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# The Impact of Drifting Clocks on ZigBee's Energy Efficiency

*and why formal methods are pivotal to assess that*

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Wireless embedded sensor networks are predicted to provide attractive application possibilities in industry as well as at home. IEEE 802.15.4 and ZigBee are proposed as standards for such networks with a particular focus on pairing reliability with energy efficiency, while sacrificing high data rates. IEEE 802.15.4 is configurable in many aspects, including the synchronicity of the communication, and the periodicity in which battery-powered sensors need to wake up to communicate.

In recent work, we have developed formal behavioural models of the energy implications of these options [1]. The models are modularly specified using the language MoDeST [2], which has a rigorous compositional semantics mapping on stochastic timed automata. The latter are simulated using a variant of discrete-event simulation implemented in the tool Möbius [3]. We managed to estimate energy consumptions of a number of possible communication scenarios in accordance with the standards, and derived very interesting conclusions about the energy optimal configuration of such networks. As a specific fine point, we investigated the effects of drifting clocks on the energy behavior of various application scenarios.

In this talk, I will review this joint work with Christian Groß and Reza Pulungan. I will give a detailed account of the formal modelling and analysis approach taken, and will point out why the use of formal methods appears as the only reliable as well as practical way to study such intricate questions.

## References

- [1] C. Groß, H. Hermanns, R. Pulungan. Does Clock Precision Influence ZigBee's Energy Consumptions?. In *OPODIS 2007*, LNCS 4878:174-188, 2007.

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- [3] D. Daly, D. D. Deavours, J. M. Doyle, P. G. Webster, and W. H. Sanders. Möbius: An extensible tool for performance and dependability modeling. In *TOOLS 2000*, LNCS 1786:332–336, 2000.