IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727,
PP 80-86
www.iosrjournals.org

Bayesian Enhanced Dynamic Framed Slotted Aloha Algorithm Using Gray Wolf Optimization For Rfid System

Kishor T. Patil,Vikas Kaul, Dr. Santosh K. Narayankhedkar
Computer Engineering Department Smt Indira Gandhi College Of Engineering Navi Mumbai, India
Information Technology TCET Mumbai
Principal MGM's College Of Engineering And Technology Navi Mumbai, India

Abstract— *One Of The Problems That We Faced In Radio Frequency Identification (RFID) System Is That The Collision Between Tags Which Lowers The Efficiency Of The RFID Systems. Enhanced Dynamic Framed Slotted ALOHA (EDFSA) Is One Of The Existing Anti Collision Protocol Which Estimates The Number Of Unread Tags First And Adjusts The Frame Size To Give The Optimal System Efficiency. But The Initial Frame Length Selected Is Not Optimum Since The Construction Of Current Frame Depends On The Previous Frames. Hence To Rectify The Above-Mentioned Issue Bayesian Estimation In Enhanced Dynamic Framed Slotted ALOHA (BEDFSA) Algorithm Using Grey Wolf Optimization (GWO) Is Proposed. Here Optimal Frame Length Is Selected Using GWO Algorithm And Hence Tag Collision Is Rectified By Automatic Updating Of The Probability Distribution Of The Tag Number On The Basis Of Empty, Success And Collision Slots. The Experimental Results Show That The Suggested Anti Collision Method Attains Maximum Throughput Value When Compared To The Existing Techniques.*

Keywords—*RFID Tag, Tag Identification, Tag Collision, BEDFSA, GWO.*

I. INTRODUCTION

Radio Frequency Identification (RFID) Is A Technology Which Uses Radio Waves In Order To Identify Several Objects [1]. RFID Is A Contactless, Without Line-Of-Sight, Low-Power And Low-Cost Wireless Communication Technology That Provides Automatic Identification And Data Collection. In Addition, RFID Can Read Multiple Tags Simultaneously And Work In Harsh Environments [2]. The Most Basic RFID System Consists Of Three Parts: Tag, Reader And Antenna. The Reader Is Mainly Composed Of An RF Module And A Control Unit For Reading And Writing Tag Information. Antennas Are Both In The Tags And The Reader Being Used To Pass RF Signals [3]. When A Tag Enters The RF Field, The Reader Asks An Interrogating Question. The Tag Then Responds With An Answer To The Reader. In A Similar Way Like Other Identifying Technologies Like Bar Codes, RFID Systems Allow Objects To Be Identified [1]. RFID Systems Consist Of Networked Electromagnetic Readers And Tags, Where The Readers Try To Identify The Tags As Quickly As Possible Via Wireless Communications. However, Since The Readers Or The Tags Communicate Over The Shared Wireless Channel, The Collision Problem Occurs In Signal Transmission Of The Readers Or The Tags, Which Leads To Slow Identification [4].

The Main Goal In Any RFID Application Is To Identify A Large Number Of Objects In A Very Small Time With High Accuracy. When Multiple Products Come Into The Range Of A Single RFID Reader, Collision Among Tags Occurs [5]. The RFID System Can Be Classified Into The Active RFID (Tag With Battery) System And The Passive RFID (Tag Without Battery) System [6]. RFID Technology Has Gained Significant Momentum In The Past Few Years. Currently, RFID Technology Is Used In Different Systems Such As Transportation, Consumer Packaging, Security And Access Control, Library System, Defense, And Military [7]. In A RFID System, When Numerous Tags Are Present In The Interrogation Zone At The Same Time, The Reader Requires An Ability To Read Data From The Individual Tag. A Technical Scheme That Handles Tag Collision Without Any Interference Is Called An Anti-Collision Protocol [8]. One Of The Largest Disadvantages In RFID System Is Its Low Tag Identification Efficiency By Tag Collision Especially When The Number Of Tags In Its Readable Range Is Large [9]. There Are Two Different Categories Of Collisions In RFID System: (1) Reader Collision And (2) Tag Collision. Reader Collision Happens When Multiple Readers Coexisting In The Same Area Interfere With Each Other And Can Be Overcome By The Coordination Strategy Among Readers. Tag Collision Occurs Among Tags Simultaneously Transmitting To The Same Reader And May Be More Difficult To Solve Because Of Constraints Of Energy Supply And Computing Complexity On Tags With Low Functionality [10].

Two Types Of Tag Anti-Collision Algorithms Widely Used In RFID Systems Are The Binary Tree Algorithm And The ALOHA Algorithm [11]. The ALOHA Algorithm Belongs To The Stochastic Collision Resolution. Tree-Based Algorithms Belong To The Deterministic Resolution [12]. Tree Based Algorithms, Such As Binary Tree Protocol (BT) And Query Tree Protocols (QT), Repeatedly Separate Collided Tags Into Two

Subsets Until Each Set Has Only One Tag Or No Tag. The Performance Of These Algorithms Is Stable, But Ids Should Not Be Long. Otherwise, It Will Cost Too Much Time To Identify All Tags. In ALOHA Algorithms, Tags Respond To The Reader By Transmitting Ids In A Probabilistic Manner. All Tags Will Randomly Pick A Number, And If There Is No More Than 2 Tags Selecting The Same Number, This Tag Will Be Identified, Otherwise Nothing Happens. The Efficiency Of ALOHA Algorithm Is Low With High Traffic Load [13]. Among ALOHA-Based RFID Protocols, Framed Slotted ALOHA (FSA) Is The Most Popular. It Reduces The Probability Of Tag Collision By Letting Each Tag Send Its Responding Signal In A Random Time Slot In A Frame. If, However, The Difference Between The Number Of The Tags And The Frame Size Is Large, The Throughput Of FSA Becomes Low [14].This ALOHA Method Can Only Work Well When The Total Number Of Tags Is Relatively Small. As The Number Of The Tags Increases, The Probability Of Tag Collision Becomes Higher And The Time Used To Identify The Tags Increases Rapidly [15].

II. Related Work

Several Techniques Were Proposed By Various Authors For Tag Estimation In RFID System And A Few Of Them Are Explained Below:

Automatic Identification Based On Radio Frequency Identification (RFID) Is Progressively Being Introduced Into Industrial Environments, Enabling New Applications And Processes. In The Context Of Communications, RFID Relies Mostly On Frame Slotted Aloha (FSA) Anti-Collision Protocols. Their Goal Is To Reduce The Time Required To Detect All The Tags Within Range. Javier Vales-Alonso *Et Al* [16] Have Introduced The New MFML-DFSA Anti-Collision Protocol. It Estimates The Number Of Contenders By Means Of A Maximum-Likelihood Estimator, Which Uses The Statistical Information From Several Frames (Multi-Frame Estimation) To Improve The Accuracy Of The Estimate. Based On This Expected Number Of Tags, The Algorithm Determines The Best Frame Length For The Next Reading Frame, Taking Into Account The Constraints Of The EPC Global Class-1 Gen-2 Standard. The MFML-DFSA Algorithm Was Compared With Previous Proposals And Found To Outperform These In Terms Of (Lower) Average Identification Time And Computational Cost, Which Makes It Suitable For Implementation In Commercial RFID Readers. The Results Have Shown That MFML-DFSA Outperforms The Current DFSA Proposals, Achieving Better Identification Time For A Low Computational Cost.

Mustapha Djeddou *Et Al* [17] Have Proposed An Improved Anti-Collision Technique Based On The Binary Search Algorithm. With Their Improved Algorithm, They Reduced The Total Length Of Transmitted Binary Data To Identify Tags Quickly During The Identification Process. This Improvement Was Due To The Manner Of Building Reader's Request Serial Number. Besides, This Improved Algorithm Could Also Be Applied To The DBSA. Further, The Algorithm Has Provided A Noticeable Advantage For The Length Of Transmitted Binary Data Compared Against Basic Binary Search And Dynamic Binary Search Algorithms. Besides, It Provides Same Performance In Terms Of Average Request's Number Making The Identification Process Faster, And The Expose Time Of Information Was Then Reduced.

WANG Shuai *Et Al* [18], A Novel Mahalanobis Distance Estimate (MDE) Method Was Proposed To Jointly Estimate The Number Of Tags And Packet Error Rate (PER). The MDE Method Was Error Resilient Owing To Its Ability To Achieve A Stable Estimation When Interference Was Impairing The Observed Information. An MDE Method Has Been Presented That Could Jointly Estimate The Number Of Tags And PER. By Taking Correlations Of The Observed Results Into Account, The MDE Have Shown That Good Performance Both In Tag And PER Estimation.

Yuan-Cheng Lai *Et Al* [19] Have Proposed A Novel Protocol, Dynamic Blocking Adaptive Binary Splitting (DBA), Based On The Blocking Mechanism, Which Prevents The Newly-Arriving Tags From Colliding With The Staying Tags. Moreover, DBA Utilizes A Dynamic Condensation Technique To Reduce The Number Of Idle Slots Produced When Recognized Tags Leave. Following The Condensation Process, Multiple Staying Tags May Be Required To Share The Same Slot, And Thus May Cause Collisions Among Them. Accordingly, An Efficient Ordering Binary Tree Mechanism Was Proposed To Split The Collided Tags Deterministically According To The Order In Which They Were Recognized. The Analytical And Simulation Results Have Shown That DBA Consistently Outperforms Previous Algorithms In All Of The Considered Environments.

Muhammad Shahzad And Alex X. Liu [20] Have Suggested A New Scheme For Estimating Tag Population Size Called Average Run-Based Tag Estimation (ART). The Technique Was Based On The Average Run Length Of Ones In The Bit String Received Using The Standardized Framed Slotted Aloha Protocol. ART Is Significantly Faster Than Prior Schemes. ART Could Estimate Arbitrarily Large Tag Populations With Arbitrarily High Accuracy. It Works With Single As Well As Multiple Readers. Their Experimental Results Have Shown That ART Was Significantly Faster Than All Prior RFID Estimation Schemes. They Have Shown, Both Theoretically And Experimentally, That The Estimation Time Of ART Was Independent Of The Tag Population Size.

To Solve The RFID Tag Collision Problem, A New Anti-Collision Algorithm Is Proposed By Bai Zhi *Et Al* [21]. Through Improving The Requesting Establishment, This Algorithm Reduces The Probability Of Collision Bits And The Number Of Tags Requiring Collision Detection Time By Using The Even Number Bits For Impact Identification. They Have Proposed A Kind Of Improved Algorithm Based On Basic BSA Algorithm, Through The Establishment Of A New Reader Request Sequence Number, The Total Length Of Two Tree Data Using The Optimized Algorithm Could Reduce The Transmission, Could Identify Tags Faster. The Simulation Results Compared With The Traditional Binary Tree Search Algorithm And Dynamic Binary Tree Search Algorithm, This Algorithm Has Obvious Advantages In Terms Of The Length Of The Transmission Of Binary Data. In Addition, In Terms Of The Average Number Of Requests, The Proposed Algorithm Provides The Same Performance With The Faster Identification Process And Reduces The Time Of The Transmission Of Information.

Junmei Yao *Et Al* [22] Have Proposed FAST That Can Fully Reuse The Collision Slots To Improve The Performance Of Tag Identification In RFID Systems. They Have Designed A Collision Tolerant Mechanism (CTM) That Can Identify Tags In Collision Slots Correctly. They Have Also Designed A Dynamic Frame Length Estimation Mechanism To Maximize The Slot Utilization By Considering The Signature Detection Ability Of CTM, So As To Further Improve The Performance Of Tag Identification. They Have Shown That The Feasibility Of This Protocol Through Both Theoretical Analysis And Hardware Experiments, And Demonstrate The Performance Improvement Of FAST Over Current EPC C1G2 And DDC Protocols Through Simulations. Theoretical Analysis And Experimental Results From The USRP2 Test Bed Demonstrate The Feasibility Of FAST. Simulation Results Have Shown That FAST Outperforms Other Protocols Dramatically.

Survey And Analysis Of Existing Anti-Collision Protocols Is Discussed In [23-25].

III. Problem Definition

Radio Frequency Identification (RFID) Is A Non-Contact Automatic Identification Technology, Which Taking The RF Signal As The Transfer Medium Of Information And Energy, So As To Complete The Information Exchange With The Measured Objects. The Common Problem In Existing RFID Tag Estimation Approaches Are:

- Collision Due To Simultaneous Response Signals From Multiple Tags To The Reader Is A Major Problem In Existing RFID System.
- Under Heavy Load Condition, The Existing RFID Tag Estimation Method Achieves Minimum Throughput Value Due To The Collision.
- In RFID System The Existing Tag Estimation Method Still Needs Improvement For Their Estimation Accuracy.
- Tag Identification Time Of Existing Method Is Also The Important Problem.

These Are The Main Drawbacks Of Various Existing Works, Which Motivate Us To Do This Research On Tag Estimation In RFID System.

IV. Proposed Method

RFID Systems Are Included Of Two Important Components Readers And Tags. One Of The Problems That We Faced RFID System Is That The Collision Between Tags Which Lowers The Efficiency Of The RFID Systems And Also Security Is One Of The Major Concerns With RFID. In The Paper, We Propose A New Anti-Collision Algorithm Called Enhanced Dynamic Framed Slotted ALOHA (EDFSA) Which Estimates The Number Of Unread Tags First And Adjusts The Number Of Responding Tags Or The Frame Size To Give The Optimal System Efficiency. Here The Initial Frame Size Is Optimally Selected With The Help Of Optimization Technique. In Our Proposed Method We Use Gray Wolf Optimization Technique Is Used To Select The Initial Frame Size. The Optimal Initial Frame Length Can Be Deduced By Maximizing The Expectation Of The System Throughput. In Order To Improve The Estimation Accuracy, The Bayesian Estimation In Enhanced Dynamic Framed Slotted ALOHA (BEDFSA) Algorithm Is Proposed. The First Step In Our Method Is Tag Identification Process; Initially, We Set The Frame Length Or Frame Size With The Help Of GWO Then The Reader Sends A Request Command To Tags In Its Interrogation Zone. Next, The Reader Initializes The Probability Distribution Function Of The Tag Number. Thereafter, At ALOHA-Based Anti-Collision Algorithms, All The Tags That Have Received The Query Choose A Slot Randomly, And Send Back Their Ids Using That Slot. For A Given Time Slot, There Are Only Three Possible Outcomes: Empty, Successful And Collision. The Channel Is Empty If No Tag Transmits Its ID In The Time Slot. A Successful Transmission Means One Tag Only Sends Its ID; If Two Or More Tags Transmit In The Same Time Slot, The Reader Suffers From The Collision And No Tag Can Be Read. Then The Reader Updates The Probability Distribution Function Of The Tag Quantity According To The Empty, Successful And Collision Value Collected At The End Of The Frame Slot. Finally, Compute The Expected Value Of The Tag Number Using Probability Distribution Function.

A. Diagramatic Representation

A Collision Occurs Due To Simultaneous Response Signals From Multiple Tags To Reader. Hence A New Anti-Collision Algorithm Called Bayesian Estimation In Enhanced Dynamic Framed Slotted ALOHA (BEDFSA) Using GWO Is Proposed Which Estimates The Number Of Unread Tags First And Adjusts The Number Of Responding Tags Or The Frame Size To Give The Optimal System Efficiency. The Diagrammatic Representation Of Tag Collision Using BEDFSA Is Shown In Fig.1,

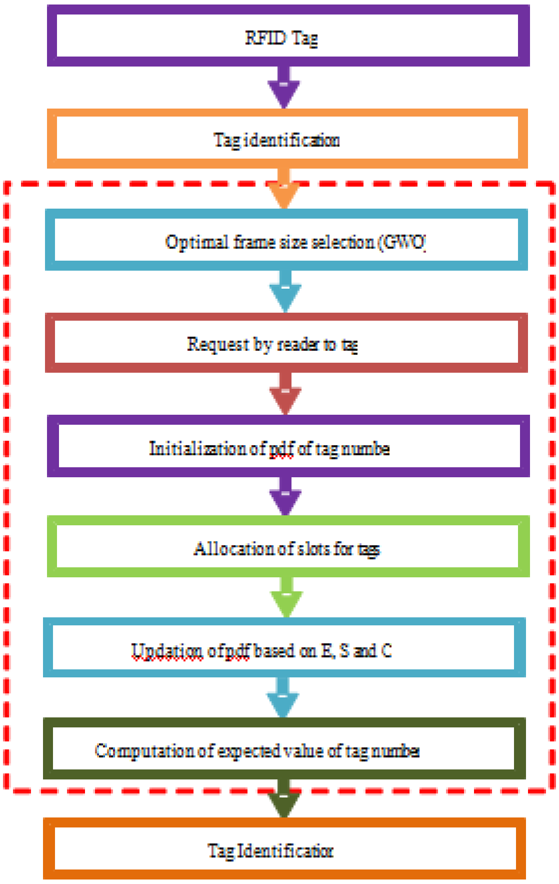

Fig. 1. Proposed Tag Anti Collision Method Using BEDFSA

B. Bayesian Estimation In Enhanced Dynamic Framed Slotted ALOHA (BEDFSA) Algorithm

The Slot Data Gathered By The Reader Toward The End Of A Frame Must Have Some Irregular Components In Light Of The Fact That Every Tag Chooses A Slot In The Frame Haphazardly. The Estimations Of E, S, And C In Two Frames Might Be Distinctive Regardless Of The Possibility That Both Frames Have The Equal Frame Length N And Number Of Tags N. Along These Lines, The Assessed Number Of Tags Ought To Be Dealt With An Irregular Variable With Certain Likelihood Dispersion As Opposed To A Constant Consistent.

Despite The Fact That A Reader May Have Effectively Utilized A Few Frames As A Part Of Its Push To Recognize All Tags When The Following Frame Length Is To Be Resolved, The Data It Gathered From The Earlier Frame May Not Consist Of Enough Data For It To Make A Decent Estimation Of The Following Frame Length. The Bayesian Strategy Is Exceptionally Appropriate For Estimation Under The Criteria That There Are Few Perception Tests. It Exploits The Confirmation In Past Frames As The Earlier Data Of The Present Frame, Which Makes The Bayesian Technique More Successful In Gathering Perceptions Than Past Strategies. In Addition, The Bayesian Could Likewise Be Utilized For The Tag Quantity Appraise. The Bayesian Strategy Is Extremely Appropriate For Upgrading The Likelihood Dispersion Of Tag Amount, A Rational Estimation Technique Is Displayed As (1) By Utilizing The Expectation Of Tag Number E (M) Probability Distribution.

$$E(m) = \sum_{m_{\min}}^{m_{\max}} mp(m) \quad (1)$$

In This Manner, A DFSA Algorithm In Light Of Bayesian Estimation Is Proposed. Bayesian Estimation Method Provides High Performance Compared To The Existing Methods. But The Selection Of Initial Frame

Length In Bayesian Estimation Method Serves As The Major Drawback. Hence In Order To Select The Optimal Frame Length Our Proposed Method Utilized GWO For Optimal Frame Length Selection. The Proposed Algorithm Strategy Can Be Separated Into The Accompanying Five Stages And Are Mentioned As Follows,

Five Stages Of Our Proposed BEDFSA Work

Step1. Set The Original Frame Length Using GWO And Sending The Request Order To Tags Requesting Their Data.
Step2. Initialize The Probability Distribution Function Of The Tag Number.
Step3. Updating The Probability Distribution Of The Tag Quantity As Indicated By E, S, C Values Gathered Towards The End Of The Frame.
Step4. Calculating The Normal Estimation Of Tag Number By Utilizing The Probability Distribution Function And Then Alter The Length Of The Following Frames.
Step5. Repeating Step 3 If A Collision Happens, Ending Generally (Since Every One Of The Tags Would Have Been Distinguished Effectively).

Pseudo Code For Gray Wolf Optimization

Begin

Step 1: Initialization Of The Random Lengths $length = (i = 1,2,3 .... m)$

Initialization Of x, y, and z As The Coefficient Vector

Step 2: Finding The Fitness Value Of The Initial Length

$$Fitness = \max \ throughput$$

Step 3: Separation Of The Solution With Respect To The Fitness Value

$length_\alpha$ = Indicates The First Best Search Length

$length_\beta$ = Indicates The Second Best Search Length

$length_\delta$ = Indicates The Third Best Search Length

While (T<Maximum Number Of Iteration)

For Every Search Length

Step 4: Update The Location Of The Present Search Length

$$length_p(t+1) = \frac{length_{p1} + length_{p2} + length_{p3}}{3}$$

End For

Step 5: Calculating The Fitness Value Of The New Search Length

Step 6: Update The Lengths $length_\alpha$, $length_\beta$ And $length_\delta$

Step 7: Retain The Best Value Of Length So Far Obtained

Iteration=Iteration+1

End While

Stop

*C. **Results And Discussion***

Throughput Achieved For Different Frame Size Is Shown In Fig.2. When Frame Size Is 128 Slots, We Get Reduced Throughput With Increasing Number Of Tags Beyond 128. Similarly, For Frame Size 256 And 512, Maximum Throughput Is Decreasing When Tag Numbers Are Less Or More Than Frame Size.

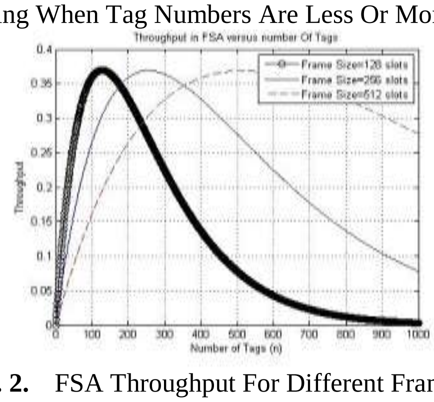

Fig. 2. FSA Throughput For Different Frame Size

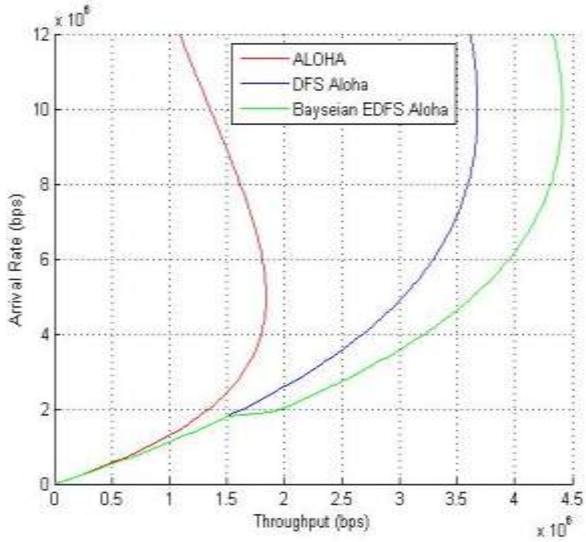

Fig. 3. Graphical Representation Of Throughput

Fig. 3 Shows The Graphical Representation Of Throughput Achieved By Existing ALOHA, DFS ALOHA And Proposed BEDFSA. It Can Be Seen That Improved Throughput Is Obtained By Proposed BEDFSA Method. Deciding Optimal Frame Size Against The Number Of Competing Tags Is Essential For Achieving Maximum Throughput. If Number Of Tags Is Less Than Frame Size, More Empty Slots Will Be There And Thus And If Number Of Tags Are More Than Frame Size, Collisions Will Be There And Thus Reduced Throughput In Either Situation. Existing Enhanced Dynamic Framed Slotted ALOHA (EDFSA) Estimates The Number Of Unread Tags First And Adjusts The Number Of Responding Tags Or The Frame Size To Give The Optimal System Efficiency. But The Initial Frame Length Selected Is Not Optimum Since The Construction Of Current Frame Depends On The Previous Frames. Hence, Here We Used Gray Wolf Optimization Algorithm To Decide Optimal Frame Length.

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