Auxiliary monitoring system for patients in need of intensive care

«EPICURUS»

(recording of oxygen saturation, heart rate, urination)

Technical description of the solution

Draft Version 1.0

Introduction

This text is the proposal of our company and its partners, for the installation of a complete solution of automatic electronic registration, monitoring and management of patients who are in a state of increased care and in particular of the following characteristics:

- Oxygen saturation (SPo2)
- Heart Rate (BPM)
- Urination.(συχνότητα διούρησης)

The proposed solution aims to minimize the visits of hospital staff in areas with a heavy load and in particular in the wards of patients in need of health care during their stay in the hospital by automatically recording oxygen saturation, heart rate and urination, without the need for medical staff to come into contact with the patient.

Theoretical approach

Pulse oximetry is necessary to assess oxygen saturation in cases of respiratory distress and to monitor anesthetized patients who are severely ill or whose condition is progressing rapidly. The pulse oximeter was an almost integral device for assessing the patient along with the stethoscope long before the pandemic.

Especially during the COVID-19 pandemic, silent hypoxia (that is, abnormally low oxygen saturation without symptoms of subjective dyspnea) is common in patients with COVID-19 infection. Early detection of hypoxia and supplemental oxygenation has been shown to reduce mortality. In conditions of high demand for medical services, where oxygen supply and beds that provide continuous monitoring of the patient's vital signs are not available to everyone, pulse oximetry plays a key role in controlling patients and consolidating the need for supplemental oxygen.

Thus, although the assessment and monitoring of oxygen saturation fluctuations is a critical component of patient clinical examination and clinical decision-making during the COVID-19 pandemic, their large-scale availability remains in demand in health structures. with limited resources. This was confirmed in a published study by Nichole Starr and associates N. Starr et al. Pulse oximetry in low-resource settings during the COVID-19 pandemic. The Lancet Global Health 03 July 2020 DOI: https://doi.org/10.1016/S2214-109X(20)30287-4 .

The Doctors of the Therapeutic Clinic of the Medical School of the National and Kapodistrian University of Athens, Ioannis Danasis, Maria Gavriatopoulou and Thanos Dimopoulos, Professor of Therapy and Rector of EKPA, summarize the findings of this study.
The researchers stress the need to address inequalities in the level of available nursing and medical equipment in the country's hospitals and to ensure the universal availability of pulse oximetry devices and oxygen supplies.
Pulse oximeters allow clinicians to diagnose and treat hypoxia promptly, monitor patients with respiratory distress or risk of deterioration, and assist in clinical decision-making and the distribution of available hospital beds and oxygen delivery devices.

At the same time, a significant number of patients with COVID-19 who are hospitalized in hospitals need care, but due to the limitations for the transmission of the disease, it is recommended to avoid contact with health personnel and limit contact to the absolutely necessary.
Thus, the need for continuous monitoring on the one hand and the avoidance of contacts on the other created the need to use the technology for the benefit of both patients and healthcare staff.

Our complete solution provides us with the possibility:

- to remotely monitor the vital characteristics of oxygen saturation (SPo2) and heart rate (BPM)
- to remotely inform the nursing staff as soon as there is a discharge of urine (urination), by being trapped at the level of the diaper or in the sub-sheet
- to manage alarm rules, by controlling the events of the listed vital characteristics and informing the competent medical staff by email or sms.
- the integration of important vital data into the patient's medical record
- the exchange of data with every third system through the exchange of HL7 messages.

Description of the solution

Introduction

This section provides a general description of the measurement methods used

Applied method of measuring heart rate

Heart rate is the rate at which the heart beats, that is, the number of heartbeats per minute and is expressed in beats per minute
One high-precision method is to use an electrocardiogram to extract the heart rate. It is the illustration of the electrical activity of the heart. Due to the high cost of the measuring devices used, the size and the complexity of this method, it is not an easy method.
In addition, it is possible to extract the heart rate through **photoplasmography**.
With this method, radiation is transmitted to the human tissue, which results in the appearance of reflection and absorption phenomena, which by receiving biomarkers and processing them give us useful information about the cardiovascular system.
This method is used in our technical solution.

Applied method of measuring blood oxygen saturation

Blood oxygen saturation (SpO2) or hemoglobin saturation in oxygen is defined as the ratio of the amount of oxyhemoglobin (oxy-Hb) to the amount of hemoglobin (Hb), where oxyhemoglobin is the substance that results from the union of hemogoblin with oxygen.
The measurement of SpO2 in the blood is done either by taking blood from the arteries or by using a device (pulse oximeter) and is based on the method of photoplasmography.

Photoplasmography (PPG)

Photoplasmography (PPG) is the non-invasive use of light interactions with the optical properties of tissue, blood vessels and blood, in order to assess vital parameters of the human body. It is a simple and low cost technique, which uses a light source and a photodetector on the surface of the skin to measure the volumetric fluctuations of the blood.

The PPG method is applied to pulse oximeters, which calculate the oxygenation of the blood, emitting light and measuring its absorption by the tissue. They rely on the property of hemoglobin to absorb infrared light at a certain wavelength, because its concentration changes dynamically in relation to the oxygenation of the blood. This means that the radiation it absorbs also changes with time. The oximeters emit red light at 660nm and infrared light at 940nm from a diode (LED) and then measure the absorption of the rays during the pulse wave.
Photopopulation is fully related to the contraction and dilation of the heart cycle.

Optical Sensors PPG

Optical measurement sensors, using the method of photoplasmography (PPG).
Portable PPG sensors are divided into 2 categories, transmission and reflectance sensors. In the first case, the transmitted light is detected by a photodetector, which is located opposite the light emitting diode (LED), while in the case of reflection the photodetector is placed on the same side as the LED and detects the blood reflected from the skin, bones and blood vessels.
In the method of transmission it is possible to obtain a relatively good signal, but the measuring position may be limited. The location of the sensor should allow easy detection of transmitted light, such as the finger, the earlobe, the cheek, the nasal septum and the tongue. In the last three points, the only way to place the sensor is if the person is under anesthesia, so the finger and the earlobe are the preferred points for monitoring with this method.
The case of reflection eliminates the problems of positioning the sensor and can be placed in various parts of the body. However, it is strongly influenced by body movements and pressure disorders. Thus, if the person moves a little or pushes the sensor more / less, it is very likely that incorrect values will occur.

Architecture

The configuration of the solution is multilevel and can be distinguished in the following sections / subsystems.

Data collection subsystem

This subsystem is responsible for collecting data through appropriate devices. It includes the oximeters, terminal devices, urination sensors, communication subsystem (Bluetooth) and the data collection nodes and forwarding to the data management subsystem (servers) of the Hospital.

Data management subsystem

The second subsystem gathers the Databases and the data interconnection section with third party systems. The subsystem is responsible for maintaining the data in organized sets and transforming them into appropriate formats for their consumption by presentation applications and their promotion to third party systems. Also through the interfaces allows the exchange of data with the HIS or LIS of the Hospital (eg patient demographics, clinic room etc)

Data presentation subsystem

The subsystem hosts applications that present data to healthcare professionals, doctors and nurses, while also providing the ability to make information available to anyone interested through organized appropriate structures.

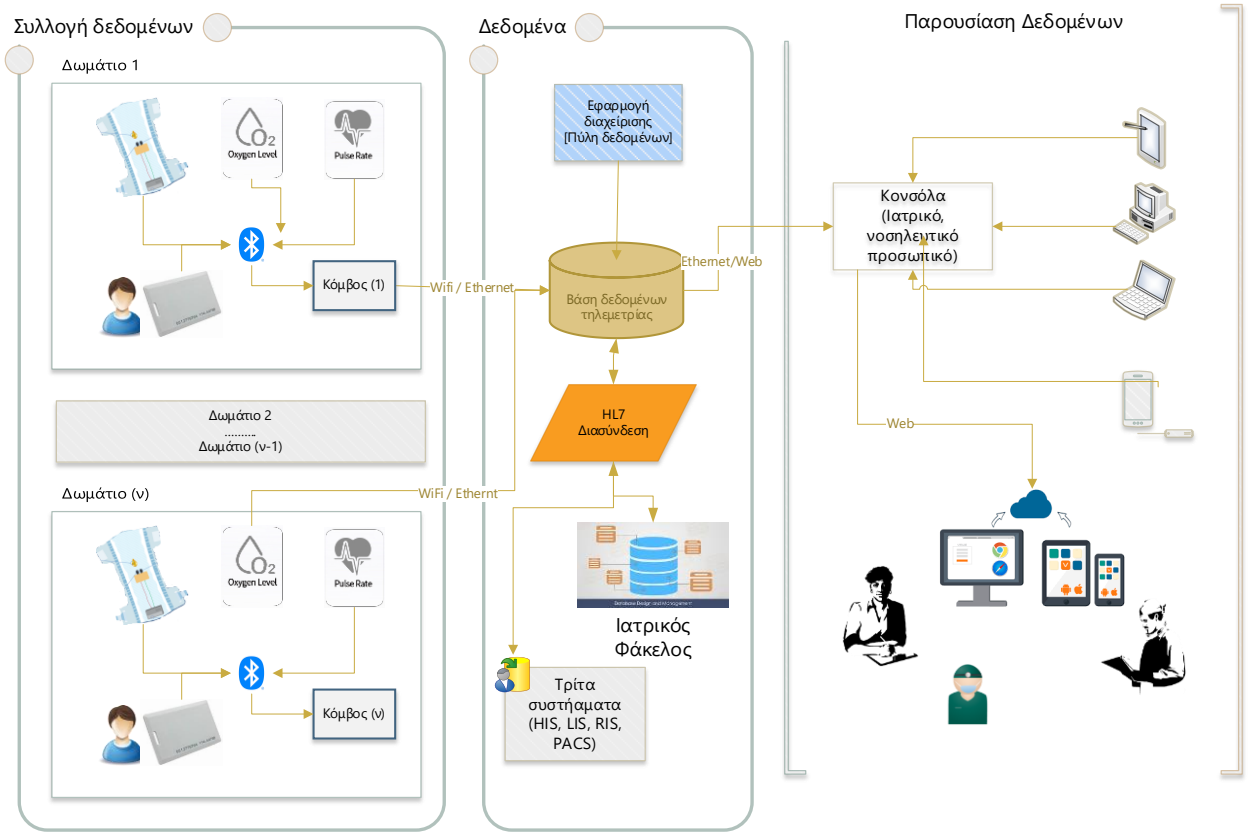


Image 1 System Architecture

Description of SPo2 and BPM recording device

The sensor used by our solution is reflected light, which allows the measurement of heart rate and oxygenated blood.
It is a small, easily transportable device used to measure the saturation of oxygen transported to the red blood cells of the subject.
It allows the recording of data even when the patient is walking and moving while carrying the device with him as he "locks" on the finger of the examinee.

Its advantages can be found in the following points:

- High sensitivity for detecting a wide variety of sizes
- Very small size dimensions 5.6mm x 3.3mm x 1.55mm, which makes it extremely easy to use
- Built-in glass cover for optimal performance
- Very low consumption:

- Programmable sampling rate and current to save energy
- Very low off current (standard value 0.7 μA)

- Resistance to movement
- Operating temperatures from -40 ° C to + 85 ° C
- Excellent ability to reject ambient light

It is equipped with 3 internal light emitting diodes (LEDs), photodetectors, optical elements and low noise electronics with light emission from the external environment. The included LEDs emit Red, Infrared and Green light.

Description of urination sensor device

The urination sensor can be placed under the sheet or in the patient's diaper. The sensor integrated in the patient's diaper is compact and wireless and communicates via bluetooth with the data collection node when the patient urinates and an indicator light is set to ON while the information is transferred to the system through the recording system and the appropriate message is displayed in the management console for the immediate intervention of the nursing staff.

Image 1 Urination Sensor

A corresponding function is performed by a device which is placed under the patient's sheet. The difference between the two devices is that the device placed under the sheet is connected wired to the recording device that is placed on the frame of the bed while the device that is placed inside the patient's diaper for obvious reasons is wirelessly connected and has no wired connection.

Change management card layout description

The change management card is the mechanism by which the nursing staff handles the change of the patient's diaper or sheet. The card is brought by the nursing staff and as soon as he approaches the patient, the node "realizes" that the diaper change process has begun. In this case no other action is required from the nursing staff. In addition to this process, it is possible to activate the change recording mechanism with a special button located on the data collection node.

Image 2 Change Management Card

Data collection device description (node)

The data collection node is responsible for recording all the information inside the hospital room, whether it comes from the oximetry devices or it comes from the urination sensors.
The node handles the transfer of information from the sensors to the log database.
Can communicate:

a. with terminal devices using the bluetooth communication protocol

b. With the logging database using the ethernet protocol either wired or wireless (wifi).

Image 3Node

The node can communicate inside the room with four (4) beds collecting data from any bed arrangement (oximeter and urination sensor).
It is also responsible for recording the change (diaper or other) through communication with the change management card as staff approach within the cabin.

Description of the communications management application.

The communications management application is responsible for managing (adding, removing) the terminal devices in each bed.
In essence, it corresponds the device (oximeter, urination sensor) with a bed and immediately to the corresponding patient.

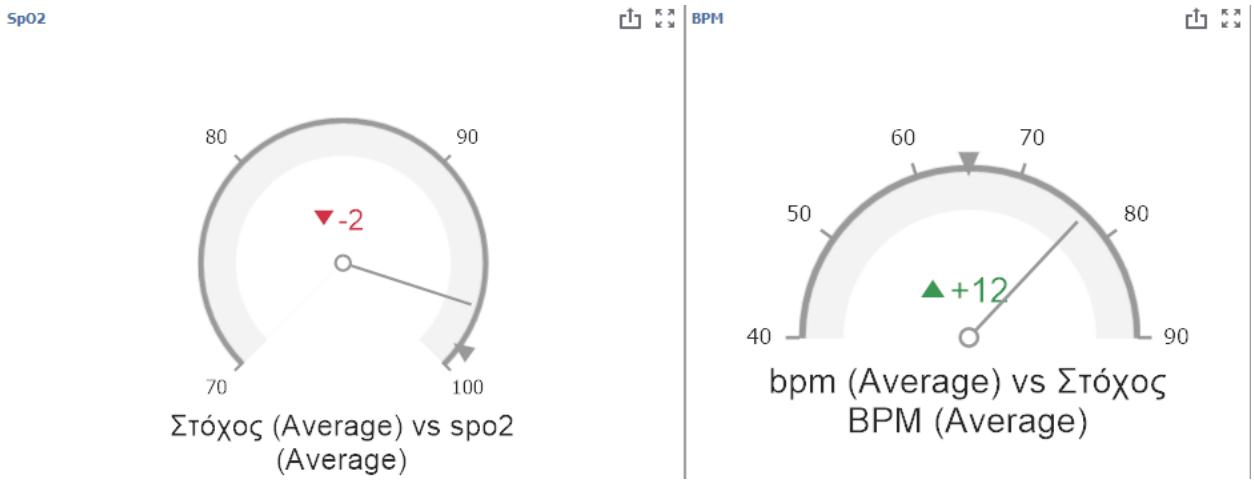
Data management subsystem (data gateway)

The data portal (database) of the subsystem stores the recorded information of all terminal devices, whether it is a change management card, a urination sensor or an oximeter (SPo2, BPM) and is stored in organized sets.
The Telemetry Portal / Database can communicate with third party systems using the HL7 data exchange protocol, while at the same time it can send the data for permanent storage in the patient's medical file to the central system of the hospital. At the same time the telemetry database sends the collected information in real time to the central console of the data presentation subsystem.

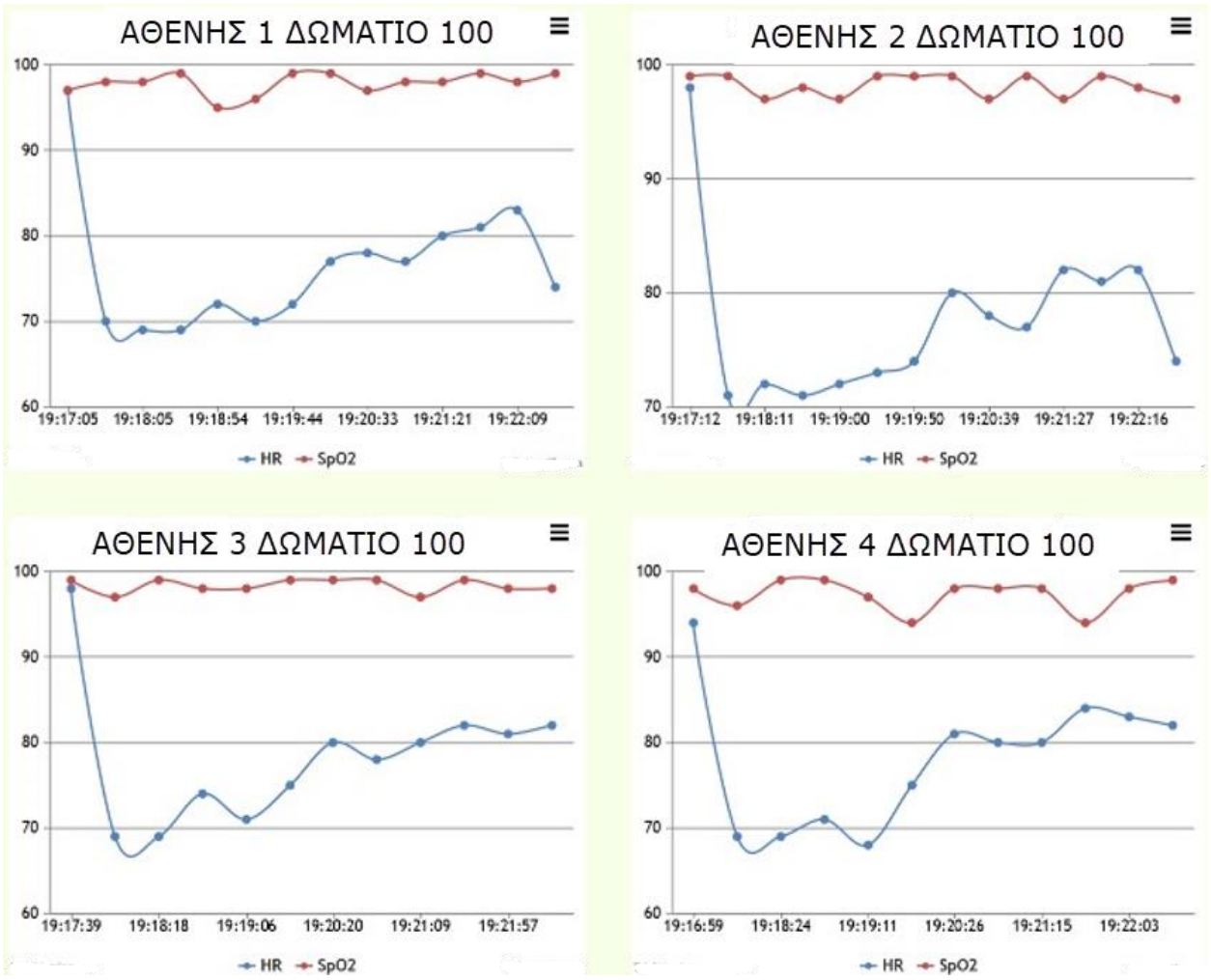
Data presentation subsystem.

The data presentation subsystem hosts applications that present data both in real time and aggregated, while allowing the management of rules, through which important events are monitored through events for each patient.
The subsystem, verifying the rules with the observed metrics, notifies with appropriate messages the designated doctor who is responsible for the patient.
The management of the messages (recording, sending) is also done by a corresponding application of the subsystem. The message management application sends SMS or e-mail messages to the corresponding doctor in order to inform him of the event that verifies a rule for the specific patient. Indicatively and for example, sending a message:
"Oxygen saturation for patient X between 06:00 and 07:30 is below the 94% threshold."
Thus by monitoring the recording of the patient's blood oxygen saturation it monitors the progression and can assess when "it is worth a visit to the patient's room".

Indicative images of the data presentation application



Εικόνα 4Ανάλυση δεδομένων Εφαρμογή παρουσίασης



Εικόνα 5 Στιγμιότυπο παρακολούθησης δωματίου ασθενών