Abstract: Wireless monitoring and control solutions (e.g., WirelessHART) in industrial harsh environments offer benefits in relation to lower cost and easier deployments than the case for wired solutions (e.g., Fieldbus system and wired HART). Therefore, a notable trend in industrial automation in recent years has been the replacement of wired communication with low power and low cost wireless sensor and actuator networks (IWSAN). The state-of-the-art researches address a multitude of objectives. However, their adaptation to the dynamics of a realistic wireless sensor network has not been investigated in a satisfactory manner. This is a key issue considering the challenges within industrial applications for wireless sensor networks, given the time-constraints and harsh environments. In addition, exceeding the required delay bound for unpredictable and emergency traffic in industrial automation applications could lead to system instability, economic and material losses, system failure and, ultimately, a threat to human safety. Therefore, guaranteeing the timely delivery of the IWSAN critical traffic and its prioritization over regular traffic (e.g. non-critical monitoring traffic) is a significant challenge. In response to those challenges, we present a Protocol Framework for Adaptive Real-Time Communication in Industrial Wireless Sensor and Actuator Networks, which consists of Adaptive Scheduling and Priority-based MAC. Adaptive Scheduling and Priority-based MAC have been implemented in TinyOS and evaluated on a test-bed of Telosb motes and/or TOSSIM network simulator. Numerical results show that the adaptive scheduling improves the quality of service for the entire network. It achieves significant improvements for realistic dynamic wireless sensor networks when compared to existing scheduling algorithms with the aim to minimize latency for real-time communication. The experimental results indicate that Priority-based MAC efficiently handles different traffic categories with different latency requirements, thereby achieving a significant improvement in the delivery latency compared to the current industrial standards.