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Workspace Allocation and Management System with Realtime Feedback from IOT Sensors

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Abstract— Office real estate space investments is one of the major capital expenditures done by any IT and ITES companies. This has a major impact on the profitability of the organizations as it adds to the capital expenditure incurred by them and also has environmental implications. As the companies grow they will be looking for more real estate space which will lead to putting more land into commercial usage for office space. Today, most of the companies allocate office space for employees statically on a 1:1 ratio i.e one cube per employee. But, given the fact that the modern workforce is mobile and at any given point of time not all the employees will be working from office for various reasons, making static allocation of office space and its usage inefficient and ineffective. So, there is a need for managing the available space efficiently and effectively. Organizations can look for saving real estate investments by increasing the user to cube ration by more than 1. This paper proposes a comprehensive system for workspace allocation and management with real time feedback from IOT sensors at the office spaces.

Keywords—IoT, Workspace, Management, IT, ITES, Sensors

I. INTRODUCTION

India is one of the fastest growing developing economies in the world. India has carved a space for itself in the global IT and ITES products and services sector with the supporting policy framework by government and availability of qualified technical personnel. India hosts all major IT and ITES companies in the world. It stands with the distinction of being the 3rd largest country in terms of the number of start-up companies. Now given that the government of India has come-up with start-up policy with various tax and other incentives for the start-up companies this trend is expected to continue in the future and would lead to proliferation of organizations of all kinds such as small, medium and big sized ones. This would push the demand for office space requirements.

Office real estate investment is the second largest capital expenditure incurred by IT and ITES organizations. As the organization grows there will be more requirement for office space and this is often met with more investments into new real estate space. Due to rise in cost of office space, the organizations are looking for comprehensive solutions to utilize the available space more efficiently and effectively and their by reducing the cost of office space per employee.

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Generally the office space in IT and ITES organizations is divided into cubes of certain dimension. The cubes in office are allocated statically 1:1 ratio. At any given point of time not all of cubes are occupied and hence leading to inefficient utilization of the office space. As per a Gartner research the office space utilizations are 40% or less due to various reasons such as some employees may be on vacation, working from home, travelling, on leave and working in different shifts. So the static allocation is inefficient and doesn't allow office space to be utilized to its fullest capacity. As the organizations grow, more and more cubes are needed to accommodate more employees. This will add additional burden to the organizations resources as it has to invest more to accommodate the growing headcount. By changing the allocation strategy of the cubes from static to dynamic and by providing a system for real time monitoring of these cubes will open up opportunities for increasing the efficiency office space than was possible with the static allocation policy. The organizations can lookout for optimized usage of the existing space to accommodate more employees than the actual seating capacity of the office. This requires an intelligent sensor based system which keeps track of the usage of the office space at any given point of time and also allows users to pre-reserve space if required.

This paper proposes building a comprehensive system with IOT sensors for effective allocation and management of office space.

II. RELATED WORK

There are some existing solutions which are designed to work using an application where the employees need to pre-reserve the cubes, this lacks the real time feedback from the cube as there is no real time status of the cube, pre-reserved un-occupied cubes may not be utilized efficiently. Nithin and Suma [1] proposes a solution for effective utilization of the office workspace by using a Radio Frequency Identification (RFID) based solution. This is a costly solution and it needs user intervention for the system to function effectively. If the user didn't swipe the RFID tag against the RFID reader then it won't be possible for the system to know the status of the cubes. It also has poor user experience as user needs to swipe the RFID tag each time he/she enters or leaves the cube. Our proposed solution addresses these limitations by using a Human presence sensor to detect the presence of humans in the office works space (cube). This makes the system intuitive as it doesn't require any explicit action by the cube user to detect the occupancy status of the cube.

III. METHODOLOGY

Our proposed solution is based on the human detection sensor located at each cube in the office. This sensor system at the cube provides the occupancy information to the centralized server in real time over Wi-Fi network. The Arduino Uno [2] board is used a sensor platform with the PIR sensor used Human Detection sensor [3] and ESP2866 as a Wi-Fi module for network connectivity between sensor platform and backend. The server analyses the data obtained from all such sensors located in the office and provides an accurate information about the occupancy status of the cubes. The system also includes an application capable of running on various device form factors such as Laptops, Desktops and Phones. This application can be used by users to query the status of the cubes, to look for un-reserved cubes, to view the status of all the cubes in the given part of the office and to reserve the cube of their interest or free the cube that is already reserved by them. The UI is implemented using HTML [4], JS [5], and CSS3 [6].

This system includes a centralized server which maintains the data base of the office cubes and their status at various locations. The sensors located at each cube continuously monitor the cube occupancy status and provide data to server whenever there is a change in the status as determined by an algorithm running on the sensor device. This algorithm can be tweaked depending on the requirements of the organization. The server which takes the feedback provided by various sensors and regularly computes / updates the occupancy status of the cubes in its database. This data can be accessed on demand by an application running on various types of client devices. The application also provides an option to look for un-reserved cubes and reserve them for occupancy by the employees. The information shown to the user provides color coded identification for different occupancy states such as Free [Green], Occupied [Red], Reserved [Yellow] and etc.
The server has been implemented using the DJANGO [7] framework in Python programming language [8].

The solution system consists of 4 main interacting components namely

1) Users
2) Sensor devices at the Cube
3) Backend(Server)
4) Client Application running on various device form factors

The Figure 1, captures the simplified view of the solution system when deployed.

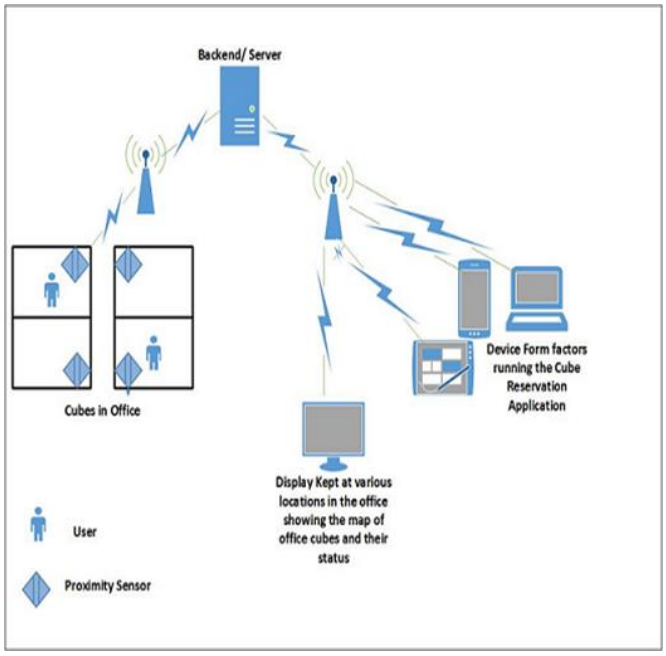

Figure 1. System Architecture of Workspace Allocation and Management Solution

The below sections provide a brief description of the major components of the solution:

User

There are mainly two categories of users Employees and Administrators. Employees would be accessing services provided by the system through an application to view status of the cubes, reserve cubes, cancel reservation of cubes etc. Administrators will be using this system for administration purposes such as to add new cubes, delete cubes, configure/tweak sensors, update cube map of the office and to perform many other administration related functionalities. The system also provides reporting options to extract the cube occupancy reports on Daily, Weekly, Monthly, Quarterly and Yearly basis

Sensor Device at the Cube

The sensor device placed at each cube monitors the real time occupancy status of the cubes and provides the data to the back end server over a wireless network, at regular intervals as configured by the backend. The Figure 2 shows the Arduino Uno based sensor platform with PIR sensor for Human detection and ESP8266 Wi-Fi module for network connectivity to backend. The sensor device is mounted at the entrance of the cube in such a way as to avoid false human presence or absence detections.

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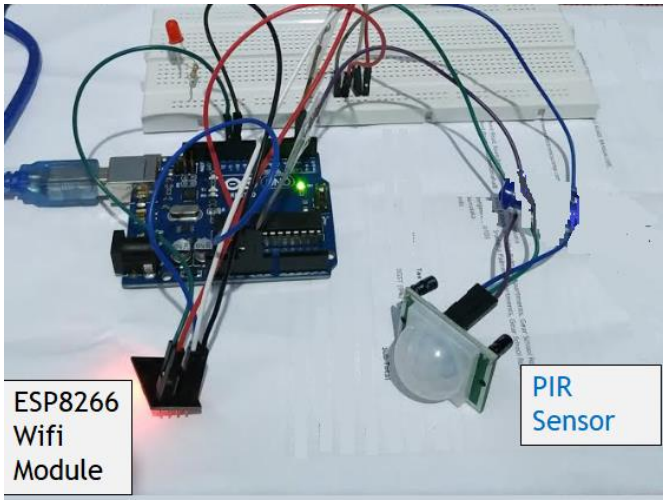

Figure 2. System Architecture of Workspace Allocation and Management Solution

Backend (Server)

This is the main processing engine and it maintains the data base of the cubes in the office and its map. It configures the sensors with the necessary parameters required for monitoring, gathers data from the sensors and updates the data base accordingly. It runs various algorithms to perform the operations requested by users of the system which are initiated through an application running on Laptops, Desktops, Phones and Display terminals. So that the users can query for the status of the cubes, can request for the cube map with the occupancy details, request for reserving cube(s), cancel the reservations made and etc. The server provides the necessary support for generating reports of various kinds and also to perform the administrative tasks as mentioned in the **User** section above

Client Application

The client application is a web based application written with HTML, JS and CSS3 scripts. This application can be accessed from various form factor devices such as Laptops, Desktops, Phones and Display terminals. This application provides the necessary client interface to access the services provided by the system. The display terminal can be of active or passive type. Rest of the client devices are active devices. The difference between an active and passive client device is that passive device allows users to view the status of the cubes at any given point of time but doesn't allow users to perform other operations such as reserving cubes, cancelling reserved cubes etc. The figure 3 shows the home page of the client application.

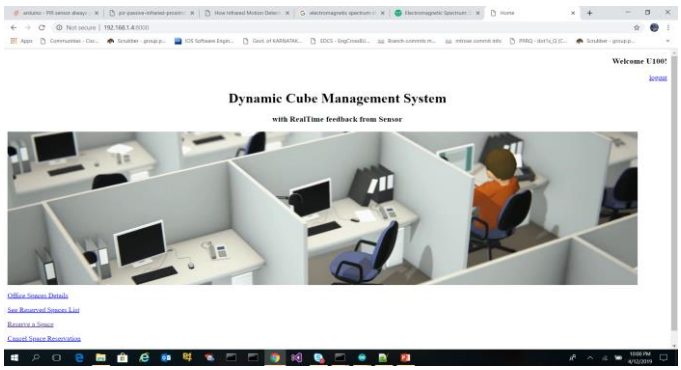

Figure 3. Home page of the Client Application

IV. USE CSES

This section provides the use cases of the system that is being built as part of this research work.

1) **User**: The cube user of the system.

- User access the client application designed to run on the client devices such as Mobile/Laptop/Desktop devices after due authentication
- Application provides option for the user to check the availability of the cubes
- Application provides option for the user to check any special features applicable to the cube such as availability of docking station with a monitor and etc.
- Application provides option to reserve the cubes and un-reserve / cancel the previously reserved cubes.
- Application provides option to reserve the cubes on behalf of another employee
- The application sends the details of the user and the cube reserved to the backend

2) **Admin User**: The Administrator of the system

- Admin user access the client application designed to run on the client devices such as Mobile/Laptop/Desktop devices after due authentication
- The application provides option to install new cube or delete an existing cube so as to accommodate the changes in the office real estate space
- The application provides option to configure the sensor devices at the individual cubes as per the office requirements
- The application provides option to view the office space map with the cube details
- The application provides option to generate reports for various durations like daily, weekly, monthly, quarterly and yearly
- The application provides configuration feature to auto generate the above reports as appropriately
- The application provides option to configure/register a display terminal

V. ALGORITHMS

The section below provides details about the algorithms which run at various parts of the system as below:

1) Algorithm at Sensor Device:

The sensor device runs the algorithm to detect the presence or absence of human being at the cube. It runs the following algorithm, which is described as a sequence of steps:

a) Initial cube status "Free", no motion detected by PIR sensor, motion-counter, and out-timer are set to 0.
b) When human enters a cube, the PIR sensor device gets activated and motion detected motion-counter is incremented.
c) If motion-counter is odd and out-timer not started updates status as "Occupied" sends a notification to backend with cube number and status as "Occupied" over Wi-Fi network.
d) If motion-counter is odd and out-timer started, update status as "Occupied" and stop out-timer
e) If motion detection counter is even and out-timer is not triggered or not started, update the status as "Free" but don't send the status to backend. If out-timer is not started start out-timer.
f) If motion detection counter is even and Out-timer expired, send cube status notification with status as "Free" to backend.
g) Start over form step (b)

2) **Display Terminal**: The display terminal can be a passive device or an active device.

The passive device is capable of getting the data from the backend at regular intervals and present it to the user for viewing the cube states. It runs the following algorithm:

a) The display terminal gets cube status data at regular intervals from the backend server
b) Displays a map of the office space along with the cube status details in different colors as determined by the administrator

Color coding: Green – Free, Red – Occupied, Yellow - Reserved

The Active display terminal besides the above functionality also provides options to view cube status, reserve and unreserved the cubes for self or on behalf of another employee

3) Backend (Server):

This is the main processing engine and acts as a data base for the cubes located in the offices. The below algorithm runs on the server

a) The back-end server maintains details of the cubes and their status such as cube number, any special features of the cube, different occupancy status of the cubes such as Empty, Reserved, Occupied etc.
b) It collects the occupancy status of the cubes from the sensor devices located at each cube at regular intervals
c) It collects the reservation details of the cubes from the users made through various client devices
d) Based on the above two information it updates the cube status details in its data base
e) Relays cube status details on demand / regularly at configured intervals to various devices such as Display devices, Mobile, laptops and Desktops etc.

VI. RESULTS AND DISCUSSION

This system helps in getting the usage statistics of the office work spaces. This data will help the organizations administrators to come-up with strategies for better utilization of the available office space. The employee to cube ratio which exactly 1 when in static allocation of the cubes will be improved by the presence of this system and has the potential to increase the employee to cube ration by close to 1.6. As the allocation and management of the space is done dynamically by the system involvement of the administrators for space allocation and management is not required much their by freeing their bandwidth for solving other admin related problems.

The below Figure 4 presents a representative dash board of the office work space occupancy status shown by the client application along with the colour coding.

Figure 4. Office Space Occupancy Dashboard

The below Figure 5 shows the desks occupied chart over between 07:00 AM to 05:00 PM time.

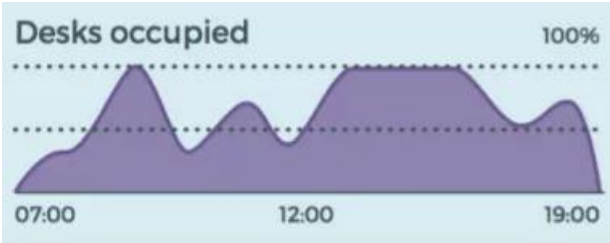

Figure 5. Desks (Cubicles) occupied on a given day

The Client application is capable of generating various useful indicators which can help the users of the office space and also the office space administrators to get a holistic view of the office space utilization patterns.

By incorporating this solution organizations can rationalize their office space usage and accommodate more employees per cube making the effective utilization of the available office space.

There by cost per employee per cube can be reduced by 25 – 30%. This will directly get reflected in the profitability of the company. This will also have an indirect benefit to the environment as more and more employees can be accommodated in the same space by utilizing the space effectively with this system. This reduces the need for growing the office space and hence associated impact on environment can be avoided. The different reports available from the system also helps the higher management in making strategic data based decisions while considering office space extension.

VII. CONCLUSION AND FUTURE SCOPE

With this solution which is based on the sensor feedback from the cube in real time the office space can be utilized to its full capacity and accommodate more users than the actual number of the seating capacity. This will help in overall reduction of the capital needed for extending the office space and hence help in improving the bottom and top lines of the company. The various reports generated from this system can be used to make an informed decision as to when and how much space needs to be added as the company grows in future. This solution can be further improved to consider improving the energy usage efficiency of the office by activating or deactivating the lights and AC outlets depending on the occupancy status obtained from the sensor at the cube. Further this system can be improved to consider the special requirements of the users while reserving the cubes such as presence of an alternative monitor, docking system, adjustable table size and etc. It can be enhanced to view the status of the conference rooms and reserve the conference rooms. The solution can be extended to support the requirements of the guest users as well. It can also be used to track the number of hours an employee spends at the cube and its impact on the overall health of employees

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REFERENCES

1. Nithin M, Suma, V, "*Workspace Management and Hot-Seating*", In the Proceedings of the IEEE 2017 International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2017, ISBN: 978-1-5386-2745-7
2. R. Blum, "Arduino Programming in 24 Hours, Sams Teach Yourself 1st Edition", Sams Publishing, USA, pp. 40-82, 2014, ISBN 1540670163
3. P Yogesh, C Abhay, N Mandar, "Motion Detection Using PIR Sensor", International Research Journal of Engineering and Technology, Pune, pp. 4753-4756, e-ISSN: 2395-0056
4. J. Duckett, "Web Design with HTML, CSS, JavaScript and jQuery Set", Wiley, Pck edition, USA, pp 60-300, ISBN 1118907442
5. J. Duckett, "Web Design with HTML, CSS, JavaScript and jQuery Set", Wiley, Pck edition, USA, pp 60-300, ISBN 1118907442
6. P Sikora, "Professional CSS3",Packt Publishing Limited, India, pp. 120-250, ISBN 1785880942
7. A Ravindran, "Django: Web Development with Python", Packt Publishing Ltd, India, pp. 310-450, ISBN 1787121380
8. M.C. Brown, "The complete Reference Python", McGraw-Hill, USA, pp. 427-471, ISBN 007212718x