Investigating Antenna Diversity for IoT Applications

Enhancing Connectivity and Reliability in Wireless Networks via Multiple Antennas

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Introduction: In many applications, the position and orientation of Internet of Things (IoT) devices cannot be freely chosen and typically cannot be modified once installed. These constraints often result in significant challenges, such as antenna misalignment and adverse effects from nearby objects, particularly metallic constructions, which can drastically degrade the quality, reliability, and throughput of network connections. This thesis explores the potential of incorporating multiple antennas with different polarizations into the devices, to enhance the performance and reliability of wireless links within the IoT network.

Approach: Multiple test networks were established using specially designed nodes that differ in size, as shown in Fig. 1, each equipped with three mutually orthogonal, linearly polarized antennas. Additionally, a browser-based live visualization tool, displayed in Fig. 3, was developed to facilitate manual interactions with the network, enabling users to change the active antenna or retrieve sensor data. Diagnostic scripts were also implemented to further evaluate the network's performance. Using these tools, the IoT networks were assessed for performance variations by measuring the received signal strength and throughput in various indoor scenarios to quantify the impact of antenna diversity on connection quality.

Conclusion: The measurements confirm that the use of antenna diversity can have a significant impact on the link quality. As illustrated in Fig. 2, improvements in certain scenarios reached up to 30dB for certain nodes. Utilizing only the two integrated PCB antennas, many connections still experienced enhancements ranging from 6 to 20dB, which can be crucial for establishing reliable connections. Even with the smaller node, improvements of 4 to 18dB were recorded. In terms of throughput, the maximum data rate was nearly doubled in some scenarios. The findings of this thesis demonstrate that although the integration of additional antennas and RF components adds complexity to hardware and software development, the effort is well justified by the substantial improvements in network stability and reliability.

Fig.1: The two developed IoT nodes, each containing two PCB antennas and one wire monopole antenna.
Own presentment

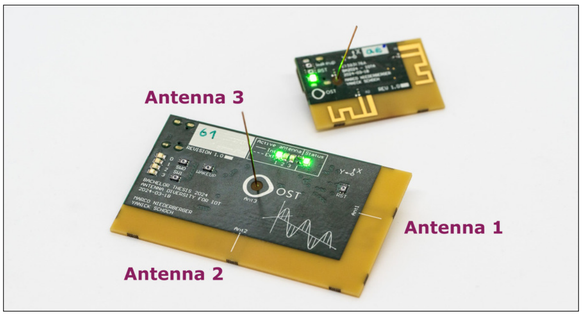


Fig. 2: By selecting the best antenna combination, the RSSI of this connection can be improved by 30dB.
Own presentment

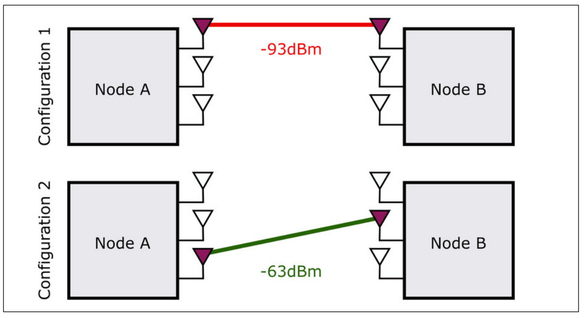
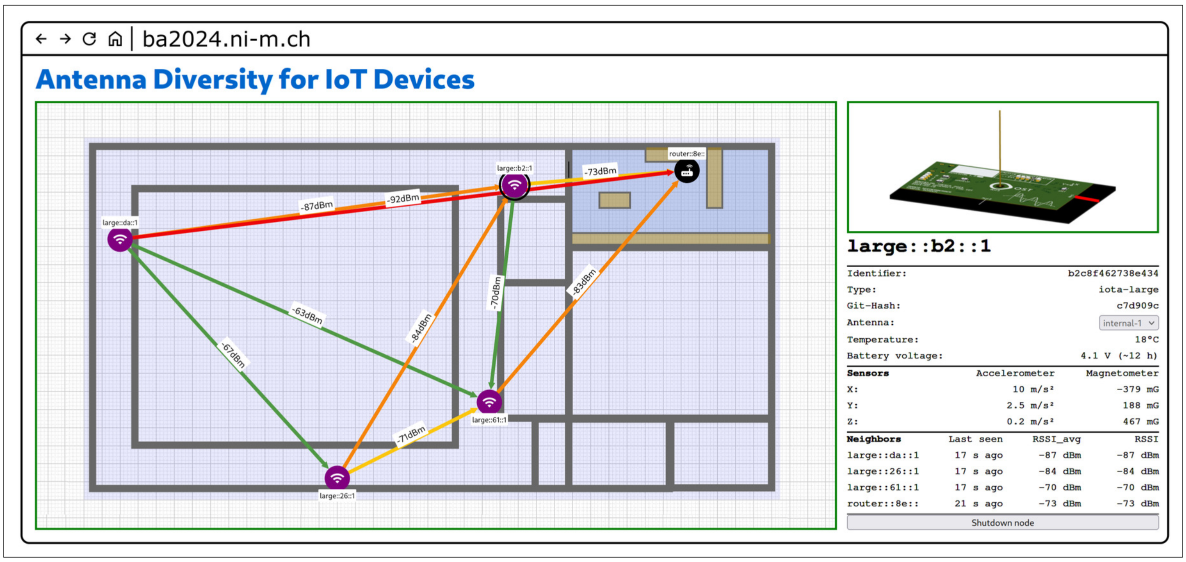


Fig. 3: Interactive web interface displaying the network connections and the node information.
Own presentment



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