Demonstration: Where's the Mote? Ask the MoteHunter!

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***Abstract*—Contrary to laboratory environments, real-world wireless sensor network deployments face harsh conditions where motes can be lost during deployment or in operation. We demonstrate MOTEHUNTER, a tool designed to support searching for such lost motes. It uses a directional antenna, a digital compass, and RSSI measurement, and provides a Java GUI to assist field work. It can be used to search for any mote compliant with IEEE 802.15.4, although a special small-footprint software component can be integrated with the mote's application to improve the search process.**

MOTEHUNTER is described in more detail in our companion paper accepted for SENSEAPP 2012.

***Index Terms*—Demonstration, wireless sensor networks, real-world deployments, localization, IEEE 802.15.4.**

I. SCOPE

"Where's the mote?" The question is not unheard when wireless sensor networks (WSNs) are applied in-field.

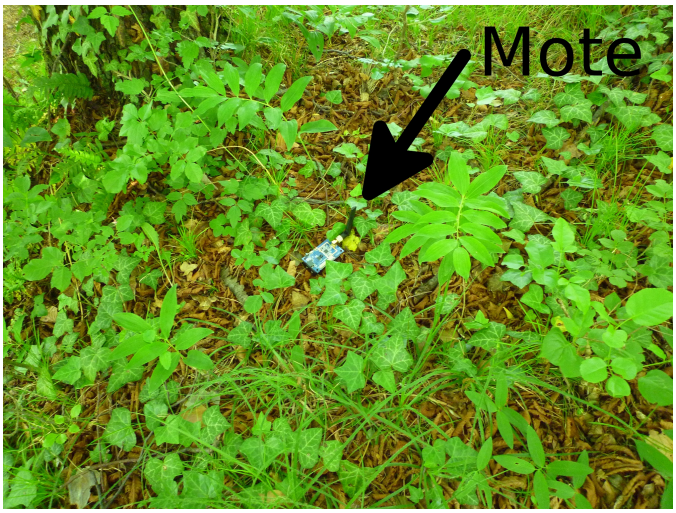

Fig. 1. A WSN mote, as (not) seen from the distance of a meter.

Installing and maintaining Wireless Sensor Networks is sometimes more challenging than it seems in the planning phase, especially when some of the tiny motes get lost during the process. Whether these have fallen in high grass, have been displaced by heavy rains, or one simply forgets where they were mounted, finding them could take considerable time. It could even lead to loss of equipment and loss of important data. Figure 1 demonstrates this problem showing a mote from the distance of a meter in high grass. Barely visible — as it is known to many WSN researchers.

MOTEHUNTER is a tool developed to search for these lost motes, supporting WSN researchers in their field work. The main part of MOTEHUNTER is the so called "Hunter", a combination of special purpose hardware, a TinyOS application similar to a sniffer, and a Java graphical user interface.

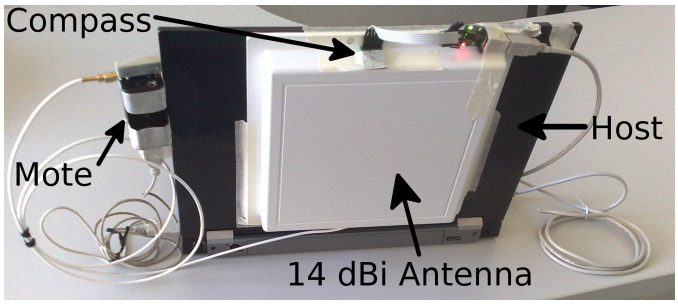

Fig. 2. The Hunter in its full configuration, equipped with a 14 dBi directional patch antenna.

We have developed two variants of the Hunter, one that is based on a laptop, a mote attached to it, a directional antenna and a digital compass (this *full configuration* is shown on Figure 2), and another one which is small and fits in a hand even when operating on difficult terrain (we call this the *standalone configuration*, as shown on Figure 3).

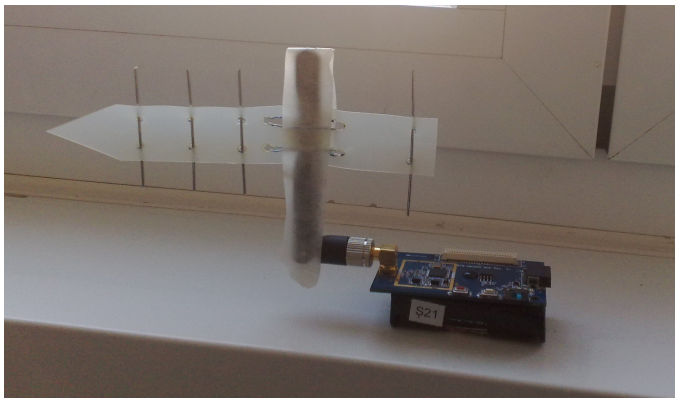

Fig. 3. The Standalone Hunter with a home-made Yagi antenna constructed on a dipole base.

The mote to search for (which we call "Prey") can be any IEEE 802.15.4 compliant mote. The Hunter works even if no

modifications are made to this mote. However, we developed a small software-only TinyOS component that can optionally be embedded in the Prey's code to facilitate the hunt.

We designed the Hunter based on the following guidelines:

- we try to create a cheap and readily available solution using components that are usually already on stock in research groups dealing with WSNs;
- we aim at the design of a tool that someone can easily bring along while doing field work;
- our tool should be composed more like a swiss army knife than like a monolithic tool;
- we design a graphical user interface that focuses on an intuitive visualization of the gathered data. The presentation and logging of exact measurements is less important;
- we provide backup options for extreme situations, when e.g. components are not available or when the tool has to be used on difficult terrain.

Principles of Operation MOTEHUNTER locates the Prey by taking advantage of the directionality of the Hunter's antenna, by taking RSSI (Received Signal Strength Indicator) measurements, and by using the acknowledgement feature of 802.15.4.

As the Hunter's antenna is rotated by the operator, it measures the reception strength of messages sent by the Prey node. Contrary to tools that try to estimate distance based on RSSI, we only look at relative changes in the RSSI as function of antenna orientation, and we search for the absolute maximum, and possibly local maximum points in these measurements. These correspond to the arrival angle of line-of-sight and reflected signals. After these are identified, it is the operator's role to move around, interpret the results, and finally arrive near enough to actually see the node with naked eyes.

Even if objects could hamper line-of-sight or rocks could create strong reflections, by having a human operator that actually sees and interprets the scene and potential reflective surfaces, the mote can easily be found.

Specially crafted "ping" messages are sent out periodically to solicit the Prey to send messages while the antenna is being rotated. A ping message is a standard IEEE 802.15.4 message with the A (ACK request) flag set. Almost any standard-compliant mote could be pinged this way, although with some issues:

- 802.15.4 acknowledgements are usually sent with the last used (or the default) TX power level, which could be set very low in some WSN applications;
- if LPL (Low Power Listening) is used, the mote will only receive and respond to part of the ping messages.

If the software running on the mote includes the Prey component, it also recognizes the message type of the ping message, and actively responds with an application level pong message that resolves these problems.

Software Interface The Hunter Java application presents the screen as shown on Figure 4. It is composed of a measurement list (left), a panorama view (middle), a time view (top), and a configuration panel (bottom).

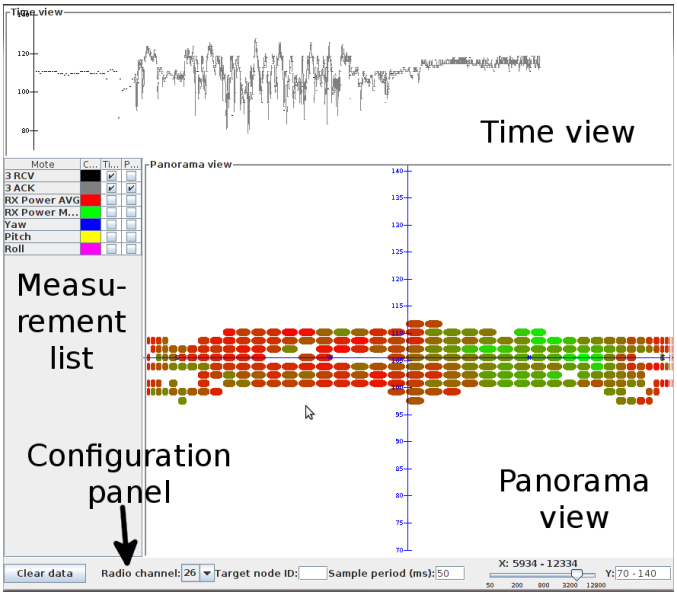

Fig. 4. The user interface of the Hunter application.

The measurement list presents the list of nodes discovered in the vicinity. The time view, at the top of the window, shows all (selected) measurements as a function of time. It could also show direction measurements, thus providing corresponding RSSI and direction values on the same plot.

The panorama view, which occupies the middle of the screen, presents the reception power from the Prey as a function of yaw and pitch (horizontal and vertical angle). In other words, it presents a 360° panorama picture of where the mote could be. Brighter (green) colors indicate stronger signal levels, while darker (red) colors mean weaker measured values. The view is rotated as one turns the device.

More details about MOTEHUNTER can be found in our companion paper accepted at the SENSEAPP workshop [1].

II. DEMO DESCRIPTION

We plan to demonstrate MOTEHUNTER by positioning some WSN nodes in the demo area, showing how their relative position is retrieved real time by the tool. Various versions of the tool (full configuration with a patch antenna, standalone configuration with a small home-made yagi antenna) will be present at the demo booth, available for visitors to pick up and try live.

Since the tool and the GUI provide a highly interactive interface and user experience, the live demo can show details that we had no space to explain in the companion paper. For instance, users will be able to play with visualization possibilities, such as the ones demonstrated on Figure 5. In our experience bin size, colors, time decay, roll sensitivity and even gamma settings have huge influence on the search process, and only a live demo can provide the feeling of it. Moreover, the tool's visualization is sensitive to position and direction of the antenna, which is also best seen live.

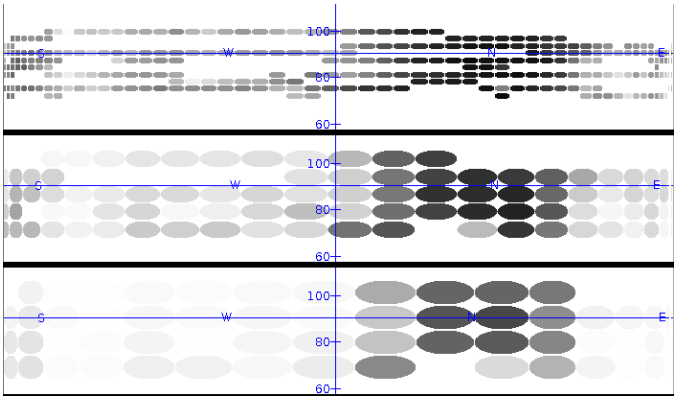

Fig. 5. Panorama view with different data aggregation policies, changing bin size and gamma parameters.

Required Equipment Our demo does not require Internet connectivity, nor special additional equipment. Apart from the tools we bring, we will only need some way to present a slideshow (an explanation of what can be seen at the demo booth) and some way to fix at least an A1-size poster. A desk and, if possible, a large screen monitor or a multimedia projector should suffice.

Space and Setup Time Needed Some motes will be positioned in the room or along the corridor, depending on where demonstrations are to be held. To provide an eye-catching demo, these are better positioned some 10-20 meters away from the demo booth. These motes will be battery-powered, there is no need to provide any additional facilities for these.

Our Hunter and Prey motes will use 802.15.4 in one selected radio channel of the 2.4 GHz ISM band. This could of course slightly interfere with other demos using 802.11 b/g/n, Bluetooth, etc. We are not generating heavy traffic and thus we do not expect particular problems, except if another WSN demo uses the same 802.15.4 channel. Once the demos have been selected, some coordination with other groups doing WSN demonstrations is required to handle the issue.

Apart from the selection of the radio channel, which is better negotiated beforehand, one hour before the demo start should be enough to set up and test the whole demo environment.

III. Acknowledgments

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References

[1] C. Kiraly and G. P. Picco, "Where's the mote? Ask the MoteHunter!" in *7th IEEE International Workshop on Practical Issues in Building Sensor Network Applications 2012 (SenseApp 2012)*, Clearwater, Florida, USA, Oct. 2012.