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LUT School of Business and Management
CT10A7041 Home automation code camp
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HOME AUTOMATION CODE CAMP

PROJECT REPORT

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1. VISION

We envision an autonomous parking facility for vehicle, where all processes required for daily operations are fully automated without the need for human assistance, while having a low carbon footprint.

2. OVERVIEW OF PROJECT

The objective of this project was to create a vision of how to utilize home automation components in a way that is profitable, environment friendly and realizable in five to ten years from now. We had to turn that vision into realistic scenarios and demonstrate some specific operations of the system we planned. Lastly, we had to present one communication protocol used in the field of home automation. In this report we present the results of our project.

Project Rationale

It can be hard to see the bigger picture when looking at a parking facility. There does not seem an obvious need to improve them and sustainability effort would be better put towards other things like buildings.

There are already companies that provide the changing of lights for parking facilities. Philipps offer this service and talk about a savings of: “80% on energy costs with a smart lighting system”.

There is also the sustainability savings of cars taking less time to get to their parking spot. There can be a total of 11 seconds saved per car to find a spot [3]. This scenario is based on a campus and over a period of 2 weeks it saved 19 miles of travel. A campus though is not as busy as a shopping mall; therefore, these numbers could be improved in certain scenarios.

Having automated cleaning in the system will reduce the need for humans to clean. This will save money for the salary of these employee’s. It can also be assumed that the cleaning needs specialized tools such as pressure cleaners and employing people with these tools usually comes from an agency which would not be that cheap.

3. COMPONENTS/MODULES

Parking Slot Allocation

Once a car enters the parking area, the display board will show the driver nearest vacant parking slot number. Afterwards, this board will guide the user to reach that parking slot by showing him the direction and distance through the display board.

Energy-Based Payment

The car will transfer its electrical energy up to a certain threshold to the central electrical reservoir of the parking area in exchange for parking payment fee.

Adaptive HVAC + Lighting

Heating, Ventilation, and Air Conditioning and Lighting will be turned on or off automatically based on the sensor response to optimize utilization.

Automated Cleaning and Waste Disposal

Image sensors will detect waste objects' presence on the parking floor and communicate the object location to the automated vacuum cleaner. This cleaner will move to that location, clean that waste and return to its original position.

Automatic Fault Detection

In case a sensor or a light or any other electronic device becomes dysfunctional, this message will automatically be communicated to the authority by an automated messaging system.

4. SCENARIOS

There are a few key scenarios that we see being the main ones for our project.

Scenario 1 - Daily commute

We can see a driver that is working in the center of a big city. They drive to the same parking garage every day as it is close to their work. If this user comes in an electric car they will have charged it over night when the cost of electricity is low. With their commute only taking a small percentage of the battery, they should be able to use some of to create a local micro grid. They would likely be parked for up to 8 hours for their shift. The facility would take some energy from their car to cover the cost of the stay, but we would make sure that the car had enough energy left for them to get home.

Scenario 2 - Shopping mall

A shopping mall is a different scenario in that the users will only stay in the facility for a few hours at a time and not the whole day. There is also the fact that the need for smart parking is a necessity here as the customers of the shopping mall spend time getting to the front of the parking facility (Closest to the mall), and then begin working backwards to find the best spot. This adds a lot of time to the time spend parking and this will only be amplified at peak times, such as at weekends and especially at Christmas time.

Scenario 3 - Long term parking

A lot of parking facilities are used to store cars for more than a day at a time, one such example would be an airport. For this example, it would be nearly impossible to have the energy transfer system, but this does not mean that the other parts of the system could not be implemented. Airports use a large part of their total area for parking, this means optimizing the lighting and cleaning of such a large space would help improve the efficiency.

5. ARCHITECTURE

The system of interest is composed of both sensors, actuators, and a central management/control/monitoring unit. The sensors are required for data collection, the actuators for taking actions and affecting the facility - since we aim it to be fully autonomous we consider the intelligent agents (i.e. robots or any other AI) to be both actuators and sensors at the same time. The central unit (CU) is mainly used to keep an overall knowledge of the facility and monitor it - and it is considered the interface of the system with the human staff in charge of maintenance.

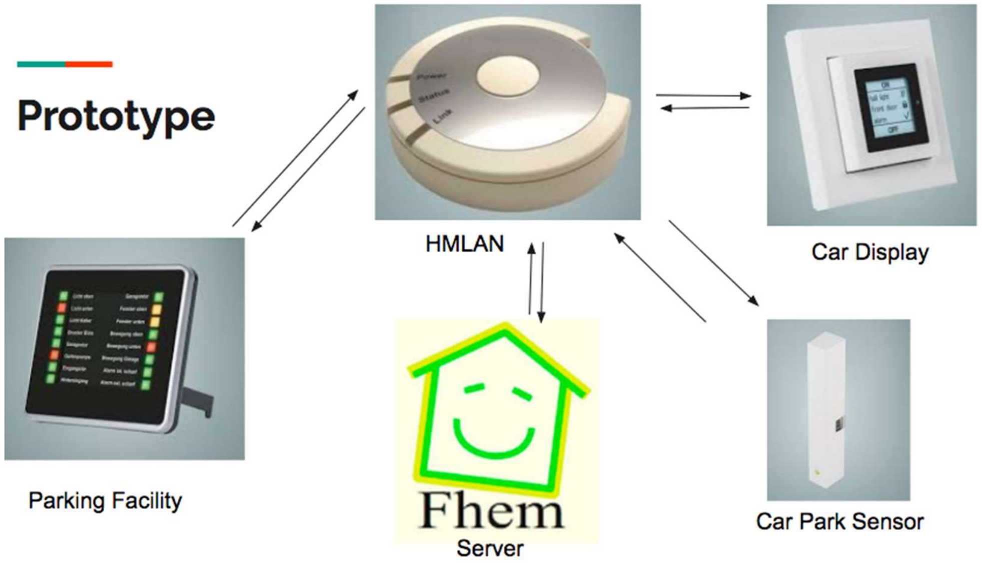

Figure 1. Prototype Architecture

The above figure describes a simplified version of the prototype that was developed, which exhibits the revamped parking experience in parking facilities equipped with **pysäköid.ai**. The FHEM server is where lies the business logic of the application, which maintains the state of the parking facility and handles any actions undertaken by the users. The status display (HM-Dis-EP-WM55) represents the car display and navigation system, which is aware of the car indoor location in addition to providing voice directions provided by the parking facility system. The optic sensor (HM-Sec-SCo) serves as a detector for proximity of cars, ideally each parking spot would be equipped with one. An aerial overall view and status of the parking facility is represented by a 16 LED 4-status monitor (HM-OU-LED16), where each LED represents one parking spot, and the color associated with it changes depending on the status of the parking spot. All communications follow the HomeMatic (HM) protocol, via an HMLAN wireless hub.

6. SWOT ANALYSIS

Strengths

- Have many returning drivers
- Has eye-catching display board to guide the drivers to reach parking slot
- Driver Satisfaction - Drivers find the system convenient as they no longer need to look for a vacant parking slot manually
- Orange light’s early reservation signal prevents more than one car from competing for the same parking slot.

Weaknesses

- Display Board’s distance measurement does not get updated based on real-time GPS data when the car starts moving towards its allocated parking slot
- Sudden disruption in LAN connectivity
- Don’t have a website to promote the system
- Don’t have sufficient marketing budget.

Opportunities

- Increasing number of vehicles looking for parking slots
- Affordable market price of LED display board and light sensor
- Growing number of electrical vehicles
- Rising use of social media for advertisement
- Most of the shopping malls have their own parking area to accommodate customers’ cars.

Threats

- Scarcity of HomeMatic (HM) compliant LED display boards and light sensors in certain countries of the world
- Expense of running media ads
- Other parking facility businesses in town, competition is increasing

7. DEVELOPED PROTOTYPE

For the prototype we developed during the code camp we merely focused on the parking experience, using the architecture outlined in "5. Architecture". A user first arrives to the parking facility, they would request for a parking spot, which would be assigned and reserved for them. The color of the LED for that spot turns from green (free) to orange (reserved). They would then get directions on how to get there, for each step along the way. Once they arrive, their spot is indicated and highlighted, and once they have parked it would be detected by the optic sensor, and the LED indicator will turn into taken (red). And once the person would have left, they would be automatically identified, and provided with their bill on their way out of the facility.

8. IOT COMMUNICATION PROTOCOL - UNIVERSAL POWERLINE BUS (UPB)

Universal Powerline Bus (UPB) is a protocol for communication among devices that uses powerline wiring for signaling and control. The protocol was developed by an American company PCS Powerline Control Systems and it was released in 1999. [1]

UPB is based on concept of X10 standard. The protocol can be used on single-phase, split-phase or 3-phase power lines. Compared to X10 UPB has an improved transmission rate and a higher reliability. UPB reliability has been reported to be more than 99 % while X10 reliability sets between 70-80 %. [1]

8.1. Physical communication method

Digitally encoded information is sent over the electrical power line as a series of precisely timed pulses. The pulses are superimposed on top of the AC sine wave (Fig. 2). [2]

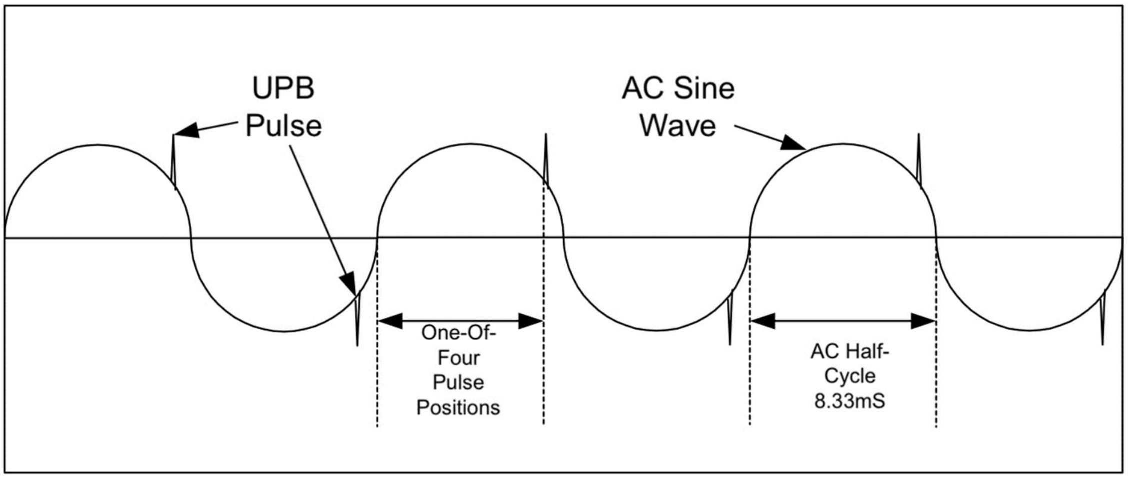

Figure 2. UPB Pulse [2]

Pulses are generated by charging a capacitor in the transmitter and then discharging it. A pulse can be sent once on each half-cycle. One pulse transmits two bits of information. Pulse value is selected by timing the pulse on one of four predefined positions (Fig. 3). Tolerance for timing the pulse is ±40 µs. [2]

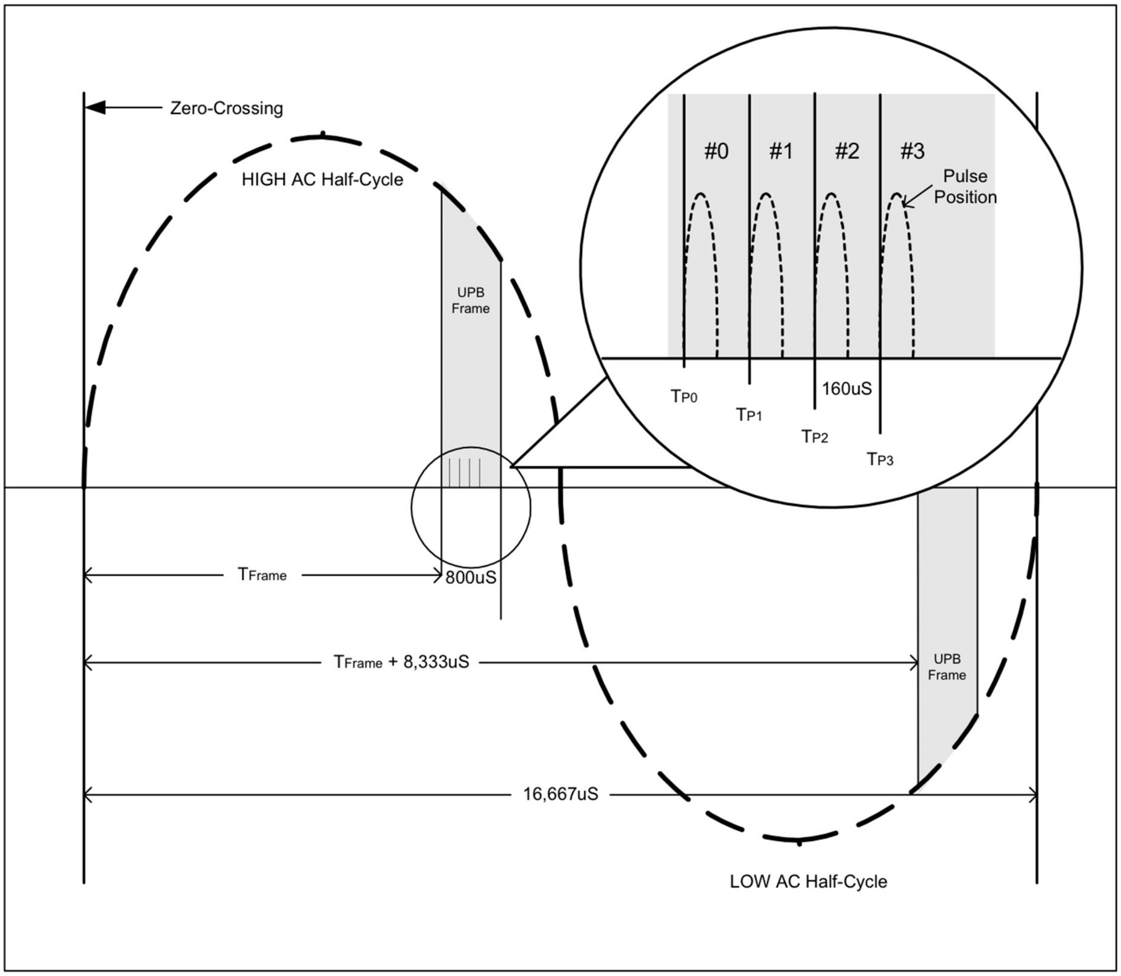

Figure 3. UPB Timing [2]

8.2. Data communications

Devices use the standard UPB Communication Packet to send information through the network (Fig. 4). The maximum size of the Packet is 25 UPB Bytes. The UPB Byte forms of four pulses, total of 8 bits. [2]

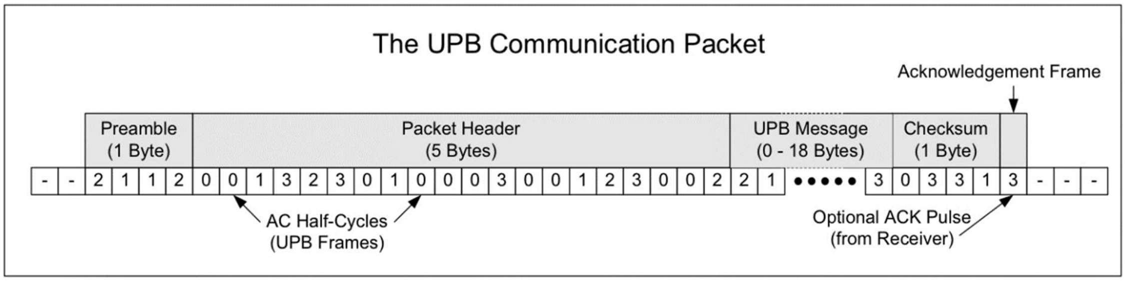

Figure 4. The standard UPB Communication Packet [2]

The first byte of the packet is called a preamble byte and it is used for synchronization on the receiver device. Preamble byte is always form of 2-1-1-2. [2]

The last byte of the packet is a checksum byte which is used to verify packet's integrity. The checksum is formed as follows: "Sum all of the bytes of the Packet Header and UPB Message fields together. Then take the 2's complement of the sum and truncate the result to 8-bits." This results the sum of all packet bytes (including the checksum byte) to be a value of 00. If the result is something else, then the receiving device knows there was an error on the message. [2]

The frame after the checksum byte is empty and it is reserved for receiver's acknowledgement signal. The source device can ask for the acknowledgement in the packet header. If the message is received successfully the receiving device sends value 3 pulse at the acknowledgement frame as a confirmation. [2]

The packet header contains information about the packet size, source, destination, and instructions how the packet is received (Fig. 5). [2]

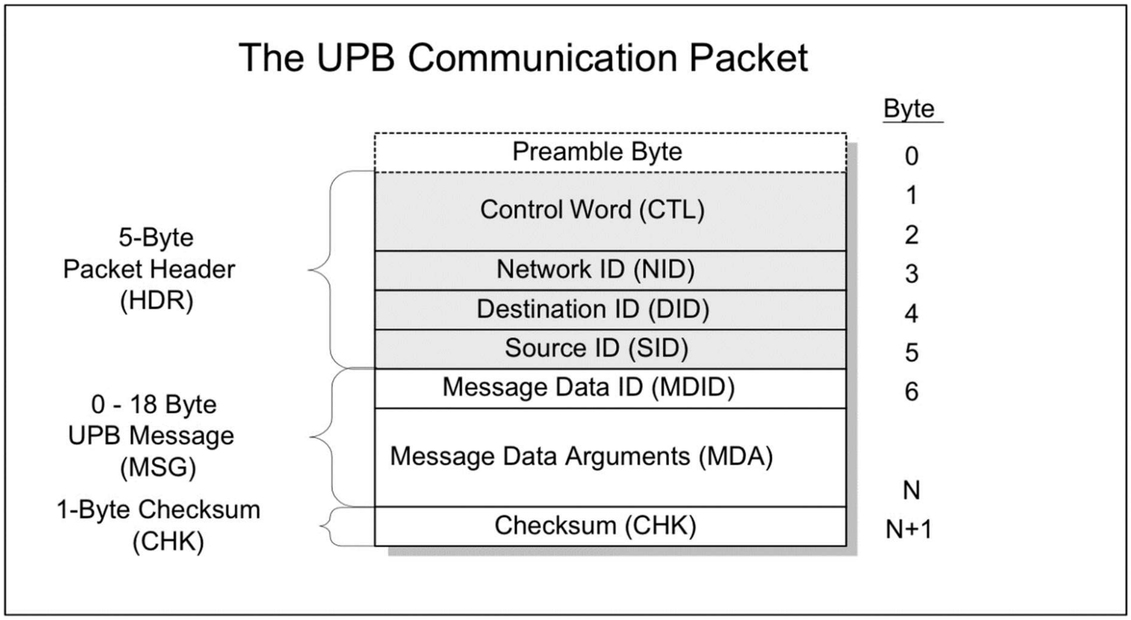

Figure 5. The Packet Header [2]

8.3. The UPB System model

The UPB System utilizes the network ID (NID) and unit ID (UID) registers to identify the devices and to which virtual networks they are assigned. Network ID consists of one byte and can hold values from 0 to 255. Each network can handle up to 250 unique devices. See Fig. 6 for the illustration of multiple UPB networks on one AC power line. [2]

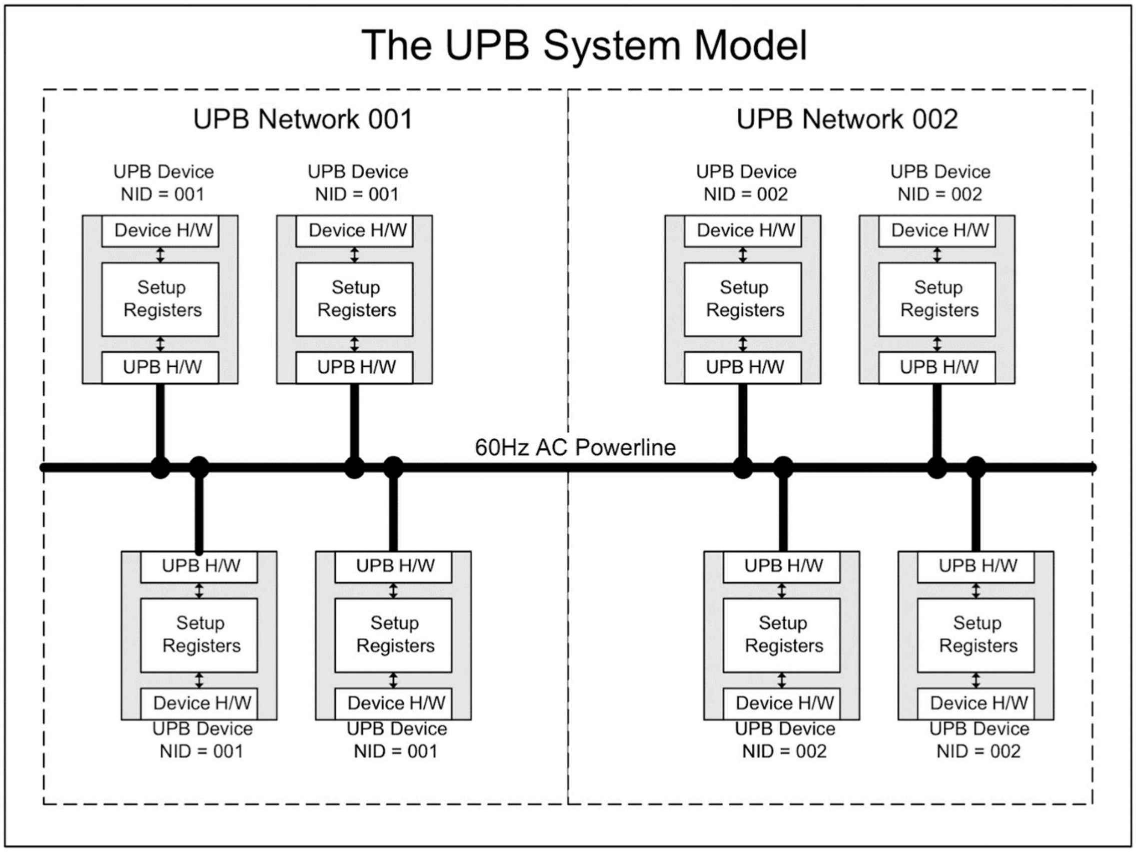

Figure 6. UPB system model [2]

Each UPB device holds the UPB setup register (Fig. 7). First part of the register UPBID is for the device identification. Size of UPBID is 64 bytes. The rest of the register contains data for configuration of the particular device. The register size can be up to 256 bytes. [2]

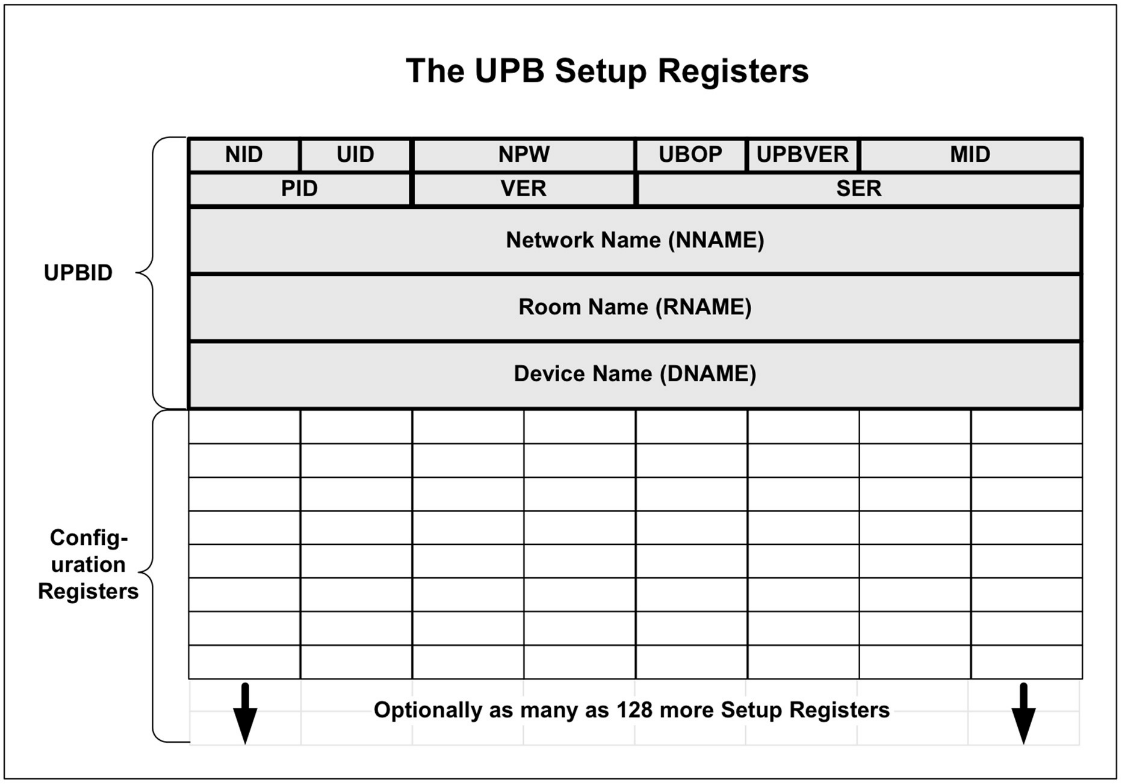

Figure 7. Setup register [2]

The UPB devices can be controlled individually by addressing the message to a specified unit ID (UID) or the control message can be sent to a larger group of devices. This grouping is done by setting up Device component attributes in the configuration register. Device components are then grouped with a Link ID register field. See the illustration of controlling linked devices in figure 8. [2]

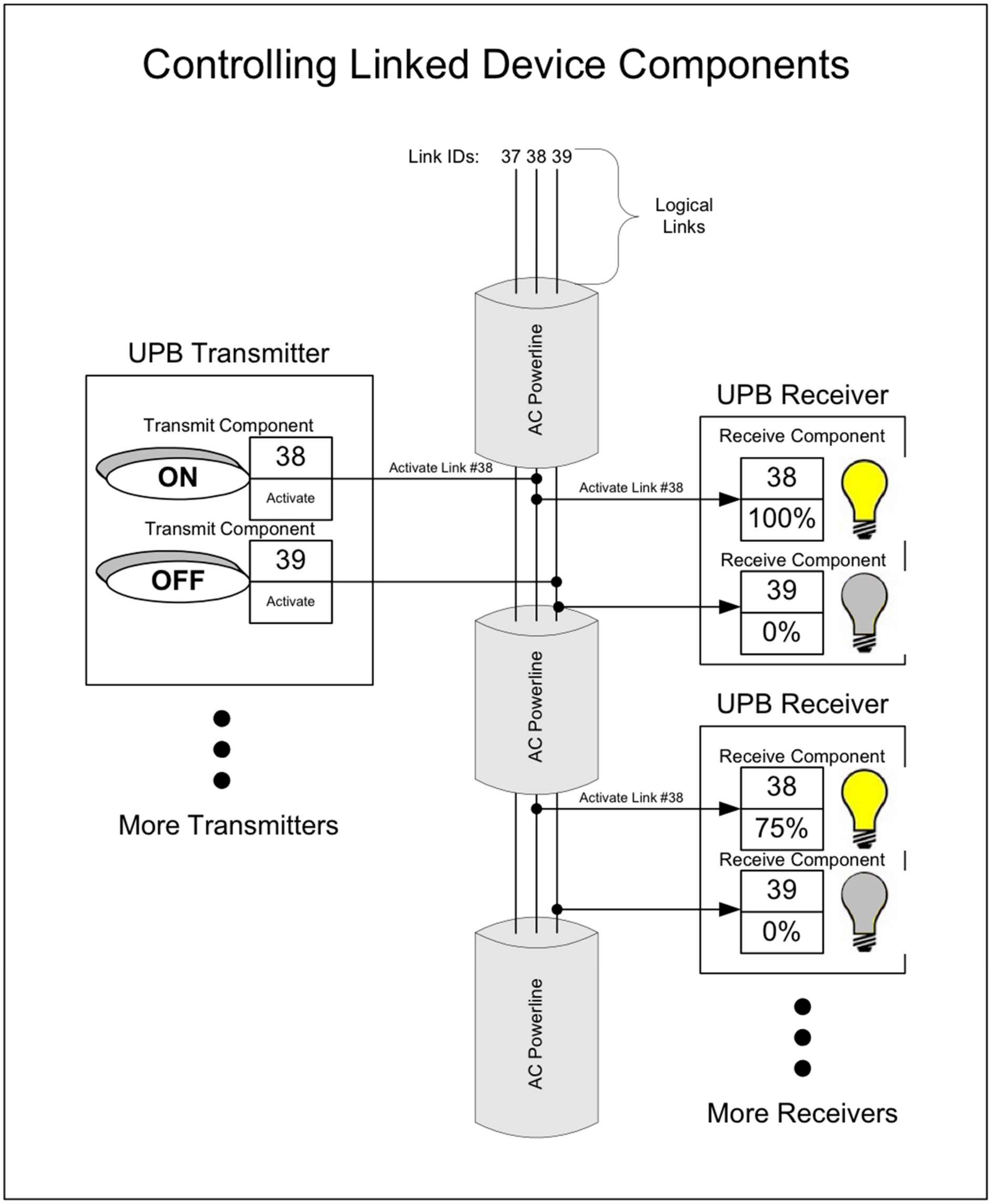

Figure 8. Linking components [2]

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