# Mitigating Container Security Risk Using Real-Time Monitoring with Active Radio Frequency Identification and Sensors

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# The Problem

- Global trade is on the rise
- ~90% of the world's cargo is transported by container
- Large enough to hold multiple nuclear warheads, many tons of Anthrax, and other mass-destruction devices
- A terrorist attack could bring this trade to a halt
- The threat itself poses challenges that create inefficiencies in the global supply chain

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# Research

- Determine major global transport risks
- E-Container proposition
  - New angle on the e-seal
- Relation framework
  - Sensor-identified signatures and phenomena
  - Behaviors representing breaches in container security
- Theoretical model
  - Which sensors are required to identify breaches
- Goal → Mitigate global transport risk

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# Four Major Container Categories

– Dry Freight

– Insulated

– Temperature Controlled

– Open Top

*Source: Isocontainer.com*

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# Modes of Transportation

– Land (Chassis)

– Rail (Rail car)

– Sea (Ship)

– Handled (Individually)

*Picture taken at Intransit Rail Yards, December 2004 and Port of Barcelona, January 2005 Source of chassis: Isocontainer.com*



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# The Risks


*Source: http://msnbc.com/news/354340.asp?cp1=1)*

**Theft Cost Breakdown by Percentage**

| Transportation Method | % of Total | $30 Billion *Estimate* |
|---|---|---|
| Road Transport (Truck) | 87% | $26.1 Billion |
| Maritime Cargo (Container Ship) | 8% | $2.4 Billion |
| Rail Cargo | 4% | $1.2 Billion |
| Air Cargo | 1% | $300 Million |

***Source: DeGeneste & Sullivan, 1994***

- Stowaways & Human Smuggling
- Weapons Smuggling
- Injection of Chemical and Biological Agents
- Nuclear Materials
- Drug Smuggling
- Theft of Containers and their Contents (Piracy)
- Explosion or Leakage of Dangerous Materials
- Size of Maritime Vessels

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# Current Security Standard

## Security Seals:


- Rubber and metal locks and/or bolts
- If broken, container will be inspected
- Known issues:
  - Rough treatment
  - Seals often damaged accidentally
- Causes unnecessary inspection

## X-Ray Machines:

- Truck moves along side container
- Not proactive
- What can you actually detect?
  - Low-level radiation source penetrates cargo
  - Drugs, humans, dangerous cargo



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*Picture taken at Intransit Rail Yards, December 2004*

*X-Ray Photo Source: http://www.copybook.com/images/publications/AirportInt/articleimages/L3detection3.jpg*

# Current Technology Standard

"e-Seal"


*Photo Source: http://www.geindustrial.com/ge-interlogix/docs/2004-2838_Sell.pdf*

- Few Sensors
- Downloaded data
  - Not Real-Time
- Conspicuous
- Remove the hinge...
- Breach the side or roof...
- Proprietary software

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# Available Sensors

- **Ambient Temperature**: Fahrenheit, Celsius, Kelvin
- **Light**: EM intensity
- **Humidity**: Moisture Density
- **Pressure**: Mass/Volume (typically air)
- **Vibration**: small-scale linear velocity, spatial displacement, acceleration
- **Sound**: decibels
- **Acceleration**: $\frac{d^2x}{dt^2}$
- **Existence**: RFID tagged objects (RFID!)
- **Current Draw**: on the Tag
- **Motion**
- **Air Exchange**
- **Explosives**
- **Location**
- **Radioactivity**

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# Relate: Sensors to Behaviors

**Ambient Temperature:**

- Determine if a container has been opened
- Determine if a chemical reaction is occurring
- Determine if a person is moving in the container and generating heat

**Light:**

- Determine if a container door has been opened
- Determine if a fire has started
- Determine if lights are changing (electronic devices such as a timer)

**Humidity:**

- Determine if a person is breathing
- Determine if a liquid is leaking inside the container
- Determine if the container itself is leaking

**Pressure:**

- If a container is sealed air-tight, determine if the seal is broken
- Determine if pressure is building inside the container from heat etc.

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# Relate: Sensors to Behaviors

**Vibration:**

- Determine if something mechanical is running inside the container
- Determine if the container is being treated in a violent fashion

**Sound:**

- Determine if a person is speaking inside the container
- Determine if a machine is running inside the container
- Determine if items inside the container are banging or breaking

**Acceleration:**

- Determine shock and vibration

**Existence:**

- Determine if RFID tagged items are being added to the container
- Determine if RFID tagged items are being removed from the container

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# Relate: Sensors to Behaviors

**Current Draw:**
- Determine if someone/something is tampering with the RFID tag

**Motion:**
- Determine is someone/something is moving inside the container

**Air Exchange:**
- Determine if a substance is being piped into or out of the container

**Explosives:**
- Determine if there are explosives inside the container

**Location:**
- Through GPS, determine the exact location of the container

**Radioactivity:**
- Determine the existence of radioactive materials
- Determine the intensity of the radioactive materials

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# Risk to Sensor Model

| Sensor Choice Model for Container Risk Mitigation | Ambient Temperature | Light | Humidity | Air Pressure | Vibration | Sound | Acceleration | RFID Existence | Current Draw | Air Exchange | Location | Explosives | Motion | Vibration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stowaways & Human Smuggling | | | | | | | | | | | | | | |
| Weapons Smuggling | | | | | | | | | | | | | | |
| Injection of Chemical and Biological Agents | | | | | | | | | | | | | | |
| Nuclear Materials | | | | | | | | | | | | | | |
| Drug Smuggling | | | | | | | | | | | | | | |
| Theft of Containers and their Contents (Piracy) | | | | | | | | | | | | | | |
| Breakin to Container | | | | | | | | | | | | | | |
| Explosion or Leakage of Dangerous Materials | | | | | | | | | | | | | | |
| Tampering with the RFID tag | | | | | | | | | | | | | | |

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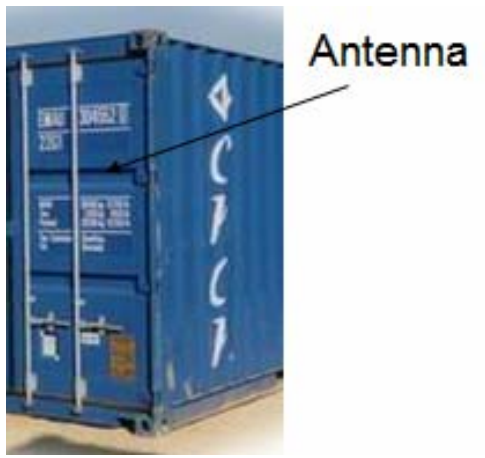
# The e-Container

- Active RFID tags connected to sensors in the container
- Connect to a network and share real-time telemetry

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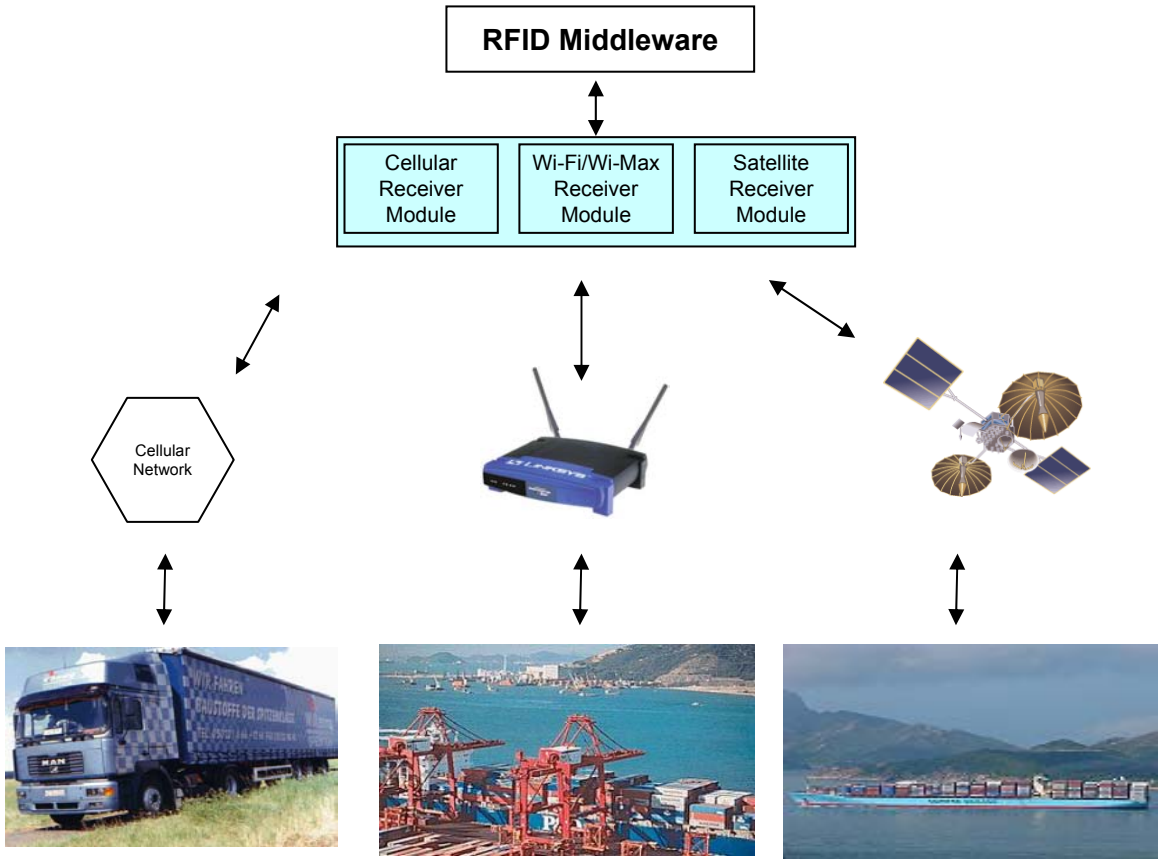
# Architecture



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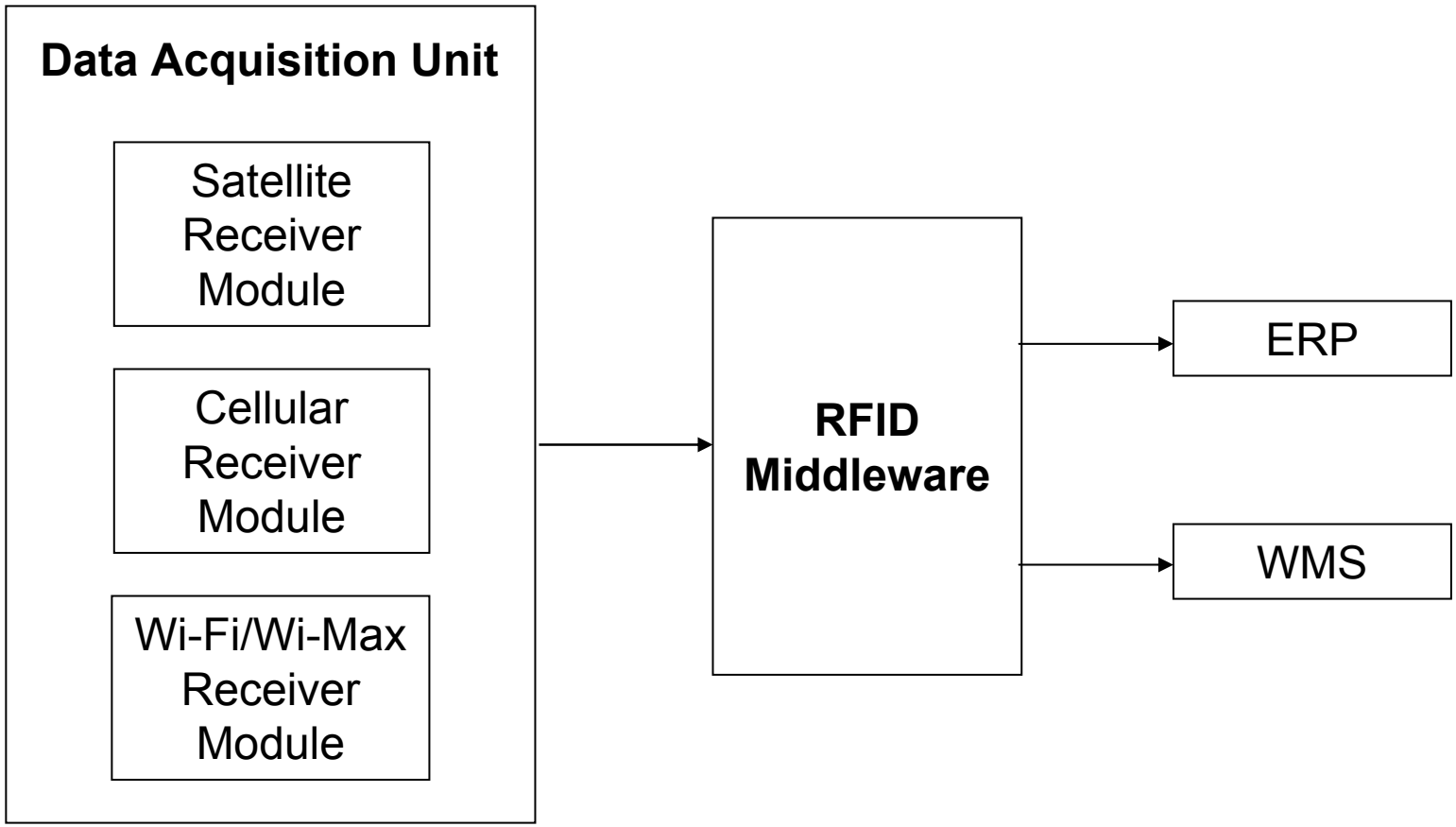
# Centralized Data Center

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# Communication

1. Heart Beat
2. Tampering Message
3. Threshold Break
4. Scheduled Scan
5. Manual Scan

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# Customs Technology Issues

- Searches are secret and random
- Evidence in prosecution

# Additional Uses for the Technology

- Food perishability notices
  - Re-order
- Placement of Goods
  - Animal Hides & Food
  - Hot & Cold
- Unloading of Containers

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Thanks

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