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Open Source Based Concept of Inteligent House

Miroslav BEHAN[a,1] and Ondrej KREJCAR[a]
[a] *Department of Information Technologies, Faculty of Informatics and Management, University of Hradec Kralove, Czech Republic*

Abstract. The evolution of cheap and ubiquitous sensors, chips and mobile devices lead to empower smart home environments where personal automation will reach conform potential of intelligent houses. The users and families benefits from sustainable, modular and social single smart interface where could interact their needs. We propose Smart Home point as Open Source solution for every intelligent house as low cost system with remote, social and sensorial control.

Keywords. Home, Automation, Smart, Social, Sensor

Introduction

Smart Home Point is open source system which for free to install in any building where habitants are looking for easy, comprehensive and social connected user interface with their home place. The system enables monitor, control and socialize householders with their facilities, families and friends. The monitoring covering any useful sensor which could be connected via Ethernet network such as motion, light intensity, temperature and other ambient sensors as well as voice, video or another signal readers. The controlling enables door locking, heating, air-conditioning, lighting and networking management on spot or remotely from mobile device or web browser. And mentioned socialization feature ability of system enables creates new interactive environment within home users who are identified by over their personal mobile devices and could share their social channels.

The cost of chips and sensors will reach ubiquitous level soon and we will interact and provide sensorial data to our environment. The smart environment at home will have for us more attractive background due to human social and personal behavior needs. Our relaxation, comfort, social zones will increase their efficiency thanks to intelligent sustainable environment. The houses will manage energy from recoverable sources and provide free of charge sustainable ecological live support without waste. The challenge is more than contrived where limited resources are drained in meaningless outcome in terms of human society. Therefore we propose sustainable open source project called Smart Home Point where all house management needs are connected in a single user interface ready for any customization.

We consider nowadays computational challenge as personal automation before at early stages of computational era that was industrial and after business process

[1] Corresponding Author: Faculty of Informatics and Management, University of Hradec Kralove, Rokitanského 62, Hradec Králové 50003, Czech Republic; Email: mirek.behan@gmail.com

automation where part of decision making is provided by computer or non-human computation power. There are two factors which enables such opportunity as wireless communication and mobile computing. Both in time will became the main stream providers of personal daily bases solution resolvers or advisers in terms of location, society or other contexts. Also the human interaction with the system is considerable as mandatory where visualization and control of human environment functionalities would be as one undivided unit which keeps purpose and sense of information.

1. Problem Definition

The main problem of smart home systems we consider in closed based solutions which are impossible to merge in low cost or at all. There is no open standard for smart sensors, applicants and Human-Machine Interface (HMI) at level of plug & play capabilities where house owners just plugin equipment in current sustainable system and it just works [12-14].

There are many sophisticated commercial solutions nowadays from companies which have to provide closed solution due to their survival on market which is leading to support non adaptive and dependable on mostly one provider of given solution. There is missing open based communication protocol which enables connect independent units into system on the fly. The part of problematic is in energy supply mechanism where for some applicants it is impossible to convert or to use low type consumption in 12V/24V voltage over unshielded twisted pair (UTP) cable and the power over Ethernet (PoE) is not an option. Other part of problem is in closed communication data exchange where designed protocols are dedicated to given solution and are unable to upgrade from third parties of manufactures or service providers.

There are also integration limitations of HMI in house environment [8] nowadays which in future will be transformed and known as intelligent walls, but current cost and technology well accepted are televisions with remote controllers. Therefore the challenge is about to integrate Smart Home Point (SHP) into current TV screens and among of house holders watched common content. Operating with such visualization is compound by usage of remote control technology or by usage of more convenient mobile devices as remote controllers where are the capabilities are much higher. Only disadvantage is battery consumptions of personal mobile device which may leads in such circumstances less usability of system.

Nevertheless due to such extend of home control there have to be covered the most common mobile platforms which are able to operate over wireless 802.11 [3] with system and present touch control functionality. Therefore Android, iOS and Windows Phone are considerable as mandatory for extension of HMI and native application of each platform benefits more usability of system.

The visualization relay to comprehensive and consistent user interface (UI) where text information is meaningless except numeric symbols in terms of simplification development process and interaction with international human [11], [15]. The principals of visualization are bound by nature of its meaning and functionality as an essence of pure knowledge expressed by 2D shapes and pictograms. Therefore the UI would correspond with real environment figure 1 and screen resolution accordingly to logical structure of building.

Other problematic of smart home environment is hidden in user's behavior and interactions which would morph current needs from system supportive to their actions.

The system would be capable of creating temporal social virtual space based on user personalities and intersected within group of users where intelligence surrounding environment became reality with real sense.

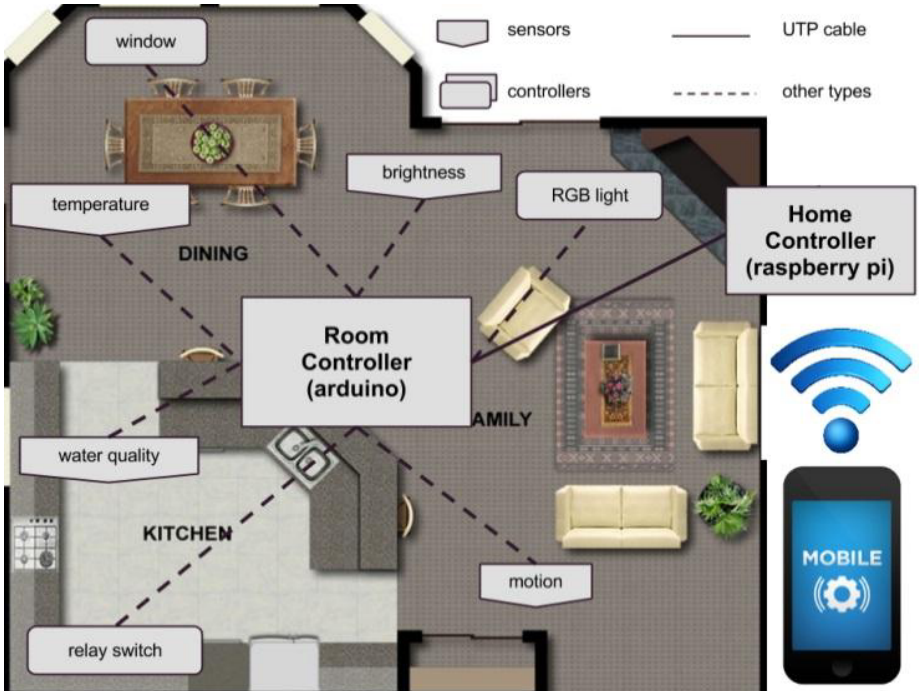

Figure 1. House overview schema – Ground floor visualization

2. New Solution

The new solution is based on open sourced and open electronics based technology within usage of Ethernet as informational and power supply medium. The core of system relies on Raspberry Pi [1] as a computational server which provides monitoring, controlling and visualization of modular units in smart home place. We propose open system prototype based on internet packet message delivery for monitoring and controlling house units over network and application interface designed to build independent solution, visualization and user control of system features.

The functionality of system we outline in figure 2 is about to merge house monitoring, controlling and personal social stream at one place. We provide administrator, householder and other user's profiles which over proper authorization process defined by OAuth 2.0 protocol specification are able to access smart home functionalities. In our solution we define house as a set of logical units which are equivalent to room or part of them. Every such logical unit has its own UTP cable and process controller which is connected in star type network. Data are transmitted over Ethernet and controller is supplied with power accordingly to 802.3af [4] where maximal 48V ~ 400mA limits possible applicants connected to controller. We choice Arduino [2] as such controller due to its open electronics principals, nevertheless it

could be any kind of dedicated Ethernet shield with logic circuits which is able to transform internet packet into electronics and backward transmit sensorial data over packets of designed protocol.

We propose communication protocol between room controllers or any other devices, applicants or some intelligent agents and visualization unit, master controller or mobile device which is equivalent as relation between in producer and consumer model. The messages from sensors are broadcast over local network, therefore any listener on specified port recognize sensorial messages and is able to take appropriate response. On the other hand commands have to be authorized by trusted controller and are broadcasted or directly sent to specific controller to provide expects actions. For instance lighting would behave on energy saving policy or on explicit user commands where broadcasting over whole building is possible. The communication is bi-directional where information distribution modeled as event is produced by every element wrapped into datagram as messages for broadcasting with content of status or measured values which could be listened on specific port. The datagrams are sent over Ethernet accordingly RFC 919 and 922 with Maximum Transmission Unit (MTU) 1500 bytes. The commands are encapsulated into datagram as message with type of command, values to be set and element identification. The datagram of commands is either unicast or broadcast dependable on destination of application. Following [Table 1] describes message definition between house unit controllers.

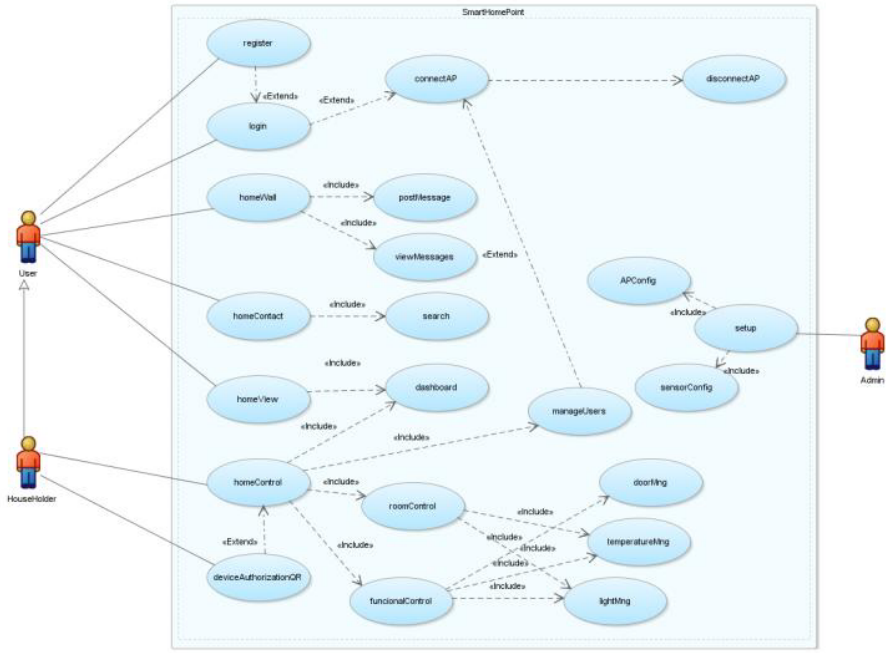

Figure 2. Use case schema of Smart Home Point

The electric signal from sensors is transformed into defined message type by controller considerable as the smallest home unit and broadcasted into local network. The magic field would be used as identification and authorization parameter of message source. Id field is incremental based stamp for synchronization and stream

purposes. The type filed defined message type whether it is Sensorial, Command or Confirmation message. Sensorial are generated invoked by sensor perception change. Commands are invoked from uses behavior or artificial knowledge and Confirmation type responses on commands with possible statuses. At last checksum and payload wraps content into JavaScript Object Notation (JSON) in case of necessity of structural data otherwise simple values like byte, int, float, double and chars not need structured bases and therefore simple chain of encoded chars are suitable.

Table 1. Message Definition of House Unit Controllers

Field	Data type/size	Description
Magic	unit32 / 4 bytes	Identifying magic value of type of message source
Id	unit32 / 4 bytes	Incremented stamp of message
Type	char / 12 bytes	ASCII string identified type of message
Checksum	unit32 / 4 bytes	Optional first 4 bytes sha256(sha256(payload))
Payload	char / ? bytes	JSON based values

The field of checksum presents integration capabilities with security option. We consider security in shared spaces where wireless access is possible and therefore this feature leads on higher performance of controller which have to also implements security check. The message itself is wrapped into Internet Packet and broadcasted over Ethernet in star schema deployment. The active nodes or controllers decide whether to broadcast further the message in other segments of network, therefore part of message delivery within system is based on correct network deployment. Following Figure 3 outline data model of system concept and from high level perspective define all data resources needed for basic scenario of house user needs.

As authorized commander house unit is any unit with computational capabilities with predefined magic values which works within system. In our case we use Raspberry Pi [1] due to cost effectiveness and openness capabilities. In different scenario that would be even mobile device or any other computer. Each commander house unit starts listening on specific port when it is deployed to system and stores history of messages. The history and statistical data are created based on time associated with recognized messages and their source. We provide in figure 3 data model annotated in Java Persistent Api (JPA) diagram where essence of gathered data are outlined. The Event and Command entity are expressing messages transmit in local network with their parameters. The element entity present all configured sensors or executable circuits with simple logic embedded within controller or have its own controller unit. Classic types of elements are predefined, but any other would be added and customized accordingly to specification. Controller represents basic building block of system which in our case represents Arduiono modules [2] suits due to its modularity and openness of electronics. The logic is programmed into the module which decides if sensorial message are broadcasted upon user location [9] and behavior [10] or ambient changes.

At last we outlined the interaction of building blocks of system where is highlighted informational view processing with authorization by secret token which enables view and controls of elements in system. The commander unit basically provides user interface interaction with other parts of system [16-17].

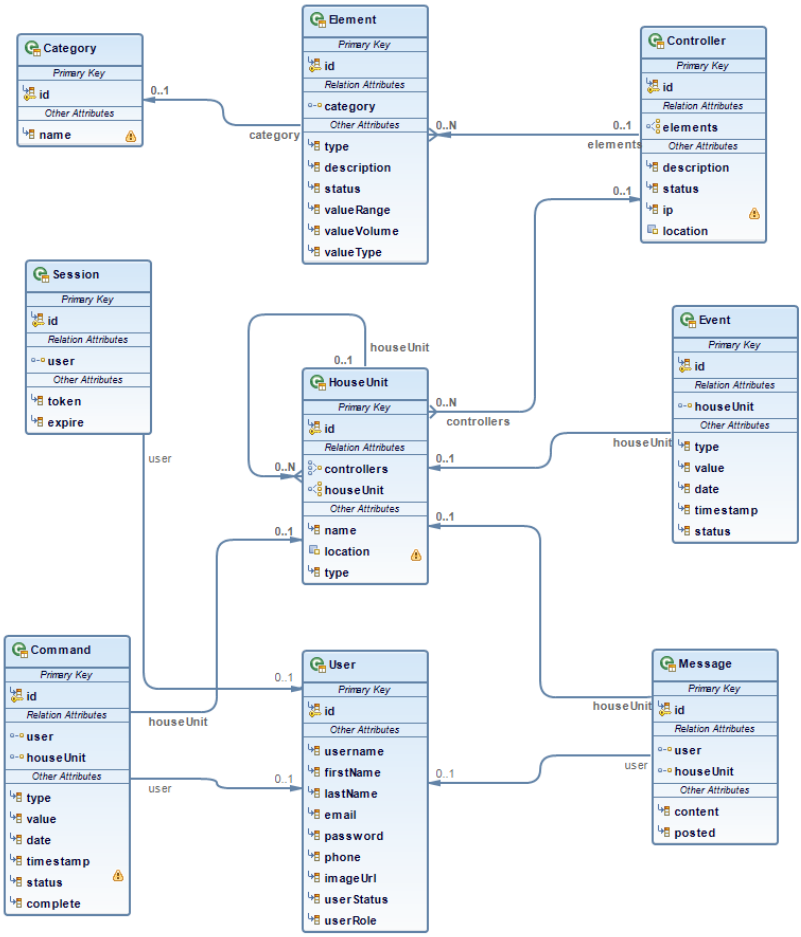

Figure 3. Data Model of Commander House Unit

3. Implementation

The prototype of system consists of Commander, Controller, Element and UI units. We consider Commander Unit as Linux based minicomputer known Raspberry Pi [1] where nonstop running web server responds for user's mobile device and other UI applications. Also inner part of system is socket server bind with logic and database which listening on port 5000 for every event or command messages transported over local network. The communication with web server is provided by Representational State Transfer (REST) as web resource based access. The Application Programing Interface (API) describes main functionalities in following figure 4. We consider also third party access, therefore open based API access is provided and the documentation with mock's objects available on web application [6]. API conforms to latest consideration of resource based best-practices where all types of resources if are allowed to access are able reach from top level hierarchy or from relation between

resources. The relations are expressed as inner mount point with identification of upper leading resource. The authorization to resource is provided by implementation of Filter class of web server where access privileges are defined in profile type of user and therefore resources are defined as accessible to specific type of profile. For instance Admin or Householder is able to add new user into system and authorize for him or her to executed commands.

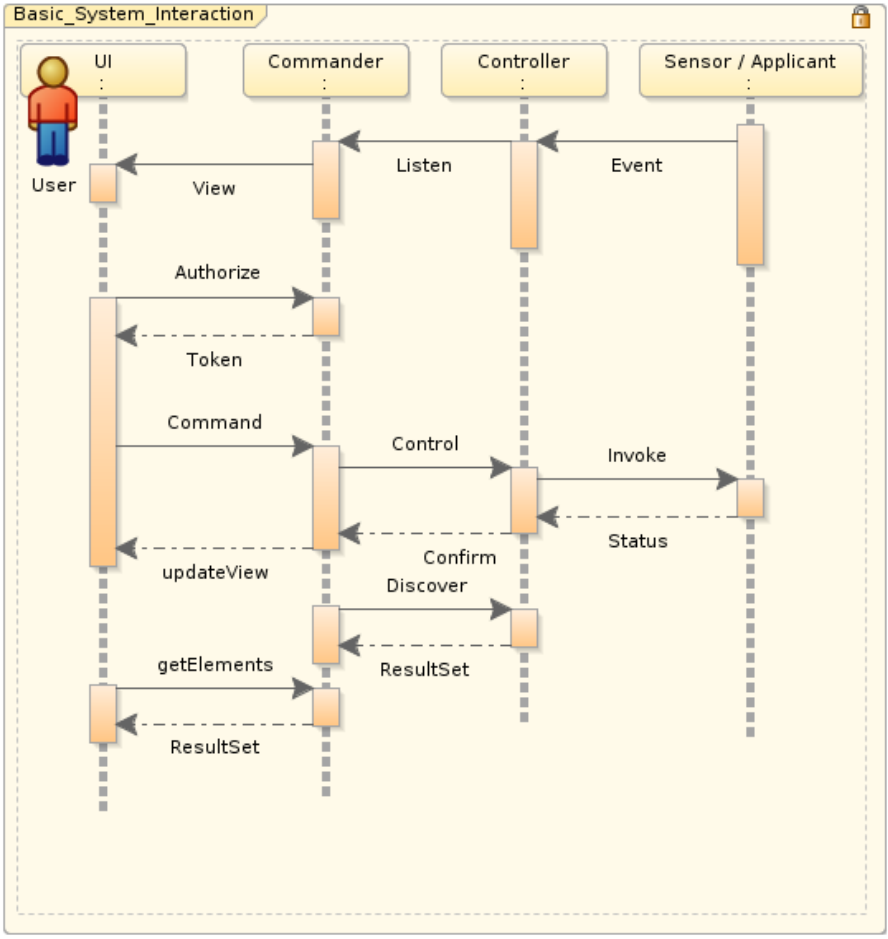

Figure 4. Interaction - Controller and Commander Units

We consider implementation on different mobile platforms as Android, iOS and Windows for UI application with simple user friendly component as a part of further discovery. Nevertheless nowadays we just propose open resource based interface which leads to correct implementation of mobile UIs. The practically are main resources User, Element, Controller, Command, Event and House which allows settings and maintaining system which was at first configured by technical person and provide proper setup of controller and commander unit. The User resource allows plain Create

Read Update Delete (CRUD) operation for authorized actor with resource. These are provided to all resources as generic plain implementation. The other operations as login, logout, findUserByKeyword, createWithArray or createWithList are provided for specific functionality where name or detailed description expresses their purpose defined by annotation on entity classes and generated on every request [6], therefore the API documentation is all the time up to date.

The solution is partially implemented and publically accessible from GitHub.com [7] where the commander unit is proposed and API for controllers is designed as blueprint for different platforms of mobile devices applications.

4. Conclusion

This project proposes web based Smart Home system realized by open technology and open source software solution as part of future intelligent house. The new solution provides connectivity between sensorial electronics signals and web resources with monitoring, controlling and visualizing elements in environment. The system is designed to be customized, upgraded and tuned by anyone under open source license.

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