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IoT based Control Panel Application

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Abstract: Internet of things (IoT) is a concept of connecting any Thing to Internet. Thing may be a device, sensor, actuators, home appliances and also connectivity which helps to connect these things to internet and also to exchange data between things and Internet. In this Project we make a control panel application and exchange data between Thing (SAM G55 Xplained Pro Board) and Internet. Control panel application contains Temperature sensor, Light sensor, an LED and a Button. Temperature sensor, light sensor data is collected from respective sensors from I/O1 Xplained Pro board and send to SAM G55 Xplained Pro board. Button and LED are present on Sam G55 Xplained Pro board itself only. Here data exchange is done using MQTT Protocol where Sam G55 Xplained Pro board is connected to I/O1 Xplained Pro board and WINC 1500 Xplained Pro board which is used for wireless connectivity and MQTT Protocol is connected to WINC 1500 board through Software code. The data is kept in Internet and is viewed using a GUI.

Keywords: MQTT, IoT, SAM G55, WINC1500, I/O1 Xplained Pro, GUI.

I. INTRODUCTION

IoT is the Most Uprising technology in 21st century. Because of IoT online capable devices figure has increased 31% from 2016 to 8.4 billion in 2017. Experts estimate that by 2020 the IoT will consist of about 30 billion objects. It is also estimated that the global market value of IoT will reach $7.1 trillion by 2020.

The IoT allows objects to be controlled or sensed remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and will result in economic benefit, accuracy, improved efficiency and reduced human intervention. When IoT is made greater with actuators and sensors, the technology becomes an instance of the more general class of cyber-physical systems. Some of the applications are smart homes, intelligent transportation, Patient monitoring, smart cities, virtual power plants and smart grids.

Internet of things (IoT) is a concept of connecting any Thing to Internet. Thing may be a device, sensor, actuators, home appliances and also connectivity which helps to connect these things to internet and also to exchange data between things and Internet.

In this Project we make a control panel application where we can get data such as sensors data and control the led, button on the Thing. We use temperature sensor and light sensor which are present on I/O1 Xplained Pro extension board. As for mechanical button and led are present on thing itself. We control button and led in both ways i.e. button on thing is used to control led on GUI and Vice versa.

II. HARDWARE COMPONENTS

1. SAMG55 Xplained Pro board (Thing):-

We are using SAMG55 Xplained Pro board as the Thing in our project where code to control or sense data then to publish or subscribe is present.

The SAM G55 is a series of Flash microcontrollers based on the high-performance ARM Cortex-M4 32-bit RISC processor with Floating Point Unit(FPU).SAMG55 maximum operating speed is 120 MHz and have features like 512 Kb of Flash and up to 176 Kbytes of SRAM. The peripheral set includes eight communication units which are flexible comprising SPIs, USARTs and I2C-bus interfaces (TWIs), two three-channel general-purpose 16-bit timers, two Inter-IC Sound controllers (I2SC's), one-channel PDM(pulse density modulation), one 8-channel 12-bit Analog to Digital converter(ADC), one real-time timer (RTT) and one real-time clock (RTC), both located in the ultra-low-power backup area.[1]

The features of ATSAMG55J19 (SAMG55 Xplained Pro board) are as follows:-

- It has 160Kb and up to 16Kb (I/D RAM + Cache) of SRAM
- It contains Memory Protection Unit(MPU)
- It uses Thumb-2 instruction set
- It contains 512Kb of Flash
- It has up to 8Kb of Cache
- It is of LPQF64 Package
- It has 48 PIO (Peripheral Input Output) pins.
- It contains 16 External Interrupts

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- It contains an 12-bit ADC which has 8 channels and performance of 500 kSps
- It has 6 channels (3 external channels) 16-bit Timer
- It has 8 Flexible SERCOM (serial communication) which can be used for USART (Universal synchronous asynchronous receiver and transmitter), TWI (Two wire Interface), TWIHS (Two wire Interface High speed), and SPI (Serial peripheral Interface).
- It has 2 I2SC's and 1 Channel 2-way PDM.
- It also contains Full speed /OHCL USB, 1 CRCCU, 1 Real time timer (RTT) and 1 Real time clock (RTC).
- Contains Power-on reset (POR) and Watchdog for safe operation.
- Up to 30 peripheral DMA (PDC) channels
- 2 three-channel 16-bit Timer/Counters (TC) with capture, waveform, compare and PWM modes
- It operates at industrial operating ranges i.e. -40° C to +85° C.[1]

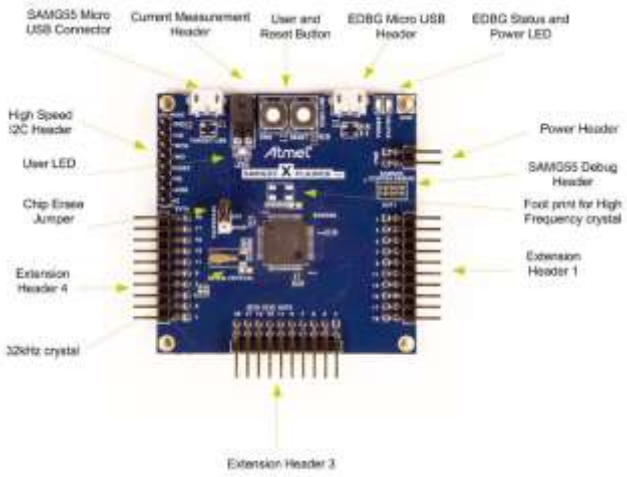

Figure 1:-SAMG55 Xplained Pro board

2. WINC1500 Xplained PRO :-

The WINC1500-Xplained PRO is an extension board to check the performance of the ATWINC15x0-MR210xB IoT (Internet of Things) module which supports an IEEE 802.11 b/g/n standard. This extension board is designed to provide Wi-Fi functionality in the 2.4 GHz ISM band to the Xplained Pro evaluation platform. Access to features of ATWINC15x0-MR210xB wireless module and explanation for how to integrate the module with custom design is provided by this kit.

ATWINC15x0-MR210xB is a module which is specifically optimized for low power 802.11 b/g/n Internet of Things (IoT) applications. The module integrates Power Low-Noise Amplifier (LNA), Switch, Amplifier (PA), Power Management, and a printed antenna or a micro co ax (u.FL) connector for an external antenna resulting in a small form factor (21.7 x 14.7 x 2.1 mm) design. It is interoperable with various vendors' 802.11 b/g/n access points. This module provides SPI ports to interface with a host controller.[5]

The Features of WINC1500 are as follows:

- IEEE 802.11 b/g/n 20 MHz (1x1) solution
- Supports 20 MHz single spatial stream , up to 72.2 Mbps PHY rate in the 2.4 GHz ISM band
- Network features which are Supported are : TCP, DHCP, ARP,UDP ,DNS, SSL, and HTTP
- Supports host interface through SPI
- Integrated Power Amplifier (PA), Tx/Rx switch and Printed Circuit Board (PCB) antenna or u.FL micro co-ax connector for external antenna
- Supports superior sensitivity and long range via advanced PHY signal processing
- Supports on-chip network stack to offload MCU
- Flash memory is integrated for system software
- I2C and UART header footprints can be debugged.
- Contains RESET switch and Extension port footprints
- Crypto authentication (optional)
- Xplained Pro extension hardware identification system
- Supports an operating temperature range from -40°C to +85°C. RF performance at room temperature of 25oC with a 2-3 dB change at boundary conditions
- The kit contains the ATWINC1510-MR210PB module by default
- Advanced equalization ,carrier ,channel estimation and timing synchronization
- Wi-Fi Direct (supported till firmware release 19.5.2)

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- Soft-AP support
- Supports IEEE 802.11 WEP, WPA, WPA2 security
- Superior MAC throughput via hardware accelerated two-level A-MSDU/A-MPDU frame aggregation and block acknowledgment
- On-chip memory management engine to reduce host load
- The operating voltage of I/O is between 2.7V to 3.6V
- It has Built-in 26 MHz crystal
- On-chip boot ROM (Firmware instant boot) has SPI flash boot. It has Low-leakage on-chip memory for state variables and Fast AP re-association (150 ms).
- Hardware accelerator for OTA security , IP checksum and for Wi-Fi and TLS security to improve connection time
- Small footprint host drive[5]

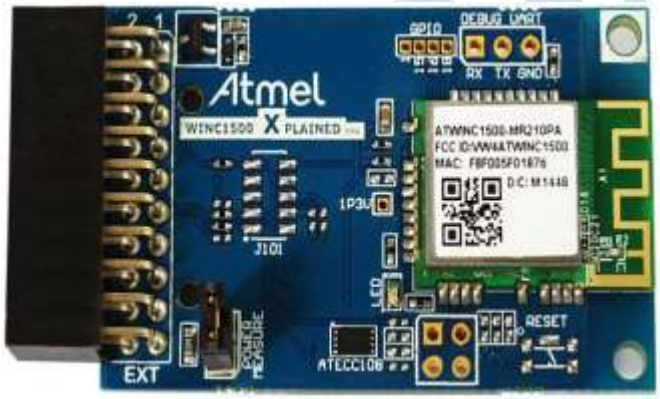

Figure 2:-WINC1500 Xplained PRO board

3. I/O1 Xplained Pro board:-

I/O1 Xplained Pro is an extension board for the Xplained Pro evaluation platform. It connects to any I/O1 Xplained Pro is designed to give a wide variety of functionality and is connected with any standard extension header on any Xplained Pro MCU boards including a temperature sensor, a light sensor, an OLED and a micro SD card. The extension board uses all functions which are present on the standard Xplained Pro extension header to further enhance the feature set of Xplained Pro MCU boards.[4]

The Features of I/O1 Xplained PRO are:

- micro SD card connector
  - 2GB micro SD card included
  - Accessed with SPI interface
- PWM
  - LED control
  - PWM → Low pass filter → ADC
- ADC
  - PWM → Low pass filter → ADC
  - Light sensor
- UART
  - Loopback interface via pin header
  - TWI
- AT30TSE758 temperature sensor with EEPROM
- Xplained Pro hardware identification system
- Compatible with the Xplained Pro extension headers
- Auto-ID for board identification in Atmel Studio
- Spare GPIO available on 100-mil pitch headers[4]

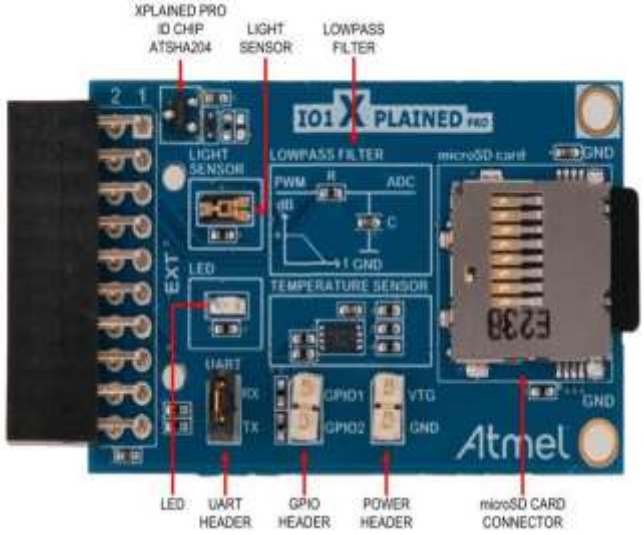

Figure 3:-I/O1 Xplained PRO board

III. SENSORS and MODULES

1. Temperature sensor:-

I/O1 Xplained Pro extension board contains a Microchip Atmel AT30TSE758 temperature sensor chip which has 8kb serial EEPROM inside. The sensor includes programmable low and high temperature alarms, up to 12 bits of user selectable temperature resolution, and an I2C or SMBus compatible serial interface.

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The AT30TS/TSE75xA digital Temperature Sensor Family composes of six devices of high-precision based on the LM75 industry-standard functionality. These devices offer designers a choice of non-volatile registers and serial EEPROM for optimal system accuracy and heightened integration. The AT30TS/TSE75xA digital Temperature Sensor is fully factory-graded, complete, Real-time temperature monitoring solution that operates in the range between -55°C to +125°C. The devices output digitized temperature data via a standard I2C/SMBus-compatible serial interface, removing the need for any A/D converters or such external components and data post-processing.

Temperature sensor has two TWI addresses; each one for the temperature sensor and EEPROM respectively. The temperature sensor address is "0b1001 A2 A1 A0" and EEPROM address is "0b1010 A2 A1 A0". Temperature sensor chip is pulled high through 100kΩ resistors by default for address selection lines (A2, A1, and A0), this makes the default addresses for temperature sensor and EEPROM 0b1001111 and 0b1010111 respectively. While communicating with the EEPROM parts of the TWI address is used as a page address.

2. Light Sensor:-

I/O1 Xplained Pro contain a TEMT6000 light sensor. ADC pin on an Xplained Pro MCU board is used to read the sensor data.
TEMT6000X01 ambient light sensor is a silicon NPN epitaxial planar phototransistor in a miniature transparent 1206 package for surface mounting. It is sensitive to visible light similar to that of the human eye and has peak sensitivity at 570 nm.

- Features:-
  - Package type: surface mount
  - Package form: 1206
  - Dimensions (L x W x H in mm): 4 x 2 x 1.05
  - AEC-Q101 qualified
  - High photo sensitivity
  - Adapted to human eye responsively
  - Angle of half sensitivity: ± 60°
  - Floor life: 168 h, MSL 3, acc. J-STD-020
  - Lead (Pb)-free reflow soldering
  - Compliant to RoHS Directive 2002/95/EC and in accordance to WEEE 2002/96/EC.
- Applications:-

Ambient light sensor can be used for control of display backlight dimming in LCD displays and keypad backlighting of mobile devices and in industrial on/off-lighting operation.

- Automotive sensors
- Mobile phones
- Notebook computers
- PDA's
- Cameras
- Dashboards

3. Mechanical buttons:-

Two mechanical buttons are present on SAM G55 Xplained Pro board. One button is the RESET button connected to the SAM G55 reset line and the other is a generic user configurable button. The I/O line is driven to ground (GND) whenever a button is pressed. We use Pin PA02 as SW0 Button, which is used to control LED on GUI (Graphical User Interface).

4. LED:-

A yellow LED is available on the SAM G55 Xplained Pro board. The LED can be activated by driving the connected I/O line to GND. Pin PA06 is connected to LED0 on the board, which is controlled using GUI button.

5. Graphical User Interface:-

Communication with electronic devices via graphical icons and visual indicators, instead of user interfaces such as text-based text navigation or typed command labels is possible in Graphical user interface (GUI). GUIs were introduced in reaction to the perceived steep learning curve of command-line interfaces (CLIs), which require commands to be typed on a computer keyboard.

Direct manipulation of the graphical elements is performed whenever an action in a GUI takes place. Beyond computers, GUIs are used in many handheld mobile devices such as MP3 players, smartphones, portable media players, gaming devices, smaller household, office and industrial controls
I have created a GUI using freeboard.io which contains gauge which can be used to see temperature in Celsius, light intensity in percentage, an LED and a message window. As for GUI button is also added to that dashboard (.json format) by adding the button code written in java script to html file which is linked to freeboard.

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IV. METHODOLOGY AND IMPLIMENTATION

In this Project we make a control panel application and exchange data between Thing (SAM G55 Xplained Pro Board) and Internet. Control panel application contains Temperature sensor, Light sensor, an LED and a Button. Temperature sensor, light sensor data is collected from respective sensors from I/O1 Xplained Pro board and send to SAM G55 Xplained Pro board. Button and LED are present on Sam G55 Xplained Pro board itself only. Here data exchange is done using MQTT Protocol where Sam G55 Xplained Pro board is connected to I/O1 Xplained Pro board and WINC 1500 Xplained Pro board which is used for wireless connectivity and MQTT Protocol is connected to WINC 1500 board through Software code. The data is kept in Internet and is viewed using a GUI.

On GUI we will see Temperature Sensor and Light Sensor data in Gauges ranging 0-100 in Celsius and % of light intensity respectively. We also have a button and LED on GUI where we use the button on GUI to control the LED present on the Thing (SAMG55 Xplained Pro board) and mechanical button (SW0) on the Thing (SAMG55 Xplained Pro board) to control the LED on GUI. Here we send messages in form of strings and compare them using GUI and code present in the Thing using MQTT protocol which publishes those messages on Internet, which are then used to compare to get result and then to show it on the GUI.
The control panel application block diagram is as shown in Figure.

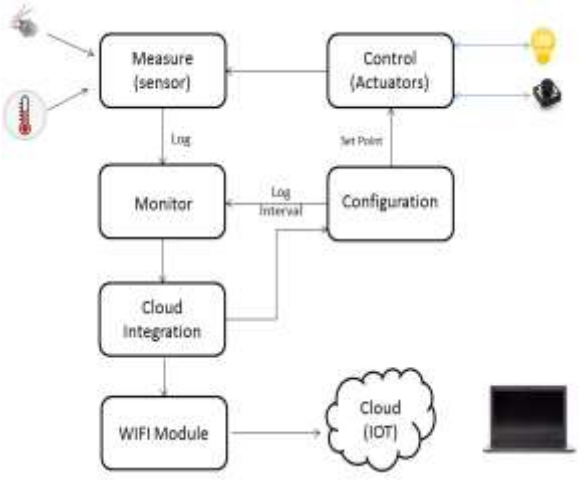

Figure 4:-IoT based Control Panel application Block Diagram

V. RESULT

The hardware setup is done as shown in Figure4.

Figure 5:- Final Hardware Setup

The messages that I am publishing into Internet can be seen through console as shown in Figure 6.

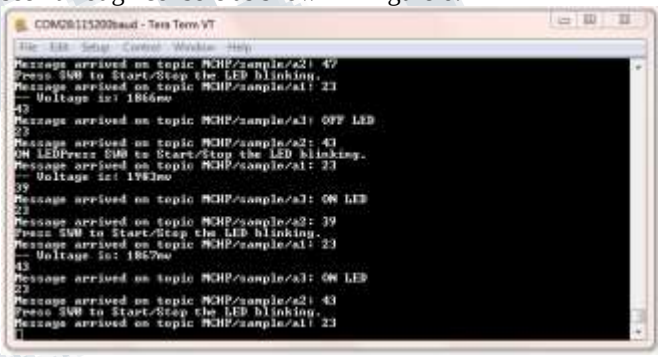

Figure 6:-Messages shown in Console

As for output can be showed in GUI where we can see temperature and light sensor data in gauge and LED using LED widget and can control Button with button widget we integrated into GUI. Here in Figure 7 we show where "LED ON" on the GUI while we press SW0 button on the SAMG55 Xplained pro board shown in Figure 5.

Figure 7:- GUI Output where LED on GUI is ON while SW0 Button is pressed

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Similarly When Button on GUI is pressed (shown in Figure 8), the LED on Thing (SAMG55 Xplained Pro) is on as shown in Figure 9. As for Temperature Sensor and light sensor data can be seen from both Figure 7 and Figure 8.

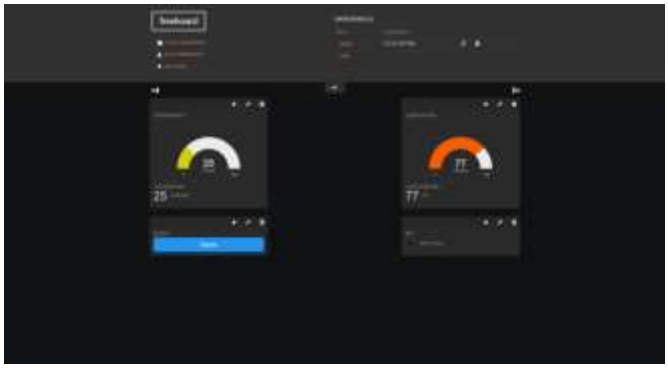

Figure 8:- Button on GUI is pressed

Figure 9:- On the Thing (SAM G55 Xplained Pro) LED in ON.

At the subscriber end if they don't have the GUI then they can see the output by running an python code which is subscribed to our topic can see the output as shown in Figure 10.

Figure 10:-Output on Subscriber End without GUI

VI. CONCLUSION

This IoT based Control panel application can be used anywhere such as home appliances, health care etc., where data from sensors are kept in internet which can be observed from anywhere and if see problem in the data reading we can know immediately. The best suited example for above mentioned scenario is patient monitoring so that doctor can monitor from his/her cabin itself and can react quickly if he sees problem in data. We have use control panel application to automatically control electronic gadgets which are far away, like by pressing button on the GUI on his/her phone or laptop he/she can switch on Lights etc., electronic gadgets which are present at home from far away if these electronic gadgets are connected to internet. So IoT based Control panel application can be used for multiple applications or usages.

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