Büro Productivity Enhancer: Beat the Büro Blues

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Abstract

In multi-billion-dollar companies, employee satisfaction is of the highest value. Because this in turn reflects on the productivity of the employee. People spend a huge amount of time in the office. Therefore, the office needs to be comfortable. Smart offices make life easier for employees and they will be at their personal best. The current trends and advancements in IoT have resulted in interactive, innovative, and automated implementations of smart systems. The Büro Productivity enhancer (BPE) system proposes a smart office automation system that creates an employee-friendly atmosphere with the help of IoT, interconnected sensor networks, and an efficient control system. The BPE system is designed to create bright and productive environment to beat the Büro blues. This is achieved by displaying bright and sunny weather on the window LCD screen, during the gloomy days. It also measures the temperature and controls different devices accordingly to maintain the suitable temperature. BPE system also controls the intensity of lights in the workplace. Thus creating a huge impact on the operation of the industrial sector and enterprises.

1 System Introduction

The main aim of the BPE system is to create a productive ambiance in the Büro, to increase the efficiency of the employee. The importance of a positive office environment raised over the last decade. It is scientifically proven that having a constructive work environment can actually improve productivity, make employees happier.

The office lighting is imperative to the productivity of people. Correct lighting helps to combat fatigue and enhances well-being. When it comes to working in an office, the dull environment outside can mentally affect a person's productivity. Research has shown that there is a significant decrease in the employee's efficiency during winter's dark weather and rainy environment. Not only it deteriorates the throughput of the company, but also affects a person's mental health. Hence, we are addressing the mundane Büro Blues.

One innovative way to improve the gray office space is to virtualize the ambiance! And there is nothing better than being able to look at bright blue sky to improve the mood.

The main aim of the project is to
- Display the bright outside environment on windows during blues.
- Enhance the comfort by controlling the temperature in the office.
- Intelligent lighting solutions by monitoring ample light from windows.

2 System Analysis

As an **employer**, I need a progressive environment in the office so that workers can accelerate the work flow.

- To achieve this goal, windows are replaced with LCD screens. So that during dull weather BPE system displays pre-recorded dynamic beauty of the nature to interior environments. During sunny weather, the live feed is anyways played on the screens.

- Economic utilization of the power is achieved by monitoring natural light entering the building and controlling the illumination inside the building.

As an **employee**, I need a comfortable environment to carry out my day to day work.

- The comfort is enhanced by maintaining the ambient temperature at the floor.

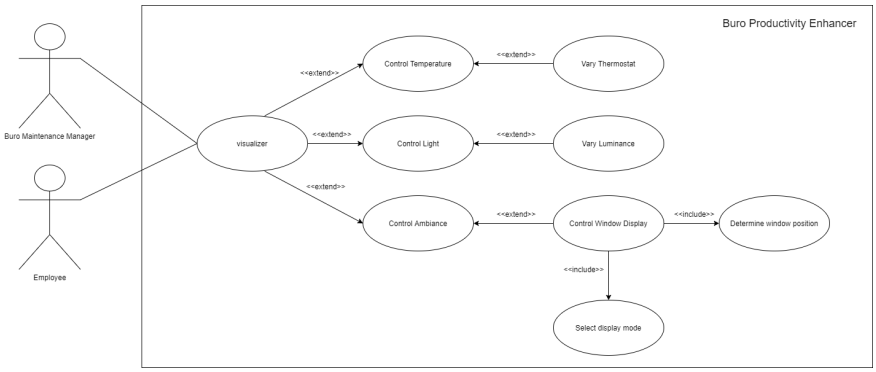


Fig. 1 Use Case diagram

3 System Architecture Design

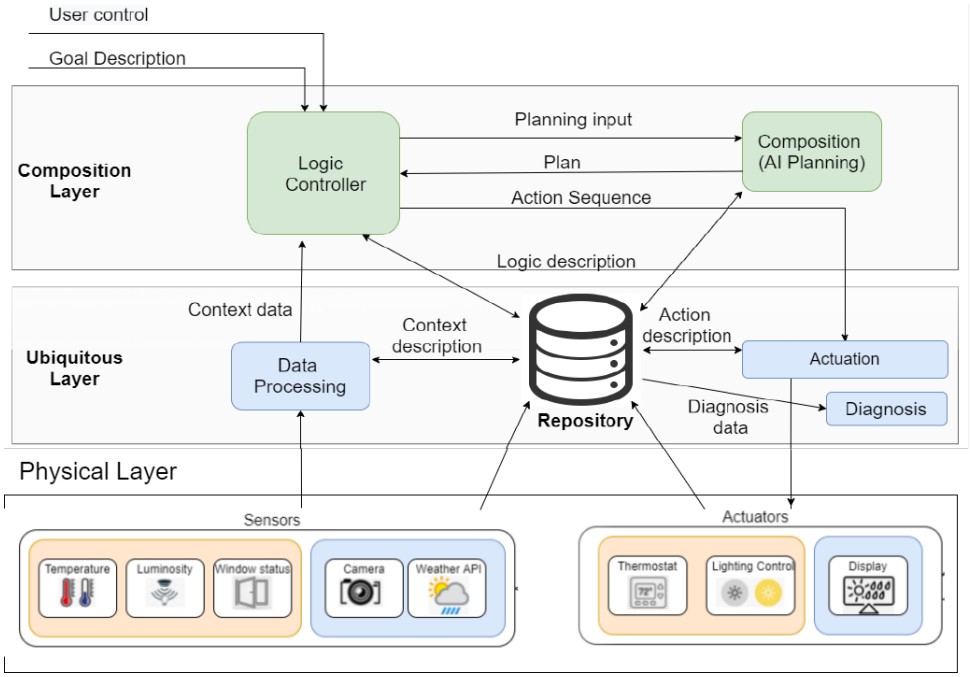


Fig. 1 BPE System Architecture

i. Physical Layer

Comprises of sensors and actuators. This layer is responsible for collecting the raw physical data from the sensors and give the data to the next layer that is the Ubiquitous layer. BPE system consists of five sensors and three actuators.

Temperature data is collected from the DHT11 sensor. To maintain the pleasant temperature a simulated thermostat is used. Next is the Luminosity sensor. It is used to detect the ambient light inside the office room. The lighting is controlled by varying the luminosity of the light source which is LED strip in our case.

At-last for the optimal workflow and positive ambience at the office, waterproof LCD screens are being installed on windows which can display pleasant environment even when it is gloomy outside. Weather API is used here to detect the weather outside the office. A camera is placed to capture the outside environment during bright days. The life feed is played when it is bright and sunny. During blue times, the recorded video is is played on the LED window screen in loop. Display will be active only when the window is closed. The status of

the window is detected by a limit switch attached to the window rack. We can identify if the window is open or closed by limit switch inputs.

ii. Ubiquitous layer:

The ubiquitous layer consists of the data processing sequence that converts the raw data from the sensors in the physical layer to context data required by the upper layer. This means, the raw temperature data received from the physical layer will be processed and converted to meaningful sense wit respect to the BPE system. For example, if the measured temperature is ¿ 30'C, this means the temperature is high. Same goes with the limit switch values as well. The raw data from the limit switch is translated to a meaningful sense by informing the system if the window is open or closed.

There is a database that stores static data about the different IoT nodes and their locations, and also the dynamic data like the sensor values. This database is available for all the upper layers, and has key importance in providing data for decision making. The ubiquitous layer also has the execution sequence that drives the actuators, based on the decisions from the upper layers, selecting the type of actuator and the actuation that needs to be done.

iii. Composition Layer

Comprises of a Logic controller and the AI planner. The Logic controller forms the brain of this system. It collects the data from the Local controller and determines the inputs for the AI planner. The AI planner generates a plan based on the reasoning data available in the repository and the inputs from the Logic controller. Based on the output from AI Plan, action sequence is decided and passed to the Ubiquitous layer. In our BPE system composition layer is responsible for making informed decisions, based on the context received from the ubiquitous layer and the inputs from the user interface. It fetches information from the database and passes the initial state that is the current context of the BPE system. And similarly the goal state that is the destination our BPE system has to reach. The AI planner develops a plan to be followed and realised by the actuation to realise the goal.

The logic controller also accepts the User control parameters, so that the acceptance criteria for the customer can be altered and the values for checking the occupancy. All these data generated and accepted by the Logic controller and the AI planner is stored in the repository.

The overall architecture is shown in the figure above where Edge Processor and Edge Controller Units are responsible for controlling the sensors and actuators and BI tool dashboard is used as a Visualisation tool.

4 System Implementation

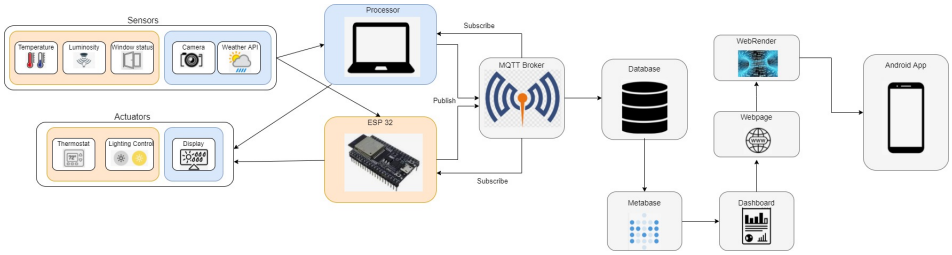


Fig. 3 Physical components involved in BPE

4.1 Components involved:

Sensors and Actuators:

BPE system includes 6 electronic based IoT device, one software based IoT device and one simulated IoT device. A total of 5 sensors and 3 actuators,

i. Temperature sensor DHT11 is used to measure the ambient temperature of the Büro. The temperature is then controlled by **Thermostat** to maintain the suitable temperature. Here thermostat is a simulated IoT device.

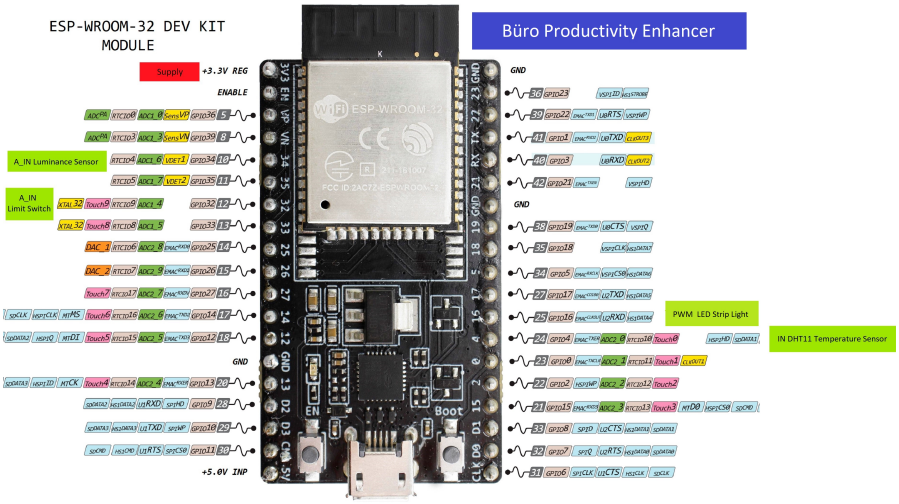
ii. Luminosity sensor LDR is used to gauge the brightness level in the Büro and then controlled by varying the brightness to a favourable level. **LED strip** is being used for this purpose. The brightness of the LED strip is maintained to a favourable lighting condition.

iii. Weather API is used to detect the weather outside the Büro. It detects the if the weather is sunny or gloomy. If it is dull and cloudy outside pre-recorded bright sunny weather is displayed on window **LCD screen**. In BPE System all the windows are replaced with LCD Screen. **Limit switch** is used to detect window status. Pre-recorded video is played only when the window is closed. **Camera** is used to play live feed on the window screen, if the weather outside is bright and sunny.

Controller:

ESP32-Wroom Model is used to gather all the information from the sensors and processes it. These dynamic sensor data is sent to the cloud with the help of MQTT docker which is dumped on the controller. The MQTT server runs on the cloud. The sensor information is subscribed and given to the AI Planner. Once the plan is generated, the controller is instructed to perform actuation actions of the connected devices. The controller is interfaced with DHT11 temperature

sensor, LDR luminosity sensor, limit switch for the window status sensing and LED strip actuator. The pin diagram is as follows:



Repository and Database:

There are 2 repositories used in the system. The first repository is available in the local controller(ESP32). The part residing on ESP32 contains the Static data comprising of the device information such as the number/type of sensors and actuators configuration. The dynamic data coming from the sensors are stored on the cloud. PostgreSQL database management system is used for this purpose. PostgreSQL, also known as Postgres, is a free and open-source relational database management system emphasizing extensible and SQL compliance. In our system PostgreSQL is used as the primary data storage. The database and the MQTT server is run on the Amazon Web Services (AWS) cloud. Amazon Web Services is a subsidiary of Amazon providing on-demand cloud computing platforms to individuals or companies on a metered pay-as-you-go basis. The sensor data base consists of dynamic temperature, luminance and humidity value from the electronic based IoT sensors. The PostgreSQL database is also fetched by BI Tool for visualization purpose.

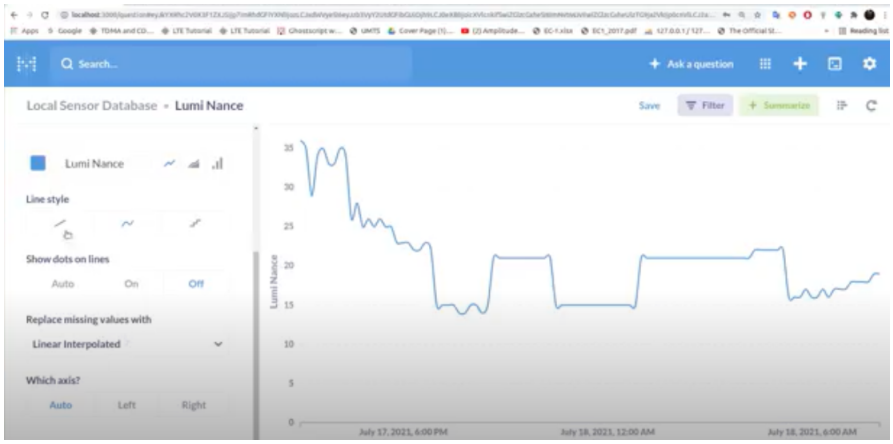
AI Planner:

AI Planner is used to make the decision process computationally in order to empower agents to pursue their goals. The standardize AI planning language Planning Domain Definition Language (PDDL) is used to for this purpose.

The domain file is already loaded in the system. Based on the input received from the sensors, the problem file is generated automatically with the help of a wrapper code. These files are fed to online AI Planner to generate the plan. The

plan will be stored as a text file which is then read by logic controller. Thus the respective action are carried out.

4.2 Visualisation:



A business intelligence tool Metabase is used for visualisation purpose. The Metabase automatically fetches the PostgreSQL database from the cloud and presents data to the user. Metabase is a BI tool to provide data insights and visualizations. It lets you ask questions about your data, and displays answers in formats that make sense, whether that's a bar graph or a detailed table. Your questions can be saved for later, making it easy to come back to them, or you can group questions into great looking dashboards.

4.3 Communication:

The system uses a Message Queuing Telemetry Transport (MQTT) which is a publish-subscribe network protocol that transports messages between devices. Mosquitto a lightweight open source message broker is used.

The temperature value, luminosity level and the window status from the limit switch are being published. These are basically the sensor values. The same topics are being subscribed by thermostat and light control for actuating purpose.

4.4 System working:

The main aim of BPE system is to create a productive ambiance in the Büro, in order to increase the efficiency of the employee. DHT11 temperature sensor is interfaced with ESP32 controller. Temperature sensor is being used to get the ambient temperature of the room. Thermostat here is an actuator to control the temperature. Thermostat is simulated on the Node-RED platform. BPE System will keep the room temperature in an optimum range by controlling the thermostat.

LDR Luminosity sensor is used to get the ambient light values in the room. LED Strip is interfaced on ESP32 to maintain the brightness in the room. LED strip is being controlled by PWM signals. Limit switch which acts as window status sensor is interfaced on ESP32. The window sensor will detect the status of the window to determine if the window is open or closed. For indirect communication between the devices MQTT Protocol is used. The Message Queuing Telemetry Transport (MQTT) is a lightweight, publish-subscribe network protocol that transports messages between devices. ESP32 controller acts as an MQTT client to publish the specific topic ie. the sensor values assigned to each room in the office. A subscribing model is also implemented on ESP32 to control the actuators. Thus the actuators performs required actions based on it.

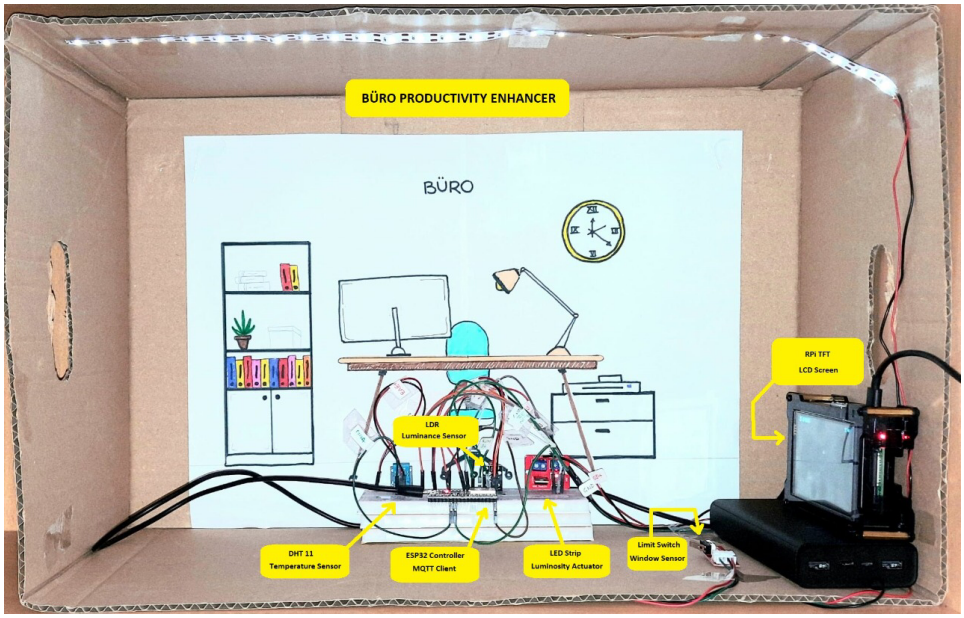


Fig. vi System View

If view from the window is dull and depressing, it automatically effects the employees mental health and hinders the work efficiency. BPE system will replace the window with LCD screen and a camera unit is attached. So Pre-recorded bright and sunny video segment is played on the window LCD Screen, when the Weather API detects the gloomy weather. This is being displayed only when the window is closed. The window status is detected by limit switch and it is published to the MQTT docker. When the window is open, there is no display on the screen. If the Weather API detects the view from the window is sunny and proficient then live feed is played on the screen. For weather data acquisition, OpenWeatherMap current weather data API is used. OpenVC is used to implement the live looping feature. It will show the live feed of the camera and loop over a certain segment. Android phone camera is used in the system.

IP Webcam application is used. It will create a continuous video stream on to the local network, which can be later used in OpenCV player. The BPE System will create an impression of always being in the sunny bright environment, thus enhancing the productivity of the workers.

In BPE system three layered architecture is made use of. The raw data is collected from various sensors in the Physical layer. This is transformed into abstract from in context with the BPE System. The dymanic sensor data is stored in the AWS cloud with the help of PostgreSQL database management service, The brain of the system is its AI Planner. The problem file in the AI Planner is auto generated by fetching the dynamic sensor data from the database. A wrapper is used for this purpose. The online PDDL solver is used to generate the plan to be executed.

With the same goal, suitable temperature and favourable brightness in the Büro is maintained. The temperature sensor and the luminosity sensor senses the ambient values which is then published to the MQTT docker. This is then subscribed by the thermostat and light source to maintain the optimal ambiance in the Büro.

All the controlling activities are managed using AI Planner with the following actions,

i. "IncreaseTemperature":

The action to increase the temperature is performed with the pecondition being the temperature is low which is not a suitable temperature at the Büro and the thermostat exist to increase the temperature. The effect here change of state from low temperature to being at a suitable temperature by increasing the thermostat value.

ii. "DecreaseTemperature"

The action to decrease the temperature is performed with the pecondition being the temperature is high, which is not a suitable temperature at the Büro. And the thermostat should exist to decrease the temperature. The effect here change of state from high temperature to being at a suitable temperature by decreasing the thermostat value.

iii. "IncreaseBrightness"

This action is performed when the luminosity in the room is low. Employees are considered to be more effective when the luminosity in the office is favourable to their visual condition. The precondition here is that the variable light source exists so that the luminosity is varied. In this case the intensity of the light is increased to a suitable value. Thus changing the state of the system to being in the Favourable Lighting condition.

iv. "DecreaseBrightness"

This action is performed when there is brilliance in the room. When the light within the field of vision that is brighter than the brightness, to which the eyes are adapted. The precondition here is that the variable light source exists so that the luminosity is varied. In this case the intensity of the light is decreased to a suitable value. Thus changing the state of the system to being in the Favourable Lighting condition. This generated plan is published with the help of MQTT, which is then used to control the LED strip.

v. "DisplaySunny"

If the weather outside the office is gloomy, Weather API detects that the weather is dull and cloudy. This is sent to the AI Planner problem file with the help of a wrapper program. So if the window is closed and the weather is dull, a bright sunny display of pre-recorded video is played on the window LCD screen. Thus making a favourable working condition at the floor.

vi. "ShowLiveFeed"

If the weather outside the office is already bright, Weather API detects that the weather is sunny. This is sent to the AI Planner problem file with the help of a wrapper program. So if the window is closed and the weather is sunny, a live feed of bright shiny weather is displayed on the screed . Thus making a proficient working condition at the floor.

vii. "NoDisplay"

Once the plan is ready each keyword from the plan is associated with a function call in the glue code, which is run sequentially. This will orchestrate the intelligence of the BPE System.

If window status is sensed by a limit switch which will be attached to the window rack. This sensor data is transformed into context data with respect to the system that is either window is open or closed. The window status is published using MQTT docker which is on the controller. The MQTT server is run on the cloud. This value is subscribed and given to the problem file of the AI Planner. Thus if the window is open, the BPE system will have no display on the screen.

AI Planning services is run on the Linux system. The second system is a set of AWS cloud instances. Services run on the AWS cloud services are, MQTT broker which is mosquitto broker, a Postgre database service which is collecting the dynamic data and a meta base service which is a BI tool and a set of services which are picking data from MQTT channel and are populating it on to postgre data base service. These are being called as MQDB service.

5 Conclusion and Future scope:

Nowadays, organizations and businesses are integrating automated systems to make their offices highly efficient, reduce operating costs, and build a connected and comfortable working environment for their workforce. In fact, research has found that the total market size of smart offices will reach 46.11 billion dollars by the year 2023.

Smart offices make employees work faster, smarter, and better. They are also equipped with technology-enabled features that help your workforce make the best use of their time in the workplace. The smart office brings with it an array of tangible benefits for you and your employees alike. All in all, smart office technology makes your office more enjoyable, modern, safer, and energy-efficient.

BPE system can have more sensors included such as a pressure sensor near the chair of an employee to detect his presence. Even an IR sensor could be used for this purpose. Sensor data fusion mechanism could be used for determining more accurate data. As IoT system is more ubiquitous, more distributed devises could be used for further enhancement of the system. The future scope is to make BPE system so imbedded, so fitting, so natural that every office should use it without even thinking about it.

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