MIDDLE EAST TECHNICAL UNIVERSITY

COMPUTER ENGINEERING DEPARTMENT

CENG 491

REQUIREMENT ANALYSIS REPORT

HSBS SMART

SERKAN ÇAĞLAR	1347285
BURAK CANSIZOĞLU	1347244
SERDAR KOÇBEY	1250471
HANİFİ ÖZTÜRK	1298140

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1. INTRODUCTION

1.1 Purpose of the Document

In this report, the requirement analysis of a Wireless Sensor Network (CENGAP-WSN) Project is presented.

CENGAP-WSN project involves implementation of a wireless sensor node and establishing a wireless sensor network using these nodes. The project will be carried out by the HSBS Smart team during 2007-2008 academic year.

In the first part of this report, the general project description is given. In addition to this, application areas of the WSN are presented. Furthermore, a summary of literature surveys and market research are shown. In the second part, hardware requirements, software requirements and non-functional requirements are explained. In the third part, data modeling and analysis is done via Use-Case diagrams, ER diagrams, Data-flow diagrams and State transition diagrams. In the fourth part process model and time schedule are presented.

1.2 Detailed Problem Definition

As the technology evolves, usage of wireless networks has been increased remarkably. In parallel to this, application area of embedded systems integrated with wireless networks has expanded. As a result of this development, wireless sensor networks emerged in the last decade.

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations.[1]

In this project, firstly, a wireless sensor node is going to be implemented. Then, using one or more of this node, a wireless sensor network will be tried to be established.

The process of the implementation of the wireless sensor node will include a group of sensors, a hardware platform which can drive these sensors and an AirTies AP-400 which is going to be used as an access point. The steps of this process are:

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[1] http://en.wikipedia.org/wiki/Wsn

1. Developing a hardware interface in order to provide a connection between some digital sensors and AP-400. This hardware interface will be a board like the board which is used in CENG 336 course. This board will consist of a microcontroller and essential integrated circuit parts. In addition to these, the sensors will be assembled on the board.
2. Developing a communication protocol between the board and AP-400 through RS-232 cable.

After obtaining a wireless node, procedures will continue as:

1. Developing a protocol for communication between a wireless node and the server.
2. Storing incoming data from the wireless node on a database.
3. Developing server side software to compute and analyze data stored in the database.
4. Effectuating a scenario using this WSN.

1.3 Application Areas

There are many different applications for WSNs. They have some advantages over wired sensors. For instance, some applications can be carried out with less effort and money or without the need of power supplies for a long time. Typical applications of WSNs are:

- Environmental monitoring
- Habitat monitoring
- Acoustic detection
- Seismic detection
- Military surveillance
- Inventory tracking
- Medical monitoring
- Smart spaces
- Process monitoring
- Structural health monitoring
- Health monitoring

1.4 Literature Survey

1.4.1 PIC-16F877

Using PIC-16F877 as the microcontroller has some assets. These can be listed as follows.

1. This microcontroller has on-chip analog to digital conversion capability which would help reduce the chip count and therefore the cost of the project.
2. It is flash programmable which would reduce the development time.
3. It is based on the concept of reduced instruction set computing (RISC) which will simplify the coding process.

Properties of PIC-16F877 are as follows.

Speed	DC – 20MHz
Program Memory	8Kx14 word Flash ROM
EEPROM data memory	256 byte
User RAM	368x8 byte
I/O number	33
Timer	Timer0, Timer1, Time2
A/D converter	8 channel 10 bit
Serial interface	SPI(Master) and I2C(Master/Slave) SPI port(synchrony serial port)
Parallel slave port	8 bit, external RD, WR and CS control
USART/SCI	9 bit with address

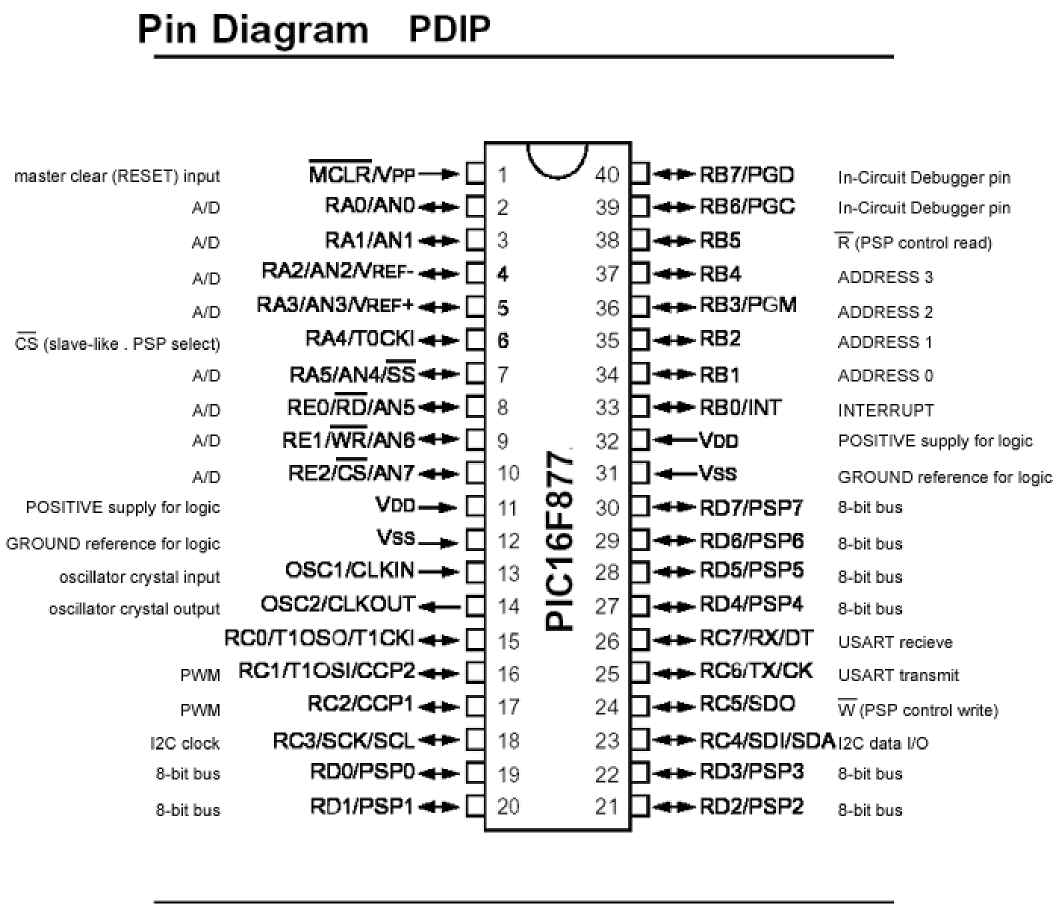


Figure 1.1 Pin Diagram of PIC16F877

1.4.2 AirTies AP-400

AirTies AP-400 will provide Wi-Fi property to the sensor nodes that are going to be built and will broadcast the data that is acquired from the sensors.

<u>Main Features:</u>

- All-in-one solution: 802.11 b/g compatible, 54Mbps Wireless Access Point, Bridge, Repeater, and 4-port Switch
- Maximum Wireless Access range and Mesh Technology: AirTies Mesh Technology support to extend wireless coverage area across very wide areas or concrete buildings where signal strength problems are common
- Multi SSID support for forming multiple wireless networks with a single AP-400
- VLAN feature provides the ability to set up secure virtual networks between different ports of the AP-400.

- Advanced Wireless Security: WPA (Wi-Fi Protected Access), WPA2 (IEEE 802.11i), WEP (Wired Equivalent Privacy) encryption and 802.1x standards
- Fully compatible with widely used Centrino laptops
- Used as a Wireless Bridge, ability to include up to 4 wired devices with an Ethernet interface in the wireless network
- Wireless operating ranges of up to 400 meters outdoors and 100 meters indoors
- High performance through the use of the latest chip technologies
- Automatic detection of straight and cross Ethernet cables with Auto MDI/MDIX feature
- Automatic local IP address assignment by the DHCP server
- Easy to use Web-based user interface
- Firmware updates through the Web interface

Technical Specifications:

- Ports: Removable antenna (Reverse SMA connector type), 5 Ethernet ports (1 WAN + 4LAN; auto MDI/MDIX), 9V DC power in
- Wireless Transmit Power: 20dBm EIRP
- Wireless Security: WPA (802.1x, TKIP, PSK), WPA2 (IEEE802.11i, AES, CCMP), WEP (64/128 bit), MAC filtering,
- SSID hiding
- Wireless Standards: Compliant with IEEE 802.11b, 802.11g, 802.11d, 802.11e and 802.11i standards
- LEDs: Power, WLAN, WAN, LAN1, LAN2, LAN3, LAN4
- Wireless Data Rates: 1, 2, 5.5, 6, 9, 11, 12, 24, 36, 48, 54Mbps (auto speed adjustment)
- Frequency: From ETSI 2400MHz to 2483.5MHz (13 channels, 3 not overlapping)
- Power: External 9V power adapter
- Mounting: wall or desktop
- Reset button to return the device to default factory settings

Figure 1.2 Airties AP-400

Having these properties, AirTies AP-400 makes the project gain functionality. For instance, with the help of mesh technology, wireless nodes will have more range than available products in the market. Besides that, multi-functionality property (access point, bridge, and repeater) will make it possible to access and process data more easily and faster.

1.4.3 Sensor

The sensors that are going to be used in the project should satisfy two main requirements. Firstly, the sensors should have I^2C bus protocol[2] in order to forward data from the sensor to the PIC-16F877. Secondly, the sensors should be digital in order to transmit data between the sensors and PIC-16F877 more accurately and without the need of A/D conversion. In the project, temperature and humidity sensors will be used. In consideration of reducing the cost of the project and the product, a type of sensor that can measure both temperature and humidity will be preferred. SHT15 is a proper sensor that will meet the needs of the project. Features of the product are as follows.

- 2 sensors for relative humidity & temperature
- Precise dew point calculation possible
- Measurement range: 0-100% RH
- Absolute RH accuracy: +/- 2% RH (10...90% RH)
- Repeatability RH: +/- 0.1% RH

[2] *Inter-Integrated Circuit is a multi-master serial computer bus invented by Philips that is used to attach low speed peripherals to a motherboard, embedded system or cell phone.*

- Temp. accuracy: +/- 0.3°C @ 25°C
- Calibrated & digital output (2-wire interface)
- Fast response time < 4 sec.
- Low power consumption (typical 30 μW)
- Leading CMOSens Technology for superior long-term stability
- Very easy-to-use due to calibration & digital 2-wire interface

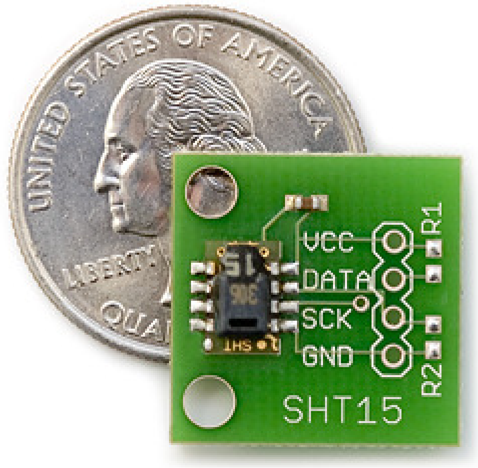


Figure 1.3 SHT15

1.5 Market Research and Results

1.5.1 Costumer Research

A senior electronics engineer Mehmet Bozuyuk from Tertek Ltd. which offers automation solutions for textile manufacturers stated some facts why they apply WSN solutions for their costumers in automation. First of all wireless applications lower the overall cost by removing the wiring expenses and possible future failures. Less noise problems occur compared to wired systems since the products execution areas are factories, production lines or warehouses. Mr. Bozuyuk has also stated that the products that they use currently are based on ZigBee but they are planning to use Wi-Fi for some new projects in order to maintain a higher security level, more portability, extensibility and larger scales of implementation.

Another academic contact from leading technical university of Turkey who is working on robotics mentioned what features they require for a wireless network and cons and pros of using Wi-Fi infrastructure for their studies. The main issue he stated as good was the portability feature of Wi-Fi such that since all university is covered with Wi-Fi infrastructure, no additional hardware required and the WSN scale is bounded with the boundary of this infrastructure. Another point is the convenience that would be provided if they could access their robots from their computers that have Wi-Fi. On the other hand the price of the devices that they are already using is far lower than HSBS Smart can offer but overall price can be feasible with the use of existing Wi-Fi infrastructure. Another disadvantage is that the product device does not support adjustable range, although the range of Wi-Fi overcomes the ZigBee. Since the Wi-Fi is not an option for robot studies yet this does not mean the forth coming improvements will not gather the attention of this area.

1.5.2 Cost Analysis

A detailed Internet search can show that the wireless sensor technology with Wi-Fi (IEEE 802.11) module is a new area since the Wi-Fi technology was assumed to require high energy, and was not useful for standalone wireless sensor nodes because of short battery life. Therefore, other protocols like ZigBee (IEEE 802.15.4), Bluetooth (IEEE 802.15.1) dominate the sensor network market. The wide usage of these types of protocols made the sensor vendors face to develop new solutions in this area and this resulted in high availability and low prices of these type devices (ZigBee, Bluetooth). On the other hand Wi-Fi is a better choice for the advantage of faster development and also there is a Wi-Fi infrastructure in most of the universities, schools, hospitals, large companies; adding sensors cost is lower compared to ZigBee, Bluetooth since the infrastructure can be reused.

On this verge there are some new low-power SoCs (System-on-a-Chip) solutions on the market that use Wi-Fi infrastructure. The vendors like GainSpan revealed such SoCs with battery life of 5-10 years in 3-4 inch devices. Moreover, vendors like Oceana Sensor are intended to leverage these SoCs for their new sensor types which will allow them to produce standalone Wi-Fi sensor nodes with long battery life. This also brings the advantage of non-proprietary if the open Wi-Fi standard is used in common which means that different devices from different vendors can be used in order to set up a network together. The Wi-Fi sensor solutions offered on market can be sampled as follows:

- WseM™ $75.00 Oceana Sensor Technologies, Inc.
- Temperature Sentinel N/A Aginova, Inc.
- TandD Web Enabled Temperature/RH Logger MicroDAQ.com, Ltd. Company

Another aspect of creating standalone Wi-Fi sensor networks combining a websensor (Ethernet interface) with the AirTies AP-400 via Internet. From this point of view, the AP-

400 can be occupied by 4 websensors to compose a multipurpose sensor node. Although this solution would satisfy all needs of such network and easy to implement, the cost is very high since websensors themselves are sold at high prices at market. The websensors on the market can be sampled as follows:

- EM01B-STD Websensor Standard $440.00 Esensors, Inc.
- SensorProbe2 $250.00 Grid Connect, Inc.
- PIC-MAXI-WEB $109.95 Olimex Ltd.

Further, there are other options of creating a wireless sensor node using commercial components like assembling serial port sensors and the AirTies AP-400. However, this solution is also not going to be an efficient one regarding high cost, high energy consumption and low performance. Therefore engineering a wireless sensor node from scratch is preferable. There is a wide range of sensors on the market that can be controlled with a control unit like PIC. Hence developing a sensor and control unit and assembling it to AP-400 is a cheap and reliable choice. Digital sensors on the market can be sampled as follows:

- One Wire Digital Temperature Sensor $4.25 SparkFun Electronics
- Humidity and Temperature Sensor $41.95 SparkFun Electronics

The overall evaluation of the market shows that faster development opportunities and functionalities come with high prices.

1.5.3 Field Research

The Wireless Sensor Networks (WSN) are increasing their popularity in every area of our lives. Hence new technologies are being developed everyday. However Wi-Fi (IEEE 802.11) technology could not get the attention of this market until the early 2007. There are too few companies using Wi-Fi for their sensor products. Further there are too few Wi-Fi WSN applications on the world. However this does not mean the need of this type of sensors is low, on the contrary Wi-Fi sensors and WSNs are promising investment fields for chip vendors.

Bluetooth and ZigBee based WSN applications seem to meet the consumer needs at present but, introduction of Wi-Fi substitute for these systems will offer more security, flexibility, reliability and interoperability. To conclude with Wi-Fi as a mature technology in networking, is still young for WSNs. Benefits will be highlighted in the future as it is going to dominate the wireless sensor market.

1.5.4 Results

Considering the field research and feasibility studies, building a sensor node via sensors on the market, microcontroller unit and ap-400 is an acceptable option. This will end up with a multipurpose device which can act as sensor node or repeater or bridge according to situation. Besides that, the cost of the device will be low compared to other options. There are of course disadvantages too, such that, time and cost of the RD will increase, the product will still be power hungry and applications might be restricted because of this.

2. REQUIREMENTS

In order to manage the project effectively, it is required to determine and use the resources perfectly. Therefore, a full understanding of the requirements prevents difficulties and unexpected situations. These requirements can be divided into four parts.

2.1.Hardware Requirements

According to field research, hardware equipments that are required for the project are as follows.

- **PIC-16F877:** A CMOS FLASH-based 8-bit microcontroller that supports I^2C and RS-232 protocols.
- **Airties AP-400:** AirTies AP-400 is a multi-function wireless communication device that can be used as a 54Mbps Wireless Access Point, Repeater, Bridge, and a 4-Port Switch.
- **Server:** Server will collect data that is broadcasted by the wireless nodes and store that data in a database. Besides this, a program will run on the server that will analyze process and monitor collected data. Minimum requirements for the server are:
  - Intel Centrino CPU or compatible
  - 512 MB RAM
  - 80 GB HDD
  - Super VGA (1024x768) or higher-resolution video adapter and monitor
- **SHT15:** A digital sensor that can measure both temperature and humidity.
- **Parallel Cable:** Parallel cable will be used to program PIC-16F877.
- **RS-232 Cable:** RS-232 cable will be used to provide the connection between PIC-16F877 and AirTies AP-400.
- **USB to Serial Converter:** USB to Serial Converter will be used to reach AirTies AP-400 from a PC.

2.2.Software Requirements

The software requirements can be examined in three parts, development tools, helper programs and platforms.

Development tools:

- **CCS C Compiler:** The set of compilers that are developed exclusively for Microchip PIC, is essential for the project since PIC 16F877 is going to be used as microcontroller of sensors.
- **MPLAB:** An Integrated Development (IDE) which is a free integrated toolset for the development of embedded applications on Windows.
- **gcc/g++:** GNU C and C++ Compiler which will be used to compile the source for the Linux AP LSDK+WLAN 5.0.0 .
- **gcc for uClibc:** The compiler for uClibc (a Small C Library for Linux) which the programs that are going to run on AP-400 will be compiled with.
- **Eclipse:** For the Java IDE that is going to be used to develop server side software.

Helper programs:

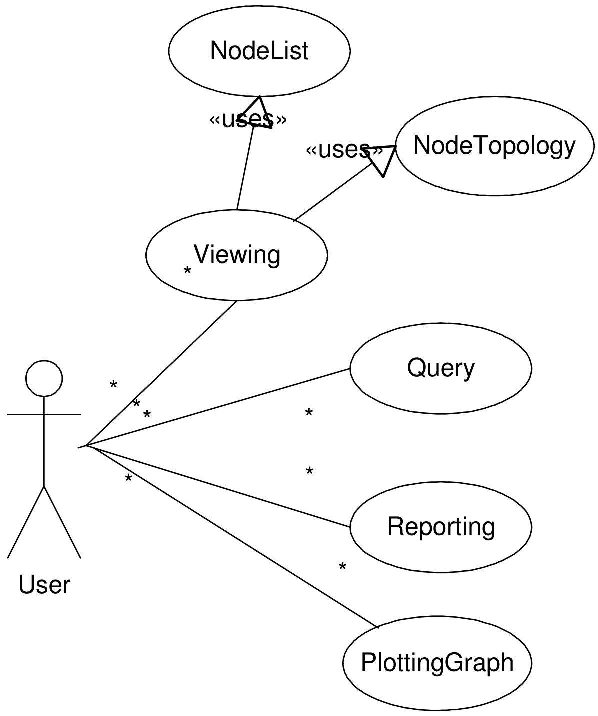
- **TeraTerm Pro:** Terminal emulator and SSH module "TTSSH" which will be used to connect and operate on AP-400 via serial port.
- **Odyssey:** PIC microcontroller programming application for Linux which will be used to program the PIC 16F877 via parallel port.
- **WinPic800:** PIC microcontroller programming application for Windows XP/Vista which will be used to program the PIC 16F877 via parallel port.
- **Altium Designer:** The electronic product development tool for designing the sensor board.

Platforms:

- **MySQL/PostgreSQL Server:** The relational database server that will store the acquired data from sensors. (to be decided later which one will be picked)
- **Linux:** is a free open-source operating system that some project parts will be developed on.
- **Windows XP:** Microsoft's operating system that some project parts will be developed on.
- **Linux AP LSDK+WLAN:** The academic release of the embedded Linux operating system which AirTies customized for their AP-400 device.

2.3.Functional Requirements

2.3.1. Use-Case Diagram



View Node List: The user can reach the list of the all nodes and their current state as; whether they are on or off, reading current values or uptime of the node.

View Node Topology: The user can see the sensor network topology in means of node locations, range information or network address.

Querying the Database: The user can query the database and retrieve the data according to his/her needs. For instance, user might want to see the time intervals that some sensors recorded values fall outside of the range defined by user.

Viewing the Data as Graphs: The data stored in the database can be shown as graphs which user can adjust the view features like zooming, put marks, etc...

Creating Reports: The software can regulate the data as hourly, weekly, monthly reports and send them as e-mails.

2.4. Non-Functional Requirements

2.4.1. Low-Cost

Existing similar products are expensive to be attained. The wireless node that will be developed by HSBS Smart costs approximately $200 and this price is about one third of the price of the cheapest wireless sensor in the market. Thus, the overall project will be affordable than the existing systems.

2.4.2. Performance

There are a number of properties that makes our product a unique product. Firstly, the product will operate on a wide-range with the help of Airties-AP400 being multi-functional. Secondly, since, the sensors (SHT15) have CMOSens Technology, they have long-term stability. By the help of this feature of the sensors, the overall product will be able to run for a long time. Thirdly, the manufacture will be able to determine accurate temperature and humidity values by the capability of high-precision measurement of the SHT15s.

2.4.3. Portability

Portability is important for a product to have a wide demand. Since HSBS WSN will be implemented using open IEEE 802.11 standards, extending or adding new components that are also based on this standard to the project does not require additional effort and cost.

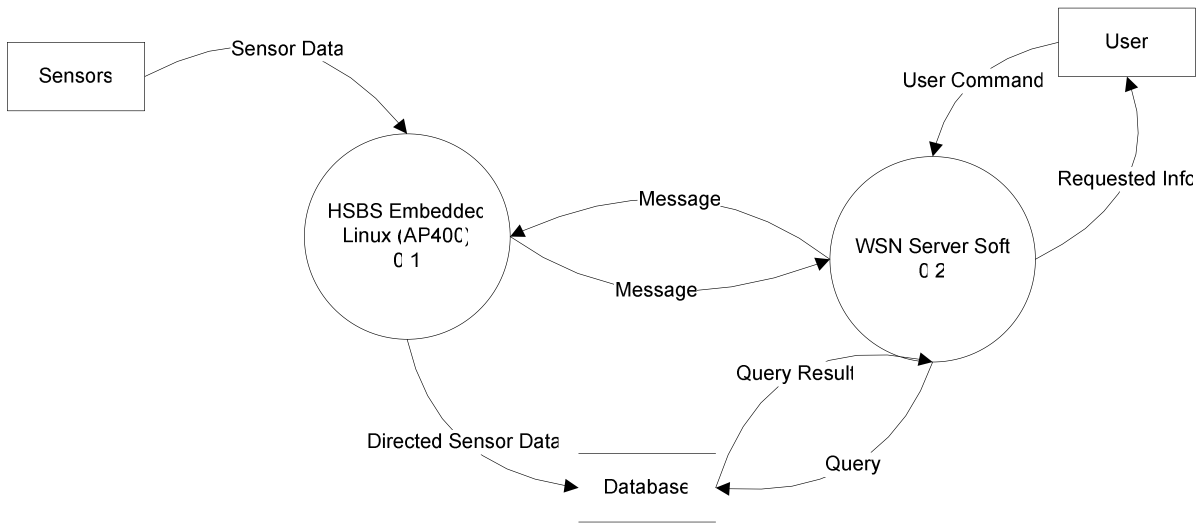
2.4.4. Security

Security issue is a big problem for WSNs, however it has been overcome by WPA (802.1x, TKIP, PSK), WPA2 (IEEE802.11i, AES, CCMP), WEP (64/128 bit), MAC filtering and SSID hiding properties of Airties AP-400.

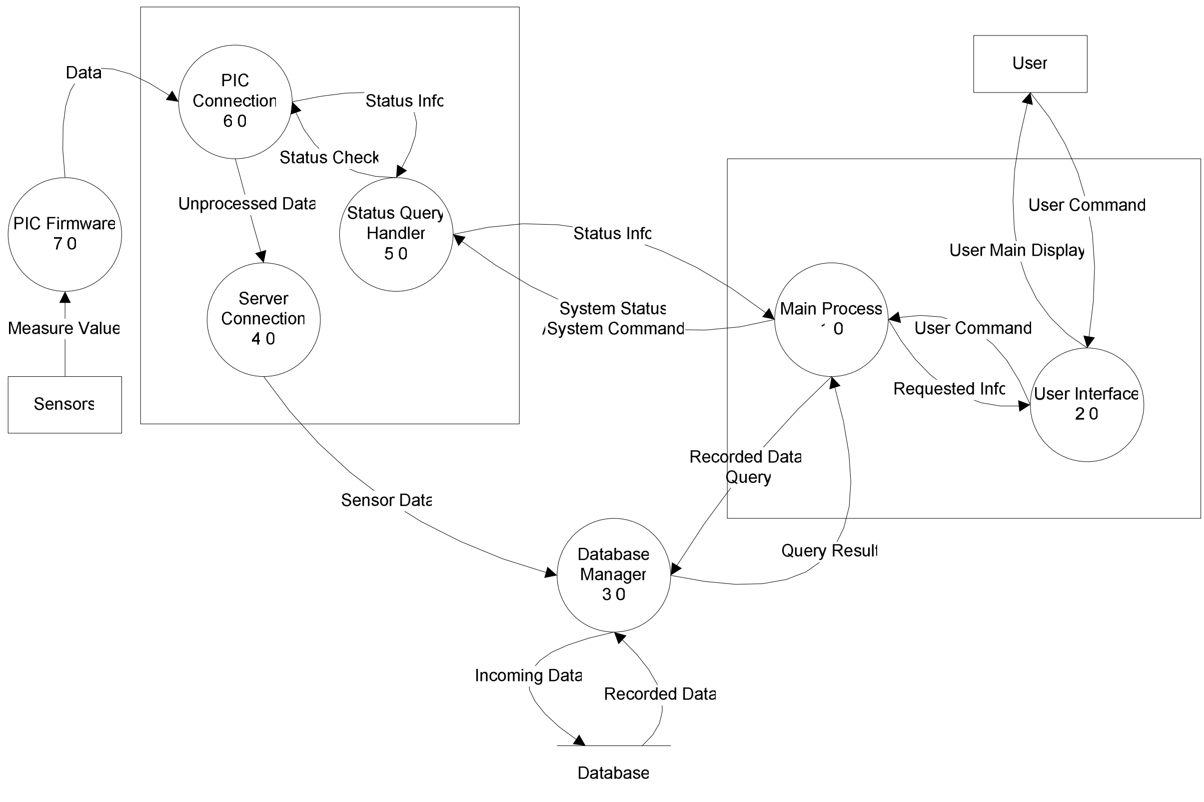
3. MODELLING

3.1. Data Modeling and Analysis DATA FLOW DIAGRAM (DFD)

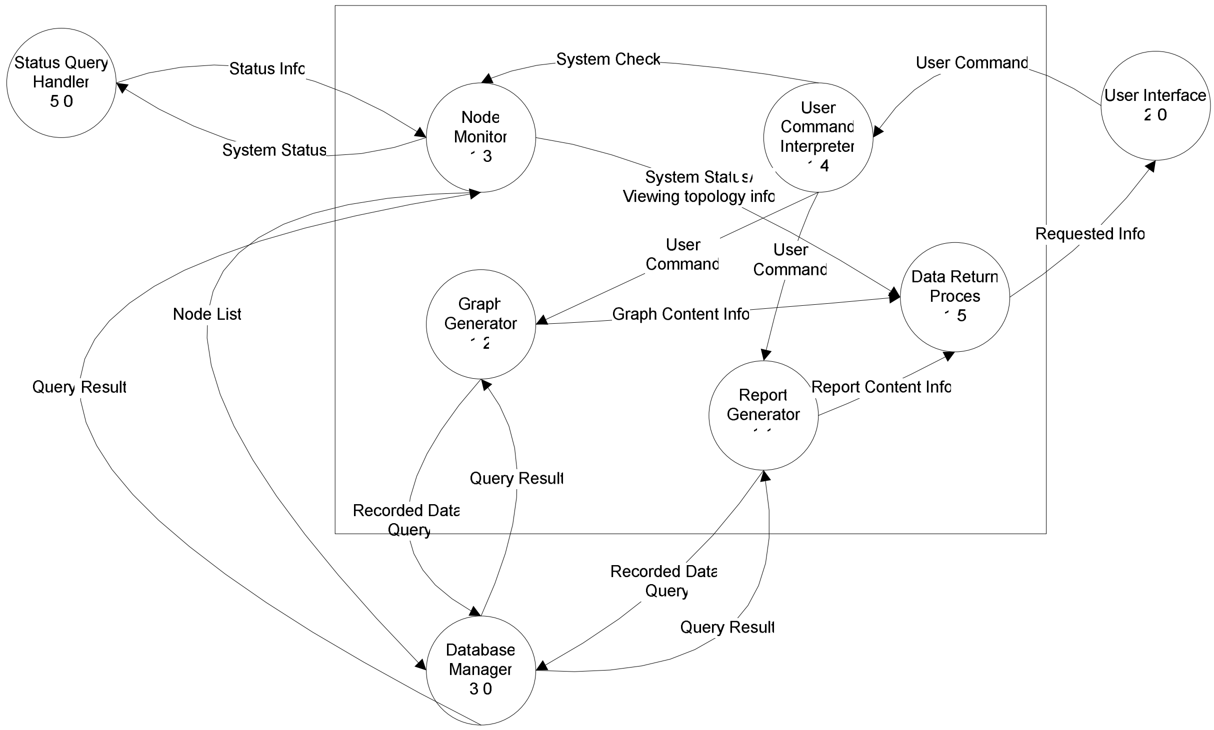
3.1.1 Level 0



3.1.2 Level 1



3.1.3 Level 2



3.1.4 Data Dictionary

name:	Sensor data
where used / how used:	Server connection (4.0) *output* given by sensor node database manager (3.0) *output*
description:	Sensor data: type of SHT15 measure

name:	user main display
where used / how used:	User interface (2.0) *output* given to user (as a simple interface)

description:	user main display = display data display data = *processed requested data according to user command*

name:	message
where used / how used:	Wsn server soft (0.2) *input /output* given by system HSBS embedded Linux (0.1) *input/output*
description:	Message as an <u>status info</u>: checking the sensor nodes alive or not can be Boolean or integer list value for nodes. Message as an <u>system command</u> : opening/closing nodes which is binary list values, getting current sensor data as sensor data type

name:	Recorded data query
where used / how used:	Report generator (1.1) *output* Graph generator (1.2) *output* Database manager (3.0) *input* given by (generator process)
description:	Recorded data query : sql query Sql query = *processed requested query according to user command*

name:	Status info

where used / how used:	PIC connection (6.0) output Status Query handler (5.0) input Status query hander (5.0) *output* Node monitoring(1.3) input
description:	Status info: checking sensor alive or not, boolean

name:	System Status
where used / how used:	Status Query Handler (5.0) input Node monitoring(1.3) output Node monitoring(1.3) output Data return process(1.5) *input*
description:	Status info: list of sensor nodes as alive which can be binary values for each node

name:	Status check
where used / how used:	Status Query Handler (5.0) output PIC connection (6.0) input
description:	Status check: checking sensor alive or not ,boolean

name:	Unprocessed data
where used / how used:	PIC connection (6.0) output Server connection (4.0) input
description:	Unprocessed data: contains data which is SHT15 sensor measured data type

name:	Measure value
where used / how used:	Given to PIC-16f877 by sensor PIC firmware (7.0) input
description:	Value : consist of values which is digitalized by sht15 sensor according to measure command

name:	Incoming data
where used / how used:	Given by Database manager (3.0) to database
description:	Incoming data : measured values from the SHT15 sensor

name:	Recorded data
where used / how used:	Given by database to Database manager (3.0) according to requested query result
description:	recorded data : table of requested values

name:	Query result

where used / how used:	Database manager(3.0) output Database manager(3.0) output Database manager(3.0) output Graph generator(1.2) input Report generator (1.1) input Node monitor (1.3) input
description:	Query result : table of requested(result of SQL query) values

name:	Requested Info
where used / how used:	Data return process(1.5) output User Interface (2.0) input
description:	According to type of user command it can be system status info value, graph content info, viewing node topology info

name:	Viewing node topology info
where used / how used:	Node monitoring (1.3) output Data return process (1.5) input

description:	Topology info: indicates the location of the sensor nodes.

name:	Node List
where used / how used:	Node monitoring (1.3) output Database manager(3.0) input
description:	List : list of lives nodes that can determined by user command or scheduled task

name:	User Command
where used / how used:	Given by user (by clicking on forms and links on interface) through the user interface(2.0) User interface(2.0) output User command interpreter(1.4) input User command interpreter(1.4) output User command interpreter(1.4) output Report generator(1.1) input Graph generator(1.2) input
description:	user command = *commands for changing sensor nodes settings,adding sensors, looking up topology and nodes list;analyzing recorded data *

3.1.5 Process Specification

<u>Report Generator (1.1)</u>

This process drive by the user with a user defined query for reporting wanted data. User interface can help the user to make a simple query for generator input. User can select the type of report format which is predefined in report generator. Query result come from Database Manager (3.0) then Data Return Process (1.5) can direct the result to interface.

Graph Generator (1.2)

User wants to view data as graph so graph generator helps the user to make graphics according to user defined query. As in the report generator process, query result come from Database Manager (3.0) then Data Return Process (1.5) can direct the result to interface.

Node Monitor (1.3)

Checking and recording the available node process is more important to keep system alive so Node Monitor should query active nodes on the system. User can also check the active nodes by System Check commands through the user command interpreter (1.4). Node Monitor saves the node list in database with database manager (3.0).

User Command Interpreter (1.4)

User commands have many types so an interpreter should analyze and direct the command to actual process. User interface (2.0) sends the user command to user command interpreter (1.4). User may select the viewing of nodes/node status, graphing the specified query, reporting the specified query .according to user selection interpreter can call the appropriate action to run.

Data Return Process (1.5)

All requested data by the user (by user commands) are collected in this facility then manipulated according to system settings to be sent to User Interface (2.0).

User Interface (2.0)

Simple, understandable and configurable interface can provide user friendly environment. Actually info requested by the user are collected in this process then this all command sending to command interpreter to execute.

Database Manager (3.0)

All sensor-related data is collected and written to Database by this process. Also node recorded data which is read from system database is decomposed and sent to other processes when needed. Incoming data comes from sensor node through the server connection (4.0) module of the sensor node.

Server Connection (4.0)

Reads the data from AP-400 memory, arranges it in order to send to database server. It is responsible for establishing a connection link to database and keep it alive. Further, the process runs as a background program on AP400 all the time unless it is stopped by user consciously. The main principle of the program is to run forever and send the read data of sensor using the TCP/IP protocol over a database connection link.

Status Query Handler (5.0)

User or the system can command the activity of the sensor nodes in the system by the help of the Node monitor (1.3). Physical or hardware problem can be detected. Connectivity of the PIC unit or sensor activity can be examined through this process.

PIC Connection (6.0)

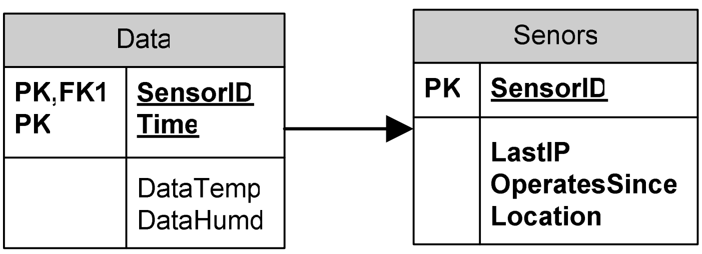
This process behaves like a bridge between AP-400 and PIC 16f877 unit. PIC connection process redirects the Incoming data to Server connection (4.0) process which sends the data according to predefined protocol. Also its check the system activity with the coordination of status query handler (5.0) process. This process creates an alarm if abnormality occurs in the connection or long term inactivity of the sensors.

PIC Firmware (7.0)

The embedded software operates on PIC and controls the device. It is supposed to answer incoming interrupts from RS232 interface, timer interrupts and record the data that sensors measure.

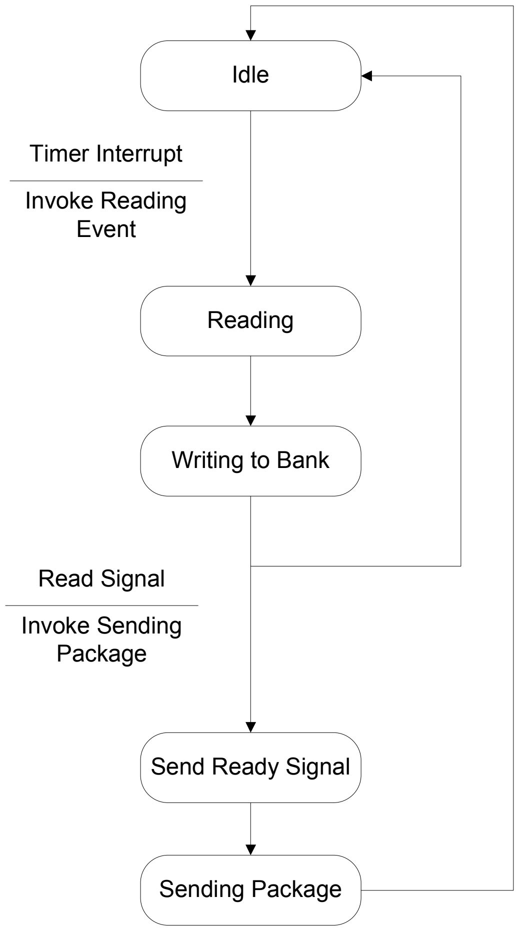
3.2 Data Object Description

Entity Relationship Diagram

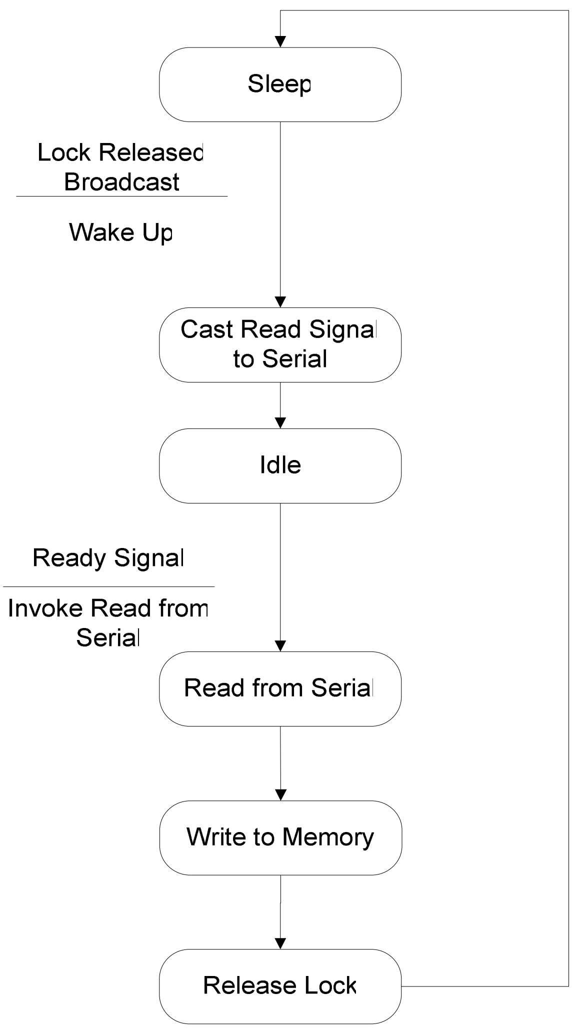


3.3 Behavioral Modeling

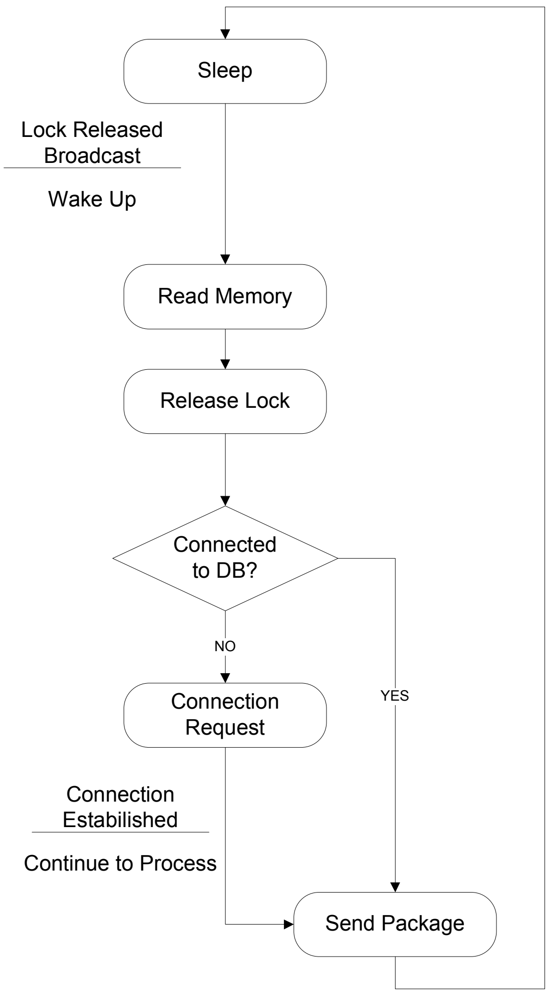
3.3.1 SP07 (Sensor PIC Board)



3.3.2 HSBS Sentinel (AP-400 with SP07)

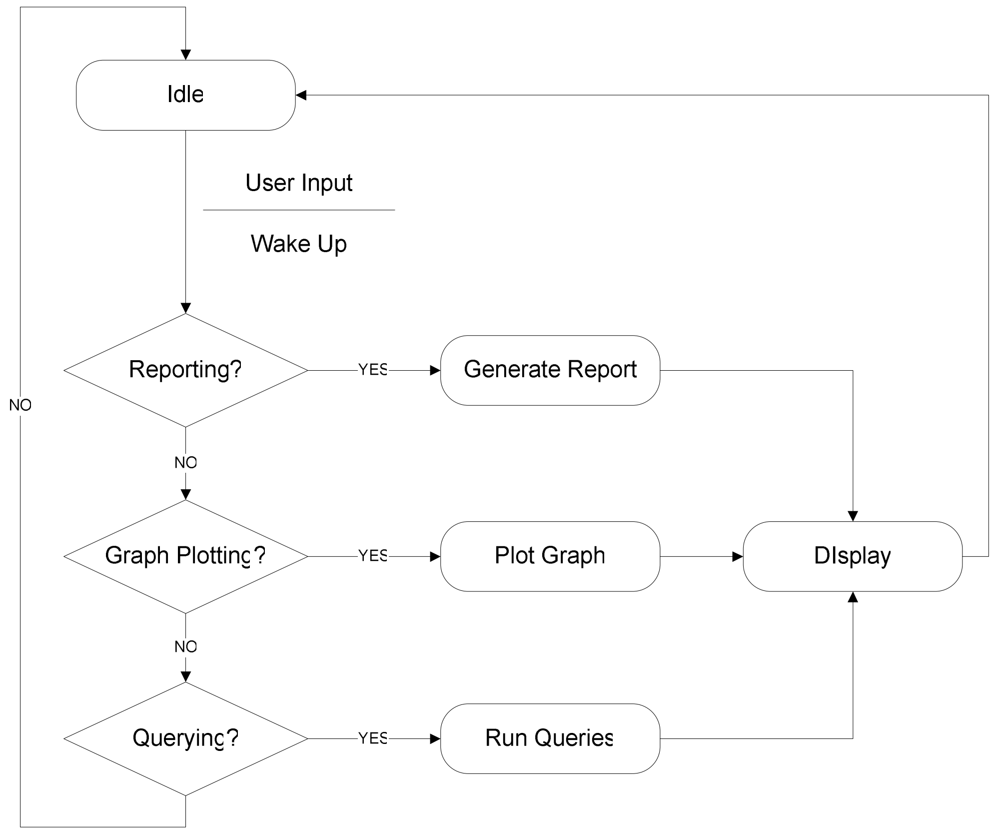


Thread 1


Sleep
Lock Released
Broadcast
Wake Up
Read Memory
Release Lock
Connected
to DB?
NO
YES
Connection
Request
Connection
Estabilished
Continue to Process
Send Package

Thread 2

3.3.3 HSBS WSN Soft (User-Side Software)



4. PROCESS MODEL

4.1 Software Model

Embedded system development has two parts which consist of developing of hardware and software component. Almost all software models are designed for pure software development so that these models do not have effective validation and verification phases. On the other hand a project like wireless sensor network requires stronger testing and verification steps for incorporating the software and the hardware. As a consequence, the V-model satisfies needs of our project as a software model.

Further, milestones like, composing a PIC, sensor embedded board, assembling it on AP400, building a network using this component device with other AP400s and server, and finally developing the user-side software, all require strict testing since the whole system can not be built up without reliable building bricks. The V-model's stepwise testing restrictions provide

the verification as well as the validation.

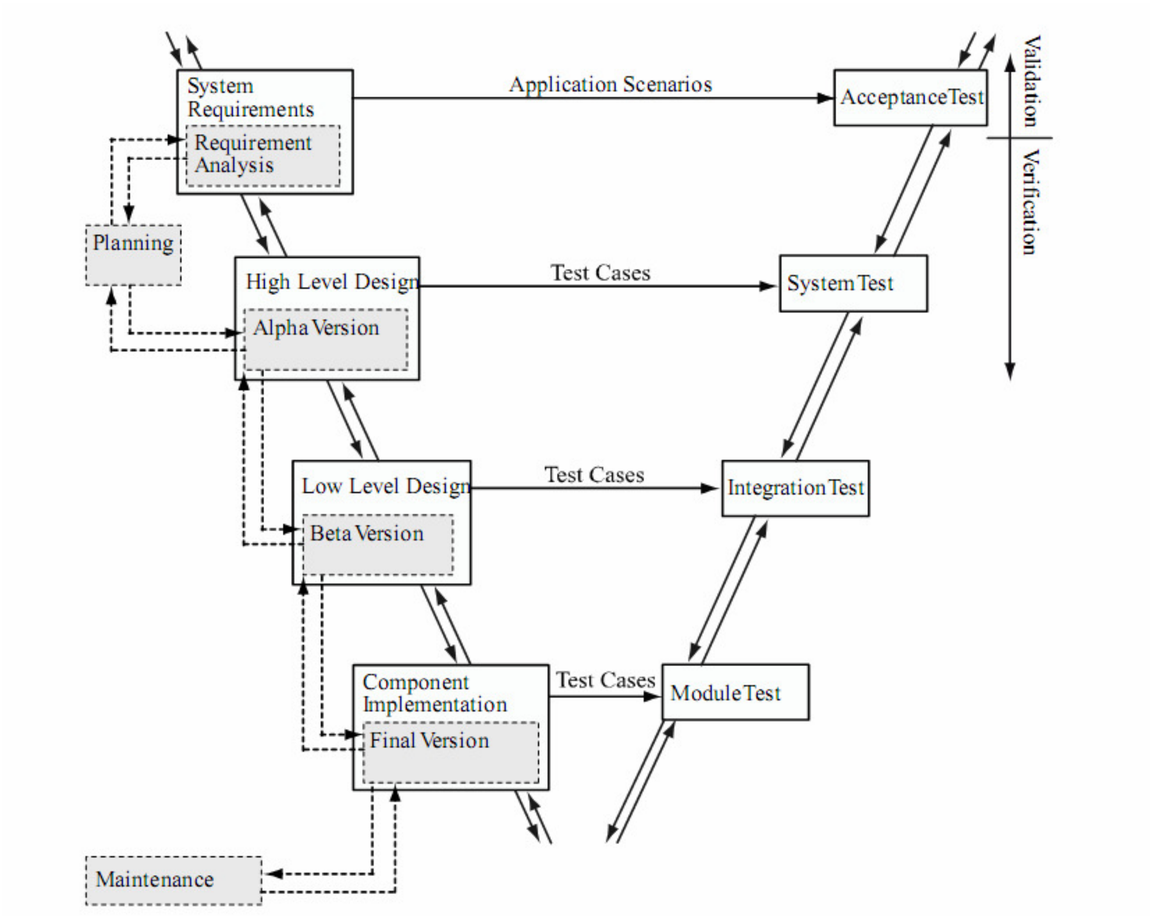


Figure 1 – V-Model (Merged) ***http://www.informatik.uni-bremen.de/agra/doc/***

To conclude with, as it can be seen from Figure 1, the V-model is perfect cut for a project like designing a wireless sensor network from scratch. Each step is stated clearly and holds for our case, and it guarantees the robustness from smallest component to the whole system.

4.2 Gantt Chart

- The Gantt Chart of the 1st semester can be found in Appendix-A.
- The Gantt Chart of the 2nd semester can be found in Appendix-B.
- Legend of the Gantt Charts can be found in Appendix-C.

5. CONCLUSION

As a consequence recent advancement in wireless communications and electronics has enabled the development of low-cost sensor networks. Our recent research and report results show that sensor network have been used for various application areas so this wide range of application areas will make sensor networks an integral part of our lives. In this manner we will try to develop a wireless node because this product brings a new approach to the market. As we stated in the Gantt chart our product process will be heavy loaded and challenging issue with the detailed sub tasks. We believe that we can complete the project at the end of the term, by the help of our embedded experience and small software development projects experience.

6. REFERENCES

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APPENDICES

APPENDIX-A

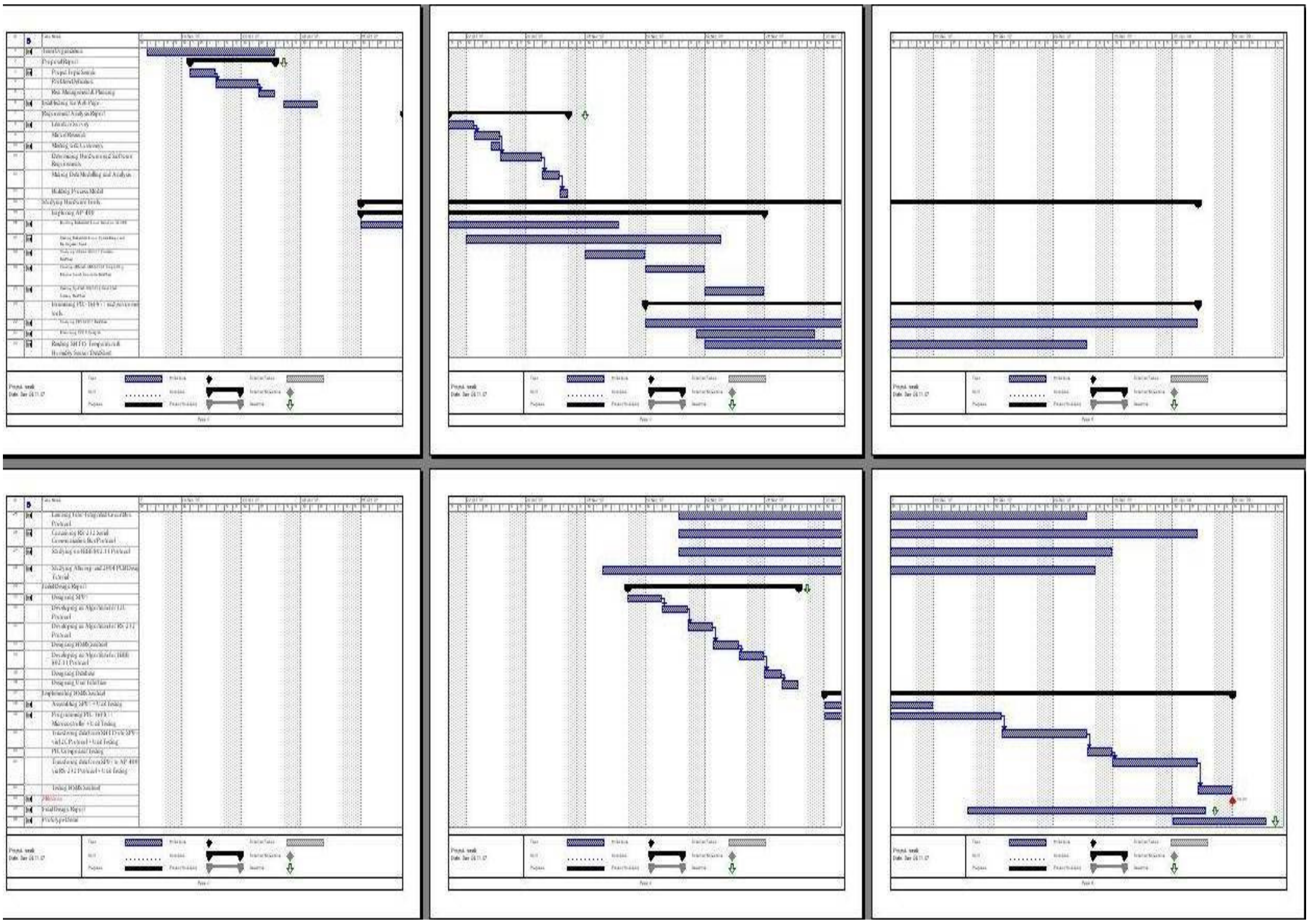
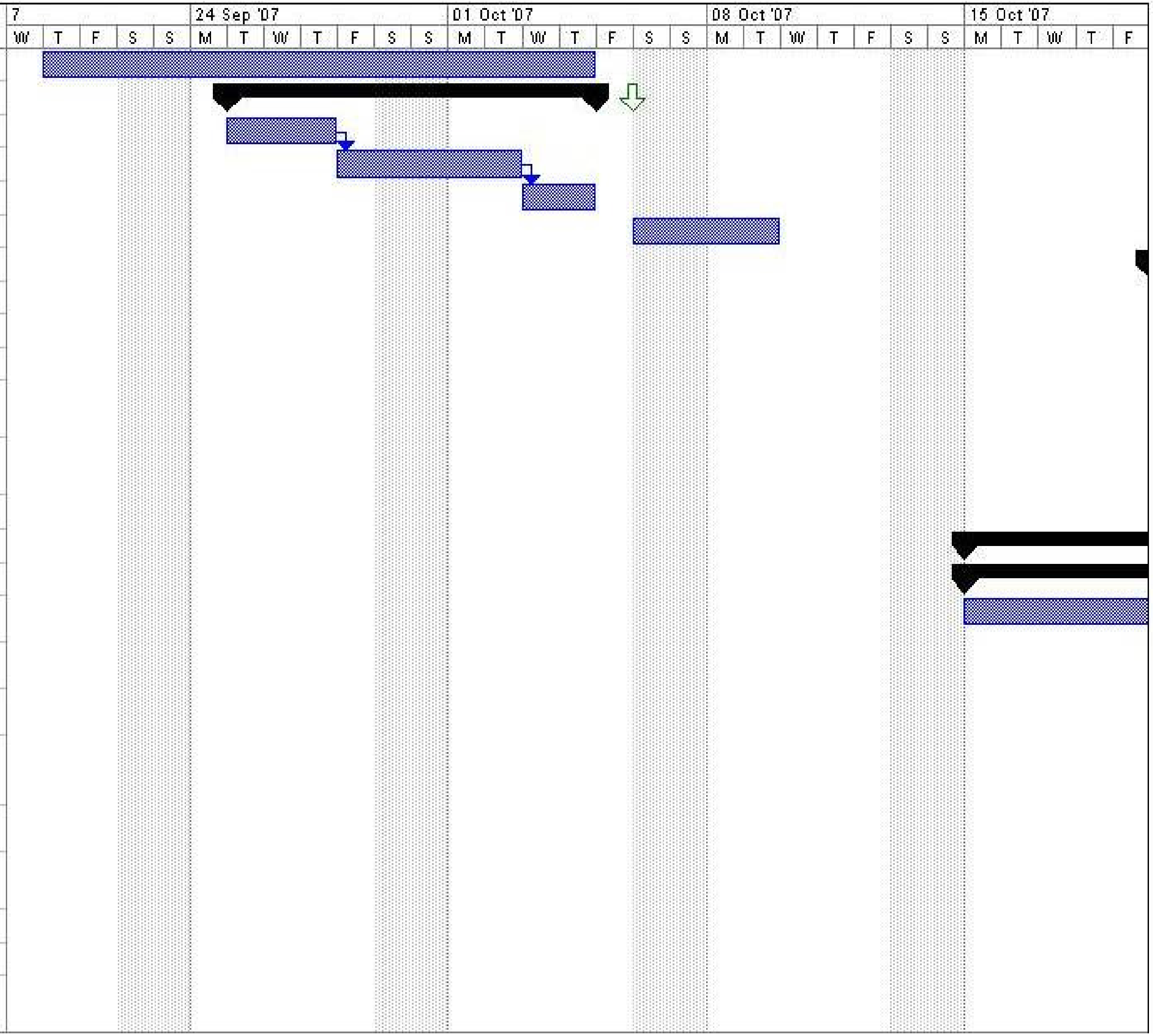
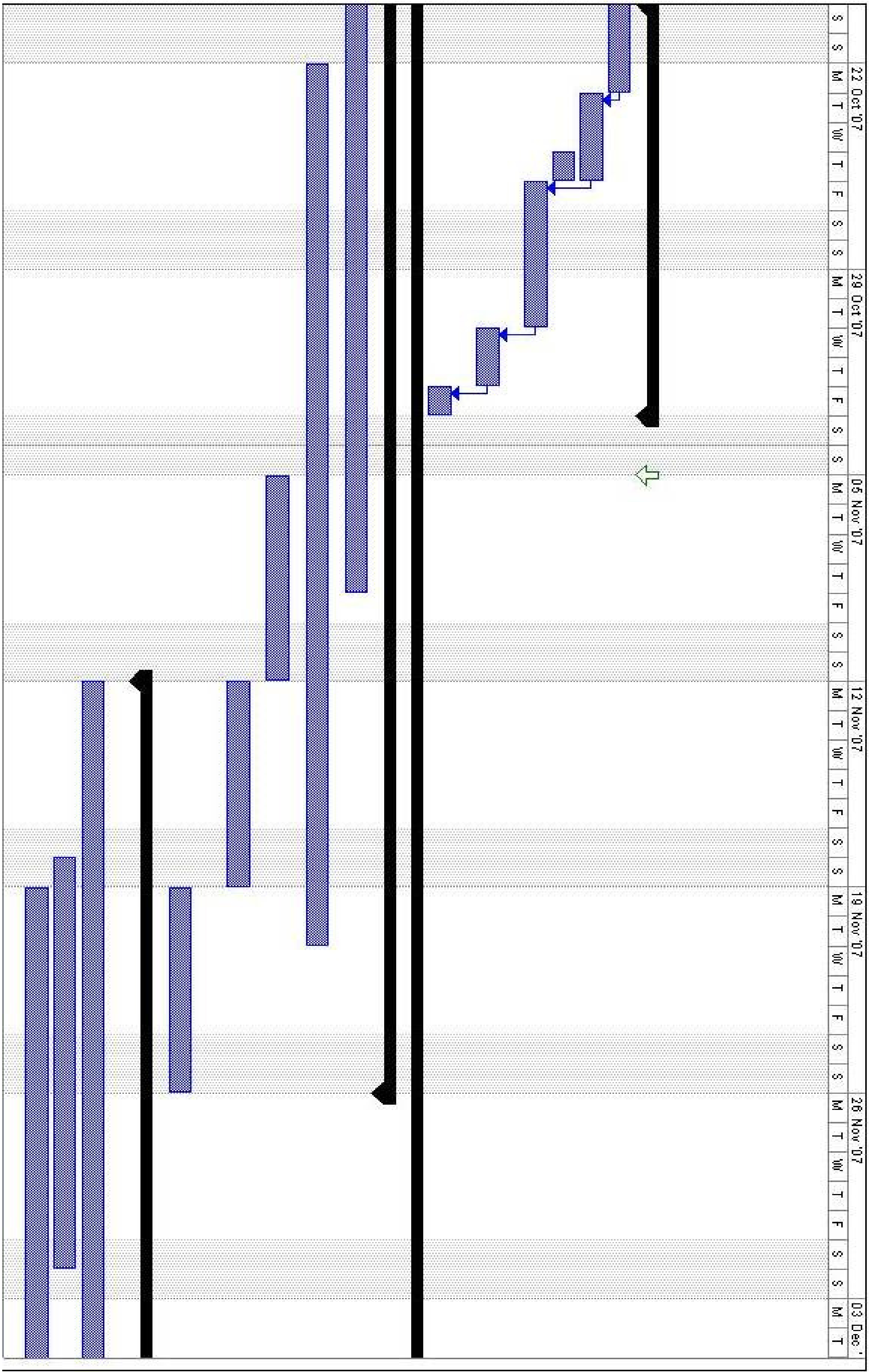


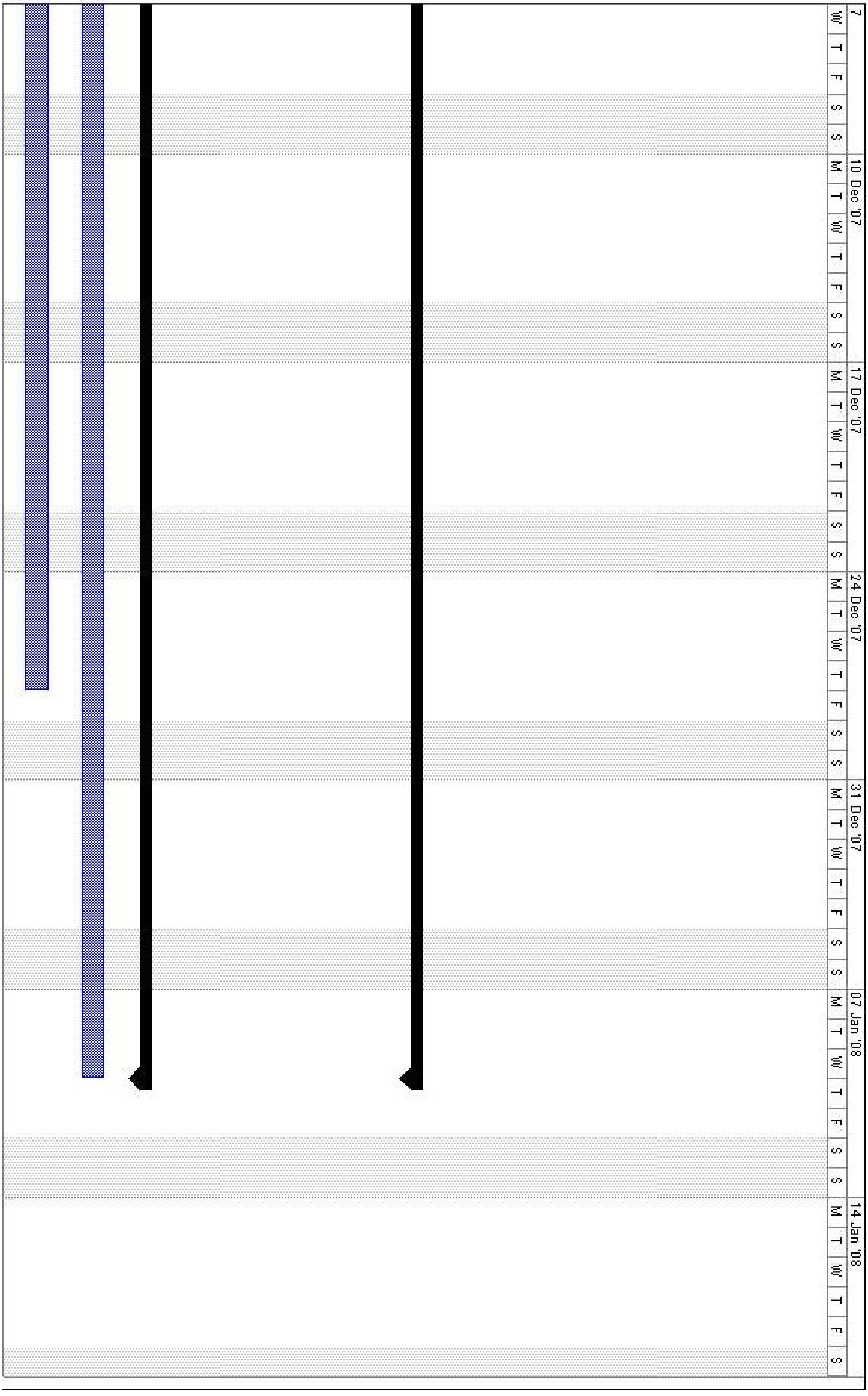
Figure A-1 General View of the Gantt Chart of 1st Semester

Following 6 pictures are the detailed view of the Gantt Chart of 1st semester.

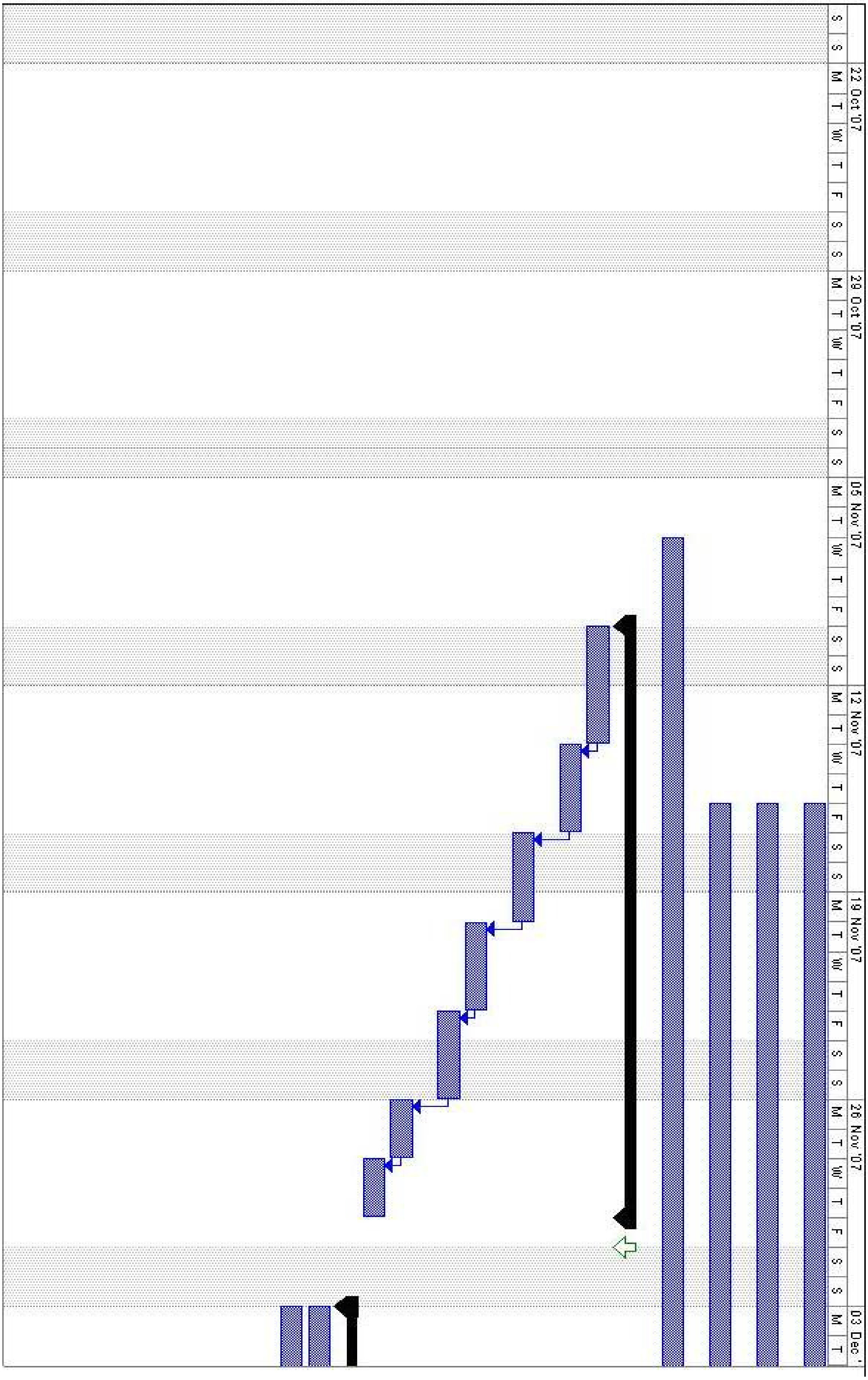
ID	Task Name
1	**Team Organization**
2	**Proposal Report**
3	Project Topic Search
4	Problem Definition
5	Risk Management & Planning
6	**Establishing the Web Page**
7	**Requirement Analysis Report**
8	Literature Survey
9	Market Research
10	Meeting with Customers
11	Determining Hardware and Software Requirements
12	Making Data Modelling and Analysis
13	Building Process Model
14	**Studying Hardware Tools**
15	Exploring AP-400
16	Building Embedded Linux Kernel on AP-400
17	Reading Embedded Linux System Design and Development book
18	Studying Atheros AR2317 Processor DataSheet
19	Perusing ADMtech ADM6996F Single Chip Ethernet Switch Controller Data Sheet
20	Reading SpiFlash NX25P16 Serial Flash Memory Data Sheet
21	Examining PIC-16F877 and enviroment tools
22	Studying PIC16F877 DataSheet
23	Discovering CCS C Compiler
24	Reading SHT15 Temperature & Humidity Sensor DataSheet

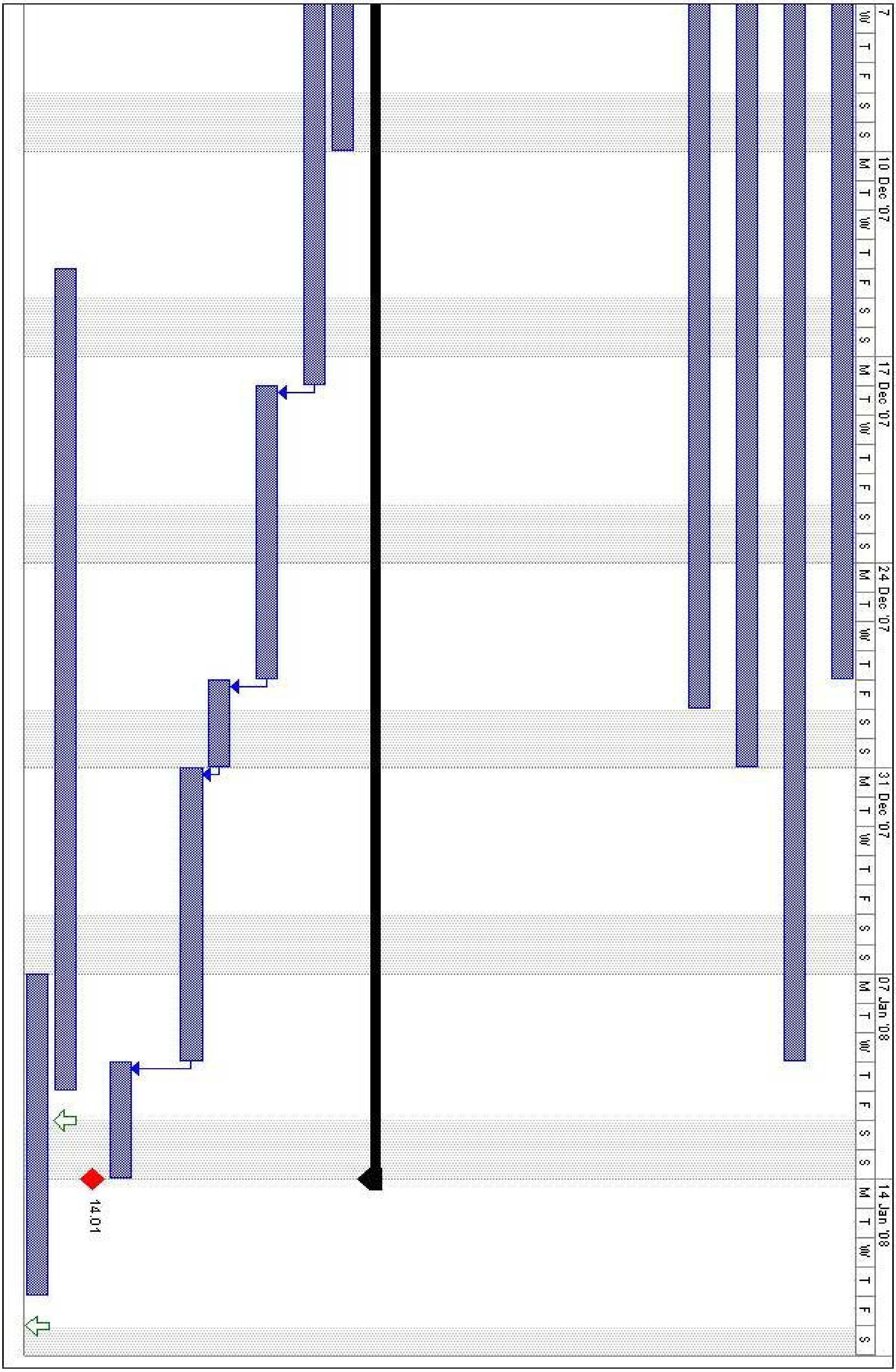



22 Oct '07
29 Oct '07
05 Nov '07
12 Nov '07
19 Nov '07
26 Nov '07
03 Dec '


7
10 Dec '07
17 Dec '07
24 Dec '07
31 Dec '07
07 Jan '08
14 Jan '08

ID		Task Name	7	24 Sep '07	01 Oct '07	08 Oct '07	15 Oct '07
			W T F S S	M T W T F S S	M T W T F S S	M T W T F S S	M T W T F
25		Learning Inter-Integrated Circuit Bus Protocol					
26		Conceiving RS-232 Serial Communication Bus Protocol					
27		Studying on IEEE 802.11 Protocol					
28		Studying Altium p-cad 2004 PCB Design Tutorial					
29		**Initial Design Report**					
30		Designing SP07					
31		Developing an Algortihm for I2C Protocol					
32		Developing an Algortihm for RS-232 Protocol					
33		Designing HSBS Sentinel					
34		Developing an Algortihm for IEEE 802.11 Protocol					
35		Designing Database					
36		Designing User Interface					
37		**Implementing HSBS Sentinel**					
38		Assembling SP07 + Unit Testing					
39		Programming PIC-16F877 Microcontroller + Unit Testing					
40		Transfering data from SHT15s to SP07 via I2C Protocol + Unit Testing					
41		PIC Component Testing					
42		Transfering data from SP07 to AP-400 via RS-232 Protocol + Unit Testing					
43		Testing HSBS Sentinel					
44		**Milestone**					
45		**Final Design Report**					
46		Prototype Demo					


22 Oct '07
29 Oct '07
05 Nov '07
12 Nov '07
19 Nov '07
26 Nov '07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17 Dec '07
24 Dec '07
31 Dec '07
07 Jan '08
14 Jan '08
14.01

APPENDIX-B

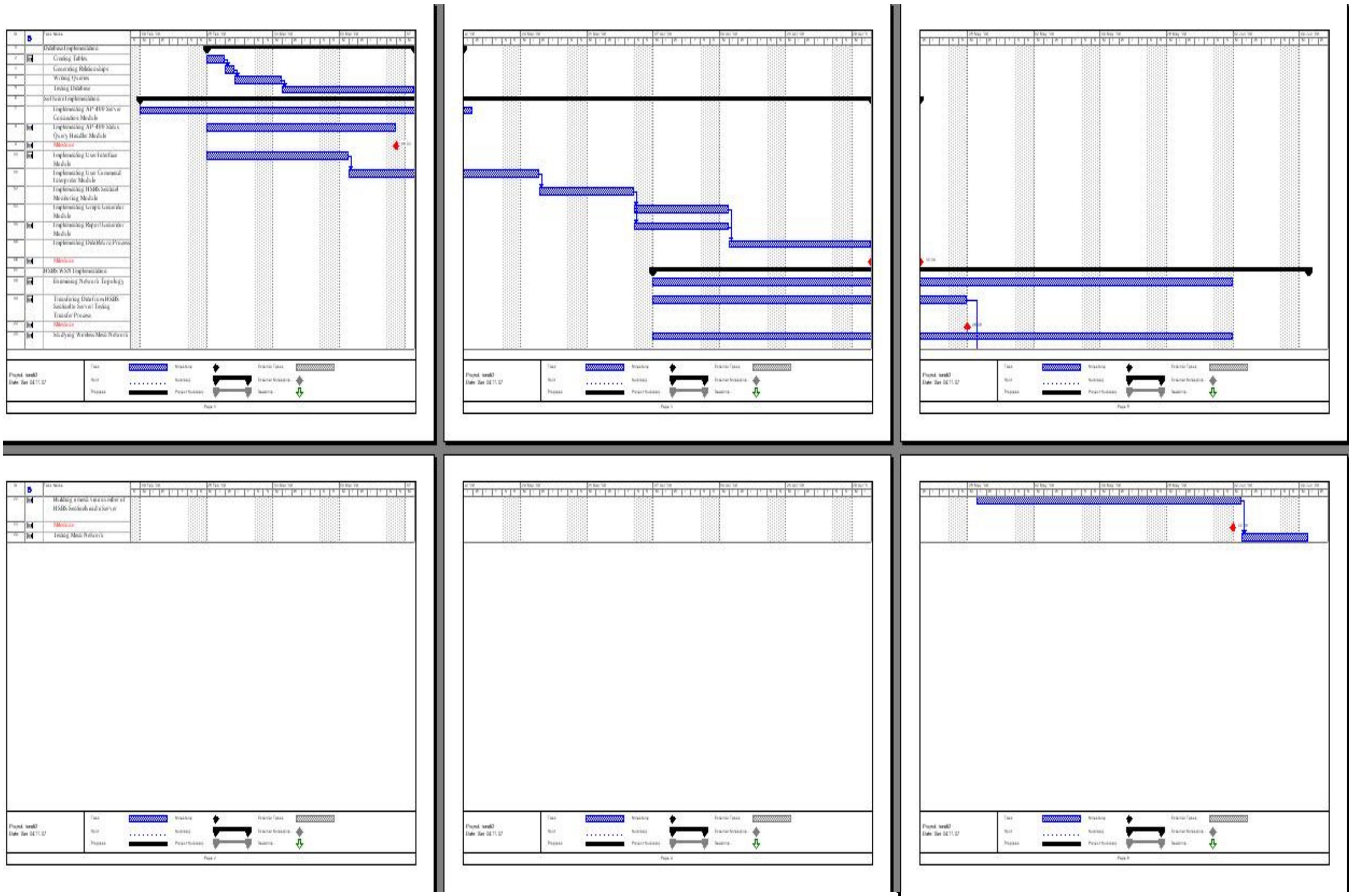
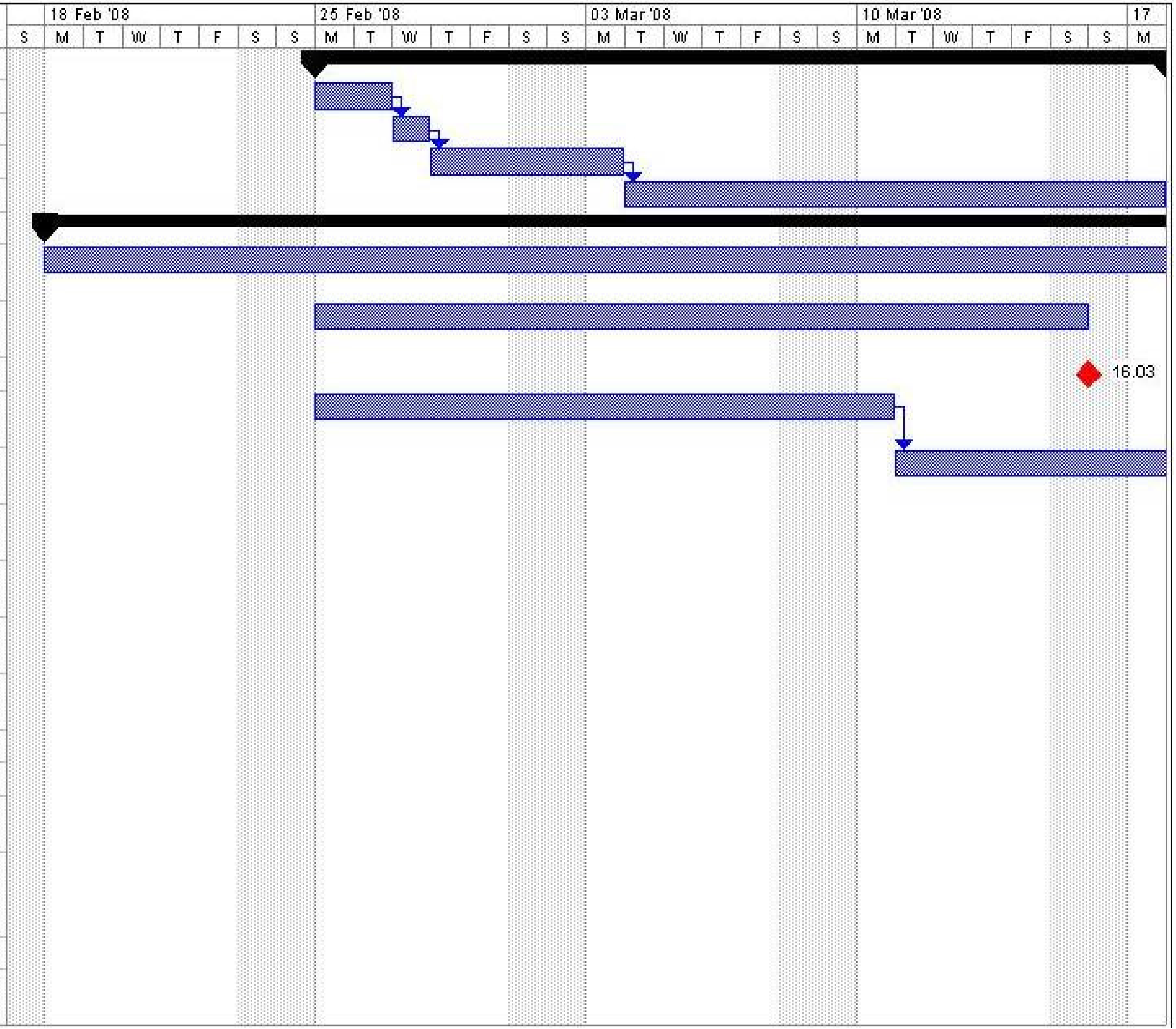
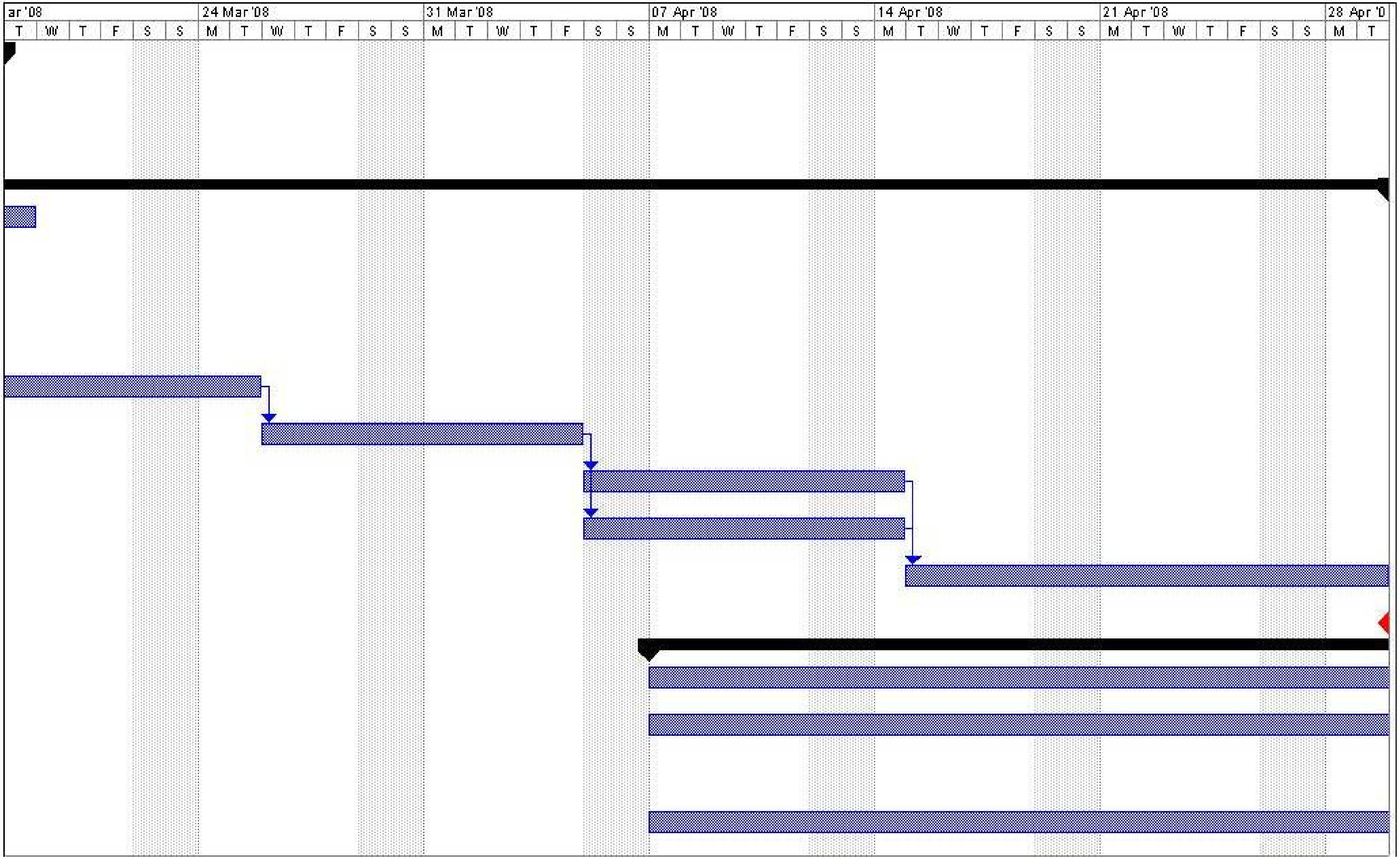


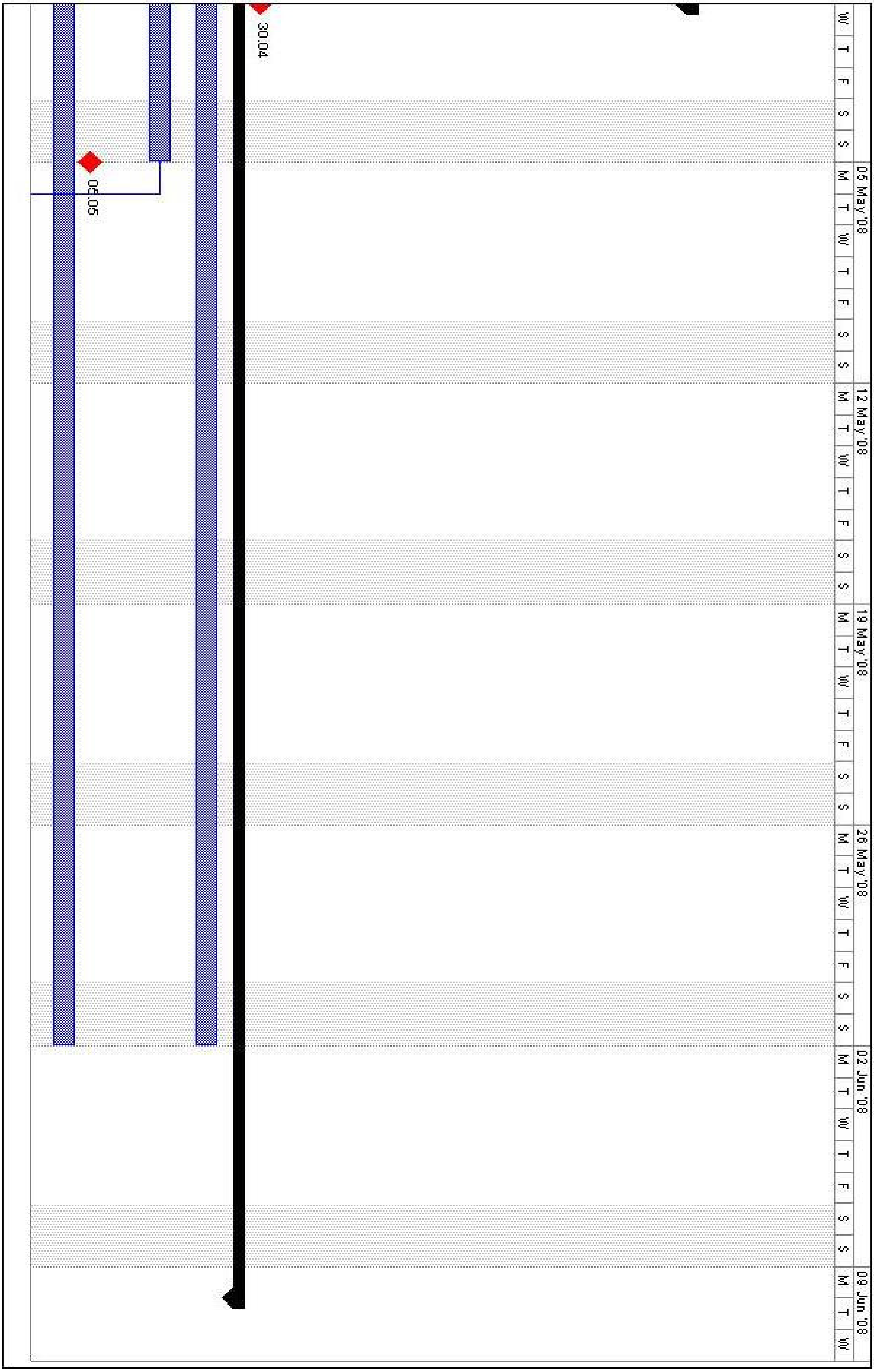
Figure B-1 General View of the Gantt Chart of 2nd Semester

Following 5 pictures are the detailed view of the Gantt Chart of 2nd semester.

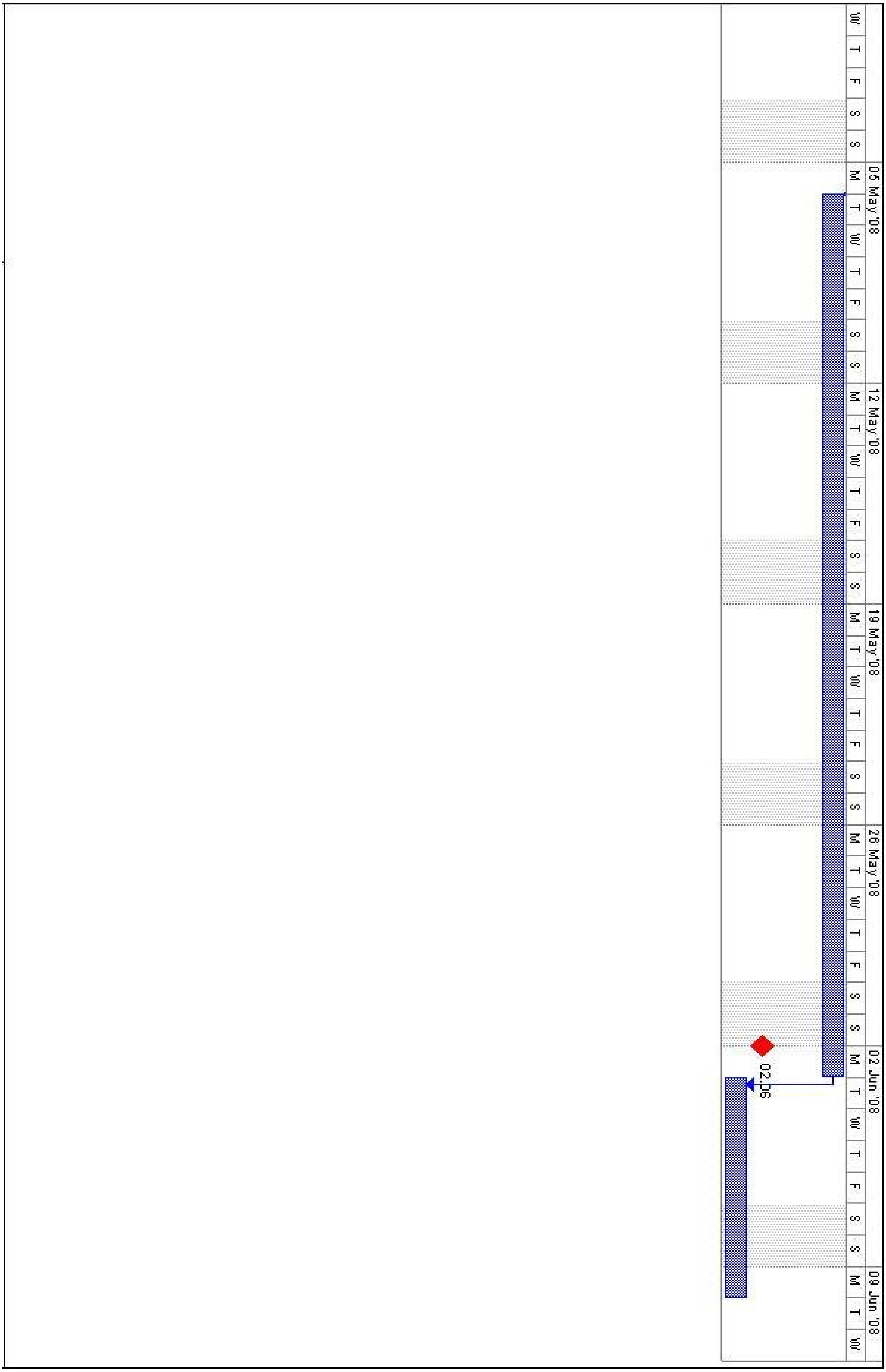
ID	Task Name
1	**Database Implementation**
2	Creating Tables
3	Generating Relationships
4	Writing Queries
5	Testing Database
6	**Software Implementation**
7	Implementing AP-400 Server Connection Module
8	Implementing AP-400 Status Query Handler Module
9	Milestone
10	Implementing User Interface Module
11	Implementing User Command Interpreter Module
12	Implementing HSBS Sentinel Monitoring Module
13	Implementing Graph Generator Module
14	Implementing Report Generator Module
15	Implementing Data Return Process
16	Milestone
17	**HSBS WSN Implementation**
18	Examining Network Topology
19	Transfering Data from HSBS Sentinel to Server/ Testing Transfer Process
20	Milestone
21	Studying Wireless Mesh Network




ar '08
24 Mar '08
31 Mar '08
07 Apr '08
14 Apr '08
21 Apr '08
28 Apr '0
T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T


05 May '08
12 May '08
19 May '08
26 May '08
02 Jun '08
09 Jun '08
30.04
06.05

ID		Task Name		18 Feb '08							25 Feb '08							03 Mar '08							10 Mar '08							17
			S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M
22		Building a mesh via a number of HSBS Sentinels and a Server																														
23		Milestone																														
24		Testing Mesh Network																														


05 May '08
12 May '08
19 May '08
26 May '08
02 Jun '08
09 Jun '08
02.06

APPENDIX-C

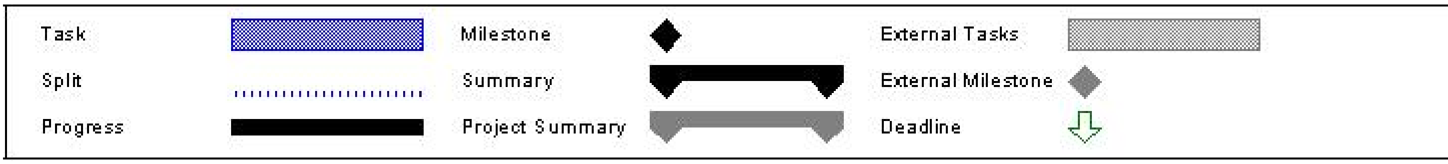


Figure C-1 Legend of Gantt Charts in Appendix-A and Appendix-B