

# **RFID Long Range Networks (LORA)**

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**Robert Cudmore  
[rhcudmore@ucdavis.edu](mailto:rhcudmore@ucdavis.edu)**

# IOT Systems we have covered

What is the IOTness of each of these?

Increasing IOTness

GPS

Phone gets location coordinates and can transmit to cloud with selected Apps

Maps

Many phones transmitting GPS position to cloud and all info comes back to your App to show crowd behavior

Ride Share

Cloud computation to pair rider with driver

Shared Rideables

Cloud collects rideable sensor data and can flag for repair or even control its behavior based on speed and location

Smart Home

Many use cases: Control “things” on/off/dim using smart phone from any location

## How does a given IOT fit into this 6-level framework?

IOT LEVEL	FEATURES	EXAMPLES
6	New features not included in levels 1-5	The future of the IOT
5	Remote data is processed and resulting information is sent back to things that take action	Shared Rideables “Smart” Home To Control Devices
4	Remote data is processed and resulting information is sent back to things	Maps, Uber
3	Thing that transmits data to a remote server on the internet for processing	“Smart” Thermometer to track Covid outbreaks
2	Thing that transmits data to a local server	Agricultural sensor
1	Thing that collects sensory data and stores it locally	Wildlife camera, Monitoring a jet engine

Level 6: My prediction is that new and novel big data insights will spawn new applications. Big data is coming from: Ride-share, bike-share, GPS mapping data, and biometric data

# When is an IOT the most useful?

“When it semi-automatically optimizes a complex process”

- Maximize profit like ride-share and shared rideables
- In the smart home, optimizing energy usage
- Optimize a manufacturing process
- Optimize product delivery
- Optimize traffic flow

# Today's overview

- RFID

A pervasive sensor to identify a thing. When coupled with IOT can track many many many “things”

- Long Range Local Area Networks (LoRaWan)

To transmit sensor data 10's of Km, well beyond WiFi and Bluetooth

# **RFID**

## **Radio Frequency Identification (RFID)**

# RFID

## Radio Frequency Identification (RFID)



- Created in 1948 by Harry Stockman, working for US military
- A sensor that can transmit a small amount of information when activated by a magnetic field
- Two Types:

**Passive**: No batteries, very small (cm), lasts for years, need to be in close proximity to activate and read (a few centimeters). Cost is about \$0.1 to \$0.5 per tag.

**Active**: Has batteries, a bit bigger, can emit a data over larger distances (10's of meters). Cost might be \$3-5 per tag.

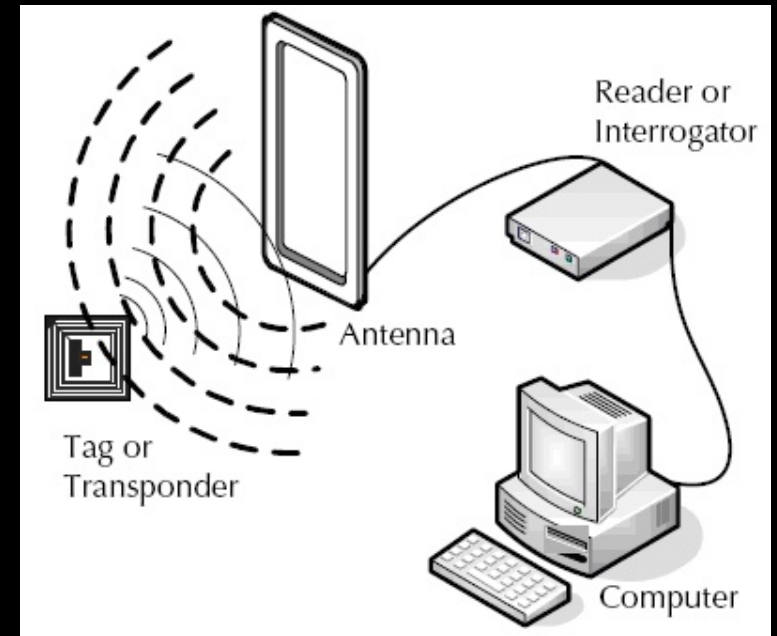
- Depending On Usage:
  - Can have one ID pre-installed
  - ID can be re-programmed
- Similar to MAC address, can encode many trillions of unique IDs



# RFID

## How It Works

- At its core, RFID is an example of “machine-to-machine” communication
- A powered reader/antenna emits a signal at an agreed upon frequency
- This powers the RFID and it emits information at a different frequency
- The information emitted by an RFID tag is often just a number that needs to be looked up in a database
- This is where it becomes IOT, the RFID reader needs to be connected to the cloud to connect this number with detailed database entries





# RFID

## Range And Possible Use Depends On the frequency

- **Low frequency or LF (125-134 KHz)**

- Can better penetrate thin and metallic objects

- Ideal for reading objects with high water content such as fruits and drinks

- Range is limited to a few centimeters

- **High frequency or HF (13.56 MHz)**

- Work very well on metal objects and products with a medium and high-water content

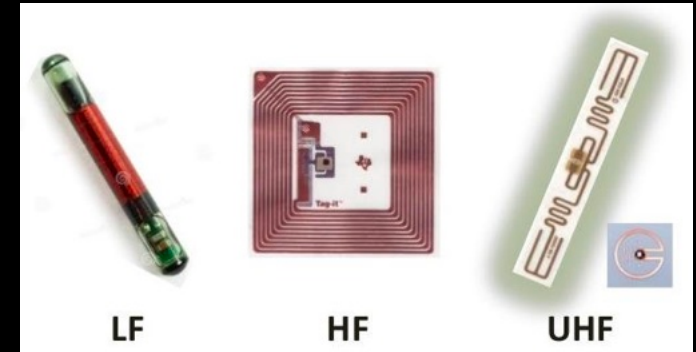
- Operate in a range of centimeters although the maximum reading is around the meter

- Larger memory options, although the reading range is still short and the data transmission rate is low.

- **Ultra-high frequency or UHF (433, 860 and 960 MHz)**

- Range is up to 20 meters (or more)

- Can read data faster, several labels per second

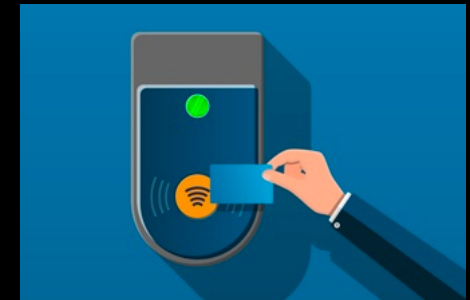


# RFID

## Use Cases Are Enormous

### “Smart Cards”

- “Tap To Pay” with a debit or credit card
- Transportation cards with payment (bus, subway, commuter train, highway tolls)
- Passports
- Near Field Communication (NFC) is what smart phones use for “Tap To Pay”. Based on RFID technology but a NFC device is both an RFID transmitter and a receiver. Allowing phones to communicate and (for example) transfer money.



# RFID

## Passport and credit card

- Have prompted fear of people stealing your identity
- In theory it is possible
- In practice is not going to happen (my opinion)
- For peace of mind, some folks get RFID blocking wallets/holders



# RFID

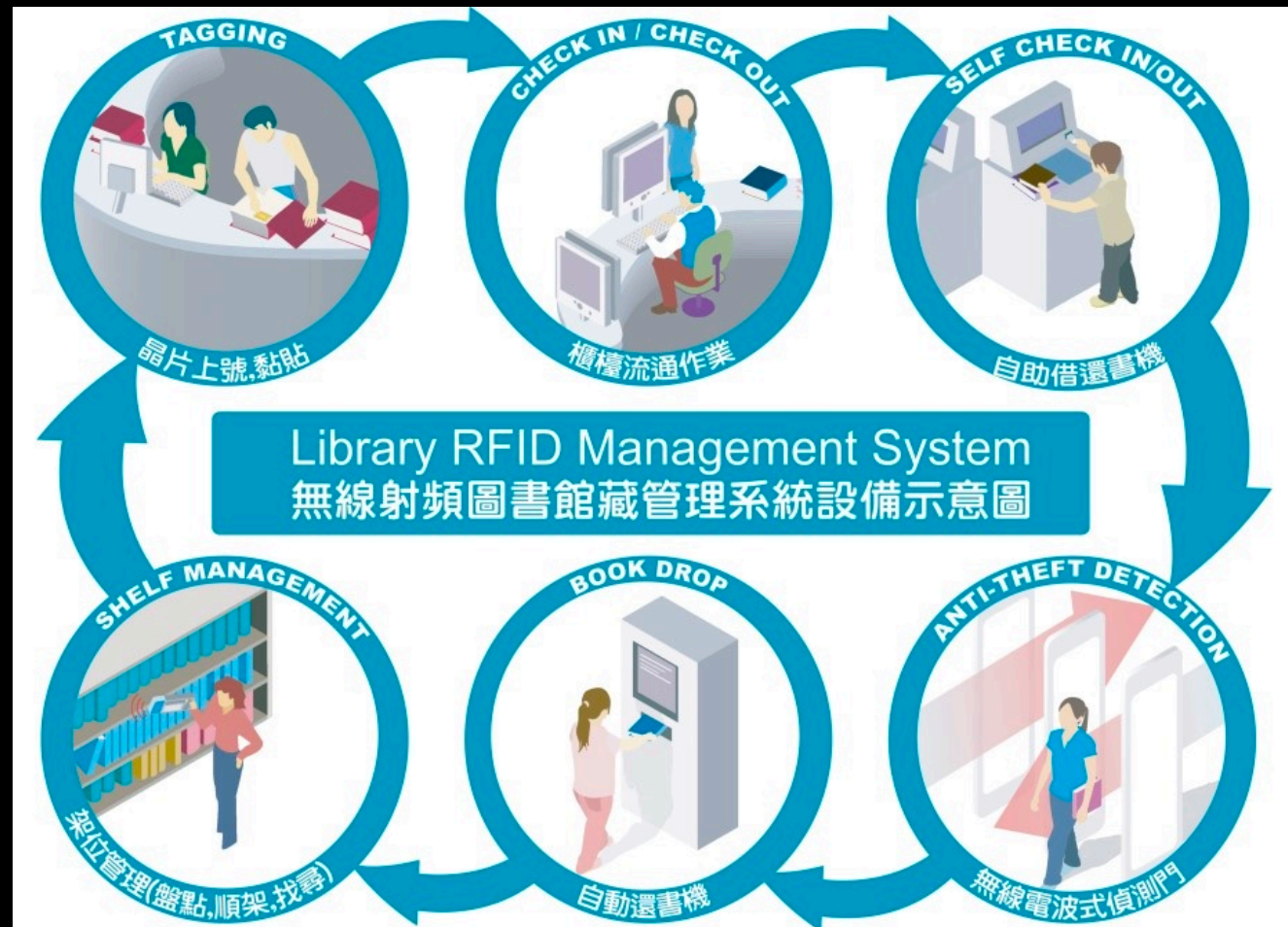
## Product Tracking

- Manufacturing assembly lines
- To track packages during shipping
- Retail inventory
- Retail theft detection
- Track Casino chips
- Library Items

# RFID

## Libraries

- Since about 2000, many libraries tag their entire collection with RFID tags
- They were early adopters !!!
- Allows rapid/reliable checkout and return
- Theft detection

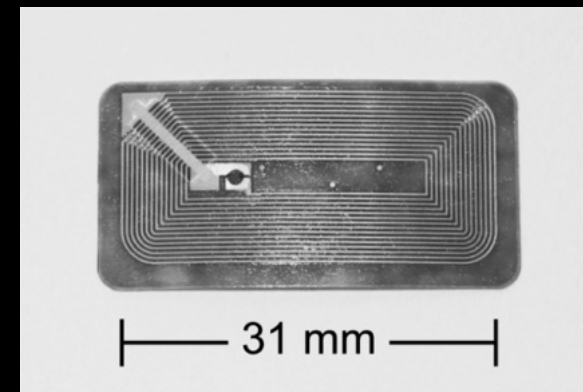
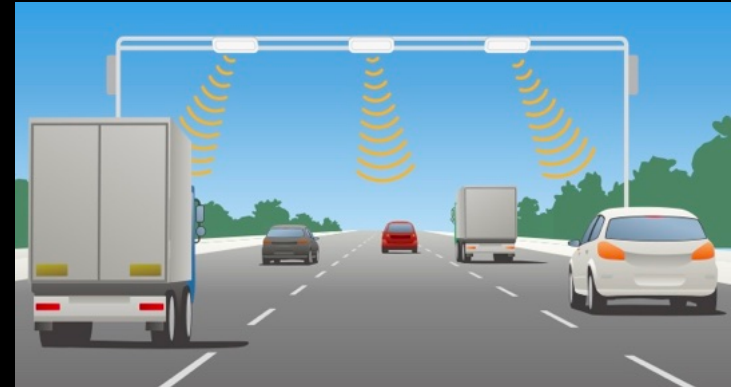


# RFID

## Toll Roads



- RFID attached to inside of windshield
- Activated when passing through a toll reader
- Once activated, transmit account information (encrypted)
- Toll is paid automatically
- Prior to this, was all done manually with paper tickets distributed and collected by people as you got on/off a toll road (Toll Attendants)
- Companies trying to implement this with cellphone BlueTooth but it is not yet as reliable.
- Simple example where an IOT system optimizes a process



- 1.2 inches

# RFID

## Track Participants

- **Marathons**. Track participants position and time. Can be shared with other chosen individuals and runner location/progress is shown on cell phone map. Automate record keeping.
- **Disneyland Tickets**. Give your logged in cell-phone app location specific information. Auto payment when entering premium areas.
- **Concert/Event Tickets**. Same idea as disney
- Could use phone GPS but requires a lot more participant interaction. Once RFID system is in place, everybody gets tracked. e.g. a marathon puts an RFID tag in your jersey number.

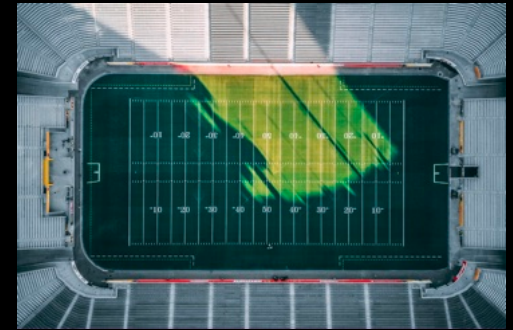




# RFID

## NFL Is Tracking All Players And The Ball!

- Each players 2-3 RFID tags “blinks” 12 times a second
- The RFID in the ball “blinks” 25 times a second
- All the field officials are also RFID tagged, as well as things like the pylons and the yardsticks on the field
- All these tags communicate with a series of receiver boxes that are permanently installed around the perimeter of all the stadiums in the NFL
- Accuracy is a few inches (maybe 6 inches) !
- Used to monitor (i) training (ii) game-play
- Also used to monitor players ability for scouting and recruitment



Real-time broadcast during the game



# RFID

## NFL Is Tracking All Players And The Ball!



Tags on players track vital stats, indoors and out, to within 6".



Coaches use motion data to change their game.



Algorithms aggregate players' stats and display them in real-time.



Easy integration with graphics systems, for both live broadcast and replay.



Real-time stats on players create a deeper fan experience.



Training applications visualize player data, making practice more powerful.

# RFID

## NFL Is Tracking All Players And The Ball!

Athlete Performance

Coaching and training

Injury prevention and recovery

Fan enhancement

<https://www.popularmechanics.com/technology/a40848969/rfid-chips-next-gen-football-stats/>

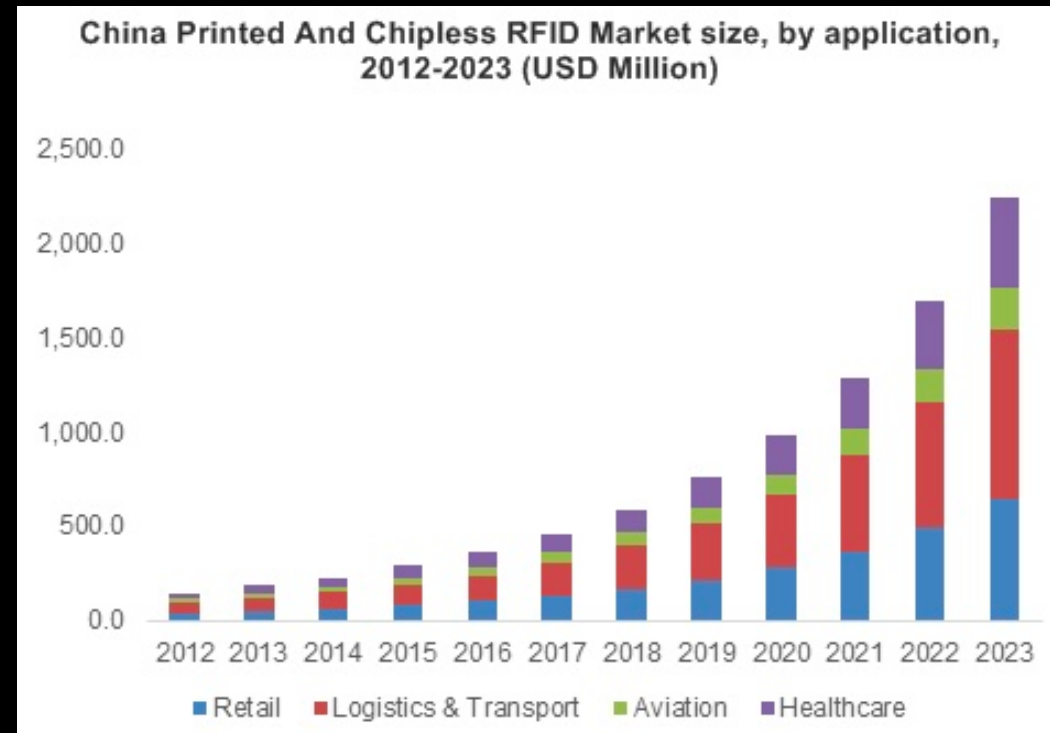
<https://operations.nfl.com/gameday/technology/nfl-next-gen-stats/>

<https://nextgenstats.nfl.com/glossary>

# RFID

## Market Scale

- In the **transport** sector, where contactless and contact smart cards contribute to the operational efficiency as well as save commute time.
- The segment will grow at 28% compound annual growth rate (CAGR) to exceed USD 16 billion by 2023.
- **Inventory** control is also likely to augment industry revenue. Remote reading of tags containing unique codes for tracking, as well as simultaneous reading enabling a large volume of products to be scanned
- Growing R&D and developments in **nanotechnology** and conductive inks will present additional growth.
- Fighting the **counterfeit drugs** ecosystem is forecast to propel adoption across the pharmaceutical sector.



- Retail
- Logistics and Transport
- Aviation
- Healthcare

# RFID (Science Fiction)

## Disaster Recovery: Dust Size RFID



- In the event of an earthquake or tsunami that destroys the local telecommunications infrastructure, RFID sensor tags could be sprinkled from helicopters.
- Maybe 10,000 individual tags might be needed to cover an area the size of a major airport.
- These tags would be equipped with integrated sensors to detect heat and vibration.
- Once deployed, they could be read at intervals by aircraft passing close overhead.
- In this way, it might be possible to quickly locate people still left alive.
- Other sensor tags exist to detect specific gases or specific organic molecules.
- “The Japanese system is supposed to be ready for testing by 2007”.

# RFID (Science Fiction)

## Human Implants

- Human implants have been proof of concept
- Implanted chips can do everything your “smart card” can do:
  - Make payments
  - Open secure doors
  - Show your Covid vaccine “passport”
- Mark Gasson (2009) demonstrated how a computer virus could wirelessly infect his implant and then be transmitted on to other systems
- Currently science fiction but could be used to monitor health



# Amazon Go Store

Do they use RFID?

# Amazon Go Store

## Do they use RFID? - NOPE

- Could not get RFID on all differently shaped products
- Vendors were slow to adapt, it is hard to use RFID on fruit/vegetables
- As typical, Amazon implemented a **complicated video AI system** in the store
- Tracks object that come off the shelf and into your bag and tracks if you put it back
- “The technology used in Amazon Go environments supplants the need to tag every item and instead uses computer vision, sensor fusion and deep learning to track inventory in real-time through the shopper journey
- Will be selling the “Just Walk Out” technology as a package
- Claimed they would open 3,000 stores in US by 2021? Did that happen? Seems to be in the works.
- Is this just another IOT overkill?
- Example of an IOT system that is highly marketable to sell to others (Uber, NFL, Car Tolls, Marathons, Amazon Go)



# RFID

## “The Thing” - The Great Seal Bug

- 1945, Presented to US Ambassador to Russia
- Created by Soviet Russian inventor, Leon Theremin, best known for his invention of the theremin. Pre-dates RFID
- No power supply or active electronic components and was thus not discovered.
- Became active only when a radio signal of the correct frequency was sent to the device from an external transmitter (a car parked outside)
- Sound waves (from voices inside the ambassador's office) passed through the thin wood case, striking the membrane and causing it to vibrate.
- The movement of the membrane varied the capacitance "seen" by the antenna, which in turn modulated the radio waves that struck and were re-transmitted by the Thing
- Basically, a remotely controlled speaker.

