Use of ICT for sustainable transportation

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Abstract. The world is experiencing an unfettered growth in terms of development but shrinking the way these developments are leading to the societal, economic and environmental changes and chaos. Sustainability is the answer and needs to be addressed effectively. ICT (Information and Communications Technology) has revolutionized the way things can change. This paper deals with sustainable transportation. Sustainable transport system is a sub topic of a bigger issue “Sustainable Development”. So what does this imply? ICT, can indeed enable the designing of smarter cities that offer a better quality of life for their residents while being more sustainable and cost effective. It is not just the citizens of a country but also the government that can gain benefit from initiatives and meet the objectives faster. This paper digs into the traditional transport systems and the sustainable transport system which we thrive for. Green vehicles/ Electric Vehicles/ Driverless cars/ Hybrid vehicles are the need of the hour. This paper extensively explores the issues and inventions that can lead to sustainable transportation. It further explores the problems associated with them and their solutions. These solutions cover the major aspects of sustainability like meticulous planning, correct usage of ICT and a well drafted and implemented governance framework.

1. Introduction
In terms of economy, sustainable transport system should be cost effective and lead to an economic growth of the country as a whole. In terms of society, it should be the one that results in less accidents, less commuting time (so that time to meet the family on to and fro from job to home is reduced), be safe and should provide comfort and convenience to the commuter and the driver, thus leading to health benefits. Traffic congestion incurs cost and reduces the economic growth by wasting people's time and energy and by slowing the delivery of goods or services. As far as environment is concerned, since transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and carbon dioxide emissions [1], so Sustainable transport system should minimize harmful emissions, should be environment friendly and thrive to use resources that are renewable and inexhaustible.

2. Background
Sustainability in the transport sector implies finding a proper balance between social, economic and environmental qualities [2] and is a major concern throughout the world. The major stakeholders are the travellers, the technologists and the government. The major concern related to non-sustainability is the traffic volume resulting in traffic congestion where [3] states that congestion is a situation that arises when addition of a vehicle to a traffic flow that might have the power to increase the trip time of others, greenhouse gas emissions – a major factor leading to climate change, vehicle accidents...
resulting in human loss. The concern and aim of this paper is to first highlight the problems related to the above issues in major and then discussing the ICT innovations that can help us to achieve sustainability. [4] discusses various definitions of ICT in various contexts but broadly associates it as use of communication technologies by people or organizations for accessing information. This paper concludes by examining the challenges in achieving sustainability and concludes by examining the fact that ICT can prove to be a major driving force if the issues are well addressed and implemented owing to the potentials that ICT possesses.

3. Literature Survey
This section provides an insight to the work that has been done in the related area. In [5], the authors discuss the influence of ICT by studying the relation between ICT and transport and examines the applications of ICT and the transport sector. They also discuss the existing and the futuristic aspects of ICT role in making transportation sustainable. They further compare the differences in adoption of ICT applications between U.S. and Europe. In [6], the author discusses about the data collection from various sources about the traffic congestion and the ways it can be improved. [7] sneaks into how extensible applications can be extended beyond the obvious e-commerce applications or the information sites. In [8], the authors discuss about how the society is changing and the use of technology particularly mobile phones is widespread across the world and in all societal layers. The paper discusses about the increased urbanization resulting in environmental problems. It thus explores the potentials and possibilities of ICT in achieving sustainability particularly in the urban context. The prime focus of this paper is the concern about climate change and how ICT can tackle the environmental issues and in order to do so they identify about 35 applications that are related to transportation, housing, consumption and urban exploration. The authors in [9] The authors in this paper discuss about the changing definitions of sustainability and its relation with transportation. The primer [10] provides an overview of the key elements of congestion pricing and illustrates the various aspects and skill sets necessary to analyze and thus implement congestion pricing. This paper further examines the effectiveness of both primary and advanced technology in tolling and congestion pricing. The focus is in identification in the current scenario and also to explore the future aspects to make it work better in the future. [11] Discusses various solutions that IBM provides in the transportation sector. They focus on resource optimization solutions from IBM that offer tools and environment for developing short term as well as long term planning and scheduling applications. These solutions are flexible enough to be adjusted with the changes in regulation, infrastructure, business and operations and can help us to take the right decisions related to transportation. In addition, IBM also provides digital video surveillance and analytical solutions on video data collected from multiple sources like video cameras and biometrics which can be used to identify risks. These solutions open an avenue for wide range of applications with respect to surveillance systems. IBM further illustrates its traffic prediction tool that can provide real time traffic predictions and support route guidance. The paper [12] discusses about the how the physical infrastructures can be interpreted as electronic ones and the changes that telecommunications can bring in structuring of the cities. In [13] the author discusses about the Intelligent Transport systems (ITS) that can use IT in enabling advanced traveler information system which can provide information related to navigation, possible accidents, weather conditions, electronic toll collection, real time data to passengers about arrival and departure of trains or buses and enable communication among various assets of the transportation sector. These changes come with a baggage of innumerable benefits which are further discussed. The paper [14] focuses on the relationships between transport and telecommunications. The paper [15] focuses on telecommuting and its impact on traffic reduction. It also talks about the social aspects of work, technological advances, management and legal issues. In [16], the paper focuses on relation between urban mobility and sustainability in terms of travel time, travel costs and travel patterns.

4. Issues, Problems and their solutions
Various inventions and concepts related to transport sustainability are discussed and their associated problems and solutions are presented in this section.
4.1 The Autonomous/ Driverless cars

Imagine a scenario. You get up in the morning, a sleep hangover and a pending presentation at office. You get into the car, take a nap for about half an hour. Post that you prepare your presentation. Aloha!!!! How is that possible? Well, it is indeed possible today. We are talking about the driverless car. A rotating LIDAR(Light Detection and Ranging) technology, radar systems on front and rear side, an Artificial Intelligence (AI) software[17] connected to all the sensors, a simulation of human perception using AI to control the steering and the brakes, “THE AUTONOMOUS VEHICLE” is one of the best examples of use of embedding ICT in the automotive industry. It is not only the comfort it provides but autonomous cars can truly minimize accidents by increasing the precision and reducing human intervention (one of the causes of traffic accidents), reduce congestion thus improve the traffic flow, and also reduce vehicle carbon emissions. This can only be achieved by deploying the “platooning” technology [18] wherein the driverless car shall travel to another driverless car at high speed so as to mitigate traffic. But it comes with its own baggage of bottlenecks. Are the things as simple as they seem? Will driving in real time traffic be capable enough to detect an anomaly? Driving in real time traffic is a challenging task for machine intelligence. A precision of as high as of milliseconds of reaction time is required to avoid unforeseen obstacles. A “Human Sense” too is necessary. Thus an extensive computing power needs to be built in to the car to minimize the latencies both application and network. It does not hold today due to space constraints, heat dissipation, and many more. IOT (internet of things), High speed networks, Sensor technology, Cloud Computing are creating huge opportunities for sustainability. As you can see a “driverless car” is not just devising “a car on wheels with no driver”, but uses all the technologies this paper mentioned above. A cloud to drive a car? Yes, an intelligence can be build into the cloud rather than a car [19]. This storage power in cloud infrastructure can be used effectively to intelligently drive a car. But this requires a paradigm shift from the centralized clouds to a local cloud and then to a mini cloud which is closer to the car. This will enable “Human Sense” and “Machine Intelligence” to work together.

4.2 Car sharing

Car sharing has a great impact on traffic control. In India, it has been observed that shared services being offered by Ola and Uber have extensively reduced the usage of personal cars as it provides comfort and moreover is economical too. These services are successful only because of smart applications installed on the phone that enables him/her to request a taxi passing by nearby location of the commuter. In addition, the application on driver’s mobile (Google Maps to name one) helps him to track the commuter for pick up fast if its confirmed booking. Further, mobile application also allows the driver to choose the best route in terms of time duration and traffic so that the commuter reaches the desired destination in best case time. taxi service, but one that is full digitally enabled. Rather than maintaining a fleet of cars, mechanics, drivers and the taxi service providers permit the cars to return to the legal car owners when not in use for a job.

4.3 Car pooling

We are sure that there must have been instances when you step out of your locality and see two persons known to you who are heading to a nearby destination as yours. This is where car sharing could work. The end user enters the travel requirements and there is a car for you. You share your travel cost and travel to reach the respective destinations. Great, isn’t it?

4.4 Eco – Driving

The concept of eco- driving has already been introduced. Though it can be achieved by keeping speed in control, syncing the speed and the gear, decreasing the car speed at turns and so on but ICT can enhance the effectiveness of these. In [20] the authors discuss the technical acquisition of data by using modern ICT tools and technologies. In so as to collect vehicle trajectory and eco-driving data, a fuel consumption sensors and a portable Global Positioning System (GPS) receiver were installed in test vehicles. But a possible drawback is a lack of satellite signal which could prevent vehicle positioning. In [21] it has been identified that eco driving can reduce GHG (Green House Emissions) by a great amount. It works through use of ICT
built into a car or through smart phone that reduces fuel consumption by updating drivers when they are accelerating too fast or their car having air pressure that is suboptimal.

4.5 **Congestion Relief**
Congestion Relief is related to decreasing the density of traffic. Certain technologies that decrease congestion need to be formulated. Various forms of ICT like Advanced Traveller information systems, Video surveillance and response are necessary to control congestion, Congestion free lanes need to be developed. In addition, when a vehicle enters the toll area it is automatically directed to a particular lane. Relating to toll fees, users set up an account and transponders initiate withdrawal of funds based on accounts.

4.6 **GPS/Navigation software**
As discussed in car sharing, GPS helps the commuters, taxi drivers in identifying the best route. But this has still not been adopted by private vehicle owners and truck drivers. Since truck is responsible for logistics and transportation of goods between states so a software that measures truck-route-efficiency is also needed. Not only shall it find best route in terms of time and congestion but also take the tolls and other barriers into account to determine which route will require the lowest amount of fuel for a particular trip and even how much profit that trip would generate. These fuel savings translate into lower GHG emissions.

4.7 **Automatic license plate recognition (ALPR) Technology**
This technology [22] is based on taking the images of the number plates of the vehicle crossing a particular area which helps in the identification of the vehicle and the driver. Front and rear cameras are installed at several locations to improve the identification rate. But the problem associated with it is the reliability of images. This can occur due to damaged or dirty license plates, light reflection on the image to name a few.

4.8 **E-world**
Use of several E-services [5] for banking, shopping, entertainment, government services, booking for hotels, holidays, trips, e-networking etc reduces travel significantly. But they may cause an addition of travel time as new travel demand, successful social networking and all. Though the concept of “Work from Home” is quite prevalent in many countries including India, where employees complete the assigned work or do chats with clients using chat applications, video-conferencing which again reduces travel time significantly.

4.9 **Informational signaling (Variable Message Signs/ Electronic signboards)**
VMS gives information on changing road network conditions ahead and have assisted in communication with drivers regarding major congestion areas ahead. Electronic boards have displays that broadcast messages on the screen about the rules to be observed for driving. In addition to directional guidance, traffic rules of a city, these boards also can also contain weather updates so that a person can route or avoid pending work enroute if a hailstorm or heavy rain forecast is seen by the driver. This could save him from resulting congestion and time wastage that may occur otherwise. The figures: Figure 1, Figure 2 are a few Electronic signboards which have been captured on roads of Delhi, India.
Figure 1. It shows a signboard depicting a traffic rule.

Figure 2. It shows a signboard

4.10 **Video Surveillance and Response**
Well, you may agree that cars may break down in the middle of the road any day, any time. We all must have faced this problem. Or let us visualize another situation particularly in India. Why we said so is because, Roads are narrow and vehicles are many. Many new flyovers have come up in metropolitan cities like Delhi. Though these infrastructures have improved the road condition but in case of break down, interrupts the traffic flow too causing a cascading effect several kilometres far off too. So it is necessary to continuously monitor locations to identify whether traffic is moving or encountering congestion. This can be achieved by strategically placing sensors or television cameras. In case of perceiving a disabled vehicle being the cause of congestion, a a repair/assistance vehicle is dispatched to the location. Upon arrival, the obstacle is removed and appropriate assistance could be offered.

4.11 **Advanced Driver’s Assistance (ADAS)**
It is generally installed on private vehicles and has inbuilt speed adaptation control system that reduces variation in acceleration and adapts speed. ADAS[23] also controls the positioning of vehicle in terms of lanes, other vehicles and obstacles. The overall benefit derived is reduction in fuel usage and fatality.

4.12 **Sensor Support with an Extended Viewing system**
Sensors can be used to detect an accident at a location and inform the nearby hospital services which reduces the waiting time for assistance post accident. In addition sensors and radar are being in built into cars which alerts drivers on blind spot and obstacles during night.

4.13 **Advanced Traveler Information systems**
The technology is not to be built into the privately owned vehicles only but also to the public transport system. The personal information systems may be portable for passengers travelling using public transport and in vehicle for car drivers. It may include data related to facilities (shops, malls, services), new travel solutions in addition to best route options display. But it incurs high cost and may also be hampered by limited needs of travellers to plan their activities.
4.14 Smart Parking facility
Appended to the list of issues discussed above that exploit ICT to its maximum which are in initial stages or being already adopted, a Smart Parking facility too can be developed. This could work as follows. Through the application installed on the mobile, we search an authorized parking lot of our destination of journey. Then a prior booking is made. When we reach the destination, we park our car in the space shown through the app. This could be done as a free service or through payment using services like payback, etc.

We hope you would agree that if each of the above usage of ICT is implemented in each city then what a wonderful experience travelling of self, goods or services could be for each one of us.

5. Conclusion
The world is urbanizing rapidly and innovations are reaching new heights too. But a long way we still have to travel to reach the goal faster. This can only be achieved through well connected networks of towns and cities which are sensor-enabled and possessing a “Human Sense- Robotic Intelligence” which is absolutely necessary as on today. Enhanced and effective mass transport solutions which are technology enabled, reduced car owners, compact cities and neighbourhoods (which shortens the trip distances and makes public transport more economically viable), car pooling, driverless cars which are fully adopted, high end applications which make travelling easier are some of the solutions which need to addressed.

In addition, each city has its own constraints in terms of buildings, income strata of the city, population of the city, location of offices and schools which also have to be taken care of in building the transport system to extract maximum benefits. There is still limited research on identification of whether significant improvements in particular parts of the network go along with overall network performance. Highly populated countries like India demand a proactive and a radical response. ICT in transportation sector can drastically improve the efficiency of logistics and also reduce the cargo transport emissions and can even reduce transportation needs by use of telecommunications and video conferencing.

It is near a decade that driverless cars were conceptualized but would near around a decade more to be adopted fully. In addition the future requires towns to be well connected to the cities and development of applications which are less expensive for users, are user friendly, applications that don’t suffer from technological uncertainty or any legal liability. A clear and simple layer of the transport system which involves stakeholders and reduces the complexity inherent in privacy, legal framework needs to be devised. Moreover, adoption of the technology and innovations has to be enhanced so as to improve the “driving experience” and lead to a more sustainable transport system the future than we see today.

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