Study on performance of Passive RFID UHF tags in the different experimental setup of a disaster like situations

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Abstract: Radio Frequency Identification (RFID) have been implemented in various areas to solve the issues related to the visibility of assets in real-time such as the supply chain, health-care, and manufacturing. The application of RFID system in disaster management & rescue operation is gaining its importance in recent years. Although, physical condition of tag constraints the reliability of an RFID system in harsh conditions. These situations can create a huge disparity between the expected performance of RFID systems and the actual performance. This research describes the performance of passive UHF RFID tags in experimental (disaster like) situations. This study also investigates systematically to probe the effects of passive RFID tags' response count per 10 second of exposure to the tag reader in a disaster like situation.

Keywords: Radio Frequency Identification, Disaster, Response count, UHF passive RFID tag, Performance analysis, Golden hour of rescue

I. INTRODUCTION

The RFID technology has brought a revolution in society and change the lifestyle of the people. Today RFID is being used in every walks of life with efficacy [1]-[4]. Since 2010, with the speedy growth of this technology, the cost of implementation and utilizing RFID technology is being continuously decreasing. In short, it makes RFID more cost-effective and efficient [2], [5]. Currently the RFID technology has extended its application to supply chain [6]; healthcare and hospitality [7]; emergency responses [8]; Knowledge management [9]; power facility [10], [11]; planning and construction in urban areas [12], [13]; traffic and parking control management system [14]-[18]; transport system [19]; Library information management [20]; consumer retail market [2]. In this paper, the application of RFID in disaster response & management has been presented, along with the results of the experimental study undertaken.

Natural disasters, both natural and man-made such as earthquakes, landslides, avalanches, floods, cloudbursts, soil erosion, forest fires, terrorist attack, bomb blasts, big industrial accidents, resulting into heavy damage and destruction of human life and health. In such situations, the RFID could be very useful to get a victim location immediately after the disaster and rescue or the medical facilities can be provided without loss of time [21]. The RFID is a wireless technology able to automatically and conclusively locate without a line of sight by collecting a unique identification from microelectronic tags connected to objects [3], [4]. In RFID Technology, electromagnetic waves transfer information from an digital tag (RFID tag) tied to an object [this may be the disaster victim) through a reader to identify and track the object, animal, and people.

Application of RFID in natural and man-made disasters such as earthquake, Tsunami, mining, accidental failures, & other emergency situations has been studied and discussed by many researchers [22]-[35]. During the post-disaster time, the injured persons without outside assistance are not able to meet their needs [33]. The RFID system typically includes a RFID tag (connected to a specific object, distinct identification); an transmitter (Tag detection system, generates magnetic field); a reader (Tag Data Receiver, data handler); a communication networks (permitting IT network to interact with reader and RFID tags); and system software (user interface/database management/application). The RFID systems operate much like every other radio frequency process. The antenna receives a signal in the form of electromagnetic waves from the microchip attached to the tag which sends out the signals. The RFID tag interacts with the antenna and a device decoding the data as the transmitter.

For this paper, to evaluate the robustness of UHF RFID tags technology, under disaster like situation, various available RFID tags has been used in the experiment.

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Initial results show that multi-path effects and efficiency errors across tags and reader variants continue to hinder the effective deployment of RFID technology. Further, to overcome such obstacles/constraints we have to select the equipment and environment characterization very careful. The system-based RFID research and analysis techniques in this study are used to imitate certain key aspects of a harsh situation in order to recognize what recommendations can be made that can improve the effectiveness of future RFID deployments in disasters like situation.

Use of RFID system in disaster like situations:

One of the problems that government and rescuers are facing is to identify the victims after rescuing them under debris after earthquake or similar disaster. Recording, storing and retrieving victims' data input systems can provide useful information to supply food and water, sanitary equipment (bath, toilet), clothes, rehabilitation and temporary healthcare services, human resources (doctor, nurse, rescuer), drug and pharmaceutical instrument, burial place for corpses, publicize victims' relatives and friends, logistics management, dispatch injured victims, stocks for victim needs etc. In short, it help in managing the disaster and mitigating measure.

Researchers have focused on all appropriate facets of disaster including readiness, reduction, evacuate and restoration in the rapidly increasing number of natural or man-made disasters. Each and every disaster can be different in terms of its scale, frequency and intensity, the impact on homes, businesses, public structures and human existence or any combination of above [34]. The detection of living beings and items especially in disaster and rescue efforts, has been considered a main aspect for researchers and scientists. Detailed study of technologies such as Auto ID, barcode, Optical character recognition, GIS etc reveals that during harsh conditions such as emergency situations they are sometimes demanding in terms of resource and their performance is debatable [35], [36]. RFID may function well for tracking, authentication, automation and management of recorded data in the tags [37] - [39].

Different types of physical objects with RFID tags attached might also affect the performance of tags. This paper doesn't really concentrate onto the conceptual competence of RFID systems in optimal conditions, it rather assessed the various types of Ultrahigh Frequency RFID tags available in the market and assessed which tag performed best in different disaster like situations. (especially till Golden hour of rescue i.e., 72 hours).

II. MATERIAL AND METHODOLOGY

The materials for this investigation comprised of eleven differing types of Passive ultrahigh frequency RFID tags (PCB Tag, Laundry Tag, Solar Tag, Pallet Tag, Wet Inlay Tag, Asset Tag, Windshield Tag, Plastic Cards Tag, Mount on Metal Tag, Jewellery Hard Tag, Tyre Tag). The characteristics of the tags varied with their materials on which the circuit is enclosed. The experimental matierials (tags) in this experiment was comprised of Paper, Polyester, plastic, mount on metals, rubber etc. These eleven RFID tags were tested for their performance in five disasters like situations with corresponding reader and compared with control situation (the controlled condition comprised of no disaster like situations).

An experiment was conducted during 2016 in randomized block design to investigate the feasibility and performance of above 11 passive UHF RFID tags. The details of the test situations used in this experiment are as follows: (i) Control condition, (ii) Disaster-like situation caused by flood, Tsunami etc., (iii) Disaster-like situation caused by earthquake, landslides etc., (iv) Disaster-like situation caused by mining accidents, and structure failures etc., (v) Disaster-like situation caused by extreme high temperature conditions such as heat waves, wild fire etc., and (vi) Disaster-like situation caused by extreme low temperature conditions such as winter storms, avalanches etc.

The above situations were virtually created on the test location using the materials generally found in disaster such as building materials, soil, rocks, trees, water, mud, high temperature condition, low temperature condition etc. The above tags were taken from nearby local market. In the experiment, UHF 4-Port Reader Imprinj IDT-404 UHF readers & compatible RFID antenna were used.

The experiment was laid out in replicated trial and each tag (treatment) was tested with three replications in five disasters like situation along with the controlled situation. There were following total eleven treatments replicated thrice in each situation. For the analysis purpose, “Response count” for 10 second between RFID tag and Reader was measured. Each tag along with replications was placed in each disaster like situation and response count per 10 second i.e., number of times response received in 10 second by reader from tag , was noted. The laptop and the reader are connected each other via a LAN cable, and the response count was recorded by the Imprinse utility software provided by the reader. The response count was calculated for a time period of 10 second to get the substantial data. The tags were kept inside the situation till 72 hrs i.e., till Golden hours of disaster response management. The response count was noted at 0 hr, 12 hrs, 24 hrs, 36 hrs, 48 hrs, 60 hrs and 72 hrs for each tag under each situation. Visual observations and statistical tools were used to analyze, evaluate the test data using analysis of variance (ANOVA).

III. RESULT & DISCUSSION

In disaster like situations and during the rescue operations, the surveillance and monitoring of living beings and objects was considered an important factor to provide a

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way out to the challenges being faced by the various for researchers and scientists [36], [40].

The anticipated performance and actual performance of RFID system in harsh environment has been studied by many researchers [41] - [51]. The aim of present study of performance analysis of Passive RFID Tags in different disaster like experimental environments was to express the role of the RFID system and their response in experimental situation of disaster. The experimental resuts is being discussed here with special focus on analyzing the best perfoming tags till 72 hours (Golden hour).

1. Performance of tags in controlled condition:

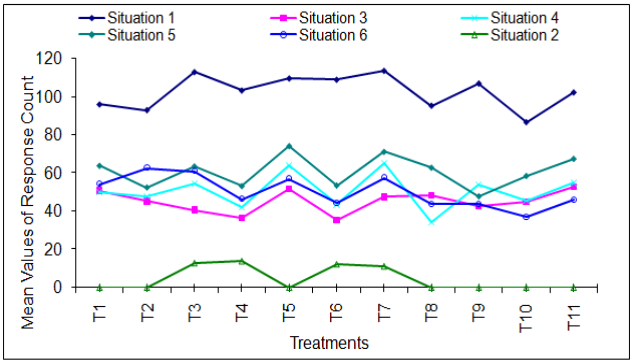
The interaction between passive RFID tags and the reader was recorded for 10 second. Data analysis (Table 1 and Fig 1) of response count per 10 second in controlled condition revealed that all the tags were significantly varied at 72 hours of investigation. The Windshield tags performed outstanding at 72 hours. The Solar tag was significantly at par with Windshield tag. The Tyre tag had minimum value for response time across the time which means it doesn't performed well in controlled situation.

Table 1 : Mean value of response count per 10 second of treatments (tags) from 0 to 72 hours of observation under disaster like situations

Tags	Situation 1	Situation 2	Situation 3	Situation 4	Situation 5	Situation 6
PCB Tag (T1)	96.00	0.00	51.00	50.00	63.67	54.33
Laundry Tag (T2)	93.00	0.00	45.33	47.67	52.33	62.67
Solar Tag (T3)	113.00	13.00	40.67	54.67	63.33	61.00
Pallet Tag (T4)	103.33	14.00	36.33	42.00	53.00	46.33
Wet Inlay Tag (T5)	109.67	0.00	52.00	64.00	74.00	57.00
Asset Tag (T6)	109.00	12.33	35.33	43.67	53.33	44.33
Windshield Tag (T7)	113.67	11.33	47.67	65.33	71.00	57.67
Cards Tag (T8)	95.33	0.00	48.33	34.33	62.67	43.67
Mount on Metal Tag (T9)	107.00	0.00	42.67	54.00	47.67	43.67
Jewellery Hard Tag (T10)	86.67	0.00	45.00	45.67	58.33	37.00
Tyre Tag (T11)	102.33	0.00	53.00	55.00	67.33	46.00

(Situation 1: Control situation; Situation 2: Disaster like situation caused by flood, Tsunami etc.; Situation 3: Disaster like situation caused by earthquake, landslides etc.; Situation 4: Disaster like situation caused by mining accidents, and structure failures etc.; Situation 5: Disaster like situation caused by extreme high temperature conditions such as heat waves, wild fire etc.; Situation 6: Disaster like situation caused by extreme low temperature conditions such as winter storms, avalanches etc.)

Fig 1: Mean value of response count per 10 second of treatments (tags) from 0 to 72 hours of observation under disaster like situations



2. Performance of tags in disaster like situation caused by flood & Tsunami etc:

Perusal of the data indicated that value of response count tended to decreased up to 72 hrs because of the obstacles between tag & reader. Results indicated that at 72 hours of intervention, Pallet Tag responded well in the disaster like situation caused by flood & Tsunami etc. Laundry tag, Wet Inlay Tag, Cards Tag, Mount on Metal Tag, Jewellery Hard Tag and Tyre Tag didn't respond at all in the present study of situation which contains water. The pallet tags are made-up of high quality materials and adhesive, hence may responded in liquid situation.

3. Performance of tags in disaster like situation caused by earthquake, landslides etc.:

The response count indicated that all the tags had significant variation at all the time periods in the experimental situation caused by debris includes building materials, soil, sediment from landslides etc. At Seventy-two hour of intervention, it was recorded that Tyre Tag had maximum mean value of response count followed by Wet Inlay Tag and PCB Tag.

4. Performance of tags in disaster like situation caused by mining accidents, and structure failures etc.:

The RFID application can be used in the disaster like situation where there are coal mines, areas sensitive to massive structure failures etc. The functions of personnel attendance, tracking, and movement tracing are valuable to these types of vulnerable environments where locations of employees or even goods are crucial. In the present hypothetical disaster like situation caused due mining accidents, mishaps due to structure failures, the tags under study among the various treatments at 72 hrs Windshield Tag, recorded the highest value of response count at par with Wet Inlay Tag significantly higher than rest of the treatments in present study.

5. Performance of tags in disaster like situation caused by extreme high temperature conditions such as heat waves, wild fire etc.:

Wet Inlay Tag recorded maximum value of response count at 72 hours of study, which was significantly higher than other treatments in the experimental setup was framed with the condition somewhat similar to high temperature condition, which might occur in disasters caused by heat waves, wild fire etc.

6. Performance of tags in disaster like situation caused by extreme low temperature conditions such as winter storms, avalanches etc.

The harsh situations causes extreme low temperature conditions in case of avalanche, winter storms, etc. The rescue operations became important for expedited recovery of a buried victim in case of many winter recreationalists, such as skiers, snowboarders, snowshoers and snowmobilers. The experimental results in present investigation recorded that at 72 hrs treatment under this situation, Laundry Tag being at par with Solar Tag recorded significantly higher value of response count than rest of the treatments of the study.

IV. SUMMARY OF RESULT

The present investigation revealed that the Windshield tag recorded highest response count followed by solar tag, Wet Inlay tag, Asset tag and Mount on Metal Tag in the controlled situation across the time of observation. Most of the tags under investigation at situation caused by flood/Tsunami etc didn't respond well because of excess water. Only Solar Tag, Pallet Tag, Asset Tag and

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Windshield Tag interacted with reader and the value for mean response count was at minimal level. In the experimental situation of earthquake, landslides etc, the mean response count was maximum in case of Tyre tag followed by PCB tag, Wet Inlay tag, Windshield tag and Card tag. The Tyre tag are designed to survive the high temperatures encountered in the tyre re-treading process and is sturdy enough, which may resulted in better interaction in the debris associated with earthquake, landslide etc. Windshield tag was recorded maximum value of mean response count per 10 second when subjected to the experimental situation as in case of mining accident or structure failure etc. Other tags such as solar tag, Wet Inlay Tag, Mount on Metal Tag and Tyre Tag also performed well in the current situation across the time. The mean response count recorded maximum in case of Wet Inlay tag amongst the tags subjected to experimental situation of high temperature situation. The mean response count was also higher in case of PCB tag, solar tag, Windshield tag and Tyre tag. Laundry tag performed better response count in the low temperature condition across the time followed by PCB tag, solar tag, Wet Inlay tag and Windshield tag. The table 2 shows the best performing tags in each expertimental situation.

Table 2: Best performing tags in each expertimental situation

Particulars	Best performing tag
Controlled conditions	Windshield Tag
Disaster like situation caused by flood & Tsunami etc	Pallet Tag
Disaster like situation caused by earthquake, landslides etc	Tyre Tag
Disaster like situation caused by mining accidents, and structure failures etc.	Windshield Tag
disaster like situation caused by extreme high temperature conditions such as heat waves, wild fire etc.	Wet Inlay Tag
disaster like situation caused by extreme low temperature conditions such as winter storms, avalanches etc	Laundry Tag

V. CONCLUSION

The present study has clearly demonstrated the fact that the passive RFID UHF tags used in the experimental set up responded & interacted significantly under each situation across the time as compared to the controlled situation. The performance data of tag is important in the process of selecting a tag and its future standardization. In the controlled situation, tag interacted optimum across the time but it varied significantly when the tags were exposed to simulated situation of disaster. This study will lead to further study predicting how various parameters such as received signal strength, read rates and read ranges of RFID systems, antenna orientation, tag & reader interaction algorithm etc., may enable specialists to improve the efficiency of RFID technology in many applications areas with special emphasis on disaster response & rescue. Studies using active RFID tags should be explored more especially for disaster rescue operations after disaster. This study explores emergency rescue procedures at the time of disaster or disaster rescue during the 'golden' rescue period using RFID system. Following is an exploration of how the best RFID tags could be leveraged to improve the efficiency of such operations, focusing specifically on the deployment of rescue personnel, search and rescue operations, emergency logistics and the transfer of injured and trapped victims. While much work on RFID applications has been conducted over the past decade, this study on performance analysis of passive RFID tags provides one step towards exploring the potential of using RFID technology in destructive disasters.

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