NETWORKED RFID SYSTEMS IN
PRODUCT RECOVERY MANAGEMENT

A.G. Kulkarni, A.K. Parlikad, D.C. McFarlane and M.G. Harrison

Cambridge Auto-ID Labs,
University of Cambridge, UK
IEEE Conference on Electronics and the Environment
17 May 2005
PRESENTATION OVERVIEW

- Research Aim
- Product recovery decisions
  - Product dispositioning decision
  - Product remanufacturing inventory decision
- Linking product information to product recovery decisions
- Enhancing product information with “networked RFID”
- Improving product recovery decisions with enhanced product information
- Quantifying value of product information
Research Focus and Aim

• To examine and quantify the impact of ready availability of product information provided by networked RFID systems on product recovery decisions.
Drivers for Product Recovery Management

Environmental
Government Regulations
– WEEE Directives

Other financial benefits...
PRODUCT RECOVERY DECISIONS

- Product Dispositioning Decisions
  - Remanufacture
  - Reuse
  - Refurbish
  - Recycle
  - Disposal

- Remanufacturing inventory decisions
  - How much to procure from outside supplier
RESEARCH QUESTIONS

▪ What is the availability and requirements of product information for making product recovery decisions in product recovery industry?

▪ How can we provide the requisite information for better decision-making?

▪ How can we quantify the impact of ready availability of product information on product recovery decisions?
Research Questions

- What is the availability and requirements of product information for making Product recovery decisions in product recovery industry?

- How can we provide the requisite information for better decision-making?

- How can we quantify the impact of ready availability of product information on product recovery decisions?
CASE STUDY EXERCISE IN EUROPE

• 12 companies located across Europe
  – 3 computer refurbishers
  – 3 photocopier remanufacturers
  – 1 phone refurbishers
  – 3 computer dismantlers
  – 2 white goods recyclers
OEM owned Photocopier Remanufacturing

What fraction of demand can be satisfied from returned products?

How much to procure?

Component Procurement from External Supplier

Inventory Decisions

Disassembly and component recovery

Serviceable and new Component Inventory

Assembly

Recycle

Product Return

Product Sorting

Remanufacturable Product Inventory

Product dispositioning decision

Info Available
- Product type
- Assembly BOM
- Component failure history

Info required
- Product type
- Current BOM
- Maint. History
- Reliability
- Component Yield
- Quantity
Third party owned computer refurbishing

Which products to be prioritised for testing and refurbishing?

Inventory Decisions

Product dispositioning decision

Check-in

To be Tested

Testing

Recoverable

Recycle

Refurbish

Recycle

Finished

Sales

Info Available
Product type
Quantity

Info required
Product type
Market value
Current BOM
Maint. History
Reliability
Product Yield
Quantity

Product to be
returns

Info Available
Product type
Quantity

Inventory Decisions

Which products to be prioritised for testing and refurbishing?

Product dispositioning decision

Check-in

To be Tested

Testing

Recoverable

Recycle

Refurbish

Recycle

Finished

Sales
## Product Information Requirements vs Availability

<table>
<thead>
<tr>
<th>Information Required</th>
<th>Pre-sorting</th>
<th>Grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material content</td>
<td>✗</td>
<td>depending on access to design data</td>
</tr>
<tr>
<td>Original specification</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Later modifications</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Reliability</td>
<td>✗</td>
<td>depending on access to design data</td>
</tr>
<tr>
<td>Age</td>
<td>✗</td>
<td>depending on access to sales &amp; maintenance data</td>
</tr>
<tr>
<td>Current condition</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Usage</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Maintenance</td>
<td>✗</td>
<td>depending on the availability &amp; accuracy of maintenance logs</td>
</tr>
</tbody>
</table>

© 2005, all rights reserved
Requirements of Information Quality for Making Product recovery Decisions

- Uniqueness
  - to enable individual information trails for each unique object throughout its lifecycle and across the whole supply chain.
Requirements of Information Quality for Making Product Recovery Decisions

- **Timeliness**
  - to ensure that information is readily available for decision-making and execution process with minimal need for manual inspection or testing.
Requirements of Information Quality for Making Product Recovery Decisions

- Completeness
  - to ensure that all relevant information is available for optimal decisions.
- Accuracy
  - to reduce or eliminate inaccurate representations of current and historical product information.
Research Questions

- What is the availability and requirements of product information for making the decisions in product recovery industry?

- How can we provide the requisite information for better decision-making?

- How can we quantify the impact of ready availability of product information on product recovery decisions?
A NETWORKED RFID APPROACH
EPC™ Network Technology
Building Blocks
Information Quality <-> EPC Network

• Uniqueness
  – Enable unique product identification
    ---> EPC

• Completeness
  – Ensure availability of relevant product info
    ---> EPCIS/ONS/XML

• Timeliness
  – Ensure “ready” availability of product info
    ---> RFID/Filtering

• Accuracy
  – Reduce/eliminate errors in info management
    ---> RFID/XML
NETWORKED RFID FOR PRODUCT LIFECYCLE INFORMATION MANAGEMENT

EPCIS Discovery Service

Date of manufacture
Parts/ materials used
(Dis)assembly recipe

Manufacture

EPCIS

Retail

Usage/Maintenance

End-of-Life

© 2005, all rights reserved
NETWORKED RFID FOR PRODUCT LIFECYCLE INFORMATION MANAGEMENT

- Date of manufacture
- Parts/ materials used
- (Dis)assembly recipe
- Date of sale
- Warranty details
- Parts replaced
- Usage/Maintenance
- End-of-Life

EPCIS Discovery Service

© 2005, all rights reserved
NETWORKED RFID FOR PRODUCT LIFECYCLE INFORMATION MANAGEMENT

EPCIS Discovery Service

- Date of manufacture
- Parts/ materials used
- (Dis)assembly recipe

- Date of sale
- Warranty details
- Parts replaced

- On-board data
- Usage history
- Parts installed

- Usage/Maintenance

- Manufacture
- Retail
- End-of-Life

© 2005, all rights reserved
NETWORKED RFID FOR PRODUCT LIFECYCLE INFORMATION MANAGEMENT

EPCIS Discovery Service

Manufacture
- Date of manufacture
- Parts/ materials used
- (Dis)assembly recipe

Retail
- Date of sale
- Warranty details
- Parts replaced

Usage/Maintenance
- On-board data
- Usage history
- Parts installed

End-of-Life
- Parts/materia; identified
- Disassembly history

EPCIS

© 2005, all rights reserved
UNIVERSITY OF CAMBRIDGE
Institute for Manufacturing
AUTO-ID LABS
NETWORKED RFID FOR PRODUCT LIFECYCLE INFORMATION MANAGEMENT

EPCIS Discovery Service

1. EPC xyz
   “Where can I find information about EPC xyz?”
   ONS

2. “Tell me which part was replaced”
   “100 GB HDD”

EPCIS

Date of manufacture
Parts/ materials used
(Dis)assembly recipe

EPCIS

Date of sale
Warranty details
Parts replaced

EPCIS

On-board data
Usage history
Parts installed

EPCIS

Parts/materials identified
Disassembly history

Manufacture

Retail

Usage/Maintenance

End-of-Life

© 2005, all rights reserved
**Research Questions**

- What is the availability and requirements of product information for making the decisions in product recovery industry?

- How can we provide the requisite information for better decision-making?

- How can we quantify the impact of ready availability of product information on product recovery decisions?
Mathematical Models are under development to quantify the impact of ready availability of product Information on Product recovery Decisions.

Example: A Bayesian product dispositioning decision model

Utility of a decision = $f$(certainty, payoff)
EPC ENHANCED PRODUCT RECOVERY DECISIONS

- Higher Utility
- Quicker decisions
- EPC enabled information

Utility (t)
Payoff
Certainty

Information

Test 1
Test 2
Test 3
Test 4
CONCLUSIONS

Networked RFID based Approach has potential to bring:

• Decision improvements
  – Better estimation of residual life and value
  – Better estimation of recyclable material content
  – Rich information leads to better decisions

• Process improvements
  – Quick and possibly automated identification & sorting
  – Error reduction
Thank You

ak426@cam.ac.uk
www.autoidlabs.org.uk