International Telecommunication Union

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Recommendation ITU-R M.2002

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Objectives, characteristics and functional requirements of wide-area sensor and/or actuator network (WASN) systems

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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Note*: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.2002

Objectives, characteristics and functional requirements of wide-area sensor and/or actuator network (WASN) systems

(Question ITU-R 250/5)

(2012)

Scope

This Recommendation provides the objectives, system characteristics, functional requirements, service applications and fundamental network functionalities for mobile wireless access systems (WAS) providing communications to a large number of ubiquitous sensors and/or actuators scattered over wide areas in the land mobile service. The key objective of wide area sensor and/or actuator network (WASN) systems is to support machine-to-machine service applications irrespective of machine location.

Related ITU Recommendations and Reports

Recommendation ITU-R M.1079	Performance and quality of service requirements for International Mobile Telecommunications-2000 (IMT-2000) access networks.
Recommendation ITU-R M.1890	Intelligent transport systems – Guidelines and objectives.
Recommendation ITU-R P.372	Radio noise.
Recommendation ITU-R P.1406	Propagation effects relating to terrestrial land mobile and broadcasting services in the VHF and UHF bands.
Recommendation ITU-R P.1812	A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands.
Recommendation ITU-R SM.329	Unwanted emissions in the spurious domain.
Recommendations ITU-T H.235	H.323 security: Framework for security in H-series (H.323 and other H.245-based) multimedia systems.
Recommendation ITU-T X.805	Security architecture for systems providing end-to-end communications.
Report ITU-R M.2224	System design guidelines for wide area sensor and/or actuator network (WASN) systems.

Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AS	Application server
BS	Base station
DB	Database
IMT	International Mobile Telecommunication
M2M	Machine-to-machine
QoS	Quality of service
WAS	Wireless access system

WASN Wide area sensor and/or actuator network

WT Wireless terminal

The ITU Radiocommunication Assembly,

considering

a) that rapid advances are being made in wireless communications to link sensors and/or actuators associated with humans and objects in various environments;

b) that sensors and/or actuators for wireless communications should be simple, small, inexpensive and have low power consumption to realize the ubiquitous network society;

c) that there are emerging applications that handle small amounts of data, such as measurement data, location information and object control signals;

d) that the application of wireless sensor and/or actuator communications may provide service to a large cell coverage and large variety of objects on a cell-by-cell basis due to the traffic characteristics of such applications stated in item c) above;

e) that mobility should be offered for wireless sensor and/or actuator communications;

f) that wireless sensor and/or actuator communications can take place in non-line-of-sight conditions;

g) that it is desirable to identify the typical characteristics for the mobile wireless access systems (WAS) used for sensor and/or actuator communications in the land mobile service;

h) that WAS used for sensor and/or actuator communications may also be used in nomadic wireless access or fixed wireless access applications,

recommends

1 that, for mobile WAS providing communications to a large number of sensors and/or actuators scattered over wide areas, the objectives in Annex 1 may be used;

2 that the characteristics and functional requirements provided in Annex 2 should be used for design of wide area sensor and/or actuator network (WASN) systems.

Annex 1

Objectives of wide area sensor and/or actuator network (WASN) systems

1 Introduction

This Annex provides the objectives for wide area sensor and/or actuator network (WASN) systems, in this Recommendation for communications to a large number of sensors and/or actuators.

2 Objectives

2.1 Support of M2M service applications

The mobile wireless access system (WAS) should support a variety of machine-to-machine (M2M) service applications such as automation and efficiency enhancement of business works, environment observation, remote control of plant facilities, social security and the reduction of environmental impact, irrespective of their locations.

2.2 Coverage of a wide range of sensor and/or actuator densities

The mobile WAS should provide these services over a wide range of sensor and/or actuator densities, irrespective of whether service areas are inhabited or uninhabited.

2.3 Accommodation of a large number of sensors and/or actuators

The mobile WAS should accommodate a large number of sensors and/or actuators and provide services at an acceptable cost. For some applications, the number of sensors and/or actuators could be several times the population.

The WAS used for sensor and/or actuator communications should support a large address space to accommodate a large number of sensor and/or actuator devices.

2.4 Easy system installation and simple deployment

The mobile WAS should provide both easy system installation and simple deployment which reduce the number of base stations (BSs).

This objective enables the operator to easily provide M2M service applications on a cell-basis.

2.5 Power efficient system

The mobile WAS should use power efficiently to ensure longer battery life of the wireless sensors and/or actuators and to minimize the environmental impact. In particular, the wireless sensors and/or actuators could be equipped with intelligent power saver algorithms and efficient sleep-wake cycle.

There are a great many wireless terminals (WTs) attached to sensors and/or actuators in a BS, so the enhancement of power efficiency per WT leads to a reduction in overall system energy consumption. This contributes to reduce the maintenance cost and environmental impact of the system, e.g. reduction of battery replacement cost and CO_2 emission.

2.6 QoS support

The mobile WAS should provide these services with a quality of service (QoS) performance equivalent to the QoS of the public mobile networks.

Since service applications may have different QoS, e.g. reliability, latency, data accuracy, it is important to support a broad range of QoS.

2.7 Security

The mobile WAS should provide these services with security features equivalent to those available for data communication services on the public mobile networks.

Since information from sensors and toward actuators may include private information and confidential business information, it is important to protect this information from unauthorized and malicious outsiders.

2.8 Providing sustainable M2M services

The mobile WAS should provide sustainable M2M services which can apply upcoming innovative technologies and incorporate their future applications.

This objective enables to enhance the conventional service applications by introducing new technologies and incorporating the future extensions while supporting the conventional service applications.

2.9 Support of nomadic and fixed services

The mobile WAS should support nomadic and fixed M2M services as well as mobile M2M services.

2.10 Wireless terminal consideration

The mobile WAS should support a variety of sensors and/or actuators, regardless of their size, shape and materials, which are maintenance-free or requiring minimum maintenance, and can be installed even in harsh conditions (e.g. extreme temperatures and humidity, etc.).

Annex 2

System characteristics, functional requirements, service applications and fundamental network functionalities of wide-area sensor and/or actuator network (WASN) systems

1 Introduction

This Annex focuses on the system characteristics, functional requirements, service applications and the fundamental network functionalities for WASN systems. The system design guidelines of WASN systems are described in Report ITU-R M.2224.

2 Service applications

The WASN systems should support a variety of service applications. Available service categories are shown below. Service categories are not limited to those listed below:

– automation and efficiency enhancement of business works such as remote meter-reading of utilities, i.e. water, gas, and electricity;
– meteorological observation such as air temperature and humidity measurement;
– environment observation, forecasting, and protection such as environmental pollution observation, including air, water, and soil;
– crime prevention and security, such as intrusion detection;
– healthcare, medical applications, and welfare support such as monitoring of vital parameters (e.g. body temperature, weight, and heart rate);
– remote control and monitoring of plant facilities;
– goods distribution;
– disaster prevention and measures, such as disaster notification;
– smart homes and control commercial building, such as home and office appliance networking;
– intelligent transportation and traffic management systems[1];
– monitoring of avian species that may carry the avian influenza virus;
– personal security, such as child tracking and intruder detection;
– reduction of environmental impact, such as energy consumption control and visualization of energy consumption.

3 Network functionalities

The fundamental network functionalities of the WASN systems are shown below:

– *Automatic sensing information collection:* This application automatically collects the information acquired by sensors and sends it to application servers (ASs) or databases (DBs) via the core network to which the WAS is connected.
– *Remote actuator control:* This application lets the users control actuators remotely via ASs via the core network. The control information for the actuators is transferred from the ASs to the actuators via the WAS.

4 System characteristics

4.1 Sensor and/or actuator density aspects

Since WASN systems are intended for humans as well as machines such as utility meters, vehicles, motorbikes, etc., the number of sensors and/or actuators to be accommodated will be very large, i.e. from tens to hundreds of times the population. Furthermore, since WASN systems are expected to handle small amounts of data such as measurement data, location information, and object control signals rather than continuous streaming content; achieving transmission over long-distances by

[1] Guidelines and objectives of Intelligent Transport Systems (ITS) are described in Recommendation ITU-R M.1890.

narrow signal bandwidth is more important than high-speed transmission with broad signal bandwidth.

Since sensors and/or actuators can be deployed anywhere, the M2M services should be provided not only to inhabited areas such as business, urban, residential, and rural but also to uninhabited areas. As noted above, sensor and/or actuator density is one of the key criteria in installing the system at a practical cost. The systems need to support some applications in the mobile and nomadic environments. To support such mobility, these systems have to be deployed using a cellular layout.

4.1.1 Low-density scenario

In areas with low-density sensors and/or actuators, the systems must employ large cells to reduce the number of required BSs which leads to a simple and cost-effective deployment.

4.1.2 High-density scenario

In areas with high-density sensors and/or actuators, the WASN system may accommodate a significantly larger number of wireless terminals (WTs) per cell. Therefore, it is more important that the radiated power from WTs does not become co-channel interference at a BS. In order to minimize the potential for co-channel interference, the systems should reduce radiated power from WTs even in their inactive cycle.

4.2 QoS

QoS needs to be expressed by user-perceivable parameters such as errors and transfer delay, independent of the internal design of the network depending on the service applications as described in Section 2.

To support different kinds of WASN services, multiple QoS classes optimized for WASN should be defined. Two example classes are discussed as follows:

– For delivery-time-sensitive services such as remote control of plant facilities or intruder detection, at least one time-sensitive QoS class could be defined and supported.

– WASN also deals with relatively delivery-time-insensitive M2M services. For delivery-time-insensitive M2M services, the use of a delay-tolerant QoS class might be dominant.

Additional important classes may be supported. An appropriate QoS mapping between that of WASN and legacy core network, defined in Recommendation ITU-R M.1079 should be made for the consistency of end-to-end services.

The definition of QoS for WASN systems is out of the scope of this Recommendation.

4.3 Security

Information transmitted from sensors and toward actuators may include private information and confidential business information. Any unauthorized access to the network will pose security risk; an outsider might peruse the sensing information or alter the control information being sent to an actuator.

To guarantee secure communications, security techniques such as authentication and encryption should be used. The sustainability of the security algorithms should be ensured. For reference, security guidance for packet-based multimedia communication systems is provided in Recommendation ITU-T H.235, and that for data networks and open system communications is provided in Recommendation ITU-T X.805.

4.4 Sustainability and scalability of system

The WASN systems can be used to support a variety of applications, such as facility automation, utility metering, and environment observation. Unlike wireless terminals such as cellular phones, most wireless terminals for M2M services are rarely exchanged once they are operational due to their number and the associated cost of replacement.

To support those services for long periods, the radio interface between the WT and the BS should be scalable and its backwards compatibility be assured.

4.5 Mobility

When used in some applications such as crime prevention, goods distribution, and intelligent transportation systems, WASN systems need to support applications in the mobile and nomadic as well as fixed environments. The fixed environment could be advantageous for power-limited WASN services such as battery-operated devices.

To support such mobility, the systems should provide these applications using a multi-cell configuration.

4.6 Medium-access

The WASN systems may accommodate a significantly large number of WTs per cell. In general, the distributed medium access protocols, such as random access, are effective. However, collisions may occur with the increased number of WTs. Due to the bandwidth limitation of the frequency band, some requests from the WTs may not be able to access the system as a consequence of congestion. To effectively accommodate all the WTs in the system, the WASN systems need to employ effective medium-access protocols including priority access schemes.

4.7 Reduction of co-channel interference

To provide M2M services in areas of high or low sensor and/or actuator density, a key issue is reduction of co-channel interference.

For example, to minimize the potential for co-channel interference, control message overhead transmission, its periodicity, and power could be decided based on the density of WTs in the cell.

4.8 Wireless terminal

Some wireless terminals for M2M services are anticipated to be in service for a long time. Due to the lack of an external power supply, their power consumption should be very low.

For M2M services such as facility control or environmental observation, sensors and/or actuators may be installed in harsh environments such as extreme high/low temperature, humidity, height or dusty air conditions. Transmission reliability should not be affected by these harsh conditions.

5 Functional requirements

5.1 Density of sensors and/or actuators to be supported

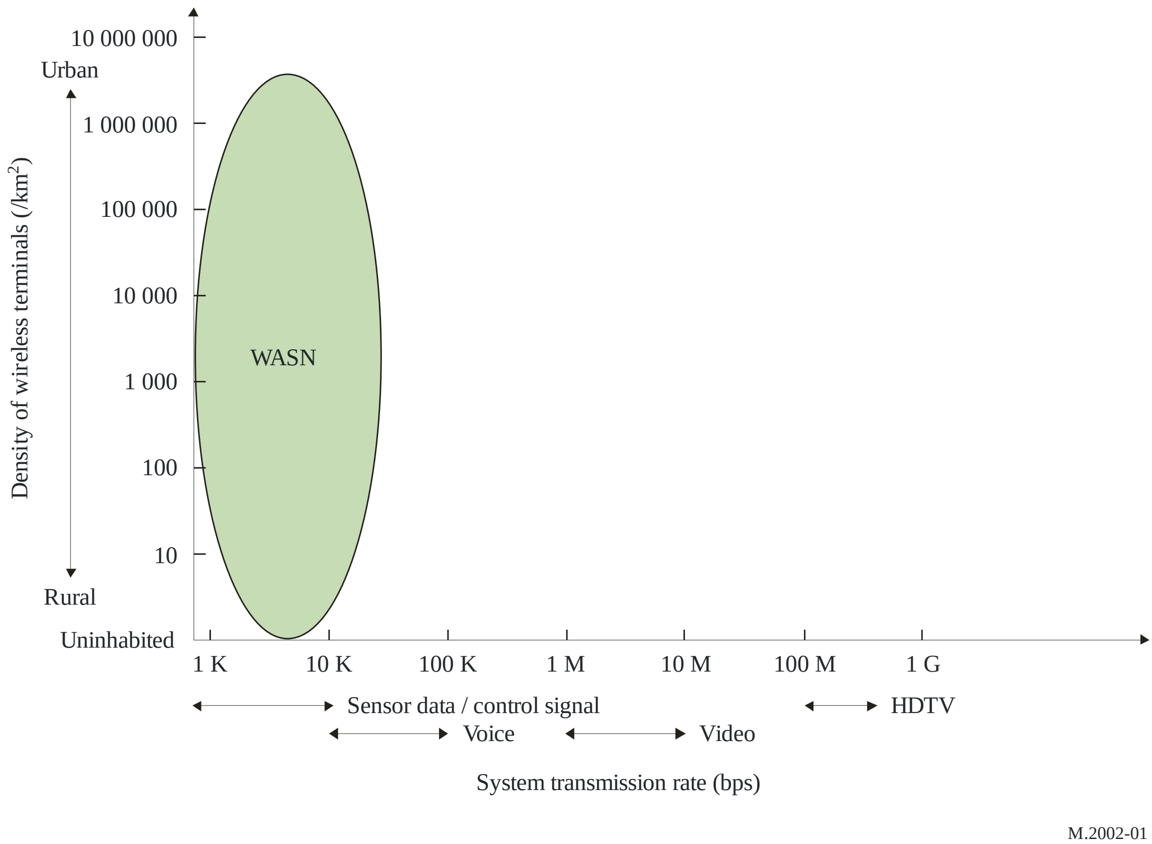
Considering the services shown in Section 2 and the characteristics shown in Section 4, it is essential to consider sensor and/or actuator density in designing a common wireless system that can support future essential services such as remote meter reading of utilities, home and office appliance networking, environmental pollution observation, and disaster notification.

Figure 1 shows the typical design areas of WASN in terms of system transmission rate and wireless terminal density.

A key characteristic of the system is that it will accommodate a great many sensors and/or actuators in extremely high-density areas like urban areas as well as a limited number of sensors and/or actuators in low-density rural areas. WASN needs to support a large number of WTs as shown in Fig. 1.

FIGURE 1

System transmission rate and density of sensors and/or actuators supported by WASN systems



5.2 Transmission rate of sensors and/or actuators to be supported

Considering the services shown in Section 2 and the characteristics shown in Section 4, it is essential for the wireless system that long-distance transmission with narrow signal bandwidth is more important than high-speed transmission with broad signal bandwidth to provide the above future essential services cost-effectively in low density areas.

As shown in Fig. 1, a key characteristic of the system is its low transmission rate which facilitates deployment of large cells and allows low-density areas to be supported cost-effectively. WASN systems typically operate at low transmission rates. On the contrary, in broadband wireless access systems, high-speed transmission has higher priority over transmission distance (i.e. cell size).

5.3 Possible frequency bands

Although a number of frequency bands could be used, considering the propagation characteristics (see Recommendations ITU-R P.1406 and ITU-R P.1812), man-made noise (see Recommendation ITU-R P.372), and the need for a large cell size, it is preferable for WASN systems to use the higher portion of VHF or the lower portion of UHF bands.