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A SELF-ADAPTIVE DATA BALANCE PROTOCOL FOR DISTRIBUTED RADIO FREQUENCY IDENTIFICATION SENSOR NETWORK

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Abstract- In this paper, we share our recent work related to Radio Frequency Identification (RFID) sensor network with readers. The work mainly focus on the protocol for network system to perform the task of autonomous decentralized data distribution with consideration of economic and low-power RFID-sensor module scheme. We analyzed data pitfall in distributed RFID-sensor network, revealing the reason lies in the phenomenon. A distributed solution to tackle the problem has been designed in a simple way. The test results show that the system with proposed approach provides an efficient and more balanced in data distribution which proves the protocol is feasible for the application scenario.

Index terms*:* RFID Sensor network, equal probability scheduling, stochastic switching, Galton effect.

I. INTRODUCTION

RFID, standing for radio-frequency identification, is mainly used for tracking and tracing specific target objects. In recent years, RFID systems has met its prosperity in many modern E-business areas such as service, purchasing and distribution logistics, manufacturing, ticketing, animal identification and material flow systems [1][2]. With the advent of comprehensive application, like agri-food warehouse management, it stimulates a type of demand on the system with both RFID and sensing functions [3][4], thus giving the birth of RFID-sensor network.

RFID-sensor network refers to a specific type of RFID network is comprised by a set of networked nodes with RFID as transponders and receivers with specific sensor [5]-[7]. Mostly, this type of RFID-sensing network is applied with many local subsystems embedded with tiny transponders and supports time-based one-way communication. The terminal nodes involve the sensor, RFID readers and actuators, connected with each other depending on the function of RFID network [8]–[10] corresponding to the monitoring tasks.

This type of applications is increasingly growing in many smart systems owing to the requirements on monitoring system with ID integration. In agri-food smart system development [3], for instance, RFID network is adopted as integrated endpoints actuator interface, in which each of the equipments is RFID tagged for specific tasks, such as tracking, tracing and positioning. The data from and to these RFID sensors would be collected and released by system. Back-end computer release the control commands to actuators [11]. Each sensor in network had been integrated with a RFID transponder so that these nodes be capable of afford some work for end-points routine without special communication module. Considering the uncertainty of the networking, self-organization has been adopted in the RFID network, thus the network protocol needs to take the autonomous strategy in terms of data transmission and network routine.

There had been many research works on data routine under hop-based wireless network. Some existed approaches advocated the distributed transmission schedules. The work in [12] exploited a protocol to derive schedules that guarantee at least one successful transmission within a frame. In [13], the throughput within the network had been further considered and an optimal algorithm was used to maximize the minimum throughput. In [14], an f-MAC protocol was proposed to synchronize the network timing without global clock even though caused certain delay and fairness of throughput was guaranteed by retransmitting the same short frames multiple times.

These works had been applied in many wireless network applications. However, when directly applying these protocols to RFID sensor network, some limitations appear and need to be tackled. The implementations of these protocols usually need certain of capability for routine programming. In order to perform distributed routine, a certain extent of topology transparence is needed for form the path for data transmission. The basic mechanism for topology independent routine is to generate algebraic structures by address computation thus forming logic linkages between the nodes in the network for routine programming to guarantee the efficacy of data routine. In some existed cases, some specific nodes, generally central, sink or leader, are required to perform the programming or scheduling for hop-based routine task [15][17]. Therefore, most topology-dependent distribution protocols need to carry out based on leader election, which needs more resources to perform the computation task.

Due to the hardware resources limitation, RFID nodes are not capable of bearing much load in both computation and communication owning to its simple hardware as a compact integration of transponder and receiver worked under machine to machine mode, and the terminal is scalable as for the actuator running thus rendering it hard to find a fixed point to perform as sink. Although the performance of RFID has been enhancing with the development of information and communication technique [18], there is still much room for it to catch up in terms of computing and data exchanging compared with specific communication equipment. Thus the resource of the node device in RFID-sensor network is limited to process the data task. For another, in some cases, distributed system scheme is more practical than central one owing to its flexibility and scalability of networking. Without leader or centre based computation, nodes, however, need to share the process to deal with the task, for instance, handling data flow, thus coordinating the system operation. How to figure out a feasible approach to perform relative topology transparence with compact of RFID device is the problem posed in front of the application on distributed RFID sensor network, especially when considering the resource economic factor.

Aiming at this, we design an integrated RFID-Sensor module according to the practical scenario and corresponding protocol for transponder to perform distributed data relay with simple response strategy. In this paper, we focus mainly on the protocol. In section II, regarding the subject involved with the work in this paper, a brief introduction of distributed RFID-sensor network with integrated module is given firstly, and then the data pitfall phenomenon and its reason are analyzed. A distributed protocol we designed to tackle the problem with self-adaptive strategy is given in section III, and section IV gives the results of tests on proposed strategy with analysis on its performance. Conclusion is made in Section V.

II. PROBLEM FORMULATION

1. Preliminary

A compact module for RFID sensor network is designed as that each node in the network exchanging the data just with RFID transponder. RFID with processing unit and sensor integrate as an entire module and data exchanging in RFID-sensor network is distributed with decentralized scheme, reducing both the size and complexity of RFID sensor network during the implementation and running. Compared with the existed centralized scheme, the system related to the work in this paper runs under distributed mode, in which whole network is peer to peer in terms of data exchanging. In other words, there is no leader or centre in data layer responsible for handling the data flow in operational procedure.

In terms of the distributed data routine, several protocols provide reference solution to perform a relative topology transparence. Protocol SEEDEX [19] gives a topology independent scheduling by exchanging pseudorandom seed values between local neighbor nodes, and selects time slots for known potential transmission. Similarly, by broadcasting one-hop neighborhood information, protocol NAMA [20] dispatches a certain time slot to each node within a priori time slot structure. Protocol NOMAD [21] provides a deterministic scheduling by exchanging detailed lists of transmissions in next period between the nodes. Implementing these protocols needs continuous communication with specific neighbor to coordinate the nodes thus causing large amounts of data load, which is not affordable for compact RFID-sensor module with simple transponder and limited memory. Therefore, load reduction is needed for the compact RFID-sensor module.

In order to reduce the load of RFID sensor network both in computation and communication for routine programming, we develop a switch strategy on account of that information path is not unique in neither fixed nor priori-known mode, especially when self-organization and self-configuration take place. The RFID tag combined broadcast actuator interface is designed so that there is no longer need for both handshaking with smart gateway to register when accessing as an actuator particularly for a temporary part of function, and exchanging the future detailed list between neighbors for next period transmission. Random walk with stochastic switch strategy is used for information transmission. Many messages are conveyed with a certain probability in each possible path with a certain chance. Regarding posteriori of the application scenario and environment, usually equal probability distribution strategy, assigning equal probability to each candidate path of each node for it to switch, is used for system initialization to deal with the unknown of the priori of the operation. This scheme is simple to implement but may cause data pitfall phenomenon.

2. Data Pitfall

In practice, data pitfall effect may happen when using switch relay with equally probable strategy. A few nodes (namely pitfalls) absorb most of the messages transmitted throughout the network, rendering the inability of other nodes to receive messages from the controller, causing failure of specific mission.

Aiming at this, we formulate the system according to the practical system as a multi-hop Random walk mesh network model (MhRWMN). The model is built as a regularized mode after simplification, as Figure 1 shown, in a mesh structure, where each edge denotes the path of routine and the sensors with transponders are abstracted as a set of nodes.

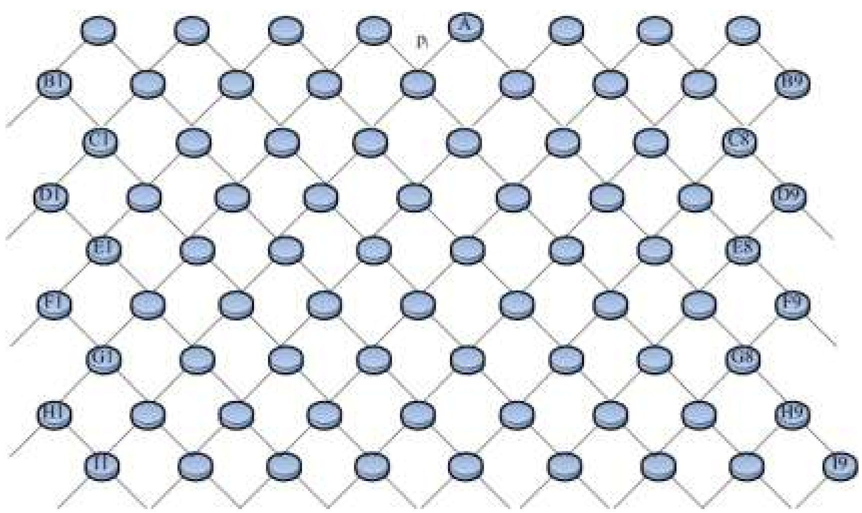

Figure 1. Regularized MhRWMN

The node A is called source node if the message is delivered from it to destination node. During the transmission procedure, lower reaches (LR) nodes refer to those which connect with source. During whole procedure of delivering, destinations are not changed until communication path is canceled after the mission is completed. All LR nodes form a sub-cluster named as layer. We define the weight of layer with consideration of number of LR nodes.

The number of layer within cluster is defined as layer width of mesh *LW*. For example, as shown in Figure 1, if *A* is information source node, the nodes connect with it are LR; nodes within the same row with B_1, B_2 connected with *A* form a layer named as layer *B*; similarly $C_1, \ldots, C_8$ form layer *C*; and so forth like to layer *I*. Layer *A, B, C* form a sub-mesh in which $LW = 3$, $weight_A = 1$, $weight_B = 2$, $weight_C = 3$.

Let whole network is *N* and includes $M_1, M_2, \ldots, M_m$ sub-meshes where M_i denote *i*th sub-mesh system and *m* denotes the quantity of sub-meshes. M_i can be formulated as:

$$M_s = \qquad X_2, \ldots, X_k) \tag{1}$$

where *k* is the width of sub-mesh M_i, and X_i ($i = 1, 2, \ldots, k$) denotes each layer with the mesh, i.e.:

$$X_s = \qquad , \ldots, x_l) \tag{2}$$

where x_j ($j = 1, 2, \ldots, l$) is the node of layer X_i with weight *l* that is $Weight(X_i) = l$, which can be generalized as:

$$Weight(X_i)_s = \sum_{j=} \tag{3}$$

where γ_j is the routine cost of node *j*, formulated in form of vector, LW is layer width and ω is parameter that involved with structure of network, protocol, data quantity and scheduling computation. Taking the network structure into consideration, information flow starting from source diffuses to LRs that is node d_x in layer X_2 can deliver its message to$X_3 \ldots X_k$ and X_l. To dispatching the data packets in autonomous RFID sensor network without leader, one main task for data routine is to guarantee each destination has well distributed probability to receive the data packets. However, without leader, each node in the decentralized network needs to transmit the data packets to the neighbors autonomously without instructions delivered from central station. Aiming at this issue, alternate switching is one usually used strategy for non priori to reach equal probability distribution. Direction relay adopted by each node selects transmit path to next LR node is satisfied with even distribution. Each node selects the path (routine address) with rolling polling strategy to perform the message delivery mission. The source node sent its specific data packets to destination layer and LR nodes need routine the data autonomously to guarantee each node in destination layer can receive a certain number of the packets.

A test was conducted on the prototype network system with topology shown in figure 1. A certain amount of data (1000 data packets) was relayed from node *A* to layer *I*. Table 1 shows the statistics on the number of the packet received by each node in layer *I*.

Table 1: Number of 1000 Data Packets Receiving Test in Destination Layer

Node Mark	I1	I2	I3	I4	I5	I6	I7	I8	I9
Received Pack	3	18	102	221	285	222	110	33	6

The result shows that node *I1* and *I9* only receive packets less than 10 while node *I4, I5, I6* handle most data packets, taking almost 70% of whole data quantity while the other 6 nodes just received only 272 packets. Most data has been absorbed by several nodes in the minority, i.e. data pitfall. This pitfall phenomenon negatively affects the fairness of other receiver but also increases the workload of several transponders. One of the negative results, for instance, is that it needs more data load to guarantee the transmission efficiency for specific task, saying command distribution to the destination layer. Data pitfall would absorb much repeated data while some of other nodes received little, causing the imbalance both for data load and system operation.

3. Galton effect

The reason underlying in this phenomenon is Galton effect [24]. To be more clarified, we regularize the model of WhRWMN with respect to source A transmission, as shown in Figure 2.

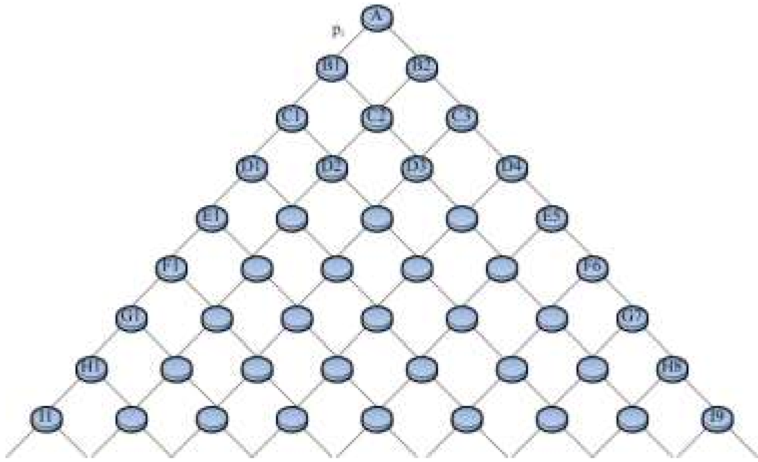

Figure 2. Regularized WhRWMN Benchmarked to Source A

In this network, default probability is initialized equally. Each branch is independent and the direction is defined as down flow from the top to the bottom. The cost of node j is$\gamma_j = 1$, where $j \in N$, and under non-priori condition, equal probability is one of the most choices of configuration for default system and each node randomly chooses the path for message routine with following probability:

$$p_i = \{ \tag{4}$$

Where i= 1denotes the behavior of selecting the first branch from left with probability $p_1 = 1/2$ as routine path; similarly, $i = 2$ denotes the selecting of the second.

It can be seen that, after regularizing, the topology of the network forms as one data funnel structure and data switching under equal probability discipline forms a binary-tree like data flow, which leads to the data pitfall caused by Galton effect. This phenomenon discovers a crux that evenly distributed delivering is not promised by node in network with average probability for data distribution. We find that in practice there is not only data pitfall that data delivering tends to reach a limited number destinations, but also further results in the bottle neck of routine that some LR nodes bear most load of transmission.

This pitfall can be solved by network schemes with leader or central router, but when it comes to short-hop based network that relies completely on nodes in network without leader or router director, which is applied in our work, the task of data distribution routine in autonomous network leaves large room to improve. Aiming at this, we design a self adaptive protocol to balance the overall load of data packets dispatching. Since each node in RFID network is implemented by simple device, the resource of the hardware could provide is limited. Thus, the strategy for data distribution for such multi-hop circumstance is designed with consideration of this limitation and would not occupied much computational resource to implement.

III. SELF ADAPTIVE BALANCE PROTOCOL

Aiming at the phenomenon of data pitfall, we design a strategy to improve the data distribution thus making each node in destination layer has more even distribution with more equal chance to receive the data. The main design is based on a main hypothesis that resource of each node is limited thus selectable branch paths are limited, and the overall network branch structure is not available for any single node to know but local information is known that each node knew the address of neighbor accessed to it. The goal of self adaptive data balance is to let each destination node in autonomous routine has similar probability to receive the data from source so that reach the even distribution. Algorithm process, like estimation or prediction support, is not available for this application. We design each node in RFID network as simple transponder and receiver and some nodes are integrated with sensor for specific measurement. Each node can obtain the information about directing to the next LRs during self-organization by hand-shaking like procedure.

The tag with RFID-sensor module is used in each node in the network, and the tags of nodes are space depended and unique marked to identify the node in whole network. This address mapping database is stored in back-end after network auto-configuration. At networking initial stage, several data capsules were set as initial data packets for networking address configuration and delivered by benchmark node, say *A* as shown in Figure 2, so as to both revise the address of node in whole network and confirm the downstream neighbor address for each layer thus relative address of lower reaches can be obtained by mapping from relative bias to absolute address.

Defines *mark*(*) as node operator that calculate the mark of node and *Layer*(*) as layer operator obtaining layer mark number, shifting s_k at time *k* as:

$$s_k = \begin{cases} \\ \qquad - \end{cases} \qquad (5)$$

Assuming *mark*(*) = *r*, *Layer*(*) = *y*, then the probability weight of each node in network *N* for next shifting is:

$$p_j(s) = \begin{cases} \quad {}_j, \psi \quad = \\ \quad \psi \quad = - \end{cases} \qquad (6)$$

where $j \in N$ is the node j in network N, ψ_j is state of node j, and the dynamic updating strategy for each h_j is designed as:

$$h_j = \quad + \frac{1}{Dy_j} \quad - \quad \times \psi \qquad (7)$$

where D refers to the number of total data packets and state ψ_j is chosen as the number of data packets received by node j. Combining (5) and (6), next shifting s_{k+1} is updated as following:

$$s_{k+} = \begin{cases} \quad) > \theta \\ \quad \le \theta \end{cases} \qquad (8)$$

where θ_j serves as threshold of path judgment. The map retrieving function is defined as *Mark*(*) and j denotes the absolute address mark. Considering the residuals in hardware computation, generally, we design h_j<1/2 lest the routine process converges on one fixed path in practice even though equation (7) serves a clear boundary to distinguish between the two choices. To further guarantee the switching range, we introduce a buffer margin Δ and equation (8) can be further updated as:

$$s_{k+} = \begin{cases} \quad) > \theta + \Delta \\ \quad \le \theta - \Delta \end{cases} \qquad (9)$$

This parameter can also server to relieve the intensity of path dithering thus making the whole network linking more stable to routine and reduce the power consumption on switching path.
With (8), data packets transmit from node j to next node j_N can be implemented by calculate the bias of path switching:

$$j_N = \qquad (10)$$

where G(*) is the operator of address calculation for transponder to obtain the address for next data routine. It serves as path switching behavior in system.
The strategy for network routine is designed as following:

1) Initialization: Pick the source node as start point, define it as initial node, mark relative position as r = 0; The other nodes get ready for receiving data, the capacity of receiving is symbolized as cost; randomly set a weight as initial value;
2) Process: Node adjusts the selecting branch weight *p* according to (6) after receive data packet;
3) Routine: Select branch according to *p* and (5) - (7) then transmit the data according to the routine path;
4) Obtain next routine hop by (9) and (10);
5) Return to 2) as loop.

The procedure of this adaptive data balance strategy (ADBS) is designed as distributed structure that all the nodes in RFID network share the load of computing. Compared with the equal probability scheduling (EPS) strategy, the probability of switching is dynamically updated rather than fixed as equal weight. After several rounds loop, the packet receiving reach the even distribution and back-end will depute the routine control to the RFID network itself. This algorithm is implemented by each node with the fixed routine table. There is no need for the distributed RFID-sensor network to adjust the data flow distribution by requiring each node to change the routine topology relationship with their neighbors, which simplifies the networking configuration for data transmission and reduces the load for each node to process.

IV. TEST

The test is carried out under a structure as Figure 1 shown, where *A* is a source node, whole quantity of data is *D*, Layer denotes the number of layers and *Weight*(*Layer*) denotes its weight. The data quantity received by destination is *d*. The maximum of *d* is denoted with d_{max} and d_{min} denotes minimum. To measure the performance changing, several indices are introduced. Define expectation of receiving data of each node as $\bar{D}$ as (11) that reflect the ideal value of data for each node to receive, i.e.:

$$\bar{D} = \frac{D}{Weight(Layer)} \tag{11}$$

and difference $\|e\|_\infty$ as (12) that reflects the extent of inhomogeneous of data distribution, i.e.:

$$\|e\|_\infty = [illegible] - [illegible] \tag{12}$$

where *d* data quantity received by destination; overloaded $\|e\|_{\hat{D}}$ that reflects the real data quantity difference compared with expectation as (13) as:

$$\|e\|_{\hat{D}} = \quad {}_{i} \quad - \tag{13}$$

under-load $\|e\|_{\breve{D}}$ that reflects the margin of load compared with expect as (14) that is:

$$\|e\|_{\breve{D}} \quad {}_{i} \quad - \tag{14}$$

the maximum of $\|e\|_{\hat{D}}$ and $\|e\|_{\breve{D}}$ as (15),

$$\|e\|_{\bar{D}} = \quad {}_{i} \quad \|\,\|_{\hat{D}}, \|e\|_{\breve{D}} \tag{15}$$

and balance residues *e* that reflects the residues compared to ideal value satisfied with even distribution as (16) that:

$$e = \quad {}_{i} \quad \|\,\|_{D} \cdot \|\,\|_{D} - \|\,\|_{\breve{D}} \tag{16}$$

and ratio criteria of unevenness υ as (17) as following:

$$\upsilon = \frac{(d \; -}{D} \times \tag{17}$$

to describe the extent of divergence from the ideal average packets quantity. Formulate the upper and infer ratio as υ and $\breve{\upsilon}$ as (18) and (19) respectively that:

$$\upsilon = \frac{\|e\|}{D} \times \tag{18}$$

$$\breve{\upsilon} \quad \frac{}{D} \tag{19}$$

to illustrate the relative extent of upper and infer dithering ratio, and mean error ratio as υ as (20) that:

$$\upsilon = \frac{\|e\| + \quad \breve{}}{2D} \times \tag{20}$$

to reflect the relative mean evenness criteria in ratio, where the more υ is, the bigger differentiation of the data load of each destination is, of which the balance is further deviate from the ideal even load. To test the efficacy of data distribution by proposed ADBS, test taking *D = 1000*; *Layer* = 9 has been carried out by rolling polling with EPS and ADBS respectively. After using proposed strategy, number of data receiving of each node as destination of layer *I* is shown in Figure 3.

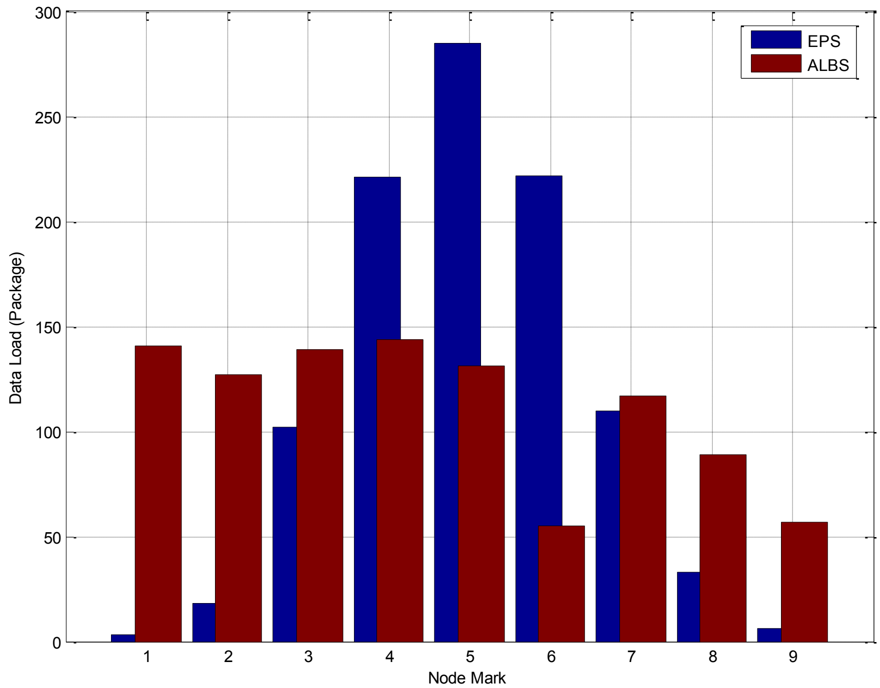

Figure 3: Result of Layer I in 1000 Data Packets Receiving with EPS and ADBS

It can be seen from the comparison on data quantity of each destination before and after using self-adaptive strategy, the data distribution by ADBS is evener than EPS. After using ADBS, the numbers of data package received by each node from *I1* to *I9* are 141, 127, 139, 144, 131, 55, 117, 89, and 57, which is more balanced compared with EPS.

Table 3: Performance Criteria Comparison between EPS and ADBS

Criteria	D	$\bar{D}$	d_{max}	d_{min}	$\|e\|_{\hat{D}}$	$\|e\|_{\hat{D}}$	$\|e\|_{\hat{D}}$	υ
EPS	1000	112	285	3	282	173	109	125.89%
ADBS	1000	112	144	55	89	32	57	39.73%

To further clarify the performance improvement, relative indices are shown in Table 3 while Table 4 gives the result on absolute ratio error criteria $|\upsilon_{,\,|}$.

Table 4: $|\upsilon_i|$ of Layer I in 1000 Data Packets Receiving with EPS and ADBS

Node Mark	I1	I2	I3	I4	I5	I6	I7	I8	I9
EPS $|\upsilon_i|$	97.32%	83.92%	8.93%	97.32%	154.46%	98.21%	1.79%	70.54%	94.64%
ADBS $|\upsilon_i|$	25.89%	13.39%	24.11%	28.57%	50.89%	16.96%	4.46%	20.53%	49.11%

According to the result shown in Table 3 and 4, the polarized differentiation is obvious caused by Galton effect with EPS and the υ is 125.89%, and the maximum overload rate appears in I5 with υ = 154.46%, and the maximum under-load over rate is around 98%, which means most resource of node have not been utilized sufficiently. It can be seen that the utilization ratio is improved after scheduling by the proposed strategy, in which υ have dropped close to 40%, more than 4 times reduction, and maximum overload rate is only 28% and highest under-load ratio is just around 50%.

We further test the system in multi-batch-scheduling (MBS) task with proposed ADBS strategy. In some cases, potential data pitfalls would not appear obviously until a certain period of data exchanging while the batches accumulating. Even though MBS multiple measurements can increase accuracy, multiple timed message exchanges may appear inefficient and less fairness in terms of throughput. Thus we conduct the MBS test and apply ADBS to the nodes (namely MBS-ADBS) to prove the improvement on the efficiency and fairness of throughput for distributed RFID-sensor network, compared with multi-batch with EPS (MB-EPS).

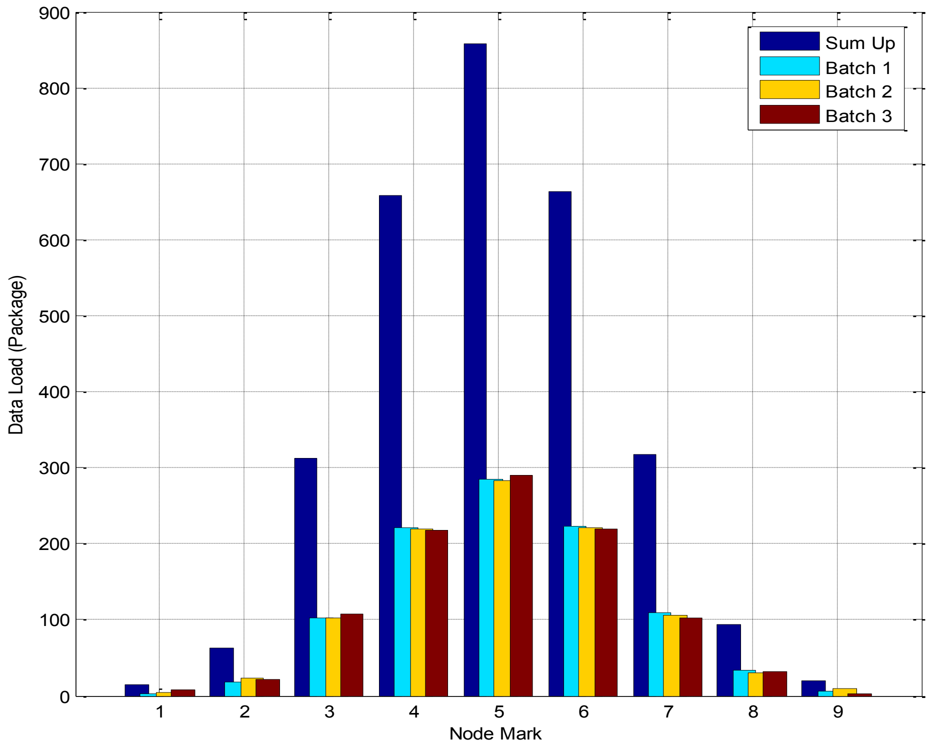

Figure 4: Test Result of 3000 Data Packets MB Receiving with EPS

In the test, the data scale of the test is set as $D = 3000$ and each batch is with 1000 packets. The network with $Layer = 9$ with strategy. Whole procedure is divided into 3 batches that $D1 = D2 = D3 = 1000$ and process with 3 times so as named as batches multi-scheduling.

The test results of MB-EPS and MBS-ADBS have been shown in Figure 4 and Figure 5 respectively. It can be seen that the superposition of MB-EPS in each batch is added up thus aggravating the unbalanced distribution caused by Galton effect (Figure 4), where the maximum of the difference between the highest and the lowest number of package receiving is over more than 800. In contrast, the superimposition with MBS-ADBS balances the data distribution, making nodes in destination layer receive packages with smaller difference between each other.

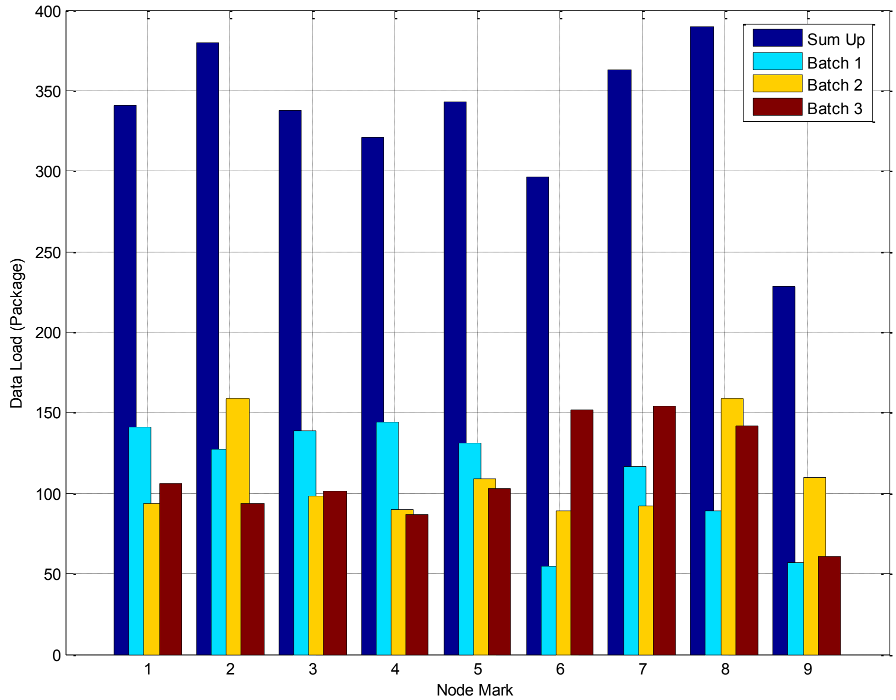

Figure 5: Test Result of 3000 Data Packets MBS Receiving with ADBS

Intuitively, MBS with ADBS has more even the data distribution in destination layer. Compared with the result of MB-EPS, the overall data distribution (which refers to the total data quantity of in MBS) and local data load (which refers to the data load received by each node) are balanced by MBS-ADBS significantly. This can also be proved in clearer way by the performance analysis.

Table 5: Performance Criterions Comparison between MB-EPS and MBS-ADBS

Criteria	D	$\bar{D}$	d_{max}	d_{min}	$\|e\|_{\hat{D}}$	$\|e\|_{\hat{D}}$	$\|e\|_{\hat{D}}$	υ
MB-EPS	3000	334	858	15	843	524	57	126.1976 %
MBS-ADBS	3000	334	390	228	162	56	106	24.25%

Table 5 shows the comparison on the criterions between MB-EPS and MBS-ADBS. It can be seen that every index of the MBS-ADBS is improved much compared with MB-EPS. Even together with Table 3, MBS-ADBS has the highest data load *D*, 3000, while the lowest mean error ratio υ, which is about 24.25%. Results show that each node takes similar data load and received from each LRs after 3 batches by MBS-ADBS, which reflects that the overall network with distributed ADBS strategy perform better balance adaptive ability in terms of data distribution in data routine.

Table 6: $|\upsilon_{j,I}|$ of Layer I in MBS Test with EPS and ADBS

Node Mark	I1	I2	I3	I4	I5	I6	I7	I8	I9
MB-EPS	95.51%	81.44%	6.59%	97.31%	156.89%	98.50%	4.79%	71.86%	94.31%
MBS-ADBS	2.10%	13.77%	1.20%	3.89%	2.69%	11.38%	8.68%	16.77%	31.74%

Table 6 gives the results on absolute ratio error criteria $|\upsilon_{j,I}|$ by MB-EPS and MBS-ADBS. It is obviously that the utilization ratio of each node in MBS task has been significantly improved by ADBS scheduling compared with MB-EPS. It can be seen in Table 6 that the minimum error ratio of MBS-ADBS is 1.2% (I3), nearly the same quantity as the ideal load while the maximum is around 30% (I9). This proves that the risk of data pitfall that causes bottleneck has been reduced by proposed method. It is helpful to perform even distribution in distributed RFID sensor network data transmission but also reduce the incidence rate of delay, queue and congestion.

V. CONCLUSION

In this paper, we focus on the decentralized communication protocol for peer to peer RFID sensor network. The design of compact RFID-sensor module is introduced. The RFID-sensor network is running under peer to peer mode without centre or leader to handle the data flow during the operation. Distributed autonomous data switching strategy with equal probability assignment and its possible data pitfall phenomenon is discussed. Modeling the RFID sensor network with simple hop routine as multi-hop random walk mesh network, we explore the reason of the data load pitfall phenomenon by means of both practical and theoretical analysis, revealing potential Galton effect in a simple binary-tree like data flow in peer to peer network with equal probability rolling polling data switching strategy. Aiming at the balance on data load, a self-adaptive adjust strategy is designed for balancing the data load of each node to reach the even distribution. Test results show that the proposed strategy enable RFID network to perform the improved effect with evenly distribute data distribution in random routine. In multi-batch-scheduling test, self-adaptive strategy shows its performance under extended without increasing the resource for each node to compute. Even the criteria $\bar{D}$ shows that there is still a lag from the ideal value of absolute evenness, however it is ignorable compared with entire data load, especially when the data quantity is not large. Further fair distribution can be balanced with multi-batch-scheduling with adaptive data distribution strategy process. The test results show that the system with proposed approach provides an efficient and more balanced in data distribution which proves the protocol is feasible for the application scenario.

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