Poster Abstract: Experimental Evaluation of Radio Transceivers for Sensor Networks in Harsh Environments

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1 Introduction

Waspmotes are a new generation of wireless sensor motes which have been recently released by Libelium [1]. They are built around the XBee transceivers [2] which provide several advantages in terms of multiplicity of operating power, protocols, and operating frequencies as depicted by the XBee features in Table 1. Other characteristics include (1) minimum power consumption of the order of 0.7 μA in the Hibernate mode (2) flexible architecture allowing extra sensors to be easily installed in a modular way, and (3) the provision of GPS, GPRS and SD card on board. Furthermore, Waspmotes are powered with a lithium battery which can be recharged through a specially dedicated socket for the solar panel; this option is specially interesting for deployments in remote environments.

This poster describes the experiments performed with Waspmote devices using different 802.15.4/ZigBee transceivers in harsh conditions over distances ranging from hundreds of meters up to tens on kilometres.

2 Performance Evaluation

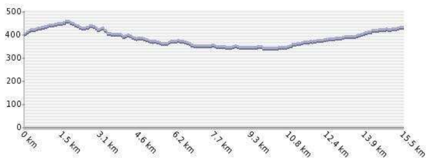
Link quality is an important parameter in setting up a wireless sensor network [3]. Building upon a testbed deployed in the Monegros desert in Huesca in Spain depicted by Figure 1, we conducted different experiments to evaluate the readiness for field deployment of the Waspmote technology in both line of sight (LOS) and non-line of sight (NLOS) settings. Both end points of our wireless link were set at an altitude of approximatively 400 m with altitude variations between the ends as illustrated by Figure 2 (a) while taking into account the Fresnel zone depicted by Figure 2 (b) for the LOS tests. The Fresnel zone is an ellipsoid area around the direct line between two communicating devices. The radius of the fresnel zone at its widest point is expressed by

$$r = 17.32\sqrt{zd/4f} \tag{1}$$

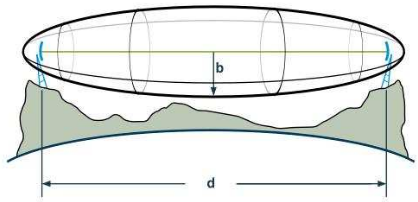
(a) Waspmote node

(b) Waspmote link

Fig. 1. *Waspmote: WSN node and link*



(a) Elevation Map



(b) Fresnel Zone

Fig. 2. *The WSN Links Configuration*

where z is the zone number with the value $z = 1$ referring to the first Fresnel Zone, f is the frequency used and d is the exact distance between the receiver and transmitter. In our tests, this distance was calculated using the GPS module integrated in the mode. Note that a close look at the elevation map depicted by Figure 2 (a) can reveal the impact of the reflections in the first Fresnel zone on the signal transmitted between the transmitter and receiver for different distances.

We tested seven different 802.15.4/ZigBee transceivers with the expectation of assessing the deployment and stability of Wireless Sensor Network (WSN) links in harsh desert conditions and in long range deployments. We considered six different WSN links (356m, 639m, 1239m, 3810m, 6363m,12136m) and tested these links by sending 100 packets of 90 Bytes each and counting how many packets were received to measure throughput. We also measured the RSSI level. Table 1 shows the results of our tests.

Table 1. Waspmote Transceiver Features and Performance.

XBee features	Feature	Dev1	Dev2	Dev3	Dev4	Dev5	Dev6	Dev7
	Protocol	802.15.4	802.15.4	Zigbee-Pro	ZigBee-Pro	RF	RF	RF
	Frequency (Hz)	2.4G	2.4G	2.4G	2.4G	868M	900M	900M
	TX power (mW)	1	63	2	50	315	50	100
	Sensivity(-dBm)	92	100	96	102	112	100	106
Throughput	Distance	Dev1	Dev2	Dev3	Dev4	Dev5	Dev6	Dev7
2dBi	356m (LOS)	85%	100%	100%	100%	100%	100%	100%
	639m (LOS)	0%	100%	0%	100%	100%	100%	100%
	1239m (NLOS)	0%	0%	100%	0%	100%	0%	70%
	3810m (NLOS)	0%	0%	0%	0%	0%	0%	0%
	6363m (LOS)	0%	18%	0%	25%	100%	0%	80%
	12136m (LOS)	0%	0%	0%	0%	100%	0%	0%
5dBi	356m (LOS)	100%	100%	100%	100%	100%	100%	100%
	639m (LOS)	19%	100%	100%	100%	100%	100%	100%
	1239m (NLOS)	0%	0%	0%	0%	100%	0%	100%
	3810m (NLOS)	0%	0%	0%	0%	50%	0%	10%
	6363m (LOS)	0%	100%	0%	100%	100%	0%	100%
	12136m (LOS)	0%	0%	0%	0%	100%	0%	100%
RSSI(dBm)	Distance	Dev1	Dev2	Dev3	Dev4	Dev5	Dev6	Dev7
2dBi	356m (LOS)	-94	-72	-84	-70	-70	-70	-70
	639m (LOS)		-91		-78	-70	-70	-70
	1239m (NLOS)							
	3810m (NLOS)					-77		
	6363m (LOS)					-97		-94
	12136m (LOS)					-100		
5dBi	356m (LOS)	-87	-70	-72	-70	-70	-70	-70
	639m (LOS)	-94	-70	-90	-70	-70	-70	-70
	1239m (NLOS)		-97		-83			-93
	3810m (NLOS)					-75		
	6363m (LOS)					-80		-101
	12136m (LOS)					-97		-83

3 Conclusions

The 2.4 GHz frequency band shows in the Line of Sight (LOS) tests better performance due to the transceiver high sensitivity. However, this frequency is not suitable for Non Line of Sight (NLOS) links. The 900 MHz and 868 MHz modules create persistent connections including the NLOS configurations and long range links. High rate (2.4GHz) vs persistent links (868MHz, 900MHz) are the characteristics which need to be balanced when planning our sensor network requirements.

References

1. http://www.libelium.com
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3. K. Srinivassan, P. dutta, A. Tavakoli, and P. Levis. 2006. Understanding the causes of packet delivery success and failure in dense wireless sensor networks. SenSys?06, pp 419 - 420