Use of 4D Digital Platform™ for Mobility

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Abstract

While the evolution of various forms of mobility, such as cars, have enriched our lives, there are concerns over deepening social problems related to road transport. This article focuses on the 4D digital platform™, which integrates many types of sensing data in real time to enable various predictions, and introduces our current effort and future prospects for solving social problems and creating value related to road transport centering on mobility, particularly regarding a cooperative connected-car platform.

Keywords: 4D digital platform, connected car, ITS

1. NTT's vision and activities in the mobility area

The evolution of various forms of mobility, such as cars, have enriched our lives. However, changes in social structures, such as declining birthrate, aging population, and population concentration in urban areas, have given rise to concerns over the following deepening social problems related to road transport:

- Increase in the number of traffic accidents involving the elderly
- Discontinuation of, or reduction in, public transport services in rural areas due to depopulation, and increase in the number of mobility-impaired people due to the elderly surrendering their driver's licenses voluntarily
- Traffic congestion in urban areas and resulting economic loss and environmental problems
- Increase in physical distribution due to e-commerce and resulting labor shortage in the logistics industry

Against the background of these social problems, automakers are conducting research and development (R&D) and demonstration experiments in collaboration with other industries to upgrade connected-car services and implement multimodal mobility as a service (MaaS). The Japanese government is also promoting R&D on common issues (cooperative domains) that need to be tackled through industry-academia-government collaboration. Advances in connected cars and autonomous driving have made communication networks an essential infrastructure for them.

The NTT Group is working to solve social problems and create new value through digital transformation of mobility. This article focuses on the four-dimensional (4D) digital platform™, which the NTT Group is now developing as a platform that can handle various types of data in an integrated manner, and describes value that the platform can provide for smooth road-traffic flow from the perspective of mobility, in particular, in cooperative intelligent transport systems (ITSs).

2. Background of the 4D digital platform

The remarkable advancement in information technology (IT) has enabled the collection of a large volume of Internet of Things (IoT) data and their analysis. Accordingly, the Japanese government and various companies are engaged in R&D with the aim of developing systems that merge cyberspace and the physical space, such as those proposed for Society 5.0. However, in the linkage of statistical data sets or

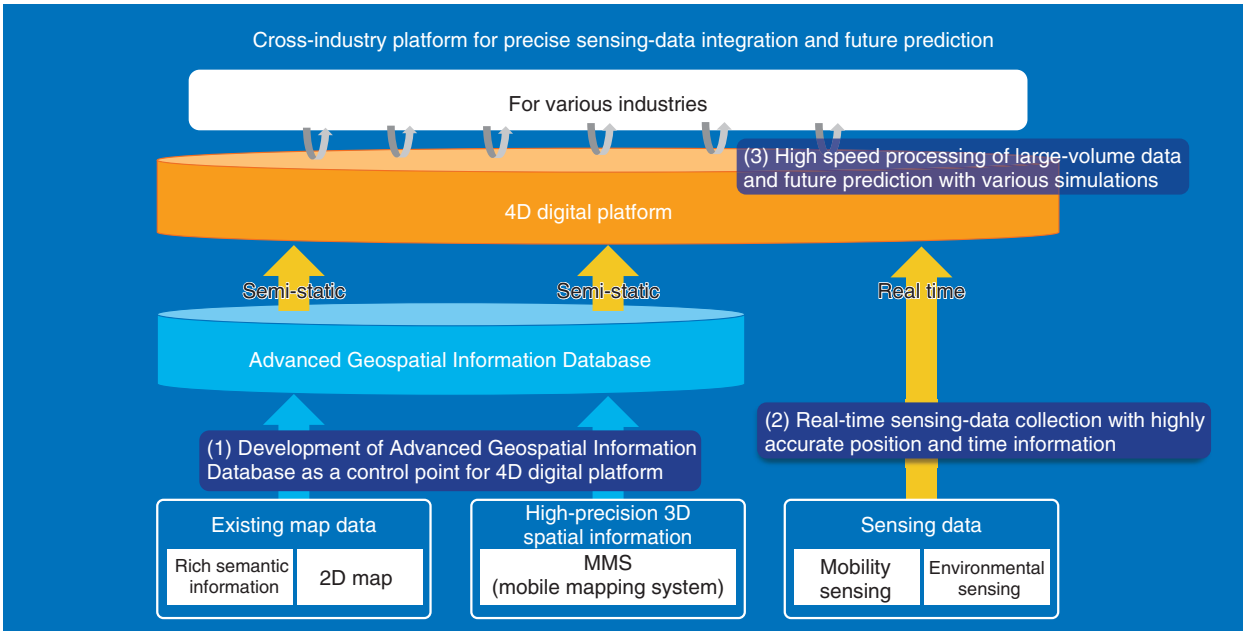


Fig. 1. Conceptual diagram of the 4D digital platform™.

the matching of misaligned position and time data, there are cases in which the accuracy of future predictions cannot be heightened.

To tackle this challenge, NTT has undertaken R&D of a 4D digital platform, making it possible to precisely integrate position and time information from sensing data in real time while also providing latitude, longitude, height, and time data useful for future predictions.

3. Overview and value creation with the 4D digital platform

As shown in **Fig. 1**, the 4D digital platform integrates sensing data in real time into the Advanced Geospatial Information Database with its highly precise and abundant semantic information and executes a variety of high-speed analyses. The following are three main features of the platform.

(1) Development of the Advanced Geospatial Information Database as a control point for the 4D digital platform
- Further improvement in the position accuracy for existing maps using the NTT Group's expertise in map data
- Development of high-definition 3D spatial information primarily for roads using a mobile mapping system (MMS) by applying infrastructure-management expertise

(2) Real-time sensing-data collection with highly accurate position and time information
- Technology, such as Smart Satellite Selection™ [1] (**Fig. 2**), that improves the accuracy of positioning and time synchronization in urban areas and real-time collection of accurate sensing data through high-speed, low-delay communications such as fifth-generation mobile communication systems (5G)
- Precise integration of sensing data into the Advanced Geospatial Information Database using mapping technology

(3) High-speed processing of large-volume data and future prediction through various simulations
- High-speed search and analysis of large-volume data sent simultaneously from moving objects by using the real-time spatio-temporal data management technology Axispot™ [2] (**Fig. 3**)
- Optimization simulation, future prediction, and behavior modification using artificial intelligence (AI) technologies

By combining the collection of high-precision sensing data and high-speed processing of large-volume data using this platform, we demonstrated the obtaining of precise and high-speed vehicle positions in real space that could not be achieved with conventional technologies.

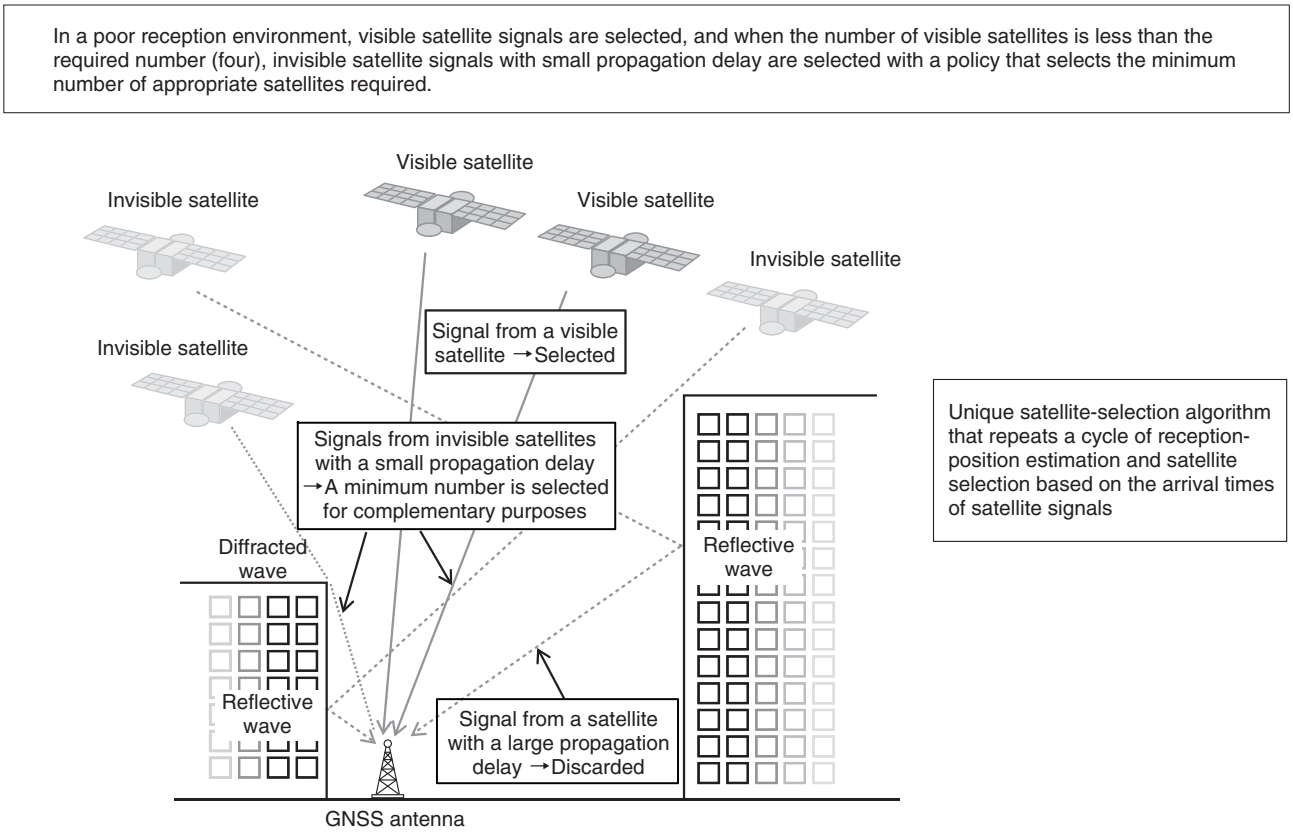


Fig. 2. Smart Satellite Selection™.

Figure 4 shows a demonstration of vehicle-position tracking on a per-lane basis by combining the aforementioned Axispot with Smart Satellite Selection to improve positioning and time synchronization accuracy in urban areas. In this demonstration, using the area near Kichijoji Station, Tokyo, as an example, plotting of vehicle position by satellite positioning and a search of the number of vehicles per lane were carried out.

With conventional technology (left in Fig. 4), satellite-positioning errors occurred in front of Kichijoji Station, which is surrounded by high-rise buildings, and the locations of vehicles plotted on the map were off the road. Furthermore, since it takes a long time to conduct a rectangular search for vehicles that match the lane shape, the number of vehicles could not be measured in time, and the final search result (number of vehicles by lane) was not correct.

In contrast, when the technologies of the 4D digital platform were applied (right in Fig. 4), the vehicle positions were correctly plotted on the map by high-precision satellite positioning, and rectangular search was conducted at high speed, so the search results for each lane were correct.

By combining these functional groups and data, we believe they will be used in a variety of fields such as road-traffic rectification, optimal use of urban assets, and maintenance and management of social infrastructure, as shown in **Fig. 5**.

4. Use of the 4D digital platform in the mobility field

As described earlier, the Japanese government is aiming to upgrade mobility services using information and communication technology (ICT) to solve social problems using future autonomous driving and create a society in which everyone can enjoy a high quality of life. To this end, it is promoting R&D of common issues (cooperative domain) that need to be tackled through industry-academia-government collaboration.

The NTT Group aims to enhance the efficiency and safety of urban transport by gaining an overall picture

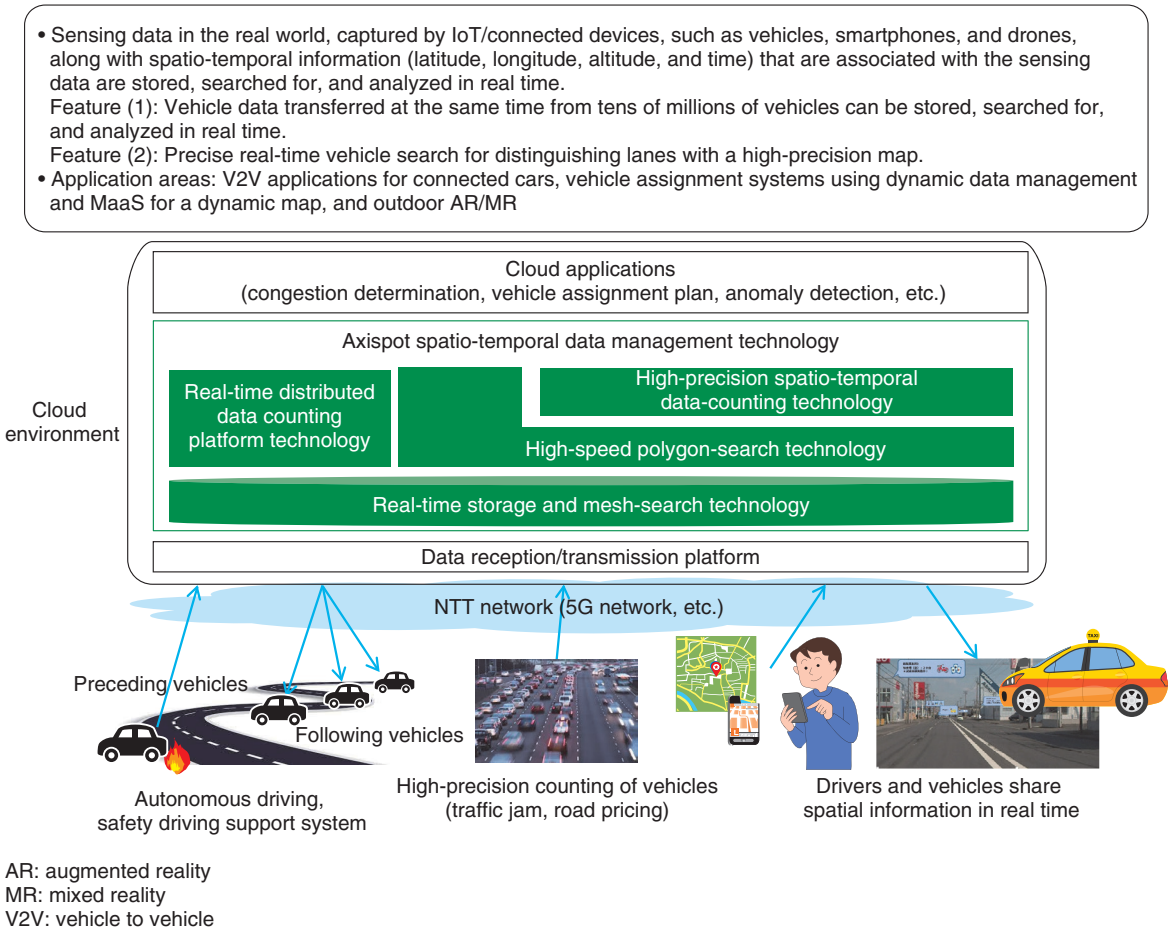


Fig. 3. Overview of the real-time spatio-temporal data management platform: Axispot™.

of traffic, which is considered difficult to achieve only with autonomous driving systems in individual vehicles. To this end, the NTT Group is aiming to contribute to the development of a cooperative connected-car platform, which handles vehicles and various data in an integrated manner using different types of communication (**Fig. 6**).

To achieve efficient and safe urban transport, it is necessary to build an efficient and high-speed network architecture, which is made possible by distributed processing platforms, and collect data on people, vehicles, and roads over a wide area using an overlay network. In the system layer, the 4D digital platform is used to store traffic-related sensing data in the Advanced Geospatial Information Database and correct (assimilate) the data so that traffic-related sensing data can be integrated with other types of sensing data and be searched for and extracted at high speed.

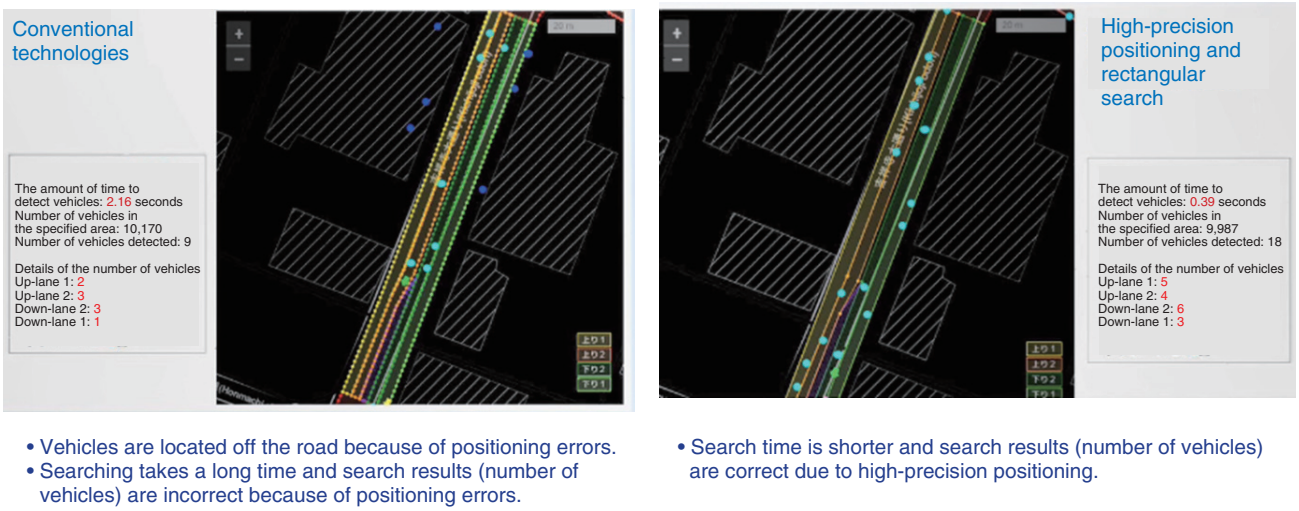
Data for which time and location are precisely aligned on the 4D digital platform will be used on the public-private partnership platform for ITS and mobility and on other industry platforms.

5. Use cases of 4D digital platform in the mobility field

The following describes what becomes technically feasible with the 4D digital platform when geographical traffic-related data are collected, aligned, and integrated on the platform. It also explains the R&D direction concerning the technologies used in these use cases.

(1) Reducing the number of traffic accidents

Dynamic dangers (objects fallen onto a road, pedestrian rushing into the road, and blind spots behind an idling car and at an intersection) can lead to serious accidents. One use case is to detect such dangers early, identify their positions quickly and



- Vehicles are located off the road because of positioning errors.
- Searching takes a long time and search results (number of vehicles) are incorrect because of positioning errors.

- Search time is shorter and search results (number of vehicles) are correct due to high-precision positioning.

Note: Pseudo data from a GNSS simulator was used for vehicle positioning.

Fig. 4. Axispot × Smart Satellite Selection.

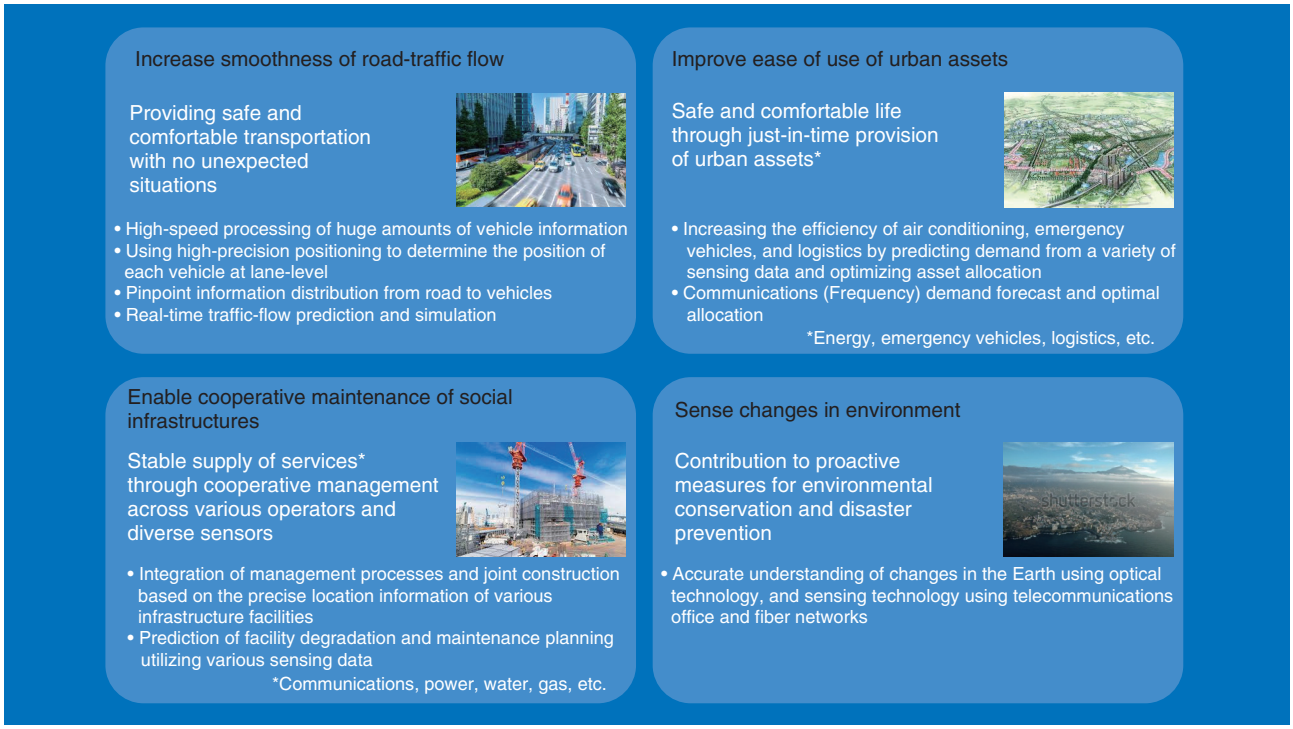


Fig. 5. Value proposition of the 4D digital platform.

accurately, and transmit information to nearby vehicles so that they can avoid accidents.

- From image data and vehicle-behavior data sent from vehicle-mounted cameras and roadside units, obstacles on the road are recognized in real time and their positions are accurately identified. Also, the area affected by the obstacles is estimated.

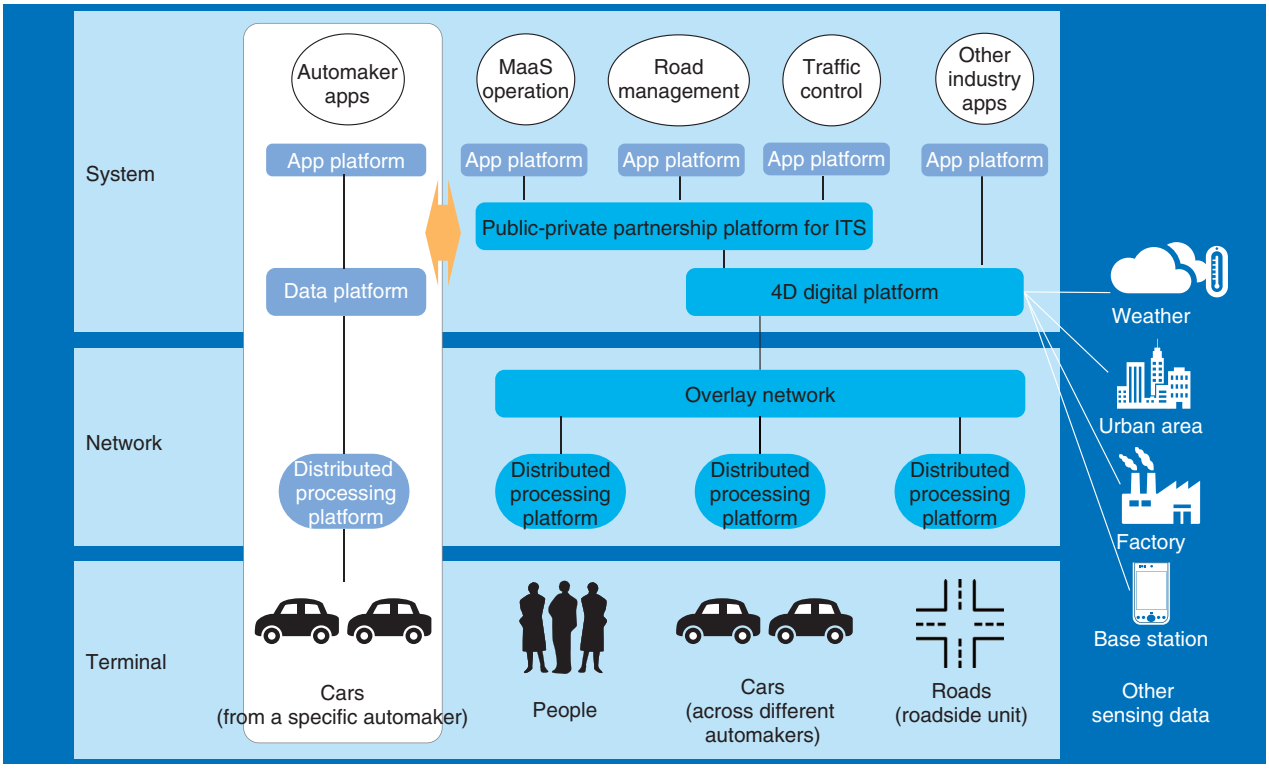


Fig. 6. Cooperative connected-car platform.

- Warnings are quickly sent out to vehicles so that they can avoid accidents.

(2) Reducing or resolving traffic congestion

Traffic congestion causes significant economic loss, particularly in urban areas. To mitigate traffic congestion, peak traffic volumes can be levelled off by controlling traffic signals to reflect the traffic volume and by configuring roads and lanes appropriately.

- Traffic volume is measured in real time using probe data and data from roadside units and by high-precision positioning.
- Traffic-congestion is predicted and congestion reduction using traffic-flow simulation that takes various environmental factors into account.
- Information for controlling traffic signals and for encouraging people to modify their behavior are transmitted.

6. Future prospects—ultimate level of mobility society through IOWN

With the Innovative Optical and Wireless Network (IOWN), which provides high-speed, low-latency, high-reliability networks and a high-speed processing platform, as well as the approaches and technologies described in this article, we believe it is possible to achieve the ultimate level of *harmonic mobility* with the highest level of safety and security and a society in which people, vehicles, and the infrastructure cooperate in a close-knit manner.

For example, overall optimized control along with autonomous driving control in individual vehicles will enable vehicles to cross without incident at a lightless intersection (**Fig. 7**). In the event of an accident or a disaster, vehicles can receive optimal guidance to minimize damage.

Achieving this comes with various challenges. We will pursue social implementation of the 4D digital platform by leveraging the characteristics of IOWN technologies as follows:

- Collect data using ultrahigh-speed low-latency communication and transmit calculation results to all vehicles
- Construct a network that spans the networks of multiple carriers using integrated ICT-resource allocation
- Calculate optimal solutions to enormous

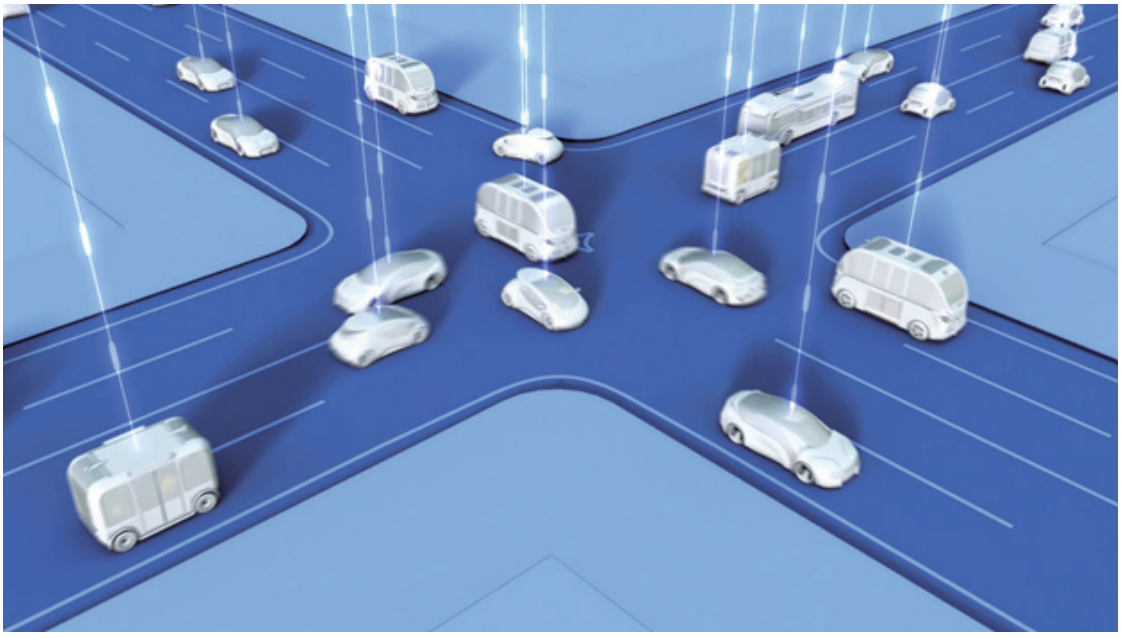


Fig. 7. Lightless-traffic-intersection management.

combinatorial problems using ultrahigh-speed information processing
- Collect and analyze accurate information about vehicles and surroundings in real time, including mapping of the vehicles and surroundings on advanced geospatial information constructed based on accurate positional reference points and generate precise predictions

7. Conclusion

The architecture for a cooperative-connected-car platform using the 4D digital platform and related technologies described in this article is extremely challenging. Various stakeholders, such as the government, automakers, map companies, and communications and IT companies, need to collaborate to study not only technical aspects but also business viability and social receptivity.

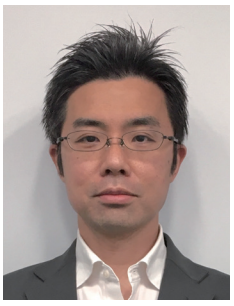
Since various unexpected events can occur in actual transport, we believe that all segments of society must work together to address mobility problems, including implementation of extremely sophisticated traffic control and traffic infrastructure, and conduct studies of legal systems and ethical issues.

With a view to providing platforms that support and services that enrich the lives of people, particularly concerning mobility, the NTT Group aims to make the most of its technologies, expertise, and assets toward this goal in collaboration with its partners.

References

[1] S. Yoshida, T. Kirihara, S. Tsuboi, T. Toyono, and T. Kuwahara, "Positional Information Service with High Added Value Based on Cooperation between GNSS and Networks," NTT Technical Review, Vol. 17, No. 6, pp. 8–12, 2019.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201906fa3.html

[2] M. Hanadate, T. Kimura, N. Oki, N. Shigematsu, I. Ueno, I. Naito, T. Kubo, K. Miyahara, and A. Isomura, "Introduction to Axispot™, Real-time Spatio-temporal Data-management System, and Its High-speed Spatio-temporal Data-search Technology," NTT Technical Review, Vol. 18, No. 1, pp. 22–29, 2020.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr202001fa3.html



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