Dissertation title:

RFID-Based Real-Time Production Monitoring in a Variant Production Environment

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Manufacturing organizations around the globe are now leaning towards just-in time or customized production in order to gain competitive advantage in an ever more intense marketplace. The problem with customized or variant production is that, organizations have to track the different product parts precisely in order to ensure that the right part is at the right place in the right amount at the right time, to deliver customized products to their customers. Due to this reason, companies are now increasingly using RFID technology to track production in real-time.

The wide spread deployment of RFID technology for production monitoring and tracking is impeded by the fact that the technology is inherently unreliable and RFID readers suffer from errors such as duplicate, false, missed and out of order readings. In this work we have presented algorithms to a) enable real-time tracking and monitoring of product parts on the production lines, b) provide probabilistic guarantees to the real-time product parts that are being tracked c) enable the RFID readers to self-calibrate their reader probabilities so that the readings that they generate are highly reliable at all times d) generate complex manufacturing events and provide probabilistic guarantees for the accuracy of these complex manufacturing events. In particular the following contributions are made in this thesis.

As a first contribution, we developed a consistency stack that conceptually divides the different consistency/reliability issues in production monitoring into separate layers. In addition to this we have built a consistency management framework to ensure consistent real-time production monitoring, using unreliable RFID devices. Secondly, we deal with the problem of detecting object sequences by a set of unreliable RFID readers that are installed along production lines. We propose a probabilistic sequence detection algorithm that assigns probabilities to objects detected by RFID devices and provides probabilistic guarantees regarding the real-time sequences of objects on the production lines.

Thirdly, we developed a probabilistic model to assign probabilities to the RFID readers and to the product part detections. We also present a probability self-calibration algorithm that automatically adapts the probabilities of RFID readers to better reflect their performance at current instance of time. This would ensure that unreliable RFID devices would have little or no say in the overall production monitoring and tracking within the production environment.

The use of RFID technology in manufacturing and production is still limited because of the non-availability of middleware solutions to transform raw RFID data into higher level meaningful information. So as our fourth contribution, we present a complex event processing framework that can be deployed in manufacturing environments. The framework is capable of processing raw RFID events to generate complex manufacturing events that are of relevance to the production operations. The framework assigns probabilities to each complex event, which are continuously updated as more information is made available regarding these events. This provides a measure to the higher level applications about how accurate or inaccurate a certain complex event really is.