Ubiquitous Building Automation System in Indian Diverse Environment Using Colored Fuzzy Petri Nets

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Abstract: -

There is a great need for a security and control system which is inexpensive, handy, and convertible, that can be operated in both manual and automated mode in a home as well as in a building. Since our framework model uses the capabilities of the pre-existing concept of ubiquity and diversity in systems, we have named it Ubiquitous Framework for Mood-Based Building Automation System in Diverse Cultural Environment (UFMBAS-DCE),it integrates many interdisciplinary fields by looking into various aspects of cultural variations. Finally,this integrated structure focuses on various artifacts and environments that capture various living styles from an architecturalpoint of view.

Keywords: - BAS, Building Automation, Mood-based building automation, colored Fuzzy Petri Nets

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1. INTRODUCTION

In today's world, the whole scenario of information technology has changed from big operating systems and system programming and engineering, the focus of developers and technology masters has changed and from big things they are shifting from small things the future of communication is quite bright as the technology is ready to cross all limits of communication i.e., the new technology would be accessing the information without the permission of the person or the device.

Due to the cultural and traditional diversity of the Indian environment, the successful implementation of self-automated and smart architectures has been very challenging. The Internet of Things (IoT) expands the network of devices, increasing hazards, and demand. According to worldwide records, there are about eight billion IoT devices and more than three billion mobile users, which is a scary situation because the number of devices is continuously increasing number.

At the same time, there is a challenge of ensuring that mobile devices provide the best use of technology and wireless technology ensures easy access to the devices and using this information on the cloud for the distributed environment.

"The meaning of things lies not in the things themselves, but our attitude towards them". By following the definition of the given quote, the proposed research is motivated by the concept of ubiquity and mobility, which should bring comfort to our lives. The proposed work is to design a unified framework for the Building Automation System (BAS) very close to real-time situations consisting of various components like the IoT, multiagent systems, and real-time systems. The proposed system focuses on some important research questions.

- What kind of solution for the continuous building performance?
- What are the experiences and especially the challenges associated?

To answer these questions, the proposed study concentrates not only on the construction of a new solution but also on the evaluation of the solution from the perspective of users. In this study, a Petri net-based building automation system and accompanying graphical user monitoring application are presented. It presents a model-based development approach using a Colored Fuzzy Petri Nets (CFPN) tool for management, monitoring and controlling. In this way, system functions and functionalities are represented as UML use cases, with Petri nets as the primary modeling tool. Each use case and its translation into a state diagram or Petri net model form the basis of the system model.

After that, a composition operation is used to merge the partial models, resulting in the building of a Petri net-based behavioral model for the entire system. The concept takes advantage of the relationship between the main characteristics of the Petri net model and the key graphical qualities given in the document. Finally, the system implements the entire interdisciplinary study and develops a well-defined prototype that can be used further on a large scale by the manufacturers. This results in an indigenous framework for Indian buildings where the miniaturization of the big circuits and devices will make this fit on a switchboard from where it can be operated manually and from any distance. The following steps have been covered in this article one by one.

The first step covers the identification of the unified framework for building automation. The second stage develops a unifying framework for simulating BAS near to real-world circumstances using a combination of mood-based controls, multiagent and IoT notations. Thethird step provides the error analysis of the proposed unified framework. The last step provides a formal verification of the entire model being developed through CFPN.The scope of the proposed work includes the application of the unified framework for BAS using IoT with special reference regional variations, and to implement the mood-based building automation using CFPN.

2. REVIEW OF EXISTING CONTRIBUTIONS

The study of building automation systems and the requirements of the diverse environment demonstrates the structure of the BAS in old times and the big changes the BAS has gone through in recent years. Several studies have been conducted during this research period, and a summary of the various relevant studies is presented as a brief review of the literature. This study provides a review of automation, control, and IoT systems.Baeten (2005) presented the origin and background of process algebra as a field of study in the theory of distributed and concurrent systems in computer science. The movement's beginnings were found at the starting of the 1970s, and advancements since then have been outlined. He also discussed the state and described the potential challenges upcoming [1]. Fokkink (2000) introduced the concepts of process algebra [2].Bennett (1996) provided a brief history of automatic control by covering the discussion of the early control era, the pre classical era, and the classical era [3]. Berkovitz (2013) emphasized the theoretical concepts of optimal control [4].Supervisory control of remote manipulation was described by Ferrell and Sheridan (1967). It was explained how the relatively short distances that could be covered with the manipulators already available allowed for real-time control systems, which were typically based on direct links. The advent of space flight necessitated the development of manipulation systems capable of performing complex tasks on the moon and beyond, all while being controlled from Earth. This design accounted for the time delay in communications caused by the distances involved, as well as a difference in the environment that was not directly visible to the human operator [5].

Bejczy (1980) outlined the historical development, provided a brief description of fundamental issues, and described the results of the Jet Propulsion Laboratory's teleoperator research and development. It demonstrated advanced teleoperation sensors, controls, and man-machine interaction [6].Sethi, S. P. (2021) described optimal control theory employing continuous-time systems and discrete-time systems. He delivered an overview of mathematical theory and then demonstrated how to apply it to a range of scenarios in management science. It included the fundamental management science applications in finance, economics, manufacturing and inventory management, marketing, maintenance and replacement, and natural resource usage [7].

Buttolo, Kung, and Hannaford (1995) presented a new approach for telemanipulator performance evaluation. They performed a sequence of functions on a physical configuration, along with a virtual development capable of delivering visual and force feedback using a haptic display and a telemanipulation system remotely on the real setup. They were able to isolate the impacts of the system's components, such as the master manipulator, display, slave manipulator, and bilateral controller, on total telemanipulation performance [8].

Saastamoinen (1995) addressed how exceptions could be managed in information systems [9]. Ellis (1999) described the problems in social interaction and the micro-macro aspects [10].Flouris, Plexousakis and Antoniou (2006) discovered the challenges of updating ataxonomy in response to a specific requirement. They explored the classification of ontology changes, as well as the precise links, connections, and overlaps between study fields and the scope of each field [11].

Banzhaf & Hofer (2008) used CIR aerial pictures to investigate and monitorarchitecture types as spatial indicators in urban environmental sustainability. They incorporated highly sophisticated color-infrared orthophoto data as well as image analysis algorithms. By characterizing typical color, texture, shape, and context characteristics, they demonstrated how an object-oriented analytic technique with CIR aerial pictures might be utilized to recognize and classify different urban structure types. On an aggregated neighborhood size, the categorization of urban structures was defined by recognizing various categories of buildings and open areas, as well as their architectural setting in terms of the quantity, interconnectivity, and distribution of land areas, green areas, and other open areas. Different forms of dwellings, industrial structures and infrastructure could be used, while open spaces could include forests, public gardens, and parks [12].

Vermesan et al. (2009) presented the framework for IoT-based approaches. They explained their unified purpose of deploying independent federated applications and services with great autonomy in data collection, event transfer, network connectivity, and interoperability [13]. Furthermore, Atzori, Iera and Morabito (2010) presented an IoT survey and review [14]. Public review draft, BSR/ASHRAE (2010) provided that the underlying idea behind this notion was the ubiquitous presence of several objects, such as Radio-Frequency Identification (RFID) tags, sensors, cell phones, actuators, and so on. This was a breakthrough in software as well as hardware as more and more emphasis should be given to the safety and security of buildings, goods, and most importantly people and their life. So, individuals are involved with one another and collaborated with their neighbors to achieve similar goals due to unique addressing methods. It developed the concept of building automation and control networks (BACnet) using the data transmission protocol [15].

Greengard (2015) explained that the IoT was still in its infancy and that was quite true for most developing countries in the world, including India [16].In the same direction, Daniel, Antonio, Giacomo, & Luigi (2010) explored several concepts of the IoT [17]. Prehofer&Chiarabini (2015) looked at tools and processes to develop IoT applications and compared application mashup tools with a model-based development approach. They gave an example and pointed out a few important contrasts to demonstrate how both approaches might benefit from one another. They found the model-based techniques more expressive in terms of modeling various perspectives and behaviors and generating code from the models for various platforms [18].

BACnet and ASHRAE extended the discussion of [15] in [19]. In the same direction, SkySpark elaborated on automated buildings and their related aspects [20]. Uckelmann, Harrison, and Michahelles (2011) explored the concept of a future IoT architecture that includes a study of developments, a record of critical needs, and a technical framework for future IoT implementation. They also explored unresolved challenges, such as stakeholder evaluations of usability in user-centric and business-centric scenarios, underlining the importance of measuring costs and benefits for enterprises, customers, the environment, and society [21].The author (2011) illustrated the concepts of the IoT, and its related Frameworks and Technologies [22]. Evans(2011) addressed IoT and its ability to revolutionize everything in the next evolution of the Internet [23].

Kiritsis (2011) introduced the ontology-based semantic guidelines for product lifecycle management and related knowledge management and sharing. He described the intelligent products of the IoT as a product system inspired by what happened in nature to humans and how humans developed intelligence, learning, and knowledge. This system has four layers of intelligence, including the sensing layer, the memory layer,the data processing layer, and the reasoningand communication layer. It incorporated new product data technologies, which allowed easy system compatibility and the interchange of dynamic and static product data. It attempted to shape the current state and potential future of product data technologies from the standpoint of closed-loop life cycle management [24].

Bandyopadhyay & Sen (2011) discussed the study in IoT research, including important technology drivers, prospective applications, difficulties, and future areas of study. In academic and industry circles, they analyzed and compared IoT from various perspectives [25]. The role of semantics in IoT was examined by Barnaghi, Wang, Henson,& Taylor (2012) to see the early development and future. They explored various problems while reviewing recent breakthroughs in the application of semantic technologies to the IoT for information modeling, ontology generation, and semantic data processing. In the IoT area, semantics was utilized to provide machine-interpretable and self-descriptive data. Together with other intelligent processing approaches, representation-based machine-interpretable semantic technologies were used to define objects, distribute and integrate information, and find new knowledge [26].

Reed, Gannon, and Larus (2012) addressed visualizing the future and computing ideas [27]. Aggarwal, Ashish, and Sheth (2013) conducted a data-centric survey on the IoT [28]. The information granules for medical infonomics were demonstrated by Ahmad, Purohit, Mohammed, and Darbari (2013) [29]. The evolution of the IoT was examined by Chase (2013) [30]. Alur et al. (2015) published a list of IoT systems' computing difficulties [31], and Fischer (2015) provided a list of commonly asked questions about IoT [32].

To address future data management difficulties in the IoT, Abbasi, Memon, Syed, Memon, and AlShboul (2017) presented a data management architecture. The massive volume of data created by IoT-enabled devices was safely managed by this architecture. Data collection, fog computing, integrity management, security, data aggregation, data analysis, data storage, application, and archiving were among the nine layers of this architecture. All layers protected data privacy and security due to the security layer known as the background layer [33]. Alex (2015) described how IoT revolutionized our lives by using the required standards [34].

The approach [35] demonstrated a mechanism for converting multi-agent protocols written in a lightweight coordination calculus language into high-level colored Petri net models automatically. It created a very well mathematical structure model that could be used for the formal analysis of multi-agent protocols and combined with a standard functional programming language to assess whether the protocol is intelligible and beneficial to the agents' goals.

There are many challenges and barriers to the IoT that are the deployment of IPv6, power for sensors, and the use of standards. Wireless sensor network (WSN) is one of the most promising technologies for some real-time applications because of its size, cost-effectiveness and easily deployable nature. Due to some external or internal factors, WSN may change dynamically and therefore it requires depreciating dispensable redesign of the network[37] They are related to IoT such as IPdeployment and sensor power requirements. With the development and popularization of mobile terminal technology, mobile wireless sensor networks (MWSNs) have become a new evolution trend in wireless sensor networks (WSNs) technology. The mobility of nodes introduced by MWSNs greatly expands the application range of WSNs. However, the mobility of the sink node also induces changes of the network topology, time delays, and packet loss rates, which can greatly affect the routing performance of the networks [38]. In addition, the reliability and robustness of the networks are also greatly affected and challenged. The theories and methods applied to WSNs previously, such as data collection, reliable data transmission, network reliability, network topologies, and routing protocols are not currently available for MWSNs. The introduction of mobility features into traditional static WSNs brings new challenges for the stability, security, and reliability of WSNs. Reliability is an important index for evaluating the performance of MWSNs. Moreover, the reliability of the data transmission determines the practical value of MWSNs. The stable and reliable operation of MWSNs requires ongoing and important work.The concern is to connect billions of devices when unique IP addresses are required for billions of new wireless sensors. Some other challenges are related to its framework and management.There is also a big challenge to see the reusability of the sensors if applied in the building automation and control, as sensor base systems definitely learn the pattern and show the best efficiency which the system self-learn and adopt but once it is done what about the usefulness of the sensor? For a sustainable building automation system, the reusability of the sensors is the key.Therefore, there is a need for a common platform for building automation that can organize and communicate well with all devices that it need to interact. The proposed research work and study establish the groundwork for the future connected world of devices and things. The difficulty lies not only in the design but also in integrating and verifying the framework's effectiveness considering future requirements. There is a need to develop a common, sustainable, and cost-effective energy-efficient framework that can deal with heterogeneous device compatibility.

1. PROPOSED PROTOTYPEOF THE UNIFIED FRAMEWORK FOR BUILDING AUTOMATION

As we know Model-driven development of a standard framework for homes where the automation and manual settings are also provided for home equipment is the need of the hour. Structural and functional analysis of the ubiquitous system in IOT using model-driven software development can be done in a better manner. To keep hardware and software running in synchronization, we must choose the one which works better for the building or home wherever implemented.

The proposed Ubiquitous Framework for Mood-Based Building Automation System in Diverse Cultural Environment (UFMBAS-DCE) integrates many interdisciplinary fields by looking at various aspects of cultural variations. Its integrated structure focuses on various artifacts and environments and captures various living styles of these architectural viewpoints and particular considerations of material types. It is shown in Figure. 1.

Figure1: Prototype model of UFMBAS-DCE System

The design of the UFMBAS-DCE model is the integrated smart BAS that involves an interdisciplinary engineering management approach for developing and validating an integrated, life-cycle-balanced set of system solutions that meet the requirements. It has two main functions. It manages the design process and consists of a primary link between technical management and the overall acquisition process. It is performed by combining the primary actions listed below.

- Development phase planning regulates and controls the design process and establishes benchmarks to coordinate design efforts.
- Required to ensure proper management of development effort and to address design difficulties.

So, it establishes the design baselines for each step of the development to regulate and control the design process. It assists acquisition management by identifying key events during the development phase that is used to evaluate design viability. The control agent is responsible here for receiving the signals and controlling the fixtures accordingly as shown in equation 1.

BAS agent = Control agent + Provider agent (1)

The characteristics of the proposed integrated architecture are the following:
It is independent of any agent-oriented methodology.
The pattern matching process gives simple explanations of the correspondences applied in the translation.

The addition of new methodologies just requires the specification of their mappings.

- Mappings with ubiquitous methodologies are a suitable resource to discover and analyze missing features in agent-oriented languages.
- The architecture has automated support tools realized through an IoT developed to support the Unified framework.

Therefore, this proposed UFMBAS-DCE model considers the successful development of an IP-based system to monitor and monitor the entire building. Wireless technologies are required for this approach to integrate numerous building appliances. In addition, in a diverse setting, smart building and lighting control must integrate total facility control. It needs component coordination for sensor collaboration, where each entity is regarded as an object and its functionality is its actions.

4. ARDUINO ESP8266 MICROCONTROLLER WI-FI MODULE

The ESP8266 Wi-Fi Module is a self-contained system-on-chip with an integrated TCP/IP protocol stack that can provide access to your Wi-Fi network to any microcontroller. The ESP8266 may host an application or offload all Wi-Fi networking functionality to a separate application processor. Figure 2 shows the Arduino ESP8266 Wi-Fi module which includes the ESP base, R1-R6 resistance, T1-T3 transistors, Di-D3 diodes, RL1-RL33 relays, and a load connector. It features a 64-kilobyte boot ROM, a 64-kilobyte instruction RAM, and a 96-kilobyte data RAM. SPI can be used to access external flash memory.

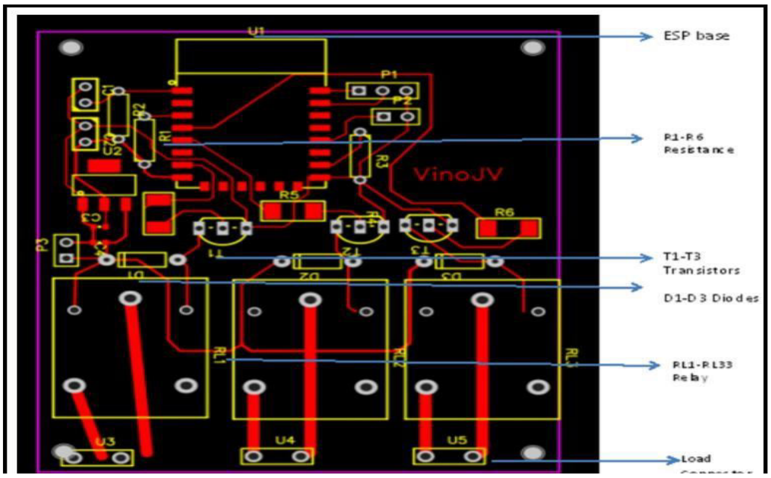

Figure 2: Arduino ESP8266 Wi-Fi Module.

Conversion is possible from analog to digital (10-bit ADC). It has an 'r' number of serial peripheral interface serial communication protocol. Pulse width modulation (PWM) is a technique for changing the width of a pulse. It runs at 80 MHz and uses a 32-bit Reduced Instruction Set Computer (RISC) CPU based on Ten silica. With this, it includes the following configuration:

- 802.11 b/g/n Wi-Fi (supporting WPA/WPA2) at 2.4 GHz.
- Input/output devices that can be used for a variety of purposes (16 GPIO).
- Serial communication protocol I2C (Inter-Integrated Circuit).
- Direct Memory Access (DMA) and Inter-IC Sound (I2S) interfaces to share the pins with GPIO.
- Transmit-only Universal Asynchronous Routing Technology (UART) on dedicated pins to be enabled on GPIO2.

Figure 3 shows the connections of Xtensa L106 (overclocked) at 160 MHzthe RX, GPIO, GPIO2, GND, 3V3, RST, EN, and TX represent the Serial Receive Pin of UART, Ground Pin, 3.3 Power Pin, Active Low Reset Pin, Active High Enable Pin, and Serial Transmit Pin of UART.

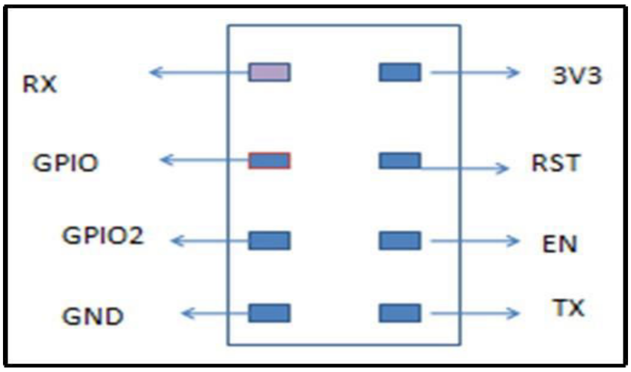

Figure 3: Connections

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Arduino Wi-Fi module is the integral part of our proposed system. As current section depicts the usefulness of Wi-Fimodule. It runs in Flash and UART mode, When the GPIO-0 and GPIO-1 pins are both active high, the module executes the software that has been uploaded. When GPIO-0 is active low and GPIO-1 is active high, the module enters programming mode and may be controlled through serial connection via an Arduino board.

5. DETAILED ARCHITECTURE OF THE PROPOSED SYSTEM

The UFMBAS-DCE model consistsof portable smart building modules using to monitor building-hold electrical devices. It consists of an SMPS, transformer stepdown, a capacitor diode (rectification) to convert AC to DC, a relay module, an ESP8266 Wi-Fi module, and an electronic board. The power consumed by the module was very low, whereas the current sensor itself only uses one 5-volt DC. Figure 4 shows the detailed architecture of the UFMBAS-DCE model. The architecture includes two relays called Relay1 and Relay2, two resistors called R1and R2, two diodes called D1 and D2, and a Node MCU V3.0 Lolin called U1. The resistors are of (+-) 5% 220 Ohm capacity. Along with this, it has atotal of 30 pins in Loin. These pins are A0, GND, VU, S0-S3, SC, 3V3, EN, RST, Vin, D0-D8, RX, and TX. A0, VU, S0-S3, SC, Vin, and D0-D8 represent labels used to assign different tasklike D0 corresponds to GPIO16 and D1 corresponds to GPIO5 respectively.

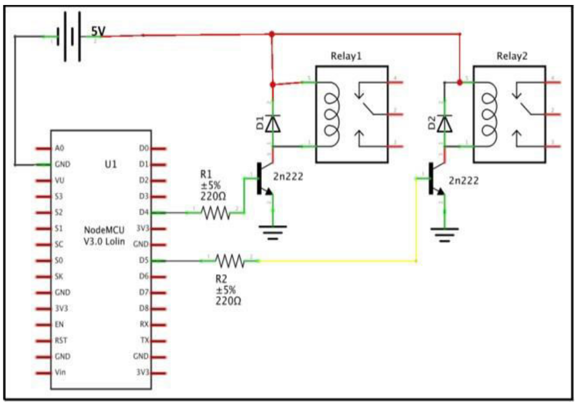

Figure 4: Detailed Architecture of the Proposed UFMBAS-DCE System.

The advantage of this type of hardware is that a portable device can be used immediately without being assembled beforehand. The transmission is done using the existing, proven protocols, assuming that data is preserved safely. The development of 3D printing technology with miniaturization of the design could provide a compact design with good functional and aesthetic usability. This model implementation iscompleted with theverification and validation using colored Petri nets withthe CFPNtool.

Algorithm

The algorithm of the UFMBAS-DCE model is given below.

Start:

Step 1: AC source input 220 volts activated.

Step 2: If the status is ON, T1 will fire otherwise STOP.

Step 3: Step-down transformer activated to convert AC to DC.

Step 4: Desired 5-volt output is generated.
Step 5: Connectivity is established using the Wi-Fi module.
Step 6: Check the connectivity status to be on.
Stop
Here is an important subsection is the indication of system connected to wifi is the LED which is been set pin D4 as an indicator.
Start
Step 1: Declare LED pin on NodeMCU Dev Kit
Step 2: Initialize the LED pin as an output
Step 3: Turn the LED on
Step 4: Wait for a second
Step 5: Turn the LED off
Step 6: Wait for a second
Stop
The algorithm depicts the flawless connection which is established with the Wi-Fi module which makes the system to be in the ready state to receive instructions from the server.

Description of the UFMBAS-DCE Components. The working of the various components of the UFMBAS-DCE model is described below. The details of all the components are given below. The ESP8266 has 17 GPIO pins (0-16), however you can only utilize 11 of them since the flash memory chip requires 6 pins (GPIO 6 - 11).

A0 Pin: GPIO is called ADC0 and it is usually marked on the silkscreen as A0.is for the analog input
VU Pin: is linked to the NodeMCU socket's USB bus at +5V. When connected to USB, this pin can be used to feed external components up to the limitations of the USB power source it's attached to
Rx and Tx Pin: 2 pins out of 11 are generally reserved for RX and TX in order to communicate with a host PC from which compiled object code is downloaded.

Vin Pin: If you have a regulated 5V voltage source, you may utilise it to power the ESP8266 and its peripherals directly. The 3.3V pins are the output of a voltage regulator on the board. Power can be supplied to external components through these pins.
D0-D8 Pin: General-purpose I/O pins as shown in table 1.

Table 1: General-purpose I/O pins

Pin Name	ESP8266 Internal GPIO Pin number
D0	GPIO16
D1	GPIO5
D2	GPIO4
D3	GPIO0
D4	GPIO2
D5	GPIO14
D6	GPIO12
D7	GPIO13
D8	GPIO15

5-Volt DC Relay: This EM switch is used for on/off. It should be equal to or greater than the coil voltage rating.For a relay, the power supply must be DC voltage.The public end of the relay is open and closed; they are electromechanical devices that use an electromagnet to operate a pair of movable contacts from an open position to a closed position.

A relay is a switch that is controlled by electricity. Their internal mechanical switching mechanism is typically operated by an electromagnet (coil) or contact device
contacts). When the coil is engaged, an open relay contact will turn on the power to a circuit.Figure 5 and Figure 6 depict the relay connection and its principle. It has two connectors, each with three sockets called COMmon (COM), Normally Closed (NC), and Normally Open (NO). The COM socket connects the current you want to control which is the main voltage. The NC socket configuration is used when you want the relay to be closed by default. The NC and COM pins are connected, so that the current flows unless you send a signal from the ESP8266 to the relay module to open the circuit and stop the current flow. The NO socket works the other way around. There is no connection between the NO and COM pins, so the circuit is broken unless you send a signal from the ESP8266 to close the circuit.

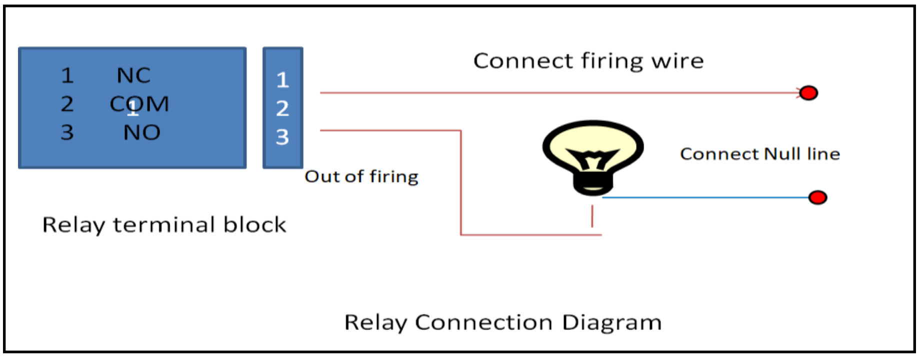

Figure 5: Relay connection diagram

- Normally Closed (NC)Configuration
- HIGH Signal: Current is flowing.
- LOW Signal: Current is NOT flowing.
- Normally Open (NO)Configuration
- HIGH Signal: Current is NOT flowing.
- LOW Signal: Current is flowing.

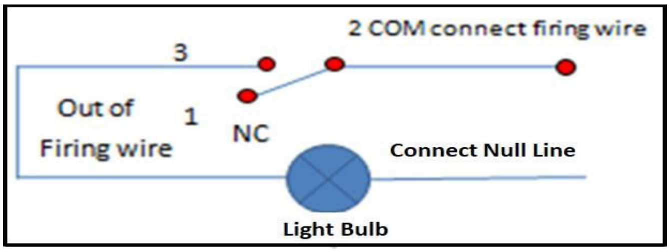

Figure 6: Relay connection principle

- **Microcontroller:**

  Espressif Systems' ESP8266 is a low-cost Wi-Fi microchip with built-in TCP/IP networking software and microcontroller functionality. The ESP8266 Wi-Fi Module is a self-contained SOC with an inbuilt TCP/IP protocol stack that can provide access to your Wi-Fi network to any microcontroller. The ESP8266 may either host an application or offload all Wi-Fi networking functionality to a separate application processor. The ESP8266 module allows microcontrollers to connect to IEEE 802.11 bgn 2.4 GHz Wi-Fi.

  Latency associated with the established connection of the Wi-Fi controller module and the server is taken into account by using a time variable notation. Once the connection is established the transition state which is associated with it fires, which transfers the control to the relay which is plugged in the post-Wi-Fi controller. The relay is kept on hold the status as the command is yet to be received by the controller when the command is given, and it is checked for equality.

  In the proposed model, different scenarios have been planned, i.e., the first load value has been set at a latency of 10 sec. Different values have been given for different time delays, which means that the command with a latency of 5 s will be assigned after 5 s to the place after the whole system has been initialized. This is a modeling of a real-world scenario that takes place and is successfully verified with the help of Petri Nets. Petri Net control behavior of systems exhibiting conjunction in their operation.In our model we have been successfully controlled the ambient settings, and devices of a building. Our model not only reduces need for sensor but at the same time very efficiently controls and manages the building automation and is a cost-effectivesolution.

6. COLORED PETRI NETWORKS AND FUNCTIONALITY

Petri nets have been used in a variety of fields including computer science Petri nets are graphical for representing a system in which there are multiple independent activities in progress at the same time. The ability to model multiple activities differentiates Petri nets from finite-state machines. In a finite-state machine, there is always a single 'current' state that determines which action can next occur. In Petri nets, there may be several states, each of which may evolve by changing the state of the

Petri net. Alternatively, some, or even all, of these states may evolve in parallel causing several independent changes to the Petri net to occur at once.

We have designed and verified the model using the Colored Petri Nets tool. CFPN Tools is a widely used program for creating and analyzing colored Petri nets. CFPN Tools performs incremental syntax checks on models, making it extremely user-friendly. it includes tools for both simulation and state analysis. It may be used for both study and industry because of its ability to generate space. CFPN Capabilities is a popular tool for modeling and analysis of colored Petri nets. Colored Petri nets (also known as place transition Petri nets. By depending on inscriptions, it is feasible to communicate the net structure. As a result, it can simulate PT-net models as a pure extension. We have the freedom to declare the statement as 'An execution depends on B', so it provides a simple declarative statement for the design.

- **Petri Nets in Various Colors**

Tokensin Colored Petri Nets (CFPNs) can have "colors" or data associated with them. Expressions that characterize the transitions/places can be found in the arcs between them. The internet's behavior, as a result, can be depicted and transitions are used to define actions and tokens which carry int, bool, or other data type values. The CFPN concept allows for hierarchical structure, and a solid mathematical theory has already been there, which supports the verification process. The issue with CFPN is that timing is not explicitly specified in the protocol. Time can be treated like any other value linked to it.There are two inputs P1 an P2 and they have 1 and 2 values in P1 and 5 in P2 respectively,the condition check is that P1 will allow to pass only 1 since the condition is applied, P2 will only allow 5 to pass and the Figure 7 depicts that transition is ready to fire and so value 101 will pass to P3.

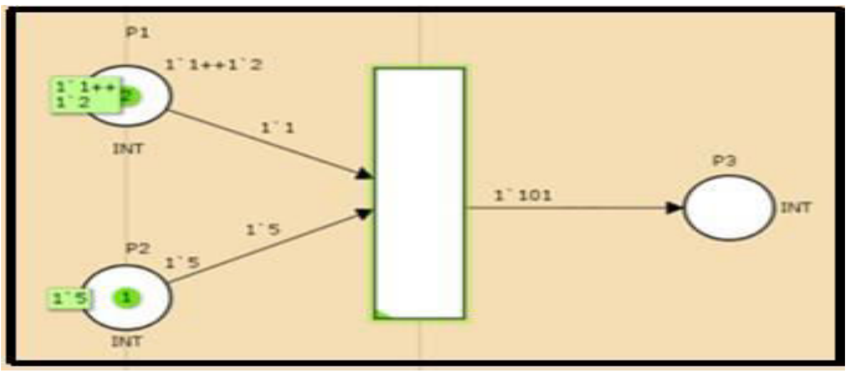

Figure 7: Petri Nets in Various Colors

- **Arduino Petri Net Controller.**
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A Petri net consists of four elements: places, transitions, edges, and tokens. Graphically, places are represented by circles, transitions by rectangles, edges by directed arrows, and tokens by small solid (filled) circles. There are a wide variety of extensions to Petri nets. These extensions add features to model probabilistic behavior, allow weighted edges, or have tokens of various colors, among others.

As depicted in the figure 8, CPN tools provides following tools.

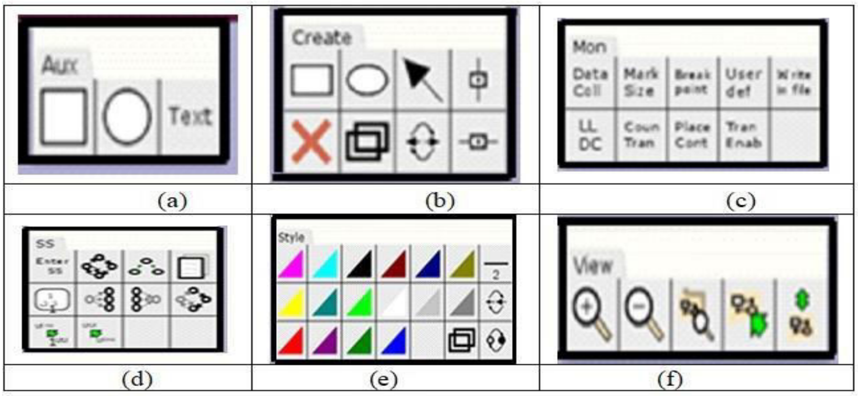

Figure 8: CFPN Tools (a) Aux (b) Create (c) Monitoring tool (d) The state space tool (e) Style tool (f) View tool

When constructing auxiliary components, the Auxiliary tools are utilized. These components have no semantic value, yet they can improve the readability of the internet. You may design them, have them snap to magnetic guidelines, and arrange them the same way you would any other net element.

Create tool palette: When developing and dealing with the basic net structure, the create tools are employed. The fundamental net elements, such as locations, transitions, and arcs, may be created, deleted, and cloned with this software. It also includes guideline tools for simple net element alignment.

Monitoring tools: Monitoring tools, are used to construct monitors to create a data collector monitoring system. To create a monitor with a marking size. To set up a breakpoint monitor. To make a monitor that you can customize. To create a monitor for write-in-files. To monitor the length of your list. To count the number of transitions that occur and keep track of them. To create a content monitor at a specific location. To create a monitor with transitions enabled.

The state space tool palette: has tools for computing a state space, storing a state space report, and moving states between the simulator and the state space tool:Concluding statements of this section.When developing and dealing with the basic net structure, the create tools are employed. The fundamental net elements, such as locations, transitions, and arcs, may be created, deleted, and cloned with this software. It also includes guideline tools for simple net element alignment.

Style Tool: To boost readability, the style tools are used to highlight significant net structures using colors, line thickness, and other features. On the internet, none of these techniques have any meaningful consequence. When applied to one element in a group or to a magnetic guideline, most of these tools affect the style of all items in the group or on the guideline. See the sections on groups and magnetic guidelines for further information.

View Tool: By grouping and zooming, these tools can modify the view of a page and its elements.

7. Mathematical Proof of Petri net implementation for Model verification and validation

Petri Nets in various colors. Tokens in Colored Petri Nets (CFPNs) can have "colors" or data associated with them. Expressions that characterize the transitions/places can be found in the arcs between them. The internet's behavior, as a result, can be depicted and transitions are used to define actions and tokens which carry int bool or other data type values. The CFPN concept allows for hierarchical structure, and a solid mathematical theory has already been there, which supports the verification process. The problem with CFPN is that the timing is not explicitly specified in the protocol. Time can be treated like any other value linked to it.

Definition 1 (Petri nets). A Petri net is a tuple (S, T,) where S is the finite set of places, T, disjoint from S, is the finite set of transitions, and is a labelling function such that:
– for all s ∈ S, (s) ⊆ D is the type of s, i.e., the values that s may contain;
– for all t ∈ T, (t) ∈ E is the guard of t, i.e., a condition for its execution;
– for all (x, y) ∈ (S × T)U(T × S), (x, y) is a multiset over E and defines the arc from x toward y.
Whereas in Marked Fuzzy Petri Nets the A marking is a vector M: P N that allocates a non-negative integer number of tokens to each location of a Petri net, represented by black dots, and may alternatively be expressed as an m-component vector. The marking of location p is denoted by M(p). A net N with an initial marking M0 is known as a marked net N,M0.

8. DISCUSSION OF EXPERIMENTAL RESULTS AND ERROR ANALYSIS

The framework indicates how a structure in a source language can be represented by a structure in a modeling language with the same meaning or at least a close one. Mappings use Petri nets as an intermediate language. This language grounded in Fuzzy is rich enough to support most intentional and social concepts presented in the agent-oriented modeling language.
It defines a refinement process that transforms an abstract medium specification into an implementation specification. An interactive communication link between the bus dispatch center

and workshop has also been implemented. All subsystems within this framework are heterogeneous as different architectures of agents cohabitate in a common environment and can interact directly or indirectly with each other. The framework as originally conceptualized implies the dynamic integration of the three subsystems allowing control policies to be applied in real-time as they are devised from the observation of the virtual domain by the expert agents. The whole process starts with the replication of the real world into the virtual domain that is simulated and evaluated by expert agents from within the control strategy inductor. Optimum policies are generated and then applied to the real world that reacts to the changes in their components. The new operational conditions of the real system are replicated into the virtual environment, and the process is repeated all over again, resulting in other coordination policies that are applied, and so on. Such an iterative loop is expected to manage the system operations and keep high levels of performance while a faithful replication of the real system. Another goal that is incorporated into the unified architecture allows for the coupling of mood-based control systems and building automation in addition to its potential application to the real world. The entire framework serves as an important tool to assess and validate innovative approaches to the implementation of sustainable solutions.

Our work has shown a ubiquitous environment using a powerful IoT framework that covers all the requirements that arise when modeling web applications. The goal is to present a coherent and complete way to integrate the modeling of wireless-specific elements with the rest of the applications such that the level of detail and abstraction is appropriate for designers, implementers, and architects of wireless applications. This extension provides a common way for architects and designers to express the design of their Fuzzy wireless applications. The framework is extended to develop a MOOD-based application independent of the Platform and Device (DIWM). It further exploits the concept of component collaboration architecture which describes how the application interactions are decomposed into synchronous messages through various ports.

9. Experiment Results

The tests were carried out on household appliances such as refrigerators, air conditioners, and ambient lighting systems. We tested the ESP8266 module as a Wi-Fi Access Point, a Wi-Fi and TCP client, and a TCP server capable of accepting inbound connections. Working perfectly and controlling the home automation as well. The switches have the freedom to work on manual mode also so, that in person controls are also available.

10. Error Analysis of theWi-Fi module EXP8266

The standard approach to building a model using error analysis requires a researcher to check the results of the model after each iteration. The data and predictions on an observational level form hypothesis as to why the model will fail on certain predictions.

The intentional approach to building a model is to use error analysis. You look at the data and predictions on an observational level and form hypotheses as to why your model failed on certain predictions. Heterogeneous sensor device networks with various maintainers and information collected through social media and crowdsourcing tend to be elements of uncertainty in IoT and Smart City networks. Often, there is no ground truth available that can be used to verify the plausibility and concordance of new information.

Case I:

Although the best-designed controller can regulate the process, some process parameters can change over time, and unstructured uncertainties can degrade the process performance. Our system is an AI-enabled Wi-Fi system where the different statuses of the Wi-Fi function. Status () is enough to describe the status of the connection as shown in table 2.

Table 2: Wi-Fi- Connection Status

Zero	WL-IDLE-STATUS when WI-FI is in the process of changing between status.
One	WL-NO-SSID_AVAIL in case a configured SSID cannot be reached.
Three	WL_Connected after a successful connection is established.
Four	WL_CONNECT_FAILED if the connection failed.
Six	WL_CONNECT_WRONG_PASSWORD if the password is incorrect.
Seven	WL_DISCONNECTED if the module is not configured in station mode.

Case II:

As hardware used in the framework is the best available in the market it is used but still some problems are unavoidable like error in power supply, heavy power in microcontroller due to which the system may not work properly. To avoid this 2-amp power supply is suggested to be maintained.

Case III:Other Issues

Electromagnetic interference: This is an important area which cannot be ignored as the Wi-Fi connection module may not work properly if installed near any device which is using electromagnetic waves for television set.So still at the time of miniaturization this problem should be check which can seriously affect the model's efficiency.

Humidity: Another important issue for which Waterproof /humidity controller /coated with material
Firewall for security:Servers must maintain security since any programme or hardware controlled by a software or server may be hacked; otherwise, no one can expect the model to provide the desired results if the security is breached.

11. QUANTITATIVE VERIFICATION AND VALIDATION OF THE MODEL USING CFPN

In this study, a Petri net-based building automated process was shown, together with a graphical user monitoring system. We have a model-based development approach, which means that we prioritize the use of models and the tools that help us manage them. In this way, system functions and functionalities are represented as UML use cases, with Petri nets as the primary modeling tool. Each use case and its translation into a state diagram or Petri net model form the basis of the system model. After that, a composition operation is used to merge the partial models, resulting in the building of a Petri net-based behavioral model for the entire system. The concept takes advantage of the relationship between the main characteristics of the Petri net model and the key graphical qualities given in the document.

The quintessential use of sensors in an ubiquitous model of any size and domain always encourages the use of sensor, which leads to the increasing cost in the installation and maintenance and power consumption of a building. On the contrary, it is found that sensor base systems look beneficial at the beginning as they are learning the behavior of the system and people associated with it, but after some time it is found that they begin to raise the cost of energy consumption of the building and household, also. We propose sensor reusability to minimize the cost. We have proposed a simple server-based framework for the middle-income group homes which we have verified and validated using Petri nets. The working of the model is as follows.

At time T is equal to zero the initialization is done for the AC input source thus the transition associated with it will only fire. A guard is set for the transition immediately following the AC input place, where the source power input is checked for the ON state. The output arch of the transition set to evaluate up to 20 which corresponds to the current-voltage of 220 volts that is sent to the SMPS input, the SMPS internally consists of a capacitor rectifier unit that is used to convert an AC input to DC output, secondly, it and also consists of a step-down transformer that steps down the voltage from 220 to 5 volts. This voltage is necessary for the Wi-Fi controller module to function properly. A step-down transformer that reduces the voltage to a permissible limit is connected with the Wi-Fi controller input and receives the voltage of 5 volts and starts operating. Initially, it checks the connection which is established with the server associated with it whose credentials are being internally fended to the Arduino control system. Figure 9(a) and shows Relay status is on when power is on is in transition mode and it is waiting to get the command from Load switch and is added to the queue as commands added to the queue and if it is. If the relay is On and forwarded to the load. Figure 9(b) shows AC input source which will be having 220 volts on state the step-down transformer is stepping it down to 5 volts and Wi-Fi module checks whether the connection is established or not.it will further send the command to relay switch and both relay switch will be in ON condition

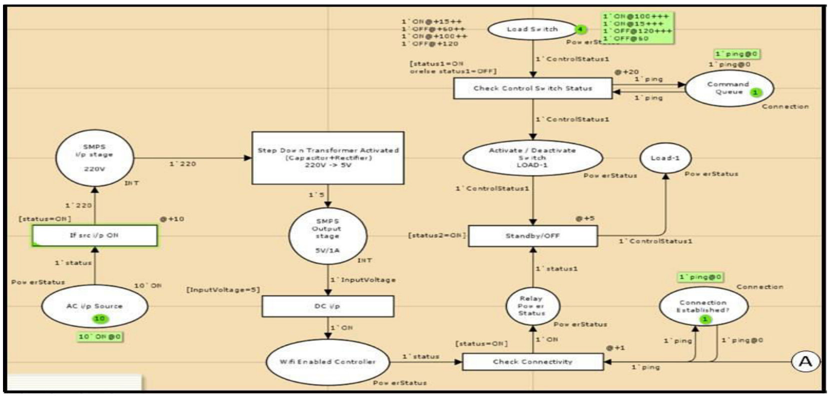

Figure 9a: Model Design ofCFPN using CFPN Tool (Left Part)

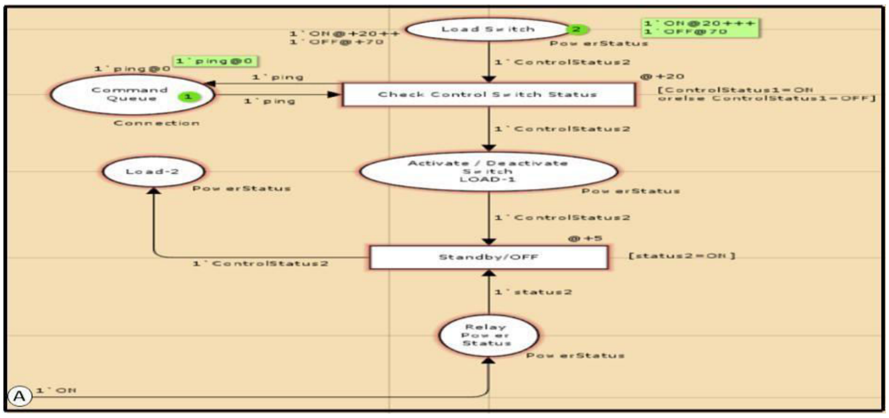

Figure 9b:CFPN model design using theCFPNtool (right part).

Any IF-THEN rule (Knybel, 2005) of the previous function can be defined with the help of Petri net as the set of IF-THEN rules, which forms the linguistic description: R1 = IF X1 is A11 AND... Xn is Aln THEN Y is B1: Rm: = IF X1 is Am, AND ....Xn is Amn THEN Y is Bm

R1: IF Xi is A1 AND X2 is UNDEF THEN Y is B1

R2: IF X, is UNDEF AND X2 is A2 THEN Y is B2

R1: IF Xi is A1 AND X2 is UNDEF THEN Y is B1

R2: IF X, is UNDEF AND X2 is A2 THEN Y is B2

In our model, we have used the following variables and created the following user-defined types (Colsets) and Variables.Table 3 specifies the details of color set used for powerstatus and for connection establishment specifically. Forpower status the type String is defined where time is also used as a constraint which make the system on in a stipulated time. Variables have been assigned for change in the status ON and OFF,variable for input and output voltage is set to int.

Table:3Color sets and variable

Colset | Variable	Name	Type	Values Allowed
Colset	PowerStatus	String, Timed	ON, OFF
Colset	Connection	Unit, Timed	Unit
Variable	Status. Status1, status2, ColntrolStatus1, ControlStatus2	PowerStatus	ON, OFF
Variable	InputVoltage, OutputVoltage	Int	Int

12. COMPARISON WITH OTHER MODELS

This paper proposes the Valid. IoT Framework is an attachable IoT framework component that can be linked to generating QOI vectors and interpolated sensory data with plausibility and quality estimations to a variety of platforms. The framework utilizes extended infrastructure knowledge and infrastructure-based interpolation algorithms to validate crowd-sourced sensor information and device-generated by sensor fusion [36]. Here we compare the Colored Petri nets models with UML models and in our studies, we found that Colored Petri nets are much better option as it is an absolute asset for the research model verification and validation. It is very much possible to transform models from UML to Petri net, but for the clarity we find Colored Petri nets better.

13. CONCLUSIONS AND RECOMMENDATIONS

The proposed framework described how the information model can be derived from real-time problems. It also discussed the concept of a Ubiquitous environment which could provide a new dimension for modeling the Building Automation System. It has presented an approach to reify high-end interaction abstractions into software components, forming a refinement process that transforms an abstract medium specification into an implementation specification.

Our work has shown a ubiquitous environment using a powerful IoT framework that covers all the requirements that arise when modeling web applications. The goal is to present a coherent and complete way to integrate the modeling of wireless-specific elements with the rest of the applications such that the level of detail and abstraction is appropriate for designers, implementers, and architects of wireless applications. This extension provides a common way for architects and designers to express the entire design of their Fuzzy wireless application with Fuzzy.

The extension of the Ubiquitous framework gives the Skelton framework of wireless applications. Our work models Building Automation into three basic parts called Service Creation, Service Integration, and Service Composition. The output of the model was saved in XML in combination with SOAP Architecture which extended its capabilities for the platform and device-independent framework design.

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