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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

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

Data model for sleep management services

Recommendation ITU-T H.862.1

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Recommendation ITU-T H.862.1

Data model for sleep management services

Summary

Recommendation ITU-T H.862.1 describes the data model for the sleep management services. This Recommendation focuses on the structured model of data for expressing data collected from sensors as information such as sleep time, sleep stage and sleep goal, to be applied to sleep management services.

In many fields of human factors including healthcare, sleep data can be obtained from a variety of sensors such as electroencephalogram (EEG), electrocardiogram (ECG), pulse, motion and sound. Sleep time and sleep quality can be calculated based on the data. A general sleep management service that can handle multiple devices independently of the raw data should be able to represent the quantity and quality of sleep. This can be the sleep stage and its time.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.862.1	2020-08-13	16	11.1002/1000/14352

Keywords

Data model, sleep, sleep management.

* 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

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

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Recommendation ITU-T H.862.1

Data model for sleep management services

1 Scope

This Recommendation describes the data model for the sleep management service. Sleep data can be expressed through data measured by various sensors such as electrocardiogram (ECG), electroencephalogram (EEG) and acceleration sensors. These data are complicated and difficult to express in an integrated system. This Recommendation describes a structured model of data for expressing data collected from sensors as information such as sleep time, sleep stage and sleep goal, to be applied to sleep management services.

2 References

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

[ISO 8601-1] ISO 8601-1:2019, *Date and time – Representations for information interchange – Part 1: Basic rules.*

[ISO 8601-2] ISO 8601-2:2019, *Date and time – Representations for information interchange – Part 2: Extensions.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ECG Electrocardiogram

EEG Electroencephalogram

IoT Internet of Things

REM Rapid Eye Movement

5 Conventions

In this Recommendation:

– The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

– The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement needs not be present to claim conformance.

– The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction

This Recommendation proposes a structured model of data generated from sleep management devices for sleep management services. In the field of healthcare, sleep data can be obtained from a variety of sensors such as EEG, ECG, pulse, motion and sound. See Figure 1. Sleep time and sleep quality can be calculated based on the data. A general sleep management service that can handle multiple devices independently of the raw data should be able to represent the quantity and quality of sleep. This can be the sleep stage and its time.

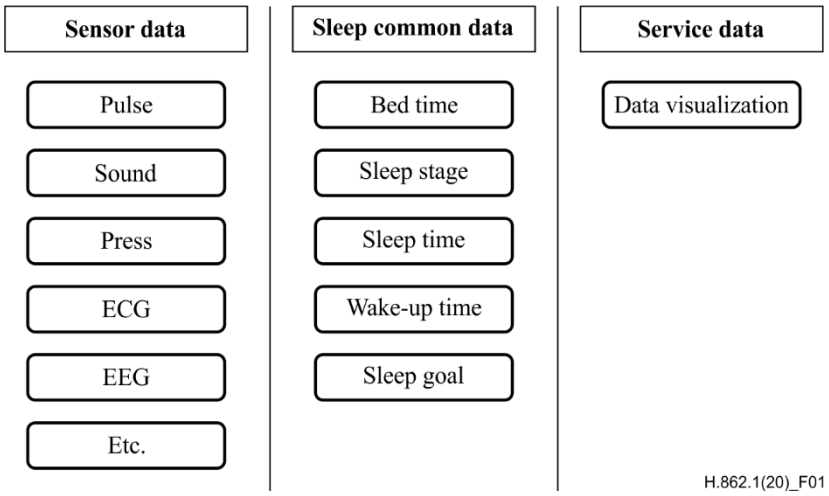

Figure 1 – Data groups for sleep management services

The sleep management service receives various types of data from different sensors. In the sleep management service, the sleep is expressed and serviced by analysing and reprocessing these data to distinguish the sleep time and the sleep stage.

This Recommendation does not deal with the form and quality of the source data from the sleep management devices, but the sleep management data model and service from the standpoint of the sleep management services.

7 Sleep data

7.1 Sleep data and sensor types

The various devices generating sleep related data do not directly provide the total time and quality of sleep, hence these data need to be processed to generate the data required for sleep management services. Data types and sensor types are shown in Table 1.

Table 1 – Sleep management device type

Device type	Sensor type	Measure method
Smart band	Pulse	Measurement of pulse change in sleep phases
Smart pillow	Pulse, Press	Measurement of pulse changes from blood vessels on the pillow contact surface Measurement of pressure on the pillow
Smart speaker	Sound	Measuring the sound of breath and snoring during sleep
ECG	ECG	Measurement of changes in ECG during sleep
ECG	ECG	Measurement of changes in EEG during sleep
Smart ring	Pulse, temperature	Measurement of pulse change in stages of sleep

This Recommendation defines a data model for ensuring interoperability by extracting only the common elements necessary for sleep management services, to allow service integration and service implementation using all these data types.

7.2 Target data

Sleep management services differ in the data presented by the service provider, but they all show to the consumer the sleep time and the time for each sleep stage. Table 2 defines the sleep management data covered by the major sleep management services.

NOTE – This Recommendation provides a data model of data for sleep management and does not cover data types coming from sensors.

Table 2 – Data types

Data type	Description
Time to sleep	Total sleep time
Bed stay time	Total time in bed
Sleep target	Goals for daily or monthly sleep time
Sleep time by stage	Sleep time for each sleep stage, including sleep stages 1, 2, 3 and REM
Apnea time during sleep	Time by stage for patients with sleep apnea
Number of apneas during sleep	Number of apnea events during sleep
The number and time of backsliding during sleep	Records of backlash during sleep
Bedtime	Time to sleep
Wake up time	Time to wake up

In addition to data elements that can be quantified, there can be many differences in processing and expression methods for each service or sensing data. The sleep management data element is defined by the items that can be used and defined for the service, based on the service data of the existing service.

7.3 Metadata

Sleep data is defined according to the data to be represented. Metadata of the sleep data is shown in Table 3.

Table 3 – Metadata

Total sleep time			
Metadata ID	sleep_duration	Data type	Time
Object type	Value	R/O	Required
Comment	Describe the total sleep time		
Usage	"sleep_duration": "HH:MM:SS"		
Goal sleep time			
Metadata ID	goal_sleep_duration	Data type	Time
Object type	Value	R/O	Optional
Comment	Describe the goal sleep time.		
Usage	"goal_sleep_duration": "HH:MM:SS"		
Sleep start time			
Metadata ID	sleep_start_time	Data type	DateTime
Object type	Value	R/O	Required
Comment	Describe the sleep start time.		
Usage	"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01"		
Sleep end time			
Metadata ID	sleep_end_time	Data type	DateTime
Object type	Value	R/O	Required
Comment	Describe the sleep end time.		
Usage	"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01"		
Sleep state			
Metadata ID	sleep_end_time	Data type	String
Object type	Value	R/O	Optional
Comment	Define sleep stages, divied into stages 1, 2, 3 and REM sleep.		
Usage	"sleep_stage": "Stage1"		
Sleep disorder			
Metadata ID	sleep_disorder_type	Data type	ID
Object type	Value	R/O	Optional
Comment	Describe the type of sleep disorder.		
Usage	"sleep_disorder_type": "Insomnia"		
Sleep event			
Metadata ID	sleep_event	Data type	ID
Object type	Set	R/O	Optional
Comment	Describe the events that occurred during sleep.		
Usage	"sleep_event": "Apnea during sleep"		
Data source			
Metadata ID	data_source	Data type	Base64, Linkage
Object type	Value	R/O	Optional
Comment	The original source of the measured data is recorded directly, or the physical path of the data is described.		
Usage	"data_source": ""		

7.4 Sleep data representation by metadata

7.4.1 Sleep time

Sleep time is expressed as the start time, end time and total time of sleep. Sleep time is an item that is visually displayed in the service and is shown as time so that it can be clearly expressed with simple data. The notation of time follows the ISO 8601 standard. An example of sleep time is as follows.

NOTE – ISO 8601 has two parts, [ISO 8601-1] and [ISO 8601-2].

```
"sleepDataModel": {
"sleepSummary": [
{
"sleep_duration": "HH:MM:SS",
"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01"
"sleep_end_time": "YYYY-MM-DDTHH:MM:SS:000Z+01"
}
}
```

7.4.2 Sleep stage

The sleep stage is expressed as a subset of sleep, and can be selectively used depending on the characteristics of the sleep management device. The sleep stage is as follows.

```
"sleepDataModel": {
"sleepSummary": [
{
"sleep_duration": "HH:MM:SS",
"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_stages": [{
"sleep_stage": "Stage1",
"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
},
{
"sleep_stage": "Stage2",
"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
}]
}]
}
```

7.4.3 Sleep event

Sleep events can be used when a special event occurs independently of the sleep phase. For example, if the ability is needed to record the section where the sleep disorder or special sleep event occurred, it can be recorded as follows:

```
{
"sleepDataModel": {
"sleepSummary": [
{
"sleep_duration": "HH:MM:SS",
"sleep_start_time": " YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": " YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_stages": [
{
"sleep_stage": "Stage1",
"sleep_start_time": " YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": " YYYY-MM-DDTHH:MM:SS:000Z+01"
},
{
"sleep_stage": "Stage2",
"sleep_start_time": " YYYY-MM-DDTHH:MM:SS:000Z+01",
```

```
"sleep_end_time": " YYYY-MM-DDTHH:MM:SS:000Z+01"
}],
"sleep_events": [
{
"sleep_event": " Sleep apnea",
"sleep_start_time": " YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": " YYYY-MM-DDTHH:MM:SS:000Z+01"}]}
]}
}
```

In the sleep management service, the expression of the type of sleep disorder is expressed based on the ICD code.

```
"sleep_disorder": [
{
"sleep_disorder_type": "F473",
"display_text": "Sleep apnea",
"coding_system": "ICD-10"
}]
```

8 Applications

8.1 Sudden death during sleep

When a cardiac arrest occurs during sleep, a notification may be provided through tracking of sleep data. If the event persists, the sleep management service may provide information through a device capable of notifying the current situation by connecting to an emergency service or providing a notification to the family or the self. The flowchart of an example of the sudden death detection during sleep is shown in Figure 2. The event can be expressed as follows.

```
"sleep_events": [
{
"sleep_event": "No sensing signal",
"sleep_start_time": "YYYY-MM-DDTHH:MM:SS:000Z+01",
"sleep_end_time": "YYYY-MM-DDTHH:MM:SS:000Z+01"
}]]
```

8.2 Sleep induction

The sleep management service can check if someone is asleep. Tools such as IoT-connected lights and sleep-inducing music can be used to aid persons with sleeping difficulties. If one falls asleep, the service can control the contents for sleep management according to the sleep data. Figure 3 in an example flowchart of the sleep induction mechanism.

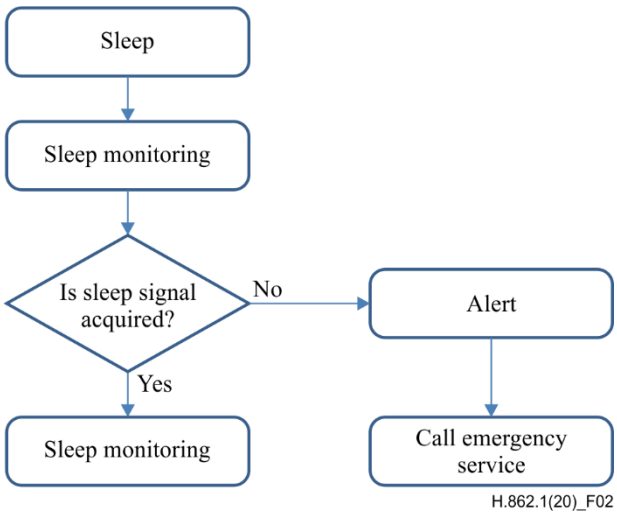

Figure 2 – Example of sudden death detection during sleep

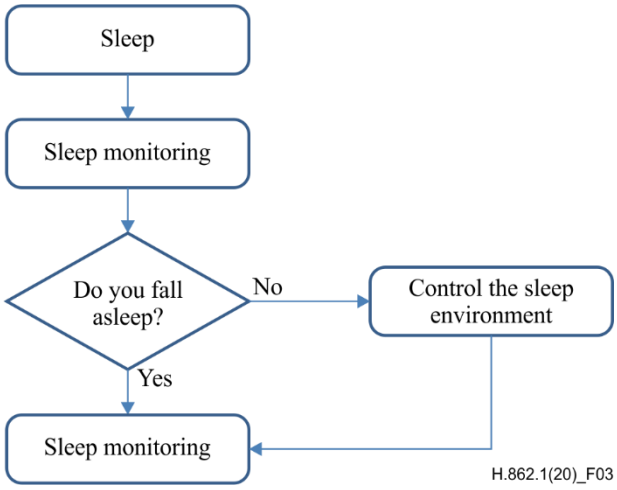

Figure 3 – Example of sleep induction

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