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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 –
Services, applications, computation and data processing

**Functions and metadata of spatiotemporal
information service for smart cities**

Recommendation ITU-T Y.4562

ITU-T



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Recommendation ITU-T Y.4562

Functions and metadata of spatiotemporal information service for smart cities

Summary

In a city, there are the basic elements like people, things and events. Their mobility and positioning are increasingly dependent upon information related to location and/or time, supported by a spatiotemporal information service (STIS). Although related services have already emerged and been provided, the lack of standards may affect their sharing, service capabilities, and interoperability. Therefore, a standard is needed to specify what kinds of STIS should be provided for people, things and events in smart cities, including the functions and metadata of STIS.

Recommendation ITU-T Y.4562 introduces the concepts of STIS for smart cities, and specifies the functions and metadata of STIS. The functions and metadata of STIS can support the applications of STIS for smart cities, so as to better meet the needs of people, things and events. The functions and metadata are universal and can be applied to any cities in the world.

History

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Recommendation ITU-T Y.4562

Functions and metadata of spatiotemporal information service for smart cities

1 Scope

This Recommendation specifies the functions and metadata of a spatiotemporal information service (STIS) for smart cities.

The scope of this Recommendation includes:

- Overview of STIS for smart cities;
- Functions of STIS for smart cities;
- Metadata of STIS for smart cities

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.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 thing [ITU-T Y.4000]: With regard to the Internet of things, this is an object of the physical world (physical things) or the information world (virtual things), which is capable of being identified and integrated into communication networks.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 spatiotemporal information service (STIS): A service that provides information related to location and/or time to meet the mobility and positioning needs of people, things and events through the Internet.

NOTE – STIS can be categorized as six services, i.e., catalogue service, positioning service, navigation service, timing service, place data service, and spatiotemporal analysis service.

3.2.2 geographical feature: An abstraction of a real-world phenomenon associated with a location relative to the Earth.

NOTE – Geographical feature can be represented by points, lines, or polygons.

3.2.3 geographical coverage: A geographical feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain.

NOTE – Geographical coverage usually represents a single layer such as roads, lakes, inhabited areas, and land use, etc., as well as an integration of these layers.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3D	Three Dimensional
GIS	Geographic Information System
IoT	Internet of Things
MTBF	Mean Time Between Failures
SOAP	Simple Object Access Protocol
STIS	Spatiotemporal Information Service
WGS84	World Geodetic System 1984
XML	Extensible Markup Language

5 Conventions

None.

6 Overview of STIS for smart cities

Spatiotemporal information service (STIS) refers to a service that provides information related to location and/or time to meet the mobility and positioning needs of people, things and events through the Internet, and STIS for smart cities supports urban management, education, health, transportation, public utilities, public safety and other activities in a city.

The STIS for smart cities can be categorized into six services (see Figure 1):

- 1) Catalogue service: To manage all the other services, making them discoverable to users in smart cities.
- 2) Positioning service: To serve a person, a thing or an event his/her/its location in smart cities.
- 3) Navigation service: To serve a citizen the route from an origin to a destination, which is now a necessity of people's everyday lives in smart cities.
- 4) Timing service: To provide time and frequency information to users in smart cities.
- 5) Place data service: To provide geographical data, which is a key and basic service that supports the management of smart cities.
- 6) Spatiotemporal analysis service: To provide spatial analysis and spatiotemporal statistics, which is nowadays a frequently used service in urban management.

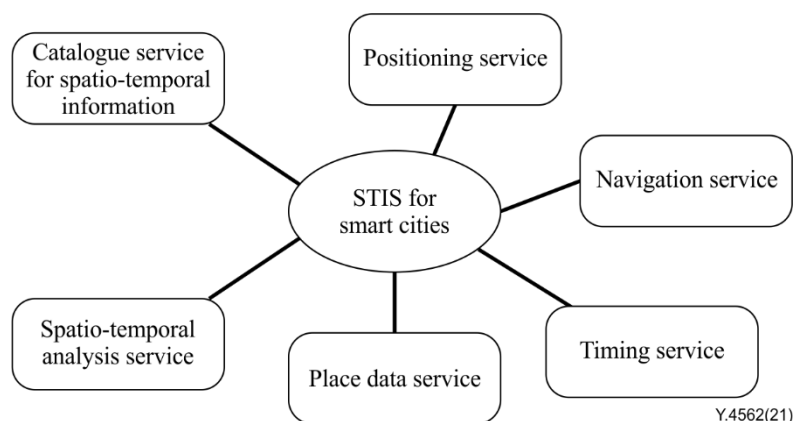


Figure 1 – Six services of STIS for smart cities

Each service has a set of related application functions that can be programmatically invoked over the Internet by applications in smart cities to meet needs of mobility and positioning.

Each service can be described by relevant metadata. To better describe the six services of STIS for smart cities in a unified way, five basic metadata components and nine kinds of metadata elements are identified.

The five basic metadata components of a STIS epitomize the common attributes including tag, performance, state, usage and accessibility, which constitute a common reusable service model. Further, the five basic metadata components are divided into nine kinds of metadata elements, including identification, characteristics, capability, quality, geolocation, working, usage, administration, and constraint.

The tag, performance, state, usage, and accessibility components of a service are supported by the identification and characteristics, capability and quality, geolocation and working, usage, and administration and constraint information, respectively. The basic components could be formalized by detailed data types. The relationship between the five metadata components and the nine metadata elements is shown in Figure 2.

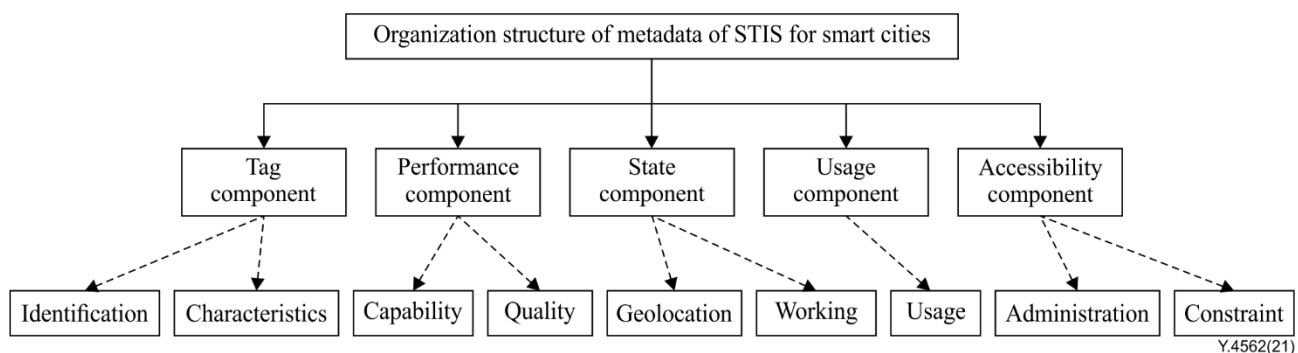


Figure 2 – Organization of metadata of STIS for smart cities

- 1) Identification element: It includes keywords, service ID, service name, service type, and service form which describe the general information of a service to identify it uniquely.
- 2) Characteristics element: It includes function, environment, and communication interface that describe the characteristics of a service.
- 3) Capability element: It includes the applying field, suitable tasks, and suitability information of a service.
- 4) Quality element: It includes quality of service (QoS) information, including service performance, service price, service reliability, service response time, and service reputation.
- 5) Geolocation element: It includes time reference, space reference, longitude, latitude, altitude, current time, life span, mean time between failures (MTBF), and valid time that describe the real location and time of a service.
- 6) Working element: It includes the using state, fault state, and resource consumption of a service, which can determine whether a service is available at a task moment.
- 7) Usage element: It includes the service address, service inputs, service outputs, service access mode, and service connection.
- 8) Administration element: It includes contactor, contactor role, contact address, contact mode, history, and document information that note the important information useable for service management.
- 9) Constraint element: It includes access role, access level, legal constraints and security constraints information, which indicate the service accessibility.

7 Functions of STIS for smart cities

7.1 Functions of catalogue service for spatiotemporal information

The catalogue service for spatiotemporal information is responsible for registration, discovery and invocation of spatiotemporal information. It provides the following functions:

1) Registration

Spatiotemporal information registration function provides the ability to register metadata of spatiotemporal information to a web server, which is the basis of discovery of spatiotemporal information through the web.

2) Discovery

Spatiotemporal information discovery function provides the ability to discover and retrieve metadata of spatiotemporal information from a web server. Based on the metadata, the spatiotemporal information itself can be retrieved.

3) Invocation

Spatiotemporal information invocation function provides the ability to invoke and utilize spatiotemporal information.

7.2 Function of positioning service

1) Positioning

The positioning function provides the ability to determining a person's, a thing's or an event's location.

7.3 Function of navigation service

1) Navigation

The navigation function provides the ability to instruct a citizen or an object how to move from one place to another.

7.4 Function of timing service

1) Timing

The timing function provides the ability to offer time and frequency information to users.

7.5 Functions of place data service

The place data service is responsible for providing service of geographical data of a place in a specified form. It consists of the following four functions:

1) Map

Map function provides the ability to serve (over the Internet) geo-referenced map images which a map server generates using data from a geographic information system (GIS) database [b-OGC 01-068r3].

2) Geographical feature

Geographical feature function provides the ability to request for geographical features (e.g., points, lines, or polygons) across the web using platform-independent calls. It offers direct fine-grained access to geographical information at the geographical feature and geographical feature property level [b-OGC 11-122r1].

3) Geographical coverage

Geographical coverage function provides the ability to access geographical coverage data, which stores a set of thematically associated data considered to be a unit, in forms that are

useful for client-side rendering, as input to processing and decision-making models, and for other clients [b-OGC 09-110r3].

4) Three-dimensional (3D) model

3D model function provides the ability to access the 3D model of a place (e.g., over-ground, underground, indoor or outdoor), which is a representation of a real-world object in a map or scene with elevation values (z-values) stored within the feature's geometry.

7.6 Functions of spatiotemporal analysis service

The analysis service is responsible for providing spatial analysis [b-OGC 05-007r7], and spatiotemporal statistics service. It consists of the following functions:

(1) Spatial analysis

Spatial analysis function provides the ability to analyse spatial data, such as road network analysis, shortest path analysis, hotspot analysis, etc. The spatial analysis service is performed to derive additional information from spatiotemporal data for better decision-making.

(2) Spatiotemporal statistics

Spatiotemporal statistics function provides the ability to conduct statistics for random variables spread out in space and evolving in time.

8 Metadata of STIS for smart cities

8.1 Identification

Identification includes keywords, service ID, service name, service type, and service form items, as detailed in the following:

1) Keywords

This metadata item refers to the words that can describe the main characteristics of a service.

2) Service ID

This metadata item refers to the unique identifier of a service.

3) Service name

This metadata item refers to the name of a service.

4) Service type

This metadata item refers to the type of a service. The type options include catalogue service, positioning service, navigation service, timing service, place data service, and spatiotemporal analysis service.

5) Service form

This metadata item refers to the form of a service, indicating whether a service is pay-as-you-go or provided for free.

8.2 Characteristics

Characteristics includes function, environment, and communication interface items, as detailed in the following:

1) Function

This metadata item refers to the descriptive information of what a service can be used for.

2) Environment

This metadata item represents characteristics of a platform to support a service.

3) Communication interface

This metadata item indicates the interface through which a service is provided, such as RESTful or simple object access protocol (SOAP).

8.3 Capability

Capability includes applying field, suitable tasks, and suitability items, as detailed in the following.

1) Applying field

This metadata item refers to the fields a service can be applied to, such as urban management, education, health, transportation, public utilities, and public safety, etc.

2) Suitable tasks

This metadata item refers to the tasks that a service is suitable for, such as offering current time, offering current location, and providing the shortest route from one place to another.

3) Suitability

This metadata item refers to the degree to which a service is suitable for a specific task. It could be represented by grades, scores, or percentages.

8.4 Quality

Quality includes service performance, service price, service reliability, service response time, and service reputation items, as detailed in the following:

1) Service performance

This metadata item refers to the performance of a service (e.g., uptime and availability of the service as well as resource utilization).

2) Service price

This metadata item refers to the cost of using a service (e.g., 30 \$/month).

3) Service reliability

This metadata item refers to the reliability of a service, which represents the correct rate of request for the service per unit time.

4) Service response time

This metadata item refers to the response time when a service is invoked (e.g., 1 ms).

5) Service reputation

This metadata item refers to the reputation of a service, which is a graded evaluation of the quality of a service. For example, in a 5-grades evaluation scheme, a service is graded 5 for the best service reputation, and 1 for the worst service reputation.

8.5 Geolocation

Geolocation includes time reference, space reference, longitude, latitude, altitude, current time, life span, MTBF, and valid time items, as detailed in the following:

1) Time reference

This metadata item indicates the time reference system of a service (e.g., Greenwich mean time).

2) Space reference

This metadata item indicates the spatial reference system of a service (e.g., World geodetic system 1984 (WGS84)).

3) Longitude

This metadata item refers to the longitude extent provided by a service.

4) Latitude

This metadata item refers to the latitude extent provided by a service.

5) Altitude

This metadata item refers to the altitude extent provided by a service.

6) Current time

This metadata item refers to the current timestamp of a service.

7) Life span

This metadata item refers to the actual period of time from the creation of a service to the destruction of the service. For example, a service is created on 2010-09-10 00:00:00, and destroyed on 2021-09-10 00:00:00.

8) MTBF

This metadata item refers to the mean time between failures of a service (e.g., 100,000 hours).

9) Valid time

This metadata item refers to a time period during which the service is valid. For example, a service is valid during the time period from 2011-08-10 07:00:00 to 2011-08-10 09:00:00.

8.6 Working

Working includes using state, fault state, and resource consuming items, as detailed in the following.

1) Using state

This metadata item refers to the using state of a service, being idle or working.

2) Fault state

This metadata item refers to the fault state of a service, being normal or at fault.

3) Resource consuming

This metadata item describes the consumption of the storage, computation and communication resources when a service is running.

8.7 Usage

Usage includes service address, service inputs, service outputs, service access mode, and service connection items, as detailed in the following.

1) Service address

This metadata item refers to the web address to access a service.

2) Service inputs

This metadata item refers to the input parameters of a service.

3) Service outputs

This metadata item refers to the output parameters of a service.

4) Service access mode

This metadata item refers to the access mode of a service (e.g., through a GET request or POST request).

5) Service connection

This metadata item refers to the connection information of a service, which specifies the links.

8.8 Administration

Administration includes contactor, contactor role, contact address, contact mode, history, and document items, as detailed in the following.

- 1) **Contactor**
This metadata item refers to the relevant contactor's information to manage a service (e.g., contactor's name, department, contacting information, etc.).
- 2) **Contactor role**
This metadata item refers to the role of a contactor of the service management, being a person or a responsible party.
- 3) **Contact address**
This metadata item refers to the contact address of the person or responsibility party who provides/manages a service.
- 4) **Contact mode**
This metadata item refers to the contact mode of a service (e.g., through phone, fax, and email, etc.).
- 5) **History**
This metadata item refers to the management history of a service.
- 6) **Document**
This metadata item refers to the relevant management documentation for a service. These management documents are usually stored in a web server and indicated by hyperlinks.

8.9 Constraint

Constraint includes access role, access level, legal constraints, and security constraints items, as detailed in the following.

- 1) **Access role**
This metadata item refers to the access role of a service, including service provider or service consumer.
- 2) **Access level**
This metadata item refers to the access level of a service, being accessible and inaccessible.
- 3) **Legal constraints**
This metadata item refers to the restrictions and legal prerequisites for accessing and using the spatiotemporal information service.
- 4) **Security constraints**
This metadata item refers to the handling restrictions imposed on the spatiotemporal information service for national security, financial or commercial sensitivity, or privacy concerns.

Appendix I

STIS use case for smart cities

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

This appendix provides a typical use case to illustrate the concept of the STIS for smart cities, especially the link between the functions and metadata of STIS for smart cities, and how they are used in the smart cities scenario.

The use case used here is a citizen's travel in the city (see Figure I.1). For example, a citizen wants to go to place B from place A, and he/she will set out at a given time and needs to arrive at the destination in a given period of time. To arrive there on time, before setting out, he/she uses a navigation software (a mobile App or web App) to find the nearest route by specifying where he/she is right now, where he/she wants to go, and at what time he/she will set out. Then, the navigation software returns the route that takes the shortest period of time, and he/she will follow the route to go to the destination.

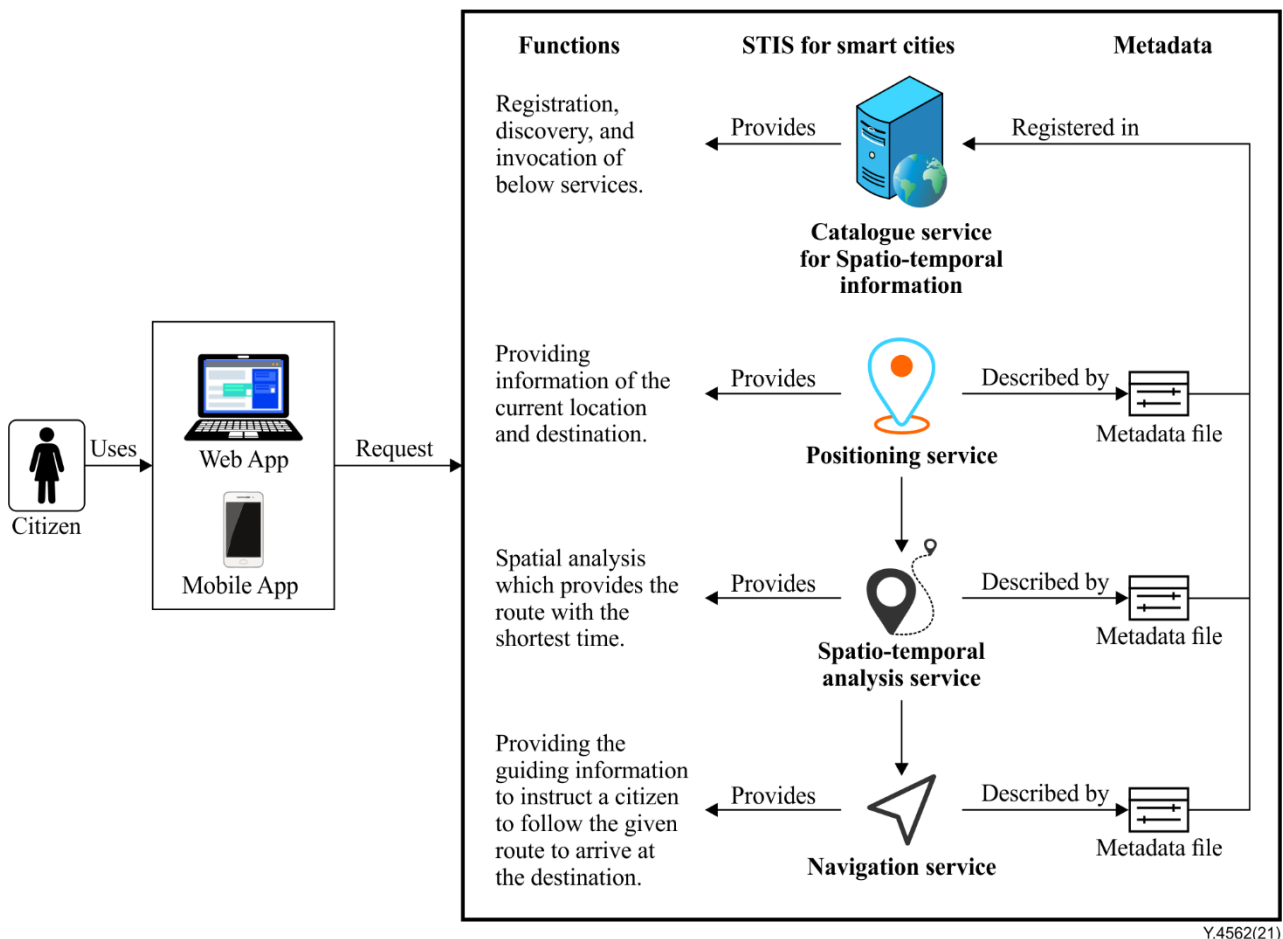


Figure I.1 – Schematic diagram of the use case of a citizen's travel

In this case, a citizen uses a navigation software to find the route with the shortest time to go to the destination. It involves the following services of STIS for smart cities with corresponding functions (see Figure I.2):

- Positioning service, with the function of providing position information of his/her current location and the destination.

- b) Spatial analysis service, with the function of spatial analysis which provides the route with the shortest time.
- c) Navigation service, with the function of providing the guiding information to instruct the citizen to follow the given route to arrive at the destination.

For each of the above services of the STIS for smart cities, five metadata components (tag, performance, state, usage, and accessibility) are used, which are further divided into nine metadata elements (identification, characteristics, capability, quality, geolocation, working, usage, administration, and constraint) (see Figure 2). The metadata of a service is instantiated and formalized into an XML file by following the metadata structure and filling in a specific value for each metadata element. The metadata file in XML format is used to describe the service instance. By registering metadata files in the catalogue service for spatiotemporal information deployed on a web server, these services can be discovered easily and invoked in an interoperable way to provide the above functions.

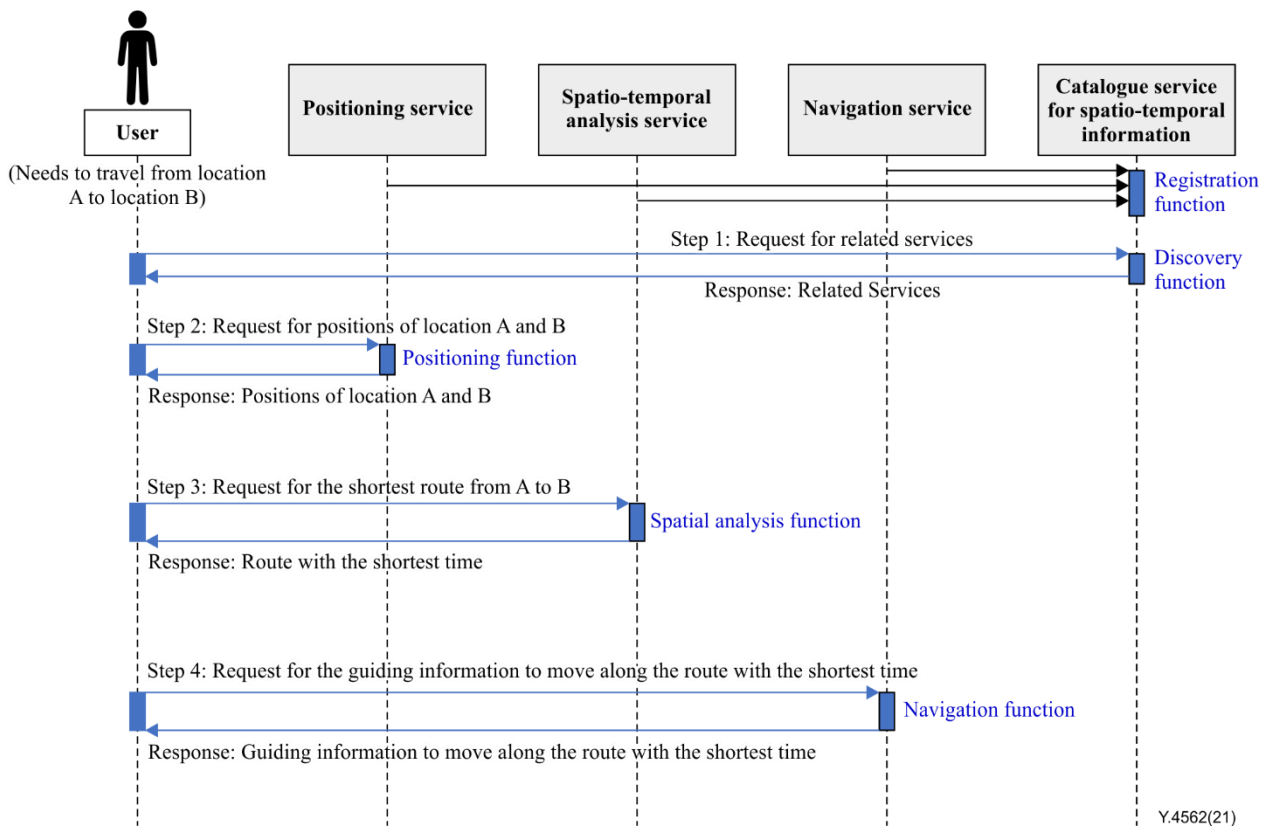


Figure I.2 – The steps of invoking services and their functions in the use case of a citizen's travel

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