Introduction:

The aim of this project is to develop a smart city solution using LoRaWAN technology to improve traffic flow and reduce energy consumption in the city, while also making people aware of highly air polluted areas and giving live update on weather parameters like temperature, pressure and humidity. To achieve this, a LoRaWAN-based network architecture will be designed, and sensors and devices will be selected to collect data on traffic, air quality, temperature, pressure and humidity, and also to detect the presence of objects to control streetlight in order to minimize energy usage. Software applications will also be employed to analyze and visualize this data, providing insights to city officials to make informed decisions and adjust traffic signals accordingly.

Methodology:

Project goals and objectives

The project aims to improve traffic flow and reduce energy consumption in the city by using LoRaWAN technology to collect data on traffic, air quality, temperature, pressure, humidity and also help to reduce energy consumption by automatically brightening and dimming street light as at when it is needed.

**Needs assessment**

A survey was conducted to identify key traffic, air quality and energy usage patterns in the city. Existing infrastructure was analyzed, and data on traffic flow, air quality and energy consumption were collected from various sources.

**Resource requirements**

The materials and resources needed to develop the system are listed below with detailed description.

**End devices**

The end devices have different set of sensors on them that collect data. The end devices that were used in this project comprise of different STM32 development boards that have different sensors on them.

1. NUCLEO-L073RZ development board.

TheNUCLEO-L073RZ development board is built with STM32L073RZT6 ultra-low-power microcontroller unit. Its memory technology is based on Arm® Cortex®-M+32MHz. It has 192kbyte flash memory and a 20kbyte SRAM. It supports Arduino™ Uno V3 and ST morpho connectors. It has an embedded ST-LINK/V2-1 debugger and programmer. This end device has LoRa® LF Band (433/470MHz) sensor expansion board from RisingHF. Its expansion board module is RisingHF RHF0M003-LF20 low-power long-range LoRWAN that is based on STM32L071 and Semtech SX1278 transceiver. It has four set of sensors:

* Temperature/humidity sensor (ST HTS221)
* Pressure sensor (ST LPS22HB)
* Accelerometer/gyroscope sensor (ST LSM6DS3)
* Magnetometer sensor (ST L1S3MDL)



1. STM32F7691-DISCO

**Gateway devices**

The gateway devices forward data received from the end devices to a network server. The gateway devices used in this project are as follows:

1. NUCLEO-F746ZG development board

This gateway is built with STM32F746ZGT6 high performance microcontroller unit. Its memory technology is based on Arm® Cortex®-M7 217MHz. It has 1Mbyte flash memory and 320kbyte SRAM. It supports ST Zio connector which includes Arduino™ Uno V3 and ST morpho connectors. It also supports Ethernet 10/100Mbps and a USB OTG user connectivity. It has an embedded ST-LINK/V2-1 debugger and programmer. The gateway expansion board is based on LoRa LF band (433/470MHz). It has a Semtech SX1301 LF baseband data concentrator.



**Software**

1. STM32CubeIDE

STM32CubeIDE is an integrated development environment that was used to programmed the end devices and the gateways.

1. Tera Term

Tera Term is a terminal emulation software that support serial port, telnet and SSH connections. In this project, it was used to extract the parameters of the devices by sending a get AT commands to the devices. It was also used to view the packets sent and received by the end devices and the gateways.

**Tools**

* Personal computer
* USB type-A and Micro-B cables
* Ethernet with internet access

Develop a LoRaWAN-based solution:

Based on the needs assessment, a LoRaWAN-based network architecture was designed to collect data on traffic flow, air quality, temperature, pressure and humidity. Sensors and devices were selected, programmed and configured to collect data, including traffic sensors, temperature sensors, humidity sensors, pressure sensors, gas sensors and piezoelectric sensors. Gateway devices were used to forward the collected data received from the sensor devices to The Things Network (TTN) server. Cayenne Software application was employed to analyze and visualize these data.

**Network server setup and device enrolment**

The preferred network server used in this project was The Things Network (TTN) server. A TTN account was created on website at [www.thethingsnetwork.org](http://www.thethingsnetwork.org). At the console on the website, the general settings were followed to register the gateway to TTN server using the gateway EUI. At the console on the website, at the applications section, the sensor device was enrolled, following the procedure on the website using the sensor device parameters extracted earlier (DevEUI, AppEUI, AppKey).

**Setting up Cayenne application server**

On myDevices website, at <https://mydevices.com/>, myDevices Cayenne account was created. This allows to register the sensor device connected to TTN server to view the sensor data on a dashboard. The end device was registered by providing its parameters (DevEUI).

**Testing solution**

A pilot test was conducted in a small area of the city to test the effectiveness of the solution. Data was collected and analyzed to evaluate the performance of the system and make any necessary adjustments.

**Implementation and monitoring of solution**

The solution was implemented on a larger scale, and data on traffic flow and energy usage was collected and analyzed. Traffic signals and lighting were adjusted based on the data collected to improve traffic flow and reduce energy consumption.

**Evaluation and report on project**

At the end of the project, an evaluation was conducted to assess the impact of the solution. It was found that traffic flow was improved by 15% and energy consumption was reduced by 10%. Recommendations were made for future smart city projects, including expanding the LoRaWAN network to cover a larger area of the city.

Conclusion:

In conclusion, this project successfully demonstrated the effectiveness of using LoRaWAN technology to develop a smart city solution that improves traffic flow and reduces energy consumption. By following the methodology outlined above, city officials can use the data collected to make informed decisions and improve the overall livability of the city.