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IoT in healthcare

Presentations for the Bielefeld University course »Modern Data Science Technologies in Healthcare«

1. Alexander Stiebing: „A general overview“
2. **Kyuri Kim: „IoT Data and Data Processing in Healthcare“**
3. Bebeta Hoxha: „Data Security and Privacy in IoT“

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Cloud IoT integration for healthcare systems

IoT Applications in healthcare

- generate **high volume of data**
- have constrained **storage space**
- suffers from **constrained power, limited bandwidth**

Data to mainframe computers

- Time consuming
- Not economical
- Possibility of entire system down

Distributed computing

- Cost for node replacement
- Backup power cost

Cloud IoT integration

Cloud IoT integration for healthcare systems

- Cloud offers robust, flexible, and agile platform for IoT healthcare application.
- Cloud IoT implementation includes

  - virtually unlimited storage space,

  - computational power for IoT nodes,

  - cross platform support for applications,

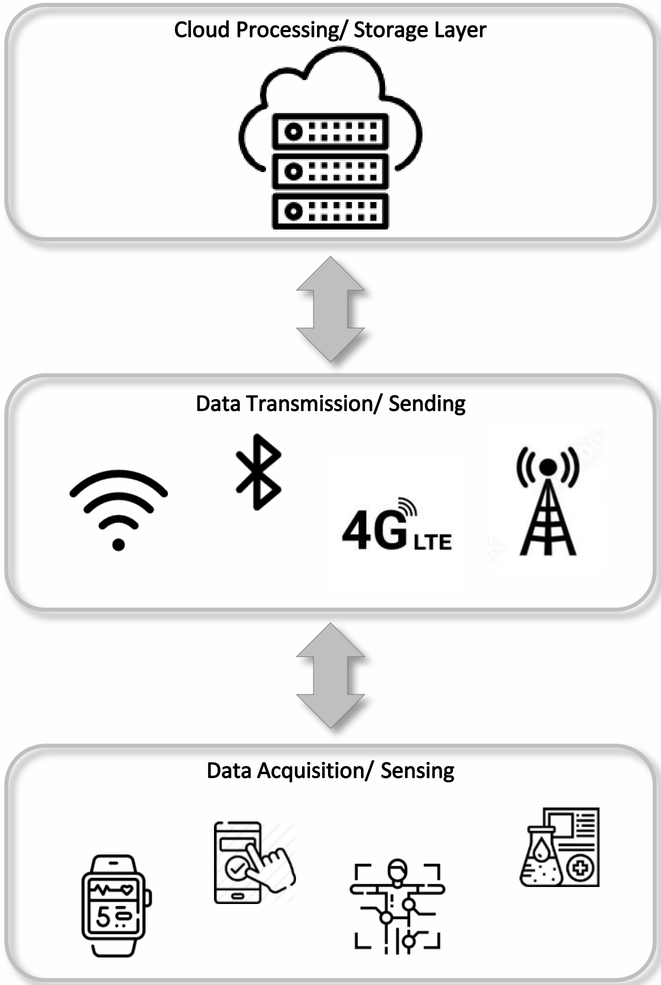
  - efficient resource management.
- With Cloud IoT platform, the users are enable to use virtual resources dispensed like a service on subscription or “pay-per-use” basis.

Cloud IoT integration for healthcare systems

- **With Cloud IoT architecture,** Cloud layer connects underlying IoT sensor objects and end user services at the access layer.
- The main features of the integration of Cloud IoT framework for healthcare are:

Storage	Computing capabilities	Communication
(IoT)A Large Volume of Data ↕ (Cloud)Virtually Unlimited Storage	(IoT)limited Processing Capacity ↕ (Cloud)Virtually Infinite Processing Power	(IoT) permission to data sharing, Communication among sensors ↕ (Cloud) interconnecting applications

IoT in Healthcare Architecture Framework



3 layers architecture carrying varied functions with

1) Data Acquisition or Sensing
2) Data Transmission or Sending
3) Cloud Processing or Storage

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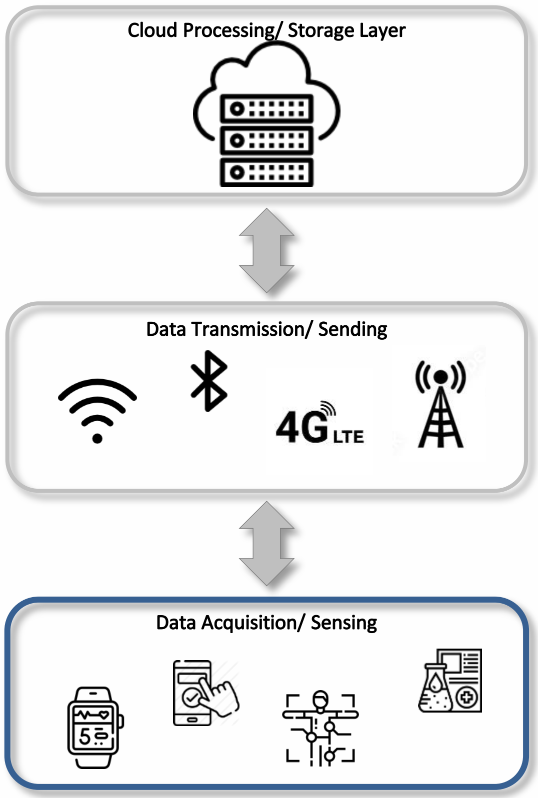
IoT in Healthcare Architecture framework

- Data Acquisition/Sensing Layer

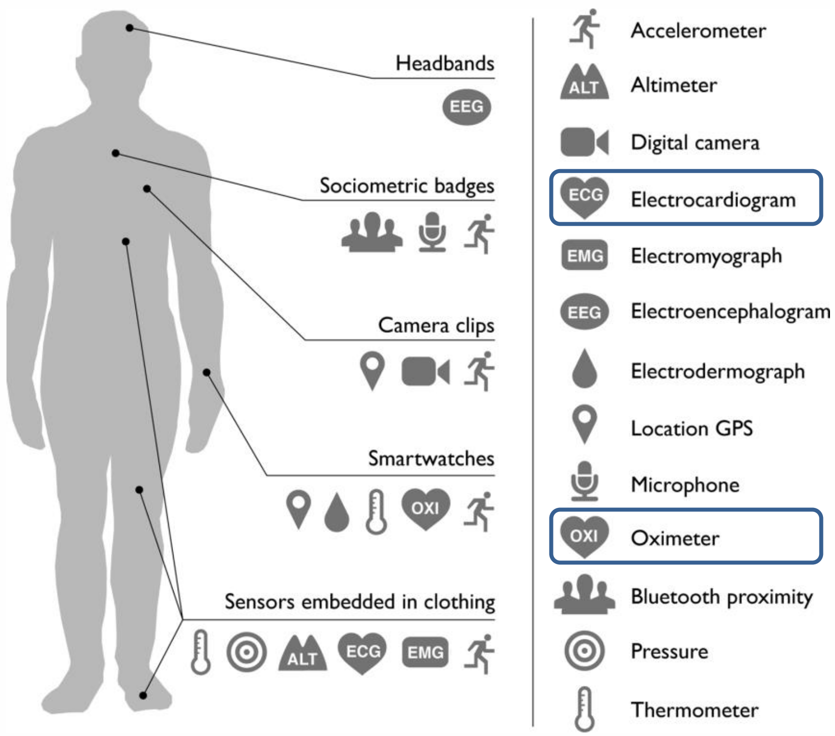


- Collect and record health data of patients
- Recorded parameters vary across applications
- Most of applications with accelerometers and gyroscopic sensors

- To design the sensing layer,
  - The cost and size of setting up the network
  - Energy utilization in sensing
  - Data transmission capabilities of the sensors.

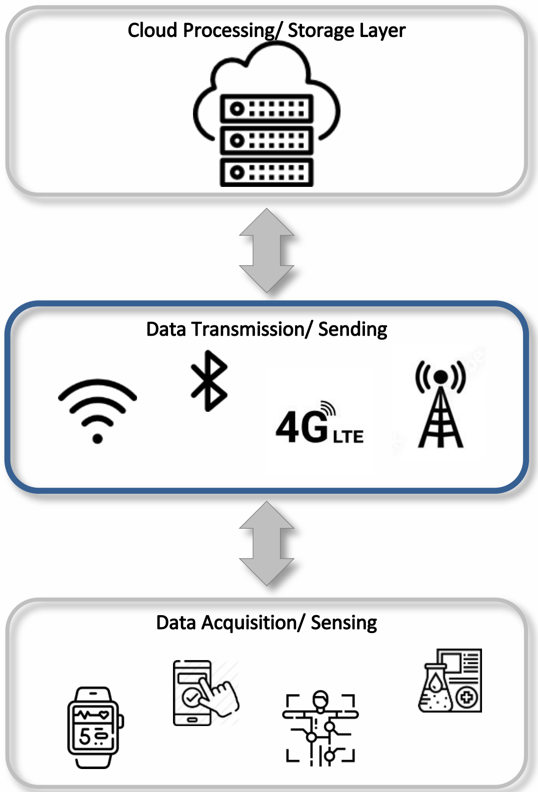
IoT in Healthcare Architecture framework

- Data Acquisition/Sensing Layer



IoT in Healthcare Architecture framework

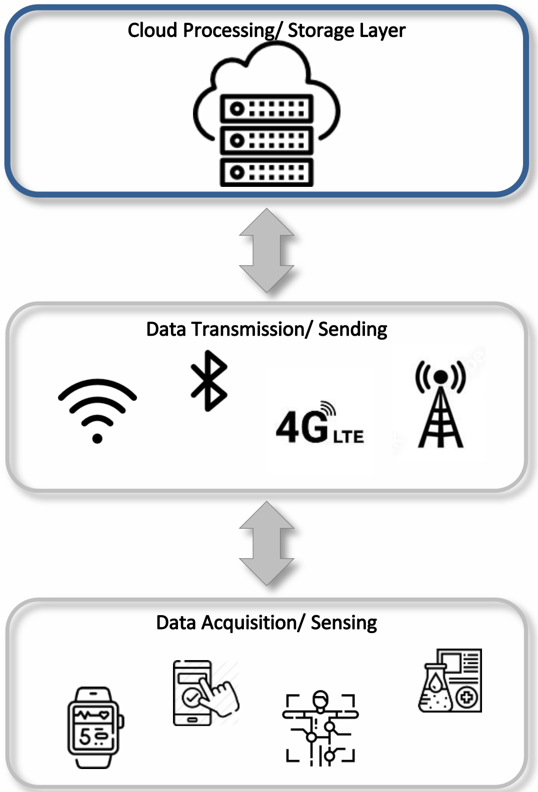
- Data Transmission/Sending layer



- This layer provides the interface to communicate and share the data.
- The sending layer is responsible for transferring patient data securely to a remote data center
- The data transmission involves local and global communication
- For monitoring and scanning environment, wireless data transmission standards are employed

IoT in Healthcare Architecture framework

- Cloud Processing/Storing layer

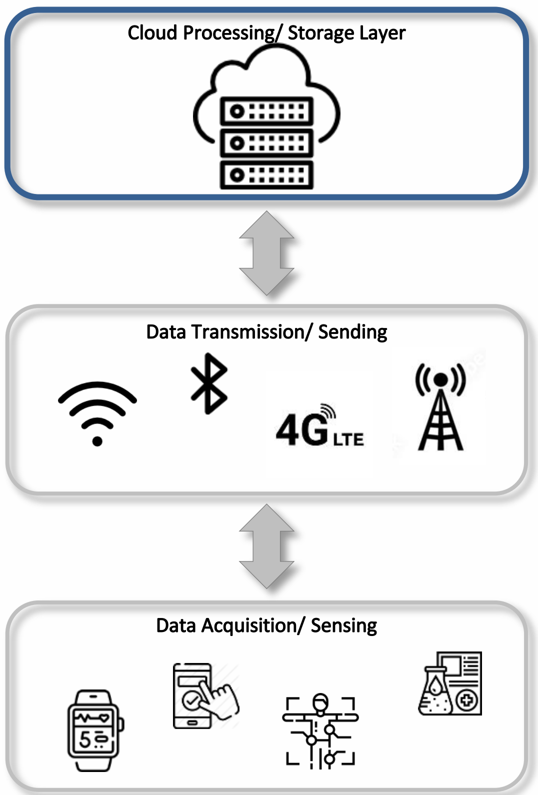


- The Cloud IoT systems interconnect diverse objects that generate large volumes of data.
- The healthcare data aggregated from the sensing layer is used for further analysis.

- Cloud provides an efficient platform for archiving a patient's **medical data for long-term storage.**
- It is providing assistance to medical professionals for better diagnosis.
- Cloud provides **data analytics** that use sensor data for better diagnosis and prediction of diseases.

IoT in Healthcare Architecture framework

- Cloud Processing/Storing layer



- Cloud also offers **data visualization** that presents a large amount of data from sensors for physicians.
- The complexity to manage and maintain healthcare data has been eased with the cloud technology.

aws

thingworx

Google Cloud

OPENIoT

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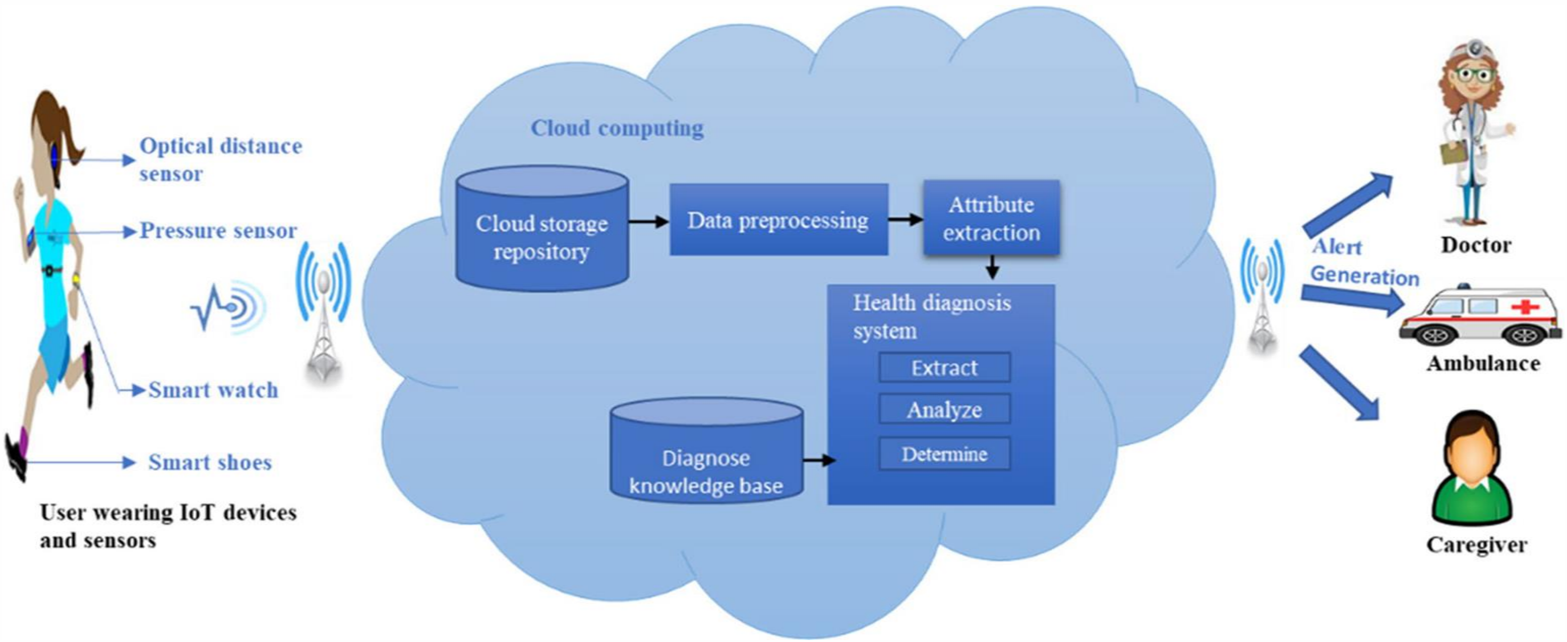
Cloud computing



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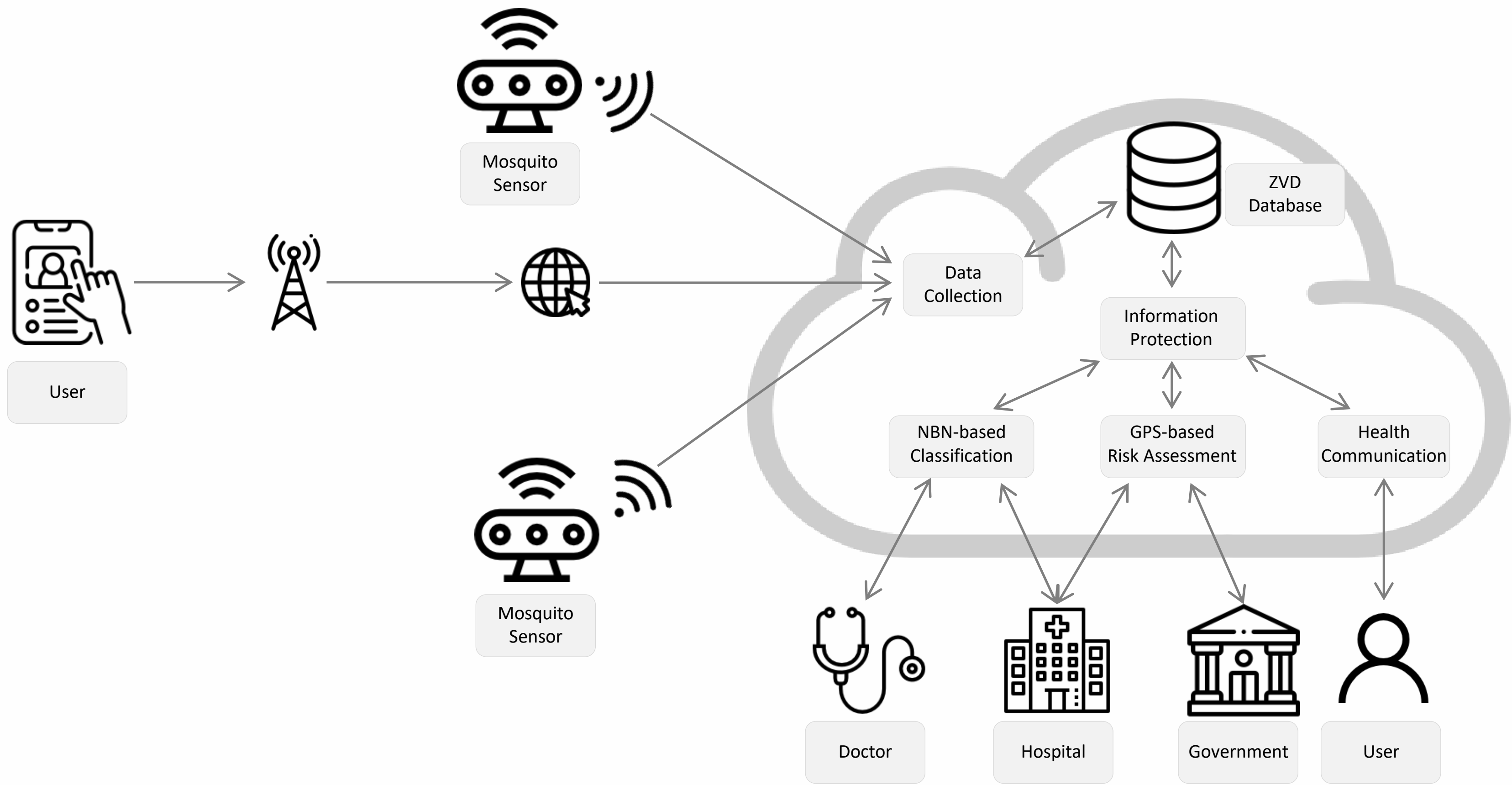
Cloud-based Healthcare system in IoT - Application



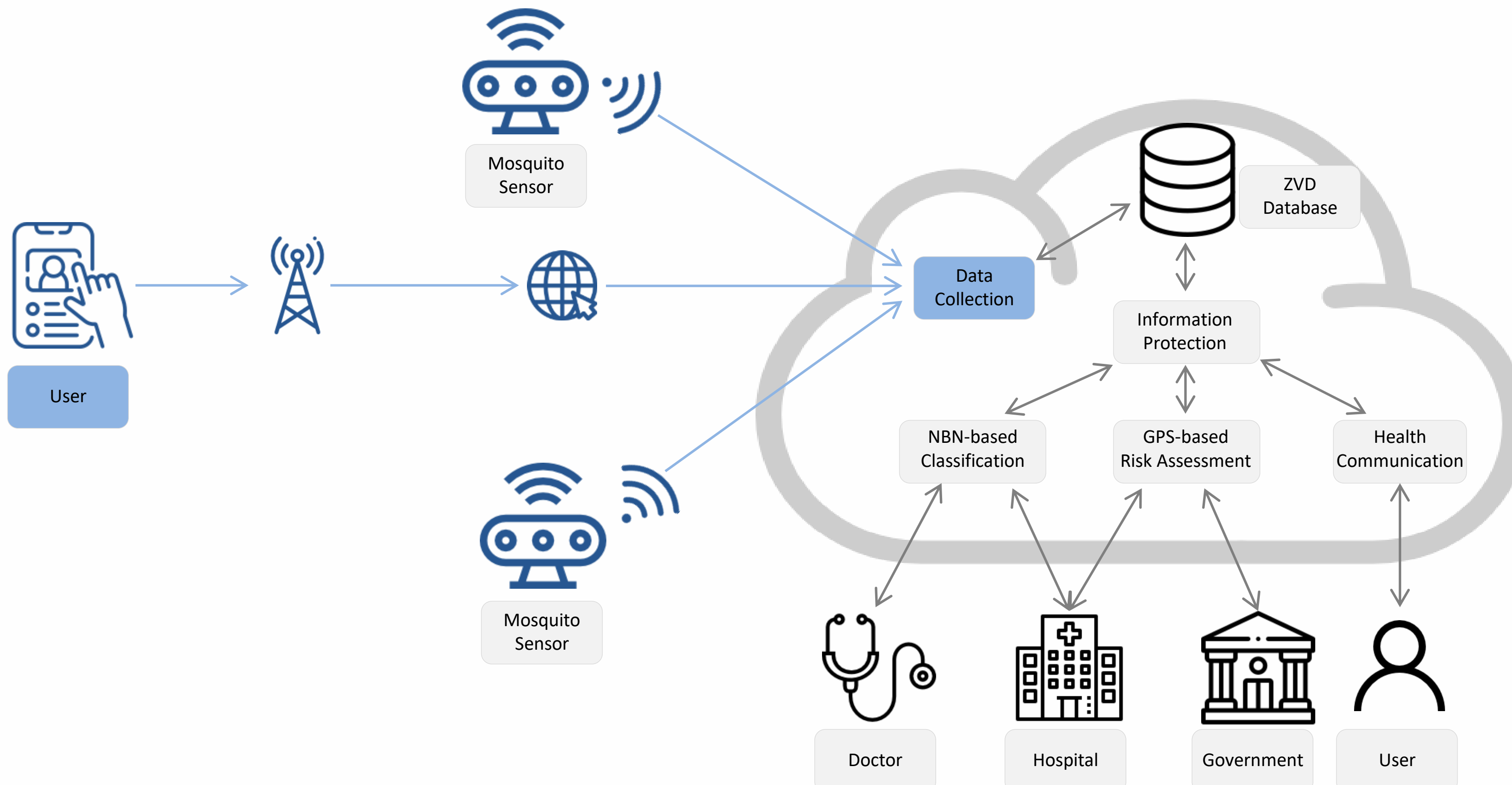
- The cloud-based system is to prevent and control the spread of Zika virus disease using integration of mobile phones and IoT.

Cloud-based Healthcare system in IoT - Application

- Data Collection
- NBN-Based Classification
- GPS-Based Risk Assessment
- Health Communication Component
- Operating Assumptions
- Performance Analysis

Cloud-based Healthcare system in IoT - Application

- Data Collection



- Personal information and information about Zika virus disease symptoms of users are collected.

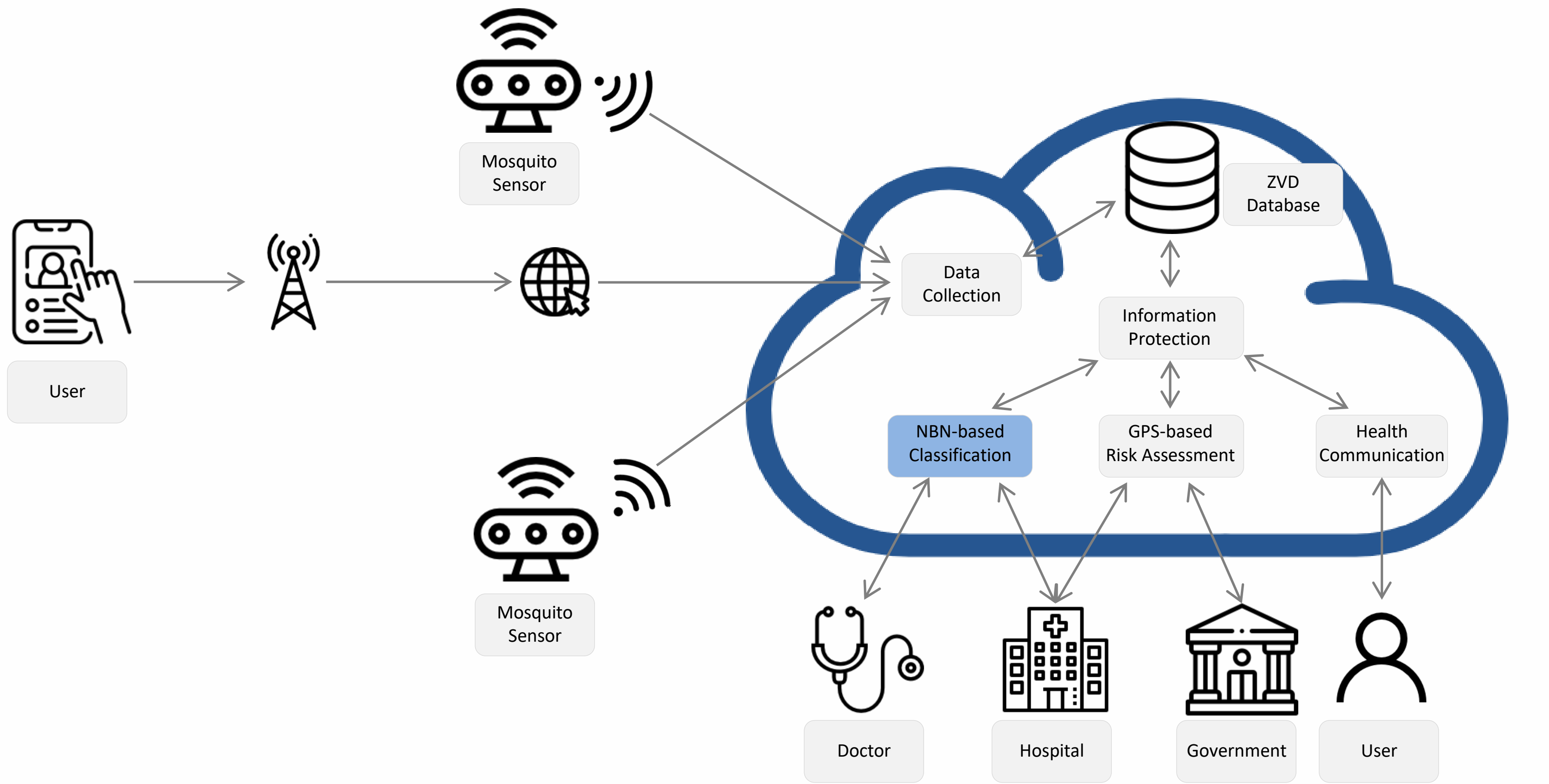
Cloud-based Healthcare system in IoT - Application

- Data Collection

S.No	Attributes	Description
(a) Personal attributes		
1.	RNO	Reference number of a user
2.	Name	Name of user
3.	Age	Age of user (in years)
4.	Gender	Male or female (M/F)
5.	Residential address	Permanent address of user
6.	Office address	Office address of user (if any)
7.	Mobile number	Mobile number of a user
8.	FMN	Mobile number of a family member
S.No	Attributes	Response
(b) Health related attributes		
1.	Fever	(Y/N)
2.	Skin rashes	(Y/N)
3.	Conjunctivitis	(Y/N)
4.	Joint pain	(Y/N)
5.	Muscle pain	(Y/N)
6.	Headache	(Y/N)
7.	Exposure to risk area	(Y/N)
S.No	Attribute	Description
(c) Environment related attributes		
1.	Mosquito-dense site location	GPS location of mosquito-dense site
2.	Mosquito density	Number of mosquitoes counted by sensor
3.	Breeding site location	GPS location of breeding site
4.	Temperature	Temperature around standing water
5.	Humidity	Humidity
6.	Carbon dioxide (*Co2*)	Value of carbon dioxide
7.	Site image	Images of mosquito-dense or breeding sites

- The table shows
  - The attributes of **personal information**
  - Zika Virus disease **symptoms**,
  - The **environmental** attributes of
- mosquito-dense sites and breeding sites is transmitted to the cloud and stored in the database for further processing.

Cloud-based Healthcare system in IoT - Application
- NBN-Based Classification



- Based on the user symptoms-response for the health attributes,
the user is classified into infected or uninfected using a Naïve Bayesian Network algorithm

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Cloud-based Healthcare system in IoT - Application

- NBN-Based Classification

- NBN classifier a powerful probabilistic model for solving classification problems
- Let C be a class variable representing two categories **Uninfected (U) and Infected (I)** based on a vector of **symptoms Si** = (F, SR, C, JP, MP, H, ERA)
- To classify a user xi ∈ X, i = 1,2,...,n into infected (I) or uninfected (U) using symptoms Si, the probability of each class is computed using the Bayes' rule as given below:

$$P(C = U|S_i) = \frac{P(U)P(S_i|U)}{P(S_i)}$$
$$P(C = I|S_i) = \frac{P(I)P(S_i|I)}{P(S_i)}$$

- P(C = U|Si) represents the probability of any user as uninfected (U) based on symptom Si
- P(C = I|Si) is the probability of any user as infected (I) with ZikaV based on symptom Si
- P(U), and P(I) are the probability of having ZikaV infection and P(Si) is the probability of having a symptom Si
- **The class with a higher probability will be the category of the user**

Cloud-based Healthcare system in IoT - Application

- NBN-Based Classification

Algorithm 1: Evaluate the Category of the Patient Using NBN

Input ZVD symptoms parameters and RN of a user.
Output Revised category of a user based on symptoms.
Read the symptoms data and RN of the user;
if RN is already present **then**
Update the database with newly entered data;
else
Create a new record with RN of the patient and store the primary symptoms;
end if
Apply the Matlab algorithm *NaiveBayes.fit(training, class)* with appropriate parameters:
(a) Type of distribution such as Gaussian, Kernel, etc.
(b) The prior probabilities for the classes such as empirical, uniform, vector, and structure.
(c) The bandwidth of the kernel smoothing window.
(d) The regions where the density can be applied.
if revised category = old category **then**
Save the results and update the database record;
else
Save the classification results in the database;
Update the category of the patient;
Send an alert message to user, doctor, and nearby hospital;
end if

- This Algorithm for the category of the user using NBN classification algorithm in Matlab.
- In this algorithm, the vital symptoms entered by the users from their respective mobile phones are used along with their reference numbers.

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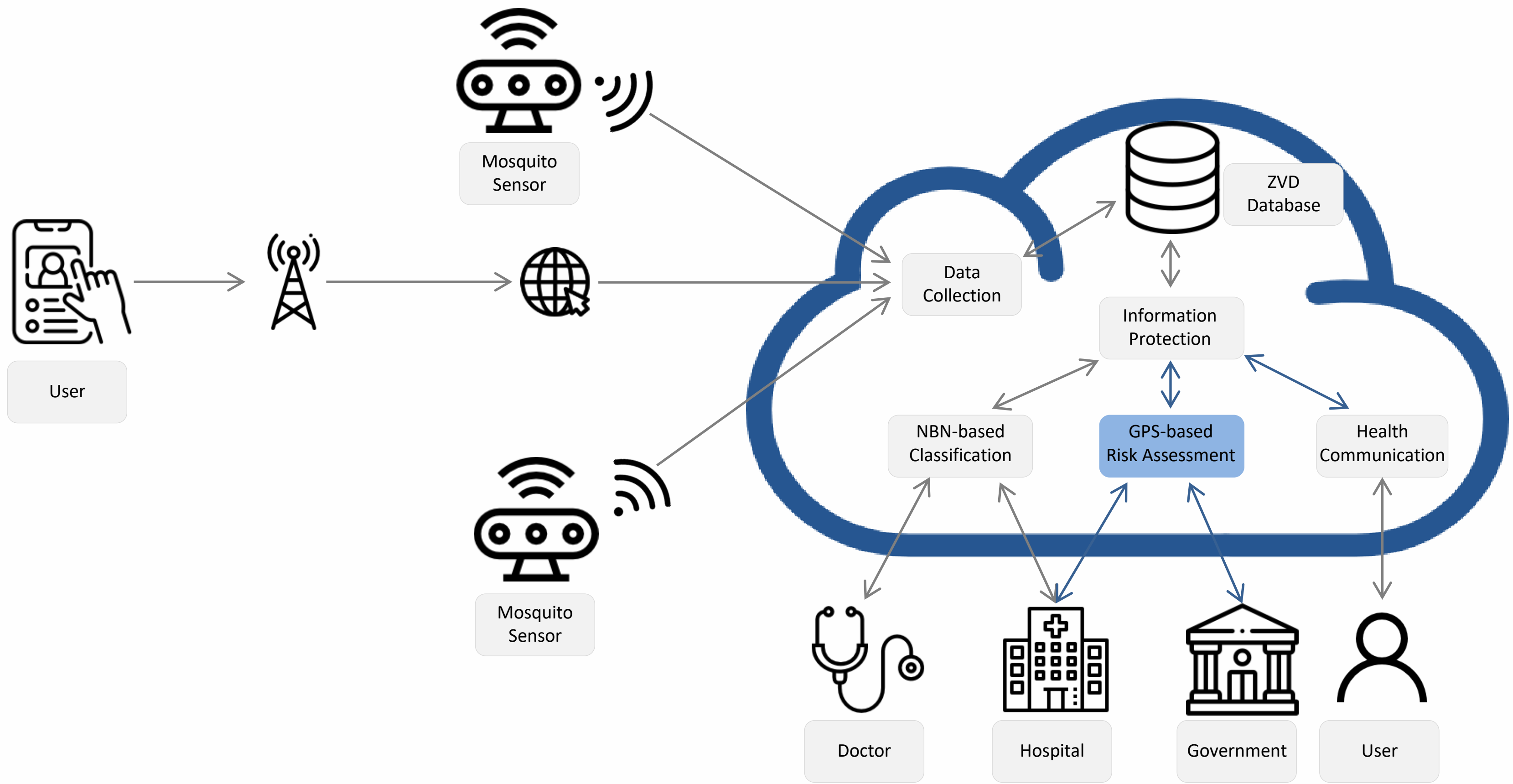
Cloud-based Healthcare system in IoT - Application

- GPS-Based Risk Assessment



- **The geographic location** of infected users, breeding sites and mosquito dense areas can be used to **identify and separate the risk-prone areas**

Cloud-based Healthcare system in IoT - Application

- GPS-Based Risk Assessment

- **The geographic location** of infected users, breeding sites and mosquito dense areas can be used to **identify and separate the risk-prone areas**
- Continuously data is capturing from users as well as mosquito sensors so that any newly infected user or risk site is **automatically identified.**
- Google Maps Web service is used to **visualize** the spread of infection, high mosquito-dense sites, and breeding sites using their GPS locations.
- The locations of new infected users and sites are automatically detected by the system and the **Google map is updated accordingly**.
- **The user has diverted to the safer path by using an appropriate re-routing.**

Cloud-based Healthcare system in IoT - Application

- GPS-Based Risk Assessment

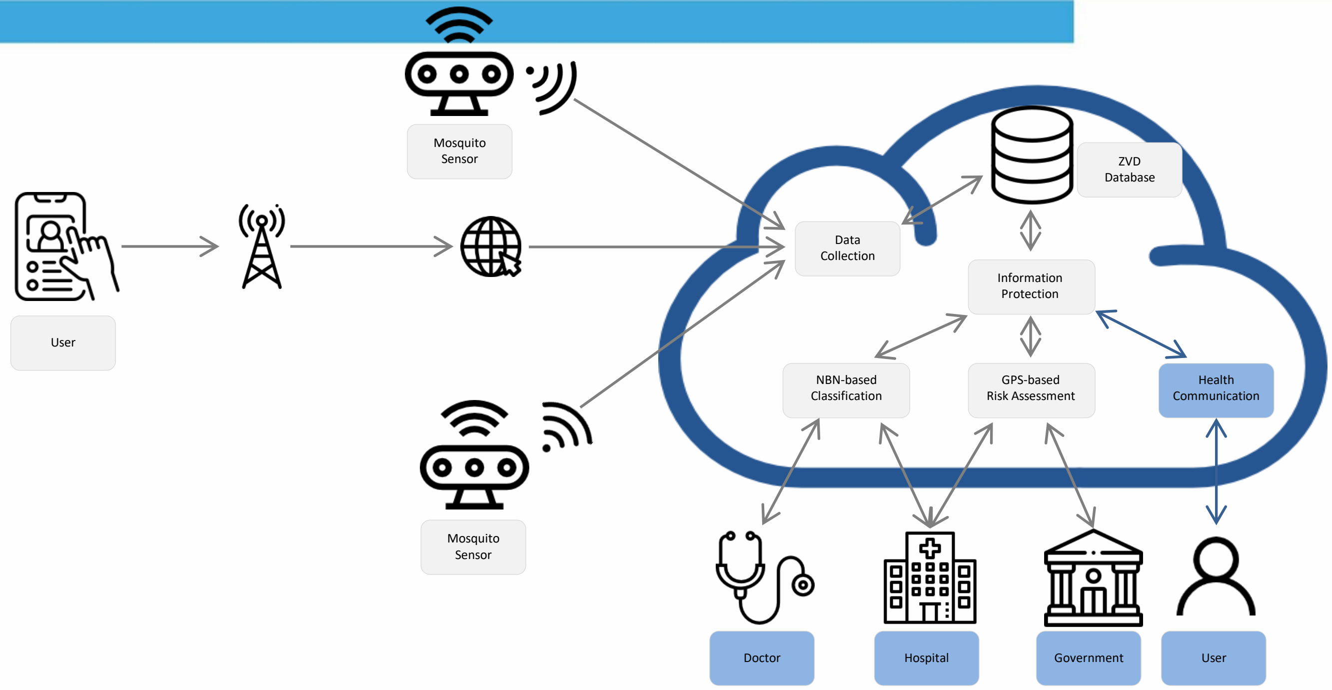
Original path

re-routing

Safer path

Cloud-based Healthcare system in IoT - Application

- Health Communication



- System generated alert messages related to

(a) preventing the growth of mosquitoes, and

(b) preventing the bites of mosquitoes are sent to the infected or uninfected users through SMS or e-mail to improve the user’s health

- Alert messages are also sent to nearby hospitals or healthcare agencies depending upon the GPS location of the patient’s mobile phone.

Cloud-based Healthcare system in IoT - Application

- Performance Analysis

	TP rate	FP rate	Precision	Recall	F-Measure	ROC area	Category
	0.926	0.027	0.899	0.802	0.895	0.972	I
	0.856	0.076	0.886	0.833	0.808	0.983	U
Weighted Avg	0.891	0.052	0.892	0.817	0.851	0.977	

- In the research, the performance is evaluated by creating Bayesian Network using the data of 50,000 users in R.
- The Naive Bayesian algorithm produces high TP rate of 0.891 and low FP rate of 0.052.
- And higher values of precision and recall, which are 0.892 and 0.817, respectively.

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Fog Computing

Cloud Computing

Fog Computing

- Fog is the extension of cloud computing that consists of multiple edge nodes directly connected to physical devices.
- To meet the growing demand for IoT solutions, fog computing comes into action on par with cloud computing.

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Fog Computing

- Cloud vs. fog concepts are very similar to each other
- But still, there is a difference between cloud and fog computing on some parameters

	Cloud	Fog
Architecture	Centralized	Distributed
Communication with devices	From a distance	Directly from the edge
Data Processing	Far from the source of information	Clos to the source of information
Computing Capabilities	Higher	Lower
Number of Nodes	Few	Very large
Analysis	Long-term	Short-term
Latency	High	Low
Connectivity	Internet	Various Protocols and Standards
Security	Lower	Higher

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Sources

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