International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

F.747.5
(01/2014)

SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Audiovisual services

Requirements and functional architecture of an automatic location identification system for ubiquitous sensor network (USN) applications and services

Recommendation ITU-T F.747.5

ITU-T

International Telecommunication Union

ITU-T F-SERIES RECOMMENDATIONS

NON-TELEPHONE TELECOMMUNICATION SERVICES

TELEGRAPH SERVICE	
Operating methods for the international public telegram service	F.1–F.19
The gentex network	F.20–F.29
Message switching	F.30–F.39
The international telemessage service	F.40–F.58
The international telex service	F.59–F.89
Statistics and publications on international telegraph services	F.90–F.99
Scheduled and leased communication services	F.100–F.104
Phototelegraph service	F.105–F.109
MOBILE SERVICE	
Mobile services and multidestination satellite services	F.110–F.159
TELEMATIC SERVICES	
Public facsimile service	F.160–F.199
Teletex service	F.200–F.299
Videotex service	F.300–F.349
General provisions for telematic services	F.350–F.399
MESSAGE HANDLING SERVICES	F.400–F.499
DIRECTORY SERVICES	F.500–F.549
DOCUMENT COMMUNICATION	
Document communication	F.550–F.579
Programming communication interfaces	F.580–F.599
DATA TRANSMISSION SERVICES	F.600–F.699
AUDIOVISUAL SERVICES	**F.700–F.799**
ISDN SERVICES	F.800–F.849
UNIVERSAL PERSONAL TELECOMMUNICATION	F.850–F.899
HUMAN FACTORS	F.900–F.999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T F.747.5

Requirements and functional architecture of an automatic location identification system for ubiquitous sensor network (USN) applications and services

Summary

Recommendation ITU-T F.747.5 defines the functional requirements, architecture and entities of automatic location identification in ubiquitous sensor networks (USNs).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.747.5	2014-01-13	16	11.1002/1000/12052-en

Keywords

Automatic positioning capability, location-based services, sensor location information.

* 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.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Introduction

With the help of numerous sensors, radio frequency identification (RFID) tags and other end-node devices, the ubiquitous sensor network (USN) can provide information exchange without any human intervention, for example, it is possible to monitor the weather in one particular area of China from the ITU office in Geneva by means of humidity and temperature sensors, and it is also possible to display traffic flow information for London via the velocity sensors on mobile phones. These trillions of new USN applications and services are built using three basic elements – data, time and location.

With the increase in USN applications and services, new positioning methods are being created and automatic location identification (ALI) capabilities need to be added to the open USN service platform which provide unified accessibility to USN resources and which allows the data of USN applications to take full advantage of the USN capabilities.

Recommendation ITU-T F.747.5

Requirements and functional architecture of an automatic location identification system for ubiquitous sensor network (USN) applications and services

1 Scope

The automatic location identification (ALI) capability enables a device to discover its own location. The ALI system can be deployed along with network equipment or independently integrated with end-node devices. It can be used in various networks such as a mobile network, the Internet, or a low power wireless network.

The scope of this Recommendation includes:

– requirements of the ALI system

– the functional architecture of the ALI system within an open USN service platform

– Specific scenarios of the ALI system.

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 F.744] Recommendation ITU-T F.744 (2009), *Service description and requirements for ubiquitous sensor network middleware*.

[ITU-T F.747.4] Recommendation ITU-T F.747.4 (2014), *Requirements and functional architecture for the open ubiquitous sensor network service platform*.

[ITU-T Y.2221] Recommendation ITU-T Y.2221 (2010), *Requirements for support of ubiquitous sensor network (USN) applications and services in the NGN environment*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 open USN service [ITU-T F.747.4]: USN service which provides unified access to USN resources and sensed data/semantic data through heterogeneous USN middleware.

3.1.2 sensor [ITU-T Y.2221]: An electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic.

3.1.3 sensor network [ITU-T Y.2221]: A network comprised of interconnected sensor nodes exchanging sensed data by wired or wireless communication.

3.1.4 sensor node [ITU-T Y.2221]: A device consisting of sensor(s) and optional actuator(s) with capabilities of sensed data processing and networking.

3.1.5 ubiquitous sensor network (USN) [ITU-T Y.2221]: A conceptual network built over existing physical networks which makes use of sensed data and provides knowledge services to anyone, anywhere and at any time, and where the information is generated by using context awareness.

3.1.6 USN middleware [ITU-T Y.2221]: A set of logical functions to support USN applications and services.

3.1.7 USN resource [ITU-T F.747.4]: An entity that provides a USN service including sensor, actuator, sensor node, sensor network and gateway.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 ALI service: A service which provides the best accessible positioning results to USN applications through heterogeneous USN middleware and open USN service platform provisioning based on the use of standard interfaces.

3.2.2 ALI system: An ALI system is a set of interacting or interdependent components forming an integrated whole or a set of elements to offer an ALI service.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ALI	Automatic Location Identification
API	Application Programming Interface
CDMA	Code Division Multiple Access
FE	Functional Entity
GPS	Global Positioning System
GSM	Global System for Mobile
RFID	Radio Frequency Identification
USN	Ubiquitous Sensor Network
UWB	Ultra-Wideband

5 Conventions

No specific conventions have been used in this Recommendation.

6 Requirements for ALI systems

6.1 General requirements

The following are the general requirements of the ALI system which address the minimum requirements of the location identification system for USN applications and services:

– ALI systems should coexist with existing location-related standards defined by other SDOs such as 3GPP2 [b-3GPP2 IP-BLS] and [b-3GPP2 b-MAPLS], 3GPP [b-3GPP LCS], and OMA [b-OMA SUPL and b-OMA MLS]. It is recommended that the introduction of an ALI system does not have any negative impact on the operation and performance of existing standards.

– The functions introduced by the ALI system are recommended to be either hosted in existing function elements of the USN or in completely new physical entities. The ALI system is required to not impose any modifications on the architecture or functionality of underlying network technology.

– It is recommended that all ALI location data be time-stamped, and the USN application and service are required to use the most recent data available.

– The ALI system is required to provide mechanisms to prevent denial of service attacks.

– The ALI system is required to ensure that data is protected in all transactions, in accordance with the user's privacy preferences, except for when this information is required for emergency or lawful purposes depending on local/regional regulations.

– The architecture is recommended to support the storage of location information for a sensor node so that it may be available later, if required.

– ALI capability is required in order to allow support for location requests, regardless of a user's privacy preferences, when associated with emergency services and applicable by local regulations. The ALI system is required to support sensor node-initiated and network-initiated positioning for emergency location requests. It is required that emergency services location information requests are given a higher priority over other location information requests, based on local regulatory requirements.

6.2 High-level requirements

The following are the high-level requirements of the ALI system, which specify the user's needs for automatic location identification for the ubiquitous sensor network.

– Supporting seamless positioning techniques:

  The ALI system is recommended to support seamless positioning techniques. This could be accomplished by automatically changing to other suitable techniques when the currently operating positioning technique cannot determine the location, or the positioning result is not acceptable.

– Supporting hybrid positioning techniques:

  The ALI system is recommended to support location identification by combining more than one positioning technique when a single positioning technique cannot specify the exact location of the device. It is also recommended to support the process of choosing the best-fit positioning technique from the many available techniques.

– Supporting USN location identification techniques:

  The device utilizes USN techniques to determine its location, such as an image processing technique, RFID or a gyroscope technique. The ALI system is recommended to support these techniques.

– Positioning data compression and conflict control management:

  When portable devices periodically update their location, network performance could be affected if a large number of USN devices are working in an inadequate network environment. It is recommended that ALI systems support conflict control and compression of the positioning data to reduce this problem.

– Conversion of coordinates:

  Location information is shared to support many USN applications which use different coordinates; as a result, the ALI system is recommended to support the uniformity of coordinates and the possible conversion of coordinates.

7 Functional architecture of the ALI system for USN applications and services

7.1 Functional architecture

The functional architecture of the ALI system for USN applications and services may be varied according to diverse USN architectures. Figure 1 shows the functional architecture of the ALI system within the open USN service platform, as a typical example. The functional entities defined in clause 7.2 and the information flow defined in Appendix II, have been applied to this architecture.

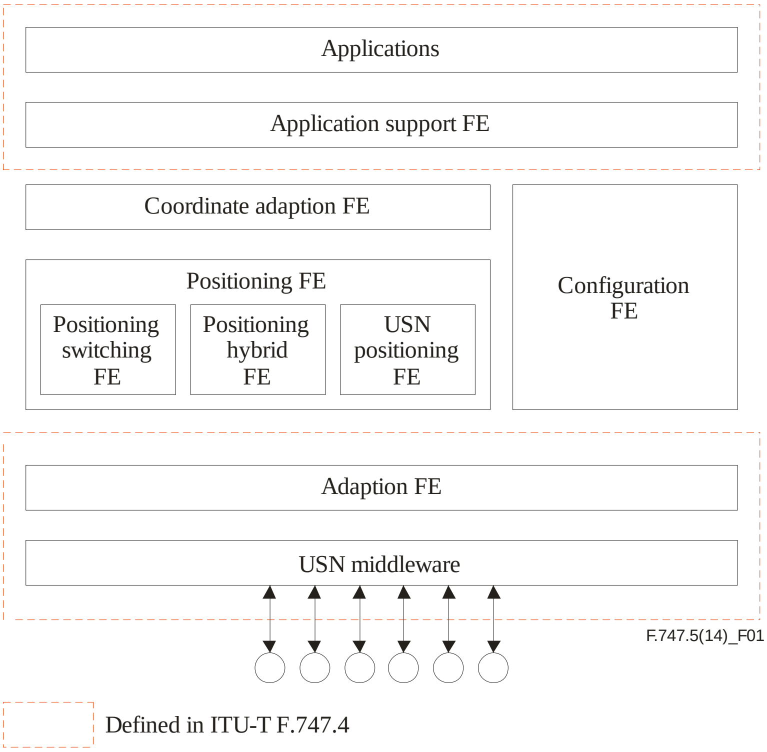

Figure 1 – Functional architecture of the ALI system

7.2 Functional entities

7.2.1 Application support FE

The application support FE provides the functions which enable open USN services to obtain ALI services and/or the positioning data from the ALI system.

Also, it supports the functions which allow the establishment or maintenance of the connection or disconnection according to the type of a request, and the access control to handle the access privileges for users and services.

7.2.2 Coordinate adaptation FE

The coordinates adaptation FE provides the functions which translate the positioning results into the standard and required coordinate, and this is provided for related open USN services.

7.2.3 Remote configuration FE

The remote configuration FE provides the function which enables applications to modify the configurations of the positioning services through an ALI system.

7.2.4 Adaptation FE

The adaption FE provides the functions which handle the protocol and message for setting the connection with USN middleware, and which deliver queries and commands as an interface for processing several types of positioning data that come from USN middleware.

Also, it supports the function to translate generated data from USN middleware to proper message specifications that are dealt with in the ALI system.

The adaptation FE provides a similar function to that of the adaptation FE which is defined in [ITU-T F.747.4]. However, the adaptation FE defined here also directly provides services to sensor nodes which require positioning results and it does not share this with other open application programming interfaces (APIs).

7.2.5 Positioning FE

7.2.5.1 Positioning switching FE

The positioning switching FE provides the functions which support the smooth transition to a valid positioning technique, and which estimate the best available positioning result when the operating positioning technique cannot determine the location or the positioning result is not acceptable.

7.2.5.2 Positioning hybrid FE

The positioning hybrid FE provides the functions which support position calculation by combining various positioning techniques when a single technique cannot specify the exact location of the device. It also supports positioning result optimization by choosing the best-fit positioning technique from the many available techniques, according to the requirements of the applications, such as accuracy first or time first.

7.2.5.3 USN positioning FE

The USN positioning FE provides the functions which support USN techniques for the determination of a sensor node location.

Appendix I

Relationship between open USN service platform and ALI capabilities

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

Figure I.1 shows the relationship between an open USN service platform and ALI capabilities. ALI capabilities are important capabilities of an open USN service platform, which are to be provided to various USN applications and services.

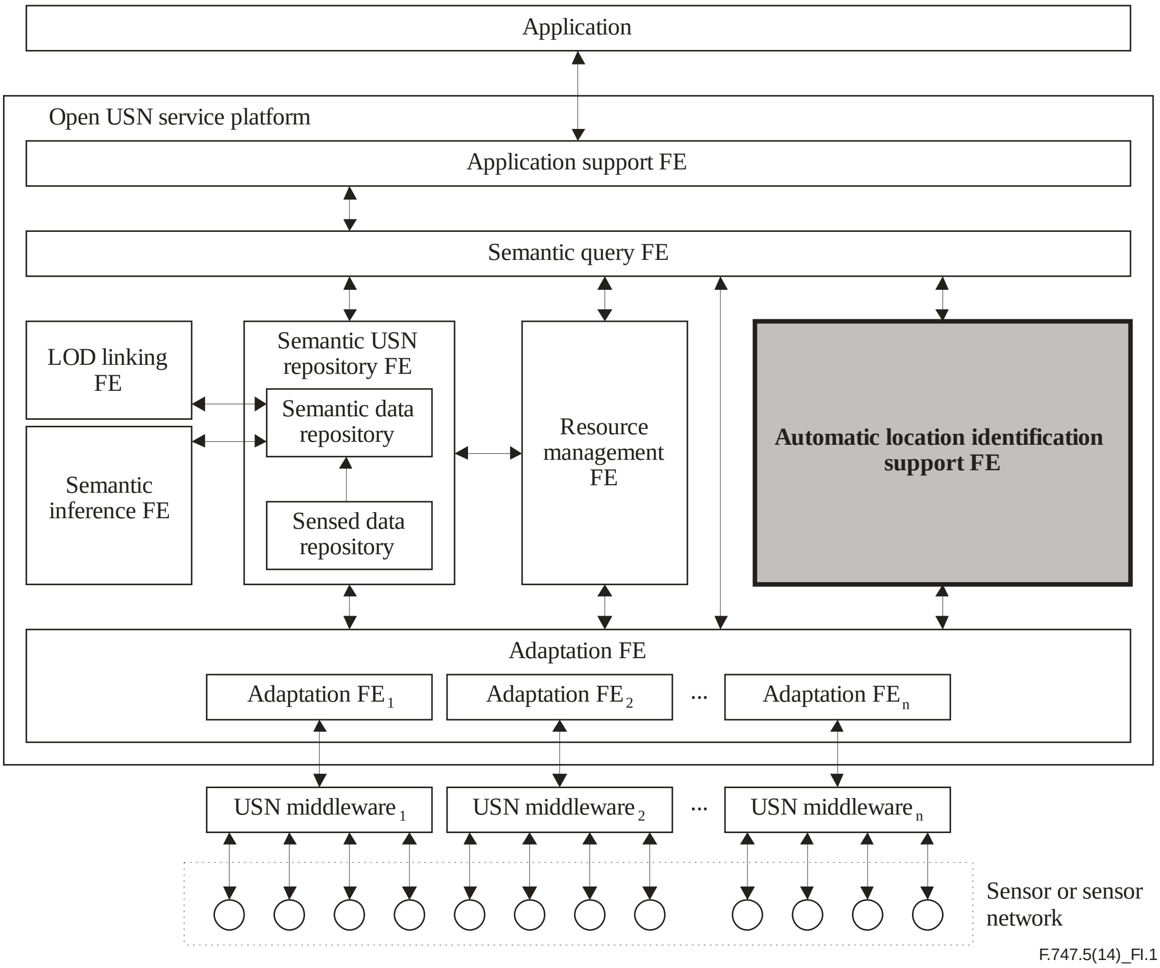

Figure I.1 – Relationship between open USN service platform and ALI capabilities

Appendix II

Information flow of ALI services

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

This appendix shows the information flow of ALI systems.

II.1 Resource registration

Figure II.1 shows the information flow of sensor node registration for the use of ALI services.

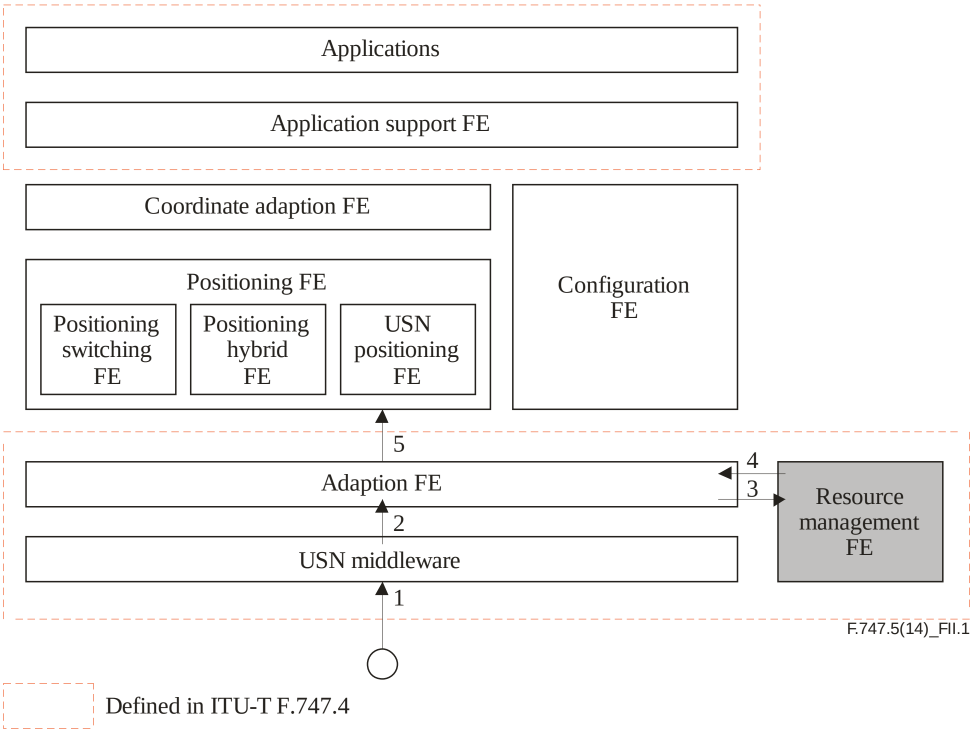

Figure II.1 – Information flow of sensor node registration for the use of ALI services

(1) After receiving an application request, the sensors send the registration requests to the ALI system with the location-related data via USN middleware.

(2) USN middleware sends a request to an open USN service platform through the adaptation FE to ensure that the sensor/application is registered.

(3) The adaptation FE sends the message to the resource management FE.

(4) The resource management FE returns the result of the registration to the adaptation FE and ensures that the sensor supports the ALI function.

(5) The adaptation FE returns the result to the ALI service; the valid requests are sent to the ALI service platform.

II.2 Positioning process

Figure II.2 shows the information flow of the positioning process of an ALI system.

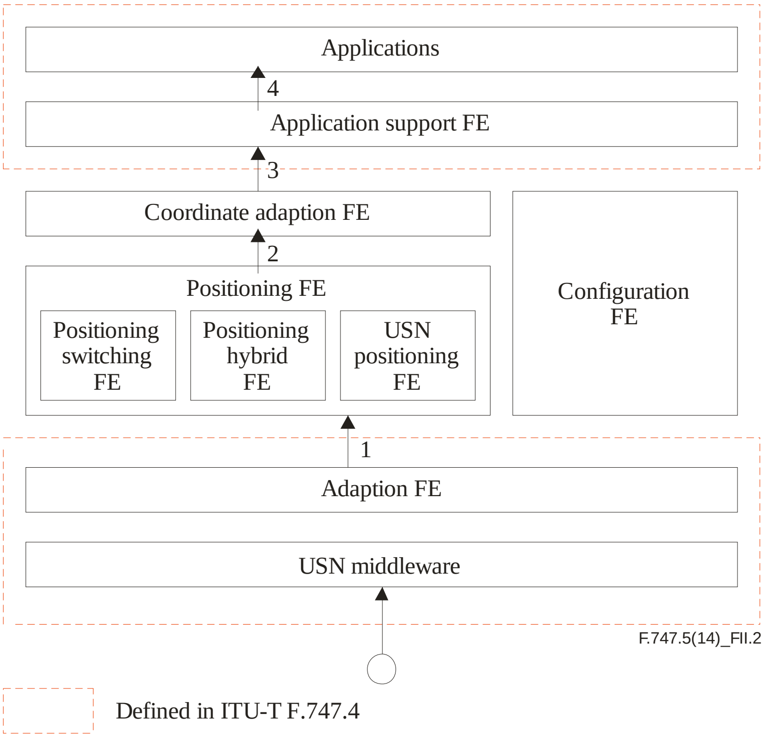

Figure II.2 – Information flow of the positioning process of an ALI system

(1) The valid requests are sent to the ALI service platform.

(2) The positioning FE will then decide, according to the positioning request and any requirements, on the best positioning method, such as positioning switching, positioning hybrid and USN positioning. Positioning switching, positioning hybrid and the USN positioning functions in the positioning FE calculate the position of the sensor.

(3) According to the positioning request, the positioning results are translated into the requested data via the coordinates adaption FE. The coordinates adaption FE sends the data to the application support FE.

(4) The application support FE sends the data to the application.

II.3 Configuration process

Figure II.3 shows the information flow of the configuration process of the ALI system.

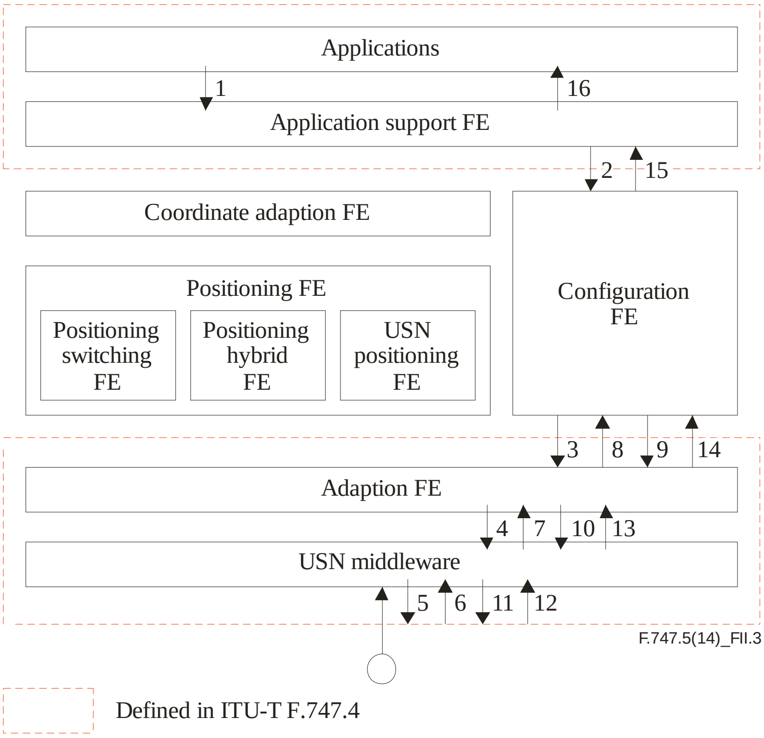

Figure II.3 – The information flow of the configuration process of the ALI system

(1) The application sends a configuration change request to the application support FE.

(2) The application support FE sends the request to the configuration FE. The configuration FE checks the request, sees if it is a valid process and accepts the rules according to the privacy policy and other rules which exist in the configuration FE.

(3) If it is acceptable, the configuration FE sends the configuration change request message to the adaptation FE. Otherwise, it will return the unsuccessful information back to the application.

(4) The adaption FE sends the information to the USN middleware.

(5) The USN middleware sends the request to the sensor.

(6) The sensor receives the configuration change message, and decides whether or not to download the new configuration. When the sensor accepts the request, it sends a request for downloading the new configuration to the USN middleware; otherwise it returns the error code and goes to step 12.

(7) The USN middleware sends the request to the adaptation FE.

(8) The adaptation FE sends the request to the configuration FE.

(9) The configuration FE sends the configuration parameters to the sensor via the adaptation FE.

(10) The adaptation FE sends the new parameters to the USN middleware.

(11) The USN middleware sends the new parameters to the sensor.

(12-14) After successfully receiving the new configuration, the sensor sends the success feedback message to the configuration FE via the USN middleware, and the adaptation FE; otherwise, the sensor sends the error code to the configuration FE via the USN middleware, and the adaptation FE.

(15-16) The configuration FE sends the information back to the application via the application support FE.

Appendix III

ALI scenarios for USN applications and services

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

Possible use cases in the ALI system are described in this appendix.

III.1 Location identification for sensor nodes working in complex environments

Compared with regular mobile positioning capabilities, sensor nodes sometimes work in complex environments. One example is that the capability of one single technique, such as a GSM/CDMA cell tower, Wi-Fi real-time locating systems or a global positioning system (GPS), is restricted and the location of a mobile unit cannot be determined, or sometimes it receives multiple location results. Therefore, in complex environments, the sensing node either supports the capability to combine multiple positioning techniques to provide a suitable positioning result or it supports the capability of choosing the best positioning method from more than one approach. The following use cases demonstrate this scenario.

III.1.1 Not receiving an acceptable result from a single positioning technique

This scenario covers an example that requires hybrid positioning techniques. The positioning for indoor sensors during a fire emergency is a typical case which requires the use of various positioning techniques.

The fire zone includes indoor and outdoor sites and many sensors are shot into the burning area. These sensors sense the temperature or capture the motion around them to detect survivors. All the sensors are communicating with wireless / near-field communication techniques, such as Wi-Fi, ZigBee, UWB, etc. With the help of one or more sink nodes, the sensor network connects to transmission networks to report the specific situation of the alerting zone. Some of the sensors contain GPS modules. These sensors are regarded as the reference points, or marks. The position of other sensors could not be determined without the help of these GPS references. By calculating the distance using the power attenuation from the reference points to the sensors, the positions of these sensors could be determined by hybrid positioning techniques, i.e., GPS and received signal strength indication. Figure III.1 illustrates this use case.

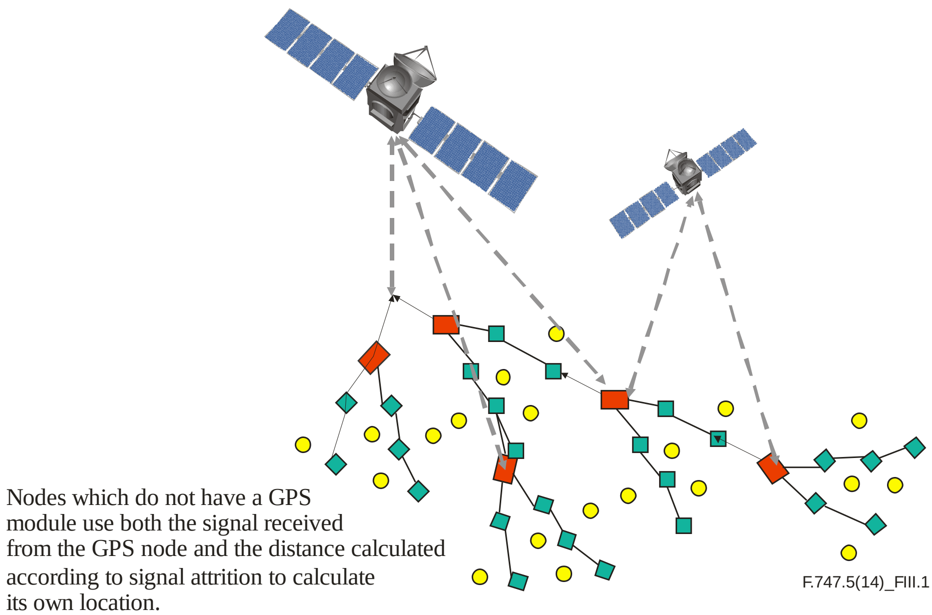

Figure III.1 – Fire emergency use case

III.1.2 Receiving more than one location identification result

With the development of positioning techniques, devices sometimes support more than one methodology of obtaining location information. Several positioning results may be attained; these are estimated via multiple procedures. It is necessary to choose the most appropriate procedure according to the requirements of the application (time-first or accurate-first) to present the most applicable outcome.

A medical emergency can be used to illustrate this. The service is highly sensitive to the amount of time used. When an emergency service requests location information, several modules (IP, cell-tower, GPS, and others) start the positioning processes. The system first informs the nearby ambulances according to the IP address, and requests that they head to the location area consistent with the result from the cell-tower. Yet, the result is not precise enough. While on the road, GPS sends the accurate position of the patient to the ambulance. The optimization of the multiple positioning methods helps the ambulance reach the site of the incident as soon as possible.

III.2 Continuing location identification for sensor nodes in a changing physical environment

Some USN applications ask for an integrated positioning solution that can provide seamless location identification in a variety of environments. This entails a positioning solution which is required to switch automatically from one positioning method to another, as soon as the node realizes the current positioning result is not acceptable to provide the required services with guaranteed quality, or the current positioning procedure cannot be supported. This scenario provides an example where nodes require seamless location identification. The following use cases describe this scenario.

III.2.1 Continuing location identification within the same system of coordinates

Traditionally, positioning results are obtained through geographical coordinates, i.e., latitude and longitude. When switching between traditional techniques, positioning results are expected to be in a uniform format and updated to applications seamlessly.

The tracking of a heart disease patient is a typical use case for the switching between traditional techniques use case. The sensors attached to a patient's body, monitors the patient's heart rate and other vital signs. They also report latitude and longitude to a health manager centre which is tracking the patient's location. When the patient walks along the street, the patient's location is obtained by the GPS module; if the patient drives into a tunnel and the GPS signal is lost, the location can be attained through GSM/CDMA cell-towers; as soon as the patient walks into a house, the device switches automatically to the Wi-Fi positioning mode to address the patient's precise location; and the hospital also provides RFID indicators to specify a more accurate position. Figure III.2 illustrates the heart disease patient use case for a multiple-location identification scenario.

Figure III.2 – Use case of heart disease patient tracking

III.2.2 Continuing location identification across different systems of coordinates

Instead of traditional geographical coordinates, the location information obtained by most new techniques is presented in other formats. When switching between a traditional positioning technique and these new positioning techniques, applications should either get the result in the same format or be informed of the change in format of the coordinates.

Shopping centre navigation is an illustration of this use case. Applications direct customers to target places. Outdoor navigation uses GPS (resulting in geographical coordinates) to help customers drive to the shopping centre; after entering the shopping centre, the indoor guiding system directs customers to their preferred shops, using Wi-Fi (resulting in indoor coordinates) or RFID (represented by a special identification string ID). The indoor coordinate system uses offset x, y, z to indicate the customer's location, while identification string ID uses strings to represent a particular spot. The change in the format of the coordinates should be notified, so that applications understand the meaning of the positioning results and give users the correct directions.

III.3 Location identification for sensor nodes using sensing and actuating techniques

Various sensing and actuating techniques are introduced in the USN. Other than the traditional cell-tower or GPS, these USN sensing and actuating techniques could also be used to determine the location. It opens the door to numerous innovative positioning ways, which also brings challenges for ALI systems to be compatible with these techniques. There are several ways of delivering these state-of-the-art techniques for location identification; these include but are not limited to the following use cases.

III.3.1 Location identification using images

With the new image processing ability, the devices with cameras or other sensors can recognize landmarks or particular patterns, thus determining the location.

The example below of robot positioning shows the image processing technique used in location identification. The robots, which are equipped with cameras/mark-readers, follow particular patterns on the floor. Each mark indicates a certain spot. The robot reads the mark and identifies the position. A supervisor thus tracks the footpaths that the robots have reported, and also gives them appropriate commands. Figure III.3 illustrates the example that the robots identify the locations with the help of an image processing technique.

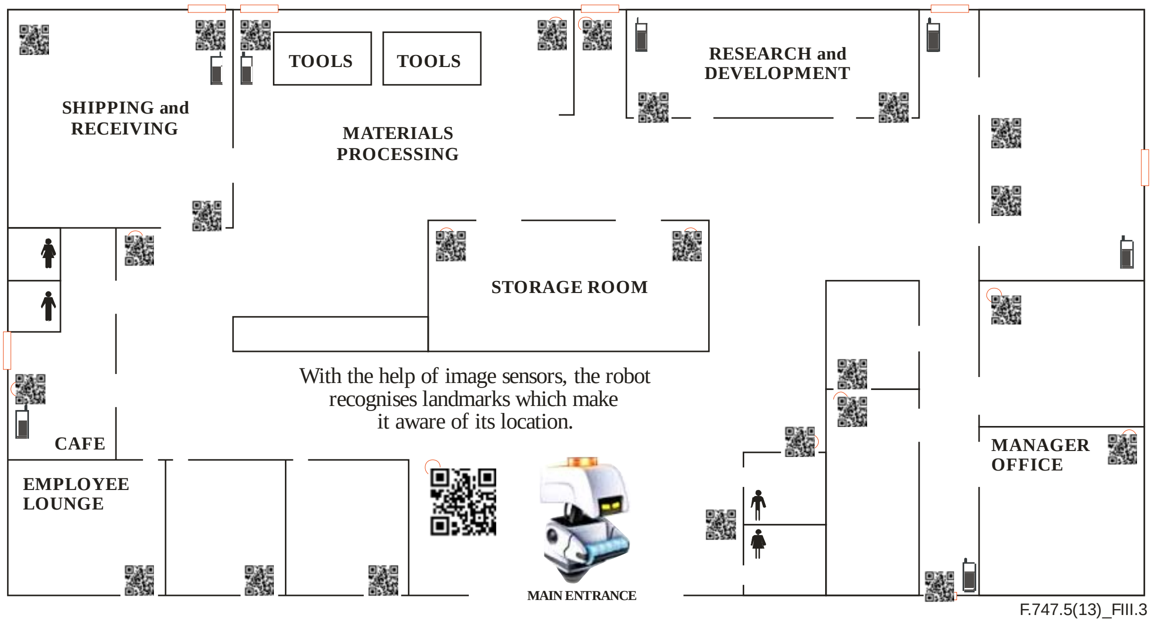

Figure III.3 – Use case of robot positioning with image processing capabilities

III.3.2 Location identification using an RFID tag

When a radio signal from a specific RFID tag is collected by devices at a certain point, the identification string of the tag can be decoded, and the corresponding location can be determined.

III.3.3 Location identification using a gyroscope

A device with a gyroscope can quantify movement in the x, y, z directions, and thus it can calculate its position from the original point.

III.4 Configuration for sensor nodes with limited processing capabilities

Sometimes, the configuration parameters of the sensor need to be modified during the positioning process according to its environment or the requirements from applications. However, the processing capabilities of the USN end nodes are limited. The ALI end node cannot adjust itself spontaneously and it needs the help of the platform. The configuration parameters may include but are not limited to the time of positioning periods, the alarming condition, etc. When sensors are not able to complete these actions dynamically, they connect to the management platform and download the configurations and process as required.

The sensor placed in a briefcase can be a typical example. It checks its position periodically. The positioning period and the sound of the alarm can be altered remotely by the management platform, according to the distance between the briefcase and the owner. If the distance between the briefcase and its owner exceeds the distance limit, the platform can send a notification to the owner.

III.5 Location identification for sensor nodes in a resource-limited USN environment

Resource-limited places are common in daily life and USN systems may be deployed in such places. Moreover, a USN may utilize resource-limited devices or terminals to facilitate its deployment. The limitation may be the power of the battery or the bandwidth of the link. This scenario demonstrates that location identification works in resource-limited environments, and it describes use cases which optimize the ALI system in such situations.

III.5.1 Power-limited environment

A power-limited environment refers to cases where, when the ALI system is used, the power of the device can be exhausted after a period of time. A typical power-limited environment is when devices adopt batteries as their power supply. Decreasing the power consumption can prolong the usage time. For instance, the ZigBee [b-ZigBee] terminal providing location identification can switch to power saving mode to extend its usage time (when batteries are used).

III.5.2 Network-limited environment

The network-limited environment includes two cases, low bandwidth and unstable connections. For example, ZigBee or some UWB technologies have very low bandwidths. The connection of GSM/CDMA is sometimes not stable, due to strong interference. In this case, the ALI system needs to increase its transmission efficiency, for instance, by compressing the payload of location information in packets.

Bibliography

[b-3GPP LCS] 3GPP (2013), *Functional stage 2 description of Location Services (LCS)* <http://www.3gpp.org/ftp/Specs/html-info/23271.htm> (accessed 2013-05-20)

[b-3GPP2 IP-BLS] 3GPP2 (2005), *IP-Based Location Services Revision: 0 – 3GPP2.* <http://www.3gpp2.org/public_html/specs/X.S0024-0_v1.0_051102.pdf>(accessed 2013-05-20)

[b-3GPP2 MAP-LS] 3GPP2 (2006), *MAP Location Services Enhancements.* <http://www.3gpp2.org/public_html/specs/X.S0002-0_v2.0_060531.pdf> (accessed 2013-05-20)

[b-OMA] OMA (2011), *Mobile Location Service V1.2*. <http://technical.openmobilealliance.org/Technical/release_program/mls_v1_2.aspx> (accessed 2013-05-20)

[b-OMA SUPL] OMA (2013), *OMA Secure User Plane Location V2.0.* <http://technical.openmobilealliance.org/technical/release_program/supl_v2_0.aspx> (accessed 2013-05-20)

[b-ZigBee] ZigBee Alliance (2007), *ZigBee Specification*. <http://www.zigbee.org/Specifications/ZigBee/download.aspx> (accessed 2013-12-12)

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	**Non-telephone telecommunication services**
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects and next-generation networks
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2014