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Smart Traffic

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ABSTRACT
The constant rise in traffic volumes in most of the cities worldwide today is causing increase in air or environmental pollution. This can have a negative impact on the health of residents or humans generally if not checked. There is therefore the need for intelligent or smart traffic management control. Traffic technology solutions are required to optimize and reduce urban traffic flows. A city is not completely smart or intelligent without a smart traffic management system. An Intelligent Transportation System (ITS), or a smart traffic management system is to help minimize congestion, improve safety on city streets, and reduce or eliminate greenhouse gas emissions through connected technology. This paper delves into the benefits, obstacles/challenges, solutions, and the future aspects of smart traffic to humanity.

KEYWORDS: *Smart traffic, smart cities, connected technology, sensors, artificial intelligence, traffic lights, greenhouse gas emissions, Internet of things*

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INTRODUCTION

Smart traffic management systems or intelligent traffic systems (ITS) are advanced technologies that aim to improve the efficiency and safety of transportation systems using real-time data, communication networks, and advanced algorithms. These systems make use of a variety of sensors, cameras, and other technologies to gather data about traffic flow, weather conditions, and other factors, which is analyzed and used to adjust traffic lights, road signage, and other infrastructure in real-time [1].

These systems help to enable safe transportation, limit and mitigate traffic collisions, fatalities, injuries, and property damage [2]. Traffic lights, also known as traffic signals, are signaling devices that control the flow of traffic at road intersections, pedestrian crossings, and other locations, as shown in Figure 1. They make use of colored lights such as red, yellow and green, to indicate when vehicles and pedestrians should stop, slow down, or go [3].

HISTORICAL BACKGROUND

The earliest road signs were milestones, giving distance or direction, e.g. as in the Romans stone columns throughout their empire. In the Middle Ages, multidirectional signs at intersections became common, giving directions to cities and towns. In 1686, the first known Traffic Regulation Act in Europe was established by King Peter ll of Portugal. The act brought about the placement of priority signs in the narrowest streets of Lisbon, stating which traffic should back up to give way – one of the signs still exists at Salvador Street, in the neighborhood of Alfama [4].

The late 1870s and early 1889s saw the first modern road signs erected on a wide scale for riders of high or "ordinary" bicycles. These machines were fast, silent, and their nature made them difficult to control, while their riders travelled considerable distances and often preferred to tour on unfamiliar roads. Cycling organizations, because of these riders started to erect signs that warned them of potential hazards ahead (particularly steep hills), and not just the giving of distance or directions to places, thereby contributing to the sign type that defines "modern" traffic signs.

More complex signage was encouraged by the development of automobiles and by the use of more than just text-based notices. The first modern road sign systems were devised by the Italian Touring Club in 1895. The proposal for the standardization of road signage was being considered in 1900 by the Congress of the International League of Touring Organizations in Paris. In 1909, nine European governments agreed on the use of four pictorial symbols, indicating "bump", "curve", "intersection", and "grade-level railroad crossing", as shown in Figure 2. Intensive work on international road signs took place between 1926 and 1949 that led to the development of the European road sign. Both Britain and the United States developed their own road signage systems, which were adopted or modified by many other nations in their respective spheres of influence. The UK adopted a version of the European road signs in 1964.

The US first road signs were erected by the American Automobile Association (AAA). Starting in 1906, regional AAA clubs began paying for and installing wooden signs to help motorists find their way. However, in 1914 the AAA started a cohesive transcontinental signage project, installing more than 4,000 signs in one stretch between Los Angeles and Kansas City alone [4].

Over the years, change was gradual. The pre-industrial signs were stone or wood, but with the development of Darby's method of smelting iron using coke – painted cast iron became favoured in the late 18th and 19th centuries. Cast iron was used until the mid-20th century, when it was displaced by aluminium or other materials and processes, such as vitreous enameled and/or pressed malleable iron, or (later) steel. Since 1945 most signs have been made from sheet aluminium with adhesive plastic coatings; these are normally retroreflective for nighttime and lowlight visibility.

New generations of traffic signs based on electronic displays can also change their text (or, in some countries, symbols) to provide for "intelligent control" linked to automated traffic sensors or remote manual input, as shown in Figure 3. In over 20 countries, real-time Traffic Message Channel incident warnings are conveyed directly to vehicle navigation systems using inaudible signals carried via FM radio, 3G cellular data, and satellite broadcasts.

Another "medium" for transferring information associated with visible signs is RIAS (Remote Infrared Audible Signage), e.g. "talking signs" for print-handicapped (including blind/low vision/illiterate) people [4].

WHAT IS SMART TRAFFIC MANAGEMENT?

Intelligent transport systems (ITS), or smart traffic management systems, provides an organized, integrated approach to minimizing congestion and improving safety on city streets through connected technology. Traffic management refers to the combination of measures that serve to preserve traffic capacity and improve the security, safety and reliability of the overall road transport system, as shown in Figures 4 and 5. These measures make use of ITS systems, services and projects in day-to-day operations that impact on road network performance [5]. Due to rising congestion being experienced in our major cities/towns which directly affects the economies of many nations, there is therefore the need for intelligent transport systems, as shown in Figures 6, 7 and 8.

The Road Network Operations (RNO) are methods at the disposal of road authorities and highway infrastructure operators that contribute to safer and more efficient travel for road users and for the society at large. This has to do with techniques such as traffic incident detection, incident management, traffic control (in urban and inter-urban), traveler information (pre-trip and on-trip), public transport priorities, electronic payment and travel demand management techniques. The following five groups of services have been identified under dedicated road network management services [5]:

1. Traffic management services designed to make best use of the available roadway and highway capacity day-by-day in real time - for very heavily trafficked routes and road networks this can be a 24/7 activity. This services principally would involve responding to "events" as they occur, contingency planning in anticipation of those events, cum planning the operational capacity to respond appropriately. Such events may be:

➢ Planned and expected events, such as regularly occurring rush hour congestion, major road works or bridge maintenance and scheduled sports or entertainment events.

➢ Unplanned and unexpected events such as road accidents, emergency situations and other traffic incidents.

2. Network control services that seek to control and influence road users over a wide area in order to spread the traffic load and optimize demand on the road network, e.g. balancing demand between alternative routes and integrated network management between different authorities.

3. Information services which have the capacity to:

➢ Collect, filter, process and disseminate data for operational traffic management (control center operators, supervisors, management and maintenance).

- Provide traffic and travel information within the organization, to stakeholder organizations (i.e. operating partners) and other external parties and the travelling public.

4. Planning and reporting services that will enable response planning for both planned and unplanned events, reports on operational and business services and performance monitoring of the highway network.
5. Support services that indirectly enable and allow other operational functions to be delivered e.g. human resource and shift planning for mobile patrols and traffic control center operatives, business plans, service development, and telecommunications networks across the various functions.

Working across jurisdictions is essential for integrated technologies, procedures, planning, and preparations to support management of recurring and non-recurring congestion.

Traffic management said to be a key branch within logistics, having to do with the planning, control and purchasing of transport services needed to physically move vehicles (such as aircraft, road vehicles, rolling stock, and watercraft) and freight. Traffic management is implemented by people working with different job titles in different branches [6]:

- Within freight and cargo logistics: traffic manager, who assesses hazardous and awkward materials, carrier choice and fees, demurrage, documentation, expediting, freight consolidation, insurance, reconsignment and tracking.
- Within air traffic management: air traffic controller is the service provided by ground-based controllers who direct aircraft.
- Within rail traffic management: tail traffic controller, train dispatcher or signalman
- Within road traffic management: traffic controller directing vehicular and pedestrian traffic around a construction zone, accident or other road disruption
- Traffic control in shipping lanes
- Urban (peak-hour) traffic management

REGIONAL OPERATIONS

This will involve the adoption of a customer focus for Road Network Operations, and will entail working across administrative boundaries to achieve transport operations that are coordinated and integrated. This will then mean that the operational reach of any single road authority or operating organization is no longer self-contained. Therefore, to this end and to a great extent the Road Network Operations must be integrated:

- Across geographical and jurisdictional boundaries between different road operators and road administrations
- To provide smooth access to ferry-terminals, ports, airports, road-rail transfer points for inter-modal transfer
- The institutional issues in network operations are significant because of the number of stakeholders involved. Network operations can:
- Be multi-modal, multi-jurisdictional, multi-national (local, regional, national authorities and concession-holders)
- Use different levels of infrastructure (rural, local, or national roads hierarchy)
- Involve interaction and cooperation between different organizations and entities on traffic management and traffic information.

Very critical too is the need for coordination between all the relevant agencies, operating partners, task forces dedicated to incident management or security, external news media and information service providers [5, 7].

ADVANTAGES/DISADVANTAGES OF INTELLIGENT TRANSPORT SYSTEMS

Some of the advantages of Intelligent Transport Systems (ITS) include [8]:

1. Helps to improve traffic management via the following ways, i. e.

- The improved potential for traffic management, providing real-time overview of traffic conditions.
- It enables the authorities to take necessary actions to alleviate congestion i. e. by adjusting the timing of traffic signals based on traffic flow.
- It helps to improve the efficiency of road usage and reduce travel time.
- It helps in the coordination of road maintenance and construction work to minimize disruption to the general public

2. Enhanced safety: ITS also helps to enhance safety for both drivers and pedestrians. ITS technologies can detect potential hazards and incidents, providing timely warnings to drivers e. g systems that alert drivers about upcoming congestion or road work, enabling them to adjust their speed or plan alternative routes. Furthermore, smart pedestrian crossing systems is very crucial in protecting pedestrian safety by syncing with traffic signals, ensuring safer street crossing periods.

3. Increased efficiency in fuel consumption: The optimization of traffic flow, help to reduce the time vehicles spend idling in traffic or searching for parking thereby leading to increased efficiency in fuel consumption, i.e. fuel savings, operating costs for drivers and transport companies.
4. Environmental benefits: ITS can as well contribute to environmental sustainability, since the reduction in traffic congestion cum improved fuel efficiency leads to a decrease in greenhouse gas emissions. ITS technologies such as electronic toll collection and smart parking systems reduce the need for physical infrastructure, resulting to less land usage and disruption of natural ecosystems – leading to supporting sustainable urban development.

In spite of the advantages, ITS is fret with some drawbacks or disadvantages, which are as follows:

1. High implementation and maintenance costs, such as the high cost of installing sensors, cameras, data processing centers, and other necessary infrastructure, as well as maintaining the systems due to need for regular systems upgrades, replacements, and repairs.
2. Reliability and technical issues: Just as any digital system, ITS are also susceptible to technical glitches and malfunctions. Hence, a single failing sensor or a glitch in the data processing software can lead to incorrect traffic management decisions that can cause chaos on the roads.
3. Policy concerns: This has to do with the use of cameras and sensors for data collection in ITS leading to concerns over privacy, due to its potential misuse of personal data of vehicles and pedestrians. The ensuring of privacy of individuals with use of ITS technologies remains a significant challenge in their deployment and acceptance.

CONCLUSION

Intelligent Traffic Systems (ITS) is intended to revolutionize our transportation systems with its numerous advantages for improved traffic management, enhanced safety, increased fuel efficiency, and environmental conservation. It can also enhance sustainable, smart cities by managing traffic effectively and reducing greenhouse gas emissions. Despite all of these advantages, the successful implementation will require addressing the challenges of high implementation costs, reliability issues, technical issues and privacy concerns. These challenges in the future can be overcome as a result of advances in technology.

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Figure 1 History of traffic lights.
Source:https://www.google.com/search?q=images+on+traffic+signs+history+by+wikipedia&sca_esv=

4f9cd8e0fdf28683&udm=2&biw=1034&bih=539&sxsrf=ADLYWIKArroouzcGKauZTQ0zJ9KavCcbcew%3A1732103097429&ei=ucs9Z6npGeKqkdUPganWgAg&ved=0ahUKEwjpqdju6uqJAxViVaQEHYGUFYAQ4dUDCBA&oq=images+on+traffic+signs+history+by+wikipedia&gs_lp=EgNpbWciLGltYWdlcyBvbiB0cmFmZmljIHNpZ25zIGhpc3Rvcnkgbnkgd2lraXBlZGlhSNCpAVCYCFiCgwFwAXgAkAEAmAGUCKABzSWqAQ8wLjIuMi4zLjEuMS4xLjG4AQzIAQD4AQGYAgGgAhTCAgQQIxgnmAMAiAYBkgcBMaAH7wM&sclient=img#vhid=odzNrsjjUCD1sMvssid=mosaic

Figure 2 1909 Paris Convention.

Source:https://www.google.com/search?q=images+on+traffic+signs+history+by+wikipedia&sca_esv=4f9cd8e0fdf28683&udm=2&biw=1034&bih=539&sxsrf=ADLYWIKArroouzcGKauZTQ0zJ9KavCcbcew%3A1732103097429&ei=ucs9Z6npGeKqkdUPganWgAg&ved=0ahUKEwjpqdju6uqJAxViVaQEHYGUFYAQ4dUDCBA&oq=images+on+traffic+signs+history+by+wikipedia&gs_lp=EgNpbWciLGltYWdlcyBvbiB0cmFmZmljIHNpZ25zIGhpc3Rvcnkgbnkgd2lraXBlZGlhSNCpAVCYCFiCgwFwAXgAkAEAmAGUCKABzSWqAQ8wLjIuMi4zLjEuMS4xLjG4AQzIAQD4AQGYAgGgAhTCAgQQIxgnmAMAiAYBkgcBMaAH7wM&sclient=img#vhid=rwHvn4vXd9y9lM&vssid=mosaic

Figure 3 Modern Traffic light

Source:https://www.google.com/search?sca_esv=396436077eb24e00&sxsrf=ADLYWIKSTwF3VueICQmvQr7yJG9Sc_QhrQ:1732290779505&q=images+on+modern+traffic+lights+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwivkr2EpvCJAxU3LPsDHbqVAl0QtKgLegQIFBAB&biw=1034&bih=539&dpr=1#vhid=xIxApFJb-HEvAM&vssid=mosaic

Figure 4 Active traffic management.

Source:https://www.google.com/search?sca_esv=332c1457e26e21ac&sxsrf=ADLYWIJQBiskd_5dedwfoBvXL4Un4qjtiw:1732248599634&q=images+on+traffic+management+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCMRK72qUv4GOvBp3LxAsC35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwjBjsbziOJAxXtT6QEHRyDCDAQtKgLegQIGBAB&biw=1034&bih=539&dpr=1#vhid=-vmJ5qdqFvvDjM&vssid=mosaic

Figure 5 Road traffic control.

Source:https://www.google.com/search?sca_esv=332c1457e26e21ac&sxsrf=ADLYWIJQBiskd_5dedwfoBvXL4Un4qjtiw:1732248599634&q=images+on+traffic+management+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObp

S5jg6J88CCMRK72qUv4GOvBp3LxAsC35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwjBjsbziOJAxXtT6QEHRyDCDAQtKgLegQIGBAB&biw=1034&bih=539&dpr=1#vhid=3TdFoF_HFhLQQM&vssid=mosaic

Figure 6 Traffic congestion.
Source:https://www.google.com/search?sca_esv=332c1457e26e21ac&sxsrf=ADLYWIJQBiskd_5dedwfoBvXL4Un4qjtiw:1732248599634&q=images+on+traffic+management+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCMRK72qUv4GOvBp3LxAsC35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwjBjsbziOJAxXtT6QEHRyDCDAQtKgLegQIGBAB&biw=1034&bih=539&dpr=1#vhid=RGxz_nutIJBtrM&vssid=mosaic

Figure 7 Lagos State (Nigeria) Traffic Management Authority.
Source:https://www.google.com/search?sca_esv=332c1457e26e21ac&sxsrf=ADLYWIJQBiskd_5dedwfoBvXL4Un4qjtiw:1732248599634&q=images+on+traffic+management+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCMRK72qUv4GOvBp3LxAsC35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwjBjsbziOJAxXtT6QEHRyDCDAQtKgLegQIGBAB&biw=1034&bih=539&dpr=1#vhid=sSAN49inKhNPdM&vssid=mosaic

Figure 8 Traffic engineering (Transportation).
Source:https://www.google.com/search?sca_esv=332c1457e26e21ac&sxsrf=ADLYWIJQBiskd_5dedwfoBvXL4Un4qjtiw:1732248599634&q=images+on+traffic+management+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCMRK72qUv4GOvBp3LxAsC35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwjBjsbziOJAxXtT6QEHRyDCDAQtKgLegQIGBAB&biw=1034&bih=539&dpr=1#vhid=g9ypuodCtnYaUM&vssid=mosaic