Multichannel Cross-Layer Routing for Sensor Networks

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***Abstract*—**

I. Introduction

The description of the RPL protocols is extremely poorly done, even with misleading sentences. For example, "RPL is a routing protocol for WSN based on IEEE 802.15.4". No, RPL has been constructed independently from the MAC layer. Also, "As in standard RPL all nodes are initialized to channel 26 by default". No, the MAC layer defines the channel, and not RPL. Finally, I think the whole paragraph on RPL should be re-written.

The authors state that they enabled "the RPL control messages to be sent through unicast in order to reduce unnecessary transmitting in broadcast". However, how can a node discover new neighbors if it does not know its address to send packets in unicast? Also, the increase in overhead is not at all studied.

Here is a list of some examples of wrong assumptions in the paper, and some comments about them: - In its most usual mode of operation, RPL operates with a layer two which uses only a single channel. - RPL is a routing layer that is independent from the underlying MAC.

- Chrysso [12] uses channel 11, 14, 20, 22 and 26, and MiCMAC [1] uses channel 15, 20, 25 and 26. - There is nothing preventing you from using all the available channels in these protocols.

- Multichannel synchronous protocols include MC-LMAC [11] which uses a time slot to transmit on a particular channel and Y-MAC [13], EM-MAC [17] and TSCH - EM-MAC is NOT synchronous. It is asynchronous.

- Recent multichannel protocols such as MiCMAC uses RPL as the routing protocol. - The MAC layer does not use a routing protocol. MiCMAC does not depend on RPL to work. It is up to the developer to select the routing protocol.

- RPL finds the path with the minimum number of transmissions .. - This is true only for the ETX metric which the default one, but RPL could another metric such as number of hops.

- As in standard RPL all nodes are initialised to channel 26 by default. - Channel 26 is not part of the standard. It is just the default one in Contiki.

* Link qualities are known to fluctuate. For this reason, RPL uses beacons, which allow nodes to determine link quality estimates. The paper doesn't explain if and how beacons are still used, and what is the overhead w.r.t. plain RPL. Indeed, in the latter a single beacon reaches all neighbors; instead, in a multichannel approach, the beacon must in principle be re-sent N times, if N is the number of distinct channels a node's neighbors are listening on. Actually, it appears that the authors assume that the tree is "frozen", and only channels are changed. This "feeling" is reinforced by the discussion at the end of IV.C where the authors argue that the channel checking cost is a "one-off" cost. This may be a very poor choice, as the parent may have been determined at a time when the corresponding link was good, and later change to dead (e.g., due to an obstruction appearing on the link, environmental conditions, etc.). The authors should discuss and evaluate this aspect.

- what's the rationale of "a node listens on a single channel but sends on many channels"? - in the related work, a citation to TSCH is needed as well. Also, about LEACH: the original work by Heinzelman et al. should be cited instead of the derivative work by others chosen by the authors - LPBR: this is mentioned in the abstract without being defined - the authors resort too much to forward references in the text, which impairs readability. - some English problems: "trickle timer to doubleS", "are less frequently invoke", "does not formed"

II. Related Work

III. Multichannel Cross-Layer Routing Protocol

Please consider the following notes on the design: - What if the current channel that you are using to communicate channel-switch decision is too bad that you could not get the message through? - Channel conditions change rapidly with time. What about the communication time from the central coordinator to the node?

* The authors state that channel quality checking is performed by sending 8 packets to each neighbor. Apart from the evaluation of this overhead, the authors fail to state the inter-packet interval, which (if too short) may have an effect on the estimate. Also, the threshold of 7 appears to be quite high. What happens if no neighbors meets the threshold (see above examples)?

IV. Evaluation

The authors present a centralized solution that wastes a lot of energy on probing. In the evaluation section, they do not compare their proposal against any of the existing solutions.

Also, the increase in overhead is not at all studied. ///need to have more details!

In the evaluation section, the proposed solution is not evaluated against the existing ones! Even the comparison against standard RPL is done using different parameter settings. ///scenario 1 and 2 -¿ single channel would have worse result

* The approach proposed by the authors is centralized, and requires communication from the LPBR to the nodes and viceversa. The latter appears to occur upon each channel switching. The communication overhead is never evaluated in the paper: only a passing mention to packets is provided, which is only a part of the picture from an energy standpoint.

* The evaluation uses end-to-end packet delivery as the main performance metric. However, the authors fail to state the key parameter affecting this metric, i.e., the diameter of the network.

* I would have expected that MCRP is able to identify the good channels and use them. Therefore, in the mixed scenario 2, I would have expected MCRP to exploit the 4 good channels, leading the performance at least in between the one of good and mild. Instead, performance is between mild and moderate... why?

* Moreover, in scenario 2 performance still appears to degrade over time as shown in Fig.3, which doesn't happen in scenario 1. Why? It seems that in this latter case MCRP provides only marginal advantages over a single channel (and I would argue it uses more energy, see above)

V. Conclusion

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