Demo: Using DTN for Controlling A Vehicle With A Self Deployed WSN

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ABSTRACT

We present an experimental mobile platform which can drop self contained sensor nodes to deploy a Wireless Sensor Network (WSN). At the same time, this network can be used to increase the operation range of the mobile platform.

1. INTRODUCTION

In this demo, a mobile outdoor robot platform that can deploy WSN nodes in the field will be presented. Thus, the range can be extended at which the platform can be controlled. This is beneficial when operating in large or obstructed areas, where total network coverage is not possible with the communication equipment available on the robot. Such an approach can be useful in several scenarios. E.g., for WSN-based wildlife or habitat monitoring it is not desirable that humans enter preserved areas in order to avoid rousing animals but keeping them calm. A small autonomous robot will cause minimal irritation, and can also be used as data-mule to gather results later.

Disaster recovery is another case where, e.g., earthquakes or explosions may cause severe damages to buildings. It may be unclear whether people are buried in the ruins. Searching buildings manually can be risky. Thus, using robots for rescue operations would be helpful. In addition to robots moving around, (semi-)static nodes can be useful as well, e.g., for monitoring the building. Movements caused by persons or by the building itself indicating further structural collapse can be detected by accelerometers. A warning may be sent to search and rescue teams that the building might collapse or inform them about survivors which might have pressed an optional emergency button on the nodes.

2. PLATFORM OVERVIEW

We use a six wheel robot platform as shown in Figure 1. It is controlled by a BeagleBone single board computer (SBC)

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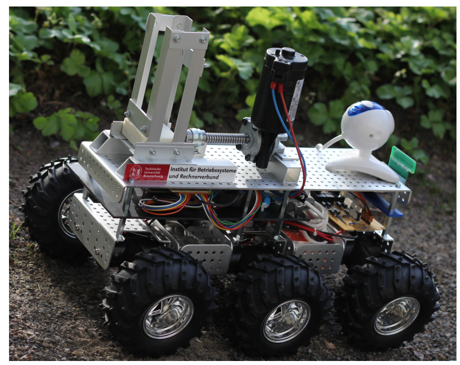

Figure 1: Prototype platform

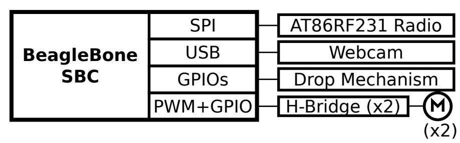

Figure 2: Block diagram of platform

running Debian Linux. Figure 2 shows an overview of the system. Two high power H-bridges are controlled by the SBC to drive the motors. An IEEE 802.15.4 radio (Atmel *AT86RF231*) is connected via SPI to the Linux system and used for DTN communications. Images captured by a USB webcam can be send via the low power radio link.

The vehicle can deploy WSN nodes in the field. Thus, a network can be setup comprising vehicles and dropped nodes. Control of the vehicle and further communication in the network is based on *IBR-DTN*[2], a DTN framework implementing the Bundle Protocol[3]. Multi-hop communication is applied for range extension, involving the dropped sensor nodes. We use INGA WSN nodes[1] running μDTN[4], a minimalistic Bundle Protocol implementation on Contiki.

While exploring an area and deploying the WSN by dropping nodes, we use a simple routing mechanism to avoid multiple copies of singe data frames in the network. Nodes are stacked with increasing CBHE addresses (cf. Figure 4) on the vehicle, so the dropped nodes can use the destination address to decide which neighbors will be used for forwarding.

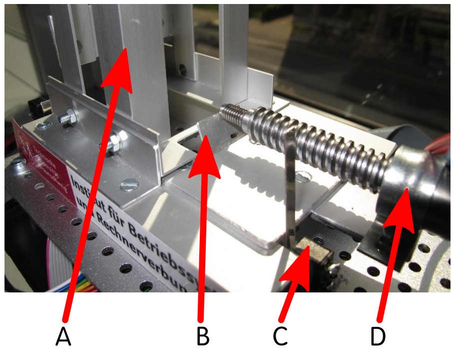

Figure 3: Dropping mechanism. A: stacking area for WSN nodes, B: spring raised plate to push nodes out, C: limit switch, D: spindle nut to move plate

The vehicle with its functions can be controlled from any system using DTN. We developed an Android App which can display an image of the front camera, and visualize other sensor readings from the mobile robot. As there are no native IEEE 802.15.4 radios for off the shelf Android devices, a gateway is needed which forwards data from WiFi (or LAN) to the next 802.15.4 hop and vice versa. Any embedded Linux platform supporting a IEEE 802.15.4 shield can be used.

3. MECHANICAL DESIGN

On the vehicle, up to seven WSN nodes can be stacked for being dropped. A close-up view of the mechanism is shown in Figure 3. A DC motor with spindle nut **D** is used to move a metal plate **B** raised by a spring mechanism. The stacking area **A** contains the sensor nodes. From the idle position shown in the figure, the plate **B** can be moved and pushes out the node at the bottom of the stack (not shown). For dropping the next node, the assembly has to drive back to the shown position. While moving back, the remaining nodes push down the plate **B** which raises when it is back at the default position. Limit switches **C** are used to detect the end positions of the assembly.

4. EVALUATION

To evaluate our experimental platform we took some measurements on an empty university campus area with some machine halls. The components of the evaluation are shown in Figure 4. In a first experiment we measured the maximum distance using single-hop line-of-sight communication between the gateway and the robot, without any intermediate node (blue connection in Figure 4). Reliable control is possible up to a distance of 80 m. The average RTT for a command packet that gets acknowledged is $\approx 127 \pm 4$ *ms*. Higher mounted antennas might extend the range. There is a trade-off between the size of the robot (and WSN nodes) and thus the ability to operate in confined spaces and range.

In a second experiment (Figure 5), a building prevented direct communication between the Gateway (1) and the robot (3), even though the linear distance is only 32 m. Using a strategically placed WSN node at a location accessible by the robot (2), communication between the gateway and the robot is possible using 2 hops (red connection in Figure 4), even though now the bridged distance totals 53 m. In this setup command packet RTT increases to $\approx 278 \pm 18$ *ms*. This result shows that the presented approach is suitable to

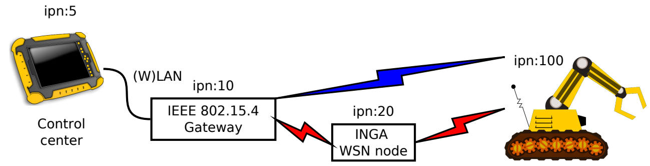

Figure 4: Measurement setup

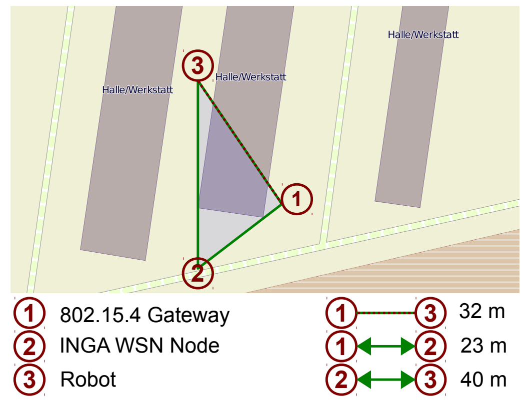

Figure 5: 2-hop Relaying

improve communication with the robot, allowing telemetry and commands to be transmitted when direct communication is not possible.

5. CONCLUSIONS AND FUTURE WORK

We have presented an experimental mobile platform, that can drop self contained sensor nodes, to deploy a WSN and at the same time use that network to increase its operation range. The shown platform is still in an early stage of development. It offers lots of opportunities for extending and refining the system. An image stream from the camera could be processed to add more autonomy. The mechanical design of the dropping mechanism can be scaled up and thus enable the possibility of dropping bigger relays such as Linux-powered SBCs. Defining and evaluating WSN node deployment strategies according to requirements of a mission will be our next focus. Using the presented platform this approach can actually be tested in reality, hopefully providing some interesting insights and practical strategies.

6. REFERENCES

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