Program: ESE 4009

INSTRUCTOR: Prof**.** Mike Aleshams

Group #4

Student Name	Student ID	Signature*
Govind Raj	C0753448	Govind Raj
Sunny Devgan	C0752045	Sunny Devgan
Varundeep Singh	C0754247	Varundeep Singh

Project Proposal

Project Title:

Car over-speed detection system**.**
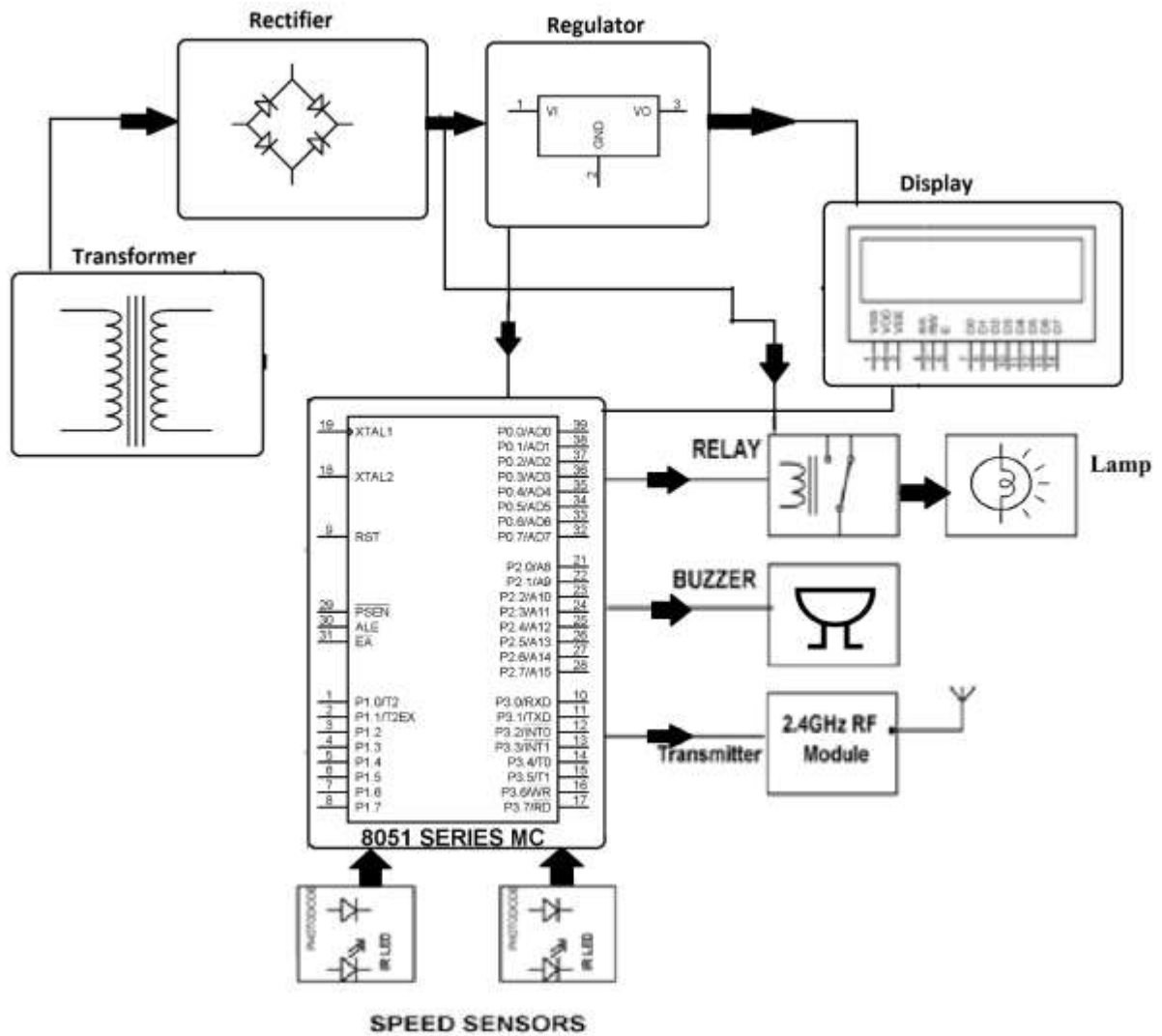
Description of the latest similar system:

Over-speeding of cars has caused many road accidents over the years. There needs to be a system which can detect the over speeding of cars. When a car goes beyond the prescribed speed limit, a detection system should be able to detect it. Also, the system will be able to display the speed of the given vehicle on the screen.
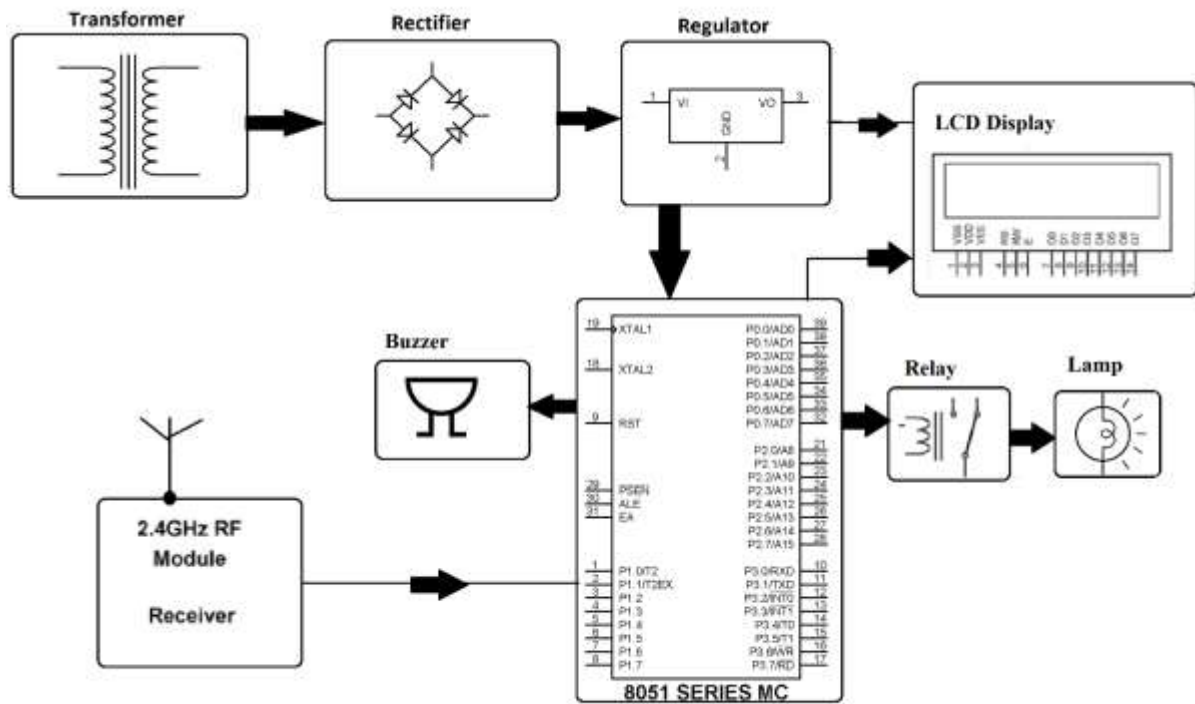
The system calculates the time for a car to cover the distance from point A to point B. This is how speed is calculated for the given car. The screen would still show the speed of the car. The assembly consists of an 8051 microcontroller and an IT transmitter-receiver pair which are responsible for calculating the speed. Depending on the time taken by the car to travel between the points, we can check if the car is over-speeding or not. If the car is over-speeding, a buzzer alarm will get activated and notify us.

Hardware and Software Requirements:

- 8051 Series Microcontroller
- LEDs
- Transistor
- Lamp
- IR LEDs
- Photodiodes
- Transformer
- LCD
- Buzzer
- Relay
- Diodes
- RF Transmitter-Receiver
- Keil Compiler
- MC Programming Language: C

Block Diagram:

Rectifier

Regulator

Transformer

Display

XTAL1   P0.0/AD0
   P0.1/AD1
   P0.2/AD2
XTAL2   P0.3/AD3
   P0.4/AD4
   P0.5/AD5
   P0.6/AD6
RST   P0.7/AD7

P2.0/A8
P2.1/A9
P2.2/A10
PSEN   P2.3/A11
ALE   P2.4/A12
EA   P2.5/A13
P2.6/A14
P2.7/A15

P1.0/T2   P3.0/RXD
P1.1/T2EX   P3.1/TXD
P1.2   P3.2/INT0
P1.3   P3.3/INT1
P1.4   P3.4/T0
P1.5   P3.5/T1
P1.6   P3.6/WR
P1.7   P3.7/RD

8051 SERIES MC

RELAY

Lamp

BUZZER

2.4GHz RF
Module

Transmitter

SPEED SENSORS

Limitations of the latest similar system:

- 8051 microcontroller is an old technology product. It can fulfil our basic need, but we need something which can give a quick response.
- This system cannot capture the number of cars that have over-sped on that road as there is no internet connectivity and cloud storage.
- This system uses an RF signal for communicating between the receiver and transmitter circuits. RF signal has limited range and poor connectivity.

Solution 1:

- **Block Diagram:**
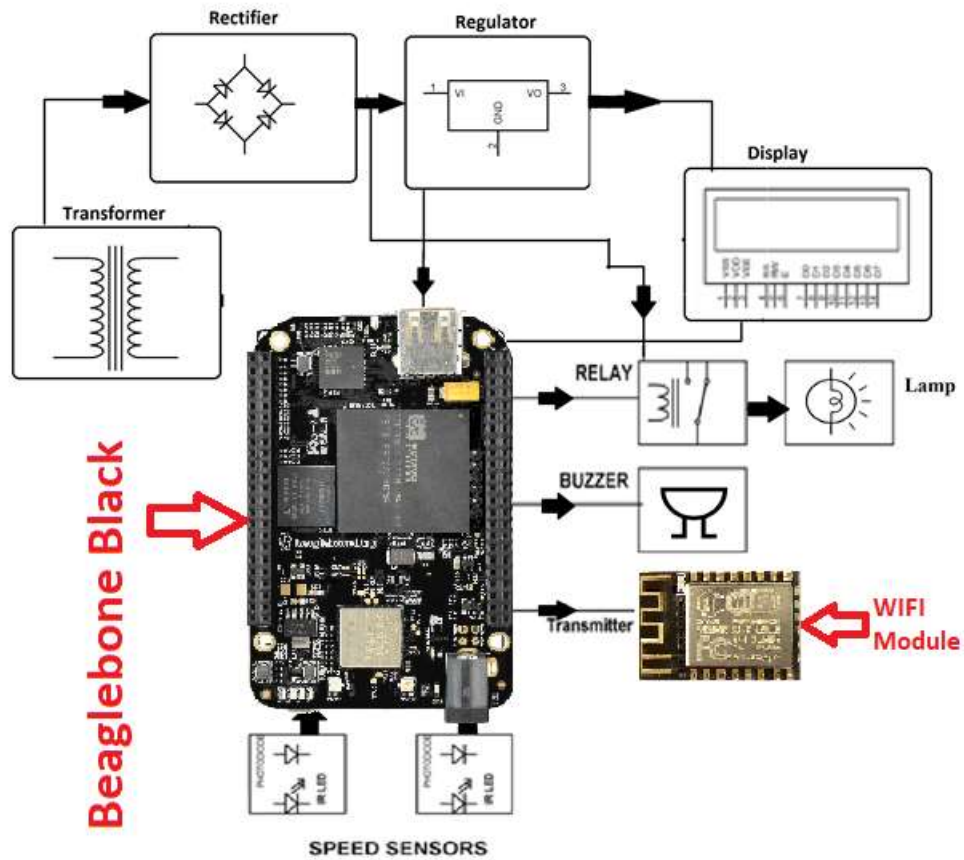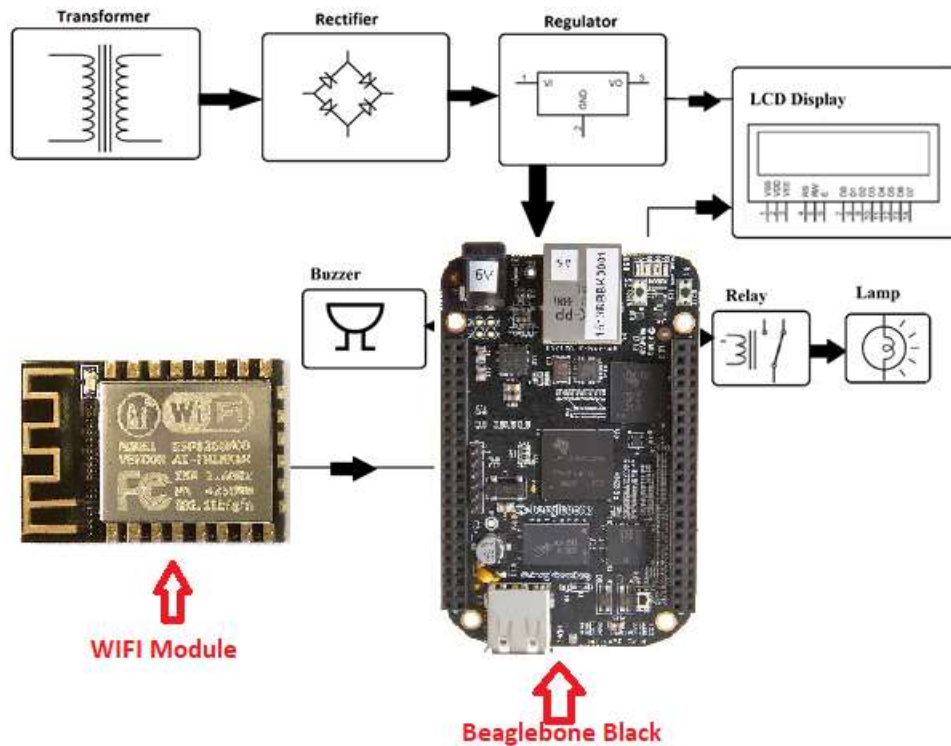
- **Features:**

In the existing system, 8051 microcontroller was being used. Because of its old technology, we decided to upgrade it. Hence, we will be using a Beaglebone Black.

As RF signals are weak and have limited range, we have decided to replace it with a better communication channel – WIFI module. We are using ESP8266 for this purpose.

As we are using a WIFI module, we are making it an IOT system. The system can be connected to the internet to store data on the cloud storage.

On the receiver end, WIFI module is optional. As the Beaglebone Black has an inbuilt IEEE 82.3 ethernet port, we can provide internet connectivity via an ethernet cable.

Specifications of Beaglebone Black –

Processor: AM335x 1GHz ARM® Cortex-A8

- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers
- USB client for power & communications
- USB host
- Ethernet

- HDMI
- 2x 46 pin headers
- Debian
- Android
- Ubuntu
- Cloud9 IDE on Node.js w/ BoneScript library

Specifications of ESP8266 –

- High durability
- Compactness
- Power-Saving architecture
- 32-bit Tensilica processor

✓ **Hardware and Software Requirements:**

- Beaglebone Black
- LEDs
- Transistor
- Lamp
- IR LEDs
- Photodiodes
- Transformer
- LCD
- Buzzer
- Relay
- Diodes
- WIFI module (ESP8266)
- MC Programming Language: C

Solution 2:

- **Block Diagram:**

Transformer → Rectifier → Regulator → LCD Display

Buzzer

Relay → Lamp

Beaglebone Black Wireless
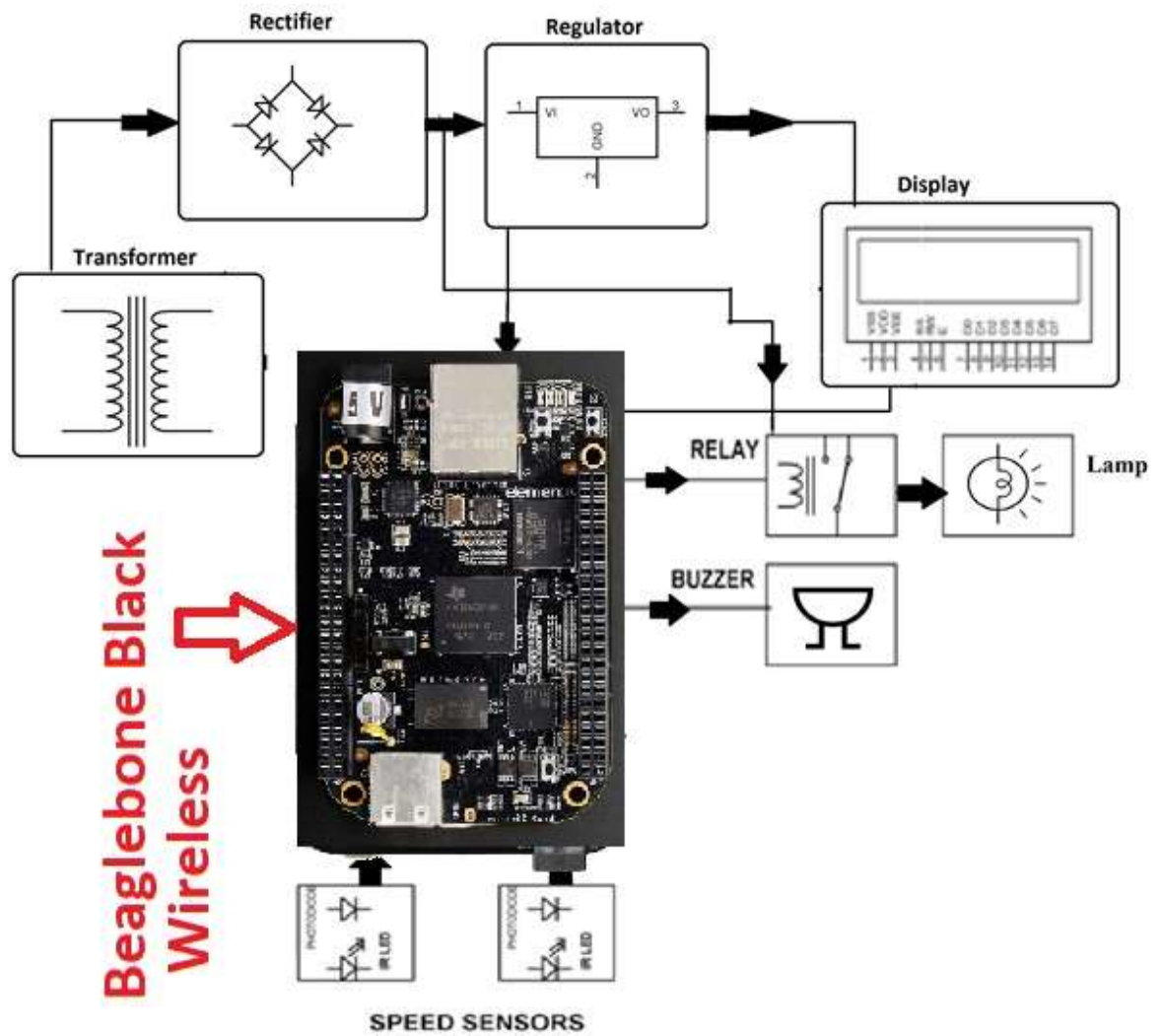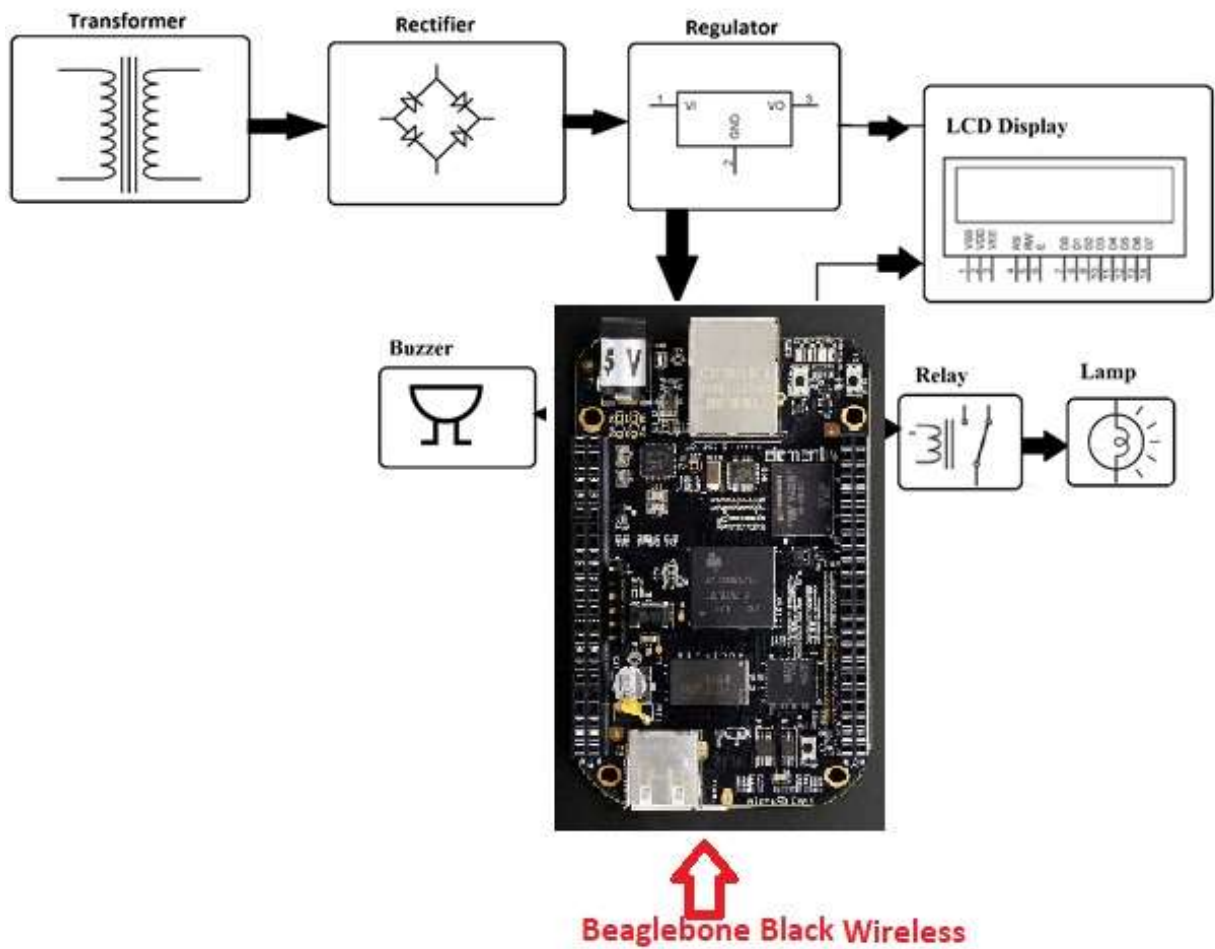
- **Features:**

In order to make the system more compact, we have replaced 2 modules with a better single module. We have replaced the Beaglebone Black and the WIFI module with a Beaglebone Black Wireless.
This model has an inbuilt WIFI module. So, we do not need to add an external WIFI module to it.
Specifications of Beaglebone Black Wireless –
Processor: Octavo Systems OSD3358 1GHz ARM® Cortex-A8

- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers
- USB client for power & communications
- USB host
- 802.11b/g/n and Bluetooth 4.1 plus BLE
- HDMI
- 2x 46 pin headers
- Debian with Cloud9 IDE on Node.js w/ BoneScript library
- Third party support for Android and Ubuntu

✓ **Hardware and Software Requirements:**

- Beaglebone Black Wireless
- LEDs
- Transistor
- Lamp
- IR LEDs
- Photodiodes
- Transformer
- LCD
- Buzzer
- Relay
- Diodes
- MC Programming Language: C

✓ **References:**
- Arduino Car Speed Detector. (2018, December 28). Retrieved from https://www.electronicshub.org/arduino-car-speed-detector/
- Beaglebone Black. (n.d). Retrieved from https://beagleboard.org/black
- Beaglebone Black Wireless. (n.d). Retrieved from https://beagleboard.org/black-wireless
- ESP8266. (n.d). Retrieved from https://www.espressif.com/en/products/socs/esp8266
- Gyawali, P. K. (2014, August). A final year project report on vehicle over speed detection and recognition. Retrieved from https://www.researchgate.net/publication/325108341_A_FINAL_YEAR_PROJECT_REPORT_ON_VEHICLE_OVER_SPEED_DETECTION_AND_RECOGNITION

Final Solution (after presentation):

- **Block Diagram:**

Block diagram of main MCU for receiving and processing data from arduino and send the data to cloud.
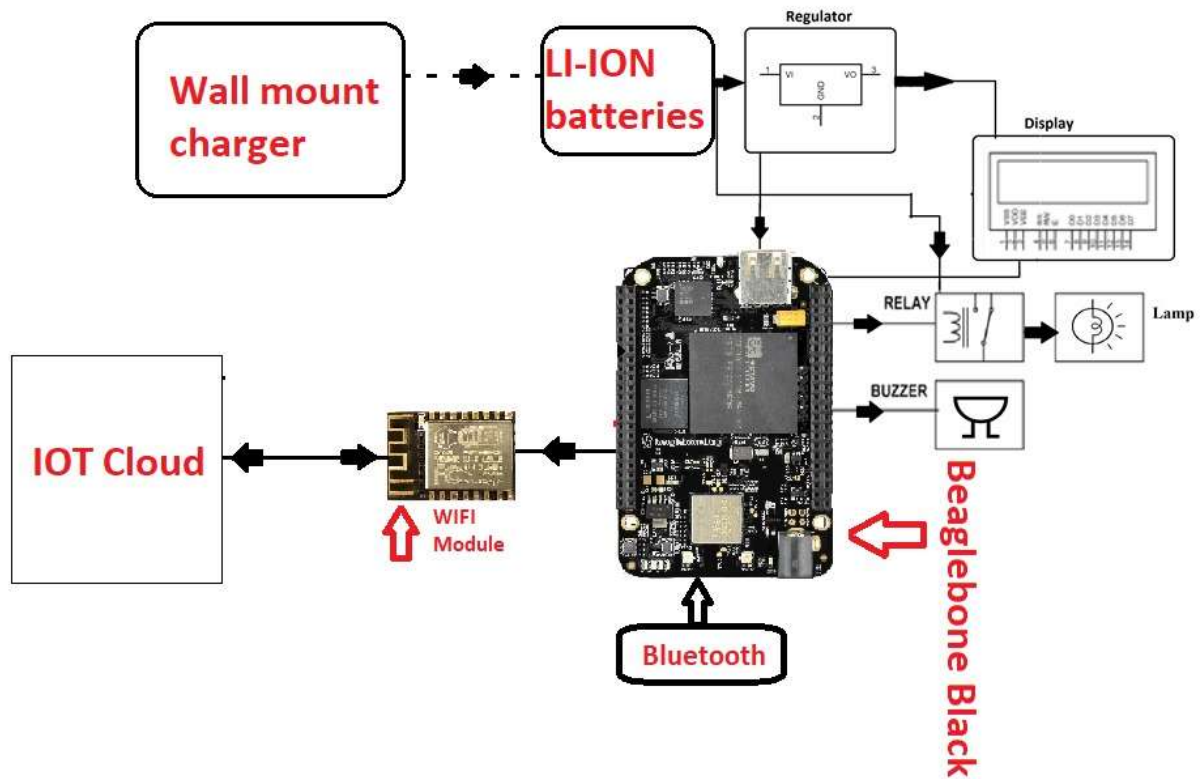
Block diagram for arduino which is used to send the sensor data to BBB.
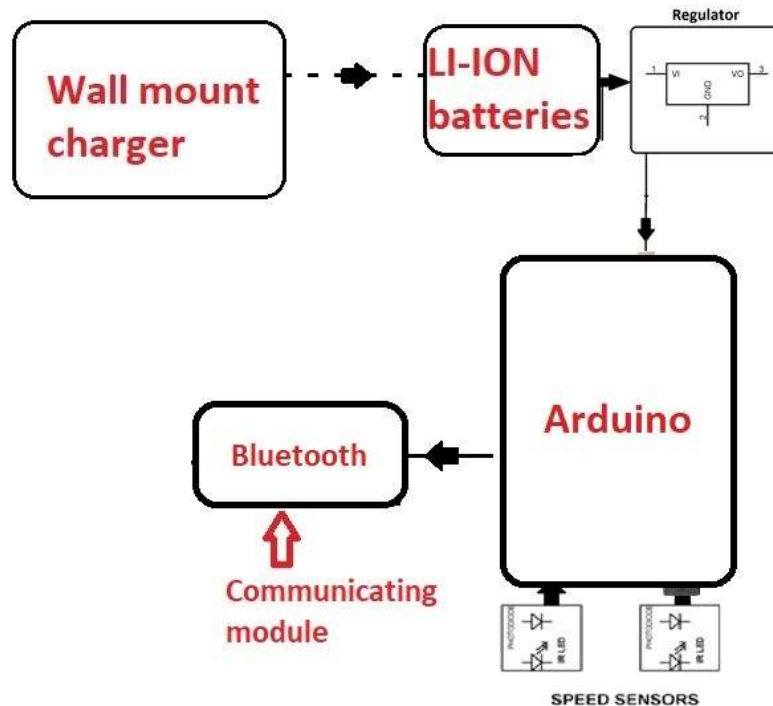
✓ **Hardware and Software Requirements:**

- Beaglebone Black
- Lamp
- IR Sensor
- Transformer
- LCD
- Buzzer
- Relay
- WIFI module (ESP8266)
- Arduino IDE, Eclipse IDE,Easy EDA
- Bluetooth 4.0
- MC Programming Language: C

✓ **Flowchart:**

```
                          ┌───────────┐
                          │   START   │
                          └─────┬─────┘
                                │
                                ▼
                    ┌───────────────────┐
              ┌────▶│  INITIALIZE ALL   │
              │     │     HARDWARE      │
              │     └─────────┬─────────┘
              │               │
              │               ▼
              │     ┌───────────────────┐
              │     │   DISPLAY START   │
              │     │     MESSAGE       │
              │     └─────────┬─────────┘
              │               │
              │               ▼
              │     ┌───────────────────┐
              │     │ START DETECTING   │
              │     │      SPEED        │
              │     └─────────┬─────────┘
              │               │
              │               ▼
              │       ╱───────────────╲
              │      ╱  CHECK           ╲◀──────────┐
              │      ╲  SENSOR 1        ╱           │
              │       ╲───────┬───────╱            │
              │               │                    │
              │               ▼                    │
              │            ◇─────────◇     NO       │
              │           ╱ IF ABJECT ╲────────────┘
              │           ╲ DETECTED  ╱
              │            ◇────┬────◇
              │              YES │
              │                  ▼
              │          ╱───────────────╲
              │         ╱  CHECK           ╲◀──────────┐
              │         ╲  SENSOR 2        ╱           │
              │          ╲───────┬───────╱            │
              │                  │                    │
              │                  ▼                    │
              │        ┌───────────────────┐          │
              │        │    RECORD TIME    │          │
              │        └─────────┬─────────┘          │
              │                  │                    │
              │                  ▼                    │
              │               ◇─────────◇    NO       │
              │              ╱ IF OBJECT  ╲───────────┘
              │              ╲ DETECTED   ╱
              │               ◇────┬────◇
              │                 YES │
              │                     ▼
              │           ┌───────────────────┐
              │           │    CALCULATE      │
              │           │      SPEED        │
              │           └─────────┬─────────┘
              │                     │
              │                     ▼
              │             ╱───────────────╲
              │            ╱  SHOW SPEED      ╲
              │            ╲  ON DISPLAY      ╱
              │             ╲───────┬───────╱
              │                     │
              │        NO           ▼            YES
              └─────────────◇───────────────◇──────────┐
                           ╲ IF OVERSPEED  ╱            │
                            ◇─────────────◇             │
                                                        ▼
                                              ╱───────────────╲
                                             ╱   BULB          ╲
                                             ╲   NOTIFICATION  ╱
                                              ╲───────┬───────╱
                                                      │
                                                      ▼
                                             ╱───────────────╲
                                            ╱  UPLOAD DATA ON ╲
                                            ╲     CLOUD       ╱
                                             ╲───────────────╱
```
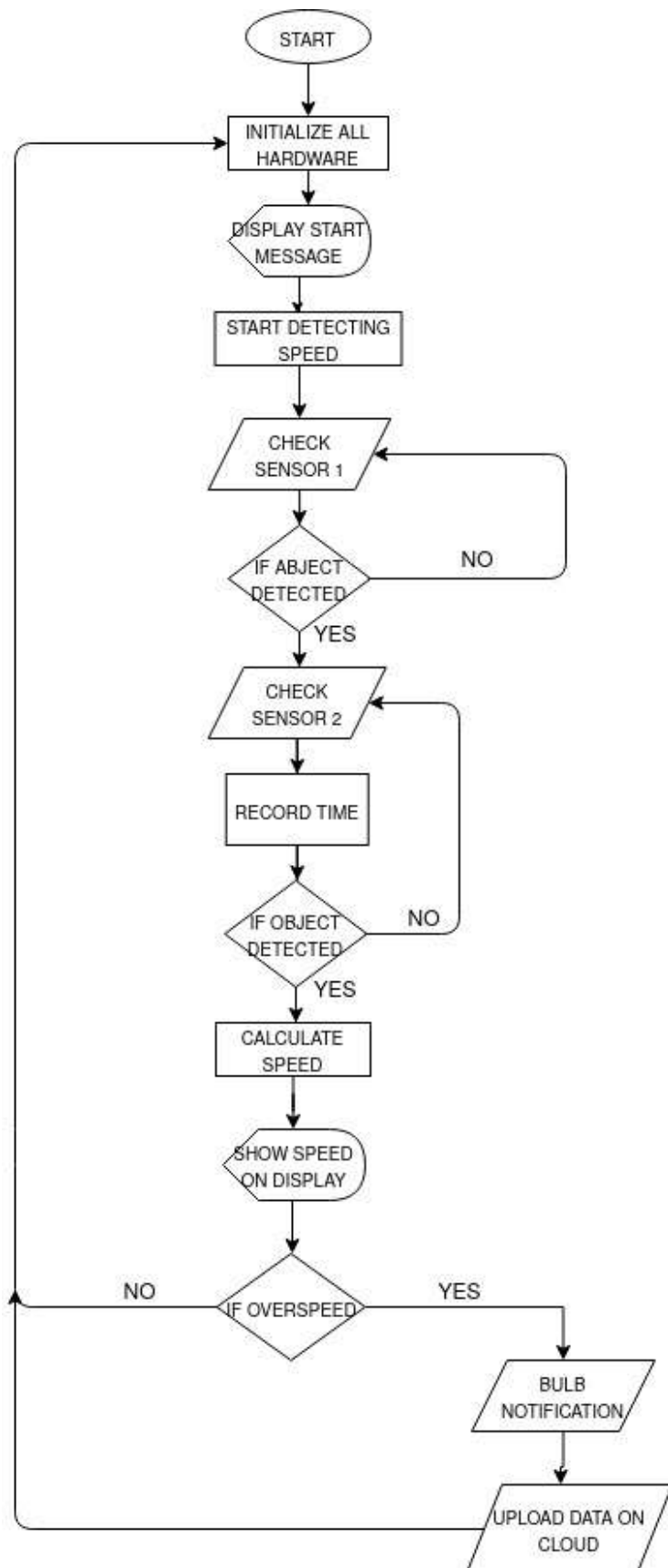
- **Features:**

- ➢ **Use of various peripherals such as touch screens, cameras, microphones and speakers, GPIOs, timers, GPS modules, Bluetooth, WiFi, and ADC/DACs?**

- Piezo Buzzer – The buzzer will go off when the system detects an over-speeding car.
- Proximity IR Sensor – 2 sensors are used to calculate the speed of the moving object. Since we know the distance between them and the time taken to cover the distance, we can find out the speed.
- 16x2 LCD Display with I2C – It shows the speed of the vehicle that travels between the sensors.
- LM2596 DC-DC Voltage Regulator Module – To regulate the voltage from the battery to 5V which is needed by the Beaglebone Black.
- 11.2 Volts Li-Ion Battery – Power supply.
- 3 cell Battery Charger – To charge the Li-ion batteries when they discharge.
- Beaglebone Black – Main microcontroller unit.
- WIFI module (ESP8266) – To provide internet connectivity to the Beaglebone Blck and connect it to the cloud storage (Thingspeak).
- Bluetooth 4.0- To communicate from arduino to Beaglebone black .
- Connecting Wires

We can also use seven-segment display instead of LCD screen. We will have the flexibility of showing some text as well as for ease of use. However, the same will not be possible with a seven-segment display.

Hardware tools: Screwdriver, Wire Cutter, Soldering Iron and Digital Multimeter.

- ➢ **Use of I2C, SPI, RS232/RS-485, IrDA infrared, JTAG, USB, Bluetooth, IEEE 802.11 WiFi, IEEE 802.3 Ethernet, CAN and GPS protocols and systems?**

Internet Connectivity will be based on WIFI with the help of a WIFI module.

Communication protocols for connecting all components: IR sensor (Digital Logic,) LCD Screen(I2C), ML-HM-10 Bluetooth module(UART)

- ➢ **Use of preemptive versus cooperative scheduler operation; tick rate and time slicing; critical code; fixed, dynamic and hybrid task priority allocation; application-specific considerations; power management tactics; semaphores, mutexes and queues; debugging strategies; performance estimation?**

Software: Eclipse IDE,Arduino IDE, GCC Compiler, SSH

The GNU Compiler Collection is a compiler system produced by the GNU project supporting various programming languages. GCC is a key component of the GNU toolchain and the standard compiler for most projects related to GNU and Linux, including the Linux kernel.

Secure Shell is a cryptographic network protocol for operating network services securely over an unsecured network. Typical applications include remote command-line, login, and remote command execution, but any network service can be secured with SSH.

Counter to show number of cars exceeded speed limit have to show that in cloud.

- Simulation tools: Proteus for hardware simulation.
- PCB design: EasyEDA.
- Schematic capture software: EasyEDA.
- Coding software: Eclipse IDE, GCC,Arduino IDE

✓ **Communication Protocols:**

- LCD Display – I2C protocol is used for interfacing the LCD screen as the screen supports I2C protocol. Advantages of I2C – maintains low pin/signal count even with many devices on the bus, adapts to the needs of different slave devices, readily supports multiple master devices and incorporates ACK/NACK functionality for improved error handling.
- ESP8266 – We have multiple protocol options as ESP8266 supports many. However, we are using UART as it has ease of communication. It requires only 2 wires for full duplex communication, and it doesn't require any address for data. Advantages of UART – hardware complexity is low and for one-to-one connection between devices, software addressing is not required.
- Wi-fi – ESP8266 is a Wi-fi module which can provide internet access to our system. Wi-fi is from the family of wireless network protocols, based on IEEE 802.11 family of standards, which is commonly used for local area networking of devices and internet access. Advantages of Wi-fi – Stable and faster signal than cellular data, ability to move the device while still in use and zero involvement of wires. Thingspeak used MQTT protocol.

- ML-HM-10 Bluetooth module- HM-10 bluetooth 4.0 used to connect arduino to beaglebone wirelessly. The module comes with UART layer which provide us a easy way to connect to different microntrollers. Here we use UART for connecting bluetooth module to both arduino and beaglebone black.

✓ **Standards for Coding:**

Coding rules and guidelines ensure that software is:

- **Safe:** It can be used without causing harm.
- **Secure:** It can't be hacked.
- **Reliable:** It functions as it should, every time.
- **Testable:** It can be tested at the code level.
- **Maintainable:** It can be maintained, even as your codebase grows.
- **Portable:** It works the same in every environment.

There are 4 key benefits of using coding standards:
1. Compliance with industry standards (e.g. ISO).
2. Consistent code quality – no matter who writes the code.
3. Software security from the start.
4. Reduced development costs and accelerated time to market.

Popular Coding Standards for C language:

1. MISRA - MISRA provides coding standards for developing safety-critical systems.
   MISRA C is the most widely used set of coding guidelines for C around the world.
   There have been three releases of the MISRA C standard -
- MISRA C:1998
- MISRA C:2004
- MISRA C:2012

2. CERT - CERT is a secure coding standard. It's developed by the CERT division of the Software Engineering Institute at Carnegie Mellon University. This secure coding standard is available for C and C++.

   The standard targets insecure coding practices and undefined behaviours that lead to security risks. Using security rules will help you identify security issues in existing code and prevent the introduction of new issues that pose a security risk.

✓ **Estimated Cost of Components:**

Components	Cost
Li-ion battery (with charger) x 2	$80
Voltage regulator x 2	$16
LCD display	$12

Lamp	$13
Relay	$10
Buzzer	$16
IR sensors x2	$14
Beaglebone Black	$120
Wi-fi module (ESP8266) x 1	$10
Wires and Breadboard	$19
Arduino Uno	$14
HM-10 Bluetooth 4.0 x 2	$30
Soldering kit	$36
SD card	$13
Header	$10
Bulb holder	$10
Resistor/capacitor kit	$31
Total cost	$444

✓ **Milestones (Deliverables and Time Schedule):**

Task name	Start Date	End Date	Person in-charge
Project Proposal	September 14, 2020	October 9, 2020	
Finalizing hardware requirements	October 10, 2020	October 13, 2020	Varun
Testing each hardware part	October 14, 2020	October 18, 2020	Govind

Designing circuit in software	October 19, 2020	November 1, 2020	Varun
Interfacing IR sensors with Beaglebone Black	November 2, 2020	November 7, 2020	Sunny
Interfacing LCD with Beaglebone Black	November 8, 2020	November 13, 2020	Govind
Interfacing ESP8266 with Beaglebone Black	November 14, 2020	November 17, 2020	Sunny
Interfacing buzzer and bulb with the Beaglebone Black	November 18, 2020	November 23, 2020	Sunny
Interfacing ThingSpeak with Beaglebone Black	November 24, 2020	December 1, 2020	Govind
Connection between the Beaglebone Black and Arduino Uno	December 2, 2020	December 9, 2020	Varun
Final Presentation	December 10, 2020	December 15, 2020	
Final Report	December 18, 2020		

✓ **Environmental, legal and ethical ramifications:**

In project management, there are many ethical issues that a person may face. Depending on the projects, a person (in an organization) may compromise on his/her own ethics in order to deliver the project on time. However, whenever this thing happens, managers and stakeholders often ignore it. In today's business climate, blown budgets, legal issues and even criminal charges are all too normal. Here, we will take a look at some of the most popular forms of ethical dilemmas that can happen in our project, and how we can safely work through them.

- Accountability:

    When things go wrong, seeking to escape the consequences and putting the blame on others is human nature. This may not only hurt jobs and reputation; it also generates additional project problems by concealing the problem's real source. Team leaders should try to manage their teams in a responsible way so that none of these issues arise.

- Conflict of interest:

    We should make sure that all members in the project should understand the ultimate aim and goal of this project. This will make sure that there is no conflict of interest while working together.

- Health and safety concerns:

  Pressure to get the job done is another important issue while doing the project. However, the team members should not feel mentally pressured while doing this. Project team leaders should be ready to raise the alarm any time they see a potentially hazardous situation. Also, members should be able to raise their voice in the institution if anything is troubling them.

- Legal consequences of the project:

  Both the parties of the project should not break the legal contract. We should identify the right delivery model for our project. The legalities include delivering the project on time and being in budget. Additionally, we need to make sure that the project is secure and safe.

- Environmental consequences of the project:

  Since main part of our project is fixed on road, we should use high performance components that can withstand different climate conditions. Location of our project in a place that have never been worked before will expose the project to an unknown regulatory environment.

Engineering drawing:

Bill of materials (BOM):

PART NAME	PART NUMBER	DESCRIPTION	COST	QUANTITY	BOM NOTES/ REMARKS
Li-ion battery (with charger)	DC512B-ND	PowerTrust 4Pcs 2800mAh AA Battery with LCD Display Charger for AA AAA NiMH Rechargeable Battery	$80	8	Here we used li-ion battery to give power to the whole circuit
Voltage regulator	LM2596	Lysignal LM2596 DC-DC Step Down Power Supply Module 3A Adjustable Step Down Module Buck Converter 24V to 12V 5V 3V	$16	2	Beaglebone works on 5v supply voltage. This is used to supply specified voltage to Beaglebone Black.
LCD display	TS0351	SunFounder IIC/I2C/TWI 1602 Serial LCD Module Display for R3 Mega 2560 16x2.	$12	1	Here LCD display is used display the speed in front of officer. PCF8574 module is used to connect LCD to BBB using i2c protocol.
Lamp	VC1511B25W3D-ND	Nada, Globe Bulb DC 12 Volt LED Lights 24 Volt Compatible 7W Night Lamp A19 E26 Base Office RV Replacement Energy Efficient Saving Warm White 3000K, Pack of 1	$13	1	Lamp is used as a signal for indicating if there is an overspeed occurred or not.

Relay	2C-5V	SunFounder 2 Channel DC 5V Relay Module with Optocoupler Low Level Trigger Expansion Board for Arduino R3 MEGA 2560 DSP ARM PIC AVR STM32 Raspberry Pi.	$10	1	This is used to power up the bulb
Buzzer	UTCA-XTMB-2617	UHPPOTE Mechanical Buzzer Sounder 12VDC Continuous Beep with Leads 75 dB for Access Control and Buzz-in System	$16	1	Buzzer is used as sound indication to officer about the over speeding vehicle
IR sensors	EK1254x5C	Gikfun IR Infrared Obstacle Avoidance Sensor Module	$14	2	Sensors are used to calculate the time so as to calculate speed of vehicle
Beaglebone Black	BB-BBLK-000-REVC-ND	Embedded Evaluation Board	$120	1	The BeagleBoard is a low-power open-source single-board computer produced by Texas Instruments in association with Digi-Key and Newark element14.
Wi-fi module (ESP8266)	KYES77-KIT@FL	KeeYees Expansion Board Kits GPIO 1 into 2 with WiFi Development Board for ESP8266 NodeMCU ESP-12E	$20	1	The **ESP8266** WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give

					any microcontroller access to your Wi-Fi network
Wires and Breadboard	ESH-PB-01	3 Pack Solderless Plug in Breadboard with 3 Pack Jumper Wires, 830 Tie-Point 4 Power Rails Breadboard for Circuit	$19	1	Wires are used for connecting components in breadboard.
Soldering kit	Ta-iron-us-2	TTABIGER Soldering Iron Kit Electronics 60W Adjustable Temperature Soldering Iron, 5pcs Soldering Iron Tips, Solder, Rosin, Solder Wick, Stand and Other Soldering Kits in Portable Toolbox	$36	1	This kit consists soldering iron which is used for soldering components to PCB. And there is a digital multimeter that comes with this kit that can be used for testing of components, power supply etc..
SD card	SDSQUNS-064G-GN3MN	Sandisk Ultra SDSQUNS-064G-GN3MN 64GB 80MB/s UHS-I Class 10 microSDXC Card.	$13	1	In case if we want to boot up Beaglebone with latest Debian image SD card can be used
Headers	EU-20Set-40pin-2.54mm	Neuftech 20Pcs 40 Pin 2.54mm Single Row Pin Header Strip Connector Male - Female and Male – Male.	$10	1	Modules such as esp8266 may come without headers so we might need to solder these headers to such modules to use

					them in breadboard.
Bulb holder	8052CC10	Legrand-Pass & Seymour 8052CC10 Medium Base Porcelain Lamp Holder, Bracket Mounted 660-watt 250-volt	$10	1	Bulb holder is used to hold the bulb which is connected to Beaglebone Black.
Resistor/ capacitor kit	9687283011	Electronic Components Kit, Electronic Components Assortment LED Diodes Transistor Electrolytic Capacitors Resistors, 1390pcs	$31	1	Resistor and capacitor kit consist of different varieties of resistors and capacitors used in this project.
Arduino Uno	EL-CB-001	Elegoo UNO R3 Board ATmega328P ATMEGA16U2 with USB Cable for Arduino	$14	1	Arduino is used as a slave device for connecting the sensors in the road.
HM-10 Bluetooth 4.0	ML-HM-10	DSD TECH HM-10 Bluetooth 4.0 BLE iBeacon UART Module with 4PIN Base Board	$30	2	Bluetooth module is used for connecting arduino to beaglebone wirelessly and so to make the data transfer

Approaches During Edit-Test-Debug Cycle:

In order to complete the expansion of a software as a product, several tasks need to be done. A development process consists of different cycles of editing, testing, debugging. When we are working on an embedded project, the hardware we finalize will be same throughout the project. But the software part has to be made perfect by going through multiple approaches.

Phases of a development process in our project:

- Using a target system -

  We are using a Beaglebone Black as a target system for our project. It is our main microcontroller unit to run this project. It is a low-cost, open source, community-supported development platform.

- Emulator -

  We are not using an emulator in our project.

- Using target processor and ICE -

  We are not using a target processor and ICE.

- Simulator –

  We are not using a simulator in our project.

- Using IDE or prototyping tool -

  Eclipse IDE:

  We are using Eclipse IDE in our project. We are using this tool to write codes and debug them using the inbuilt debugger. As our main coding language is C, we are going to use its C/C++ IDE.

  Arduino IDE:

  The Arduino Integrated Development Environment is a cross platfrom application that is written in functions from C and C++. Arduino IDE is used to write and upload programs to arduino boards. But also can be used with some other development boards.(eg: ESP32)

✓ **References:**

- Abiger. (n.d). TTABIGER Soldering Iron Kit Electronics 60W Adjustable Temperature Soldering Iron, 5pcs Soldering Iron Tips, Solder, Rosin, Solder Wick, Stand and Other Soldering Kits in Portable Toolbox. Retrieved from https://www.amazon.ca/Soldering-Electronics-Adjustable-Temperature-Portable/dp/B071VLFGXL/ref=sr_1_4_sspa?crid=15HQUUE0A0FF5&dchild=1&keywords=soldering+kit&qid=1601328332&sprefix=solder%2Caps%2C217&sr=8-4-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzMjRROVhRRVI2M01DJmVuY3J5cHRlZElkPUEwNzU3NzkxM0FZU1VTSVcxRERYUCZlbmNyeXB0ZWRBZElkPUEwODUxNTg3MVdGGS1FGT0ZXSVdNVyZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=
- Arduino Car Speed Detector. (2018, December 28). Retrieved from https://www.electronicshub.org/arduino-car-speed-detector/
- Beaglebone Black. (n.d). Retrieved from https://beagleboard.org/black

- Beaglebone Black Wireless. (n.d). Retrieved from https://beagleboard.org/black-wireless
- Bellairs, R. (2018, October 8). What are Secure Coding Standards: CERT C and CWE. Retrieved from https://www.perforce.com/blog/qac/secure-coding-standards
- Campbell, S. (n.d). Basics of UART Communication. Retrieved from https://www.circuitbasics.com/basics-uart-communication/
- Coding Standards for Quality and Compliance. (n.d). Retrieved from https://www.perforce.com/resources/qac/coding-standards
- ESP8266. (n.d). Retrieved from https://www.espressif.com/en/products/socs/esp8266
- Gikfun IR Infrared Obstacle Avoidance Sensor Module for Arduino Smart Car Robot Practice DIY (Case Pack of 5) EK1254x5C. (n.d). Retrieved from https://www.amazon.ca/Gikfun-Infrared-Obstacle-Avoidance-EK1254x5C/dp/B07FFM7DYQ/ref=sr_1_1_sspa?crid=17EDSCXZHM7R1&dchild=1&keywords=ir+sensor&qid=1601321709&sprefix=IR+se%2Caps%2C158&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExTFJKRURMRzhYQ0FLJmVuY3J5cHRlZElkPUEwNTc4NTU2MThBBTjFOR1VRUENQVCZlbmNyeXB0ZWRBZElkPUEwNjI0MDc2MTVDDWDYyRzNETVpUQSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=
- Circuitco Electronics LLC. (n.d). BeagleBone Black Rev C. Retrieved from https://www.digikey.ca/en/products/detail/circuitco-electronics-llc/BB-BBLK-000/4842211
- Gyawali, P. K. (2014, August). A final year project report on vehicle over speed detection and recognition. Retrieved from https://www.researchgate.net/publication/325108341_A_FINAL_YEAR_PROJECT_REPORT_ON_VEHICLE_OVER_SPEED_DETECTION_AND_RECOGNITION
- Haraqi.(n.d). 3 Pack Solderless Plug in Breadboard with 3 Pack Jumper Wires, 830 Tie-Point 4 Power Rails Breadboard for Circuit Test,Arduino (40 Pin Male to Female,40 Pin Male to Male,40 Pin Female to Female) Retrieved from https://www.amazon.ca/Solderless-Breadboard-Tie-Point-Circuit-Arduino/dp/B07P1GWN3F/ref=sr_1_4?crid=2VTGTIWBR8A5K&dchild=1&keywords=breadboard&qid=1601335159&s=electronics&sprefix=bread%2Celectronics%2C168&sr=1-4
- Keim, R. (2015, December 16). Introduction to the I2C Bus. Retrieved from https://www.allaboutcircuits.com/technical-articles/introduction-to-the-i2c-bus/
- Legrand-Pass & Seymour. (n.d). Legrand-Pass & Seymour 8052CC10 Medium Base Porcelain Lamp Holder, Bracket Mounted 660-watt 250-volt. Retrieved from https://www.amazon.ca/Legrand-Pass-Seymour-8052CC10-Porcelain-660-watt/dp/B000BPEDZC/ref=sr_1_27?crid=5HUP2RX4JNE9&dchild=1&keywords=bulb+holder&qid=1601336204&sprefix=bulb+ho%2Celectronics%2C155&sr=8-27

- Lysignal. (n.d). Lysignal LM2596 DC-DC Step Down Power Supply Module 3A Adjustable Step Down Module Buck Converter 24V to 12V 5V 3V. Retrieved from https://www.amazon.ca/Lysignal-LM2596-Supply-Adjustable-Converter/dp/B074J4NXCM

- MISRA C and MISRA C++. (n.d). Retrieved from https://www.perforce.com/resources/qac/misra-c-cpp

- Nada. (n.d). Globe Bulb DC 12 Volt LED Lights 24 Volt Compatible 7W Night Lamp A19 E26 Base Office RV Replacement Energy Efficient Saving Warm White 3000K, Pack of 1. Retrieved from https://www.amazon.ca/Nada-Bulbs-Powered-Traditional-Equivalent/dp/B0781M55BN/ref=sr_1_17?crid=Y2QD3VDTABAN&dchild=1&keywords=12v+bulb&qid=1601321528&sprefix=12v+bu%2Caps%2C164&sr=8-17

- KeeYees. (n.d). KeeYees Expansion Board Kits GPIO 1 into 2 with WiFi Development Board for ESP8266 NodeMCU ESP-12E Retrieved from https://www.amazon.ca/KeeYees-Expansion-Development-ESP8266-NodeMCU/dp/B08D3G3J4V/ref=sr_1_4_sspa?dchild=1&keywords=esp8266&qid=1601926603&sr=8-4-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExT0U0UlEyWUczRFhFJmVuY3J5cHRlZElkPUEwNDAxNDI1MjlUUjGSkRSOFNBVSZlbmNyeXB0ZWRBZElkPUEwNDI5NjYzMjMzVlhSWVc4QkJBWiZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=

- Neuftech (n.d). Neuftech 20Pcs 40 Pin 2.54mm Single Row Pin Header Strip Connector Male - Female and Male – Male. Retrieved from https://www.amazon.ca/Neuftech-2-54mm-Single-Header-cannector/dp/B00QHS1IYG/ref=sr_1_11?crid=29SJSVTBL2Q3&dchild=1&keywords=header+pin&qid=1601329341&sprefix=header+pin%2Caps%2C204&sr=8-11

- Elegoo(n.d). Elegoo UNO R3 Board ATmega328P ATMEGA16U2 with USB Cable for Arduino. Retrieved from https://www.amazon.ca/Elegoo-Board-ATmega328P-ATMEGA16U2-Arduino/dp/B01EWOE0UU/ref=sxts_sxwds-bia-wc-drs-ajax1_0?crid=F0L7W51ZQMQK&cv_ct_cx=arduino+uno&dchild=1&keywords=arduino+uno&pd_rd_i=B01EWOE0UU&pd_rd_r=47ef37d4-3379-4979-8332-dcc7dcbb8bbe&pd_rd_w=QUd8S&pd_rd_wg=glW2P&pf_rd_p=8265b151-560f-440d-99fe-dd8921246a8e&pf_rd_r=TVFKMBW401CD35XBSCP4&psc=1&qid=1602083131&sprefix=arduin%2Caps%2C163&sr=1-1-25b07e09-600a-4f0d-816e-b06387f8bcf1

- PCB Specifications. (n.d). Retrieved from https://onlinequote.7pcb.com/PCBFab?Project=%3a22X7JzdxWHeUWncwSlJtV3dtGn%5b7JT%5bl%3aXU1mH%5bGKDMmOIci%5bnPjRodiOFctWoS4%3aHbUKDMjNkJ7JTf1mHevGXeSKDMjZn%5bzKjPjVXci6lJtRkPjVHd6SmdmSndQKDMxpkJFmVcmSYT1KYZEKzf

- SanDisk. (n.d). Sandisk Ultra SDSQUNS-064G-GN3MN 64GB 80MB/s UHS-I Class 10 microSDXC Card. Retrieved from https://www.amazon.ca/SanDisk-Ultra-SDSQUNS-064G-GN3MN-UHS-I-microSDXC/dp/B074B4BFHJ/ref=sr_1_34?dchild=1&keywords=SD+card&qid=1601328519&sr=8-34

- Sunfounder. (n.d). SunFounder 2 Channel DC 5V Relay Module with Optocoupler Low Level Trigger Expansion Board for Arduino R3 MEGA 2560 DSP ARM PIC AVR STM32 Raspberry Pi. Retrieved from https://www.amazon.ca/SunFounder-Channel-Shield-Arduino-Raspberry/dp/B00E0NTPP4/ref=sr_1_6?dchild=1&keywords=relay&qid=1601321987&sr=8-6

- SunFounder. (n.d). SunFounder IIC/I2C/TWI 1602 Serial LCD Module Display for R3 Mega 2560 16x2. Retrieved from https://www.amazon.ca/SunFounder-Serial-Module-Display-Arduino/dp/B019K5X53O/ref=sr_1_8?dchild=1&keywords=16*2+LCD&qid=1601334018&sr=8-8

- Uhppote. (n.d). UHPPOTE Mechanical Buzzer Sounder 12VDC Continuous Beep with Leads 75 dB for Access Control and Buzz-in System (Pack of 5). Retrieved from https://www.amazon.ca/UHPPOTE-Mechanical-Sounder-Continuous-Control/dp/B07N1B3528/ref=sr_1_16?crid=3J9EKUMZHTRAC&dchild=1&keywords=buzzer&qid=1601321786&sprefix=buzzer%2Caps%2C170&sr=8-16

- PowerTrust 4Pcs 2800mAh AA Battery with LCD Display Charger for AA AAA NiMH Rechargeable Battery (n.d). Retrieved from https://www.amazon.ca/PowerTrust-2800mAh-Battery-Display-Rechargeable/dp/B089995TSP/ref=sr_1_72_sspa?dchild=1&keywords=%E2%80%A2+Universal+Smart+Battery+Charger+4+Bay+Fast+Charger+for+18650+Rechargeable+Battery+%2B+Vtc6+3.7V+2500+Mah+Li-Ion+Rechargeable+Battery+18650+Rechargeable+Battery+4Pcs+%28Purple%29.&qid=1601927361&sr=8-72-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFPTVlNNjFORUNPNUImZW5jcnlwdGVkSWQ9QTEwMzUyMDBHVlNBVlNMTk1CSlImZW5jnlwdGVkQWRJZD1BMTAwODU0NjNFRkJJSkhZS0s3WFcmd2lkZ2V0TmFtZT1zcF9tdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl

- Walfront(n.d). Electronic Components Kit, Electronic Components Assortment LED Diodes Transistor Electrolytic Capacitors Resistors, 1390pcs Retrieved from https://www.amazon.ca/Electronic-Components-Assortment-Transistor-Electrolytic/dp/B07GCBSCM3/ref=sr_1_16?crid=TZWZA8EBY8M2&dchild=1&keywords=resistor+capacitor+kit&qid=1601928030&sprefix=resistor+capa%2Caps%2C155&sr=8-16

- Wi-fi – IEEE Standards. (n.d). Retrieved from https://www.tutorialspoint.com/wi-fi/wifi_ieee_standards.htm

- The canadian institute. (2017, september 27). Legal issues in Project manage,net and infrastructure development. Retrieved from

https://www.canadianinstitute.com/legal-issues-project-management-infrastructure-development/

- Raj, A(2018, oct 15).Circuit digest. Programming esp32 Board with Arduini ide. Retrieve from https://circuitdigest.com/microcontroller-projects/programming-esp32-with-arduino-ide
- Catambay, A (2017, June 13). Ethical issues in project management. Retrieved from https://www.clarizen.com/ethical-issues-project-management-deal/
- Dsd Tech(n.d).DSD TECH HM-10 Bluetooth 4.0 BLE iBeacon UART Module with 4PIN Base Board for Arduino UNO R3 Mega 2560 Nano. Retrieved from https://www.amazon.ca/DSD-TECH-Bluetooth-iBeacon-Arduino/dp/B06WGZB2N4/ref=asc_df_B06WGZB2N4/?tag=googlemobshop-20&linkCode=df0&hvadid=292952161850&hvpos=&hvnetw=g&hvrand=12314 567869965253968&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvloc int=&hvlocphy=9000899&hvtargid=pla-350315945458&psc=1
- Pandit, A(2019, June 10).Curcuit Digest. How to Use HM-10 BLE Module with Arduino to Control an LED using Android App. Retrieve from https://circuitdigest.com/microcontroller-projects/how-to-use-arduino-and-hm-10-ble-module-to-control-led-with-android-app

- Currey, M(2016, April 09). Arduino to Arduino by Bluetooth. Retrieve from http://www.martyncurrey.com/arduino-to-arduino-by-bluetooth/

✓ **Instructor's Remarks:**