# WBAN, MBAN or WBSN? A Taxonomy for Learning, Teaching, and Assessing Wireless Body Area Networks.

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# WBANs for what?

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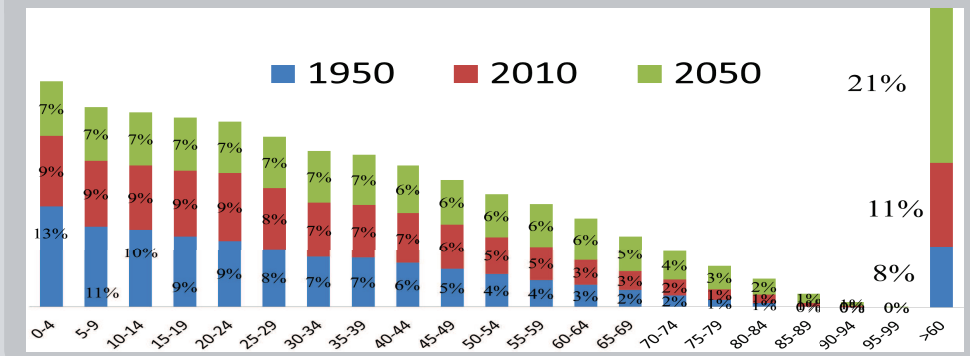


## Observation 2

The human life expectancy has increased too, in the same period, the elderly population (60 years old or older) augmented by about 410,647,596 individuals, representing a change from 8% to 11.1% on the composition of the population [1]

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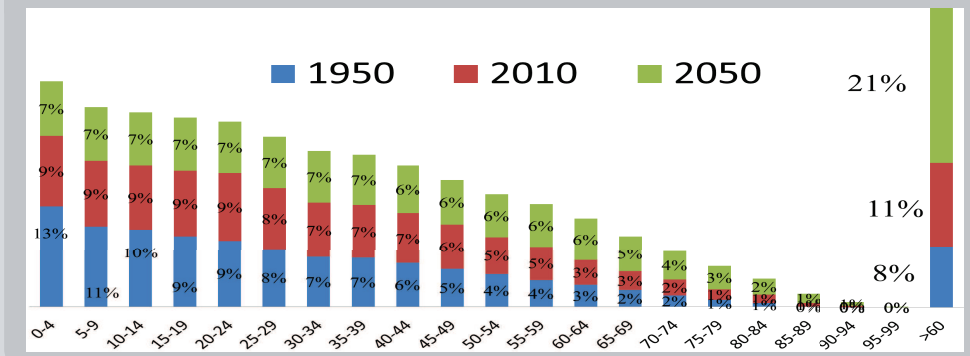


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## Conclusion

Our world is aging very FAST

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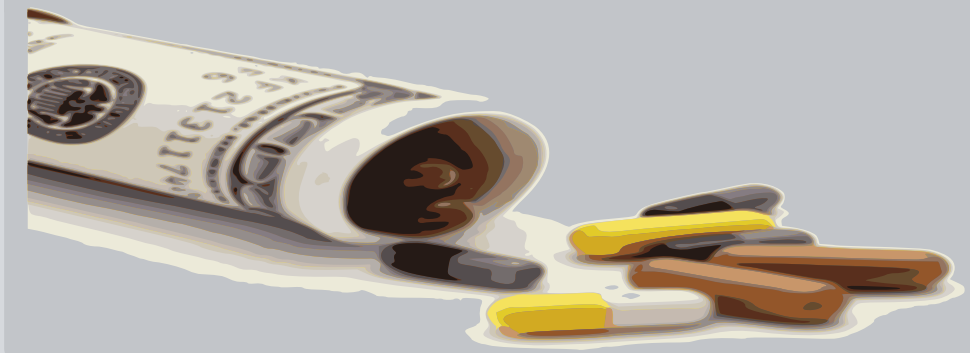
Millions of people develop chronic or fatal diseases every year and around 80% of health-care system spending is on chronic condition management [2].



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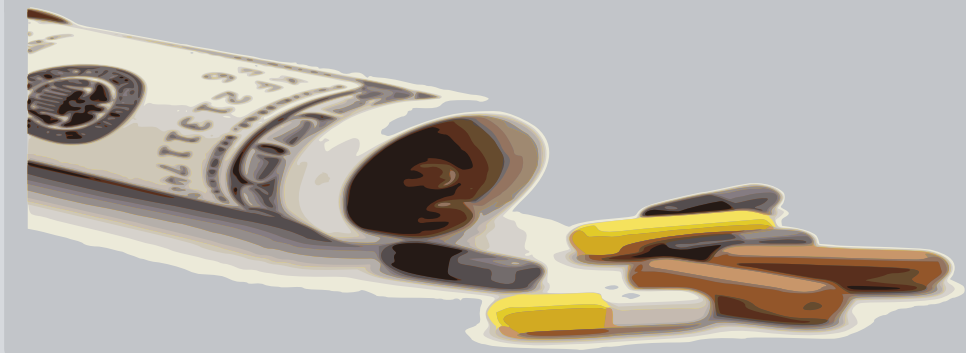
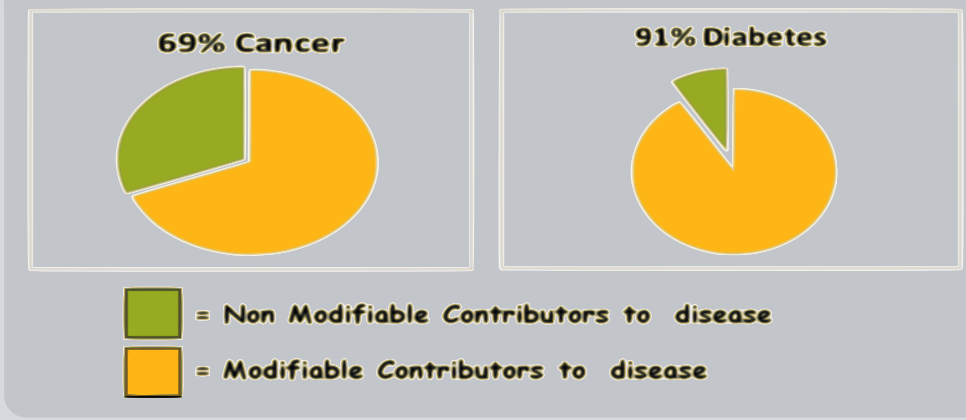


## Observation 4

As shown in [3], most diseases could be prevented if they were detected in their early stages.



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- Our world is old and sick.
- Future health systems need to change the current medical care paradigms.

If the system DOES NOT change, it will collapse.

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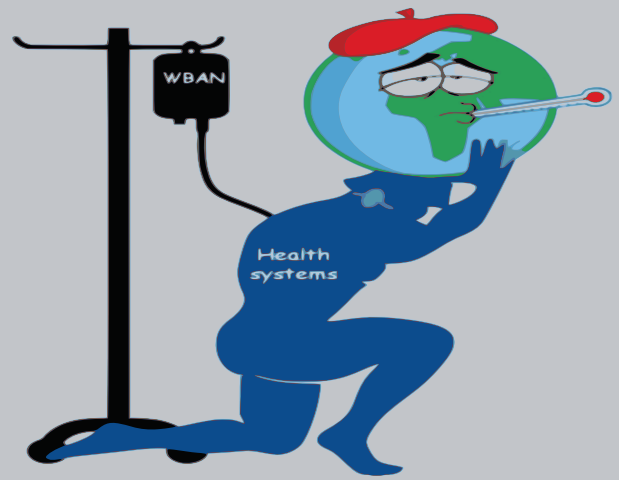
## One Solution:

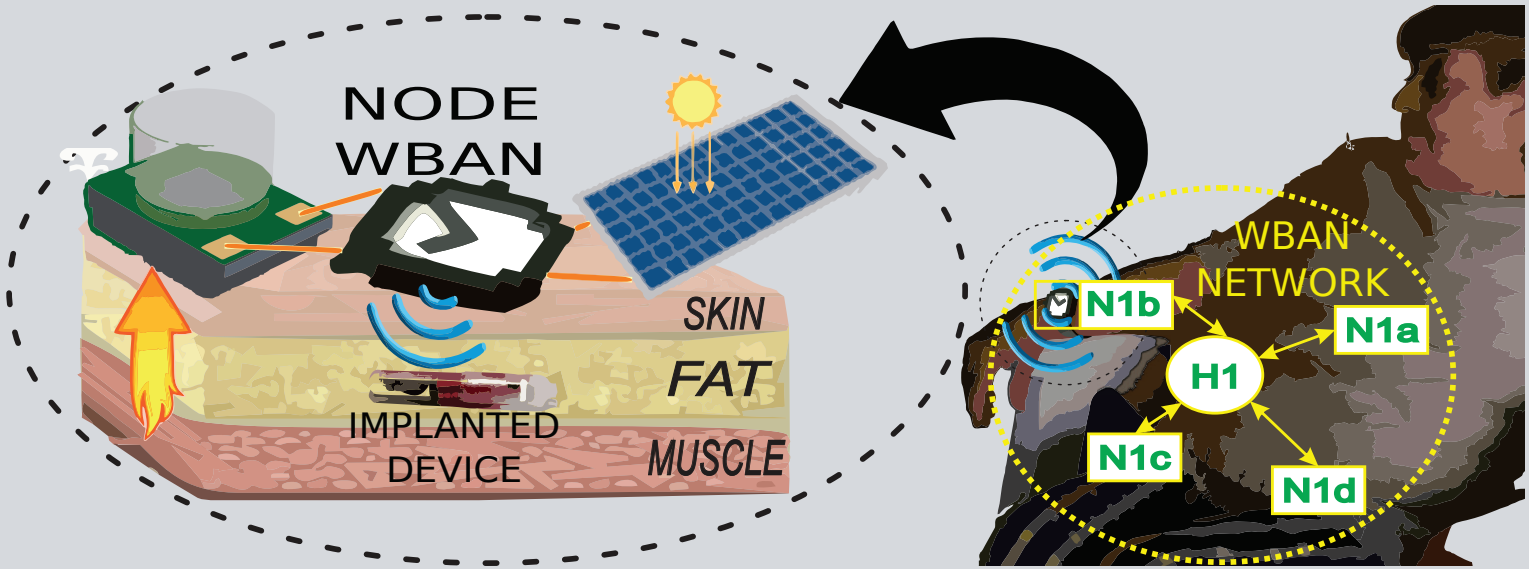
### Personal Connected Healthcare

In order to achieve health-care systems connected at person level, at least a network which can be wearable, or implanted in the human body is needed [4]. Commonly referred as Wireless Body Area Networks (WBAN) [4, 5, 6, 7, 8, 9, 10, 11].



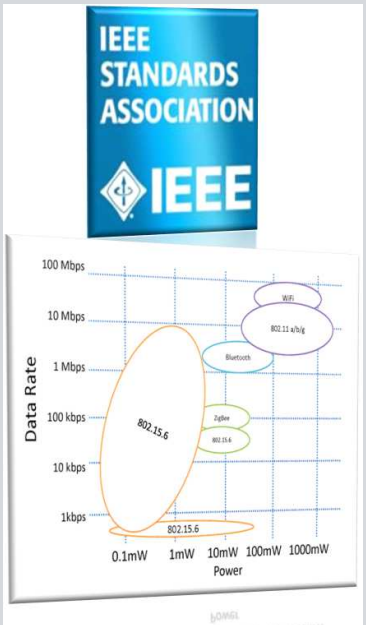
# Example of Personal Connected Healthcare

In [12] was proposed a system concept where a WBAN node transfers energy and receives information from an implanted device. In order to achieve energy autonomy, the WBAN node harvests energy from the body environment (i.e. solar and thermal). This energy is transferred through an inductive link to the passive implanted device that answers with the biomedical data. These data could be used to achieve the goal of the specific application. For example, if any abnormalities are found an alarm can notify by email or short message service (SMS), if the gateway of the WBAN node has at least 3G connectivity.



# WBAN Players

We are in the early years of the networks in, on and around the human body. There are many researchers, companies, professionals, students and consortiums developing products acknowledging for this type of networks [2, 13, 4, 14, 15]





## Futurology 1

WBANs are expected to cause a dramatic shift in how people behave, in the same way the internet did. However, technical and social challenges must be faced before an adoption [4].

## Futurology 2

- The WBANs can change our perception of the world.

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## Futurology 2

- The WBANs can change our perception of the world.
- WBAN Technology proves Science Fiction can become a reality.
- How you and I could become nodes in the internet of things?.

# About this work

## The problem

Since people with different skills and academic background are working on this subject, the information about the topic is sometimes difficult to understand, mainly due to the lack of standardization. It is common to find different terminologies associated to a single subject.

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## The Proposed Solution

The fundamental purpose of this paper is to analyze the recent literature about WBAN focusing on applications and network properties, and achieve a coherent taxonomy for Learning, Teaching, and Assessing WBAN networks.

# Applications of WBAN

The applications of WBAN based IT systems as reported in [2, 13, 4, 6, 7, 11, 16, 17, 18, 19].

## Medical

- Medical treatment, monitoring and diagnosis
- Prevention of medical accidents
- Remote health/fitness monitoring
- Disability assistance
- Safeguarding of uninformed (e.g. a WBAN can monitor the level of toxics in the air and warns the firefighters or soldiers when a life-threatening level is detected)
- Remote control of medical devices
- Tele-medicine systems

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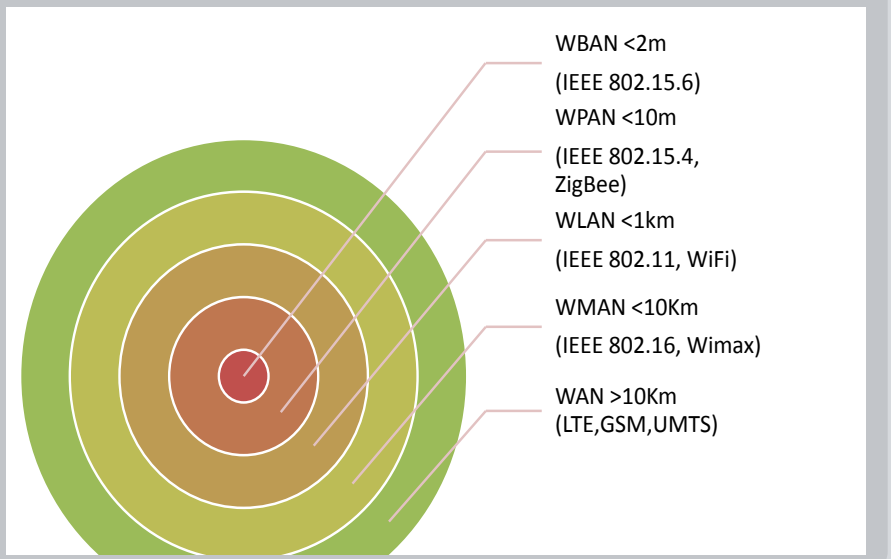
## Non Medical

- Training schedule of professional athletes
- Consumer electronics
- Advanced human-computer interfaces such as a neural interfaces, gaming consoles and virtual reality
- Personal information sharing (i.e.private or business information can be stored in body sensors for many daily life applications such as shopping)
- Secure authentication
- Non-medical emergency alert (i.e. detection such as fire at home).

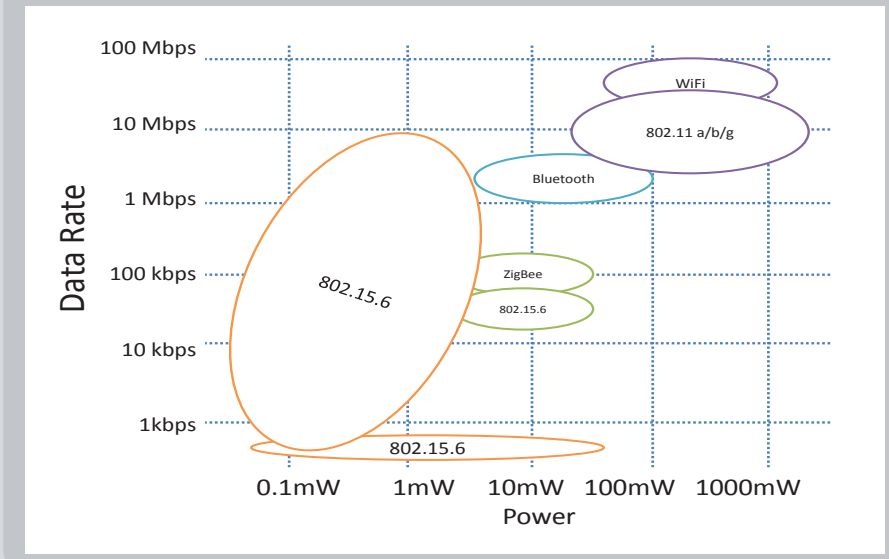
# WBAN comparison with other networks

The wireless networks can be categorized based on their geographical coverage, date rate, and power consumption. In the Figure based in [4], the WBAN (IEEE 812.15.6) are compared with others wireless networks such as Wireless Personal Area Networks (WPAN), Wireless Local Area Networks (WLAN), Wireless Metropolitan Area Networks (WMAN) , Wireless Wide Area Networks (WWAN), Zigbee, IEEE 802.15.4, and Bluetooth.

## Geographical coverage

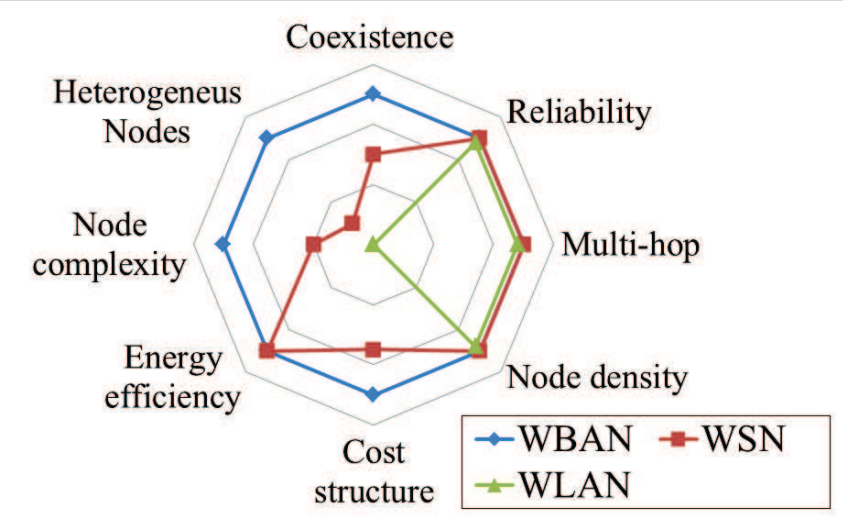



## Date rate and power



# Conventional network challenges

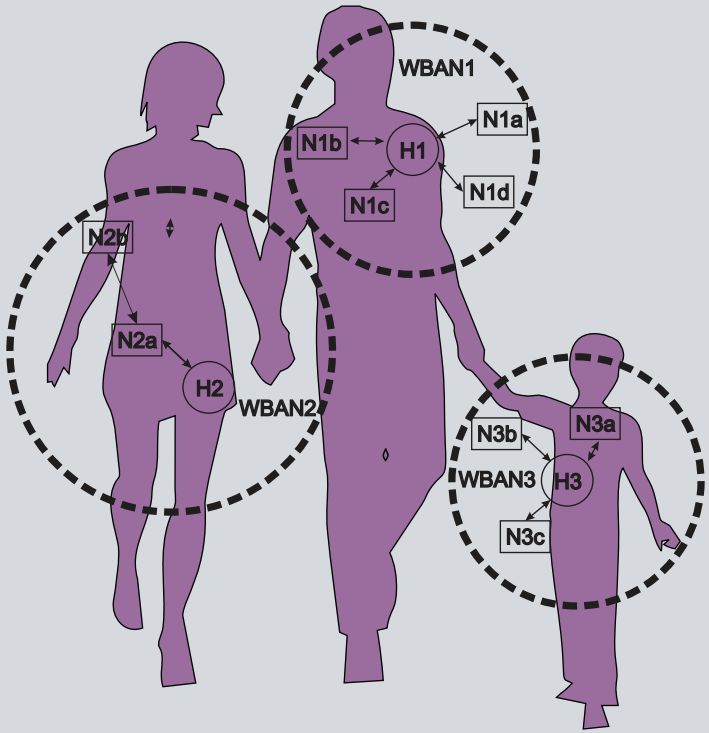
In several works, Wireless Body Area Networks are considered as a special type of a Wireless Sensor Network (WSN), with its own requirements. However, traditional sensor networks do not tackle the specific challenges associated with the interaction between the network and the human body.




Schematic view of conventional network challenges based on [20].

# Isolated WBAN

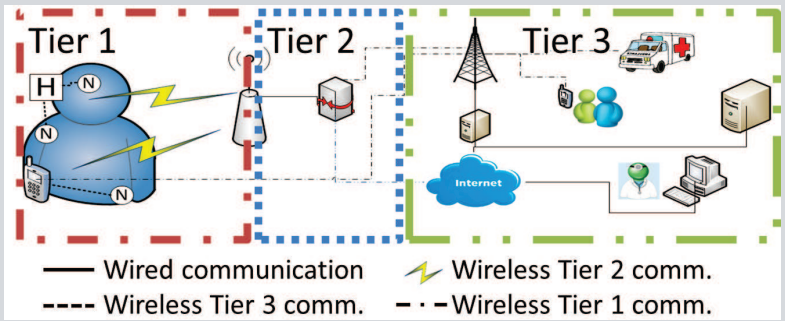
- Unlike WSNs that normally operate as autonomous systems, a WBAN seldom works alone [16].
- Sensor/actuators nodes (N) and hubs (H), that operates in, on, or around body.
- Two possible topologies: one-hop or two-hop star topology with one node in the center of the star [6].
- The nodes are classified as coordinator, end nodes and relay nodes.
- A difference between the end nodes and the relay nodes is that the relay node may transfer messages to end notes or to coordinator
- Concerning the implementation: implant node (in body), body surface node (0-2 cm away from the body) and external node (around 2-5 cm away from the body).




Isolated WBAN

# IT solution based in WBAN

- In the tier-1 the internal WBAN communication between nodes takes place (IEEE 812.15.6).
- The communication going on the tier-2 is used to interconnect WBANs with various networks that are easy to access in daily life, such as the Internet and cellular networks.
- Tier-3 communications are used to achieve the goal of the specific application, and should adapt to the requirements of user-specific services. (i.e. 3G if email or short message service (SMS) were needed)




Simplified architecture of Medical TI solution

# Proposed taxonomy for WBAN I

Using the analyzed references we propose some definitions for the most common type of WBAN networks.

**WBAN Definition based in [4, 6, 7, 11, 16, 21]**

Wireless network composed by sensor/actuators nodes (N) and hubs (H), that operates in, on, or around body (but not limited to human bodies) and supports a variety of medical and non-medical applications.

# Proposed taxonomy for WBAN II

## Special cases of the WBAN

- In agreement with [22, 23, 24, 25, 26], Wireless Body Sensor Networks (WBSN) : A WBAN where all nodes (N) are sensors.
- In agreement with [27, 28], Wearable WBAN: A WBAN where all the nodes (N) and hubs (H) are on the human body.
- In agreement with [26, 29, 30, 31], Implanted WBAN: A WBAN where some N or H are in the human body.

# Proposed taxonomy for WBAN III

## Very Special case The Medical Wireless Body Area Network (MWBAN)

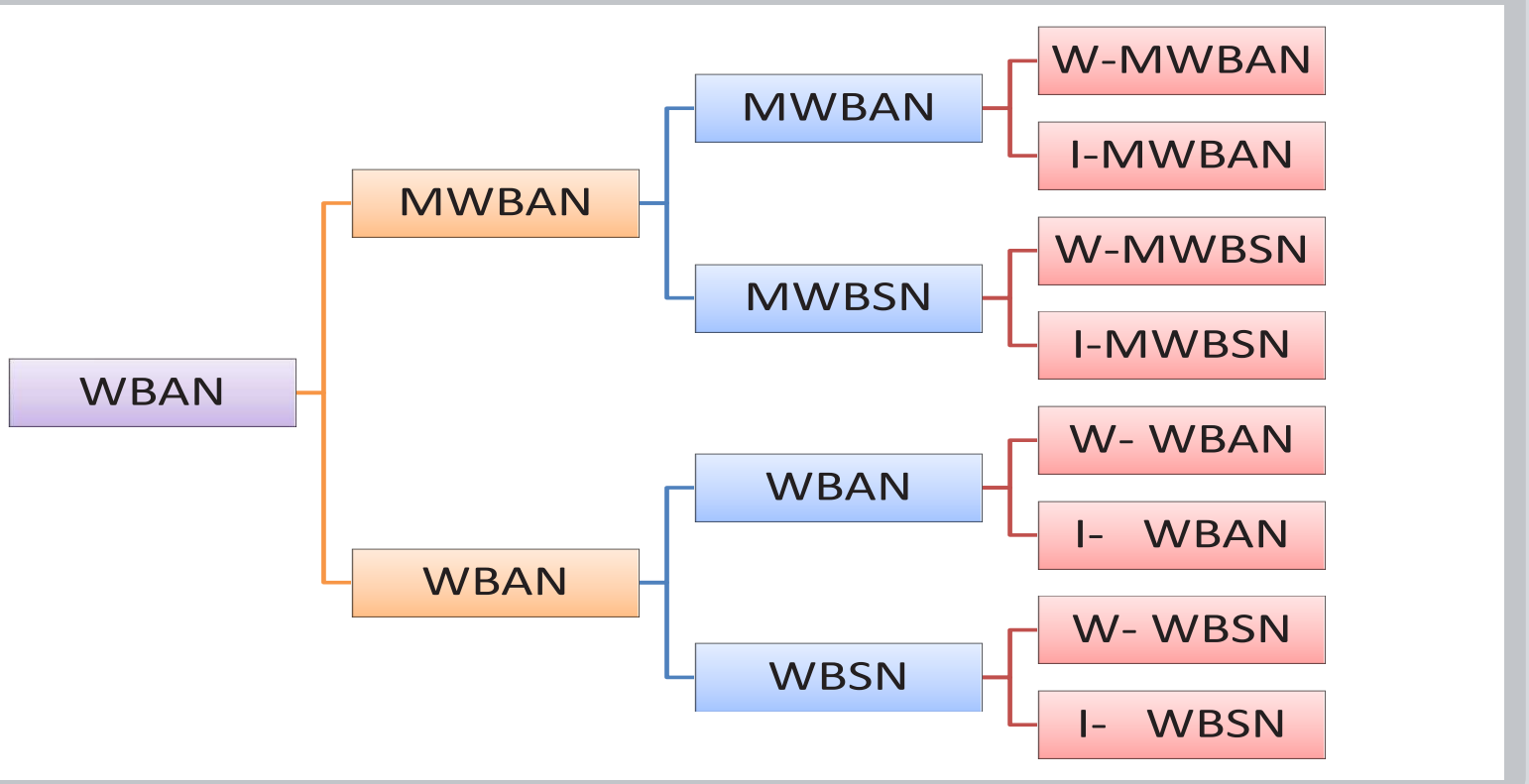
The WBAN have many applications, but the medical field is maybe the most important. There are many players working to develop products that changes the medical paradigm of prognosis and treatment. In this scenario the WBAN must be explored, developed and implemented in a specific framework (legal, safety, ethic, etc).

## MWBAN Definition based in [17, 32, 33, 5]

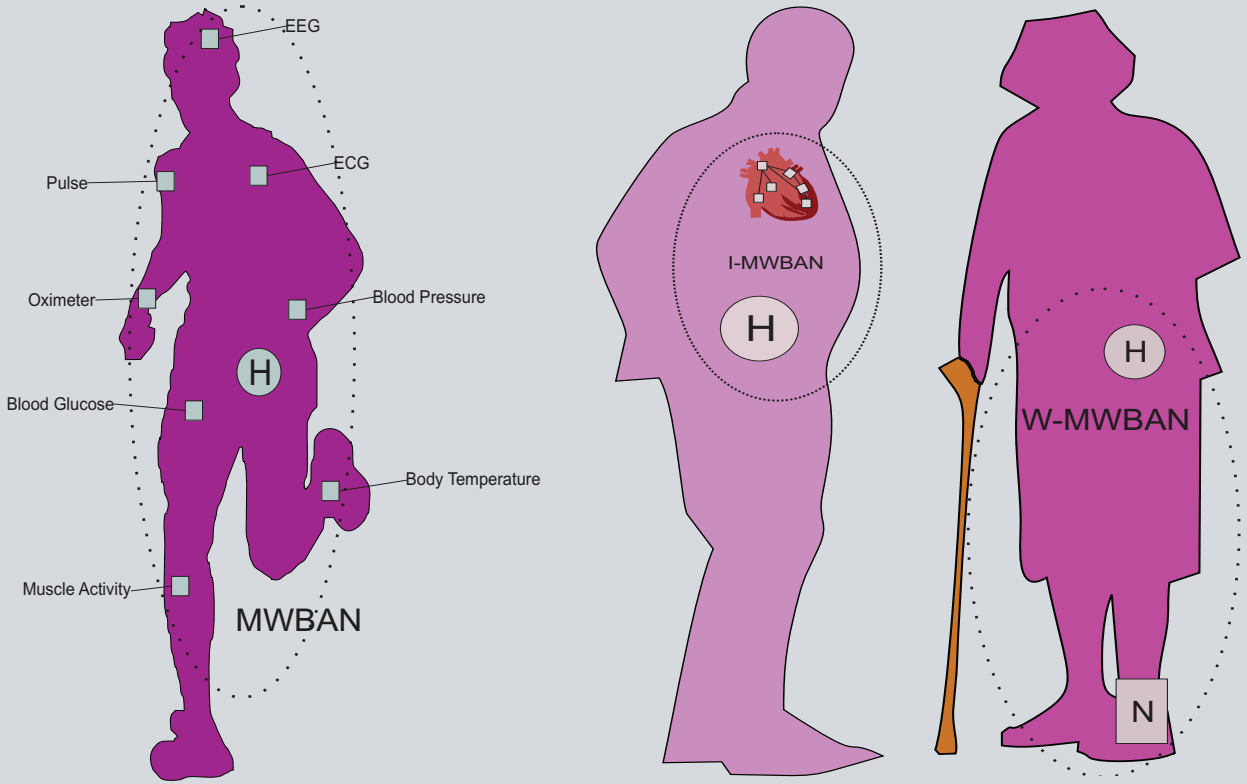
The Medical Wireless Body Area Network (MWBAN) is a wireless communication technology designed to electro-monitoring and electro-stimulating the human body wirelessly, through tiny nodes/actuators in, on or around the body.

# The proposed taxonomy I

## Taxonomy tree



# The proposed taxonomy II




(a) MWBAN (b) I-MWBAN (c) W-MWBAN

# Conclusions

- The proposed taxonomy allows to unify and centralize discussions about the WBAN technologies, departing from the adequate terminology.

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- The proposed taxonomy allows to unify and centralize discussions about the WBAN technologies, departing from the adequate terminology.
- The proposed taxonomy could simplify the process of searching and indexing the information associated to these technologies, saving time and accelerating the process of understanding the WBAN key concepts.

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