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Quality of Service (QoS) in Healthcare Applications: Colored Petri Net Simulation for Design of Heterogeneous, Multi-Vendor, Integrated, Life-Critical Wireless (802.x) Patient Care Device Networks

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ABSTRACT

The ability to deploy wireless patient monitors using industry-standard IEEE 802.x technologies allows patient mobility and clinical flexibility. However, interconnecting multiple life-critical medical devices from multiple vendors can introduce unintended life-threatening risks unless delivery of critical patient alarms to central monitoring systems and/or clinical personnel is assured. Petri net tools allow automated testing of all possible states and transitions between devices and/or systems to detect potential failure modes in advance. Colored Petri Net (CPN) tools allow tracking and controlling each message in a network based on pre-selected criteria. This paper describes a research project using CPN to simulate and validate alarm integrity in a small multi-modality wireless patient monitoring system. Free research CPN software, CPNTool, is used to simulate two, 20-monitor wireless patient monitoring networks. One network simulated standard non-prioritized 802.x IP protocols and simulated Quality of Service (QoS) capabilities similar to 802.11e, allowing message priority management. In the standard 802.x network, dangerous heart arrhythmia and pulse oximetry alarms were missed, but QoS priority management reduced that risk significantly.