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CART 360, October 2019
https://github.com/Justinel2/cart360-2019

THIS = THEN = THAT

PROTOTYPE REPORT

Our main objective is to evaluate and possibly influence the synchrony between the two users according to their heart beat, breathing and beta wave activities. Our project, still untitled, would be two identical electronic accessories that are meant to be worn by two distinct bodies. These accessories sense the previously enumerated types of data for each user. Each vital signs of a user will be represented to the other one as a multisensory experience, with the objective to cross-influence the synchronicity of their autonomic nervous system activities.

(Project Brief from Project Proposal)

~ INITIAL DATA FLOW

By prototyping, we want to specify each component and their ways to communicate in the most efficient (in regards to our objective) and possible (in time, resources and cost).

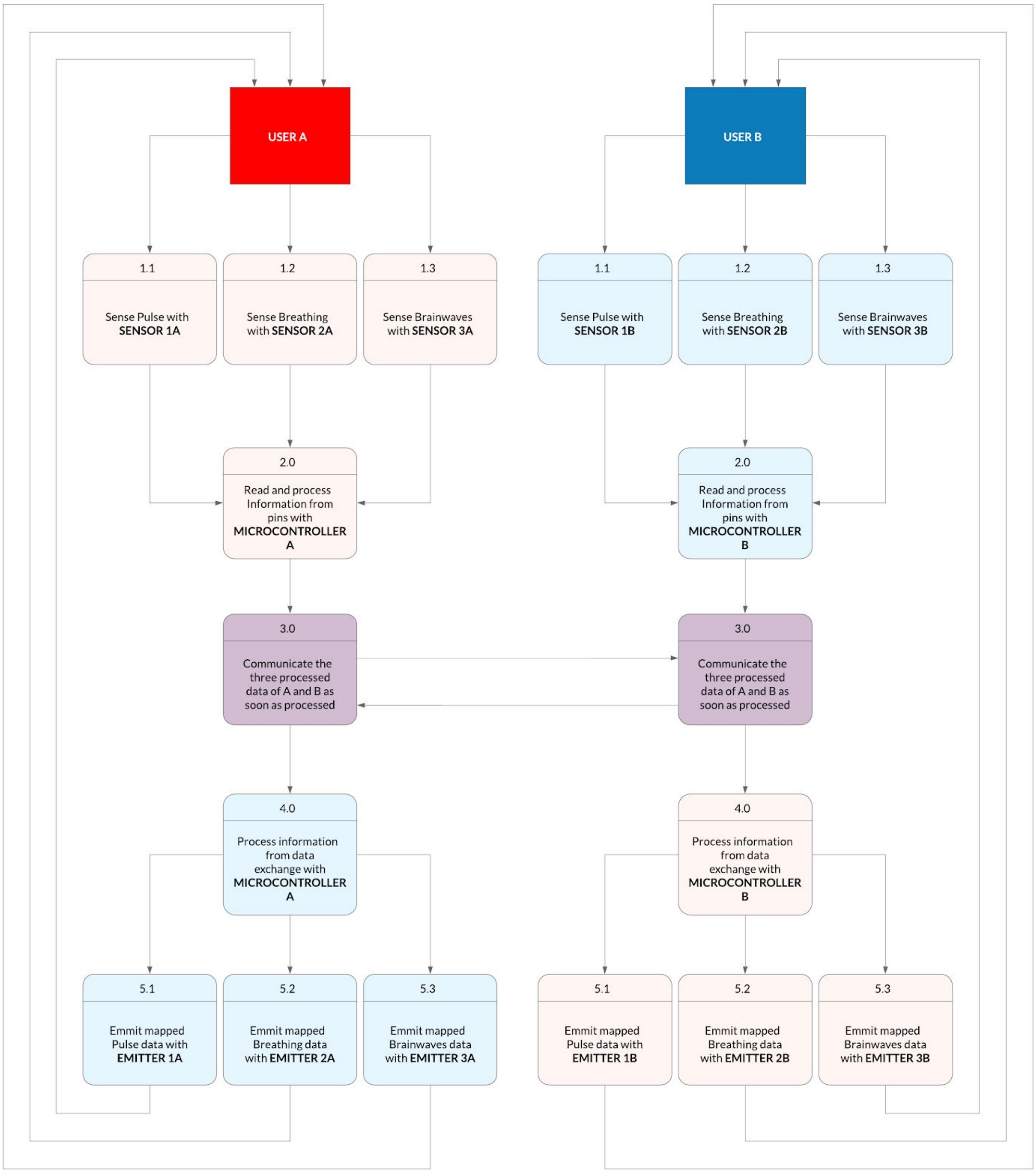


Figure 1

From the initial data flow chart, we can observe the different components and processes needed to create the data communication between USER A -> USER B and USER B -> USER A (Figure 1). These processes are continuously looping and each circuit (A and B) is working simultaneously.

~ PROCESSES

Our exploration of the different ideas that we proposed is based on our initial data flow chart (Figure 1). To keep the user experience as the main focus, we prioritized (or ordered) our processes to go counter courant with the flow of data. More precisely, we explored the processes illustrated in our data flow chart from 5 to 1.

EMISSION (5)

We investigated the pertinence and efficiency of the three sensory stimulations that we planned on emitting to the users. This step is the most important since it is directly related to the user's experience, so, the success of the project.

Pulse (5.1)

The initial idea was to display the electrocardiogram on a screen/projection next to the users. This would have been a visual support for the users, allowing them to see the two hearts' electrical activity next to each other. This would have been, mainly, for them to notice their level of synchronicity. It did not take long for us to realize that the visual display is distracting for the users. The user's concentration should be oriented towards the perception of the breathing instead of the heart's activity; the breathing, in this case, is the one component each user can manipulate to achieve (possibly) pulse synchronicity. Basically, we realized that the most important aspect of the pulse display is to indicate the synchronicity; the pulse should be displayed visually, as a small, personal cue when the two users are in synchronicity. We thought of a heart made of LEDs, placed on the chest of each user (Figure 2).

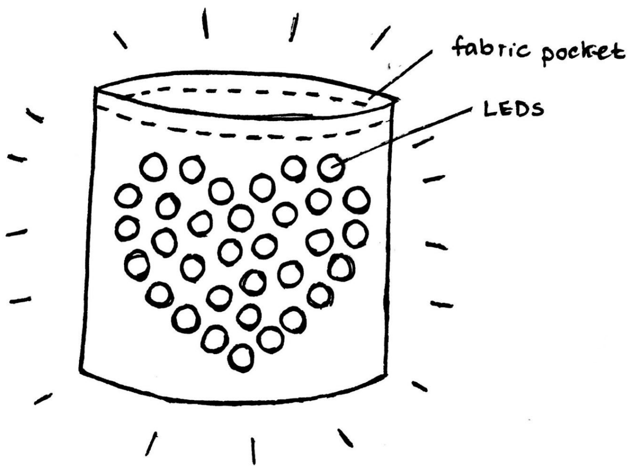
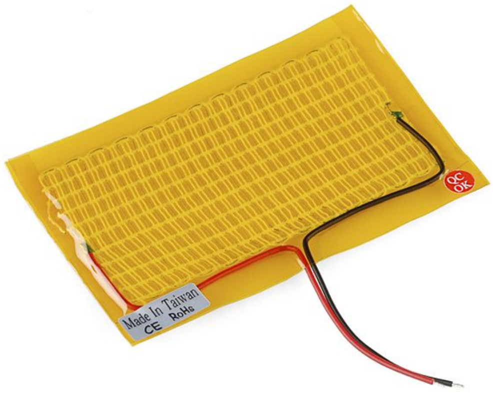


Figure 2

Breathing (5.2)

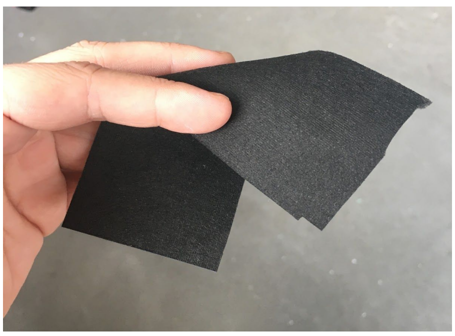
In our proposal, we established that using heat on the chest skin would be an interesting sensory cue for the breathing. In fact, heating is a gradient process, just like the inspiration/expiration processes. We tested the effect of the sensory experience on ourselves; the warmth in the chest is a sensation that reminded us of some previously lived physiological reactions to intense emotions. This sensation relates to the whole concept of connection (to ourselves and to others) that is at the core of our concept. Given that and our tryouts, the heat transmitted should be significantly warm to hot to be unnoticeable. It should be the most distracting sensory experience for the user.



We tried out a few tools to emit heat by passing **current** in a conductive material. The first option we found was a 5x10cm heating pad found online. This one is made of polyester filament and micro metal conductive fibers. This mesh is protected into two layers of protective Polyimide Film (Figure 2). What concerned us is the time it takes to heat, which could be too long to represent accurately the breathing.

Figure 3

An alternative option was to create our own "mesh" using nickel chromium wires and creating a shape, like a spiral. This option would have allowed us to control the surface of conductive material. By that, we could have concentrated the power into a smaller area of conduction; so, to accelerate/intensify the heating process with the same values of amperes and volts. Our concern with this option is to burn the skin of the user since it is extremely conductive and can rapidly become dangerous.



Our last relevant idea was to use a patch of a conductive fabric. For our tests, we used a small square of Eeontex Conductive Fabric. We also plugged it to a DC Power Supply and, to be hot to the touch it needed about 40 volts so using a battery to supply enough power is out. The batteries would also need to be changed quite often. (Fig.3)

Figure 4

We are still figuring out a way to produce significant waves of heat within the time restrictions (inspiration/expiration). Maybe, we will try to diminish the size of the waves and to add another cue, sensory cues, like a vibration, to make the waves more noticeable.

Brainwaves (5.3)

In terms of the brainwaves component, we quickly realized that displaying it is not pertinent towards the user experience. In fact, it would be more distracting than anything. Therefore, we took the decision to eliminate the whole component and to continue working with the two first branches and to discard the third one, all together.

DATA MANIPULATION TOWARDS EMITTER (4)

During that step, we considered each previously confirmed emitters to structure our processing code. For the pulse, the two LED installations are only mimicking the heartbeats when the two users are sensed in synchrony. We then created a formula to verify synchrony. When the synchrony is true, the LEDs can now shine according to a **map()** function that will output a value between 0 (LOW) and 255 (HIGH). The first minimum/maximum values corresponds to the lowest and highest blood pressure point. The value to convert is an integer previously received by the microcontroller. The process is the same for the breathing. In that case, the values of the function will differ:
map(passed int, value when lungs emptied, value when lungs full, min. Heat value, max. Heat value);

DATA COMMUNICATION (3)

There were different options that we considered to transfer data between the two microcontrollers. The first option was to create an Inter-Integrated Circuit (I2C), a protocol where one Arduino is the Master and the other one is the Slave. That option requires a wire connection between the two Arduinos. This way would limit the movement/space in which the users can interact. With that in mind, we needed to find a wireless way to transfer data between the microcontrollers in a bilateral manner. In that case, we would use WIFI, Bluetooth or another Radio Frequency module. Looking into it, WIFI and Bluetooth seemed a bit more complex than other basic RF modules. The Sensor Lab was able to provide us with two SparkFun RFM69 (915 MHz) module, which provides a good short-range capacity (approx. 500m in open air). To set them up, we included the RFM69 and SPI libraries. With those, we are able to make both microcontrollers exchange data in a fast manner. A next step will definitely be to build stronger antennas to reach the desired range.

DATA MANIPULATION FROM SENSORS (2)

This process represents the first stop for the users' physiological data. The microcontrollers are able to read and store in integer variables the different analog data coming from their chosen pins. This information will then be transferred and assimilated by the opposite microcontroller. At this point, because of the amount of input/output modules we understand that it would be better and easier to use two Arduinos as microcontrollers. Even if they are bigger in size than other microcontrollers, they usually have more pins, their capacity of storage is bigger and they are accessible to us (we already have two).

SENSING (1)

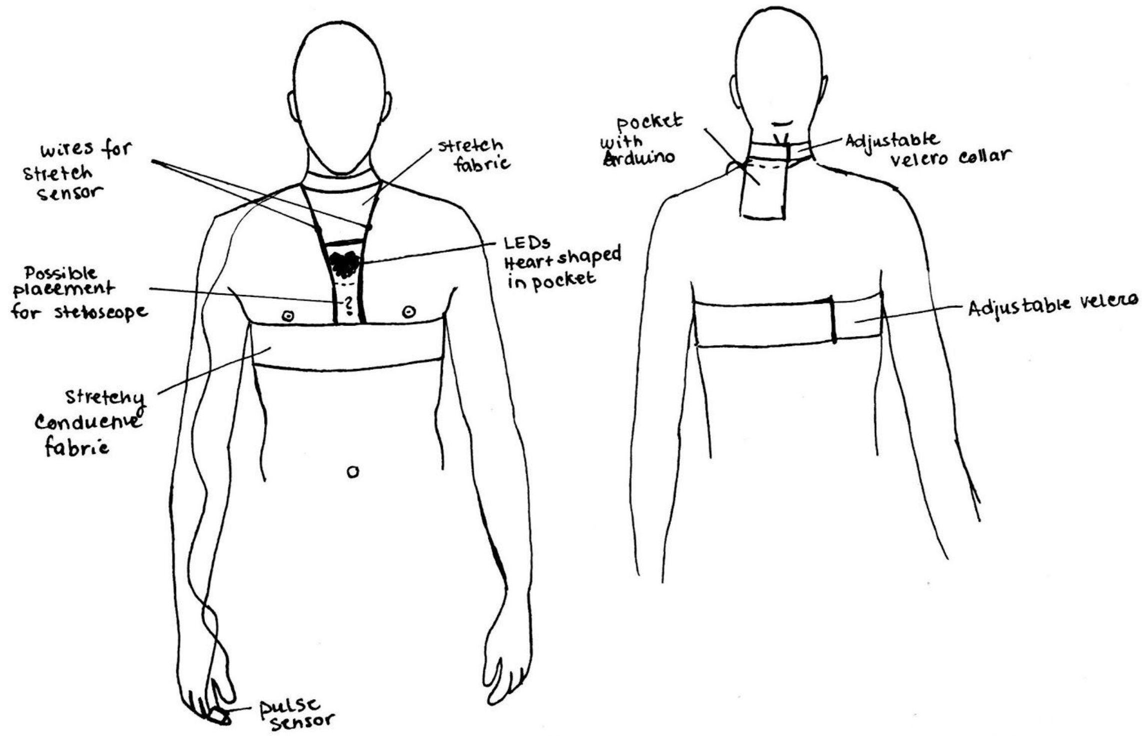
Pulse (1.1)

To sense the pulse of each user, we wanted to try infrared technology allowing to sense when red blood cells are flowing through areas of the body with high transparency. The first sensor we tried was the KY-039 which was very inexpensive, but was detecting too much noise from ambient light that the results were too random. Since we want a very precise result of when every heartbeat are happening, we opted for a better sensor, the SEN203 made by robotlab. It has an analog and a digital mode allowing to get an analog diagram of the heartbeat or simply transmitting a digital value when they are happening (this might be the best option). For every beat, a radio signal could be sent activating a buzzer on the other person's wearable. If we simply want to use the heartbeat to show when synchronicity is happening, we count the heart rate per minute of both persons and activate the LED's when they have equal values.

Breathing (1.2)

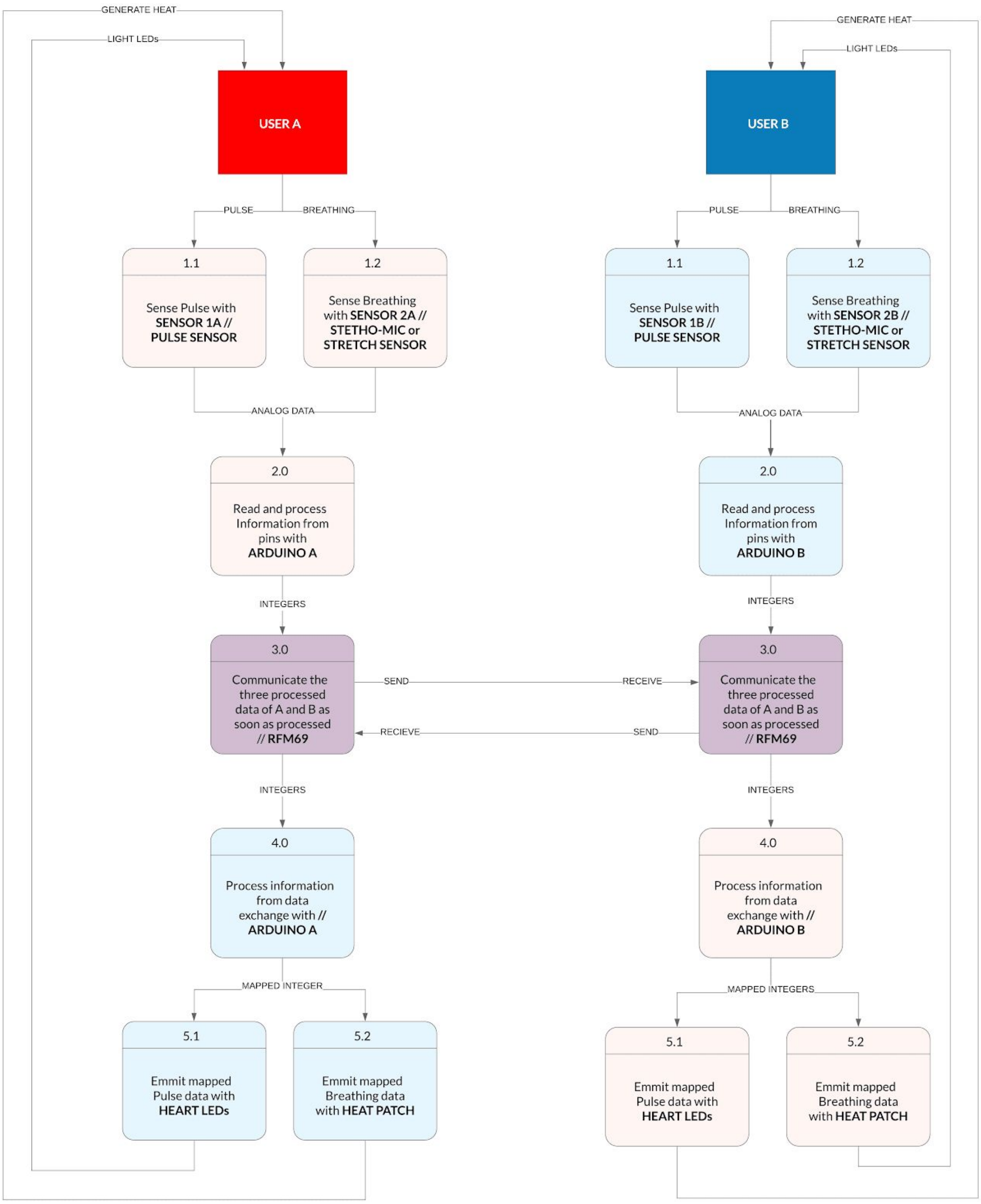
Breathing is more tricky to sense, we have to use custom sensors to get our data. The first way to achieve this task is with a stretch sensor. By using an elastic band that will go all around the body most particularly in front of the diaphragm, we are able to get some values out of the stretching when someone is breathing and enlarging his diaphragm. After a lot of testing we came to the conclusion that conductive fabric was our best solution. When stretched, the fabric will have a lower resistance value allowing more current to flow through the fabric. Using these data we are able to determine when the breathing is happening and it's intensity. Another way of sensing breathing is to use a noise sensor inside a medical stethoscope. The stethoscope will naturally amplify the sounds of the inner body and allow the noise sensor to capture the sounds of breathing in and breathing out. It is important to be careful with how we use these data because we want the noise sensor and the stretch sensor to be as synchronized as possible.

WEARABLE

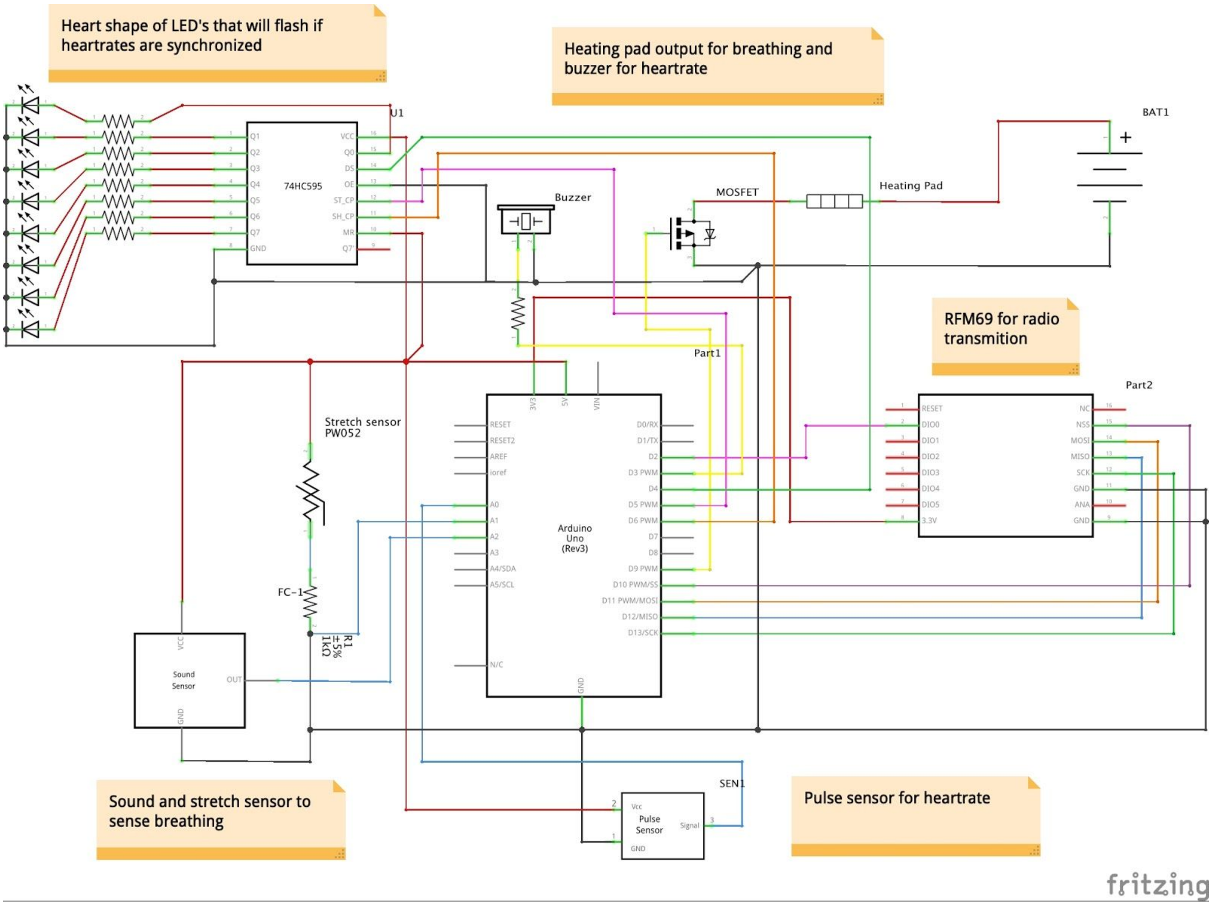


The wearable is the part of the project that puts all the electrical components together on the users' bodies. The biggest challenge was to integrate the breathing sensor(s), notably the stretch sensor for the lungs expansion. It has to be placed tightly on the thoracic cage AND ideally fit most people. To do that, we used a velcro system that would allow the conductive fabric to be tight on different bodies. We thought of using pockets to install the heart shaped LEDs systems and the Arduinos in pockets, so that it is possible for us to remove the component if needed without affecting the integrity of the wearable. For the fabric, we want to use a stretchy and not-opaque fabric, a bit like tights, so that it seems light and adaptable. This is to amplify the idea of a "second-skin"; to user wears closely the other's organs. Also, it is made to be worn under or over clothes, which can also let the users play with the level of intimacy. The heating emitter is situated in a pocket just on top of the LED heart. The wires are enclosed in seams, except the one connecting the pulse sensor. This allows the user to attach it to his finger or ear.

~ REVISED DATA FLOW



~ FULL CIRCUIT DIAGRAM



~ CONCLUSION

In conclusion, our low-fidelity prototype allowed us to experiment and specifies the component needed for the success of our project. We realized that the electroencephalogram was not pertinent in our project, and even distracting. It also made us realize how important the breathing sensing and emission is to possibly achieve synchrony. We also downgraded the size of the pulse/synchrony display so it is more personal and less distracting.

By doing so, the project has become a site non-specific one (except for the range of the RF). This new notion of space allowed us to deepen the meaning of our project. The idea that users can not be in the same room, or even the same building and “feel” one another is truly romantic. Also, the adjustable and versatile wearable allows more users to experience different levels of intimacy, so by putting it under or over their clothes. It becomes something you can choose to wear in secret, or not.

Thus, the prototype allowed us to concretize our previous intentions and to deepen the meaning of our project. It made us focus more on the user's experience rather than the technicities, which made us add/remove some components. Because of that, the initial project brief should be revised.