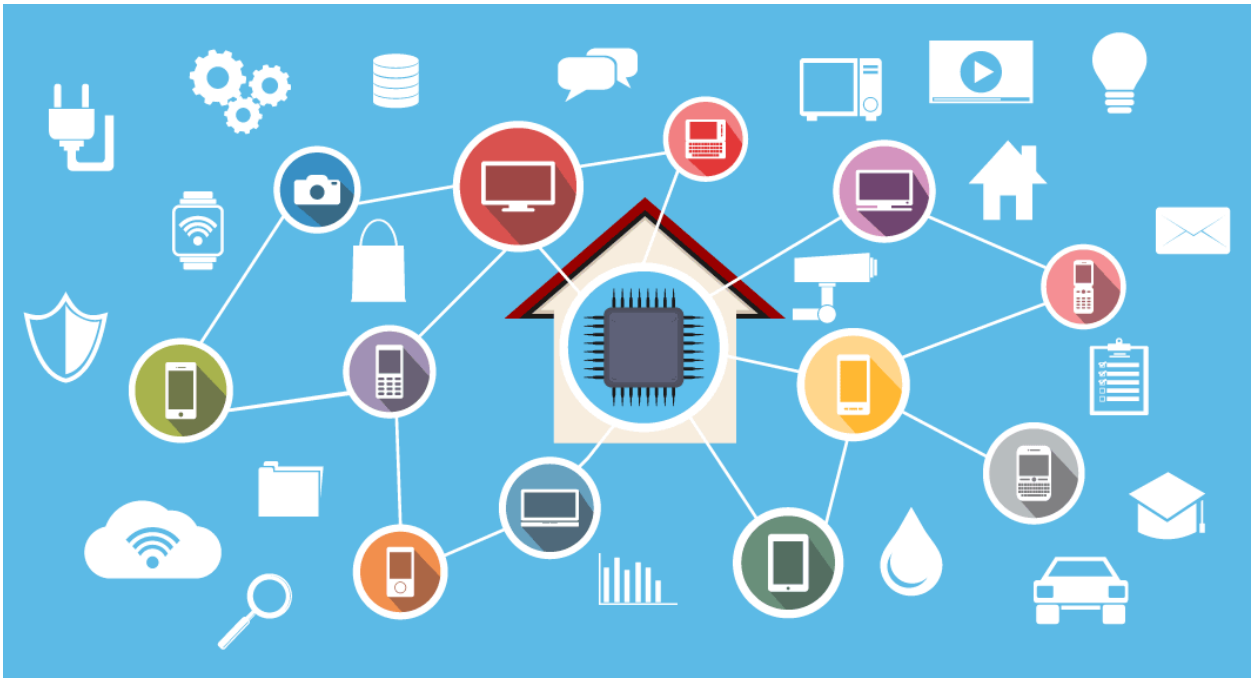
My connected environment



Picture available at: Exciting, new IoT SoC coming soon thanks to Microsoft-MediaTek partnership – IoT Times (eetimes.com)[Accessed, 2021]

When I think about 'Connected environments' the first thing that comes to mind is the advert I saw on the television the other day wherein, a differently abled person commands his Alexa smart home device to start his morning routine. Alexa routines*(Amazon,2021)* clubs one's regular activities together into a routine which can be triggered by a single command like "Alexa, start my day". I casually browsed to find a number of videos*(Youtube, 2021)* on interesting suggestions on setting up a morning routine which includes things like brewing one's morning coffee, doing yoga, playing music and other things. In terms of connected environments, this is a quintessential example of the namesake. There are more than one take-aways from this advert.

1. A device which brings together other smart devices has now successfully penetrated the retail market not just for the coterie of technophiles but the general population. Additionally, the demand for such features automatically begs an assumption that people now have multiple smart devices which have become readily available and affordable.
2. An important, and arguably most popular, utility of the smart devices is the ability to personalize based on individual choices. The skill of observation

and learning is akin to human behavior and gains quick acceptance from the user.

3. Products like Alexa and Google home have become quite successful in removing a lot of the skepticism involving smart devices. This has opened the door to more smart devices to come in future.

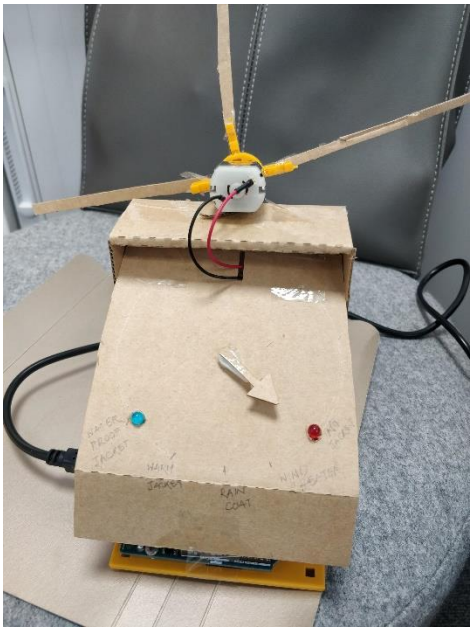
Admittedly, smart home technology is one of the most successful implementation areas of the connected environment in consumer sector and has witnessed a steady growth through the years. A market research report *(Mordor intelligence,2020)* corroborates this observation stating that while the number of consumer-IOT devices was 5.4 billion back in 2018, it now stands at 7.9 billion and predicted to reach 11.4 billion in 2025. It also reports that "As of September 2019, Amazon Alexa's skills stood at 100,000, which was at 80,000, back in December 2018". This increase in Alexa's skills can be attributed to numerous small IOT companies/standalone devices that are now compatible with Alexa.

But this is not to say that IOTs devices are only limited to personal or home devices. While we have been busy reading about the latest wearables and smart home assistants in adverts and newspapers, weather monitoring systems, water monitoring sensors and CCTV cameras around the corner have been silently gathering data from the environment. Governments have started investing more in building the infrastructure and the technology necessary to transform their cities. One such example is the CityVerve project *(Case study, The University of Manchester)* which was undertaken to leverage IOT technologies and convert Manchester in UK into a smart city in major areas of public governance like travel, healthcare etc. These are the sectors where the personalization aspect of connected devices could prove especially beneficial. As an example, Manchester introduced personalized travel planners for daily commuters based on individual travel history and preferences. It doesn't seem too far away when these changes would become ingrained in one's daily life. Taking an excerpt from a whitepaper published on IOT Ignite, "We can say with ease that the Internet of Things will become successful once it becomes completely invisible." *(Towards the invisible IOTs, 2016).*

Based on my view of role of IOT devices in the connected environment, I built two projects through the duration of 'Connected environments' course.

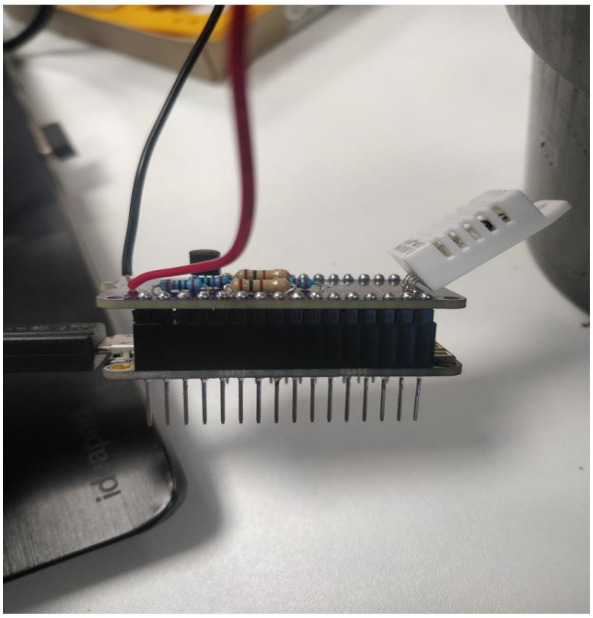
The first project, the Jacket guide*(Abhipsa kar, GitHub, 2021)* was created to streamline my morning routine, similar to what we discussed in the beginning of

the post. I usually spent a lot of time deciding what jacket to wear when I stepped out for the day. I would blame this on the fact that I was new to the country and to its weather patterns which changed frequently. I decided that if I could sense the outside humidity and temperature, I could make a quick decision. But this wasn't enough. I needed an easy visualization which I could just glance at to make a choice.



Displayed alongside is a picture of the prototype of the Arduino based device. All the components were picked from the basic Arduino Uno IOT kit provided to us. While it is enclosed in a cardboard box and works well indoors, it is easy to note that this design would not sustain the outdoors where the device was originally meant to be deployed. Also, making the prototype on a breadboard has made the inner circuit fragile and prone to erroneous readings on the sensor. An important point of discussion in the device is the creation of baselines, which is specific to everyone. While a temperature of 15 degrees might get me running for my jacket, it may not be enough to warrant a winter gear for the local population.

The second project, the Plant monitor *(Abhipsa kar, GitHub, 2021)* used the same principle of weather monitoring through multiple sensors. While the first setup had an actuator to process the information and perform an action to provide me with a choice, the second setup monitored the health of the plant and regularly pushed the data on to an MQTT server and updated on a dashboard for the plant-owner. It is noteworthy that creation of baselines is an important process in this setup too, considering that each plant has unique requirements.



The above shows the prototype of the plant monitor SoC working with a Raspberry Pi for internet connection. Even though the design was considerably sturdier than the jacket guide because it was soldered, the open sensors still posed a threat. Additionally, the loose ends of the soil sensor were prone to be tampered, disturbing the baselines. Although this plant monitor is a standalone IOT device, the data collected from the device is collected along with other plant monitors in the workshop to display on a common dashboard. This works well for a home project, but one rarely owns just one plant. If this setup were to be implemented on a larger scale, the design must be reconsidered in terms of cost and power. Additionally, it would make sense to make the network wireless. Low power Wireless networks like LoRa, Bluetooth and HaLoW could be used to connect the plant monitors and a gateway device could be added to push the data. Oh but wait! Once we start adding more IOT devices to the network, the data stream starts getting heavier. Now, we must start thinking about processing on the IOT device to reduce the data stream on the network, perhaps an algorithm to compress/remove repetitive data or use edge computing to decide the next action based on the data.

In both above setups, the sensor readings rely heavily on the environment conditions in their vicinity as is the case with all sensor setups. Ironically, the pitfall of IOT networks is that they require human supervision to verify their performance even though they are made to replace manual supervision. The level of supervision required varies with the objectives of the system and its level of accuracy. When my ‘Jacket guide’ provides faulty readings, I would possibly be drenched in the worst case because it suggested ‘No jacket required’ when it was

supposed to rain. On the other hand, consistent faulty moisture readings (due to wrong placement of the moisture sensor, perhaps) in my plant monitor setup would result in the plant dying. One might ask why it was necessary to take sensor readings on site rather than fetch it from the nearest weather station. My answer is: Microclimates! Additionally, multiple sensors on site usually reduce the margin of error by averaging the readings.

I found that it is useful to analyze the design considerations like size, blueprints and user experience early on in the project to avoid rework at a later stage.

Neither of my projects used or collected any sensitive data from user and did not require to be hidden from other users. In fact, it made sense to make this data accessible to the public owing to its nature. However, while building an IOT device, it is pertinent to understand the end user's expectations in terms of security. For example, it is easy to understand why the data from CCTV cameras in 'Queen Elizabeth Olympic' park is protected (Prof. Duncan Wilson, Lecture, 2021). Home automation systems like Alexa have gone a long way to provide users control over their data by being transparent about the data(Amazon,2021) that they collect and process using opt-in and opt-out categories of data collection. Even so, it was a bit unsettling to see so many unlabeled, inconspicuous devices in the 'IOTs in the wild' workshop that we know nothing about (Connected Environments 2021, Lecture, 11 October). In my opinion, the way forward is to be completely transparent and informative about these connected devices. This would go a long way to instill confidence in users.

The forte of connected devices is to sense and automate. It can automate everyday activities (daily routines, plant monitoring, transit planning) as well as sense the extra sensory (health parameters, soil nutrient content). If deployed with adequate accuracy and security, these devices could act as bridges to the environment.

References:

1. *https://www.amazon.com/alexa-routines/b?ie=UTF8&node=21442922011 [Accessed 11 Nov,2021]*
2. *alexa daily routines - YouTube[Accessed 11 Nov,2021]*
3. *Consumer IoT Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence (2020)*
4. *The CityVerve Project | Digital Futures (manchester.ac.uk)[University of Manchester]*
5. *IOT Ignite 2016. [Online],Towards-the-Invisible-IoT, Available from: Microsoft Word - Ardic_WhitePaper_1.docx (iot-ignite.com) [Accessed 11 Nov,2021]*
6. *Abhipsa kar, The Jacket Guide, 2021 -casa0014/The Jacket guide at main · AbhipsaKar/casa0014 (github.com)*
7. *Abhipsa kar, The Plant monitor, 2021 -casa0014/Plant monitor at main · AbhipsaKar/casa0014 (github.com)*
8. *Prof. Duncan Wilson, Connected environments, Lecture, 13 October 2021*
9. *Alexa Privacy – Learn how Alexa works | Amazon.com[Accessed 11 Nov,2021]*
10. *IOTs in the Wild Workshop, Connected Environments 2021, Lecture, 18 October*