On Performance Metrics for Guaranteed QoS in Industrial Mobile Wireless Sensor Networks

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Wireless technology is fueling new paradigms in personal, commercial, and industrial communications systems throughout the marketplace. The industrial community is poised to adopt wireless technology to support technical innovations, e.g., widespread use of wireless sensors forecasted to improve manufacturing production and energy efficiency by 10% and reduce emissions by 15%. The presidential committee of advisors on science and technology stated that “industrial wireless sensors can improve efficiency by 10% and cut emissions by more than 25%”. However, the savings are achieved if they are deployed in large quantities. The inherent unpredictability of wireless networks coupled with their integration into legacy systems makes the networked-control problem particularly challenging. For example, 4% jitter in the process control loop can cause the PID controller to become unstable. This tolerance is about 1% for model-based, multi-variable and feed forward control loops, but the ability of a wireless network to support this type of quality of service cannot always be guaranteed. Environments like the industrial environment are particularly harsh with interference from metal structures (pipes, motors, fork-lifts etc.), interference generated during wireless propagation and multi-path fading of the RF signal all invite novel mitigation techniques. Assessment and management of QoS needs to occur, allowing the network to adapt to changes in the RF, information, and operational environments. The capacity to adapt is paramount to maintaining the required operational performance (throughput, latency, reliability and security). The advent of multiple wireless networks in the same frequency band poses a coexistence problem that needs to be addressed. Modeling EM wave propagation in this kind of highly cluttered environment is also a challenge since ray-tracing methods are non-realistic due to constant change in the geometry and finite-difference time-domain (FDTD) methods are computationally expensive.

The mobility as described in the industrial environments is typically not close to Doppler but large enough to change the multi-path characteristics of the environment. This will have impact on the latency, throughput, reliability and security of the wireless network. Communication channels may be described by their impulse or frequency response, and therefore may be viewed as dynamical systems in their own right. The assumption that the communication mechanism can be characterized independently of the application is fundamentally flawed. There should be a periodic feedback of the channel state into the QoS mechanism of the network to preserve the value-proposition of the data being collected over the network.

As the industry is adapting these new-generation wireless sensors there is an inherent need to develop:

- Performance metrics – Latency, Throughput, Reliability, Security, Adaptability, and Fragility
- Online network & channel health monitoring
- Robust, fast EM propagation modeling and simulation tools

We intend to present the problems of the wireless networks from the industrial end-user and OEM perspectives. A non-orthogonal set of performance metrics should be discussed to assist in easy adaptation of these new systems with guaranteed QoS in an industrial setting. As always standards drive economics, adaptation, and innovation. The ISA SP100, Wireless for Industrial Automation*, efforts in addressing the fundamental issues in varying channels will be discussed.