SAPIENZA
UNIVERSITÀ DI ROMA

DIPARTIMENTO DI INGEGNERIA INFORMATICA AUTOMATICA E GESTIONALE
ANTONIO RUBERTI

Master Degree Programme in
Management Engineering

Enterprise Information Systems

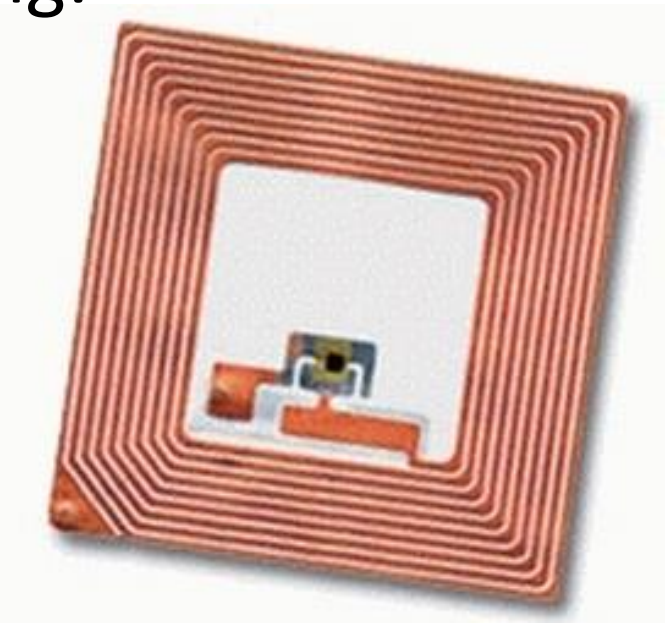
Umberto Nanni

Introduction to RFId – Radio Frequency Identification

What is RFID?

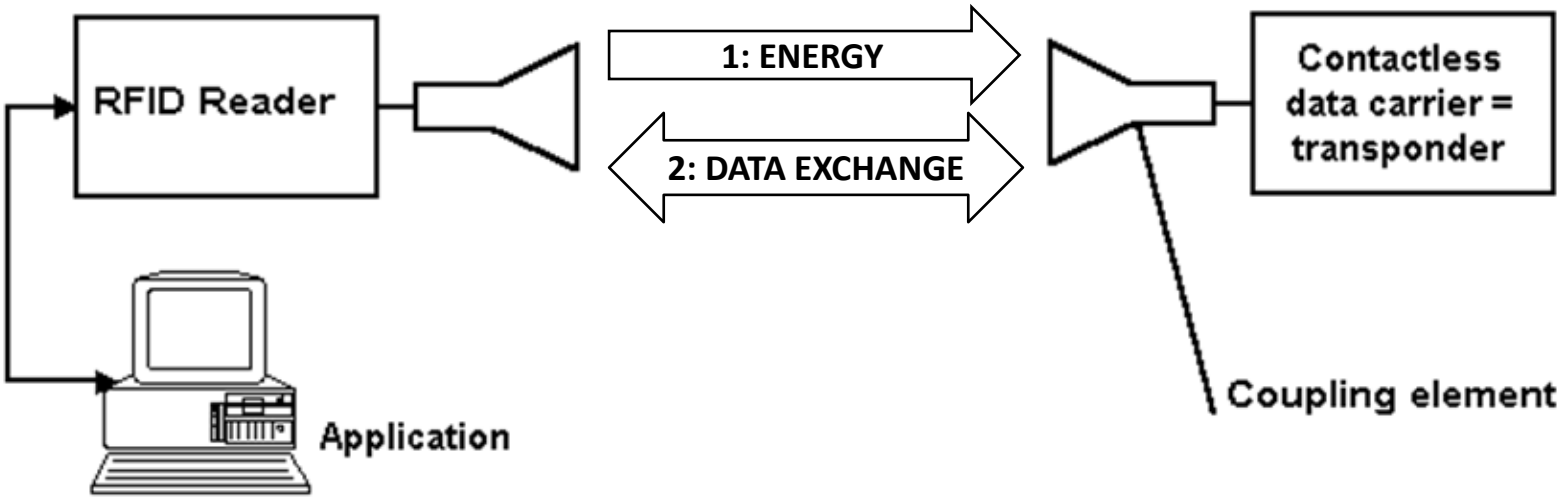
A “label” or “tag” containing:

- a micro-chip
- antenna (receiver/transmitter)
- a small memory (*), containing:
  - identification code
  - additional information

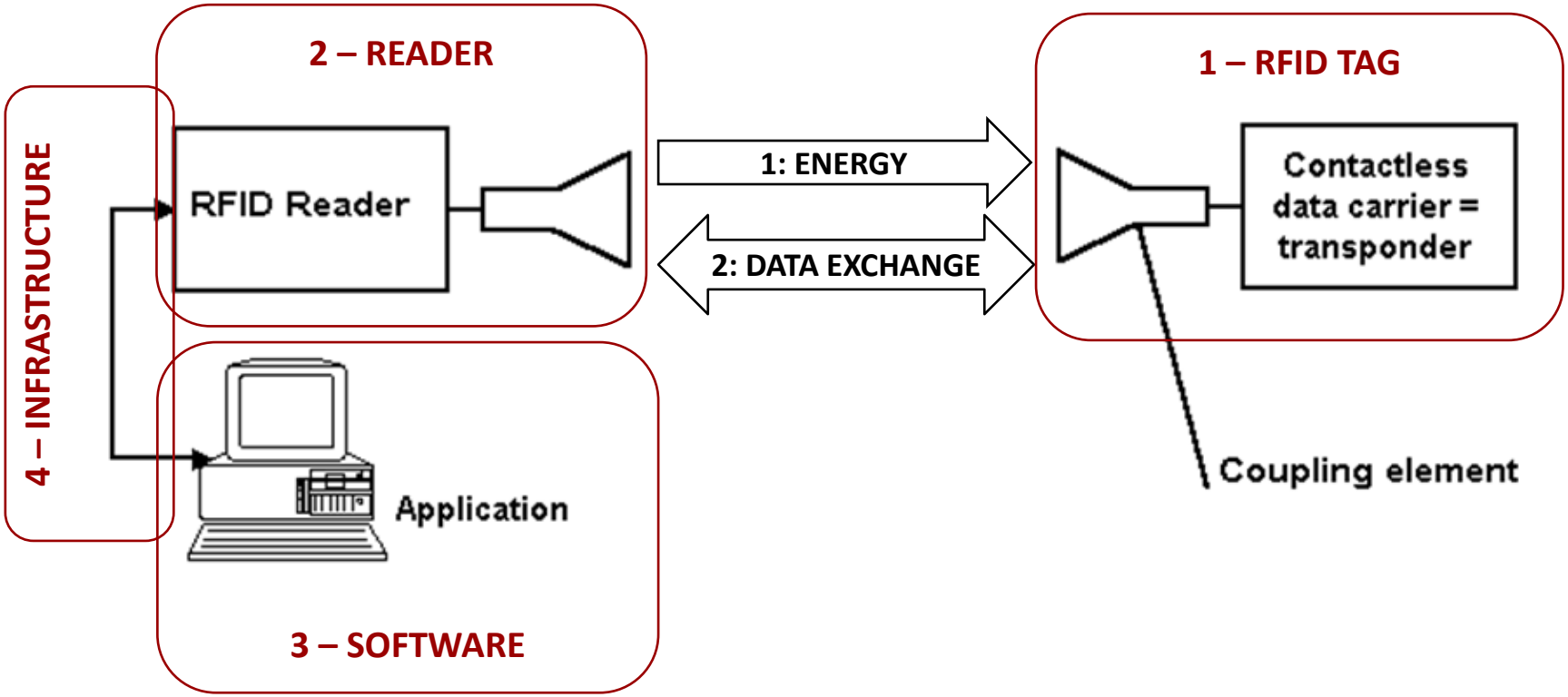


(*) read-only, write-once, read/write

Principles of Operation

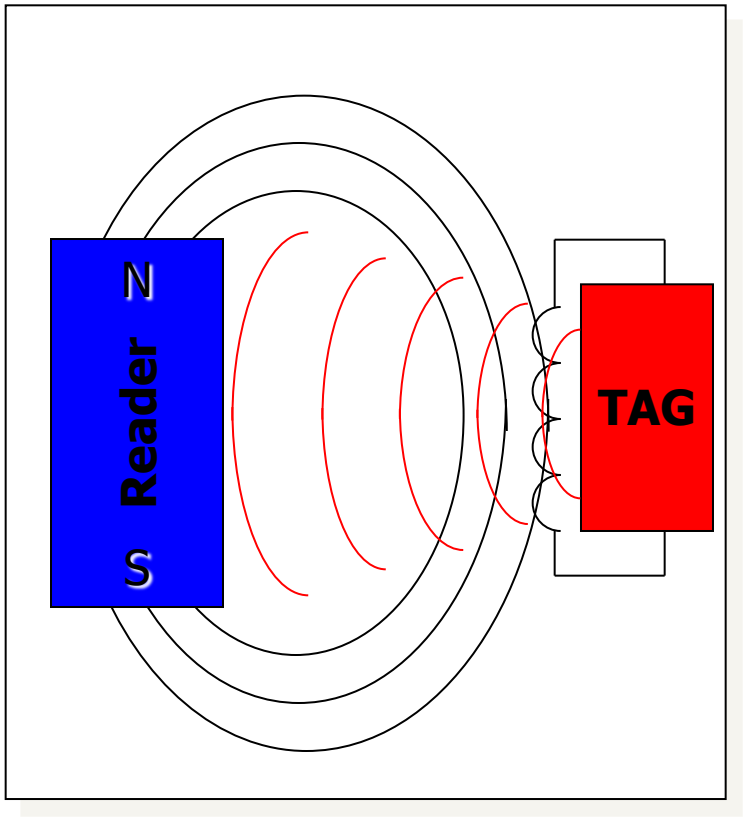


Operational components of a RFID system

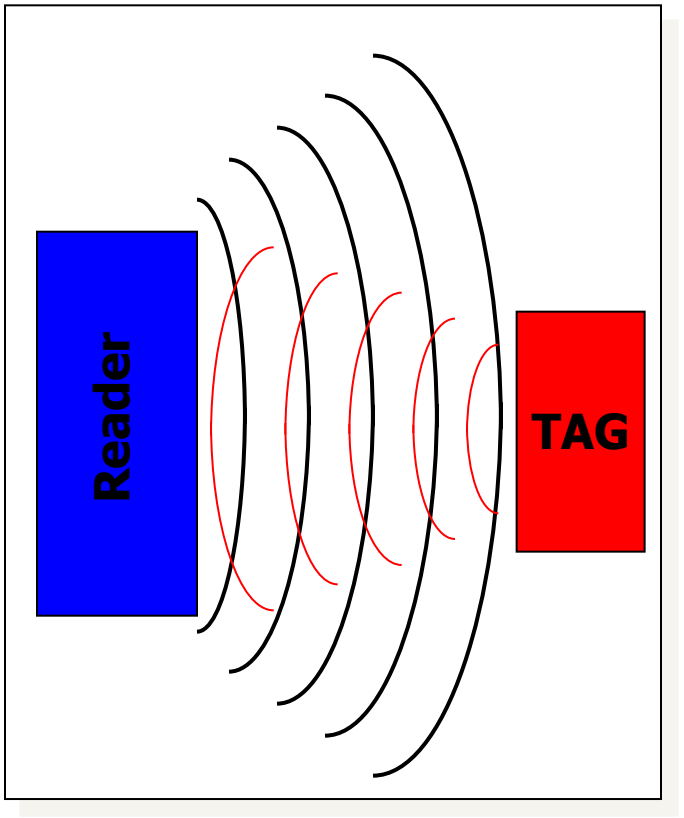


Principles of Operation - coupling

Low Frequency
inductive coupling



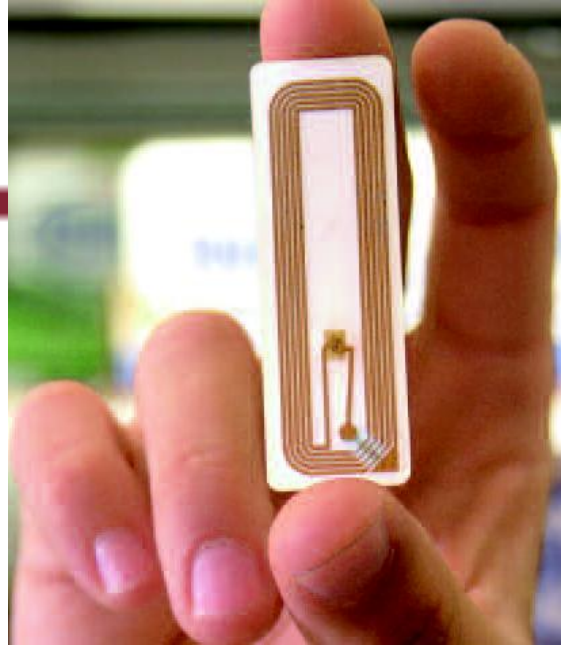
High Frequency
Back Scattering



Frequencies

	Frequency	Distance	Example Application
LF	125khz	Few cm	Auto-Immobilizer
HF	13.56Mhz	1m	Building Access
UHF	900Mhz	~7m	Supply Chain
µwave	2.4Ghz	10m	Traffic Toll

RFID-Tag types



Passive tags

- low unit cost
- no power supply (energy from the reader)
- transmission when reading

Semi-active tag

- independent power from the reader, but with limited autonomy (or for additional sensors)
- data transmission only when interrogated by the reader (no autonomous transmission)

Active tags

- power completely independent from the drive (battery to power
- the chip and the transmission system)
- generate RF energy to transmit the data independently

Components of a RFID system

PRINTER

- a suitable printer can write information on the tag (equivalent to printing the bar code)

LABELING

- the tag must be attached on the interested "thing"

OPERATIONAL CONDITIONS

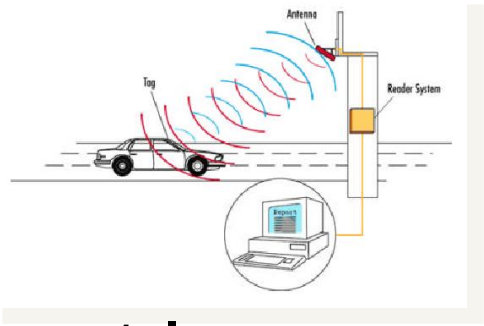
tag (chip+antenna+physical support): stores a unique identifier and optionally further data

reader: coupling between the tag antenna andthe infrastructure

infrastructure: connects the reader and the information system

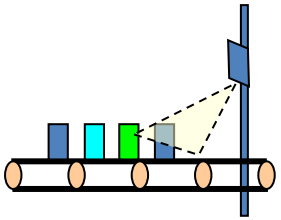
driver and application software: registers the reading event

Some Applications and devices

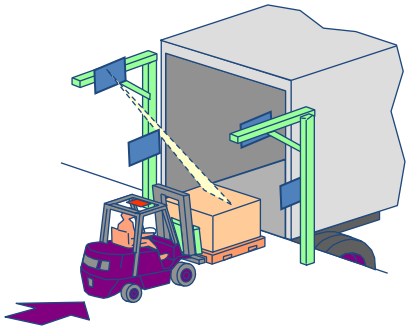


telepass

forklift



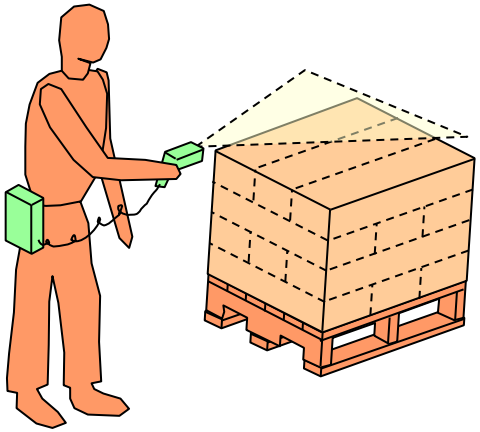
tape conveyor



vehicles

Container, Pallet, Munitions

printers



hand-held reader

point of sale

intelligent shelves

Handheld Readers

- Handheld systems with integrated RFID reader and antenna
- Sometimes integrated into an existing barcode scanner product

Fixed RFID Readers

- “Pizza box” readers with ~2-8 antennas
- Typically used in supply chain applications

Embedded Readers

- "Credit Card-sized" module
  used to add RFID to a special-purpose device
- Examples: RFID printer/encoders,
  package sorters and POS terminals (cash registers)

Traditional Applications

Auto Immobilizers

Automated Vehicle Id

- ***Stand-alone systems***
- ***Basic Information***

Access Control

Animal Tracking

Integrated Reader/Antenna

- Single antenna with integrated reader capability

BARCODE/RFID	Barcode	RFID
Memory	limited capacity	high capacity
Access to data	read-only	Ability to rewrite
Metering Modes	A single reading at a time	More contemporary readings
Read range	A few cm manually	Up to a few meters in automatic or manual mode
Robustness of the device	easily consumable	Wear-resistant (with proper packaging)
Mode of interaction	Need to aim for the label	Omnidirectional reading
Quality of support	Reading difficulties (dirt, damage)	Immunity to dirt, structural strength
Cost	inexpensive	Still relatively high
Adoption	Worldwide	Still in the process of adoption
Standard	Established for decades (EAN-UCC)	Several have been established (*) – quite young
Inclusion in the product	easy	Not always easy

(*) Two main international RFID standardisation bodies:

- ISO - International Standards Organisation
- EPCglobal - Electronics Product Code Global Incorporated

In 2015: sensors everywhere, computers invisible

By *Dan Farber*, Tech Update
March 30, 2004

Ten years from now, the computer as we know it today will be an anachronism, a device consigned to museums, dumpsters and garages. Instead, according to Gartner analysts, the digital information and services once delivered via conventional computers will be available through almost everything we touch—kiosks, airplane seats, newspapers and a broad array of new devices.

At the heart of this next generation of computing is the network. It will be pervasive and personal, and you'll pay for the services that you consume, said Gartner Fellow Tom Austin during the analyst firm's Symposium/ITxpo 2004.

The amount of information, delivered by billions if not trillions of RFID sensors, or smart dust, functioning as self-organizing and managed networks, will explode, requiring an event-driven model that Gartner calls a "tera" architecture. "A tera architecture must be capable of processing terabytes of data every second," Austin said. The tera architecture combination of smart sensor networks and an event-driven data will be common in five years and pervasive within 10 years.

However, managing a world with sensors scattered about like grains of sand will require a new class of operating system that can auto-discover and organize networks, Austin said. The TinyOS, for example, is designed for very small networked sensors running low power CPUs with a few kilobytes of RAM.

Item Level RFID Gathers Pace

Feb 07, 2005

Item level RFID is the Mount Everest of RFID, with by far the largest potential at up to ten trillion tags yearly as most barcodes are replaced. Infrastructure, software and services to make it happen are likely to approach one hundred billion dollars yearly across the world - roughly the sum that will be needed for the tags. Item level is a term that usually refers to fairly small items in high volume. We do not include animals, where about one billion, relatively expensive tags yearly will be needed in 10-15 years. Vehicles, transport containers, conveyances and so on are not called "items" - they also need very different RFID tags and infrastructure at very different prices. The biggest potential for item level after consumer packaged goods is the postal items, books and the packets of drugs we see in the home. These add up to enormous figures as we show below.

Potential maximum yearly sales by 2020 or earlier for different types of item level RFID tagging

Global Potential Billion/Year		RFID Leadership
Library	0.1	Singapore
Museums, art galleries	0.1	Europe
Laundry	1	Europe
Tires	1	Europe
Military items	2	US
Blood	2	Europe/US
Test tubes	2	Europe/US
Archiving paperwork	2	US
Drugs	30	US
Books	**50**	**Japan**
Postal	**650**	**Europe**
Retail items	**10,000**	**Europe/Japan/US**

10.000.000.000.000

InformationWeek
BUSINESS INNOVATION POWERED BY TECHNOLOGY

individual items, each generating a silent "here I am" signal

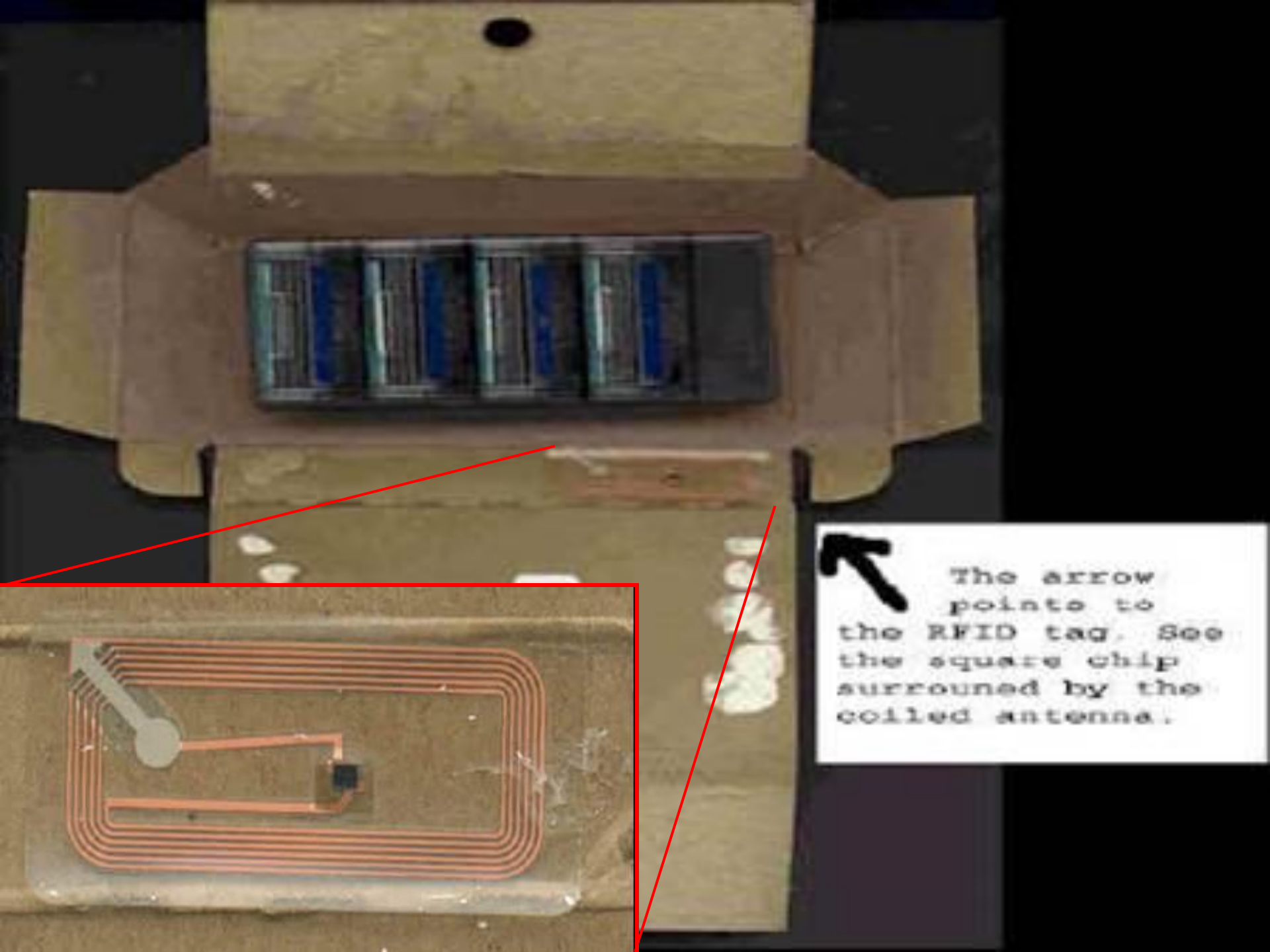
Data Avalanche

RFID chips have the potential to produce huge amounts of information. How will companies recognize valuable data and avoid getting buried by what they don't need?

By Rick Whiting, InformationWeek
Feb. 16, 2004
URL: http://www.informationweek.com/story/showArticle.jhtml?articleID=17700027

Within 10 years, it's expected that billions of radio-frequency identification chips will be attached to shipping pallets, boxes, and even individual items, each generating a silent "here I am" signal at least three times per second. Those signals will be picked up by 300 million RFID readers located in warehouses, distribution centers, and other facilities worldwide. Some predict that RFID-related traffic could predominate on company networks in as little as five years, particularly in the retail and consumer packaged-goods industries.

Are we ready for this? And what are we going to do with all of the data RFID chips generate? Business-technology managers who are designing and implementing pilot RFID systems deserve kudos for taking the lead on a promising new technology, but alarmingly few of them can answer those questions. If businesses don't start planning for which technologies they'll use to collect and manage the data RFID chips and readers generate-or consider whether their supply-chain and warehouse-management applications can scale to handle the additional information-the result could be a chaotic data overload.


The arrow points to the RFID tag. See the square chip surrouned by the coiled antenna.

RFID – fragments of history

1. First Bar code patents – 1930s
2. First use of RFID device – 2nd world war – Brittan used RFID-like technology for Identify- Friend or Foe
3. Harry Stockman October 1948 Paper – Communication by means of reflected power (The proceedings of the Institute of Radio Engineers)
4. First RFID Patent – 1973
5. Auto-ID center founded at MIT – 1999
   - Standardization effort taken over by EPC Global (Electronic Product Code)
6. Current thrust primarily driven by Wal-Mart and DoD
   - Automate Distribution:
     - Reduce cost (man power, shipping mistakes)
     - Increase sales (keep shelves full)
     - DoD Total Asset Visibility Initiative

What are the advantages of RFID?

- No contact requirement
- Invisible
- Read capability and sometimes a write capability
- Real-time response
- More durable than bar code
- No need for multiple bar codes

What are the disadvantages (so far)?

- Average selling price (ASP) of $0.25
- Relatively few industry standards
- Occasional no-reads and mis-reads
- Software integration hurdles
- Requisite physical infrastructure

Top Users

Wal-Mart

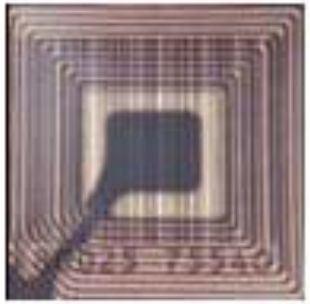
- June ’03 announcement
- Pallet/Case tagging
  - Top 100 suppliers Jan ’05
  - Other 30K by end of ’06
- 4 Billion tags/year
- 300k direct readers
- 18 Million indirect readers

+

- ***Inter-connected systems***
- ***Complex information***

The top investor

WAL★MART®
ALWAYS LOW PRICES. Always.



billions of

individual items

per year from

the pallet and

packing slip

How large?

WAL★MART
Save money. Live better.™

	$ millions	% change from 2005
Revenues	351,139.0	11.2
Profits	11,284.0	0.5

1999 (press release)
(Sales: $137.6 billion; Net income: $4.4 billion)

"[Our] information systems extends far beyond the walls of any one store. Starting from the basic information compiled at the checkout stand, at the shelves, and gathered by associates equipped with hand-held computer monitors, [we] works to manage its supplies and inventories not only in the stores, but all the way back to the original store. ... In today's retailing world, speed is a crucial competitive advantage. And when it comes to turning information into improved merchandising and service to the customer, [we are] out in front and gaining speed. In the word of Randy Mott, senior vice president and chief information officer, 'The surest way to predict the future is to invent it.'"

GPD 2006

1	United States	13,163,870
2	Rep. of China	6,091,977
3	Japan	4,081,442
4	India	2,740,066
...		
9	Italy	1,709,548
...		
26	Egypt	367,366
27	Belgium	353,570
28	Greece	349,817
29	Malaysia	327,364
30	Sweden	310,602
31	Venezuela	298,862
32	Austria	298,521
...		

Figures 2012

Rank	Company	Revenues ($ millions)	Profits ($ millions)
1	Exxon Mobil	452,926.0	41,060.0
2	Wal-Mart Stores	446,950.0	15,699.0

#	Country	2012 GDP (million)
1	United States	15.650.000
2	China	8.250.000
3	Japan	5.984.000
4	Germany	3.367.000
5	France	2.580.000
6	United Kingdom	2.434.000
7	Brazil	2.425.000
8	Russia	2.053.000
9	Italy	1.980.000
10	India	1.947.000
11	Canada	1.770.000
12	Australia	1.542.000
13	Spain	1.340.000
14	Mexico	1.163.000

#	Country	2012 GDP (million)
15	South Korea	1.151.000
16	Indonesia	894.900
17	Turkey	783.100
18	Netherlands	770.200
19	Saudi Arabia	657.000
20	Switzerland	622.900
21	Sweden	520.600
22	Norway	499.800
23	Iran	488.300
24	Belgium	476.800
25	Argentina	474.800
26	Poland	470.400
27	Taiwan	466.100
28	Austria	391.500

Wal*Mart

Wal*Mart is the largest supermarket chain in the world.

Its revenue is about $ 450 billion

Wal*Mart has asked its suppliers to adopt more percent, starting in January 2005, containers and pallets equipped with RFID tags.

After all the suppliers have adapted, main benefits obtained:

- Out of stock: - 16%
- Replenishment of the missing products: 3 times faster
- Excess inventory: - 10%

Main problems to be solved:

- Reading in the presence of water and metal (shampoo, canned foods, etc ...)
- Standard non-aligned globally
- Infrastructure costs for providers (SW, service, wireless networks, etc ...)

Another application of RFID technology

Trash | Track

introduction

visualizations

how it works

exhibitions

press

publications

For more information, please contact:
senseable-trash@mit.edu

"Nobody wonders where, each day, they carry their load of refuse. Outside the city, surely; but each year the city expands, and the street cleaners have to fall farther back. The bulk of the outflow increases and the piles rise higher, become stratified, extend over a wider perimeter"

– Italo Calvino, Invisible Cities

why do we know so much about the supply chain and so little about the 'removal-chain'?

Plastic Container of Liquid Soap

Disposed at

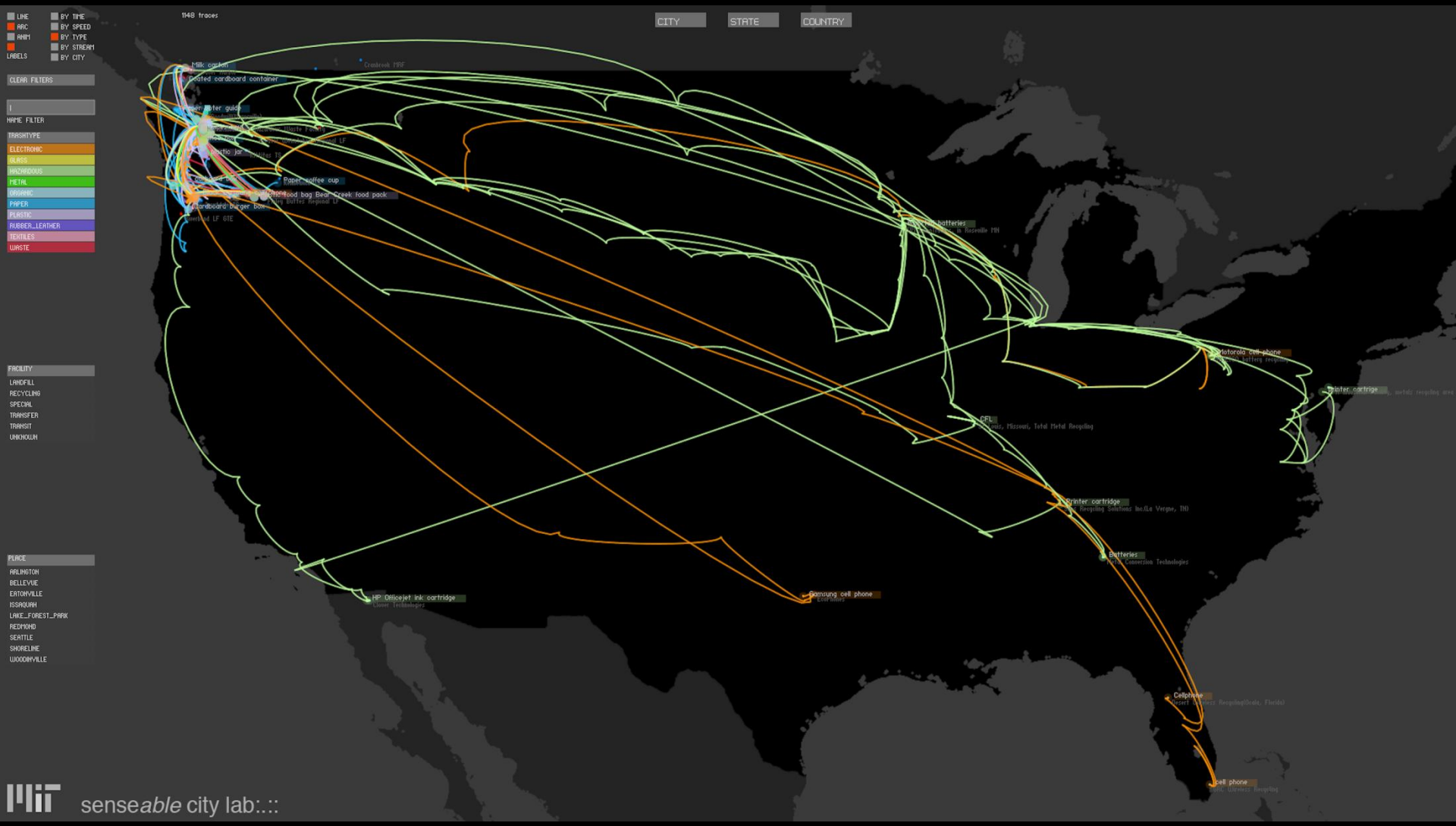
457 Madison Ave New York, NY 10022

Traveled

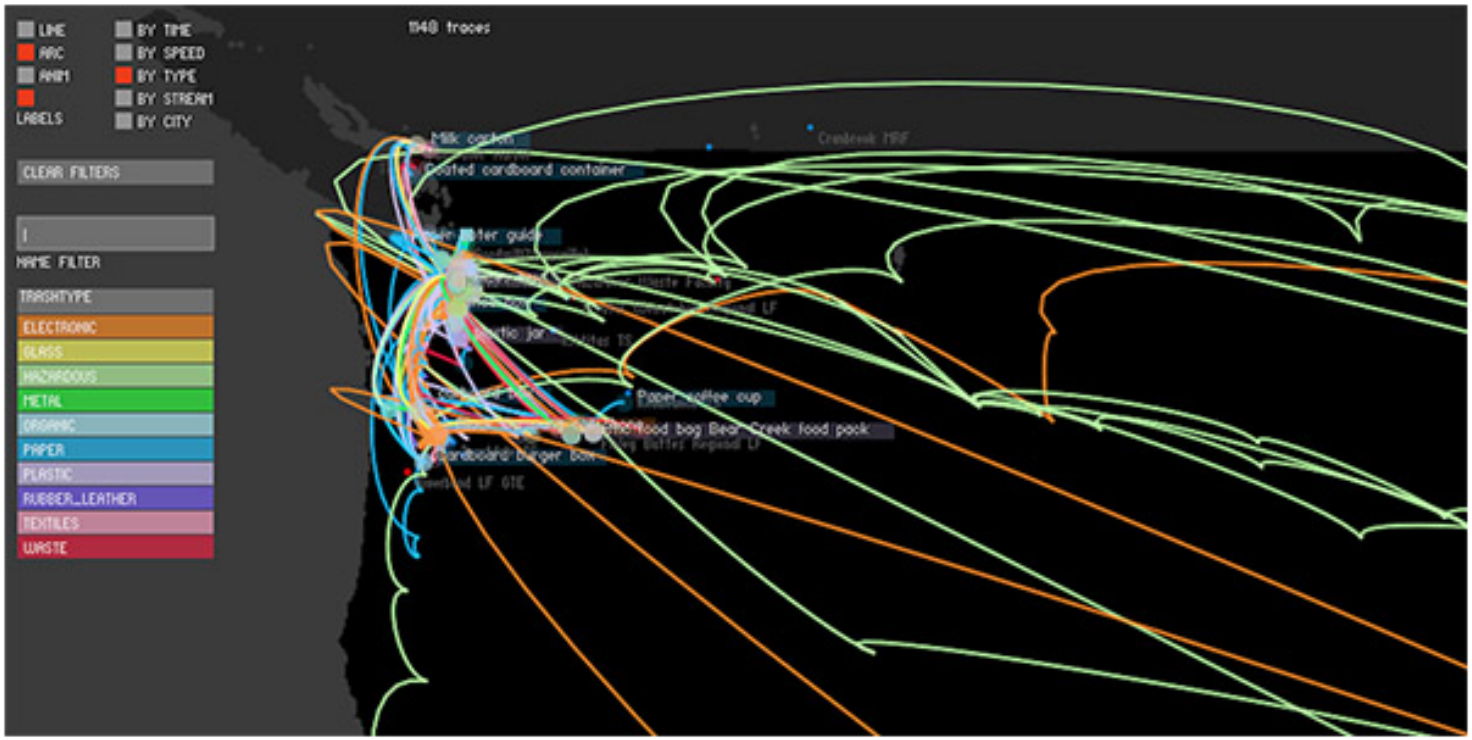
18.3 Miles

Category

Plastic


LINE
ARC
ANIM
LABELS
BY TIME
BY SPEED
BY TYPE
BY STREAM
BY CITY
1148 traces
CITY
STATE
COUNTRY
CLEAR FILTERS
NAME FILTER
TRASHTYPE
ELECTRONIC
GLASS
HAZARDOUS
METAL
ORGANIC
PAPER
PLASTIC
RUBBER_LEATHER
TEXTILES
WASTE
FACILITY
LANDFILL
RECYCLING
SPECIAL
TRANSFER
TRANSIT
UNKNOWN
PLACE
ARLINGTON
BELLEVUE
EATONVILLE
ISSAQUAH
LAKE_FOREST_PARK
REDMOND
SEATTLE
SHORELINE
WOODINVILLE
Milk carton
Coated cardboard container
Paper coffee cup
Cardboard burger box
Motorola cell phone
Printer cartridge
CFL
Batteries
HP Officejet ink cartridge
Samsung cell phone
Cellphone
cell phone

Trash Track wins NSF Visualization Challenge 2010



A little while ago, the US National Science Foundation and Science Magazine announced the winners of their yearly **International Science & Engineering Visualization Challenge**. One of the honorable mentions, the infographic poster **Everyone Ever in the World**, has been posted here before. While some of you might particularly enjoy watching inside the representation of a gaping "Human Immunodeficiency Virus 3D", or wish to explore the "Gene Function Association Network for Arabidopsis thaliana" ("hairball" do I hear someone say?), one more entry stands out in particular.

INFO GRAPHICS
ORDER THE BOOK NOW

Magnetic Resonance Imaging & VeriChip™ RFID Human Implant at 1.5 Tesla

VeriChip™ RFID human implant device

stract—We have researched studies on the magnetic ance imaging (MRI) effects on certain metallic nted medical devices. A great deal of research has been on MRI compatibility of medical devices and most e devices are contraindicated for use in an MR onment. We have performed a MRI compatibility test) on the VeriChip™ RFID human implant device. We found that the VeriChip™ device would not create se medical effects for an implanted patient. However, ve found that the device may be inactivated as a result testing.

ex Terms— MRI Compatibility, Safety, Implantable es, Medical Devices, VeriChip

I. Introduction

current Magnetic Resonance Imaging (MRI) devices beled by the Food and Drug Administration (FDA) to

not all metallic objects can harm or kill a patient, it is ve important to weight the risks and benefits for any implanted metallic biomedical device.

II. Methodology & Theory

1) *Introduction to Device Movement in MRI*

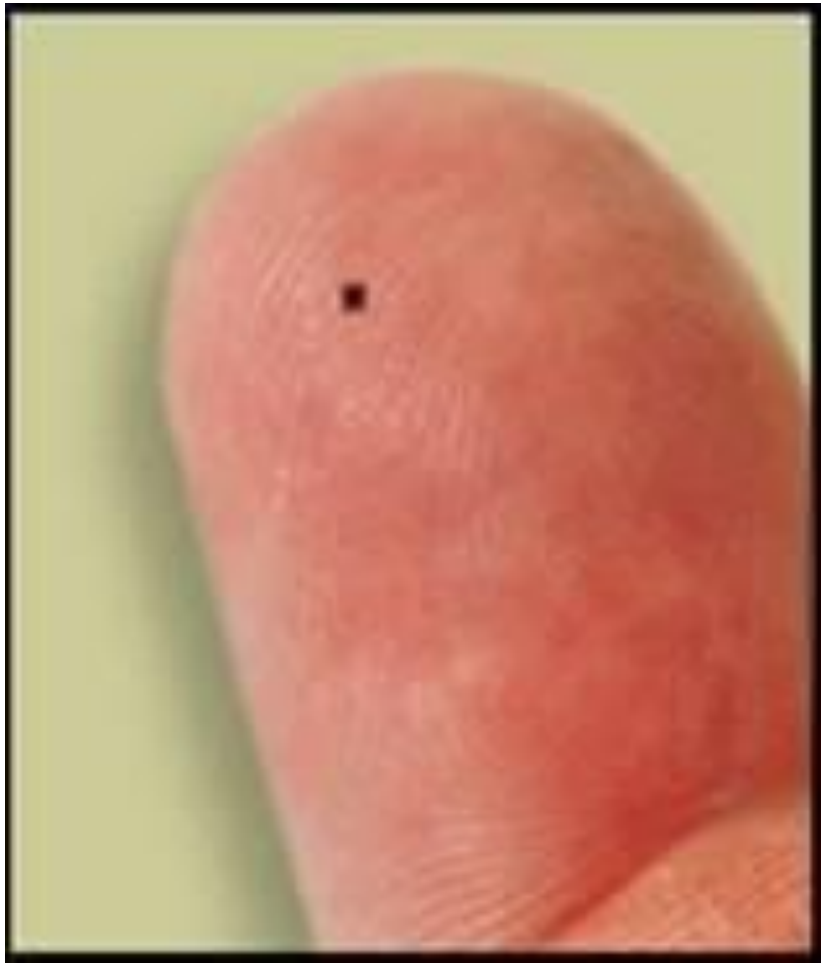
There are two types of movement that can occur fr MR fields on biomedical devices. They are deflection, translational movement, and torque, or rotatio movement. When the spatial magnetic field exists, we translational movement. When the field gradient is sm and magnetic field large, we see more rotational movem effects.

Deflection Force measurements are described by New al. A metal device is hung near the magnetic portal a adjusted so that the angle of deflection greatest vertical

GOOD AFTERNOON, MR. HENFENNEL! HEMORRHOID CREAM AISLE SIX!
BEEP!
TOO MUCH INFORMATION IN MY MEDICAL I.D. CHIP.
TOLES
UNIVERSAL PRESS SYND.
(C) 2004 THE WASHINGTON POST
DON'T FORGET MOUTHWASH. I FIGURED THAT ONE OUT BY MYSELF. —

10-17-04

RFID can be small



but, is it sufficient?

Method and apparatus for transmitting power and data using the human body.

United States Patent
6,754,472

Williams , et al.
June 22, 2004

Method and apparatus for transmitting power and data using the human body

Abstract

Methods and apparatus for distributing power and data to devices coupled to the human body are described. The human body is used as a conductive medium, e.g., a bus, over which power and/or data is distributed. Power is distributed by coupling a power source to the human body via a first set of electrodes. One or more devise to be powered, e.g., peripheral devices, are also coupled to the human body via additional sets of electrodes. The devices may be, e.g., a speaker, display, watch, keyboard, etc. A pulsed DC signal or AC signal may be used as the power source. By using multiple power supply signals of differing frequencies, different devices can be selectively powered. Digital data and/or other information signals, e.g., audio signals, can be modulated on the power signal using frequency and/or amplitude modulation techniques.