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# Architecture and Framework for Group Profiling System in Smart Homes

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**Abstract**— Smart homes are becoming a progressive reality in our society. Automation and customization are at the center of the functionality of smart homes. User profiles record the user preferences of the inhabitants. User profiles are the heart of smart home systems. Real-world smart homes have multiple residents in them. Most smart homes treat the gathering of users in the same area just as a collection of users, but in real-world scenarios, such a group has its own identity. The proposed system tackles this problem by introducing the notion of Group Profiling. This paper presents the significance of profiles and group profiles in a smart home to achieve better customization and automation.

**Keywords**- Group Profiles; Group Profiling System; User Profiles; Smart homes; conflict resolution in smart homes

## I. INTRODUCTION

The Internet of Things (IoT) is one of the hot topics in the research community. IoT has numerous applications in various fields. It is estimated that by 2025 over 70 million IoT devices will be used [1]. Some of these are: - Health & Wellness [2][3][4], Industrial Processing [5][6], Agriculture [7][8], Safety [9][10], Energy Grids [11][12], Smart Homes [13][14] etc.

The Internet of Things (IoT) has many great uses, but one of the finest is smart homes. Smart homes are popularly being adapted into our daily lives. The driving force behind this rapid growth of smart homes is the ever-increasing need for a higher quality of living. This can be only achieved through automation and customization. Automation and customization are possible only if we record and store the preferences of inhabitants. The entities where we store the user preferences are called User profiles.

Classification of Profiles: Profiles in the proposed smart home system are classified in these two types: *i) Individual profiles; ii) Group Profiles.*

*i) Individual Profiles:* The user profiles which record the preferences of the individual residents only are called individual profiles (IPs).

*ii) Group Profiles:* The user profiles which record the preferences of the group of users sharing a common living space are called group profiles (GPs).

This text is organized into four parts: part II explains the review of the related literature, part III states the architecture of the proposed system, part IV describes some of the implementation details for the proposed system, and finally, part V explains the paper's conclusion and potential future applications.

### *A. Significance Of Group Profiles*

A smart home inhibits multiple residents at a time. Each of such residents has its preferences recorded in its respective user profile. The main problem arises when we move toward a more realistic scenario. When more than one resident is present in a particular living space, conflict arises in the system. Any such gathering of two or more persons in the same living space is not a mere collection of individuals. Therefore, it can't be

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represented as a simple collection of user profiles. To tackle this issue the notion of "Group Profiles" is presented [15].

Whenever a user enters a room, the devices in the room are configured according to the user preferences stored in the respective user profile.

The group profiles are necessary for the smart home systems due to:

1) *Real-world scenario Representation:* The group profiles created by the proposed system truly represent the real-world scenario. Here a group of specific residents is treated as a separate entity just like any other user. These can be updated periodically by implicit or explicit feedback by the residents.
2) *Better Customization:* A particular living space is customized according to the users present in that environment. Group profiles offer better customization as it considers the preferences of all the users present in a particular space.
3) *Conflict Resolution:* When multiple users occupy a common living space, the system faces a conflict "According to which user the particular living space is to be configured?" As no single user is to be given higher priority always.
4) *Higher Quality of Living:* The implementation of group profiles in smart homes is aimed at a higher quality of living. It also results in Optimized automation which again supports higher Quality of Living.

## II. Review of Related Literature

Bing et al. [16] divided the smart home system into three layers: one dedicated to sensors and actuators, the second dedicated to networking, and the third layer dedicated to the applications and software.

Zhang et al. [17] also proposed a three-layered architecture for a smart home system. The authors proposed distributed intelligent control using home gateways, regional management centers, and a gateway operator.

A cloud-based smart home design was presented by Zhou et al. [18], in which the gadgets, sensors, and actuators are linked to the cloud through a gateway. The suggested smart home design makes use of cloud services like IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service).

Irawan et al. [19] proposed a light-based service-oriented architecture for smart homes. The authors implemented the proposed system using Raspberry Pi and Relay to control the lights in a smart home.

Jie et al. [20] proposed an IoT-based smart home. The authors described the 5 layered architecture of the proposed smart home. RFID tags are used for appliance identification and control. An agent is assigned to each device along with their respective RFID tag. The agents may interact with each other for more complex tasks. The authors also describe the issues in the implementation.

Nabil Khalid et al. [21] a battery-less wireless sensor design using RFID tags for smart homes. The authors claim that the proposed system delivers better coverage in comparison to others and with the added advantage of no need for a battery.

## III. The Proposed System Architecture

A smart home is essentially a collection of various modules. Fig. 1 represents the architecture of the proposed smart home.

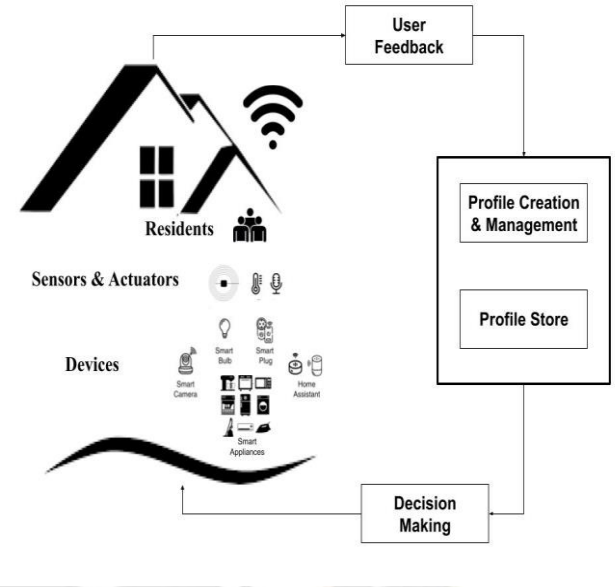


Figure 1. Proposed System Architecture

Various components in the architecture of the proposed smart home system are: -

1) *Home:* The smart home itself is represented as the collection of users and hardware components. These are:
   i. Residents: This includes all the residents living inside the smart home.
   ii. Sensors and actuators: Numerous sensors and actuators are installed inside the smart home.
   iii. Devices: This refers to all the IoT-enabled devices connected to the smart home network.
2) *User Feedback:* This comprises the user feedback system used for the update of user profiles.
3) *Profile Creation & Management:* User profiles are created and updated by this component of the smart home. The very first time the individual user profiles will be created through input from the users via web forms. Later, these profiles will be managed by this module. This module is explained in detail in the upcoming section of this paper.
4) *Profile store:* All user profiles will be stored here once created.

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5) *Decision Making:* User preferences from the profile store are fetched. The preferences saved in user profiles serve as the foundation for all decisions.

The main modules explained in this section are Profile Creation and Management Module (PCMM), Profile Store (PS), and Group Profile Creator (GPC) along with the process flowchart for the proposed system.

### *A. Profile Creation And Management Module (PCMM)*

This module of the proposed smart home is accountable of creating and maintaining user profiles. A user profile records user preference, which in turn is directly responsible for decision-making by the smart home system.

Ziegler et al. [22] have proposed a profile management system that is secure and claims it is apt for private smart homes. The authors introduce different security levels for different services to improve the security of the system. The higher the security level, the more authentication methods are to be employed. Distributed architecture and separate modules for different services are used for abstraction and better security.

Fengou et al. [23] have proposed a healthcare profile management system using smart card technology. The authors presented a generic profile structure with five categories dedicated to the healthcare system. Whenever an event is detected, a group of profiles is activated associated with the index stored in the User Healthcare Profiles.

### *B. Structure of PCMM*

The proposed structure of PCMM mainly consists of i) Profile Store (PS), ii) Group Profile Creator (GPC), and iii) Feedback/Reward Function (FRF). Figure 2 describes Profile Creation and Management Module.

1) *Profile store (PS):* PS contains all the individual user profiles and group user profiles.
2) *Group Profile Creator (GPC):* GPC is solely responsible for the generation of Group user Profiles (GP). Individual user Profiles (IP) are initially created by direct interaction with users at the time of smart home setup.
3) *Feedback/ Reward Function (FRF):* This part of PCMM is responsible for the periodical updating of PS. All the GP and IP files are regularly updated after a particular time interval.

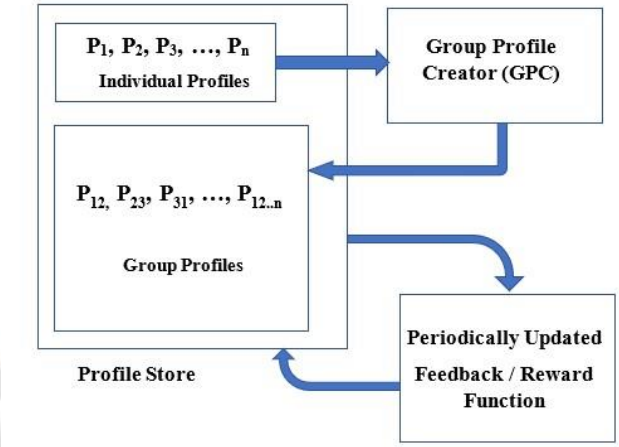


Figure 2. Profile Creation and Management Module (PCMM)

### *C. Profile Store (PS)*

This module of the system is accountable for the collection of User Profiles and Device Profiles. User profiles (UP) and Device profiles (DP) are to be saved in two different tables.

The formats for the UP and DP (UPIF & DPIF) are given here in these tables:

TABLE 1. USER PROFILE INFORMATION FORMAT (UPIF)

| PID | PName | DOB | MedCon | UsrPriorityRank |
|---|---|---|---|---|

TABLE 2. DEVICE PROFILE INFORMATION FORMAT (DPIF)

| DID | DName | DCat | DvcPriorityRank |
|---|---|---|---|

UPIF consists of 5 fields, namely: - PID (Profile ID), PName (Profile Name), DOB (Date of Birth), MedCon (Medical Condition), and UsrPriorityRank (Priority Number).

DPIF consists of 4 fields, namely: - DID (Device ID), DName (Device Name), DCat (Device Category), and DvcPriorityRank (Priority Number).

PS stores both IP and GP files along with DP files. These two tables are created and managed by the system.

### *D. Process Flow Chart*

The proposed system Figure 3 portrays the process flow chart for the proposed system. Individual User Profiles (IPs) are created by the interaction of the user initially and stored in the PS. As soon as user presence is detected inside a room, the system checks for multiple residents in the room, if multiple residents are not found inside the room, then the system implements the decisions according to the IPs.

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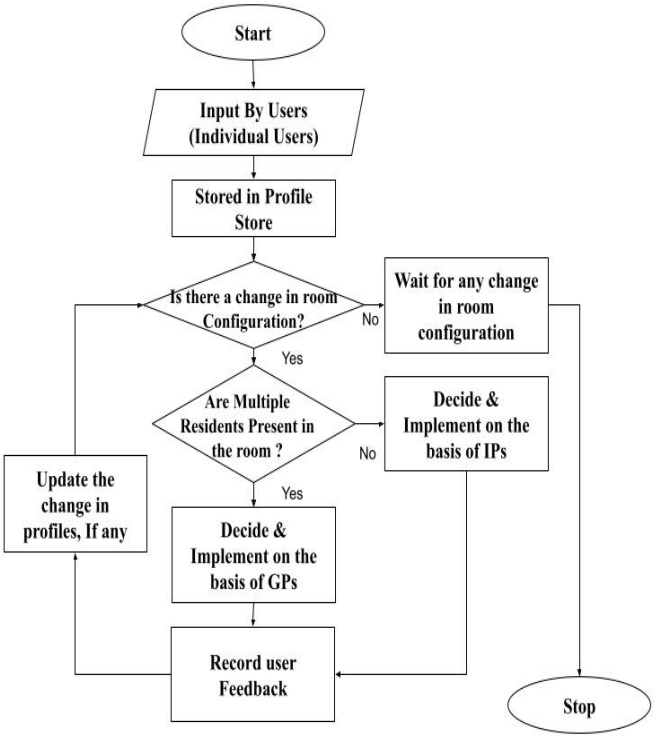


Figure 3. Flow Chart for the proposed system

Otherwise, the system decides and implements on the basis of the GPs of the particular group present in the same room. Implicit and explicit user feedback is recorded by the system. Then the updates in profiles are recorded in the PS, if any. The system monitors and waits for any change in the room configuration, if any change is noticed the whole process repeats itself.

### *E. Group Profile Creator (GPC)*

GPC is responsible for the creation of GPs. The individual profiles are used for the generation of group profiles. Group Profiles are generated by all the possible combinations of the users registered in the house. This exhaustive approach ensures all the possible amalgamations are targeted and user profiles are stored for each possible group for the given set of residents. Figure 4 represents the working of GPC using a block diagram.

These group profiles are static in nature but updated periodically to incorporate the customization according to the users more effectively.

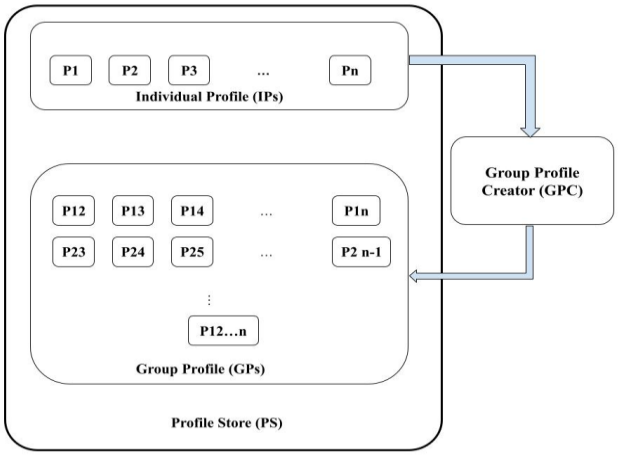


Figure 4. Working of Group Profile Creator (GPC)

### *F. Feedback/ Reward Function (FRF)*

The feedback/ reward function serves as a way to update the profiles of both IPs and GPs. The secondary function of the FRF is to work as a metric to measure the effectiveness or performance of the proposed system. FRF records positive and negative rewards acquired by the system. These reward values may be explicitly specified by the users or implicitly attained by the proposed system. For example, the system may implicitly perceive the negative rewards by monitoring the rollback of any decision executed by the system within a short observation period for each action by the system. The final value of FRF signifies the usefulness of the group profile system over conventional smart home systems.

## IV. HARDWARE/ LAB SETUP

The lab setup for the proposed smart home system is shown in Figure 5. There are various connected devices throughout the smart home. A total of 3 residents will be residing in the smart home. Their presence will be detected using an RFID scanner. Separate RFID Tags will be issued to the residents, for easy and accurate location detection inside the smart home.

The devices will be controlled via devices like ESP8266 MCU, and Relays (2 and 4 channel) as per the requirements. Figure 6 (a) and (b) show these devices.

The data will be collected for a fixed period (e.g., 3 or 6 months) and then it will be analyzed and compared against the same data but without group profiles implementation.

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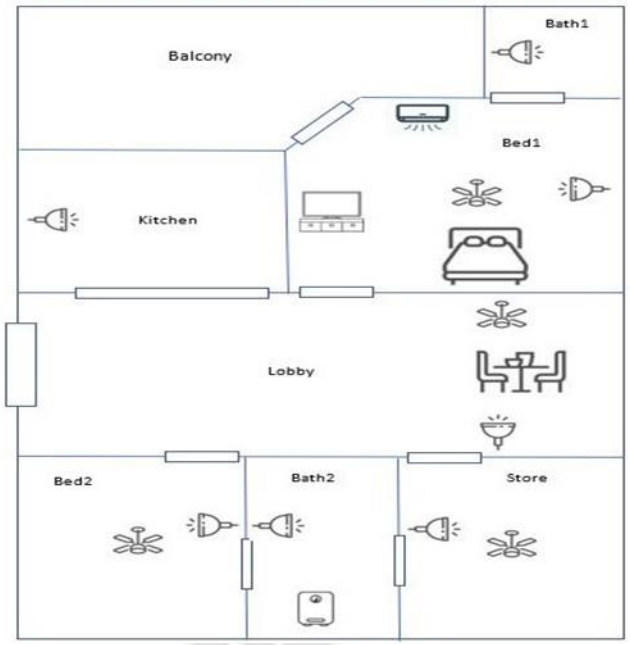


Figure5. Floor Plan for System Setup

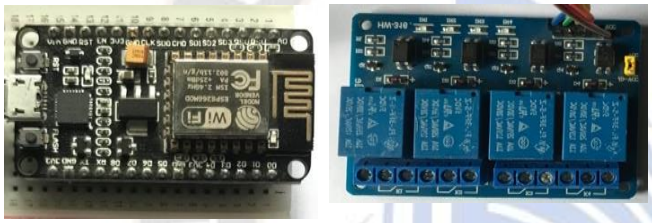

Figure 6. (a) NodeMCU ESP8266 (b) 4-Channel Relay

FRF will serve as an important metric for the comparison of these two scenarios.

## V. CONCLUSION AND FUTURE SCOPE

The proposed Group Profiling System for Smart Homes will be proven effective as both the profiles (UP and DP) play a key role in the implementation of automation and customization of a smart home. Execution of Group profiles in a smart home takes it a step closer to an ideal and real-world realization of a smart home. For further enhancement in the work, one can implement machine learning algorithms for the creation of group profiles instead of some non-learning algorithm.

## REFERENCES

[1] Columbus, L. (2015). Roundup of Internet of things forecasts and market estimates. In Forbes, Vol. 27.

[2] Mezghani, E., Exposito, E., & Drira K., "A Model-Driven Methodology for the Design of Autonomic and Cognitive IoT-Based Systems: Application to Healthcare," in IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 1, no. 3, pp. 224-234, June 2017, doi: 10.1109/TETCI.2017.2699218.

[3] Mathew, P. S., "Applications of IoT in healthcare," in Cognitive Computing for Big Data Systems over IoT, pp. 263–288, Springer, Berlin, Germany, 2018.

[4] Alraja, M. N., Barhamgi, H., Rattrout, A., & Barhamgi, M. (2021). An integrated framework for privacy protection in IoT—Applied to smart healthcare. Computers & Electrical Engineering, 91, 107060.

[5] Rahim, M. A., Rahman, M. A., Rahman, M. M., Asyhari, A. T., Bhuiyan, M. Z. A., & Ramasamy, D. (2021). Evolution of IoT-enabled connectivity and applications in automotive industry: A review. Vehicular Communications, 27, 100285.

[6] Salhaoui, M., Guerrero-González, A., Arioua, M., Ortiz, F. J., El Oualkadi, A., & Torregrosa, C. L. (2019). Smart industrial IoT monitoring and control system based on UAV and cloud computing applied to a concrete plant. Sensors, 19(15), 3316.

[7] Dholu, M., & Ghodinde, K. A. (2018, May). Internet of things (iot) for precision agriculture application. In 2018 2nd International conference on trends in electronics and informatics (ICOEI) (pp. 339-342). IEEE.

[8] Gómez-Chabla, R., Real-Avilés, K., Morán, C., Grijalva, P., & Recalde, T. (2019, January). IoT applications in agriculture: A systematic literature review. In 2nd International conference on ICTs in agronomy and environment (pp. 68-76). Springer, Cham.

[9] Chung, W. W. S., Tariq, S., Mohandes, S. R., & Zayed, T. (2020). IoT-based application for construction site safety monitoring. International Journal of Construction Management, 1-17.

[10] Singh, A., Kumar, D., & Hötzel, J. (2018). IoT Based information and communication system for enhancing underground mines safety and productivity: Genesis, taxonomy and open issues. Ad Hoc Networks, 78, 115-129.

[11] Shahinzadeh, H., Moradi, J., Gharehpetian, G. B., Nafisi, H., & Abedi, M. (2019, January). IoT architecture for smart grids. In 2019 International Conference on Protection and Automation of Power System (IPAPS) (pp. 22-30). IEEE.

[12] Avancini, D. B., Rodrigues, J. J., Rabêlo, R. A., Das, A. K., Kozlov, S., & Solic, P. (2021). A new IoT-based smart energy meter for smart grids. International Journal of Energy Research, 45(1), 189-202.

[13] Bing, K., Fu, L., Zhuo, Y., & Yanlei, L. (2011, July). Design of an Internet of Things-based smart home system. In 2011 2nd International Conference on Intelligent Control and Information Processing (Vol. 2, pp. 921-924). IEEE.

[14] Pirbhulal, S., Zhang, H., E Alahi, M. E., Ghayvat, H., Mukhopadhyay, S. C., Zhang, Y. T., & Wu, W. (2017). A novel secure IoT-based smart home automation system using a wireless sensor network. Sensors, 17(1), 69.

[15] Rahul, Solanki, K., & Dalal, S. (2021). Systematic Literature Study on User Profiles in Smart Homes.

[16] Bing, K., Fu, L., Zhuo, Y., & Yanlei, L. (2011, July). Design of an Internet of Things-based smart home system. In 2011 2nd International Conference on Intelligent Control and Information Processing (Vol. 2, pp. 921-924). IEEE.

[17] Zhang, H., Wang, F. Y., & Ai, Y. (2005, March). An OSGi and agent-based control system architecture for smart home.

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In Proceedings. 2005 IEEE Networking, Sensing and Control, 2005. (pp. 13-18). IEEE.

[18] Zhou, J., Leppanen, T., Harjula, E., Ylianttila, M., Ojala, T., Yu, C., ... & Yang, L. T. (2013, June). Cloudthings: A common architecture for integrating the internet of things with cloud computing. In Proceedings of the 2013 IEEE 17th international conference on computer supported cooperative work in design (CSCWD) (pp. 651-657). IEEE.

[19] Irawan, Y., Linarta, A., & Febriani, A. (2021, March). Smart Home Light Based Service Oriented Architecture and IoT. In Journal of Physics: Conference Series (Vol. 1845, No. 1, p. 012070). IOP Publishing.

[20] Jie, Y., Pei, J. Y., Jun, L., Yun, G., & Wei, X. (2013, June). Smart home system based on iot technologies. In 2013 International conference on computational and information sciences (pp. 1789-1791). IEEE.

[21] Khalid, N., Mirzavand, R., Saghlatoon, H., Honari, M. M., Iyer, A. K., & Mousavi, P. (2021). A Batteryless RFID sensor architecture with distance ambiguity resolution for smart home IoT applications. IEEE Internet of Things Journal, 9(4), 2960-2972.

[22] Ziegler, M., Mueller, W., Schaefer, R., & Loeser, C. (2005, August). Secure profile management in smart home networks. In 16th International Workshop on Database and Expert Systems Applications (DEXA'05) (pp. 209-213). IEEE.

[23] Fengou, M. A., Mantas, G., Lymberopoulos, D., & Komninos, N. (2011, October). Ubiquitous healthcare profile management applying smart card technology. In International Conference on Wireless Mobile Communication and Healthcare (pp. 248-255). Springer, Berlin, Heidelberg.