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Tag Detection in RFID System Based on RSSI Technique for UHF Passive Tag with Slotted Aloha Method Under Interference Environment

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Abstract. Radio Frequency Identification (RFID) is a wireless technology that uses radio waves as a key for item tracking, localization of movable assets and for automatic operations. In some cases, it is not possible for the reader to identify all the tags which result in the tag being undetected. One of the factors that influence tag identification is interference. In RFID tag reading, data collisions often occur, therefore a method is needed to avoid data collisions, namely using the Slotted Aloha Method Under Interference Environment. In this paper discusses the calculation of distance calculations obtained using the RSSI technique and the speed of detection at the time of the interference and simulation of the detection at the time of the interference influence using the slotted aloha method. And the results obtained calculations results in the smallest distance difference is 0.00639 meters and the largest is 0.3877 meters, and the fastest average time when detecting 10 tags is when the interference probability is 0 which is 27.1828 ms and the longest average time when the detection of 10 tags is when the interference probability is 0.5 that is 54,3656 ms.

Introduction

One of the disadvantages in identifying tags, at least in the case of passive UHF RFID tags, is that an RFID reader can only determine whether a tag is within the read range. However, tags can be detected without contact and even without the need for a line of sight, because electromagnetic waves can pass through objects. However, many factors can interfere with the transmission of radio signals, resulting in high uncertainty about the identification results.[1] An RFID reader has the ability to read a large number of tags located in the range of reading distance. When this occurs, the probability of collision tag is high. To avoid collision tags, an anti-collision protocol is used. One of the main anti-collision protocols is Slotted Aloha[2].

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The problem formulation in this paper is to implement the RSSI technique in comparing signal strength values in tag detection; the use of the slotted aloha technique in the tag identification system; calculates the speed of tag detection during interference. This paper aims to calculate the results of producing the smallest distance. in addition to knowing the fastest average time when detecting tags and also the probability of interference so that the effect will be known on the tag reading.

Literature Study

RFID System

The RFID system consists of 2 main components namely a Tag and Reader. Tag and reader communicate using radio waves. In principle, the RFID tag works as follows: the reading unit generates an electromagnetic field that induces current to the tag antenna. Current is used to power the chip. In passive tags, the current is also subject to a load of a condenser which ensures uninterrupted power to the chip. In the active tag, the battery replaces the condenser. Once activated, the tag will shortly receive a command from the reader and send a reply by sending a serial number or requested information[3].

RSSI (Received Signal Strength Indicator)

Radio signal strength indicator (RSSI) is a standard feature in most localization solutions and is defined as the voltage signal strength indicator of the pin received on a radio signal. RSSI is considered a key parameter for estimating target coordinates and as such, it is very important for accurate localization. Algorithm-based RSSI indicates a complete profile of the distribution area or a specific signal attenuation model that can provide direct or indirect distance or field of information from raw RSSI data[4].

SLOTTED ALOHA PROTOCOL WITH RFID

Tags can send data at any time by using Pure Aloha. But by using the Slotted Aloha protocol, tags are not permitted to send data at any time. With the Slotted Aloha protocol, tags must be transmitted at the beginning of the slot, if there is no high possibility that the tags will collide. Every tag that needs to be read must have a unique identification number. The RFID reader in wait mode will send the request command, and the tag in the reader range will recognize the request command and respond to the reader by randomly selecting a slot to send the tag identification number to the reader. Collisions occur when more than one tag responds to the same slot. Colliding tags will be re-read. If there is no tag that responds to the request command, the request command will be repeated at the cyclical interval. If the reader identifies the tag identification number without error (collision), then the detected tag can be selected using the select command to perform read/write operations without colliding with other tags. By using the read_data command, the selected tag will be sent to save the data to the reader[5].

SLOTTED ALOHA WITH INTERFERENCE

Wireless communication between the tag and reader is influenced by factors such as the type of reader, the position of the tag, the direction of the tag, the material of the object to which the tag is attached, the angle of the antenna, and the speed of the object.[6] When other radio frequencies interfere with the frequency with which the tag and reader communicate, the reader cannot identify the tag successfully. For the reasons stated above it is very clear that the object attached to the tag or material contained in the surrounding area can result in changes in tag performance and reader.

METHODOLOGY

This methodology stage follows the research framework that was previously designed including literature survey related to research, after getting the results of the research then conclusions can be drawn.

DESIGN PARAMETERS

The design of this research uses work area with size 150 cm x 100 cm. In this workspace, will be divided into 15 columns and 10 rows, where each column measures 10 cm. The work area of this research can be seen in Figure 1.

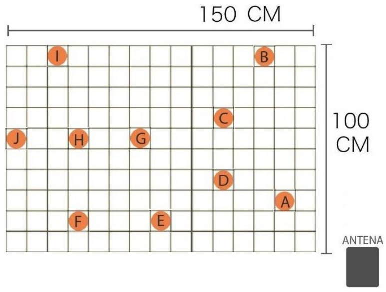

Figure 1. Work Area

Position of Tags and Reader

In this study, researchers used ALIEN ALR - 9900 Reader with polarized external antenna types and 10 passive tags. The position of the reader is within the reach of the antenna cable and tags are placed randomly but still in a work area measuring 150 cm x 100 cm.

Distance Calculation

The distance value gives an estimate of which tags are close to the reader and which tags are far. Equation 1 from **Bagirathi** [2] provides a calculation of distance calculation between the reader and tag.

$$d = \sqrt{\frac{cP_{tx}}{P_{recv}}} \quad (1)$$

Where:

d = distance between tag and reader (m)
Ptx = Transmission power of the reader (dbm)
Precv = Receiver / RSSI signal strength (dbm)
c = path loss (db)

Path loss values can be found using the formula FSPL (Free Path Loss), as seen in formula 2 below.

$$20\log 10(d) + 20\log 10(f) + 20\log 10(\frac{4\pi}{c} - GTx - GRx) \quad (2)$$

Where:

d = Distance between the antennas (m)
f = Frequency (mhz)
c = Speed of light (m/s)
G (Tx) = The Gain of the Transmitting Antenna (db)
G (Rx) = The Gain of the Receiving Antenna (db)

Calculation of the Mathematical Model for the Slotted Aloha Protocol with Interference

In this paper, to get the value of time required (number of time slots) to read the RFID tags available in the RFID reader range when interference occurs using the mathematical model that has been used previously. Equation 3 of **Deegala** [7] below is used to find the amount of time needed to detect tags at the time of interference.

$$T(\beta) = \frac{\beta . e}{1-Q} \quad (3)$$

Where:

T (β)= The time needed to identify the tag (ms)
β= The total number of tags that need to be identified
Q= Probability of Interference
e= Equivalent

Tag Detection Simulation Program on the Effects of Interference

In this section, the researchers used a simulator created using Matlab to calculate the time needed to identify an RFID tag using the Frame Slotted Aloha protocol when the interference occurred. The simulator allows the user to enter the number of tags (β) needed to be read and the probability of interference (Q). The tag will select slots randomly and respond to reader requests. When more than one tag responds using the same slot will result in a collision at the end of the RFID reader. Those who experience a collision must be reread until the total number of tags is identified. Each interference tag that does not experience a collision will be compared with the interference probability entered by the user, and each tag will be successfully read if the number of interference tags that did not crash is more than the probability entered by the user. If not, the tag that did not experience the collision must be reread again.

RESULTS AND DISCUSSION

There are 4 stages of testing in this study, the first stage is looking RSSI value, stage two is to calculate the distance from the RSSI which have been obtained, and then calculate the average time detection speed at the time of the interference and the last is using the MATLAB to make Slotted Aloha simulation.

Taking RSSI Value

Initial testing is to look for the RSSI (Received Signal Strength Indicator) value for each tag. In this stage, the retrieval of RSSI value data from the RFID reader on 10 tags are 10 times in a row and simultaneously. That is to say, the RSSI value data on all tags taken simultaneously not one by one and the data is taken in a row. The RSSI values generated from the first data collection can be seen in table 1 below.

Table 1. RSSI Tag Value

Tag Name	Tag a	Tag b	Tag c	Tag d	Tag e	Tag f	Tag g	Tag h	Tag i	Tag j
RSSI (dbm)	2079.3	1821.3	1291.3	1201.4	1031.7	939.4	909.3	869.3	707.3	664.3

Distance Calculation

Based on the RSSI results that have been obtained, finding the value of the tag and reader distance in this paper using equation 1 of **Bagirathi** [2] can be produced as follows.

Table 2. Overall Results of Distance Calculation

Tag Name	Original Distance (m)	Estimated Distance (m)	Difference (m)
T ag a	1.04 m	0.826988 m	0.213012 m
T ag b	1.27 m	0.882348 m	0.387765 m
T ag c	1.12 m	1,047406 m	0.072594 m
T ag d	1.08 m	1,086392 m	0.00639 m
T ag e	1.23 m	1,17234 m	0.05766 m
T ag f	1.48 m	1.228585 m	0.251415 m
T ag g	1.42 m	1,248754 m	0.171246 m
T ag h	1.54 m	1,277161 m	0.262839 m
T ag i	1.76 m	1,415887 m	0.344113 m
T ag j	1.65 m	1,460994 m	0.189006 m

Based on the results obtained from Table 2 above, it can be concluded temporarily that the distance difference obtained has a range from 0.05766 m to 0.387765 m.

Mathematical Models for the Slotted Aloha Protocol on Interference

Q is defined as the probability of an unidentified tag due to interference. Therefore, the possibility of the tag being identified is the same as (1-Q). Tags cannot be read under interference. In each round, a small portion of the identified tags is (1-Q) / e. The remaining tag fraction as unidentified is the same as [1- (1-Q) / e][7]. Tag Detection Average Time (ms) can be seen in table 3.

Table 3. Tag Detection Average Time (ms)

Probability (Q)	0	0.05	0.1	0.25	0.4	0.5
Number of Tags (β)						
1	2.71828	2.861347	3.020311	3,624373	4 , 530467	5.43656
2	5.43656	57,722695	6.040622	7.248747	9,060933	10,87312
3	8.15484	8.584042	9,060933	10,87312	13,5914	16,30968
4	10,87312	11,44539	12.08124	14,49749	18,12187	21,74624
5	13,5914	14.30674	15,10156	18,12187	22,65233	27,1828
6	16,30968	17,16808	18,12187	21,76424	27,1828	32,61936
7	19,027	20,02943	21,14248	25,37061	31,71327	38,05592
8	21,74624	22.89078	24,16249	28.99499	36,24373	43.49248
9	24, 46452	25,75213	27,1828	32,61936	40,7742	48.92904
10	27,1828	28,61347	30,20311	36,24373	45,30467	54,3656

Simulation of Slotted Aloha Tag Detection on Interference

In this section, the researcher used a simulator created using Matlab to calculate the time needed to identify an RFID tag using the Frame Slotted Aloha protocol when the interference occurred. The simulator allows the user to enter the number of tags (β) needed to be read and the probability of interference (Q). The tag will select slots randomly and respond to reader requests. When more than one tag responds using the same slot will result in a collision at the end of the RFID reader. Tags that experience a collision must be reread until the total number of tags is identified. Each interference tag that does not experience the collision will be compared with the interference probability entered by the user, and each tag will be read successfully if the number of interference tags that did not crash is more than the probability entered by the user. If not, the tag that did not experience the collision must be read again. The simulator works until all RFID tags are identified. The figure 2 below shows the output of the MATLAB program used in the command window. The result of output is the number of slots used during tag detection, the number of collisions that occur during the detection process, the number of tags that avoid collisions, the number of tags that were successfully read and the amount of time needed when detecting the tags.

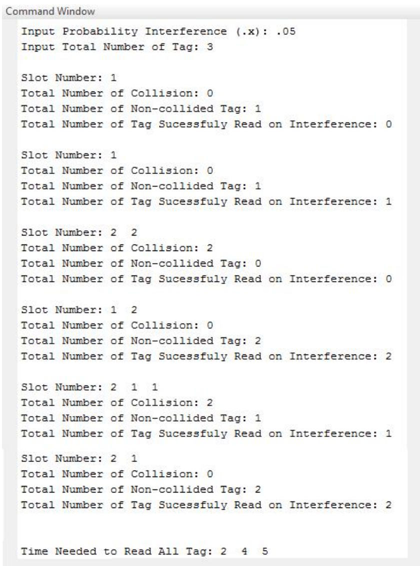

Figure 2. Matlab command window for calculating the time when RFID reader detecting tags on interference

Figure 3. explains the Slotted Aloha Scenario, where there are 10 time slots, slot numbers, number of collisions, number of non collided tags, number of successful tags. The number of successful tags results varies from 0 to 3.

Time Slot	Slot Number										Number of Collisions	Number of Non Collided Tag	Number of Successful tag
1	1										0	1	1
2	1	2									0	2	2
3	1	2	3								0	3	3
4	4	2	4	1							2	2	2
5	2	2	2								2	0	0
6	2	1									0	2	2
7	4	4	4	2	4						4	1	1
8	3	1	2	1							2	2	2
9	2	1									0	2	2
10	3	3	5	5	2	3					5	1	1

Figure 3. Slotted Aloha Scenario

SUMMARY

Based on the testing that has been done, the author gives the conclusion that the calculation results produce the smallest distance difference of 0.00639 meters and the largest of 0.3877 meters. Based on the analysis of these results, the conclusions obtained are due to the shape of the antenna coverage area. Even though a tag is positioned close to the antenna, the tag is not necessarily included in the antenna coverage area, so it affects the RSSI value when retrieving data. The fastest average time when detecting 10 tags is when the interference probability is 0, which is 27.1828 ms and the longest average time when detecting 10 tags is when the interference probability is 0.5, 54.33656 ms. Then it can be concluded that when the value of the interference probability increases the time needed to read all the tags is also more and more.

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