WIRELESS BODY NETWORK TO PREDICT HEART ATTACKS

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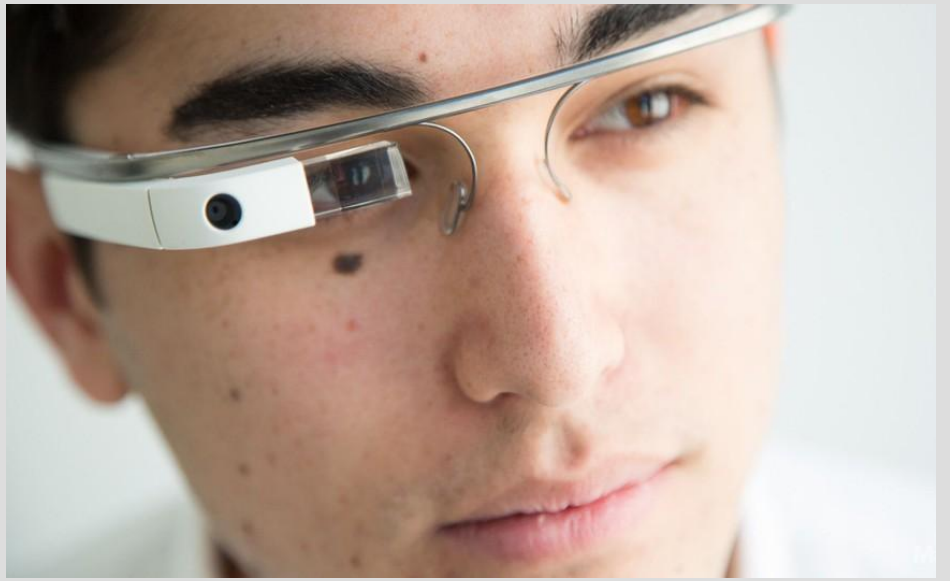
WHAT ARE WEARABLE DEVICES?

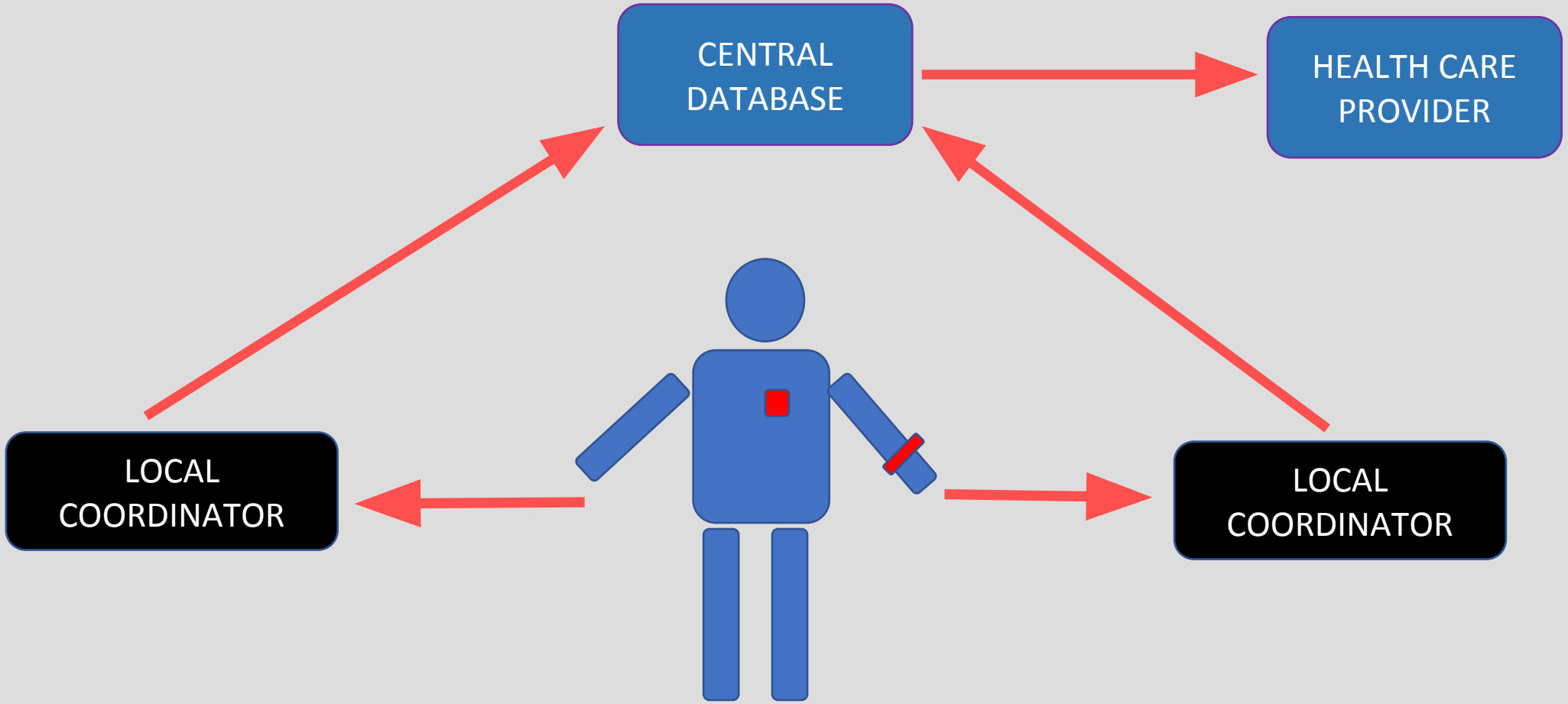
They are small personal mobile computing devices meant to be worn as accessories or as part of regular clothing.

They are commonly used in conjunction with smart phones.

Primary purpose is to sense , collect and upload physiological data to improve the quality of life.



BLOCK DIAGRAM



WHAT WILL WE DISCUSS?

HARDWARE SPECIFICATIONS OF WATCH

WHAT SENSORS & HOW TO INTERFACE WITH WATCH?

WHERE WILL WE DO COMPUTATION? - DUST

SECURITY OF COMMUNICATION – EAP & AES-128 BASED

PORTABILITY TO VARIOUS WRISTWATCHES- SPINE2

WHAT MACHINE LEARNING ALGORITHMS TO RUN?

WRIST BAND USED

SPECIFICATIONS: MOTOROLA 360 SMART WATCH

CPU: QUALCOMM SNAPDRAGON 400 WITH 1.2 GHZ QUAD-CORE RISC MODEL

INTERNAL STORAGE: 4 GB RAM: 512 MB

BATTERY: LI- POLY /300 MAH UP TO 1-1.5 DAYS BATTERY LIFE

CONNECTIVITY: BLUETOOTH LOW ENERGY, BLUETOOTH 4.0

SENSORS

HEART RATE SENSOR(SFH7051)

- Integrated optical sensor from OSRAM opto semicomductors.
- Used in Fitness trackers, smart watches and other wearables.
- Consumes low power and maximises the battery life.
- Consists of photodiode and 3 green LEDs
- By measuring volume of blood through blood vessels.
- Different locations of body requires LED lights of diff wavelengths
- Green light 530nm for wrists, red light 660nm for fingers.

BLOOD OXYGEN SATURATION(SPO2)

- Ultra low power Pulse Oximeters with energy efficient Transimpedance amplifier is fast,non-invasive way to measure oxygen level in blood.
- By comparing the transmission characteristics of red and infrared light-emitting diode light through the patient's finger with a photoreceptor(4.8mW).
- Estimation is from absorption characteristics of blood inresponse to Red(660nm) & IR light(940nm).
- Haemoglobin becomes oxygenated n changes colour from dark red to bright red, reducing the absorption of red light.
- Very suitable for portable medical applications.

SKIN TEMPERATURE SENSOR

- TMP007 is an IR Thermopile sensor.
- Absorbs IR radiations emitted by the skin.
- Works on Thermopile principle.
- Senses the radiation by absorbing radiation on hot junction.
- Hot junction is determined by object temp
- Low power consumption and low operating voltages
- Optimal for thrmal management & protection apps where remote noncontact temperature sensing is desired.
- I2C interface compatible, and temperature range of –40°C to 125°C.

BMA400 ACCELERATION SENSOR

- First real ultra low-power acceleration sensor by Bosch.
- Current consumption of 14microamps.
- Allows low noise measurements of accelerations in three perpendicular axis.
- Senses tilt, orientation, enables step counting with activity recognition esp suited for wearable devices for long lasting battery life.

BODY FAT CALCULATOR

- Body Fat can be calculated by inputting Gender, Height, Weight, Circumference of Neck, Waist and Hips.
- BFP of a human being is the total mass of fat divided by total body mass.
- The body fat percentage is a measure of fitness level, since it is the only body measurement which directly calculates a person's relative body composition without regard to height or weight.

Body Fat Percentage Categories

Classification	Women (% Fat)	Men (% Fat)
Essential Fat	10-12%	2-4%
Athletes	14-20%	6-13%
Fitness	21-24%	14-17%
Acceptable	25-31%	18-25%
Obese	32% +	25% +

PREPROCESSING
(WRIST WATCH / LOCAL COORDINATOR)

FEATURE EXTRACTION
(LOCAL COORDINATOR/WRIST WATCH)

ML ALGORITHM
(CLOUD)

LOCAL COORDINATOR

COMMUNICATION WITH WEARABLE VIA BLUETOOTH LOW ENERGY, BLUETOOTH 4.0

CAN BE PHONE OR LAPTOP

SENDS DATA TO CENTRAL DATABASE ON CLOUD (EG. MYSQL)

REQUIREMENTS TO USER

- Meta data:
- Weight
- Height
- Age
- Gender
- History of vital signs
- History of previous Decisions

CENTRAL DATABASE

- Feature Extraction Techniques
- Training and running of ML algorithm
- Interpretation of output
- API's for more functionality to communicate with health care provider

PREPROCESSING

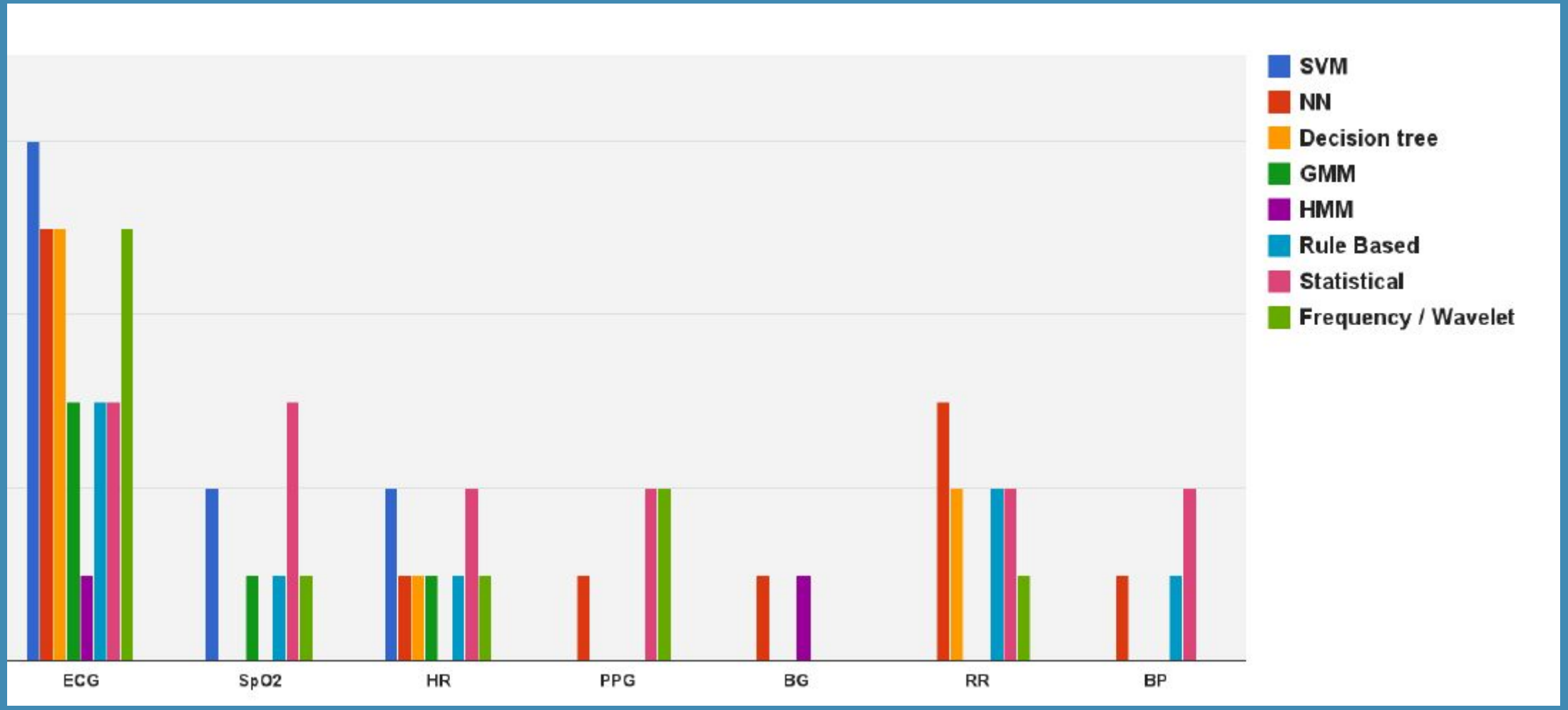
- Used to remove motion artifacts via Threshold Based Methods

- Used to remove high frequency noise via - High pass filter, Power spectral density, Fast Fourier Transform(FFT), Data Normalization

FEATURE EXTRACTION

Parameter	Time Domain	Spectral Domain
ECG	Mean R-R, Std R-R interval, Number of R-R interval	Spectral Energy, Power spectral Density, Low-pass filter
SpO2	Mean, Zero crossing counts, entropy, Slop	Energy, low frequency analysis
HR	Mean, Slope	Energy, low frequency analysis, wavelet coefficients of data segments
BP	Mean, Slope	
RR	Mean, Min, max	-
RR	Mean, Min, max	-

SURVEY FOR ML ALGORITHMS



OVERVIEW OF ML ALGORITHMS

SVM	NN	DECISION TREE	RULE BASED
ECG	RR	HR, ACCELERATION DATA	RR, BP

SVM(SUPPORT VECTOR MACHINE)

- Classify unseen information by deriving selected features constructing high dimensional hyper plane to separate the data points into two classes in order to make decision.
- Used for ECG, HR, SpO2.
- Not appropriate model to use metadata with sensors data

NN(NEURAL NETWORKS)

- Used for classification and prediction
- Train data by learning the known classification of records and comparing with the predicted classes of records in order to modify the network weights for next iteration of learning.
- Feedforward neural network on ECG and RR features in frequency domain.
- Not counted as a portable technique to easily apply for diverse data sets.

DECISION TREE

- Initial splitting the input data by creating Tree-like model
- Suitable for handling multivariant sensors due to construction of independent levels in decision tree.
- Output of the tree is label of danger or safe.
- More features lesser the efficiency
- Eg. ECG, HR, Accelerometer data

RULED BASED

- Recognize patterns, anomaly and specific events based on predefined and stored rules and conditions.
- Threshold-Based Rule applied.
- Eg. RR, BP, ECG

CHALLENGES

- SVM, NN, Decision Tree good in decision making.
- SVM, NN,GMM uses to model long term data.
- For real time health monitoring, NN, GMM, frequency analysis not efficient because computational complexities. Rule-Based, Decision Tree are efficient.
- SVM and NN widely used in health monitoring system.

COMPUTING, SECURITY & PORTABILITY

SECURITY – FINDING A LIGHT WEIGHT BUT EFFICIENT PROTOCOL

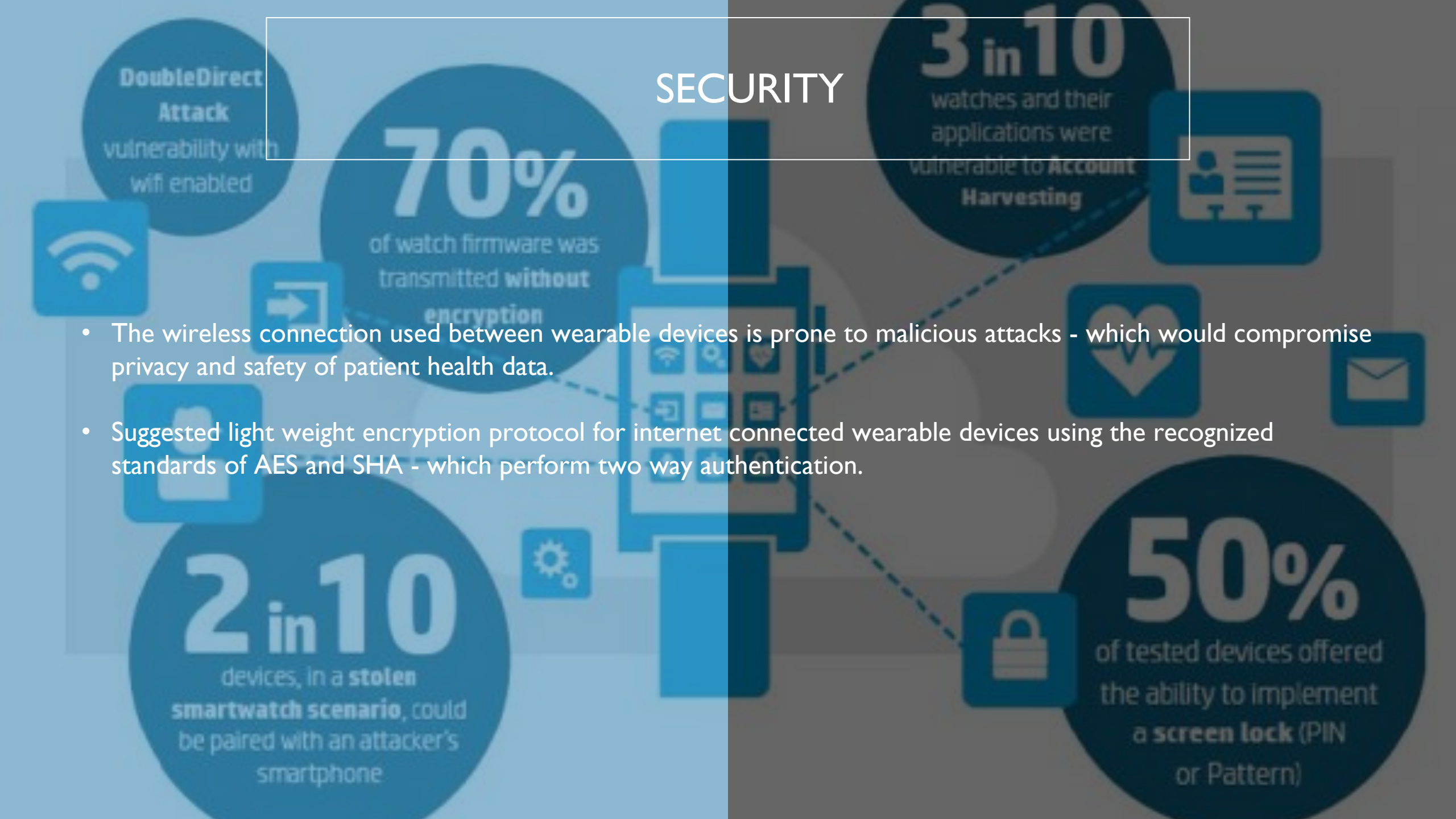
OFFLOADING ALGORITHMS & COMPUTATION.

OFFLOADING VS ON DEVICE COMPUTATION

CLOUD OFFLOADING VS DEVICE OFFLOADING

PORTABILITY TO DIFFERENT WRIST BANDS

SECURITY



- The wireless connection used between wearable devices is prone to malicious attacks - which would compromise privacy and safety of patient health data.
- Suggested light weight encryption protocol for internet connected wearable devices using the recognized standards of AES and SHA - which perform two way authentication.

SECURITY

- Standard internet encryption protocols like SSL and TLS are too computationally intensive for wearable devices.
- The protocol was a two stage one - the first stage being an authentication scheme based on the EAP framework and the second being encrypted data communication.
- The server and client exchange a 128 bit authentication key in the first stage - along with a 64 bit encryption key.
- The network transport protocol was UDP. This was followed by encryption of data using the AES-128 protocol.
- The packet fields of the data were a header, timestamp, data length, checksum and lastly data.

SECURITY

- The authentication protocol relies on randomly generated numbers called nonces - each 24 bytes long.
- The first step is client identity verification. The server initiates this by sending a nonce to the client. The client then performs a predefined hash function and replies.
- The server then computes itself using the hash function and compares the two for authentication. This process is then performed in reverse for server verification.
- Encryption is then done using the AES-128 protocol since it is standard and readily compatible with the microcontroller chosen.

COMPUTATIONAL OFFLOADING & DUST

SPECIAL OFFLOADING ALGORITHMS MUST BE DEVELOPED FOR DEVICES IN WBANS

DUST IS A LIGHTWEIGHT DEVICE TO DEVICE OFFLOADING ALGORITHM WHICH SPECIALIZES IN DEALING WITH HEAVY OR REAL TIME OPERATIONS

ITS TASK QUEUE HAS A MAXIMUM LENGTH OF 30 AND FOLLOWS A FIRST COME FIRST SERVE BASIS & LIMITS TASKS PER APPLICATION.

TWO TASK DISSEMINATION ALGORITHMS- THE GLOBAL OPTIMIZATION & GREEDY SOLUTIONS.

COMPUTATIONAL OFFLOADING & DUST

THE GLOBAL OPTIMIZATION SOLUTION IS FOR FEW TAKS AS IT VARIES EXPONENTIALLY WITH IT.

IN THE GREEDY METHOD, THE SCHEDULER RUNS AN EVALUATION FUNCTION TO BEST DECIDE WHICH TASKS CAN BE OPTIMALLY OFFLOADED.

THE RECOVERY HANDLER DEALS QUICKLY WITH EXCEPTIONS THAT ARISE DURING THE OFFLOADING PROCESS

DUST CONSTRAINS THE NUMBER OF HOPS FOR OFFLOADING TO ONE

PORTABILITY & SPINE2

- The next step in wearable computing is the development of wireless body sensor networks (WBSN).
- First option while programming these devices – low level language specific to hardware – efficient but not portable.
- Second option, use automatic code generation – convert high level to low level. But conversion difficult.
- SPINE2 abstracts platform specific hardware requirements and low-level communication protocols into a high level language, it ensures portability and extensibility to any type of wearable device.
- Defines tasks which are atomic units- sensor reading, message transmission.
- Allows you to deal with the big picture with a task oriented structure that allows you to offload various tasks to various sensors
- You have a main coordinator and other nodes are wearables.

PORTABILITY & SPINE2

- Tasks are defined by the attributes input, output and parameters
- SPINE2 manager which is responsible for initializing the system, managing those modules which control access to resources such as memory, sensors etc. and high level bidirectional communication with the coordinator
- SPINE2 abstracts platform specific hardware requirements and low-level communication protocols into a high level language, it ensures portability and extensibility to any type of wearable device.
- SPINE2 Coordinator deploys a GUI that uses API's to control nodes, manage and deploy tasks and gather preprocessed data from specific nodes.
- When an application is registered with it, it will also show the user new nodes in the network and any network errors