IoT in Healthcare: Using the PI System for Continuous Patient Monitoring

Presented by José Miguel Gutiérrez Guerrero,
Juan Antonio Holgado-Terriza.

Agenda

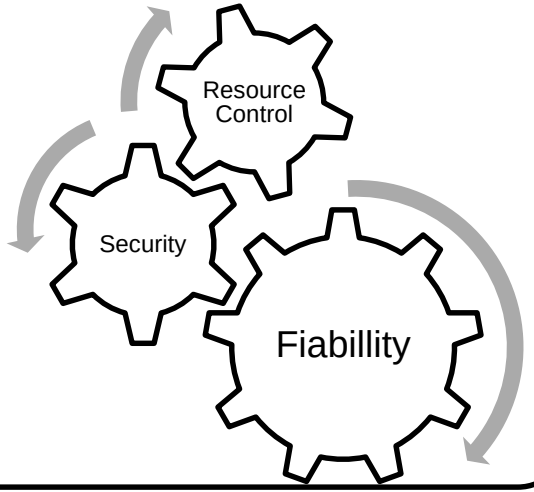
- About Granada University & Research Group
- Motivation
- The evolution from eHealth to uHealth. Monitoring
- Healthcare System
- PI system infrastructure
- Study case: COPD.
- Conclusion and Future works

Granada University, Concurrent Systems Research Group

- The University of Granada was officially founded in 1531 by Carlos I of Spain.
- It is the fourth university in Spain by number of students, member of the Coimbra Group and Campus of International Excellence.
- The University of Granada is among the top ten in Spain.
- Globally, it is one of the top fifty universities in computer engineering and one of the top hundred in mathematics.

Granada University, Concurrent Systems Research Group

Concurrent Systems Research Group



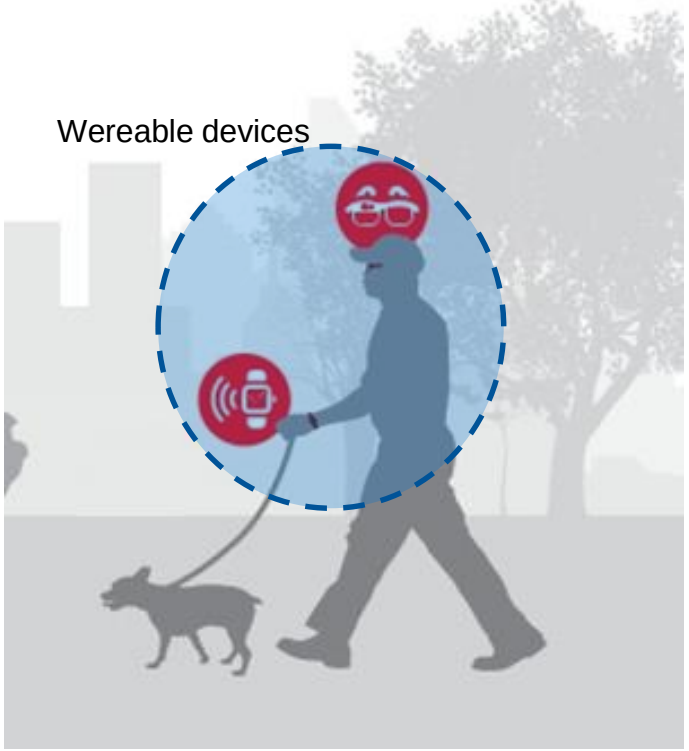
Hardware	Industrial System	Comunications	Middleware Frameworks	Software, semantics and reasoning, final applications.

Motivation

- Hospital health systems are expensive and have to attend a greater number of patients each day.
- Monitoring systems can reduce the cost of healthcare by taking monitoring outside the hospital environment.
- There are many diseases that require a continuous treatment (periodic visits in hospital) such as COPD.

Traditional Monitoring System

Online Monitoring system



Evolution: E-Health, M-Health, U-Health

E-Health System.

(Electronic)

Evolution: E-Health, M-Health, U-Health

M-Health System.

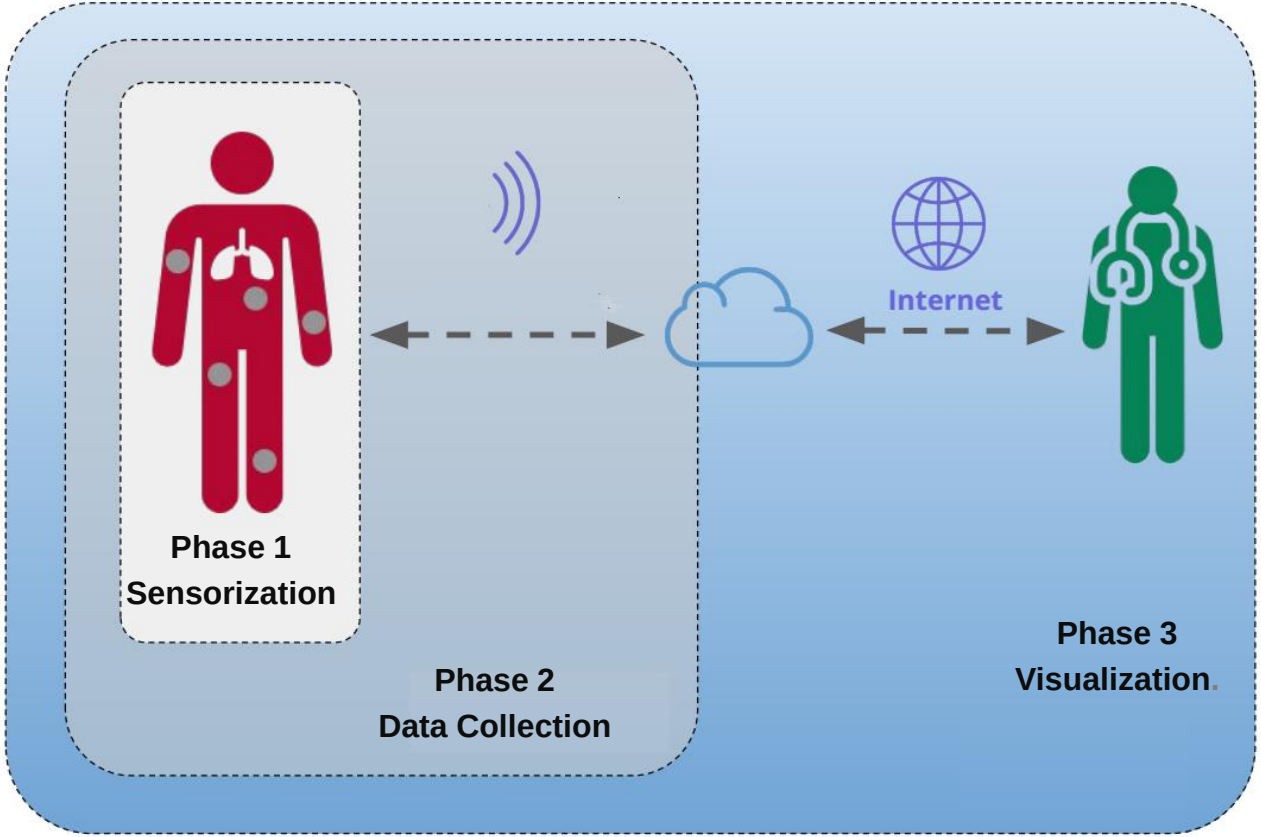
(Mobile)

Evolution: E-Health, M-Health, U-Health

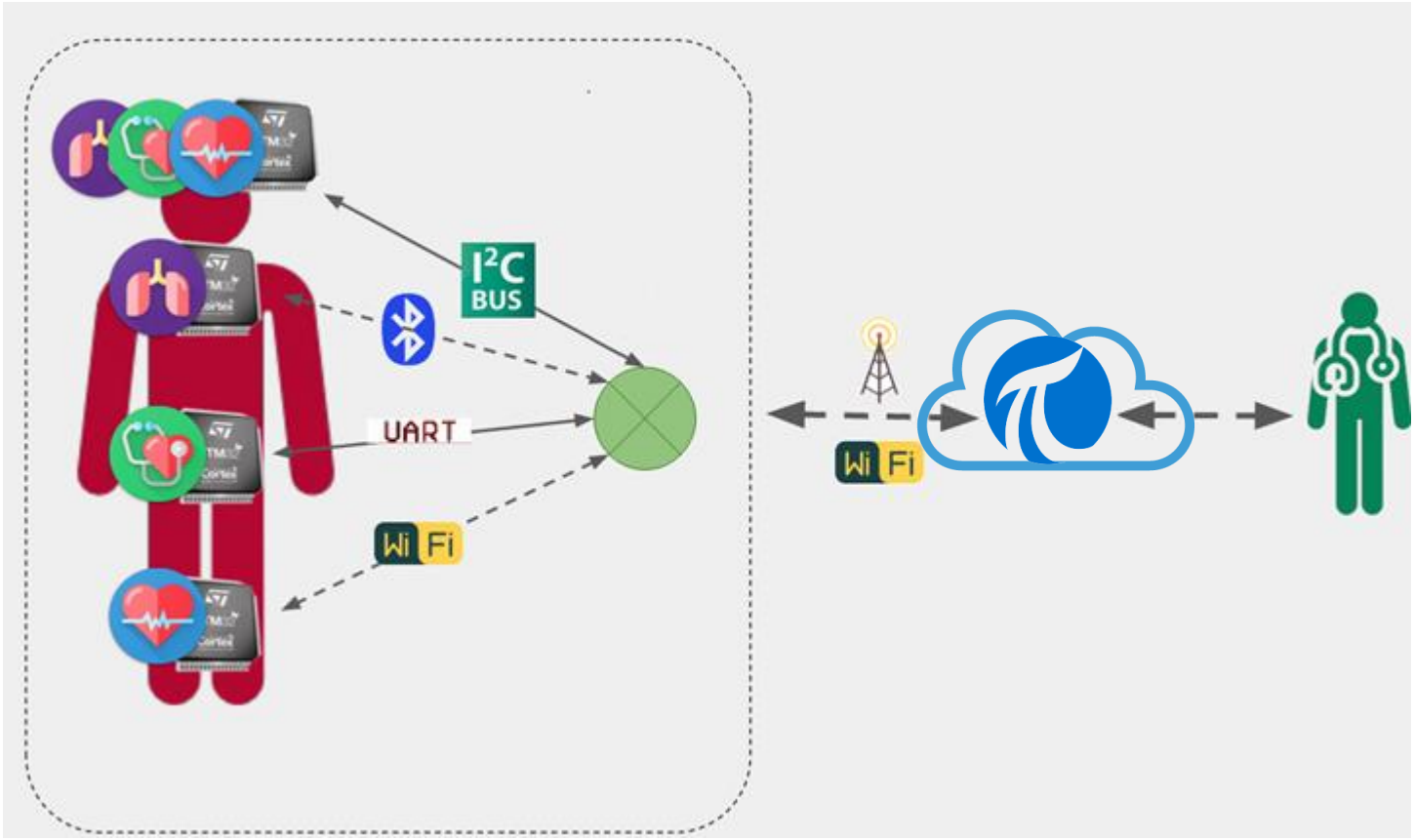
U-Health System.

(Ubiquitous)

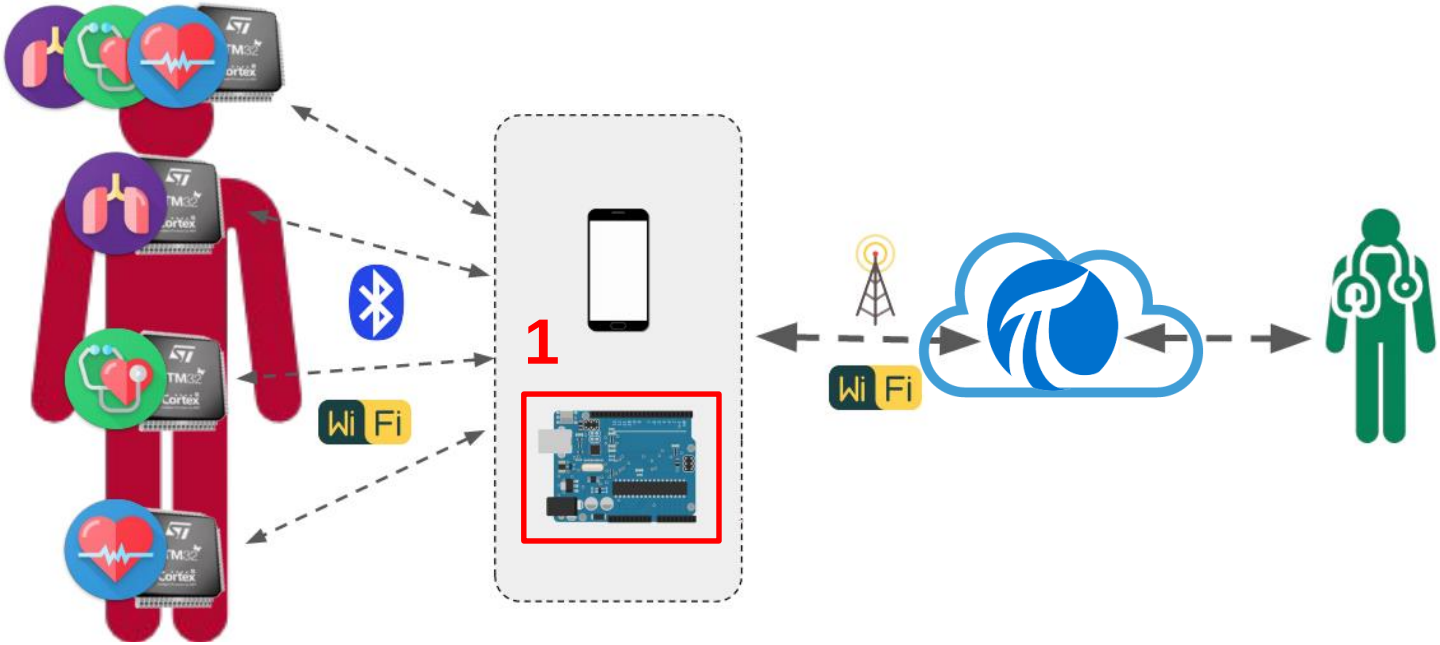
uHealth Infrastructure



uHealth Infrastructure: Monitoring



uHealth Infrastructure: Monitoring

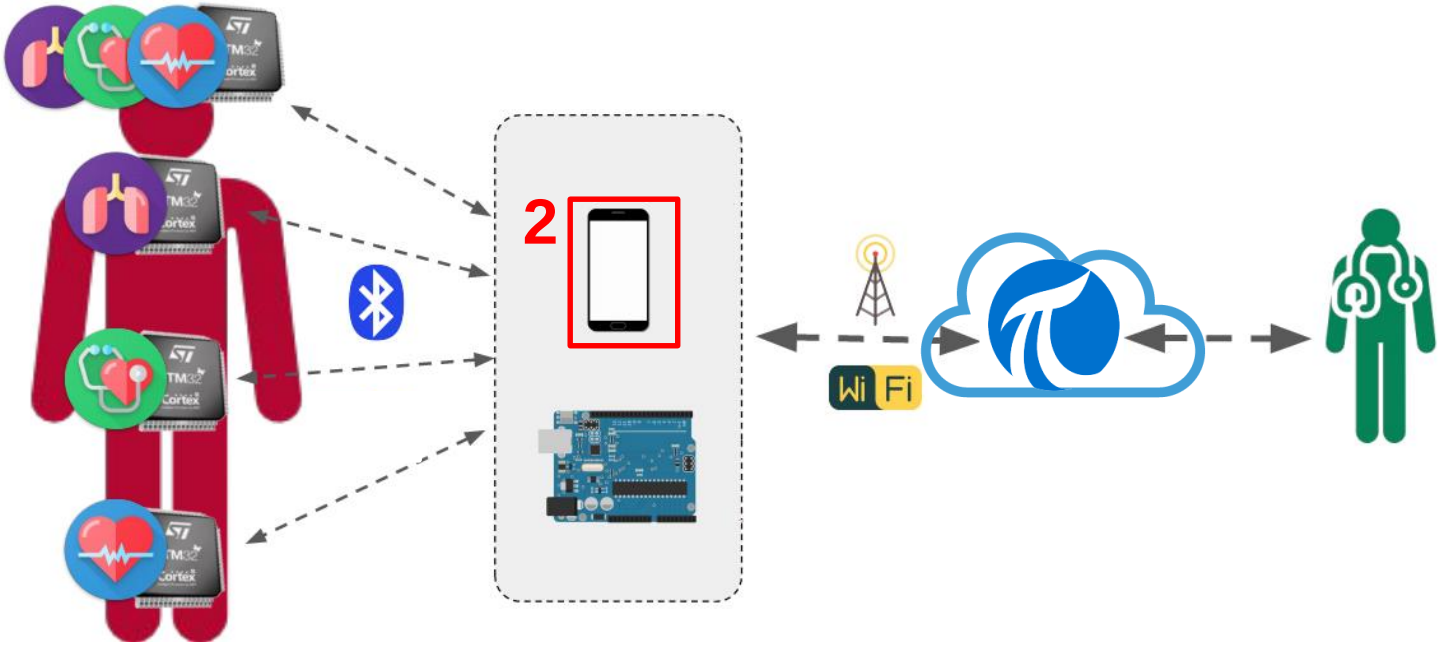


uHealth Infrastructure: First approach

- **Features**
  - ❑ Using special embedded devices (Arduino-based)
  - ❑ All sensors are connected to these devices.
  - ❑ The data are monitored and stored into a local PC.

- **Features that need improvements:**
  - ❑ Complexity of the system.
  - ❑ Use of standard devices such as smartphone.
  - ❑ The storage of the data in remote systems.
  - ❑ Organization of the patient data.

uHealth Infrastructure: Monitoring

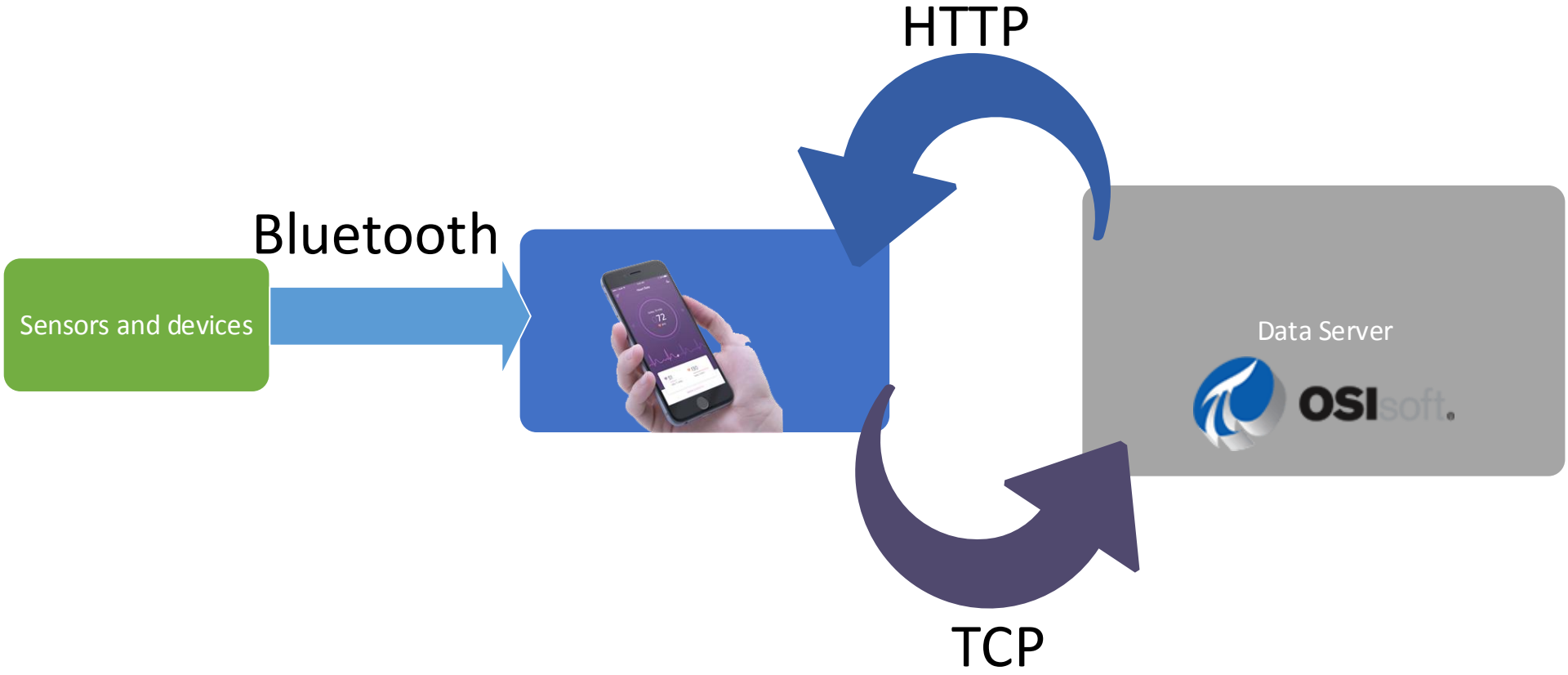


uHealth Infrastructure: Second approach

- **Features**
  - ❑ Use of standard devices for monitoring and storing data.
  - ❑ All sensors are connected to these devices (Bluetooth)
  - ❑ The data are monitored and stored in a remote system.
  - ❑ The system complexity is reduced.

- **Features that need improvements:**
  - ❑ How the data is organized?
  - ❑ How the information is exploited?
  - ❑ Security of data.

uHealth Infrastructure: Backend



PI system infrastructure

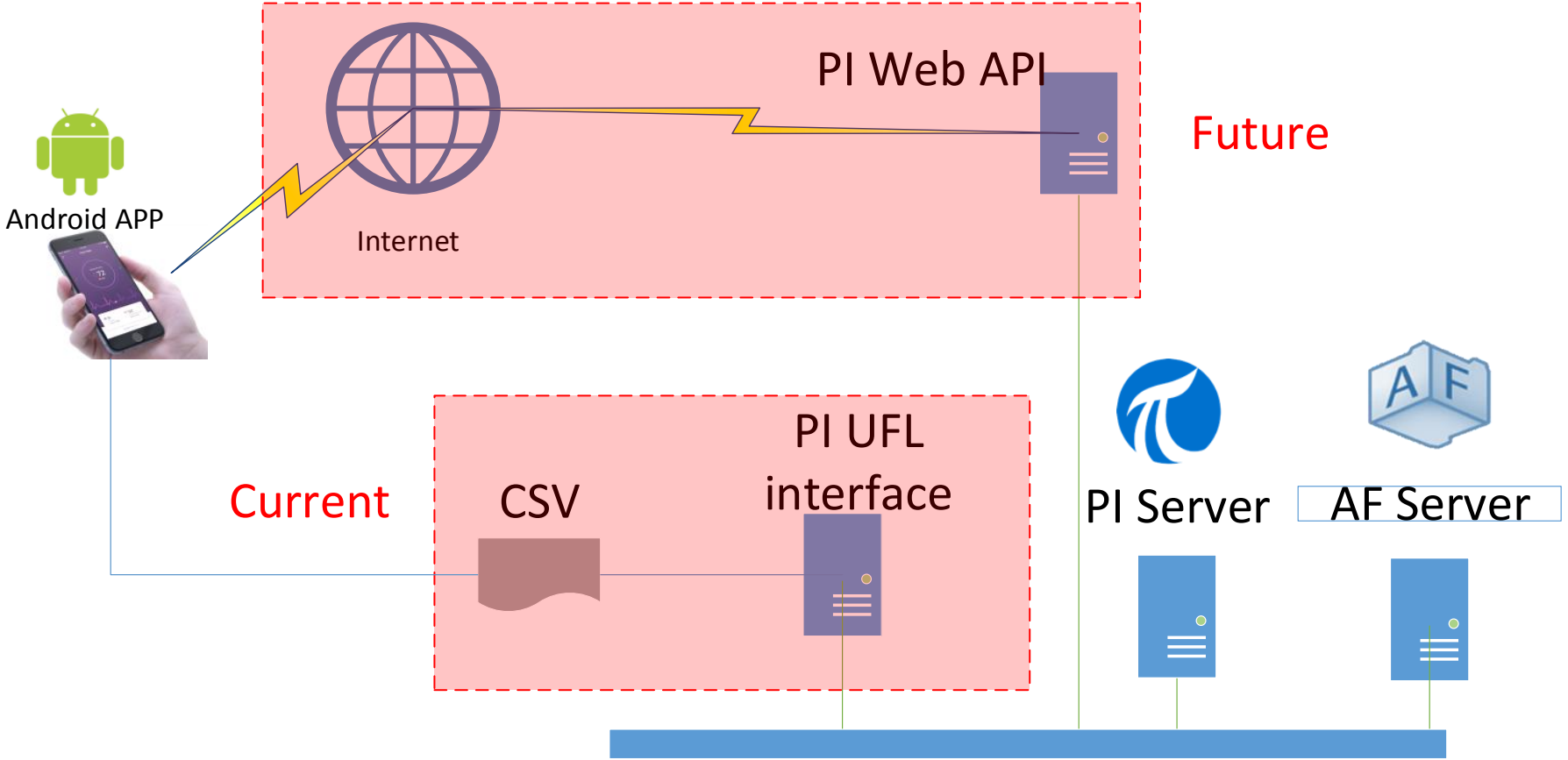
- It is necessary to build a robust and flexible platform to store the data of the uHealth infrastructure.

- Also this platform must provide tools for:

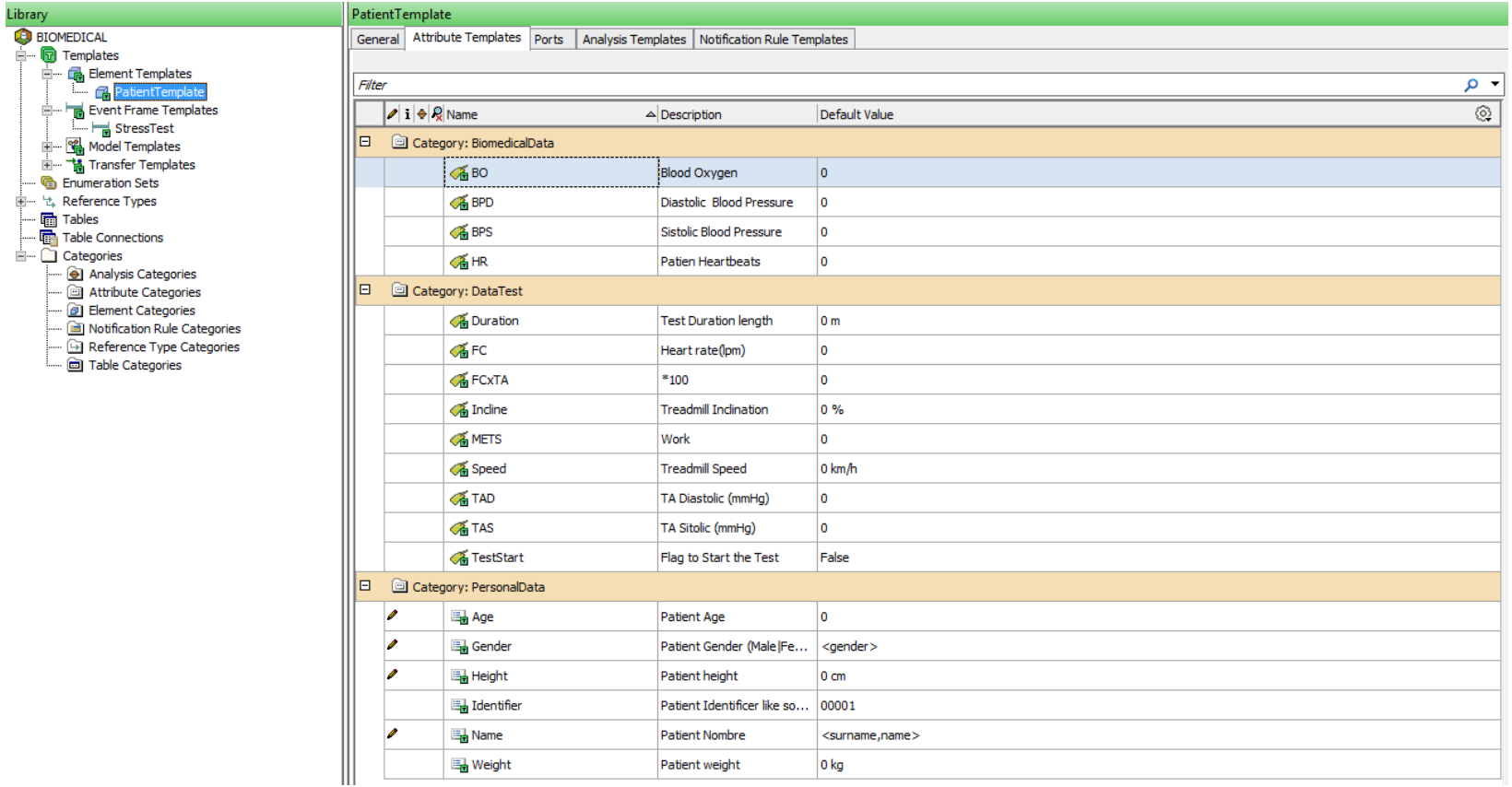
  - ✓ High availability and capacity to store any information type.
  - ✓ Organizing data in order to identify patients data easily
  - ✓ Providing mechanisms to exploit data and build analysis with them.

Our approach uses PI system

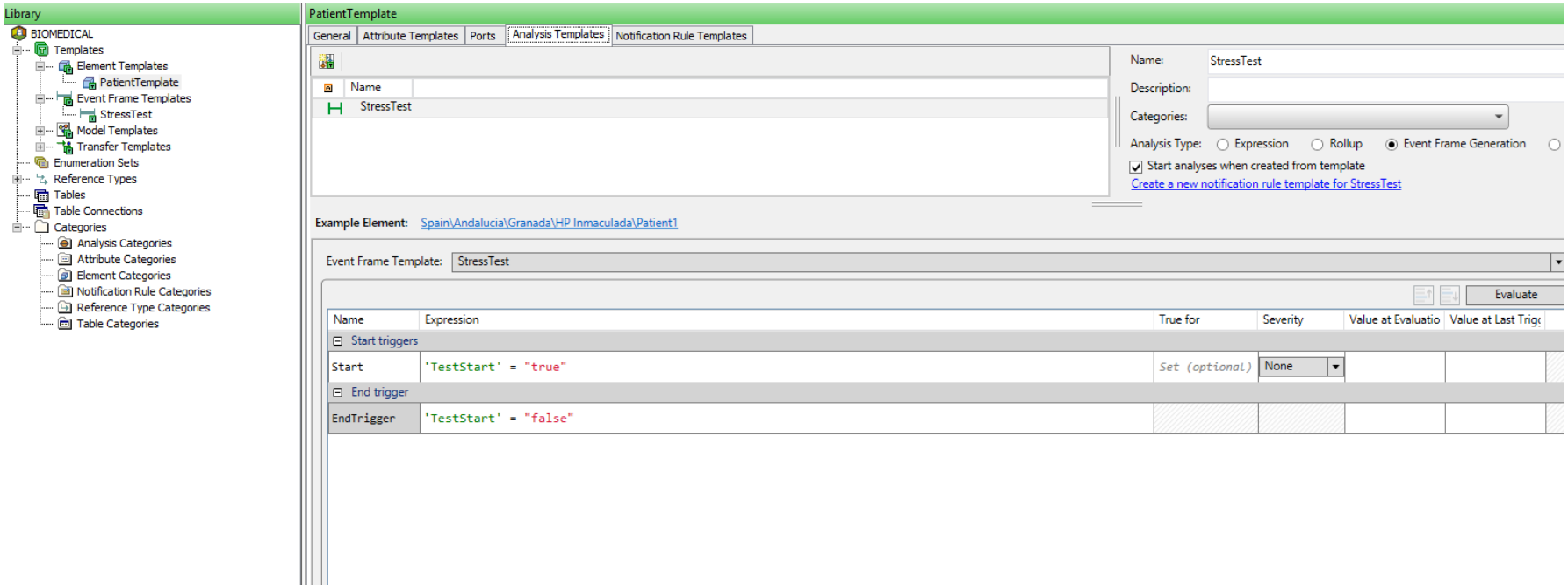
PI system infrastructure



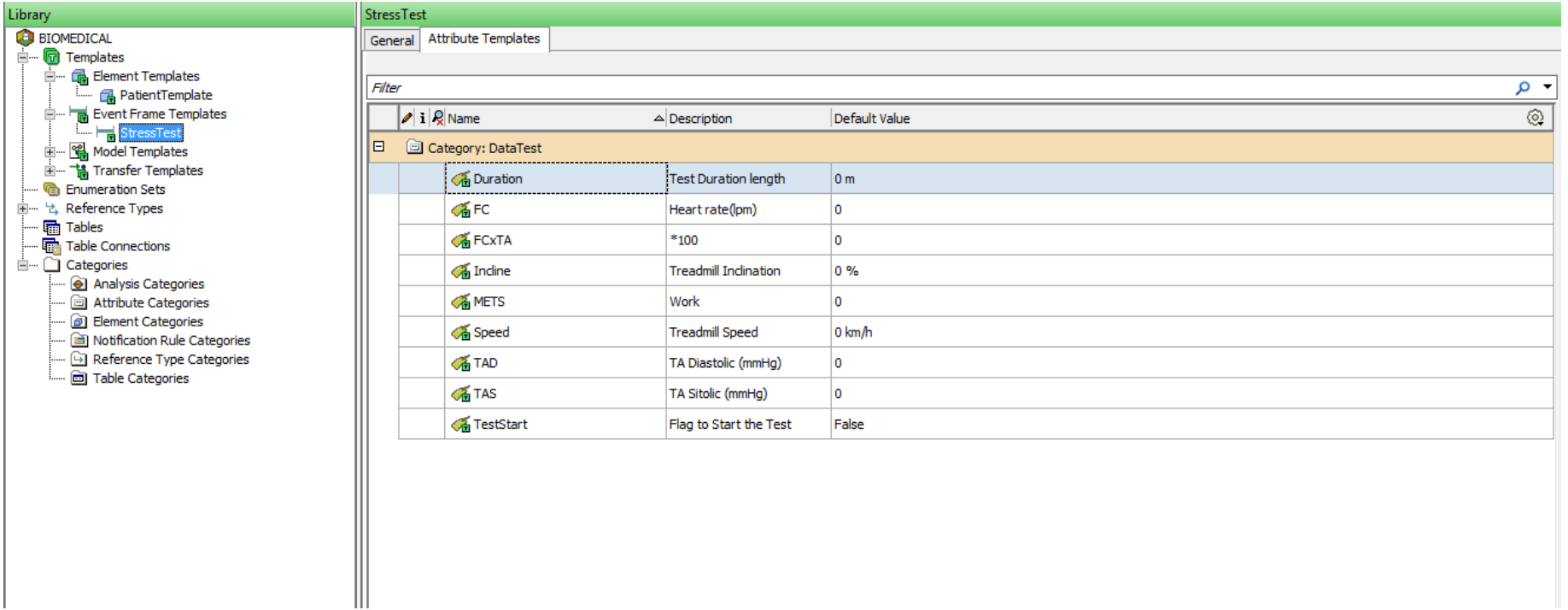
Data Model in PI: AF structure (ElementTemplate).



Data Model in PI: AF structure (Analysis Template).



Data Model in PI: AF structure (EventFrame Template).



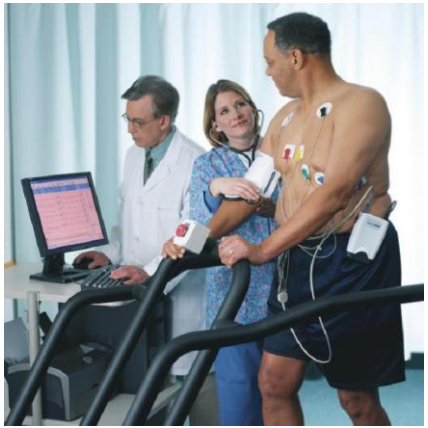
Study case: COPD (*Chronic Obstructive Pulmonary Disease)*

- **COPD :** Obstruction of the airways in a progressive and non-reversible manner, with a decrease in respiratory capacity that can lead to death:
  - ❑ 65 million suffer from it in the world.
  - ❑ 3 million deaths a year.
  - ❑ 18 thousand deaths in Spain.
  - ❑ 90% of deaths in low-income countries.
  - ❑ Smoker disease: Appears in 20% to 25% of the total.

Clinical Study

Stress Test :

- ❑ % Oxygen in blood.
- ❑ Heart Beats.
- ❑ Blood pressure.
- ❑ Speed
- ❑ Inclination
- ❑ Distance

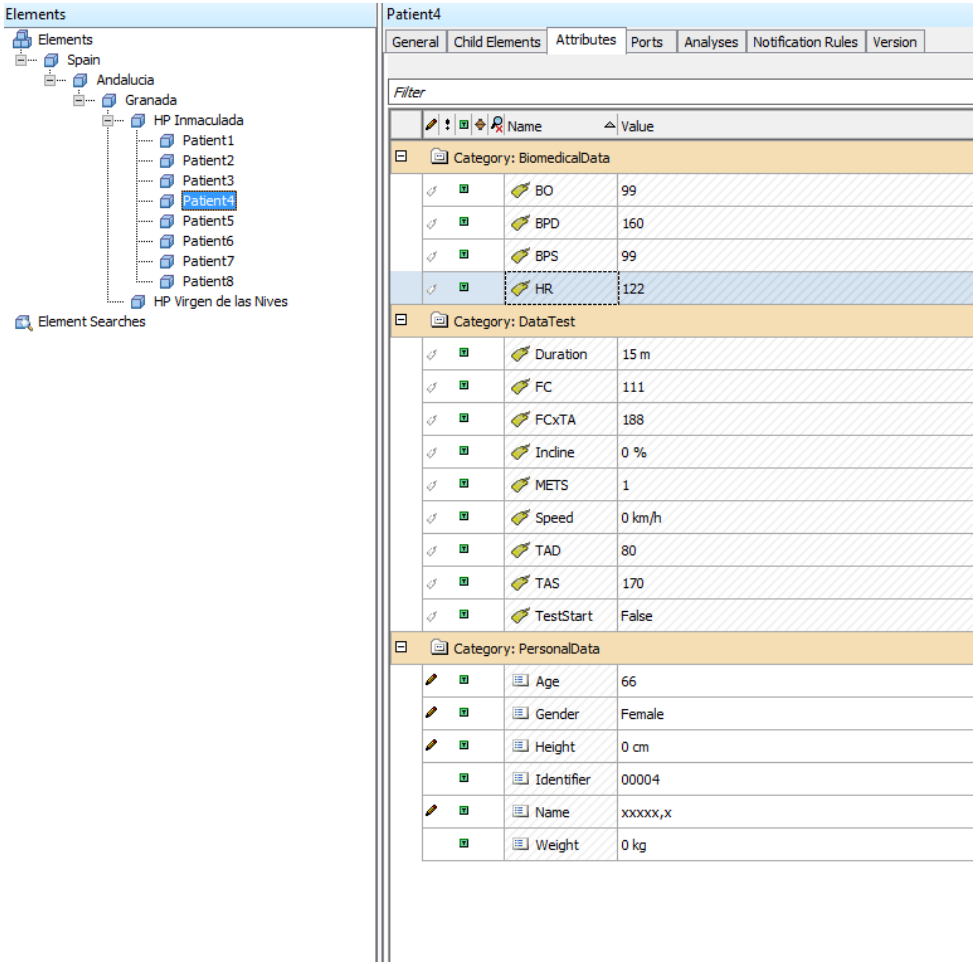


- Hospital Inmaculada (Granada)
- Participants: 18 patients
- Medical Staff:
  - Pedro Romero (Pneumology).
  - Luis Arrebola Moreno (Cardiology)
- Technical: José Francisco Matas

Study case: COPD

Set of parameters to monitoring (continuously**):**

- ❑ % Oxygen in blood.
- ❑ Heart Beats.
- ❑ Blood pressure.



Study case: COPD

Stress Test :

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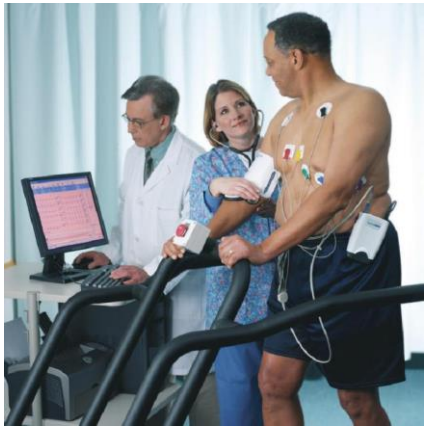


Event Frames

- Event Frame Searches
  - Event Frame Search 1
    - StressTest 2017-09-19 05:12:10.000
    - StressTest 2017-09-20 04:12:10.000
    - StressTest 2017-09-20 05:12:10.000
    - StressTest 2017-09-20 06:12:10.000
    - StressTest 2017-09-21 03:12:10.000
- Transfer Searches
  - Transfer Search 1

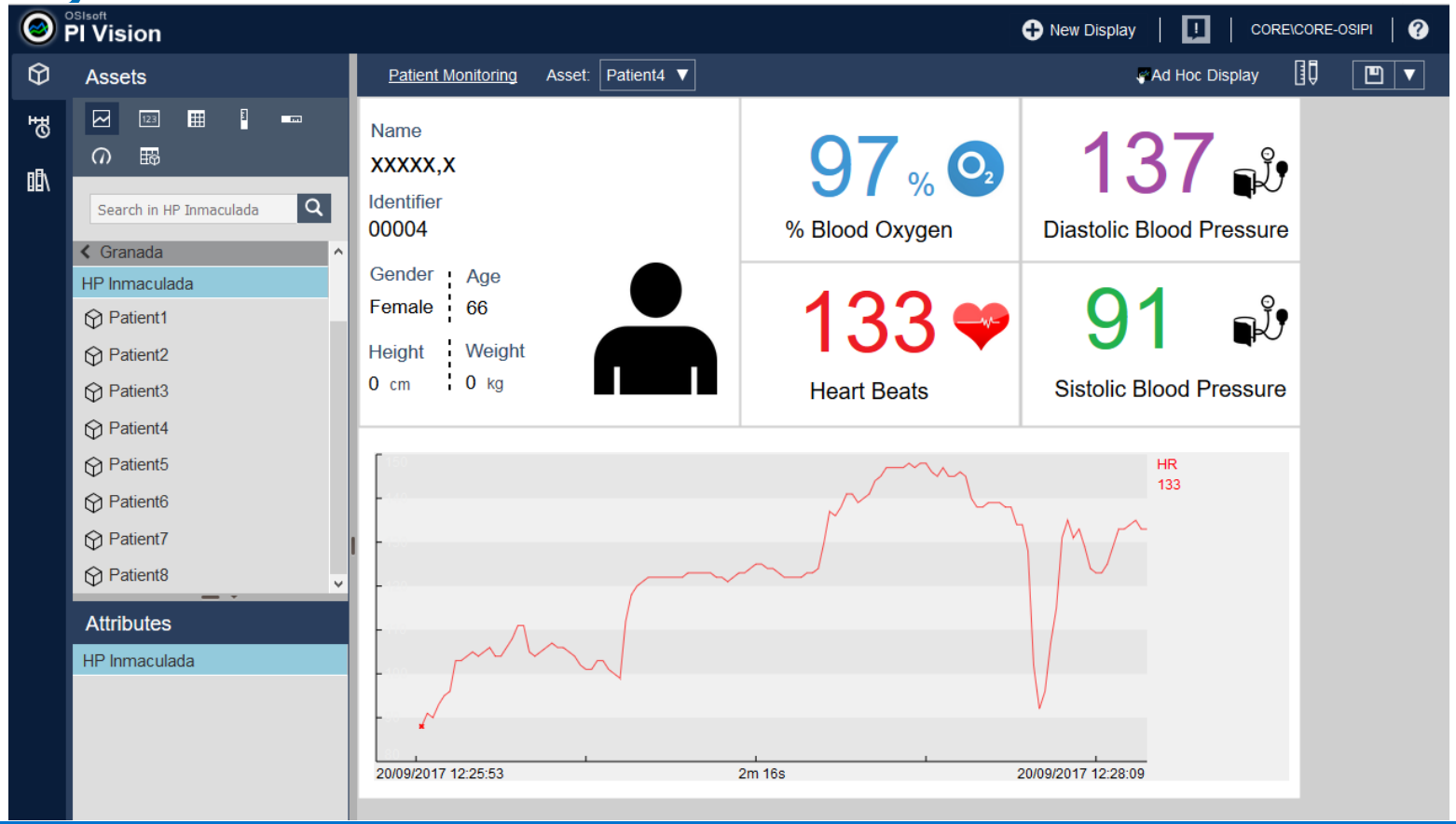
Event Frame Search 1

Filter

Name	1 [1.22:10:02] .	Duration	Start Time	End Time
StressTes...		0:13:10	19/09/2017 14:12:10	19/09/2017 14:25:20
StressTes...		0:14:40	20/09/2017 13:12:10	20/09/2017 13:26:50
StressTes...		0:14:40	20/09/2017 14:12:10	20/09/2017 14:26:50
StressTes...		0:14:40	20/09/2017 15:12:10	20/09/2017 15:26:50
StressTes...		0:10:02	21/09/2017 12:12:10	21/09/2017 12:22:12

Study case: COPD

PI Vision Dashboard



Summary

COMPANY and GOAL

Company: Research group in real time and Industrial systems

Goal: To achieve an U-Health system using wearable devices with a robust platform to exploit the information.

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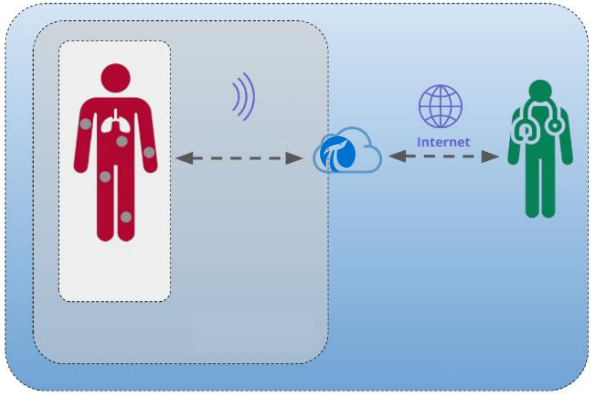
sistemas concurrentes

Granada University



CHALLENGE

1. Create a robust sensorization system.
2. Build flexible and simple data collection system
3. Plan the organization and persistence of data
4. Exploit the information to create predictive and visualization system

SOLUTION

1. Development of uHealth Infrastructure based on wearables devices and smartphones.
2. Using PI system to store and organize the information
3. Develop a visualization and prediction system with PI tools and SDKs

RESULTS

1. App in Android to collect the data coming from wearables devices through Bluetooth.
2. Continuous monitoring system for chronic diseases.
3. Use PI system to development of a U-Health system for COPD.

Conclusion

- The PI system offers a powerful platform to:
  - ❑ Store and collect data.
  - ❑ Organize information coming from different sources.
  - ❑ Provide Robust and High availability platform.
  - ❑ Achieve flexibility to exploit de data, get several SDKs and connectors for developing and programming.

- We need to store huge amounts of data in a robust, accessible and manageable way in order to deal with this data (Timely data).

- The study will correlate the monitored data with the evolution of the disease; that is important for therapeutic treatment.

Future Works

- Use PI analytic tools analytic tools to analyze the collected data (Predictive system).
- Use the same architecture to monitoring cardiovascular diseases.
- Study the application of the PI uHealth solution to other areas (e.g., sport monitoring).
- Collaborate with technology companies, universities and public health systems.

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Merci

Gracias

Thank You

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