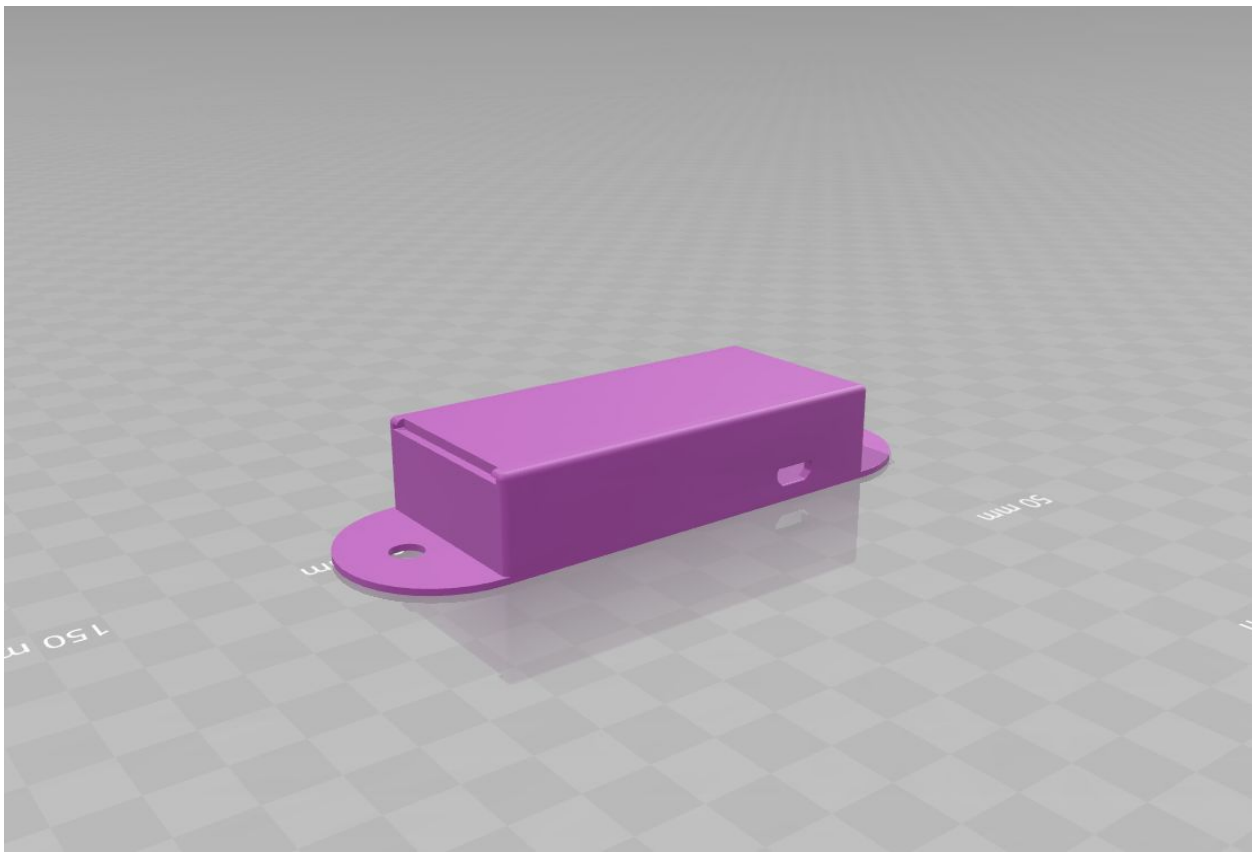
GNG 2101 - Dr. David Knox

VOLUNTEER CALL BELL
CLOUD-BASED CALL BELL SYSTEM



Abstract

The volunteer call bell system is used by hospital patients to request basic, non-medical assistance from volunteers. The system utilizes a small wearable bluetooth remote transmitter and a wired-in Wi-Fi connected receiver to make a call to the volunteer center. In addition, all calls are logged on an online database for future statistical and analytical purposes.

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Introduction

Modern hospitals are becoming a technological sight to behold. Many come fully equipped with state-of-the-art patient care units, advanced rehabilitation programs, and software to automate almost every task previously toiled over by employees. A very important technology to hit hospitals everywhere was the Nurse Call Bell System. No longer did patients need a nurse to be with them at all times; now with the push of a button they could summon a nurse in seconds. This tool became a staple of efficient hospital processes, and was soon adopted everywhere.

Recently, as patient numbers in hospitals increase due to the rising number of retiring workers, the demand for nurses has skyrocketed. Unfortunately, many hospitals still do not have enough nurses to comfortably care for all patients. This has raised a serious safety concern with regards to the response time of the nurse call bells. Often times, nurses do not know whether a call is for a simple task such as fetching a glass of water, or a life-threatening emergency. With this problem in mind, our client approached us to find a solution to the issue by differentiating between simple tasks that can be carried out by volunteers, and health related tasks required to be completed by nurses.

The end goal of the volunteer call button is to create a direct pipeline between the patient and the volunteers of a hospital without going through a nurse. The system needs to be simple enough to be used by a patient with diminishing mental health, and must be comfortable enough for the patient to not feel their personal space is being invaded by a rugged piece of technology. The whole transmitter receiver system should also be easy to maintain by hospital staff without needing to call for support from the design team.

Ultimately, the conclusion drawn for the requirements of the system is that our system must overcome the issues that patients see with current call bell systems. Although comfort is a huge priority for the patient, one of the biggest differentiations between our system and currently installed call bells is that it uses the cloud rather than a large wired-together data transmission arrangement. This will cut costs significantly, and will allow the data to be accessed from anywhere in the world.

Design Process

Initial Research

Prior to gaining refined details from our client, we needed to see some other systems that were being implemented by companies in the same market as us. The first company we looked at was a healthcare organization based out of Massachusetts, USA. Their integrated nurse call bell system claimed to have optimized staff workflow which is achieved by a multi-button wired remote system.[1] In order for a volunteer call bell system to compete with multi-use nurse call systems, it needs to have a simpler and more accessible data bank with real time call updates.

Another company whose work we looked into was an integrated technology manufacturer named BEC Integrated Solutions. After viewing their system which had a very high sale price[2], we noticed we needed to create an affordable solution for our client in order to make sure it was scalable.

Now that we had benchmarked a series of similar technology companies and discovered caveats in their end-user design, we could begin to create our own system.

Empathizing

Once we knew the basic details of the problem we were trying to solve, we met with our client in order to figure out exactly what he wanted for his hospital. By inciting conversation regarding past experiences with call bell systems and other forms of inter-building communications, he was able to give us very important information that we were able to use in defining our problem statement. We discovered very early into the interview what he was looking for exactly, and we understood what his motives were for needing the technology created for an affordable price.

Some observations we collected during the interview were as follows:

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[1] *"Wireless Nurse Call Systems Integration." Wireless Nurse Call Systems | STANLEY Healthcare, www.stanleyhealthcare.com/solutions/health-systems/clinical-operations-workflow/nurse-call-integration.*
[2] *"Wireless Nurse Call System Stations & Pendant Options." BEC Store, becintegrated.com/call-systems/wireless-nurse-call.*

- Accessible, easy to press (by patient), but not prone to accidental activation.
- Adaptable to patient mobility.
- Lightweight and wireless since most rooms were already cuttered from wires from other technologies in the room.
- Emphasis on wearable and portable technology.

Alongside meeting with our client, we also interviewed several different patients who expressed their own concerns and interests. One eye opening detail we received from a patient was that she felt discouraged to use the call bell for minor assistance because she felt as though nurses would not respond as quickly in the future if she called too often. This thought process meant that patients often waited till a nurse or volunteer was doing a round before asking for minor assistance, meaning they could be in discomfort for an extended amount of time. Another interesting request by a patient was for the remote to be wireless or wearable so she could be elsewhere in a room without needing to stay near her call bell wire.

Defining

Once we had compiled all the ideas and requests together and picked out interesting design and functional requirements we were able to create our problem statement:

"Design a system that allows patients to request a volunteer's help. System is intuitive and able to be used by patients with limited mobility."

By defining the problem statement, we have effectively created an understanding of the overall goal of this product. At this point the project is set to move into the phase of brainstorming and creating ideas.

Ideating

The most creative element of the product development process was the ideating phase, which really allowed us to set our visions into applicable and designable products. Beginning with the problem statement, we attempted to create several basic designs that matched the client criteria during the empathizing stage. We looked at patient comments,

client remarks, and benchmarked data from competitors to create a few rough designs for how the transmitter and receiver apparatus' must look and behave. An important consideration for the design was the table of design specifications. Ideally, the product will be created with these considerations in mind to create the most optimal solution to our client's problem.

Design Specification

Table 1. Quantitative Specifications

Specification	**Metric**
Bluetooth Range	5m optimally
Size of remote/wearable	5cm x 5cm x 3cm
Size of button	$\pi(1cm)^2$
Receiver power required	5V
Dimensions of the receiver	10cm x 8cm x 4cm
Pressure required to hit down button	20g
Bluetooth Frequency	2.4GHz
Remote Weight	90-100g

Table 1: Quantitative design specifications and optimal metrics for prototype.

Qualitative Specifications

- Easy to use for many different patients
- Unobtrusive for nurses and other patients in the ward, has to work alongside nurses' call bell
- Easy for patients to access and activate
- Must have a way for volunteers to turn off the notification

Every member of the team took their own take on the problem and created individual conceptual design ideas.

Proposed Design Ideas

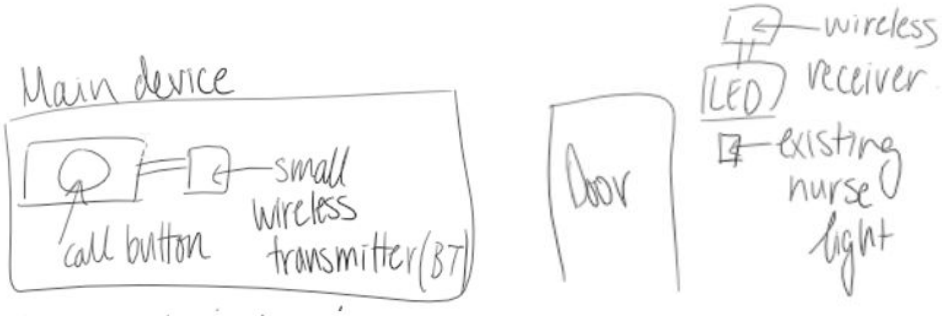

Figure 1: First proposed design idea.

- Simple modular design, plate containing button.
- Wireless transmitter connected to button transmits to receiver.
- Receiver situated outside door in hallway to notify passing volunteers.

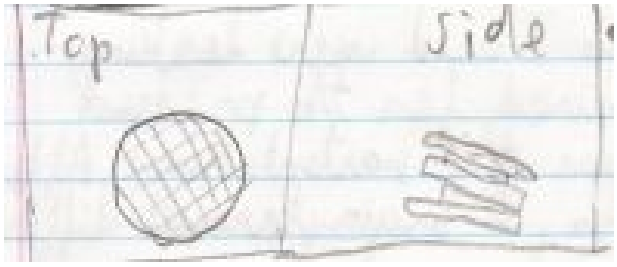

Figure 2: Seconds proposed design idea.

- Clip on with large plastic button over smaller plastic button, easier to press.
- Adaptable to any situation.
- When pressed, it will signal door light.

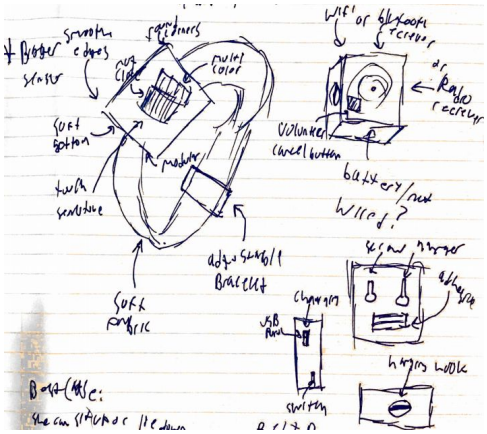

Figure 3: Third proposed design idea.

- Touch sensor button, modular remote is adaptable.
- Wireless transmission to receiver which is mounted nearby.
- Receiver is connected to volunteer signalling light.
- Emphasis on adaptability and modular design on both remote and receiver.

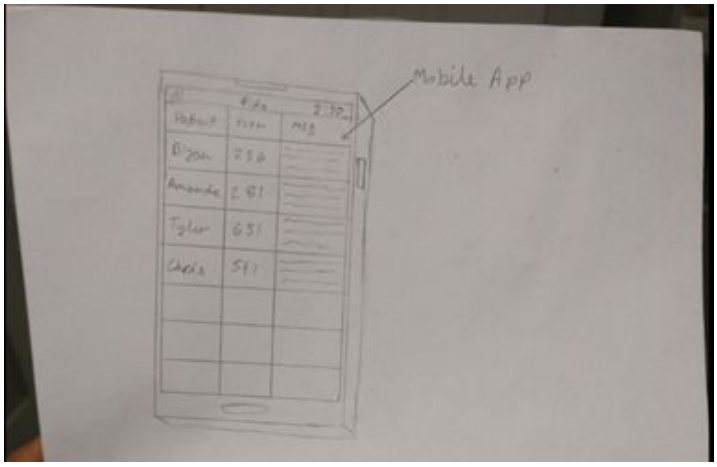

Figure 4: Fourth proposed design idea.

- Use mobile app to connect patients to volunteers.
- Users can write instructions on message.

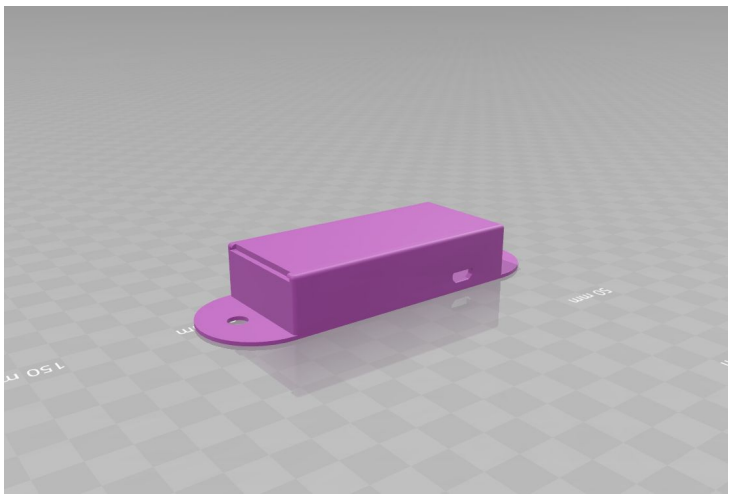

Figure 5: Receiver of the second prototype.

- Uses Raspberry Pi Zero W for wifi and bluetooth
- Logs all calls made

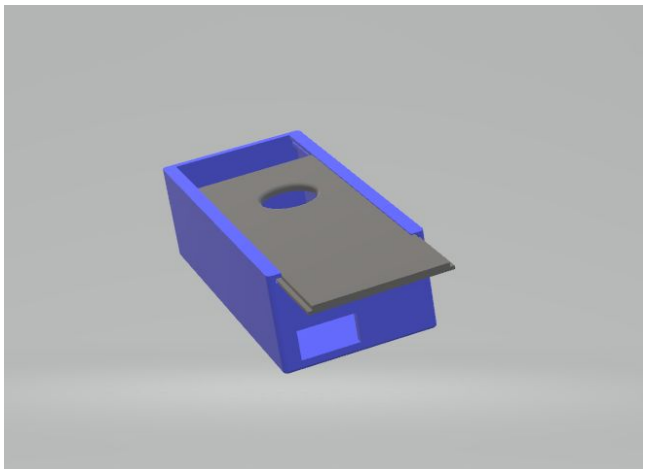

Figure 6: Button for the second prototype.

- Uses a touch sensor to send calls

Constraints

Most of the constraints on your design solution was mainly generated from the hardware aspect. We encountered many issues with port compatibility and adapter designs as the raspberry pi zero we were using had a singular micro USB data port and a mini HDMI out for display which both needed an adapter to their respected full size but the PCB design was so small that it was only able to support one adapter at a time. To cope with this we had to take an unorthodox method and slightly torque the PCB so that it has just enough

room to support both the adapters at the same time. We also outright received wrong products from the ones we ordered from buyapi.com. We originally ordered a USB type a battery charger/power converter but only received a power converted, we were unable to overcome this problem within the given tie and our product was unable to charge. Other constraints were the form factor, we originally had to go with a raspberry pi zero instead of the full sized one as our product needed to be compact. If we had went with the full sized raspberry pi, there would have been no port compatibility issues as the it has two full sized USB type A ports for data and a full sized HDMI out for display.

Prototyping Strategy and Testing Results

Our strategy for prototyping was to first create an initial prototype for the client so they could get an idea of the size and shape of our product. Next was to create a casing for the actual product so the client could approve of the design of our product and to creating the modifications using the feedback from the first prototype. Finally, we would rebuild the design of the 2nd prototype for the final design and create the functional product.

This was done through the creation of a prototype made out of cardboard which was low fidelity prototype thus it was not costly and was quick and easy to make. The results we got from this prototype were that the size could have been made slightly smaller to fit on a person's wrist better and that the look of the design was good.

We redesigned our product to become less of a hindrance for the client by making the product smaller as well as making rounded edges so they would not hurt the client. There was no functionality in this prototype due the delay in receiving the electrical components so the prototype was used to gather more data on the design of the product. The feedback we received was positive and that there were no other modification needed for the casing of our product. Through testing our second prototype, we found that we needed some adjustment made to our design such as holes to plug in our electronics in later prototypes.

Our final prototype was the electronic portion of our product finished with the casing modified from our second prototype. Through testing the final prototype, we found that some of the holes needed to be changed to fit different kinds of port as well the addition of a hangar for better adaptability of our product. After testing, we decided to also

incorporate an app for our product to create more options to be used. Our final design was the transmitter and the receiver as well as an app with the same functionality as the pair.

Conclusion

In conclusion, to ameliorate the nurse to patient ratio imbalance, our group created a volunteer call bell system, similar to that of the nurse call bell system, but functions independently and allows hospitals to fully utilize the help of volunteers. It works by allowing patients to signal for assistance by activating a touch sensor which then sends a short-distance signal via bluetooth to the receiver. The receiver then sends a message to the volunteer call center via WiFi to a Google Firebase server, which devises two databases. One of these databases displays active calls and is accessible to anyone with access. The other databases logs all calls made by patients which can then be used by hospital staff as statistical and analytical data. All logs record the room number as well as the time and date from which the call was made, allowing volunteers to know what room needs assistance and for hospital staff to know which rooms make the most calls.

In the future, possible improvements that could be added to the system include Google Authentication. Having a higher level of security would mean that patient names would also be able to be added to the data that is sent by the receiver to the database, which would add clarification for which patient needs help, in rooms where there is more than one patient, allowing for even more applications.

Overall, a functional proof of concept was created to be a ubiquitous support system in hospitals which would support the current system of care, mostly upheld by nurses. With a volunteer call bell system, volunteers would finally be an empowered group in hospitals, unifying volunteers and nurses together to provide patients with higher levels of care.