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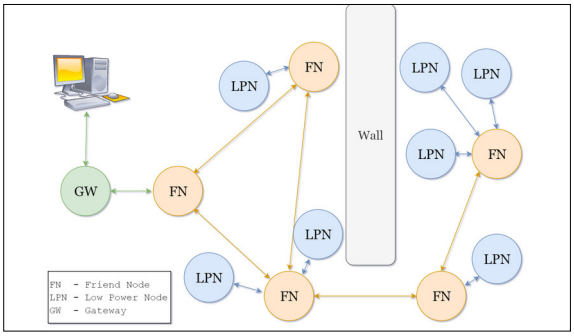
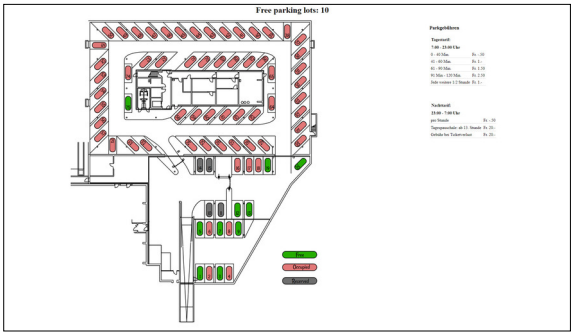
Subject Area	Wireless Communications

Parking Lot Monitoring System



Bluetooth Mesh Network
Own presentment

Hardware of the low-power device
Own presentment



Website with the occupancy plan
Own presentment

Definition of Task: The task of this thesis is to develop a parking lot monitoring system, which tracks the occupancy of the parking lots in the HSR parking garage. The final system should later on be able to replace the current system, which uses the turnpike to count the amount of free parking spaces.
The system has to be low-power and a sensor device has to be placed at each parking space. Furthermore, Bluetooth 5 with its meshing and low-power functionality has to be used since the connection to common wireless networks is not guaranteed throughout the entire garage. If possible, the sensor devices should be self-sustaining. Furthermore, the occupancy plan of the parking spaces should be displayed on an appropriate website.

Approach: To meet the requirements, the nRF52840 chip from Nordic Semiconductor is used. It includes Bluetooth 5 and has meshing capabilities. Nordic also provides a software development kit with many examples. Three different firmware versions are implemented, one for the low-power sensor device, one for the friend node and one for the gateway.
An ultrasonic sensor is used to measure the distance from ceiling to ground every ten seconds, which indicates if a car is underneath the sensor or not. The sensor data is then transmitted through the mesh from friend node to friend node over Bluetooth until it reaches the Gateway, which then transmits the data over UART to a Raspberry Pi.
The parking space occupancy state is stored in a database on the Raspberry Pi. A publicly accessible website is used to illustrate the states.

Result: In the course of this work, a complete and functioning measurement and communication system was developed that meets the system requirements. One newly developed hardware is used for all three devices. Depending on the firmware and the fitting configuration, it can act as a gateway, a friend node or as a low-power node, whereas only the low-power node is equipped with a sensor.
As for the self-sustainability, measurements have shown that the amount of light is not sufficient to power the devices, therefore a battery is used as a power source.
The website uses the floor plan of the car park with colored rectangles indicating free or occupied parking spaces. Whenever a car enters or leaves the parking space, the color of the associated rectangle changes automatically. The website is optimized for desktop and mobile screens so users can also check the amount of free parking spaces on their phones.
As a final conclusion it can be said that the system performs as desired. The low power sensor nodes can successfully transmit the parking state and the website is correctly updated. Only the self-sustainability requirement could not be fulfilled.