Optimization of Workflow Processes & Resources Through the Focused Deployment of Enabling Technologies

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Memorial Sloan-Kettering Cancer Center

- **Statistics**
  - Beds: 470
  - Admitted Patients: 21,868
  - Average LOS: 6.3
  - Bed Occupancy Rate: 87.4%
  - Surgical cases: 16,951
  - Out Patient Visits: 443,831
  - Radiation treatments & Implants: 101,922
  - X-ray Exam & Special Procedures: 329,329
  - Active Clinical Trials: 493 (13,000 Participations)

- **MSKCC**
  - Memorial Hospital
  - Sloan Kettering Research Center
• **Drivers:**
  – Increased Patient Acuity
  – Increased Device / Technology Complexity
  – Increasing Volume of Information
  – Increasing Workloads on Clinical Staff

• **Increasing Medical Errors:**
  – Medication Errors $^{1,2}$
    • 1:5 Doses Incorrectly Delivered
    • 7,000 – 98,000 Deaths Annually
    • 54% – 61% Errors Occur in IV Medication Adminsitration
  – Device Operating Errors
    • 15-20% of Identified Device Failures
      – (Errors / Failure + Errors)
  – Identification Errors

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2. Cardinal Health: Statistics – Medication Safety & Education
JCAHO National Patient Safety Goals

- “Improve the Effectiveness of Clinical Alarm Systems”
  - Enhanced Alarm Management
  - Improve Alarm Communication and Response

- “Improve the Accuracy of Patient Identification”

- “Improve the Safety of Using High-Alert Medications”

- “Improve the Safety of Using Infusion Pumps”

- “Improve the Effectiveness of Communication Among Caregivers”
How Can Technology Impact Patient Safety?

- **Increased Data Accuracy & Availability**
  - Electronic Medical Records
  - Medical Device Interconnectivity and Integration
  - Global View of the Patient / Unit

- **Rapid Information Dissemination**
  - Alarm Event Management
  - Advanced Communication Platforms (PDA, iPhone, etc.)
  - Real Time Location Systems

- **Enhanced Error Checking**
  - Identification & Association
    - (Barcodes, RTLS/RFID)
The Wireless Medical Center

Connectivity

- Physiologic Parameters
- Access Points RF
- Critical Alarms
- Physiological Data
- Biomedical PM & Test Data
- Archival Patient Record

Locations:
- Alarm Information
- Self Test Data
- Guard Rails & Configuration Parameters
- Device ID Information
- Location Tracking

Network Backbone

The Wireless Medical Center

Memorial Sloan-Kettering Cancer Center
Requirements for Device Connectivity & Data Sharing

- Common Infrastructure
- Centralized Data Acquisition
- Event Stream Processing Across Devices
- Common Communications Devices
- **Dynamic Association (Institutional)**
- Intelligent Alarm Processing
- Archival → Electronic Medical Record
Wired & Wireless Connectivity

11-13 AP per 20,000 sq. ft

STANDARD DATA
STANDARD VOICE
WIRELESS ACCESS POINT
Local Area Wireless at MSKCC

- 2,300 + Access Points
- 15,000 Wireless Devices
- Five segments per wireless antenna:

1st Segment  Authenticated Staff Requires WEP key security, VPN accounts for laptops, PDAs, etc.

2nd Segment  On-Demand Internet (Patients & Families)
Overlaid VLAN with WEP key

3rd Segment  Wireless Phones Secured using WEP and LEAP security, along with QOS for voice quality - voice is low bandwidth but requires priority routing for quality

4th Segment  Medical Devices Vents, EKG machines, etc, each with their own WiFi power, reliability and security issues

5th Segment  VOCERA Voice Recognition (WiFi VoIP) Communications Hands-free voice command pendants
Identification & Association

- Equipment to Patient
- Patient to Staff
Association Problem

Association Problem

ADT

Active Directory

Biomed Equipment Database

Patient Demographics

Staff

Device Identification

Nurse Call

Physiological Monitoring

Ventilators

Infusion Pumps

15

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Advantages of RFID

- Does Not Require Any Intervention or Compliance
- Is Not dependent on Line of Site
- Full Automatic Update and Sampling
- Compatible With Wi-Fi and Barcoding
- Potentially Provides a Completely Dynamic & Transparent Operation
Identification & Association

Equipment to Patient

Pharmaceutical
Active vs. Passive RFID
Active RFID System

Existing 802.11 Wireless Infrastructure

RFID Engine & User Interface

Exciter

Tag ID + Exciter ID

Signal Strength S1

Access Point

R1

S2

R2

S3

R3

Tag ID

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RF-ID Application Topologies

Presence

Location

Choke-point

Approx. 15 feet

Room Level Or Better

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RFID Applications

• **Inventory Management**
  – Locating & Tracking Critical Devices
  – PM Compliance
  – Distribution of Costs
  – Auditing – Tax Write Off

• **Workflow and Optimization**
  – Staff Tracking
  – Asset Utilization
  – Identification & Association
  – Metrics on Dynamic Time Sequence of Events
  – Optimization of Processes

Memorial Sloan-Kettering Cancer Center
Zuckerman Research Center

- ZRC 20
- ZRC 19
- ZRC 18
- ZRC 17
- ZRC 16
- ZRC 15
- ZRC 14
- ZRC 13
- ZRC 12
- ZRC 11
- ZRC 10
- ZRC 9
- ZRC 8
- ZRC 7
- ZRC 6
RFID Deployments (Active)

- SKI Capital Inventory Tracking 3500
- Wheelchairs & Stretchers 140
- Alaris Infusion Pumps 2100
- Wound Healing Device 12
- ICU Critical Inventory 51
- C-Arms for Radiology 24
- Feeding Pumps 55
- Compression Devices 12
- Animal Cages 42
- Biomed Devices for PM Compliance 520
- Hospital Capital Devices 4200

Find a Device for Use, Preventative Maintenance, etc
Workflow & Optimization

• **Correlates Location Information with:**
  – Device Data
  – Time
  – Identifiers

• **Results Information on:**
  – Status - Availability
  – Response Metrics
  – Event Stream Information
Coupling Device Information With RTLS
Infusion Pump Deployment

- Identified the Potential for Enhanced Utilization of Devices & Staff Resources

![Diagram of Infusion Pump Deployment]

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## Device Availability and Utilization

<table>
<thead>
<tr>
<th></th>
<th>Average pumps per unit</th>
<th>Average Pumps in use</th>
<th>Average Unused Pumps</th>
<th>Percentage Utilization</th>
<th>Pumps (% of total)</th>
<th>Used Pumps (% of Total)</th>
<th>Unused Pumps (% of Total)</th>
<th>Impact Rank</th>
</tr>
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<tbody>
<tr>
<td>MP 2</td>
<td>8</td>
<td>1</td>
<td>7</td>
<td>17%</td>
<td>1.30%</td>
<td>0.22%</td>
<td>1.08%</td>
<td>18</td>
</tr>
<tr>
<td>MP 6</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>35%</td>
<td>0.97%</td>
<td>0.34%</td>
<td>0.62%</td>
<td>22</td>
</tr>
<tr>
<td>M 1</td>
<td>17</td>
<td>2</td>
<td>15</td>
<td>9%</td>
<td>2.79%</td>
<td>0.25%</td>
<td>2.54%</td>
<td>7</td>
</tr>
<tr>
<td>M 10</td>
<td>44</td>
<td>15</td>
<td>28</td>
<td>35%</td>
<td>7.31%</td>
<td>2.57%</td>
<td>4.75%</td>
<td>1</td>
</tr>
<tr>
<td>M 11</td>
<td>44</td>
<td>19</td>
<td>26</td>
<td>42%</td>
<td>7.42%</td>
<td>3.11%</td>
<td>4.31%</td>
<td>2</td>
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<tr>
<td>M 12</td>
<td>41</td>
<td>31</td>
<td>10</td>
<td>75%</td>
<td>6.95%</td>
<td>5.21%</td>
<td>1.74%</td>
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<tr>
<td>M 14</td>
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<td>26</td>
<td>43%</td>
<td>7.46%</td>
<td>3.17%</td>
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<tr>
<td>M 15</td>
<td>44</td>
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<td>25</td>
<td>44%</td>
<td>7.37%</td>
<td>3.23%</td>
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<tr>
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<tr>
<td>M 17</td>
<td>38</td>
<td>17</td>
<td>21</td>
<td>45%</td>
<td>6.43%</td>
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<td>3.51%</td>
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<tr>
<td>M 19</td>
<td>16</td>
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<td>15</td>
<td>9%</td>
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<td>0.23%</td>
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<tr>
<td>M 4</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>25%</td>
<td>0.84%</td>
<td>0.21%</td>
<td>0.63%</td>
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<tr>
<td>M 5</td>
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<td>15</td>
<td>61%</td>
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<td>3.97%</td>
<td>2.54%</td>
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<tr>
<td>M 6</td>
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<td>8</td>
<td>7</td>
<td>56%</td>
<td>2.54%</td>
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<tr>
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<td>62%</td>
<td>6.74%</td>
<td>4.16%</td>
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<tr>
<td>M 8</td>
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<td>25</td>
<td>9</td>
<td>74%</td>
<td>5.71%</td>
<td>4.24%</td>
<td>1.47%</td>
<td>14</td>
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</tbody>
</table>

*Memorial Sloan-Kettering Cancer Center*
# Formulary Validation Report

<table>
<thead>
<tr>
<th>Device ID</th>
<th>Serial #</th>
<th>Formulary #</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>100016118</td>
<td>12869292</td>
<td>MSKCC v.46</td>
<td>Haupt/Floor 5/Haupt 5</td>
</tr>
<tr>
<td>100016135</td>
<td>12870775</td>
<td>MSKCC v.46</td>
<td>Memorial/Floor 10/M 10</td>
</tr>
<tr>
<td>1000012044</td>
<td>12749091</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 2/53rd 2</td>
</tr>
<tr>
<td>1000012059</td>
<td>12757873</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 2/53rd 2</td>
</tr>
<tr>
<td>1000012074</td>
<td>12758505</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 2/53rd 2</td>
</tr>
<tr>
<td>1000012042</td>
<td>12748574</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 3/53rd 3</td>
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<tr>
<td>1000012054</td>
<td>12757429</td>
<td>MSKCC v.37</td>
<td>53rd/Floor 3/53rd 3</td>
</tr>
<tr>
<td>1000012055</td>
<td>12757874</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 3/53rd 3</td>
</tr>
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<td>MSKCC v.37</td>
<td>53rd/Floor 3/53rd 3</td>
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<tr>
<td>1000012085</td>
<td>12747892</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 4/53rd 4</td>
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<tr>
<td>1000012087</td>
<td>12747812</td>
<td>MSKCC v.38</td>
<td>53rd/Floor 5/53rd 5</td>
</tr>
<tr>
<td>1000012032</td>
<td>12758316</td>
<td>MSKCC v.46</td>
<td>53rd/Floor 6/53rd 6</td>
</tr>
</tbody>
</table>

**Current Formulary Version:** MSKCCv.47
Patient Centric Identification & Association

Bed Centric Identification Envelope

Equipment to Patient

Bed Embedded RF Transmitter Receiver

Embedded Bed / Nurse Call Staff Workstation

Pharmaceutical

Middleware

Devices

EMR

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Nursing Validation Interface

Patient: John Smith
MR# 1000009876
M10: Bed 1041

Physiologic Monitor
Ventilator
Infusion Pump 1000008799
Infusion Pump 1000007654

Pharmaceutical
Pharmaceutical “XXXXXXXX”

Application Trigger:
Alarm Management (Emergin)
Physiological Data (Capsule / GE)
Medication Administration
Sample Collection

Confirm Ignore

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Biomedical Device Information System

- Patient Centric Identification
- Alarm & Physiologic Data Manager
- Physiologic Data Manager
- Hospital Backbone
- Nurse Call Application Server
- Ventilator Management Application
- Physiological Monitoring
- Pump Medication Management
- Aeroscout Active RFID
- Hospital Gateway

CISCO Access Point

Nurse Hands Free Wireless Devices

Directed Communications

(Vocera)
Synchronized RF-ID & Event Stream Workflow
Dynamic Location & Tracking

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Workflow Visualization & Reporting

Area - Hospital/4th floor

Area ID: 106
Name: 4th floor
Description:
Authentication Level: None
Status: Active
Origin: (1.349, 1.2832) (meters)

GE Monitoring
Infusion Pump
MD
RN

Nursing Station

Douglas
Thomas
Ramos

SJones

JSmith

Clean Utility Room

Patient Room #2

Patient Room #1

Time: 12:02AM

Weiss

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PUT RFID TO WORK
Workflow Visualization & Reporting

AeroScout MobileView v3.0 (b1.0)

Area - Hospital/4th Floor

GE Monitoring
Infusion Pump

MD
RN

Nursing Station

Ramos

SJones

Clean Utility Room

Patient Room #2

Patient Room #1

VTach Monitoring Alarm
Code Blue

Weiss

Douglas

Thomas JSmith

Time: 12:05AM

Memorial Sloan-Kettering Cancer Center
Cautions & Pitfalls
Be Aware & Plan

• **Significant Cost of Technology**
  – Direct Cost of Technology
  – In-Direct Costs – Network Upgrades, Wireless AP
  – ROI is Difficult to Project

• **Staffing & Operations**
  – Trade-off Clinical Staff vs. Technical Staff
  – Workflow (Optimize or Impact)

• **Unexpected Issues**
  – Electromagnetic Interference
  – Primary vs. Secondary Information
  – Potential FDA Regulations
Identification & Association Processes

• Medical Devices & Systems
  – Physiological Monitoring
  – Bernoulli Ventilator Management
  – Infusion Pump Systems
  – Nurse Call
• Alarm Management & Data Distribution
• Medication Administration
• Sample Collection
• Electronic Medical Record
Active RFID System

Existing 802.11 Wireless Infrastructure

RFID Engine & User Interface

Access Point

Access Point

Tag ID

Exciter

Signal Strength S1

Tag ID + Exciter ID

R1

S2

R2

S3

R3

Memorial Sloan-Kettering Cancer Center
## OVER-THE-AIR IMPACT

<table>
<thead>
<tr>
<th>1000000</th>
<th>bits per second / preamble speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>416</td>
<td>bits in a &quot;tag beep&quot;</td>
</tr>
<tr>
<td>416</td>
<td>microseconds tag duration</td>
</tr>
<tr>
<td>0.416</td>
<td>milliseconds of tag beep duration</td>
</tr>
<tr>
<td>0.000416</td>
<td>seconds per &quot;beep&quot; @ 1 megabit/sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1000</th>
<th>number of tags within range of a single AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>beep interval in seconds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>125</th>
<th>number of beeps per second heard by this AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.052</td>
<td>total time consumed by beeps in a second</td>
</tr>
<tr>
<td>5.20%</td>
<td>percent of one second consumed by beeping</td>
</tr>
</tbody>
</table>

## LAN IMPACT

<table>
<thead>
<tr>
<th>24</th>
<th>bytes in a TOA or RSSI LAN message</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>number of RSSI messages per second sent by this AP (FROM LINE 13)</td>
</tr>
<tr>
<td>3000</td>
<td>number of bytes per second sent by this AP for RSSI reports</td>
</tr>
<tr>
<td>0.03</td>
<td>number of megabits per second sent by this AP for RSSI reports</td>
</tr>
<tr>
<td>0.0300%</td>
<td>percent of one 100 base T (100 mbit/sec) on a switchport</td>
</tr>
</tbody>
</table>
Interference ¹,²

- **Wi-Fi Based Interference:** (Undocumented)
  - 802.11 Wireless Running @ MSK for up to 10 years
  - ECG Data → GE MUSE Archive 65 carts
  - Vocera 2000 (+)
  - Ventilators 40
  - Infusion Pumps (PCModule) 900
  - Active RFID 12,000
  - Physiological Monitoring 10
  - **Laboratory Testing:**
    - 6 Active RFID Tags – Broadcasting at 8 sec intervals for 12 hours

- **Exciter Based Testing** 125 Khz. Transmitter
  - 12 Lead ECG Systems and Ventilator - Exciter Range @ 1 foot

No Direct Interference Observed on Device Functionality
Can not Test for all Conditions
Establish Mounting Specifications to Limit Range to Device


Medical Devices

Clinical Data

Middleware Application

Communication Device

Secondary Data Source

EMR Archive

Primary Source of Medical Information

FDA Regulated

Not A Medical Device
Not Regulated by the FDA

Not A Medical Device
Not Regulated by the FDA
Questions?