Sequential development of integrated remote-control Smart Home/Office systems

Georgi Kolev*
University of Chemical Technology and Metallurgy, Bulgaria
*georgi.i.kolev@abv.bg

Abstract: *An integrated smart home system for monitoring and management of the elements of the working environment or at home in Home Assistant platform and is integrated with a voice assistant (Google Assistant) has been developed. It allows monitoring and control of various parameters of the environment, determination of geolocation, tracking the state of the connected devices, provides ascertainment of conditions or constraints during the implementation of logical algorithms or actions, etc. The developed integrated system solves the problem of using various interface applications, communication protocols and standards by integration of all its elements in one Application Programming Interface (API) and simultaneously expanding its scope through integration with a voice assistant (Google Assistant). The development of a dataset of interoperable rules integrated in the Smart Home/Office system should be done function by function. This paper is directed toward the sequential development of integrated remote-control Smart Home/Office systems by adding additional functionality to the already developed integrated system.*
Keywords*: SMART HOME/OFFICE, INTERNET OF THINGS, HOME ASSISTANT PLATFORM, VOICE ASSISTANT.*

1. Introduction

An integrated smart home system for monitoring and management of the elements of the working environment or at home in Home Assistant platform [1] and is integrated with a voice assistant (Google Assistant) has been developed [2, 3]. The structure of the Smart Home/Office system is based on the concept of the Internet of Things (IoT), which includes connectivity of devices and actuators, as well as the presence of Wireless Sensor Network (WSN). It allows monitoring and control of various parameters of the environment, determination of geolocation, tracking the state of the connected devices, provides ascertainment of conditions or constraints during the implementation of logical algorithms or actions, etc. The developed integrated system solves the problem of using various interface applications, communication protocols and standards by integration of all its elements in one Application Programming Interface (API) and simultaneously the system is expanding its scope through its integration with a voice assistant (Google Assistant). The functions of the system include performing actions by request from the users, but also predefined (default) values and actions. The development of a dataset of interoperable rules integrated in the Smart Home/Office system should be done function by function. This paper is directed toward the sequential development of integrated remote-control Smart Home/Office (SH/O) systems by adding additional functionality, including intelligent data analysis, to the already developed integrated system. This process can continue without limitation in time as far as the imagination of the designer and/or the users reaches.

2. Integrated Smart Home/Office system

Depending on the specific operational function, both connected devices or actuators and sensors can be used in the operation of the system to detect the presence or absence of certain conditions, followed by appropriate specific actions. They are realized on the basis of the logical algorithms introduced in the system. The general view of the developed integrated system [4] is presented in Fig. 1. The most frequently used data on the condition of the home and the members of the household are presented there. All objects included in the current integrated SH/O system are over 100, and historical data about them can be traced for a given period of time through the option "History" (Fig. 2).

The built system also includes services available through Home Assistant as presented in Fig. 3 estimation of the time for driving between two points - for example, from to the office, based on the Waze application. Other possibilities are creating a calendar with tasks or a list of purchases available to all members of the household (Fig. 1).

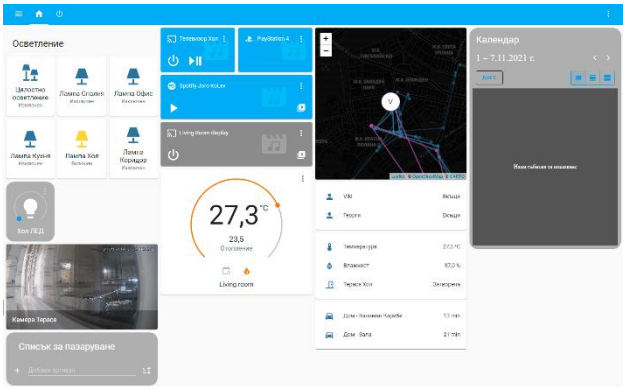

Fig. 1 *Google Home synchronized integrated system.*

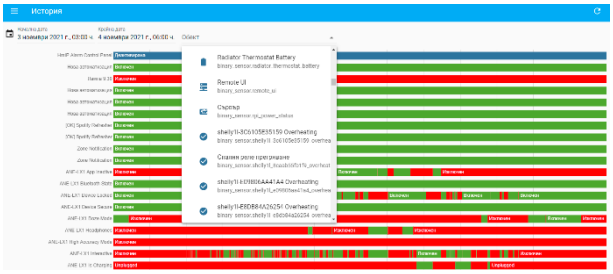

Fig. 2 *Historical data.*

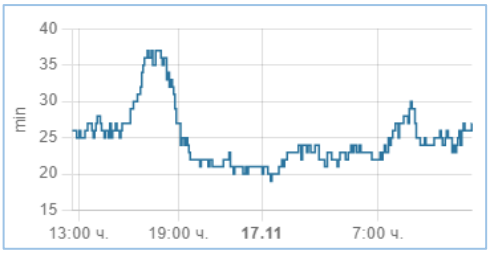

Fig. 3 *Estimation of travel time by car between home and office – Waze [5].*

The functions of the system include performing actions on request by users, but also on predefined values and actions. The development of a set of data from interoperable rules integrated into the Smart Home system must be performed function by function. The structure of a standard interoperable rules can be represented as follows:

"If Condition (& Condition2,…), THEN Action (Action2,…)"

"IF Condition11 (& Condition12,…), then IF Condition21 (& Condition22,…), ……THEN Action (Action2,…)"

The conditions can be set by the user (directly or in time) or depending on the values obtained from the sensors (Sensor-based Linked Open Rules). When analyzing the patterns of the behavior

of the inhabitants of the Smart Home from the collected data, it is possible to offer additional built-in functions [4].

The MQTT (Message Queue Telemetry Transport) protocol is used to ensure the connectivity of the elements in the integrated system and the connected applications, for which many implementations are available. This is a two-way communication protocol through which connected devices can publish data from sensors and at the same time receive configuration information or control commands.

3. Functionality and structure of SH/O system

The presented in the current paper integrated SH/O system integrates the following general functions [2-4]:

- Security – video surveillance, sensor monitoring, fire and flood detection;
- Comfort – remote and/or intelligent control of lighting, curtains, switching on and off appliances, control of video and audio equipment, TV, PlayStation, temperature control – air conditioning, heaters and central heating;
- Healthcare – measurement of environmental indicators – temperature, light, pressure, humidity, CO_2 content, dust, smoke, alarms or reminders for medications;
- Energy consumption and efficiency – consumption of electricity and heat (central heating).
- Indoor care – cleaning, ventilation, air purification and humidification, pet feeding.
- Activities organizer – calendar of events and tasks (individual and common), shopping list, traveling information (Waze), suggestions for spending the holiday time;
- Information – information from the connected mobile phones – geolocation, activities, settings, state of the batteries, sensor data, Wi-Fi connection, data transfer quantity etc.; news, weather information, data storage of historical data from all connected objects, sensor data acquisition and processing.
- Voice control integration – the voice communication is realized through the application for Android – Google Assistant, which is connected to Google Home. On the other hand, the open source Home Assistant application developed on the local server (Raspberry Pi) is synchronized via an API with Google Home.
- Remote access and management.

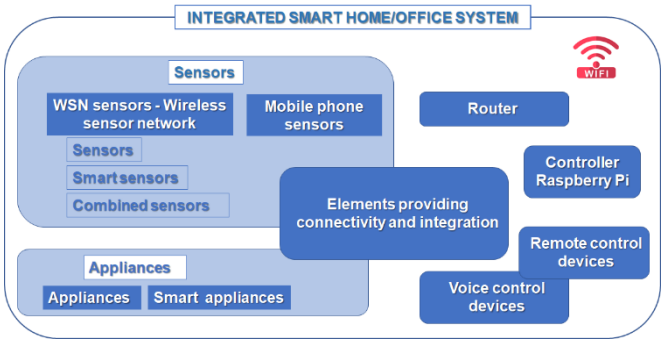

Fig. 4 *Integrated SH/O system elements (devices).*

The described functionality of the integrated system can be successfully applied both in home and in office environment. Each individual project is developed according the individual requirements from the users, connected with their needs, the object specifications – apartment, house, office, their location size, already build or in process of designing or building etc., the selection of its elements and the estimation of its cost.

An overview of the elements integrated in the SH/O system is presented in Fig. 4. Description of the elements can be found in [2, 3].

4. Sequentially expanding of the integrated SH/O system functionality

In order to include additional functions to the developed integrated SH/O system the shown in Fig. 5 algorithm should be followed. Here three cases will be considered:

- Integration of new smart device;
- Development of new function without adding new elements;
- Development of new function, when not all elements are available in the SN/O system.

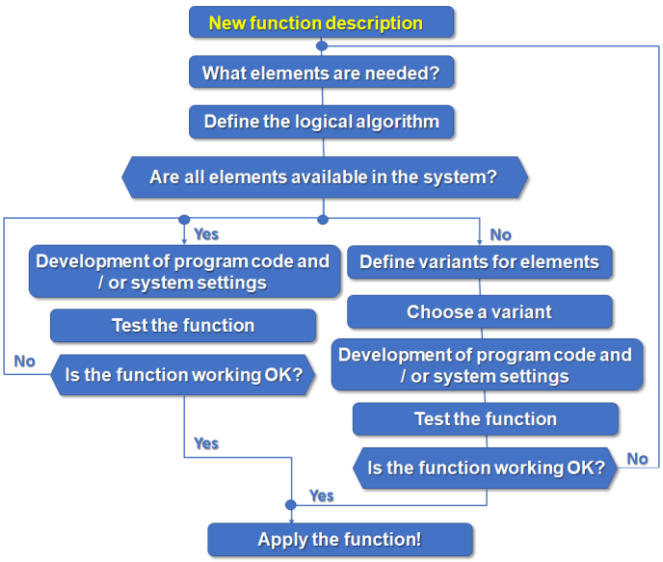

Fig. 5 *Algorithm for new function implementation.*

If a smart device – Canon TR500 series printer must be integrated in the system it should be connected to the Wi-Fi network during the installation of the driver, then the Home Assistant finds the new compatible with the system device, sends notification and the new device can be configured and added to the elements of the SH/O system. This allows the system and the user to monitor the state of the printer, the rate of toner consumption over time and notify the user(s) in advance when the toner reaches predefined level in order to avoid the situation shown in Fig. 6.

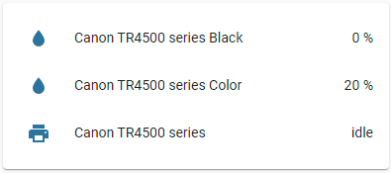

Fig. 6 *State of Canon TR500 series printer.*

As an example for the development of a new function without adding new elements here will be considered the possibility to set the time of for a meeting or an appointment outside the office/home, or waking up in the morning or preparing to go to go work according to the traffic and setting time to prepare (pre-defined time before leaving). In order to set such notification a script defining the arrival time, the time needed for preparation and the target location should be written. That is why it is convenient for repeated actions, like waking up in the morning for work.

The developed function, which uses Waze [5] service for estimation of driving time (*Td*) between two locations, works as it is shown in Fig. 7. For example, the employee should be at the office from 9:00 h. Then the arrival time can be set to *Ta* = 8.55 and the time for preparation is *Tp* = 30 minutes. If the estimated time by Waze is also *Td* = 30 min, then "Notification 1" or the predefined actions (like turning on the lights, playing music, etc.) should be started within the time interval 7:52 ÷ 7:58 a.m. and the "Notification 2" stays in order that the traffic changes and correspondingly the estimated time. If the estimated time for driving

changes to 35 min, then the second notification (or predefined actions) should be started in the time interval 8:14 – 8:20 a.m. The tolerances depend on the frequency of updating of Waze service in the system (current time for update of Waze service is 5 minutes).

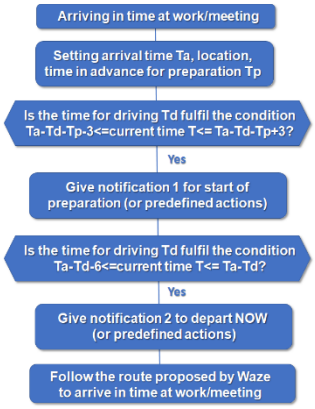

Fig. 7 *Algorithm of arriving in time function.*

The considered here function, which will need additional elements, is a function, which aims to locate if the employee is in the office and if she/he is in her/his workplace. In this case all the elements are not present in the integrated SH/O system (Fig. 5).

The available function is geolocation by GPS in the mobile phones of the connected devices (Fig. 8). In work environment using this function is connected with the availability of business mobile phones of the employees, that can be integrated in the company integrated system, with the knowledge and agreement of the employees.

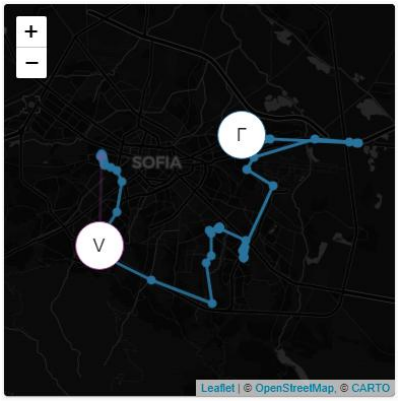

Fig. 8 *Geolocation determined by GPS in a mobile device.*

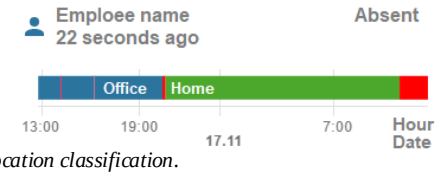

Fig. 9 *Geolocation classification.*

The classification in this case can be done – "in the office" and "out of the office" (Fig. 9).

Another solution, based on Bluetooth connection, is presented in Fig 7. It includes TUYA Bluetooth Gateway and GPS trackers. If the tracker comes into the range of the Bluetooth Gateway it will be registered in the system and the employee can be considered as located in the office. There are different models of trackers and gateways and an appropriate solution should be chosen, depending the size of the office, the number of employees etc. The chosen TUYA Bluetooth Gateway ensures connectivity to the Wi-Fi network and to the SH/O system, besides of Bluetooth devices (trackers), but also of the devices, that use Zigbee communication protocol.

Fig. 8 *TUYA Bluetooth Gateway and GPS trackers.*

The other part of the function is connected with the location of the employee on her/his workplace. This question depends on the type of work of the employees and is not necessarily connected only with the efficiency of the work process, but also can indicate the time the employees sit without movement on their computers (workplaces). In the COVID-19 pandemic the time people, including children, stay behind the computers drastically increases. It is important to add some motion and interruption of the work process in order to let the body and eyes rest.

The integrated SH/O system in this case can register the time spend on the workplace and also can send notification to the employees to interrupt their work for a while and have a rest.

The detection for this function can be done with one or two PIR sensor per employee (Fig. 9), depending on the number of people in the office. The suggested solution is placing the sensor below the desk plate and measurement of the time without movement after registering motion. The suggestion is that, if no motion occurs in the period of 5 minutes, for example, the employee has left his/her workplace.

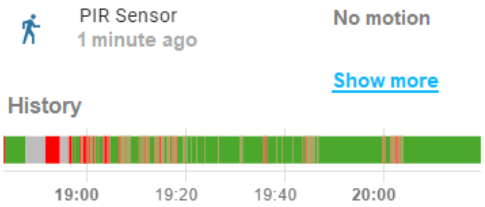

Fig. 9 *PIR sensor historical data.*

In our case the solution with Geolocation, determined by GPS in a mobile device, is appropriate and chosen for realization.

5. Conclusions

This paper is directed toward the sequential development of integrated remote-control Smart Home/Office systems by adding additional functionality, to the already developed integrated system.

Three cases of sequentially expanding of the integrated SH/O system functionality are considered: integration of new smart device, development of new function without adding new elements and development of new function, when not all elements are available in the SN/O system.

The process of the sequential development of integrated remote-control Smart Home/Office systems can continue without limitation in time as far as the imagination of the designer and/or the users reaches.

Acknowledgements

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