Flood level indicator and risk warning system for remote location monitoring using Flood Observatory System

SIVA KUMAR SUBRAMANIAM [1], VIGNESWARA RAO GANNAPATHY [2], SIVARAO SUBRAMONIAN [3] and ABDUL HAMID HAMIDON [4]
[1] *Lecturer, Department of Industrial Electronics Engineering*
Faculty of Electronics and Computer Engineering
[2] *Tutor, Department of Computer Engineering*
Faculty of Electronics and Computer Engineering
[3] *Lecturer, Department of Manufacturing Process Engineering*
Faculty of Manufacturing Engineering
[4] *Professor, Department of Industrial Electronics Engineering*
Faculty of Electronics and Computer Engineering
Universiti Teknikal Malaysia Melaka
MALAYSIA

siva@utem.edu.my, vigneswara@utem.edu.my, sivarao@utem.edu.my, hamid@utem.edu.my

Abstract: - Flooding is a great treat towards mankind as it is also considered one of the most devastating natural disasters in the world. Flooding is not any abnormal scenario worldwide, since flooding results in great damages to agriculture land, residential area and even cities with high cost in lives and towards the economy of the country. The government has to spend tons of money in flood mitigation plans in afford to help the victims and also to reduce the number in the long run. Most of the flood mitigating plans has high cost and only can be implemented base on priority. Baring the cost and safety measures, this paper highlights the Flood Observatory System (FOS) as a warning and alert system to efficiently monitor the critical flood prone areas in real time basis. FOS can be deployed in flood prone areas in afford to create a well-used standard for remote flood observation systems. The ability to receive real time information on flood level empowers both government and private organizations to react to imminent danger in an effective manner. With the real time flood information, allows public safety organizations and other emergency managers to effectively plan their resource deployment within the limited time of alert. Warning as flood rises could be used to save life's and properties in many ways can help such organization and government to spend sufficient amount of money in restoration process. The simple and practicality of a system should be useful in all means towards mankind.

Key-Words: - Flood Observatory System, flood mitigation plans, wireless sensor, programmable logic controller.

1 Flooding and the impact towards mankind

Flooding is the most common natural disaster worldwide happens without prior warning. Floods have been known to do some significant damage. They destroy homes, crops, cars, buildings and anything in their path. Animals and people get caught in the current of the flowing water and can't get out before rescue attempts are made. Although flooding was an abnormal phenomena agers ago, but now it is considered a life treating natural disaster for the mankind [1].

Flooding has always resulting in enormous anxiety on countries across the continent whereby lost of life's, people displaced, agricultural land submerged in mud's, roads, bridges and houses washed away [2,3]. As a result of flooding, the damages on properties are clearly visible.

Many individual and organization required to spend time and afford to reduce the overhead on the flood restoration plans for the infected locations and as well as for the victims [4, 5]. Most of these plans involve big amount of money and lots of human force such as rescue workers, doctors, nurses, engineers and etc. Other then the human forces, the government has to spend a big amount of money in

various restorations of physical structures in the flood infected locations. If only early flood warning system has been effectively utilized, these losses can be reduced and appropriate steps in fighting against the flooding scenario can be taken in the shortest time within the available resources.

Some of the flooding events in the city of Kuala Lumpur, Malaysia and the damages being made by flooding are shown in Fig. 1 and Fig. 2.

Fig. 1: Flash flood in Kuala Lumpur, Malaysia

Fig. 2: Flash flood in Kuala Lumpur, Malaysia

In most cases flood water level rise faster and less time is given for the people for their evacuation. In some cases the people around the flood prone locations have to plans wisely and according to the water level change by them self's. The alerts for early flood warning system are usually intended for the respective organizations and authorities. When there is a flooding scenario in a certain location, this will take time for them to reach as water rises quickly in most cases [6 - 8]. At the peak of the flood, residential areas, public buildings and bridges will be submerged in flood and instant damages are to be faced.

In general flooding is unavoidable but the early detection or warning system can be used to reduce overheads bared by the victims and government.

The rescue activities in a flooding scenario in Kuala Lumpur, Malaysia is as shown in Fig. 3.

Fig. 3: Rescue workers recuing victims trapped in a van during a flash flood in Kuala Lumpur, Malaysia

There are many sophisticated system widely in practice by some organizations and responsible authorities in monitoring flood level in a certain location. Most of these devices are very high in costly to be used and maintained. Apart from that, these devices are usually used only for monitoring purposes between the flood prone location and the monitoring station [8].

With real time detection and alert system all the responsible organization can be on their toes when there is an urge for a certain task related to their core job during flood. Such a system enables both private and government organizations to work on their emergency evacuation and mitigation plans for a saver move before the flood situation gets worse.

Within a limited time and available man power the rescue team and fire fighting department has to plan for the best possible evacuation and rescue activities during flood. In most cases these rescue workers have to risk their life's in the afford to help

the flood victims to safety in the shortest time possible with the available resources.

The Fire fighting department is in a rescue activities during a flooding event is shown in Fig. 4.

Fig. 4: Fire fighters rescuing some flood victims during a flash flood in Kuala Lumpur, Malaysia

Researchers around the world are attempting many methods and to the best means of available technology in early flood detection and monitoring for remote locations. One of the methods and technology exploit in early flood detection and alert system is highlighted in this paper.

2 Important factors in the hardware development

Some of the critical factors during a flood event are such as highlighted in Fig. 5.

Fig. 5: Factors of flood

Studies have been carried out in many possible ways to highlight the factors and effects of flooding towards mankind from time to time. These factors play an important role for the researchers in development of the hardware and a complete system to assist authorities in monitoring flood prone locations in real time basis.

2.1 Time

Time is one of the most important factors in a flooding event. Time can be distributed into three categories. The three categories of time with the relevant activities are as shown in Fig. 6.

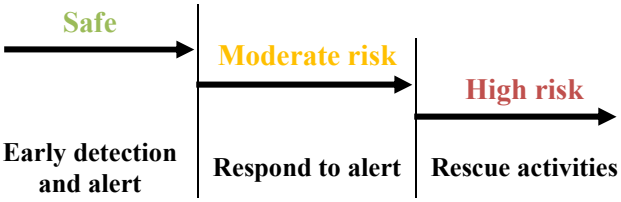

Fig. 6: The time distribution on a certain flooding event

2.1.1 Early detection and alert

At the event where water rise is detected indicating possibilities for flooding on a certain location is detected. This is the golden period where flood mitigation plans should be taken as precaution by both authorities and the people at the flood prone location before the water rise to a critical level.

Most of the available systems are able to detect the water rise and communicate it to the monitoring station or to the responsible authorities. When the water rise is still in safe level, the authorities are given the warnings of the possible flooding on a certain location. The duration taken from the first detection of water rise till the information is send to the responsible authorities is very important and should be done in the shortest time possible. Most of the system available today is only communicating to the engaged system in the monitoring center.

2.1.2 Respond to alert

Once the alert is received in the monitoring center, the authorities will respond to it based on the resources available. The rescue teams will be informed and there will be some personnel directed to the location of flooding to inform the people.

In most cases this process is time consuming and at times it is impossible to reach all the rescue teams at the same instance due to working time and weather conditions.

2.1.3 Rescue activities

This will be last stage, where the rescue team will be able to respond to the flood alert and make wise decisions at the flood locations. The time taken for the rescue team to reach the flood locations is very uncertain. At times this is a time consuming process and many drag time during bad weather conditions. Things will get even worse during of off working hours.

The traveling time to flooding locations is always considered critical since at this stage every seconds is important for the rescue team in the afford to help and save the flood victims.

2.2 Cost

The authorities are bond to two type of costing when they are investing into a system. The first type of costing is the costing of a certain device. Usually this would be paid once during the purchase. If the costing of a device is very high, then only a few critical and necessary flooding locations will be fitted with the flood monitoring system.

The second type of costing is the maintenance of the system. These costing are a long term commitment until the still is still in use. In most cases the maintenance cost would be high in the long run due to the replacement of necessary components, software licensing and etc.

2.3 Plan

During worse situation, the authorities have to make wise decision to assist the victims in the flooded locations. The authorities would be able to plan according to the time and available resources within for the rescue activities. In most cases the information on the flooded locations are informed during critical level and this makes the authorities to struggle in the rescue activities. Worse still if there are various locations to be monitored and wise actions to be made.

When a system is capable to alert the authorities as early as the water rises, then they may react accordingly in ensuring the safety of the flooded victims and every second count in the rescue afford.

3 Flood Observatory System

The Flood Observatory System is designed to be an intelligent system for monitoring flood at remote locations which has a high frequency of flooding. The Flood Observatory System is fully automated device which is capable of operating without human intervention at all time regardless of the location being installed.

The basic structure of the flood observatory system is shown in Fig. 6.

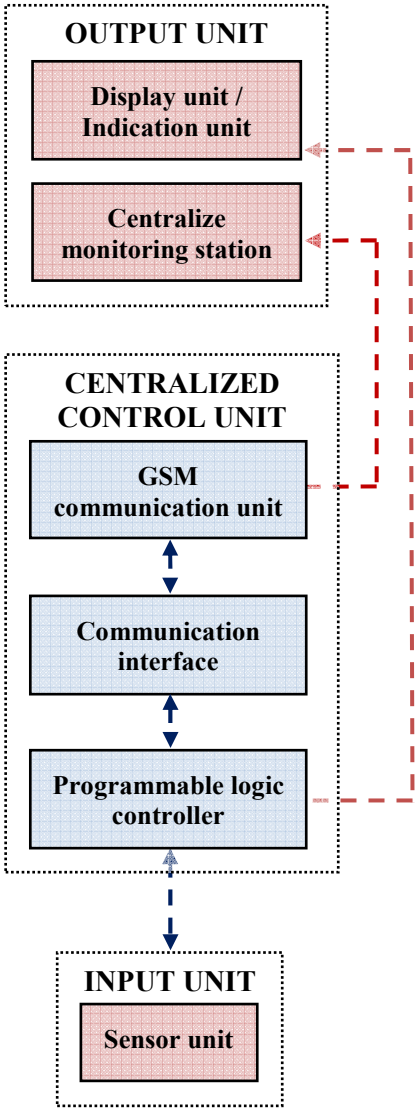

Fig. 6: Structure of a Flood Observatory System

Some of the features of the Flood Observatory System are very helpful for the monitoring station in assisting the monitoring station management when there is flood at the measured location. This self

operated system enables the monitoring station to be informed on the water level changes at a certain location on real time basis.

In most cases the flood prone locations requires regular monitoring and visits especially during rainy seasons since continuous rainfall can cause flooding [1 - 3]. The Flood Observatory System is best installed at locations where high potential of flooding for effective and timely monitoring.

The most valuable data given by this system to the monitoring station is instant water rise information. This information is calculated by performing a simple mathematical operation consisting of water level and real time. If a system is capable of sending such information in real time to the monitoring station without human intervention and regardless of the weather condition, wise decisions could be made in the shortest time possible.

Apart from alerting the monitoring stations, the system can also be used to trigger flood warning signs for road users, buildings and public areas instantly. Electronic display system will be best to display such information in public locations. When there are changes in water level at flood prone locations, the information can be translated and displayed in this display system.

Fig. 7 shows an example of sensors which can be integrated with the Flood Observatory System prototype with detection criteria. The number of sensors used in each system may vary based on the installed location and the water rise level.

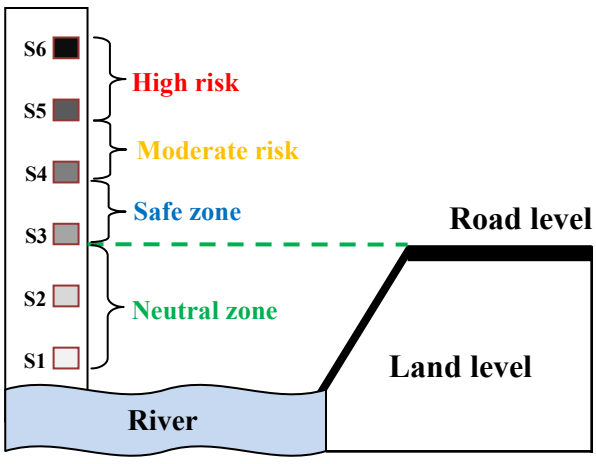

Fig. 7. Sensor position of the Flood Observatory System with the various level of risk zone

The Flood Observatory System consists of a number of components working together to perform simple repetitive task as preprogrammed [9]. The basic system requires s number of water detection sensors to detect the water level, a control unit to process the information and a GSM modem to establish wireless communication between Flood Observatory System and the monitoring station [9 - 11].

The water level is detected by utilizing wireless sensor technology which is designed to generate a digital signal from the monitored location. The Radio Frequency (RF) receiver is placed in the centralized control unit to receive signals to be processed. The real time water level information is sent to the monitoring station as programmed, via the short message system (SMS).

The Flood Observatory System consists of three main components which are connected to one another wirelessly via RF. The centralized control unit and display system can be placed at a distance away from the sensors situated in a remote high risk flooding locations.

The Flood Observatory System is capable of performing the entire process without human intervention.

3.1 Water detection sensor

Sensors are the best device to use in an automation system especially for remote locations where human excess is limited. There are many sensors which can be used in measuring water level. Studying all the available sensor and the best sensors for flood water measurement is using wireless sensor technology. The wireless sensor is employed as the best alternative for detection from a safe distance where the control system will not be placed in the flood prone locations. The sensor unit is designed to be located approximately 100 meters in radius from the centralized control unit.

Water detection at the flood prone locations using sensors is a critical task and will be very costly when it comes to replacement. Most of the water sensors in the market are very costly and the risk of damage is very high too. Basically there are two types of water detections sensors, which is contractive sensor and non contractive sensor.

The contractive sensors are the type of sensors which will be submerged into water and has direct

contact with water. This type of sensors are very cheap in cost but when it comes to durability is less due to the wear and tear on the sensors itself. The non contractive sensors are the type of sensors which is placed away from the water. This type of sensor is very safe and less maintenance in required. For the Flood Observatory System both types of sensors are used based on the critical position and water rise level on a certain flood prone location.

The water detection sensors are positioned at a certain location where water level measurement can best be obtained. One of the factors considered when positioning the sensor are weather conditions. During dry seasons the water level will remain at low level or at the safe zone and during rainy seasons the water level will rise drastically to high risk level.

The water level changes will be detected by the water detection sensors and the information will be instantly transmitted to the centralized control unit via RF. The output of the RF receiver is connected to the main control unit to update the system in real time.

Table 1 shows an example of flooding zone with alert/warning information.

Table 1. The risk zone in a flood event

Zone	Description
Neutral zone	All types of vehicle can use the road
Safe zone	All types of vehicle can use the road
Low risk zone	Heavy and light vehicle can use the road
Moderate risk zone	Only heavy vehicle can use the road
High risk zone	Road is closed for all vehicles

The water detection level is to be determined by the total number of sensors used in the system. The detection level which includes the minimum water detection level, highest water detection level and variance between each sensor are determined by the monitoring station management. This may vary according to the monitored location based on the water rise level.

3.2 Controller unit

The controller unit for the Flood Observatory System detects the information from the sensors wirelessly if there are any changes in the water level. Wireless communications is established via an RF transmitter and receiver in real time based on the detection, a programmable logic controller (PLC) process the data. The control unit will then send the information to the monitoring station via the SMS.

The communication between the Flood Observatory System and the monitoring station is established by using a GSM modem to send real time water level information and to receive special commands from the monitoring station [6 ,14, 15]. The PLC is connected with a GSM modem thru a communication interface to perform communication as programmed in the system [4]. The prototype of a Flood Observatory System and the water level simulator is shown in Fig. 7.

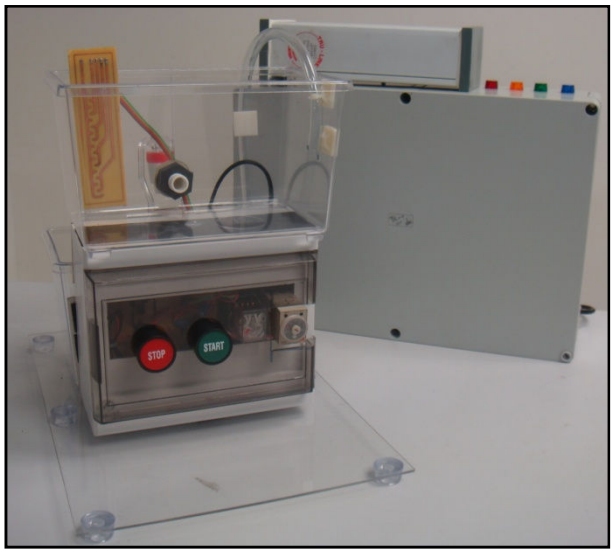

Fig. 7. The prototype of a Flood Observatory System

The control unit is also programmed to perform basic calculations on the next water level prediction based on real time sensor detection. The water rise prediction time can then be transmitted to the monitoring station as programmed. The water rise prediction is the comparison from one level to another level. The water rise time prediction message will be instantly transmitted once the water level increases from one level to another. The number of zones is determined by the management in the monitoring system is based on the frequency of water rise in a monitored location.

The Flood Observatory System simulator and the visual indication system is shown in Fig. 8.

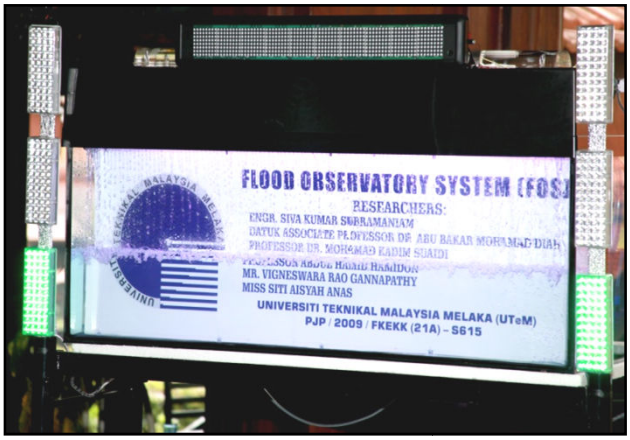

Fig. 8. The Flood Observatory System simulator unit with indication system

3.3 Display and warning indication

Apart from sending real time water information the Flood Observatory System is capable of displaying warning signs if required. For example a running LED text display unit is connected to the control unit to display and alert road users on safety during flood.

The display unit will display a few sets of information which are very useful to road users to avoid damage to their vehicles. The display system is designed to be placed at a distance of approximately 100 meters in radius from the control unit. Apart from the text display unit, the control unit can also be connected to a nearby traffic light as a warning system for road uses approaching the flood prone locations. The traffic light system can be used to indicate the road conditions during flood. The system is capable of determining whether the road is safe for users as the water level changes.

4 Operation of a Flood Observatory System

The system operates with a few sets of water detection sensors which are located on the river bank or any location where the water level measurement is required. For the prototype unit shown in Fig. 7, there are four sensors connected to the system.

As the water level changes, the detection on the sensor will increase according to where the sensors are placed. The sensors will send the detected information wirelessly to the control unit. The control unit will determine which input port is to be used to indicate the water level.

Based on the detected port, the PLC will send the information to a communication interface to transmit the water level information in SMS format to the monitoring station management. The Flood Observatory System can be programmed to transmit SMS to the monitoring station management on all water change information i.e. changes in a fixed level periodically during normal operations [16].

The Flood Observatory System is also capable of responding with the monitoring station management at any time. When the GSM modem receives a SMS command from the management, it sends the information to the communication interface [7, 8]. The SMS will then be converted and send to the PLC. The PLC will read the sent code and run a system check on the current water level placed at a distance away and sends an instant reply message to the monitoring station management on the latest water level information [8, 16].

5 Advantages of Flood Observatory System

The new revolution in alerting both the remote station personnel and users on real time water level information using Flood Observatory System is an effective and efficient technique. Instant alerts on water level change using SMS is the most common technology that humans are engaged with during working hours and during their leisure time [7, 8, 16]. In addition to that the remote station personnel's are also capable of checking real time water level status just by sending a SMS to the Flood Observatory System. The control system embedded on the flooding location will instantly respond the users of the current status.

The advantages of Flood Observatory System compared to the conventional system which is the manual data collection by humans at the flood prone locations are shown in Table 2.

Table 2. Factors on water level monitoring by conventional system

Factors	Conventional system	FOS
Receive real time water level alerts	No	Automatic
Display instant warning sign	No	Automatic
Request remote location water level information	No	Instantly
Initial cost of installation	Daily basis	Low cost

The conventional system is still widely practiced in most countries. The management has to depend on manually collected data from the flood prone locations periodically. This method is not only expensive but impractical during bad weather conditions.

The advantages of the Flood Observatory System comparing to software based system are shown in Table 3.

Table 3. Factors on water level monitoring by software base system

Factors	Software system	FOS
Receive real time water level alerts	Automatic	Automatic
Display instant warning sign	No	Automatic
Request remote location water level information	Instantly	Instantly
Initial cost of installation	Very costly	Low cost
Maintenance	Very costly	Low cost
Upgrading the system	Very costly	Low cost

There are some sophisticated software's for monitoring the water level change from a distance [4, 6, 7]. Custom made software's are only practical on a one to one basis, whereby the monitoring station management can only monitor a single station at one time. The system also requires internet connections and not practical for remote locations.

The system has a few factors within the capability of a Flood Observatory System, but the only difference is in the costs for initial investment and also for long run maintenance.

5 Conclusion

The Flood Observatory System is designed to be an intelligent gadget which is capable of sending real time water level information from a remote location to a monitoring station which could be at a distance away, regardless of time.

The Flood Observatory System is a standalone unit which requires no additional devices or system to work with it. The self monitoring in the Flood Observatory System ensures that the system performs efficiently and reliably for the monitoring station. At the event of a system failure, which includes failure in the sensor unit and power supply unit failure will be notified to the monitoring station personnel via SMS in real time basis.

The Flood Observatory System can be linked to a visual and audio unit to display warnings and alerts the users via text displays or traffic light system in an event of flooding.

The implementation cost is invaluable to the efficiency and usefulness of the system towards mankind. The practicality of the system helps to minimize overheads due to floods and also prevents catastrophe at flood prone locations. A system for flood monitoring and alert system was developed especially for critical flood prone remote locations to ensure mankind safety and savings to all sectors.

6 Future works

Sensors are important elements in the Flood Observatory System. Further studies on wireless sensor technology will be best to replace the current sensors. Precise and accurate detection of water

level will improve the data collection system for the monitoring station.

The flood alert information's can be displayed on LED display boards for road users and for safety reasons could be placed at strategic locations. Such information's should be in real time and transmitted wirelessly from the measured location.

A possible means of power supply for the sensors and centralized control unit is via solar cells. The Flood Observatory System will be easy to install and maintained if it is powered by solar cells. The use of solar energy will also provide cheaper source of power to the entire system to operate especially if the system is placed in a remote location. For sustainability the circuits and control unit should be designed to consume minimum power during operation.

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Ministry of Works Melaka (JKR)

8 Patent

The Flood Observatory System is being filed for patent in October 2009 and still in the process of granting the patent entitled a self monitored flood Observatory system. The patent pending number is PI: PI 2009 4488.

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10 Biographies

Siva Kumar Subramaniam was born on 16 July 1981. He received his Diploma of Electronics Engineering from Politeknik Ungku Omar, Malaysia in 2002. He then graduated with a Bachelor Degree in Electronics Engineering (Industrial Electronics) from KUTKM Malaysia in 2006 and his Master studies in Electronics Engineering in the same institution in 2009 which is now known as Universiti Teknikal Malaysia, Melaka. Engr. Siva Kumar is working as a Lecturer in the same organization ever since of graduating. Since his keen interest in industries matters and strong support from the university, the author is involved in the development of the industrial based application such as monitoring systems, automation for industries and control base applications. Engr. Siva Kumar has a few collaboration with industries in accomplishing a number of research projects and consultancy works in Malaysia for the past few years. He was involved in such projects from his basic degree whereby he won several medals in National and International competitions such as the MTE, ITEX and PECIPTA. Apart from research works with industries, Engr. Siva Kumar also supervises Diploma and Degree students for their final year projects within the same institution.

Vigneswara Rao Gannapathy was born on 30 August 1982. He is currently serving as a tutor in the Computer Engineering Department in the Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM). He received his Certificate of Electronic Engineering (Telecommunication) in 2002 from Polytechnic of Shah Alam, Malaysia. He then pursue further in his higher education and received his Degree (B. Eng) from University Technical of Malaysia Malacca (UTeM) in Electronic Engineering (Telecommunication) in 2007. Currently, he is doing his Master studies by research in Wireless Communication Engineering at University Technical of Malaysia Malacca (UTeM) and expected to finish his Master (MSc) by June 2010. His research interests are in the field of wireless communication and networks, in particular medium access control, routing and cross layer design. His research direction has focused on Wireless Mesh Networks which emerged as a key technology for next-generation wireless networking. Mr. Vigneswara Rao also actively participated in numerous competitions in National and International

level in Malaysia and have won a few medals for a number of research projects.

Ir. Sivarao is an academic and researcher at the Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM). He is a Professional Engineer in the field of mechanical engineering. He is currently active in his research area namely precision machining, Product design and artificial intelligence in the area of manufacturing. He has published his research finding in few international journal and proceedings. He is also a reviewer for UK based JEM, JMES and JEEER journals. His product innovation has won him eight medals including few from Geneva.

Abdul Hamid bin Hamidon @ Hamid Don was born on 3 March 1950. He received his Bachelor of Electrical Engineering from Monash University, Australia and Masters of Science (Electronics) from the University of Wales Institute of Science and Technology, Cardiff, Wales. In 1976 he began his career as lecturer with Fakulti Kejuruteraan Elektrik UTM. In 1986 he was promoted to Associate Professor and made the Deputy Dean (Academic) for 6 years. In 1995 he was Director of the Student Support Services Unit. He was also Head of the RF Subsystem Research Group and was responsible for several course and curriculum development. He was one of the task force responsible for the development of KUTKM now known as Universiti Teknikal Malaysia, Melaka. In 2001 he promoted to Professor and was made the Dean of the Electronic and Computer Engineering Faculty.