# Project Brief

In this Hackathon, our brief was to reduce waste through usage of an Arduino incorporating IOT concepts in the city of Tempe, Phoenix, United State and Belfast, Northern Ireland.

# Project Objective

In this project, we set out to reduce waste through adaptive resource usage. We focused on waste such as electrical power. This helps reduce both Arizona State University and Queens University Belfast’s carbon footprint.

Through using sensors to provide input to the system, we can accurately determine where resources would be best needed such as lighting as per ASU and QUB’s Carbon Management plans. In the Carbon Management plan from Queens University Belfast[[1]](#footnote-1), Lighting is listed as 34% of the current emissions throughout the campus. On Arizona State University’s Carbon Management plan[[2]](#footnote-2) energy is listed at 75% emissions throughout the campus with 35% being anticipated as a reduction due to direct energy demand. The project should be adaptable to allow control of many other devices such as Air Conditioning (HVAC), Heating, etc to suit each university’s specific needs.

# Concept Design and Demonstration

In our concept we planned to use ultrasonic sensors to detect when an entity entered and left a room. By using this information, we could know the amount of people within the room and therefore allocate resources accordingly. This would be done using relays and servo motors. We could also use the Arduino’s expandability to allow it to communicate over a wireless network with a database and a machine learning server which could begin to predict patterns within behaviours and allow for more efficient resource allocation throughout the university campus. This would also allow control over set targets for the universities.

By demonstrating the prototype as a compact solution, we can show the design of a final solution that would incorporate our concept. This would help ensure that the proposed solution would be viable within the real world and not a laboratory environment.

# Does our prototype provide a strong visual model for the solution?

Due to the restriction of additional parts such as having multiple ultrasonic sensors or access to RFID equipment such as tags and detectors we would have used them however we did not have the equipment. Due to this restriction, we visualised how the solution would work by using Light Dependent Resistors to mimic the sensors we did not have. The logical steps would be the same if we had the sensors however the implementation on how to gain each variable from the different sensors would differ. We also do not have access to several Arduino systems and a central server with possibly a machine learning server too. This means we would have implemented a wireless connection to connect the Arduinos to the server and send the data over the internet through a secure connection, therefore each system becoming an IoT stand-alone system.

# Can the proposed solution be implemented?

Using Computer Aided Design and access to 3D printers in the 3D Printing labs, we designed, modelled and printed a prototype faceplate which can hold the prototype. This shows that we considered implementation of the system instead of prototyping it with a breadboard, the inputs and the outputs within a lab environment.

The proposed solution, when using RFID technology or Ultrasonic detectors as well as connectivity to the internet, would be implemented using the same system however debug components such as the debug operators within the code and the 7-segment digit display could be removed as it provides no significant benefit to the end user or client.

# Does our prototype adequately represent the solution?

Through the issues we faced with implementing a full solution such as not having all the components on hand during the prototyping phase, we used alternative sensors such as Light Dependent Resistors, which mimics Ultrasonic sensors or RFID triggers. The output from the logic decisions such as direction of travel and number of people in the room on the prototype board is represented by powering an LED where in the solution we would use a relay to provide power to the rooms lighting system. This could be further extended through the concept where we could begin operating Heating, Ventilation and Air Conditioning (HVAC) systems as well as even security systems where security personnel could be alerted, using IoT connectivity, to someone entering a room or building that is restricted and the event recorded in a database.

# Is the proposed solution unique or a unique adaption to something that already exists?

Our solution is a unique adaption to an existing solution which already exists. In 2008, at the International Conference on Computer Science and Software Engineering a paper was shown titled “Building A Smart University using RFID Technology”[[3]](#footnote-3). In this paper, 3 researchers from the National University of Computer and Emerging Sciences researched the most efficient way to build a smart university while reducing power usage was to use RFID technology as well as ZigBee to communicate between each device. However, in this paper, the authors didn’t mention where to place these control circuits. Our unique adaption and solution are to fit these control circuits into the light switches right next to the door. Not only does this provide ease of use to the circuit but also allows input in order to change the circuit’s behaviour. It also allows us to adapt the sensing when implemented around both ASU’s and QUB’s campuses.

# Does the proposed solution provide value to society?

Through the project objective, we plan to reduce waste such as electricity waste as well other waste such as oil if a heating system is to be attached to it. From referencing the “Building A Smart University Using RFID Technology”, we can see that 26.95% energy was reserved due to the implementation of the system. Through reducing the power usage around the world, this means there is less demand for fuel and therefore the fossil fuel reserves can last longer. It also means that carbon levels will drop as we depends less on solid fuels and would allow for cleaner sources of power such as solar panels, wind turbines, etc. Through reducing carbon, it would help ASU and QUB meet their respective targets in carbon management, ASU focusing on the Centre for Negative Carbon Emissions and QUB raising awareness to Staff through the Carbon profile in Queen’s Online. If this system was to be implemented in other areas outside the universities, it would provide a benefit to whoever pays the bill for electric as it would be lower. Another scenario that benefits society is that if this solution was to be widely adopted, it would make for cleaner air as the power stations which have to provide power to each site doesn’t have to work as hard.

# Is the solution scalable to its targeted population?

The solution that we have came up with can be expanded to most buildings around the globe. This is because using pre-packaged microcontrollers with electronics on a board is relatively cheap. The downfall of scalability is that there must be a central device, known as the “master”, on the other end of the ZigBee network which will process the data received by each Arduino and increment and decrement values accordingly. However, the master device does not have to be an enterprise-grade server for applications such as residential use or small business use cases. It could be as simple as using another Arduino or, if need be, another microprocessor such as a Raspberry Pi. Through the previous example, we could also use enterprise servers for large applications such as University campus-wide scenarios as well as using machine learning. Through using communication links and booming recent technology subjects such as machine learning our solution is relevant to the engineers of today

# Does this solution work in both Phoenix and Belfast?

Through the previous questions, we can show that the system can be adapted to control a multitude of devices such as HVAC devices, lighting to even activating power sockets within the room. Because the solution is so adaptable, ASU in Phoenix can use the solution to control Air Conditioning adaptively so that it is not wasted in a room where there is no-one and that the temperature can be monitored too to ensure that a room remains within compliance. The solution could also be used within Belfast to be attached to a heating system where rooms can be heated to compliant temperatures or temperatures maintained within compliance in a room, such as a lecture early in the morning would need heating at first but when the students arrive, may need air conditioning or venting to avoid the students overheating. Due to the adaptability, this solution could work outside of the university’s grounds in residential use cases too.

# Does this solution showcase the use of IoT technology?

Although we didn’t consider IoT until a basic prototype was completed during this event, we realised we could extend the functionality of the solution across several rooms and buildings through using communication protocols such as ZigBee, Bluetooth, Wibree, Wifi and 6LoWPAN. Using low power communication protocols within the deployment between each node and the central master node, we could also provide smart home adaption from the internet through the use of Wifi/Ethernet connections to the master which would signal and command the slave nodes to switch values.

1. <https://www.qub.ac.uk/sites/CarbonManagementatQueens/QueensCarbonJourney/CarbonManagementPlan/Currentemissions/> [↑](#footnote-ref-1)
2. <https://stars.aashe.org/media/secure/21/7/679/6093/CarbonPlan.pdf> [↑](#footnote-ref-2)
3. <https://www.researchgate.net/publication/221195787_Building_a_Smart_University_Using_RFID_Technology> [↑](#footnote-ref-3)