The 4 I's of Data-Driven Multimodal Mobility Management

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Abstract

Automation, connectivity, electrification and shared mobility (ACES) are the four defining trends that are shaping up smart mobility.[1] In the future, connected vehicles and road infrastructure will be in two-way conversations, coordinating with each other for a cooperative intelligent transport system (C-ITS) resulting in increased flow, safety, and road capacity. Connected cooperative automated mobility (CCAM) will be more affordable, accessible and inclusive. Mobility as a Service (MaaS) will enable frictionless door-to-door journeys through integrated, on demand, shared and mass mobility services. Mobility ecosystem data will be the new oil powering multimodal transport networks.

This paper explores some of the key asks of traffic and transit agencies and operators in the context of multimodal mobility management. It highlights the opportunities to leverage mobility ecosystem data in the end-to-end value chain and identifies the key capabilities required by transport agencies and operators to realize these opportunities.

[1] Mckinsey Centre for Future Mobility, accessed March 16, 2021 https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/overview

Transform with the 4 I framework

As per the latest United Nation's World Urbanization Prospects report about 55% of the world's population lives in urban areas and this proportion is expected to increase to 68% by 2050.[2] With rapid rise in urban population, transport agencies and operators are faced with challenges of congested cities and constrained budgets limiting their ability to expand the infrastructure. Demand for seamless and interoperable services is increasing. However, stakeholders like agencies and operators serving the mobility ecosystem lack a holistic network view. There is an imperative need to improve the coverage and situational awareness of the transport network and multimodal services. This includes a need for proactive and effective planning for planned or unforeseen events and minimizing their impact on travelers.

Rapid adoption of connected on the move devices and systems in mobility ecosystems is generating large volumes of continuous and multi-dimensional data. This presents enormous opportunity for transport agencies and operators to leverage data in the end-to-end operations value chain. Data is critical to extract information for improving operations, increase interoperability, draw inferences and influence traveler's route, mode and time choices.

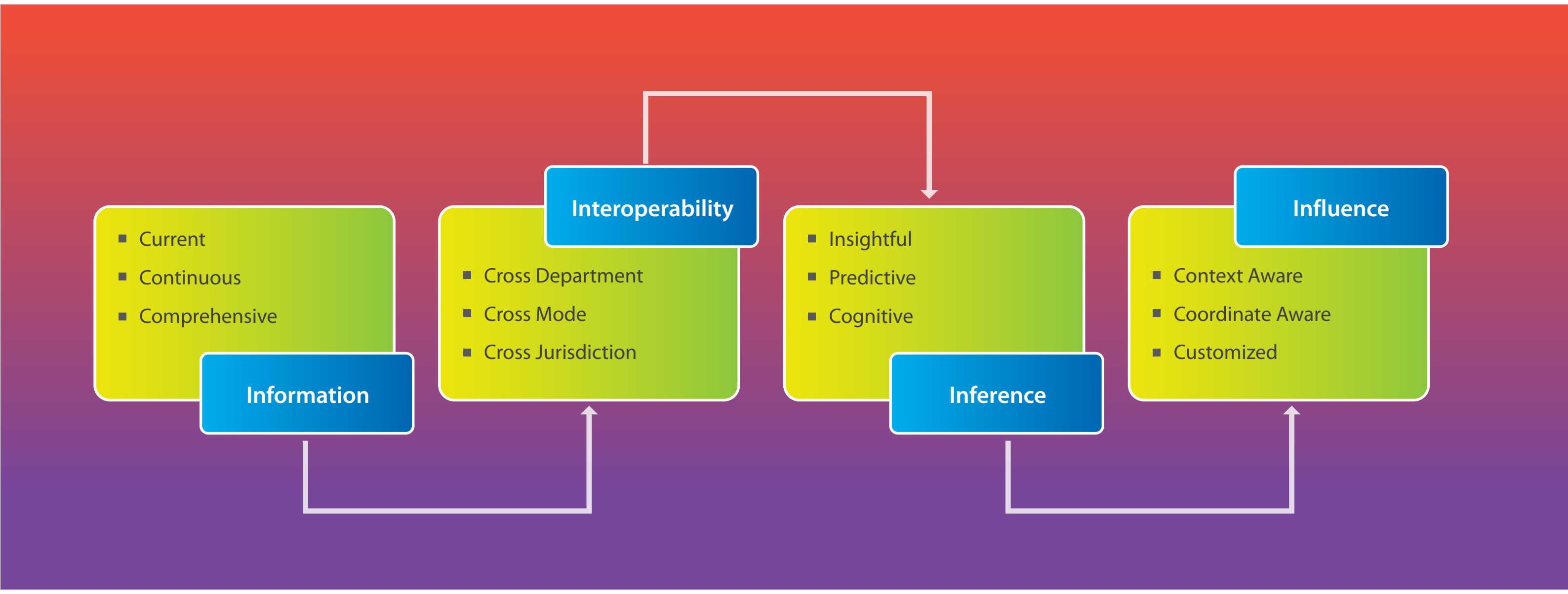

Figure 1: The 4 I's of Mobility Management

[2] United Nations World Urbanization Prospects (May 2018), accessed February 16, 2021 https://population.un.org/wup/

Information

Traffic and transit data sources are witnessing shift to mobile information sources like navigation devices and smart phones capable of providing speed and travel time information continuously along the route. According to a 2019 HIS Markit forecast report,[3] 12% of the light vehicle fleet produced globally in 2024, will be fitted with some form of vehicle-to-everything (V2X) system to support C-ITS capabilities. Transit operators are also exploring new ways to measure passenger occupancy and flow for more efficient operations. For example, Sydney Train is using carriage weight measurement sensors and Opal network card data to monitor train occupancy levels in real time. The information enabled it to evenly distribute passengers and pre-empt crowding through the train, maintaining passenger safety in the pandemic.[4]

Digital exhaust of connected vehicles and infrastructure will provide huge amount of real-time multi-dimensional, high-quality data with details of vehicle location, trajectory, and kinematics. The currency, continuity and comprehensiveness of this data will bring improvements in multimodal mobility management. This heterogeneous and voluminous data will need to be fused together in real time to improve quality of traffic and transit information, derive inferences on status of networks and services and to generate new insights on driver and traveler behavior. Organizations will need following capabilities to handle this data and derive information:

- **Scalable, flexible, reliable and on demand storage and compute services** to store and process large volumes of structured and unstructured data coming from multiple data sources.
- **Real-time streaming and processing** capabilities to ingest, process and fuse the data in real time managing varying network definitions, speed, sparsity and granularity.
- **Advanced machine learning algorithms and techniques** to increase confidence and reliability of data, spatial and temporal correlation, and knowledge derivation.

Interoperability

Seamless and agile mobility ecosystem will require highly synchronized planning and operations involving stakeholders across multiple jurisdictions, modes and departments in the entire travel value chain. It will require improvement in stakeholder communication,

[3] HIS Markit forecast for connected vehicles (May 16, 2019), accessed February 17, 2021 https://news.ihsmarkit.com/prviewer/release_only/slug/automotive-more-112-million-vehicles-will-be-equipped-v2x-communications-2024-ihs-mark

[4] COVID-19 pushes Sydney Trains to build occupancy reporting app for staff (May 27th, 2020), accessed January 10, 2021 https://www.itnews.com.au/news/covid-19-pushes-sydney-trains-to-build-occupancy-reporting-app-for-staff-548650

cooperative and collaborative network-wide service planning and coordinated operations. European Union member states have recognized this need for interlinking and interoperability of all elements of transport to provide a single European transport area and are setting up National Access Points[5] to help support easy exchange of transport related data and multimodal travel information. NordicWay[6] interchange node is one such concept which aims at a solution for future C-ITS services for exchange of road safety related messages across multiple stakeholders for advising commuters with aim to improve safety and fluency of the network and contribute to development of CCAM. The need for interoperability and standardization of data across all stakeholders in the MaaS ecosystem has been highlighted in the past by members of the MaaS Alliance.

To achieve these asks, easy exchange and reuse of real-time mobility data needs to be facilitated. This will require:

- **Harmonization and standardization** of diverse traffic and transit data by adoption of industry standard data formats like DATEX 2, NETex, SIRI and GTFS
- **Real-time and reliable information exchanges**
- **Open exchange of data**

Inference

Improvements in data currency, continuity, coverage, and comprehensiveness will bring enormous opportunities for authorities and operators to get spatio temporal insights on vehicles, locations, events and incidents, drivers and infrastructure assets and to draw inferences to increase safety, efficiency and reliability of the transport network and assets. Connected vehicle data can be used to infer traffic flows, road conditions and can act as virtual patrol to identify accident hot spot with increased danger of accidents to alert first responders and travelers. Transport Certification Australia's (TCA) is using telematics data to provide bridge heavy vehicle usage analysis to road managers.[7] MaaS ecosystem data can be leveraged by operators, public transport agencies, fleet managers and traffic managers to derive inferences and improve services.

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[5] *Monitoring and Harmonisation of National Access Points, accessed January 06, 2021*
https://eip.its-platform.eu/activities/monitoring-and-harmonisation-national-access-points

[6] *NordicWay – Pilot demonstration of C-ITS services for interaction between multiple actors in the Nordic region, accessed February 16, 2021*
https://www.nordicway.net/

[7] *Policy Paper on Government access to vehicle-generated data, National Transport Commission, Australia (December 02, 2020), accessed January 06, 2021*
http://www.ntc.gov.au/transport-reform/ntc-projects/government-access-vehicle-generated-data

Advanced analytics, artificial and cognitive intelligence has relevance in the entire value chain in traffic and transit management. To harness and harvest the power of data to its full potential, organizations will need:

- **Stream analytics:** Capabilities to process continuous stream of data and to identify patterns and anomalies in real time.
- **Advanced visualization platforms:** To derive real time spatial and temporal insights on traffic and transit networks.
- **Deep learning platforms:** Artificial intelligence and machine learning for machine vision, spatio-temporal correlation, pattern/ anomaly detection, validation and predictions.
- **Decision support systems:** Modelling and simulation using traffic/ transit data to forecast and plan for event/network change.

Influence

Always connected travelers would expect to know solutions such as the best route, mode and time choices for their journeys instead of just knowing about problems like congestion and service disruptions.

To enhance journey experiences and influence travelers, authorities and operators will need:

- **Context of journey:** Details of journey origin and destination, daily commute or tourism, urgency of travel and other such relevant information.
- **Space and time coordinates:** Services and traveler's spatio-temporal coordinates and associated information such as weather/environment status, restrictions and disturbances.
- **Customized preferences:** Understanding of the traveler preferences and requirements such as age, special ability, mode, social and environment preferences.

Nordicway's Dynamically Controlled Zones project demonstrates a future where in hybrid vehicles shift to electric mode as they approach dynamically controlled geo fenced zones with high pollution or noise levels. Real-time location of public transport buses contextualized with traffic information on the route can be used to avoid bus bunching /gapping episodes by controlling dispatches, alerting following drivers in real time and advising ETA to commuters to minimize extra waiting and for optimal utilization of bus capacity.

Operators will need to adopt open data and APIs and dynamic routing capabilities to be able to offer most efficient, economical and environment friendly route, mode and time choices based on location, context and preferences of traveler.

Conclusion

Finland's projects of NordicWay C-ITS, MaaS and FABULOS[8] highlight mobility's transformation to be highly connected, seamless, automated, agile and on demand. This will require agencies and operators to be equipped with current, comprehensive and continuous information on the state of network and services. Seamless, safer, reliable and sustainable journeys will require highly integrated, interoperable, predictive and proactive operations across stakeholders. This is a prerequisite to inform and influence traveler journey decisions. Authorities and operators need to embrace and prepare for a significant surge in data from connected vehicle, infrastructure and travelers. To exploit this data, they need to digitally transform to elevate their existing storage, processing, analytical, artificial intelligence and decision-making capabilities. They need to be able to derive real-time information, interoperability, inferences and influences in the end-to-end travel value chain of smart mobility.

[8] *FABULOS: Helsinki Pilot for Robot buses as part of urban public transportation, accessed February 25, 2021 https://fabulos.eu/helsinki-pilot/*

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