

## Achievement #2: System-Wide Coordination with Guarantees

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The ability to safely coordinate distributed sensors and actuators in a cyber-physical system is a prerequisite for closed-loop stability and fault tolerance. However, as noted by leading researchers in the field, “... because of the large scale, nondeterminism, noise, etc., it is *extremely difficult* to guarantee real-time properties” and “... [virtual synchrony is] *impossible* to achieve in sensor networks, where groups are highly dynamic and membership changes occur at a very high rate compared to the time scales of basic algorithm functions” [2].

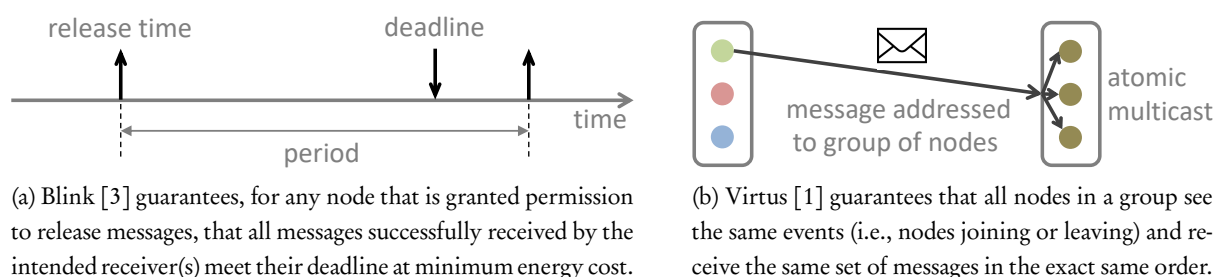


Figure 1: Illustration of the real-time and virtual-synchrony guarantees we provide.

Our research on Blink [3] and Virtus [1] has solved these long-standing problems by providing real-time and virtual-synchrony guarantees (see Figure 1) in resource-constrained wireless embedded systems with formal proofs. Further, our work moved these kinds of systems closer to traditional real-time and distributed systems, which are based on more powerful platforms and wired communication. We thus make existing results from these areas applicable in a new setting, while providing abstractions and guarantees people are used to. Our follow-up work on real-time guarantees among application tasks also leverages this opportunity [4].

**Academic Impact.** The results of this line of work have appeared at top venues of **three** different communities: cyber-physical systems (ACM TCPS), real-time systems (IEEE RTSS), and distributed systems (IEEE SRDS). Our work on Blink was also recognized through prestigious prizes for my PhD thesis: the **ACM SIGBED Paul Caspi Memorial Dissertation Award** and the **EDAA Outstanding Dissertation Award**.

## References

- [1] F. Ferrari, **M. Zimmerling**, L. Mottola, L. Thiele. [Virtual Synchrony Guarantees for Cyber-Physical Systems](#). In *IEEE Int. Symp. on Reliable Distributed Systems (SRDS)*, 2013.
- [2] J. A. Stankovic, T. F. Abdelzaher, C. Lu, L. Sha, J. C. Hou. Real-Time Communication and Coordination in Embedded Sensor Networks. *Proceedings of the IEEE*, 2003.
- [3] **M. Zimmerling**, L. Mottola, P. Kumar, F. Ferrari, L. Thiele. [Adaptive Real-time Communication for Wireless Cyber-physical Systems](#). *ACM Transactions on Cyber-Physical Systems*, 2017.
- [4] R. Jacob, **M. Zimmerling**, P. Huang, J. Beutel, L. Thiele. [End-to-end Real-time Guarantees in Wireless Cyber-physical Systems](#). In *IEEE Real-Time Systems Symposium (RTSS)*, 2016.