RFID is everywhere. RFID is an amazing technology worthy of knowing! RFID stands for Radio Frequency Identification. RFID is a way to transfer data using electromagnetic waves when a sender is in range of a reader. While the idea was first invented in theory in the late 1940's, it began to be usable in the 1960's. Since then, it has become very widespread and now is used in almost every industry. The history of RFID, the technology RFID is associated with, and the applications of RFID is absolutely fascinating!

Before the invention of RFID in 1960, radar, Broadcasting technology, and more were used to communicate wirelessly. RFID made those technologies partially obsolete. Radar and Broadcasting technology are still used today but have different uses thanks to RFID.

RFID has an interesting history. Harry Stockman, the Swedish scientist and inventor who is credited to be the inventor of RFID, explored RFID technology in his 1948 paper, "Communication by Means of Reflected Power." RFID was made to distinguish between allies and enemies. At the time RFID was not usable and would take another few decades for RFID to become feasible. RFID did not work for those few decades because of technical limitations and a lack of research/development at the time.

RFID has had a large number of milestones over the years. In 1960 was the invention of RFID as a whole, this revolutionized contactless technology because you can scan RFID enabled devices through objects. It's cheap, easy, and long lasting. In

1990 was when the founding of E-Z Pass took place. E-Z Pass took on a mission to make a tag compatible with multiple toll collection organizations. Before E-Z Pass,

there were cash tolls and E-toll collection systems which only worked in a specific region. Cash tolls were extremely inefficient and caused traffic jams. Cash tolls are extremely inefficient because someone has to reach into their wallet, take out cash, and someone has to take the cash and give the change. E-Z Pass made cash tolls obsolete because all you need to do is to drive through an E-Z Pass reader and the toll is paid. If for some reason E-Z Pass failed to detect your tag, there are cameras that capture your license plate and bill you accordingly.

In 1994 the invention of the MIFARE series took place. The MIFARE series is a series of RFID cards and fobs, the most popular being the MIFARE classic 1K card. The classic 1K is popular among Arduino and Engineering hobbyists because of its price, simplicity, read-write capabilities, and that it is compatible with the RC522 reader, a popular RFID reader among hobbyists.

To top it off, 1995 was when the founding of ID&C took place. ID&C allows you to order RFID bands and you can create custom designs on your bands. This is revolutionary because you can custom order RFID bands for specific events or businesses, and make it fit the theme so people will know that this band is for this and that band is for that.

RFID has gone through massive change and upgrades over the years. In the 1960's companies, for example Sensormatic, started to use simple and inexpensive RFID tags to track items to provide tracking for customers and to stop theft. For example, Amazon, FedEx, and UPS, all very popular delivery services, use RFID for tracking your package!

In the 1970's, Northwestern University and other organizations started inventing RFID for things such as: vehicle tracking for tolls, animal microchips, and assembly line automations.

In the 1980's, RFID became used on an International level. Mostly for toll collection but also for personnel access, animal tagging, and for automations.

A really important part of RFID history was when the first tolls collected using RFID were collected. The first RFID toll in 1986 in Norway, and the first RFID toll in the 'States was in 1989 at the Dallas North Turnpike. Moving away from the topic of tolls, In the 1990's, The TIRIS system was created by Texas Instruments. TIRIS appears in multiple locations, including Gas Stations, Access to gated areas, Ski Passes, and even in Casinos. TIRIS appears in casinos for complying with laws while ensuring a good experience for customers. TIRIS stands for Texas Interoperable Radio Interconnect System.

Currently, RFID is everywhere, it's in newer car keys, it's in offices with fobs where you tap into the building, it's in schools with the same implementation as in offices, it's in your phone with Tap to pay capabilities, credit and debit card also include tap to pay, it's in some wristbands at some events, it's in fancier hotel in the form of cards, it's everywhere.

There are many signs that RFID will continue to improve. Firstly, A lot of hotels have RFID cards, so it may be implemented at the rest of the hotels and into homes and apartments. Second, It's cheaper than ever to get custom cards for events, and it will get cheaper, making it easier to access events with a custom card. RFID is everywhere, and it will become even more widespread.

Even though there is good potential for RFID to improve, there are some technologies that might lead RFID to its demise. One technology is Bluetooth Low Energy (BLE) which is basically the exact same as Regular Bluetooth, also known as Bluetooth Classic. The difference between Regular Bluetooth and BLE is that BLE is lightweight and takes up less energy than Regular Bluetooth. Another competitor of RFID is Ultra-wideband (UWD.) UWD is a type of low energy radio which works short range and it can transfer data fast. Some UWD systems are effective up to 200 meters away, but typical UWD systems work best 1-50 meters away. UWD readers can also detect the position of UWD devices making it so you only need to walk up to a door you have the key to and it will open.

While RFID has many positives, it does have security issues. Firstly, if you go to where you scan your card, someone can put a replica scanner on top which then replicates the card to the real scanner. Secondly, someone can hack and steal access by replicating what the reader is looking for into a replica card. Also, the fob/card can break or be disabled easily. Adding on is that some cards change their data based on what the reader is telling it to.

You need materials for any technology to work, to please the requirements to get RFID to work, you require to have antennas. Antennas are used in RFID to communicate with the reader. The Antennas are usually thin straps of metal wrapped around the card and the reader. The Antenna won't be able to send anything without a microchip. Microchips are used for storing the card's data and the Microchips send the data to the reader using the antenna. Some Microchips allow for the reader to change the data and some change the data when an action happens. If the microchip holds

sensitive data in an RFID card, anyone can steal it and read the data. To counteract the flaw of being able to look at the data without permission, there is something called encryption. Encryption is used to make data harder to read. Let's say you have an RFID card for your hotel, it stores information about your hotel and room number. It is encrypted so people who copied your card's data know where to use it. A common encryption technique is called Secure Hashing Algorithm(SHA.) If I want to turn "Hotel RFID Room 203" into SHA-256(A type of SHA) it will be "13f93f292a6409dd3adf3fe4ab8a065eb45a69a97c600016302a8acf21db3c93" which is possible to decode back but it is time consuming. You can't transfer anything wirelessly without wireless communication. Wireless communication is how the data is communicated between the card and the reader. We want the card to say this is my Unique ID, and this is my Data while there is no contact.

RFID has a plethora of scientific principles related to it. For anything technology related, you need current. Current in electricity is how fast charged particles move. Current is related to RFID because there is current in the antennas shen reading and microchips need electricity. Current is part of electricity. Wireless Communication requires Electromagnetic Waves to work. Electromagnetic Waves is light which is invisible to the naked eye. Electromagnetic Waves allow readers to send power to cards and the cards to send data. Using Electromagnetic Waves, you can do wireless power transfer. Power Transfer uses Electromagnetic Waves, Most RFID cards have no battery and they need to be powered somehow. So the reader sends electricity in exchange for data.

Another scientific principle made possible with the help of Electromagnetic Waves, Data Transfer. Data transfer is how the reader and card communicate. Data transfer happens with Electromagnetic Waves. Data transfer happens through bits, 1's and 0's. Those 1's and 0's create numbers in a way which can be used for multiple things, including text, regular numbers, and hexadecimal. RFID tags usually use hexadecimal. The numbers we are used to use base 10, hexadecimal uses base 16. You can identify a hexadecimal string by seeing if it only has numbers 0-9, and/or letters A, B, C, D, E, and/or F.

One of the most important ingredient used for making RFID is metal. Metal is used to make the antenna's. The 3 most common metals used for creating antenna's from cheapest to most expensive are: Aluminum, Copper, and Silver. For storing and sending data, you need a microchip. Microchips are used for storing, sending, and sometimes rewriting RFID cards. To know what card does what, you need a database. Databases are used in RFID to store information about what cards do when scanned and what cards are valid/invalid. To give RFID cards a simple look, plastic is usually used. Plastic is cheap, hides all the electronics, and allows the RFID signal to pass through without a problem.

There is a lot of data that you can collect, The most obvious one is a Card's Data. Data in the RFID card is stored on the card so the data will be the same unless changed. On the topic of a card's data, the RFID Cards Unique ID. RFID Cards Unique ID(UID) is a piece of the data with a number that usually only that card has. To know how many times the data is correct, there is something called Success rate. Success rate is a percentage of successful read/write commands. To know more about the card

that is read, there is something called Card Information. Card Information is a piece of information that tells the reader who made the card and the model.

RFID has created massive change in the past in multiple ways. RFID made it possible to use fobs for entry to offices and into public transport systems. On the topic of entry, RFID makes it possible for you to just walk up to a gate and the gate will open. An example of this is a ski resort. Ski resorts use RFID to make people who have a valid card be able to ski up to a lift and the gates open to them. RFID also made it possible for payment to be as simple as tap and go. For example: RFID made tap to pay exist. You just have to tap your card on a reader and boom, you paid. Another example of how RFID made change, is that RFID made it possible for you to have a card to access where you live, or where you are staying. In addition, If for some reason you lose your card they can just create a new one.

RFID has not just changed the past, it affects the present in multiple ways. RFID is making keys obsolete. With keys you need to search for the right key and then enter the key then twist it and it sometimes gets stuck. With RFID you just tap and enter, with some Frequencies of RFID you can just walk up and enter. Another reason is that RFID is making public transport easier. Instead of buying a ticket you buy a card, you get a balance on it, and then you tap wherever you go whenever you want if you have enough money. RFID is in your pocket in the form of your phone, popularly used for tap to pay. Your phone can emulate a tap to pay card, It can also work as an RFID reader. Your phone's RFID abilities can be used for other applications. One example used in Japan is a debit card which only exists on your phone. Another piece of RFID that is also in your Pocket is your car keys. When you enter newer vehicles that have start buttons

that only work when the key is in the car, you probably guessed it, RFID made it possible. The car uses readers that detect when the RFID key is in the premises of the car.

RFID will definitely change the future. RFID will make accessing property easier than ever. RFID is very compact and cheap and it probably will become even more compact and even cheaper. RFID might be applied in ways you would never think of that will make you think "Wow, I did not think of that." RFID might be injected into humans to make it so you just walk up to a door and it will open.

With all of RFIDs positives, there are negatives that need to be dealt with. Some RFID cards need a specialized reader to be read, but as far as I know RFID cards can not detect the ID of the reader, as if a reader has an ID. It should be that some RFID cards export different data based on the reader's ID.

RFID cards can also be easily duplicated and emulated. To counteract that there is something called a Rolling Code which changes with a pattern after every read. The problem is that the duplicated card can be used once because after that one time the read code expires, but in this case, once is too many, you could be robbed and there is no broken/open window. There should be a way for the card to communicate to a server or the reader to tell it that it has been read. A reader can be placed on top of an existing reader to steal a card, such as a credit card. But it can be easily counteracted with a rolling code; most cards that access expensive stuff use a rolling code, but not all. Some cards you can change, most of those cards are for DIY projects. But some writable cards are used to access things, especially ones that are DIY. Lastly,If there is a power outage or if your RFID card breaks or is deactivated, you won't have access. To

easily counteract that, just have a spare mechanical key for accessing something important, especially a house and a car.

Radio Frequency Identification is a primary modern technology. Its history, the technology, and the applications are all fascinating. RFID has made payment and personnel access easier and has prevented theft in amazing ways. RFID is applied in a lot of ways; there seems to be no limit of the usability of RFID. It's only a matter of time to see how RFID will be applied in ways we never thought of.