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RFID Based Marathon Tracking System

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Abstract: ***The most daunting task in any type of marathon running event is the correct, impartial tracking and positioning of participating athletes. Notwithstanding the tens of thousands of marathon runners congregating at the starting point of the race, this system accurately tracks the chip-time of each and every runner thus providing the organizers with fair and exact results at the end of the event. All this technological leap in race timing is only possible via Radio-frequency identification (RFID). This cost-effective marathon tracking system implements disposable passive RFID tags on the bibs of the marathon runners to track their chip-time as soon as they pass the starting point of the race where the UHF RFID reader is positioned.***
Keywords: RFID, Marathon, Arduino Uno, UHF, Passive RFID tag, chip-time.

I. INTRODUCTION

A marathon is an extensive-distance race with an approved distance of 42 kilometres approximately, generally run as a foot race. Being inspired by the iconic event which was inaugurated in honour of the noteworthy run of the Greek soldier Pheidippides, a messenger who ran from Marathon to Athens, carrying the victory message of the battle of marathon. A marathon is a test of your mental endurance. Running a marathon is not about momentary rewards or gains. It's about realizing a long-term goal and vision. To do so requires dedication which leads to immense physical and mental health benefits. These benefits include improved working memory, enhanced task-switching ability and elevated mood. The most vital part of any marathon is to decide the number of winning athletes after the completion of the corresponding event. The procedure of determining winners in any marathon race is very intricate and perplexing because of the end number of participants and various initial starting points in a very confined space.

In the view of the fact that it is not obligatory the runner who crosses the finishing line first, as in terms of physically crossing the line, is not the actual winner at all times. Since more than tens of thousands of athletes gather together at the starting line, the runner at the end of the enormous pile of athletes may cross the initial starting point as late as thirty minutes behind the other athletes positioning high up the runners' stack. To review the actual winning participants with precision and impartial judgement, the organizer of the race needs to calculate a chip-time in marking participants. The chip-time is the actual difference between the time noted at the finishing line and the time taken down at the starting point when the participant crosses the line. It is the individual clock timing for all the respective participants and does not begin timing until the runner has crossed the starting line.

For any race organizer, keeping track of the net time and ranking of each participating athlete could present a very demanding task. Fortunately, with the help of RFID technology, this endeavour can be made much easier. By affixing RFID labels to the bib or one of the shoes of each runner, it's possible to track the progress and finishing time of each runner. This RFID tracking project is built on the Arduino Uno microcontroller making it a cost-effective solution.

II. LITERATURE SURVEY

United States has embraced RFID technology and has used the largest number of applications and ordered the greatest number of tags that are in millions. The United Kingdom is on the second place by the number of the application. China recorded the third position, thereafter is Korea and Japan. Research completed by the 'IDTechEx' using a database with approximately 2300 applications covering over 2500 organizations and more than 90 countries indicates the exponential growth in RFID applications in a short period due to the fact nowadays it is extensively used in hospitals, tollbooths, libraries and many livestock applications for tracking cattle and domesticated animals.[1] RFID is an acronym used for technologies using radiofrequency waves for identifying, tracking and updating individual items' position and location automatically. RFID has analogous applications to barcodes. It is developed to track entries in the supply chain without any line of vision requirement. As compared to RFID, a bar code has to stay in the line of sight of the scanner for determining the product appropriately. This weakness is mitigated by using RFID technology.[3]

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RFID technology works at a number of different frequencies. Low-frequency tags operate at the 120 kHz-140 kHz frequency range. On the other hand, high-frequency tags operate along with the 13.56MHz radio frequencies. Ultra-high frequency (UHF) tags operate at the 850-900 MHz range which transfers data faster therefore they are expensive.[9] Low-frequency tags are comparatively less expensive and use less power compared to other kinds of tags.

Analysts have lately noticed a downturn in the number of individuals participating in events like long distance races community five-kilometres races. In a 2018 paper, Heather Kennedy from Temple University and her teammates named the phenomenon a "running recession." [11]

By participating in marathons on a regular basis, the person remains to procure something more than just physical benefits and fitness over time. Running a Marathon is the absolute best thing one can do to slow down the cognitive decay that accompanies typical aging. It blunts the brain's response to physical and mental stress. [13]

The COVID-19 pandemic came about in mandated stay-at-home orders, bringing negative changes in mental well-being (e.g., anxiety, stress) and difficulties keeping up with sound dietary and physical activities leading to weight-gain and obesity. [12]

All these undesirable and adverse changes in physical and mental health can be resolved by participating in a marathon or a long-distance running event. This cost-effective venture will help organizers to promote and encourage participation in marathon events in neighbourhoods and communities.

III. METHODOLOGY

The main ideology of this research revolves around the concept of tracking 'chip-time' of racing individuals using RFID technology. According to track and field general rules for athletes, the two types of footrace timings are gun-time and chip-time. Gun-time is the time which is based on when the gun at the starting line goes off that is when the actual race clock begins. Every participant who starts in the race is assigned with the same gun time.

Now, the chip-time is the personal time for each and every participant when he/she crosses the starting point respectively. It is unique for every runner in the race. If the participant doesn't directly begin the race at the starting point, his/her chip-time will be altogether quicker than the overall gun-time. Chip-time plays a crucial role in marathon events where vast numbers of athletes assemble together at the starting point.

A. Design

This RFID technology-based marathon tracking design recognizes passive RFID tags on each and every participant congregating at the starting line, up to 5 meters and does not require a direct line of sight of the reader.

The most prominent feature of this tracking device is to accurately record the chip-time of participating athletes for equitable results and ranking of each participant

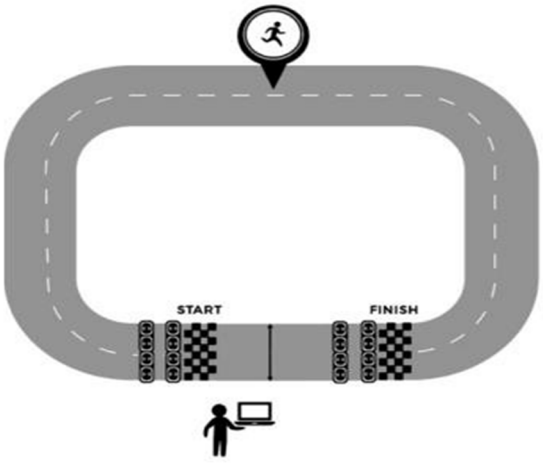


Fig. 1 Generic illustration of tracking system

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B. Block Diagram

The following block diagram explains the proposed RFID based marathon tracking system. The various parts involved in this block diagram are elaborated in the forthcoming sections. The interface between the participating athletes and the tracking system is handled by the Arduino Uno module. The communication between the reader and Arduino Uno microcontroller is 'Simplex': from RFID reader to Arduino.

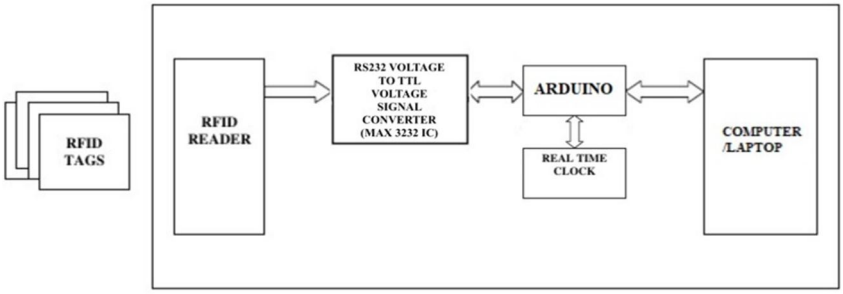


Fig. 2 Block diagram

C. System Approach

As soon as the passive RFID tags are detected by the UHF reader, the information of each and every tag is recorded and transferred from the reader to the Arduino Serial Monitor. The Arduino serial monitor records the unique tag ID along with the instantaneous timestamp of all the participants giving the required chip-time which is different for every participant.[8]

The RS232 port of the UHF reader is being used in the system. The input information signal is fed to pin number 3 of the RS232 port that is the TXD pin. The only other pin used is the ground pin for safety measures. The MAX 3232 IC which is the TTL converter, is then utilized to convert the RS232 voltages into TTL voltages (logic conversion). For the converter output, pin number 12 (RXD pin) of the TTL converter is connected to digital pin number 2 of the Arduino Uno. The 3.3 V DC from the Arduino Uno is connected to the VCC of MAX3232 IC.[2] The digital pin of the Arduino Uno is configured in receiving mode only since the communication and transfer of Athlete information from the reader to the Arduino Uno is simplex which means the transmission of the signals is only unidirectional and not vice-versa. The Arduino Uno is configured in receiving mode using a software serial library. The unique tag ID and the timestamp at the starting point and the finishing point respectively are recorded by the serial monitor of the Arduino Uno consequently giving the organizer the chip-time.[4]

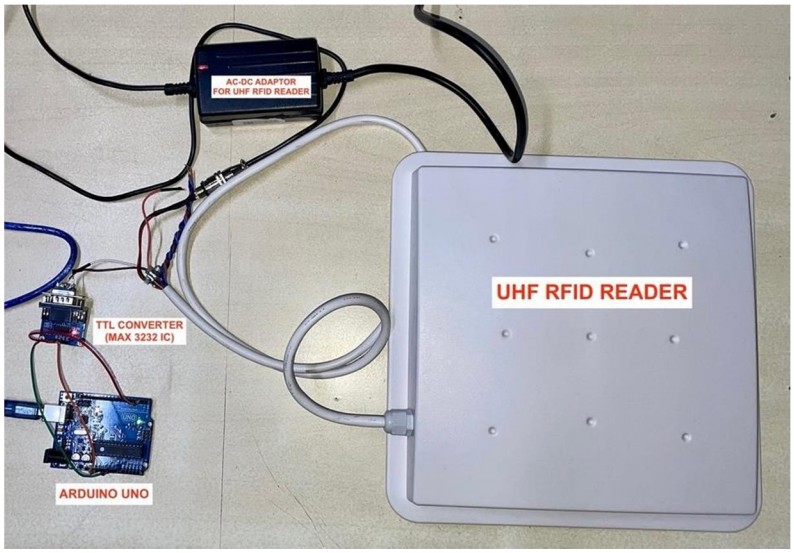


Fig. 3 Hardware setup of RFID based Marathon tracking system

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D. UHF RFID Reader

A UHF RFID reader is a gadget utilizing an Ultra-High Frequency range, between 840 MHz and 960 MHz Its protracted read range contrasted with high-frequency NFC readers, empowers one single reader to scan numerous passive RFID tags simultaneously with an instantaneous range up to 5 meters and a UHF reader can read up to 250 tags per second [5]. It is being used to track the chip-time of all corresponding participants in the marathon. Waterproof readers are a necessity for this project because of its outdoor marathon application and various weather conditions.



Fig. 2 UHF RFID reader

E. MAX 3232 IC (TTL Converter)

The most generally utilized RS232 to TTL/CMOS logic converter IC is the MAX232 IC which has been on the lookout for quite a while now. The current generation replacement is the MAX3232 IC which is used in this project.[6] The reason why MAX3232 IC is chosen over its prior counterpart is that the former supports both 3.3V and 5V systems and the latter only support 5V systems. Hence if you are interfacing with a 3.3 V system then MAX3232 IC is preferred and the problem of logic level conversion is avoided. 3.3 V DC is drawn out from Arduino Uno in this project.

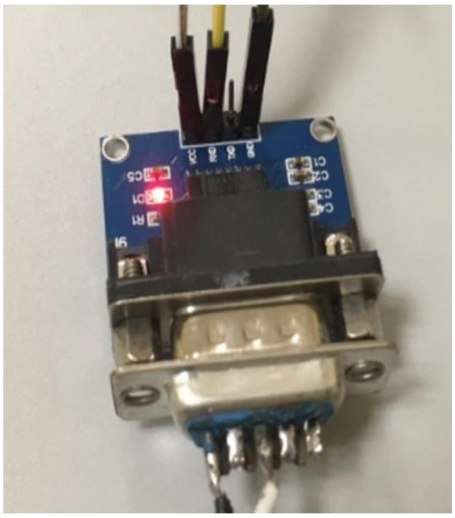


Fig. 4 Example of an image with acceptable resolution

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F. Arduino Uno Microcontroller

Arduino Uno is a microcontroller board created upon an 8-bit ATmega328P microcontroller. Alongside A Tmega328P, it comprises different segments like crystal oscillator, serial communication, voltage controller to help the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be utilized as PWM outputs), 6 Analog I/p pins, a USB connection, an ICSP header, a power barrel jack, and a reset button.

The digital pin of the Arduino is configured in the receiving mode in this project. The Arduino Uno is the interface between the UHF RFID reader and the computer. The Timestamp feature in the serial monitor of the Arduino Uno is utilized to capture and then calculate the chip-time of all participants in the marathon.

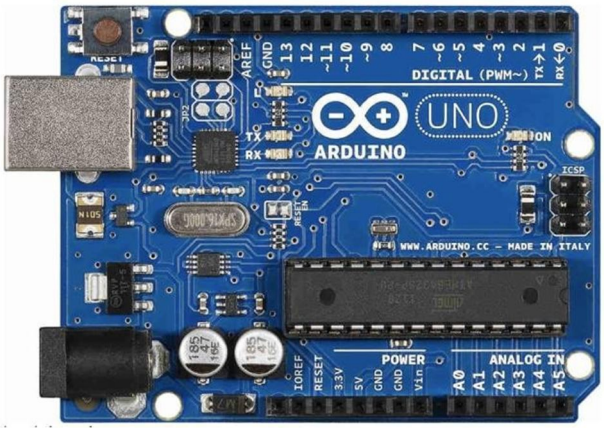


Fig. 5 Arduino Uno Microcontroller

G. Passive RFID tags

Passive RFID tags have no internal power source and are powered by the electromagnetic energy transmitted from an RFID reader. On the other hand, Active tags are battery-powered RFID tags that are very bulky and up to 20 times expensive than passive tags. The applications of passive RFID tags other than race timing are file tracking, supply chain management and smart labels.[7] Every participant in the marathon is equipped with a passive RFID tag on their respective bibs and the tags are scanned by the UHF reader as soon as the runner crosses the starting line.



Fig. 6 Passive UHF RFID tags

IV. RESULTS AND DISCUSSION

The most salient feature of the present system is the detection of the unique identification number stored within each single passive UHF tag placed on the bibs of the athletes and in doing so, calculating the chip-time using the Timestamp feature in the Arduino serial monitor. The UHF RFID reader is of perennial importance in the marathon tracking system because of its expansive range and instantaneous detection speeds. It gives the organizers a major advantage in conducting large-scale half- marathon and full-marathon events where the reader can detect up to 250 tags per second as soon as they cross the starting line. Passive tags do not require an individual power source and are miniature in size and thus, are preferred over active tags in this system. These tags can also survive various outdoor conditions which are very decisive in marathon events.

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The integration of GSM technology in this system is the biggest proposed future advancement for this project. A GSM module can send notifications to the parents or relatives of the athlete on their mobile numbers, the moment the athlete crosses the starting line and the passive tag is detected by the reader. The information includes the race timing of the particular athlete namely both of the starting and finishing timings which will verify that he or she has started and then finished the race.

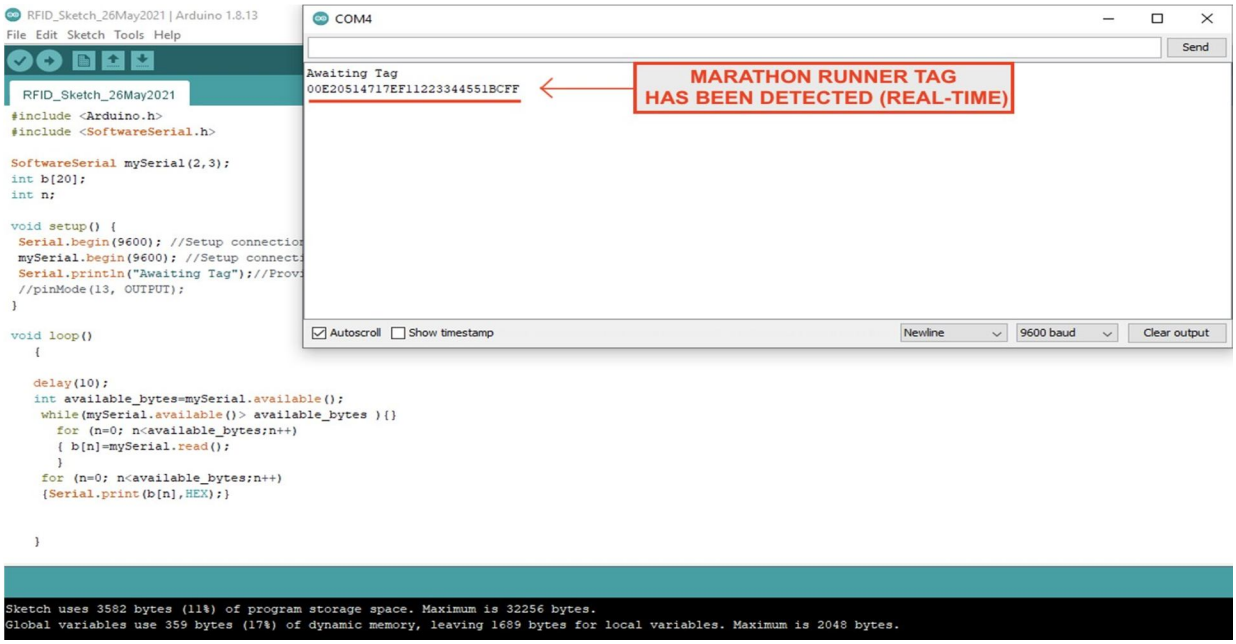


Fig.7 Output screenshot on Serial Monitor of Arduino IDE

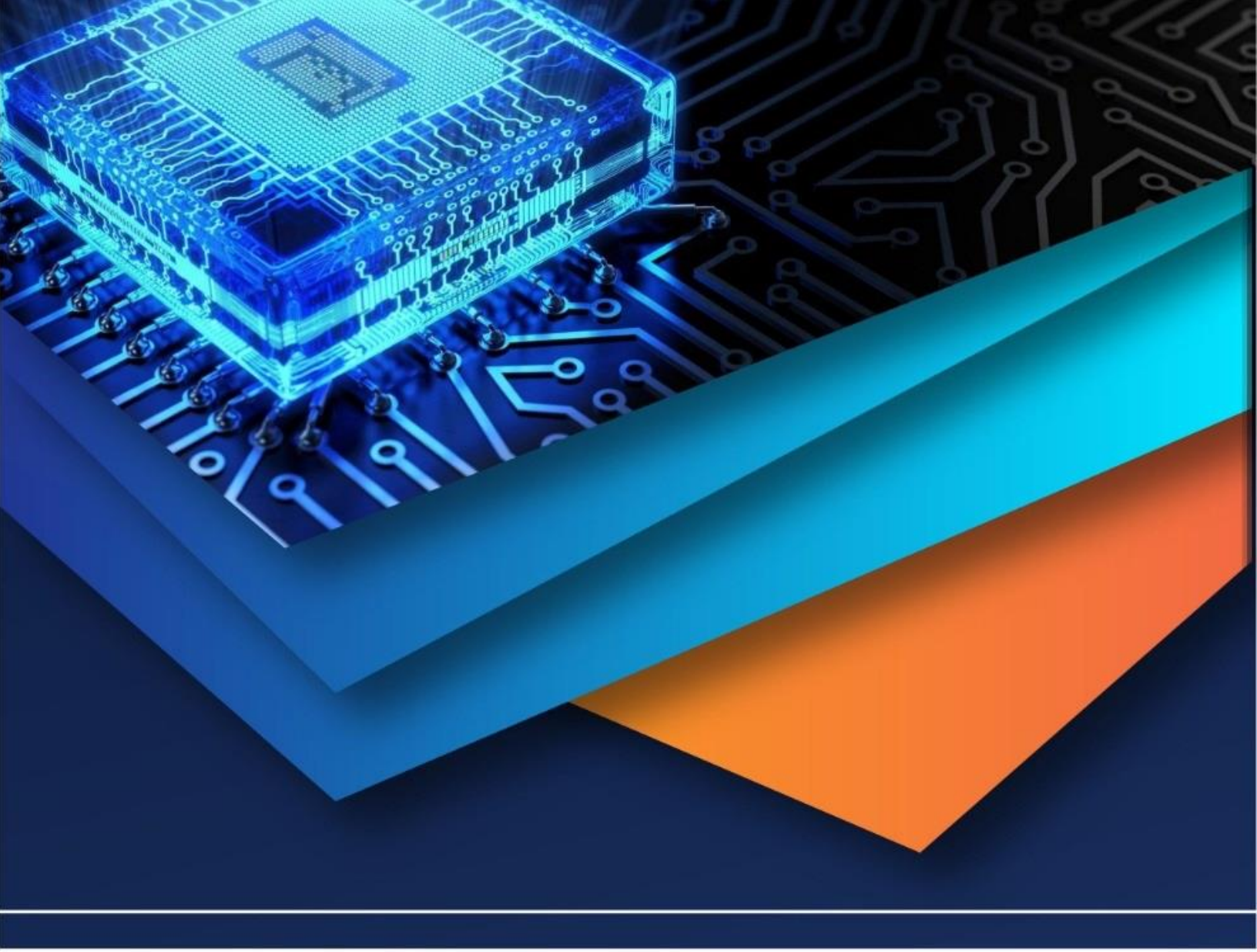
V. CONCLUSIONS

The extensive difficulties faced during race timing and declaring accurate and impartial results at the end of any marathon event are resolved by this Radio-frequency Identification based solution. This marathon tracking system utilizes the potential of Ultra-high frequency RFID to its maximum and makes it fairly straightforward for the organizers to track and manage the chip- time of a myriad of athletes associated with the marathon event. Chip-time gives the personalized timing for every participant depending upon the particular moment he/she crosses the starting point and thus providing unbiased and independent results with utmost precision. Passive tags will not be a hindrance to the athletes participating in the event because of their miniature size and light in weight features. The proposed integration of GSM technology alongside RFID will give unique connected features to notify friends and family of the participants the very moment they start and later finish the marathon event respectively.

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