Implementing IEEE 1451 sensors: a case study

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Summary

The IEEE 1451 smart transducer interface standard aims at establishing a common interface to promote interoperability among the myriad of transducers currently in the market. Nonetheless, the acceptance of the standard in the realm of Wireless Sensor Networks[1] seems to be constrained by apparently incompatible operation semantics: while ordinary transducers deployed in control networks usually operate at fixed periods, or even as slaves of master controllers, wireless sensors mostly avoid such regimens due to inherent energy and bandwidth utilization inefficiencies. In this paper, we propose a reconciling strategy based on *Transducer Interface Module Initiated Messages* (TIM-IM) that enables *Wireless Transducer Interface Modules* (WTIM) to efficiently communicate with a *Network-Capable Application Processor* (NCAP). The proposed strategy has been validated through prototype implementations for two representative motes, the MICA2 and the SUN SPOT, with significant efficiency gains.

Motivation

Past efforts to bring IEEE 1451 (see Figure 1) to the realm of WSN focused mainly on interoperability, without major concerns about efficiency and conformance to the traditional semantics of such networks[2,3]. The reconciling strategy proposed in this paper is build around the fact the NCAP can potentially close the gap between WTIM and control applications by deploying the concept of *Information Freshness*. Instead of polling WTIMs for fresh information about sensed data, NCAPs can rely on the TIM-IM feature of IEEE 1451 and let WTIMs report new information whenever there is new information to be reported (see Figure 3). In this context, WTIMs associate *Transducer Electronic Data Sheet* (TEDS) to *Operational Range Tables* (ORT) that are used to decide whether an observed variation in sensed data is to be reported to NCAP via a TIM-IM, or simply ignored. In the worst-case, that is, in a constantly changing environment, this strategy spares NCAP request messages, thus improving on network bandwidth and also on mote's energy, since it no longer needs to constantly listen the channel for NCAP messages and neither needs to receive request messages from it. In the case of relatively stable environments, efficiency can be largely improved.

Results

We validated the proposed strategy to build IEEE 1451-compliant WSN by implementing it for two widely used mote architectures: MICA2 and SUN SPOT. The goal of this implementations was solely to determine the overhead of traditional operating mode (i.e. polling) versus TIM-IM, yet standard conformance was fully respect. The chosen application was a simple wireless temperature sensor and the respective TEDS was the same for both implementations (see message format in Figure 2). Figure 4 shows the worst-case improvements on bandwidth obtained by eliminating NCAP messages: 54,18% for MICA2 and 53,21% for SUN SPOT. Long-term energy evaluation is being carried out and will be described in the paper.

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[1]Gilsinn, J. D and Lee, K. “Wireless interfaces for IEEE 1451 sensor networks”, Proc. of the First ISA/IEEE Conference Sensor for Industry, p. 45-50, 2001.

[2]Oostdyk, R.L., Mata, C.T. and Perotti, J.M. “A Kennedy Space Center implementation of IEEE 1451 networked smart sensors and lessons learned”, IEEE Aerospace Conference, 20pp.-, 2006.

[3]Song, E.Y and Kang, L. “Understanding IEEE 1451-Networked smart transducer interface standard - What is a smart transducer?”, IEEE Instrumentation & Measurement Magazine, vol 11, p. 11-17, April 2008.

Figures

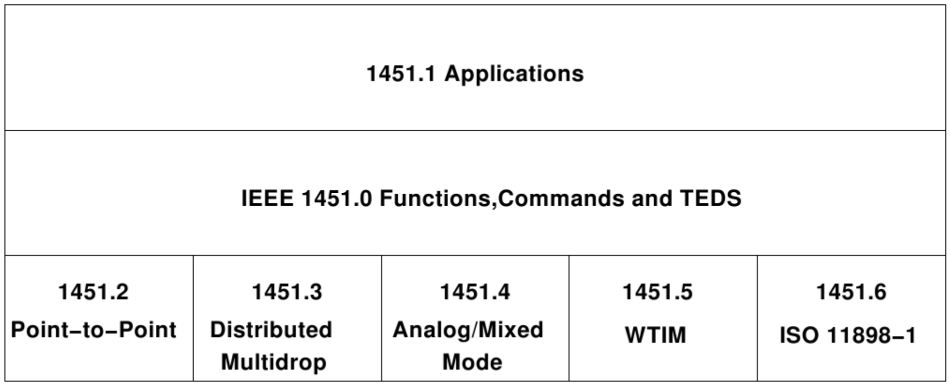

Fig. 1: The IEEE 1451 standard family.

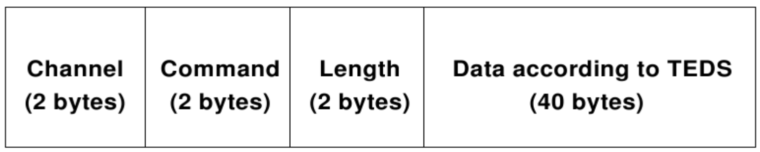

Fig. 2: TIM Initiated Message format.

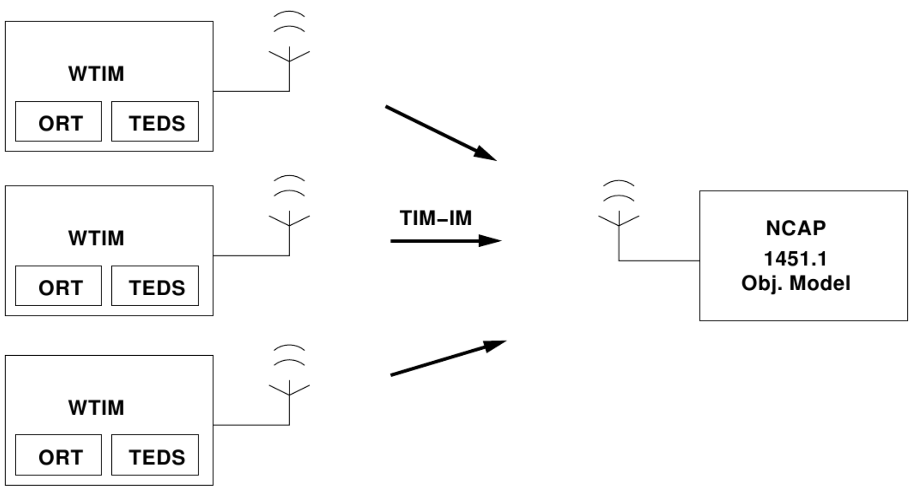

Fig 3: Overview of proposed IEEE 1451 WSN strategy.

Message		Size (bytes)	
		Mica2	Sun SPOT
1	MAC overhead	124	180
2	Polling request	200	256
3	Polling reply	171	227
4	TIM-IM report	170	226
5	Polling total (2 + 3)	371	483
6	TIM-IM total (4)	170	226
7	**TIM-IM improvement over polling (6 / 5)**	**54,18%**	**53,21%**

Fig 4: Overview of proposed IEEE 1451 WSN strategy.