



## Design and Implementation of a Telemetry System for Environmental Applications

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### Abstract

The Environmental Data Acquisition Telemetry System is a versatile, flexible and economical means to accumulate data from multiple sensors at remote locations over an extended period of time; the data is normally transferred to the final destination and saved for further analysis.

This paper introduces the design and implementation of a simplified, economical and practical telemetry system to collect and transfer the environmental parameters (humidity, temperature, pressure etc.) from a remote location (Rural Area) to the processing and displaying unit.

To get a flexible and practical system, three data transfer methods (three systems) were proposed (including the design and implementation) for rural area services, the first method is an RF link which can be used for field applications and rural areas. The other two methods are based on the utilization of packet-switching network (GPRS and Internet networks) to transfer the collected data to the required destination.

Remote and Master units which represents the break down of the three proposed system are designed and implemented

**Keywords :** Telemetry, GPRS, remote master units, wireless communications, TDM.

### 1. Introduction

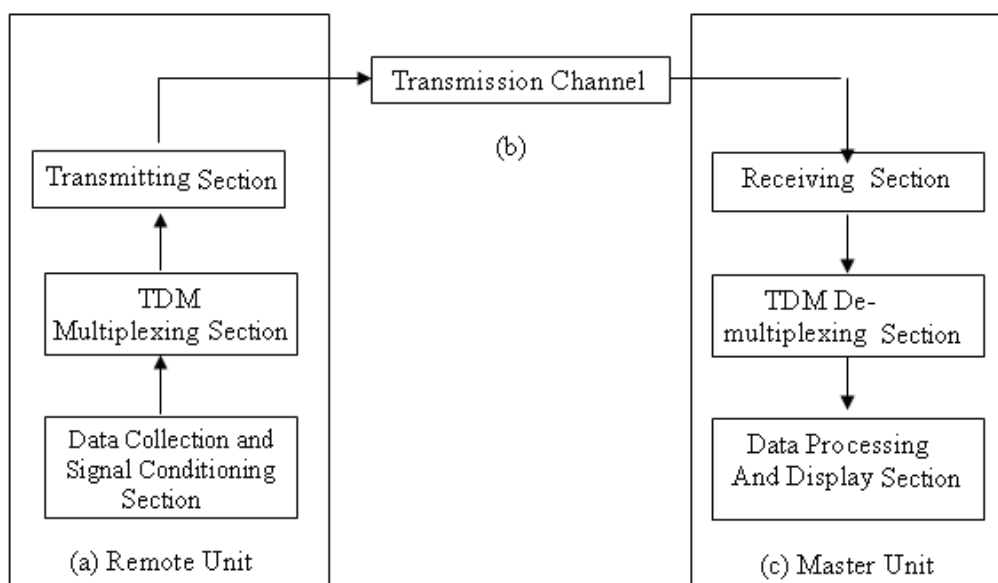


Fig. 1. Block Diagram of A Telemetry System.

The purpose of a telemetry system is to collect data at a place that is remote or inconvenient and to relay the data to a point where the data may be evaluated [1]. This process can be achieved via wire-line or wireless links. Telemetry has the advantage of reducing the cost of manually reading, checking and controlling remote devices. When telemetry applications use wireless technology, additional benefits accrue. The use of wireless technology enables systems to be located virtually anywhere without depending on the telephone company for line installation [2, 3].

Telemetry system has a wide range of applications such as [2, 4]:

- \* Environmental monitoring.
- \* Telemedicine.
- \* Space applications.
- \* Security applications.
- \* Utility meter reading.
- \* Load management.
- \* Vending machine management.
- \* Land mobile vehicles.

Most of today's telemetry systems consist of the sections shown in figure (1).

## 2. Telemetry System Categories

In order to evaluate the type of communications required for a telemetry application, it is important to consider telemetry systems in specific categories, i.e.:

- (a) High integrity, High data throughput, Continuous communications
- (b) High integrity, Low data throughput, Continuous communications
- (c) High integrity, Low data throughput, Intermittent communications
- (d) Low integrity, High data throughput, Continuous communications
- (e) Low integrity, Low data throughput, Continuous communications
- (f) Low integrity, Low data throughput, Intermittent communications

Category (a) may require a quality microwave link, fiber optic cable or dedicated digital tie line service.

Category (b) may require a quality radio link, data quality copper cable or dedicated analog data tie line.

Category (d) may require connection into a LAN or an ISDN connection.

Category (e) may require connection into a radio link, on-site telephone cabling or analog tie line.

Categories (c) and (f), the application would involve a master site accessing the Remote Terminal Units (RTUs) at regular intervals of greater than 10 minutes, or at irregular intervals, of anything from 10 minutes to several days [5].

By placing a telemetry application into one of these categories, it is possible to determine the most appropriate and cost effective communications link solution

It is often more appropriate to implement this category of telemetry system over an existing radio system, the major advantage of such an implementation is the significant cost savings, in not having to design and install new master site radio equipment [6].

## 3. The proposed Telemetry System

A practical environmental telemetry system is proposed to collect the environmental parameters (humidity, temperature, pressure etc.) from a remote location (Rural Area) to the processing and displaying destination.

The transmission channel was represented by three proposed data transfer methods:

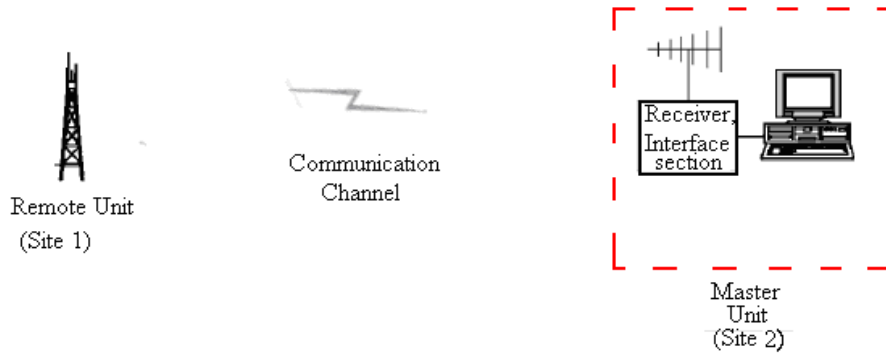
- RF link which can be used for field applications and rural
- areas where the GSM and Internet networks don't exist.
- Intranet over GPRS network.
- Internet over GPRS network.

Thus three scenarios can be provided for data transfer from the remote unit to the master unit at the required destination.

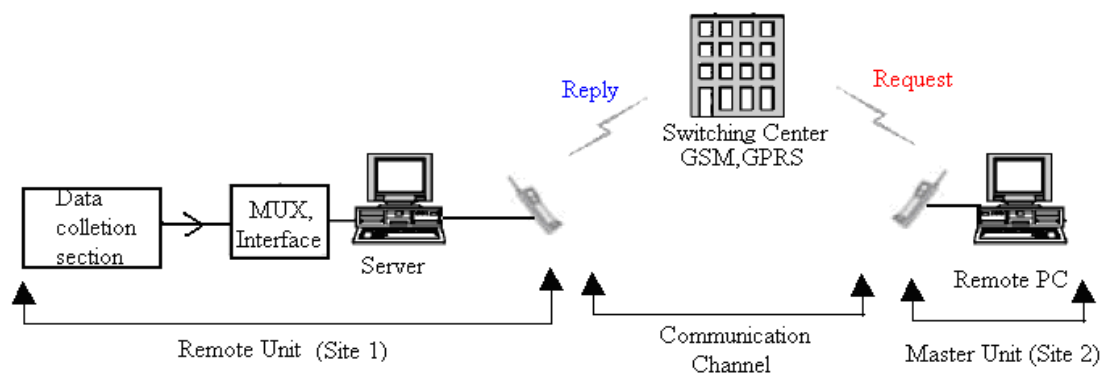
Figure (2) represents three scenarios of the designed and implemented telemetry system.

## 4. Design and Implementation

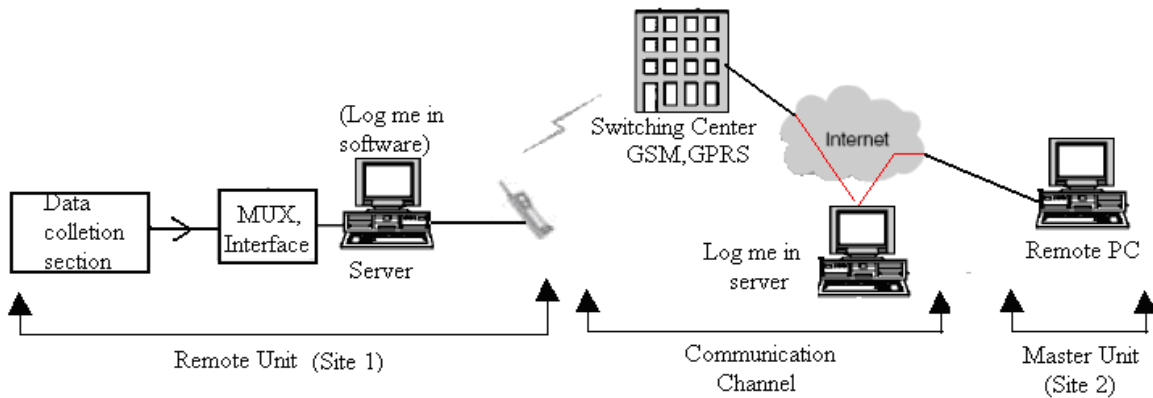
The designed and implemented Telemetry System consists of three scenarios, for scenario one it can be classified into category (f) since the data to be measured has a low rate of change. This system was set to transmit two channels each of 8 bit resolution and can be extended to 16 channels; these channels will be transmitted on periodic basis (15 minutes for each).



(a) Scenario 1: Data transfer via RF.



(b) Scenario 2: Data transfer via intranet over GPRS.



(c) Scenario 3: Data transfer via Internet over GPRS.

Fig. 2. Three Scenarios of the Designed and Implemented Telemetry System.

Design and implementation of the remote, master and communication channel is illustrated in this section, through the following scenarios:

**I. Scenario One: Data Transfer via RF**

This scenario can be described through the remote and master units as shown in figure (2-a).

**a. Remote Unit**

The remote unit consists of the following sections:

**i. Data Collection and Signal Conditioning Section**

The circuit shown in figure (3) was build to achieve the functions of sensing, data collection and signal conditioning, in which LM35 is used as a linear temperature sensor, A/D 0804 and OP-AMP are used as the data collection and signal conditioning section.

The circuit is practical and generic i.e. the LM35 can be replaced by other sensor.

**ii. TDM Multiplexing Section**

Two channels each of 8 bits are the input of the multiplexing section; TDM ID technique is used as the multiplexing technique with 4 bits as the ID of each channel thus the ability to address up to 16 channels.

PIC16F84A microcontroller is used with tri-state buffers (74244) as the controller section.; the microcontroller is also used to control the transmission period. Figure (4) represents schematic diagram of the multiplexer and Controller section.

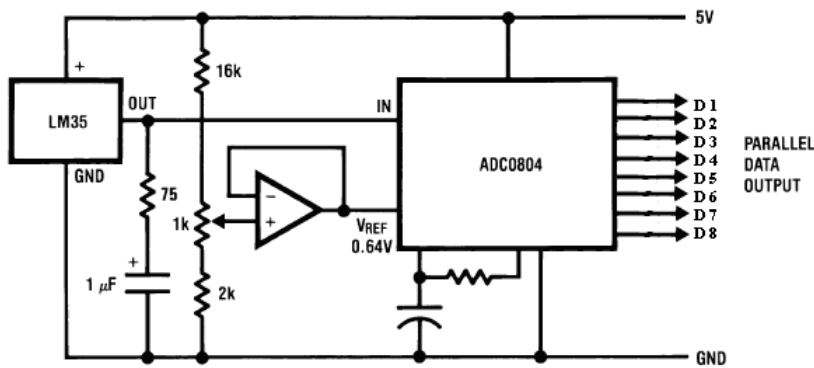
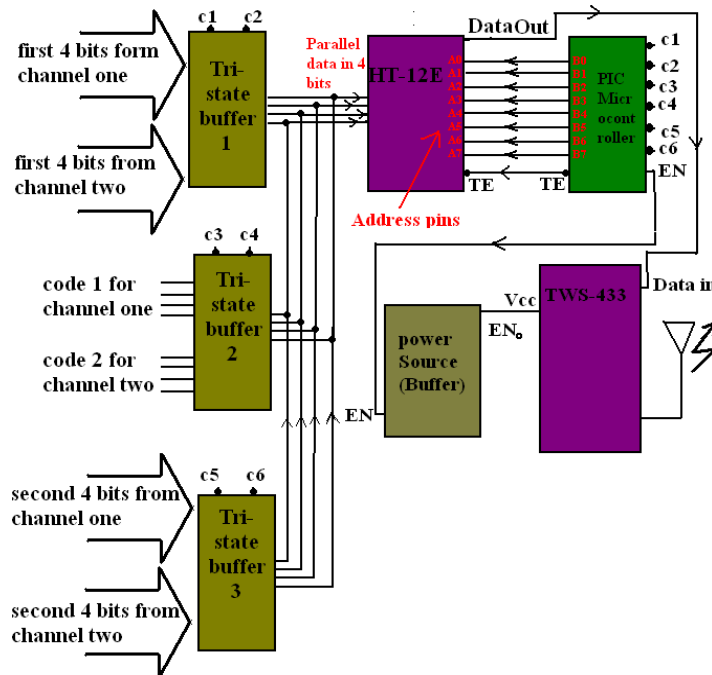


Fig. 3. Data Collection Section.



Note: A bubbled input indicates active low

Fig. 4. Schematic Diagram of the Implemented Remote Unit.

**iii. Transmitting Section**

The carrier frequency used in this process is 433 MHz with 20 mwatt as transmitter power, when using whip antenna of 15 cm the max distance is 300 meters of isotropic transmission; the max. distance can be extended either by using directional antenna such as the Yagi antenna or by using RF power amplifier.

TWS-433 which is off-the-shelf hardware is used as the transmitter; it is ASK, 433 MHz modulator with its compatible Encoder HT-12E

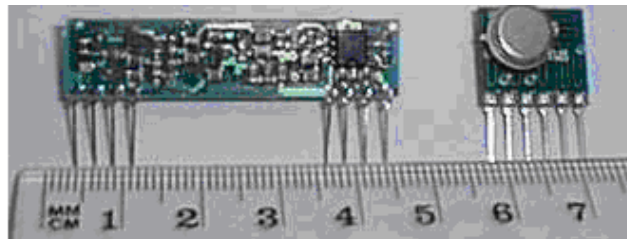
(it converts 4 parallel bits at input to serial output).

Figure (5) shows the TWS and RWS modules.

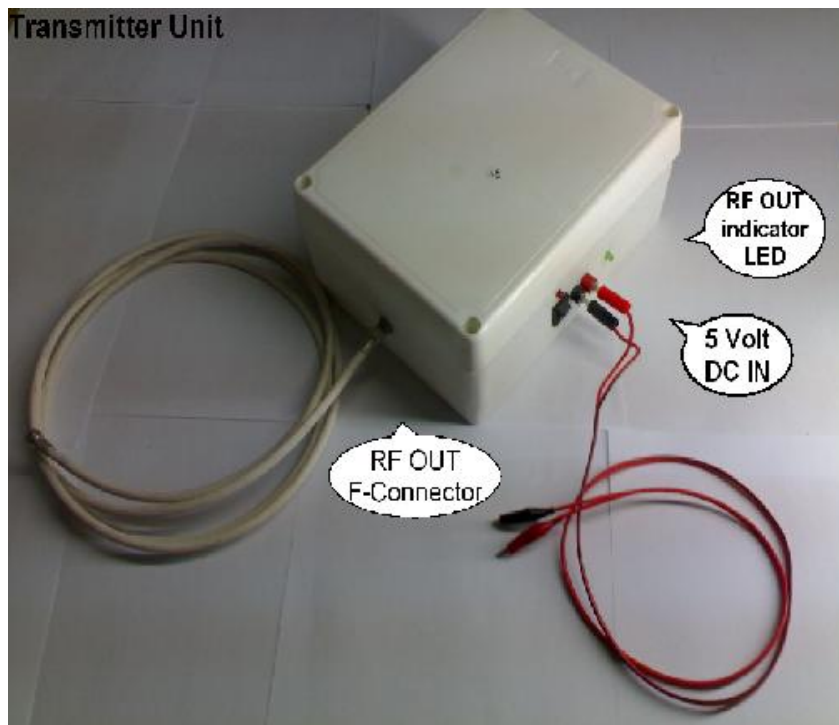
Holtek is the manufacturer of the modulator (TWS-433) it has a wide product line which includes the same modulators with different operating frequencies; this provides the flexibility to change the operating frequency easily just by changing the modulator, and even to provide diversity facilities. Figure (6) shows the implemented remote unit.

TWS modulator product line.

TWS-433	433.92 MHz transmitter
TWS-303	303.875 MHz transmitter
TWS-315	315 MHz transmitter
TWS-418	418 MHz transmitter



**Fig. 5. RWS-TWS Modules.**



**Fig. 6. The Implemented Remote Unit.**

**b. Transmission Channel**

Free space is the propagation media for this scenario. Maximum range depends on the

transmitted power, frequency and the gain of the transmitting and receiving antenna.

**c. Master Unit**

It receives the collected data from the remote unit and it consists of the following sections:

**i. Receiving section**

RWS-433 receiver module is used with compatible decoder HT-12D to convert the serially received data into frames of 4 bits. Whip antenna or directional antennas can be used at the receiver unit.

**ii. TDM De-multiplexing Section**

De-multiplexing can be achieved using hardware or software methods; for the designed and implemented unit, software processing was used to de-multiplex the received data according to their channel ID as shown in table-1.

**Table 1,  
Channel IDs**

Channel Number	Channel ID
Channel 1	1010
Channel 2	0101

**iii. Data Processing and Display Section**

It is the final stage in the master unit; it will provide monitoring and data archiving capabilities, it consists of:

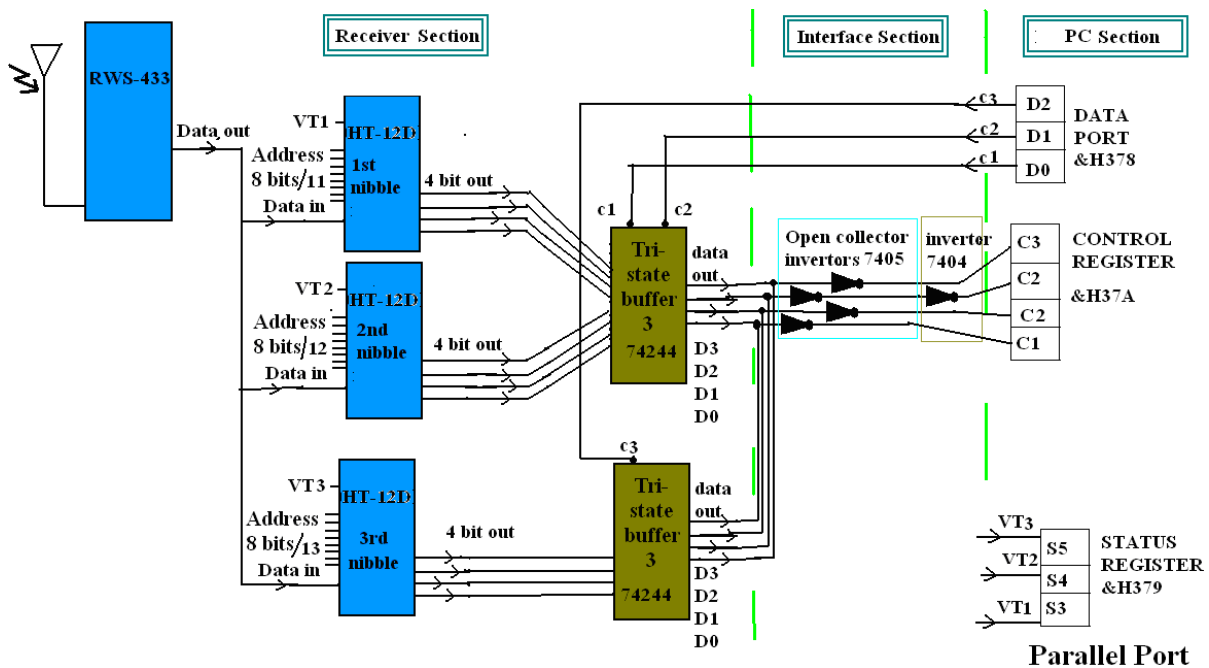
**(1). Interface Sub-Section**

It provides buffering and matches the electrical characteristics of the received data to the electrical characteristics of the parallel port of the PC; it also provides isolation and protection.

**(2). PC Sub-Section**

The receiver section is interfaced to the parallel port of a PC, thus the PC will be used to de-multiplex the received data by using software written in visual basic, performing error detection and correction algorithm, store the data in Text, HTML, excel formats and provide terminal monitoring to the user.

Schematic diagram of the implemented master unit is shown in figure (7), the implemented master unit is shown in figure (8).



**Fig. 7. Schematic Diagram of the Implemented Master Unit.**



Fig. 8. The Implemented Master Unit.

**II. Scenario Two: Data Transfer via Intranet over GPRS Network**

This scenario utilizes the GPRS network as the communication channel; the data was saved in the server computer of the remote unit and not sent to the master unit. The remote user (in the master unit) has the capability to browse the data, any user can access the data either by using a 3G mobile phone that supports Web-browsing or by attaching the mobile device to the PC and using it as GPRS modem and browse the data.

This Telemetry system can be classified into categories (d), (e) depending on the available B.W from the GPRS service provider thus it can be high speed category (d) or low speed category. (e).

**a. Remote Unit**

The remote unit for this scenario consists of data collection section connected to the parallel port of a PC, Web server application is installed on the PC (Apache server) thus the stored data can be accessed using browsing technology.

**i. Data Collection Section**

It is similar to the data collection section of Scenario one.

**ii. Multiplexing Section**

Binary data from the data collection section is fed to the parallel port of the PC where multiplexing is done in software written in visual basic thus data from different sensors is read and stored on the PC.

**iii. Transmitter Section**

Mobile device is attached to the PC and by simple network settings the GPRS services would be provided on the PC; thus the mobile device is used as GPRS modem.

**b. Communication Channel**

GPRS network is a Packet-Switched Network; within this network small units of data called packets are routed through a network based on the destination address contained within each packet.

Every packet has to contain a header; the header for example contains information about the sender (source address) and the receiver (destination address) of the packet. This information is used in the network to route the packets through the different network elements. The GPRS network overlays the existing GSM circuit switch



networks. The main goals of GPRS network are to:

- Enable GSM network operators to operate packet data services utilizing the existing GSM radio infrastructures on a dynamic and flexible basis.
- Efficient use of bandwidth.
- Usually Packet switching network charged by volume and not by time unit, for subscribers this has the advantage that they pay for downloading a web page but not for the time reading it [7,8].

This paper suggests establishing a local intranet between the GPRS devices i.e. intranet between

the private IP addresses of the network. By using the mobile devices as GPRS modems for the workstation and PC's which will communicate with each other and exchange data between other through this network, as shown in figure (9) where the workstation 10.3.0.124 can communicate with any other one where its requests will be forwarded to the appropriate destinations through SGSN whenever the destination inside the GPRS network but if it outside the GPRS network then this request will be forwarded to the GGSN where it's the GPRS gate to the out side network.

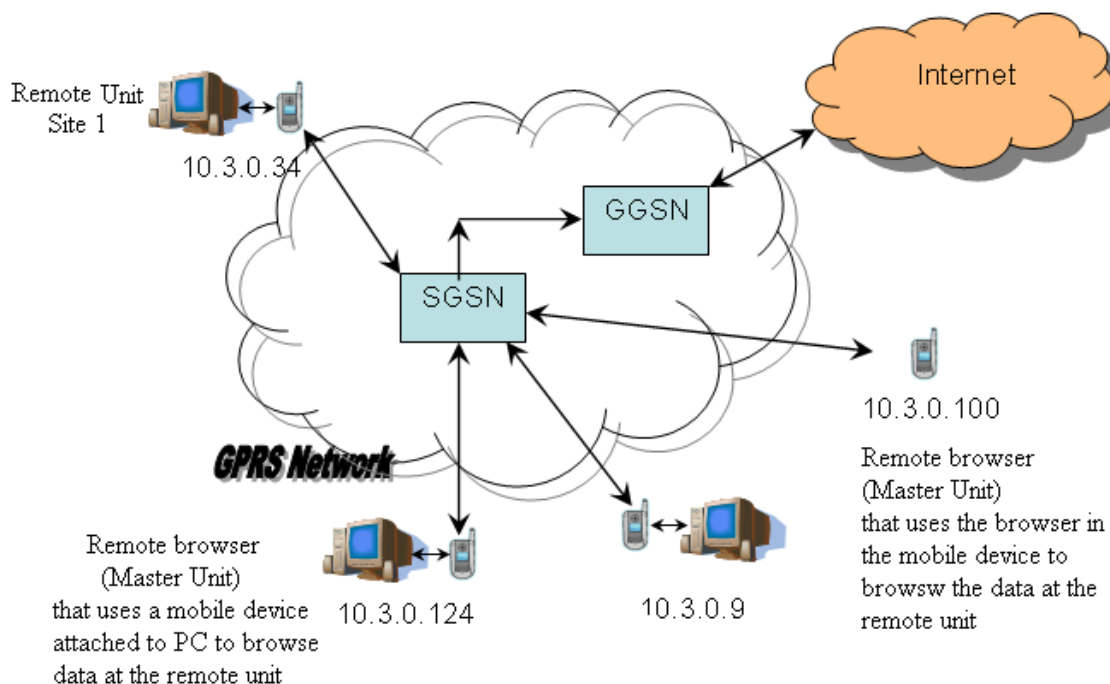


Fig.9. Intranet Connection Between GPRS Devices Over the GPRS Network.

### c. Master Unit

For this scenario the master unit is any remote browser that is capable of browsing the remote unit, the remote browser can be a mobile device that supports browsing technology, or a mobile device connected to a PC thus using the PC to browse the data at the remote unit.

It should be noted that the intranet connection is done between private IP addresses on the same network (the network of the GPRS service Provider) so data on the remote unit is not accessible from other networks.

### III. Scenario Three: Data Transfer via Internet over GPRS Network

In scenario two it was shown that data at the remote units is not accessible from other network but from devices on the same GPRS network, this scenario overcomes this limitation by using the mobile device to provide Internet service at the remote unit and by using the LogMeIn software that enables the access to the remote unit from any Internet connection.

For more info about the LogMeIn check <http://secure.logmein.com> .

Scenario three can be classified into category (e).



**a. Remote Unit**

The remote unit used for this scenario is the same remote unit used in scenario two, the LogMeIn software has been installed on the Server of the remote unit in this scenario.

**b. Communication Channel**

Any two computers can communicate with each other through Internet; in order to provide direct access from one computer to another they should be assigned public IP addresses; using public IP addresses requires to rent a public IP address, and extra equipments equipments; although the application we are using (Telemetry for environmental applications) does not require high speed connection or continuous connection.

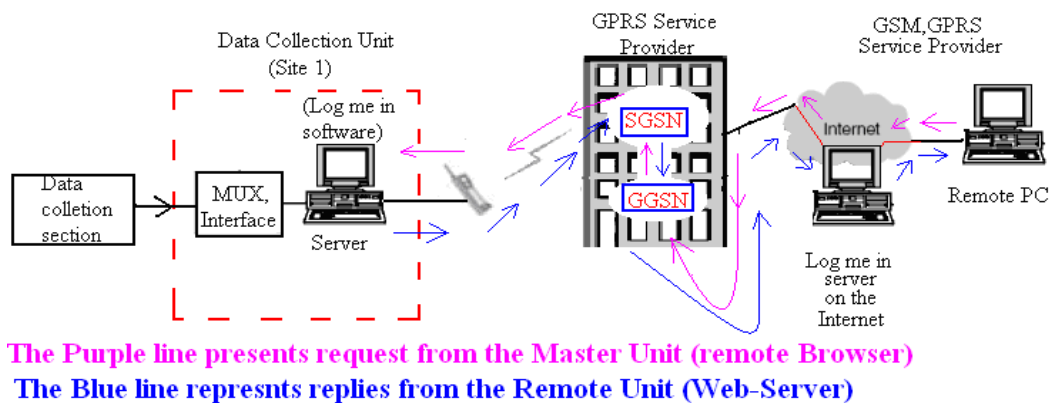
The LogMeIn software is an application that allows direct computer access between two computers with private IP addresses on the Internet. The LogMeIn software application is

installed on the PC of the remote unit which is provided with Internet connection from the GPRS network as shown in figure (10).

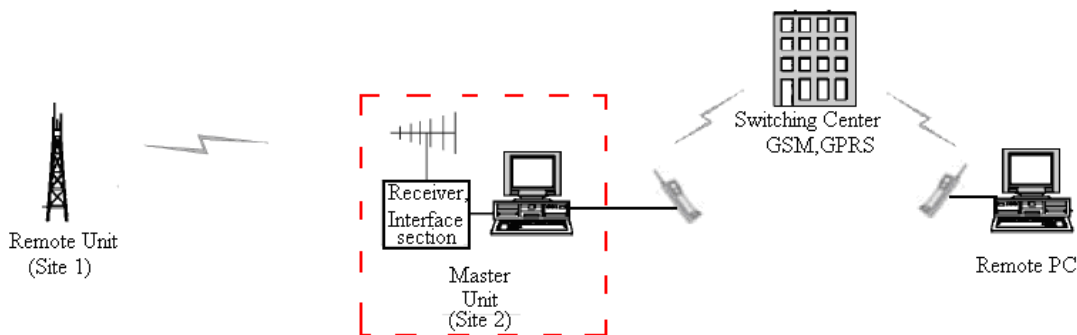
**c. Master Unit**

For this scenario the master unit is any remote browser (PC or mobile device), that is provided with Internet connection; on start the LogMeIn server in the remote unit will automatically connect the PC of the remote unit to the LogMeIn site on the Internet, the master unit would connect to the LogMeIn site <http://secure.logmein.com> where it will find a link that connects it directly to the PC of the remote unit.

The scenarios mentioned above can be used individually or a combination of more than one scenario according to user needs, figure (11) illustrates a telemetry system that uses RF link to collect data from remote unit and intranet over GPRS network to relay data to remote users.



**Fig.10. Data Transfer Between PC's With Private IP Addresses Over the Internet.**



**Fig.11. RF is Used to Transfer Data From the Remote Unit to the Master Unit, Internet Over GPRS Service is Used to Provide the Data to the Remote Users.**

### 5. Results

For scenario one the transmitted and received data is shown in table-2. This table shows that the transmitted data was received successfully without any error and with acceptable time delay.

For Scenario two and three the transmitted data from the remote unit is shown in table-3; the received data is saved on the Server PC in the master unit in html pages as show in figure (12).

**Table 2,  
Transmitted and Received Data for Scenario One.**

Input Data At the Remote Unit	Transmission Time (hh:mm:ss)	Received Data at the Master Unit	Arrival Time (hh:mm:ss)
Channel One (Temperature) 101000 40 C°	06:08:33	Channel One (Temperature) 101000 40 C°	06:08:34
Channel Two (Humidity) 00001101 13 %	06:08:36	Channel Two (Humidity) 00001110 14%	06:08:37

**Table 3,  
Transmitted Data From the Remote Unit for Scenario Two and Three.**

Input Data at the Remote Unit	Transmission Time
Channel One Temperature 40 C°	15:01:21
Channel Two Humidity 13%	15:01:43
Channel One Temperature 41 C°	15:02:04
Channel Two Humidity 14%	15:02:25



**Fig.12. Received Data from Remote Unit-A Saved in HTML Page in the Master Unit.**

## 6. Conclusions

This paper introduces the design and implementation of a flexible and practical telemetry system to collect and transfer the environmental data (temperature and humidity) from rural areas to the processing and displaying destination. The implemented system has the advantage of its simplicity, low cost, and easy to adapt with the available means of communication. The results of testing the different approaches (scenarios) give an accurate results and acceptable time response. This system can be considered as generic system which can be utilized for many other applications.

## 7. References

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## تصميم وتنفيذ نظام جمع بيانات لتطبيقات بيئية

جابر عزيز اسامة حسين

قسم هندسة الالكترون والاتصالات/ كلية الهندسة/ جامعة النهريين

### الخلاصة

ان نظام جمع البيانات البيئي يمثل وسيلة اقتصادية ومرنة ومُعدّدة الإستعمال لتجميع البيانات من الم تحسّسات المتعدّدة في المواقع البعيدة على فترة زمنية طويلة؛ البيانات المستلمة تخزن عادة على حاسوبٍ للتحليلات لاحقة. النظام التقليدي يتشمل محطة مستلم واحد أو العديد من المحطات الطرفية البعيدة التي تقع بعيداً من محطة المستلم. تستجوب محطة المستلم المحطة الطرفية البعيدة بشكل متسلسل وتُخزّن البيانات على حاسوب. تستلم المحطة الطرفية البعيدة إشارة الإستجواب التي تبدأ تسلسل المتحسسات. العوامل المُختلفة تُقاس والمعلومات تُسّلة عن طريق وصلة آر إف إلى محطة المستلم لمعالجة ومشاركتها عبر شبكة حاسبات.

في المحطة الطرفية البعيدة، أكثر من محسّس واحد يمكن أن يُستعمل لجمع البيانات الضرورية، محسّسات الرطوبة ودرجة الحرارة أُخذاً كَمثال في هذا العمل.

تي دي إم وتي دي إم أي إخترا كتقنيات دمج لإرسال القنوات المختلفة.

ارسال المعلومات البيانات بين المحطة الطرفية البعيدة ووحدة المستلم (خادم) أنجزا بأكثر من طريقة واحدة (إتصال مباشر، وصلة آر إف واحدة،

وصلتي آر إف).

تبادل البيانات بين وحدة المستلم (خادم) والزبون أنجزَ خلال شبكة باكثر من طريقة واحدة (إنترنت، جي إس إم، الإنترنت بعنوان أي بي عام والإنترنت

بعنوان أي بي خاص).