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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

E-health multimedia systems, services and applications –
Multimedia e-health data exchange services

**Requirements and framework for ICT sleep
management service models**

Recommendation ITU-T H.862.0

ITU-T



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Recommendation ITU-T H.862.0

Requirements and framework for ICT sleep management service models

Summary

Recommendation ITU-T H.862.0 specifies requirements and a framework for information and communication technology (ICT) sleep management services. The scope of Recommendation ITU-T H.862.0 focuses on the reference model of the sleep management service and introduces sleep safety services and sleep quality improvement services.

Solutions exist for sleep-monitoring and sleep status check services that use a variety of sensors and technologies. While they lead to quantitative expansion of sleep management services, they are difficult to integrate into one service due to the different sleep visualization methods that vary across service devices. To address these challenges, approaches are proposed to ensure interoperability by expressing various types of sleep data in an integrated process. Recommendation ITU-T H.862.0 specifies a service model and requirements for sleep-monitoring and sleep status check services to ensure interoperability of sleep management services.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Recommendation ITU-T H.862.0

Requirements and framework for ICT sleep management service models

1 Scope

This Recommendation specifies the architecture, functional entities and interfaces for information and communication technology (ICT) sleep management services.

Sleep management services cover an area that uses sleep management devices to collect data about sleep states or induce a good night's sleep and includes fields that record and monitor sleep, as well as providing services for sleep through data collected by the device.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 sleep management service: A service that records and assists sleep using Internet of things devices and its services.

3.2.2 sleep sensor: A sensor used to measure sleep. Various types of sensors can be used, e.g., for pulse, pressure, motion detection, electrocardiographic activity and electroencephalographic activity.

3.2.3 sleep induction service: A service that helps sleep by using information and communication technology.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API	Application Program Interface
app	application
ECG	Electrocardiogram
EEG	Electroencephalogram
ICT	Information and Communication Technology
IoT	Internet of Things
REM	Rapid-Eye Movement
UI	User Interface

5 Conventions

In this Recommendation:

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

6 Introduction

Lack of sleep can affect labour productivity and health. While sleep management aids have traditionally focused on furniture, including bedding, recent medical sleep management trends include a convergence of existing sleep management methodology and ICTs, which are reflected in various proprietary technology products and services found in the marketplace. Human factors for this class of products and services remain an issue to be standardized.

The most actively studied areas of sleep management services are:

- sleep monitoring (sleep-monitoring devices using various sensors);
- sleep improvement (sleep-improvement devices to enhance sleep quality);
- induction of deep sleep (inducing deep sleep using lighting, white noise, etc.).

Many companies offer sleep-monitoring and sleep status check services using a variety of sensors and technologies. While these factors lead to quantitative expansion of sleep management services, it is difficult to offer an integrated service, because various sleep visualization methods depend on different service devices. From the perspective of a service company or hospital that provides healthcare services, this is ultimately difficult to use. To address these challenges, interoperability needs to be enabled by expressing various types of sleep data in an integrated process. Figure 1 shows examples of sleep management services.

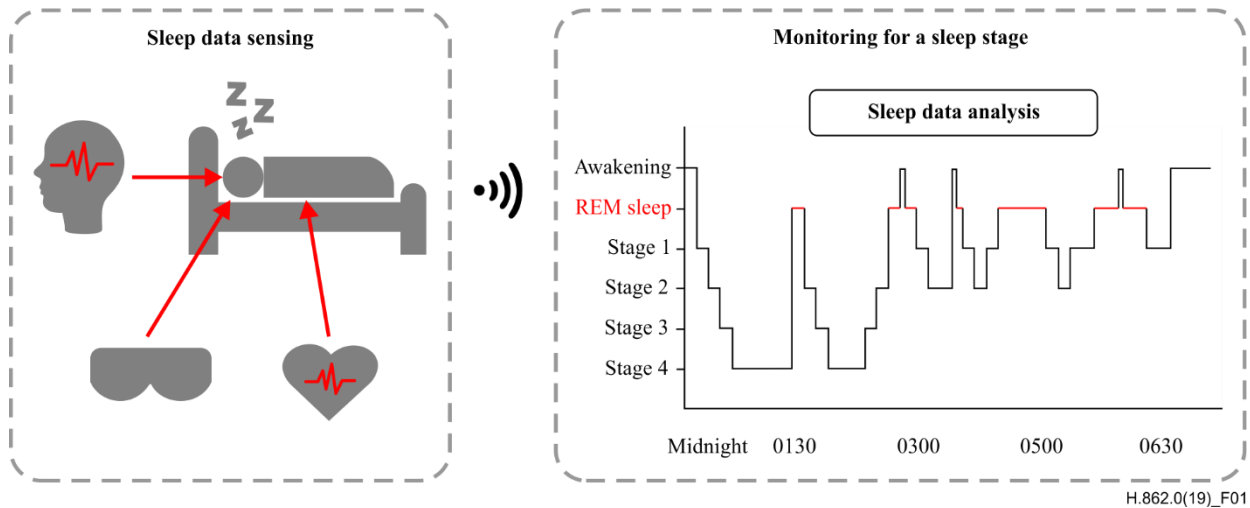
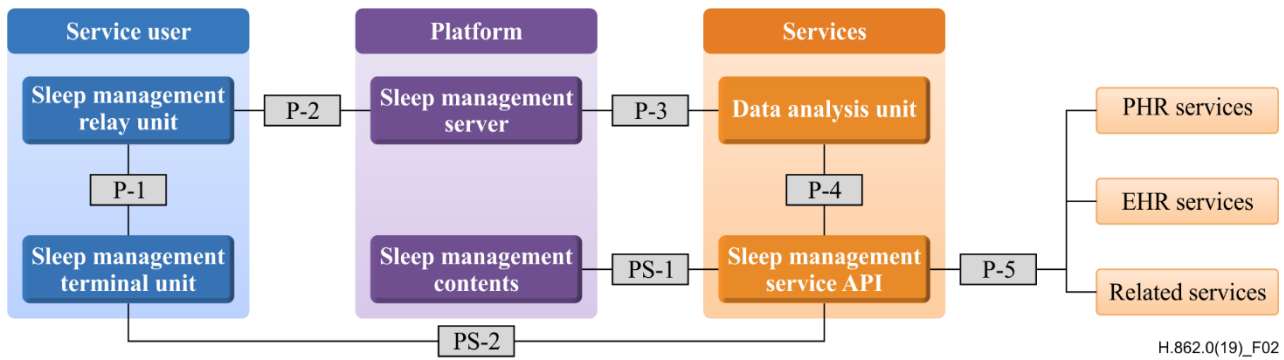


Figure 1 – Examples of sleep management services

7 Framework for sleep management services

7.1 Sleep management service

Sleep management services cover an area that uses sleep management devices to collect data about sleep states or induce a good night's sleep and includes fields that record and monitor sleep, as well as providing services for sleep through data collected by the device. Figure 2 shows the reference model of sleep management services.



Sleep management service protocol

- P-1: Sleep management terminal unit – Sleep management relay unit
- P-2: Sleep management relay unit – Sleep management server
- P-3: Sleep management server (Database) – Data analysis unit
- P-4: Data analysis unit – Sleep management service API
- P-5: Sleep management service API – Related services
- PS-1: Sleep management service API – Sleep management contents
- PS-2: Sleep management service API – Sleep management terminal unit

Figure 2 – Reference model of sleep management services

7.2 Sleep management service model

7.2.1 Sleep management terminal unit

A sleep management terminal unit is a device for sleep management or a smartphone application (app). The terminal collects data when the device accumulates a sleep-related log, and identifies sleep patterns and management guide content collected on a user display terminal, e.g., an app.

A sleep management terminal unit can include several functions, e.g., sleep management devices, sleep-monitoring service devices, sleep induction devices and sleep disorder management. Figure 3 shows the components of a sleep management terminal unit.

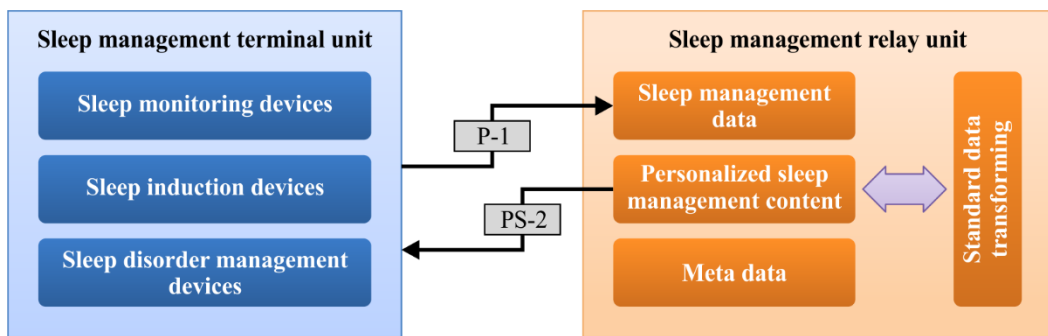


Figure 3 – Components of a sleep management terminal unit and a sleep management relay unit

7.2.1.1 Sleep management devices

A general sleep management device is a health management device for measuring the amount and quality of sleep using various types of sensor. It quantifies the amount and quality of sleep by using various bio-signals, e.g., pulse, respiration, brain wave or electrocardiographic activity. In addition, audio equipment that automatically adjusts the amount of light used to induce a sleeping sound or sounds good for sleeping is also used as a sleep management device.

7.2.1.2 Sleep-monitoring devices

Devices for sleep-monitoring services measure pulse, breathing rate, brain waves, electrocardiograms and movement. These devices continuously collect bio-signals during the user's sleep, whether or not in contact with the user's body, analyse the data and record the sleep pattern.

7.2.1.3 Sleep induction devices

Sleep induction devices are produced and marketed using devices based on the Internet of things (IoT) that control lighting based on sleep patterns collected through sleep monitoring, audio devices that induce sleep through white noise, and neuro-feedback products using electroencephalography. Most devices perform functions that create optimal conditions for monitoring current status and sleep induction.

7.2.1.4 Sleep disorder management devices

Sleep disorder management devices can overcome and alleviate various disorders related to sleep. Sleep disorder management devices focus on improving their condition by functioning to improve the symptoms of sleep-related disorders. For example, devices are commercially available like a pillow used during sleep to move the head to relieve snoring.

A sleep management relay unit transmits the data collected from the user device of the terminal unit to the relay unit through protocol P-1 and converts the data received into standard data. The relay unit includes the function of protocol for services PS-2 for transmitting personal sleep management content to the terminal unit. Figure 3 shows components of the sleep management relay unit.

7.2.3 Sleep management server

A sleep management server must serve as a service interface, security and verification to store and manage standards-based sleep management data. The sleep management server is a component on which sensitive personal data is stored and it should include an audit module that can be monitored for individual activities or transactions.

7.2.4 Sleep management content

Sleep management content is part of a guide to customized sleep management that includes data on good sleep, diet and habits. The content should be segmented or categorized to provide customized data from sleep management services.

7.2.5 Data analysis unit

Based on the sleep pattern data and the original bio-signal data collected from the sleep management device, the sleep management analysis unit analyses the state, amount and quality of sleep, as well as producing data to provide a personalized service. The unit also includes an analysis function for providing analysed content data for various sleep management devices. The model of the analysis unit can be limited to the measurement data collected by the service and the range of services provided by the service. Components of the data analysis unit are shown in Figure 4.

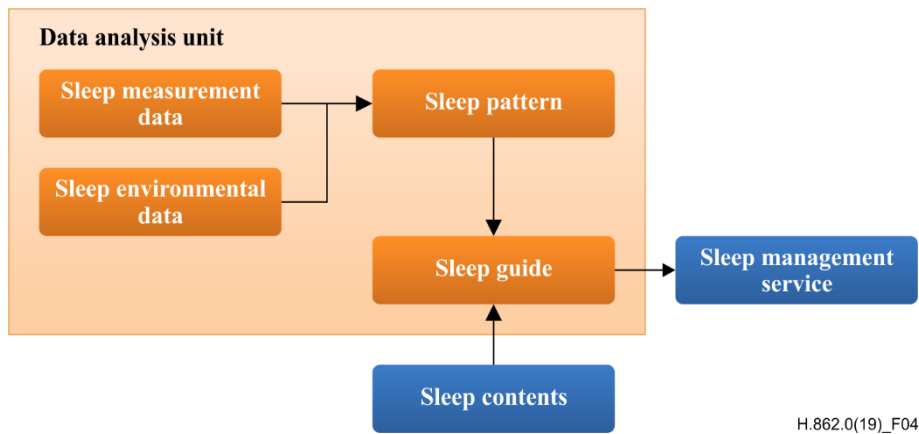


Figure 4 – Components of the data analysis unit

7.2.6 Sleep management service

The sleep management service is the part of the model that specifies the interface for the final service through the individual components of the service reference model. Sleep management services can be viewed in a user interface (UI), such as an app or a website, and may be presented in the form of an API that excludes the UI. Sleep management services can be configured differently depending on the characteristics both of the service device and the service itself. Components of the sleep management service are shown in Figure 5.

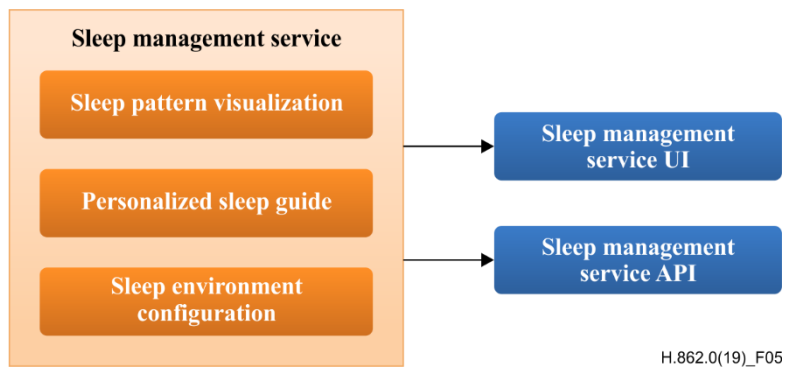


Figure 5 – Components of the sleep management service

7.3 Sleep safety service

Various emergency events, in severe cases leading to death, can occur during sleep. Figure 6 is a block diagram of the sleep safety service.

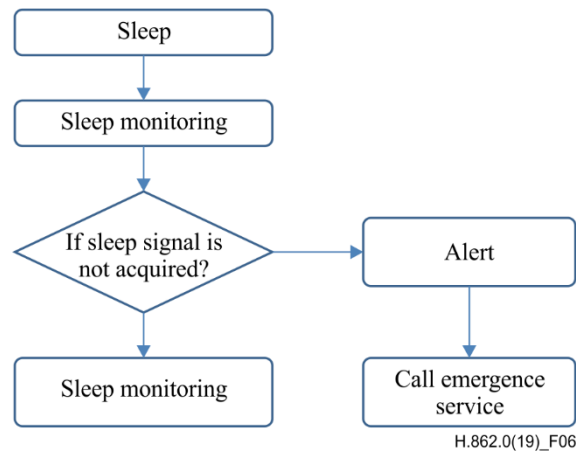


Figure 6 – Block diagram of the sleep safety service

7.3.1 Sudden death during sleep

Causes of sudden death during sleep include cerebrovascular disease and heart disease. Sleep apnoea (which is a potentially serious sleep disorder in which breathing repeatedly stops and starts during sleeping) can also be an important factor. A fall in oxygen level in the blood during sleep increases the risk of sudden and cardiac death. The management service continuously monitors the sleep signal during sleep and can notify an emergency centre if an incident occurs.

7.3.2 Fall accident during sleep

Serious physical problems may arise in the elderly or those with physical disabilities because they cannot cope with falling during sleep. In this case, a quick response is possible through continuous monitoring. Devices capable of continuously acquiring data are able to detect data changes. Also, variations in the data can quantify changes in user state. In this way, if a fall occurs during sleep, the patient's caregiver can be notified or the emergency centre called.

7.4 Sleep quality improvement service

7.4.1 Induction of sleep

7.4.1.1 Providing improvement of sleep environment

The sleep data collected and measured can be used to identify the level of sleep and to provide customized services. Depending on the measurement data obtained during sleep, lighting can be adjusted, curtains automatically adjusted and music played to assist with sleep, for example.

7.4.1.2 Providing a summary of sleep

The sleep data collected and measured can summarize the duration, quality and disorders of sleep in sleep services. The summary can be provided as a user-verifiable UI.

7.4.1.3 Providing a guide to improving sleep quality

If necessary, it is possible to provide customized content that automatically manages sleep devices and guides the sleeper to improve sleep quality.

8 Requirements for sleep management services

The sleep management service aims to collect data through the device (or the sensor) during sleep, to judge the quality and quantity of sleep based on the data, and to provide services to help sleep. Sleep management technologies can include sound, lighting, bedding and other physical factors, e.g., sleeping conditions and sleeping disorders.

8.1 Consideration of sleep-monitoring services

Sleep-monitoring services are recommended to ensure that sleep devices do not malfunction in their environment under usual conditions to obtain stable sleep data.

8.2 Sleep-monitoring device

Sleep measurement devices are recommended to ensure continuous data acquisition during sleep. During sleep, the device should neither interfere with various problems nor cause any problems in data measurement. In addition, ensure that there are no problems with various scenarios in which a malfunction of the device may occur.

8.3 Sleep data type

Sleep data are recommended to be expressed as both quantitative sleep and qualitative sleep. Sleep management devices collect or measure data and the data can be synchronized in real time or following a synchronization request. Sleep-monitoring data can be represented by various types of data for judging sleep, e.g., an image, electrocardiogram (ECG), electroencephalogram (EEG) or pulse.

It is recommended that sleep data be synchronized, including the duration of the service. Device and sensor types for sleep management services are listed in Table 1.

Table 1 – Types of devices and sensors for the sleep management services

Device type	Sensor type	How to measure
Smart band	Pulse	Measurement of change in pulse rate at each sleep stage
Smart pillow	Pulse, pressure	Measurement of change in pulse from blood vessels in contact with the pillow and pressure measurement on the pillow
Speaker	Sound	Measurement of breathing and snoring sounds during sleep
Electrocardiograph	Electrocardiographic activity	Measurement of changes in ECG during sleep
Electroencephalograph	Electroencephalographic activity	Measurement of changes in EEG during sleep

8.4 Sleep data management

Users are recommended to record duration and quality of sleep by hand if there is no sleep device. When a sleep-related device is used, sleep data can be automatically collected and registered.

Appendix I

Sleep stage

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

Sleep is divided into non-rapid-eye movement (non-REM) sleep and REM sleep. Non-REM sleep and REM sleep have various physiological differences, e.g., changes in eye movement, pulse, brain activity and muscle tension. This is measured with an IoT device. This data is used to evaluate the quality and quantity of sleep through changes in non-REM sleep and REM sleep levels and total sleep time. The characteristics of each sleep stage are listed in Table I.1.

Table I.1 – Characteristics of each sleep stage

Stage		Brain wave form	Note
Non-REM	Stage 1	Alpha waves disappear and the theta wave appears	
	Stage 2	Sleep spindles and K-complexes	
	Stage 3	Delta waves	Deep sleep
REM		Similar to when one is awake	

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