

## **AT&T IoT and M2M Project: prUVent**

Engineering Design 100: Section 018

Submitted to: Professor Bevin Etienne

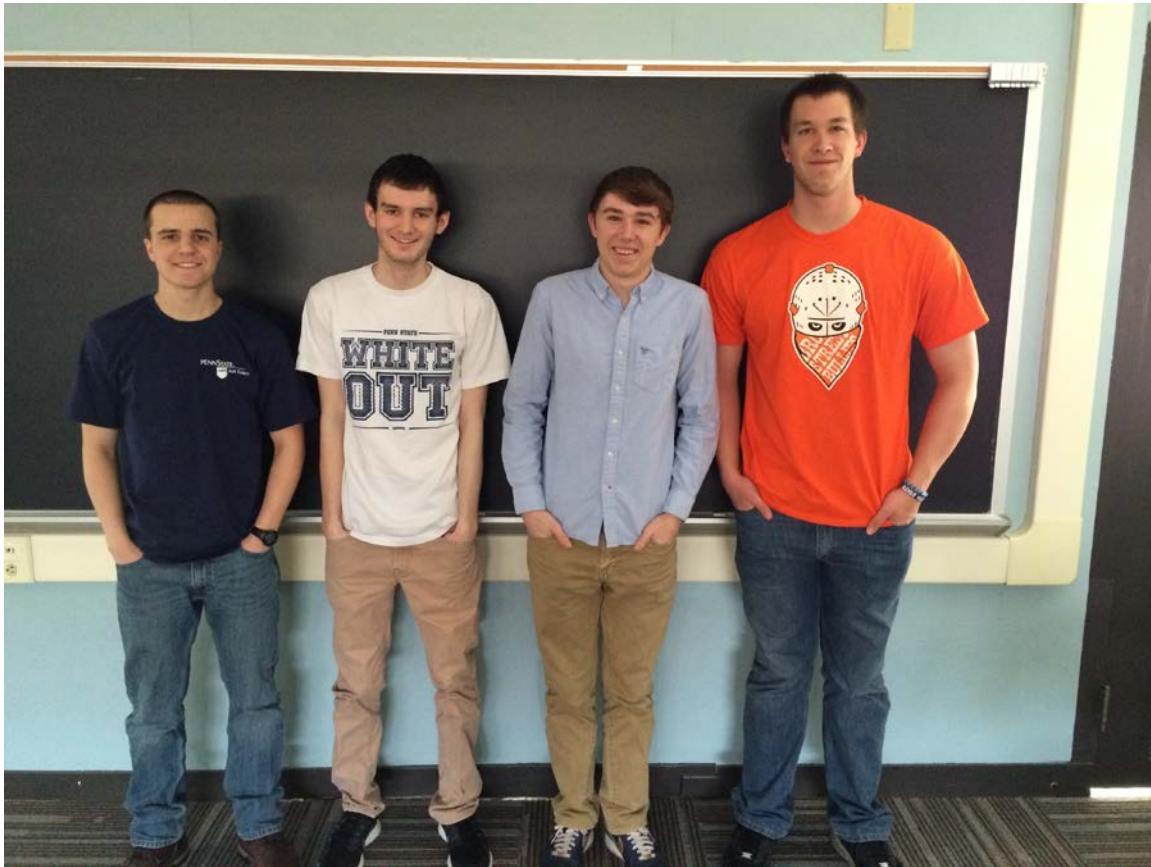
### **Team Pure Energy**

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## 1. Introduction

In the 21<sup>st</sup> Century, thousands of technological advancements are made each year toward a more interconnected society. AT&T approached Penn State Universities Engineering Design 100 class for their client-driven design challenge during the spring 2014 semester. The mission statement of the design challenge is to explore one area of society affected by the Internet of Things or Machine-to-Machine technology. AT&T has defined the Internet of Things as “a scenario in which objects, animals, or people are provided with unique identifiers and the ability to automatically transfer data over a network without requiring human-to-human or human- to-computer interaction” (Taken from AT&T’s PowerPoint presented in class). Machine-to-Machine can be defined as “solutions wirelessly connect millions of diverse devices to a network, enabling two-way communication. From trucks and turbines to heart monitors and vending machines, M2M allows network- ready devices to connect and share reliable real-time data via radio signals. Monitored and managed remotely, M2M automates processes in industries from transportation to healthcare” (Taken from AT&T’s PowerPoint presented in class).

Possible areas of consideration for our design project include Digital Life, which can include wearable technology and home system integration (Taken from AT&T’s PowerPoint presented in class). Another popular area is the connected car, including the fields of

combating distracted driving, switching costs, situational awareness, cognitive overload, multitasking, vehicle alerts, haptics, and security assessment (Taken from AT&T's PowerPoint presented in class).

Finally, there is the area of wearable technology, which includes user needs assessment, human design performance analysis, and innovate design (Taken from AT&T's PowerPoint presented in class).

## **2. Mission Statement**

AT&T has defined the project challenge with the following criteria (Taken from AT&T's PowerPoint presented in class):

- I. Identify a category and opportunity that employs IoT and/or M2M
- II. Examine your opportunity as a system and create a concept of operations and systems diagram
- III. Examine important aspects of your system for feasibility and adoption, such as bandwidth usage, security issues, privacy issues, etc.
- IV. Show how the user will interact with your system, i.e., is there a device, and app, etc.?
- V. Ensure that the solution is economically viable, i.e., will people pay for it?

## **3. Concept Generation and External Research**

When we began brainstorming possible opportunities that utilize IoT and M2M technology, we realized the market is heavily saturated with an enormous amount of new products. Simply doing a few Google searches can give one an idea for just how important the

Internet of Things and Machine-to-Machine connectivity will become in the coming decades. In a study by Cisco from an article in the Huffington Post, Cisco predicts, “Global adoption of the IoT concept will, eventually, lead to the estimated 50 to 100 trillion connections” (Moore).

To begin the design challenge, our group decided to make a Gantt chart, which would allow us to plan out how we will use our time throughout the semester most effectively. In our Gantt chart, we allowed ourselves 3 class periods for concept generation. 3 class periods were set aside to examine the inputs/outputs, feasibility/adoption/costs, sustainability, mechanical and electrical design, bandwidth usage, and security/privacy of the opportunity. We then gave ourselves 3 periods to create the concept of operations and systems diagram. Finally, we gave ourselves 6 periods to create the solid works model, the final report, and the PowerPoint presentation.

Before team Pure Energy decided on a final concept, we conceptualized a previous idea. Our first idea was a smart kitchen, which would have sensors in the refrigerator, cabinets, oven, stove and microwave, which would create an interactive cooking environment. This environment would monitor what types and quantities of food are available within the kitchen and would recommend recipes and assist with cooking. We decided to scrap this

idea due to LG having already developed the impressive LFX3199FST smart fridge (LG).

After more brainstorming, we finally decided on a concept to further pursue for the design challenge. Our concept is a wearable device and phone application interface called prUVent. Our vision was to make prUVent a wearable band similar to a LiveStrong bracelet or Balance Band in shape. The bracelet will have a UV sensor that will monitor harmful rays from the sun. Combined with information from the application, the band will notify the user when to apply sunscreen based on previous application time, user skin tone, and real time updated UV intensity data. We have envisioned an application that pulls real time weather data from a weather service to show the user basic weather data. The app will also uniquely synch each users band to the app to add personal preferences such as skin tone.

#### **4. Concept Selection**

To begin the conceptual development part of the design project, we first decided to analyze similar products already on the market and see what could be improved upon. The first product we looked at was UVeBand, an unsuccessfully funded Kickstarter project that ended in April of 2013 (UVeBAND). UVeBand inspired us to use a similar electronic design in our band, however we felt the UVeBand lacked aesthetic appeal and a useful app interface. The second product we looked at is the June by Netatmo (JUNE). We were

impressed by June's elegant application interface, however we felt that the product again lacked the aesthetic appeal to be marketable. We also found the price point of the June, \$100, to be overly expensive for the consumer base we hoped to market to.

After looking at existing products, we then began to analyze the various aspects that we would need to research in order to better develop the product. We decided to break up our research into parts assigned to individual group members. Cole was assigned research into the processor, algorithm, and bandwidth. Shane was assigned research into the inputs and outputs along with solar cell, which will charge the battery. Jon was assigned research into inputs and outputs, the battery, and the UV sensor. Steve was assigned research into the Bluetooth connectivity as well as the cost analysis and economic model.

For the processor, we looked heavily into various ARM processors, which we compared in a decision matrix based on size, power consumption, performance, and bits. (Appendices). Research into the algorithm showed that two types of ultraviolet radiation cause sunburn and must be measured, UVA and UVB (sunscreens). The algorithm must also take into account skin tone, time of previous application, and must make assumptions based on density of application on the skin and the SPF used.

In terms of inputs and outputs, we wanted the band to be able to send and receive data from the phone application. At the beginning of the project, we realized one of the most important aspects of the bracelet would be how it would interact with a person's smartphone. Though this seemed like a simple task it became a much more complicated and intricate process. First of all, we needed to decide upon the type of chip and signal that the bracelet would use. After initial research we came down to two separate signals, low energy Bluetooth and Zigbee. At first it seemed that Zigbee would be the smarter choice as it is a small chip and offers great range and low power consumption for the simple signal we would be sending. Upon further research it became evident that while this seemed like a good idea, the Zigbee signal was not compatible with smartphones and therefore would not work. This left our only remaining option as being a low energy Bluetooth chip. After this discovery we began to research into the different types of chips and which one would best work for our device. The decision would mainly be based on 4 attributes, price, size, maximum operating voltage, and minimum operating voltage. These attributes would be further broken down as size is 40% of the decision, price is 30%, maximum operating voltage is 20%, and minimum operating voltage is 10%. We chose to have size be the most important aspect due to the extremely small packaging space we had inside the band, as it must be a bracelet that fits around

a person's wrist and not be bulky. Secondly, we decided to have price be the second most important attribute as the Bluetooth chip would most likely be one of the most expensive parts of the band. The maximum and minimum operating voltages would be very important factors because we want to use as little power as possible in order to use the smallest batteries available.

Decision matrices were used heavily in the selection process for the solar cell, UV sensor, battery, and vibrating disks. These matrices can all be found in the appendix of the report,

## **5. Final Design**

### **a. Inputs and Outputs**

For the final design of the band in terms of inputs and outputs, we decided upon having a Bluetooth XCC2564MODNCMOFT chip inside the band. The device will function by having a button located on the bottom ball of the band. The user will download the free app and synch their unique band to the app by holding down the button. Once synched, the user will set up skin tone preferences, which will then be sent to the processor via Bluetooth and incorporated into the algorithm. When the user has applied sun tan lotion, they can either let the app know when in range of the Bluetooth or by simply pressing the button. The band will then begin monitoring real time UV intensity as well as making assumptions



about SPF used and application density. The band will vibrate and send the user a phone notification (if in range) when it is time to reapply sunscreen. Finally, the user will then hit the button again and the process will cycle. A detailed description of this process can be found in our systems diagram in the appendices (appendices).

### **b. Mechanical Design**

For the mechanical design of the bracelet, we wanted the band to be as slim as possible for an appealing looks. Having analyzed two competitors, one aspect of both designs we were put off by was the appearance. During the design process, we decided to make a CAD model in Solidworks, which would be a rough example of how we wanted our design to look. This design can be found in our appendices.

### **c. Electrical Design**

In terms of the electrical design, we decided to go with an ARM Cortex-M0 processor, a XCC2564MODNCMOFT Bluetooth chip, two CPC1822 solar cells, two PGEB021212 batteries, a ROHM ML8511 UV sensor, and finally a compact mini motor disc for the vibrating feature. The majority of these elements will populate a double layer PCB board microcontroller located on the topside of the band. This included the UV sensor and two solar cells, which will be facing the sunlight. One unique feature is the fact that the batteries are flexible

and will be inserted lengthwise along the band parallel to the board to conserve space.

#### **d. Bandwidth Usage**

One aspect of the project that AT&T discussed while describing the project were possible problems regarding bandwidth. As more and more devices become interconnected, the bandwidth can become very crowded and slow. After some research we discovered that the Bluetooth has a bandwidth of 800 kbps. This is relatively small value especially compared to a more complex network such as Wifi which is about 11Mbps (Bluetooth). Due to this fact, we concluded that our bandwidth usage would not be a problem.

#### **e. Security and Privacy**

Another aspect which AT&T stressed when describing the project was security. As the world become more interconnected, it also becomes more at risk for cyber-attacks such as hacking. For many of the other groups in the class, this security could be a very large issue as they are transferring a large amount of important data between devices. In the case of the prUVent bracelet, security was not one of our largest concerns. While it is theoretically possible for someone to obtain the data over Bluetooth through hacking process such as bluejacking or bluebugging, they would have no reason to take the data. The only data that is being transferred from the bracelet to the phone is

meaningless UV data (Types). Due to this fact we believe that security will not be an issue for the product.

#### **f. Design Sustainability**

Throughout the duration of this course, one of the main focuses has been on sustainability. It is our duty as humans to protect the earth we live in. While creating our product we brainstormed ways to make it more sustainable. Our main conclusion was to power the band with two small solar cells rather than with a replaceable watch battery. This allows the band to be essentially self-sustainable on the power from the sun. The prUVent band also promotes sustainability in a less obvious way. By knowing exactly when to reapply sunscreen, you will not use excess, thereby wasting the lotion as well as the bottle it is contained in.

### **6. Cost Analysis and Economic Model**

While going through the design process, we also had to keep in mind the costs we were incurring as well as approximately how much the product would cost. In addition to this fact, we wanted to gain a broad idea of where we would sell it as well as who our target audience was. Once we had decided on the product and had split it up into parts we began making decision matrices with price being one of the most important aspects. After the choices were made the UV sensor would cost approximately \$3.00, the processor \$1.00, the vibrating disk \$1.56, the Bluetooth sensor \$7.38, the two batteries

would cost \$2.22 each, and the two solar cells would cost \$1.50 each. This makes the total price for the components to be around \$20 dollars. After accounting for mobile application development, advertising, the manufacturing and transportation costs, and making a profit on the product we chose to set the price to be between 40 and 50 dollars per band. While this may seem expensive, it is important to realize how much money you can save by not using excess sunscreen, as it retails for as much as 12 dollars a can. More importantly, proper use of the bracelet will greatly reduce the chance of getting sun cancer. This disease is not only deadly but extremely costly. The prUVent bracelet is also cost efficient when compared to its only competitor, the Netatmo June, which costs \$99.99 (JUNE). While developing the overall cost of the product we also had to keep in mind where it would be sold and what type of people we would try to sell it to. Our final decision was to have an emphasis on selling the bracelet near beaches and in sporting good stores so to create an emphasis on active lifestyles. These locations would also benefit our target audiences, which are athletes, beach goers, and parents purchasing for their children.

## **7. Conclusions**

In conclusion, Team Pure Energy is incredibly satisfied with prUVent as a product. To reiterate, the design challenge was as follows:

- I. Identify a category and opportunity that employs IoT and/or M2M
- II. Examine your opportunity as a system and create a concept of operations and systems diagram
- III. Examine important aspects of your system for feasibility and adoption, such as bandwidth usage, security issues, privacy issues, etc.
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We feel we did successfully identify an opportunity that employs IoT technology. prUVent uses Bluetooth communications to connect to cell phones and thus the internet making it very much a part of the internet of “things”. The second part of the design challenge was to create a concept of operations and systems diagram which we did successfully do and are located in the appendices. We did in fact examine all aspects of the device including feasibility and adoption, bandwidth usage, security and privacy, as well as sustainability. Finally, we did show how used will interact with the device and planned out an economic model for the product.

Although this design challenge was long and hard, we are, as a group, very proud of the final design.

## 8. References

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"Sunscreen." *Wikipedia*. Wikimedia Foundation, 05 May 2014. Web. 05 May 2014.

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## 9. Appendices

	1	1	1	1	1	5	
	20%	20%	20%	20%	20%	100%	
UV Senesor	Price	Supply Voltage	Temp. Range	Size		Score	
ROHM ML8511	\$3.00	3.6-2.7 V	70- -20 *C	4x3.7x. 73 mm		80	
ROHM BH1603FVC	\$0.51	2.4-7 V	85- -40 *C	3x1.6 mm		65	
DFR TOY0044	\$9.00	3.3-5 V	85- -20 *C	27x22 mm		68	
	1	1	1	1	1	5	
	20%	20%	20%	20%	20%	100%	
Battery	Price	Size	Voltage	Temp. Range	Charge	Score	
PGEBO21212	\$2.22	2x2x0. 5 mm	3.6 V	60- -20 *C	recharge no	87	
Alibaba 052323	\$2.00	2.5x2.5 x1 mm	3.7 V	70- -20 *C	recharge no	75	
Size 10 Hearing Aid Battery	\$10.00	5.8x5.8 x3.6 mm	1.4 V	50- 0 *C	recharge	55	
	2	1	1		1	1	6
	33%	17%	17%		17%	17%	100 %
Processors	Size	Power Consumption	Performance Efficiency	Optimized for low power connectivity?	Bits	Score	
ARM Cortex - M3	80	70	85		80	100	83
ARM Cortex - M0	90	80	80		90	100	88
ARM Cortex - M0+	90	85	75		80	100	87

	1 20%	1 20%	1 20%	1 20%	1 20%	5 100%	
<b>Solar Cells</b>	<b>Size</b>	<b>Voltage</b>	<b>Current</b>	<b>Cost</b>	<b>Water proof</b>	<b>Score</b>	
BPW34	90	80	85	85	85	85	
CPC1822	95	85	85	90	85	88	
Mini Solar Cells	75	90	90	80	80	83	
	4 36%	3 27%	2 18%	1 9%	1 9%	11 100%	
<b>Bluetooth</b>	<b>Size</b>	<b>Price</b>	<b>Max Voltage</b>	<b>Min Voltage</b>		<b>Score</b>	
AM29FO16							
O-90SI	25	85	40	25		42	
XCC2564M							
ODNCMOFT	85	60	55	70		64	
PTR5518	65	45	70	65		55	
ADT7463AR							
Q	75	55	40	40		53	
nRF51822	60	35	50	75		47	



