Smart Study Room (SSR)

While the execution of the "*fremdriftsreform*" by the government has resulted in public savings, the reform has also resulted in tighter, longer, more compact and stressful schedules for the students with many long days spend on the universities, working alone or in groups, trying to complete various school tasks, such as assignments, homework, bachelors and master thesis. As a student myself, attending third semester on the Master of Science in engineering, in technology-based business development at the university of Aarhus in Herning, I do recognize the long days on the school's cadastral.

With the long days on school working in small study rooms, the quality of the indoor climate tends to decrease throughout the day, resulting in poor mental health and deficient quality of work done, due to breaks and ventilation not being executed by the students.

The focus of this paper is to design a room with features that enhances the quality of work the students are carrying out, when working on the university's cadastral. This includes the implementation of Internet of Things (IoT) and Smart Assistants such as Google Assistant powered by Artificial Intelligence (AI). The work within this report is based on Aarhus University in Herning and shall be part of the Smart Campus Herning challenge.

Technologies

The following technologies presented in table 1, is based on *"Arbejdsmiljø i Danmark"* for optimal indoor climate. The suggestions by "*Arbejdsmiljø i Danmark"* has been translated into a set of SSR guidelines with the aim of keeping an optimal indoor environment throughout the day.

SSR guidelines	Smart device (IoT)	AI	Cost
Temp. between 20-22 degrees centigrade	Netatmo smart radiator		1499 DKK
Temp. cannot exceed 4 degrees centigrade over a day	Netatmo smart radiator		-
Keep room tidy & clean	N/A	Google Home Mini	381 DKK
Airing regularly	RF Remote window opener		2000 DKK
Noise levels below 85 dB(A)	Netatmo healthy homecoach	Google Home Mini	749 DKK
Adoption of artificial lights to prevent headaches	Philips Hue White Ambiance		800 DKK
Formaldehyde levels below 0,15 mg per m^3 air	Netatmo healthy homecoach		-
Air humidity between 25 – 60 %	Netatmo healthy homecoach		-
CO_2 levels below 0,1%	Netatmo healthy homecoach		-

Table 1 - Smart Devices

Due to the size of the report the smart devices will not be technologically explained. The total cost of implementing the smart devices is (1499 + 381 + 2000 + 749 + 800) = (5429 / 1,25) = 4343 DKK. It is important to mention that some of the devices are part of a "starter pack" with a bridge that allow mesh network – thus it will be cheaper the more SSR implemented.

Digital Architecture

To make the SSR more tangible and to show how the digital flow is, the digital architecture is presented below. The flow diagram shows how the components are working together throughout a random day at the SSR on AU HIH and is explained beneath figure 1.

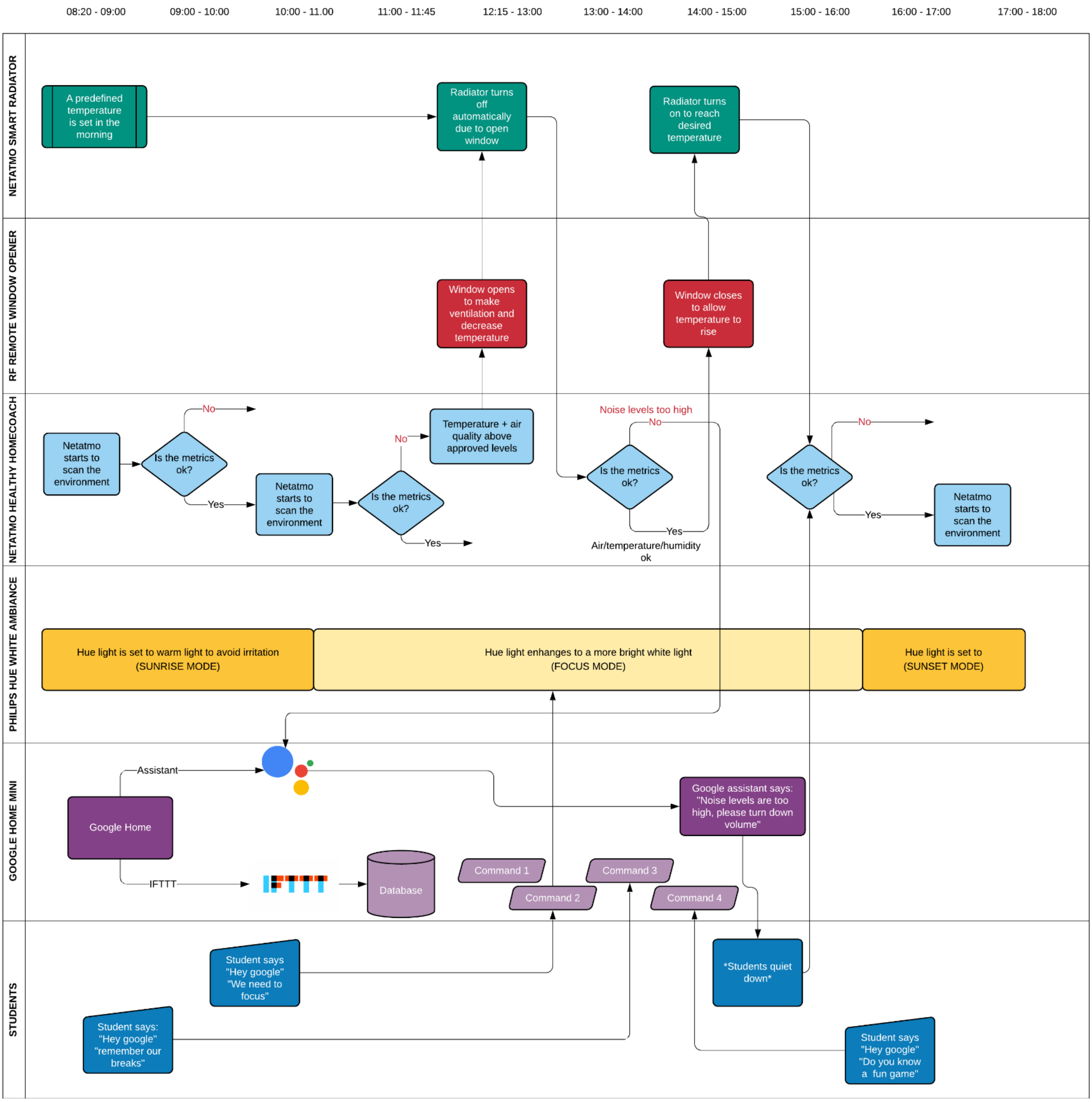

Figure 1 - Digital Architecture

Upper three technologies

Because the different components are working concurrently, a brief description of the tasks in the flow diagram is explained. The heart of the room is the Netatmo Healthy Homecoach – it keeps the room at an optimal environment, where it continuously scans the environment, if the metrics (temperature, humidity, noise level and air quality) is acceptable, nothing happens. However, if some of the metrics are off, for instance the temperature and air quality, a signal is send to RF Remote Window Opener to open the window and ventilate the room, thus decreasing the temperature and increasing the air quality. Meanwhile the Netatmo Smart Radiator senses that a window has been opened and will turn off mediately. The Netatmo Healthy Homecoach will then scan the environment again. Ultimately the environment will return to the optimal metrics and the window closes and the radiator starts again.

Lower two technologies

Simultaneously with the upper technologies, the students have entered the room. To ensure breaks are kept regularly, the students initiates a predefined command 3 via the application IFTTT (if this then that), which is a app that allows a predefined command to be executed when a key sentence is executed. In this case, the key sentence is *"Hey google" "remember our breaks"*, which sets a reminder for the Google Home Mini every hour saying: "*Hey students, remember to get some fresh air, go for a walk".* At 10 AM the student starts to get tired due to the warm light from the Philips Hue – another command 2 is then executed via the IFTTT app, that now reacts to the key sentence "*we need to focus",* which causes the Philips Hue light to change the settings to a brighter light that ensures better concentration. At 2 PM the noise level reaches non-acceptable levels – this causes the Netatmo Smart Homecoach to react and sends a message to the Google Home Assistant telling the students to turn down the volume. At 4 PM the students become bored and need a fun game to give them more energy – they ask the Google Home Mini if it knows any fun games. Via the predefined command 4 from the ITFFF app, a fun game initiates.

The next section contains the engineering setup, which illustrates how the SSR should be designed with the various smart devices, and how they interact with each other on a digital level.

Engineering Setup

Figure 2 illustrates a regular 6-person room at AU Herning. These are mostly located at the ground floor and second floor on the east wing of the school. The room contains six chairs and a table, in the lower left corner is the main entry/exit door placed which leads directly to the hallway, in the right site of the room is a whiteboard placed next to the google home mini. In the opposite direction is the window and door that leads to the outside.

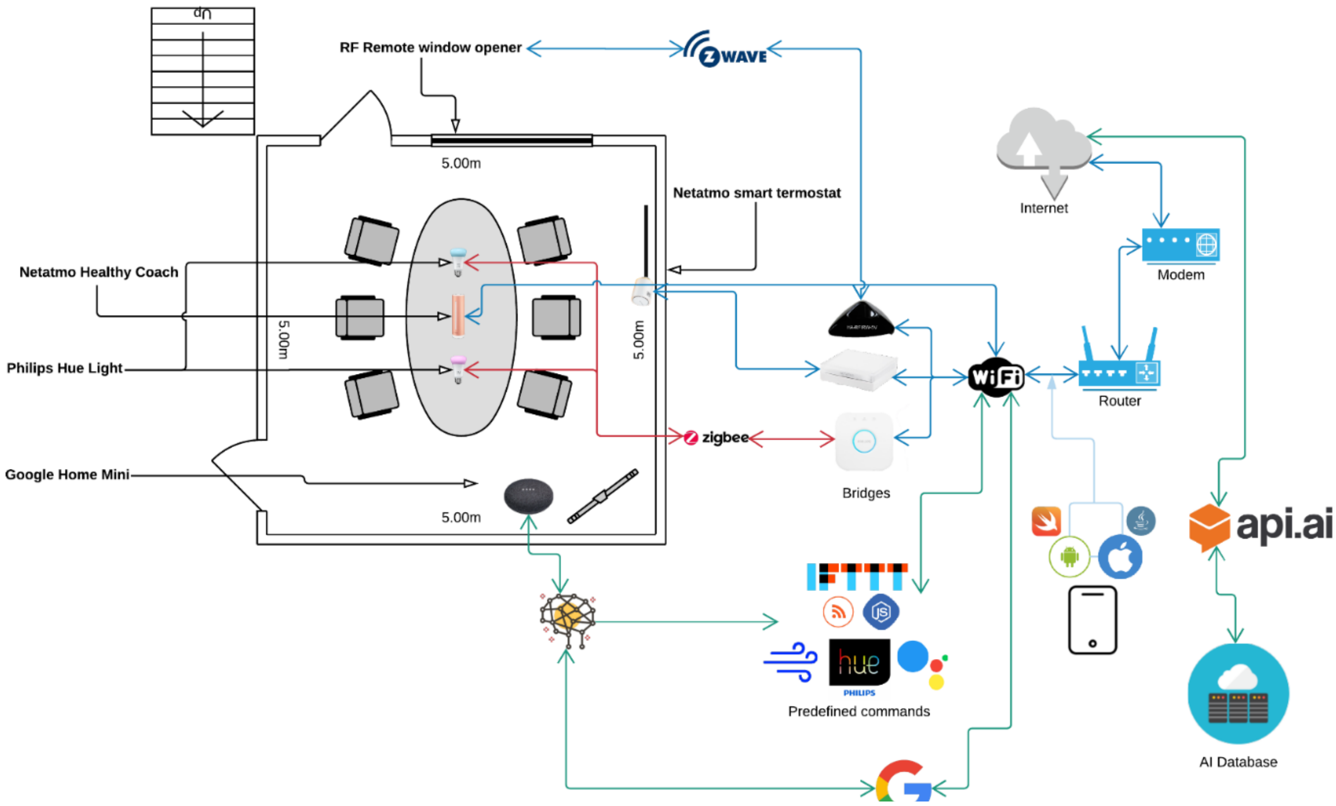

Figure 2 - Engineering setup

The Netatmo Healthy Coach shall be installed on the table in the room. The device is connected to the router via build-in Wi-Fi 802.11 b/g/n compatible (2.4GHz) network. The two Philips Hue Light-bulbs are connected from the lamps to a bridge via ZigBee, which is a IEEE 802.15.4-based specification suitable for personal networks. The Philips bridge is then connected to the Wi-Fi and act as the control panel for the Hue bulbs, thus "talking" to the bulbs, turning them on and off etc.

The hub is connected to the router via a ethernet cable. The Netatmo Smart Thermostat is, just like the healthy coach, connected to the Wi-Fi, it is however connected via the Netatmo bridge, which connects with the Wi-Fi wirelessly, thus does not need a ethernet cable plugged into the router. The RF window opener is connected to the wired wall switch to add power. To connect it to the Wi-

Fi a Z-Wave signal goes from the RF remote device and to the bridge (RT Smart Hub RF-IR Wi-Fi) to make it compatible with the other smart devices.

The last smart device is the Google Home Mini, which is powered by the Google AI "Google Assistant". The device is wirelessly connected to the Wi-Fi via a build in Marwell Avastar 88E8887 WLAN/BT/NFC SoC. To execute orders the Google Home Mini can go one of two ways, either it responds to a predefined command in the IFTTT app, that allows "if x, then y", for instance "if google assistant, then Philips Hue", which can be broken further down to "if "*hey google, we need to focus*", then *set Philips hue to focus mode*", which is extremely helpful to make the SSR execute a specific operation with the least amount of energy. The other way the Google Home Mini can go, is via the integrated Google Assistant, which is a AI driven smart assistant. Here the students can ask "*what's the weather like", "set an alarm every hour"* or "*Call our Supervisor"* to name a few. To allow the students to interact with the AI assistant in Google or IFTTT, the technology needs to be setup to api.ai, which is a software provided by Dialogflow, that allows customers to setup example dialogs for possible topics, which Dialogflow uses in their machine learning algorithm, to better understand the students.

Future directions

As part of making the SSR more personalized, a suggestion could be to develop an application to be installed on the students smartphones, both on Android via Android Studio (Java), and iPhone via Swift (Swift) – the application should integrate the software from all the different devices, hereby centralizing the controlling of the SSR –making it possible for the students to design the digital aspect of the SSR completely by their preferences. This includes customizing the Philips Hue lighting to different settings, editing the temperature that the window should open, to personal preferences, and lastly to add customized IFTTT commands directly from the app.

Furthermore, should the three bridges/hubs be replaced with the Wink Hub 2 in order to centralize the technologies. The Wink Hub 2 supports Bluetooth, ZigBee, Z-Wave, Wi-Fi, Lutron & Kidde – and is therefore suitable for most technologies running on these wireless protocols.

After implementation of the SSR and proof of concept, I suggest making the software open-source while inviting students from lead tech universities, such as SFIT, CALTECH, Cornell and MIT, to tweak and configure the SSR – hereby expanding the possibilities to other smart devices such as image recognition, monitors, robots, alarms etc. This would also expand the eco system of the SSR making it possible to develop a community of SSR users to personalize and share their favorite settings to other users.