Anti-Collision in WSN and RFID Network Integration

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Abstract: ***Wireless Sensor Network (WSN) and Radio Frequency Identification (RFID) systems have engrossed considerable attention in recent years for ubiquitous computing. Their use revolutionizes diverse application areas. The integration of WSN and RFID enhances the capabilities of both the technologies providing way to diverse research areas. The integrated network of WSN and RFID systems involves various challenges among which Anti collision is significant. This is because it is directly related to time delay and energy consumption and result in waste of various network resources. In this paper, Anti collision challenge is taken into consideration to improve the performance of integrated RFID sensor network. An algorithm is proposed to overcome Anti collision problem. Anti collision is discussed in detail along with its effects on system. Proposed algorithm is compared with previous available technique. The performance of Anti-collision algorithm is tested in terms of throughput and mean delay. Simulation results show that the proposed algorithm successfully achieves Anti-collision.***

Keywords: Anti-collision, Wireless sensor network (WSN), Radio Frequency Identification (RFID), Integration, Data collision.

1. Introduction

Recent remarkable advances in micro-electro-mechanical systems, very large integrated systems and highly integrated low power digital electronics have led to the improvement of WSN and RFID systems. Sensor networks found important applications in harsh environment conditions while RFID technology has been adopted extensively in industrial applications [1]. Due to various noticeable advantages and ubiquitous computing capabilities, WSN and RFID technologies have received great attention.

An RFID network is formed by readers and tags. A tag consists of a chip and an antenna. This tag is incorporated in target object. A reader obtains information by scanning these tags and accordingly transmits information to the server. General applications of an RFID systems are supply chain management, highway toll collection, controlling building access, public transportation, developing smart home appliances, animal tracking etc [2]. WSN is a network consisting of a Base station (BS) also known as Sink node and a number of small, light weight and wireless nodes called sensor nodes. These sensor nodes sense the environmental conditions like temperature, humidity, pressure, light, sound, and vibration and accordingly collect the information [3]. The sensor nodes collaboratively collect and process the information which is further transmitted to the base station. WSNs provide cost effective monitoring of critical applications including border monitoring, industrial control, military, environmental monitoring and healthcare application [2]. In contrast RFID technology enables detection and identification of an object. There are many applications where the information retrieved through sensing environmental condition is not sufficient and the identity or location of the object is important [3]. A Wireless Sensor Network can also be used in these environments as well but the identity and location of an object remain crucial information which can be retrieved through RFID systems. The integration of both these technologies in these cases is the optimal solution as they complement each other. The integration of RFID and WSNs maximizes their effectiveness and give new perspectives to a broad range of useful applications [2]. The Hybrid network formed by integration of WSN and RFID networks has various identified challenges viz. energy conservation, data cleaning and filtering, real-time performance, anti-collision, localization, and authentication [4]. Anti-collision is one among the severe problem as it results in energy and time consumption. In WSN, three layer architecture is preferred to increase the life time of a network. This implies dividing entire network into a number of small clusters where each cluster has one cluster head (CH) node. This CH is similar to other node present in cluster but perform more complicated tasks like various data processing operations. In cluster architecture many to one traffic pattern are generated which further result in data collision. Similar is the case in RFID, where a single reader scans a number of tags, existing in its area of interrogation. As various ranges of frequency are present, problem of interference exist which causes collision [5].

The remainder of this paper is as follows. Section 2 gives a brief idea about the architecture used for evaluating the performance of proposed scheme. Section 3 deals with a detailed description of proposed technique. In Section 4 discusses simulation results and finally Section 5 concludes the paper.

2. Architecture

The architecture of RFID and WSN integrated network is shown in figure 1. The integrated network uses cluster topology for communication purpose. The architecture consists of four types of nodes [6]:

- Conventional sensor node (CSN)
- Cluster head sensor node (CH)
- Sensor tag (ST)
- Hybrid Sensor node (HSN)

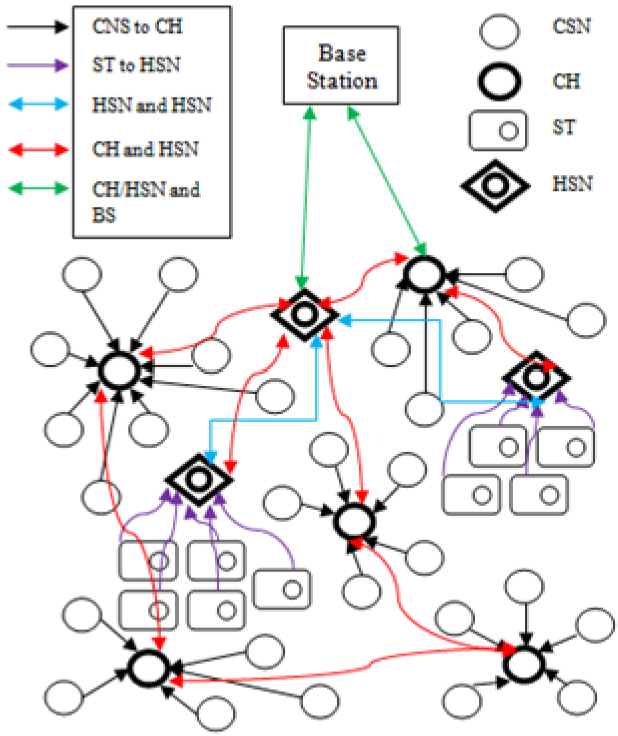

Figure 1: Architechture

As the integrated network consists of four different types of node, successful communication between them is important. Entire network is divided into clusters. This clustering is achieved by Data Density Correlation Degree Clustering Method. Thus the cluster formation takes place considering the density of data in particular region. The clusters of Sensor tags and wireless sensor nodes are formed, where a cluster-head is elected. A cluster may or may not contain an HSN. CSN transfer data to its respective CH. The CH aggregates the entire received data along with its own sensed data and forward it to Base Station. The cluster head can forward data to BS directly or via another cluster head whichever is more efficient. The integrated sensor tag forms its own cluster and HSN acts as its cluster head. STs are located within HSN reading range. The communication between STs and HSN is similar to that between CSN and CH. HSN nearer to the BS act as a relay for the HSNs that are farther from base station.

Conventional sensor nodes (CSN) are normal sensor nodes which sense physical conditions of the environment and accordingly transfer the sensed information to their respective cluster head (CH). They are the most fundamental and simple component of integrated network. The main role of CSN is to act as relays while providing additional information about the environment [6]. CH nodes are identical to CSN but perform certain additional functions like data aggregation and processing of information. Each sensor cluster contains one CH.

A sensor tag (ST) is the node formed by the integration of RFID tag and Sensor. Thus it has sole identity due to RFID tag and sensing capability due to Sensor incorporated in it. There three types of ST, viz. Active, Passive and Semi-active. A Passive sensor tags are used in above architecture which do not utilize battery power for sensing and communication purpose. Another key component is Hybrid Sensor Node (HSN) which is a combination of a sensor node and an RFID reader in one single node.

The resultant device can perform:
- Sensing of environmental conditions.
- Wireless communication with each other
- Reading of identification numbers from tagged objects or persons
- Transmission of this information to the sink or next HSN node.

All nodes present in the network are immobile. The CH and HSN can communicate with each other and they can also act as a relay for each other to transfer information to BS in an efficient manner.

3. Algorithmic Description

In [7] author N. Konstantinou has proposed a reader anti-collision scheme which is similar to Colorwave, it has introduced following modifications :

1) Expowave has introduced an upper bound for colors (time slots) beyond which they are prevented from increasing to unpredictable or even unacceptable levels. This is done to reduce time between algorithm iteration.
2) In case of collision, the behavior of Expowave is similar to that of slotted aloha i.e. reader waits for random amount of time between zero and 2^{nd} attempt.

The proposed scheme is identical to Expowave in many aspects with minor change in 2^{nd} modification stated above. The change is:

In Expowave, after collision, reader waits random amount of time as in Slotted Aloha and then retransmit the collided packet in other slot in next iteration. This concept of Aloha is been eliminated as it involves exponential backoff which introduces delay in the system. It is been replaced by another notion inspired from [8] which proves that on decreasing the probability of color change, chances of new collision also reduces. Thus in proposed scheme, whenever a collision results between two nodes, any one of the two nodes changes its color while other utilizing same initial color/slot.

Also Expowave algorithm is designed to reduce reader collision but the proposed algorithm deals with collision occurring within a cluster i.e collision resulting when more than one node attempt to transmit data to its respective CH/HSN as described in section 2.

On data collision, the ultimate solution is to retransmit the collided data packet. This retransmission unnecessarily consumes network resources and introduces delay in the network. To avoid this, following an anti-collision algorithm is proposed.

3.1. Definitions

1) *Time slot* or *color*: Time slot or color is the reserved slot for Conventional Sensor node (CSN) / Sensor tag (ST) in

which it can communicate with Cluster Head (CH) / Hybrid Sensor Node (HSN) of their respective cluster.

2) *Kick slot:* A slot in which a node can communicate with its neighbor nodes.
3) *Iteration*: It is the time amid two successive kick slot.
4) *Transmission*: The state when the (CSN) / (ST) communicate with (CH) / (HSN).
5) *Attempt:* When a (CSN) / (ST) attempts to transmit its sensed information to its respective (CH) / (HSN). An attempt can either result a success or a collision defined further.
6) *Neighbors*: Two (CSN) / (ST) are considered as neighbor if transmitting at the same time slot result in a collision between them.
7) *Idle*: It is the state of a node when it does not perform any kind of communication with its environment.
8) *Collision*: An interference that arise between two (CSN) / (ST), preventing them from successfully transmitting information to their respective (CH) / (HSN).
9) *Success*: When a (CSN) / (ST) is able to transmit information to (CH) / (HSN) without any collision [7].

3.2. Assumptions

1) Discrete time slots are obtained through time division. During these time slots, either a node can either transmit information to its respective cluster head (color slot) or interrogate with its neighbor (kick slot) which avoids the need of separate communication channel.
2) Nodes are Synchronized i.e. nodes need not need to remember the iteration number but start and end of a timeslot.
3) Each (CH) / (HSN) is capable of detecting a collision.
4) Nodes can communicate with each other in kick time slot. Collisions occurring during kick slots are kick collisions divergent to the previously defined collisions.
5) Each node possesses one of the three states: idle, transmitting, or collided [7].

3.3. Description of algorithm

In many to one traffic pattern, which exists in cluster topology, chance of collision exists. In cluster topology, as a number of nodes transmit collected data to single cluster head (CH), there is always a possibility of more than one node attempting transfer of data to CH, thus resulting in collision. Upon collision the collided data packet in needed to be retransmitted which results in unnecessary consumption of network resources. To overcome stated problem, an anti-collision algorithm is proposed as follows:

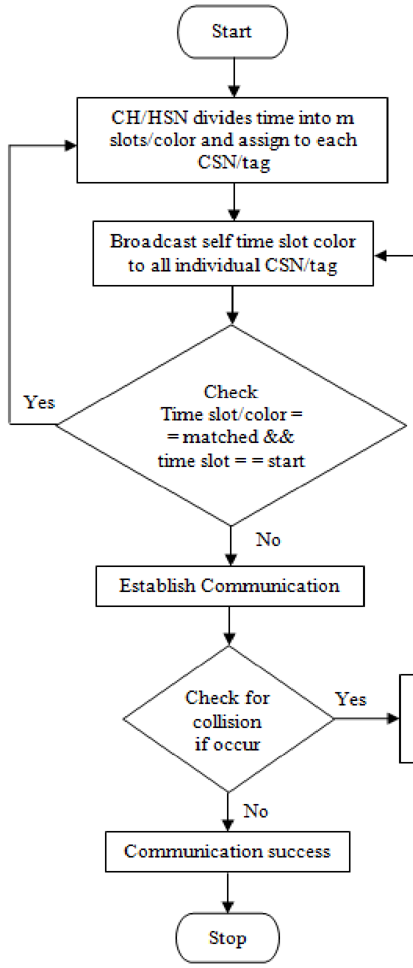

Figure 2: Flow Diagram of Anti-collision Algorithm

1. The communication channel is divided into m colors/time slots. HSN/CH assigns one color/time slot to each STs/CSNs present within its cluster.
2. After slot allotment, each STs/CSNs broadcasts its own color/time slot to other STs/CSNs present within a cluster.
3. Check weather a STs/CSNs’ color/time slot is identical to other STs/CSNs’ color/time slot. If YES, go to step 1 and if NO proceed to step 4.
4. Communication is established such that STs/CSNs transmit its sensed information to HSN/CH in their allotted color/time slot.
5. Check whether collision occurs during communication,
   i. If collision occurs, the collided ST/CSN goes in collided state and jump to step 1.
   ii. If collision does not occur, communication is successful.

Proposed algorithm is a distributed algorithm thus there is no need of a central authority. Every node operation is based on local information of cluster.

4. Simulation Results

The simulation of modified Expowave in integrated network is carried out in Network Simulator-2 (NS-2). The integrated network similar to the network developed by researchers in [10] consists of total 75 nodes among which some are sensor nodes and some are integrated nodes as discussed in section

III. The performance of the modified Expowave algorithm is tested in terms of Throughput and Mean Delay.

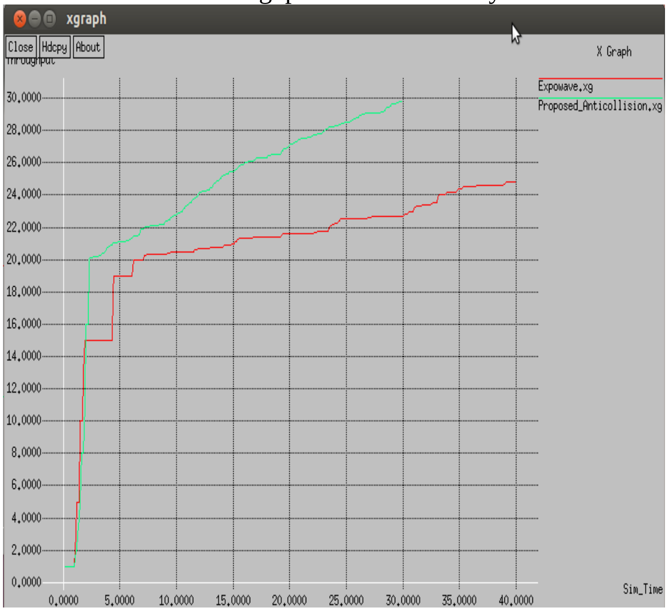

Figure 3: Comparison of Throughput between Expowave and Modified Expowave

Figure 3 above shows Throughput graph plotted against Simulation Time. Throughput is a measure of data rate and it is given by:

TP = ∑ Size of Packet / (Arrival of Packet – Start of Packet)

In other words, throughput is equal to total amount of data transferred upon total time required for transfer.

In Graph, Red line indicates the performance of Expowave in integrated network and green line indicates the performance of proposed scheme.The graph obtained shows noticeable increase in throughput.

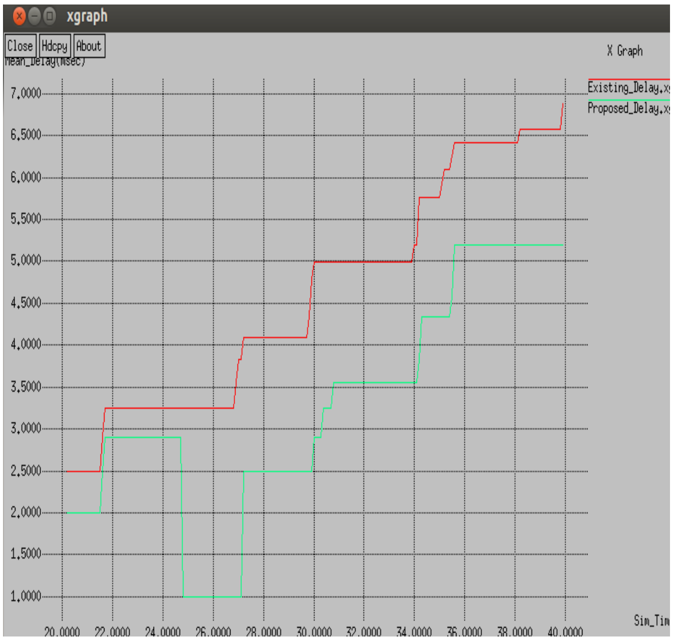

Figure 4: Comparison of Mean Delay between Expowave and Modified Expowave

Figure 4 shows the graph of Mean Delay plotted against simulation time. The mean delay is given by:

Mean Delay = (Arrival of Packet – Start of Packet) / n

where, n denotes total number of packets.

In graph, red line indicates the behavior of Expowave and green line indicates the behavior of Modified Expowave. Result obtained indicates significant decrease in mean delay. As the slotted Aloha perception of waiting random amount of time is modified, considerable decrease in delay is obtained.

5. Conclusion

In this paper, a brief overview of WSN and RFID Integrated network is provided. The integrated network has various challenges among which Anti-collision issue is taken into consideration. Data collision result in waste of time, energy and other network resources since it requires retransmission. To overcome this problem a Modified Expowave algorithm is proposed which is similar to Expowave with minor modifications. Simulation results obtained validates the effectiveness of the proposed algorithm. The proposed scheme successfully achieves Anti-collision making integrated network a resource efficient network.

References

[1] Ashwini W. Nagpurkar, Siddhant K. Jaiswal, "An Overview of WSN and RFID Network Integration", *IEEE Sponsored Second International Conference On Electronics And Communication Systems (Icecs '2015).*

[2] Hai Liu, Miodrag Bolic, Amiya Nayak and Ivan Stojmenovic, "Taxonomy and Challenges of the Integration of RFID and Wireless Sensor Networks", *Network, IEEE* , Vol.22, No.6, pp.26-35, November-December 2008.

[3] Fadi M. Al-Turjman, Ashraf E. Al-Fagih1 and Hossam S. Hassanein, "A Novel Cost-Effective Architecture and Deployment Strategy for Integrated RFID and WSN Systems", *International Conference on Computing, Networking and Communications, Network Architecture & P2P Protocol Symposium*, 2012.

[4] Li Wang, Li Da Xu,"Data Cleaning for RFID and WSN Integration", *IEEE Transactions On Industrial Informatics, Vol. 10, No. 1, February 2014.*

[5] Yuan-Hsin Chen, Shi-Jinn Horng, Ray-Shine Run, Jui-Lin Lai, Senior Member, IEEE, Rong-Jian Chen, Wei-Chih Chen, Yi Pan, and Terano Takao, "A Novel Anti-Collision Algorithm in RFID Systems for Identifying Passive Tags," *IEEE transactions on communications*, VOL. 60, NO. 2, February 2012.

[6] D. M. Boneke Nokonoko, G. A. Lusilao-Zodi, A. B. Bagula, M. E. Dlodlo, "An Energy-Efficient Routing Protocol for Hybrid-RFID Sensor Network", *IEEE Transactions On Industrial Informatics, VOL. 6, NO. 1, February 2010.*

[7] Nikolaos Konstantinou, Member, IEEE, "Expowave: An RFID Anti-Collision Algorithm for Dense and

Lively Environments," *IEEE transactions on communications*, VOL. 60, NO. 2, February 2012.

[8] Gandino, F., Ferrero, R., Montrucchio, B., Rebaudengo, M. (2011). Probabilistic DCS: An RFID reader-to-reader anti-collision protocol. Journal of Network and Computer Applications, 34(3), 821–832. doi:10.1016/j.jnca.2010.04.007.

[9] Yuhao Wang, Member, IEEE, Yi Liu, Henry Leung, Member, IEEE, and Ronglin Chen, "A Segment Collision Inversion Protocol for RFID Tag Reading", *IEEE Communications Letters, Vol. 17, No. 10, October 2013.*

[10] Anis Koubâa, Ricardo Severino, Mário Alves, and Eduardo Tovar, "Improving Quality-of-Service in Wireless Sensor Networks by Mitigating "Hidden-Node Collisions"", *IEEE transactions on industrial informatics, vol. 5, no. 3, august 2009.*

[11] Javier Vales-Alonso, Member, IEEE, Victoria Bueno-Delgado, Member, IEEE, Esteban Egea-Lopez, Francisco J. Gonzalez-Castaño, and Juan Alcaraz, "Multiframe Maximum-Likelihood Tag Estimation for RFID Anticollision Protocols", *IEEE Transactions On Industrial Informatics, Vol. 7, No. 3, August 2011*

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