# Artificial Intelligent based Smart Drainage System

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# Abstract

Clever monitoring and eliminating of clog in drainage is become very arduous in recent times. Presence of congestion and poorly maintained drainage system is leading various disturbances, like overflow of dirt water in streets, environmental issues and urban flooding, which in turn cause various water borne diseases and other hazards. This paper presents a smart drainage monitoring system. This advanced internet of things (IoT) based electronic system is capable of finding the blockage and removing the same using IoT. In order to do that, system consist of, a variety of sensors and clog finding modules are kept in several positions along the drainage network and the information is brought together using IoT. The ultrasonic level indicator finds whether there is any obstruction in between two successive manholes then it will activate cloud monitoring system to inform the responsible authority about the accurate location and amount of blockage. The various sensors give information about the pressure, presence of toxic gases and temperature of the particular drain. All this information is collected and analyzed by Arduino UNO microcontroller. The important aspects of the devise are economical, minimal maintenance, fast operation, and precise sensors, durable and high quality of server.


# Introduction

Till now not all drainage system of cities is smart, it is very difficult to find out the location of blockage in any drainage system and also not possible to obtain any quick information of blockage. Thus, it takes too much time for detection and clearing of obstruction. Situation becomes more problematic when pipes are clogged totally. This would create sewer flooding that likely to rise due to environmental change (i.e., heavy rainfall) and increase in suburbanization that effects in an acceleration of impermeable regions, therefore, increase of surface runoff. Figure 1 shows blocked drain due to waste product.

The occasional inspection causes more obstacles in the sewage system that enhances flooding in the neighboring region. Visual checking is a popular technique for the finding of blockage in city. But this way of finding blockage totaly depends on the awareness and knowledge of the person examining the system. It also lacks of conceptual analysis of the system which needs scientific apparatus and technical personnel. These are very expensive and merely a scanty number of checking can be executed. Consequently, present urban drainage monitoring systems become heavily loaded during rainy events, mainly in the presence of obstructions and blockages in drain and catch basins, often caused by infrequent maintenance, strongly reduces their hydraulic capacity, which causes heavy risk to human life, economic assets and the environment due to flood. Measures need to be adopted to cope up with storm water volumes and sewer flooding in urban areas. In various surveys it is also found that hundreds of people died every year due to manual cleaning of drainage system. This system is having a significant role to keep city clean. Figure 2 shows blocked drain due to waste product.

In IoT the things are intelligent and can connect to people (using radio communication networks) for achieving better decisions [1]. Various technique operated wirelessly for communication and their range; power consumption is shown in Table 1. Network of intelligent devices through IoT is shown in

Fig. 3.Nowadays, study on embedded systems has been directed towards the incorporation of computational sources within the physical arrangement under monitoring and control, which popularly known Cyber-Physical Systems (CPS) [2], i.e., composite networks of interrelated embedded objects are integrated with the physical procedure under control. Cyber-Physical systems are available in areas such as supply energy-services to end-users, control, Bio-medical systems, structural health monitoring of building and many others [3]. The idea of CPS can be a useful way to overcome problems occurred at the drainage network scenario [4]. In the proposed system, the communication of interrelated devices suitably used to construct a real time control, where the electronic sensors supervise and regulate the functionality of the water network in real-time according to the predefined programming and the rainfall events. This method can be an exact way for dynamically and effectively handling urban flood.

Table 1
Comparison of Wi-Fi network with other network technologies

| Category | Zigbee | Bluetooth | Wi-Fi | Tele Communication |
|---|---|---|---|---|
| Single point coverage range | 50–300 (m) | 10 (m) | 50 (m) | Several (km) |
| Network expansion capabilities | Automatic | None | None | Relying on existing network coverage |
| Complexity | High | Medium | High | Medium |
| Time for network connection | 30 s | 10 s | 3s | Several seconds |
| Fee | None | None | None | High |
| power consumption | Low | High | High | Medium |
| Data rate | 250 Kbps | 1 Mbps | 1 to 11 Mbps | Norma1ly 19.2 Kbps |

In this work, a real time distributed structure of devices and actuators is set up on an urban drainage network. In this system, automation of drainage system is done using number of moveable gateways, operating as actuators, and ultrasonic sensor HC-SR04 which checks water level and monitor the amount of water present in each conduit. After analyzing the data obtained from the sensors, the gates are automatically controlled in order to use the complete storage capacity of the conduit by transferring the additional storm water in the less overloaded drain thus avoiding overflow from the sewer systems to the paths and street paving.

Initial trials were done using water management model software which resembles the behavior of an urban drainage system controlled by moveable gates during severe rainy events. Real time status was added in the software which help it in online communication [5]. This solution can be an important way for lively and effectively handling urban flood risks and useful for smart city application. The work is exclusively the first effort that reflects searching of exact location of obstruction together with level of waste and the way it informs to the responsible authority. To make it more effective one, we take assistance of twitter.com and thingspeak.com.

# Background

Internet of Things (IoT) and its applications becomes very much significance in Smart City solutions. It is expected 70% of world's population will start to stay cities and its encompasses area within a few years [6]. So, to manage such huge population, the cities necessarily to be automated for its various services. For fostering the system, some of the features of smart waste management system are considered. This arrangement works on gathering information from sensors, convey it to distant cloud server, then information is managed and used for observing, supervision and finally taking smart decision for set-up or serviceability [7]. The proposed approach uses an app-based monitoring system for this purpose.

Our main aim is to develop an optimized solution for proper drainage system by introducing intelligence in the system.

### Theory of drainage design

Drainage system can be classified as

1. A dendritic drainage design: It is the greatest available design and similar to the branched shape of plants roots. It grows in areas underneath by similar material i.e.; the subsurface geology which has an alike resistance; therefore, no such regulation over the path of the branches moves. These branches meet with greater waterbodies at an acute angle (less than 90 degrees).
2. A rectangular drainage: This pattern is grown on areas of rocks which are very susceptive to erosion. It has two directions of joint at approximately right angles or 90 degrees. The direction of the stream's changes to the weak areas of the rock due to joints or faults. Therefore, the feeder streams make sharp curves and enter the standard at high points. As a result, the tributary streams make sharp bends and enter the main stream at high angles.
3. A Parallel drainage: These shapes created where there is a strong slope to the surface. Pronounced slope forms in regions of parallel, extend landforms like extension resilient rock regions.
4. A Trellis drainage: The pattern seems like to its namesake, the general park trellis. This type of drainage grows in patched topography mostly create in the Appalachian Mountains.
5. A Deranged or contorted pattern can found in drift covered region. It is known by this name because of the frequent irregularities of its shape and the doubtful intermingling of various water bodies like lake, swamp, and wide-open valleys. Various drainage pattern shown in Fig. 4.

The work suggests the way of smart monitoring of drainage system and blockage removal using IOT. Proposed system suggests a unique way which automatically monitor the sewage blockage using water level sensors (HCSRO4) and IoT unit in order to create a healthy environment save administrative time and cost being spent on blockage identification and reduces the use of human labor.

Primarily, a drainage network can be formally seen as a graph (G, W) of nodes $g \in G$ linked with edges $w \in W$. Particularly G comprises Junctions $\in k$, Inlets $i \in I$ and Outlets $o \in O$. W consist of Channels c ∈ C. Junction are just meeting nodes for channels. Opening or inlets are lumps where dispel water appears into the network. Exit nodes are the nodes of the system where water is releases into a large water bodies and other water bodies. In the propose technique, the model of a typical urban drainage scenario has been considered. The entire drainage watershed can be broken into several non-linked network having one outfall.

Actually, there is a web like structure as a core conduit, terminated by the only exit node. Lastly, it is projected that inward conduit are placed in the "leaves" of the tree.

A sewerage drainage network (VSDN = (c,l)) created by one channel c ending with inlet node l shown in Fig. 5 (a). Then, we define a drainage network (DN) as either just an VSDN or a couple (S, N) where S signifies the main channel and N a set of DN's. The primary conduit M is well-ordered collection of conduits in which every channel is connected with the following one through a joint. The end channel occasionally ceases with an end node. Figure 5(b) represents clearly this recursive representation. Figure 6(a) shows an instance of realistic drainage web and 6(b) represents sub-networks, encircled by dashed lines. Value of a DN is usually a usual number D that is 0 for VSDN and 1 + max (Deg(s)) for a DN = (S, N) whereas n∈ N and Deg(s) is the degree of n.

The complex network is divided into number of subsystems. Given a drainage network, *netws* (*DN*) as the set of all networks of *DN* as follows:

$$\mathrm{nets(DN)} = \begin{cases} \emptyset, ifDNissimple \\ drainagenetwork \\ \mathrm{(DN)} \cup \bigcup \mathrm{n_i} \in \mathrm{N} \bigcup_{\mathrm{n_i} \in \mathrm{N}} \\ ifDN = \mathrm{(M, S)} \end{cases} \text{(i)}$$

We know that in most of the system drainage network DN can represented as $DN^* = netsw(DN) = \left\{dn_i\right\}$ and $dn_i = (S_i, N_i)$

From it we generate group network $GN$={g$n_i$}having degree {g$n_i$}=1, in this case {g$n_i$}=($S_i^{'}$, $N_i^{'}$) is given by

$$\mathrm{S}_{\mathrm{I}}^{'} = \begin{cases} \mathrm{S_i}, ifi = 0 \\ \mathrm{S_i} \cup \mathrm{O_i}, elsewhere \end{cases} \text{(ii)}$$

$$\mathrm{N}_{\mathrm{i}}^{'} = \left\{\mathrm{vsdn_k} = \left(\mathrm{c_k}, \mathrm{l_k}\right) : \exists \mathrm{dn_k} \in \mathrm{N_i}\right\} \cup \left\{\mathrm{vsdn_x} : \mathrm{vsdn_x} \in \mathrm{N_i}\right\} \text{(iii)}$$

Drainage network mainly created where exterior overflow is higher and earth materials deliver the minimum resistance to erosion. For that reason, the drainage design of a watershed helps understand the topographic and structural controls on the water flow. This basic idea is very much essential for designing of proper drainage network. Figure 7 represents sub network in realistic case.

## Review Of Previous Work

Different towns across the globe are confronting drainage system problems even in presence of advance technology and cost-effective solutions. The sewage management system has some restrictions. The key restrictions are improper maintaining the drainage system and contaminating element. Due to improper maintains, difficulty arises in finding leakages. The key reason of leakage is congestion. Immense burden due to additional obstruction can lead to slight outflow which in future creates a major rupture in drainage conduit. Change of drainage inlay is also a tough procedure. It also leads to huge budget and resource to replace. Hence, the way of recognizing a drainage clog in underground still stays on a tedious and long procedure if done physically by utilizing outdated approaches.

S Shaikh et. al [8] have suggested supervising smart city operations using IoT based Raspberry PI controller. The system consists a no. of electronic detectors which picked up several sorts of data from sensors and delivers to the Raspberry Pi controller. After processing, useful result from the controller is sent to the responsible authority through email.

Yash Narale et al [9] has suggested IoT based underground drainage monitoring arrangement using various sensors such as, level sensor, DS18B20 temperature sensor and MQ135 to recognize flow rate of water, the level of water, temperature in $^{O}C$, and to detect CO density in air respectively. It finds accurate place using GPS and send message through GSM. Muragesh et al [10] also suggested IoT based underground sewage system and continuous manhole surveillance scheme for big cities. Wireless sensor system can effectively use for the application and plan of underground drainage for IoT applications [9–10]. Sumathy et al [11] has designed sewage level monitoring system using IoT which can sense the level of water, process the data by a controller, a communication network to communicate the information of blockage and real time data to responsible authority. Karale et al. [12] has given an idea of identifying of blockage in underground drainage system but unable to clarify the real time performance of the proposed system properly. Hussein et al studied storm water management model (SWMM) [13] to estimates flood in sewer systems. Several actions have been proposed in the model, for example, volume enhancing of sewer system and rate of decreasing of measure to manage the problem. Obaid HA et al [14] presents a model of excess water management system for a city with a large floating population. The model gives an idea about utilization of SWMM in it. This experiment explains the conceivable specialized estimates that can be taken to improve this issue with regards to the developing populace. Fujitsu et al [15] have created a low-cost advance sensing system which is able to indicate overflows in sewer system.

They have arranged sewer vents with sensors to measures water level in order to find early signs of flood. Considering an examination of the time needed for water to pour out of upstream lines to downstream region according to land topography and the shape and length of sewer pipes, the system can choose the zone and number of sewer vents where sensors are presented. This makes it possible to follow and predict the flood through a sewer system using some similar sensors. With the quick advancement of sensors, Wireless Sensor Network (WSN) plays a major role in IoT.

To keep away from unusual and manual noticing process, Retno Tri Wahyuni et al. [16] proposed a system which is remotely monitor the drainage conditions at real time continuously, and also store useful data at cloud-based system. This data is visualized by Geographical Information System (GIS).

Ka-Heng Chan et. al. [17] proposed ZigBee based WSN system for surface seepage observing and flood prediction. The system electronically able to measure water level in the drainage system using UV sensor and helps to find out flood prediction. It can measure 2cm to 4m. The sensor hub used in this work is energized up by a standard 3.70V battery. An investigation was done using variable stream in water and waste simultaneously to examine execution of water level identification and shows the flood speculation capacity. A comparative study is also completed by Li Xiaoman et. al. [18] for checking aqua chemical utilizing ZigBee WSN. The design of aquaculture distant sensor coordinate for data transmission is finished using ZigBee wireless technology. The hardware arrangement used is ZigBee RF module, the parent hub correspondence module, and its corresponding module.

Initial phases of detecting any blockage can be useful in avoiding both leakages and runoff of drainage water and consequently gives information about location & removal of the blockage. In our proposed framework, we recognize the area by utilizing IoT and the live information for every space is checked persistently by utilizing cloud server. The information is then communicated through mobile app $\text{Thingsview}^{\text{TM}}$ particularly for the municipal authority in city through sensors.

# System Description

The main idea of the work is control water level through channels of the drainage system and therefore reducing water level in the extra filled channels. To get the expected result, the system should develop by: (i) electronic sensor, computational nodes and “smart” gates. The main sensors are

a. Ultrasonic Sensor: Ultrasonic sensors are utilized for distance estimation of water with an exactness up to 3.0 mm. The unit is fit for estimating distance with a range of 2.0–400 cm with an accuracy ± 3.0 mm. The detector circuit is kept so that it isn't in direct contact with water to accomplish sturdiness of the detector circuit. For estimation reason, the detector HC-SR04 requires10-µs beats as trigger information. It transmits 8 cycle pulse of ultrasound of frequency 40 kHz and creates its reverberation. The distance is obtained by estimating time taken by ultrasonic signal return back after colliding with the article [19]. The ultrasonic sensor acts as an information source to the Arduino microcontroller. The information is processed by the microcontroller, sent to the dependable authority through Wi-Fi which require just couple of moments. Nonetheless, the receiving signal too relies upon web speed accessible right then and there of time.

In this paper, we have studied the various waste material which are the main reason for clogging of drain. These are to be squander materials for example, food, plastic trash containers, and house hold squander materials. In most of the city, it is found that the vast majority of the waste product contains biodegradable food waste like cooked and uncooked vegetables, food grains, eggshells, fish/meat bones, bloom and natural product squander including juice strips. Moreover, non-biodegradable squanders such as plastic sacks, jugs and can, slow down the current present in the drainage system. Presence of waste creates blockage, which in term increases level of water; further it will be one of the main cause of flood which can be prevented by our system because it can sense level and takes necessary steps or provides alternative way to avoid any further increasing of water level in drainage system.

This is a distributed system of sensors and actuators which is established on an urban drainage arrangement. Mainly we design the structure with a number of moveable gates, acts as actuators, and sensors which monitor water level and, hence, the degree of filling in each conduit.

The ultrasonic sensor measures the level of water inside the drainage system. The information is processed and decision is taken for dynamic regulation of gates. The main idea is when any channel (drain) is overloaded, its water is diverted to a less overloaded channels to prevent overflowing from drainage system and which in turn prevents flood also. Solenoid valve, flow sensor and HCSR04 are the main sensor used in this work.Here, the entire drainage system is assumed as number of computing nodes which are connected to sensors and gate actuators i.e., solenoid valve. Every computing node can link only with its neighbourhood, i.e., sensors, actuators at other nodes, it can reach through wireless connection. The genetic optimization algorithm is used for this work. The main function is to distribute equally the degree of filling of the conduits thus preventing overflow phenomena as far as possible.

Primary trials were done using $MATLAB^R$ software which simulates the operation of a typical urban drainage network controlled by moveable gates during heavy rainy events [20]. The actual time regulation was added by means of customizing $MATLAB^R$ software permitting it to real-time communicate with a separate multi-agent Java controller implemented using rainbow architecture. The experimental results have proved that our experiment gives a positive effect on the total hydraulic performance of the network as it is intelligent to avoid flooding events that would occur in the original network.

After finding suitable results in simulator, the system is implemented as described below:

a. Arduino platform is used for processing data of solenoid valve and HC SR04. The HC-SR04 detector work as an input device to the microcontroller. The data are managed by the microcontroller and transmitted to the responsible authority through Wi-Fi which take only few seconds. Yet, the reception depends on internet speed available at that instant of time. These devices arranged inside the drainage network. It consumes very low amount of battery and size are small also.

Solenoid valve operated smart gates, automatically regulates the gate movement, made up of mobile plates rotating around a horizontal hinge. On the other hand, the gate is entirely open when the plate is parallel to the flow. The computational nodes collect information from detector and on the whole intricate the acquired data to trigger appropriate actuations on the gates. The combined calculation of the network of nodes supplies the entryways with a "smart" behaviour.

Smart gates are placed at the place of the network where sub-networks are associated to a main channel. Figure 8(a) shows the actual point for implanting the gates, while Fig. 8(b) represents the gates insertion in a case of a realistic web. Each computational hub has a partial perspective of the network as it reads only from sensors located in its spatial neighbourhood. In the same way, it can activate only on its neighbour gates.

b. To measure the rate of flow of sewage, flow sensor is used. When water passes through the flow sensor's rotor, rotor rotates. Its speed changes with a different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. This one is appropriate to detect flow in water drainage system. The sensor circuit is mounted in such a way that it is not in direct contact with the sewage water to achieve durability of the sensor circuit. The flow rate of drainage water is calculated by,

$flowrateinL/hr = flowfrequency \times 60min/7.5Q$ (iv)

Where, Q = V × A, and Q is flow rate/total flow of water through the conduit, V is average velocity of flow & A is cross sectional area of conduit.

Microcontroller: The optimal low power advanced microcontroller is a one of the challenges of this work. The data collected by sensors is processed by the microcontroller and after processing it is sent to a remote server via a wireless link. Uninterrupted internet connection is required which the main limitation of the work. The state of drainage is transmitted to the end-user and can be viewed in smart gadgets like cell phone, tablets or other navigation systems with internet connectivity. Figure 9 shows a schematic diagram of the proposed system and flow of operation. The required information obtained by the sensing units is available after processing to the end user.

Table 1 Comparison of Wi-Fi network with other network technologies

| Category | Zigbee | Bluetooth | Wi-Fi | Tele Communication |
|---|---|---|---|---|
| Single point coverage range | 50–300 (m) | 10 (m) | 50 (m) | Several (km) |
| Network expansion capabilities | Automatic | None | None | Relying on existing network coverage |
| Complexity | High | Medium | High | Medium |
| Time for network connection | 30 s | 10 s | 3s | Several seconds |
| Fee | None | None | None | High |
| power consumption | Low | High | High | Medium |
| Data rate | 250 Kbps | 1 Mbps | 1 to 11 Mbps | Norma1ly 19.2 Kbps |

As the power consumption is an important factor in remote area, Arduino Pro Mini (Atmel 328p) (consumes 6.48 mA current during wake condition and 4.3$\mu A$ during sleep condition) is used instead of common Arduino Uno (consumes 45 mA current during wake condition and 6.2 mA during sleep condition. It runs at 16MHz clock. It comes with on 40 pin Integrated chip. The functional Voltage is 3.3V. The microcontroller is enabled for accepting up information from sensors and transmits it to the internet through a network interface. The below Table 2 represents the comparison of various microcontroller board based on the ATmega328P chip which are Pro Mini and Arduino Uno.

Table 2
Comparison of various microcontrollers and their current consumption during sleep and weak condition

| VCC | Clock Speed (MHz) | Wake Current (mA) | Sleep Current (µA) |
|---|---|---|---|
| 5.0 | 16 | 15 | 6.2 |
| 5.0 | 8 | 9.03 | 6.2 |
| 3.3 | 16 | 6.48 | 4.3 |
| 3.3 | 8 | 3.87 | 4.3 |

Battery: Battery plays an important role for for a wireless device placed in distant place. Hence, to enhance lifetime of battery, the code is written in such a way that instead of remains ‘ON’ continuously, the controller remains in ‘sleep mode’ most of the time and only remains on when we want to take an action or read a sensor value. This reduces the current to somewhere close to 4.3uA. A standard Arduino (Uno for instance) consumes more than 15mA. For a typical Alkaline 9V block with capacity of approximate 450mAh, will drain out in 30 hours (450mAh/15mA). On the hardware side also, we made some adjustment because things like standard USB interface, power regulation and some LEDs that make Arduino hardware great are also increases current consumption. We are using Arduino Pro Mini and makes it active only five times per day for only ten second and keep in sleep mode for rest of times in a day. In the model there are two sensors which are ultrasonic sensor & flow sensor. The cuKrrent consumption for ultrasonic sensor and flow sensor are 10mA and 15 mA respectively. The software programming is such that devices are becomes on only five times per day. All other time they remain in off and controller remains in sleep mode.

Therefore, total consumption of average current

$$\text{Average current during active/weak condition} = \frac{(15\text{mA}+1\text{irment is minimum}0\text{mA}+6.48\text{mA})\times 10\text{s}}{10\text{s}} \times 5(\text{times/day}) \quad =157.44\text{mA} \quad (v)$$

During sleep condition current requirement is minimum, therefore it is not taken under consideration.

Calculated battery life time

$$=450\text{mAh}/157.44\text{mA} \quad =2.86\ \text{hrs}$$

Therefore, we can use it for 2.86 hrs.

$$\text{Totalduration the model is used only 50sec} \quad \text{No.ofdays it can use} = (2.86\times 3600\text{s})/50\text{stimes} \quad =205\ \text{days}$$

After receiving the information from various sensors of system, it has been transferred to the microprocessor for processing, which further uploaded to the cloud server. In order to do that we using 2400−2484 MHz band based (the IEEE 802.11 b/g/n) Wi-Fi transreceiver module. Level of water in the drain is accessible on the website of cloud server. Alarm messages were sent to the respective authority, for identified overflow of the drain with location for obtaining suitable measures.

Access Network Interface: The information obtained must be sent to a remote server via a wireless link. In our proposed system, we utilize Wi-Fi as a network access technology. We used Wi-Fi serial module ESP 8266. The Wi-Fi unit provides an exact interfacing with the microcontroller used. This module comprises of a 32-bit microcontroller, ADC, UART, PLL and memories.

It has its own self-calibrated RF which allows it to operate under all working situation and requires no external RF parts. Access Network helps to send details of drainage system at the receiver side. Figure 10. represents circuit arrangement of proposed system.

In our work, the cloud server is additionally interfaced with mobile application. The application allows us to visualize our data channels in a simple way by only providing the channel ID and we are ready to check the status of drain i.e., fill up condition. By observing status responsible authority can take suitable action, not only that if the level is above certain fixed level, nearby alternative gate will open which allows drain water to pass through another conduit.

End user Visualization: This IoT based system will detect the blockage in the sewer lines and offers the early alarms so that responsible authority can clean it as early as possible.

## Case Study

For authentication of the methodology, SWMM programming is used [21]. It is a unique artificial rainfall model for foreseeing hydrology quantity and pressure driven performance of metropolitan drainage system. It is created by the US environmental protection agency. The SWMM programming is generally utilized by established researchers and specialists for arranging, design and planning for stormwater overflow problem and other drainage problem in metropolitan zones. SWMM recreates any sort of precipitation event. It additionally incorporates a directing unit which mimics the flow of precipitation water through an arrangement of conduits, channels, storage/treatment gadgets, pumps, controllers, etc. SWMM depends on a period ventured recreation, where the model advancement is completed step by step by mathematically addressing the stream directing conditions (dynamic wave). Figure 11 shows arrangement of catch basin in the system. The trials were completed utilizing a web like structure which comprises of a primary conduit of 1 m diameter and a sum of 35 lines present in the inner surface of the sub-network. The system conveys the stormwater circulation and after that it will reach in a storage water body. All lines have round form segment with a slant of 2%. In the drainage framework the joining between the primary channel and secondary lines (intersection nodes) are made of 1.5 m tall catch basins.

All the information i.e., water pressure, level etc. are collected by above mentioned senor (section III) and processed by SWMM software and it is also conveyed to Thingspeak cloud server. The concerned authority can access all the data through Thingspeak.

During experiment, we utilize a 30 minutes precipitation/runoff event with a flow rate of 0.25 $\mathrm{m}^3/\mathrm{sec}$ for every inlet node. The outcomes are appeared in Fig. 12(a) and 12(b), where the level of filling of channels, addressed by values somewhere in the range of 0 and 1, are plotted with time. In the unrestricted situation (a), the levels of fulfilling of the smaller charged channels are much lower than the level of filling of the high charged one. As a result, a drain becomes excessive charged where different ones result undercharged. This implies that the organization doesn't function properly as it is unable to transmit the leftover water to the undercharged conduits.

The performance of the same system becomes extraordinarily good after the application of the proposed strategy (Fig. 12(b)). The load curves are much nearer to one another as the load is distributed on the whole network. That means the controlled network shows an improvement in the behavior of the critical overcharged conduit than an uncontrolled network.

Introduction of ultrasonic sensor is an important issue in this study.

The sensor hub is fixed in front of the vessel and zero level was adjusted. At the time when vessel is filled up with definite volume of water, the UV detector can differentiate the range dissimilarity & determined the related water level. In the Fig. 10, the water volume in the pipe can be logged and noticed. The water level at various time interval was observed online through sensors and internet connectivity.

The threshold value for HCSR04 (ultrasonic sensor) is 36 inches. Any values more than 36 inches are considered as normal. Values below 36 inches is decided as overflow. The value of Ultra sonic sensor decreases as level of water is increases. Table 3 shows ultrasonic level sensor and stinky gas concentration at different time in the drain. When volume fall under the threshold level, then corresponding information is sent to the appropriate agencies via mobile application ($Thingsview^R$) with exact place. A blockage or obstruction is detected when flow detector senses the speed of water flow is below 10L/hour and the corresponding data acquire from flow detector is represented in Table 4. When the water volume/hour reaches the values somewhere 9 or 7, as shown in Table 4, a message is sent continuously to the authorities till the blockage is repaired. When these sensors value reaches beyond the threshold value alarm message is send to the responsible authority with the information of concern area.

Table 3
Values of ultrasonic level sensor and stinky gas concentration at different time on the drain.

| **Data taken at** | **Values (inches)** | **Ammonia (ppm)** | **Hydrogen Sulphide (ppm)** |
|---|---|---|---|
| 2020-01-0504:00:02 UTC | 32.75 | 25 | 6 |
| 2017-03-05 12:00:00 UTC | 64.44 | 10 | 1 |
| 2017-03-05 17:00:00 UTC | 77.0 | 15 | 3 |
| 2017-03-06 04:00:00 UTC | 6.98 | 19 | 16 |
| 2017-03-06 12:00:08 UTC | 4.44 | 6 | 11 |

Table 4
Flow sensor Value

| **Values Lt/hour** | **Outcome** |
|---|---|
| 240 | Normal |
| 129 | Normal |
| 55 | Normal |
| 9 | Blockage Detected |
| 7 | Blockage Detected |

The level & speed of water is checked constantly. If any obstruction is detected, the pressure of water on conduit changes. Speed of water stream diminishes when there is a growth of blockage.

Figure 13, 14 & 15 shows experimental setup at practical location of smart drainage system. Experiment is carried out at different location on municipally owned drainage system in Siliguri city, West Bengal, India.

# Conclusion

The system effectively monitors real-time status of urban drainage system using cloud-based monitoring. This system uses IoT technology for monitoring drainage network. The arrangement is able to monitor overflow & blockage in the system & convey the information to a cloud server for storing & additional processing. The information can be access by responsible authority to know drainage condition of the system, without physical inspection. The received data provide an early indication of flood and provides the information whether blockage in system required to clear up or not. This early detection saves money, manpower and time, which is the uniqueness of the work. This ICT based arrangement consists of microprocessor, Wi-Fi unit & cloud server $Thingspeak^R$. For the purpose the theory of various drainage system is applied & is implemented using the microprocessor & various intelligent sensors like flow sensor, ultrasonic sensors etc. The system has been validated using a drainage network which is able to detect the problems present in the system and convey the same to responsible authority.

Initial trials were performed applying the SWMM simulation software. The software was suitably custom-made as to permit an exterior unit to regulate the simulated system. The actual outcome witnesses a remarkable drop of the overload times, henceforth shows the usefulness of the approach.

# Declarations

### Ethical Approval

*This is an original article.*

# Conflict of Interest

None.

### Consent to Participate

None

### Consent to Publish

Not applicable

## Authors Contributions

DM, GD & DD wrote the manuscript and provided data for table, also involved in this research work. All authors reviewed the final manuscript.

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There are no relevant financial or non-financial competing interests to report

## Availability of data and materials

Not applicable

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# Figures

**Figure 1**

Blocked drain due to waste product.

**Figure 2**

Flooding of road due to waste product.

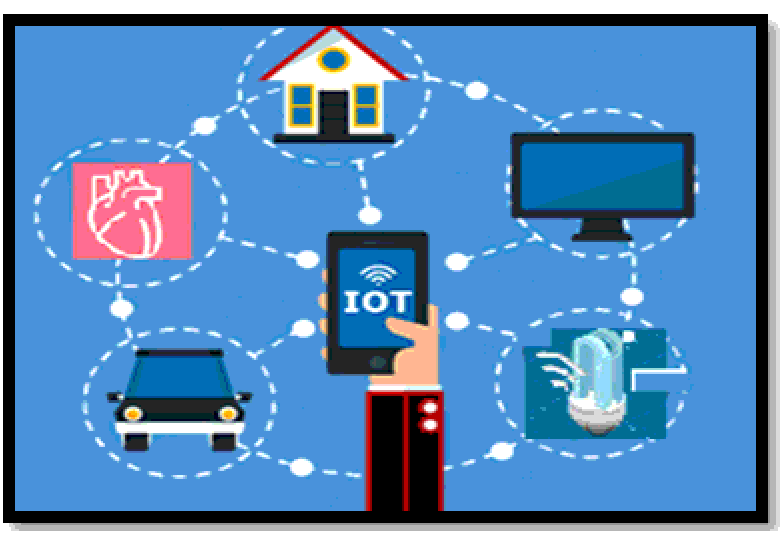



**Figure 3**

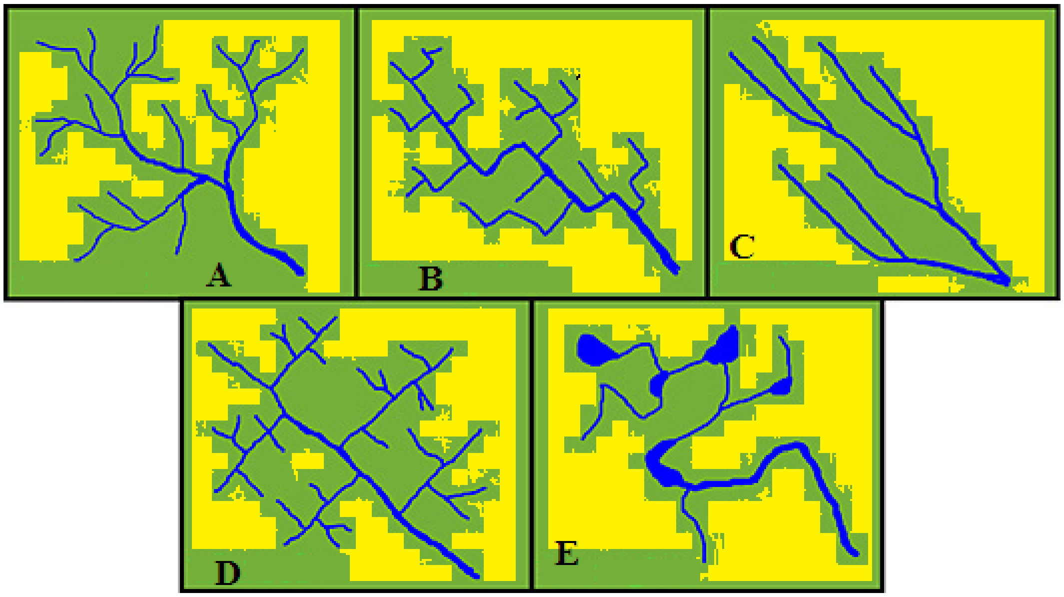



**Figure 4**

Common drainage pattern types. (A. Dendritic, B. Rectangular, C. Parallel, D. Trellised, E. Deranged)

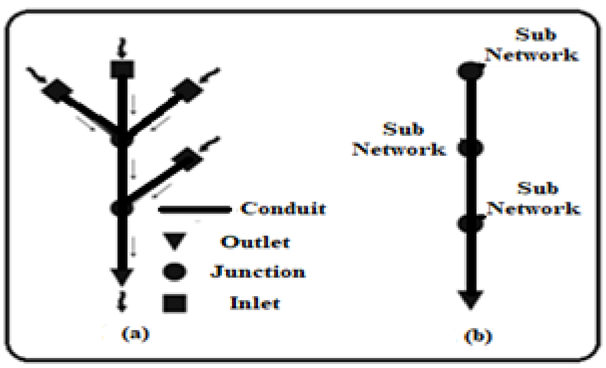
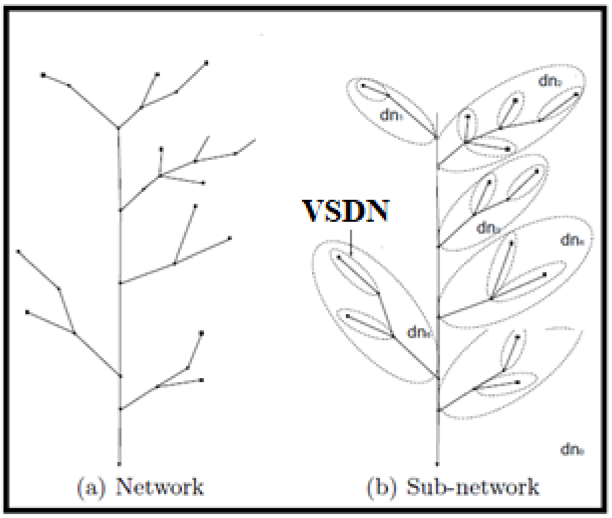


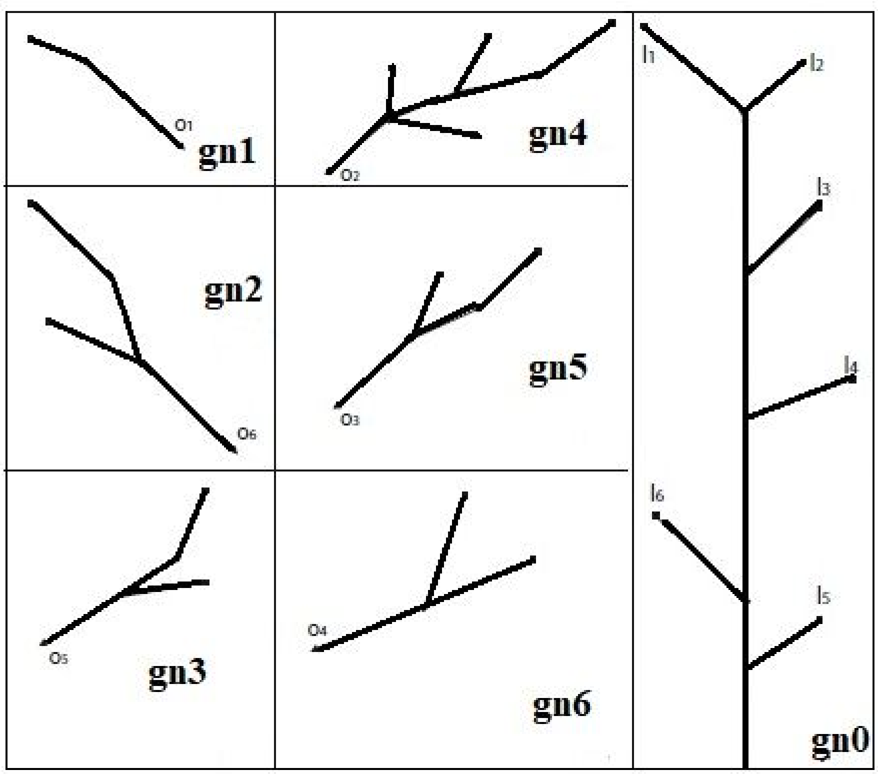

**Figure 5**

Actual Sub-Network in a practical situation (a) A simple drainage Network (b) Recursive definition of drainage network.




## Figure 6

Sub network used for practical purpose




## Figure 7

Sub network in realistic case

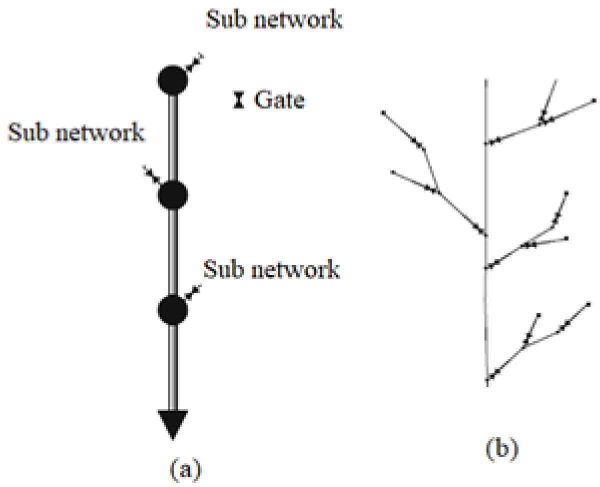



**Figure 8**

(a) Logical (b) Realistic drainage network.

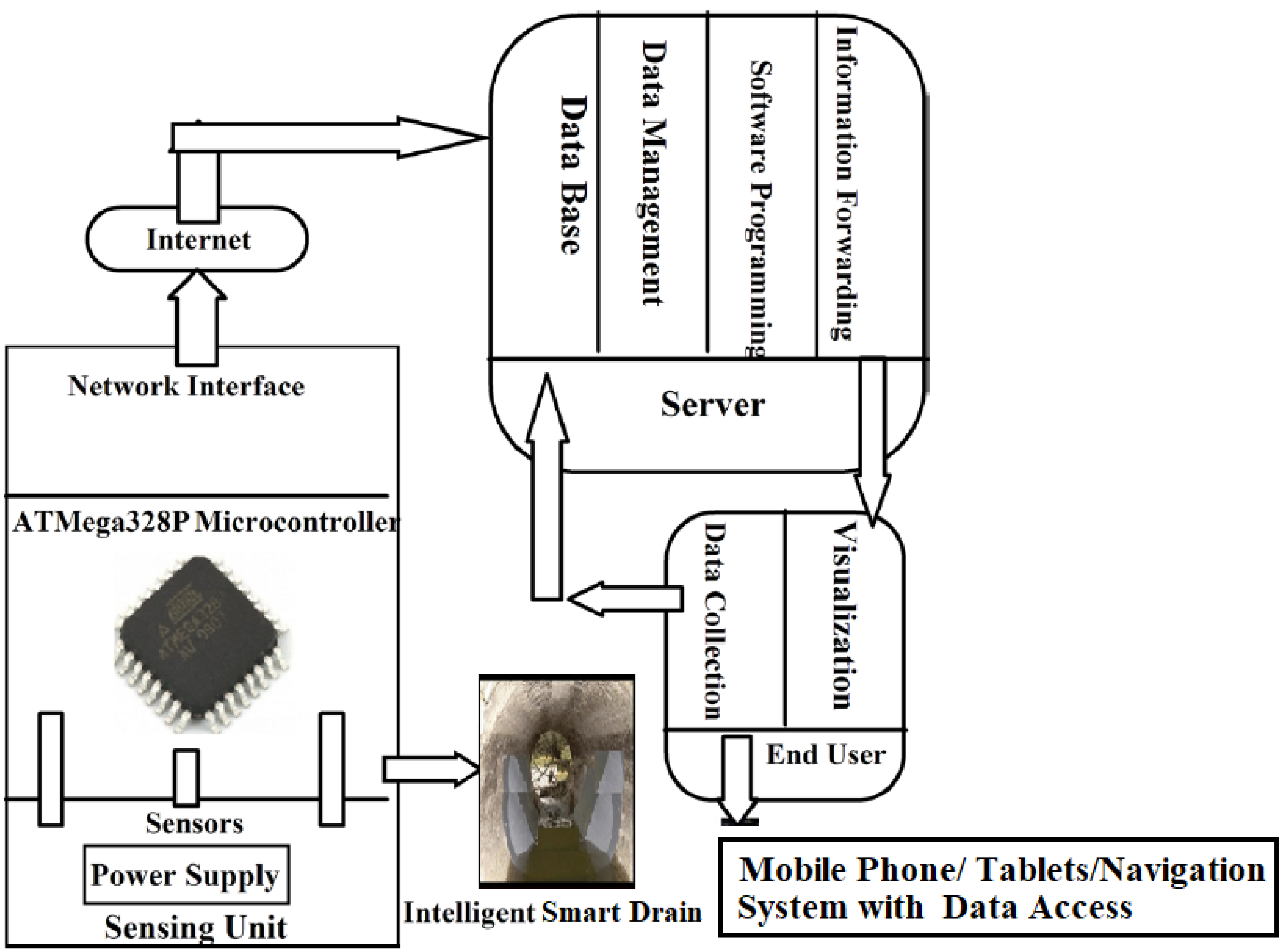



**Figure 9**

Schematic diagram of the proposed system and flow of operation.

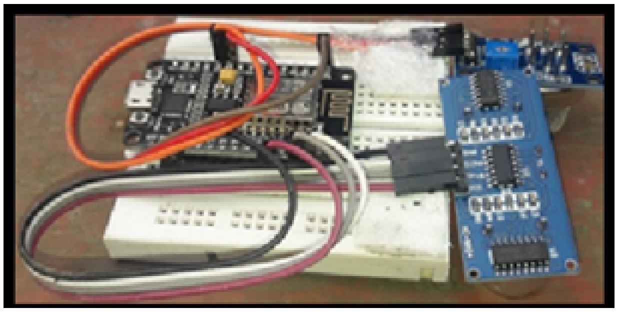


**Figure 10**

Circuit arrangement of proposed system.

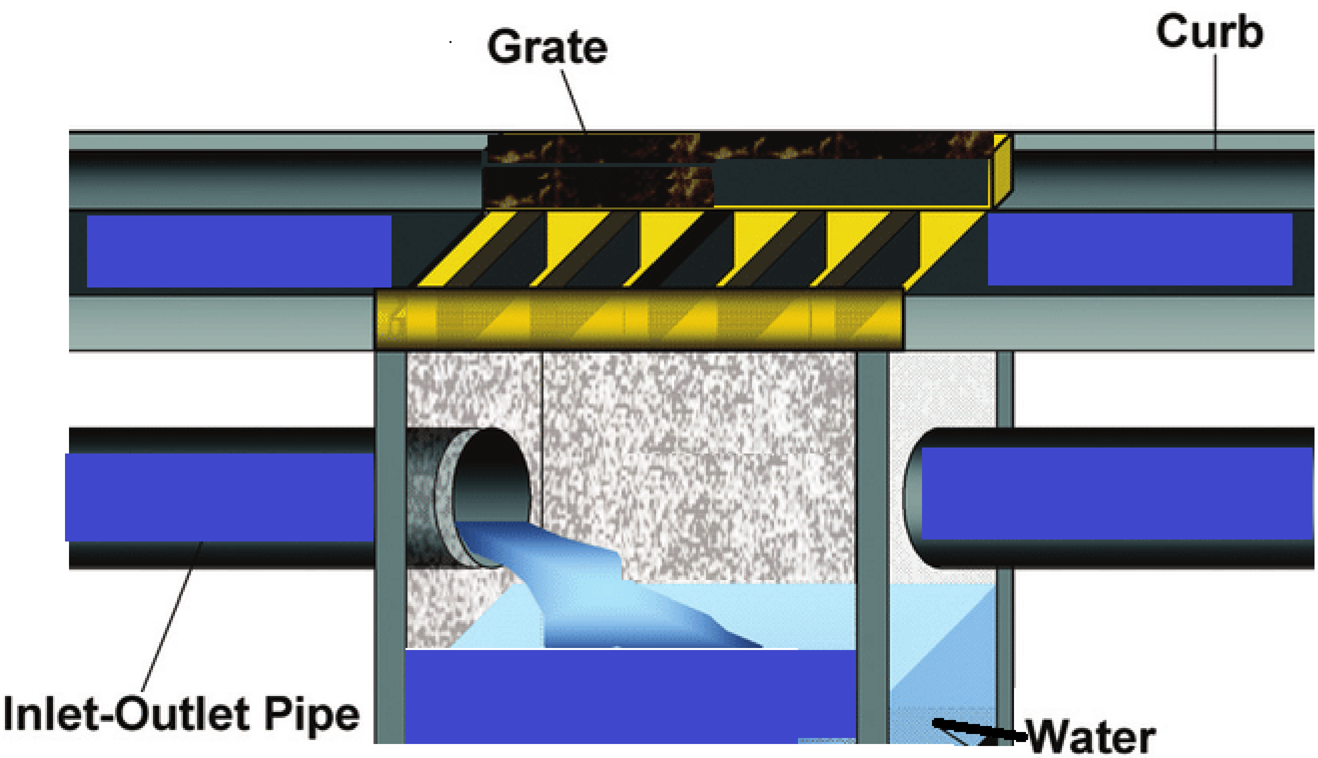



**Figure 11**

Arrangement of catch basin in the system.

**Figure 13**

Position of sensor at smart drainage system.

**Figure 14**

Position of sensor at smart drainage system. (Vertical View)

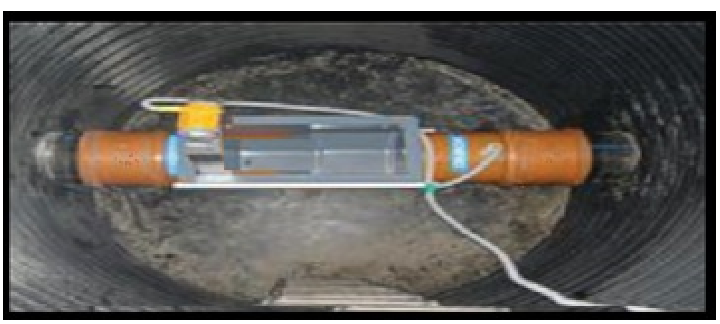


**Figure 15**

Experimental setup at practical location of smart drainage system (Horizontal view)