1. Requirements Documentation

1.1. Overview

Today's medical clinic can be a busy, fast-paced environment. In order to effectively attend to their patients, clinic staff must be able to maximize exam room use. This can be accomplished by using some means of indicating each room's status to other staff members.

A typical progression of events in an exam room is as follows:

(1) A medical assistant accompanies a patient to the exam room.
(2) The medical assistant takes the patient's vital statistics.
(3) The patient waits in the exam room to be seen by the doctor.
(4) The doctor sees the patient, at which time some treatment may be administered.
(5) The doctor proceeds to the next waiting patient, and the exam room is cleaned and prepared to accept a new patient.

Many medial clinics use simple mechanical systems of colored flags to display the status of each exam room. These outdated systems have the following drawbacks:

They are cumbersome. – Because the flags are mounted near the tops of doorways, it is awkward for clinic staff to change them. They are also susceptible to being incorrectly changed.

They are not automated. – Flags do not recognize when a doctor has finished attending to a patient in another room. Therefore, clinic staff must manually change the position of the flags.

They do not prioritize workflow. – Colored flags can't indicate to the doctor which patient to see next. They also cannot keep track of time for specific types of treatment.

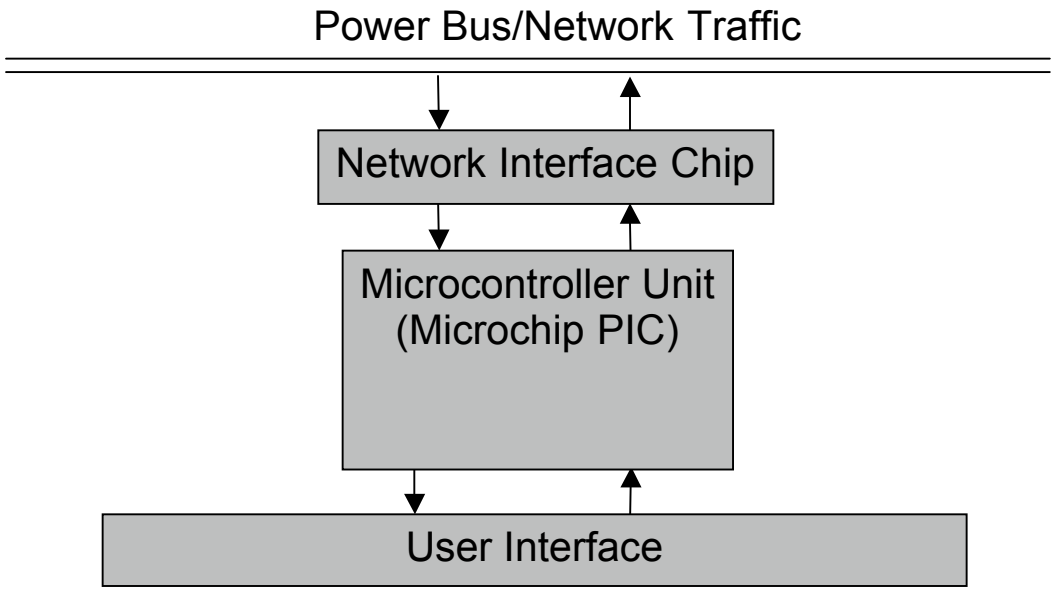
For these reasons, administrators feel the need to upgrade to a modern system.

While inexpensive electronic systems exist, they lack capabilities. They are typically switch-based systems whose units do not communicate with each other. Such systems are not much more than an electronic version of colored flags.

There are more comprehensive solutions, but they are much more expensive. These systems require significant consultation and design for each individual application. Furthermore, they can be difficult to set up, to use, and to maintain.

Our goal is to design an affordable, modular electronic system that will effectively improve a typical medical clinic's workflow. Our system will consist of multiple modular in-wall electronic indicators. These units will be easy to set up and operate. They will be interconnected, so as to display thorough information about exam room's status. Optionally, our system will include a computer interface to display and log room status.

1.2. Block Diagram



1.3. Requirements

1.3.1. Electrical

1.3.1.1. Microcontroller

This project is centered on the use of microcontrollers for each multi-use station. Therefore most of the electrical requirements pertain to the selected microcontroller's specifications.

1.3.1.2. Power

The multi-use stations will require one or more power supplies to deliver the proper voltages and currents for each microcontroller that is used.

1.3.1.3. Interfacing

The multi-use stations require a reliable communication link and protocol. Additionally, the customer has specifically requested that each unit contain its own microprocessor and interface hardware so that the stations will be modular.

Table 1.3.1. Electrical Specifications

Requirement	*Value*
Microprocessor Type	Microchip PIC16F877
Voltage Rating	2.0 to 5.5 Volts
Communication Link Type	13-pair cable
Communication Protocol	RS-485
Electrical Guidelines	The National Electric Code

1.3.2. Mechanical

1.3.2.1. Size

The size of the multi-use station is limited by the requirement that it must fit into a single gang electrical outlet box, and the control panel must be made from a simple outlet box blank. There are many variations on outlet box sizes, which requires the stations fit within the minimal box dimensions in order to be universally accepted for production.

1.3.2.2. Weight

Weight is only a factor in each station be mounted in an electrical outlet box, which is where it will be permanently installed and will not pose a constraint.

Table 1.3.2. Mechanical Specifications

Requirement	*Value*
Size of electronics component	Must not be greater than the following Height = 2__ Width = 2_ Depth = 2__
Size of control panel	Typical electrical outlet blank Height = 4__ Width = 2__
Weight	No pertinent constraint
Interconnection	Multiple twisted paired telephone cable or thermostat cable
Protection	Electrically isolated from ESD and if a metallic blank is used then it must be properly grounded.
Controls	Pushbuttons must be durable to withstand years of daily use.

1.1.3. Environment

1.1.3.1. Temperature

Each multi-use station will reside in a room temperature atmosphere, and the units must not build up excessive heat within the in-wall box. Also, the stations will be designed to meet specifications given by the given microcontroller's data sheets.

1.1.3.2. Humidity

The multi-use stations must not malfunction as a result of excessive moisture within the wall in which it installed. The stations must use fuses or circuit breakers to prevent fire hazards in the event of direct contact with moisture, such as a leaky pipe.

1.1.3.3. Vibration/Shock

The multi-use stations must withstand vibrations of the wall in which it is installed, such as vibration from nearby doors being closed.

1.1.3.4. Packaging

Since both plastic and metal blank covers will be options for the control panel, proper electrical grounding and isolation will be required to protect against electrical shocks and ESD discharges.

Table 1.3.3. Environmental Specifications

Requirement	*Value*
Absolute Maximum Temperature	+125°C

1.1.4. Documentation

1.1.4.1. User's Manual

A user's manual will be made available once the design has been completed and tested. This manual will include how to configure the call light system as well as how to use the call light system on a day to day basis.

1.1.4.2. Maintenance Manual

A maintenance manual to accompany the user's manual will specify any required maintenance and installation procedures. Also included will be a number of design documents relating to how the project was engineered. This document will include specifics on hardware wiring, network interfacing, and programming.

1.1.5. Testing

1.1.5.1. Procedures

Testing will be done by temporarily interfacing inputs and outputs to a test chip. No permanent connections will be made, and it will be easy to insert and remove a chip for ease of testing and debugging.

1.1.5.2. Equipment

Our testing environment will consist of a breadboard for interfacing inputs, outputs and power to the chip. Connected to the breadboard will be a power supply, LEDs, buttons, and other interface elements as needed. We will also use a programming board, in order to reprogram and debug chips.

1.1.6. General

1.1.6.1. Safety

This system will be installed in commercial settings where its safety and performance will be critical. This will require that the system meet all electrical codes and regulations.

1.1.6.2. Client Preferences

The client has purchased Microchip PIC16F877 chips for use in each multi-use station, and prefers the use of these chips in the design.

2. Design Plan

2.1. Design Philosophy

The design philosophy involves general design goals applicable to this engineering design effort.

2.1.1 Performance

System performance must not rely on a single microcontroller. The system should be comprised of autonomous, interconnected units. Failure of a single unit should not affect the performance of the rest of the system. The system must take advantage of the distributed microcontroller design, so as to be a superior alternative to simpler switch-based systems.

2.1.2 Ease of Operation

The operation of the system must be easy for new users to learn. It must improve, not hinder, the workflow of a typical medical clinic. Complicated button combinations and programming options must be kept to a minimum.

2.1.3 Installation

Installation of the units should be simple. Upon installation, each unit should not require extensive programming. When linked together with the specified connections, communication between the units should occur automatically.

2.1.4 Quality

The product will be used in a setting that normally consists of high-quality products and materials. The final product will meet the needs of a fast-paced and demanding workplace by providing a smart, user-friendly alternative to existing office technologies.

2.1.5 Design Safety

It is important to incorporate safety in our design. This is because the biggest gains in safety and the biggest reductions in cost tend to come when safety is inherent in any design. The doctors call light will be safe to the user, patients, doctors and everyone.

2.1.6 Environmental Protection

Environmental protection will also be our integral part of our design. Our final design of the doctor's call light will operate in such a way that maximum environmental protection is ensured. All team members have an ethical duty to ensure environmental protection during the course of this project.

2.1.7 Manufacturability

Manufacturing ease of the multi-use stations is desired. This project requires multiple interconnected units in order to function properly. Therefore a design will be ineffective if it is difficult to create or duplicate.

2.1.8 Maintainability

Similar to most office installations, a desire exists to have a product that does not need any substantial amount of upkeep and maintenance. All time spent maintaining an office product means less time is being spent on customers.

2.2. Design Approach

The design approach contains specific design goals and how the team will be organized to attach the problem.

2.2.1. Design Goals

2.2.1.1 Improve Medical Clinic Communication

The system should improve communication between the doctor and the patient, medical assistant(s), front desk, and cleaning assistant.

2.2.1.2 Modular Design

Most designs require a specific number of units in order to function properly. In a modular design, the number of units in a system can vary. This is an advantage because a modular system will have smooth transitions in the event of remodeling, moving, or marketing this product to another company.

2.2.2 Team Organization

Each problem should be distributed to a group or team member based up each team member's strengths.

2.2.2.1 Hardware

Alan, Bill and Rob will be directing their attention toward the hardware subsystem. This includes interfacing the microcontroller to output lights, a power supply, and a communication chip used to transmit information on the network.

2.2.2.2 Software

Kevin and Tom will be focusing on the software. The software subsystem involves completing the basic functions of the unit as well as communicating with the other units on the network.

2.2.3 Schedule

The design process consists of four stages in the following sequence: a requirement stage, a proposal stage, a design phase, and an implementation phase. The first two will take place during the fall semester of 2003. The last two will be carried out during the spring semester of 2004. This will then be followed by the capstone design conference on April 26, 2004 in which the project will be presented. This schedule is standard of the senior capstone design process, and each stage is equally important for the overall success of the project.

2.2.4 Cost Analysis

This is a vital aspect of the project to meet the client's expectations. The goal of the analysis is to minimize and assess the costs associated with the final product to be marketed to its target segment. Our client specifically needs to know the costs of each unit for personal use as well as costs of multiple units for future plans to market the product. Providing accurate costs information will undoubtedly assist our client in assessing marketing feasibility of the product. The overall costs of this project must remain within our client's means and must follow a direction that meets the client's needs.

2.3. Project Deliverables

2.3.1. Client Status Report

This report allows for you to assess how well the team understands the proposed project. This will give a good chance to redefine objectives that are unclear or misunderstood.

2.3.2. Proposal Document

The proposal document is another chance to ensure that the team has a good understanding of the project and the team is on the way to begin initial design.

2.3.3. Status Report

This status report is a relatively informal document to the client, which will allow for team assessment of the progress made to date and allow for the client to monitor our status as well.

2.3.4. Capstone Design Conference

The Capstone Design Conference is the final presentation for the completed project. The conference is intended for each design team to present the projects they worked on throughout the year. The display is open to the pubic, and the client will be invited to attend.

2.3.5. Final Report

This will be the final document delivered to the client. The report will include any and all information discussed in the design conference and much more. All final design specifications will be provided in extensive detail. A final status report will also be included to let the client know how well the team performed throughout the year in trying to fulfill the assigned endeavor.

2.3.6. Installation

The call light system will be installed into our client's medical clinic. This will include the installation of a multi-use station for each room.

3. Project Schedule

Following is a list of events that will take place during the course of the design. Note that several events take place on January 19, 2004. This is not the actual date these events will occur. These events will be scheduled by that date.

Event	*Begin Date*	*End Date*
Client Status Report (Rough Draft)	Tue 9/9/03	Fri 10/31/03
Client Status Report (Final Draft)	Mon 11/3/03	Tue 11/4/03
First Class Presentation	Tue 11/4/03	Tue 11/4/03
Faculty Advisor Meetings	Every Tuesday	
Team Meetings	Every Monday	
Research	Mon 1/19/04	
Hardware	Mon 1/19/04	
Software	Mon 1/19/04	
Capstone Demonstration	Mon 4/26/04	
Testing/Prototyping	Mon 1/19/04	
Purchasing/Vendors	Mon 1/19/04	
Web Site	Tue 9/30/03	Mon 1/19/04
Travel	Mon 1/19/04	
Financial Tasks	Mon 1/19/04	