School of Industrial Engineering & Management, Oklahoma State University, Stillwater, OK 74078

Title: Experimentation Test-bed for evaluation and benchmarking of RFID technologies: From data to decisions

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Project Description

This project leverages the *recent multi-university (Oklahoma State, Penn State, MIT and Berkeley) grant from the National Science Foundation (NSF) on new wireless (RF) sensing technology.* The advent of RFID and such technologies for asset and good tracking in warehousing and depot support operations has thrown new challenges to companies on ● how to best connect the various heterogeneous platforms and middleware to handle data, and ● how to manage and harness the data for effective decision support so that ROI is maximized.

EXPERIMENTAL PLAN

The specific scope of the project will involve accomplishing the following tasks:

1. Create a test platform with a controlled environment simulating real manufacturing scenarios
2. Evaluate and benchmark RFID systems, RFID enabled smart sensor systems and system components in such environments
3. Develop a simulation modeling framework that will complement the experimentation setup to study the effects of RFID capabilities and alternative configurations on the dynamics of the supply networks and depot environments
4. Validate and benchmark the findings from simulations through physical experiments on the test-bed

RESEARCH OBJECTIVE:

To create a test-bed that serves companies to evaluate and benchmark critical data transmission (emission and receiving) and management techniques and practices in a non-commercial setting. The recently initiated NSF project will bolster the objectives of the project in providing innovative physical testing platform, software and data management solutions.

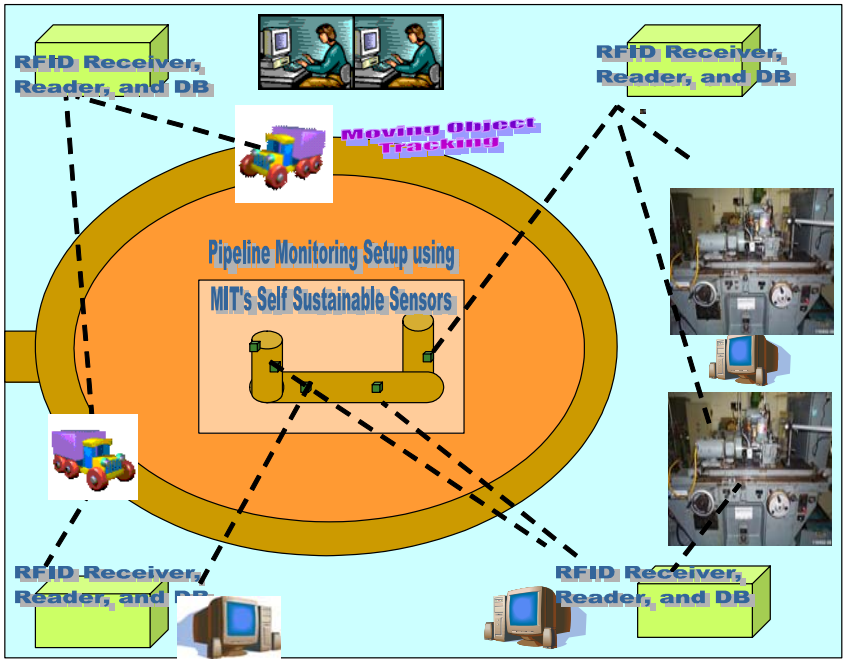

Fig. 1: Schematic of laboratory environment under development at OSU

RFID & ADVANCED SENSOR TECHNOLOGY RESEARCH LAB

Oklahoma State University has sanctioned a total of **1500 sq**. ft. space, including a **1000 sq. ft**. fully furnished lab space, to conduct our research on Sensors, RFID and related topics. A rough schematic of the lab is shown in Figure 1. We have placed orders for the computing resources and have finalized the list of vendors for procuring the various components of an RFID system.

The uniqueness of this lab will be that the test-beds will be among the first ones designed to evaluate the integration of sensors with RFID systems that operate with EPC tags. We are aware of two commercial vendors that have this capability to deliver RFID systems that meet this emerging need. Several RFID component vendors are actively pursuing the development of such systems. The test-bed under development will facilitate investigations into the salient issues pertaining to the tuning and deployment of these new generations of RFID systems.

POTENTIAL BENEFITS TO MEMBER COMPANIES

The project will lead to

1. A non-commercial platform for evaluation of RFID technologies and practices
2. A new lab dedicated to advanced research on sensor and sensing technologies, which can provide innovative data management solutions for member companies
3. The uniqueness of this lab will be that the test-beds will be among the first ones designed to evaluate the integration of sensors with RFID systems that operate with EPC tags.
4. Deeper insights into the use of RFID for asset management, especially the condition based maintenance of critical items and assets in depot environments
5. Hands-on educations experiences in RFID technologies for students, who will be part of member companies' future work

MILESTONES

1.	Procure RFID system components (readers, tags, antennae, middleware) and Smart sensors	02/20/2005
2.	Evaluate current methods for carrying out physical testing and develop better methods	03/01/2005
3.	Set-up test-beds simulating various manufacturing scenarios	04/30/2005
4.	Invite vendors and users to\participate in design tuning and experimentations:	Summer 2005
5.	Adapt simulation and difference equation models of supply chain and depot environment dynamics	06/31/2005
6.	Conduct series of simulation and physical experiments customized to specific vendor requests	10/31/2005
7.	Final Documentation of test-bed designs, experimentation details, best practices, and performance benchmarks	12/15/2005

1. 0 DEVELOPMENT OF RFID TEST PLATFORM

A rough schematic of the lab is shown in Figure 1. We have placed orders for the computing resources and have finalized the list of vendors for procuring the various components of RFID system.

2.0 SIMULATION FRAMEWORK DEVELOPMENT

The major objectives of our simulation studies are to:

- To capture the effects and ROI from the installation of RFID technologies
- To assess the relative merits of event-based and time-based approaches
- Thorough characterization of enterprise system dynamics
- To derive performance benchmarks on using appropriate anomaly detection and control policies

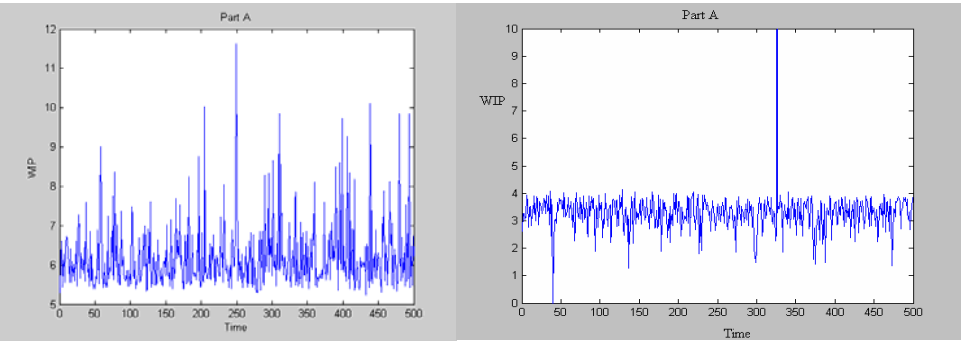

Figure 2. WIP levels of a component (Part A) at various times (a) without and (b) with RFID systems.

OUR APPROACH

Traditionally event-based simulation models are extensively used in studying what-if scenarios that arise in various environments. While these systems model the flows of individual entities accurately, extraction of global measures from these systems is extremely challenging. An alternative approach is a state-space modeling approach, which is rooted in dynamic systems theory. This approach can lead to fast and reasonably accurate extraction of system performance measures as it aggregates the flow of entities over time. We have compared the relative merits and de-merits of these approaches by applying them to study two similar yet relevant scenarios.

2.1 EFFECT OF RFID INSTALLATION IN DEPOT SUPPORT ENVIRONMENT

Here we used an ***event-based simulation*** model implementing using Arena to capture repair/refurbishment operations in a hypothetical depot support environment.

In this model we consider two kinds of “assets” that need require maintenance (breakdown repair or preventive service). The depot additionally gets supplies of the necessary components and sub-assemblies that get stored in a local warehouse.

OBSERVATIONS: EFFECT OF RFID INSTALLATION IN DEPOT SUPPORT ENVIRONMENT

Our studies show that the reduction of information delays resulting from the use of RFID systems lead to (a) significant (about 200% in this simplistic simulation model) reductions in WIP inventory levels of various components as summarized in Figure 2. Please note that a sharp spike in the WIP was caused due to a large ordering of a particular component. We are currently updating the simulation model to include the effects of sensors.

We also have plans to identify the various entities so that we can undertake more accurate assessments of ROI from RFID systems in depot support, manufacturing enterprise and supply chain environments of realistic scales.

2.2 EVALUATION OF RFID SYSTEMS FOR BULLWHIP MITIGATION IN MULTI-ECHELON SYSTEMS

Here we used a ***state-space approach*** to study the dynamic behaviors of a four-echelon system, and investigate the effects of RFID systems in mitigating bullwhip effects. The model was implemented using Matlab/Simulink (see Figure 3). This is a preliminary model to study bullwhip mitigation using RFID systems in multi-echelon systems

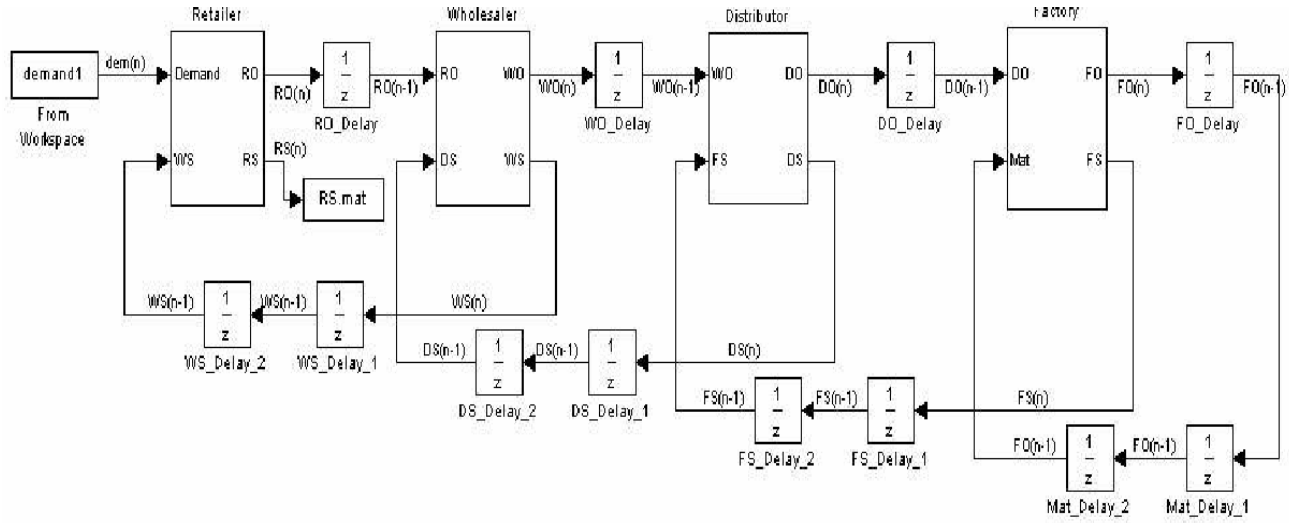

Fig. 3: Simulink implementation of a 4-echelon supply chain dynamics (Initial Model)

OBSERVATIONS: EVALUATION OF RFID SYSTEMS FOR BULLWHIP MITIGATION IN MULTI-ECHELON SYSTEMS

Our initial study shows that the geometric amplification of demand as it propagates upstream can be mitigated from the use of RFID systems. This approach provides an efficient means to capture the effects of information availability and propagation, and it has shown a significant promise in delivering fast and reasonably accurate estimates of performance of an enterprise system resulting from the use of RFID. We are currently working on a white paper that delineates the relative merits and shortcomings of state space and event based approaches to study the effects of improved information visibility (resulting perhaps from using RFID systems).