Kroger Store Wireless Network Analysis

By

Spencer Mueller, Nicholas Setser and Eric Cox

A Design Freeze Submitted to
The Faculty of the Information Technology Program
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________________________  ______________________
Spencer Mueller/Nicholas Setser/Eric Cox        Date

________________________
Mark Stockman, Faculty Advisor        Date

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Acknowledgments

Our project team would like to acknowledge the members of Kroger's IS&S Distributed Networks team for their support, resources, and advice in the execution of our project. Their sponsorship allowed us to obtain the hardware and software without exorbitant to our project team. Special thanks to Cheryl Robin and Rich Inman for providing hours' worth of background information and context that allowed us to deliver a successful solution.

We'd also like to thank members of the UC faculty that have offered guidance - particularly Professor Stockman for his help aligning project deliverables for UC and Kroger. He and Dr. Said both provided valuable feedback, especially in determining the scope and requirements of our project.
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Abstract

On the heels of decades’ worth of acquisitions, the Kroger Co has become a national presence with over 3,000 locations. As a result of such rapid growth, Kroger’s most significant challenges arise from fragmented lines of business and disparate retail formats. In response, Kroger prioritizes technology projects designed to streamline store systems and processes, but also sees a pressing need to deliver a modern suite of digital shopping options to their customers. To accomplish both goals, Kroger must move to assess their in-store networks, and standardize the implementation of wireless infrastructure. The authors have developed, documented, and tested a process that will assist Kroger in evaluating store’s wireless network capacity in its current state, and offer a roadmap for future wireless applications.
Section 1. Project Description and Intended Use

1.1 Problem Statement

The Kroger Co. is the largest grocery store chain and second largest general retailer in the United States. Much of Kroger’s growth in the past 30 years comes from the acquisition of several existing grocery chains across the country. This includes conventional grocers such as Dillons and Fred Meyer, as well as smaller-format convenience stores such as Loaf N’ Jug, Kwik Shop, and Turkey Hill. As of 2010, Kroger operated 3,619 stores under 26 different banners (14).

Though acquisitions have contributed to its success as an enterprise, Kroger now faces challenges in centralizing business processes and establishing corporate standards in operations, logistics, and technology. One consideration, as it pertains to stores, is the number and variety of retail store layouts, and the differences inherent to each. The current state of Kroger’s in-store wireless networks reflects some of the challenges of standardizing operations across the enterprise.

Kroger’s current implementation of 802.11 wireless is responsible for several key business tasks, such as inventory management, scales, mobile checkout stations and others. As Kroger acquired more retail locations, the immediate demand for wireless infrastructure (and mainstay inventory applications) led to fragmented and sometimes haphazard deployment of wireless access points, resulting in coverage gaps, cross-channel interference, and potential security problems.
Because of the inconsistent wireless infrastructure, Kroger lacks the data it needs for considering future applications to run on the network [2]. As an example, were Kroger to consider replacing its current telephony solution with VOIP, there would be no clear path for implementation. Absent baseline data regarding the current state of store wireless networks, enhancement efforts would be ineffective [2].

No enterprise initiative has taken place to assess or remediate the problems with store wireless network infrastructure. The corporate team responsible for provisioning, performance, and maintenance of store networks simply does not have the resources to dedicate at this time. Kroger has not established a procedure to gather the necessary data or selected a tool to be used for the effort.

1.2 Description of the Solution

Our project aims to remediate current situation in several areas. First, we will obtain an 802.11 wireless survey tool as a means to assess network coverage and configuration in Kroger stores [1]. Using the survey tool, our team will establish a comprehensive survey process, and test it in a sample set of local Kroger stores. The process will be aimed at capturing AP locations and RF proliferation in all areas of the store.

Second, our team will analyze the sample results to drive best practices and optimal AP deployments. We will also test several current and future client devices on the network to estimate its general capacity to handle several applications. During this step, we hope to optimize
wireless network quality with the resources that are already in the stores, while also planning for long-term remediation where necessary.

Third, we will create an internal process that will allow our process to be replicated in another 3,600 locations. Included in this step will be thorough documentation of our process, administering training to Kroger division contacts, and providing some means to gather and stores results from all enterprise locations via a content management tool.

1.3 User Profile
Our deliverables are aimed primarily toward Kroger IS&S Distributed Networks team, who are responsible for the planning, implementation, and maintenance of wireless networks within Kroger stores. Our deliverables will equip the Distributed Networks team with a tested process to determine the current health of existing store wireless networks, evaluate their ability to handle future applications and devices, and best practice guidelines for optimal placement of wireless APs in Kroger stores.

In the delivery of our project, division KTMs (Kroger Technology Managers) and survey groups will receive the tools and training they need for collecting data in stores across the country. At the conclusion of our project, personnel in the divisions will have greater technical expertise to maintain their stores’ wireless networks.

Finally, the short-term optimization of APs in stores will reduce the instances of coverage gaps that affect inventory scanning and other applications in stores. As a result, our project will provide immediate benefit for users across the country, and increase productivity for wireless application users in stores.
Section 2: Design Protocols

2.1 Use Case Diagram

For analyzing the store WLANs, our project team will be using Motorola’s laptop-based wireless diagnostic software called AirDefense Mobile v. 8.1.2. This tool will be used throughout Stage 1 of the process, and will also be supplied to divisions for use enterprise-wide. We will be using the site survey module for determining weak spots and overlaps in store WLAN coverage, as well as analyzing AP channel assignments (11).

Kroger stores WLANs use Motorola 5131 and Motorola 4131 wireless access point’s for their 802.11 networks enterprise-wide. No other 802.11 access points or wireless hardware is permitted for use within the store for broadcasting the stores wireless network. Handheld devices that use the WLAN include Motorola 9090, 9060, and some 5846 devices, which are all used for inventory management (9) (10). The Motorola 9090 and 9060 devices transmit at 30-35mW, which represents the weakest transmitting device currently used in all Kroger stores. Other devices using the Kroger store WLAN include the U-Scan Mobile Attendant (Fujitsu OEM), Mobile Point of Sale stations, Deli/Meat scales for price lookups, wireless handheld printers (price tags/labels) and public internet access.

TUNA (The Utility for Network Administrators) is Kroger’s proprietary network management software. The project team will use TUNA to capture the locations of APs in the stores surveyed, as will divisions as information is returned. The project team will also utilize Kroger’s SharePoint environment to host a collaborative site for store diagrams, heat maps, AP locations, project tasks, etc.
Figure 1: Kroger use case diagram
2.2 User Interface

The diagram below, Figure 2, depicts the typical Kroger store network topology and layout from a store’s T1 internet connection down to how a handheld device communicates on the network. Many devices play key roles in allowing the store network to functional properly and effectively.

Figure 2: Kroger store network topology

Our project directly involves the wireless scales, handheld devices, wireless printers, and wireless sign carts all of which communicate via the stores 802.11 AP’s.
Motorola 5131 (Figure 3) and 4131 (Figure 4) are the primary hardware used within the Kroger stores for providing wireless functionality. The Motorola 5131 Access Point, which represent a majority of the APs in the stores todays are the new standard, in some stores legacy hardware such as the Motorola 4131 Access Point still exist and are being actively used, however these devices are being phased out and replaced. Both access points are POE (Power over Ethernet) devices that require connectivity via an HP ProCurve 2608 Switch as this is the only switch in the stores that are approved for POE. Access Points are only allowed to be hardwired to a 2608 switch as this is the only switch in the store that is connected to the Kroger’s in store firewall, the Nymbol server. This being the case the HP 2608 is considered a non-trusted device within the stores network and requires authentication via the Nymbol server.

![Motorola 5131 access point](image)

**Figure 3: Motorola 5131 access point**
Section 3: Deliverables and Testing

Step 1: Select Survey Tools and Gather/Visualize Data in Sample Stores

Our team selected Motorola as our primary vendor, and purchased licenses to use Motorola AirDefense Mobile 6.1 as our site survey tool. One of the capabilities of the application is to generate 802.11 heatmaps on an existing site physical diagram.

We executed site surveys in several Cincinnati-based Kroger stores using an IBM Lenovo R61 laptop and a Proxim 8494 external USB wireless card [2]. To minimize absorption of the signal, the hardware was mounted to the top of a shopping cart. The figures below show the dB strength heatmaps generated for three of the stores we surveyed.
Figure 5: CI 00390 heatmap
Figure 6: CI 00430 heatmap

Figure 7: CI 00435 heatmap
Our team also took note of AP placement, as well as the way they were mounted, antennae orientation, height, and spacing. In addition, we took note of potential physical obstructions to the wireless signal in each store. During the surveys, we noticed three distinct AP mounting styles. The figures below demonstrate the significant variations.

Figure 8: Column mounted
Figure 9: Drop conduit
Figure 10: Ceiling mounted

Step 2: Analyze/Interpret Findings

The first analysis we performed was looking for common signal proliferation problem among the sample stores. We quickly identified several cooler and freezer areas in the back of the store that faced coverage issues, chiefly due to their distance from AP on the main sales floor and to their glass or steel enclosures. Due to poor coverage in those areas, inventory operations that involve scanning in those areas would be spotty at best. The figure below highlights the problem areas in store 00390 with an adjusted dB threshold for a Motorola 9060 inventory scanner.
After identifying coverage problems for a single device, our team tested several other devices during follow-up visits to stores 00390 and 00435. The devices chosen represent both those used in current applications (inventory, scales) and those intended for use with future applications (smartphones, electronic shelf tags, VOIP). Our findings are summarized in the table below.
<table>
<thead>
<tr>
<th>Categories / Devices</th>
<th>Transmit Power (dBm)</th>
<th>Min Network dB Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Store Handhelds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. RF Handhelds</td>
<td>20dBm</td>
<td>-70db</td>
</tr>
<tr>
<td>a. Motorola 9060</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Motorola 9090</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Personal Liaison Assistant (PAL)</td>
<td>25dBm</td>
<td>-65db</td>
</tr>
<tr>
<td><strong>Mobile Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Smartphone Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Customer Mobile Tracking</td>
<td>25dBm</td>
<td>-45db</td>
</tr>
<tr>
<td>b. Smartphone Applications</td>
<td>25dBm</td>
<td>-45db</td>
</tr>
<tr>
<td>c. Smartphones</td>
<td>25dBm</td>
<td>-50db</td>
</tr>
<tr>
<td>2. Tablets</td>
<td>15dBm</td>
<td>-45db</td>
</tr>
<tr>
<td>3. Social Networking Tools</td>
<td>25dBm</td>
<td>-40db</td>
</tr>
<tr>
<td><strong>Store Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Smart Carts</td>
<td>20dBm</td>
<td>-40db</td>
</tr>
<tr>
<td>2. Electronic Shelf Tags</td>
<td>30dBm</td>
<td>-60db</td>
</tr>
<tr>
<td>3. Deli/Meat Scales</td>
<td>35dBm</td>
<td>-65db</td>
</tr>
<tr>
<td>4. Mobile Point of Sale</td>
<td>30dBm</td>
<td>-65db</td>
</tr>
<tr>
<td>5. VOIP</td>
<td>35dBm</td>
<td>-40db</td>
</tr>
</tbody>
</table>

**dBm** – Power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW)

**Table 1: **db threshold table

The table shows the average transmit power for each device, as well as the minimum wireless dB threshold at which each device consistently operated on the network during testing. In combination with the signal heatmaps, this effectively allows Kroger to plan for both short-term remediation of coverage issues by optimizing existing AP placement and for the long-term capacity considerations of new applications/devices.

**Step 3: Enterprise Adoption**

Though our sample store analysis provided groundwork for wireless infrastructure standards, our team was limited to survey locations in the Cincinnati area. To drive enterprise strategy, Kroger
needs a statistically comprehensive dataset from which to make decisions. Kroger operates a number of disparate retail formats, including those with an expansive non-foods inventory in Fred Meyer, and convenience store formats in Jay-C.

The final task for our project team was to create a Kroger internal process that would allow for wide-spread replication of our survey process in another 3,600 locations across 19 divisions. To accomplish this, our team was responsible for training contacts in each division and giving them the resources necessary to generate and manage the survey outputs.

Rather than administer many training sessions, our team opted to create a comprehensive training video that showed how to prepare for and execute a store survey using Motorola AirDefense Mobile. The video features our team using AirDefense live in Cincinnati store 00435, demonstrating proper use of the application during the survey. It also outlines preparation steps, ensuring APs are mounted with proper antennae alignment prior to the survey.

To manage training resources and survey outputs, our team developed a custom SharePoint 2010 collaboration site from a Kroger-provided SharePoint Server 2010 instance. Using SharePoint’s content management capabilities, we created directories for each Kroger division, district, and store to upload AirDefense Mobile project files, AP location diagrams, and store wireless heatmaps. In addition, the site hosts the training documents and video our team developed for quick-reference. Finally, using SharePoint calendars, the site also contains important training and survey dates as they’re executed across the enterprise.
Section 4: Project Planning

4.1 Project Schedule

Figures 12 and figure 13 below show the final project timeline. We presented multiple versions over the past two quarters, but this is the final version representative of how we completed the project. Due dates for Sr. Design have been included throughout.

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Selection</td>
<td>6 days?</td>
<td>Tue 9/27/11</td>
<td>Tue 10/4/11</td>
</tr>
<tr>
<td>Project Definition</td>
<td>41 days?</td>
<td>Mon 10/10/11</td>
<td>Mon 12/5/11</td>
</tr>
<tr>
<td>Problem Need</td>
<td>6 days?</td>
<td>Mon 10/10/11</td>
<td>Mon 12/17/11</td>
</tr>
<tr>
<td>User Profile</td>
<td>1 day?</td>
<td>Mon 10/24/11</td>
<td>Mon 10/24/11</td>
</tr>
<tr>
<td>Final Problem Statement</td>
<td>5 days?</td>
<td>Tue 10/25/11</td>
<td>Mon 10/31/11</td>
</tr>
<tr>
<td>Use Case Diagram</td>
<td>5 days?</td>
<td>Tue 11/1/11</td>
<td>Mon 11/7/11</td>
</tr>
<tr>
<td>Draft Proposal</td>
<td>1 day?</td>
<td>Mon 11/14/11</td>
<td>Mon 11/14/11</td>
</tr>
<tr>
<td>Final Proposal</td>
<td>1 day?</td>
<td>Mon 12/5/11</td>
<td>Mon 12/5/11</td>
</tr>
<tr>
<td>Proposal Presentation</td>
<td>1 day?</td>
<td>Mon 11/28/11</td>
<td>Mon 11/28/11</td>
</tr>
<tr>
<td>Store Wireless Analysis Product Selection</td>
<td>5 days?</td>
<td>Mon 11/28/11</td>
<td>Fri 12/2/11</td>
</tr>
<tr>
<td>Motorola Air Defense Selected</td>
<td>1 day?</td>
<td>Mon 12/6/11</td>
<td>Mon 12/5/11</td>
</tr>
<tr>
<td>Stage 1 - Analysis</td>
<td>64 days?</td>
<td>Mon 12/12/11</td>
<td>Wed 3/7/12</td>
</tr>
<tr>
<td>Air Defense Training</td>
<td>3 days?</td>
<td>Mon 12/14/11</td>
<td>Wed 12/14/11</td>
</tr>
<tr>
<td>Analysis Procedure Defined</td>
<td>5 days?</td>
<td>Mon 12/14/11</td>
<td>Fri 12/15/11</td>
</tr>
<tr>
<td>Store 1 Analysis Conducted</td>
<td>1 day?</td>
<td>Tue 2/21/12</td>
<td>Tue 2/21/12</td>
</tr>
<tr>
<td>Store 1 Heatmap and Store Drawing Completed. Findings Evaluated</td>
<td>1 day?</td>
<td>Wed 2/22/12</td>
<td>Wed 2/22/12</td>
</tr>
<tr>
<td>Store 2 Analysis Conducted</td>
<td>1 day?</td>
<td>Tue 2/28/12</td>
<td>Tue 3/2/12</td>
</tr>
<tr>
<td>Store 3 Analysis Conducted</td>
<td>1 day?</td>
<td>Tue 3/8/12</td>
<td>Tue 3/8/12</td>
</tr>
<tr>
<td>Store 3 Heatmap and Store Drawing Completed. Findings Evaluated</td>
<td>1 day?</td>
<td>Wed 3/7/12</td>
<td>Wed 3/7/12</td>
</tr>
<tr>
<td>Stage 2 - Formalize Procedure</td>
<td>12 days?</td>
<td>Fri 3/9/12</td>
<td>Mon 3/25/12</td>
</tr>
<tr>
<td>Analysis Procedure Documented for Divisions with Templates</td>
<td>6 days?</td>
<td>Mon 3/9/12</td>
<td>Mon 3/25/12</td>
</tr>
<tr>
<td>All Divisions Contacted</td>
<td>1 day?</td>
<td>Fri 3/9/12</td>
<td>Fri 3/9/12</td>
</tr>
</tbody>
</table>

Figure 12: Final project timeline
### Figure 13: Final project timeline continued

#### 4.2 Project Resources

**Individual/Personnel Resources:**

Cheryl Robin – Cheryl Robin is our lead project sponsor. She is the IS&S Distributed Networks Team Manager.

Chet Stewart – Chet Stewart is an IS&S Technology Engineer for the Distributed Networks Team who was assigned to answer any questions we might have along the way.

Rich Inman – Rich Inman is also an IS&S Technology Engineer for the Distributed Networks Team. Rich has assisted us with the acquisition of hardware and software with which will conducted our analysis. He was also heavily involved with our training of the Motorola Airdefense software.

Sean Tobin – Sean Tobin is our Motorola contact responsible for the Motorola Training sessions and on-site demonstrations.
Hardware/Software Resources

Motorola Airdefense 8.1.2 - For analyzing the store WLANs, our project used Motorola’s laptop-based wireless diagnostic software called AirDefense Mobile version 8.1.2. We have used this tool throughout Stage 1 of the process, and will also be supplied to divisions for use enterprise-wide. We used the SiteSurvey module found within Motorola Airdefense 8.1.2 for determining weak spots and overlaps in store WLAN coverage, as well as analyzing AP channel assignments.

TUNA - (The Utility for Network Administration) is a utility used to install and administer the devices connected to the in-store Network. When adding a device to the network it automates the process of creating and or the updating of configuration files needed to have it communicate on the network. It also helps organize the network so IP duplication does not occur.

NetMapper – NetMapper is a tool used to determine which devices are connected to which switches. We utilized NetMapper while conducting our analysis to reduce confusion on our part.

IBM Lenovo R61 – We acquired an IBM Lenovo R61 laptop to utilize our mobile software and to conduct the actual in-store surveys.

4.3 Project Budget
The costs of the project are completely absorbed by Kroger as the project sponsor, with the exception of minimal travel expenses to travel to stores during Step 1. Kroger will also provide training and tools necessary to complete the project including diagnostic tools, existing infrastructure, test devices, and hardware to potentially remediate problems per our recommendation. Our project team does not have the means to obtain cost figures for Kroger hardware, software, or training sessions. Figure 8 represents the hardware and software requirements for our project. Our budgeted cost for the project is $0.00.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Budgeted Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td></td>
</tr>
<tr>
<td>Lenovo R61 and T400 laptops</td>
<td>$0.00</td>
</tr>
<tr>
<td>Motorola 9090, 9060, and 5846 RF Handhelds</td>
<td>$0.00</td>
</tr>
<tr>
<td>Motorola 5131 Wireless Access Points</td>
<td>$0.00</td>
</tr>
<tr>
<td>U-scan Mobile Attendant device (Fujitsu OEM)</td>
<td>$0.00</td>
</tr>
<tr>
<td>Metler Toledo and Hobart digital scales</td>
<td>$0.00</td>
</tr>
<tr>
<td>Personal Assistant Liaison (Fujitsu OEM)</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td></td>
</tr>
<tr>
<td>Motorola AirDefense Mobile suit version 8.0.1</td>
<td>$0.00</td>
</tr>
<tr>
<td>Motorola Site Scanner</td>
<td>$0.00</td>
</tr>
<tr>
<td>TUNA (The Utilities for Network Administration) – Kroger proprietary network management</td>
<td>$0.00</td>
</tr>
<tr>
<td>SharePoint server 2010</td>
<td>$0.00</td>
</tr>
</tbody>
</table>

Table 2: Project budget

**Section 5: Conclusions and Recommendations**

At the date of this publishing, Kroger is preparing to distribute the necessary hardware with AirDefense to division contacts across the enterprise [3]. Using the training video and other SharePoint-hosted training materials, employees in each division will be able to schedule and execute surveys. At the conclusion of the effort, Kroger will have the data they need to drive an enterprise strategy for the planning, implementation, and maintenance of store wireless networks.
In addition, as the result of our project, Kroger has a better understanding of the requirements applications in development will place on the network, and can begin to plan for future enhancements to store wireless infrastructure.
Section 6: References


