Code Camp on Home Automation

Office automation

Emil Hedemalm, Valentin Poirot, Atefe Maleki, Joseph El Khoury, Carlos Martinez, Mustaqim Rahman

Abstract

In this report we take a look at home automation equipment and how it can be applied in an office environment. We set up an imaginary scenario where an office has some optimizations to do, and we present some methods of increasing efficiency. This includes detecting open windows, and detecting employee presence overall. When windows are left open, a notification system sends notifications about it, and when employees leave the office electricity is turned off for all equipment and the temperature is decreased. In the calculations we assume that equipment can be turned off 12 hours a day, saving the company around 170 to 280 euros per employee per year. Taking into account the price of the automation equipment, the solution becomes profitable already after 1 year, with up to 10’000 or 20’000 euros being saved over a 5 year period.

1. Introduction

Rapid advancement in ICT, the features and ease of use they provide to the users increase the expectations. It is not beyond thoughts to be able to control our house or office with the smart phones or portals from distance. They enhanced the comfort and help us in this fast-paced world with repeating tasks. But there is one question remaining that how these technologies can be beneficial and how they can affect our lifestyle.

In the “Home Automation Code Camp 2016” we, “Awesome Perccomies”, use the home automation devices under supervision of Prof. Dr. Olaf Drögehorn to make our living environment smarter.

In the next section we present the scenario. We then proceed with describing our solution, what it entails and calculate the possible savings. The use of scripts in the FHEM setup is also described here. Finally a small conclusion and references are listed.

2. The scenario

Our scenario is an office environment where we want to influence and educate the employees to maintain good working habits. This includes reminding to close windows, etc. The idea is also to automate shutting off power and turning down heating when the office is empty, and turning it on in the morning again in order to reduce energy consumption.

In our scenario we use the open-source FHEM home automation management server which helps coordinate sensors and regulating devices such as lamps, power, heating, etc. It also integrates a default front-end but more front-ends can be enabled or integrated later on.

3. The Solution

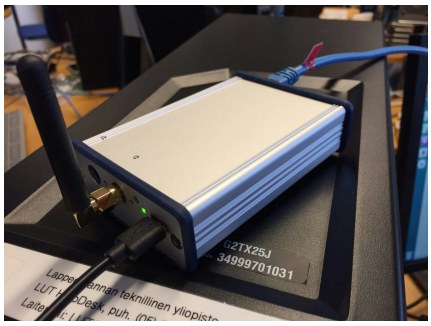
3.1. Features

We will use window sensors to check if windows have been closed properly (checked at midnight), and if they aren't emails are sent to the responsible persons.

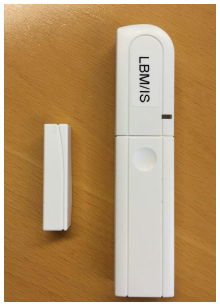
For the heating and power regulation by default heating will lower from 20 to 18 degrees at 19:00 and power will be turned off for all other devices (computers, lighting, etc.) and turned on at 7:00 again. If there are still employees left in the building, a motion sensor will ensure that power and heating remains on until they leave. This is checked via a motion sensor that evaluates employee presence every half-hour. Over the weekend and holidays the same policies as in the nights are applied.

3.2. Devices we've used

We used the Radio-3 (pre-configured Debian Linux) as our main server which provide us a centralized control plane to connect all the devices and sensors.



For sensors and regulating devices we used: a Thermostat FHT 80b, a motion detector, a door/window open/closed sensor and a switch for electric socket.



3.3. Estimated savings

3.3.1. Electricity

We measured the power consumption of equipments present during the code camp which are usually used in an office environment. Per employee, we obtain the following electricity consumptions: 55W for a light,14W for a computer screen, 85W for a desktop computer, running.

The above totals to 154 Watts, which over a 12-hour period equates to 1824 Watt-hours of possible savings nighttime per employee (assuming they would normally leave all devices on).

For calculating the price and CO2 emissions equivalent of such a saving we have the following formulae…

$$totalWattHoursPerEmployee = 1824\ Wh * 365 = 665760\ Wh \approx 666\ kWh$$
$$pricePerEmployee = 666\ kWh * 0.0637\ €/kWh\ (Finland) \approx 42.4242\ €$$
$$co2SavedPerEmployee = 666\ kWh * 0.2254\ kgCO2/kWh\ (Finland) \approx 150.088\ kgCO2$$

Finland references numbers taken from Brander et al[1] and Eurostat (medium-sized industries, 500 to 2000 MWh yearly consumption, excluding VAT[2])[3]. Tax rate in Finland is 24% for

[1] M. Brander, A. Sood, C. Wylie, A. Haughton, J. Lovell, Technical paper|electricity-specific emission factors for grid electricity, (2011)
http://ecometrica-cms-media.s3.amazonaws.com/assets/media/pdf/electricity_factors_paper.pdf
[2] Eurostat, Eurostat statistics explained, *Energy price statistics*, 2015
http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_price_statistics#Electricity_prices_for_industrial_consumers
[3] Eurostat, *Electricity prices by type of user*, 2015,
http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=ten00117&language=en

electricity[4], which would lead the total saving per employee to around: $42.4242\,€ * 1.24 = 52.6060\,€$.

3.3.2. Heating

Using setback during nights for thermostats savings can be up to 10~15% (D. Quentzel, ASHRAE J), and with using certain classifiers of temperature and comfort reductions up to 20% could be found (Hamdi M., IEEE).

Using the reference figures of 1.23 euros in price per square foot per year (National Grid), the mean of 890 square feet usage per employee (US EIA), gives the of total cost of 1094.7 euros per employee per year without savings.

Possible savings should therefore be in the range of 109 to 219 euros (10~20%) per year per employee.

3.3.3. Cost of solution

In order to identify the viability of our solution, we calculate its cost. Each product used for the solution costs:

- FS20 PIRI-2 Motion detector: 39.95 Euros, can use one for every k employees
- Thermostat FHT 80b: 69.95 Euros
- FS20 Window open-sensor FHT 80TF-2: 69.95 Euros, per employee
- FS20 Wireless switch 1-channel Adapter, 32.99 Euros, per employee
- The server Radio-3: estimated at 80 Euros

We obtain a standard cost of 149.95 Euros, plus an additional cost between 102.94 and 142.89 Euros per employee. For example, for 15 employees, our solution will cost 149.95+15*(69.95+32.99)+5*39.95 = 1893.80 Euros. (considering one motion detector for every five employees and one window sensor per employee).

3.3.4. Total savings

Based on our previous results (52€ per employee for the electricity, 109 to 219€ per employee for the heating), we can deduct that our solution will permit to cut expense between 170 and 280 Euros per year per employee.

Taking again the example from before, with 15 employees, a company can save between 2550 and 4200 Euros per year. Considering the cost of our solution of 1900€, the cost of the solution would be refunded within one year. Over a 5 year period the company would gain 12750€ to 21000€, which subtracting the initial cost would yield a net profit of 10850€ to 19100€.

[4] Vero Skatt, *Value added Tax*, 2013, https://www.vero.fi/en-US/Companies_and_organisations/VAT

3.4. Scripts used

Definition of our sensors:

```
define FS_Switch FS20 24242424 1111
define FHT_Group5 FHT 3133
define MotionSensor_Group5 FS20 815a 00
define Window_sensor_Group5 CUL_FHTTK b9b7d6
attr Window_sensor_Group5 model FHT80TF-2
```

Morning script: enabling power and setting temperature to 20°C

```
define morningSchedule at *07:00:00 set FHT_Group5 desired-temp
20.0;
set FS_Switch on
```

Evening script: setting temperature to 18°C, setting a timer to look for movement

```
define eveningSchedule at *19:00:00 set FHT_Group5 desired-temp
18.0;
define timer at +00:30 trigger HeatingMacro
```

Window script: if a window is open, we send a mail

```
define WindowAtNight at *00:00:00 IF ([Window_sensor_Group5] eq
"Open") (
{
 DebianMail('mail address','Window','The window at the office was
left open at night.','');
 }
set FS_Switch on-for-timer 10
)
```

Macro to stop power and lower temperature during night if nobody is in the office

```
define HeatingMacro notify HeatingMacro set FHT_Group5 desired-temp
15.0;
set FS_Switch off;
```

```
{
  DebianMail('mail address','Heating','The heating in the office
was turned off at this moment.','');
}
```

After 7pm, is somebody is moving, we reset the timer to 15min

```
define DetectMovement notify MotionSensor_Group5 IF
([MotionSensor_Group5] eq "on")
( set timer modifyTimeSpec 00:15 )
```

4. Conclusion

Looking at the cost analysis it seems like Office Automation really is essential to consider specially due to the fact that employees are not responsible to pay for the energy costs. Of course it will vary more depending on each company, but possible savings could be both larger and smaller than our projected one. We have also just looked at mainly 2 things - the savings from adjusting electricity usage and applying heating adjustments during nights. The idea to keep windows and doors closed may also be relevant to heating and cooling systems, but was not analyzed further as assumptions on the issue are harder to make.

References

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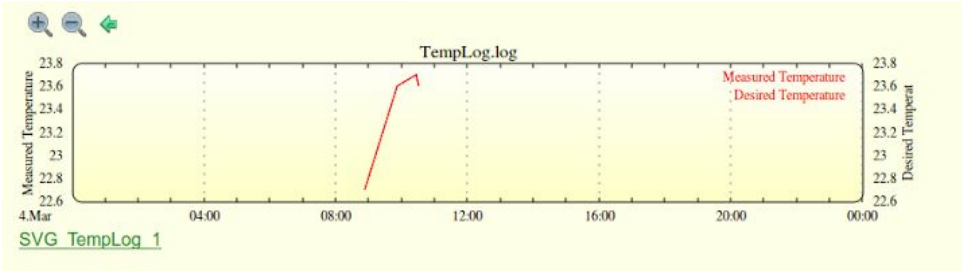
Appendix

Temperature data from FHEM server



Scripts and sensors from FHEM server