1 Introduction

The Internet of Things (IoT) will change humanity in profound and unforeseeable ways[1]. According to a report by Cisco, between 2015 and 2020 the number of connected IoT devices is set to double from 25 billion to 50 billion[1]. This new revolution is driven by lower prices in manufacturing IoT devices as well as new inventions in radio communication and better processing power. This means more data than ever will be collected and automation will be the norm, rather than the exception. Industrial IoT (IIoT) and smart home are prime example for this. New factories are often operated by only a few or no workers at all. The former is called smart factories and the latter or lights-out factories[2]. In homes lights and temperature are increasingly controlled by an AI rather than the human living in it. This leads to higher productivity, better power management, more comfort and ther improvements. In most cases, this new technology is used to aid humans, but recent history has shown that IoT also brings many diverse challenges in technology, security and social life.

In 2016 a botnet with over 600k infected devices, primarily IoT devices, overwhelmed several high-profile targets like the DNS provider Dyn with massive distributed denial-of-service (DDoS) attacks. This caused a temporary outage of their DNS servers making many webpages, among others Twitter, Spotify und Amazon, temporally inaccessible.

The sheer number of IoT devices also makes it important to think about their sustainability. Many IoT devices are cheap to manufacturer and thus only used for a short period of time. They are hard to update, because they usually lack a simple connection mechanism for updating and are placed in hard to reach places. Often, this makes them throwaway products.

Finlly, some IoT devices are designed to aid homes in their homes and outside and are intended to analyze what they say, do and how their body behaves. This leads many professionals to the opinion that IoT, especially smart home and activity tracking are incompatible with privacy[3]. In the past many companies crossed the socially excepted line and had to roll back certain "features"[4]. Google recordered open WiFis during its Street View program and Amazons Echo, was and still is, recording all conversations. Studies have shown that for many consumers privacy is the major concern in smart home[4] and legislations have to be in place to check and balance the producers of IoT devices.

These four areas, technological improvements, security, sustainability and privacy, are the four areas shaping the development of IoT and the main drivers for many technological as well as architectural decisions in the development process of the product developed as part of this project. The reminder or this report is structured as follows, ***

1.1 Motivation

In this project we develop a new wireless goal for foosball tables for the IAFoosball project. We already developed a self counting goal, but it was not portable to other tables. The setup was table specific and wired up in such a way that was not scalable nor future proven. In this project, we would like to improve these shortcomings. The goal is the central part of the table. Making it scalable and easy to maintain is very important for the IAFoosball project going forward.

The backend software to manage user data and a primary architecture was part of a previous project and is shortly discussed in the next chapter. However, the choice of our backend software heavily influenced the software choice and automation flow. In our vision the table is a special, but integrated, part of our server architecture. This vision is shortly explained as orchestration in IoT is not part of the curriculum.

In order to make our solution attractive to bars and companies alike the solution neeeds to be easy to implement and manage. The resulting research question for this project is as follow:

What is the optimal design for a scalable wireless foosball goal?

We will answer the question based on the four aspects: technology, security, sustainability and privacy.

1.2 Delimitations

Due to time and equipment limitations we will focus on the technology in this report. Also, the findings from our tests are useful as a general reference point when discussing the strength and weaknesses of competing solutions. But as the tests do not follow strict academic rules, these findings are not statistical significant.
We also limit the main scope of this report to how we send and receive data from the goal to its controller. We will show the entire architecture but it is not part of the requirements and often not analyze or explained as throughly as the goal sensors.
Finally, we did not gather input from experts. This is something we would have wished to do, but was not possible due to time constraints.

2 IAFoosball

IAFoosball is the name of the project and startup we developed in the previous semester. It is meant to make foosball more interactive, to show and share statistics, and make it more sociable by using new technologies. The planned services include global and private rankings, table finder, friends, automatic tournaments and more. Because it is part of an university project, we used the latest and greatest technology. The front end is written in Flutter and pReact, the back end is separated in containerized microservices written in Go and all communication is done through gRPC, which uses protobuffs and HTTP/2. Figure 1 shows this architecture.

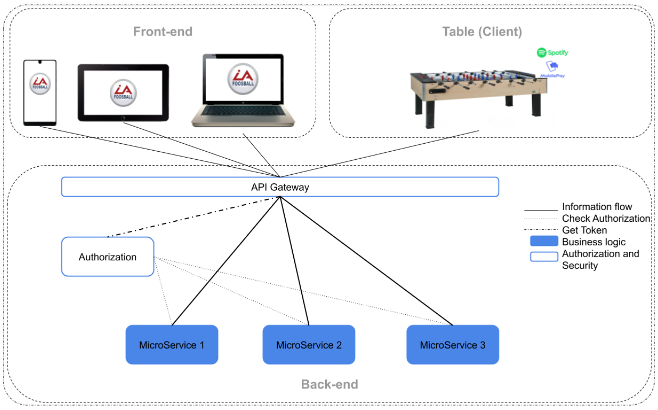

Figure 1: The current IAFoosball architecture

The foosball table in ***PLEASE UPLOAD PICTURE***is the development version and has all features. It includes, speakers with Spotify integration, LED lights, automatic ball release and a tablet. However, the software and hardware used on the table does not life up to the software standards at IAFoosball. The software needs to be updated locally without a CI/CD (continous integration and continous delivery) pipeline and is attached physically to the IoT gateway, the raspberry pi. This makes it very hard to scale and not mainstream suitable. To make IAFoosball more compelling for people and business which just want goal counting, and possibly ball speed measurments, we wanted to cut down on features and instead concentrate on quality.

2.1 Goal Design

The goal design is the primary part of this report and the most lacking part in the old setup. Figure 2 shows the electronic wiring of the old goal.

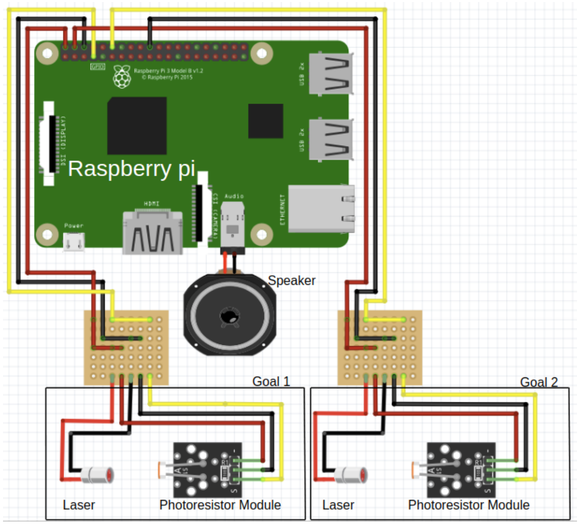

Figure 2: The old IAFoosball goal

The sensors were directly connected to raspberry pi and a simple javascript application registered the goals and send them to a remote server. This required a power outlet and a raspberry pi on each table. It also required cables from each goal to the raspberry pi. This approach did not scale well and in a multi-table setup also wasted money as each table needed its own raspberry pi. We re-thought the design, making it more varsatile, easier to integrate and manage and also cheaper for multiple tables.

Figure 3 shows this new setup. Marked in grey are the components used for each goal, a battery (we use a lithium-ion battery), one laser, one light sensor and one esp32. To measure goal speed we would need to have to lasers and two sensors. The esp32 is the component doing the computation and sending data to a raspberry pi via bluetooth low energy (BLE). It is powered by a battery pack

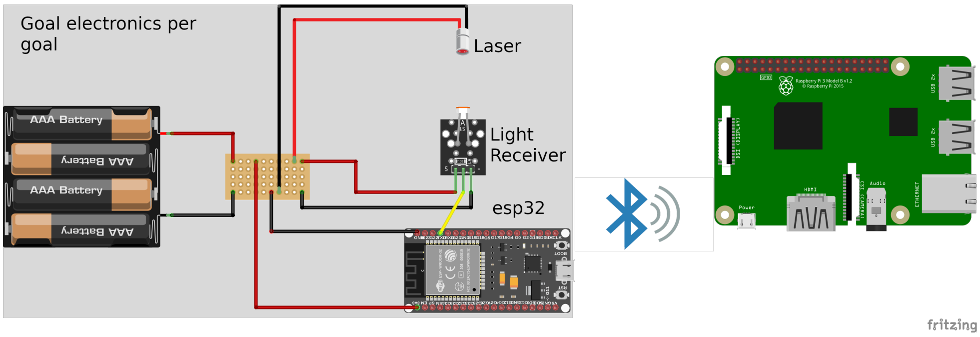

Figure 3: The new IAFoosball goal

and only active when the need arises.

3 Tests

The tests cover the power drain from the sensor, laser and the esp32 to determine the optimal setup. We tested 10 times to see if our tests were acurate. This is not enough for statisitcal significance but enough to give us at least an order of magnitude of the power consumption by the individual components.

3.1 Laser

We tested the laser on a power source of $4.695V$. It consumed on average $0.025A$ and thus the power consumption is

$$4.695V * 0.025A = 0.117W$$

References

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