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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet of things and smart cities and communities – Requirements and use cases

Accessibility requirements for smart public transport services

Recommendation ITU-T Y.4211

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Recommendation ITU-T Y.4211

Accessibility requirements for smart public transport services

Summary

Recommendation ITU-T Y.4211 specifies accessibility requirements for smart public transport services. The concept of accessibility in public transport services has been mainly concerned with eliminating physical barriers such as adopting accessible trains and buses that allow wheelchair accessibility by mechanical lowering-entrance floors. In smart public transport services, the use of Internet of things (IoT), when properly designed, may increase accessibility of public transport services by providing access of information and physical accessibility. The IoT can be used to create tools for persons with many types of disability and specific needs, including physical, visual, hearing and cognitive disabilities. In order for the smart transport services to appropriately provide accessible services, information about accessibility profiles must be agreed upon in advance. Such accessibility profiles should basically include information on accessibility needs while travelling on public transport services.

History

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Introduction

Many persons with disabilities (PWDs) have difficulty in using public transport. Transportation issues also apply to persons with age-related disabilities and those with specific needs, which include temporary disabilities as well as literacy difficulties. If the use of public transport is challenging, PWDs and those with specific needs would be socially disconnected and their quality of life would, as a result, be degraded. Thus, mobility rights are an important issue for PWDs. The use of the Internet of things (IoT), when properly designed, may increase accessibility to smart public transport services by providing appropriate information. This information can be used by persons with many types of disability and those with specific needs. In order for smart transport services to appropriately provide accessible services, information on the type of disability profiles must be agreed upon in advance. Such accessibility profiles basically include information about the accessibility needs of PWDs while travelling on public transport services.

Recommendation ITU-T Y.4211

Accessibility requirements for smart public transport services

1 Scope

This Recommendation specifies accessibility requirements for smart public transport services.

This Recommendation includes:

– accessibility requirements for smart public transport services for persons with disabilities (PWDs), persons with age-related disabilities and those with specific needs to utilize the benefits of Internet of things (IoT) applications and services;

– accessibility profile requirements for accessible smart public transport services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4204] Recommendation ITU-T Y.4204 (2019), *Accessibility requirements for Internet of things applications and services.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 accessibility [b-ITU-T F.791]: The degree to which a product, device, service or environment (virtual or real) is available to as many people as possible.

3.1.2 accessibility feature [b-ITU-T F.791]: An additional content component that is intended to assist people hindered in their ability to perceive an aspect of the main content.

3.1.3 assistive technology [b-ITU-T F.791]: Piece of equipment, product system, hardware, software or service that is used to enable, maintain or improve functional capabilities of individuals with disabilities.

3.1.4 Internet of things (IoT) [b-ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.5 person with age-related disabilities [b-ITU-T F.791]: A person with cognitive or physical disabilities caused by the aging process. Examples are impaired eyesight, deafness in varying degrees, reduced mobility or cognitive abilities.

3.1.6 person with specific needs [b-ITU-T F.791]: Includes persons with disabilities (PWDs), persons who are not literate, those with learning disabilities, children, indigenous people, older persons with age-related disabilities, and anyone who has a temporary disability.

3.1.7 platform accessibility feature [b-ITU-T F.791]: Accessibility functionality provided as standard on a particular hardware or software platform.

3.1.8 profile setting [b-ITU-T F.791]: The ability for users to store and retrieve multiple profiles containing sets of user interface preference settings without having to reset them each time, including accessibility settings.

3.1.9 specific needs [b-ITU-T F.791]: This replaces the use of the term 'special needs'. This term refers to a wide range of categories including women, children, youth, indigenous people, older persons with age-related disabilities, persons with illiteracy, as well as persons with disabilities (PWDs), see [b-ITU PP Res.175], [b-WTDC Res.58], and [b-WTDC AP] and clause 6.39 (of [b-ITU-T F.791]).

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 universal design: The design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. "Universal design" shall not exclude assistive devices for particular groups of persons with disabilities where this is needed.

NOTE – Paraphrased from [b-UNCRPD].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAC	Alternative Augmentative Communication
AT	Assistive Technology
GPS	Global Positioning System
ICT	Information and Communication Technology
IoT	Internet of Things
IPTV	Internet Protocol Television
PWD	Person with Disabilities
UI	User Interface

5 Conventions

In this Recommendation:

The expression "**is required to**" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The expression "**is recommended**" indicates a requirement that is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The expression "**can optionally**" and "**may**" indicates an optional requirement that is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

The expression "**user**" indicates any public transport service customer who is using the service. The user can be any person with or without disabilities.

6 Accessible smart public transport services

In the UN Convention on the Rights of Persons with Disabilities (UNCRPD), Article 20 on personal mobility states

> "to ensure personal mobility … by facilitating access … to quality mobility aids, devices … including … making them available at affordable cost; … encouraging entities that produce mobility aids, devices and other assistive technologies to take into account all aspects of mobility for persons with disabilities." (p. 12 of [b-UNCRPD])

Also, in Article 26, it further mentions that:

> "States Parties shall promote the availability, knowledge and use of assistive devices and technologies, designed for persons with disabilities ..."(p. 17 of [b-UNCRPD])

Therefore, public transport service providers have been working on rectifying lack of accessibility in transportation. The concept of accessibility in transportation has been mainly concerned with eliminating physical barriers such as the adoption of accessible trains and buses that allows wheelchair access by mechanical lowering-entrance floors. Smart services for public transport that make usage of the IoT, when properly designed, may increase accessibility. This can be done by providing information that can be used by persons with various types of disabilities including physical, visual, hearing and cognitive impairments. For example, persons with visual disabilities may purchase a bus ticket by using their smartphone with accessibility features already set up. Persons with physical disabilities may use their computer to search the route and any accessibility information about the train services prior to leaving home. Persons with hearing disabilities could receive an alert message through their smartphones activated by the message as it is broadcast on the speakers of a train station. Such features not only increase the accessibility for PWDs, but also expand usability for everyone, including persons with and without disabilities.

Smart services embedded into the existing public transport system would improve service quality radically. Such smart public transport services will include various passenger services. However, the level of sophistication of different services may vary. The most elementary service may be a simple presentation of information, such as timetables, stop locations and terminal information, route and fare information, and any notice of exceptional conditions. More sophisticated services may include automatic ticket purchasing, finding the best route, arrival and departure information and information on how crowded a vehicle is. There will be many other creative services under development for future introduction.

As anticipated, IoT can be utilized in smart public transport services. IoT is defined in clause 3.1.4. IoT may be used to recognize the information and communicate it to passengers and service providers. It can also assist in the integration of communication, control and information processing across various transport systems.

Each state has its own public transport service systems. A centralized service system might provide different public transport services such as bus, train, metro and tram. Others might have independent providers for each service. Moreover, a provider of smart services may differ from a transport service provider. Thus, in order for smart transport services to appropriately provide accessibility, information on a set of accessibility profiles must be agreed upon in advance, which basically includes information on accessibility while travelling through a public transport system, e.g., wheelchair accessible departures and arrivals at train stations and timetables of low-floor buses on specific routes.

Even though the public transport ecosystem may involve various players, passengers do not need to know whether systems are integrated. A smart public transport system seeks to create seamless services no matter how the underlying operational systems are organized. To achieve this goal, a vast

amount of information must be exchanged among public transport service providers. From the accessibility standpoint, such information includes passenger accessibility needs and preferences, and the service provider's list of accessible services including detailed information. When enough information is obtained, smart public transport services can provide the most convenient means of travel while taking into account user needs and capabilities.

There are significant barriers to the use of public transport by some PWDs. Some of the most salient problems of the public transport services for PWDs include safety, frequency and reliability of services, connectivity and transfer between the departure location and other bus stops and train stations in the absence of direct services.

Information that needs to be provided prior to travel for PWDs mostly concerns access to specific services. This includes the provision and location of lifts at metro stations, the availability of clear signage for persons with vision impairment, the use of audible announcements for persons with hearing disabilities, the availability of amenities including accessible toilets and the capacity to access bus or train stations.

An environment ensuring appropriate pedestrian access to public transport services is also important. Thus, it is essential that walkways offer a direct and safe route to public transport and are free of obstacles that hinder access for PWDs. [b-ITU-T F.921] addresses these aspects with applicable audiovisual guidelines for designing and operating such pathways for persons with impaired vision.

Note that not all such barriers can be removed with the aid of IoT services. However, an IoT can provide efficient and economical means to remove at least some of the significant barriers.

Appendix II presents use cases indicating the needs for smart public transportation systems that benefit PWDs. The use cases serve the role of identifying accessibility requirements for smart public transport services. Clause 7 identifies accessibility requirements for smart public transport services. Clause 8 presents the accessibility profile requirements for smart public transport services.

7 Accessibility requirements for smart public transport services

This clause addresses accessibility requirements specific to smart public transport services. Accessibility requirements listed here are based on general IoT accessibility requirements as identified by [ITU-T Y.4204] and are categorized by functional areas of public transport services.

7.1 Overview of accessibility requirements for accessible smart public transport services

Concerning smart public transport services, which may provide personalized services to address each user's needs, the information that can be beneficial to PWDs and those with specific needs also needs to consider the content of the information in addition to the accessible interface. In this regard, the general accessibility requirements for IoT identified in [ITU-T Y.4204] are the basis for the requirements identified in this Recommendation. In the context of smart public transport services, those requirements can be classified into two groups, which concern the content of information and how the information interfaces with users. Therefore, a two-layer structure of the requirements for accessible smart public transportation is suggested.

[ITU-T Y.4204] provides general requirements for accessible IoT applications and services. Smart public transport services that incorporate IoT technology are bounded by the general accessibility requirements for IoT as stated in [ITU-T Y.4204]. Figure 1 summarizes [ITU-T Y.4204].

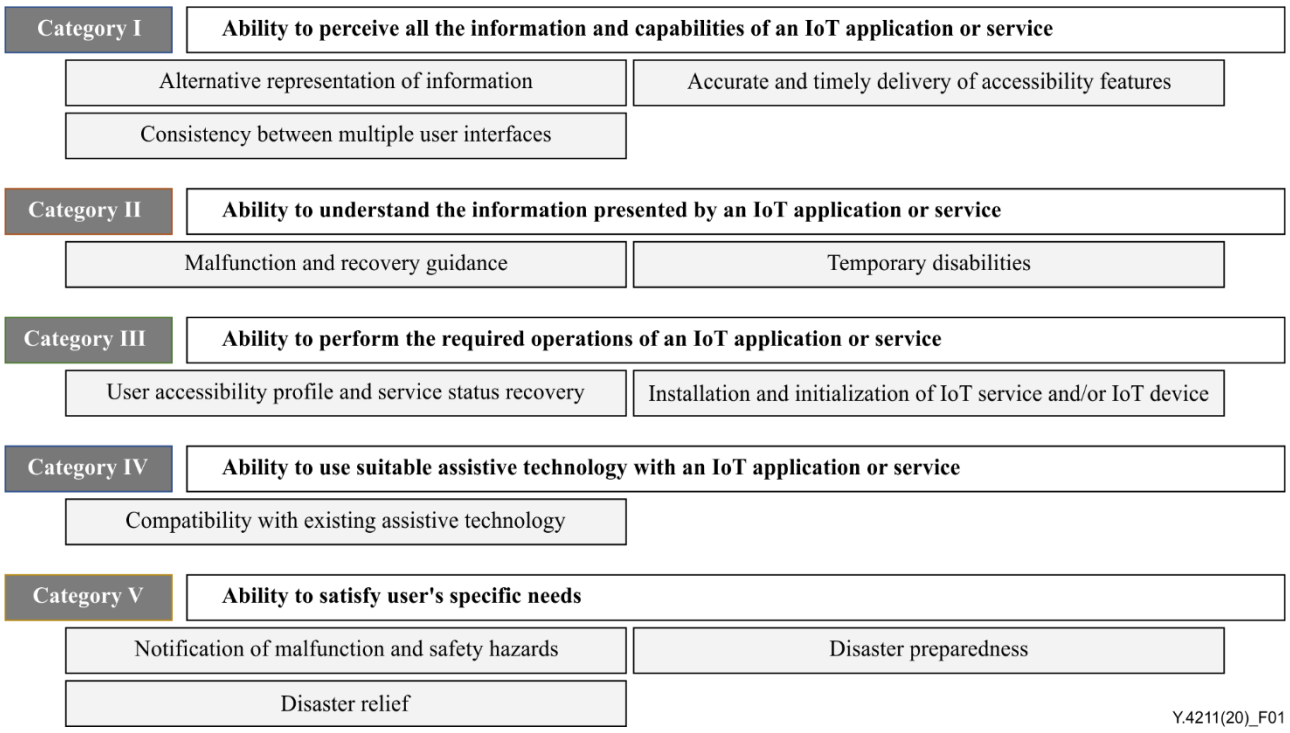

Figure 1 – Summary of IoT applications and services accessibility requirements (Source – [ITU-T Y.4204])

Categories I and IV of [ITU-T Y.4204] mainly focus on communicating information through a user interface (UI). Category I is about the ability to perceive information to communicate with IoT application. Ability to perceive information mainly focuses on operation and communication through UI. Therefore, Category I mainly focuses on requirements of accessible UI. Moreover, Category IV is about the compatibility with assistive technology (AT), which is also a type of UI dedicated to PWDs and those with specific needs.

However, just communicating the information perceivable and understandable to PWDs is not enough. The content of the information should consider a user's capabilities. Categories II and V of [ITU-T Y.4204] concern how the information should be prepared so that users can clearly understand the information. Requirements from those categories mainly focus on accessible information that should be understandable regardless of disability.

In addition, Category III of [ITU-T Y.4204] concerns both an accessible UI and accessible information. Use of a user profile and installation process for first time use of IoT devices must be accessible so that the UI is easily accessible, and, at the same time, information provided should be understandable.

To make smart public transport services accessible in accordance with [ITU-T Y.4204], all information presented to a user should be accessible. Meaning that the information should be presented in an audio and visual format, supporting sign language, braille, text-to-speech, and so on. Moreover, the information should also be prepared considering the user's specific requirements. For example, a pathway for a user using a wheelchair to a platform in an metro station may not be the same as that for one who can walk.

7.2 Two-layer structure of accessibility requirements

In this Recommendation, a two-layer structure is recommended for accessibility requirements that fulfil each user's specific demands for accessibility. Figure 2 illustrates the two-layer structure of accessibility requirements.

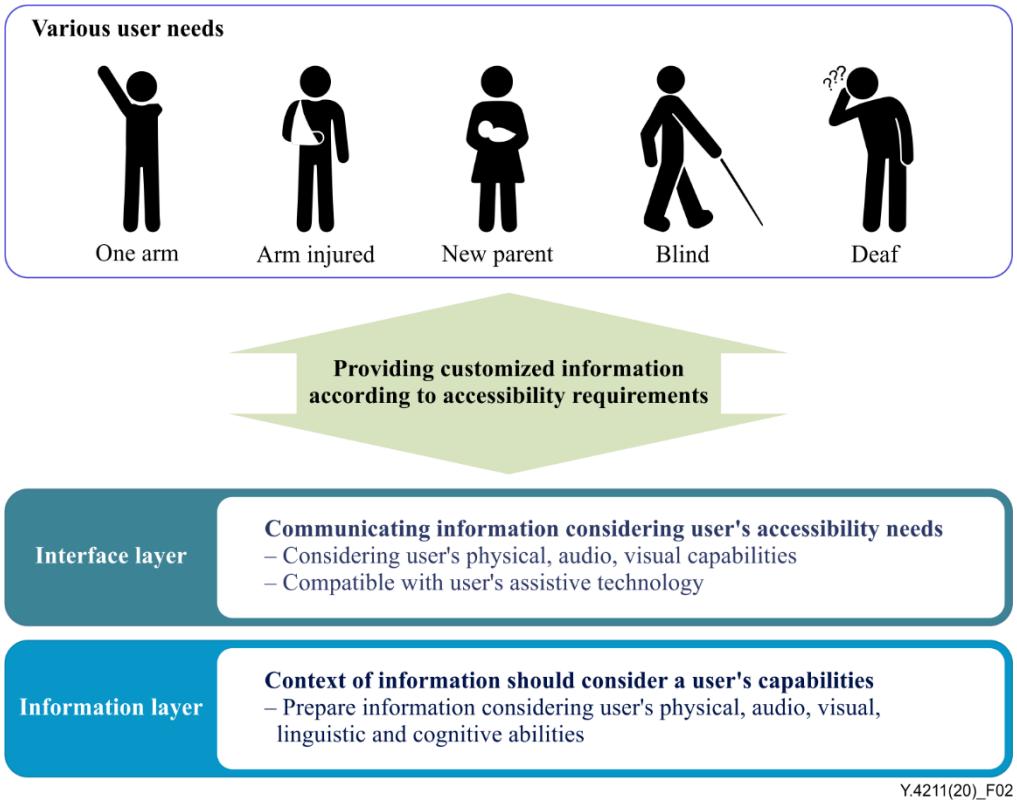

Figure 2 – The two-layer structure of accessibility requirements

To provide customized information using user accessibility requirements to fulfil various user needs, a two-layer approach is recommended. The first layer is the information layer, which prepares information concerning the user's physical, audio, visual, linguistic and cognitive abilities. Then the information prepared is manipulated in the interface layer, taking into account the user's physical, audio and visual capabilities, and considering compatibility with any AT used by the user. One benefit of using this two-layer approach is that, in many cases, information is prepared by the service provider or in a dedicated server and presented using a UI. One distinguishing characteristic of IoT is that various UIs can be used at the same time.

Figure 3 summarizes the concept of information layer.

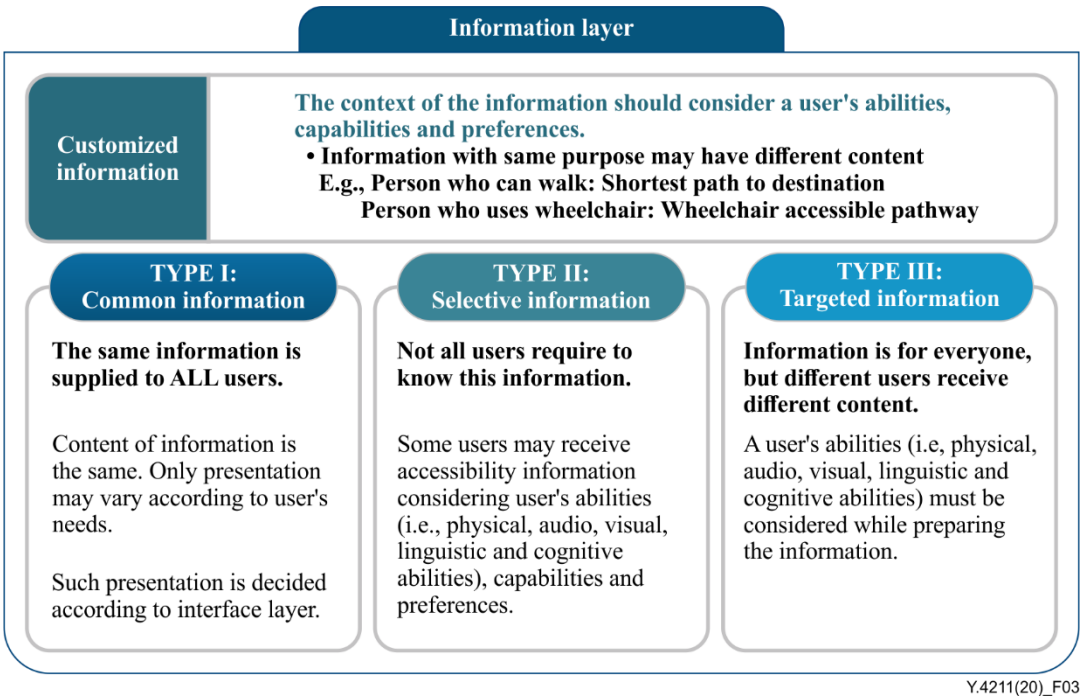

Figure 3 – Information layer

Accessible information required for PWDs can be categorized into three types, as follows.

The first type is common information (type I). The same information is supplied to all users. For PWDs and those with specific needs, only the presentation of the information needs to be accessible, but the content itself is common to everyone. This common information includes fixed and floating information. The common information may be announced to the public ahead of time, and does not change over a certain period of time. Therefore, many routine users are well informed. Examples of this type of information are location of a bus stop, a timetable, and a regularly scheduled vehicle route. This type of information is announced or posted to all users. It does not require any customization of content. The information is prepared and supplied to users in advance possibly through a pre-recorded announcement, printed material or a signboard. Floating information can be a specific announcement for special or abnormal events, such as an emergency or an accident. Such information cannot be prepared ahead of time. Also, it is critical to deliver prompt information to affected users. However, this information is also announced to all users, and does not require any customization of its content. Note that this information only concerns alert messages to users, not specific information on a course of action following an alert. A specific course of action in response to certain events may vary according to a user's capabilities, and thus, such information can be classified as selective information, which is explained in next paragraph.

Another type is selective information (type II). The accessibility information specific to PWDs and those with specific needs falls into this category. Not all users are required to know this information, and various users will receive different information according to their needs (including user-specific needs). For example, not everyone using public transport needs to know how to access assistance services for PWDs. However, those with disabilities who require such services for their journey need to know about service availability. Therefore, such information must be selectively supplied to users who need such information. A user's physical, audio, visual, linguistic and cognitive abilities must be considered when preparing the information.

The final type is targeted information (type III). Examples of such information are a route to a station or a stop and a route to a destination from the user's current location. This type of targeted information is for everyone, but various users will receive different content as needed. For example, there could be more than one access path to a particular station. The information is prepared according to each

user's requirements. A user's physical, audio, visual, linguistic and cognitive abilities must be considered when preparing the information.

In this Recommendation, accessibility requirements for smart public transport services are identified according to their functional areas.

NOTE – For details of the identified functional areas of public transport, see Appendix I.

In Table 1, accessible information needed for PWDs and those with specific needs for each functional area are listed according to the type of information discussed in the preceding paragraphs.

Table 1 – Type of accessible information identified for each functional area

Functional area	Accessible information needed for persons with disabilities	Type of information
Access to information and services	Access to customer services	I
	Service change notice	I
	Access to assistance services	II
	Toilet information	I
	Information to other service facilities	I
Journey planning	Route to destination	III
	Transit timetable	I
	Transfer information	III
	Station/stop location	I
Travel to point of boarding	Footpath to station or stop	III
	Wheelchair accessible path to station or stop	II
Finding the correct service	Route within the station	III
	Finding a platform or stop	III
	Transfer information	III
	Wheelchair accessibility	II
	Lift availability	II
Purchasing ticket(s)	Ticket purchasing and validating information	I
	Ticket office location	I
	Vending machine (kiosk) usage information	III
	Mobile ticket usage information	I
Boarding	Gap or step to vehicle	I
	Getting assistance from the driver	II
	Baggage checking	I
	Crowdedness of vehicle	III
In transit	Finding (assigned) seats	III
	Finding priority seats	II
	Access to audiovisual information (including signage)	II
Alighting	Notifying driver of alighting (bell)	I
	Upcoming stop information	I
	Claim checked baggage	I

Regardless of the type of information identified in the information layer, the information prepared may be presented through various UIs of the user's choice and availability. When communicating the

information with users, user preferences (i.e., whether the user prefers text, audio, sign language, braille, caption, etc.) should be considered. Then, the information is manipulated and presented through the UI according to user preferences or capabilities. The communication method should also be chosen by users. Figure 4 summarizes the interface layer.

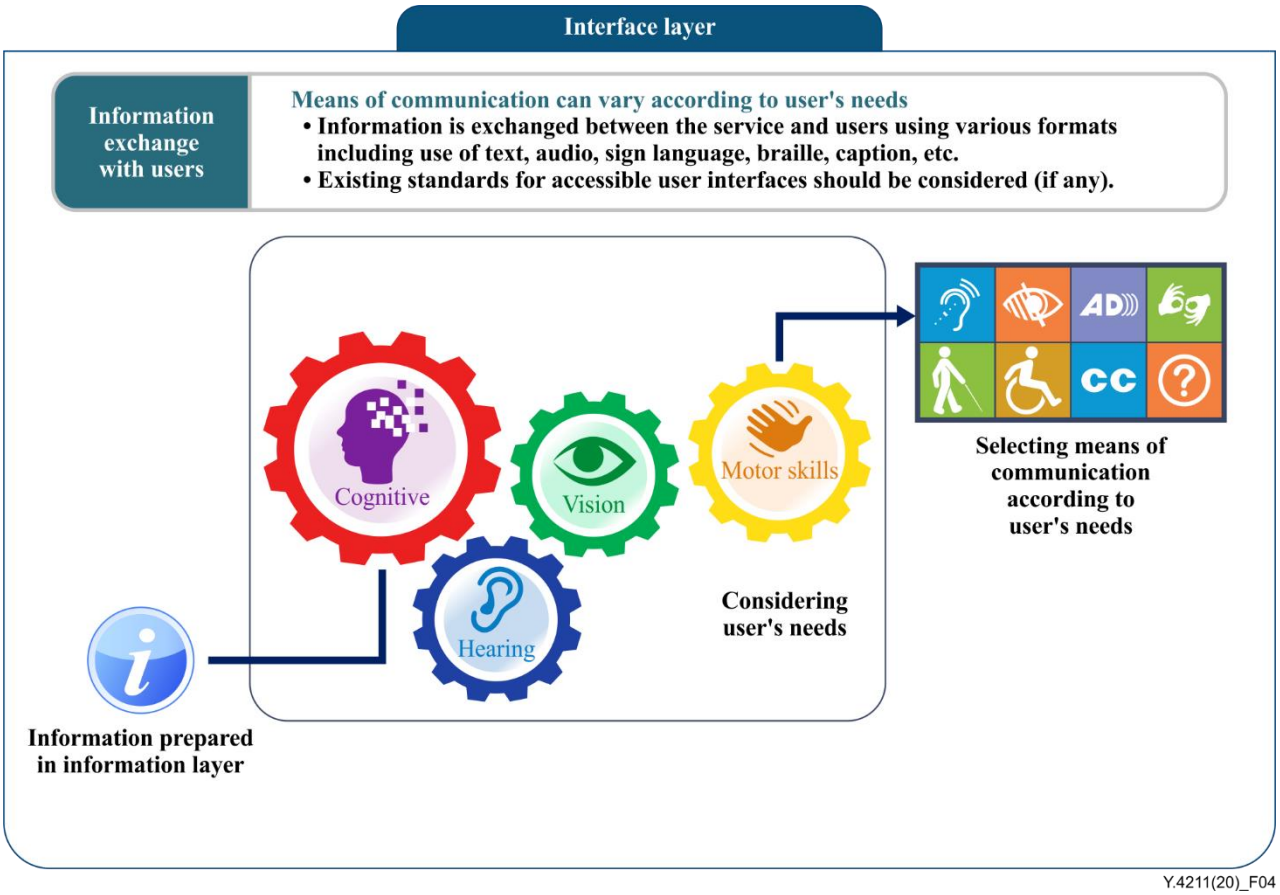

Figure 4 – Interface layer

7.3 Accessibility requirements for the information layer

In this clause, accessibility requirements for each type of information are presented.

7.3.1 Accessibility requirements applicable to all information types (I, II and III)

All types of information need to satisfy following accessibility requirements:

1) an expression that describes the same information is required to be consistent throughout the service;
2) an expression that describes the same information is required to remain semantically the same when translated into another language (including sign language);
3) provision of a means to control the level of exposure of the user's own sensitive information is required;
4) the content of information is recommended not to depend on specific senses (e.g., colour, sound and flicker) – however, if the content cannot avoid relying on a specific sense (e.g., a red-light image), provision of alternatives (e.g., a word "stop" in text format) is required.

7.3.2 Accessibility requirements for common information (type I)

Common information (type I) needs to satisfy following accessibility requirements:

1) provision without the assumption that the user has any prior knowledge or memory that is needed to understand it;

2) standard conventions, words and symbols used in any information are readily comprehensible;

3) provision is recommended with minimized interference with the user's social, cultural and geographical background;

4) provision is recommended using non-linguistic methods – where possible – to make it easier for users who do not understand language adequately.

5) where appropriate, provision in multiple steps with details addressing all steps, along with any sequential repetition at all steps.

7.3.3 Accessibility requirements for selective information (type II)

Selective information (type II) needs to satisfy following accessibility requirements:

1) identification of the user who is a recipient of selective information according to the user accessibility profile that is entered in advance;

2) clear information to the user when selective information is not available to the user whose accessibility needs are indicated in the accessibility profile;

3) on request of a user, provision is recommended of selective information on the following accessibility features:
   - languages supported by the service (including sign language),
   - wheelchair access support,
   - support for accompanying service animals,
   - availability of accessible facilities (e.g., toilets),
   - availability and types of priority services for PWDs,
   - availability of accessible vehicles (e.g., low floor or wheelchair lift-equipped bus),
   - availability and location of priority seats on vehicles,
   - fare reduction for PWDs,
   - availability of parental or guardian notifications,
   - availability of human assistance support (e.g., from bus driver or service personnel),
   - novice user assistance.

7.3.4 Accessibility requirements for targeted information (type III)

Targeted information type (type III) needs to satisfy following accessibility requirements:

1) on receipt, notification of the user that the information is provided according to the user's accessibility profile;

2) for users who are unable to understand the information provided in the default format, optional provision of the information in alternative layouts, as appropriate;

3) for location-based services, optional incorporation of the following information:
   - braille blocks linked with the information,
   - pedestrian risk factors, such as ramps, road width and obstacles, like stairs, walls and bollards,
   - wheelchair accessibility,
   - presence of any devices requiring operation on the move (e.g., door open push buttons);

4) for users who require full learning experience prior to usage of a specific service (due to developmental or cognitive disabilities or other reasons), optional provision of the following information:

– ability to store previous trip information (e.g., footpath, station or stop, route or transfer information),
– assignment of priority to known routes when planning a new trip,
– warning to user, parent or guardian when the user is off a known route;

5) on user request, optional provision of the following medical-related information:
– first aid kit availability,
– automated external defibrillator availability,
– location of medical office.

7.4 Accessibility requirements for the interface layer

Smart public transport services need to satisfy the following interface accessibility requirements.

1) Provision of appropriate presentation alternatives ensuring semantically equivalent visual or auditory information. In addition, two or more alternative means are recommended to provide for multiple disabilities.
2) Ability to provide information that can be expressed via appropriate alternative means (e.g., speech to text or image to voice) according to the accessibility profile set by the user in advance.
3) Provision of appropriate accessibility features for visual and auditory information according to the accessibility profile set by the user in advance.

Examples of accessibility features that visual information may provide are:

– appropriate brightness;
– colour change function, such as inversion and highlight;
– zoom function;
– glare avoidance;
– clear distinction between background and foreground;
– support for simultaneous operation of text and voice.

Examples of accessibility features that auditory information may provide are as follows:

– adequate volume;
– appropriate quality audio;
– control of audio properties, such as pitch, balance, volume and tone.

4) When the UI supports accessibility features (e.g., screen reading capabilities or screen-magnifying functionality), the service is required to be compatible with them.
5) According to the accessibility profile set by the user in advance, the following presentation features are recommended to be adjustable:
– fount size;
– colour of icons, buttons, etc;
– magnifying features;
– size of actionable elements;
– location and layout of controls.
6) Depending on the user profile, one of the following methods of feedback to the user in response to input is recommended to be selected and provided:
– audio;
– visual;

– tactile.

7) Depending on the user's choice, utilization is recommended of a user input method without using one or more of the following functionalities:
   – touch or very light touch;
   – speech;
   – simultaneous actions;
   – pushing with high force or continuous high force;
   – pinching;
   – direct body contact;
   – manipulation.
8) When using biometric information for user identification, provision of appropriate alternative means is required according to the user profile.
9) Compatibility of services with known assistive technologies is recommended.
10) If online services are not available due to lack of service coverage, the following essential features are required to be available even in offline mode:
   – latest timetable for the route the user is on;
   – location of the stop for alighting;
   – upcoming stop information;
   – connection information.
11) Depending on the user profile, the interface can optionally be configured with one of the following language support features:
   – default language:
   – one of the other supporting languages, including sign language (if any);
   – interface using non-linguistic expression (if any).
12) Depending on the user profile, only the previously learned or used transportation method can optionally be provided.

8 Accessibility profile requirements for smart public transport services

In this clause, accessibility profiles for smart public transport services are addressed. As an example, in Internet protocol television (IPTV), the service supports the ability to save and retrieve multiple profiles that contain a set of UI preferences and language settings, as it provides users with the ability to easily switch to different personal preferences without having to reset each time. User profiles are used as a tool for personalization. In [b-ITU-T H.702], the profile includes accessibility features such as captions, sign language and audio description settings.

Similarly, in a smart public transport service, an accessibility profile is a set of capabilities for accessibility to be implemented. This profile can be used in communications among different transport service providers within the same geographical locations, or between the information and communication technology (ICT) service providers and transport service providers. Figure 5 illustrates the use of an accessibility profile in smart public transport services.

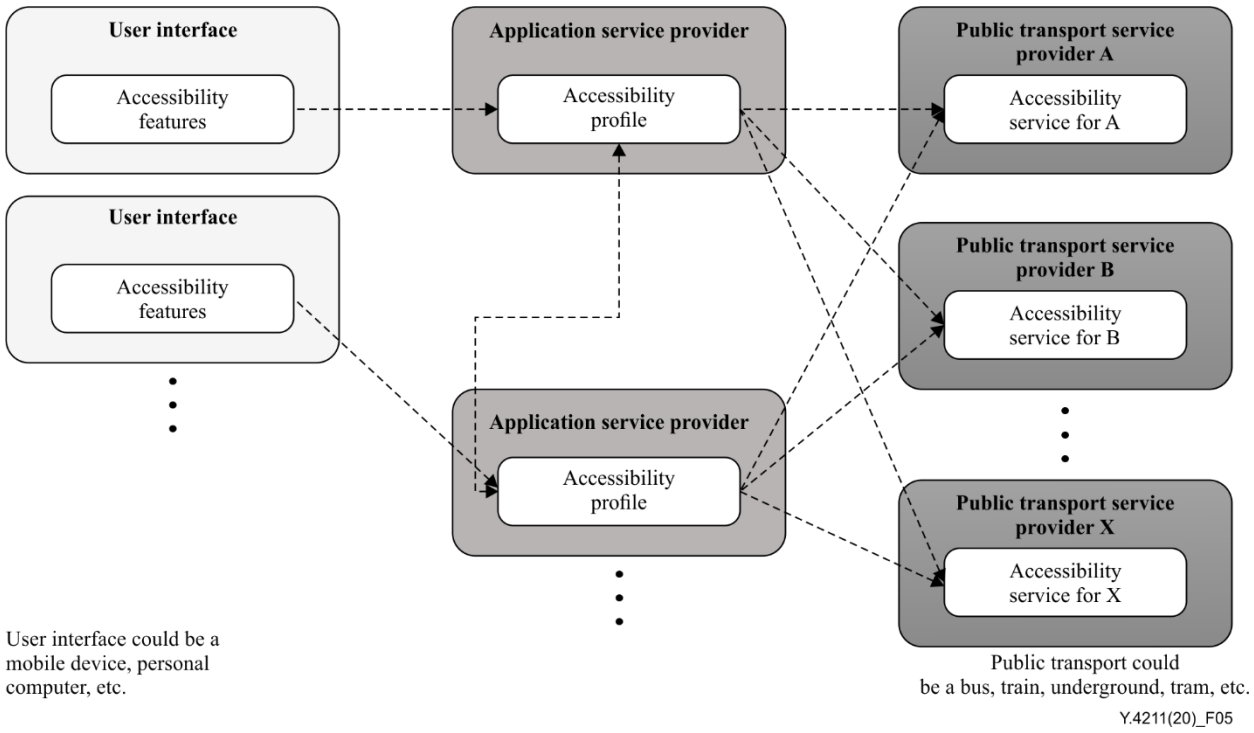

Figure 5 – The use of accessibility profile in smart public transport services

In order for smart transport to appropriately provide accessible services, user accessibility profiles must be known to service providers in advance. Such accessibility profiles basically include information on accessibility needs of PWDs while travelling on public transport services. Clauses 8.1 and 8.2 specify accessibility profile requirements for the information layer and the interface layer.

8.1 Accessibility profile requirements for the information layer

To support information requirements for smart public transport services, as identified in clause 7, the accessibility profile is required to identify the following user accessibility information:

– preferred language;
– use of walking aids (e.g., assistive canes, crutches, walkers);
– use of wheelchair;
– use of alternative augmentative communication (AAC);
– physical abilities related to mobility;
– communication abilities;
– health information (e.g., allergy, chronic disease).

8.2 Accessibility profile requirements for the interface layer

To support interface requirements for smart public transport services, as identified in clause 7, the accessibility profile is required to identify the following user information:

– ability to use camera on a personal communication device;
– preferences to AAC;
– degree of sensory utilization (e.g., sight, hearing, touch);
– mental functions (e.g., attention function, thought function, calculation function):
– communication ability (to understand, for example, sign language, verbal communication, how to send and receive text messages);
– ability to utilize complex gestures to control touchscreen-based devices.

Appendix I

Functional areas of accessible public transport services

(This appendix does not form an integral part of this Recommendation.)

Several studies have identified accessibility barriers to public transportation for PWDs, including older persons with age-related disabilities and those with specific needs. An early study [b-Griffin] pointed out that entrances must be fully accessible and provide convenient access for passengers.

PWDs, including older persons with age-related disabilities, find standing for any length of time uncomfortable or even impossible, so providing seating at appropriate points throughout the terminal is very important. [b-Sawyer] stressed that the provision of accessible toilet facilities in the building is important. In 2010, Malhotra (as cited in [b-Soltani]) conducted a study in accessible public transport, and suggested that highlighted priority seats for PWDs in the vehicle should be close to both the driver and to the entrance or exit of vehicles to ease communication with the driver and minimize the distance to be walked in the bus.

[b-Soltani] identified several areas that are the most problematic travel components. This includes walking to and from the terminal, buying tickets, finding the correct service, and boarding and alighting the vehicle. The authors also reported that there is a lack of standardization of accessibility for the provision of public transport information, including signage and audible announcements both in the terminal and the vehicle.

[b-Haning] also studied accessibility for PWDs in transportation through a survey. Many respondents provided suggestions to assist in increasing transport accessibility for PWDs. The most common responses were related to the pedestrian environment. With respect to public transport, the following common suggestions were identified:

– more carriages on trains to prevent overcrowding and to ensure more seats designated and reserved for PWDs;
– more frequent accessible buses;
– improved alignment of the vehicle step height with the curb or platform.

[b-Bezyak] also reported a number of public transport barriers. Further analysis uncovered significant differences in the experience of barriers in public transport according to the type of disability. The list of barriers reported includes drivers not calling out stops, no accessible route to a stop or station, driver's lack of knowledge, inability to navigate the public system, inaccessible stop or station, gap or step to vehicle and problems with lifts.

[b-Mashiri] scans the existing practices in both developed and developing countries relating to the provision of public transport information to PWDs. The contribution also provides an overview of the range of issues including technology features and the general environment that need to be taken into account in designing inclusive, robust, easily accessible and practical public transport information packages to facilitate ever-increasing and stress-free travel not only for PWDs, but for all passengers.

Pp. 151-154 of [b-NCD] also reported that policies should be implemented that support the availability of accessible transport modes, such as taxis, buses and trains.

Figure I.1 shows the journey cycle for PWDs and those with specific needs. According to Lafratta (as cited in [b-Soltani]), it is important to consider the journey cycle for a better understanding of the experience of the whole journey for PWDs. It also helps to know the problems faced by a person with disabilities and those with specific needs.

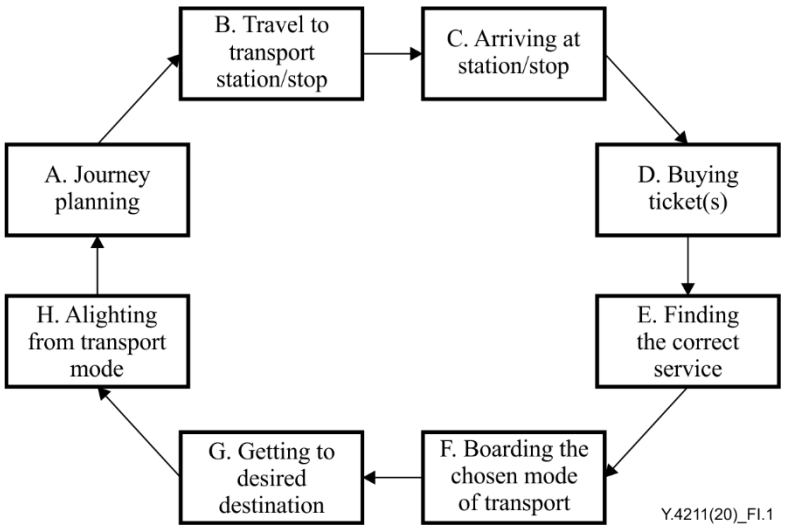

Figure I.1 – The journey cycle (source – Lafratta (as cited in [b-Soltani])

Based on the assessment of the existing studies cited previously, functional areas of public transport service and information that may be provided to enhance accessibility are identified and illustrated in Table I.1.

Table I.1 – Functional areas and accessible information needed for persons with disabilities for public transport services

Functional area	Accessible information needed for persons with disabilities
Access to information and services	Access to customer services Service change notice (alert, detour, schedule change (delay), emergency, hazards, etc.) Access to assistance services Toilet information Information to other service facilities
Journey planning	Route to destination Transit timetable Transfer information Station or stop location
Travel to point of boarding	Footpath to station or stop Wheelchair accessible path to station or stop
Finding the correct service	Route within the station Finding a platform/stop Transfer information Wheelchair accessibility Lift availability

Table I.1 – Functional areas and accessible information needed for persons with disabilities for public transport services

Functional area	Accessible information needed for persons with disabilities
Purchasing ticket(s)	Ticket purchasing and validating information Ticket office location Vending machine (kiosk) usage information Mobile ticket usage information
Boarding	Gap or step to vehicle Getting assistance from the driver Baggage checking Crowdedness of vehicle
In transit	Finding (assigned) seats Finding priority seats Access to audio/visual information (including signage)
Alighting	Notifying driver of alighting (bell) Upcoming stop information Claim checked baggage

Smart public transport services may provide at least some of the information listed in Table I.1 to improve accessibility. Much of the information listed in Table I.1 is straightforward, but items are often not explicitly provided. However, many PWDs find it difficult to obtain such information. Lack of such information may be considered a barrier to the use of public transport services.

NOTE – The accessible information items listed in Table I.1 cover only the principal elements. Many other services may be provided using IoT applications (i.e., more intelligent services using artificial intelligence technology, etc.).

Appendix II

Use cases indicating the need for accessible smart public transport services that benefit persons with disabilities and those with specific needs

(This appendix does not form an integral part of this Recommendation.)

In this appendix, some accessible smart public transport services use cases that benefit PWDs are presented as examples. Use cases are presented to explain the needs for accessibility when developing smart public transport services.

II.1 Use case 1. Person with low vision travel by metro

Mr Kim, who has low-vision, and works for an information technology company, needs to move to a business meeting in a location he had never been before. He decides to use the metro as the destination is close to a station. Although he knows exactly where he can find the assistive personnel at the station from where he departs, he is not sure about their location in the destination station. He is even not sure if the assistive personnel are available there or how to access such services in detail.

He uses a smartphone application that the metro service has provided. He has been using the application for a long time, and he has updated his accessibility needs to the application. He just enters his travel details including the destination station into the app.

Immediately, the application answers with the information that the assistive personnel service is available. He is told that his request for assistance has been received. When the metro train approaches the destination station, the mobile phone transmits a global positioning system (GPS) signal to the service personnel information indicating the exact location of the metro train he is on. Although not all stations have assistive personnel, it is possible to successfully deliver services by moving assistants from one station to another.

When he arrives at the station, a member of the assistive personnel is already there to assist him.

II.2 Use case 2. Person with a physical disability riding on a bus

See Figure II.1.

Mr A has a physical disability. Every morning, he rides on a bus to get to work. At home, he selects the departing and arrival bus stop, and the bus that he wants to ride. He uses his smartphone and makes a reservation. During the booking process, the smart public transport service acknowledges Mr A's specific requests and knows his needs using previously entered profile.

When Mr A arrives at the bus stop, his smartphone and the wireless communication terminal installed at the bus stop communicate with each other to confirm his arrival. The smart public transport service informs Mr A about the anticipated arrival time of the bus he wants to board through his smartphone. At the same time, the driver on the bus that Mr A will be boarding is informed of Mr A's reservation and his specific needs, so that the driver, can give Mr A proper assistance to board the bus.

When Mr A gets on the bus, the smart public transport service notifies the accessibility services of his boarding. When the bus is approaching Mr A's destination, the smart public transport service notifies Mr A with exit guidance information. At the same time, the bus driver is also informed that Mr A will get off the bus at a specific stop, so that Mr A can receive necessary assistance and the smart public transport service is also informed of the stop to greet Mr A.

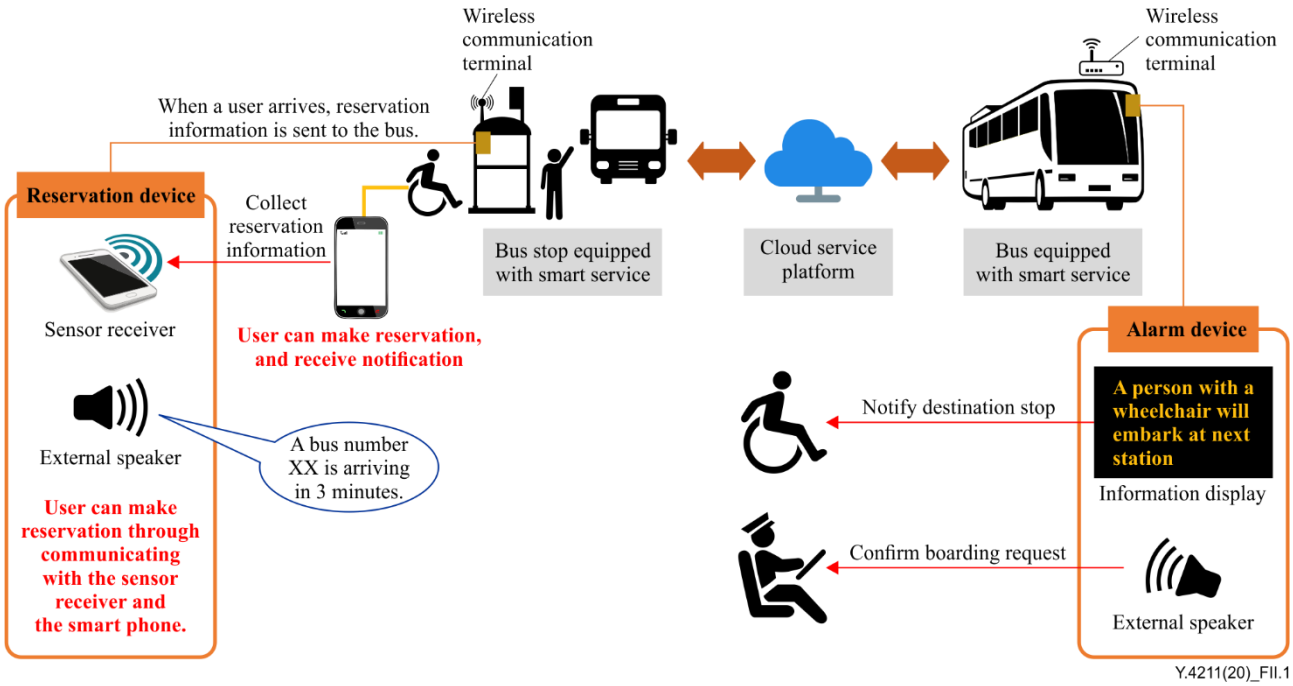

Figure II.1 – Service scenario of the bus trip assistance service for persons with disabilities

II.3 Use case 3. Finding a way to the metro platform

Ms. Jay, a person who uses motorized wheelchairs, must use lifts instead of stairs or escalators to move within a metro station, and must also use a ticket barrier that is wheelchair accessible.

The city where Ms. Jay lives provides a smart service including an interactive map of metro stations. The smart service has an application that guides the user through the most convenient route to the boarding platform from the user's current location. The users can use the service through a mobile application that is capable of tracking the user's location.

Ms. Jay would like to avoid stairs and ticket barriers that are not wheelchair accessible on her way to the boarding platform. So, Ms. Jay sets her accessibility preferences in her smartphone application in advance. The application provides the most convenient routes accommodating her accessibility needs. This is done by downloading details of and analysing the station's available accessibility services to her smartphone.

Note that to maintain the confidentiality of sensitive personal information, personal accessibility preferences must be stored and used in the user's personal UIs (in this case, a smartphone). Even in an environment where multiple UIs are available, transferring a user's accessibility preferences from one interface to another must be handled strictly at the user's discretion. Clear instructions and information about how the user's accessibility preferences are handled must be provided.

II.4 Use case 4. Paratransit service

Many municipalities provide complementary paratransit service for PWDs. A paratransit service is provided as a supplement to fixed-route bus and rail systems. Those with disabilities who for diverse reasons cannot use public transport services may alternatively choose to use a paratransit service.

However, even with a specifically designed service to satisfy PWDs, there are still some barriers such as difficulties in scheduling reservations, excessive waiting times for vehicles to arrive, late arrivals, no show and lengthy travel times. Individuals with disabilities who rely on paratransit services typically have to schedule and plan their activities well in advance to receive transport services.

Not all barriers to (complementary) paratransit services can be resolved with the introduction of smart services geared to IoT technology. However, many issues can be resolved when utilizing location

services (e.g., GPS tracking of the driver or customer) in real-time and interactive notification of information services, etc.

II.5 Use case 5. Temporal bus timetable changes

Ms. Kay, who has visual impairment, routinely takes a bus to work at a bus stop in front of her home. The bus runs according to a predetermined schedule, and Ms. Kay leaves home every day according to the timetable.

One day, road construction begins on one of Ms. Kay's bus routes, and the buses temporarily operate on a different route from usual. The bus company decides to change the bus timetable to reflect delays due to the detour. Notice of the schedule change is posted at the bus stop. Because of her visual impairment, Ms. Kay is unaware of the changed bus timetable as notification was provided in a printed paper format.

Bus companies can increase reliability and predictability of their service by directly informing users of changes in public transport services using push notification services in a smartphone application. More sophisticatedly, the company may provide real-time tracking of the vehicle on the road and its expected time schedule using real-time information collection and traffic prediction technology.

Smart services using a smartphone application and real-time vehicle tracking technology (e.g., GPS transmitter) can provide users with more accurate information in timely manner. Also, PWDs may benefit from services that provide accessibility functionalities, such as screen-reading tools, vibration notification and automatic captioning functionality. Without much effort, digitally formatted information can be transformed into different formats (e.g., text-to-audio and vice-versa) compared to its traditional counterparts (e.g., printed paper format and audio announcements).

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