INTERNATIONAL STANDARD

ISO 37184

First edition
2023-03

Sustainable mobility and transportation — Framework for transportation services by providing meshes for 5G communication

Mobilité et transport durable — Cadre pour les services de transport en fournissant des mailles pour la communication 5G

Reference number
ISO 37184:2023(E)

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Foreword

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This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 2, *Sustainable cities and communities - Sustainable mobility and transportation*.

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Introduction

5G is the latest generation of cellular mobile communication services, connecting multiple terminals and devices such as PCs and smartphones. Non-electronic objects can also be involved in 5G communication, when they are electronically recognized using methods such as QR-codes and face recognition by converting their images into electronic data. Thus, no matter whether things are digitally processed/processable or not, all items can be connected in 5G communication, which is characterized by high speed, negligible delay and large capacity traffic in data transmission, assisted with edge computing.

In 5G communication, carrier waves in high-frequency ranges are used, where many frequency channels had been vacant. However, high frequency waves are easily scattered by objects while propagating. This shortcoming requires building many base stations to successfully receive and forward waves.

Transportation services are the most widely networked to connect people, delivery items and freight to villages, towns, cities and large city zones with public roads, railroads and rivers or canals which have transportation facilities, i.e. streetlamps, traffic signals, signboards, bus stops, railroad instruments, stations, ports. Private and commercial vehicles are active wherever human activities are in place. Transportation facilities and vehicles are, therefore, operative places to install nodes with a transceiver for carrier waves. The facilities and vehicles statically or dynamically form local ad hoc networks of meshes which can organically be overlapped with backbone networks of 5G communication. This complements the current transportation services using 5G communication services, indirectly and effectively.

This document outlines how transportation facilities and vehicles can contribute to transportation services using 5G communication services by providing as many large and stable meshes as possible, as a means to support the current 5G backbone networks.

In the development of this document, ISO Guide 82 has been taken into account in addressing sustainability issues.

Sustainable mobility and transportation — Framework for transportation services by providing meshes for 5G communication

1 Scope

This document provides:

— a framework for transportation services using 5G communication by providing meshes;

— a description on expanding the service coverage of 5G backbone networks for transportation and mobility by applying meshes created in transportation facilities, vehicles and service dispatches;

— a service framework using infrastructure, vehicles and mobility service providers;

— a description on the effective transportation service for sustainable cities and communities.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Concept of framework for transportation services by providing meshes for 5G communication

4.1 Background

5G communication services are starting to become widespread worldwide to transmit more data by increasing the number of carrier wave channels. Since 3G and 4G communication mainly uses low frequency channels, most countries use high frequency ranges to adopt 5G communication by following 3GPP TS 38.104 V16.7.0. The frequency ranges used for 5G communication, which are normally 3,5 GHz to 3,8 GHz, are higher compared to those for 3G and 4G communication. Owing to the short wavelengths of the carrier waves in 5G communication, the waves can be easily scattered while propagating and drastically attenuating. To gain wave signal amplitude or power for longer distance transmission and expand the service coverage, more base stations should be built up, but they require sufficient power supply and large premises for operation, which results in increased capital costs. As the service areas remain limited due to such reasons, 5G communication has not yet become common worldwide.

As transportation systems already have dense and large networks, it is expected that transportation infrastructures can be used as places to install small cells for mesh networking to enlarge 5G communication coverage. Small cells, the size and weight of which are minimized, can be simply placed at as many spots as possible to locally process communication signals. Such a small cell, called a mesh node, forms a mesh. Meshes overlap with each other and generate mesh networks. Individual meshes and mesh networks further overlap with the current backbone networks of 5G communication.

Wherever human activities take place, transportation is used. Every city has transportation vehicles and facilities such as bus stops, rail stations, ports, airports, public roads, railroad tracks, transportation operators' buildings, service facilities and related commercial architecture, even if the transportation operation and service scale depends on populations and population density, as noted in ISO 37154:2017, 5.2 to 6.2. Lampposts, traffic lights and signboards as well as electric and signalling poles are built on public roads and railroad tracks and their entire networks extended in a city or a large city zone. Thus, as mentioned earlier, transportation vehicles and facilities are good places to install mesh nodes. Mesh nodes, which are characterized by small and light device scales and low power consumption, are also low maintenance. A mesh node has a low coverage of about 150 m area in radius. However, a number of meshes created by placing many mesh nodes forms large networks. Vehicles effectively help in dynamically forming meshes by moving. Smartphones can also create meshes, if the phone has high enough power to perform routing. Thus, walking is still good transportation contributing to mesh formation as people with phones spread in a city.

4.2 Meshes and mesh network creation and connection to 5G backbone networks

The number of meshes that are created with many mesh nodes placed in transportation facilities and vehicles, can work to automatically route communication signals in and between meshes organically overlapping each other. In the mesh networks, a signal wave launched from a mesh node runs by hopping from node to node to find the shortest way to reach gateways to/from 5G backbone networks.

The communication services in the meshes and mesh networks are provided additionally and adaptably to the current 5G communication services. Thus, the mesh communication does not negatively affect the 5G communication technologies and services. The meshes should be adaptive and agile to realize dynamic adjustment and optimization of network configuration efficiently.

Smart transportation by providing meshes are designated targeting a means to support the current 5G backbone network of contributing to transportation services using 5G communication services. Predictably, with the development of communication technology in the future (e.g. 6G, 7G), smart transportation by providing meshes in communication should be rearranged accordingly.

4.3 Target city issues and effectiveness of transportation services by providing meshes

City residents and visitors require stable communication and high-speed and high traffic data transmission when they use transportation services. 5G communication can fulfil this demand, but the service area is currently limited. Smart transportation services, by providing meshes, accelerate service area expansion and assists customers in enhancing their access through such upgraded communication services. In addition to the fundamental demands on communication and transportation business requirements, the following examples demonstrate the use of smart transportation services providing meshes for 5G communication.

EXAMPLE 1 Automobiles operate on public roads autonomously by the availability of information on obstacles and current positioning. Smart transportation services, by providing meshes for 5G communication, provide reliable information on traffic and delays that satisfy such requirements. This information should be provided to vehicles on all roads. Smart transportation services will extend the operation areas by expanding 5G communication service areas.

EXAMPLE 2 It is not easy to track bus and truck services running between stations or terminals as it is costly to install and maintain wayside monitors at short intervals. However, the fleet information collected in real time with smartphones in 5G communication enables tracking and controlling bus and truck dispatches for on-time operation. This meets the needs of customers who want to travel or ship and receive delivery items and freight as planned or scheduled. Such service tracking is available when service routes are sufficiently covered with 5G communication.

4.4 Meeting the sustainable development goals (SDSs)

Smart transportation services aim to make city life and activities for citizens and transportation customers more convenient, which meets the following UN-SDGs: goal 8 ‘Decent work and economic growth’, goal 9 ‘Industry, innovation and infrastructure’, goal 10 ‘Reduced inequalities’, goal 11 ‘Sustainable cities and communities’, goal 12 ‘Responsible consumption and production’ and goal 15 ‘Life on land’.

5 Adoption of framework for transportation services by providing meshes for 5G communication

5.1 General

Organically overlapping individual meshes with each other to form mesh networks and connecting the networks to 5G backbone networks are the goals of a framework for transportation services by providing meshes for 5G communication. In the meshes and mesh networks, transportation facilities and vehicles are used as places for automatic routing in meshes and connection to 5G backbone networks. All mesh nodes and gateways should not affect end-to-end communication through meshes or be affected thereby whenever joining and leaving the meshes. The meshes should be designed to be highly robust since they are connected to the backbone networks which are already established and serviced. Such functions are known as integrated access and backhaul, as designated in 3GPP TR 38.874 v16.0.0.

Even in a small village or town, there are bus vehicles and stops, streetlights, road signs, motorbikes, as well as automobiles that can work as routing points by attaching to mesh nodes. If protocol translation software is installed together with mesh nodes, such transportation facilities and vehicles can function as gateways to pass signal waves to/from 5G backbone networks. In a mid-sized or large city, there are more transportation services with a higher number of trains, rail stations and other operation facilities, with which larger transportation networks are organized. Thus, transportation network scales depend on local populations, i.e. transportation networks are ready-to-use for mesh provision and mesh networking which match their 5G communication markets.

5.2 Promotion of transportation services

To extend the smart transportation services, revenues for transportation operators can be provided by telecommunication customers and companies. This accelerates the operators’ contributions to mesh networking using their transportation facilities. It is still effective to invite citizens and transportation customers, not as the service users, but as the service supporters, to the smart transportation services, by requesting that they equip mesh nodes on their personal vehicles. To promote this, incentives can be offered to mesh node holders, such as discounts on 5G communication fees. Fiscal measures and tax incentives can also be offered by governments to encourage the smart transportation services and make the communication viable this way as public infrastructure.

6 Security in transportation services by providing meshes for 5G communication

6.1 Data transmission performance by transportation services

To secure 5G communication in the meshes provided with transportation facilities and vehicles, specific conditions should be satisfied. Massive data are transmitted in real time at high speed without failure within a mesh and from mesh to mesh where individual meshes, including ones dynamically created, are integrated. The data transmission should be protected from cyberattacks since 5G communication is used in highly secured operations such as autonomous vehicle transportation, which aims at no collisions or accidents on public roads by communicating with other vehicles and obstacles on real time.

When meshes, mesh networks and gateways are malfunctioned or damaged, the communication passing such points and networks will be disturbed or disconnected. To avoid the situation rather than essential mechanical failure of small cells, the batteries should be periodically replaced with new ones or those used which work for the period longer than the lifetime of small cells.

As the meshes provided by smart transportation facilities and vehicles are involved in 5G communication, data transmission in the meshes should be:

— in non-centralized end-to-end transmission modes;

— with large transmission traffic capacity, which is over 10 GB and 1 GB for downlink and uplink, respectively;

— at high speed more than 1 GB/s;

— by online or offline;

— with low latency, e.g. less than 5 ms for vehicle-to-vehicle services (e.g. car, bus or truck);

— at high efficiency;

NOTE Public-key cryptography works on highly efficient and latent data transmission, by dynamically using public and private keys and matching fields.

— without being tampered and negated;

— with easy-to-handle information collection, transmission and publication;

— at low cost.

6.2 Data transmission security for transportation services

6.2.1 General

Ensuring security is the most important procedure in smart transportation services, since it is related to resilience: the capacity to perform its mission or critical functions despite risks posed by cyberattacks as mentioned in 4.1 and 6.1, especially when dynamically created by vehicles and moving objects such as pedestrians.

As some transportation services and operations rely on 5G communication, the communication in the meshes should not be malfunctioned or attacked by terrorism. Therefore, security should work at least:

— in real time;

— dynamically;

— for any terminals, even if mobile;

— without forgery;

— without repeatable transmission;

— non-disavow;

— free of damages (e.g. sensing and positioning devices).

To ensure highly secure communication in the meshes provided by smart transportation facilities and vehicles, by retaining high-speed and low-latency data transmission performance, data should be encrypted by quickly switching to/from handshake, authentication and encryption. Reducing the costs for setting-up, operation and maintenance of the security should be taken into consideration as well. The encryption applied in data transmission in the meshes should use:

— asymmetric public keys;

— keys with large capacity;

