# A Methodology Based On an Expert Fuzzy System for the Selection of the Architecture, Technology and Characteristics of a Domotics System


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## Abstract.

The main aims of this work are:

1) *To simplify the tasks related to the selection and development of domotics projects, facilitating the introduction of this technology in the market.*

2) *To help the different sectors involved in construction (architects, property developers, electricians, users, etc.) to find a rational use of the building installations, with the resulting energy savings.*

3) *The wide variety of existing systems, technologies and manufacturers hinds learning and taking decisions. With this work, the confluence points and the most objectives mechanisms for comparison and selection can be found.*

In this work, a methodology for helping to mitigate the doubts and problems that domotics installations convey is developed. That Methodology for the Selection and Development of Domotics Projects is based on well defined phases or sequences, and will allow the direct and unambiguous selection of the best domotics systems for each particular building, according to multiple criteria. The set of criteria are obtained from the knowledge of experts, using a **fuzzy logic expert system (ES).**

This methodology materializes in a software application with a friendly graphic interface which presents the final results by means of a set of comparative tables for the different architectures and domotics technologies.



## Key words

*Domotics, Expert System, Fuzzy Logic, Methodology, Building Automation*


## 1. Introduction

The term Domotics can be defined as the technology for developing the automation of common installations in a house or building. Safety, energy savings, comfort and communications are its main aims. There are many different domotics products, which involve the use of diverse technologies and architectures (centralized, decentralized and distributed).

Little by little, domotics is getting in the property market and in the construction of large buildings. However, the increase of domotics installations since their origins is lower than expected. Some reasons for this low rate are:

1) *The variety of existing products.*
2) *The difficulty end users can find in their management.*
3) *The complexity in their design, programming and further maintenance.*
4) *Their functionality sometimes doesn't match with that demanded by the potential users.*
5) *The belief that domotics is expensive, without taking into account the important energy savings it can convey.*

With this work, we intend to contribute to the solution of the mentioned problems.

## 2. The Idea

The first step to undertake a domotics installation must consist in determining the functionalities the client wants to control. Also, it is necessary to analyze in detail the physical and spatial characteristics of the building, starting from its plans. It will make easy to select the best domotics architecture and technology.

However, these guidelines are frequently relegated, and the engineer or the installer selects a specific technology or architecture with regard to their own previous personal experience and knowledge of some particular systems. This way of acting can make the project more expensive, and can convey the implementation of systems that fail to keep the client's demands.

These reasons motivate the idea of defining a *Methodology for the Selection and Development of Domotics Projects*. Following a sequence of precise and well defined steps, it will allow the direct and unambiguous selection of the best domotics system for each building, based on multiple criteria obtained from the knowledge of experts.

## 3. Expert Systems

Like we explained before, the selection of a domotics project for a specialist is a difficult task for the variety of technologies that we can use and the numerous factors that we have to consider to the final decision, so there are not many experts with the capability to find an efficient solution for a particular solution.

For this reason was developed this methodology, which simulates the expert knowledge using techniques based in Expert systems with a software application that will select the most suitable system to use in our case showing the final results using comparative tables and diagrams.

The idea of the development of this expert system comes from the possibility of having a solution to resolve the complex problem of selecting the most suitable domotics project for edification. This selection needs a specialized analyst in this area, but the results were not reliable for the big amount of available technologies.

An Expert System is part of the Artificial Intelligence. Our program makes a decision like an expert analyst would make using his knowledge. The Expert System offers an intelligent support and the capacity to justify the conclusions it deduces to the user.

An Expert System computer aid helps to organize all the studied parameters, expand and extend the existing knowledge about the investigated subject. Is important the capacity of explaining to the user the reasoning process to get the results expanding the expert knowledge.

Just than an Expert System, we better must talk about a Knowledge Based System, because it uses the present natural knowledge in this subject. In the next figure we can see the major parts of the system.

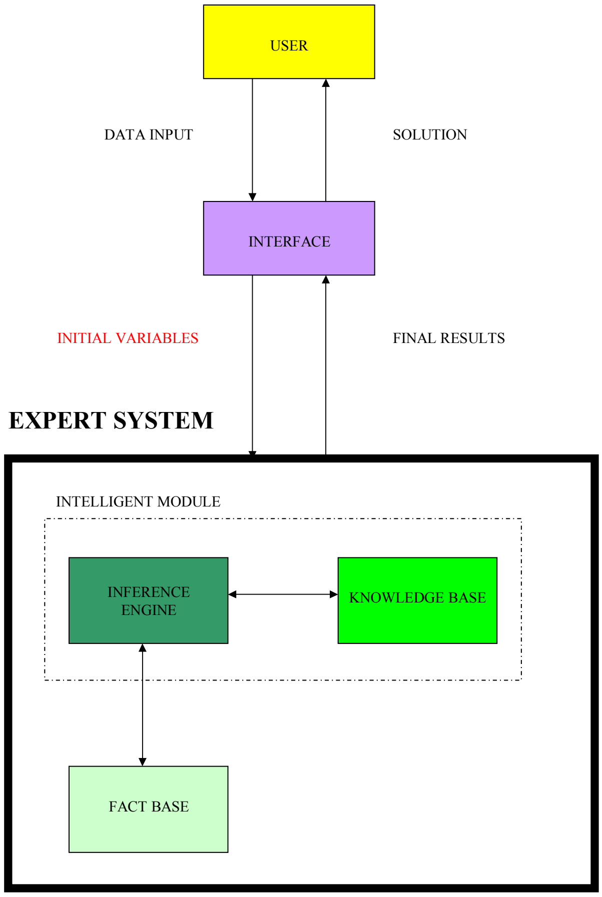


**Fig. 1.** Basic Schema for Expert Systems

### *A. Our System*

Before explaining the applied concepts we used, only mention that we decided to select an Expert System technology based in fuzzy logic using a software tool called ***FuzzyCLIPS,*** which lend us work with inaccuracy basics terms like the fuzziness and the uncertainty to represent inexact, erratic or equivocal information which is in the real world, because each person has a particular vision of the things.

The fuzziness appears when the limits of our information are not well-defined and not enough clear, so the uncertainty about this information grows.

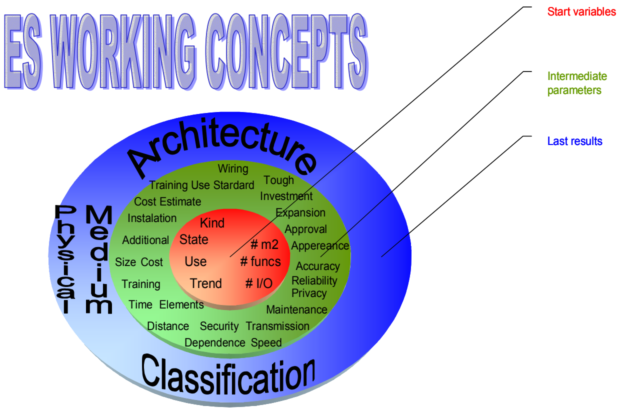


**Fig. 2.** Working Concepts

With this system we pretend to deduce some intermediate parameters to the domotics installation from some initial data or facts that the user provides. With these we can link the initial data with the final results that the Expert System will provide.

*B. Initial factors*

The selection of the most suitable domotics system for an individual building is made in base to the variables or beginning facts concerned to that installation and which is the user input in the system using the software program.

***Type of Building:*** Characteristic of the building, e.g. if it is a public building, a government installation, or a private house, etc.

***State of Building:*** Describes the building concerning to its age. It can be old, new or reinstated. It is a deterministic concept that designates the building.

***Use of Building:*** Destination of the installation. It can be a family home, a flat, a shop, a hospital, a school, a factory, etc.

***Number of functions required in the installation***: Domotics functionalities that the client demands. It is a fuzzy concept, so it can be high, medium or low according to the client needs. These factors are not very clear.

***Number of the resulting inputs and outputs:*** This is obtained automatically by the software program after the user inputs the basics characteristics of the building and the required functionalities. This is a fuzzy fact, because we have to make a division between high, medium and low. The inputs and outputs can be distinguished between analog and digital type.

***Number of square feet, number of floors:*** They are the parameters that the user inputs and which come fuzzy by means of their ambiguity treatment.

***Market Trend:*** It can be conventional or modern depending of client likes about the domotics systems or technologies (it is the only variable that doesn't depends of the building).

*C. Intermediate parameters*

With all this information, the Expert System will make a list of fuzzy intermediate concepts like:

***Standardization:*** It refers to the wish of having the most standard domotics installation considering the technologies and the communication protocols.

***Cost value:*** Subjective validation of the price importance.

***Installation value:*** Final price depending of the client desires.

***Maintenance:*** When we have installed the system, the number of periodical revisions that it will need for a normal operation.

***Enlargement:*** Capacity of functional growing of the installation.

***Use learning:*** Easy handling of the domotics system of the building.

***Installation learning:*** Easy installation of the domotics system of the building.

***Appearance:*** Select the components of the system according with the place where the system is installed.

***Strengths:*** Robustness to the possible adverse environmental conditions and system faults. As more functionality we use more worried about robustness we must be.

***Accuracy:*** Trust in the good system behaviour.

***Reliability:*** Trust in some brand or technology.

***Elements dependency:*** Relation between the elements. Is a fundamental skill when we have to select the system architecture.

***Transmission ratio:*** Speed of data sending for the physical medium.

***Time install:*** Time needed for install the system.

***Distance between elements:*** Position of the systems components, referring to the architecture and the state to maximize its operation.

***Installation size:*** It is obtained with the number and kind of inputs and outputs, the functionalities and the surface and the building plants.

***Transmission security:*** Reliability of data transmission, that the data sent reach their final destiny.

***Additional wiring:*** Needs of auxiliary electrical elements in the installation like power supplies, junction boxes, etc.

***Additional installation:*** Number of auxiliary generic components (PC's, visualization screens, etc) needed in the system.

***Energetic expenses:*** Energetic cost of the system.

***Acceptability:*** Receptivity of some brand or technology in the market.

***Privacy:*** Capacity of avoid hacking the messages and information that the components of the installation send between them.

*D. Final results*

The ES, using fuzzy technology, generates a list of final results for the feasible solutions. These results are organized according to the following aspects:

- System architecture
  - Centralized
  - Decentralized
  - Distributed

- Physical Media of the System
  - Twisted Pair
  - Electric Supply System
  - Radio-Frequency
  - IR
  - Optical Fiber
  - Field Buses

- Classification
  - Domotics Product
  - Domotics System
  - Proprietary System
  - System Management

According to the classification that we made of the different domotics systems, we explain each of them:

***Domotics Product:*** Small independent components that achieve one domotics function. An example can be a movement sensor which turns on the lights in the building entrance.

***Domotics System:*** It is upper level than a domotics product and it is thought for doing more functionality (more of one). They achieve some domotics functions and can be used in medium or large installations. Some examples are the EIB system, Lon-Works, etc.

***Proprietary System***: Specific kind of domotics system which are designed and produced exclusively for a company using own components and programming. They are some kind of black box. Some examples are the products of Robot, Domaike, etc.

***System Management***: It is the top level in buildings management. Like the proprietary system is a specialization of the conventional domotics systems that is applied to large installations like buildings with many plants or government buildings. They need extern elements like computes to control all the installation, gateways to monitor the different systems of the building, conditioned air, lighting, energetic expenses, etc.

## 3. The Structure

The generated software application has a well conceived structure, and allows the execution of the following steps:

***1. INITIAL DATA INPUT***
Information about the client must be introduced. There is the possibility of looking for previously stored clients. Also, the building must be divided in sections and in functional groups (i.e., rooms grouped by domotics functionalities).

***2. PHYSICAL STRUCTURE OF THE BUILDING***
The application must have clear information about the building: type of building, number of floors and rooms, square meters, and basic architectonic characteristics.

***3. ACTUATION FIELDS, FUNCTIONALITIES***
The client must be informed about the different possibilities offered by the technical management of the building. We will call these actuation fields or domotics functionalities.
Nevertheless, depending on the architectonic characteristics, the software application will establish a series of possible priorities for those actuation fields.

***4. I/O***
From the previous module, the application must have a good estimation of the number of the required input and output devices (sensors and actuators). With this step, we already can have an idea about the system to be used and about the rest of the needed elements in the installation.

***5. EXPERT SYSTEMS AND REPORTS***
With the experience (that we must represent in an expert system), the application must provide information about different technologies and architectures for developing the installation. Together with the intrinsic application priorities, some comparative reports will be obtained.

***EDITORS***
In all these steps, there must be the possibility of:

1) *Editing new functionalities and modes of actuation.*
2) *Editing new architectonic conditions.*
3) *Editing number and type of I/O, to cover the different particular needs.*

## 4. Key Concepts

Next, some basic concepts to understand the correct running of the program are explained.

### *A. Classes and Modes of Functionalities*

With the term *modes of functionalities* we mean the different forms of management in a house or building, i.e., the functions our domotics system must automatically control.

- Doors and Windows Automation
- Basic Security (Fire Detection, Intruders Detection...)
- Technical Security (Gas Leaks, Electrical Power Faults...)
- Medical Security
- Temperature, Air Conditioning Automation
- Lighting Control
- Hot Water Storage and Optimization
- Comfort Management
- Electrical Spending Management
- Ecologic Control
- Access and Periphery Control

Each of this groups present different performances or functionalities, depending on the control we require for the building. As an example, we illustrate the Lighting Management, with its functionalities:

**Presence Detection in general areas (**garden**,** stairway, garage, storage room, etc.)

*Garden lighting.*

With programmed time.
Depending on external luminosity.
Depending on solar time.

*Way through lighting*.

For personal comfort.
As a dissuasive element for intruders.
Accompanied of indoor acoustic warning.
Accompanied of outdoor alarm.

*Garage, storage room lighting.*

Manual switch on, time programmed switch off.
Manual switch on, no presence detection switch off.
Presence detection switch on/off.

*Presence detection in main doors.*

Automatic lighting.
Acoustic alarm in case of intruder detection.
Telephone call in case of intruder detection..

**Detection of the external light level** for automatic regulation.

**Manual lighting regulation**

By means of buttons in walls.
By means of remote control.

### *B. Functional Groups*

This concept is probably one of the most difficult to understand in the software application. It arises as an abstraction of funcionalities for a set of rooms in a building. And those abstractions can be associated to different and several domotics technologies.

We can think that in a house or building, the rooms on each floor, work area, etc. They can be grouped according to their domotics functionalities. However, this is not always true; there are some cases in which this division is inappropriate. The following example will clarify this concept.

"We must develop a domotics project for a four floor office building. In the bathrooms on the first and third floors, lighting, heating and hot water spending are going to be controlled automatically. In the bathrooms on the rest of floors, only heating control is needed. We must create two functional groups: one for the $1^{st}$ and $3^{rd}$ floor bathrooms, and the other for those on $2^{nd}$ y $4^{th}$ floors".

It can occurs that one room belongs to more than one group, and also that different groups are controlled by different domotics systems, due to economic or administrative reasons, or due to the client desire.

### *C. Inputs and Outputs*

At the time of implanting a domotics system, it is important to point up the fact that sensors and actuators define respectively the outputs and the inputs of the different elements that constitute the installation.

Their number and type (analog or digital) are also determining criteria in the selection of the particular technology to be installed. The software application generates these data from the functionalities demanded by the client.

## Conclusions

Results of this work will be shown in graphics and tabular way inside Microsoft Excel application.

TABLE II. Conclusions of this Work

| | |
|---|---|
| The problem is | Wide variety of domotics systems. Lack of standardization. Control functions in disagreement with the real demand. |
| *Affects to* | Architects, Electric Installers, Engineers / Consulters, Commercials, Final Clients |
| *Its impact is* | Domotics technology is generally unknown. Installations are expensive and do not fit the user needs. Installation errors. |
| *An ideal solution would be* | To develop simple and intuitive steps to optimize the selection of systems for technical management of buildings. |

Helping people involved in domotics work is our final purpose.


## Acknowledgement

We want to express our acknowledgement for their support to:

- ATD S.L.
- Dr. Santiago Lorente. Universidad Politécnica de Madrid.
- Reyes Poo Argüelles.
- Iván Rodrigo Buján Otero.
- FICYT, Fundación para el Fomento en Asturias de la Investigación Científica Aplicada y la Tecnología.


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