THAT Home Automation Topology (THAT)

Digital Thermostat Module
Electronic Access Module

Functional Description and Complete System Block Diagram
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Project By:
Nick Viera
Chris Miller

Advised By:
Dr. James Irwin
Dr. Aleksander Malinowski

System Overview

The terms “home automation” and “building automation” are often used to describe a wide array of products and systems. These products aim to provide the user(s) with better, more-intelligent control over their environment as it relates to a home, building, or other indoor space. Unfortunately, most “automation” products are either inexpensive, simplistic, and severely limited in functionality, or they are very expensive, complex, and functionally chaotic.

THAT Home Automation Topology, also known as THAT System, describes a new, comprehensive, IP/Ethernet-based home automation system. THAT System is designed to be as modular and economically feasible as possible, while retaining a rich, usable feature set.

THAT System is defined to be used in two basic configurations: minimalistic and comprehensive. The minimalistic configuration describes a “system” consisting of only a couple THAT modules. These modules operate essentially as “stand-alone” devices, with little or no communication between modules.

The comprehensive configuration describes a system consisting of a few to many modules, with a “master” computer. In this system the computer is the master arbitrator of the system, using information from some modules to dictate the behavior of other modules. The computer shall run comprehensive control software writing in Python or similar cross-platform compatible software. Should the computer fail or otherwise disappear from the network, certain modules controlling critical systems shall revert to self-contained, “fail-safe” modes. Possible modules to be designed for THAT System are listed in Figure 2-1.

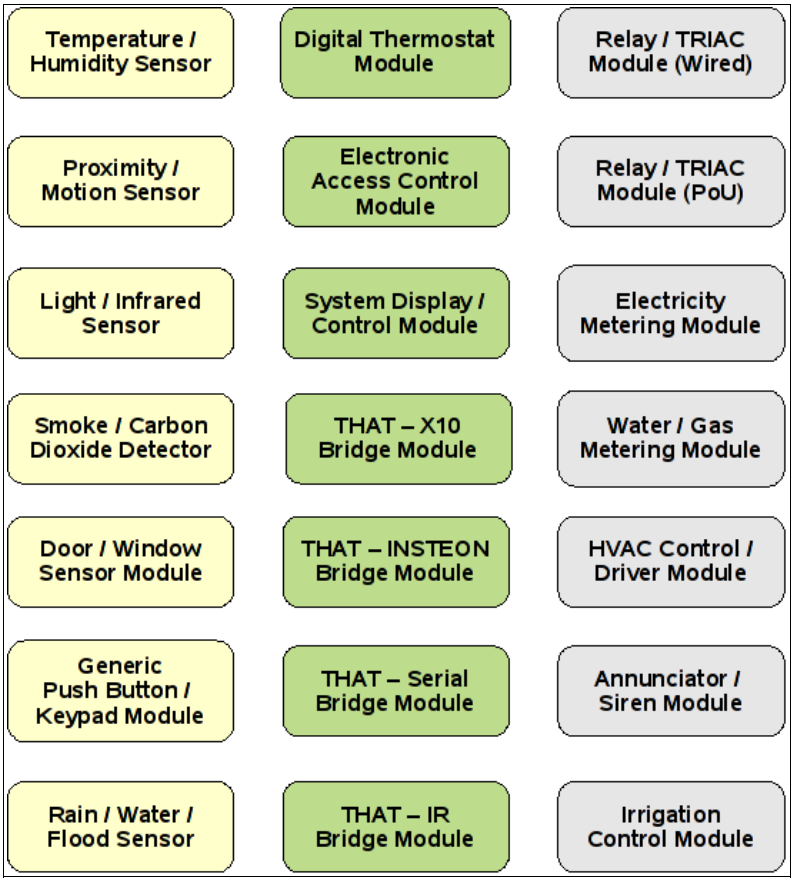

Figure 2-1 : Possible Modules incorporated into THAT System.

THAT System Goals:

- Overall Goals
  - Modularity on the lowest feasible level.
  - Standardization of hardware to the largest extent possible.
  - Standardization of communication to the largest extent possible.
  - Standardization of master-to-modules system control, including “fail-safe” modes.
  - Form follows function.
  - Design integrity takes precedence over design cost.
  - Open Source Software for most functionality
  - Open Hardware for most functionality
  - “Freemium” philosophy for advanced functionality

- Hardware Design Goals
  - Link Protocol: 10BASE-T, 100BASE-TX Ethernet
  - Transport Protocol: TCP/IP
  - Primary Power Supply: IEEE 802.3 Power over Ethernet (PoE)
  - Secondary Power Supply: External “point-of-use” power supply

Digital Thermostat Module (COPTA)

The Digital Thermostat Module (version 1.0), code-named COPTA, is an advanced control module for use with THAT System. As such, the COPTA design shares the basic goals and requirements defined for THAT System. This module shall be developed by Nick Viera in collaboration with Chris Miller.

COPTA is an advanced, digital thermostat with an advanced feature set and programmable control. It is designed for use with most standardized residential and light-commercial, single or split-unit HVAC systems. COPTA shall perform most basic functions as a stand-alone device or it can be integrated into a larger THAT System to provide maximum flexibility and functionality.

Module Goals:

- Hardware Design Goals
  - Graphic, back-lit, monochromatic LCD display.
  - Integral temperature and humidity sensors.
  - Integral outputs for simple 24VAC HVAC system control (Heat, A/C, Fan).
  - Support for advanced 24VAC HVAC system control (w/ separate relay module).
  - LED indicator lamps for easy system status notification.
  - Real time clock with calendar.
  - Non-volatile memory for storing "permanent" system settings.
  - Battery-backup for temporary settings and RTC.
  - Infrared Receiver.

- Software Design Goals
  - Modularity in design.
  - Configurable support for single and multi-stage A/C and heat-pump systems.
  - Configurable support for controlling dynamically variable HVAC systems.
  - Configurable support for reading external temperature/humidity sensors.
  - “Learning” of codes from Infrared remotes.

- Packaging Goals
  - Form Factor: Wall mount, round.
  - Physical size: Approx. 4.5” diameter, < 2” depth.
  - Main user interface: 6-button direct input, LCD/LED output.

Hardware Description:

The COPTA hardware shall be based on an 8-bit microcontroller system. Communication in conformance with THAT will be made possible using a hardware Ethernet controller designed for 10/100Base-TX data rates.

Most of the hardware for COPTA falls into the category of general digital I/O. However, some aspects of the design will utilize more advanced communication interfaces, such as synchronous 2-wire serial (I2C) and 3-wire serial (SPI) interfaces. These interfaces shall be used for communication between the microcontroller and the temperature, humidity, and Ethernet ICs.

The power supply for this module shall comply with THAT System power specifications. All on-board outputs for basic HVAC control will be in the form of mechanical relays. Other control outputs shall be made possible using an external relay module.

The direct user interface, consisting of six (6) pushbuttons, four (4) LEDs, and the LCD screen, shall allow for direct control and programming of the thermostat. The overall hardware block diagram for the module is shown in figure 4-1.

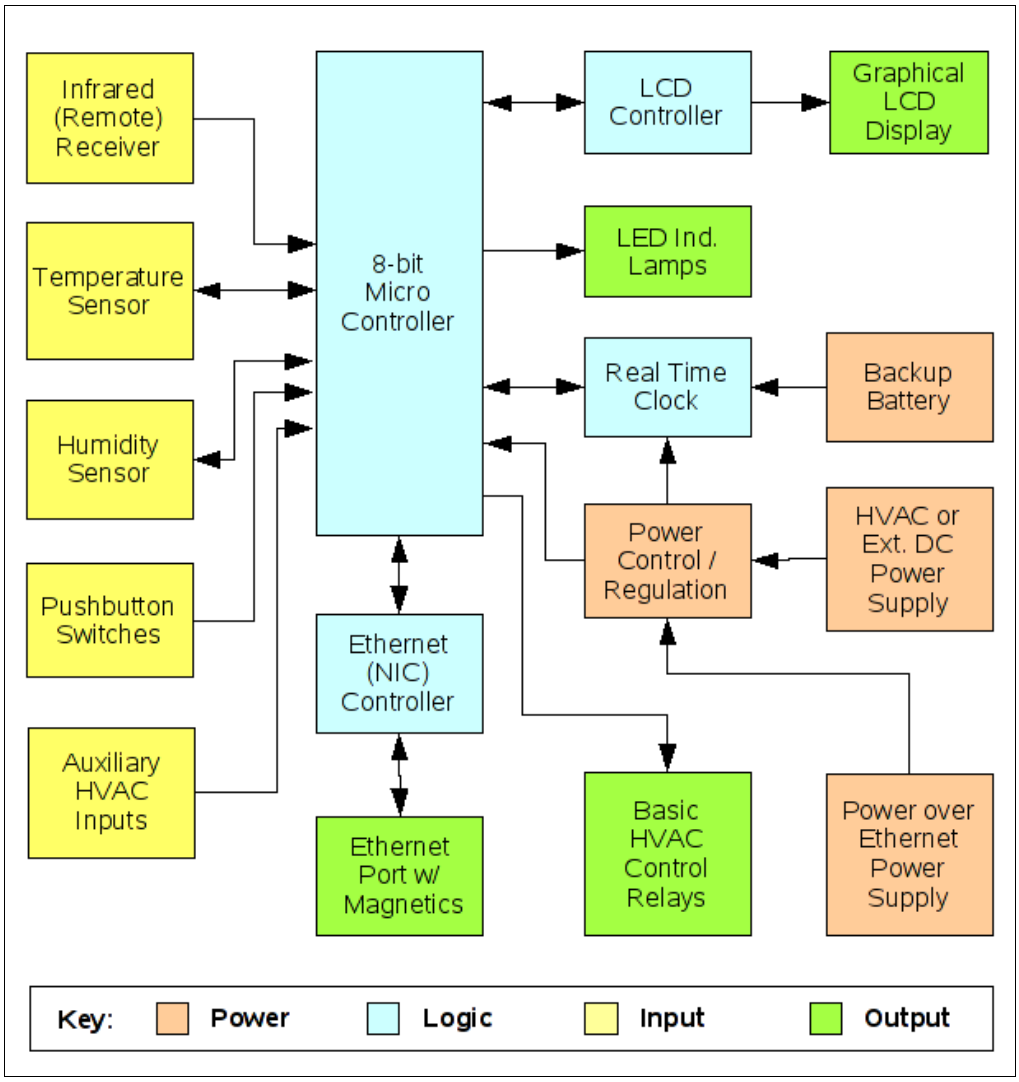

Figure 4-1: COPTA Hardware Block Diagram

Software Description:

The base firmware for COPTA shall be written using C and assembly programming languages, as necessary. The firmware shall implement both the functionality necessary for thermostat operation, and the Ethernet / TCP stack necessary for communication with other THAT modules.

Additional software residing on a computer, PDA, cell phone, etc. can allow for the remote control of the thermostat module. Such software could provide further options for advanced control and integration of the module into a larger system of THAT modules.

Physical Description:

The COPTA module shall be a stand-alone unit capable of directly replacing any "standard" wall-mount thermostat. To achieve this goal, the unit shall not be too large in size and shall be as aesthetically pleasing as possible. The initial physical concept design for COPTA is a unit approximately 4.5" in diameter, and less than 1.5" deep. The design is shown in figure 5-1.

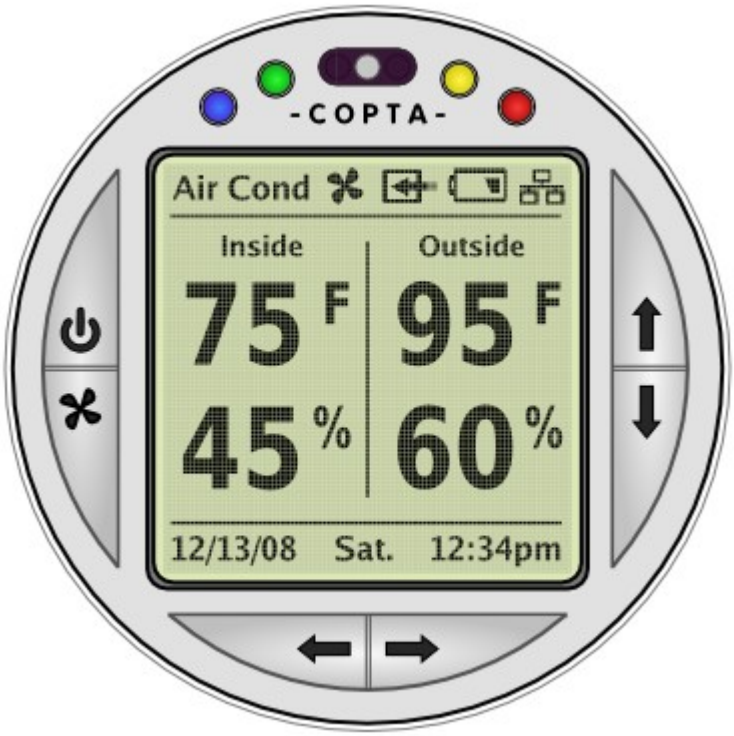

Figure 5-1: COPTA physical concept drawing

Electronic Access Module (EAM)

The Electronic Access Module (EAM) shall be a flexible entry and security system, equipped with programmable control, that shares the basic goals and requirements defined for THAT System. It will be designed for residential and light-commercial buildings. The EAM will be able to function as a stand-alone device or in a larger THAT System to provide maximum flexibility and functionality. This module will be developed by Chris Miller in collaboration with Nick Viera.

Module Goals:

- Hardware Design Goals
  - Monochromatic VFD or backlit LCD display
  - Passcode keypad
  - Wireless receiver for basic lock/unlock remote control
  - Wireless key-chain dongle support (AES encrypted)
  - LED indicators for easy system status notification
  - Non-volatile memory for storing "permanent" system settings
  - Battery-backup for temporary settings

- Software Design Goals
  - Configurable support for access input modules (doorbell, keypad, wireless dongle, card reader, etc.)
  - Configurable support for access output modules (relays for door strikes, keyless deadbolts, and magnetic door closers)
  - Configurable support for security input modules (window / door, smoke / CO, motion, water, etc.)
  - Configurable support for security output modules (siren, phone / SMS / email notifier, X10 / Insteon, etc.)

Hardware Description:

The EAM hardware will be based on an 8-bit microcontroller. Most of the hardware will fall into the category of general digital I/O. Additionally, 3-wire serial (SPI) will be used for communication between the microcontroller and the Ethernet IC. Communication in conformance with THAT will be made possible using a hardware Ethernet controller designed for 10/100Base-TX data rates. See Figure 7-1 for the hardware block diagram.

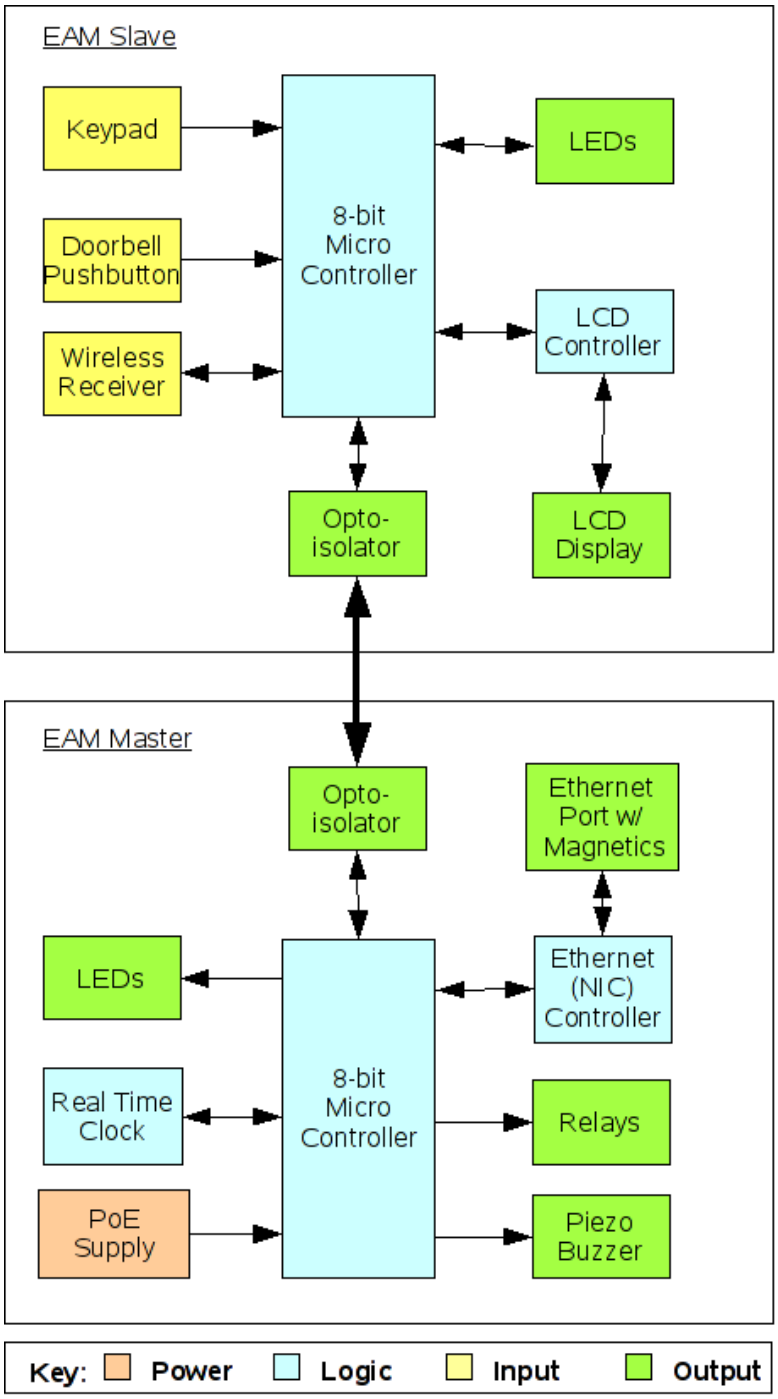

Figure 7-1: EAM Hardware Block Diagram

Software Description:

EAM firmware will be consist of mainly C code. The firmware will implement both the functionality necessary for the entry and security functionality as well as the Ethernet / networking stack necessary for communication with other THAT modules.

Physical Description:

The EAM master module is a device that should be installed by the homeowner in an out-of-the-way place (such as a basement or closet), like most security systems, to prevent tampering by intruders. For this reason the master module shall be housed in an ordinary-looking plastic box.

The EAM slave module, however, shall need to be aesthetically pleasing and blend in to the front of a home. It will be rectangular with a doorbell pushbutton, ten (10) passcode pushbuttons, and a monochromatic VFD or backlit LCD display.