DEVELOPMENT OF REAL-TIME AUTOMATIC WEATHER SYSTEM FOR MET3A/MET4A METEOROLOGICAL SENSORS

Wayan Suparta[1] *, Lai Khuan Leng*[2]

ABSTRACT:
A system that can be used to monitor and saving the pressure, temperature and relative humidity acquired by broadband meteorological sensors (MET3A/MET4A) has been developed using a Visual Basic in 2009 at Universiti Kebangsaan Malaysia (UKM). The system has been tested time to time that capable operated in all Windows based platform. This user friendly system is developed to resolve the problem in the Digiquartz®Interactive (DQI) software from Paroscientific, Inc. that have a limitation in displaying the third parameters above simultaneously. The system has also an advantage to upload the data into a File Transfer Protocol (FTP) and maintaining the time series when the sensor or electricity trouble in a certain period.

Keywords: Development, UAWS, Visual Basic, Broadband meteorological sensor.

1. INTRODUCTION

Weather is an engine in our life and is plays a crucial role in all activities from microbes to beyond of our home planet. Extreme weather phenomena can disrupt daily activities, settlements, security and human wealth. The frequent of sudden weather changes in a place tend to change the attitudes and mentality of the people in their vicinity (*Suparta et al., 2009*). Therefore, improved knowledge on the accurate prediction of weather systems at anytime at a location in the world can have a direct or indirect impact on the improving the quality of human life. Unfortunately, not all weather parameters taking place in the land, ocean and space are well quantified or sensed due to limitation such as knowledge, political manner and awareness. In addition, the mindset of traditional communities in regions where the weather does not become a major nuisance in their activities, they are usually less concerned about the extreme weather events. Although very simple, efforts should be made to avoid fatalities and sustaining our environments. GPS Meteorology is one field that has initiated to sense the weather systems such as water vapor from GPS and the surface meteorology measurements for improved nowcasting, weather forecasting and global climate model prediction. On the other hand, the meteorology sensors used in this work was widely employed for GPS Meteorology studies (e.g. *Suparta et al., 2009; Suparta, 2009; Suparta et al., 2011*).

This paper is aims to develop of a weather information system called the Real-Time UKM Automatic Weather System (UAWS) using Visual Basic programs. The system development can display and stores the weather information such as pressure (P), temperature (T) and relative humidity (H) via the meteorological MET3A/MET4A sensors (*Paroscientific, 2007*). The idea of this work is to improve the capability of

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[1] *Institute of Space Science (ANGKASA), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia, E-mail: wayan@ukm.my.*

[2] *Graduated from Dept of Electrical, Electronic and System Engineering, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia.*

Digiquartz®Interactive (DQI) software that has used to activate the Paroscientific meteorological sensors. DQI is simply operation but rather complicated to display the P, T, and H simultaneously. The data missing due to electricity problems are not automatically handled in the correct time series. In this work, UAWS will manipulate the information from meteorological sensors, displaying the quantity in the graph and store the information automatically and systematically into the local directory. In addition, information on the third parameters will be saved and uploaded to the Internet via File Transfer Protocol (FTP) that can be accessed online at anytime and anywhere.

2. METHODOLOGY: SYSTEM DEVELOPMENT

2.1. Connecting the meteorology sensors to computer

MET3A sensors have been installed at the Institute of Space Science (ANGKASA), Universiti Kebangsaan Malaysia (UKM) in the roof of Faculty of Enginnering and Built Environment Building, where the MET3A cable was connected to a COM port of PC (*Suparta et al., 2009*). As for data communication, to connect the sensors to a PC it is using a serial cable with default port active was COM1. A serial RS232 to USB converter is needed to connect the sensors if the laptop provided without serial port (D9). The active COM port on Laptop for MET3A/MET4A connection can be checked through Device Manager on *Ports (COM & LPT)*. **Fig. 1** depicts the system connection to MET4A sensors, which was tested for Northern Hemisphere water vapor experiments (*Suparta, 2009*). The Digiquartz®Interactive 2.0 (DQI) provided by Paroscientific, Inc., can also be used to test the operation of the system. This software can be downloaded at the http://www.paroscientific.com/software.htm. On the other hand, detail installations of the sensors (Programming & Operations Manuals) are also provided in this website.
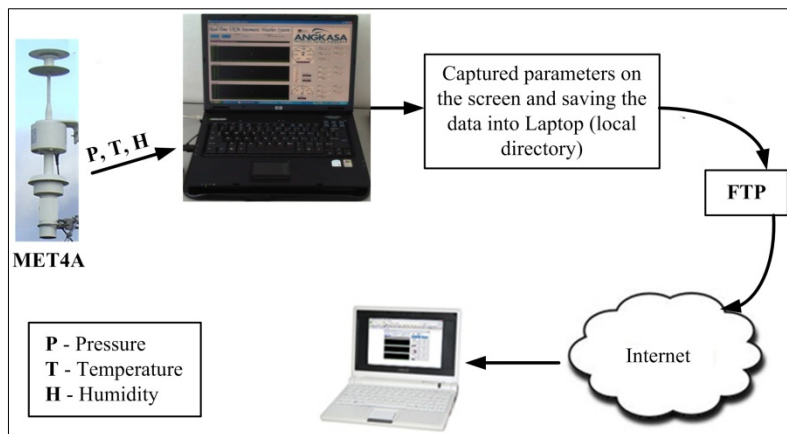

Fig. 1 Flow diagram for UKM Automatic Weather System development.

For this work, a Visual Basic 6.0 (*Thayer, 1999*) were used to develop UAWS through MSCOMM function that able to communicate with MET3A/MET4A. The response of MET4A sensors can be done through *HyperTerminal* in the *Microsoft Windows*. When the MET4A received the *0100L1, then they will response with *098765, +01.005874, +23.45, +045.7,1. Responses are in the format such as *<Time series - 6 digit>,<Pressure - 10

digit>,<Temperature - 6 digit>,<Relative humidity - 6 digit>,<Fan Status - 1 digit>. The next step after the MET3A/MET4A responded is to develop a program for plotting the data (P, T, H) versus time, saving the data into the computer and upload the data saved into a FTP.

2.2. Programming

The next step for UAWS development is programming as described in the following. A *MS COMM Control 6.0* component in Visual Basic 6.0 was used to connect the software with MET3A/MET4A sensors. **Fig. 2** summarizes the UAWS development from creating a new file or open the saved file until plotting and saving the data into a local directory and FTP.
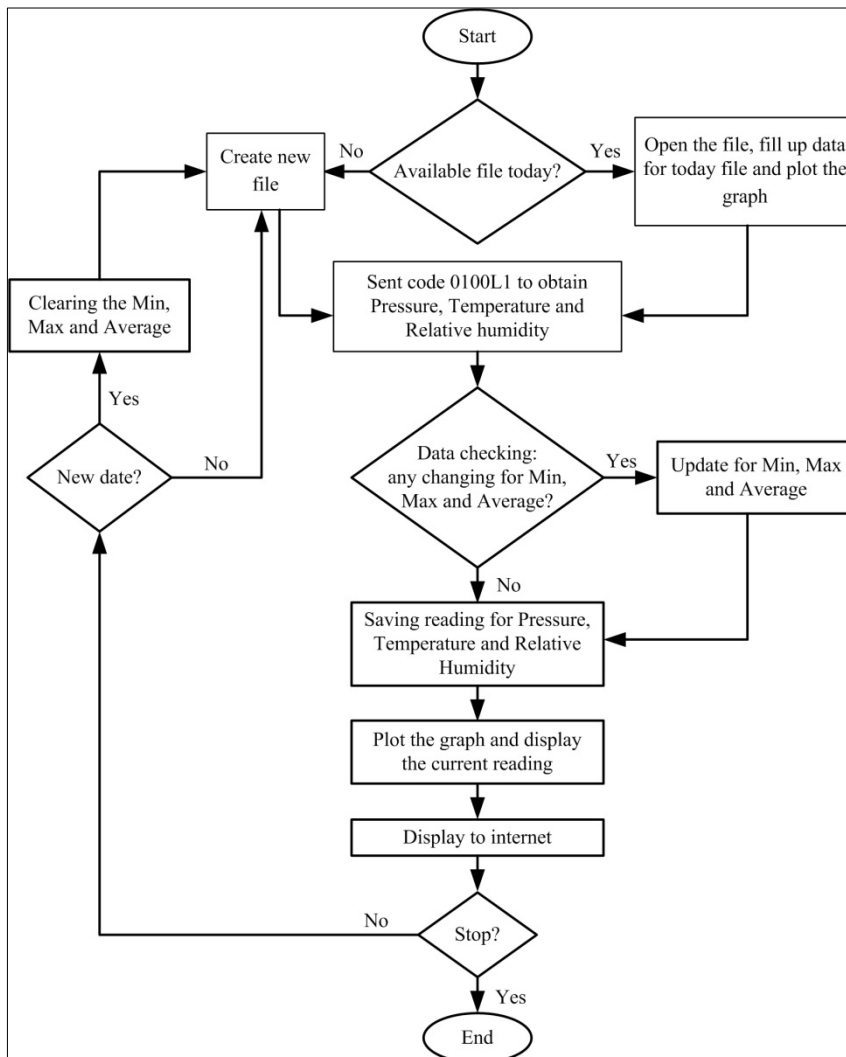

Fig. 2 A flow diagram for UKM Automatic Weather Systsem (UAWS).

There are eight steps to accomplish the UAWS development.

a). Opening the port with setting as follows:

```
MSComm1.CommPort = Mid(COMPort, 4)        'Select COM Port
MSComm1.RThreshold = 1
MSComm1.InputLen = 1
MSComm1.Handshaking = comNone
MSComm1.Settings = COMSpeed & ",N,8,1" 'Entry Baudrate COM Port
MSComm1.PortOpen = True   'Open COM Port
```

b). Send the code to MET3A/MET4A sensors:

```
MSComm1.Output = "*0100L1" & vbCrLf  '*0100L1 sending to sensors
```

c). The MET3A sensors received the responses one by one.

```
Public Sub MSComm1_OnComm()
        Dim CharIn As String
        Select Case MSComm1.CommEvent
        Case comEvReceive   'Select data accepted
            CharIn = MSComm1.Input
     End select
End Sub
```

d). Save the data into a file with *.txt format.

```
Open strFilePath For Append As #1     'strFilePath is where file will be saved
    Print #1, strData   'strData is data to be stored into a file
Close #1    'File closed
```

e). Read the information saved in the database (*.txt).

```
Open filePath For Input As #1
   While Not EOF(1)
      Line Input #1, strLineIn
      [String manipulation code "strLineIn"]
Wend
 Close #1
```

After the data saved in the txt file, it will be saved to string "*strLineIn*". Then followed by manipulation to obtain the time and Y-axis values, and ended by plotting the graph.

```
[Code for displaying and naming the graph axis]
frm.graph(num).PSet (dataTime, dataY - lyMin), vbBlue
```

f). Uploaded the data into FTP.

```
InetFTP.URL = FTPHost       'Entry your FTP address
```

> *InetFTP.UserName = FTPUsername*   'Entry your *Username*
> *InetFTP.Password = FTPPassword*   'Your *Password*
> *InetFTP.Execute , "Put " & FilePath & " " & FileNameFTP*
> (*FilePath* is a file needs uploaded)
> (*FileNameFTP* is file name given after the data uploaded into FTP)

g). To change the current active directory:

> *InetFTP.Execute , "CD " & FTPDir(x)* '*FTPDir(x)* is directory name

h). Using a *Timer* (after pressed the *cmStart*, *Timer1* is started).

> *Private Sub cmdStart_Click()*
> > *Timer1.interval = 4000*   'Call *Timer1* every 4s
> > *Timer1.enabled = True* 'Starting *Timer1*
> *End Sub*
> *Private Sub Timer1_Timer()*
> > *MSComm1.Output = "*0100L1" & vbCrLf*
> *End Sub*

2.3. FTP setting

Fig. 3 shows the *Command Prompt* used to open a FTP. It can be opened through *cmd.exe*. Type a"ftp" and followed by "*open* <your ftp >", fill in your *username* and *password* (if any). Your FTP address should be given by your authority company, or from your personal servers. A file with name "AWS.jpg" will be displayed in the website after the data is uploaded to FTP every 5 minutes. A website to display the graph of measured parameters has been developed (not shown). From the figure, data in txt format has been saved into the FTP.

Fig. 3 *Command Prompt* to store the data via FTP.

3. RESULT AND DISCUSSION

3.1. UAWS GUI result

    Fig. 4a shows the UAWS that has been developed, installed and activated at the ANGKASA, UKM Laboratory. **Fig. 4b** shows more clearly the UAWS graphical user interface (GUI) that has been completed for one-day measurement. The system status showing the "*Connected*", "*Disconnect*", "*Running*" or "Stopped", and the FTP Status will show the "*Connecting*", "*Upload Complete*" or "*Fail to Upload*". The status for "*Last Update*" will display when the last data updated. A user needs to press a "*Connect*" button to connect the meteorology sensors and then followed by a click "*Start*" button to activate the operation. After UAWS started and a file was created, they will read and automatically starting to acquire the data from MET3A/MET4A, plotting and stored the data into a computer. The file created following the YYMMDD in a daily format. Overall, the system has an advantage to open the saving file and upload it to the FTP every day. The system also captured the graph and saved to local directory in JPEG format, and it later uploaded to FTP every 5 minutes.
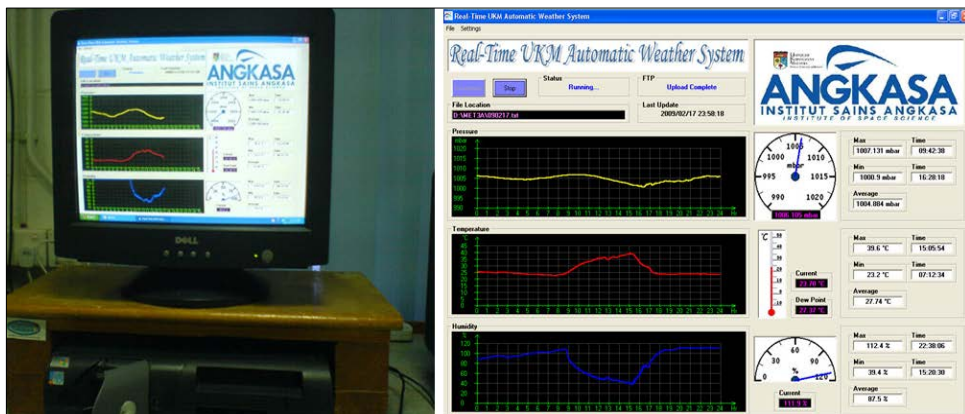

Fig. 4 UAWS at ANGKASA, UKM Laboratory **(a)** the system and **(b)** GUI.

    As demonstrated in **Fig. 4b**, the plotting graph is pressure vs time, temperature vs time and relative humidity vs time in a daily based. The quantity measured at the current time is exhibited by reading of each needle (similar as in an analog meter). Measurement of pressure is in mbar, temperature in degree Celsius and relative humidity in percent. In addition, Dew Point can be calculated and displayed. It is calculated by using a formula given as follows (see *Suparta, 2008*):

$$D = [(0.198 + 0.0017 \times T) \times RH] - 19.2 + 0.84 \times T \tag{1}$$

where D and T are *dew point* and temperature, which both are in degree Celsius units, respectively. RH is the relative humidity in percent. The UAWS GUI also shows the basic statistic (Min, Max and Average) with their time occurrence from the beginning to the current measurements.

3.2. Database management

Data from this measurements is very important such as for meteorology applications. In this work, data are managed from menu options. From **Fig. 4b** on the menu "File", data can be opened by "Load Data". **Fig. 5a** shows the GUI for selecting file to be opened. When the file selected from GUI, user can see the previous data and a graph pattern. The values for minimum, maximum, average, and when the last data updated is also presented (similar to **Fig. 4b** presentation).

Every day, UAWS will create a new file to store the data measured. The format of file name that stores the weather information is YYMMDD.txt, where YY is the year, MM is the month and DD is the day. For example, on day 1January 2009, the data will be stored with 090101.txt file name. The content of data stored in that file when opened using a Notepad is shown in **Fig. 5b**. The format of the data content is YYYY/MM/DD, hh:mm:ss, <Pressure (bar)>, <Temperature (˚C)>, <Relative Humidity (%)>. As can be seen in **Fig. 4b**, data are sampled every 4s.
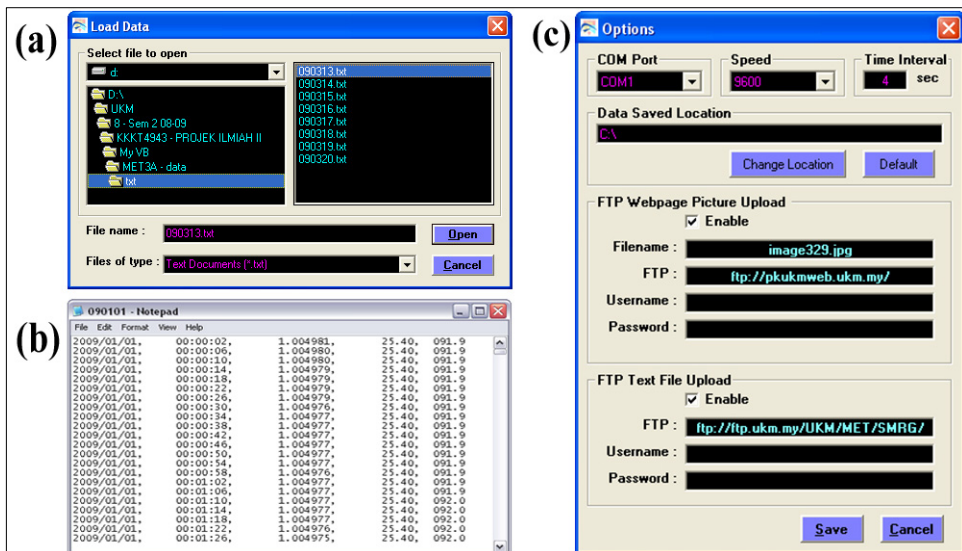

Fig. 5 Database management from menu options (a) Select file to open, (b) type of data, and (c) data uploaded through a FTP.

For uploading the data into FTP (see **Fig. 5c**), make sure that in the "Options" menu the COM Port, baud rate (*Default* is 9600) and data saved location is correct. Fill in all informationd required for FTP such as FTP address, *username* and *password*. When it is completed, then click "Save". Note that the data uploaded to FTP is similar that of stored in the local directory of computer, except the sampling interval is changed (*Default* is 4s). In addition, the graph presented in **Fig. 4b** was also stored to FTP in JPEG format. This picture will be uploaded later into a website address and updated every 5 minutes. With data available in the internet, it can be downloaded at anywhere and anytime around the world for scientific or any purposes.

3.3. Discussion

The advantage of UAWS developed it can save the weather information automatically every day to the computer and FTP. The previous data can be opened, and all size parameters can be plotted simultaneously in one screen. If the electricity recovered from shutdown at some period, the system could continue to store data in the same file on the day, the data stored in the file before shutdown is not lost. This is different with DQI software, when the power shutdown, the system always creating a new file. Because the DQI provided might be only for testing connection, there is no strategy how to combine automatically all files created during the day and how to solve the missing data. With UAWS, the missing data or no observed data due to power blackouts from opening file was solved as depicted in **Fig. 6**. As seen in the figure, the time series of the data will be continued until end of the day (at 24:00). To save valuable data and operating system, and if the data to be needs for certain purposes, an uninterruptible power supply (UPS) should be provided.

Fig. 6 Missing data due to the electricity problem has been handled by UAWS.

In the view point of sensor resolution (http://www.paroscientific.com), the total accuracy of pressure sensor for MET4A is better than ±0.08 hPa over the extended barometric range of 500 to 1100 hPa (or, from 620 to 1100 hPa for MET3A). There is no significant resolution different for temperature and relative humidity sensors, both ranges are operated from -50 to +60 °C and from 0 to 100%, respectively. With this performance,

the weather information that has been acquired by UAWS of several months found the patterns of pressure, temperature and relative humidity have a relationship to each other. In this result, the relative humidity varies inversely with temperature, because when the temperature rises, the moisture will decrease, and vice versa. On the other hand, the pressure pattern is depending on the amount of air above the location of sensors installed. It is generated by the downward force of Earth's gravity, and their values were higher (above 1013.25 mbar) for the station located in low latitude (e.g. equatorial region). The temperature pattern with sensor resolution of 0.01°C showed a sinusoidal which is a higher in the afternoon and a low in the early morning (local time). This pattern was clearly influenced by solar radiation.

4. CONCLUSION

A UKM Automatic Weather System (UAWS) has been developed using a Visual Basic program. This system has been tested and has the capability to measure the weather (pressure, temperature and relative humidity), manipulate the information, displaying the real-time measurements in GUI platform, storing the data into computer and FTP. The parameters measured are based on the broadband meteorological MET3A/MET4A sensors developed by Paroscientific, Inc. The data measured from the sensors and saved automatically with handling systematically the period of missing due to the electricity problem will give a benefit to forecaster and modeler for improving the weather forecasting and prediction. On the other hand, the connection for system developed and the sensors produced remain a further work that can be operated directly in all Windows based platform (e.g. Windows 7, Windows Vista, etc.).

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