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| SDR | February 10  2016 | |
| Making Facility Management more intelligent and efficient. | | System Definition Review |

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| 1.0 | 07.03.16 | Arshad Shakil,  Badis Madani,  [Håkon Hedlund](https://www.facebook.com/hakon.hedlund)**,**  Zhili Shao |  |
| 2.0 | 11.04.16 | Badis Madani,  [Håkon Hedlund](https://www.facebook.com/hakon.hedlund)**,**  Zhili Shao | More detail about different solutions and preferred solution choosing process. |

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# Identification of design concepts

For the concepts of HVAC control system, we identified the possible methods can be used by users, based on our stakeholder requirements and some criteria, we choose three the most important ones as our potential solutions: Penal Control, App Control, Remote Control.

## Panel Control

In this concept, a control panel will be used as the way for users to access the HVAC control system. Users can set the value of temperature, humidity, CO2 level they prefer through this panel. Sensors, which are assembled in one specific closed space like office or classroom, will collect the indoor environment data and translate them to the controller inside the panel. After calculating the regulation data and sensor data, the adjusting data will be created and translated to actuators like motors, valves, and dampers of HVAC system to change the indoor environment.

## Remote Control

Remote Control solution is similar with panel control, it contains a remote controller and a receiver box like a TV remote control system. Users can use the remote controller to send regulation date to the receiver box. The receiver box should contain a microprocessor to calculate the data from user and sensors, then send the result to actuators to change the indoor temperature, humidity, and CO2 level.

## App Control

Compared with the previous solution, App Control solution use the latest high technology and have different system structure with them. All sensors and actuators will be connected to a centralized server, this server will also provide access for mobile app or website app. Users will input the regulation data through the app, then the server will receive the data and calculate with data from sensors. After calculation, the result will send to actuators to change the indoor environment.

# Selection of preferred design concept

## Criteria

Based on the stakeholders’ requirements and references of former projects, we decided crucial criteria for our design concepts:

**Initial cost** - Cost of implementation and deployment of the solution

**Life cycle cost** - maintenance, electrical cost, etc. on lifetime

**Easiness of use** - Is solution user-friendly

**Easiness of installing** - is it easy to install the solution to the exist HVAC system

## Pugh matrix

The Pugh matrix gives a general suggestion to the preferred design concept.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Solutions** | | |
| **Criteria** | Panel | App | Remote Control |
| Initial cost | - | s | - |
| Life-cycle cost | + | - | s |
| Easiness of use | + | s | + |
| Easiness of installing | - | s | - |
| Σ+ | 2 | 0 | 1 |
| Σ- | 2 | 1 | 2 |
| Σs | 0 | 3 | 1 |
|  | **“+” represents performance better than required** | | |
|  | **“-” represents performance lower than required** | | |
|  | **“s” represents performance as required** | | |

Table 3.2.1 Pugh matrix evaluation

The NovoFM team members worked together on rating different solutions according to each criteria, by giving “+”, which represents better performance than required, “-” represents lower performance than required and “s” if the performance as required. As seen from the Table 3.2.1, the selection method suggests panel as the best solution.

## AHP matrix

Because of the difference in the importance of the criteria, the Pugh matrix is not enough for a well-evaluated concept selection. To be more certain it’s the correct concept, an AHP matrix is used. The AHP matrix is included in an attachment to this document, and only the most important results will be showed in this part.

**Criteria weights**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Initial cost | Life cycle cost | Easiness of use | Easiness of installing |
| Initial cost | 1 | 0,2 | 0,2 | 1 |
| Life-cycle cost | 5 | 1 | 0,3333 | 5 |
| Easiness of use | 5 | 3 | 1 | 7 |
| Easiness of installing | 1 | 0,2 | 0,1429 | 1 |
|  | 12 | 4,4 | 1,676190476 | 14 |

Table 3.3.1 Criteria weights

**Initial cost**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Decimal Equivalents | | | Normalized Weights | | | Row | Average |
| Initial cost | Panel Control | App Control | Remote Control | Panel Control | App Control | Remote Control |
| Panel Control | 1,0000 | 0,2000 | 3,0000 | 0,1579 | 0,1429 | 0,3333 | 0,6341 | 0,2114 |
| App Control | 5,0000 | 1,0000 | 5,0000 | 0,7895 | 0,7143 | 0,5556 | 2,0593 | 0,6864 |
| Remote Control | 0,3333 | 0,2000 | 1,0000 | 0,0526 | 0,1429 | 0,1111 | 0,3066 | 0,1022 |
|  | 6,3333 | 1,4000 | 9,0000 | 1,0000 | 1,0000 | 1,0000 | 3,0000 | 1,0000 |

Table 3.3.2 Initial cost

**Life-cycle cost**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Decimal Equivalents | | | Normalized Weights | | | Row | Average |
| Life-cycle cost | Panel Control | App Control | Remote Control | Panel Control | App Control | Remote Control |
| Panel Control | 1,0000 | 0,2000 | 3,0000 | 0,1579 | 0,1304 | 0,4286 | 0,7169 | 0,2390 |
| App Control | 5,0000 | 1,0000 | 3,0000 | 0,7895 | 0,6522 | 0,4286 | 1,8702 | 0,6234 |
| Remote Control | 0,3333 | 0,3333 | 1,0000 | 0,0526 | 0,2174 | 0,1429 | 0,4129 | 0,1376 |
|  | 6,3333 | 1,5333 | 7,0000 | 1,0000 | 1,0000 | 1,0000 | 3,0000 | 1,0000 |

Table 3.3.3 Life-cycle cost

**Easiness of use**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Decimal Equivalents | | | Normalized Weights | | | Row | Average |
| Easiness of use | Panel Control | App Control | Remote Control | Panel Control | App Control | Remote Control |
| Panel Control | 1,0000 | 5,0000 | 3,0000 | 0,6522 | 0,4545 | 0,7143 | 1,8210 | 0,6070 |
| App Control | 0,2000 | 1,0000 | 0,2000 | 0,1304 | 0,0909 | 0,0476 | 0,2690 | 0,0897 |
| Remote Control | 0,3333 | 5,0000 | 1,0000 | 0,2174 | 0,4545 | 0,2381 | 0,9100 | 0,3033 |
|  | 1,5333 | 11,0000 | 4,2000 | 1,0000 | 1,0000 | 1,0000 | 3,0000 | 1,0000 |

Table 3.3.4 Easiness of use

**Easiness of installing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Decimal Equivalents | | | Normalized Weights | | | Row | Average |
| Easiness of installing | Panel Control | App Control | Remote Control | Panel Control | App Control | Remote Control |
| Panel Control | 1,0000 | 0,2000 | 1,0000 | 0,1429 | 0,1429 | 0,1429 | 0,4286 | 0,1429 |
| App Control | 5,0000 | 1,0000 | 5,0000 | 0,7143 | 0,7143 | 0,7143 | 2,1429 | 0,7143 |
| Remote Control | 1,0000 | 0,2000 | 1,0000 | 0,1429 | 0,1429 | 0,1429 | 0,4286 | 0,1429 |
|  | 7,0000 | 1,4000 | 7,0000 | 1,0000 | 1,0000 | 1,0000 | 3,000 | 1,0000 |

Table 3.3.5 Easiness of installing

**Final result**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Initial cost | Life cycle cost | Easiness of use | Easiness of installing | Alternative Weighted Evaluation |
| Criteria Weights | 0,0799 | 0,3000 | 0,5488 | 0,0714 |
| Design Concepts |  |  |  |  |
| Panel Control | 0,2114 | 0,2390 | 0,6070 | 0,1429 | 0,4319 |
| App Control | 0,6864 | 0,6234 | 0,0897 | 0,7143 | 0,3420 |
| Remote Control | 0,1022 | 0,1376 | 0,3033 | 0,1429 | 0,2261 |

Table 3.3.6 Final result

This evaluation shows panel as the most preferred solution. It had a consistency ratio of 0,063377. This is below 0,1 so the evaluation has been consistent.

## Preferred design concept

Both the Pugh and AHP matrix points out panel as the best solution. This was also the most preferred solution of the users as shown in the survey analysis. So the preferred design concept will be Panel Control solution for our project, more details about this design concept is stated at the Identification of Design Concepts part.