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Use of Body Area Network in Woman Health Monitoring System

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Abstract: *The paper presents a remote monitoring system for women using wearable devices like TOCO pressure sensor, accelerometer or ultrasound transducer. The wearable devices along with wireless sensor networks form body area network. The proposed system named woman health monitoring system (WHMS) consists of patient side BAN and server side module for storing monitored data, detecting abnormal change in vital parameters and generating alert for physician or gynecologist. The advantage of proposed system is woman's health will be monitored without visiting to physician or gynecologist. Though the lady is travelling in crowded train, or she is working under stress, fetus safety in case of pregnant woman as well as all aged lady's health is monitored using proposed system. This system is also useful for expecting lady to follow her pregnancy status as well as fetus growth using wearable sensors. The proposed system can be useful for any age woman to follow her health status on her own and making her more health conscious.*
Keywords: *remote monitoring system, body area network, WHMS, health status, fetus growth and safety*

I. Introduction

Ubiquitous Healthcare provides healthcare services to remote users, at any time, at any location with any network. It is possible by full support of personal area network, wireless sensor networks, wide area network, mobile phone network, local area network, wearable devices and smartphone equipped with multiple utilities. In u-healthcare, monitoring of body-parameters is essential which is done by wearable devices. Multiple wearable devices are used for monitoring form body area networks. Body area network consists of mobile base unit which collects vital physiological parameters from wearable devices and transmits them to Healthcare service provider through wireless sensor network[1][2].

Application of u-Healthcare using body area network for woman health parameters monitoring is proposed in this research paper. Woman health monitoring is possible through accelerometer, cardiotocography and electronic fetal monitor. This research paper proposes the multi-agent autonomic woman health monitoring system (WHMS) with the support of body Area Network and wearable devices which can record BP, sugar level, stress level, fetus heartbeats as well as uterine contraction in case of expecting lady on daily or weekly basis remotely. The lady doesn't have to visit hospital frequently to check fetus growth. The proposed system is also useful in the scenario when the pregnant woman is traveling into crowded public place and safety of mother is a critical issue. The wearable device can monitor fetus and mother's body parameters during travelling also. If anything goes wrong the wearable device will communicate to caretakers through mobile app. The proposed system also generates alarm for workingwoman to remind her about intake of food or water if she engrossed in work. The gynecologist or physician can retrieve and monitor the recorded parameters. If the doctor observes any abnormal pattern in parameters, he may ask the concerned lady to visit hospital immediately. In emergency situations,the doctor can identify the problem and think of solution till the lady reaches the hospital [3][4].
This paper describes different networks for proposed multi-agent autonomic woman health monitoring system (WHMS). Section II explores concept of u- health care concept of BAN, case based reasoning and functional view of WHMS. Section III proposes design of patient server architecture and formation of knowledge base. Section IV explains implementation details of mentioned architecture. Section 5 concludes the research work.

II. Literature Review:

1.1 U-Healthcare:

As stated by Yvette E. Gelogo and Haeng-Kon Kim in [5], u-healthcare monitoring system is an integration of wearable monitoring device and android smartphone Apps. Ubiquitous healthcare system means the environment which provides the medical treatment to needy person regardless of location and time as well as it helps physicians to give better treatment because they get the monitored data about the patient.U-Healthcare strongly depends on different types of networks like personal area network, wireless sensor network for data collection from body sensors and dispatching to and from internet. U-Healthcare also requires smartphone equipped with sensors and data ports for sensing temperature, humidity, pressure and movements the smart phones will also get data feed from external medical sensors like ToCo senses. Following services can be implemented with u-Healthcare via smartphone

i) Location tracking service
ii) behavioral monitor monitoring
iii) sleep analysis
iv) vital sign monitoring
v) Pedometer and fall detection[1][5]

1.2 Body Area Network:

When multiple wearable devices are connected with a body for monitoring different parameters, they form Healthcare body area network. E.g. Gyroscope and magnetometer can be integrated with smartphone to identify sleep patterns for the patients who have sleep problem the gyroscope and accelerometer are used to identify fall detection of remote patient. The concept of body area network came from IBM [6] and defined in Wireless World Research Forums book of Visions as "a collection of intercommunicating devices which are worn on the body providing an integrated set of personalized services to the user". [7]

The mobile base unit is the gateway of healthcare body area network which collects vital sensor parameters from wearable device and transmits to backend systems for analysis. Mobile base unit implements intra-BAN communication among wearable devices with wireless networks like Bluetooth and extra-BAN communication through GPRS and UMTS. The mobile based unit on mobile devices works in J2ME environment. As shown in fig. 1 wearable devices and actuators are connected through intra-BAN and they use mobile based unit to communicate with the backend of Healthcare system. The wearable device in the BAN is responsible for monitored data collection. The Healthcare wearable device has a power supply and facilities for amplification, conditioning, digitization help these devices are self-supporting[2][8].

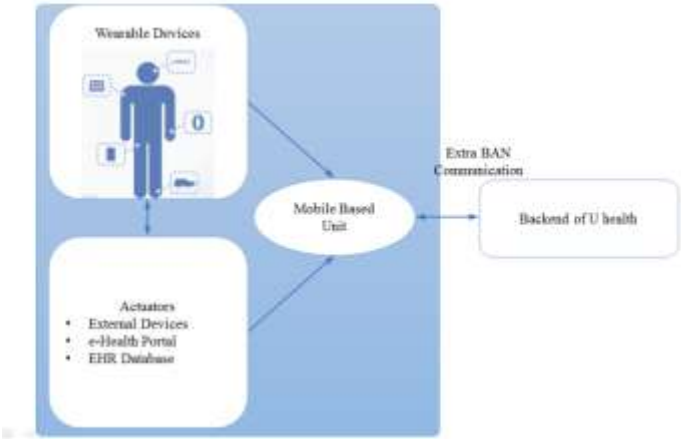

Fig 1: BAN Architecture

1.3 MAPE-K loop with case base reasoning:

CBR resembles human reasoning where symptoms represent problem, diagnosis and treatment represent solution. CBR collects cases where each case consists of a problem, solution and its result. The CBR cycle is as shown in figure 2. The CBR cycle consists of 4 steps which are performed on case base. i) The Retrieve phase selects one or several similar cases from the case base. ii) In Reuse phase, historical similar cases are decided to be implemented. iii) In the revise phase, the matched solution is verified according to environment and corrected or improved if required. iv) Finally, the retain phase takes the feedback from the revise phase and updates the case base. Thus, CBR either converts new cases in learned cases which will be available for future decisions or finds similar historical case and reuses it[9].

Fig 3 describes MAPE-k Cycle. Kephert and Chess [11] designed the architecture for self-adaptive system with autonomic element. The autonomic element consists of managed element and autonomic manager. The managed element is adaptable software and autonomic manager is adaptation engine to execute MAPE-k engine. MAPE-k engine consists of monitor to sense the managed process, its context and stores relevant events in knowledge base for further reference. The analyzer compares scenarios with patterns in knowledge base to diagnose symptoms, the new symptoms can be stored in knowledge base. The planner interprets the symptoms and designs a plan to execute change in managed process. The executor executes plans to adapt actual system and obtain the desired output. The sensors and effectors collaborate data and control among autonomic elements. MAPE-k cycle is called feedback-loop used for engineering self-adaptive software system. The feedback loop ensures that the adaptation engine helps the adaptable software to respond change in requirements from the environment [10]. Feedback loop helps self-adaptive software system approach from analysis design till implementation.

Case base reasoning can be incorporated with MAPE-k cycle for adaptivity. As shown in fig 2, case base reasoning consists of case base which represents all cases learnt by the system. The case base can represent domain knowledge or ontology for the system. Using case base, the analyzer of MAPE-k loop can analyze the scenarios and if new scenario occurs then it will be compared with existing scenarios. The scenario is converted into case and case base is updated if completely new scenario is identified i.e. retain process is followed. The planner plans the new scenario with the reference of new case. The implementation of MAPE-k cycle will be easy with case base reasoning.

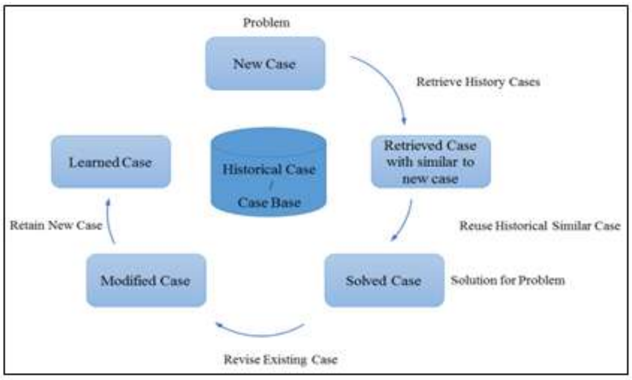

Fig 2: Case Base Reasoning Cycle

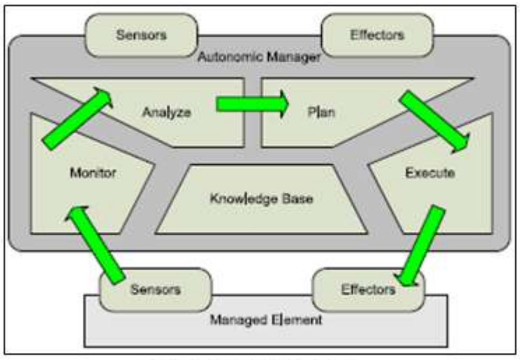

Fig 3: MAPE-k Cycle
Source: Model-Driven Engineering of Adaptation Engines for Self-Adaptive Software: Executable

1.4 Woman Health Monitoring System:

The main goal of Woman Health Monitoring System is to design monitoring system for woman of any age. Following types of monitoring is possible with WHMS: i) Ovulation monitoring if the woman wants to conceive and she is under treatment of obstetrician ii) Fetus monitoring if the woman is pregnant iii) Menopause monitoring if the woman is facing hormonal imbalance problem iv) Regular body parameters like pulse rate, heart rate, blood-sugar level, body temperature, workout monitoring etc. Consider the WHMS as shown in figure 4. The woman has to wear appropriate wearable device depending on nature of monitoring. The device is connected with mobile app where monitored raw data will be sent for storage as well as further diagnosis. If the monitoring data shows abnormal changes in parameters, the system generates alerts for physician and home caretaker as well as case base reasoning is implemented and solution is searched for the support of physician. Here, the system depends on two databases: EHR database which will be governed by government and records important medical history, the second database is patient's recent data captured by wearable devices. The app includes health service provider which will diagnose change in body parameters. The important conclusion body parameters pattern can be updated in EHR if necessary. This data will be made available for different health services like i) Diagnosis and treatment by concerned physician ii) The possibility of emergency can be detected by stored pattern. If emergency occurs the caretaker can bring the patient to hospital as fast as possible through ambulance tracking system of WHMS. iii) The diagnosis monitored data, patient's medical history can be used for further medical inventions. If some new scenario is detected during technique, case base is updated as learned case [15][16][17][18].

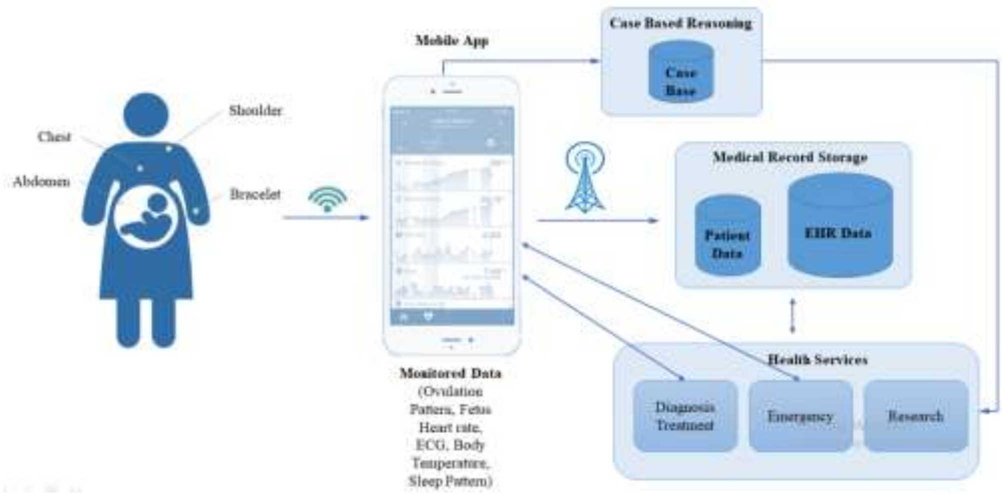

Fig. 4: Functional View of WHMS

II. Proposed Research Work:

2.1 Proposed patient-server architecture:

The proposed architecture for WHMS has two parts as patient side and server side. Fig 5 represents patient side modules. At the patient side the TOCO pressure sensor and CTG sensor which forms body area network are connected to mobile phone through the Bluetooth interface. The data is sent from mobile to server.

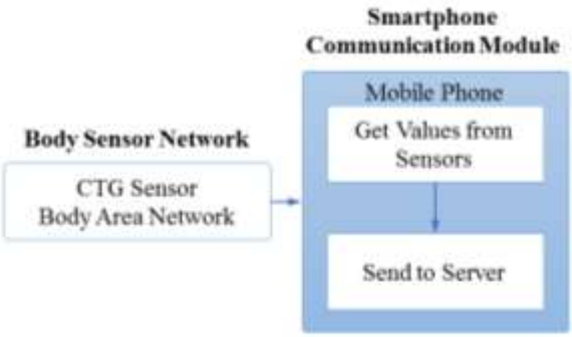

Fig 5: Patient Side MAA-FMS

The patient side consists of i) BSN module: multiple sensors form body sensor network module. They will get the monitor data and form personal health information such as Heartbeat blood sugar level blood pressure etc. ii) Smartphone communication module: data transmitted from body sensor network will be gathered by Smartphone and it will be transmitted to server-side application.

The server-side architecture consists of three layers: communication layer, processing layer and alert layer. Fig 6 describes these three modules. i) Communication layer: Mobile phone of the patient is registered and authenticated, the patient profile is created in this layer. ii) In processing layer, the patient monitored data will be analyzed by case-based reasoning module. Circadian Activity Rhythm (CAR) is analyzedbased on the pattern stored in knowledge base[14]. If there is a drastic deviation in CAR and monitored data then alert layer will generate alert for gynecologist and care taker. The gynecologist will take emergency action if needed. If analysis of pattern from k-based shows small deviation then report will be generated for the gynecologist.

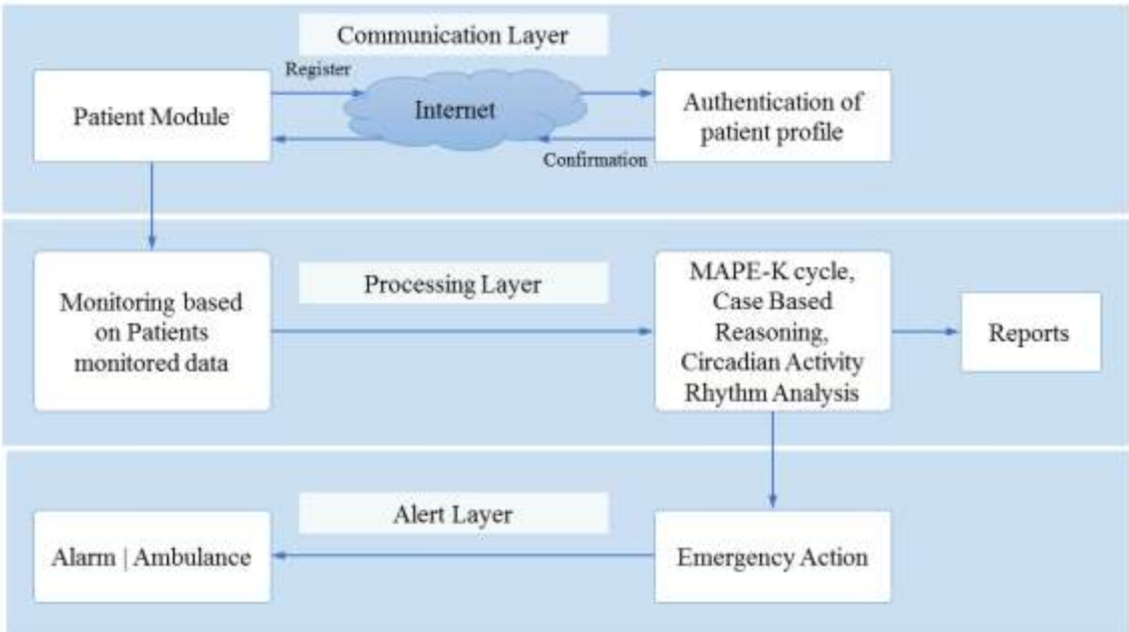

Fig 6: Server Side WHMS

3.2 Formation of K-Base:

To identify emergency, processing layer executes MAPE-k cycle and case base reasoning based on monitored data. Hence MAPE-K cycle can identify new scenario and update k-base. The figure7 shows 2 ways to create and update knowledge base for the proposed system.

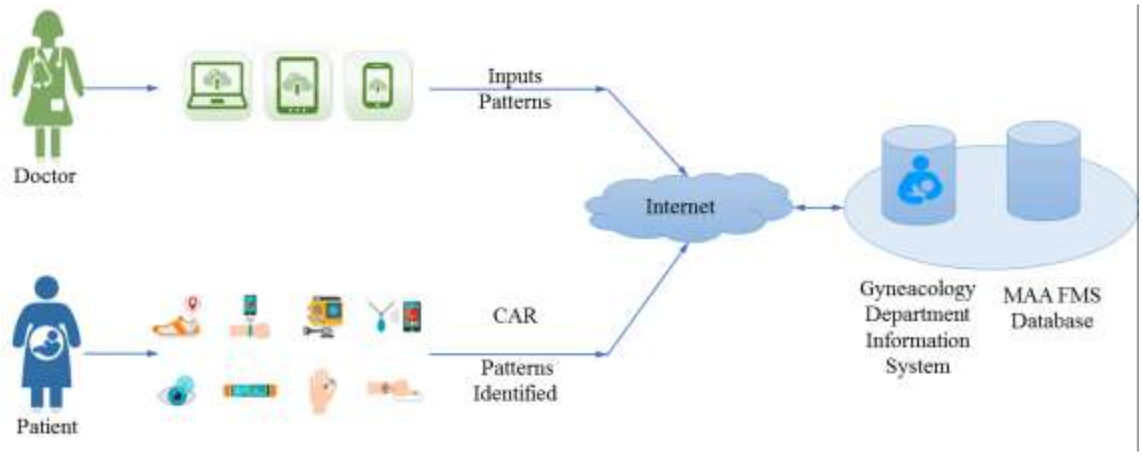

Fig 7: Formation of knowledge base with two methods

First method to create and update k-base is doctor enters standard data or standard patterns in knowledge base through smartphone or laptop.

The second method to update k-base is to through BAN. When patient is monitored,the CAR patterns are identified and stored into a database . Circadian activity rhythm is the standard behavioral pattern or physiological pattern which can be executed in 24 hours cycle[14]. During monitoring particular patient's data, the body sensor network module will collect data, through smartphone communication module, the data is sent to server. The data is stored in a database as well as analyzed by the system. The data is compared with standard Input patterns as well as CAR patterns.

Thus, the above research work represents patient server architecture for WHMS. It also describes formation of k-base to make the system autonomous.

III. Implementation

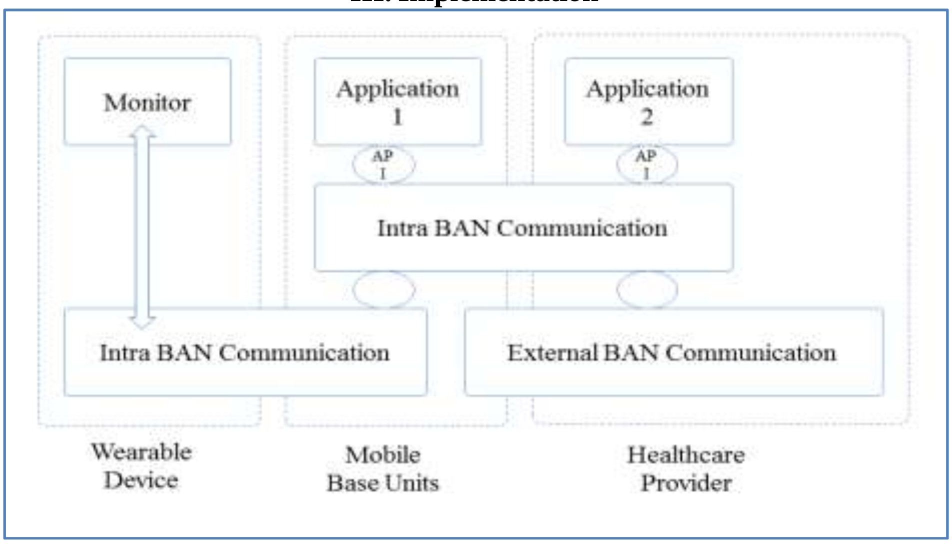

Fig 8: Implementation of WHMS

The figure 8 shows the implementation of WHMS with body area network, mobile base unit, and Healthcare provider. The dotted lines show the location of each application. For implementation purpose the system is divided into three parts: wearable devices, mobile base unit and Healthcare provider. Wearable device part is responsible for collecting data. Second part which is mobile based unit consists of set of applications which are responsible for storing data, providing health status of fetus like fetus heart rate and CTG and generation of alarms for expecting lady for intake of food or water. Mobile base unit is executed in the environment of a smartphone . Thus, mobile base unit can be used by patient or any medical uses like nurse or doctor. The nurse or doctor can check patient health status or prescription details on their mobile when a patient is in hospital. IntraBAN communication works for wearable devices and mobile base unit applications within the boundary of body area network e.g. Bluetooth or WiFi. Thus, IntraBANcovers wearable devices and mobile applications.

Set of said applications function remotely at the backend of WHMS. It can be called heart and brain of the system because it implements monitoring of data, analyzing scenarios, updating case base or k-base if new scenarios are identified, providing remote services to patients and generating alert etc. Some part of these applications may reside on gynecologist mobile or laptop to retrieve similar cases and updating existing ones. The extraBAN communication brings remote functionality for the application. It connects mobile base unit and Healthcare provider

WHMS service layer provides functionalities for the working of both sets of applications. The first type of applications is for direct interaction with system's users like patient, nurses to generate an alarm, to view prescriptions etc. These applications work on mobiles of these users. The second set of applications represent core functionality of WHMS of providing medical treatment or supporting in emergency situations. These applications mainly work on smartphone or laptops of Gynecologist or physician.

IV. Conclusion:

As a proposed system is implemented, WHMS represents actual system with GUI. The goal of the system is to monitor lady's body parameters like stress level, heart beats, fall detection, fetus heart rate and uterine contractions without affecting expecting lady's mobility and flexibility. The system generates CAR or CTG time to time which is cheaper and helps to monitor health status of a lady or the growth of fetus and vital signs of a mother as well as fetus. It also supports mother with small alert and alarm module. Another goal of the proposed work is to provide time to time information with diagnostic mechanism for detection of emergency. Thus, the proposed system offers easy monitoring and alarming support for patients as well as fast and accurate detection of emergency situations and taking decisions based on continuously monitored data for the gynecologist or any other medical practitioner. In the future, the system can be enhanced to locate patients' geographical location in case of emergency situations.

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