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Ubiquitous data gathering: wearable static and mobile sensors.
(based on the basic rules for ubiquitous monitoring D1.2)

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Public Document

K·SERA

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Contents

Glossary of terms used

Acronym / terms	Definition
ADL	Activities of Daily Living
AR	Assistive Robotics
BPM	Blood Pressure Measurement
COPD	Chronic Obstructive Pulmonary Disease
ER	Emergence Room
FEV1	Forced expiratory volume in 1 second
FVC	Forced expiratory vital capacity
GOLD	The Global Initiative for Chronic Obstructive Lung Disease
HCI	Human Computer Interaction
HRI	Human Robot Interaction
iADL	Instrumental Activities of Daily Living
ICF	International Classification of Functioning
KSERA	Knowledgeable Service Robots for Aging
KSERA-system	A smart home environment and a mobile platform, i.e. NAO
KSERA ubiquitous home environment	A smart home environment
NAO	Humanoid Robot
UCD	User Centred Design
Scenario	Usage narrative
Use case	Describe the functional requirements
WHO-ICF	See International Classification of Functioning
WP	Work package

Executive summary

This deliverable presents the considerations about the ubiquitous data gathering contributing in KSERA Ubiquitous Monitoring system. As such this deliverable serves as a blueprint for the partners involved in the technological aspects of KSERA to allow them to plan for the deployment of the system (Sensors, sensing, execution of the rules, triggering the events based on the sensing).
The discussed sensors are those needed to implement the rules established in D1.2 based on the needs of the patients/users as defined in D1.1 with an understanding that not all the sensors/rules may be adhered to as they broaden the scope of the project and the resources available. Since not all the sensors discussed in this document will be implemented in Ubiquitous monitoring System, the deliverable prioritizes them in order to create the ground for implementation.

Purpose of this deliverable

This document defines the sensors used by KSERA Ubiquitous Monitoring sub-system defined in architectural requirements (D2.1).

Suggested readers

This document is public and it might be used by those willing to know more about the sensing in a robotic system used for AAL.
It is specifically recommended to all KSERA partners and in particular to those involved in the KSERA system design, development and evaluation.

Relationship to other documents

This document inherits directly from the D1.2 and D2.1, where KSERA system design decisions are made and monitoring rules are described. The work packages WP1, WP2, and WP3 use this document to design and develop the KSERA system components. It contains the outcomes from WP4.

1. Introduction

1.1 Ubiquitous Monitoring Sub-system (UMS hereafter)

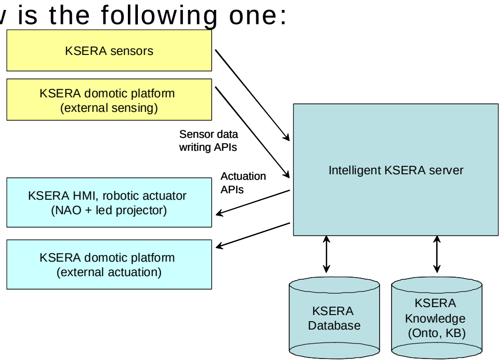
KSERA artificial cognitive system can perceive the external events using the Ubiquitous Monitoring (sensing) sub-system (UMS, WP4). UMS can write the data to the database, making them available for the further processing.
UMS might be logically sub-divided in 3 main categories of sensing instruments included in it: wearable sensing devices (for example wrist watch), static sensors (temperature, gas analysers etc.) and mobile (oxy-pulsimeters, blood pressure, medical sensors and similar).

UMS does acquire the awareness about the events not related to the patient's life, such as environment (weather conditions, indoor conditions), the direct knowledge about the events in everyday's life of the patient, plus certain living parameters.

KSERA holds a number of the rules (Rules subsystem) permitting to actuate the reactions, those are defined in the D1.2.

KSERA Event Engine (EE) will be processing the data in the database (made available by the UMS) to detect the relevant situations requiring the actuation. The actuation is possible through the external Units, such as NAO robot (mobile Unit) and Domotic platform (fixed assets installed at home).

Conceptually, the overall view is the following one:



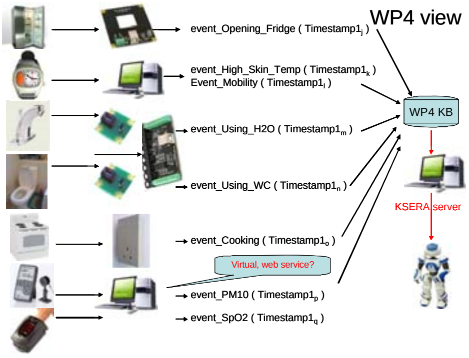
The database entities making the acquired data persistent are those detailed in D2.1 (architecture).

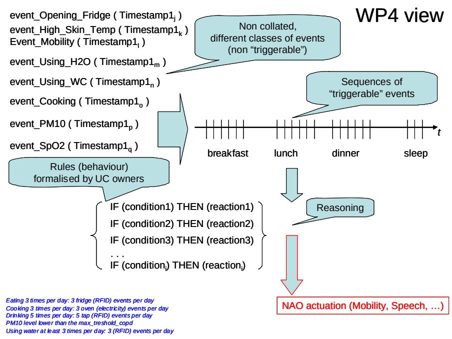
	DbField	Datatype
1	Sensor Id	integer
2	Type of sensor	enumeration
3	Sensed value	number
4	Timestamp	datetime

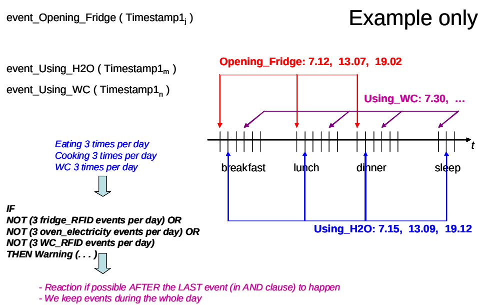
The historical entity showing the events happened during one time interval and permitting to mine for the patterns and the trends is the following DataSet, which can be retrieved from the above Database { (SensorId$_0$, TypeOfSensor$_0$, SensedValue$_0$, Timestamp$_0$), …, (SensorId$_i$, TypeOfSensor$_i$, SensedValue$_i$, Timestamp$_i$)}.

1.2 Real user and context sensitiveness

Ubiquitous Monitoring sub-system (UC) is the main sensing component of KSERA. It integrates all the sensors included in the project, e.g. those required to implement the Use Cases.
KSERA context sensitiveness and all the events being monitored by KSERA **are only those described in Use Cases (D1.1)**.







1.2.1 Sensor integration

Indoor (and outdoor) air sensors and calculations

Sensor	Interface	Model description	Comments	COST
CO2-sensor	Bluetooth/USB	Figaro CD4161	Pre calibaretd sensor from figaro	99€ + Carrier Board
Air temperature Relative humidity	TBD Depends Bluetooth/USB	Sensrion SHT71	One only sensor for both Temp and humidity	24€ +Carrier Board
Fall (risk) detection	Radio 869MHz	Caretek ADAMO	Base Station can be used as gateway to gather data and forward to KSERA DB	780€

Sensors continuously available for irregular or 2x/day use

Sensor	Interface	Model description	Comments	COST
Digital FEV1 meter (EU approved)	Bluetooth	Corscience AM1 + BT		600 €
O2-saturation of the blood, %	Bluetooth	Nonin 9560		475 US$
Systolic blood pressure, kPa Diastolic blood pressure, kPa Systolic / Diastolic blood pressure, kPa/kPa	Bluetooth	Taidoc TD3250C		200€
Electrocardiogram (ECG)	Bluetooth	Corscience 1-lead BT		399 €

- A single board acquires Temperature, Relative Humidity and CO2
- DC in may be a battery (9V) or USB powered.
- Integration of COTS modules
- Availability of both wired and wireless interface (Bluetooth and USB)

Sensor	Interface	Model description	Comments	COST
CO2		Figaro CDM4161		99 €
Temp / Humidity		Sensirion SHT71		25 €
Transceiver		XBT		51 €
Analog board		Arduino Proto Shield		6 €

The integration of the KSERA sensors can be made using the Arduino integration board, which is the state-of-the-art solution better discussed hereunder.

2. Use cases

A use case is an operative description of a system, the functionalities and its users. Since Use Case explains the interaction steps between the user and the system, focusing on the user's actions, in this vision it specifies **how** user interacts with the system (Jacobson 1992) explaining which sensing and actuation tools are needed to implement each Use Case.

This set of KSERA Use Cases inherits from the D1.1 but develops further the vision of WP4 regarding the use of the sensors (wearable, fixed, mobile, and virtual ones).

Category	Use Case ID	Use case name	Owners		Priority
			partner	WP	
Monitor medical parameters	UC1.1	O_2 measurement	ISMB Consoft	WP1/WP4	high
	UC1.2	Blood pressure measurement	ISMB Consoft	WP1/WP4	high
	UC1.3	FEV1 measurement	ISMB Consoft	WP1/WP4	high
	UC1.4	Vital signs recognition	Consoft	WP1/WP4	medium
	UC1.5	Assess medical condition	Maccabi ISMB Consoft	WP1/WP4	high
Monitor environmental parameters	UC2.1	Temperature measurement	ISMB Consoft TU/e	WP4	high
	UC2.2	Humidity measurement	ISMB Consoft TU/e	WP4	high
	UC2.3	CO_2 measurement			high
	UC2.4	Indoor air quality measurement	ISMB Consoft TU/e	WP4	medium
	UC2.5	Assess outdoor conditions	ISMB TU/e	WP4	high
	UC2.6	Combination of environmental information	Consoft TU/e	WP1/WP4	high
	UC2.7	Combine medical and environmental data for decision making	Consoft Maccabi TU/e	WP1/WP4	high
Monitor activities of daily life	UC3.1	Check ADL schedule	Maccabi	WP1, WP4	high
	UC3.2	Receive training program	Maccabi	WP1, WP4	medium
	UC3.3	Fall Recognition	TUW RALTEC	WP4	high
	UC3.4	Detect wake activity	UH	WP2	low
	UC3.5	Receive medication reminder	Maccabi	WP1/WP3	low
NAO interaction	UC4.1	NAO attracts and regains attention	UH TU/e	WP2/WP3	high
	UC4.2	NAO monitors joint attention	TU/e	WP3	high
	UC4.3	NAO approaches	UH TU/e	WP2	high
	UC4.4	NAO follows and leads	UH TU/e	WP2	high
	UC4.5	NAO brings and takes objects	TU/e	WP2/WP3	low
	UC4.6	NAO motivates	UH TU/e	WP2/WP3	low
	UC4.7	Intention recognition	TU/e	WP2/WP3	high
	UC4.8	NAO gives feedback	UH TU/e	WP2/WP3	high
Communication	UC5.1	Communicate with a	TUW, Maccabi	WP3	high

Category	Use Case ID	Use case name	Owners		Priority
			partner	WP	
& alarm		medical professional			
	UC5.2	Communicate with a family member or friend	TUW RALTEC	WP3	high
	UC5.3	Send an alarm	TUW	WP1/WP3/WP4	high
	UC5.4	Receive messages	TUW	WP3	high
Entertainment & domotica	UC6.1	Watch a video clip	to be decided	WP3	medium
	UC6.2	Play music	to be decided	WP3	Low
	UC6.3	Open door	to be decided	WP4	Low
	UC6.4	Turn on the light	to be decided	WP4	Low

2.1 Monitor medical parameters

The use case category "*monitor medical parameters"* describes all system behaviour that uses external medical devices/sensors to assess the physical condition of the primary user. Data mining and learning rules are applied to infer meaningful knowledge about the user's physical condition.

2.1.1 O2 Measurement (Use Case 1.1)

The measurement of O2 might be acquired using an oxy-pulsimeter. KSERA considers the NONIN model because offering the wireless interface facilitating the integration with KSERA. There is the same kind of the communication between the NAO and KSERA, and between the KSERA and SPO2 measurement device.
The wireless pulsioxymeter to be integrated in KSERA is the off-the-shelf NONIN 9560, www.turnermedical.com/Nonin_Onyx_2_9560_Bluetooth_Pulse_Oximeter.htm. Its street price is 450 US$.

SITUATION (context)	Measurement of SpO2 might be undertaken at any time by COPD patient. There is no compulsory scheduling pending. KSERA passively waits for any measurement (listening Bluetooth). Once measured, the data will be sent to the KSERA server, so acquired and written into the database.
CONTEXT (being recognized)	SpO2 measurement is arriving. The measurement brings four main attributes (SensorID, class, value, timestamp,). The Patient ID is not necessary because KSERA is mono-patient. This ID might be added in the export/transmission towards the Remote Service Centre, if any.
IF (rules for recognition)	The SpO2 value is to be evaluated against the "normality" threshold. The Rules are fixed (in D1.4) The comparison with the past known values should assess if the values are steadily decreasing.
THEN (rules for actuation)	Accordingly the Rules, the NAO reaction has to be programmed.

Use case ID:	**UC1.1**
Use case name:	**O_2 measurement**

Description	The **pulsoximeter** is connected **wirelessly** to the KSERA-system. The KSERA-system first reports if the measurement could be successfully completed. Afterwards the KSERA-system gives an appropriate **feedback**. **This feedback could come from any level of the entire KSERA System**.
Pre conditions	Availability of a standard short range radio protocol (Bluetooth) between the sensor and the KSERA ubiquitous-home system. Telemedicine device to measure O_2.
Post conditions	The O2 saturation was successfully measured. OR The O2 saturation was not measured.
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until any SpO2 event comes 2. WHEN SPO2_Measurement_Event come from the sensor, KSERA write the record in the database/knowledge base (and optionally raise / propagate the KSERA event enabling NAO immediate reaction, if any). 3. END **KSERA.RULE_ENGINE.EVENTS** 1. START: KSERA identifies the patient (ID) and read his/her SpO2 measurements' time-schedule encoded in the database 2. UNTIL Time1 DO: KSERA runs the (timer-driven) event monitoring tread to detect any new SpO2 measurement stored in the database 3. IF no measurements from the time-window THEN (after the Time1 passed) NAO_REACTION 4. END **WP2.MOBILE_BEHAVIOUR.NAO_REACTION** 1. NAO detect the user coordinates (X2, Y2) 2. NAO takes the own coordinates (X1, Y1) 3. NAO calculates the mobility to go "nearby" patient from (X1, Y1) to (X2, Y2) 4. NAO moves to "nearby" patient (X2, Y2) 5. NAO attract the patient's attention 6. NAO starts speaking 7. NAO say the message from database, like "please do the Sp02 measurement" 8. NAO manage the user reaction 9. NAO "go home" and stitch to stand-by 10. END ALTERNATIVE 1: User dialog: user doesn't want to measure SpO2. ALTERNATIVE 2: There is another nested activity suggesting asking SpO2 measurement.
DEVICES	O2 measurement in domestic environment might be made using pulsioxymeter. Integration know-how is available in ISMB.

TECHNICAL IMPLICATIONS	Wireless link should cover the distance between the device and the base station. So, according to standard Bluetooth, this distance should not overcome 10m in open air (a couple of meters in a home environment). The time schedule of the measurements should be encoded for each patient in KSERA system. If the period is too long, the KSERA reaction might not be timely, so useless. Too frequent BPM would be too noisy for the patient. KSERA system should understand if the measurement is valid before sending the data to the database. KSERA system, using NAO interface should help and drive the user to do the measurement, if the first measurement is not valid.

N.B. In ***each*** Use Case the corresponding final implementation might differ because depending on the concrete circumstances discussed and decided accordingly the detailed design and the field validation. Therefore all the reported algorithms are indicative.

2.1.2 Blood pressure measurement (Use Case 1.2)

In KSERA should be used a wireless blood pressure measurement in order to facilitate the integration and the acceptance by the user. The wireless BPM integrated in the system is an off-the-shelf provided by Taidoc. TD3250C.

SITUATION (context)	Sensors continuously available for irregular or 2x/day use There is no compulsory scheduling pending. KSERA passively waits for any measurement (listening Bluetooth).
CONTEXT (being recognized)	BP measurement is arriving (sensor ID, class, timestamp, valueHi, valueLo). Though KSERA system is mono-user, the patient ID might be added in the export/transmission towards the Remote Service Center, if any.
IF (rules for recognition)	The BP values are to be evaluated against the “normality” threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	According with the rules, tha NAO reaction has to be programmed.

Use case ID:	**UC1.2**
Use case name:	**Blood Pressure Measurement (BPM)**
Description	The **BPM** is connected **wirelessly** to the KSERA. KSERA first reports if the measurement could be successfully completed. Afterwards KSERA gives an appropriate feedback. This feedback could come from any level of the entire KSERA System.
Pre conditions	Availability of standard short range radio protocol (Bluetooth) between sensor and KSERA system. Telemedicine devices to measure Blood Pressure.
Post conditions	Measurement of BP was successfully accomplished OR BPM was not measured
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until any BPM event comes 2. WHEN BPM_Measurement_Event come from the sensor, KSERA write the record in the database/knowledge base (and optionally raise / propagate the KSERA event enabling NAO immediate reaction, if any). 3. END **KSERA.RULE_ENGINE.EVENTS** 1. START: KSERA identifies the patient (ID) and read his/her BP measurements’ time-schedule encoded in the database 2. UNTIL Time1 DO: KSERA runs the (timer-driven) event monitoring tread to detect any new BP measurement stored in the database 3. IF no measurements from the time-window THEN (after the Time1 passed) NAO_REACTION 4. END **WP2.MOBILE_BEHAVIOUR.NAO_REACTION** 1. NAO detect the user coordinates (X2, Y2) 2. NAO takes the own coordinates (X1, Y1) 3. NAO calculates the mobility to go “nearby” patient from (X1, Y1)

	to (X2, Y2) 4. NAO moves to “nearby” patient (X2, Y2) 5. NAO attract the patient’s attention 6. NAO starts speaking 7. NAO say the message from database, like “please do the Blood Pressure measurement” 8. NAO manage the user reaction 9. NAO “go home” and stitch to stand-by 10. END ALTERNATIVE 1: User dialog: user doesn’t want to measure Blood Pressure. ALTERNATIVE 2: There is another nested activity suggesting asking Blood Pressure measurement.

DEVICES	TAIDOC TD3250C (200€+delivery) Integration know-how is available in ISMB.
TECHNICAL IMPLICATIONS	Wireless link should cover the distance between the device and the base station. So, according to standard Bluetooth, this distance should not overcome 10m in open air (a couple of meters in a home environment). The time schedule of the measurements should be encoded for each patient in KSERA system. If the period is too long, the KSERA reaction might not be timely, so useless. Too frequent BPM would be too noisy for the patient. KSERA system should understand if the measurement is valid before sending the data to the database. KSERA system, using NAO interface should help and drive the user to do the measurement, if the first measurement is not valid.

2.1.3 FEV1 measurement (Use Case 1.3)

In KSERA should be used a wireless FEV1 measurement in order to facilitate the integration and the acceptance by the user. The wireless FEV1 measurement integrated in the system is an off-the-shelf provided by Corscience. Corscience AM1 + BT.

SITUATION (context)	Sensors continuously available for irregular or 2x/day use There is no compulsory scheduling pending. KSERA passively waits for any measurement (listening Bluetooth).
CONTEXT (being recognized)	BP measurement is arriving (sensor ID, class, timestamp, value). Though KSERA system is mono-user, the patient ID might be added in the export/transmission towards the Remote Service Center, if any.
IF (rules for recognition)	The FEV1 values are to be evaluated against the “normality” threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	According with the rules, tha NAO reaction has to be programmed.

Use case ID:	**UC1.3**
Use case name:	**FEV1 Measurement**
Description	The **device** is connected **wirelessly** to the KSERA. KSERA first reports if the measurement could be successfully completed. Afterwards KSERA gives an appropriate feedback. This feedback could come from any level of the entire KSERA System.
Pre conditions	Availability of standard short range radio protocol (Bluetooth) between sensor and KSERA system. Telemedicine devices to measure FEV1.
Post conditions	Measurement of FEV1 was successfully accomplished OR FEV1 was not measured
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until any FEV1 measurement event comes 2. WHEN FEV1_Measurement_Event come from the sensor, KSERA write the record in the database/knowledge base (and optionally raise / propagate the KSERA event enabling NAO immediate reaction, if any). 3. END **KSERA.RULE_ENGINE.EVENTS** 1. START: KSERA identifies the patient (ID) and read his/her FEV1 measurements’ time-schedule encoded in the database 2. UNTIL Time1 DO: KSERA runs the (timer-driven) event monitoring tread to detect any new FEV1 measurement stored in the database 3. IF no measurements from the time-window THEN (after the Time1 passed) NAO_REACTION 4. END **WP2.MOBILE_BEHAVIOUR.NAO_REACTION** 1. NAO detect the user coordinates (X2, Y2)

	2. NAO takes the own coordinates (X1, Y1) 3. NAO calculates the mobility to go “nearby” patient from (X1, Y1) to (X2, Y2) 4. NAO moves to “nearby” patient (X2, Y2) 5. NAO attract the patient’s attention 6. NAO starts speaking 7. NAO say the message from database, like “please do the FEV1 measurement” 8. NAO manage the user reaction 9. NAO “go home” and stitch to stand-by 10. END ALTERNATIVE 1: User dialog: user doesn’t want to measure FEV1. ALTERNATIVE 2: There is another nested activity suggesting asking FEV1 measurement.

DEVICES	Corscience AM1+BT (506€ + delivery) Integration know-how is available in ISMB.
TECHNICAL IMPLICATIONS	Wireless link should cover the distance between the device and the base station. So, according to standard Bluetooth, this distance should not overcome 10m in open air (a couple of meters in a home environment). The time schedule of the measurements should be encoded for each patient in KSERA system. If the period is too long, the KSERA reaction might not be timely, so useless. Too frequent FEV1 measurement would be too noisy for the patient. KSERA system should understand if the measurement is valid before sending the data to the database. KSERA system, using NAO interface should help and drive the user to do the measurement, if the first measurement is not valid.

2.1.4 1-lead ECG measurement (Use Case 1.4)

In KSERA should be used a wireless Electrocardiogram in order to facilitate the integration and the acceptance by the user. The wireless ECG integrated in the system is an off-the-shelf provided by Corscience.
The ECG is 1-lead according with the Rules described in D1.2

SITUATION (context)	Sensors continuously available for irregular or 2x/day use According to request by medical professional and in response to changes in HR, blood pressure and O2 saturation abnormalities.
CONTEXT (being recognized)	ECG stream is activating by the user after a request of KSERA system. After received the stream, it should be stored in the database with sensor ID, class, timestamp, values. (values contain the data stream of the ECG)
IF (rules for recognition)	N/A
THEN (rules for actuation)	N/A

Use case ID:	**N/A**
Use case name:	**N/A**
Description	The **ECG** is connected **wirelessly** to the KSERA. KSERA first reports if the measurement could be successfully completed. Afterwards KSERA gives an appropriate feedback. This feedback could come from any level of the entire KSERA System.
Pre conditions	Availability of standard short range radio protocol (Bluetooth) between sensor and KSERA system. Telemedicine devices to capture ECG stream.
Post conditions	Streaming of ECG was successfully accomplished OR Streaming of ECG was not measured
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until any ECG stream request event comes. 2. WHEN ECG stream request comes from the system, NAO_REACTION 3. KSERA writes the record in the database/knowledge base. 4. END **KSERA.RULE_ENGINE.EVENTS** 1. START: KSERA identifies the request to capture a ECG stream from a patient (ID) 2. UNTIL Time1 DO: KSERA runs the (timer-driven) event monitoring tread to detect any new ECG stream to store in the database 3. IF no measurements from the time-window THEN (after the Time1 passed) NAO_REACTION 4. END **WP2.MOBILE_BEHAVIOUR.NAO_REACTION** 1. NAO detect the user coordinates (X2, Y2) 2. NAO takes the own coordinates (X1, Y1) 3. NAO calculates the mobility to go “nearby” patient from (X1, Y1)

	to (X2, Y2) 4. NAO moves to “nearby” patient (X2, Y2) 5. NAO attract the patient’s attention 6. NAO starts speaking 7. NAO say the message from database, like “please do the ECG” 8. NAO manage the user reaction 9. NAO “go home” and stitch to stand-by 10. END ALTERNATIVE 1: User dialog: user doesn’t want to capture ECG. ALTERNATIVE 2: There is another nested activity suggesting asking ECG.

DEVICES	CORSCIENCE 1 lead belt (299€+delivery) Integration know-how is available in ISMB.
TECHNICAL IMPLICATIONS	Wireless link should cover the distance between the device and the base station. So, according to standard Bluetooth, this distance should not overcome 10m in open air (a couple of meters in a home environment). KSERA system, using NAO interface should help and drive the user to do the measurement.

Medically it is unnecessary for these COPD patients/users involved in KSERA. Therefore it was agreed that the ECG monitor would not be necessary neither in Prototype 1 (PT1) or in the final prototype. We report the above information because mentioned in the Rules. It complete the view.

2.1.5 Vital signs recognition (Use Case 1.4)

SITUATION (context)	Sensors continuously available and worn by the monitored user. Receiver powered on. KSERA receives measurements and detects critical events.
CONTEXT (being recognized)	Heart rate measurement is arriving (sensor ID, class, timestamp, value).
IF (rules for recognition)	The heart rate measurements values are to be evaluated against the “normality” threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	Critical events must be managed according to the rules.

Use case ID	UC1.4
Use case name	Vital signs recognition.
Description	The KSERA **Vital Signs recognition** should be able to constantly measure heart rate in order to recognize potentially critical situations. Wearable devices monitoring heart rate are therefore employed.
Pre conditions	• The heart rate wearable sensor is available. • Availability of standard short range radio protocol (Bluetooth, Zigbee or proprietary) between the sensors and the KSERA ubiquitous-home system.
Post conditions	• Heart rate is measured. • Critical events are detected
UML	**WP4.UBIQUITOUS_MONITORING.VITAL_SIGNS** 1. INFINITE LOOP (TREAD): KSERA wait until a data packet is sent from the remote sensing device to the gateway device. 2. KSERA writes the record in the database/knowledge base. 3. Measurement value is checked according to rules, thresholds and past values 4. If a critical event is detected, actions are to be preformed accordingly to defined rules. END

DEVICES	Heart rate belt
TECHNICAL IMPLICATIONS	Belt must be worn in order to provide continous heart rate monitoring, even though such approach is rather invasive. Heart rate data must be forwarded wirelessly to the KSERA system

2.1.6 Assess medical condition

Once the (different, more than one) medical parameters have been acquired, they have to be processed in order to detect if everything seems to be OK or if there is a conspicuous change in the health status, which requires further advice of an expert.

Since it is the aggregated task, it is solved at the dedicated monitoring function level. It is not relevant here because the sensors suiting the individual elementary parameters were discussed.

2.2 Monitor environmental parameters

The use case category "*monitor environmental parameters"* describes all system behaviour that uses external devices/sensors and information sources such as Internet blogs to measure indoor and outdoor environmental parameters. Data mining and learning rules are applied to infer meaningful knowledge about the environment and the consequences for the user's physical condition.

2.2.1 Temperature measurement (Use Case 2.1)

SITUATION (context)	Periodic temperature measurements coming from indoor and/or outdoor sensor devices.
CONTEXT (being recognized)	The temperature measurement is performed and information sent to the database.
IF (rules for recognition)	The measured values are to be evaluated against the "normality" threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	

Use case ID	UC2.1
Use case name	Temperature measurement.
Description	The KSERA ubiquitous-home system collects **temperature measurements** both in and outside the home, by means of physical indoor sensors and virtual ones concerning the outdoor temperature.
Pre conditions	An internet/network link is required in order to get information from the virtual sensors. The indoor temperature sensor is connected to the KSERA system by means of a wired or wireless interface, namely a USB connection or a short range radio protocol.
Post conditions	Temperature was successfully measured. OR Temperature was not measured due to device unavailability
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 5. INFINITE LOOP (TREAD): KSERA wait until a data packet is sent from the remote sensing device to the gateway device. 6. KSERA writes the record in the database/knowledge base. 7. END

DEVICES	Sensing Device board

TECHNICAL IMPLICATIONS	An Arduino 2009 board is used to acquire the sefnsing components mounted on a separate module (Proto shield): o Temperature and Humidity sensor: Sensirion SHT71 o CO2 sensor: Figaro CDM4161 o Air quality sensor Figaro TGS2600 The Proto Shield may host a radio transceiver as well, for instance a Bluetooh or Zigbee one. The Arduino board host a USB connector, so that a wired solution may be implemented as well. Such approach will be initially employed.

2.2.2 Humidity measurement (Use Case 2.2)

SITUATION (context)	Periodic relative humidity measurements coming from indoor and/or outdoor sensor devices.
CONTEXT (being recognized)	The relative humidity measurement is performed and information sent to the database.
IF (rules for recognition)	The measured values are to be evaluated against the “normality” threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	

Use case ID	UC2.2
Use case name	Humidity measurement.
Description	The KSERA ubiquitous-home system collects **Relative Humidity measurements** both in and outside the home, by means of physical indoor sensors and virtual ones concerning the outdoor measurements.
Pre conditions	An internet/network link is required in order to get information from the virtual sensors. The indoor relative humidity sensor is connected to the KSERA system by means of a wired or wireless interface, namely a USB connection or a short range radio protocol.
Post conditions	Relative humidity was successfully measured. OR Relative humidity was not measured due to device unavailability
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until a data packet is sent from the remote sensing device to the gateway device. 2. KSERA writes the record in the database/knowledge base. 3. END

DEVICES	Remote Sensing Device board
TECHNICAL IMPLICATIONS	An Arduino 2009 board is used to acquire the sensing components mounted on a separate module (Proto shield): o Temperature and Humidity sensor: Sensirion SHT71 o CO2 sensor: Figaro CDM4161 o Air quality sensor Figaro TGS2600 The Proto Shield may host a radio transceiver as well, for instance a Bluetooh or Zigbee one. The Arduino board host a USB connector, so that a wired solution may be implemented as well. Such approach will be initially employed.

2.2.3 CO_2 measurement (Use Case 2.3)

SITUATION (context)	Periodic CO_2 measurements coming from indoor sensor devices.
CONTEXT (being recognized)	The CO_2 measurement is performed and information sent to the database.
IF (rules for recognition)	The measured values are to be evaluated against the "normality" threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	

Use case ID	UC2.3
Use case name	CO_2 measurement.
Description	The KSERA ubiquitous-home system collects **CO2 measurements** in the home, by means of physical indoor sensors.
Pre conditions	The indoor CO_2 sensor is connected to the KSERA system by means of a wired or wireless interface, namely a USB connection or a short range radio protocol.
Post conditions	CO_2 was successfully measured. OR CO_2 was not measured due to device unavailability
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until a data packet is sent from the remote sensing device to the gateway device. 2. KSERA writes the record in the database/knowledge base. 3. END

DEVICES	Remote Sensing Device board
TECHNICAL IMPLICATIONS	An Arduino 2009 board is used to acquire the sensing components mounted on a separate module (Proto shield): o Temperature and Humidity sensor: Sensirion SHT71 o CO2 sensor: Figaro CDM4161 o Air quality sensor Figaro TGS2600 The Proto Shield may host a radio transceiver as well, for instance a Bluetooh or Zigbee one. The Arduino board host a USB connector, so that a wired solution may be implemented as well. Such approach will be initially employed.

2.2.4 Indoor air quality measurement (Use Case 2.4)

SITUATION (context)	Periodic indoor air quality measurements coming from indoor sensor devices.
CONTEXT (being recognized)	The indoor air quality measurement is performed and information sent to the database.
IF (rules for recognition)	The measured values are to be evaluated against the "normality" threshold (in D1.4) The comparison with the past known values should assess if the values stay in the normal range.
THEN (rules for actuation)	

Use case ID	UC2.4
Use case name	Indoor air quality measurement.
Description	The KSERA ubiquitous-home system collects **indoor air quality measurements** in the home, by means of physical indoor sensors.
Pre conditions	The indoor air quality sensor is connected to the KSERA system by means of a wired or wireless interface, namely a USB connection or a short range radio protocol.
Post conditions	Indoor air quality was successfully measured. OR Indoor air quality was not measured due to device unavailability
UML	**WP4.UBIQUITOUS_MONITORING.WATCHING_DAEMON** 1. INFINITE LOOP (TREAD): KSERA wait until a data packet is sent from the remote sensing device to the gateway device. 2. KSERA writes the record in the database/knowledge base. 3. END

DEVICES	Remote Sensing Device board
TECHNICAL IMPLICATIONS	An Arduino 2009 board is used to acquire the sensing components mounted on a separate module (Proto shield): o Temperature and Humidity sensor: Sensirion SHT71 o CO2 sensor: Figaro CDM4161 o Air quality sensor Figaro TGS2600 The Proto Shield may host a radio transceiver as well, for instance a Bluetooh or Zigbee one. The Arduino board host a USB connector, so that a wired solution may be implemented as well. Such approach will be initially employed.

2.2.5 Assess outdoor conditions (Use Case 2.5)

In order to contain costs, while ensuring the quality of the system and the revelations, it is preferable to retrieve the outdoors information, with no external sensors, but using information gathered from web services. In particular the above option is relevant when driven by the very high costs of the PM10 instruments (895 $ street price for one sensor only).

As mentioned above, the knowledge about the OUTDOOR conditions might be made available form the external sources. Assuming this, the environmental sensors listed for outdoor purposes might become extraneous. In KSERA it was agreed that environmental information would come from external (web) sources and/or environmental agencies.

Therefore, another important issue is the necessity to have a common (web) service between the two locations for the evaluation, Austria and Israel.

The examples giving the ***possible candidates*** for the above outdoor awareness acquisition through web services are:

- **Wetter.com** http://at.wetter.com/api/downloads/
- **Yahoo Wetter** http://developer.yahoo.com/weather/
- **Worldweatheronline** http://www.worldweatheronline.com/ (Schwechat http://www.worldweatheronline.com/weather.aspx?q=schwechat&day=7)
- **webservicex.net** http://webservicex.net/ws/default.aspx
- **National Digital Forecast Database** http://www.nws.noaa.gov/forecasts/xml/ (nur USA)

An example of the XML formats from the above web services:


```
<?xml version="1.0" encoding="utf-16"?> <CurrentWeather> <Location>Wien / Schwechat-Flughafen, Austria (LOWW) 48-07N 016-34E 190M</Location> <Time>Jan 28, 2011 - 10:20 AM EST / 2011.01.28 1520 UTC</Time> <Wind> from the NE (040 degrees) at 5 MPH (4 KT):0</Wind> <Visibility> 2 mile(s):0</Visibility> <SkyConditions> partly cloudy</SkyConditions> <Temperature> 23 F (-5 C)</Temperature> <Wind>Windchill: 15 F (-9 C):1</Wind> <DewPoint> 21 F (-6 C)</DewPoint> <RelativeHumidity> 92%</RelativeHumidity> <Pressure> 30.30 in. Hg (1026 hPa)</Pressure> <Status>Success</Status> </CurrentWeather>
```


The above incoming data streams will be likely feeded in different XML formats. The brokerage (mapping) will be implemented ad hoc in KSERA and will provide as the output the standard KSERA XML as specified in the KSERA Database records.

Finally, we conclude that the same information (data elements) about outdoor condition will be made available to Ubiquitous Monitoring system in KSERA, to be stored in the internal KSERA database. The sensorId in this case indicates the virtual outdoor sensor instead of the internal physical one.

2.2.6 Combination of environmental information

Being the reasoning envisaged about the aggregated entities, the argument is not relevant to D4.2.

2.3 Monitor activities of daily life

The use case category "*monitor activities of daily life"* describes all system behaviour that checks activities of daily life and detects abnormalities.

2.3.1 Check ADL schedule

The reasoning about the ADL is made by the dedicated monitoring function since the aggregation of the parameters/values is used.

2.3.2 Receive training program (Use Case 3.2)

Once the condition of the patient is defined a training program will be recommended by the medical authorities. It is not relevant to D4.2 because not directly related to the sensorial data.

2.3.3 Fall Recognition (Use Case 3.3)

SITUATION (context)	The assistive watch is worn by the monitored user
CONTEXT (being recognized)	In case of fall, the user may press the Panic button to summon an emergency call. If the user is unconscious, the watch is able to detect the fall acceleration profile followed by an immobility status. In this case an emergency call is performed automatically.
IF (rules for recognition)	If the watch is actually worn and a fall followed by immobility is detected, an emergency call is forwarded to the Care Center. Is the Panic Button is pressed, an emergency call is forwarded to the Care Center
THEN (rules for actuation)	If a fall alarm is generated, the ADAMO System summons an emergency call to Care Center and activates local speakerphone system. Send Alarm notification to Database

Use case ID	UC3.3
Use case name	Fall Recognition.
Description	The assistive watch may be used to summon an emergency call by pressing the panic button. An automatic alarm scenario is enabled when a fall followed by immobility is detected.
Pre conditions	The Base Station must be powered. The watch must be worn and used inside the operative range
Post conditions	Panic button is pressed and an emergency call is established directly to the Care Center. Fall followed by immobility is detected and an emergency call is forwarded directly to the care center. The speakerphone system is enabled
UML	**WP4.Fall detection** 1. The watch waits until an emergency is detected 2. A radio emergency packet is sent to the Receiver onto the Base Station (the ADAMO set top box). 3. The Base station establish a voice call towards the Care Center 4. The Base Station activates the speakerphone system. 5. The alarm is recorded into the KSERA database through the internet interface

DEVICES	ADAMO Assistive watch
TECHNICAL IMPLICATIONS	ADAMO assistive watch is equipped by a set of sensor aimed to detect if the watch is actually worn, to acquire acceleration and mobility data, temperature data and light intensity data. Moreover a Piani button is available to send emergency signals. The watch communicates to a set top box (the Base Station), providing a speakerphone system, telephone modems (PSTN and GSM) and network interfaces. Such device may be used as gateway between the UM system, the database, the main KSERA system and the Care Center.

2.3.4 Detect wake activity (Use Case 3.4)

SITUATION (context)	The assistive watch is worn by the monitored user
CONTEXT (being recognized)	If no activity is detected for 3 hours, an emergency call is performed automatically. The inactivity time interval may be configured, 3 hours is the default
IF (rules for recognition)	If the watch is actually worn and a 3 hours inactivity is detected, an emergency call is forwarded to the Care Center.
THEN (rules for actuation)	If an inactivity alarm is generated, the ADAMO System summons an emergency call to Care Center and activates local speakerphone system. Send Alarm notification to Database

Use case ID	UC3.4
Use case name	Detect wake activity.
Description	An automatic alarm scenario is enabled when a 3 hours inactivity is detected.
Pre conditions	The Base Station must be powered. The watch must be worn and used inside the operative range
Post conditions	No activity has been detected for 3 hours and an emergency call is forwarded directly to the care center. The speakerphone system is enabled
UML	**WP4.Fall detection** 6. The watch waits until an emergency is detected 7. A radio emergency packet is sent to the Receiver onto the Base Station (the ADAMO set top box). 8. The Base station establish a voice call towards the Care Center 9. The Base Station activates the speakerphone system. 10. The alarm is recorded into the KSERA database through the internet interface

DEVICES	ADAMO Assistive watch
TECHNICAL IMPLICATIONS	ADAMO assistive watch is equipped by a set of sensor aimed to detect if the watch is actually worn, to acquire acceleration and mobility data, temperature data and light intensity data. Moreover a Piani button is available to send emergency signals. The watch communicates to a set top box (the Base Station), providing a speakerphone system, telephone modems (PSTN and GSM) and network interfaces. Such device may be used as gateway between the UM system, the database, the main KSERA system and the Care Center.

2.3.5 Receive medication reminder (Use Case 3.5)

The user receives a **reminder** when the **medication is not taken at the right time**. It is not relevant to D4.2 since dealing with the feedback delivery. It is not directly related to the sensors.

2.4 NAO Interaction

The use case category "*NAO interaction*" describes the mobile system behaviour, i.e. the interaction or the preparation for a successful interaction between the user and the NAO.

2.4.1 NAO attracts and regains attention (Use Case 4.1)

Use case ID	UC4.1
Use case name	NAO attracts and regains attention.
Scenario	1, 2, 3, 4 and 5.
Actors	Older person, NAO.
Owner	UH, TU/e.
Author	Maccabi, RALTEC, TUW.
Description	NAO attracts the attention of the user. When the attention is lost, NAO will wait and at an appropriate time, NAO again attracts the attention of the user.
Pre conditions	• NAO is close to the user, looking at his face.
Post conditions	• The user is looking at NAO.

This Use Case is not sensor related. Therefore it is not relevant in this Deliverable.

2.4.2 NAO monitors joint attention (Use Case 4.2)

The robot checks whether the older person is paying attention. NAO monitors whether the older person is looking at NAO or not. NAO estimates the gaze direction and checks for "eye contact". In case of nearby identifiable objects NAO checks whether it is likely that the user looks at one of the identified objects.
This is the Use Case not directly relevant to D4.2 because using no data coming from the sensors belonging to UMS. The NAO robot device is autonomously managing them locally.

2.4.3 NAO approaches (Use Case 4.3)

NAO approaches the user. To do so NAO tries to infer the user's intentions and, if successful, **anticipates the user's future location**. NAO knows how to approach the user in a proper way without being in the way.
This Use Case is not directly relevant to D4.2 because dealing with the local intelligence of NAO, involving no UMS sensors.

2.4.4 NAO follows and leads (Use Case 4.4)

Idem. This case is very similar to the previous one, therefore it is not relevant to this deliverable.

2.4.5 NAO brings and takes objects (Use Case 4.5)

Use case ID	UC4.5
Use case name	NAO brings and takes objects.
Actors	Older person, NAO.
Description	NAO brings and takes away objects, in particular light-weight devices that can be grasped easily. NAO brings the pulsoximeter to the user.
Pre conditions	• Objects are easy identifiable. • Lightweight objects with easy colourful grips. • Easy accessible storage location for NAO.
Post conditions	• Object/device left at patient or returned to storage location.

This Use Case is suggested for discard. NAO will not bring to and will not take any object from the COPD patient because of the insufficient safety. The NAO implementation has no control of the forces applied to the arm during the handshake. The insufficient internal control of the above forces makes impossible the unattended interaction between the NAO arm and the COPD patient.

2.4.6 NAO motivates (Use Case 4.6)

Not relevant to D4.2 because no direct sensors form UMS are involved.

2.4.7 Intention recognition (Use Case 4.7)

Not relevant to D4.2 because no direct sensors form UMS are involved.

2.4.8 NAO gives feedback

Not relevant to D4.2 because no direct sensors form UMS are involved.

2.5 Communication & alarm

The use case category *"communication & alarm"* describes the system behavior that is needed to communicate with others or alarm the outside world.

2.5.1 Communicate with a medical professional (Use Case 5.1)

The KSERA system establishes a communication using NAO and his video-communication capabilities. A medical professional, for instance, a doctor or a therapist talks with the COPD patient and gives him advice.

Not relevant to D4.2 because no direct sensors form UMS are involved.

2.5.2 Communicate with a family member or friend

Idem.

2.5.3 Send an alarm

The KSERA ubiquitous-home system recognizes that an abnormal situation has occurred and alarms a family member, a friend or a medical professional.
It is the composed activity relying on the monitoring function.
It is not relevant to D4.2.

2.5.4 Receive messages (Use Case 5.4)

The KSERA ubiquitous-home system presents the latest messages to the user. These include also rescheduling of upcoming activities.
This Use Case is HMI related, not sensor-related.
It is not relevant to D4.2.

2.6 Entertainment & domotica

The use case category "*entertainment & domotica*" describes the system behaviour that is needed for entertainment services and to control functionalities in the home.

2.6.1 Watch a video clip (Use Case 6.1)

A video clip, for instance, about the exercise is shown to the older person.
This Use Case is not relevant to D4.2.

2.6.2 Play music (Use Case 6.2)

The older person can select and play music. The NAO is the interface. NAO can also receive instructions from the KSERA ubiquitous-home system to select, play and stop the music.
No sensors required. This Use case is not relevant to D4.2.

2.6.3 Open door (Use Case 6.3)

KSERA ubiquitous-home system can actuate the door opening. It deals with the e-Home platform connected to KSERA.
Since it is not possible to control the safety of the operation directly, the Use Case likely stays outside the KSERA scope. The door or window can be controlled by eHome over a wireless connection and the functionality to open / close the door or window is provided to KSERA via a connector interface.

2.6.4 Turn on the light

KSERA ubiquitous-home system can actuate the light on/off operations. It deals with the e-Home platform connected to KSERA. The domotic system is capable of switching common 230V devices via a switchable wireless power adapter. The power adapter is connected wirelessly to the ehome control unit, which is further connected to the KSERA system via LAN. Lamps and other devices not exceeding a power of 3000VA can be controlled with this interface.

3. Architecture

KSERA Ubiquitous Monitoring sub-system (UM sub-system) comprises the interface of the wearable, fixed, mobile and virtual sensors, selected in this document because contributing to achieve the functionalities described in Use Cases. UM acquires the data (snapshots) from the sensors and write the gathered data in KSERA main database. The above-writing is notified to KSERA system as a “relevant” event to manage by the Event Engine (EE), calculating the dedicated monitoring functions (D4.1).

The database might be used for the snapshot-based analysis (data mining) or for data warehousing along the timeline.

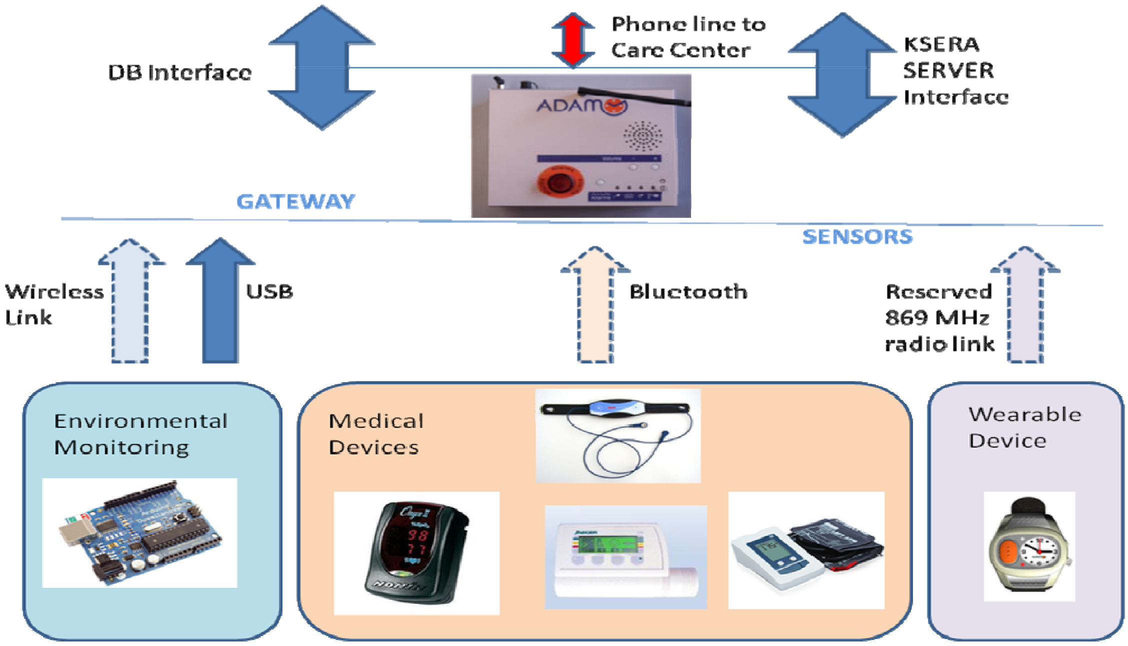
UM sub-system is not responsible for any reasoning over the real life happenings. It simply acquires the context awareness about the user and the environment, making it available for any reasoning.

UM sub-system is not responsible for any communication with the remote call centre. It simply acquires the context awareness about the user and the environment, making it available for any future elaborations by KSERA intelligent server. The analysis of the situations and the triggering of the events which might originate the call to the service centre is left up to the KSERA RULES. Therefore, the D4.2 does not mention any call center. Speaking about medical professionals, as the secondary persons involved, the call center is intended as a venue for intervention in case of emergencies, but those are handled by the rules.

UC.ReadSensorStatus(sId)	Read a given sensor “worn” status. Boolean predicate T/F.
UC.ReadSensorData(sId)	Forces the reading of the sensor data. Return a typed value/recordset.
UC.DispatchEvent()	Propagates any new event. The sId and the Database might be read
UC.UpdateDB()	Update the status of Database (synchronization).

3.1 Ubiqitous Monitoring Sub-System Architecture

The Ubiquitous Monitoring sub-system is made of three sections: Medical devices, Environmental devices and Wearable devices.
Al these components send data to a gateway unit, providing internet connectivity and thus interfacing the UM system to the physical units implementing the main KSERA system and the Database.
The following picture represents UM sub-system architecture. A description of the main components follows.


DB Interface
Phone line to
Care Center
KSERA
SERVER
Interface
ADAMO
GATEWAY
SENSORS
Wireless
Link
USB
Bluetooth
Reserved
869 MHz
radio link
Environmental
Monitoring
Medical
Devices
Wearable
Device

3.2 Communication protocol

The sensors integrated into the Ubiquitous Monitoring sub-system are connected to the Gateway through standard communication protocols (Bluetooth, Zigbee, etc.), but using custom data exchange, as explained in Deliverable D6.4.
This is mainly due to the choice of using commercial products, in which the communication protocol is already defined by the manufacturer. For each sensor KSERA, integrates and develops the communication data exchange with the gateway, in this case the Base Station ADAMO, according to datasheet provided by the manufacturers.

3.3 Medical Sensors

One of the most important constrain for wireless devices is the power management. For this reason the devices couldn’t stay active 24/24, but they should go in a sleep mode to preserve the duration of the battery.
KSERA is designed to use in the best way wireless devices. Medical sensors will be activated by the user, when he/she has to do the measurement. The gateway continuously listen to connection from the sensors. When it receives medical data, it propagates the information to the KSERA server and then to the KSERA DB in order to store the data and check the measures.

3.3.1 O2 Saturation

Nonin Onyx II 9560 is a wireless fingertip Pulse Oxymeter, thus providing data about O2 saturation in blood and heart rate.

Based on the Bluetooth 2.0 Wireless Technology, the Onyx II, Model 9560 provides a secure wireless. It easily connects to communication devices and it is designed to meet the requirements of the emerging open standards such as the Bluetooth Health Device Profile (HDP) or IEEE11073.

The Onyx II, Model 9560 has a new power saving feature that automatically adjusts transmitted power based on distance from the main unit. This unique feature allows for approximately 600 spot checks on 2 AAA batteries. Moreover it has an extended range of up to 100 meters (Class I).

Specifications:

Oxygen Saturation Display Range	0 – 100% SpO2
Pulse Rate Display Range	18 to 321 beats per minute (BPM)
Oxygen Saturation Declared Accuracy Range	70 – 100% SpO2 ±2 digits
Low Perfusion Oxygen Saturation Declared Accuracy Range	70– 100% SpO2 ±2 digits
Pulse Rate Declared Accuracy Range (Arms*)	20 – 250 BPM ±3 digits
Low Perfusion Pulse Rate Declared Accuracy Range	40 – 240 ±3 digits
Measurement Wavelengths and Output Power**	Red: 660 nanometers @ 0.8 mw maximum average

	Infrared: 910 nanometers @ 1.2 mw maximum average

3.3.2 FEV1

The Corscience AM1 + BT is a peak flow meter, which has been additionally equipped with a wireless data transmission for the measured values. It allows the peak flow to be measured, as well as the FEV1 value.
the AM1 + BT is a telemedical diagnosis device for clinical studies or for telemonitoring of patients at risk e.g. with COPD or asthma.

Specifications:

Volume:	0 to 8 liters
PEF:	60 to 840 liters/minute
FEV1:	0.5 to 8 liters
PEF accuracy	+/- 4 % or +/- 10 liters/minute
FEV1 accuracy	: +/- 3 % or +/- 0.05 liters/minute

3.3.3 Blood Pressure

Taidoc TD3250C is a 2 in one medical device able to measure glicemy and blood pressure values.
Measurements can be sent to a processing unit wirelessly exploiting a luettoth connection.

Specifications:

BG Result Range	20 ~ 600 mg/dL
Hematocrit Range	20 - 60%
BP result range	0 ~ 300 mmHg
Heart rate result reange	40 ~ 199 beats / min

3.3.4 1-lead ECG measurement

Corscience Corbelt 1 channel ECG belt is a small, mobile event recorder with an automatic alarm function. This allows the immediate activation of the rescue chain In case an acute event

occurs. It employs a dry electrode technology allowing a sure ECG measurement without bothersome electrode gel or adhesive electrodes.
An integrated motion sensor eliminates motion artifacts. allowing false positive eventdetections to be reduced to under a minimum.
Finally, The Corbelt have integrated an integrated Bluetooth data telemetry, thus allowing data to be sent fully automatically .

Specifications:

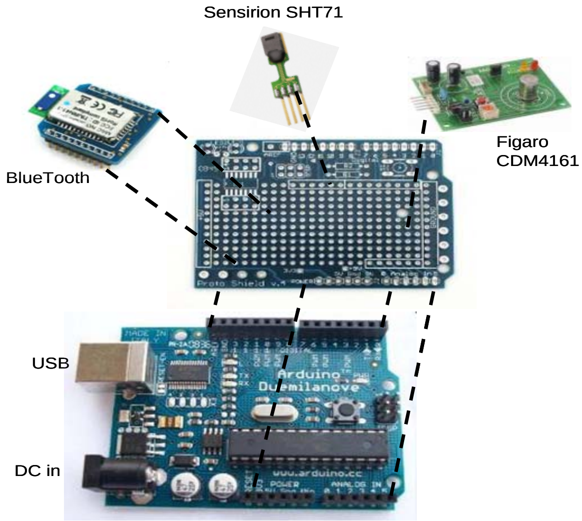
Sensors
- 1 channel ECG lead
- Dry electrodes (no gel electrodes necessary)
- Integrated acceleration sensor

Basic functions
- Automatic detection of:
    - tachycardia and VF/VT
    - bradycardia
    - absolute arrhythmia
- Intelligent two-stage alarm management
- Alarm limits remotely confi gurable
- Wireless transmission of the detected events
- atient-triggered data transmission by push of a button
- Simple adaptation of chest strap to individual

3.4 Environmental Sensor

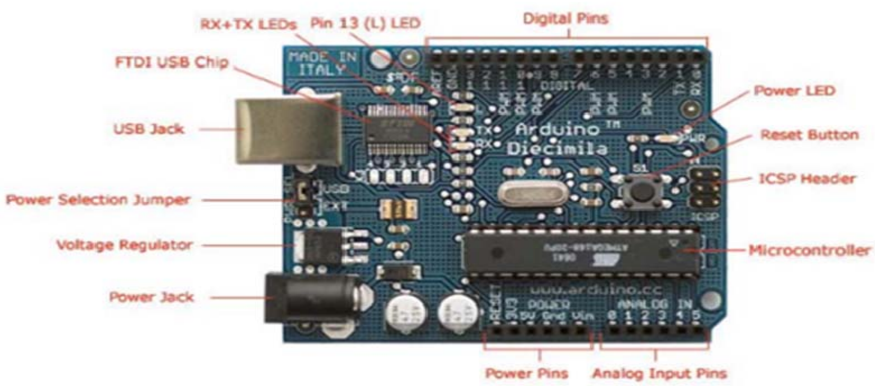
The environmental sensors aim on the acquisition of the awareness about the INDOOR and OUTDOOR conditions, because of the certain parameters reputed important and impacting on the living conditions of the patients with COPD. For example among the KSERA rules there are some relations using the PM10 level, the indoor and outdoor temperature, the relative humidity and other parameters. We distinguish between the ***indoor sensors***, which are physical, and the ***outdoor sensors***, which might be physical or the virtual ones. The environmental sensors about outdoor conditions likely are extraneous in this chapter, as KSERA agreed on the consensus about the environmental information, which would come from external (web) sources.

The indoor environmental (aggregated) sensor device is made of different components:



3.4.1 Main board:

Arduino 2009 provides a microcontroller ATMEL ATMEGA328, USB connector, Coaxial DC input connector, useful for the integration of the sensor-components.



3.4.2 Communication interfaces:
The module may be equipped with the most suitable communication interface, according to its deployment position and environmental characteristics.

- USB Interface
- Radio interface:
    - Xbee modules 802.15.4
    - Bluetooth XBT modules
    - 868 MHz proprietary radio protocol

3.4.3 Power Supply:
Standard 9V battery pack.

3.4.4 Peripheral Board:
Peripheral board, connected to the main board and carrying the sensor elements and the transceiver (for wireless nodes only).

The considered sensing elements are:

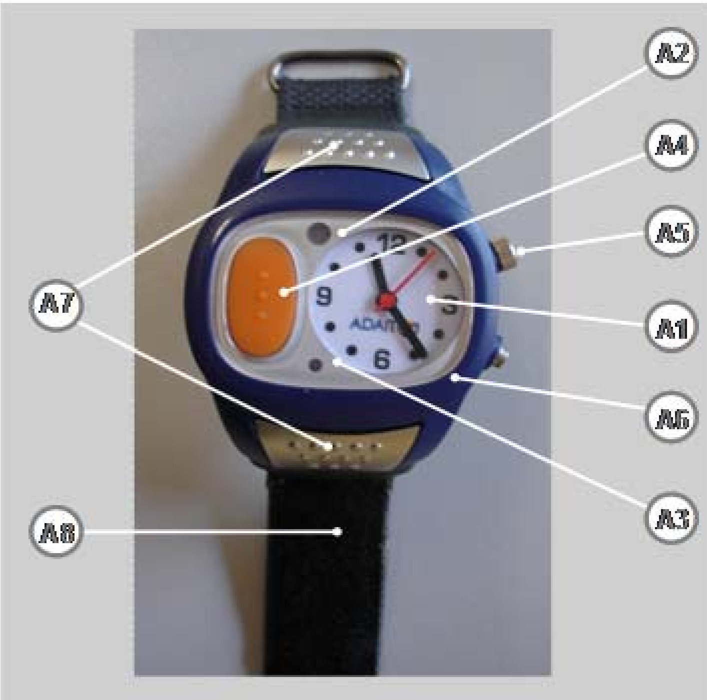
- Temperature and relative humidity sensor: Sensiron SHT71
- CO2 sensor: Figaro CDM4161
- Air quality sensor: Figaro TGS2600

3.5 Wristwatch

The Assistance Watch looks like a normal wristwatch designed to be carried by the user at any time day or night. It is non-allergenic, water resistant and shock-proof, and can offer both tele-assistance and tele-monitoring, as well as provide a wealth of physiological and environmental information.

The watch contains several sensors that measure parameters, such as skin temperature, environmental temperature, light levels, mobility of the wrist and fingers, if the instrument is being worn, as well as a tri-axial acceleration meter. The instrument also includes a signaler that supplies acoustic feedback when a user-activated or automatic alarm notification takes place.

The watch is powered by a replaceable battery which guarantees autonomy for at least three years of use in tele-assistance mode with one alarm per day, or about one year in tele-monitoring mode.



A1 Watch face

A2 Operation/Cover warning light

A3 Light sensor

A4 Panic Button

A5 Crown for adjusting time

A6 Tri-axial acceleration meter (inside the Watch)

A7 Skin temperature sensor (on base) and 'near body sensor' (under the cover)

A8 Watch strap with 'being worn' sensor and micro-mobility sensor

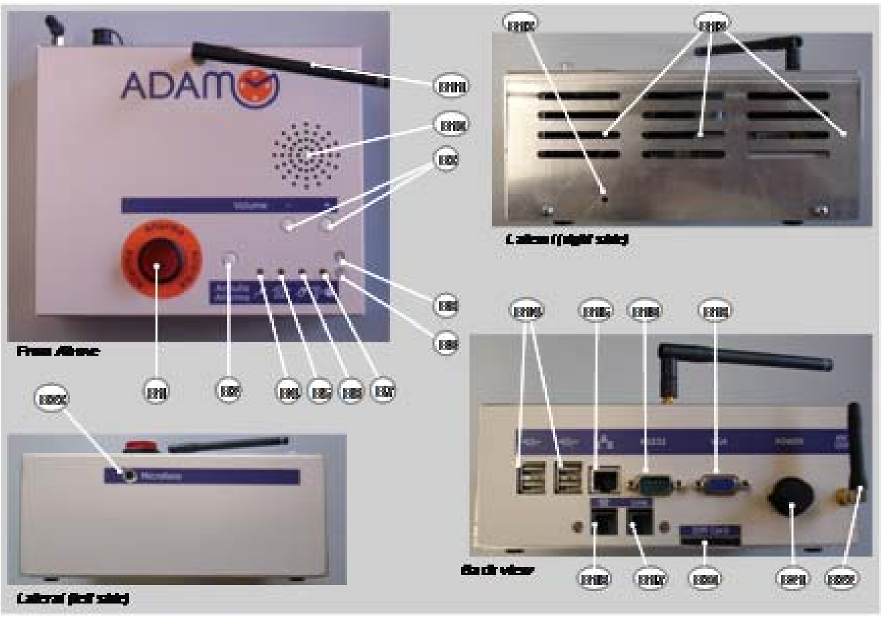
3.6 Gateway

The ADAMO receiver, called Base Station, is a suitable solution able to integrate both the assistive watch receiver, and the remote sensing devices. Moreover it is able to acquire data from the medical devices and act as a gateway toward the main KSERA System, exploiting its embedded system functionalities.

The taks of the Base Station is to receive, store and analyse the vital signs measured by the watch, as well as those provided by the other sensors, in order to identify potentially critical situations.

The Base Station contains temperature, humidity and light meters and integrates a hands-free listening system for the vocal management of emergencies. It also manages the audio/video assistance system and has its own panic button for user-activated emergency calls.

The Base Station is directly connected to the building's power supply and has a back-up battery which guarantees the operation of tele-assistance and tele-monitoring functions in case of power blackouts.

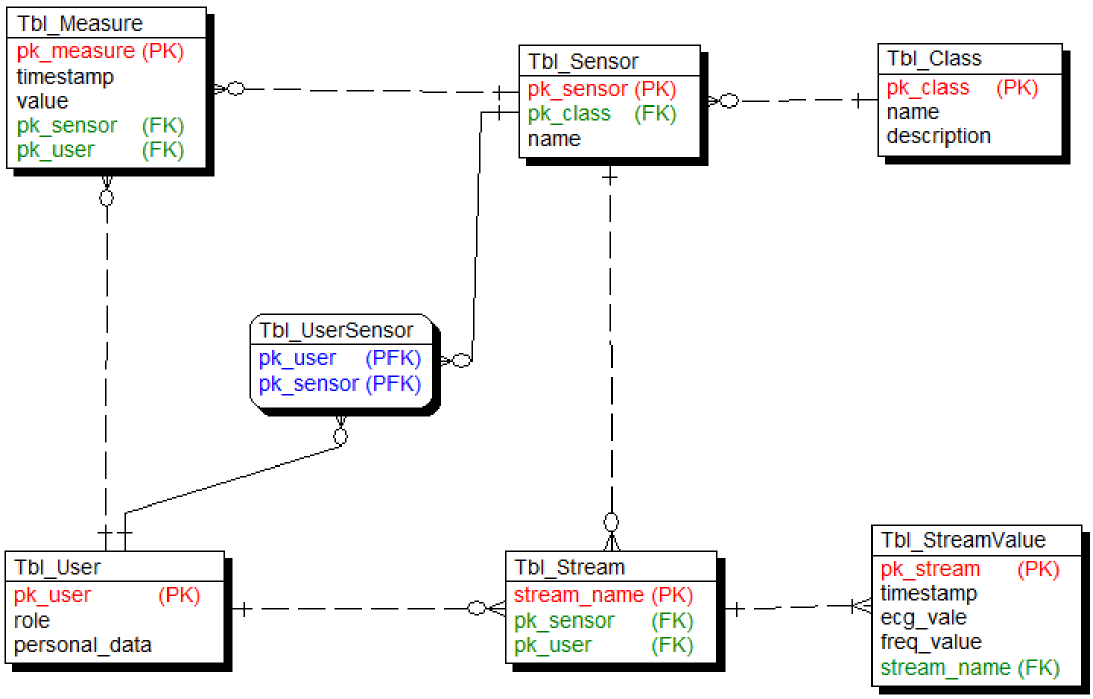


B1	Alarm Button	B7	RX active functioning light	B13	Reset Base Station	B19	VGA video out
B2	Alarm cancel Button	B8	Light sensor	B14	USB Port	B20	Sim card slot
B3	Loud speaker volume adjust button	B9	Temperature and humidity sensor	B15	Network Socket	B21	Power Supply
B4	Power Supply warning light	B10	Loud speaker	B16	Telefone Socket	B22	GSM/GPRS antenna
B5	PSTN state functioning light	B11	ADAMO antenna	B17	Data line Socket	B23	Microphone
B6	GSM/GPRS state functioning light	B12	Air intake	B18	Serial Port		

3.7 Database

KSERA writes the incoming data received directly from the sensors to the Database, making them persistent.
The figure below shows a diagram of the KSERA database, with the definition of tables and the relationships between them. In particular:

- Tbl_Sensor: contains the sensors, their class and the description
- Tbl_Measure: contains the value of the measure collected by the user with the sensor
- Tbl_StreamValue: contains the stream data from the ECG devices



4. Rules for Older Persons with COPD

The Rules for COPD monitoring are those fixed by D1-4. Among the basic assumptions there are:

1. Indoor air quality is defined by the EN 15421 and EN 15242 standards (ref.)
2. COPD patients are more sensitive to changes and the rate of changes in air parameters levels
3. Outdoor air quality is monitored by environmental public services and will be used in KSERA system (external input)

The sensors sensitivity will be determined according to the minimal requirements as defined for the elderly COPD person.

4.1 Outdoor air sensors and calculations

Presently the environmental parameters are being monitored by local /national authorities. This data is collected with the best available sensors.
The relevant data from the outdoor sensors will be collected by the KSERA system (from public domain) and will be analyzed according to defined set of rules
The comfort range is smaller for the elderly and COPD person specially in moderate to severe illness (stages 3-4 of the disease).

4.1.1 A.3. Relative humidity (RH) outdoors in the shade, and shielded from wind, %

SENSOR: Electronic hygrometer (see above in Use Case section).

Sensitivity: 3%
Accuracy: 5%
Range: at least 10-95% at temperatures of -20 to +45^{o}C
Measurement frequency: each 30 minutes
Rules: **A.3.a.** Dynamic baseline to catch daily and seasonal changes in individual comfort range (in combination with temperature)
A.3.b. Inside current individual comfort range (in combination with temperature), and remains stable: no action
A.3.c. Still inside current individual comfort range, but the prediction is that it will within 60 minutes/hours be outside this range: warning to the person as to outdoor activities
A.3.d. Outside current individual comfort range (in combination with temperature): message not to venture outside
A.3.e. Information is also used for calculating (i) the outdoor experienced temperature in summer (heat index), and (ii) the indoor minus outdoor difference in absolute humidity (g water/m^3 air)

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Prevention of exposure to adverse outdoor temp. And relative humidity	20-30 Deg. C. and stable, RH stable	none	No	0800-2000	NR
Caregiver(s)- in addition to	"	<30..and expected	Warning concerning	Yes	0800-2000	In proximity to patient/caregiver

patient		to rise to 30 with High Humidity	outdoor activities			in home
Caregiver(s)- in addition to patient	"	>30 Deg. C.+ High RH	Advised not to venture outdoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

The implementation of the outdoor relative humidity sensor will be performed employing a wireless device based on the same architecture previously descript for the environmental sensor devices. In particular the envisaged solution wil integrate an Arduino board and a peripheral board carrying a wireless transceiver (Zigbee or Bluetooth) ad the sensible component, the Sensirion SHT71.

Component	**Device**	**Cost per Prototype**
Temp / Humidity	Sensirion SHT71	25 €
Transceiver	Xbee	30 €
Analog board	*Arduino Proto Shield*	*6 €*
Carrier Board	*Arduino 2009*	*26 €*

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.1.2 A.4. Wind speed, m/s; and wind-chill index

SENSOR: Anemometer (see above in Use Case section)
Sensitivity: 1 m/s
Accuracy: 1 m/s
Range: 1-50 m/s (for -46 to +10°C)
Measurement frequency: 30 minutes
Rules:
A.4.a. wind speed over40 Km/h the person is advice not to venture outdoor
A.4.b. Information will be used for calculating the outdoor experienced temperature in winter (wind-chill index)
A.4.c. If the indoor temperature minus the experienced (wind-chill) outdoor temperature <5°C and stable: no action
A.4.d. If the indoor temperature minus the experienced outdoor temperature <5°C, but is predicted to reach 5°C today, the person is warned as to outdoor activities
A.4.e. If the indoor temperature minus the experiences outdoor temperature >5°C, the person is advised not to venture outdoors

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Prevention of exposure to adverse wind speed and wind-chill index	Indoor temp.minus wind chill outdoors is >5	none	No	0800-2000	NR
Caregiver(s)-in addition to patient	"	Indoor temp.minus wind chill outdoors is <5, predicted to reach 5deg.	Warning concerning outdoor activities	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient	"	Indoor temp.minus wind chill outdoors is >5	Advised not to venture outdoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

Due to the cost of the possible candidate sensors (for instance www.cascadelaser.com/coh1097901.html) it is discouraging the direct use in KSERA. Therefore a solution is being considered based on web service instead of direct measurements. The candidate web service for Israel trial site comes from D5.1.
The candidate web service for Austria trial site comes from D5.1

4.1.3 A.5. Heat index in summer

Heat index is calculated from outdoor temperature and relative humidity. It does not require one dedicated sensor.

Calculation frequency: 30 minutes.

Rules: **A.5.a**. Heat index 20-30 Deg.and stable: no action

A.5.b. Heat index <30°C, but is predicted to reach 30°C today, the person is warned as to outdoor activities

A.5.c. Heat index >25°C, the person is advised not to venture outdoors

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Prevention of exposure to adverse outdoor temp.	20-30 Deg. C. and stable, RH stable	none	No	0800-2000	NR
Caregiver(s)- in addition to patient	"	<30..and expected to rise to 30 with High Humidity	Warning concerning outdoor activities	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)- in addition to patient	"	>30 Deg. C.+ High RH	Advised not to venture outdoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

The outdoor temperature measurements can be performed by means of the same board used for evaluating the outdoor relative humidity.

With both the temperature and the humidity measurements, heat index can be calculated

Component	**Device**	**Cost [€] per Prototype**
CO2	Figaro CDM4161	99
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	*Arduino Proto Shield*	*6*
Carrier Board	*Arduino 2009*	*26*

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules. Heat index can be estimated starting from temperature and humidity values, by means of reference tables (for instance the Steadman table).

4.1.4 A.6. Inhalable dust particle counts / m^3 outdoor air

A6a PM10- Inhalable Particles smaller than 10µM
This parameter in KSERA comes from the external web services; see above in Use Case section. However it can be also implemented using the direct sensor as well.
Range: Current American standard for air quality is 150 µg/ m3 /24h & 50 µg/ m3 /year
Measurement frequency: 30 minutes
Rules: **A.6.a**.1 Counts <50 µg/ m3 /24h air and stable: no action
A.6.b. Counts <50-100 µg/ m3 /24h, the person is warned as to outdoor activities
A.6.c. Counts >100 µg/ m3 /24h, the person is advised not to venture outdoors,

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measurement of inhalable dust particles to forewarn of adverse outdoor conditions	1 Counts <50 µg/ m3 /24h air and stable	none	No	0800-2000	NR
Caregiver(s)-in addition to patient	"	Counts <50-100 µg/ m3 /24h	Warning concerning outdoor activities	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient	"	Counts >100 µg/ m3 /24h /	Advised not to venture outdoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

The cost of the possible candidate sensor (for instance www.cascadelaser.com/coh1097901.html) is very high, 885 US$ per unit, discouraging the direct use in KSERA.
The PM10 measurements are available at the Municipality level. Those are also available in the weather forecast.
Therefore KSERA will not implementation the direct measurement of PM10 but will use the web service instead. The web service should be available for both the trial sites Israel and Austria giving the same kind of the data.

The candidate web service for Israel trial site comes from D5.1.
The candidate web service for Austria trial site comes from D5.1

4.1.5 A7. CO

This parameter in KSERA comes from the external web services; see above in Use Case section. However it can be also implemented using the direct sensor as well.

Range: Current American standard for air quality is 60000 µg/ m3 /8h & 10000 µg/ m3 /30 minutes

Measurement frequency: 30 minutes

Rules **A7a**: Counts <5000 µg/ m3 /30 minutes: No action

A7b. : Counts 5000-8000 µg/ m3 /30 minutes: the person is advised not to perform physical activities outdoor

A7c. : Counts >8000 µg/ m3 /30 minutes: the person is advised to stay indoor

A7d. Counts >40000 µg/ m3 /8h: the person is advised to stay indoor

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measurement of CO to forewarn of adverse outdoor conditions forperforming physical activities	Counts <5000 µg/ m3 /30 minutes	none	No	0800-2000	NR
Caregiver(s)-in addition to patient	"	Counts 5000-8000 µg/ m3 /30 minutes	Warning concerning performing phys.act. outdoors	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient	"	Counts >8000 µg/ m3 /30 minutes	Advised to stay indoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home
Caregiver(s)-in addition to patient	"	Counts >40000 µg/ m3 /8h	Advised to stay indoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

The same approach used for the outdoor temperature and relative humidity measurements can be employed, just considering the dedicated sensing component for CO evaluation.

Component	**Device**	**Cost [€] per Prototype**
CO	WEB service/ or TBD (if direct sensor)	Web/ TBD
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.1.6 A8. SO2

This parameter in KSERA comes from the external web services; see above in Use Case section. However it can be also implemented using the direct sensor as well.

Range: Current American standard for air quality is 350 µg/ m3 /1h & 125 µg/ m3 /24h

Measurement frequency: 30 minutes

Rules A8a: Counts <300 µg/ m3 /1h: No action

A8b. : Counts 300-400 µg/ m3 /1h: the person is advised not to perform physical activities outdoor

A8c. : Counts >400 µg/ m3 /1h: the person is advised to stay indoor

A7d. Counts >100 µg/ m3 /24h: the person is advised to stay indoor

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measurement of SO 2 to forewarn of adverse outdoor conditions forperforming physical activities	Counts <300 µg/ m3	none	No	0800-2000	NR
Caregiver(s)-in addition to patient	"	: Counts 300-400 µg/ m3 /1h	Warning concerning performing phys.act. outdoors	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient	"	Counts >400 µg/ m3 /1h	Advised to stay indoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home
Caregiver(s)-in addition to patient	"	Counts >100 µg/ m3 /24h	Advised to stay indoors	Yes	0800-2000	Inrpoximity to patient/caregiver at home

The same approach used for the outdoor temperature and relative humidity measurements can be employed, just considering the dedicated sensing component for SO2 evaluation.

Component	Device	Cost [€] per Prototype
SO2		300
Air qaulity	TGS2600	15
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

However, due to the high cost of the SO_2 sensing element (cost of the single component: about 300€), a solution based on a generic air quality sensor (for example the Figaro TGS2600) shall be envisaged.

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the decision rules.

4.1.7 A9. NO_2

This parameter in KSERA comes from the external web services; see above in Use Case section. However it can be also implemented using the direct sensor as well.

Range: Current American standard for air quality is 200 µg/ m3 /1h & 40 µg/ m3 /year

Measurement frequency: 30 minutes

Rules **A9a**: Counts <200 µg/ m3 /1h: No action

A9b. : Counts 200-300 µg/ m3 /1h: the person is advised not to perform physical activities outdoor

A9c. : Counts >300 µg/ m3 /1h: the person is advised to stay indoor

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measuring air quality	Counts <200 µg/ m3 /1h	None	NR	0800-2000	NR
Caregiver(s)- in addition to patient		Counts 200-300 µg/ m3 /1h	Advised not to perform phys.act.	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)- in addition to patient		Counts >300 µg/ m3 /1h	Advised to stay indoors	Yes	0800-2000	In proximity to patient/caregiver in home

The same approach used for the outdoor temperature and relative humidity measurements can be employed, just considering the dedicated sensing component for NO2 evaluation.

Component	Device	Cost [€] per Prototype
NO2		300
Air qaulity	TGS2600	15
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

However, due to the high cost of the NO_2 sensing element (cost of the single component: about 300€), a solution based on a generic air quality sensor (for example the Figaro TGS2600) shall be envisaged.

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the decision rules.

4.1.8 A10 O_3

This parameter in KSERA comes from the external web services; see above in Use Case section. However it can be also implemented using the direct sensor as well.
Range: Current American standard for air quality is 230 µg/ m3 /30 minutes & 160 µg/ m3 /8h
Measurement frequency: 30 minutes
Rules **A10a**: Counts <100 µg/ m3 /30 minutes: No action
A10b. : Counts 100-120 µg/ m3 /30 minutes the person is advised not to perform physical activities outdoor
A10c. : Counts >120 µg/ m3 /30 minutes: the person is advised to stay indoor
A10d. : Counts >140 µg/ m3 / in consecutive measurements within 8h: the person is advised to stay indoor

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measurement of Oxygen (air quality)	Counts <100 µg/ m3 /30 minutes	None	NR	0800-2000	NR
Caregiver(s)-in addition to patient		Counts 100-120 µg/ m3 /30 minutes	Advise patient not to perform phys.act.	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient		Counts >120 µg/ m3 /30 minutes	Advised to stay indoors	Yes	0800-2000	In proximity to patient/caregiver in home
Caregiver(s)-in addition to patient		Counts >140 µg/ m3 / in consecutive measurements within 8h	Advised to stay indoors	Yes	0800-2000	In proximity to patient/caregiver in home

The same approach used for the outdoor temperature and relative humidity measurements can be employed, just considering the dedicated sensing component for O_3 evaluation.

Component	Device	Cost [€] per Prototype
O_3		300
Air quality	TGS2600	15
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

However, due to the high cost of the O_3 sensing element (cost of the single component: about 300€), a solution based on a generic air quality sensor (for example the Figaro TGS2600) shall be envisaged.
Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.2 Indoor air sensors and calculations

The standard range for indoor is defined for healthy person according to European standard ref no. EN13779:2007:E .
For the elderly and COPD person we will define lower contamination levels. The suggested level are based on clinical recommendations and not validated (not existing in the literature)
There is a wide range of sensors in the market for the following parameters. The sensor type, sensitivity and accuracy of the sensor will be determined by local manufactures and price

4.2.1 B.1. CO2-sensor (in each room of the dwelling), mg/m3

This indoor parameter in KSERA is calculated, it comes from ARDUINO integration board.
Range: short term 10000 mg/m3 Long term 6300 mg/m3
Measurement frequency: each 30 minutes
Rules: **B.1.a.** If <5000 mg/m3 and remains stable, : no action
B.1.b. If >5000 mg/m3, , adjust room ventilation, until a stable level of <5000 is reached

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measure CO_2 inside the dwelling/room	<5000 mg/m3 and remains stable	None	No	All hours	In proximity to patient/caregiver in home
Caregiver(s)- in addition to patient		>5000 mg/m3,	adjust room ventilation until >5000 attained	Yes	All hours	In proximity to patient/caregiver in home

The implementation of the indoor CO_2 sensor will be performed employing a wireless/wired device based on the same architecture previously descript for the environmental sensor devices. In particular the envisaged solution wil integrate an Arduino board and a peripheral board carrying a wireless transceiver (Zigbee or Bluetooth) or a USB interface and the sensible component, the Figaro CDM4161.

Component	Device	Cost [€] per Prototype
CO2	Figaro CDM4161	99
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.2.2 B.2. Air temperature indoors (in the living space of each room), oC

This indoor parameter in KSERA is calculated, it comes from ARDUINO integration board.
Range: According to standard EN15251 Summer tmp. 23 ±1.5 °C. Winter tmp 22 ±1.5 °C
Measurement frequency: each 30 minutes
Rules: These standards are controlled by the programmed air condition system

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measure indoor air temp.	Summer tmp. 23 ±1.5 °C	Controllled by programmed a/c system	No	All hours	NR
Caregiver(s)- in addition to patient		Winter tmp 22 ±1.5 °C	"	"	"	"

The implementation of the indoor temperature sensor will be performed employing a wireless/wired device based on the same architecture previously descript for the environmental sensor devices. In particular the envisaged solution wil integrate an Arduino board and a peripheral board carrying a wireless transceiver (Zigbee or Bluetooth) or a USB interface and the sensible component, the Figaro CDM4161.

Component	Device	Cost [€] per Prototype
CO2	Figaro CDM4161	99
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.2.3 B.3. Relative humidity (RH) indoors, % (in each room in the dwelling)

This indoor parameter in KSERA is calculated, it comes from ARDUINO integration board.

Range: The comfort humidity zone inhouse suggested by the EN15251 standard is relative humidity 30% for Winter 60% for Summer. The air condition system will be programmed accordingly

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measuring relative humidity indoors	30% for Winter	a/c system will beprogrammed accordingly	No	All hours	NR
Caregiver(s)-in addition to patient		60% for Summer		No	All hours	NR

The implementation of the indoor relative humidity sensor will be performed employing a wireless/wired device based on the same architecture previously descript for the environmental sensor devices. In particular the envisaged solution wil integrate an Arduino board and a peripheral board carrying a wireless transceiver (Zigbee or Bluetooth) or a USB interface and the sensible component, the Figaro CDM4161.

Component	Device	Cost [€] per Prototype
CO2	Figaro CDM4161	99
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.2.4 B.4. Noise level

Range: Optimal noise levels suggested by the EN15251 standard is 20-35 DB for the air control system

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measure noise level	20-25 DB	Air control system	No	NR	NR

A solution shall be envisaged and evaluated, based on a microphone connected to the UM subsystem, periodically recording a stream of audio data. Such stream is processed by a dedicated audio software application, which candidate comes from off-the-shelf (in alternative the internal solution can be developed if the field trial will provide the evidence of the need) extracting noise level parameters.
Such measured data is sent to the main KSERA database and made available to the KSERA server for the algorithms implementing the above reported decision rules.

4.2.5 B.5. Inhalable dust particle, Co, No2, So2 and O3 are as for outdoor.

The levels will be monitored and controlled by the air condition system.

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Measure inhalable dust particles in the home	Co, No_2, So_2 and O_3 are as for outdoor	Monitored by a/c system	NR	NR	NR

The same approach used for the outdoor measurements can be employed, based on the integration with an Arduino 2009 board.

Component	Device	Cost [€] per Prototype
Air quality	TGS2600	15
Temp / Humidity	Sensirion SHT71	25
Transceiver	XBT	51
Analog board	Arduino Proto Shield	6
Carrier Board	Arduino 2009	26

However, due to the high cost of the dedicated SO_2, NO_2 and O_3 sensing element (cost of the single component: about 300€), a solution based on a generic air quality sensor (for example the Figaro TGS2600) shall be envisaged.
Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the decision rules.

B.6. Coughing assessment, coughs/hour, total duration / hour (in each room in the dwelling)

SENSOR: Microphone connected to the UM system.
Range: No range is presently defined in the literature.
The levels will be determined by our group and will be validated in clinical trial.

Measurement frequency: each min, and calculate the moving average over 12 hours of both coughs / hour, and total duration of coughing in min/hour

Rules:

B.6.a. Dynamic baseline to catch coughing pattern from GOLD 0 to GOLD IV stage

B.6.b. If the moving average of the number of cough / hour or duration/hour decreases by 30%: congratulate the person with his/her improved health

B.6.c. If the moving average of the number of coughs/hour or duration of coughing in min / hour increases by 30%: check the environmental measurements to find out if this caused the problem and act accordingly

B.6.d. If the moving average of the number of cough / hour or duration of coughing in min/hour increases by 30%: also offer an FEV1 measurement (and act accordingly)

B.6.e. If the moving average of the duration of coughing in min / hour or duration of coughing in min/hour increases by 30%, and no FEV1 measurement is done: contact the treating care professional

B.6.f. If the moving average of the duration of coughing in min / hour or duration of coughing in min/hour increases by 30%, and no FEV1 measurement is done, nor a care professional is contacted, and GOLD III/IV: alarm to call center

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To assess cough severity-set baseline per patient and measure changes in coughs	Dynamic baseline to ctach coughing pattern from GOLD 0-GOLD IV	Measure average over 12 hours of coughs/hr and duration of coughing in min/hr	No	0800-1200	By sensors
Patient/user		>30% moving average of cough/hr or duration	Congratulate the patient	No	0800-2000	"
Patient/user		<30% as above	Check environmental measures and act accordingly	No	0800-2000	"
Patient/user		<30% also offer FEV1 measurement	Act accordingly	No	0800-2000	"
Patient/user		<30% and no FEV done	Contact health professional	No	0800-2000	"
Patient/user		<30% and no FEV done and no health care professional contacted	If Gold III-IV alarm to call center	No	0800-2000	"

This rule could be implemented by integration in kSERA system using a common software algorithm (for example coming from the asthma detection, by Karmelsonix, Israel, www.karmelsonix.com/documents/CoughMagazineMay2010.pdf).
In order to apply this rules, it needs to place at least a microphone in each room.

Risk management option. If the above solution will not be available for any reason, there is the alternative possible option to implement it internally. While cough is an important defence mechanism of the respiratory system, its chronic presence is bothersome and may indicate the presence of a serious disease. The validation process is based on the analysis of the tracheal and chest wall sounds, ambient sounds and chest motion. Coughing while (a) laying supine, (b) sitting, (c) sitting with strong ambient noise, (d) walking, and (e) climbing stairs, gives the different patterns to recognize. The cough monitoring algorithm might be applied to the recorded data to detect and count coughs. The detection algorithm might search for cough candidates by identifying loud sounds with a cough pattern, followed by a secondary verification process based on detection of specific characteristics of cough first. The recorded data has to be evaluated. The validation process might refer to an expert consensus as gold standard, and comparing each cough detected by the algorithm to the expert marking, we marked True and False, positive and negative detections. This will requires some man-months.

4.3 c. Sensors worn by the person for continuous measurement

4.3.1 C.1. Mobility, steps / day

SENSOR: step meter. N.B. this functionality might come from the multi-sensorial wearable device ADAMO.

Sensitivity: 10 steps / day
Accuracy: 10 steps / day
Range: 0-20,000 steps / day
Measurement frequency: each 15 minutes ongoing
Rules:
C.1.a. Dynamic baseline to catch daily mobility fluctuation and changes from GOLD 0 to GOLD IV
C.1.b. If steps increase with 20%: congratulate the person
C.1.c. If (steps <20/day or steps decrease with 50%): check environmental measurements, and act accordingly
C.1.d. If (steps <20/day or steps decrease with 50%) and GOLD II-IV: perform an FEV1 measurement (and act accordingly)

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To monitor steps taken as indicator of increasing/decreasing function	Baseline to catch daily fluctuation and changes from GOLD 0-GOLD IV	Check steps with pedometer	No	0800-2000	NR
Patient		If steps increase by 20% congratulate person	As above	No	"	"
Patient		If steps >20 per day or decrease by 50%	Check environmental measures and act accordingly	No	"	"
Patient		If steps >20 per day or decrease by 50% AND gold II-IV	Perform FEV1 and act accordingly			

Mobility in terms of steps/day can be measured by a simple step meter. Even though such devices are now easily available on the market at a low cost, it is difficult to integrate a device to the KSERA system, due to the lack of low cost devices equipped with a wireless real time data transmission.
A solution shall be envisaged by employing the ADAMO assistive wrist watch (cost: 200 for the watch plus 550 for the receiver unit) able to measure the mobility in terms of acceleration data. Such data is processed at the gateway and mobility parameters can be estimated.
Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.3.2 C.2. Heart rate, +ECG beats / min

SENSOR: CORSCIENCE CORBEL
Sensitivity: 1 beat / min
Accuracy: 3% of measured value
Range: 0 -240 beats / min
Measurement frequency: 1/h resting mesurments
Normal range for elderly COPD person: 50-100 beats/minutes sinus rhythm and 40-120 for chronic arterial fibrillation
Rules: **C.2.a.** Dynamic baseline to catch daily heart rate fluctuation and changes from GOLD 0 to GOLD IV and COPD associated pathology
C.2.b. If (heart rate decreases below 50 b/m or increases above 120 b/m perform 1 lead ECG and send to the call center (and act accordingly)
C.2.c. If (heart rate decreases below 50 b/m or increases above 120 b/m and no ECG is taken, consult a medical professional within 15 min, and act according to the advice given
C.2.d. If (heart rate decreases below 50 b/m or increases above 120 b/m: and no ECG is taken, and no consultation of a medical professional took place within 15 min: call for an ambulance to the emergency room

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To monitor heart rate of patient (as an indicator of function change)	Dynamic baseline to catch daily heart rate fluctuation and changes from GOLD 0-GOLD IV and COPD associated pathology	Check heart rate	NO	0800-2000	NR
Patient		. If (heart rate decreases below 50 b/m or increases above 120 b/m	Perform 1 lead ECG and send to the call center(act accordingly)	No	0800-2000	NR
Patient		. If (heart rate decreases below 50 b/m or increases above 120 b/m and no ECG taken	Consult medical professional within 15 min/ and act accordingly	No	0800-2000	NR
Patient		If (heart rate decreases below 50 b/m or increases	Call for ambulance to the emergency room	No	24/7	"

		above 120 b/m and no ECG taken and no consultation within 15 min.				

Since the Medical device used for ECG measurements is based on a wearable belt, and it is also able to measure the heart rate, a solution based on such device, the Corscience Corbelt, will be envisaged. Due to the high price (cost: 1250 €) different solutions may be considered.

Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.4 D. Sensors continuously available for irregular or 2x/day use

4.4.1 D.1. FEV1 (Forced Expiratory Volume over 1 min), I

SENSOR: Digital FEV1 meter, EU approved (see above in Use Case section).

Measurement frequency: 2x/day, after wake-up and before going to bed; additionally when called upon by the system

Rules: **D.1.a.** Dynamic baseline to catch daily FEV1 fluctuation and changes from GOLD 0 to GOLD IV

D.1.b. If FEV1 increases by 30%: congratulate the person with the increase of his/her health

D.1.c. If FEV1 decreases by 30%; check environmental measurements and measure O_2-saturation of the blood, HR, body tmp and advice the patient to perform a bronchodilator inhalation. Assess again in 30 minutes.if no improvement alert the call center

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To measure FEV in patient	Dynamic baseline to catch daily FEV1 and changes from GOLD 0- GOLD IV	Sensor will take initial measurement	Yes	0800,1900(after wake-up and before bed)	Near patient
Patient		If FEV1 increases by 30%	Congratulate person	Yes	"	"
Caregiver(s)- in addition to patient		If FEV1 deceases by 30%	Check environmental measurements, and 02 saturation, HR, body temp+ advise to perform broncodilator inhalation. Assess in 30 min. If no change, contact call center	Yes (together with sensors)	"	"

Measurements will be performed by integating the Digital FEV1 meter Corscience Am1+BT (cost:600€). Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.4.2 D.2. O2-saturation of the blood, %

SENSOR: pulse oxymeter, EU approved (see above in Use Case section).

Measurement frequency: 2x/day, in parallel to FEV1 assesment

Rules:

D.2.a. GOLD II-IV: If O_2-saturation of the blood is better than 88%: no further action

D.2.b. GOLD II-IV: If O_2-saturation of the blood is <88%: the person is requested to contact his/her treating physician, and act according to the advice given

D.2.c. GOLD 0-I: If O_2-saturation of the blood drops by <2%: no action

D.3.d. GOLD 0-I: If O_2-saturation of the blood drops by >2%: complete the SF12, and act accordingly

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To measure **O_2-saturation of the blood, %**	Level of blood saturation, using pulse oxymeter	Perform baseline	Yes	0800,1900	In proximity to patient—presenting pulse oxymeter
Patient		GOLD II-IV: If O_2-saturation of the blood is better than 88%-	no further action			
Patient		GOLD II-IV: If O_2-saturation of the blood is <88 %	Patient requested to contact phys. And act according to advice	Yes	"	"
Patient		GOLD 0-I: If O_2-saturation of the blood drops by <2 %	No action	Yes	"	"
Patient		GOLD 0-I: If O_2-saturation of the blood drops by >2%:	Complete SF 12 and act acordingly	" (in combination with medical team)	"	"

Measurements will be performed by integating the Nonin Onyx2 9560 pulse oxymeter (cost: 475 $). Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.4.3 D.3. Blood pressure, mmHg

SENSOR: Blood pressure monitor by TAIDOC, EU approved (see above in Use Case section),
Measurement frequency: irregular at the request of the professional care giver, or the system
Rules: **D.3.a.** Systolic dynamic baseline to catch daily, fluctuations and changes in systolic blood pressure from GOLD 0 to GOLD IV
D.3.b. If the systolic pressure drops below 90 mmHg, or above 180 mmHg HR should be assessed and 1 lead ECG performed and delivered to the call center

Rules: **D.3.c.** Diastolic dynamic baseline to catch daily, fluctuations and changes in diastolic blood pressure from GOLD 0 to GOLD IV
D.3.d. If the diastolic pressure drops below 50 mmHg or increases above 120, mmHg HR should be assessed and 1 lead ECG performed and delivered to the call center

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To measure the patient's BP	Systolic dynamic Baseline to catch daily fluctuations	Check BP (using cuff with signals to call center)	No	Irreg., by care plan	NR
Patient		If the systolic pressure drops below 90 mmHg, or above 180 mmHg	HR should be assessed and 1 lead ECG performed and sent to call center	"	"	"
Patient		Diastolic dynamic baseline to catch daily, fluctuations	As above			
Caregiver(s)- in addition to patient		If the diastolic pressure drops below 50 mmHg or increases above 120, mmHg	HR should be assessed and 1 lead ECG performed and sent to call center	"	"	"

Measurements will be performed by integrating the Taidoc TD3250 blood pressure monitoring system (cost: 200€). Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules.

4.4.4 D.4. Electrocardiogram (ECG)

SENSOR: 1 lead ECG wearable sensor from CORSCIENCE, EU approved (see above in Use Case section).
Measurement frequency: By demand and in response to changes in HR, blood pressure and O2 saturation abnormalities.

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	Check HR	1 lead ECG wearable sensor	By demand and in response to changes in HR, blood pressure and O2 saturation abnormalities	No	By demand of health professional	NR

Measurements will be performed by integrating the 1 channel ECG Corscience Corbelt (cost 1250 €). Measured data is sent to the KSERA database and made available to the KSERA Server for learning and decision making algorithms, implementing the above reported decision rules. Due to the high price different solutions may be considered.

4.5 E. Behavioral sensors and Quality of Life (QoL) assessments

E.1. Perceived morning situation

SENSOR: NAO in dialogue
Measurement frequency: each morning after waking-up
Question: How do you feel this morning?
Answer: If ‘good’: OK, have a nice day!
If ‘bad’: person is requested to take the SF12 test, and the environmental measurements are checked

User	Purpose	Parameter	Action	NAO (yes/no)	When	Where
Patient/user	To measure quality of life	Questions asked by NAO	Upon waking: NAO asks- "How do you feel today?"	Yes	Wake up	Next to patient
Patient			If good" NA says – "Have a good day."	Yes	"	"
Caregiver(s)- in addition to patient			If "bad" patient takes SF-12 (gives to care team) and environmental measures checked	No	Wake up or during morning	NR

This rule should be implemented using the microphone inside NAO or the microphones used for other rules. With an algorithm developed, NAO could recognize the user’s answer and send the information to KSERA system.

E.2. Perceived medical quality of life assessment (SF12), score

This Rule deals with the SF12 questionnaire, which is the tool of the different nature, compared with the sensors. Therefore it is not relevant for this deliverable because out of scope.
Since it deals with the aggregation of the elementary data, it is handled (processed) at the rule level.

5. Rules for Older Persons in General

5.1 Scenario 1: Healthy through indoor exercise

N/A (because not depending on the direct sensors).

5.2 Scenario 2: Disease self-management

N/A (because not depending on the direct sensors).

5.3 Scenario 3: A safe environment

For older persons in general it might be useful to check for good weather / bad weather and for extreme outdoor temperatures or snow and to warn if there might be slippery condition (ice on pathway). Weather conditions might be different between test sites (e.g. winter in Israel near coast differs compared to weather in Austria).

Proposed rules: If an appointment outside flat is in today's calendar then remind user well in advance, inform about weather conditions and potential dangerous conditions (temperature - too hot, too low), precipitation (rainfall), snow, ice on road, pathway (possibly also hotness, ozone problem).

The scenario can be implemented using the data flows coming form the already described individual sensors, making available the dedicated monitoring function being triggered by the specific event like "Venturing outdoor" (for instance opening the door before going outside). Therefore, it is not relevant in this deliverable.

5.4 Scenario 4: Medical alarm

This is about abnormal activity patterns. The system should monitor usual activity patterns (e.g. leaving bed, going to different rooms). The detection of the abnormal activities needs to be formalised by the Rules. Therefore it is not relevant in this deliverable because it is not based on the specific sensors but on the aggregation of the data flows coming from the different sensors.

5.5 Scenario 5: Socializing and entertainment

The scenario relies on the capability to process the messages like (door bell rings or phone call comes or sms/email arrives and no reaction of user), or the (phone call arrives and user does not pick up in time or is not present).
KSERA Ubiquitous monitoring system has no adequate sensors and/or hooks to intercept the above situations and (missing) reaction. Therefore it is not relevant in this deliverable because it cannot be implemented in the UMS layer.

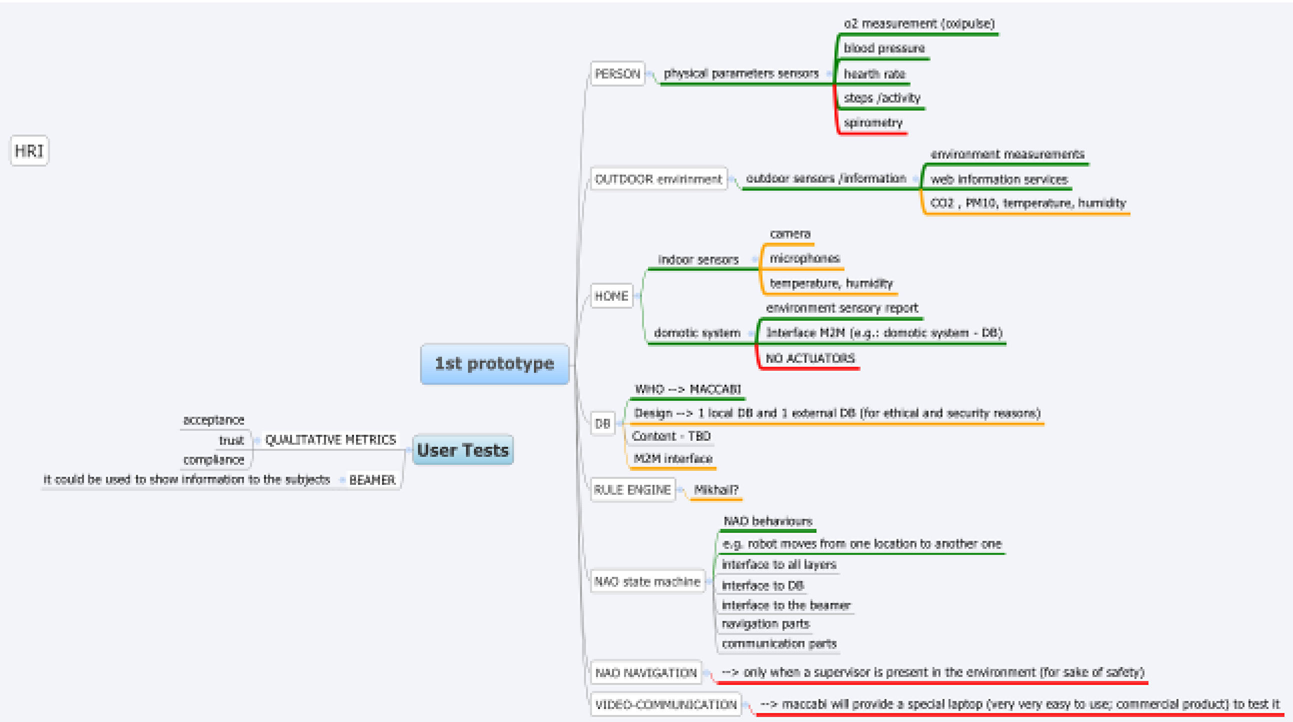
5.6 Scenario 6: Smart home & navigation

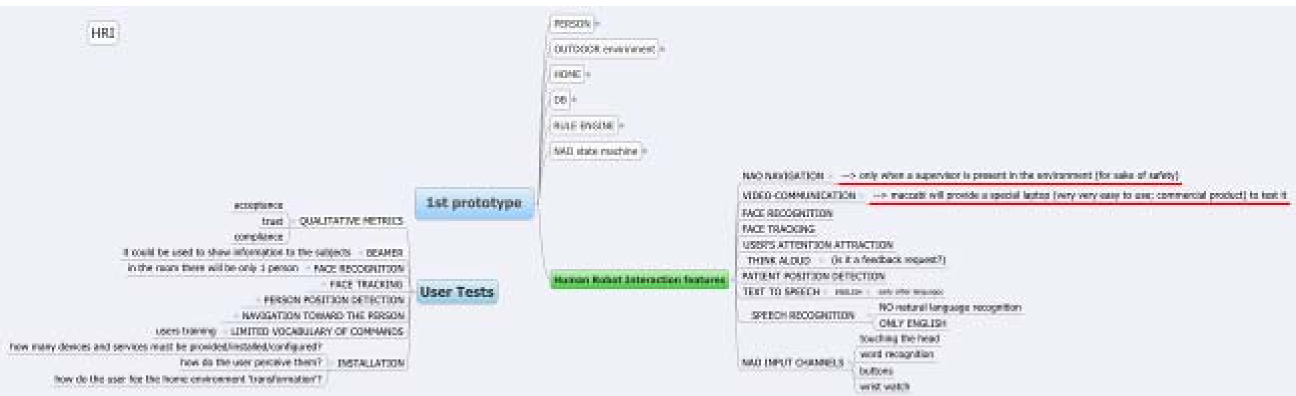
General rule: NAO must not come to near to old person s/he is moving to avoid dangerous situations. This is the capability coming form the WP2 Robot Mobile Behaviour.
Therefore it is not relevant in this deliverable because out of scope.

6. Conclusion

The present document has described the sensors needed to implement the KSERA system.
The Deliverable has fixed three main classes of the sensorial devices being used in KSERA: the indoor environmental sensors (temperature, humidity and similar), the medical devices revealing the COPD patient living parameters (O2, FEV1, Blood pressure and similar), the intelligent Housing sensors and actuators, interfaced through e-Home domotic system, and the web sevices characterising the outdoor and weather conditions.
The Deliverables has mapped technically the Use Cases and the application of the Rules, describing the implementation choices adopted in KSERA prototyping.

During the 2nd PMB meeting in Torino, it was decided the composition of the sensors used for the first prototype. The minimal setup therefore will comprise one indoor temperature sensor, one humidity sensor, one multi-sensorial wearable device (wrist watch), one SPO2 measurement device, one FEV1 device, one blood pressure monitor, one 1-lead ECG, a number of the virtual outdoor sensors (e.g. web services), and the connector to the domotic platform e-Home.





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