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# Implementation of web based biotelemetry applications on WiMAX networks

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ABSTRACT

In this world, health is the most important factor and subject in society and social life. Thus, this sector gets more importance to give better service and to use resources more efficiently under the health economy. In this paper, it is designed and conducted a web based biotelemetry application works on WiMAX. First; Patient Communication Node (PCN), Client Communication Node (CCN) and Administrative Communication Node (ACN) systems are designed. Then these systems are implemented on WiMAX networks. Finally proposed model is compared with other equivalents.



## 1. Introduction

In today's world, the most important element of society and social life is human. Politics, law, religion and many more social and scientific cases are all based on "Everything is for human" philosophy. The use of technology in the service of environmental and human beings are the core of this goal. With this idea, it is intended to make people physically and spiritually healthy, happy and live in prosperity. At this point, the human health appears to be one of the most important issues.

Medical networks has emerged as a result of the implementation of computer and communication technologies in health field. The most important function of medical networks is that provides remote controlling for doctors to observe their patients. This is called biotelemetry in the literature. There is a wide spectrum if it is looked at studies about biotelemetry and medical networks. AMON [1], SMART [2], CodeBlue [3], UbiMon [4], PPMIM [5], MobiCare [6], AGnES [7], Bi-Fi [8], Alarm-Net [9], AID-N [10], CustoMed [11], MobiHealth [12] and PadNET [13] are examples for such studies. While some of studies focus on specific subjects, some of them approach as a whole to create solutions. The adaptation of existing information and communication technologies to telemedicine and biotelemetry or the implementation of completely new ideas are observed in studied subjects. The basic main points are transmitting vital information of patients to health centers in accurate and quick way and making patient independent from hospital by increasing their life quality. These studies focus on designing miniaturized, easy to carry sensors that not bothering patients to increase life quality while monitoring vital data. Another research field studies about providing long life and managing power for these sensors [1–18].

Another studied subject about telemedicine and biotelemetry in literature focus on creating solutions to read the vital information on patients quickly and accurately, without calling interrupted and restricting the patient from social environment. Especially in recent years, wireless communication technologies are being used in every area of our lives as well as in biotelemetry field, and various studies on this subject were made [1–18].

Biotelemetry systems usually use Wi-Fi, Bluetooth or ZigBee networks when there is mobility. Such networks have narrow range, this is because WiMAX which has larger range is more popular [19–21].

WiMAX (Worldwide Interoperability for Microwave Access) is a technology based on IEEE 802.16 specification of wireless communication standard. According to the standard known as Wi-Fi 802.1 group serves rapidly in much more extensive areas. WiMAX offers 70 Mbps communication in 50 km area. Thus, by using this technology in biotelemetry field, patients will be more comfortable in their social life [19–21].

In this paper, it is designed and conducted a web based biotelemetry application that works on WiMAX by reference of authors solution approach published in [22,23]. First; Patient Communication Node (PCN), Client Communication Node (CCN) and Administrative Communication Node (ACN) systems have been designed as

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it is mentioned in the solution approach of model [23]. Second; these systems are implemented and WiMAX networks based on the communication issues in a proposed system then compared with other equivalents.

## 2. The implementation of layered units in model based solution approach

Patient, client and central units are the end points (CU). Patient, client and central units may take different goals and tasks in solution approach. Therefore, it is clear that it will be bringing the appropriate modules together as shown in Fig. 2.1 in [22].

### *2.1. Modular concept for patient application (Patient Communication Node – PCN)*

In the solution approach based on model for biotelemetry applications, patient is the center of the system and the system is designed as patient-central. Biotelemetry applications are based on the observation of vital information about the patient from a remote location [22]. According to this idea there should be a module that measures vital information of the patient. For this SCM module [22] is used. Thus, the measuring problem of vital information is solved. The SCM module is represented by DU in

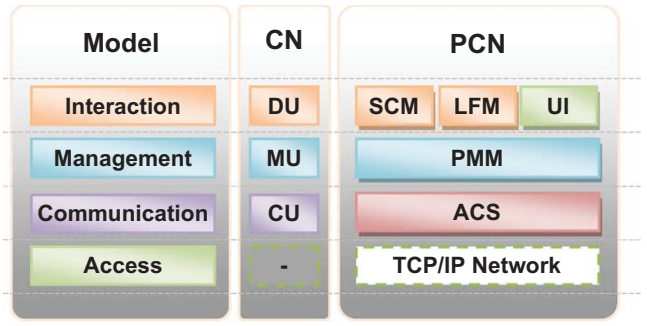


**Fig. 2.1.** Modular solution and layered units for PCN.

CN = CU + MU + DU equation. One SCM that can measures more than one vital information is used for this application. Also, LFM module which is for measuring of patient's position and UI module for interaction of application and patient are used in this application. There should be a management unit to manage DU and other unit in network. The PMM module is used for this approach. MCM and ACS modules are used according to the operating modes on patient in link layer [22]. The ASC module was preferred for this application since it is web based. This module is the best suited one for web based applications.

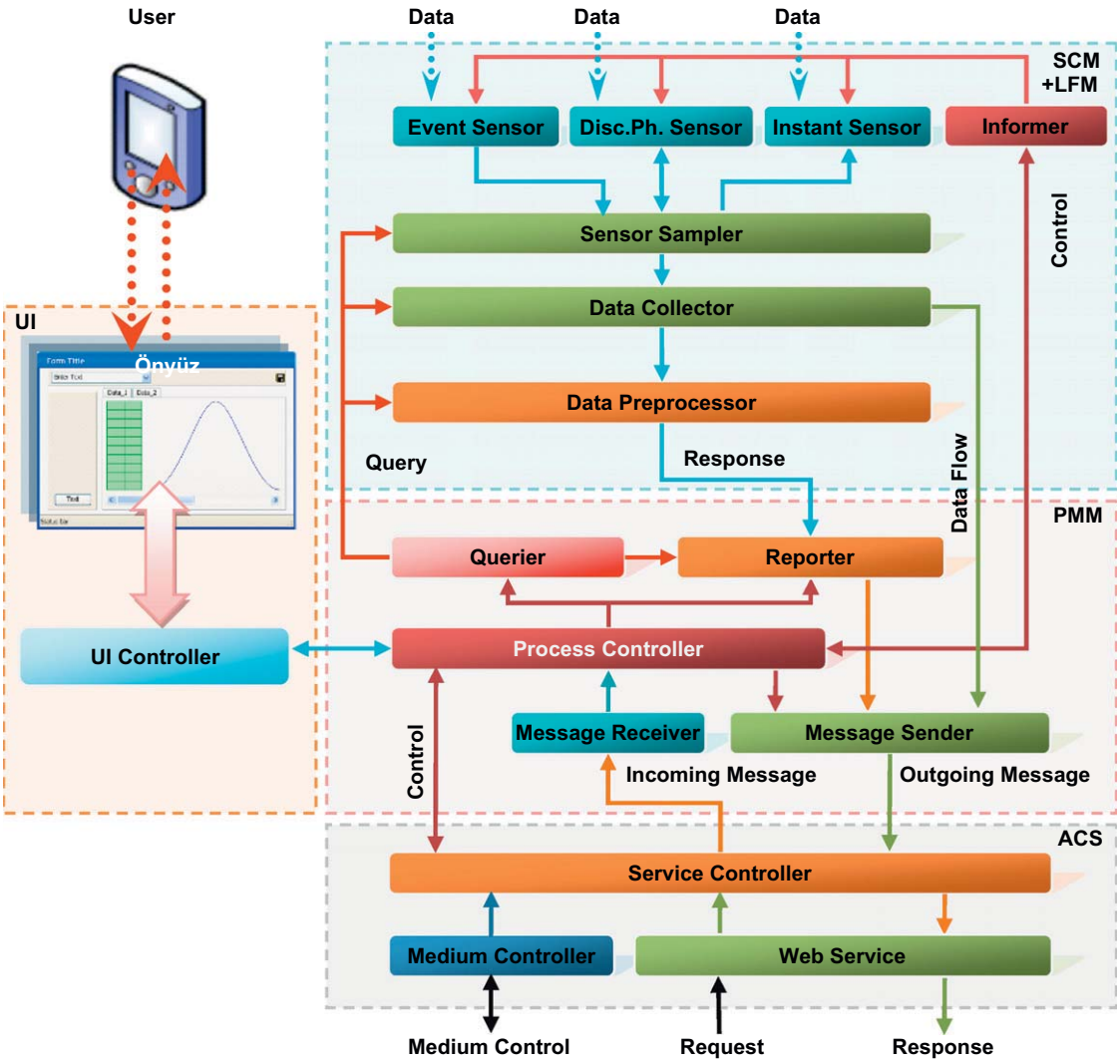


**Fig. 2.2.** PCN structure for web based biotelemetry application.

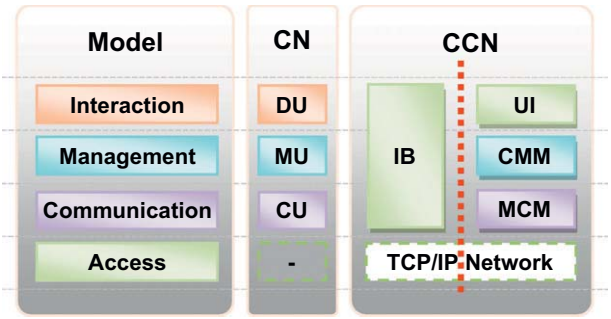


**Fig. 2.3.** Modular solution and layered units for CCN.

In this contribution, the patient link module called PCN has a structure as PCN = ACS + PMM + SCM + LFM + UI. The implementation of PCN is based on this structure. The system is modularly structured and every module is explained in detail in the solution approach based on the model [22]. The modular solution applications and layered units for PCN is shown in Fig. 2.1.

As shown in Fig. 2.1, there are five implemented modules in which three of them are located in the interaction module, one is in the management layer and one is in the link layer. SCM and LFM modules have same implementation but they have differences at the driver point. Thus, these two modules are shown as one module. The structure of implemented PCN is shown in Fig. 2.2.

Since PCN is a web based application, any user who use web browser can access to PCN and make processes within the given authority. Also, PCN users can access directly to PCN via the UI and enter required parameters as well as data as shown in Fig. 2.2.

### *2.2. Modular concept for client application (Client Communication Node – CCN)*

The implementation of clients in the application is based on CN = CU + MU + DU equation just like CCN = IB and CCN = MCM + CMM + UI. Used units in developed solution approach are shown in Fig. 2.3.

The first application of the client is CCN = IB. In this paper, IB module is conceptual and it guarantees the interoperability of web based biotelemetry applications with TCP/IP based systems. In brief, IB module is an internet browser and any kind of internet browser can use this module easily. Thus, it makes the system flexible and extensible.

The second application of client is developed as CCN = MCM + CMM + UI. It transfers the requests of user to CMM via UI module. CMM [22] grants the requests within the authority. CCN can communicate with PCN and ACN ends via MCM when necessary. The modular structure of CCN = MCM + CMM + UI application and the relational links between modules are shown in Fig. 2.4.

### *2.3. Modular concept for central management application (Administrative Communication Node – ACN)*

The central management is the hardest one to implement in terms of functions and role in the network. This application saves

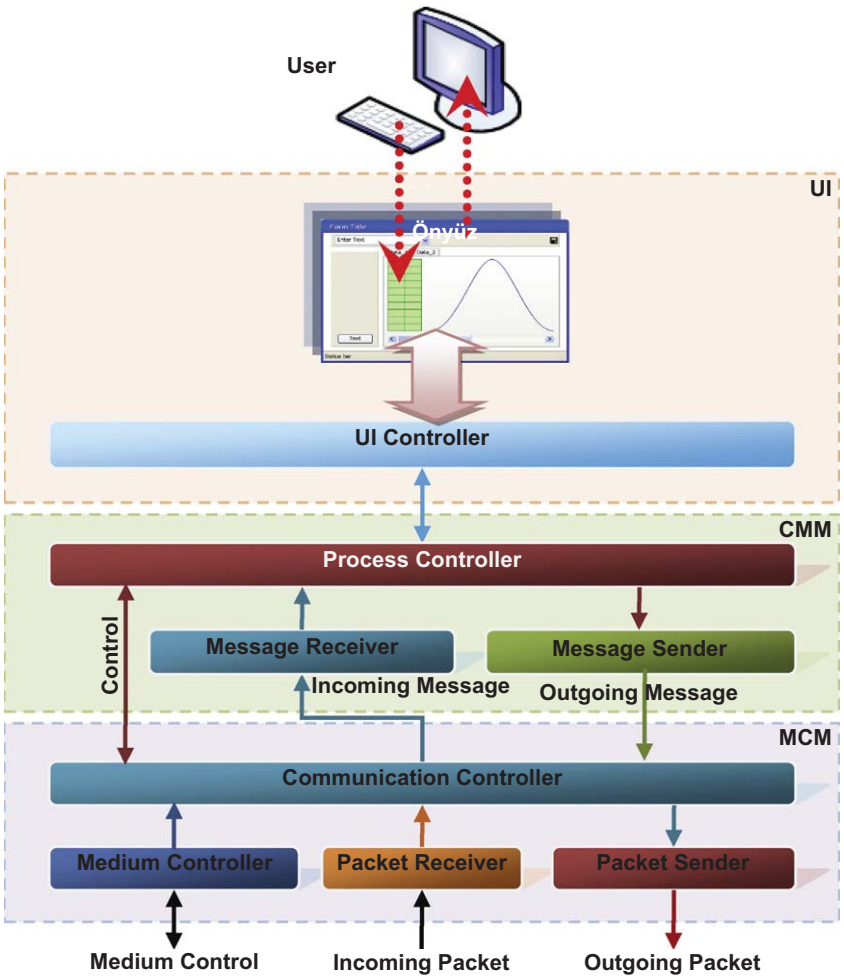


**Fig. 2.4.** CCN structure for web based biotelemetry application.

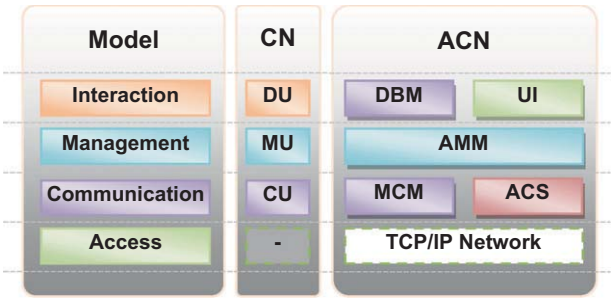


**Fig. 2.5.** Modular solution and layered units for ACN.

data to database which is send by PCN and also serves the queries and links requested by CCN. ACN includes MCM and ACS modules which are located in link layer. This is because ACN is the major serving note of the network. What is more, ACN has to know all formal communications since it is the manager of the network. In this implementation, ACN includes all modules of communication layer. It is implemented as CN = CU + MU + DU on the basis of ACN = MCM + ACS + AMM + DBM + UI. Equivalents of units in use are shown in Fig. 2.5.

It is designed as central management can be used by authorized administrators. Administrator accesses ACN via UI and transfers his demands and requests to AMM by using this interface. Moreover, DBMS (database management system) that is distinct from central management is used in this application. DBMS serves central management and meets the demand. DBMS include a database which hosts data such as sensor data, information about user on network, authorization information and login/sign-out data. The modular structure of ACN that include DBMS and the relations between modules are shown in Fig. 2.6.

### 2.4. Access medium concept

Access medium builds up the infrastructure for the application network and provides the communication among PCN, CCN and ACN. The function for the access medium is that it enables the transmission, directing and connecting tasks in order to transmit packets end to end in the network. For the access medium, the TCP/IP networks are used in the applications. For users to be mobile, thus not restricted by any limitations, small size wireless network medium is constructed on TCP/IP during the application and WiMAX technology is utilized for composing wireless network.

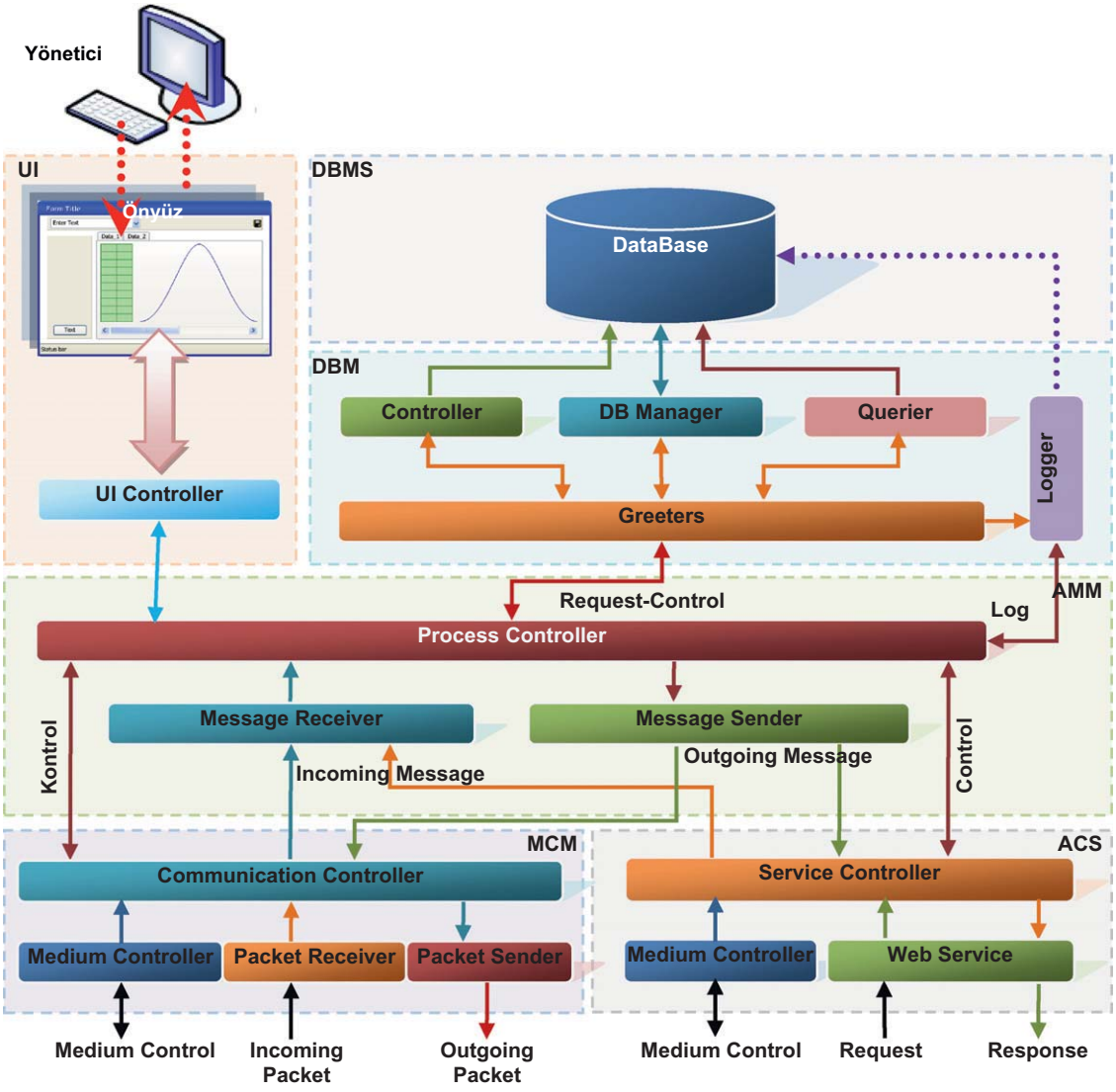


**Fig. 2.6.** ACN structure for web based biotelemetry application.

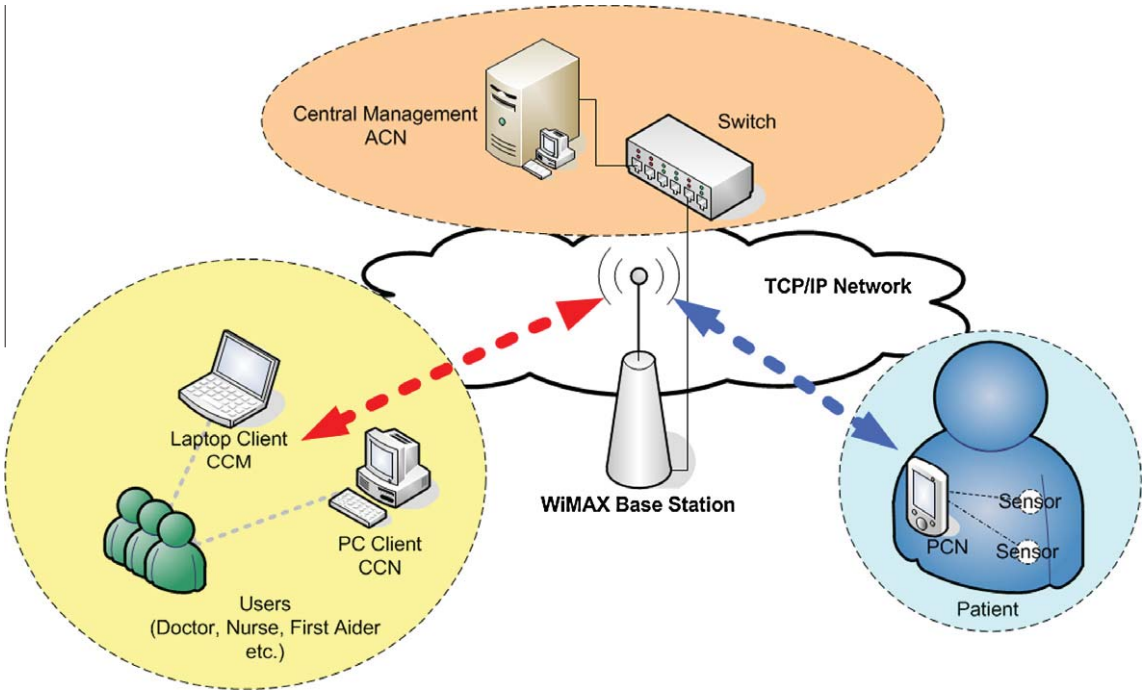


**Fig. 2.7.** Access medium for web based biotelemetry application.

**Fig. 2.8.** WiNetworks WiN7000 series base station and field-mounted version.

Therefore, users become flexible in large distances and freely move in this zone. Along with this advantage, high speed data transmission enables efficient performances for communication applications. As an access medium for the web based biotelemetry application, the medical network is depicted in Fig. 2.7 for this study.

### *2.5. Equipment and platform set up for application*

Hardware equipments are used in the physical communication medium and in the end devices for the application. Initially, a necessary WiMAX based TCP/IP network is developed for end devices to be communicated. In the network, a WiN7000 compact base station is used, which is manufactured by WiNetworks [24] company. For instance, this type of WiMAX base station mounted in the field is shown in Fig. 2.8.

WiN7000 base station is the wireless access point for the medical network. With the base station, PCN and CCN devices are connected to the medical network via wireless technology. In this application, configuration of the base station is performed with the web based interface. This interface screen is shown in Fig. 2.9.

PCN and CCN devices are investigated so that it could be found a WiMAX supported device to connect to the WiMAX base station. WiMAX cards are used with USB and PCMCIA interfaces. AWB [25] company's products; PC200 WiMAX 802.16e PCMCIA card and US210 WiMAX 802.16e USB adaptor are used for this purpose. Fig. 2.10 shows this card and adaptor products.

PDA and laptop are used in this application. WiMAX PCMCIA card and USB adaptor are connected to the PDA/laptop, and communication with the ACN is established over wireless WiMAX technology. Work station, a server, with capability of running necessary service and programs is preferred for ACN device application. The connection with the ACN device and WiMAX base station is realized with a network switch. This switch is nothing but a regular switch with portals having 100 Mbps speed capability. Software is developed for each end user devices for this application. Windows Mobile platform is used to make PDA device work as PCN in this work. While performing this work, the emulator shown in Fig. 2.11 is utilized. The trials for the developed programs are performed by laptop with PCMCIA WiMAX card and by PDA emulator.

ASP.NET and AJAX web technologies are used while developing the web site whereas HTML, ASP and ASPX are used to design the web site. Microsoft's product; Internet Information Server (IIS) program is used to publish the web site. Microsoft SQL Server as database management system (DBMS) is used while developing ACN side of the program, and Delphi application developing tool is used to build the interface program.

## 3. Comparison of the developed application with the literature

This work with its solutions and applications is compared with the following similar works done in the literature. AMON [1],

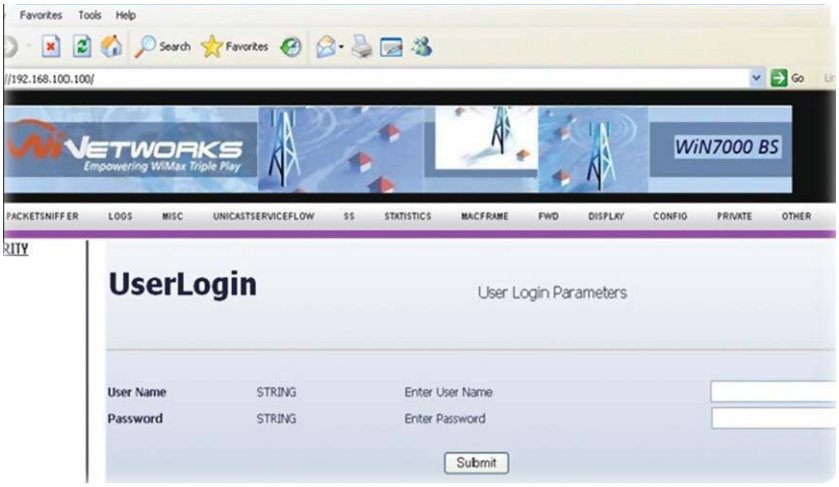


**Fig. 2.9.** Web user interface for WiN7000 base station.

**Fig. 2.10.** AWB PC200 WiMAX PCMCIA card and US210 WiMAX USB adaptor.

SMART [2], CodeBlue [3], UbiMon [4], PPMIM [5], MobiCare [6], AGnES [7], Bi-Fi [8], Alarm-Net [9] and AID-N [10]. Then, the results are given in the Table 3.1.


**Fig. 2.11.** A sample application developed over PDA simulator [26].

After performing a literature review, it has not been encountered a general modeling approach for biotelemetry application and medical network. Most literature work came up with a specific solution and approaches on their own. CodeBlue and Alarm-Net works have model and solution architecture that are more inclusive, and have general architectural approach. These works vastly use GSM, sensor network or TCP/IP as communication platforms. When technologies used and mobile users are considered, GSM based GPRS, TCP/IP based Wi-Fi, Bluetooth or ZigBee etc. are generally used in these studies. GSM has a large coverage area but data transfer speed is low. Thus, real-time and large data transmissions are specifically the limitation of this technology. Wi-Fi, Bluetooth or ZigBee etc. technologies are limited on the geographic distribution applications. On the other hand, WiMAX technology has very large coverage area and it will be a very common technology in the future. In AGnES study, WiMAX is partially used, however in our study, WiMAX technology is completed utilized. Thereby, a superior infrastructure is developed with very large coverage area for high speed data transfer and real time communications.

## 4. Results and evaluation

In today's technology, there are vital developments to cure several patents or to help humans to increase the life quality. In this world, health is the most important factor and subject in society

**Table 3.1**
The comparison of similar studies in the literature.

| | Communication model proposal (Service, protocol) | Solution architecture | Communication platform | Technology | Custom hardware design | Software design | Positioning | Security | Medical communication | Application |
|---|---|---|---|---|---|---|---|---|---|---|
| AMON | No | Yes | GSM | GPRS | Yes | Yes | ? | ? | HM | Yes |
| SMART | ? | Yes | TCP/IP | Wi-Fi | No | Yes | IPS | ? | DM | Yes |
| CodeBlue | Yes | Yes | Special | Wi-Fi | Yes | Yes | IPS | Yes | Hybrid | Yes |
| UbiMon | ? | Yes | Hybrid | Wi-Fi GPRS | No | Yes | ? | ? | Hybrid | Yes |
| PPMIM | ? | Yes | GSM | GPRS | Yes | Yes | ? | Yes | HM | Yes |
| MobiCare | ? | Yes | GSM | GPRS | No | Yes | ? | ? | DM | No |
| AGnES | No | Yes | TCP/IP | Wi-Fi WiMAX | No | Yes | GPS | Yes | HM | Yes |
| Bi-Fi | No | Yes | Special | ZiBee | Yes | Yes | ? | ? | Hybrid | Yes |
| Alarm-Net | Yes | Yes | Sensor Network | ZigBee | Yes | Yes | IPS | Yes | HM | Yes |
| AID_N | No | Yes | Sensor Network | ZigBee | No | Yes | IPS GPS | ? | HM | Yes |
| This study (MCNet) | Yes | Yes | TCP/IP | WiMAX | No | Yes | GPS | Yes | Hybrid | Yes |

and social life. Healthy people and community provide better services to their social environment and to their countries. However, health is not sustainable forever for human beings. For this reason, people spend tremendous efforts and fund to monitor their health by using developed technologies. Thus, this sector gets more importance to give better service and to use resources more efficiently under the health economy.

For doctors, it is very precious to get information about the patients healthy, to monitor them frequently and to react when required. In this case, doctor can give decision more accurately on the diagnoses and treatment. There is the part where biotelemetry and medical networks get into the human life. If this system utilized correctly, efficiently and effectively, not only in health but also it will make people satisfied and more positive.

In this study, based on the developed model for biotelemetry networks [22] and solution approach [22], web based biotelemetry application is performed. A patent's vital data is simulated and this information is transferred to the center. This information is stored and monitored at the client in the center. As a communication technology, a WiMAX wireless network is used with its superior performance and coverage when compared with the existing technologies. Developed medical network works on this WiMAX technology.

Addition to this study, this application will be performed in a hospital environment. Thus, we will have a chance to apply this model on real patients and in more realistic medium data so that more beneficial real results can be obtained, and these results can be a demo to convert this project into a product. In conclusion, the biotelemetry system developed for medical industry will help health sector to be more effective and efficient.

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