Designing the Club of the Future with Data: A Case Study on Collaboration of Creative Industries

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Abstract
This paper reflects on the development of a multi-sensory clubbing experience which was deployed during a two-day event within the context of the *Amsterdam Dance Event* in October 2016 in Amsterdam. We present how the entire experience was developed end-to-end and deployed at the event through the collaboration of several project partners from industries such as art and design, music, food, technology and research. Central to the system are smart textiles, namely wristbands equipped with Bluetooth LE sensors which were used to sense people attending the dance event. We describe the components of the system, the development process, the collaboration between the involved entities and the event itself. To conclude the paper, we highlight insights gained from conducting a real world research deployment across many collaborators and stakeholders with different backgrounds.

Author Keywords
Artifacts; System Design; Datasets; Smart Textiles; Wearables; Sensors; Activity Recognition

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Figure 1: Box with personal invitation and wristband which was sent to the guests. (Author's image)

Introduction

Wearable technology has been of rising interest with fitness trackers [5] and smart watches [9] becoming commonplace in the consumer market. Additionally, events and theme parks have begun using wrist bands for payments and/or to track visitors [6, 7]. In a departure from these system, we discuss the use of wearables as a fashion object for nightclubs. The goal is not utility (payments or ticketing) but rather club experience; using multi-sensory experiences to enable a live dialogue between the club and the guests and to create long-lasting memories that extend the experience beyond the club.

In this case study, we reflect on the collaboration and challenges across several stakeholders organizations who came together to build the 2016 Red Bull Playrooms at the Amsterdam Dance Event[1] on October 21st and 22nd in Amsterdam. The primary sponsor, RedBull, contracted Byborre, a young Amsterdam fashion label to curate the experiences across the senses: artists designed custom sound and light experiences, chefs were brought in to create a menu intended to rouse the senses and perfume designers composed a scent just for the evening. 4D Sound, an artist group, was charged with building out a sound and light experience room. A graphic design study, CleverFranke, was brought in to build out the visualizations for the in club and post club experiences. Centrum Wiskunde & Informatica (the Dutch National Research Institute for Mathematics and Computer Science), us, was brought in to *connect the senses* through technology. We focus on the core technology and our individual and shared research goals. Each of the collaborators had their own particular mission objective which needed meaningful club integration with minimal interference; which was amplified by the rather short—less than 90 days—from inception to opening night turn around.

[1] https://www.amsterdam-dance-event.nl/

We believe our (the researcher's) connective organizational structure can benefit others developing wearable interactive installations with several partners for real world deployment.

Interesting lessons were learned during the project. From the human experience perspective, we explored novel ways of creating long-lasting memories from personal data (e.g. a scarf). From the technical perspective, we stretched the expected limitations of Bluetooth LE, and developed a platform ready to deploy in similar experiments. Finally, from the project management perspective, the loosely couple network collaborations made agile development a poor fit for the project.

Red Bull Playrooms

The event took place on two days during the week-long *Amsterdam Dance Event* in October 2016 in a multi-room venue with a dance floor, a dinner room and several bars. Each guest was personally invited and received a box, as shown in Figure 1, with an invitation to the event and a wristband. Our part in this endeavor was to develop the technology infrastructure to connect all of the components of the experience together. Moreover, we wanted to explore interaction in the club of the future.

The selected venue was the first floor of the emblematic (and abandoned) *Het Bungehuis*[2] building in the city center of Amsterdam. The core idea was to find ways to design an experience which would stimulate all the senses at once: Specially created dinner menus, drinks and perfumes, an adaptive sound system and light show with technology playing the role of connecting all the senses into an all-encompassing experience.

To achieve this, we opted for specially designed bespoke

[2] https://nl.wikipedia.org/wiki/Bungehuis

wristbands, which we fitted with off-the-shelf, Bluetooth LE-enabled circuit boards. These boards met our requirements of being adequately small and having long battery life. We decided to create two different types of bands, as the event would have a special program for a selected few of the guests—*Friends of Red Bull* — which required some of the bands to be able to provide direct feedback to the wearer. However, both of the wristbands would broadcast packets containing sensor data via Bluetooth to Raspberry Pi base stations. Both bands were created using a special knitting process and designed in such a way that the boards could be easily embedded in the band and to hide the circuitry as good as possible.

Two types of guests where invited to the event: *VIPs* who enjoyed the party, and *Friends of Red Bull* who also enjoyed dinner and an introductory tour around the venue. Around 18:00, Amsterdam time, each day, Friends of Red Bull were welcomed and given a tour of the space, which included a special cocktail in the *Housewarming Bar*. At around 18:30, dinner started. While the special guests were at dinner, VIPs started arriving around 19:00 and the event ended after midnight. All guests collected their wristbands at the reception as they entered the building, and brought them with them when they left. Figure 2 shows the event space, the rooms, the approximate tour itinerary, and the locations of our infrastructure which we will describe later in this document.

Project Partners

While the project itself was initiated by Red Bull and Byborre was responsible for all the curator aspects, the tasks of creating the different parts of the final experience were given to a heterogeneous mix of companies and individuals. So for instance an interactive artist was responsible for creating an interactive sound and light show which would

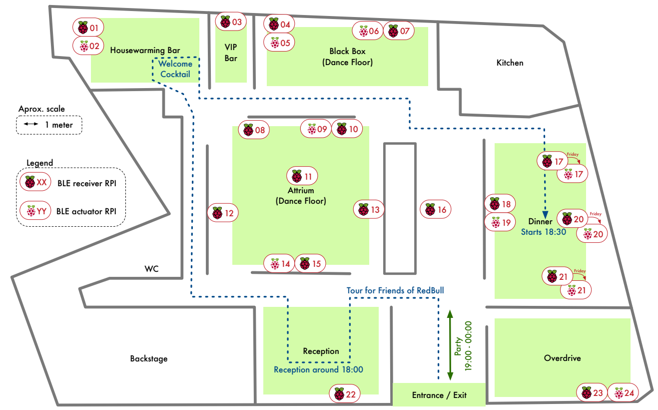

Figure 2: Location of RPIs in the improvised night club.

adapt to the amount of activity on the dance floor and stage designers created the stage setting for the two DJ stages. A well known chef was brought in to put together a special menu for the evening, which was enjoyed by the special guests and a perfume designer created a new scent specifically for the event.

In terms of technology, the design firm *CleverFranke* was responsible for the graphic design and the development of the visualization which was driven by the sensor data collected from the wristbands and they also put together the personalized post-experience graphics which were printed and sent to each guest as a personal souvenir of the evening. Our part was the planning and the instrumentation of the event space, the preliminary research into how we could track and measure the amount of activity on the dance floor and finally—together with Byborre—the creation of the wristbands. Moreover, after the event, the collected data was shared among the parties and was for instance used by CleverFranke to create the post-event graphics and by Byborre to create specially knitted scarves, which sent out to a select few of the guests. As each of the project partners had their work and requirements well planned and organized, we were all able to work in relative autonomy, with only the occasional meeting held to update each other on our progress.

Figure 3: One of the wristbands that each guest received as part of their invitation, which would measure their activity level throughout the event. (🅭🅯 Ayman on Flickr)

Research Challenges

Having briefly outlined our tasks within the project in the previous section, this section shall elaborate on each of the aspect in greater detail. Being a research institute, our interests were not really commercially motivated, but more so by the research aspects and insights that could be gained from such a project. The following subsections will touch on each of the components of the final system, the development process and the potential research insights we gained from it.

Sensors & Wristbands

The theme of the event was stimulating the senses and being in the moment. Technology had to be the sixth sense that connected the others. However, technology is often seen as a distraction that brings us far away from our current physical experience. We wanted people to be connected to the club, but not to be distracted by their smartphones or other gadgets. Therefore, we were required to make data gathering technology (almost) invisible to the audience. The purpose was not to hide the fact that people were being monitored, they all were aware of it, but to make them forget about it. Whatever sensor would be used, ought to be small and have a way to communicate wirelessly. In addition to that, power consumption should be low enough to, at least, last for the whole party, but ideally a couple of weeks longer to account for manufacturing times. Finally, any system used for data gathering should be able to support a large number of simultaneous users, in our case 500 users per night, inside a relatively small venue. In other words, we needed to support a network with a high density of devices.

Leveraging the signature textile manufacturing techniques of Byborre, we opted for wristbands with embedded sensors to monitor party guests. This seemed to be the most sensible way to approach this, since in regular events, guests are commonly wearing wristbands after entering the venue. However, in this event, the wristbands were also carefully designed to be a fashionable memory of the event. Two model of wristbands were designed: one for the VIP guests (see Figure 3) and one for the Friends of Red Bull, see Figure 1. The wristbands were created in such a way that electronics were not visible from the outside, although the wristbands of Friends of Red Bull included a LED strip that, when activated, could be seen through the fabric. So people could easily forget that they were being monitored.

As communication technology, we selected Bluetooth Low Energy (BLE) advertisement/broadcast messages as the way to obtain data from the wristbands. Although more efficient protocols in terms of range, scalability, or power consumption exist, BLE is well-known and available in a wide range of affordable devices. Thus, it was a safe choice to comply with the project budget, as well as the tight development and manufacturing times. Nonetheless, BLE is rarely used in such a demanding environment. Getting data from 450 devices per night inside an improvised club space of about 500 m^2 is challenging because of the amount of devices, the expected density in areas such as the dance floors, and the limitations of BLE [1, 4]. Moreover, the 2.4 GHz frequency band used by BLE is shared with WiFi. This encouraged us to carry out several experiments to explore BLE feasibility in dense networks, which also brought us a much better understanding of its performance.

Figure 4: Separate room of the venue in which the sound and light was controlled by the activity level measured in the crowd in the main room. (🅭🅯 Ayman on Flickr)

Figure 5: Real-time data visualization, by CLEVER°FRANKE, in the main room, which illustrates the amount of activity of the crowd as measured by the wristbands. (Author's image)

Out of the total 900 wristbands that we produced, 800 were fitted with *Estimote Sticker* boards for VIP guests. These coin-sized boards broadcast a UUID, 3-axis accelerometer values and ambient temperature readings using a protocol similar to Apple's *iBeacon* over BLE, i.e. they embed sensor readings in Manufacturer Data BLE advertisements [2]. The second type of wristband for *Friends of Red Bull*, of which only 100 were made, uses a *SensorTag CC2650* board from *Texas Instruments (TI)*. It is slightly larger than the Estimote board, but it is a more general-purpose board for IoT applications, has more sensors built-in and is fully programmable. Both boards were configured to broadcast data every 1.25 seconds, but *Estimote Stickers* saved battery by doubling this period when static.

Data Collection Infrastructure

Commercial wearable devices, e.g. fitness trackers, typically rely on smartphones to gather data. In our pursuit of making technology invisible, we did not want to ask guests to install anything on their phones. This could not only distract them from the club experience, but also create the concern that we could be monitoring private data stored in their phones too. Instead, our wristbands communicated with the club directly, thanks to our own network infrastructure. To make this infrastructure unnoticeable, we used small computers (Raspberry Pi) that received the data captured by the wristbands.

Our data collection system, and the whole data pipeline supporting it, needed to factor in possible interference and packet losses. The system also needed to be easy to install and remove, as well as cost effective. For these reasons, we opted for a network of Raspberry Pis (RPIs) that listened to BLE advertisement channels. They were then connected via Ethernet—to diminish interference—to a central server, which stored the data, in a MongoDB database, and forwarded it to the rest of the systems. This system not only captured and stored BLE packets emitted by wristbands, but also by any BLE devices broadcasting in range of our receivers. Since these packets occupy BLE resources anyway, we captured them to understand network performance and to explore potential correlations between wristbands and other devices. RPIs were carefully placed to be able to cover the whole space in an attempt to maximize the likelihood of receiving BLE packets. Thus, more RPIs were located in rooms, such as dance floors, were we expect higher density of people. Their approximate location is shown in Figure 2. We captured over 40 Million packets that are publicly available in the CWI-ADE2016 dataset described in [3]. During the event, the throughput of sensor data is, in average, about half the expected. This means that our system was able to receive a sensor reading every 2 seconds.

The map also shows the location of the RPIs used as actuators. The role of these devices was to connect to *TI SensorTags* using BLE and activate their LED lights. Light patterns in the wristbands of Friends of Red Bull were designed to indicated events during the dinner. This functionality is not trivial in a system like this. First, the network must find the RPI closer to the wristband to connect to. Then, this RPI must attempt the connection, which can be a slow process due to the way BLE is designed and the high number of devices. The complexity of the problem explodes if the number of wristbands to connect to is large, e.g. 50 people having dinner at the same time. As a consequence, despite the success of our system during previous tests, we hit many scalability barriers that limited its performance during the real event. During the party, wireless communication was hindered by the presence of people and more interference sources, such as smartphones.

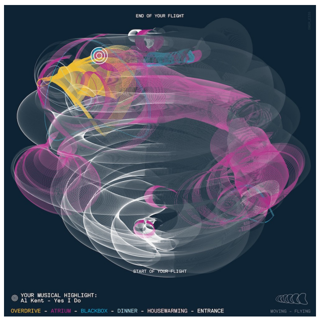

Figure 6: Post-event graphic by CLEVER°FRANKE which was sent to each guest, representing a summary of their experience.

From Data to Insights

Our task was to capture the club experience both from the individual, and the crowd. We asked ourselves questions such as *what is the energy of the dance floor?* or *what are someone's night highlights?*. The raw data drawn by our system had to be transformed in valuable insights to answer these questions. We focused on temperature, location and energy level, each of them required us to solve different challenges. Each wristband had a temperature sensor inside. Therefore, the temperature measured is not ambient temperature, as the sensor is affected by the fabric covering it. Nevertheless, these values can be used as relative levels to compare different rooms or the same room at different times. More temperature in the room may be caused by more people, but also by more physical activity—in our case more dancing.

Locating wristbands in the club was also an interesting challenge, as in the end, it allowed us to follow each guest and to get a feeling of popular spaces in the club. The challenges of indoor location using BLE have been studied by both commercial applications and research [8]. We were soon aware of the complexity of doing it precisely, which require fine grained calibration and precise triangulation techniques. These difficulties are aggravated in densely populated spaces, where moving people heavily influence electromagnetic wave propagation. For these reasons, we focused on obtaining room level location. This was possible due to the large number of Raspberry Pis and their distribution in the space. They were strategically located to be able to determine a wristband's location using the RPIs that received its last BLE packet with the highest signal strength (RSSI). Note that our approach here is reverse to the *traditional* approach, which uses several BLE beacon senders to locate a beacon receiver—often a smartphone. In our case, senders move while receivers remain static.

To define energy levels, we looked into recognizing people dancing. Activity recognition is an active area of research [10], but unfortunately dancing in a club is not among the studied activities. For that reason, we designed and trained a Convolutional Neural Network (CNN) using open fitness activity. Then, we collected data in house of three distinct energy levels representing increasing levels of movement intensity: standing, walking and dancing. Finally, using transfer-learning, we were able to predict our classes with accuracy above 90%. This event being sponsored by Red Bull, so these were renamed to *landed* (low), *taking-off* (medium), and *flying* (high). Besides, most activity recognition relies on reliable and high frequency data sources. In our case, the maximum frequency expected from sensors is 0.8Hz, and this does not take into account the intrinsic unreliability of a dense BLE network. Therefore, our CNN had to be prepared to produce energy level estimations with these data sources. Estimating energy levels allowed us to label everyone in the club with an energy level in real-time. Then, by linking them to location data, we were also able to infer the energy level of the different rooms.

On top of our system to gather and process data, we build a layer of services that forwarded data to interactive experiences specially created for the occasion. Figure 7 is a visual representation of the whole system. For this, the system employed a wired network and a series of APIs, offering the data as a JSON stream, feeding into the visualization or OSC, informing the interactive sound and light system.

Interactive Experiences

Data insights were transformed in different interactive experiences during the party. A special room, called Overdrive, seen in Figure 4, was designed to react to the energy in the club. Lights and sound were generated from live data

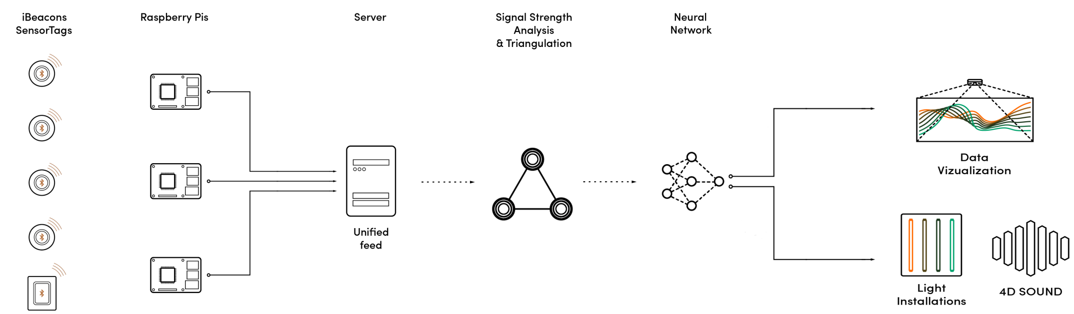

Figure 7: The layout of the final system and all its components

insights in such a way that the energy in this room was inverse to the energy in the main dance floor. When the dance floor was crowded with people dancing, this room was a calm place to chill-out. On the contrary, when the dance floor was calm, this room produced more energetic sound and light combinations. In addition, a live visualization was projected in the reception area, see Figure 5. It shows data from individuals, rooms or the whole club.

Data was also used to produce personalized artifacts sent to guest after the party. Everyone received a *Flight of the Night* which represents the aggregated energy levels and location of the crowd during the night. In addition, each person received a personalized visualization, see Figure 6, that shows their personal highlights. Finally, a scarf with patterns knitted following personal data was given to every Friend of Red Bull. This added a constraint as the visualization pattern from CleverFranke needed to be realized by the Byborre circular knit device.

During the Show

After two months of planning, development and construction, the venue and all the technology was ready on time. The construction crews had cleared the event space shortly before the evening and we also had already installed all components of our infrastructure. On the day of the event itself, our team set up at the venue to run the initial (and final) field tests to make sure everything worked as intended and all parts of the infrastructure were able to communicate with each other, i.e. that the wristbands were powered on and were communicating with the base stations, that the base stations were connected to the Ethernet and were able to communicate with the central server. The server was the most crucial part of the infrastructure, as it was responsible to collecting all, processing it, storing it, forwarding it to the visualization and the sound system as well as performing activity recognition. Therefore we made absolutely sure that it was working correctly. The system was monitored constantly and we devised contingency plans in case one of the processes would crash. We also had people on standby in case one of the base stations had a hardware failure which needed to be fixed in person by e.g. rebooting it or swapping it out with a working one.

During the actual party, the central server stood up to the load without problems, we did however discover a bug which caused sensors which had left the range of all base stations (i.e. people wearing them had left) would still show on up the visualization. This bug was caught during the first night and we were able to patch in while the system was running. While our base stations, the sensors and the server did not exhibit any critical failures, the live visualization did crash at some point during the first evening. The issue was addressed by people from CleverFranke that very evening. This resulted in some downtime though.

The second evening passed without any major issues and we used the morning and afternoon of that evening to inspect the system and properly address minor issues which were hot-fixed the evening before. This also gave us the chance to do some preliminary data analysis. After the party on the second evening had ended shortly after midnight, we collected all our machines and base stations and were able to vacate the premises an hour later, deeming the event a full success.

Conclusion

In this paper, we described the development of a multi-sensory clubbing experience from its inception as a simple idea, namely, to use technology to enhance a dance party, through the development of the idea and the challenges we encountered during that phase to its final deployment and use on two evenings. During the development process, which was loosely coordinated by a single party, several groups coming from fields such as design, fashion, construction, technology and research worked towards a defined goal to successfully complete the project. The project was laid out in such a way that each party could work in relative autonomy without much overbearing bureaucracy. Even given the tight deadline of roughly two months, the project was completed within one long sprint. This, combined with the fact that the teams were not tightly coupled made this a poor fit for agile development strategies and daily stand-up meetings between the teams, even though within the teams agile methodologies were followed to some extent to achieve the individual goal.

While it was our main goal to provide the hidden sense within the club, the data became the connecting component between the partners. This meant, as the people building the data infrastructure, we had to be agnostic to any one particular representation (as we would have to deliver JSON or OSC or any other format on the fly) and two we had to generate sufficient simulation data for the partners to test their systems before ours was ever in place. In effect, the data lead and informed the digital and physical design of the space and the fashion (wristbands and scarfs).

In the end, our goal was not only to deliver a working product, but also to gain meaningful research insights and develop a platform for development and experimentation moving forward. Each project partner was content with the goals they had achieved and gained new insights from the collaboration. We specifically as a research institute, came out of this project with a reusable and pluggable platform for running more experiments of this kind in the future and new results related to sensor technology or activity recognition. Most notably, we were able to publish said results as datasets to be used by other researchers and papers to highlight the technology. On the downside, we could not conduct interviews or have direct contact with the party guests, so measuring the direct impact of these technologies is complex.

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