrov, 2017), enhance the quality of service provided, and facilitate the provision of smart digital services (Yang, 2013). Thus,the concept of 'intelligenttransportation'using (ITS)systems appeared (Chenbi, 2017). Itsmain aimis to create a safe and intelligent transportation environment (Ferman, 2005; Ben-Akiva, 2010). For example, current traffic management systems use a fixed video camera to monitor traffic flows. This requires high cost, high maintenance costs, in addition to deteriorating weather conditions. The problem of the study lies in smart cities' need to adopt new methods of transportation (Ismail, 2018), especially public transportation (Ferman, 2005). In this rapidly changing world and with intense competition, it became necessary for cities to adopt new methods, especially in the field of public transportation (Raya, 2007), due to theiradvantages, including:

1. Raising the level of road safety (Boulkouas, 2014) (Bylykbashi, 2019).
2. Traffic control and management of emergencies on the roads (Ali, 2019).
3. Increasing the energy and operational efficiency of the transportationnetwork (Harrison, 2010).
4. Managing the demand ontransportation services and improvingthe movement and mobility for recipients of transportation services (Jordan, 2001).
5. Reducing the effects of using vehicles on the environment (Lu, 2019).
6. The use of electronic simulation systems to evaluate plans and engineering changes before implementing the design in the field (Ben-Akiva, 2010)) thus having a comprehensive view before implementation and a reducingconstruction costs for the transport network infrastructure (Torabi, 2018).

Some believe that enhancingthe efficiency of the transportation system in any city means building new roads or repairing the oldones. This belief is often incorrect because the future of transportation lies in the rapid development of information and communication technology systems and their interactions with the requirements and needs of society through aIntelligentTransportation System(ITS) (Al-kahtanik, 2019). Through this system,the public transport system in Jordan can be improvedto overcome many problems of the transport sector,

especially traffic congestion,whichhas become the focus of Jordanian society's talk alongwith its association withthe waste of resources and capabilities of the national economy due to the high costof the energy bill (Chaudhary, 2019). Also, the increase in transportation allowances from the income of individuals, the low level of road safety, the increase in the rate of vehicle accidents, deaths and injuries resulting from them, and the ensuing social or environmental problemsare results of the lack of an integrated public transport system (Sumra, 2015) that the recipients of transport services rely on. Hence, this study attempts to answer the following questions:

1. What is the reality of the public transportation system in Jordan, and what are itsmain problems?
2. Howpreparedand suitableisthe technical environment and infrastructure in Jordan to operate intelligenttransportation systems in the public transport sector?
3. What are the most important applications of intelligenttransport systems that must be adopted in the field of developing the efficiency of the public transport system in Jordan?
4. How can ITS applications be used as tools to improvethe public transport system in Jordan?

This study aims to achieve the following objectives:

1. Identifying the problems that the public transport system in Jordan suffers from.
2. Clarifying what is meant by intelligent transport systems and how their applications improve the efficiency of the public transport system in Jordan in the following areas: the contribution of intelligent transport systems in raising the level of road safety;increasing the energy and operational efficiency of the public transport network, its role in improving the levels of movement and mobility for recipients of transport services,and its contribution to reducing carbon Footprintand preservingof the environment.
3. Demonstrating the readiness and suitability of the technical environment in Jordan to operate intelligent transportation systems in the public transport sector.

Based on the above, the presentstudy explains the importance of smart cities adoptionof the intelligenttransportation system and the use of information and communication technologies in all services provided by cities to enhance the quality of service provided and facilitate the provision of intelligent digital services.Through this study, planners in construction projects can benefit from the new data and new methodsto be applied in these projects to increase the use of information and communication technologies, especially in public transport, andenhance the quality of service provided and facilitate providingintelligent digital services.

A model was built showing what Intelligent Transportation Systems (ITS) are, what are the most important functions and tasks they perform, and what are the most important features and advantages they provide by enabling drivers to exchange warning messages, thus enhancing road

safety and reducing the possibility of collision, using wireless networks.

Figure 1. Study form

Source: The study model was developed by referring to a number of studies, including: (Sheikh. 2019; Torabi, 2018; Lu Lin, 2018; Alsarhan, 2018; Chenbi, 2017; Meribout, 2009; Martin, 2005; Jordan, 2001).

What Is a Smart City?

It can be said that there is an enormousgrowth in information and communication technology (ICT) due to the progress in the design of hardware and software, which led to the use of information and communication technology in cities in different forms to carry out various activities.This in turnleads to an increase in the effectiveness of the city's operations. There are several terms that can be applied to these definitions, includingcyberville, digital city, electronic city, flexibility, information city, television, wired city, and smart city (Hajduk, 2016).

The smart city is the largest idea and practical application of all activities and operations that use the communications and information sector (Chen, 2011) very effectively in all operations and achieve all the functions entrusted to it. There is no clear and agreed-upon definition of the concept among the academic community.However, it can be said that a smart city is a place where traditional networks and services are made more flexible, efficient and sustainable by using information, digital technologies, and telecommunications to improve theoperations for the benefit of residents (Hamour, 2023).

In other words,the smart city translates all digital technologies into better public services for the population and better use of resources with reducing the impact on the environment, making it greener and more sustainable (Mohanty, 2016; Sedjelmaci, 2019). A smart city is one that connects the components of the physical infrastructure with the information technologyandbusiness infrastructure to take advantage of the collective intelligence of the city (information and communication technology) (Lyapin, 2020) and other means to improve lifequality, the efficiency

of urban operations, services, and competitiveness while ensuring that all the economic, social and environmental needs of present and future generations are met (Schmeidler, 2016; Małecki, 2014). Through a broad view of all technologies, these technologies can be included in the following figure, which shows the most important technologies and means used in smart cities.

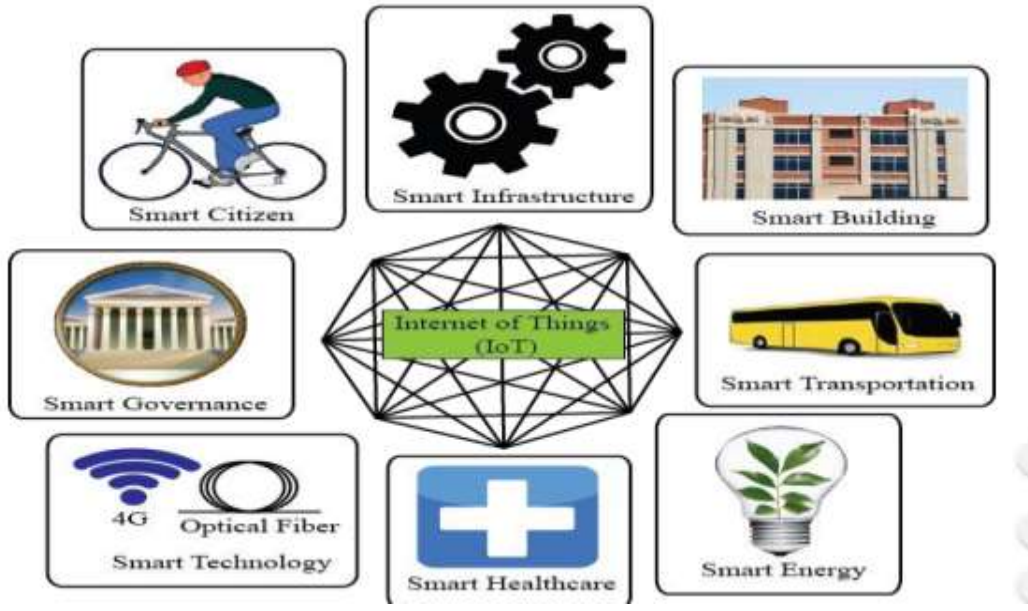

Figure 2. The smart city model (Mohanty, 2016).

According to the latest statistics, the world population has increased dramatically in the past decades,and so have the expectations of living standards. Accordingly, most studies predict that about 70% of the world's population will live in urban areas by 2050. Cities now consume 75% of the world's resources and energy, generating 80% ofGlobal warming. Studies indicate that,within a few decades,the establishmentof smart cities will bea natural strategy to mitigate the problems arising from rapid urbanisationand urban population growth (Dangelmaier, 2004). Despite the costs associated with establishing smart cities, once implemented, they will reduce the consumption of natural resources (water consumption, carbon emissions, transportation requirements, and city waste).

Smart cities worldwidevary in terms of their characteristics, requirements, and components. Some organisationsspecialising in unified standards and systems, such as the International Organization for Standardization (ISO), provide specifications and standards for smart cities to provide and ensure quality, efficiency,safety. and the requirements for monitoring the technical and functional performance of smart cities. Standards can also help address climate change,security, and transportation issues while ensuring the quality of water services. These standards take into account various factors, such as business practices and resource management, and help monitor the smart

city's performance,thus reducing its impact on the environment.

The IEEE Organisationdevelops standards for smart cities and their various components, including smart grids, the Internet of Things (IoT), e-health, and intelligent transportation system(ITS) (Zhang, 2020). The ISO 37120 standard defines 100 smart city performance indicators that include46 coreindicators and 54 supporting ones.There are some selected indicators in many fields, such as the economy, education, energy, and the environment.Theycan be used by city agencies to measure service performance, apply best practices in cities, and perform benchmarking between cities (Sakher, 2023).

The following figure shows the most important topics and the number of indicators in ISO 37120 (coreand supporting indicators):

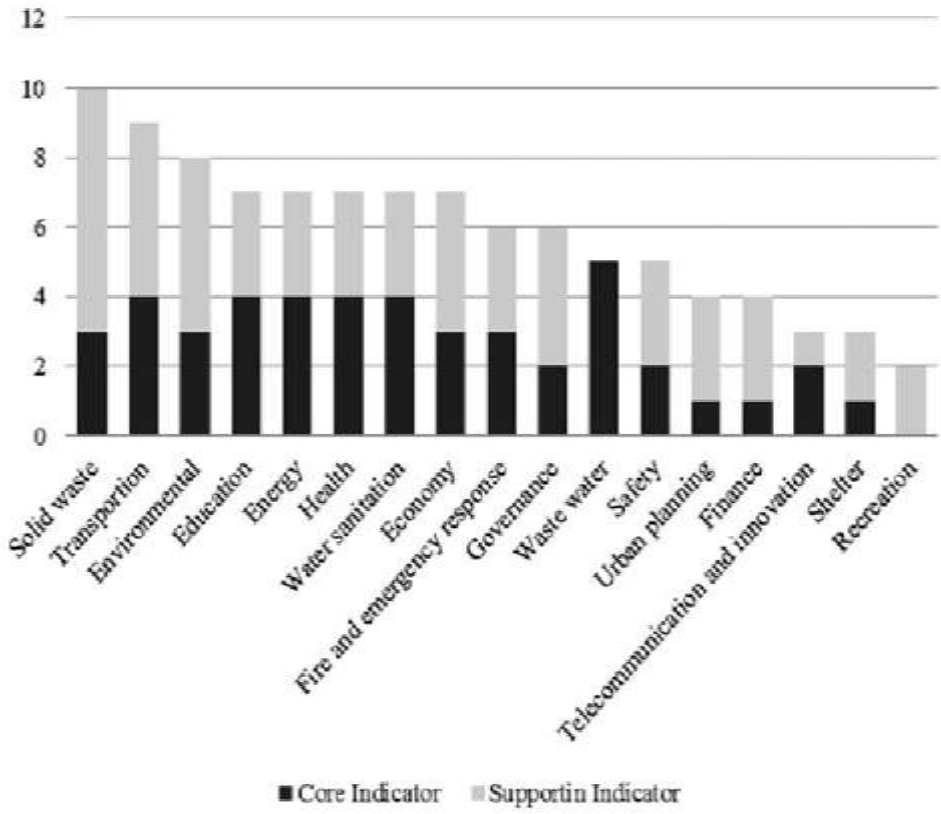

Figure 3. The most important topics and the number of indicators in ISO 37120.

Here, WCCD (World Council on City Data),a world company in standardisation, appears. WCCD implements ISO 37120 standards in the sustainable development of societies as itdeveloped the first ISO 37120 certification system and the World Cities Registry. The following figure shows the most important certificates awarded by WCCD.

Figure 4. The most important certificates awarded by the WCCD.

The following table shows the levels of the cities and the number of indicators theymust obtain to reachthe required level.

Table1: levels of cites and the number of indicators theymust obtain to reachthe required level.

Cities level certificates	number of standards
Aspirational	30–45 core indicators
Bronze	46 core + 0–13 supporting
Silver	46 core + 14–29 supporting
Gold	46 core + 30–44 supporting
Platinum	46 core + 45–54 supporting

Urban planning is one of the 17 topics defined by the ISO 37120 standard. It is a reporting indicator of green areas, trees planted per person/area of informal space, and employment rate.

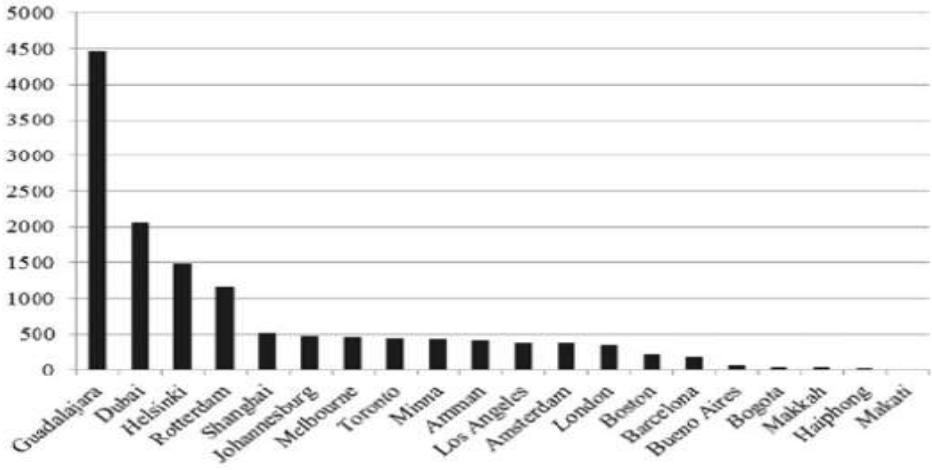

Figure 5. shows green city areas [hectares / 100,000 person].

Smart Cities: Components and Characteristics

Components can be summarisedby categorisingthem according to components, features, topics, and infrastructure asin Figure (6).

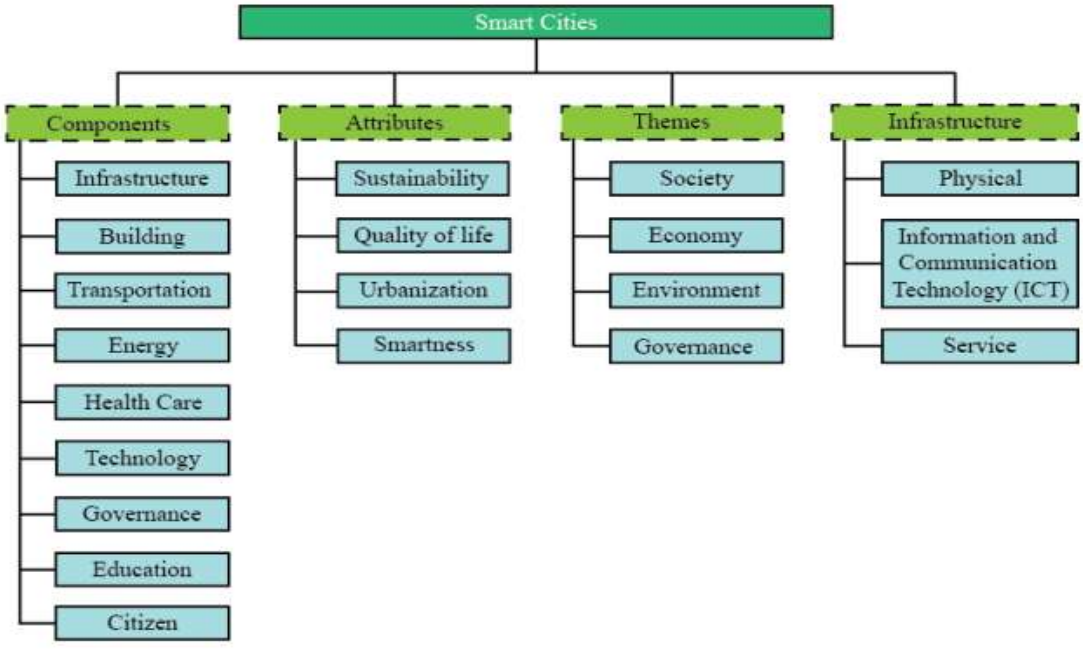

Figure 6. The most important components and characteristics of smart cities. Source: (Mohanty, 2016).

Here, we should mention the most important features of smart cities: sustainability, quality of life, urbanisation,and intelligence. Smart city sustainability is also related to infrastructure and governance, energy and climate change, pollution and waste, and social, economic, and health issues. It is important to mention that the Quality of Life (QoL) is measured in terms of citizens' emotional and financial well-being. We also notice the manifestations of urbanisationin the smart city in various aspects and indicators, such as technology, infrastructure, and governance. Here, a smart city is envisioned with economic intelligence, smart people, smart governance, smart mobility (Amditis, 200) and smart living(Jin, 2019).

The smart city infrastructure includes physical information and communication technology and services (Torabi, 2018). Physical infrastructure is a smart city's physical entity or real structure, including buildings, roads, railways, power supply lines, and water supply systems (Trullols, 2010). It is usually the non-intelligent component of smart cities.Information and communication technologyinfrastructure isthe primary smart component and is the nerve centreof a smart city (Washburn, 2010; Wang, 2020). The number of city facilities required as a function of city population can be calculated as follows:

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$$N_f = N_p \left(\frac{R_p}{Year}\right)\left(\frac{1\ Year}{D\ Days}\right)\left(\frac{1\ Hour}{N_c\ People}\right)\left(\frac{1\ Day}{H\ Hours}\right)$$

Where Nf is the number of facilities, Np is the city population in millions, Rp is the rate per person use in year/week, D is days per year, Nc is the customers per hour, and H is the hours per day.

Smart Infrastructure and Building

In the classical sense, the infrastructure of a city is any physical component of a city, such as roads, buildings, and bridges. In the context of smart cities, it can be said that the physical, electrical, and digital infrastructure is the spineof the smart city. There are many examples, such as rapid transit systems, waste management systems, road networks, railway networks, communication systems, traffic light systems, street lighting systems, water supply, gas supply systems, power supply systems, fire extinguishing systems, hospital systems, bridges, apartments, houses, hotels, law enforcement, and economic system.

- Information and communication technology infrastructure includes:
- Fiber Optics
- Wi-Fi Networks
- Wireless hotspots andservice-oriented information systems

A smart infrastructure may contain physical infrastructure, sensors,firmware, software, and middleware, which play a crucial role in smart infrastructure's automation and rapid response.Thismiddleware also aggregates data and combines it into a common platform for analytics and reporting (Zeyu, 2017; Dimitrakopoulos, 2020).

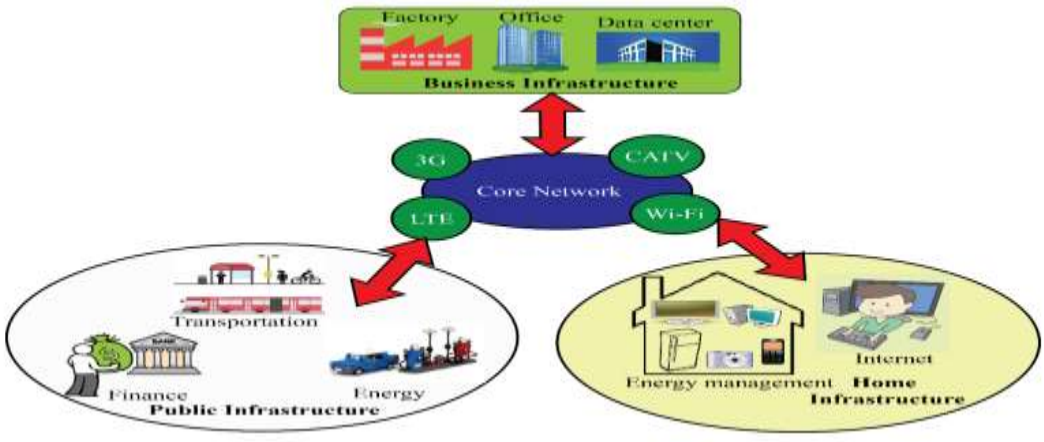

Figure 7. The complete conception of the smart city with all its functions (Mohanty, 2016).

A distinction must be made here between green buildings and smart buildings. The former buildings are sustainable structures with high energy and high efficiency in water control and internal environmental control to reduce carbon emissions and provide optimal energy performance. Smart buildings, in contrast, are a much larger concept than green buildings. They can easily connect with other buildings, persons, and technology worldwide, with very high efficiency.

The use of the Internet of Things (IoT) (Zhang, 2020) also provides integrated solutions that can process and analyselarge data (Khan, 2017), which will increase the operational efficiency and energy efficiency of smart buildings. The advantages of a smart building include Data-driven decision-making for high efficiency, performing operations at a low cost, increased use of resources, and lower operational costs.

Smart Cities: Dubai - United Arab Emirates

Smart Dubai: Inspiring new reality

With these words, Sheikh Mohammed bin Rashid Al Maktoum expressed his vision for Dubai to become one of the best smart cities in the world.Dubai has taken decisive and effective measures in digital transformation and smart transformation in all operations and functions carried out by the city.

The most important modern initiatives for smart transformation in Dubai can be listed as below:

1. Paperless transactions.

2. Support for new companies.

3. Artificial Intelligence Lab.

In intelligent transportation, the Roads and Transport Authority - Dubai recently announced the transfer of all its work to services applicable to smart applications, by introducing nine smart applications on mobile phones. The authority provides about 173 services to help the residents complete transactions with a single click on their smart phones. The applications available on all smartphone platforms include:

- Smart Drive

- Wojhati

- Smart Salik

- Smart Parking

- Smart Taxi

- Drivers and Vehicles

- Public Transport

The authority has also commissioned a study on the use of self-driving cars (cars without a driver) in Dubai, hoping to pioneer this concept in the region.

Dubai government has also downloaded (Santander) software and installed more than 12,000 sensors (Askari, 2019) that help the city manage traffic more effectively and reduce energy consumption, waste disposal, and other issues. These sensors measure different factors, such as temperature, light, and carbon emissions (Zhang, 2018). It has placed about 400 sensors at the city entrances that can be controlled through 60 devices to measure traffic volume, road occupancy, and vehicle speed. This will help planners and decisionmakers (Zhankaziev, 2018) to monitor road patterns, which constitutes a large knowledge base for them to allow this data to control traffic lights and direct the traffic. Accordingly, Santander and associated acoustic sensors were provided with two-year traffic data to monitor the urban noise movement and traffic light administration (Richter, 2020).

The Roads and Transport Authority - Dubai has also encouraged environment-friendly traffic by establishing pedestrian walkways (Guo, 2012) and bicycle tracks. It has developed a master plan for bikeways that will cover 900 km.Dubai residents can download all RTA applications through the App Store; these applications are linked to the user's bank account, as shown in Figure (8).

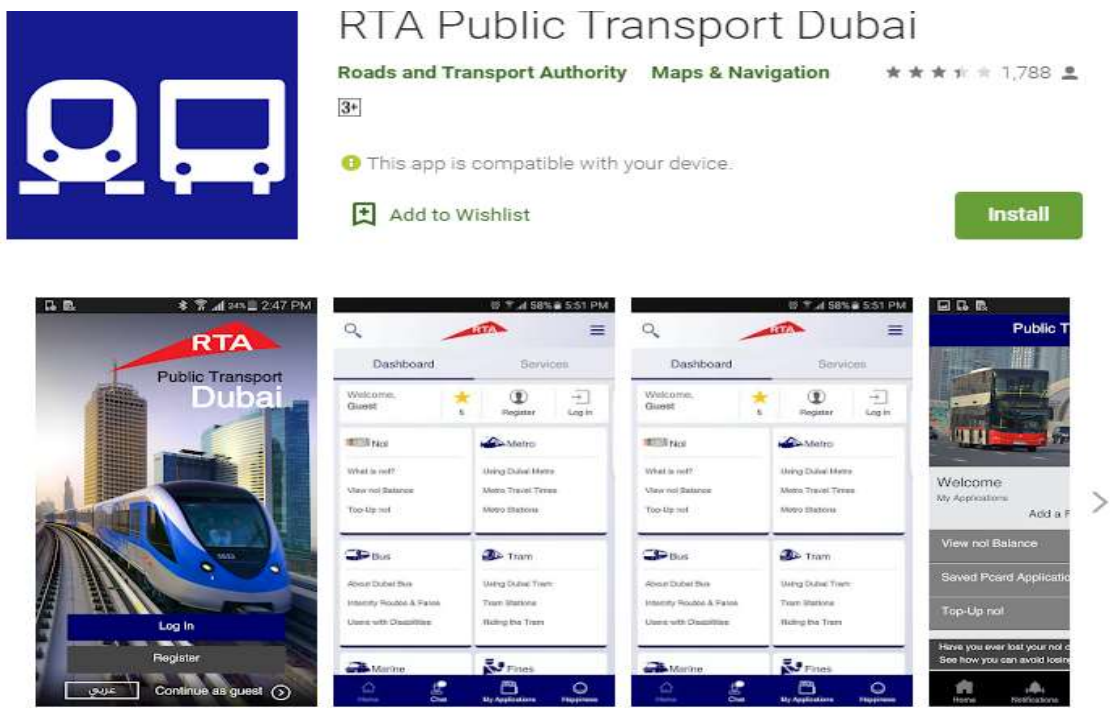

Figure 8. One of the applications available for Dubai residents to book transportation.

Figure 9 shows Saliksmart application, which provides the following features:

- Improved display screen: it enables you to see the most important information about your account ina single screen.
- Meterindicator: where you are fully aware of the deadlineforrecharging your account to avoid violations.
- Recharging your Salik account by using phone number and vehicle plate instead of account number and PIN.
- Loging in with fingerprint.
- No need to enter the password every time.
- Enhanced digital identification feature for easy entry of recharge card number, traffic file number, and Salik card number
- Smart watches.
- Managing different personal profiles for all your family and friends.
- Happiness index.

Figure 9. Salik Smart application.

Intelligent Transportation Systems

It can be said that the traditional transportation system is all the means and facilities used to transport passengers and goods from one place to another, such as the railway, land transport, air transport, and water transport.However,eachworks independently, which makes the

complementarity process very difficult.This is in addition to traffic congestion, especially after the large population growth; the large increase in the number of cars and vehicles, traffic crises,traffic accidents, noise in urban cities,carbon emissions; and the global warming problem that the Earthsuffers from. Therefore, it became necessary for us to search for solutions to the traffic problem;hence, the term 'Information and Communication Technologies' ICT appeared, which refers to the technologies that provide access to information through communications using information technology (IT) through the Internet and wireless networks (Meriboutk 2009), mobile phones, and other communication media (Nureni, 2014) and Galkin (2020).

What are Intelligent Transportation Systems?

Public transportation is the main driver of intelligent transportation systems. The application of modern technologies aims to improve the traditional operations of public transportation (Paul, 2017). These achievements include:

- Monitoring the traffic on highways (Mfenjou, 2019) , early notification of accidents, and urban traffic management.
- Controlling traffic lights and measuring slopes to improve traffic flow and safety (Shaheen, 2013).
- Improvingtraveler information.
- Examiningcommercial vehicles and collect electronic fees.
- Controllingpublic transport operations throughsatellites (Shaheen, 2013).
- Controllingvehicles' navigation systems
- Managingsmart parking
- Environmental leadership and guidance (Shaheen, 2016);
- Public car and bicycle sharing services.

Intelligent transport systems have gone through several stages. The first stage began many years ago, by working to improve the operations related to traffic management, suchaslinking the traffic controlcenters with each other, advanced coordination of traffic lights, real-time adjusted slope measurement, and passenger information systems coordinated with vehicle instrumentation.Through this stage, the basic nature of driving and driver behavior in transportation models is understood. Moreover, at this stage, the coordination between the multiple modes of transport and the improvement of system management weredone through the analysis of data collected through various tools toanalysethe actual performance of the modes of transport and create the most important collision avoidance systems insidevehicles (Labourczi, 2010; Galkin, 2018).

For this purpose, the US Department of Transportation, in collaborationwith National ITS Architecture, issued a general framework for the planning and implementation of Intelligent Transportation Systems (ITS) in the mid-1990s included 33 ITS architectures classified into eight categories:

1. Travel and traffic management
2. Public transportation management
3. Electronic payment
4. Commercial vehicle operations
5. Emergency management
6. Advanced vehicle safety systems.
7. Information management
8. Maintenance and construction management

The guide also includes several items classified into eight categories, as shown in Figure 10 below:

User Services Bundle	*User Services*
Travel and Traffic Management	• Pre-tip Travel Information • En-route Driver Information • Route Guidance • Ride Matching and Reservation • Traveler Services Information • Traffic Control • Incident Management • Travel Demand Management • Emissions Testing and Mitigation • Highway Rail Intersections
Public Transportation Management	• Public Transportation Management • En-route Transit Information • Personalized Public Transit • Public Travel Security
Electronic Payment	• Electronic Payment Services
Commercial Vehicle Operations	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspection • On-board Safety and Security Monitoring • Commercial Vehicle Administration Processes • Hazardous Material Security and Incident Response • Freight Mobility
Emergency Management	• Emergency Notification and Personal Security • Emergency Vehicle Management • Disaster Response and Evacuation
Advanced Vehicle Safety Systems	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-crash Restraint Deployment • Automated Vehicle Operation
Information Management	• Archived Data Function
Maintenance and Construction Management	• Maintenance and Construction Operations

Figure 10. The structure of the ITS system.

The National ITS Architectureis linked to the Ten-Year Plan released in 2002, which addresses aims and objectives, user service, requirements, and expected benefits. It includes the five main objectives identified in the Ten-year Plan:

1. Safety
2. Security
3. Efficiency
4. mobility/access
5. Energy/environment

Moreover, the Ten-year Plan has established a series of programmed and enabling topicsto describe the opportunities, benefits and challenges faced by future transportation systems (Shaheen, 2013).

Smart Parking Management

Intelligent parking management system refers to a set of technologies that help find and reserve a parking space and reduce the energy consumed while searching for parking spaces (Peng, 2019); it alsoprovides the additional benefit of reducing congestion for all vehicles in one area. Bayless and Neelakantanindicatethat 30% of urban congestion is caused by drivers making trips to park their cars (Bayless, 2012). Also, smart parking technologies include locating parking information, pricing, vehicle detection sensor systems, and a communication system, such as mobile phone apps, to inform drivers and direct them to available spaces (Shao, 2020), as shown in Figure (11).

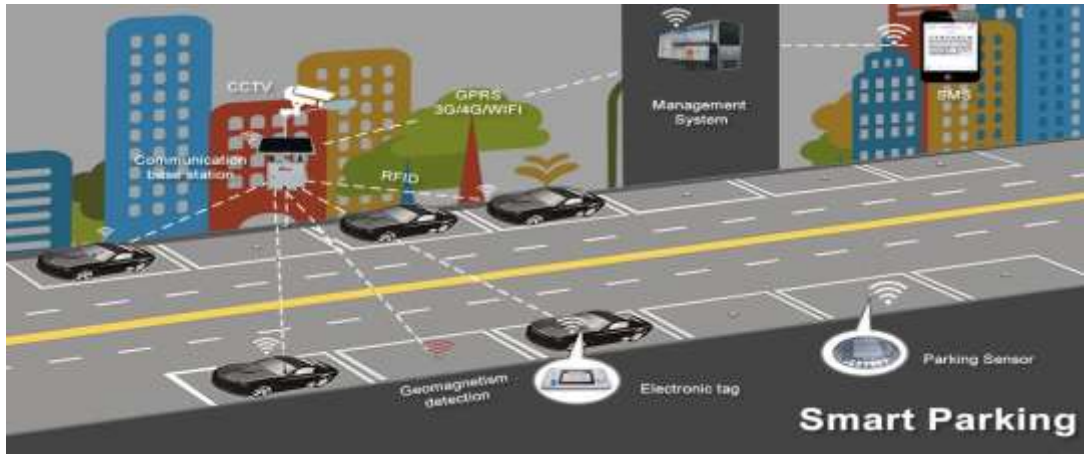

Figure 11. Smart Parking Management

Public Transportation Management

This technology is based on the application of ITS technologies to improve service through automatically locating the vehicle, real-time bus arrival signals, traffic light priority, and automated

information announcements, Such as the Bus Rapid Transit (BRT), which is based on the use of a series of ITS technologies, route planning, and traffic rights (Dong, 2011).

Bus Rapid Transit (BRT)

Also called bus lane or transit road, it is a public transport system based on buses designed to improve capacity and reliability over a conventional bus system.The BRT system includes lanes designated for buses, and gives priority to buses at junctions.Moreover, it has several advantages, including reducing delays caused by passengers boarding, deboarding, or paying fares. The BRT aims to combine the capacity and speed of the metro with the flexibility, low cost, and easeof a bus system, as shown in Figure (12).

Figure 12. Bus Rapid Transit (BRT) in Jakarta - Indonesia.

Intelligent Transport Systems Techniques

Static sensing techniques

It is done through magnetic sensors to detect the number of vehicles using magnetic sensors or rings under the road surface and deployed systems, as shown in Figure (13).

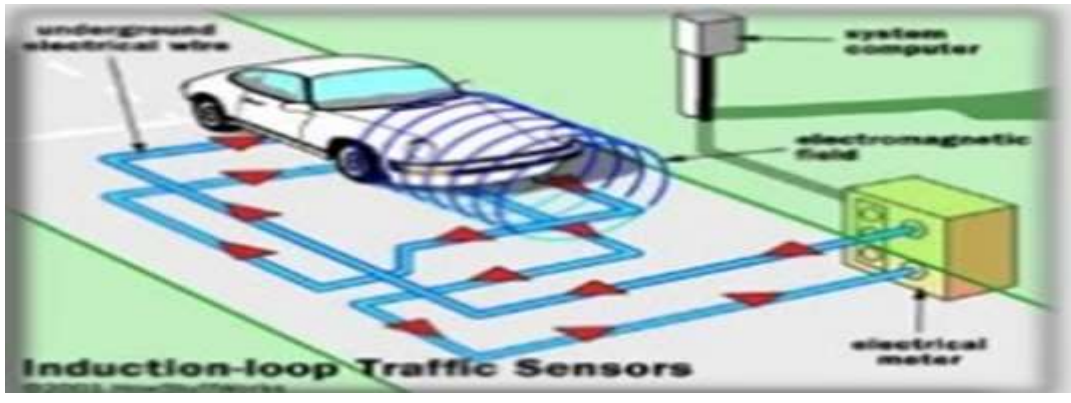

Figure13. Loops and magnetic sensors

Pictures and videos

Vehicles are monitored by video camera to monitor traffic conditions and detect accidents and hot spots.That gives a comprehensive survey of the main computer vision techniques used in traffic applications (Syed, 2019), as Figure (14) shows.

Figure 14. Video surveillance

Acoustic sensors

Some recent research is being done to use acoustic sensors to estimate traffic conditions, especially in developing regions, where traffic movement is noisy.

RF sensors - Wireless radios

They are placed across the road to send communication signals affected by the movement of vehicles on the roads (Daoud, 2020), as shown in Figure (15).

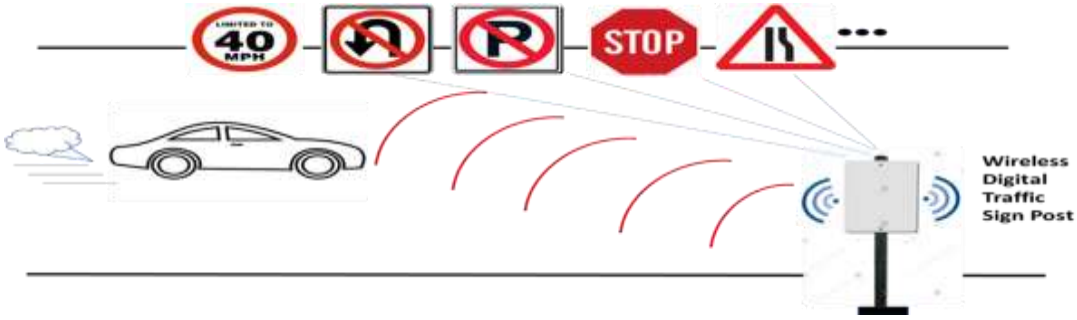

Figure 15. Wireless digital traffic signs

Mobile sensing techniques

Global Positioning System(GPS) on public transport or fleet vehicles

- The Global Positioning System (GPS) is installed in vehicles for real-time tracking in many public transport companies and fleets, as shown in Figure No. (16), detecting hot spots, and estimating travel time after dealing with noise in GPS records (Astarita, 2018).

Figure 16. GPS on Smartphone's.

- Solving the problem of reorienting the smartphone accelerometer to match the axles of the car (Khalid, 2018).

Hybrid sensing

A range of technologies (fixed infrastructure and portable sensors) are used to acquire traffic information.

- Teledensity: phone operators can give data about the density of vehicles in a specific area through the tower installed in the area (Quang, 2014).
- Bluetooth: A system in which bluetooth detectors on the side of the road sense bluetooth radios in phones inside the vehicles.Bluetooth addresses are linked between the different detectors, giving travel times for vehicles between the detectors.
- The use of RFID systems (Bani Younes, 2018).

Real-Time Traffic Information Systems

Through these systems, traffic speed is monitored and displayed on large screens at highway service stations, airports, hotels, and offices to provide information to passengers before or during the trip (Hassan, 2019). A schematic diagram of highway networksis used, specific sections can be displayed as desired, and online information about traffic conditions on highways, main roads, and urban strategic roads is accessed through a network of speed control points (Askari, 2019)(Sumalee, 2018), as shown in Figure (17).

Figure 17. Real Time Traffic Information Systems

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It should be noted that a Traffic Management Systemisan integrated process between advanced traffic management systems (ATMS) and Intelligent Transportation Systems (ITS), so that real-time transportation data flows from the entire traffic infrastructure to a single Transportation Management Center (TMC). This data is then processed into the TMC system to take smart actions that increase transportation efficiency (Yang, 2019), ease traffic congestion, and improve road safety (Zhao, 2018), as shown in Figure (18).

Figure 18. Traffic Management Systems

The public transportation system in Jordan

Jordan is a small country in the Middle East. It is bordered by Syria from the north, Iraq from the East, Saudi Arabia from the East and South, and from the West Israel and the occupied West Bank.The country's only outlet to the sea is the Gulf of Aqaba. Jordan occupies an area of approximately 96,188 square kilometers.However, there is a great diversity in the topographic and geographic nature of the region, which makes urban planning a matter of great importance (Hassan, 2019). The population of Jordan is about (10) ten million people, and (3) three million refugees (Iraqisor Syrians).Jordan is also a major transport hub in the region. The transport sector contributes about 10% tothe gross national product, including passenger and goods transport, which makes it essentialto achieve sustainability and economic, social and, environmental development (Galkin, 2020). The Ministry of Transport in Jordan supervises thetransportation of passengers and goods within the Kingdom. Its mission is to plan, develop, implement, and supervise public transport and setstrategies, policies, and procedures to improve this sector. During the past few years, Jordanian cities have witnessed a great deal of overcrowding due to congestion on the main roads and on passenger transport services, which led private vehicles' owners to use their vehicles.This in turncreated great pressure on the existing infrastructure (He, 2010).The means of passenger transport include buses, minibuses, shared taxis that operate on fixed routes,and taxis.

This prompted the Jordanian government to devise several means to reduce the pressure on public transportation and use effective and highly efficient methods (Huang, 2019), thus reducing road congestion (Haynes, 2000) and increasing performance indicators, such as accessibility, mobility, productivity, punctuality (Ferman, 2005), and passenger waiting time.

Table 2: The number of modes ofpassenger transport by category, which fall within the jurisdiction of the Land Transport Regulatory Commission, according to the quarterly report for the months (October / November / December, 2019).

Statement	December	November	October
Number of fleets for public transport (buses, medium passenger cars, minivans and taxis)	37699	37251	37175
Public buses within the jurisdiction of the commission	1018	1018	1018
Public Medium within the jurisdiction of the commission	3620	3611	3607
public bus within the jurisdiction of the commission	776	787	822
Tourist rental cars	12649	12627	12653
Number of tourist rental car offices	233	233	233
The number of privately registered vehicles	12532	12797	13770
The number of medium buses registered asprivate	11620	11870	12827
The number of privately registered buses	912	927	943
Number of vehicles registered as tourist transport	727	727	715
The number of medium buses registered as tourist transport	242	242	176
The number of buses registered as a tourist transport	485	485	539
Number of tourist transport companies	11	11	8
Yellow taxi	5361	5361	5410
Number of yellow taxi offices	135	135	135
Airport taxis	228	228	228
Number of airport taxi offices	1	1	1
BorderCrossing taxis	30	30	30
The number of the bordercrossing taxi's offices	1	1	1
Luxury taxis (limousines)	426	395	324
Number of luxury taxi offices	18	18	16
Hotel taxi office cars	104	104	93
Number of hotel taxi offices	12	12	12
Number of taxis for people with special needs (yellow taxi)	30	30	30
The international transport fleet	234	230	190
Number of international transport companies	19	19	19
Fleet rental companies	1079	1097	1123
The number of medium buses registered as a rental	620	607	600
The number of buses registered as rental	459	490	523
Number of rental companies	22	22	22
Foreign travel cars	1066	1066	1084
Number of smart application companies	6	6	6
smart applications fleet	12367	11970	11850
The number of school transport companies	3	3	2
School transport fleet	7	4	4

Number of buses for people with special needs	24	24	24
Number of activity management center companies	0	0	0
Number of public buses that have been updated	35	35	35
Number of public buses updated (cumulative for the year)	452	422	387
Number of public buses updated (cumulative for all years)	3300	3270	3235

Source: Land Transport Regulatory Commission http://www.ltrc.gov.jo/?q=ar/node/133

Table 3. shows the average operating age of the public transport fleet for 2019.

Table 3. The average operating age of the public transport fleet for 2019.

Indicator	**October**	**November**	**December**
The average operating age of the public transport fleet**(2019)**		10.76	

Table 4. The number of buses per (1000) thousand people.

Statement	**October**	**November**	**December**
The number of buses per 1000 people		0.62	

Table No. (4): Number of buses per (1000) thousand people.

Table 5. The capital expenditure of the Public Land Transport Regulatory Commission for Passengers (Jordanian Dinars).

October	**November**	**December**
11750334	12184237.51	14651644.69

Table (5): Capital Expenditure of the Public Land Transport Regulatory commission for Passengers (Jordanian Dinars)

Table 6. shows the number of trucks owned by licensed transport companies and individuals.

	Truck numbers		**Truck ownership percentages**	
	individuals	**company**	**Individuals**	**company**
Until the end of December	14000	7000	%69,4	**%30,6**
Total		21000	**% 100**	

Table (6): Number of trucks owned by licensed transport companies and individuals.

Source: Land Transport Regulatory commissionhttp://www.ltrc.gov.jo/?q=ar/node/133

Table 7. numbers of trailers/semi-trailers

statement	**October**	**November**	**December**
numbers of trailers	21000	21000	21000
semi-trailers	28500	28500	28500

Table No.7: Number of trailers/semi-trailers

Table 8. The average age of the freight fleet and the number of new trucks

statement	October	November	December
average age of freight fleet (years)	17.75	17.75	17.75

Table (8): The average age of the freight fleet and the number of new trucks

As Table No. (9) shows: Numbers of specialisedroad transport companies.

Table 9. Number of specialisedroad transport companies

statement	October	November	December
containers	124	125	123
general goods	112	112	113
Cars	10	10	10
Heavy lifting	10	10	13
coolant	7	7	7
Sheep and cattle	4	4	3
Vegetable oils	3	3	3
Rawoil and its derivatives	57	57	58
Ready-made concrete	6	6	6
Total	333	334	336

The following figure shows a map of Amman, showing the most important main and secondary roads and the most important stations.

Figure 19. A map of Amman, showing the most important main and secondary roads, as well as the most important stations

Figure 20 shows a map of Amman (a specific area)

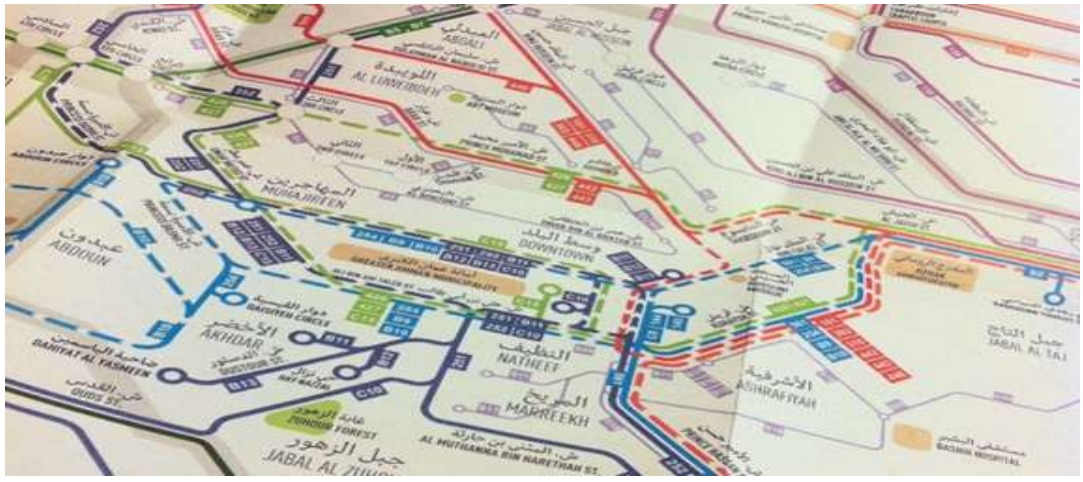

Figure 20. Map of Amman (a specific area).

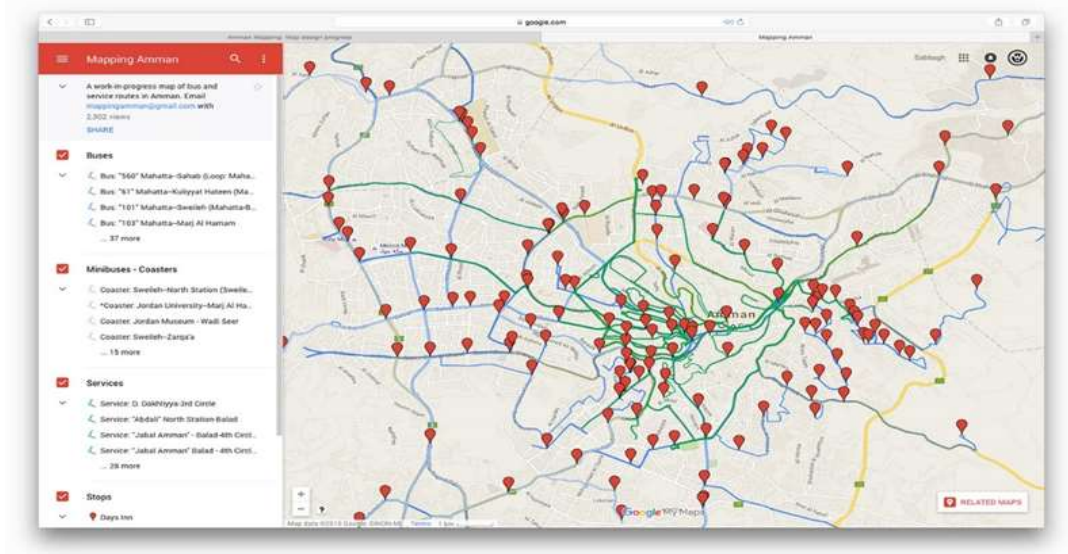

Figure 21. A detailed map of Amman showing roads.

The most prominent problems of the public transportation system in Jordancan be summarisedin the following points

1. Increased use of private vehicles and thus increased traffic crises.
2. Similar working hours, so we notice that working hours are similar for all employees, whether in the public or private sectors. Most employees start their

work at eight in the morning and finishat 4 in the evening, which increases rushhours.

3. The long time that citizens spend to go to their work due to the suffocating traffic in most of the Kingdom's governorates, especially in the capital, Amman.(Al-Habahbeh, 2019).
4. The weakness of the infrastructure, and the inability of the Ministry of Transport to moderniseit, which causes a great weakness in terms of road and street maintenance, the large spread of potholes, and the great need for road maintenance, especially after Wintersand rainy seasons (Chenbi, 2017)
5. Absence of positive competition between companies providingtransportation services to provide highly efficient services.
6. The problem of refugees and their increasingnumber, especially after the asylum of about two million Syrians and the great pressure on infrastructure and transportation.
7. Poor urban planning in land use, especially in economic activities, such as building malls, complexes, and hospitals.
8. Lack awareness among drivers of the importance of traffic awareness, and their commitment to traffic rules and traffic safety rules. We notice the spread of excessive speed among large bus drivers and non-compliance with traffic lights.
9. Increased fuel and energy consumption due to the increasingnumber of vehicles.
10. Increasing environmental pollution, thus increasing the gases emitted and exacerbating the problem of global warming.
11. There are no designated parking spaces to wait for passengers.
12. Instability of public vehicle routes and frequencies on roads (Wu, 2018).

The preparednessand suitability of the technical environment and infrastructure in Jordan to operate intelligent transportation systems in the public transport sector

It can be said that the infrastructure in Jordan suffers from several problems due to the large increase in the opening and paving of new roads and the high maintenance costs of the sprawling road network in all regions of the Kingdom.The asphalt mixtures were based on limestone, which requires periodic maintenance forthese roads.However, the Greater Amman Municipality has recently taken several measures to use basalt because it has greater hardness, with the slight increase in their prices, and it is a sustainable material that can be reused. Regarding the infrastructure of technological and electronic technologies in transportation,it can be said that Jordan is still a beginner.The experience of the Greater Amman Municipality is still in its first steps through the

implementation of the "Amman Bus" initiativeto provide better services. Amman Vision Transport Company announced the routes and lines of modern buses, "Amman Bus". The 135 buses will cover 55 destinations across 23 lanesinthe first phase. Thehead of the Greater Amman Municipality, Dr. Yousef Al-Shawarbeh, confirmed that the Municipality will grant the citizen the card at two dinars (one dinar account and one dinar card).The card will be sold at commercial points and transportation complexes. He pointed out that the cost of the trip (the fare) will be one piaster, so that the citizen gets to know the services;then the the approved farewil be determined.He explained that the Greater Amman Municipality bears the differences in the fare of passengers on the new buses, and accordingly the Municipality has allocated 4 million dinars to support citizens.The experiment or its steps began on Sunday, 23/6/2019. Also, The Greater Amman Municipality emphasisedthe importance of introducing advanced payment systems for modern buses,which includes financial wallets and credit cards. Thismakes it easier for the citizen to ride the bus and deal with the driver and increases the level of safety and comfort in vehicles and public transport buses (Lu, 2019). The Municipality also emphasisedthe implementation of its plan to establish 55 parking lots and 33 stationsto cover the points,indicating that the goal is to reach 220 stations by the end of 2020.The frequency of buses will reach about 30-50 times, so that the efficiency of services will be very high.Likewise, the frequencies of each line differ from the other while the distance is between (20-25 minutes) according to each track.

Smart applications in public transport

They are technology startups, based on the use of telephone technology, automobile transportation, and logistics.Uber acquires the largest share in the smart applications market, and its headquarter is in San Francisco-USA.The application is a platform that connects passengers with drivers who have a contract with these companies.The passenger must have a smartphone and register onthe mobile application by entering his/her name, address, email, phone number, and credit card number (Saharan, 2020)to be billed automatically at the end of the trip.GPS has been used in smartphones to identifythe location.It is not necessary for the passenger to specify the destinationaddress, but he/she can leave it free to locateit later. The followingtheare most important smart applications in the world:

Company name	**logo**
Uber	
Careem	

Jeeny	

Figure 29. The most important smart applications for public transport in the world.

The app can be downloaded from the App Store for both Android and Apple's iOS and is free of charge,as Figure (30) shows:

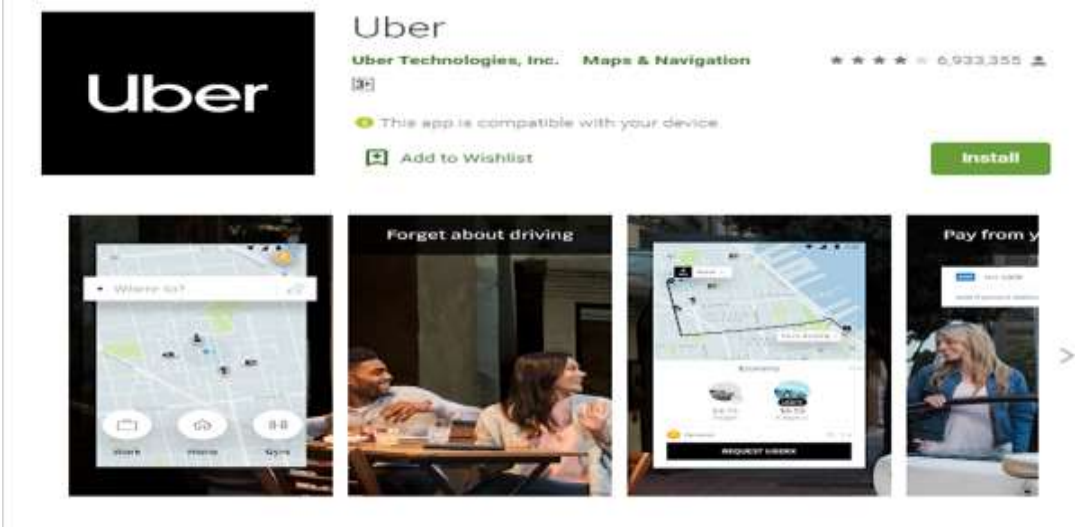

Figure 30. The Uber app.

Through this application, you can choose the services you want, as shown in Figure (31):

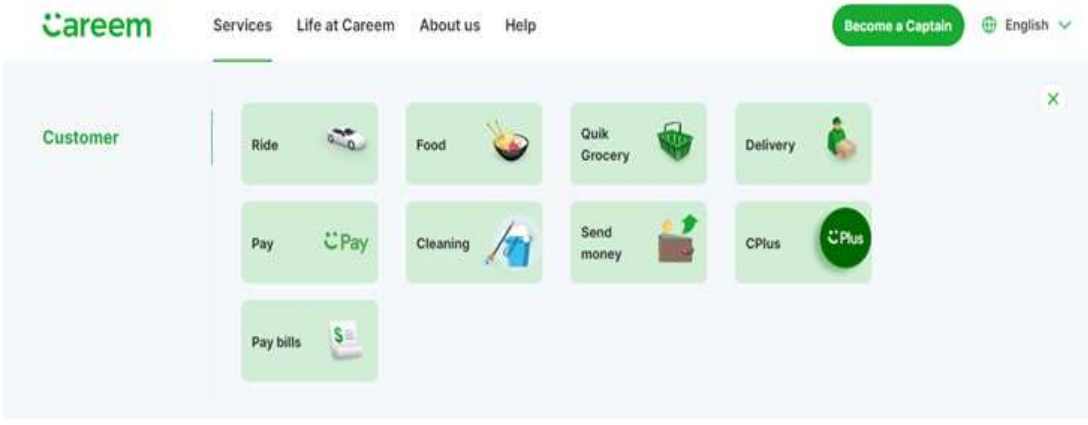

Figure 31. Services provided by Careem application

You can also specify the departure area and the point of arrivalspecified by the application using GPS, as shown in Figure (32).

Figure 32. Determining the point of departure and arrival in Careem application.

Then, the application sends the bill to the email previously registered in the database,as shown in Figure (33).

Figure 33. Careem application showing the passenger's bill.

Evaluation of smart application programs in Jordan

The experience of smart applications in the field of public transport in Jordan is a successful experiencefor the reasons listed below:

1. These applications have createddiversity and efficiency inpublic transport
2. They provided several job opportunities for many people, especially for young people, as Uber confirmed that a total of 75% of its drivers are university students, and some of them work for less than 4 hours.
3. Through these applications, you can request a modern and clean vehicle with a private driver who is highly professional in providing transportation service to passengers atprices close to the prices of a regular taxi.
4. These applications provided vehicles that are comfortable for passengers and a high level of safety and reliability (Gaber, 2018).
5. By using these applications, the passenger gets rid of the yellow (taxi) drivers' mood.
6. The degree of safety in these applications is very high since the driver's data, which contains the driver's name, car number, and phone number appears to the user before arrival to the passenger, which allows passengers to view this data with any other party.

It can be concluded that the public transport system in Jordan needs to restructureall procedures and legislations related to public transport to face the hugechallenges and changes in this changing worldand the new phases in the world of technology and communications.The authorities should be updated on new trends (Sirohi.- Deepika (et.al, 2020), new concepts in the world of transportation (Yang, 2019), (Lyapin, 2019)and the adopt new concepts in infrastructure, such as RFID, Wireless Communication, and Bluetooth and their application in means of transportation, such as BRT buses, express trains orwhat is known as the term "magnetically levitating train", a train that works by magnetic levitation.That is, theydepend in theirwork on magnets, as they do not contain mechanical motors ort moveon iron rails.They float in the air relying on a magnetic cushion that creates strong electromagnetic fields.These trains are distinguished by their high speed, which reaches 550 km / h (Jin, 2019).

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