



SMART*move*
INNOVATIVE URBAN MOBILITY CHALLENGE



Technical Partner



COMPENDIUM OF TOP IDEAS 2021

Driven by

National Institute of Urban Affairs

Supported by:

GIZ India

Technical Partner:

Cities Forum

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SMART*move*

INNOVATIVE URBAN MOBILITY CHALLENGE

The global call to foster mobility innovation in
Indian Cities

**JAIDEEP**

*Officer on Special Duty and Ex-Officio Joint Secretary (Urban Transport),
Ministry of Housing and Urban Affairs*



The Smart Move: Innovative Urban Mobility Challenge is a harmonious collaboration of the private and public sectors, where innovators receive the necessary facilitation to inject new thought into the development of responsible, intelligent and dynamic transport solutions.

**KUNAL KUMAR**

*Joint Secretary and Mission Director (Smart Cities Mission),
Ministry of Housing and Urban Affairs*



The Smart Move: Innovative Urban Mobility Challenge provides promising urbanists with a platform to imagine, create, and implement innovative solutions that are both radical and disruptive, challenging the urban mobility status quo in Indian cities.

**RAHUL KAPOOR**

*Director (Smart Cities Mission),
Ministry of Housing and Urban Affairs*



Real innovation, co-creation and collaboration take place when you create enabling platforms such as Smart Move: Innovative Urban Mobility Challenge, that allows stakeholders to solve contextual challenges.

**HITESH VAIDYA**

*Director,
National Institute of Urban Affairs*



The National Institute of Urban Affairs aims to act like an incubation laboratory for urban practitioners to step into the daunting innovation ecosystem, by providing facilitation through challenges such as the Smart Move: Innovative Urban Mobility Challenge.





JUERGEN BAUMANN

Project Head,
Integrated Sustainable Urban Transport Systems for Smart Cities
(SMART-SUT), GIZ India



As India progresses towards increased adoption of data for effective planning and governance, the Smart Move: Innovative Urban Mobility Challenge is a constructive step toward encouraging open data systems that are accessible to diverse stakeholder groups and enable informed mobility-related decision-making.



LAGHU PARASHAR

Deputy Project Head,
Integrated Sustainable Urban Transport Systems for Smart Cities
(SMART-SUT), GIZ India



Innovation without inclusivity at its core can lead to social instabilities, resulting in an exclusionary mobility experience. The Smart Move: Innovative Urban Mobility Challenge focuses on fostering innovation that not only counters inefficiencies in cost and energy but also ensures the inclusion of marginalised and vulnerable communities.



NABAMALIKA JOARDAR

Lead - Organizational Innovation & Program Manager,
National Institute of Urban Affairs



The journey from idea to implementation is an uphill, arduous task which the innovators of the Smart Move: Innovative Urban Mobility Challenge have accomplished with continued vigour and interest, resulting in competitive outcomes from the Challenge.



SHAILENDRA KAUSHIK

Co-founder,
Cities Forum



The advancement of mobile technologies and location-based services is leading to a transition in mobility provision, from being a product-based solution to a service-based solution. The Smart Move: Innovative Urban Mobility Challenge is about unlocking the value of the data that gets generated while accessing mobility services, and how such data can be used in solving urban transport complexities.

WE WISH TO THANK

GRAND JURY PANELLISTS



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Dr Sanjay Gupta is presently Dean-Research and Professor of Transport Planning at School of Planning and Architecture (SPA), New Delhi. He has over three decades of academic, research and professional experience in the field of transport planning and urban development at SPA. He holds a Ph.D degree in Transport Planning from SPA Delhi.



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Dr. Sewa Ram is the Head of Department of Transport Planning and Coordinator of the PhD Programme at School of Planning and Architecture, Delhi. Dr. Ram has more than 22 years of experience and his area of interest includes transport system's engineering, infrastructure, planning and design, technology, mobility solutions and universal accessibility, and transport – environment relation and safety. Dr. Sewa Ram is an alumnus of IIT Delhi and holds a Ph.D. from SPA Delhi.



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Ms Gadepalli is the Managing Trustee of the Urban Works Institute, an Indian think-n-do tank that helps cities develop green and inclusive mobility solutions and create safe and engaging public spaces. Ms Gadepalli founded and led the immensely successful India Programme of the Institute for Transportation & Development Policy (ITDP) for over two decades. She helped the Smart Cities Mission of the Government of India conceptualise and launch three transformative national programmes: Cycles4Change, Streets4People, and Transport4All.



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Ms Weinberger is a changemaker in the smart mobility area. She is an expert on leveraging data in developing innovative mobility solutions. She has been an entrepreneur in Ayalon Highways, a government company of the Israeli Ministry of transportation, where she founded the Innovation Product Team. She has founded 11 innovative projects such as Israel's Mobility as a Service national project, AI-based public transportation grid planning, positive incentive-based program aiming to reduce traffic and more.



VINAYAK BHAVNANI

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Mr Bhavnani is responsible for product and technology at Chalo since its inception in 2014. At Chalo, Mr Bhavnani oversees the development of all products - for consumers, bus operators, and regulatory partners, and the entire technology platform, spanning live tracking, ticketing, payments, cards, and more. Prior to Chalo, Mr Bhavnani worked at Directi, building large-scale consumer chat and voice products. Vinayak hails from Kota and is a Computer Science graduate from IIT Delhi.



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Mr. Sinha is aligned to the office of the CEO and the transport vertical at NITI Aayog. He is responsible for the overall coordination of the NDC-TIA and ITF-DTEE project at NITI and is part of the EDISON Alliance of the World Economic Forum. Prior to this, he worked as a Strategy Consultant with KPMG. Mr Sinha has a Masters degree in Public Administration with an International Development specialization from the London School of Economics and Political Science.

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Mr. Mishra is a clean energy expert. His expertise focuses on the energy need requirement for charging infrastructure facilities, and institutional capacity building support for electric vehicles. Mr. Mishra holds a Master of Science in Physics from the University of Allahabad, and has a Master of Technology in Renewable Energy Engineering and Management from TERI School of Advanced Studies, New Delhi.



DR. RAVI GADEPALLI

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Dr Gadepalli works on projects advancing bus systems, paratransit services and electric mobility with the International Association of Public Transport (UITP), World Bank, Asian Development Bank and GIZ. He has more than 13 years of experience working as a researcher, consultant and philanthropic fund manager on transport policy, planning and advocacy projects. Dr Gadepalli has completed his Ph.D. in public transport planning from IIT Delhi, and a Masters in Transportation Engineering from IIT Delhi. design and implementation.



KRISHNA DESAI

Technical Expert, SMART-SUT,
GIZ India

Ms Desai is a technical expert for the GIZ supported SMART-SUT project. Under SMART-SUT, Ms Desai has worked with various state and parastatal agencies of Kerala for projects such as gender studies for improving women's safety in public transport, route rationalization, and strategies for implementation of hydrogen fuel cell based public transport. Additionally, she has also worked on projects focussing on legislative and institutional framework, financial feasibility, and has worked with cities on the smart cities' proposal and its implementation.



KUNAL PARIKH

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Mr Parikh is a transportation engineer. His work has focused on addressing urban transport and highway infrastructure. It involves conceptualization, designs, engineering and implementation of projects like BRTS, urban bus systems, ITS, ATCS, parking policy and designs. He has also been involved in large EPC projects for design and implementation. Kunal holds a Master's Degree in Transportation Engineering.

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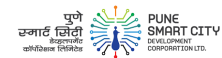




TABLE OF CONTENTS

14	Table of Definitions
15	List of Abbreviations
16	Executive Summary
17	The Smart Move Team
20	Introduction
21	Milestones
23	Winning Idea: Indian Institute of Technology, New Delhi
26	Winning Idea: Indian Institute of Technology, Roorkee
29	Winning Idea: Council of Energy, Environment and Water, CITYDATA.ai
33	Special Mention: Evers Technoservices LLP
37	Special Mention: Directorate of Urban Land Transport, Bengaluru
40	Finalist Idea: Council of Energy, Environment and Water
43	Finalist Idea: Sardar Vallabhbhai National Institute of Technology, Surat
46	Finalist Idea: Sardar Vallabhbhai National Institute of Technology, Surat
50	Finalist Idea: Independent team, Germany
53	Finalist Idea: Independent team, Dubai



DEFINITIONS

ADAPTIVE TRAFFIC SIGNAL CONTROL

A technology that automatically adapts the timing of lights at signalized intersections to accommodate changing traffic patterns and eases traffic congestion.

BECKN OPEN PROTOCOL

An open protocol that is a set of recommendations and rules that outline specific technical standards that can be adopted for an industry, in a region or a market among its participants to enable open interoperable interactions between them.

DISUTILITY INDEX (CROWDING INDEX)

Visualization of the condition (capacity and crowding) of a bus together with a descriptor of the number seated and standing and how people perceive this in terms of a source of disutility (or dissatisfaction).

FREQUENCY

The number of transit units passing through a given point on a transit route in one direction per hour.

OVERLAP

Dispatching of trips between the same origin and destination at the same time

PEOPLE TRIP

Movement of person measured by the movement of GPS-enabled smartphone devices.

RIDERSHIP INDEX

The specific ratio of the hourly ridership over the daily ridership, which can capture passenger flow variations throughout a day.

ROUTE DIRECTNESS

The ratio of the travel time by city bus or IPT to the travel time for the same route on private mode (automobile). The smaller the ratio, the better the service.

SEAT AVAILABILITY RATE

The ratio of the total number of seats available to the total number of passengers traveling during peak hours.

TIME SERIES MODEL

A specific way of analyzing a sequence of data points collected at successive equally spaced points in time.

UNDERSERVED

Areas with low or no public transport supply or service.



ABBREVIATIONS

AFCS	Automated Fare Collection System
API	Application Programming Interface
ASRTU	Association of State Road Transport Undertakings
ATSC	Adaptive Traffic Signal Control
AVLS	Automatic Vehicle Location Systems
BBMP	Bruhat Bengaluru Mahanagara Palike
BCC	Bankers Charnes and Cooper
BMTC	Bangalore Metropolitan Transport Corporation
BRTS	Bus Rapid Transit System
CaaS	Charging-as-a-Service
CB-LSTM	Clustering-Based Long Short-Term Memory
CCTV	Closed-Circuit Television
CMS	Central Management System
CNN	Convolutional Neural Network
COMP2aaS	Communication and Messaging to Promote Public Transport as a Service
COVID-19	Coronavirus Disease 2019
CPO	Charge Point Operators
CRUT	Capital Region Urban Transport
CSML	Cochin Smart Mission Limited
CV	Computer Vision
DEA	Data Envelopment Analysis
DIMTS	Delhi Integrated Multi-Modal Transit System
DISCOM	Distribution Company
DMU	Decision Making Unit
DRT	Demand Responsive Transportation
DULT	Directorate of Urban Land Transport
EMSP	Electric Mobility Service Provider
EV	Electric Vehicle
EVMS	Enforcement & Violation Management System
FLM	First and Last Mile
FPS	Frames Per Second
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit

GNCTD	Government of National Capital Territory of Delhi
GPS	Global Positioning System
HDBRTS	Hubballi-Dharwad Bus Rapid Transit System
IIIT Delhi	Indraprastha Institute of Information Technology Delhi
IPT	Intermediate Public Transport
ITDP	Institute for Transportation and Development Policy
ITS	Intelligent Transportation System
KMTA	Kerala Metropolitan Transport Authority
KOMN	Kochi Open Mobility Network
KPI	Key Performance Indicators
LPC	Live Person Count
MoHUA	Ministry of Housing and Urban Affairs
NIUA	National Institute of Urban Affairs
NMT	Non-Motorized Transport
OD	Origin-Destination
OPC	Overall Person Count
OTD	Open Transit Data
PAS	Passenger/ Public Announcement System
PIS	Passenger Information System
PT	Public Transport
PVM	Personal License and Vehicle Management
SLB	Service Level Benchmark
SOP	Standard Operating Procedure
SSD	Single-Shot Detector
STU	State Transport Unit
TCQSM	Transit Capacity and Quality Service Manual
UI	User Interface
ULB	Urban Local Body
UNDP	United Nations Development Programme
USP	Unique Selling Proposition
UX	User Experience
WFH	Work from Home
WRI	World Resources Institute

EXECUTIVE SUMMARY

The Smart Move: Innovative Urban Mobility Challenge is a data-driven innovation challenge focused on urban mobility and transport in Indian cities. The project is an initiative of the Ministry of Housing and Urban Affairs as part of the Green Urban Mobility Partnership which is supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and driven by National Institute of Urban Affairs, with technical facilitation from Cities Forum.

The Challenge fosters innovative solutions for urban mobility complexities via a challenge model, which culminated with the selection of three winning teams. With the help of a team of mentors and industry experts, the working ideas presented by these three teams will be fine-tuned and developed into implementable solutions, for further use by cities.

Along with innovative solutions, the Smart Move project is a step towards encouraging and enabling collection and sharing of mobility datasets. The Mobility DataSpace platform was developed to support this purpose, and to act as the launch platform for the Challenge. Effectively, Smart Move, via Mobility DataSpace, can become a repository for innovation in the urban mobility space providing a space for digital solutions.

The first phase of the Challenge involved coordinating with partner cities, onboarding transport data sharing agencies, acquiring relevant data, hosting it on the Mobility Dataspace platform, evaluating concept notes, shortlisting the teams, and matching them with cities. The next phase of the Challenge involved constant steering of the ten final teams towards the end-goal of presenting a Minimum Viable Product. The final phase will involve the handholding of the top three winners to pilot their projects, in an effort to enable the solutions to function in a marketable domain.

The top ten solutions are diverse in nature. Focus areas include bus route optimization, journey planning, electric vehicles, transit demand assessment, safety and accessibility.

For instance, multiple teams have proposed unique solutions in the bus system optimization domain. Team Commutify aims to improve transit scheduling via prediction of transit crowding levels through machine learning. A team from SVNIT, Surat is working on increasing the efficiencies in bus routes through performance evaluation of operations, route design, and cost efficiency. B-SOT is a dashboard that will optimise bus schedules by redeployment and reducing trip overlaps. Another team from SVNIT, Surat has proposed bus-priority signalization using Intelligent Transport System to increase transit travel-time savings.

Working on the subject of safety, accessibility and the perception of safety, team Here-to-There has developed a dashboard for targeted and systematic communication and outreach programmes, aimed at regaining the trust of the citizenry in the public transportation system, and to increase ridership. In a similar response to a crucial urban issue of perceived lack of safety, a team from CEEW has developed a computer vision approach for rapid assessment and identification of bus stops that need safety and accessibility upgrades.

Some solutions fall under more than one domain. While targeting women safety, team Mobilizer has created a journey planning app that provides real time details on available modes. Team iConnect has proposed a solution in the journey planning domain as well, pitching an approach to help achieve an integrated shared mobility system and solve Indian cities' first and last mile complexities. To address the transit demand-supply gap faced by cities, a team from CEEW has developed a tool for bus operators that maps GPS and user smartphone data to assess this transit demand. The EVERs Charging Platform addresses the upcoming field of electric vehicles by intending to map all Electric Vehicle (EV) charge points and thereby increase ease of convenience.

The top 3 proposals will be provided contracts jointly worth 2 millions and will receive the opportunity to present their solutions to Smart Cities Mission, Ministry of Housing and Urban Affairs, Government of India. A grand jury was held with an illustrious panel that had representation from policy, industry and academia in the urban mobility. The winning ideas were:

B-SOT, a dashboard built by the team from IIT Delhi that will optimise bus schedules by redeployment and reducing trip overlaps.

Commutify, the app developed by the team from IIT Roorkee to improve transit scheduling via prediction of crowding levels through machine learning.

Real-Time Public Transport Demand-Supply Gap Assessment Tool, created by the team from CEEW for bus operators, that maps GPS and user smartphone data to assess transit demand.

The ideas that received a special mention were:

The EVERs Charging Platform, developed by Evers Technoservices LLP to map all Electric Vehicle charge points.

Here-to-There, a dashboard developed by the team from DULT for targeted and systematic communication aimed to regain the trust of the public in the public transportation system and increase ridership.

THE SMART MOVE TEAM



LAGHU PARASHAR

Deputy Project Head

SMART- SUT, GIZ India

Mr Parashar is currently the deputy project head of the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) project, and e-mobility projects at GIZ India. He also leads a team supporting partner cities/ states/ ministries in implementing measures on sustainable mobility and building their capacity. He is a transportation planner and has more than 17 years of experience in planning, design and implementation of sustainable transportation projects. He has led teams delivering various sustainable transport projects including Bus Rapid Transit System (BRTS) and city bus operations from concept to implementation stage. He has been instrumental in drafting "Urban Bus Specifications" (UBS-II) and various model documents, policies, schemes and implementation of urban transport reforms at various levels of governments. He has been the honorary secretary of Institute of Urban Transport (IUT), India and is active as a visiting faculty in leading planning institutes.



SHAILENDRA KAUSHIK

Co-founder

Cities Forum

Mr Kaushik is the co-founder of Cities Forum, a global strategic advisory firm specializing in cities, mobility and PPP infrastructure projects. Mr Kaushik is a transport planner with more than two decades of experience across Asia, Europe, Africa, Middle East, Latin America, and the Pacific Region. Currently based in Dubai, he is helping global clients with implementing technology driven urban and transport solutions. Mr Kaushik has previously worked with global advisory firms such as Arup, Jacobs, WSP on futuristic planning studies, multimodal transit solutions and innovative financing for urban transport solutions.



NABAMALIKA JOARDAR

Lead - Organizational Innovation & Program Manager

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Ms Joardar is an architect and an urban planner associated with the National Institute of Urban Affairs as Lead - Organizational Innovation & Program Manager, where she manages the India Smart Cities Fellowship Program and Smart Move: Innovative Urban Mobility Challenge. Prior to this, she has worked in urban policy and program research and implementation, focusing on access to housing for marginalized and vulnerable communities. Her interests are in the field of urban policy, specifically focusing on land and housing, and innovation. Ms Joardar is an alumna of the School of Planning and Architecture, Delhi and holds a Master's degree in Planning, with a specialization in Housing.



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Mr Mahendru is a transportation planner associated with GIZ as the technical expert in the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) project. His work has focused on transport vision preparation, policy preparation & assistance in strategy formulation for shift towards alternative clean fuels, performance enhancement of city-based bus services, transport-based capacity building, gender sensitization in transport, and road safety auditing & advocacy. Prior to this, he was associated with Delhi Integrated Multi-Modal Transit System Ltd., handling various public transport consulting projects. Mr Mahendru is an alumnus of School of Planning and Architecture, New Delhi and holds a Master's degree in Transportation Planning. He is presently pursuing his PhD on sustainable transport policy interventions.



AMEGH GOPINATH

Technical Expert, SMART-SUT and E-Mobility
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Mr Gopinath is an engineer-transport planner. He works in the area of electric mobility, electric buses, public bus transport and road safety. He is presently associated with GIZ as a technical expert in the Integrated SMART-SUT and e-mobility project. Prior to this, he worked at L&T, World Resources Institute (WRI) and School of Planning and Architecture, where he was actively involved in improving road safety and air pollution for Indian, South Asian and African cities. He holds a Bachelor's degree in Civil Engineering and a Master's degree in Transportation Planning.



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Mr Rai is a transportation engineer associated with the National Institute of Urban Affairs as the senior associate in the Smart Move: Innovative Urban Mobility Challenge. His interests are in the field of traffic & transport modelling, and sustainable transport planning. Prior to this, he was associated with the Sustainable Transportation Lab at the Indian Institute of Science, Bangalore, researching on various elements of transportation engineering and planning. He is an alumnus of REVA University, Bangalore and holds a Master's degree in Transportation Engineering.



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Ms Mishra is an urban and transport planner associated with the National Institute of Urban Affairs as Research Associate in the Smart Move: Innovative Urban Mobility Challenge. Her interests are in the fields of active mobility, pedestrian safety, multi-modal integration and shared mobility in e-commerce. Prior to this, she was a visiting faculty member at the School of Planning and Architecture, New Delhi while consulting for Meinhardt India. Ms Mishra is an alumna of the University of Illinois at Urbana-Champaign and holds a Master's degree in Planning, with a specialization in Transport.



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APARNA RAMESH

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INTRODUCTION

The Smart Move: Innovative Urban Mobility Challenge was launched with the aim to provide young academicians and professionals with an opportunity to address pressing issues that commuters face, thereby helping cities to build more efficient, sustainable and resilient transport systems.

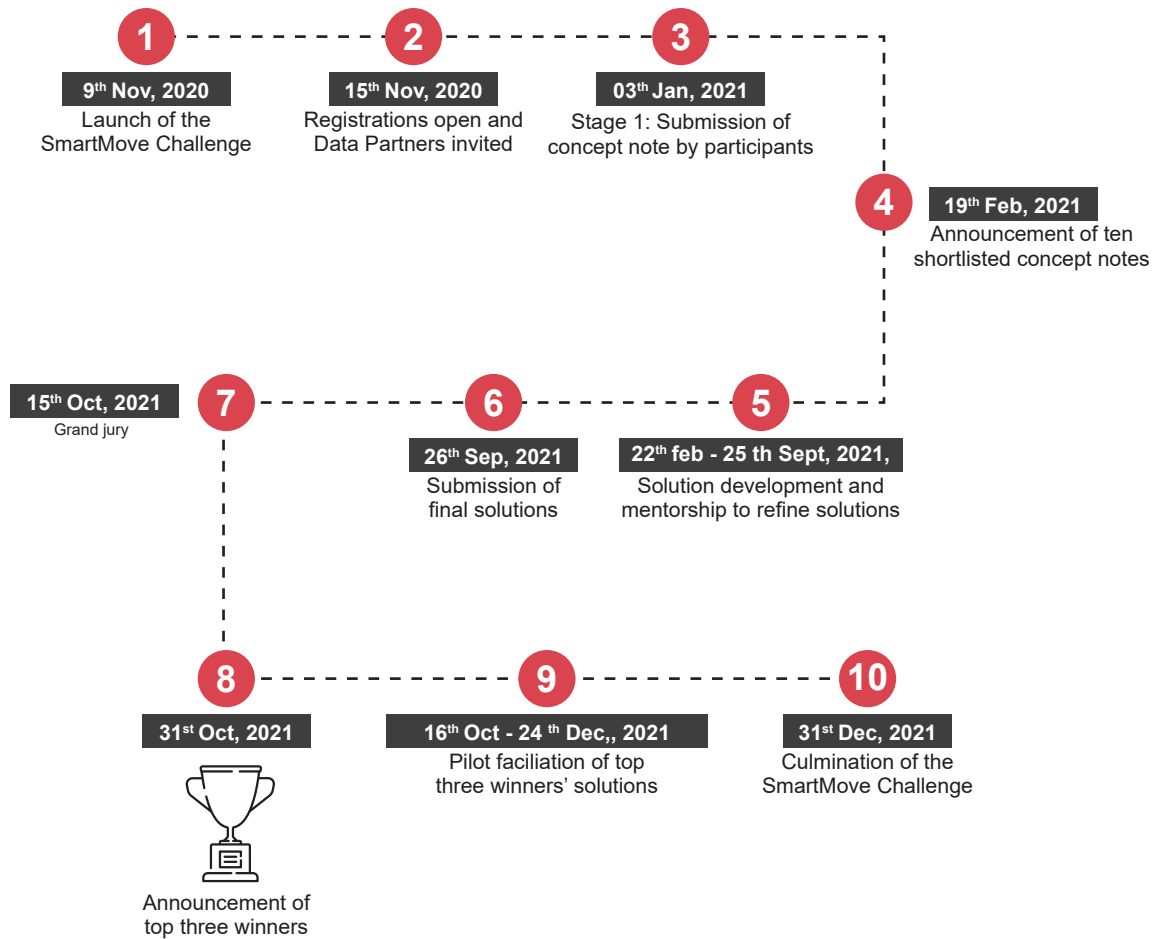
COVID-19 has drastically changed our travel patterns in a fairly short, sudden timeframe. Cities are struggling to restore mobility, and have a huge responsibility to provide sustainable, safe, and seamless mobility systems for its citizens. Globally, COVID-19 has impacted public transport ridership, while cycling and walking have had a relative increase. For cities in India, public transport will continue to be the most favoured mode of transport, which makes it essential that cities consider the safety and health of the passengers and staff involved in this service as the prime area of focus. It is imperative to consider pandemics and impacts of climate challenges as a critical aspect while developing innovative approaches. The Challenge is also focused on encouraging and enabling data collection and data sharing so that cities eventually will be better prepared to fight challenges and threats in future.

Public transport services in India have consistently been plagued by overcrowding, unreliability, unpredictable travel time and poor access. They aren't always accessible to marginalized and vulnerable populations, nor suitable for persons with disabilities and older citizens. Infrastructure improvements alone cannot solve these complexities, as is evidenced in the case of metro-rails, which despite 1.5 billion USD worth of earmarked investment, is failing to meet ridership expectations in most cities. A multi-pronged approach is key for ridership revival and innovation is a crucial cog in the wheel. A lack of perceived safety is another aspect of mobility that requires innovative reworking. Currently, large vulnerable populations have a lower quality of life due to limited travel options they perceive to be 'safe'.

Multi-modal integration, a novel idea till a few years ago, is now widely accepted as intrinsic to the improvement of transit systems. The complexity of the solution itself gives rise to various avenues for improvement. Such approaches need to be developed keeping in mind the variety of tasks and processes involved.

Finally, sustainability cannot be compromised for modal efficiency. It is therefore no surprise that many solutions received for the challenge broached and addressed sustainability issues in the innovative solutions they have proposed. The umbrella themes under which the topics were submitted for the first stage of the challenge were restoring public transport ridership, achieving sustainable transport and resilience, and equity in mobility.

JOURNEY



By focusing on city administrations, NIUA connected the top three SMART Move teams to local players and relevant agencies; provided necessary regulatory support; made data available for plugging into and ensuring the integration of the solution within the city's existing ecosystem of services. As the award money covered a major part of the solution development cost, the onus on the city was only to take care of administrative and regulatory bottlenecks in facilitating pilot. The Smart Cities Mission's ecosystem of cities is very competitive and success stories from one city motivates other cities for faster adoption. Through its in-house capacity and experts on board, GIZ and NIUA ensured support to cities in preparing for solution roll-out by providing solution's outreach, marketing, and pre-launch testing i.e. manual test, functional test, load testing and design test, among others. Availability of such ready-to-launch solutions will be very beneficial for the cities, which are preoccupied with routine tasks and does not possess the technical capacity or resources to take such initiatives.



WINNING IDEA

B-SOT - Bus Scheduling Optimization Toolkit

Indian Institute of Technology, Delhi; IIT Kharagpur

CONTEXT:

The solution is a PT schedule automation and optimization toolkit to address the inefficiencies in the existing bus schedules. The toolkit is fully developed as an executable software. It takes existing PT schedule as input, identifies inefficiencies and addresses them, and provides updated optimized schedule automatically. It was tested for Bangalore Metropolitan Transport Corporation (BMTTC), the largest public bus operator in India. The toolkit does not require any capital expenditure, and is ready to be scaled up to other cities and their unique data formats.

PROBLEM STATEMENT:

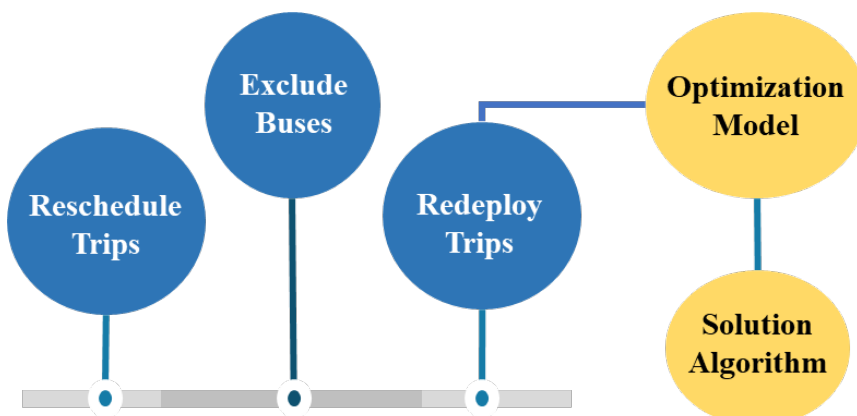
Scheduling is an analytically intensive exercise that should reduce cost of operations while ensuring service levels, meeting travel demand, incorporating travel, rest times as well as availability of resources such as fleet, crew and depots. Indian bus agencies typically adopt manual scheduling practices, thereby being able to use only simple calculations, and they employ scheduling at the bus-level without incorporating network attributes. Both of these attributes limit them in incorporating service levels and resource constraints highlighted in the first statement of this section. This leads to significant inefficiencies in timetables, vehicles and crew scheduling practices.

In addition to traditional route wise timetables and bus-wise schedules, large bus networks also face the problem of schedule overlaps. For example, the city of Bengaluru has 11 percent of its trips overlapping and 47 percent of the bus fleet having schedules with such overlaps. Despite awareness of this, resolving this is challenging due to network complexities and requires data analytics and Operations Research expertise.

OBJECTIVE

The overall objective of the solution is to develop an automated and optimized timetabling and scheduling toolkit for PT agencies. In this regard, the toolkit performs the following activities:

- Cleanse and standardizes the data as required for its purposes;
- Groups the problems into appropriate small sub-problems to get faster solution to the specific sub-problem of interest;
- Develops efficient strategies to reduce overlaps by minimum disruption in the schedule; and,
- Develops efficient algorithm to redeploy non-overlapping excluded trips.



APPROACH AND METHOD

The Toolkit takes the current schedule available with transit authorities as input and generates improved schedules as output. It uses principles of operations research, advanced analytics, and tools such as Python. These approaches are built into the Toolkit, reducing the need for transit authorities to deal with methodological details.

The Toolkit involves two key steps.

Rescheduling

Rescheduling was the first key step of the toolkit. We first defined the maximum deviation allowed in the rescheduled trips. Then, we estimated the number of overlapping trips in the existing schedule. If there were overlapping trips, we checked the headways of the preceding and succeeding trips. Next, we estimated the number of overlapping trips that could be rescheduled without disturbing the schedules of non-overlapping trips.

Finally, we started rescheduling the overlapping trips by either dispatching them earlier or later than the existing schedules. If the preceding headway was less than or equal to the succeeding headway, we first rescheduled the trips by dispatching them before the current start time until the headway after rescheduling was more than the minimum allowed limit. We then rescheduled the remaining trips by dispatching them after the current start time.

This step has two major benefits from the perspective of PT agencies and the toolkit solutioning: minimal scheduling disruptions and significant reduction in the computational burden for the redeployment step detailed in the next section

Redeployment

In this step, we first removed the buses that had overlapping trips even after rescheduling. This naturally caused the cancellation of the non-overlapping trips of the removed buses which needed to be restored for the satisfaction of passenger demand. We resolved this by redeploying the remaining buses to undertake these trips as follows: Redeployment of the non-overlapping trips of excluded buses should be done in an efficient way to save buses and have minimal disruptions. For this purpose, a 'redemption' module is developed within the toolkit. This module effectively implements a mathematical model that determines the minimum number of buses required to undertake all the remaining non-overlapping trips. To determine the allocation of buses to these trips, we first formulate a cluster of adjacent trips. Each cluster consists of a group of trips having immediate connectivity. A single bus will cover at least one cluster. However, after completing all the trips within the given cluster, if time is still available, i.e., travel time in a cluster is less than the shift duration, the bus can also serve another cluster.

EXPECTED RESULTS AND OUTCOMES

The toolkit outputs an optimized schedule for PT agencies by a mere click of the toolkit button. The toolkit and its solution are highly beneficial for both users as well as service providers. Eighty-two buses were saved for BMTC which resulted in financial saving of more than 130 billions rupees per year without increasing the waiting time for users. Further, it provides regular breaks to crew members after every relevant trip which leads to appropriate rest for them. Finally, it enables a much more regularized, hassle-free system as opposed to manual scheduling of buses. The UI of the dashboard is indicated in the associated image.

CONCLUSION

The toolkit is highly relevant and financially viable for PT agencies in India and other developing world because it does not require any capital expenditure. It is easy to replicate for any city having detailed scheduling data and also easy to scale as there is no restriction on the amount of data that can be fed into it. Further, it provides a unique opportunity to PT agencies to automate and optimize their bus scheduling, something which was impossible to achieve with their conventional and manual scheduling based practices.

Bus Operations Toolkit

Upload current FORM-IV

Min safety headway (min)

Max running time of bus (hr)

Travel time b/w two stations (hr)

Done

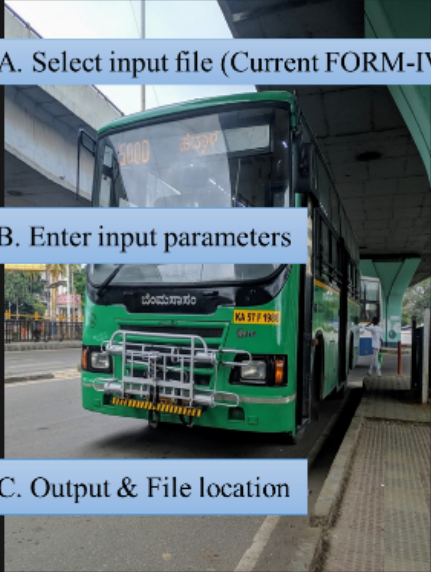
Download outputs: [Intermediate_analysis_output.zip](#) | [Results_output.zip](#)

Intermediate file created
Okay
Program completed successfully

A. Select input file (Current FORM-IV)

B. Enter input parameters

C. Output & File location



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WINNING IDEA

Commutify - Empowering Public Transit Using Machine Learning

Indian Institute of Technology, Roorkee

CONTEXT:

India's road transport system has long been struggling with inefficiencies, such as high congestion levels, limited multi-modal integration, and inadequate PT systems. With the onset of the global COVID-19 pandemic that put lives of many on hold and prompted people to rethink their choices and behaviour. This shift can be seen in the perception study of TERI on the impact of COVID-19 in urban mobility, which shows a decrease of around 40 percent in the use of the metro and a 45 percent decrease in the use of buses in Delhi.

PROBLEM STATEMENT:

Post-COVID PT ridership has witnessed a huge downfall due to cognizant cautiousness and poor effectiveness toward curbing physical contact, especially in the context of Indian cities where PT is a crucial mode of transport. In mega-cities, high-performance transit systems were equally affected. There is a need to understand the possible nature of this shift in mobility patterns and devise appropriate strategies to promote sustainable modes of transport. Some of the overarching issues plaguing transportation systems presently include:

- Lack of reliable, updated and sufficient information to plan journey in advance
- Unavailability of waiting time information at various stations of urban public transport system
- In post-COVID scenarios, health and public safety is compromised in shared transportation systems.

Therefore, an integrated, data-driven solution needs to be developed to empower and encourage the populace towards the adoption of a revamped transportation system, which is far more reliable, convenient, and accessible. A solution that will not only boost the ridership but also ensure equity for all user segments.

OBJECTIVE:

In order to restore the ridership and to attract new PT riders, following factors can be considered from the user's perspective:

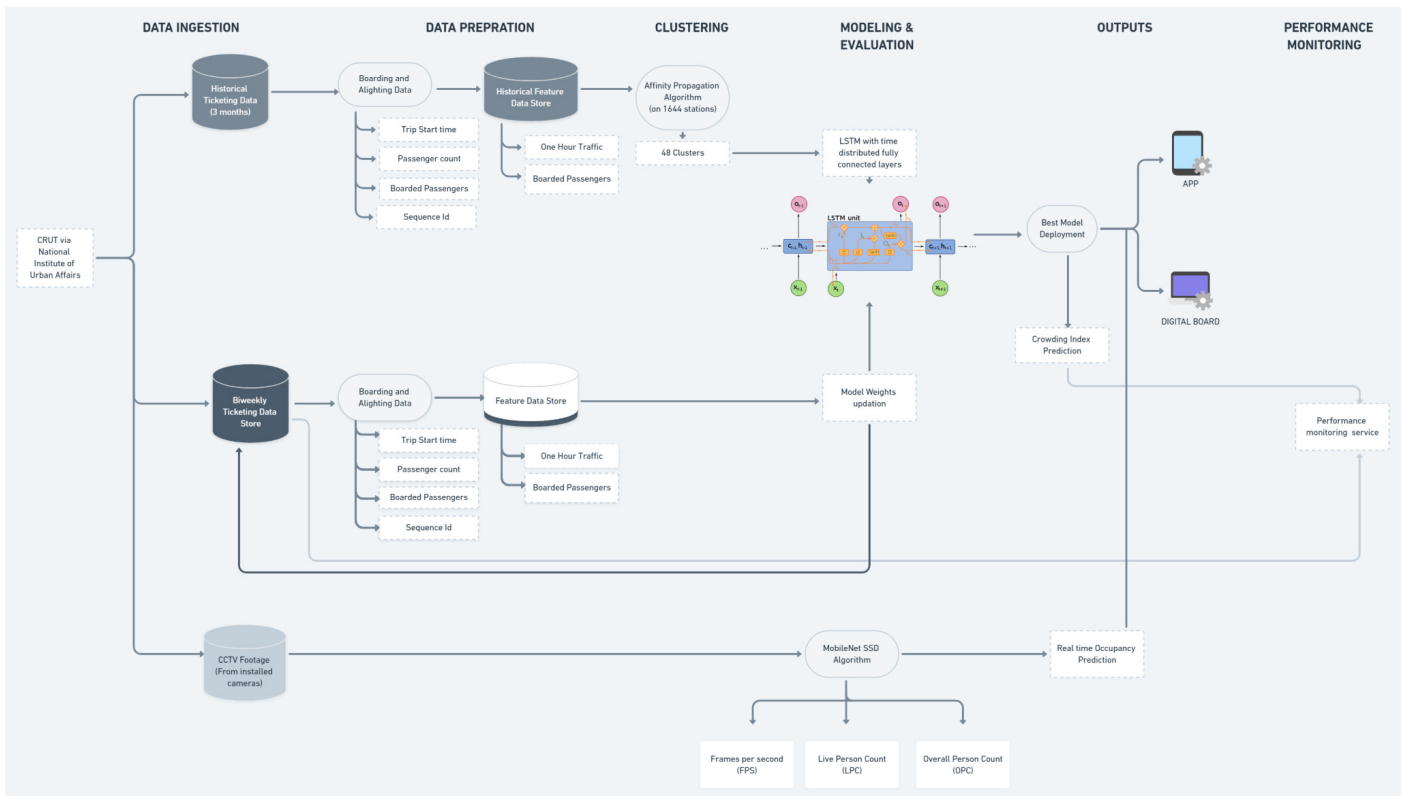
- Prior Occupancy information
- Real-time transit vehicle information
- Increased reliability

The core component of the proposal is a route planning platform, which embeds a multi-modal routing algorithm to suggest the various alternatives to users, provides real-time occupancy of a public transport vehicle and the expected occupancy at a transit station. It also provides dynamic vehicle load information i.e. dynamic occupancy for each vehicle.

APPROACH AND METHOD:

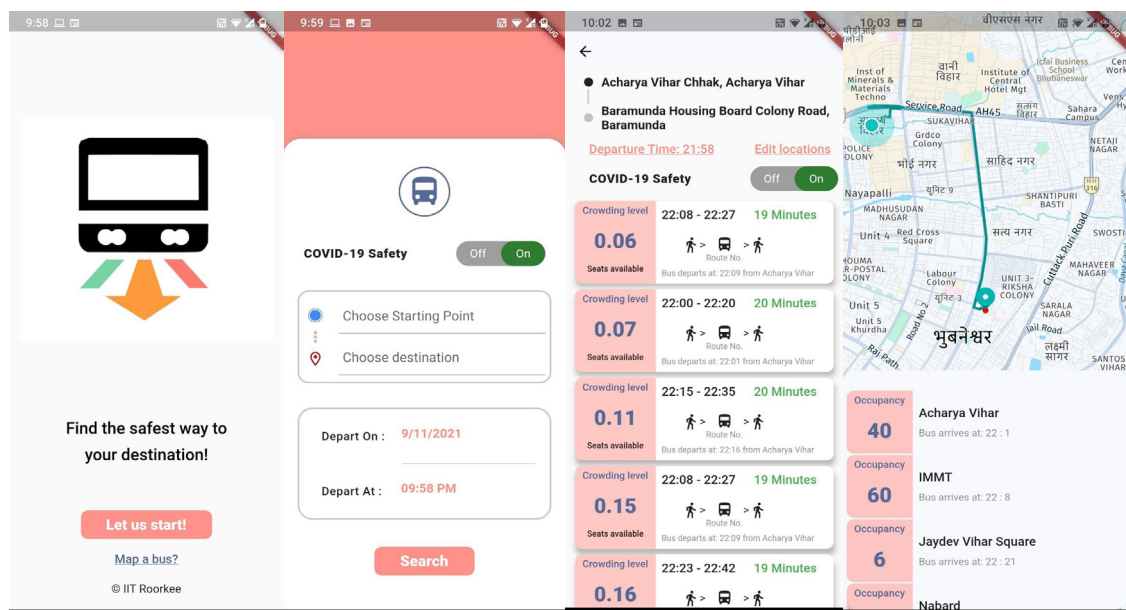
The flow diagram presented shows the Machine Learning (ML) pipeline of the model. It shows the data input and its processing to extract the necessary features for the occupancy prediction in the transit. Weights of the model trained on historic data will be updated biweekly with the Electronic Ticketing Machine data from Capital Region Urban Transport (CRUT). The best model is finally used for the deployment of mobile application and digital board. Real-time occupancy data from CCTV footage of interiors of transit operated by CRUT will be extracted and then will be displayed on the installed digital boards of stations in Bhubaneswar.

A crowd measuring Application Programming Interface (API) is developed to present results of



occupancy of public transits in future trips along with the stations to board and alight on, with time and route information. It also provides metadata such as transit agencies and popular route names. It takes three parameters as input: first origin place identity, second destination place identity and third departure time. The output of the API gives six alternatives computed on the cost function (described as disutility function) for any origin-destination pair and provides information about each alternative with respect to 'arrival', 'transport mode', 'departure', 'transport mode', and 'sequence of stops'.

The major objective of the mobile application is to convey the Disutility Index of each trip between the chosen boarding and destination locations. A user is required to enter the boarding point, destination and time of the departure in the app, which fetches and displays various alternatives to the users, differentiated in terms of crowding indices, transit routes, time of departure, among others. By selecting one of the alternatives, a user can visualize crowding on each segment of the selected route. With the aim of developing a simple and user-friendly mobile application, the User Interface (UI) of the app has been designed considering the demographics and utility so as to target a large audience. The app will allow all necessary information to be fetched with just a few clicks. The interface of the mobile application is indicated below.



Digital dynamic information boards were developed to re-establish the trust of the community in the public transportation systems. Installation of digital boards at PT stations for mass communication will increase the efficiency of travelling experience by providing current occupancy and predicted occupancy at the current station of all upcoming vehicles in the next 24 hours. Empowering decision-making of each commuter to choose the vehicle to board and thus ensuring comfort and public safety is the USP of the solution.

To incorporate the real-time tracking of the passenger count inside a transit vehicle with the help of available CCTV footage, computer vision techniques have been utilized. Human detection is performed by using the MobileNet Single-Shot Detector (SSD) Caffe model of OpenCV. to track a person in the video file, the Centroid tracking algorithm of OpenCV has been used and based on it, an object identity is assigned to a person, as long as they are in the frame. If that person moves out of the frame, the object is de-registered. Finally the count of these identities are used to output the Live Person Count (LPC). In the final output, three parameters are displayed including LPS, Frames Per Second (FPS), and Overall Person Count (OPC).

EXPECTED RESULTS AND OUTCOMES:

Major highlights of the idea are:

- Prior occupancy information;
- Real-time transit vehicle information; and,
- Increased reliability.

For users, planning future trips is now easy, in terms of the possible alternatives depending on the different levels of occupancy in the transit vehicles during the departure. The available multi-modal information will empower the user to decide a PT mode and departure time of their choice. To empower the decision-making of users while planning their trips, a special disutility function has been coined and the cost function for the route has also been kept the same. Planned suggested routes will be an outcome of user preferences and requirements which can be configured easily in the application. The solution is a step towards making PT systems in Indian cities sustainable as well as reliable since it would facilitate real-time spatio-temporal locations as well as predicted crowding levels in the transit vehicles. It would also ensure equity in mobility as it would provide availability and occupancy information of women-only coaches, thus ensuring their safety.

CONCLUSION:

The benefit of using neural networks is that they allow us, with a single model, to be able to predict any of the bus lines in each one of the stops, without having to make a model or specialized algorithm for each one of the lines. This simplifies the complexity of implementation when it comes to production and also allows it to be easily applied in other cities, where lines and stops will be completely different. The solution provides a special uniqueness to stations of each city and thus provides a separate model to be trained for stations showing similar characteristics, which considers the personalization while considering the computational cost at the same time. The core algorithm is designed in a pluggable mode so that the same infrastructure can be used for different cities, provided the similar input datasets are available. Additionally, the application interface will be common to all residents and thus has no issue of scalability.

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WINNING IDEA

Real-Time Public Transport Demand-Supply Gap Assessment Tool

Mobility Team of Council on Energy, Environment and Water; CITYDATA.ai

CONTEXT:

Indian cities have seen a precipitous fall in the modal share of buses over the past decade. Buses running on outdated schedules and routes are unable to adapt to the changing urban trends and mobility patterns. A host of other factors, including shrinking bus fleet size, congestion leading to poor service levels and an operating environment that is often completely uncoordinated, have contributed to this decline in Indian cities. A pan-India urban mobility survey found quality of infrastructure, frequency of service and lack of seamless travel to be the top barriers to using PT in Indian cities. The result is increasing private vehicle ownership, which further aggravates the issues faced by PT. This renders the PT system inequitable and disproportionately impacts communities in the lower socio-economic strata.

PROBLEM STATEMENT:

Extensive city-level surveys are carried out to adapt PT services to mobility demand. Owing to the time and financial resources involved, these surveys are carried out once in seven to ten years, which is a very long timeframe for a dynamic system such as transportation. For example, Delhi conducted its last comprehensive survey for mobility patterns and transit in 2010 through RITES. Since then, all the transit and mobility planning has been based on it. Repeating such surveys can often be taxing and financially unviable. Moreover, mobility patterns vary daily, weekly, and seasonally which city-level surveys fail to capture in greater granularity. Additionally, the impacts of policy, regulatory, and infrastructure interventions, land use development, population, and projects-related impacts during last decade are not accurately considered.

High-frequency data on mobility needs and trends offer promising solution. It informs decisions on augmenting or scaling back PT services, especially in the periphery of the system. We adopt a non-intrusive, data-powered analysis to help solve for improving the PT services and increasing its accessibility to users. The proposed solution will help to enable continuous monitoring of real-time gap in the demand and supply of bus services to adapt Indian cities.

OBJECTIVE:

To develop a dynamic web-tool that can identify gap in demand and supply of bus services at three levels:

- Geographical accessibility;
- Adequate frequency for inter-ward movement of people; and,
- Bus connectivity and services at key land-uses.

The solution is in the form of a tool for operators to regularly fine-tune bus services to offer connected and easy travel experience, thereby improving ridership and revenues. The tool and its related analytics further support bus route rationalization and aids the development of demand responsive schedule for bus services. Also, the insights overlaid with land uses further supports the IPT, feeder services and metro service integration.

APPROACH AND METHODS:

The popularity of GPS tracking devices in city buses and smartphones in Indian cities allows for a rich and high frequency data collection. It can be put to use to identify the gap in demand and supply of bus services. For this solution, the GPS data from the buses act as the supply-side data. GPS data from smartphones of the residents of the city forms the demand-side data. These two datasets help identify the gap in demand and supply of bus services in the city, in a real-time and continuous manner.

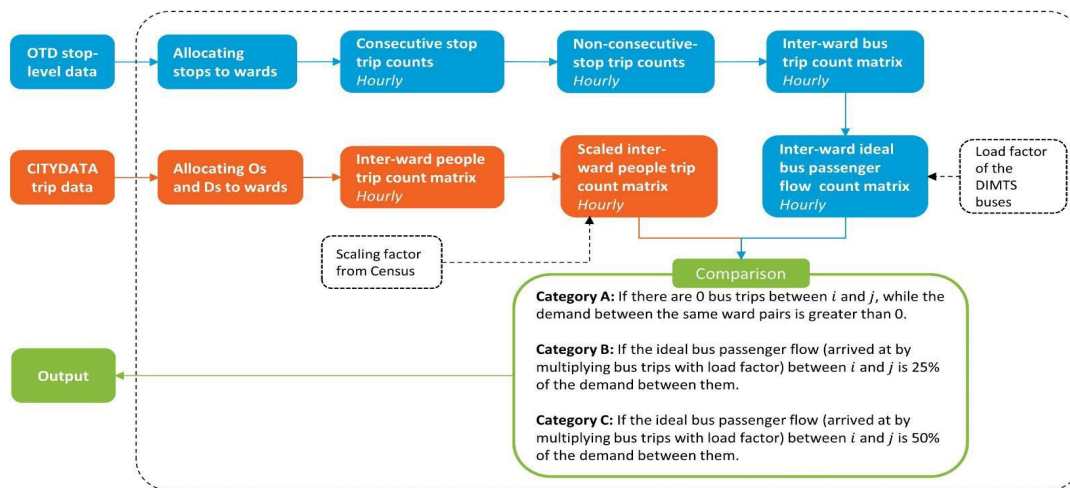
For the purpose of developing this solution, Delhi was chosen as a representative city owing to the availability of data with the team. The GPS data from buses is obtained from the Open Transit Data portal developed by IIIT Delhi in partnership with DIMTS and GNCTD (IIIT Delhi 2018). The smartphone GPS data was a proprietary data obtained from the data partner of the team – CITYDATA.ai, a California-based geo-analytics company.

The web dashboard identifies the gap in demand and supply of bus services at the following three-levels:

Adequate frequency of bus services for inter-ward movement of people

The bus GPS data and the smartphone GPS data is mapped to the designated wards. Inter-ward matrices are constructed to compute the count of inter-ward bus movement and passenger movement. In order to establish the ideal passenger count in the buses, the load factor of 85 percent was used on the seating capacity of the DIMTS buses to calculate the matrix with inter-ward ideal passenger flow (GNCTD 2019). Additionally, since the smartphone GPS data does not consider the complete population of Delhi, the Census 2011 ward-level population data was used to scale the people movement matrix. This can be further adjusted to Delhi Integrated Multi-Modal Transit System (DIMTS) survey 2020 or Census 2021 (subject to availability).

In the last-step, the scaled passenger movement matrices and bus passenger flow matrices were compared to identify the underserved wards. These wards were divided into three categories and the results of the comparison are stored in a comparison matrix. The stages of solution development for the city of Delhi are indicated in the associated image.



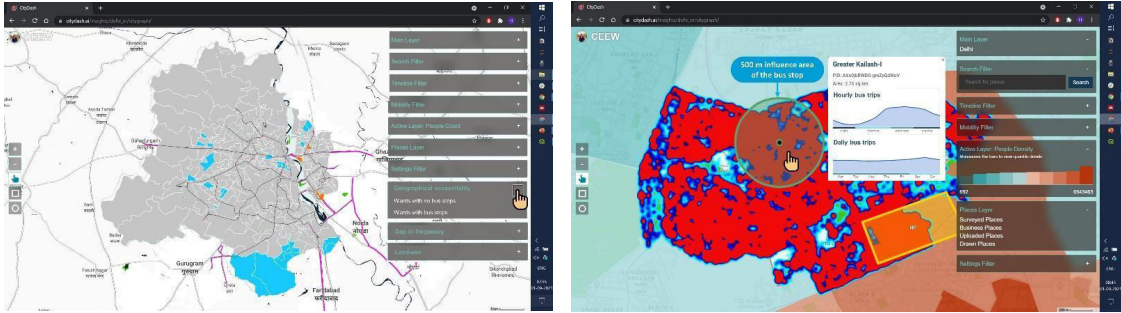
Geographical coverage of bus services

The city of Delhi is divided into wards and the bus stops were mapped to identify the wards without any bus stops. Using the smartphone GPS data, the Origins and Destinations (ODs) from these wards (with no bus stops) were calculated to identify the travel demand to and from these wards. In case of passenger trips are more than zero in these wards, the ward was marked as an 'underserved ward'.

Bus connectivity and services at key land-uses

The key land uses identified that needed adequate bus transport connectivity included markets, educational institutions and recreational areas. The dashboard calculates the number of bus stops in their 100 metre catchment area of the land uses, and the ones without any bus stops are marked as underserved areas.

Upon closer inspection and detailed analysis, the tailored solutions can be developed such as enhanced area coverage with higher Level of Service using route rationalizing, optimization of frequency or headway of buses, matching trip schedules to demand, and planned, phased increment of buses to the fleet. Additionally, service gaps and other insights in specific areas, corridors may suggest need for different types of services like premium or seated buses, women special, university special, bazaar and mall links, to name a few.



The UI of the web-dashboard highlighting the key features is indicated in the associated image.

EXPECTED RESULTS AND OUTCOMES:

The dynamic web dashboard will allow the city transit agency to monitor the gap in demand and supply of bus services. This can be done in real-time in a cost-effective manner, and tailored solutions can be adopted to increase ridership. The increased ridership directly benefits the bus operators, both by increasing their revenues and by bringing down operational costs through optimized bus operations.

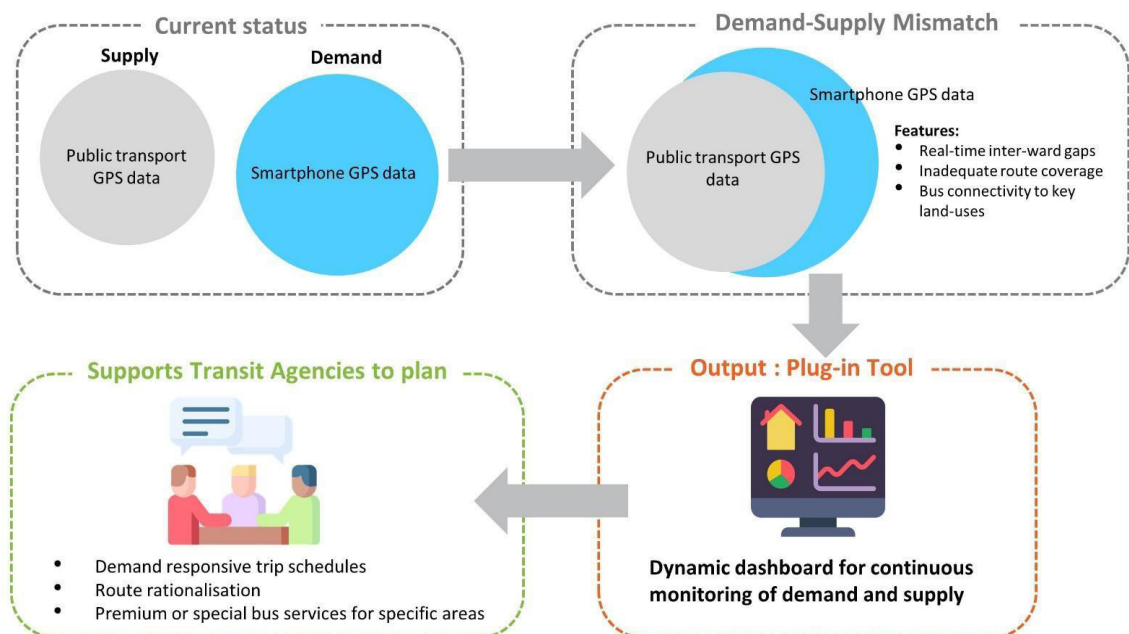
Further, it allows bus agencies to meticulously plan for acquiring new buses through comprehensive operations and financial planning, made possible by the availability of passenger movement data. The bus operators and transit agencies can continually measure the impact of the interventions to fine-tune operations to close gap in demand and supply of bus services.

The key outcome of the proposed solution is about better and improved services. With adequate last-mile connectivity and integration of bus services with metro services in the city, buses will become an attractive and convenient mode of commute.

CONCLUSION:

At present, about 71 percent of the city buses already have GPS devices, and 20 percent plan to install the devices in the next two years. Thus, the tool offers replication potential to 91 percent of all cities with bus systems. Owing to the popularity of the smartphones, the demand-side data is currently available for all Indian cities.

Additionally, data from feeder buses, metro rail, auto-rickshaws, city-level surveys can also be integrated into the dashboard for supply-side insights. Similarly, call detail records, traffic



surveys can be used for demand-side data. Thus, the solution is replicable and scalable to any city and context in the country.

Prolonged supply of good quality PT services has the potential to cause mode-shift from private vehicles. This can lead to 57 percent reduction in vehicles on road, lowering congestion and local pollution. Additionally, transport-poor communities in the urban periphery, and other low-income areas will have improved access to PT and increase the prospects of enhanced livelihood and services such as education and health. Moreover, transit operators will benefit from improved ridership, revenues by efficient and demand-responsive services.

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SPECIAL MENTION IDEA

EVERs Charging Platform Evers Technoservices LLP

CONTEXT:

The EVERs concept initially targeted aggregation of Electric Vehicle (EV) charge points for the consumer to map all charging points that includes private Charge Point Operators (CPO), public charging points, and semi-private charging points. There existed a gap where individual apps were created to cater to only the private CPO's customer base. A platform with universal mapping and interoperability with various CPOs and public providers does not exist. Another key problem identified was the mapping of decentralized service providers such as individual or semi-private charging points, not having access to an aggregating network to list their charging point via an integrated platform. The current CPOs and their private management platforms lack uniform deployment of smart chargers, Energy Management System, tariff management and open charge point protocols.

PROBLEM STATEMENT:

The current gaps in the Charging-as-a-Service (CaaS) model have been identified with both the Electric Mobility Service Providers (EMSPs) who manage the relationships with EV drivers and the CPOs who operate and manage the charging infrastructure. Presently, all EMSPs have independent applications to manage their respective users with payment, mapping of their own network and some other user features. There does not exist interoperability between the CPO networks and EMSPs. Most large CPOs operate independently without engaging multiple EMSPs. Furthermore, they do not have an integrated platform with open communication protocols with DISCOMs. All of the above limit effective EV-grid integration, improving the business model of charging service providers and increasing the EV penetration rate across the country.

OBJECTIVE:

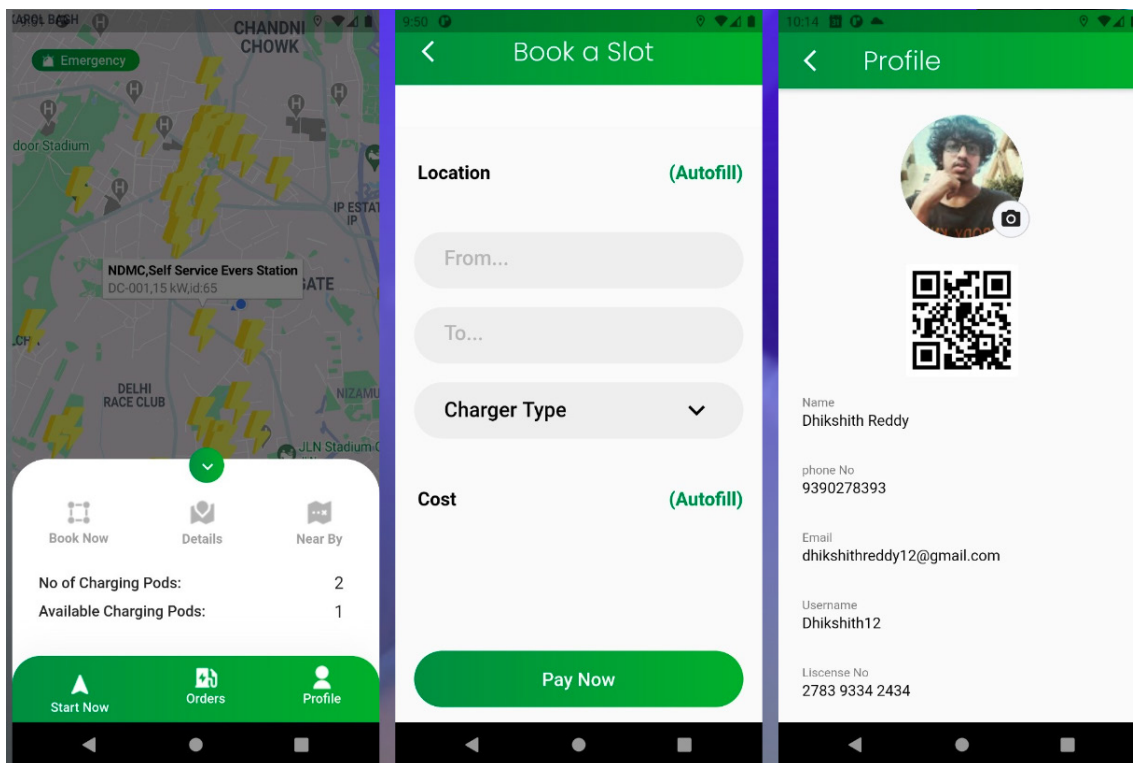
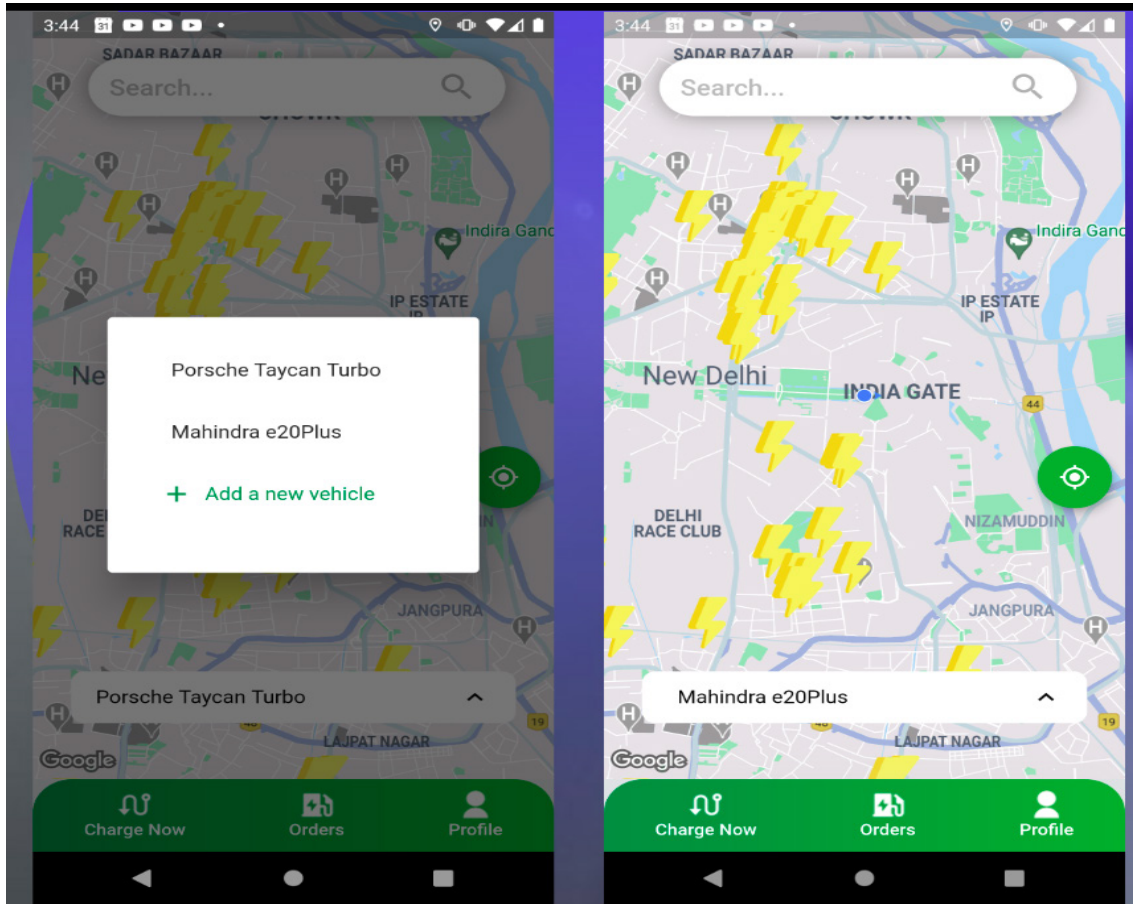
The objective of the EVERs charging platform is to promote the CaaS model, by developing a fully integrated platform that provides services to consumers as an EMSP via the consumer app that provides a universal mapping of all charge points, with key unique user features to enhance and enable EV users ease of access and hassle-free charging experience.

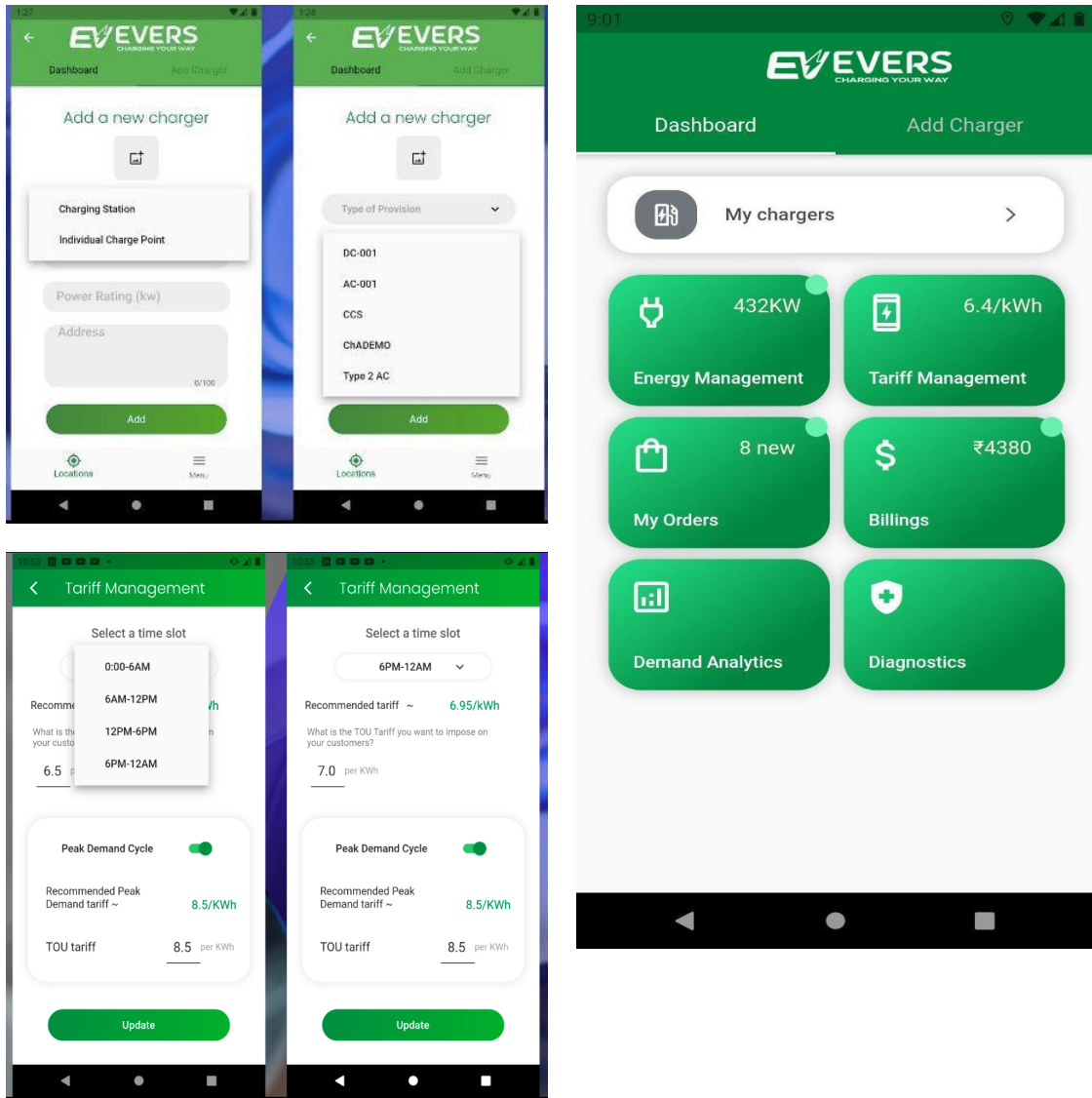
APPROACH AND METHODS:

The initial approach was to develop a universal EMSP application which would provide CaaS and as part of it, the EVERs user application was developed. The consumer app includes features like compatibility check, real-time mapping, real-time availability, shortest route to charging point, slot booking and QR Code authentication. The associated showcases the Home Page of the user screen, indicating charge point mapping with compatibility checks.

The app allows the user to identify charging points compatible with their vehicle selection, and the "charge now" feature computes the closest available charging point. The associated image highlights some of the key features including real time feedback, slot booking and QR code enabled charge validation.

The scope of the solution was then expanded to also have a CPO app to facilitate easy and efficient operations and management of charging points. A CPO application with a fully integrated back end was developed, paired with a CMS. The charging network registration on the CPO app allows for the CPOs or any individual service provider to register their EVSE with necessary details. The next image showcases the CPO app's registration screen interface.





The CPO app also allows dynamic tariff management, as a response to varying demand. Tariff management helps the CPOs to dynamically manage the tariffs based on user demand, as well as during peak energy demand cycles. The next image highlights the tariff management functionality of the application.

The app also consists of a dashboard which is a consolidated platform to manage electric vehicle supply equipment. The dashboard has multiple tabs that provide key information, as well as access to energy and tariff management features. The operator can manage the entire infrastructure as well as monitor orders and sales revenues through the application using these features. The next image showcases the dashboard view.

EXPECTED RESULTS AND OUTCOMES:

Some of the key expected results include uniform aggregation of users through the consumer application by providing unique user friendly features to enhance the EV charging experience. This, paired with a CPO application developed specifically to improve charging efficiencies both on the demand and energy side will enable to connect both users and service providers effectively. The common platform will help create a large decentralized network with better user penetration and the easily accessible CPO app will enable better integration of private and semi-public charging points to the network.

CONCLUSION:

The second aspect of the platform will be a CPO application paired along with a Central Management Software (CMS) to optimize tariff management, energy management with green power integration, micro-grid integration, and smart charging which is hardware agnostic. The entire platform is built with open communication protocols to engage multiple EMSPs, CPOs and DISCOMs to achieve interoperability and effective EV-grid integration.

The EVERs charging platform will help to promote the transformation of mobility from integrated circuit-based automobiles to EV, by providing an end-to-end EV charging platform. This would enable effective user aggregation and charging point aggregation of both CPOs and independent charging points. By having users and service providers plugged into this open network, we can achieve effective connection of EV-grid integration, create and assess various models of EV charging, analyze charging demands and forecasts. A fully integrated platform will be able to connect all key stakeholders through an open communication protocol. This would have key benefits such as passive and active load management, micro grid integration, smart charging hardware integration with Open Charge Point Protocol and Open Automated Demand Response.

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SPECIAL MENTION IDEA

Here to There – Changing Perception through Communication

Directorate of Urban Land Transport, Bengaluru

CONTEXT:

The COVID-19 pandemic has challenged and affected various sectors of the economy and people in distinctive but myriad ways. Across the world, governments enforced massive restrictions in the form of lockdowns to limit the transmission of the virus to ensure the health and safety of its citizens. These restrictions such as limiting public transport for only essential workers, discouraging unnecessary travel, enforcing physical distancing norms, encouraging Work from Home (WFH), created startling and unforeseen effects on public transport and the travel behaviour of individuals. The Global Mass Transit Report - Ridership Plunge: Limited Services, Declining Patronage Due to COVID-19, 2020 presents convincing data on plummeting public transport ridership across the world. Further, studies have revealed that with the opening of lockdowns and increased vaccination rates, there is an increasing preference for the personal vehicle. Thus, it is evident that concerted measures need to be implemented to retain and increase the public transport mode share to achieve the goal of sustainable mobility.

PROBLEM STATEMENT:

Presently, public transport operators are grappling with reduced ridership mainly owing to two broad reasons: one, COVID-19 associated restrictions such as physical distancing, discouraging unnecessary travel, etc. and two, the behavioural and attitudinal change of individuals due to the general myth that public transport is unsafe. Contrary to this general perception, there is extensive research showing that public transport poses a very low risk of transmitting COVID-19 and is a safe mode for commuting. However, this information is not convincingly conveyed to the general public in an effective manner. Even in normal times, the increasing number of personal vehicles in cities is leading to erosion of public transport's modal share. Public Transport Operators need to use effective data-driven communication strategies to continuously obtain feedback on the perceptions of citizens on the quality of public transport infrastructure and services. These communication strategies need to clearly present that the public transport services are modern, efficient, rapid, reliable, convenient, comfortable, and safe. Such effective and targeted communication strategies have the potential to retain the existing public transport users, attract new users and also build support for public transport.

OBJECTIVE:

Successful businesses continuously strive to understand the needs and perceptions of their customers about their products and/ or services. It is an established fact that it is far costlier to bring in new customers than to keep existing ones. However, public transport operators do not spend the required time and effort to continuously engage with their customers and may need to borrow strategies used by the private sector to develop a loyal commuter base.

COMP²aaS, **C**ommunication, and **M**essaging to **P**romote **P**ublic Transport **as a Service**, is a bouquet of tools to develop and implement communication and messaging strategies through a data-driven approach to

- Measure customer satisfaction levels with respect to public transport infrastructure and services,
- Engage with the larger community on the importance of Public Transport and
- Nudge citizens towards using public transport for their mobility needs.

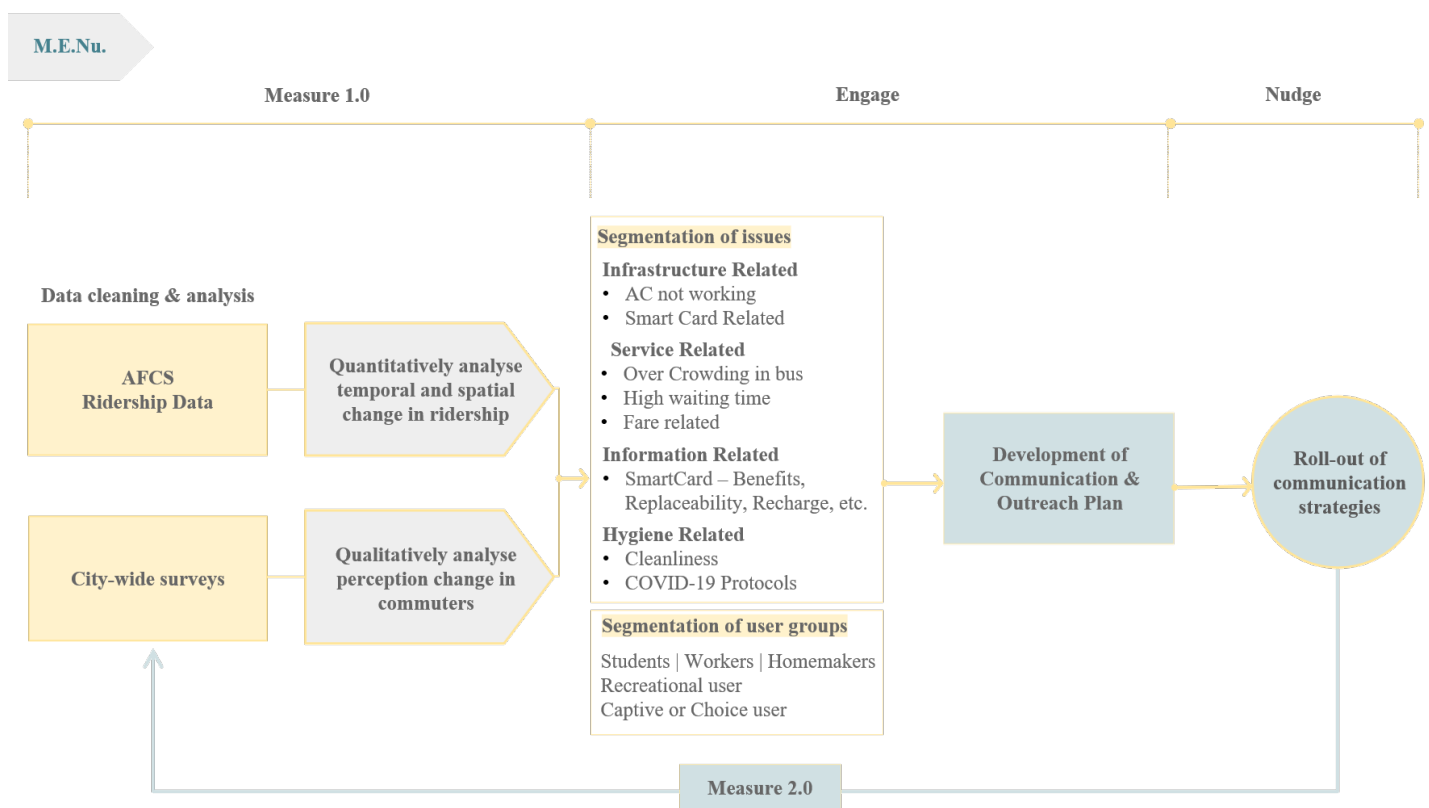
APPROACH AND METHODS:

The solution aims to:

- Increase the inferential ability of the vast amount of data collected through the ITS system, especially the Automated Fare Collection System (AFCS) and Smart Card Ridership data, using the dashboard;
- Understand the needs, attitudes, biases, and perceptions of citizens towards public transport services in the city;
- Adopt effective communication strategies to address and tackle these concerns using the toolkit.

Currently, the approach has been tried and tested on data sources from Hubli-Dharwad Bus Rapid Transit System (HDBRTS), one of the successful BRTS projects in India.

The solution 'COMP2aaS' uses a data-centric methodology to develop effective communication strategies to constantly engage with the existing, new, and potential customers, and thereby understand their mobility needs and build brand value. This is based on the looped process of "M.E.Nu." where **M** is measure, **E** is Engage, **Nu** is Nudge.



Measure

'Measure' is a process of analysing two sources of data, ITS-sourced AFCS data sets (which include ridership and smart card-related data) and city-wide survey. The data reading process here involves quantitatively understanding the rise and fall in ridership level on a temporal (daily to annual) as well as spatial (station-wise) basis through the dashboard. This dashboard will visualise these data sets for the public transport operators to understand the 'what, when, and where' regarding the fluctuations in the ridership. The visualisation on these dashboards also enables the public transport operators to understand the customer behavioural pattern including churn, including the number of customers that defect (cease using) a service during a particular time frame. The second source of data is the city-wide survey, which gives a qualitative understanding of the change in the ridership and the reasons for churn. This survey dashboard helps understand the existing perception of the public transport service.

Engage

Based on the insights gained from the dashboard of the HDBRTS, a toolkit has been developed. The next stage, 'Engage' involves using this toolkit for the formulation of communication strategies.

This toolkit lists communication strategies that are bucketed into segments pertaining to physical infrastructure, information, or service-related issues which can be further disaggregated for different personas based on age, gender, or occupation. The public transport operators are required to develop communication material in the form of audio, video, posters, for different platforms such as Public Announcement System (PAS), Passenger Information System (PIS), social and traditional media.

Nudge -

Based on the issue-bucketing, the 'Nudge' process is where various strategies developed are rolled out on digital and traditional platforms to nudge the customers. This segment also involves nudging people for various reasons, including but not limited to- adopting appropriate commuter behavior (COVID and other etiquettes), promotion of smart card usage, retaining the existing customer and gaining new customers.

The digital dashboard solution, supported by a toolkit, will enable public transport operators in reading, analyzing, and interpreting the data to facilitate communication strategy development.

EXPECTED RESULTS AND OUTCOMES:

For communication strategies, there can be no one-size-fits-all approach since the strategies need to be contextualized to the current challenges, as well as the general ethos and pathos of the city. Therefore, COMP2aaS enables public transport operators to collect and analyze data from various sources such as AFCS and survey. This dashboard will enable easy reading of data from different perspectives at the disaggregated level, and also understand the reason for continuously using or churning out from public transport. These conclusions, using the toolkit booklet, will then enable the public transport operator to develop a mix of digital as well as non-digital communication and messaging strategies for different platforms. COMP2aaS, therefore, is a yardstick that measures the effectiveness in reducing customer churn and increasing customer acquisition through communication and outreach strategies.

CONCLUSION:

Effective, targeted, and data-led communication strategies have the potential to retain the existing public transport users, attract new public transport users and thereby maintain the existing and generate new and increased ridership demand for public transport. Further, communication strategies, when executed effectively, can establish a connection with their users and thereby allow public transport operators to understand their users better. At a city scale, it will help operators to build support for public transport. This dashboard, along with the toolkit, is a plug-and-play solution that will enable any public transport operator to undertake effective communication strategies and also measure the impact of these strategies.

Several BRTS's in India (such as Indore and Ahmedabad) and even metro systems have invested heavily in the ITS system especially AFCS and Automatic Vehicle Location System. Therefore, the public transport operators will only require to connect their dataset using API. The COMP2aaS dashboard has been developed using the live dataset and tested on one of the most successful BRT - HDBRTS and therefore any other BRTS or metro can easily adopt this COMP2aaS and develop appropriate communication strategies.

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FINALIST IDEA

Automated Bus Shelter Safety and Accessibility Audit

Mobility Team of Council on Energy, Environment and Water

CONTEXT:

In a survey carried out by the Council on Energy, Environment and Water in 2019, 53 percent of the female respondents reported 'quality of infrastructure' as a barrier to using public transport. 'Quality of infrastructure' as captured in the survey included poor quality bus stops or metro stations, inadequate lighting, and lack of level access. For public transport to be truly inclusive, the special needs of the older population and women passengers have to be addressed. Evaluating the quality of bus stops from a safety and accessibility perspective manually can be an onerous task for State Transport Units (STU) and Urban Local Bodies (ULB) that have limited resources at their disposal. Moreover, such infrastructure evaluations cannot be a singular, sporadic exercise and will have to be repeated periodically, as damage to public property and ageing cannot be completely avoided. There is thus a need for a low cost and rapid method to spot bus stops with infrastructure issues.

PROBLEM STATEMENT:

Bus shelter audits for safety and accessibility need to be carried out periodically for timely intervention to repair damages and regular maintenance. The process, however, is time and cost intensive, given the number of bus shelters in metro cities such as Bengaluru. Therefore, most bus shelters are not audited and there is no process in place to ensure compliance with safety and accessibility standards as stipulated in the 'Public Transport Accessibility Toolkit', developed by the Ministry of Urban Development, now Ministry of Housing and Urban Affairs (MoHUA), in 2013. In the absence of such upkeep, ridership of public transport is affected over time and there is a disproportionate impact of limited accessibility and safety at bus shelters for women, elderly, and children.

OBJECTIVE:

To develop a computer vision model that allows for periodic assessment of bus shelters in a city by detecting:

- Features impacting perception of safety near a bus shelter; and,
- Features impacting accessibility to the bus shelter.

The solution is in the form of a tool for operators to regularly fine-tune bus services to offer connected and easy travel experience, thereby improving ridership and revenues. The tool and its related analytics further support bus route rationalization and aid the development of demand-responsive schedule for bus services. Also, the insights overlaid with land uses further supports the IPT, feeder services and metro service integration.

APPROACH AND METHODS:

Identification of standards for safety and accessibility

The key safety and accessibility features for detection were identified from a literature review and three main reference reports 'Public Transport Accessibility Toolkit' mentioned earlier, 'Women's Safety in Public Transport' by WRI India in 2015, and 'Urban Street Design Guidelines' by ITDP in 2016. The features described as being critical and recurring in the different guidelines were shortlisted for detection via Computer Vision (CV).

The features for the safety parameter include the presence or absence of lighting at and around bus shelter at night. The features for the accessibility parameter include cleanliness of the

bus stop, presence of debris or other unwanted material near the entry/exit points or near the seating, vehicle obstruction when no person is inside a parked vehicle, vendors obstructing bus stop access, and damaged footpaths.

Training dataset collation

In order to train the CV model, a training dataset was created comprising of images of bus shelters. While these images are typically sourced from on-ground image collection or any existing databases, for the purposes of building a prototype to demonstrate utility, Indian bus shelter images from Google images were relied upon. A limited dataset of 500-odd images was collated and annotated for the purpose of identifying lighting, detecting obstructions in the form of debris, garbage or vehicles, and damaged footpaths.

Training

A set of Convolutional Neural Network (CNN) models were trained using the annotated training dataset. The lighting detection involved a binary classification whereas detecting debris, damaged footpaths, and garbage near bus shelters were based on object detection. The next image indicates the classification of bus shelters based on lighting by the CV mode



Creation of the Dashboard

A dashboard was created using Python that would provide an interface for the user to upload a set of images of bus shelters, and receive an output summary table and a label for each bus shelter image indicating its accessibility and safety status. The images uploaded onto the

Upload file/files for assessment of safety and accessibility

Drag and drop or click to select a file to upload.

Names of bus shelters uploaded (Click on image link to download)

- BusStop-12.jpg
- 45B41819-76CE-4BEA-AB53-FCBE8347EF06.jpeg
- 16D8E670-957F-457B-8FD8-1CA794245428.jpeg
- BusStop-16.jpg
- 71EBAB6B-CC37-4145-B66F-D54C70E416B7.jpeg
- BusStop-20.jpg

Press to generate labels

Summary Table

	Label	Count
	Unsafe Bus Shelters	0
	Safe Bus Shelters	3
	Accessible Bus Shelters	2
	Inaccessible Bus Shelters	1

Bus Shelter Name	Safety Label	Accessibility Label
BusStop-12.jpg	Safe	Accessib
BusStop-20.jpg	Safe	Inaccessibl
BusStop-16.jpg	Safe	Accessible

dashboard were processed by the CV model developed in the previous step to assign a safety and accessibility status. This output was then displayed on the dashboard with the options to view any image that needs to be reviewed against its assigned label. The next image shows the UI for the tool to upload images and obtain labelled results.

EXPECTED RESULTS AND OUTCOMES:

By automating and speeding up the process of bus shelter audits, the main outcome anticipated is an increase in ridership of buses especially among women, elderly, and children. These rapid audits can be expected to lead to timely interventions for upkeep and maintenance of bus shelters to address safety and accessibility issues. From the ULB's perspective, they can carry out audits at nearly half the cost, consuming 60 percent less time compared to a standard manual audit. If dashboard cams are used for image collection instead of deploying a third party for the same, bus shelter monitoring can be carried out on a daily basis along with the added ability of crowd monitoring at stops and road safety incidents. This can significantly reduce the burden on ULB and help them focus on resolving issues in a near real time manner. Bus users benefit from the constant vigilance offered by dashcams.

CONCLUSION:

In order to automate the process of image data collection and make the tool ready for real-world application, the team pursued collaboration with Bruhat Bengaluru Mahanagara Palike which is responsible for upkeep of bus shelters in Bengaluru and Bangalore Smart City Ltd. Dashboard cams installed on the sides of buses would help automate the data collection process and allow for daily monitoring of conditions at the bus shelter. The tool will be integrated with existing apps such as Sahaaya and associated backend IT infrastructure. Further, upon successful demonstration in Bengaluru, the same tool and approach would be scaled to other cities without significant changes to the CV model. The insights from the tool can be used by ULBs to maintain bus shelters in a timely manner which could increase bus user satisfaction and ridership in these cities.

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FINALIST IDEA

Devising a Bus Priority Signalization Logic Using An ITS-based Architecture Sardar Vallabhbhai National Institute of Technology, Surat

CONTEXT:

Due to the rapid urbanization in India, travel demand has increased, leading to an increase in the number of vehicles on the road, and therefore, congestion on city roads. Compared to other modes of transportation, the Bus Rapid Transit System (BRTS) is a highly effective transportation mode that can relieve urban traffic congestion due to its high quality, efficiency, low energy consumption, and low cost. Unlike subway systems, however, the operation of BRTS is dependent on signal timing at the intersections through which BRTS vehicles travel. The quality of BRTS operation is directly influenced by the design of traffic signal phases, circle length, and delay. In light of the increasing share of private vehicles, increase in modal share of four-wheelers, worsening urban congestion, and increasing pollution, it is critical to improve the BRTS operations' quality by implementing advanced technologies such as ITS-based adaptive signal control, thereby enabling bus priority at signalized intersections.

PROBLEM STATEMENT:

Sustainable transportation, particularly efficient management of multi-modal transportation systems using real-time Intelligent Transport Systems (ITS), is a pressing need for Indian cities. Multi-modal integration for traffic operations under heterogeneous traffic conditions (with varying traffic conditions such as volume and composition) is a key step towards achieving sustainability. Therefore, on a selected BRTS corridor, the smart camera-based loop detectors are located on four approaches for real-time bus demand and assigning a bus priority using a developed logic/idea. The novelty of this design is to locate these detectors for measuring the travel time and occupancy for different vehicles operating in mixed traffic lanes. Further, to cross the intersection, the BRTS must merge with the regular traffic. Therefore, BRTS must wait for its turn to cross the signalized intersection according to the prescribed cycle and signal times. In the past, researchers proposed the 'adaptive signal control concept' to reduce intersection delays. The adaptive signal control concept can be used to give priority to the BRTS at the intersection. This idea is especially relevant for signalized intersections where buses must be given priority to make them a more appealing mode of transportation. The ultimate focus will be on developing a web-based intelligent traffic management system.

OBJECTIVES:

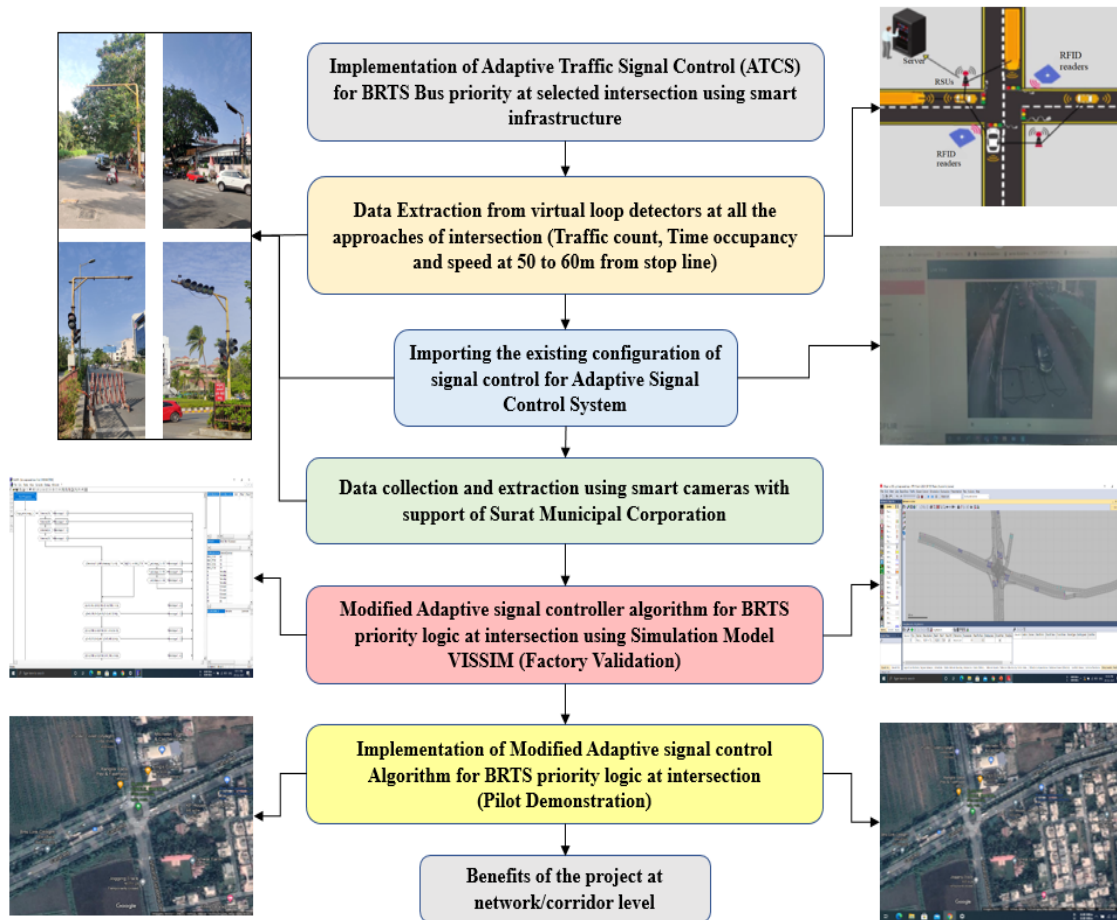
The solution has a three-fold focus:

- To develop adaptive signal control logic and algorithm for prioritizing the BRTS at the signalized intersections on a selected corridor.
- To demonstrate a reduction in the delay for the buses incorporating bus prioritizing logic for the bus movement on BRT lane at selected signalized intersections using computer-aided simulation.
- To quantify the benefits of implementing bus-prioritizing logic on BRT lanes at selected signalized intersections in terms of travel time savings, reduced air pollution and carbon footprints.

APPROACH AND METHODS:

A BRT corridor in Surat city was considered for implementing adaptive signal controls for prioritizing the bus movements from BRT lanes at selected intersections. The smart cameras were installed at four approaches to the intersection to estimate real-time traffic demand. The

adaptive signal control was based on the predefined logic for control given to the signal controller near the intersection. The demand was calculated as a function of occupancy-time and velocity. Further, loop detectors were installed at all legs at the stop line and on the upstream side of the stop line to estimate the robust demand. Upstream side detectors provided an indirect estimate of the queue up to that detector location. The methodology and procedure adopted for carrying out the work are depicted below.



The real-time data was collected using a smart camera. The data collected was fed into VISSIM software, which simulates the effect of adaptive signal control at the intersection. The condition is implemented in three stages, as shown below:

- Fixed time control (business-as-usual)
- Fixed time + bus priority control
- Adaptive traffic signal control + bus priority control

The base condition was simulated in the first case by providing the observed fixed-time signal control for BRTS, treating it as a business-as-usual case. The BRTS is given priority over other traffic in the second case. The traffic signal for the other lanes remains unchanged. Detectors in the BRTS lane are provided to identify the bus arrival and, in some cases, bus is prioritised. In addition to the BRTS, the other traffic lane is given a green signal, and the time cycle is then followed. In the third case, the BRTS is prioritised in the same way as in the second case. Still, the signal control for other traffic is converted to adaptive signal control by implementing the devised logic. To identify traffic demand, detectors are placed at the stop line and on the upstream side of the stop line. The automated traffic data extractor is also developed as one of the important outcomes of the project, which detects buses and other vehicles while approaching the intersection. This enables the derivation of the real-time demand and hence enables traffic managers to assign priority at different approaches based on real-time demand. The results for the intersection delay are extracted from the VISSIM for all three cases.

EXPECTED RESULTS AND OUTCOMES:

The use of ITS (smart camera-based detections) as a traffic-data collection technique can easily replace conventional data collection and add significant value due to its enhanced promptness, reliability and accuracy. Further, the simulation results revealed very clearly that the delay to (BRTS) bus movements is significantly reduced (in the range of 20-50 percent) after implementing the adaptive signal control at the intersection. With lesser installation cost, ease of collection and non-invasiveness, and better collection accuracy, ITS can provide better opportunities to understanding traffic, travel, and mobility patterns in a particular city. Moreover, it also offers a great opportunity for monitoring real-time traffic congestion, thereby aiding city authorities (Surat Municipal Corporation in this case) to provide more decent solutions for making city transport infrastructure operation more effective. This is likely to generate significantly more employment/ start-up-related opportunities for students and researchers.

CONCLUSION:

The project idea presented here will be extremely useful for implementing the developed bus-priority logic considering real-time traffic demand to reduce BRTS delays. For this purpose, BRT corridor traffic operations are simulated using VISSIM, a traffic simulation software, before it could be implemented in the real field conditions for obvious reasons. It is quite evident that implementing the novel bus-priority logic and adaptive traffic signal control requires significant travel time saving, reducing carbon footprints at a selected BRT corridor with signalized intersections. The results generated from this idea will help develop solutions to make public transportation a more attractive mode of transport. This would contribute significantly in improving and providing sustainable urban transportation solutions with better multi-modal transportation planning and operations on the BRT corridor.

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FINALIST IDEA

Transit Evaluation Tool for Smart Mobility - Progress Towards Efficient Public Transport

Sardar Vallabhbhai National Institute of Technology, Surat

CONTEXT:

The rapid development of cities and an enhanced quality of life has increased the affordability of private modes, resulting in increased transport externalities. To achieve sustainability, the outlook of transportation policies has undergone a paradigm shift, with more emphasis on passengers' movement instead of vehicles. However, even after implementing policies to promote public transportation, the mode share of these systems in cities are found to be dismally low. As a result, transportation modes face contradicting and competing objectives. Bus and paratransit systems need to plan their operations to complement each other and deliver a more comprehensive network of services. In order to achieve this, there is a need to evaluate both public and paratransit systems at the microscopic levels to facilitate their possible integration under a coordinated multi-modal transportation perspective.

PROBLEM STATEMENT:

Conventionally, Public Transport (PT) systems in Indian cities consist of bus-based systems, rail-based systems, and Intermediate Public Transport (IPT) systems. Additionally, as per the Association of State Road Transport Undertakings (ASRTU) in 2015, operators could recover the overall cost of 86 percent from revenue, leaving 14 percent of total cost uncovered, resulting in a net loss of ₹7112.62 crores per year. Thus, evaluating the existing PT system's route, cost, and operational efficiencies becomes necessary to improve PT performance. 'Route efficiency' provides an idea about the supply and demand relationship. 'Cost efficiency' represents a comprehensive assessment of financial performance at the route level. 'Operational efficiency' provides information about how well the current schedule can cater to the transit demand.

OBJECTIVE OF THE STUDY:

The idea presented focuses on designing an efficient transit system by incorporating responses to lacunae identified from the performance evaluation of the existing PT services. The primary objectives of the present study are:

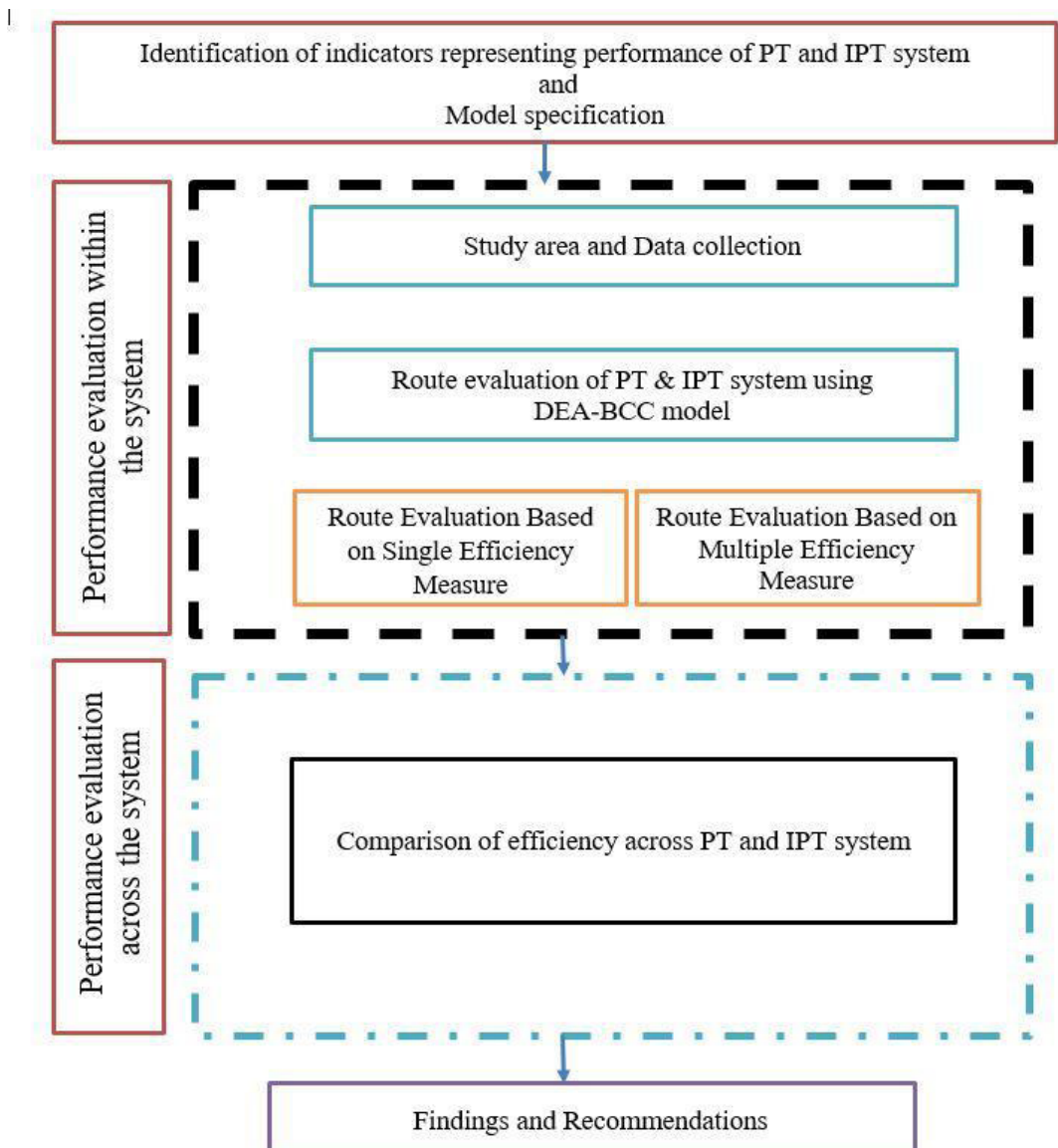
- To evaluate the performance of existing transit services (in terms of operations, route design, and cost efficiency) and to propose suitable policy recommendations.
- To develop a user-friendly Excel and Google Studio dashboard that city bus operators can easily use to analyze the existing performance of the transit services.

APPROACH AND METHODS:

Performance measures like Transit Capacity and Quality of Service Manual (TCQSM) and Service Level Benchmarks (SLBs) are essential tools to evaluate a city's PT system's existing condition. However, in response to the absence of efficiency evaluation tools for PT systems, the present idea proposes a framework for evaluations using Data Envelopment Analysis (DEA) techniques. DEA is a non-parametric approach and linear programming technique to measure relative efficiencies of a set of peer units called Decision Making Units (DMUs). In DEA analysis, each PT and IPT route is treated as a DMU. Six BCC-DEA models are developed to evaluate their route, cost, and operational efficiencies.

In the table that provides a description of the proposed model, column 1 represents the efficiency measure used to identify efficiencies of PT and IPT routes. Associated input and output parameters and their units are provided in columns 2 to 5 respectively. Finally, column 6 provides the model orientation. The analysis of the transit routes using single and multiple efficiencies gives a comprehensive picture of the present performance of the transit services

		CITY BUS MODEL		IPT MODEL		
S. No.	Efficiency Measure (1)	Input Parameters (2)	Output Parameters (3)	Input Parameters (4)	Output Parameters (5)	Model Orientation (6)
1	Route Design efficiency	Route length (Km), No. of stops, No. of transit units (Nos.)	Ridership (Passengers/day), Vehicle-Km (Km/day)	Route length (Km), No. of stops, No. of IPT units (Numbers)	Ridership (Passengers/day), Vehicle-Km (Km/day)	Input-oriented
2	Cost efficiency	Fuel cost (INR), Operational & maintenance cost (INR)	Revenue generated (INR)	Fuel cost, Operational & maintenance cost (INR)	Revenue generated (INR)	Output-oriented
3	Operational efficiency	No. of stops (Numbers), off-peak frequency peak frequency (TU/hr.)	Seat availability rate (Seats/passenger), 1/Route directness (Travel time by private mode/ Travel time by transit or IPT)	No. of stops (Numbers), Average frequency (TU/hr.)	Seat availability rate (Seats/passenger), 1/Route directness (Travel time by private mode/ Travel time by transit or IPT)	Input-oriented



from the user's and operator's perspective. The input-oriented model is used to minimize the inputs of inefficient routes, while the output-oriented model is used to maximize the outputs of the inefficient routes. The operator can use the model to determine the desirable inputs required on each route to achieve maximum efficiency. This will help the operator to cut off the extra expense and improve the operations of the transit services.

To achieve the proposed results, a detailed methodology was followed.

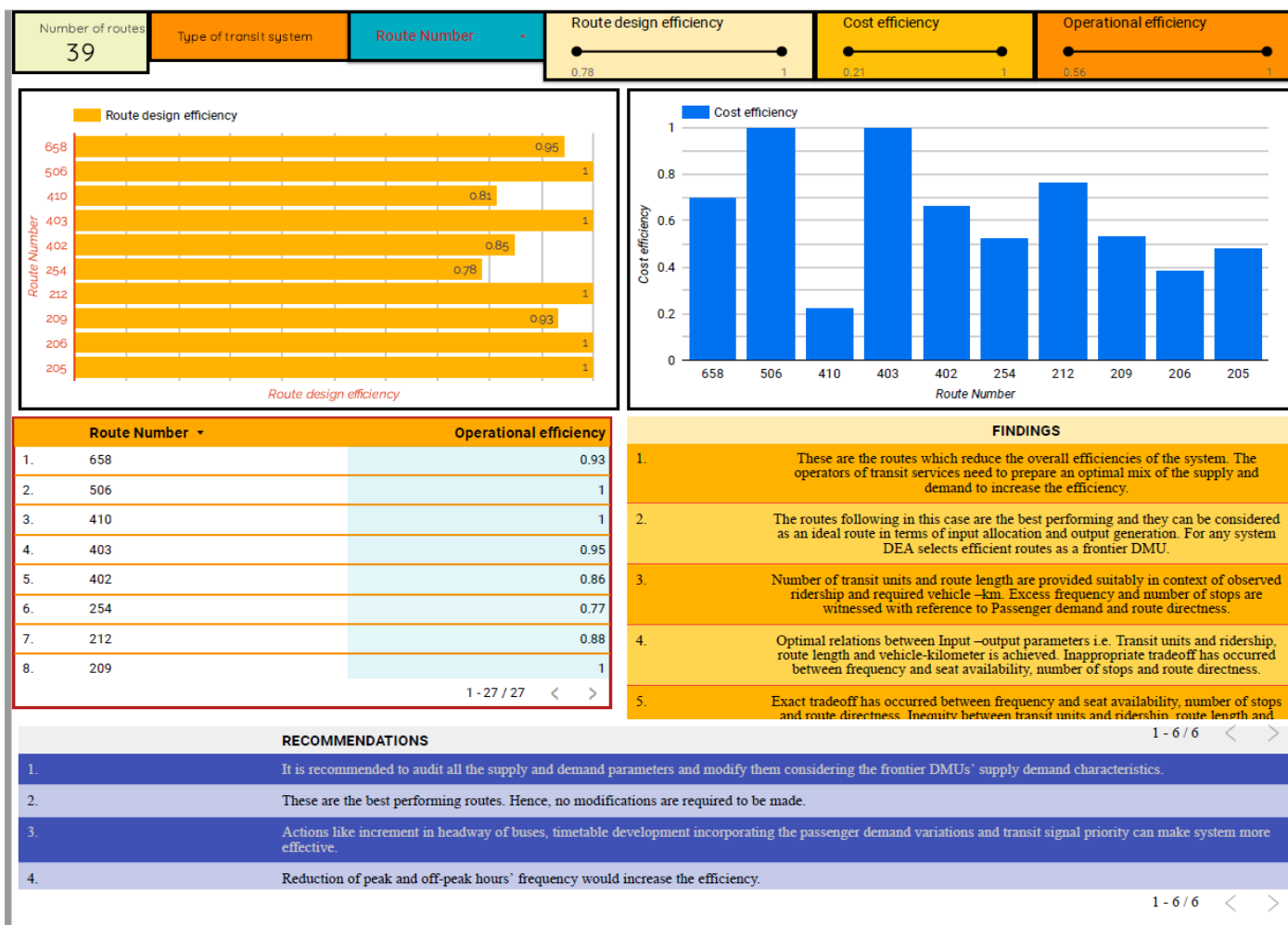
EXPECTED RESULTS AND OUTCOMES:

The solution proposes to submit two significant outcomes:

- **Excel Solver Spreadsheet:** This will help transit operators to determine the efficiency scores of each route of transit services by giving the inputs mentioned. Using the four-step procedure, i.e., the data input, solution generation, visualization tool, and data solver, the operator can derive the current performance score of the transit routes.
- **Dynamic Google Studio dashboard:** The dashboard will help the transit operator to identify the present gaps between the inputs and outputs. The findings and recommendations proposed in the dashboard will be based on the overall evaluation of all three efficiency scores. The recommendations will guide the operator to decide the appropriate policy measures, which will ultimately help to increase the efficiency score of the evaluated transit route. The User Interface of the dashboard is expected to be as follows.

CONCLUSION

The non-existence of integration between the different public modes of transport in cities has resulted into the inefficiency of the PT system along different routes. The team's solution proposes a methodology for route-level evaluation of these modes. To evaluate the existing PT system, three efficiency measures are proposed, namely route, cost, and operation. The pertinent findings and recommendations proposed in the present solution will assist city bus operators to plan/ modify the operations of transit services to make them more efficient.



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FINALIST IDEA

Mobilizer

Independent team, Germany

CONTEXT:

India faces major obstacles when it comes to equality in mobility; safety for women and making public transport inclusive and affordable, are some of the major ones. The 'Mobilizer' solution primarily addresses these issues. As a first step, the Mobilizer digital mobility platform is developed for travel in and across all the major cities in India. All citizens with an Aadhar card or any other official government document will be able to register on this platform and avail its services and benefits such as ticket booking and travel planning, among others.

PROBLEM STATEMENT:

The deficit of the current system is the lack of flexibility to adapt to the growing digital needs of customers. Most of the transport systems in India, apart from the recently developed metro systems in some of the major cities, provide outdated services such as paper ticketing, present a lack of timetable adherence of buses, and therefore inconvenience customers. Due to the lack of alternative services, a majority of the customers are forced to use private transportation. This not only increases traffic congestion but is also currently responsible for huge losses the public transport system is incurring each year. The goal of Mobilizer is to mitigate some of the reasons responsible for low public transport usage.

OBJECTIVE:

Mobilizer replaces the old paper-based ticketing system with a new digital platform. This will help address the inherent flaws of the old system, while also creating new jobs and promoting a sense of equality, as well as helping Indian cities lean towards greener solutions. In addition, Mobilizer also provides an incentive-based platform for frequent users which will help attract more users. As this is a digital platform, it is easily scalable through updating of software, adding more tools, and constantly updating the datasets. In fact, as users increase, more data is available. This will help increase the efficiency of the app using machine learning and artificial intelligence-based algorithms.

The objectives of Mobilizer are:

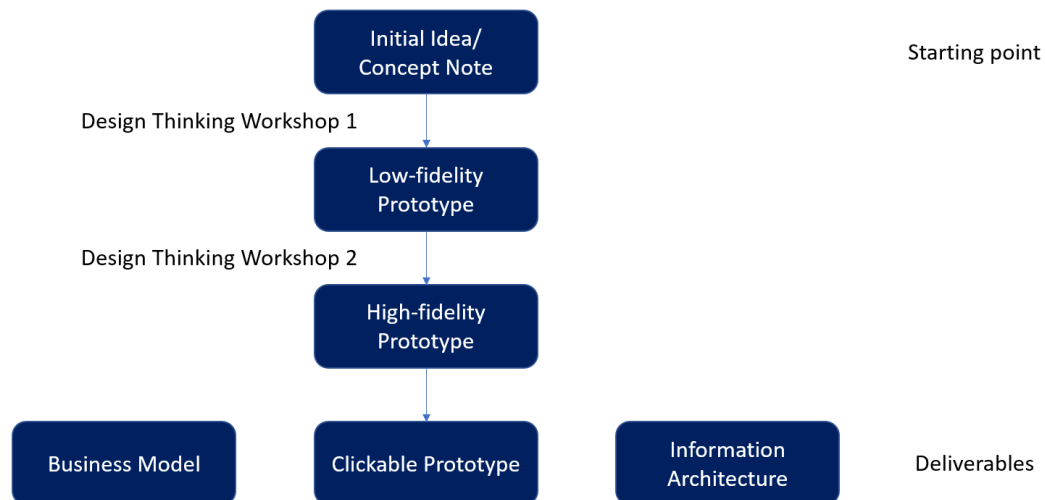
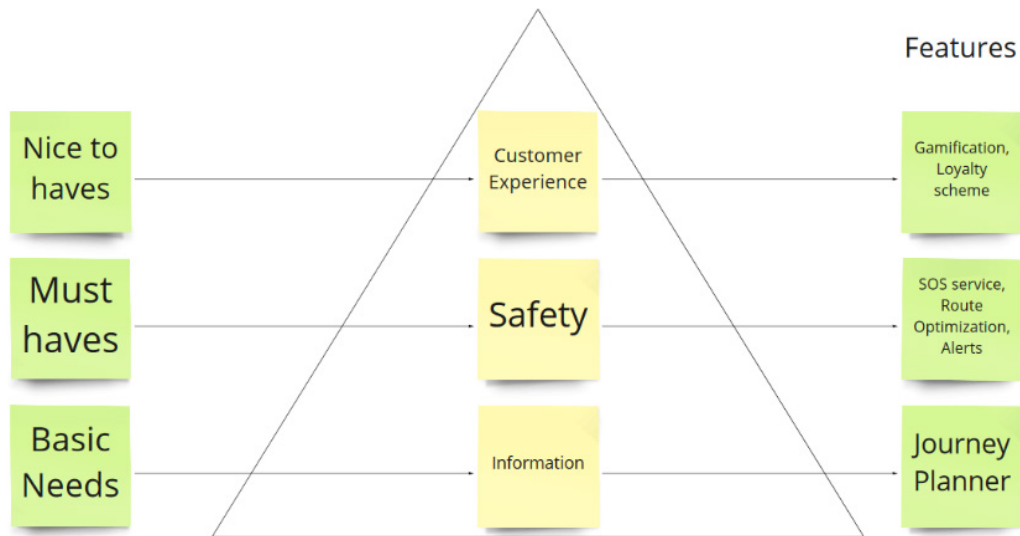
- Enhancing customer experience for travel planning and ticket booking
- Increasing safety levels for women and children; through digital service provision.
- Paperless ticketing

APPROACH AND METHODS:

To approach the challenge of solving gender safety in public transportation, the first step was conducting exploratory interviews with women of various age groups and identifying their issues. The main issues identified were regarding safety in the last mile, inability to report their current location, and the inability to retrieve the current location of their family members. This problem will be solved holistically by developing a journey planner on which safety features will be added, so that the Mobilizer digital mobility platform will be a one-stop solution for multiple mobility needs. The concept is based on successfully implemented models from Europe and North America with inputs based on the team's experiences in using public transportation and journey planning apps in Germany such as Jelbi, DB Navigator, and Rydes.

The image above depicts the main issues faced by the customers, clustered into three different pillars, defined qualitatively based on a quantitative customer survey.

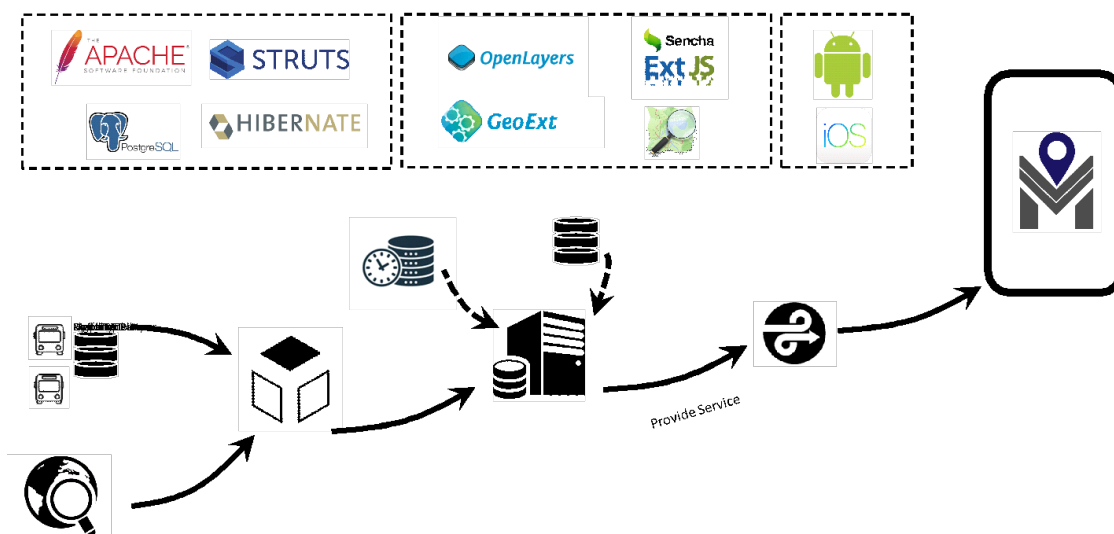
Since this is a complex challenge involving stakeholders that include taxpayers, transport



authorities and the government, a design thinking approach was utilized to derive the solution. Design thinking is a methodology or a framework used to solve complex and wicked problems. This was done in collaboration with Cochin Smart Mission Limited (CSML) and Kerala Metropolitan Transport Authority (KMTA) from Kochi City. The co-creation partners also provided their expertise resulting from a direct contact with all stakeholders. We conducted regular design thinking workshops to iterate on the ideas and also scheduled regular feedback sessions with our mentors and experts from CSML, KMTA, NIUA and GIZ India.

Simultaneously, we also worked on the business model and pricing strategy for the Mobilizer App and also its information architecture and backend. The development of Kochi Open Mobility Network (KOMN) enabled by Beckn Open Protocol is a major advantage for Mobilizer as it provides live location of buses and other transportation services in Kochi which can be fetched by our App to provide dynamic location of the buses/trains/ferries to the users in real-time. The app's architecture is indicated as follows.

Mobilizer will be developed for iOS and Android mobile phone operating systems. Since Android is the biggest market, the first phase of app release will be for the Android platform. There are different ways in which the app can be implemented. Since most of the top-notch and modern operating systems support Java Virtual Machine (JVM) technology, the core of Mobilizer will be written in Java. This provides the added advantage of enabling customized web interfaces to



be developed for each running interface of Mobilizer. This approach enables an efficient way to exchange information between the application server and users.

EXPECTED RESULTS AND OUTCOMES:

Some of the expected impact from Mobilizer are listed below:

- Enables environment-friendly mobility both with mobility services as well as paperless and cashless transactions. This not only saves paper and natural resources but also paves the way for Digital India.
- Earn additional revenue from each transaction in the platform, creating employment opportunities for digital talents.
- Aids in data collection about mobility behaviour resulting in better planning of further mobility and city infrastructure. Predicting demand for public transportation with direct data sources and hence efficient system management.
- Attracts teenagers and young people to public transport with a 'cool' digital platform. With a digital platform, public transport is made attractive by using state of the art technology.

CONCLUSION:

Passenger Information System (PIS) is a crucial factor affecting the Level of Service (LoS) being offered by any public transport, as access to timely information helps commuters in better decision making. With the growing adoption of app-based services across various sectors, it is important for transport sector agencies to also leverage it by offering services over mobile applications. Through Mobilizer, trip makers can access real-time information about available modes and also book tickets. These services extended to users over the mobile application will bring in seamlessness into the trip making. The app's exclusive feature of safety for women commuters will help in reinforcing women's trust in public transport services. By offering such on-the-go services, Mobilizer, post implementation, is expected to improve the efficiency of the services and thereby help boost the ridership.

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FINALIST IDEA

i-Connect (India Urban Mobility Management Platform)

Independent team, Dubai

CONTEXT:

Over 40 percent of the Indian population will live in urban areas by 2030. It is expected that 68 cities will cross the one million population mark, and 13 will cross the four million mark. In 14 cities, the share of public transport is projected to decrease from 75.7 percent (2000-01) to 44.7 percent (2030-31). Today, the private vehicle ownership rate in India has already reached 30 to 35 vehicles per 1,000 people and the road density is one of the highest in the world at 1.9 kilometres per square kilometre. The direct result is an exponential increase in traffic in the last few years. Even with the current size of the urban population, Indian cities face issues that include severe congestion, deteriorating air quality, increasing greenhouse gas emissions from the transport sector, increasing road crashes, and an exploding growth in the number of private vehicles. The situation could quickly get out of control in the next few years unless integrated remedial measures are taken. An application/ platform which brings in multiple customizable urban mobility technology and management solutions together for quick implementation can address this.

53

PROBLEM STATEMENT:

Indian cities are experiencing a rising urban sprawl, where residents inside urban boundaries have been pushing into peri-urban areas, often beyond public transit services. In most Indian cities, public transport modes are non-optimized and have poor service reliability. As a result, private transportation is significantly increasing in urban areas. Indian cities have not managed mobility systems efficiently and are unable to provide customer-centric services primarily due to scarcity of continued financial resources. Following are the critical problem areas that need an immediate integrated solution:

OPTIMIZATION OF MODES	PASSENGER SATISFACTION	DATA-DRIVEN IMPROVEMENT
<ul style="list-style-type: none"> Limited/no integration of PT Modes Underutilization of vehicles Poor connectivity Lack of intelligent tools to optimize PT services 	<ul style="list-style-type: none"> Limited customer-centric services Low priority to customer preferences Safety concerns Passenger opinions are rarely heard 	<ul style="list-style-type: none"> Conventional routing and decision making Little or no use of real-time data Scattered and fragmented projects

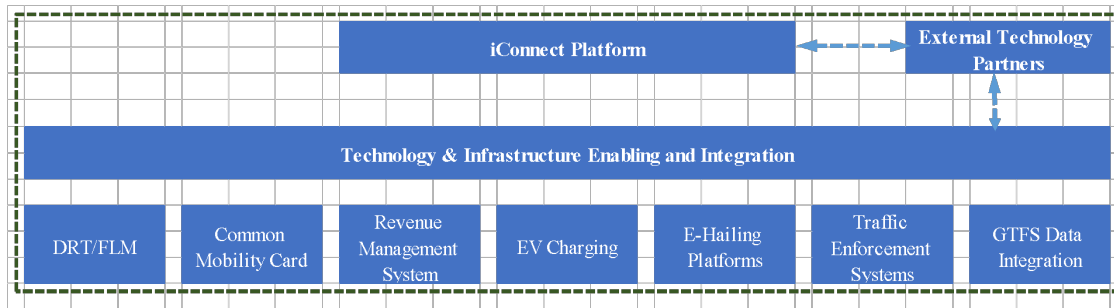
OBJECTIVE:

The proposed solution will help achieve the integrated shared mobility system through the scalable introduction of on-demand first /last mile solutions to complement traditional core PT modes. The aim of i-Connect is to provide an all-in-one data-driven open platform that will be the backbone of the city's mobility management system. Accordingly, the objectives of the current solution are:

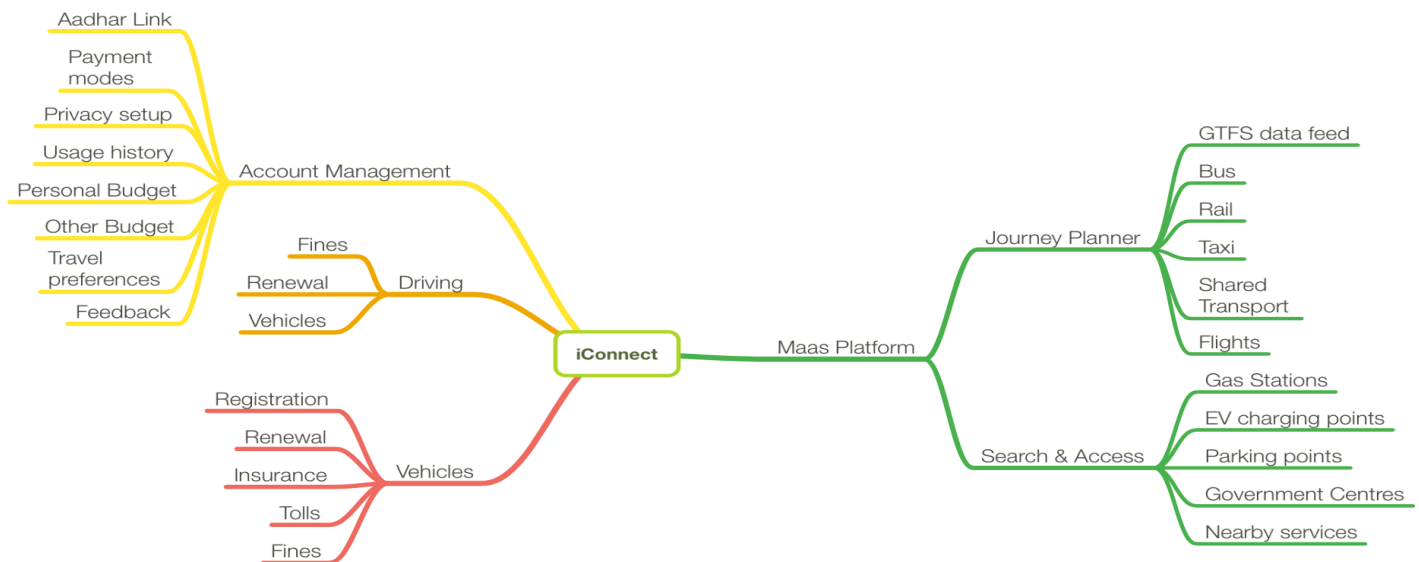
- To provide an India-centric solution focusing on bus/ metro/ taxi/ auto/ NMT and socio-economic/ behavioral parameters to ensure leak-proof revenue generation for city authorities.
- Integration of e-hailing choices for first and last mile solutions with public transport and payment solutions.

APPROACH AND METHODS:

The solution baseline, app backend framework and the basic architecture of the solution is depicted as follows:



i-Connect optimizes a city's existing ITS infrastructure base and enables innovative technology and infrastructure integration with city command and control centres quickly and sustainably. i-Connect provides a modular platform for various local and international technology/ mobility providers to quickly deploy new technologies (on-demand shared mobility, EV-charging, bike sharing, connected car, among others) under one umbrella app with payment integration. The product development/ integration of i-Connect platform is divided into three distinctive phases, out of which Phase I consisting of on-demand shared mobility application for first-and-last mile is ready for commercial deployment. The solution architecture may be depicted as:



EXPECTED RESULTS AND OUTCOMES:

During the next stages of development, the i-Connect platform can be expected to cover the following suite of solutions. The development and execution of the next phase should ideally empower cities to monitor trips, plan additional mobility choices, and generate new revenue streams for the up-gradation of future infrastructure needs:

- i-Connect as a 'Journey Planner' with Payment Integration: At its core, i-Connect is a digital platform that integrates end-to-end trip planning, booking, electronic ticketing, and payment services across all modes of transportation, public or private. Rather than locating, booking, and paying for each mode of transportation separately, i-Connect shall let users plan and book door-to-door, intermodal journeys using a single app.
- i-Connect as a 'PVM' (Personal License and Vehicle Management): A system to manage vehicle registration, licensing and traffic files. New vehicle registration can be conducted virtually. For mandatory Vehicle Renewal (no law exists currently), authorities can establish mandatory annual checks before renewal of vehicles after a certain age.
- i-Connect as a 'EVMS' (Enforcement & Violation Management System): Uses of technology can reduce human intervention and streamline violation management systems e.g., jumping

red signals, driving on the wrong side of the roads, and unsafe practices (not wearing helmets, seat belts, children on the lap in front seats).

The i-Connect platform is scalable to other cities with low investment (25-50 lakh rupees depending on city size and multi-modality presence) and time effort (three to six months) and is easily implementable, including additional revenue enhancement measures to achieve city financial sustainability.

On-demand shared mobility application for first-and-last mile is expected to help in the recovery of shared transport modes in post pandemic cities. The solution shall facilitate decision-making for optimal allocation of resources and thus support the planning of a resilient and sustainable transport system. A first-and-last mile solution shall help reduce the congestion on roads and reduce carbon dioxide emission in the city, there by supporting a city's reduction in carbon footprint.

CONCLUSION:

i-Connect is a user-friendly, all-in-one app that helps the user to get around the city in the fastest and simplest way by using public transportation along with various other features that helps in maintaining personal car users' dashboard on vehicle registration, license, insurance, toll tax, parking fee, and fines management. The solution is user-friendly and intuitive, with real-time traffic updates, predictive Artificial Intelligence-based routing and matching, integrated payments, and bringing optimized fleet together for all city transportation services under one platform. The app provides an automated and seamless customer and driver experience for both public transport and personal car users. It also provides configurable service parameters and flexibility, particularly for IPT-based first-and-last mile connectivity to public transportation.

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DISCLAIMER

As rapid urbanization and technologies are changing the mobility patterns of people, authorities must incorporate innovative approaches to transport challenges, as traditional mobility options have not been able to keep up. The main objective of developing the Smart Move: Innovative Urban Mobility Compendium is to showcase the ideas of young professionals, academics and student working towards improvements in the mobility sector. These ideas have been mentored by the industry's leading experts and have been continuously assessed on their progress for six months.

The compendium enables the teams to display their ideas so that it reaches a wider audience. The focus is on promoting innovation, and creating a repository of ideas. The compendium does not promote one solution over another but rather displays the ideas in juxtaposition, for users to understand and compare as per their needs. NIUA will be happy to facilitate any engagement requests with the finalist teams.

