Construction of a General-Purpose Infrastructure for Rfid – Based Applications

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ABSTRACT:

The aim of advancements in technologies is to increase scientific development and get the overall human satisfaction and comfortability. One of the active research area in recent years that addresses the above mentioned issues, is the integration of radio frequency identification (RFID) technology into network-based systems. Even though, RFID is considered as a promising technology, it has some bleeding points. This paper identifies seven intertwined deficiencies, namely: remote setting, scalability, power saving, remote and concurrent tracking, reusability, automation, and continuity in work. This paper proposes the construction of a general purpose infrastructure for RFID-based applications (IRFID) to tackle these deficiencies. Finally, the proposed IRFID is compared against eight existing systems. As a result, IRFID can be considered as a prototype for the futuristic with flexibility and generality in a wide-range of automation and development areas.

Keywords: RFID. Remotely Setting. Scalability. Automation. Power Saving. Continuity. Backup.

تشييد البنية التحتية للتطبيقات العامة لنظام التعريف باستخذام الموجات الراديوية

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الخلاصة:

مع ظهور عصر الاتمتة اصبح الهدف من التحديث في التقنيات هو زيادة التطور العلمي وبالتالي تحقيق الرضا العام و توفير الراحة للبشرية مع عصرنة الحياة. ونتيجة لذلك ،اصبح لزاماً ايجاد و تطوير الانظمة الالية التي لها القدرة على التحكم بمتطلبات العمل الالي والتي تقوم بجمع المعلومات تلقائيا لتتفاعل مع العالم بشكل فعلي. ان من اهم مجالات البحوث النشطة في السنوات الاخيرة لمعالجة القضايا المذكورة اعلاه، هو دمج تقنية تحديد الهوية باستعمال الترددات الراديوية (RFID) في انظمة الشبكات. وعلى الرغم من ان هذه التقنية تعتبر من التقنيات الواعدة، الا انه يوجد بعض نقاط الضعف فيها. أن هذا البحث يسلط الضوء على احدث المستجدات في مستويات التطوروما تم التوصل اليه في الانظمة الموجودة حاليا و التي تم ادراجها في البحث. وللقيام بذلك، فان هذا البحث يعرف سبعة اوجه من اشكال القصور وهي: الضبط عن بعد، قابلية التوسع، توفير الطاقة، التتبع عن بعد بشكل متزامن، إعادة الاستخدام، التشغيل الآلي، والاستمرارية في العمل. وبالتصويب للاعمال السابقة وتطويرها، يقترح هذا البحث

تشييد البنية التحتية العامة للتطبيقات المعتمدة على التعريف الالي باستعمال الترددات الراديوية (IRFID) . ان IRFID المقترح تمت مقارنته مع ثمانية انظمة قائمة. ومن خلال تقييم مزايا و عيوب هذه الانظمة، فلقد تم عرض مزايا الـ IRFID المقترح من خلال قائمة التدقيق المجدولة. وهكذا، فان الـ IRFID يعتبر نموذجا مستقبليا لانظمة مستقبلية تملك المرونة اللازمة للعمل ضمن مجالات الاتمتة وتطويرها و ضمن نطاق واسع.

الكلمات الرئيسية: تحديد الهوية باستعمال الموجات الراديوية، الضبط عن بعد، قابلية التوسع، التشغيل الالي، توفير الطاقة، الاستمرارية في العمل، الدعم.

1. INTRODUCTION

As a result of the increasing complexity, and modernization of life, it is necessary to develop and enhance the life styles in all of its branches. Many branches appear to fulfill the demands of modernizing and digitizing like the Information and Communication Technology (ICT), distributed system, networking, automated system and automatic identification technology **(Ali M. F. M. et al, 2010)**. In the new world, computer networks gave businesses the ability to cleverly handle vast amounts of information and the Internet gave them the resources to share them. However, computers remain unable to interact with the real world and gather information automatically, without human intervention which is subject to human error and waste of human's resources. Many technologies in the Auto-ID field have appeared and many researchers nowadays focus on RFID technology combined with computer networks to make one of the core technologies for realizing ubiquitous computing identification **(David S. and Cobain C, 2002, Byun Y.C. et al, 2009)**.

1.1 RFID Technology

RFID is an electronic and wireless sensor technology which is based on the detection of electromagnetic signals **(Mishra D. et al, 2012)**. The use of RFID tag which identifies an object and

thing will be expanded with the growth of ubiquitous society; therefore, it is essential to construct an RFID network system as a social infrastructure **(Kuribayashi S. and Osana Y., 2010)**. Recently, the hierarchical organization in any network (e.g. RFID network) has been highly recommended to make a centralized control possible to the entire system to improve network management **(Wang Y., 2010).**

1.2 Components of RFID System

RFID System components can be divided into four parts: first part is the RFID tag that is a small device which can store and transmit data in a contactless manner (wirelessly) using radio waves. Most common tags today consist firstly of an Integrated Circuit (IC) with memory and secondly of an antenna to communicate with the reader through this antenna [**Ali M. F. M. et al, 2010, Al-Tameemi Z. F. A., 2011**, **Manish B. and Shahram M., 2005)**, the second part is the RFID reader (interrogator) that is a device gathers information from tags and sends data to the host computers which have the software application (**Ali M. F. M. et al, 2010)**. The third part is the antenna which is the conduits for data communication between the reader and the tag. It sends wireless signals from the reader to the tags, and receives wireless information from the tags in the coverage zone of the reader. The last part is the host computer, the data acquired from the tags must be put for practical use, and this is done by using a host computer to process the data. The arrangement of all components of an RFID system is shown in Figure (1).

2- DEVELOPING RFID BASED APPLICATIONS ISSUES

Due to the complexity and diversity of RFID network's resources, the design and implementation of recourses manageability and usability of RFID network system is a complex and a challenging process **(Abed al Hussain S.H., 2010, Su X. et al, 2008)**. However, many intertwined deficiencies appeared in the implementation of RFID systems. These deficiencies are scheduled as follows:

1. Remotely setting: It is the ability to remotely make the configuration setting of RFID network system parameters by a central monitoring and management computer. If RFID networks are set up in remote geographical areas, central monitoring and management will be important **(Roberti M., 2007)**.
2. Scalability: It is a desirable attribute of a network, system, or process that gives a rich system performance and robot capability without the need to duplicate or reengineer the system. This accommodates an increasing of objects and elements number to handle the growing volume of work gracefully **(Bondi A. B., 2000)**. These attribute features are stated as follows:

a- Networking and management: It is a set of technologies that enable immediate, automatic identification, monitoring, devices configuration, deployment, initialization, control of receivers and transponders and sharing of information on items in the RFID application. By this way, the RFID network will make organizations more effective by enabling true visibility of information about items

in the application **(Ham Y. H., 2005, Ismail M. N. and Zin A. M., 2010)**.

b- Structural extendibility: The system is said to be structurally scalable if its standards or implementation do not impede the growth of object numbers [**(Bondi A. B., 2000)**.

3- Remote and Concurrent Tracking: Remote tracking is the ability of tracking the object situation remotely **(Al-Tameemi Z. F. A., 2011)**; whilst the concurrent tracking of any system is the ability of concurrently tracking the activities of a number of individuals in a specified unit of time and position **(Aguzzi J. et al, 2011)**.

4- Reusability: It is the ability to use all or a greater part of the same programming code or system design in another application, thus avoiding time wastage and reducing the cost **(Al-Tameemi Z. F. A., 2011**).

5- Automation: This feature includes supporting a fully automated start and a termination of every executed acquisition process **(Al-Tameemi Z. F. A., 2011**).

6- Remote power saving: Power save uses intelligent energy management to ensure that the system is available when system resources are required, and conserves power during productivity downtimes. Sometimes it needs a centralized system power status control **(Faronics Corporation, 2009)**.

7- Continuity in work: This feature includes supporting the continuity of work in case of failure.

It must be mentioned that RFID network needs some other feature such as reliability of reaching data in the network, economical, information availability, universal timing and green system.

2. RELATED WORK

This section gives the art-of-the-practice of the up-to-date RFID-based systems. Qaiser A. and Khan S.A. 2006 **(Qaiser A. and Khan S.A., 2006)** proposed an improvement in the university based on RFID technology. A system is implemented for the Automation of Time and Attendance using RFID Systems (ATAS). Lim T.S. et al. 2009 **(Lim T.S., et al, 2009)** proposed a system called RFID Based Attendance System (BAS). BAS takes the attendance of students in school, college, and university. Hornback G. et al. 2010 **(Hornback G., 2010)** proposed an Automatic Attendance System using RFID network called (AAS). AAS takes the attendance of students in a classroom by using passive RFID reader. Abdul hussain S. H. 2010 **(Abed al Hussain S.H., 2010)** proposed a simulation protocol for Vehicle Tracking System (VTS) using a passive RFID technology. Ali M. F.M. et al. 2010 **(Ali M. F. M. et al, 2010)** proposed a reusable RFID Tracking & Monitoring Application Programmable Interface (RFIDTMAPI)

for heterogeneous RFID environment. Al-Tameemi Z. F. A. 2011 **(Al-Tameemi Z. F. A., 2011)** proposed a Scalable and Automated RFID-based Attendance System (SAAS). Khor J.H. et al. 2012 **(Khor J. et al, 2012)** presented the potential of using Electronic Product Code (EPC) Class-1 Generation-2 RFID-based Malaysian University

Communities (RFIDBMUC). RFIDBMUS is used in an automate data management system for different applications. Younis M.I. 2012 **(Younis M.I., 2012)** proposed a Smart Library Management System (SLMS). SLMS integrates the passive RFID technology into a library management system.

4. HIERARCHICAL ORGANIZATION OF THE IRFID

The IRFID has a hierarchical organization as a tree topology with four levels as shown in Figure (2). The four levels are defined briefly as follows:

Level 1: It is the top level of hierarchy. This level constitutes the Main Management Administrator (MMA), which in turn consists of the following devices: main management controller server, backup server, database server and web server.

Level 2: This level represents Edge Management Controller (s) (EMCs), which is a computer or a number of computers that represents client(s).

Level 3: This level represents RFID readers. They are distributed to cover a special region as desired.

Level 4: This level is considered as a leaf of the tree (i.e. the low level of the topology); it represents all tag's ID used in the infrastructure. The hierarchical relationships of controlling and management from top to bottom are shown in Figure (2).

5. ARCHITECTURAL DESIGN OF THE IRFID

This section focuses on the components of the infrastructure and unifies them as follows:

5.1 Main Management Administration (MMA)

MMA is the top level of the proposed architecture topology. It consists of several equipments as follows:

a. Main Management Control Server (MMC)

It is the main management control server in the system that categorizes the managerial functions to the level beneath it. Management functions include organizing processes of planning, directing and controlling operations to meet the goal of the infrastructure. MMC handles the management functions by using specific commands. These commands are listed as follows: System initialization, Clock synchronization (using universal time clock), Remote setting of EMCs and readers parameters, Acquisition of EMCs parameters and readers parameters, Acquisition of the number of tag IDs and send poll command.MMC controls the above actions automatically and sends commands to EMC(s) and RFID reader(s). The Schematic Diagram of IRFID is shown in Figure (3).

b- Database Server

The main database contains tables. Each table contains fields; therefore, the role of this server is recording data that comes from MMC, EMCs, and RFID readers in tables. For any event, data will be recorded with its time. Also, it makes updating on the stored information and any authorized user can read from it. The stored tables of database can be classified into five tables as follows: System events table: this table records any event that occurred in the system with its time, EMC parameters information table: this table records the parameters of EMCs, reader parameters information table: this table records the parameters of RFID readers, tag information table: this table contains the information regarding the identification objects, tag ID table: this table contains EMC name, reader name, and tag ID associates to that tag,

c- MMC Backup Server

The backup server is a copy of MMC server. It will work instead of MMC when the MMC is fault. It has all facilities of the MMC server; thereby, it gives continuous working to the system.

d- Web Server

To give remote information access and reporting of the data that exists in the database as web pages, a Web server is made as one of the elements of the proposed IRFID. Any authorized person has the right to login into the system and access to the data. Only the administrator has ability to update or remove information from the tables. The Web Server helps to transport accessed content through the internet.

5.2 Edge Management Controller (EMC)

The EMC job is briefly defined as follows:

1- Response to the initialization command that comes from MMC, gathers its own initial parameters and the initial parameters of readers and then sends them to the MMC.
2- Response to the clock synchronization command comes from MMC. So, synchronization will be done between EMC and MMC for purpose of clock synchronization depending on NTP (Network Time Protocol) in addition to using universal time server.
3- Taking the RFID readers information, which is gathered automatically from the tags and sending this information to the main database to store it with its time.
4- Sending acquired parameters to MMC in an acquisition process.
5- Setting its parameters and the readers parameters when a command arrives from the MMC. The parameters of EMC and RFID reader are listed as follows:

EMC parameters are listed as: EMC name, EMC ID, EMC password, EMC Time Interval for Auto Acquisition (TIAA, Number of Tag ID for Auto Acquisition (QTYAA), EMC mode: this parameter defines the ways of sending Tag IDs from EMC to the main database, which are automatically continuous, automatically with a certain time interval, automatically with a certain number of tags, and poll mode. The poll mode means that the collected tag IDs can not be sent from EMC to the main database unless MMC sends a poll command to that EMC to sending IDs.
RFID reader parameters are listed as: Reader name, Reader protocol, Reader mode: this parameter determines the modes of reading tag ID which are; continuous mode and poll mode, Reader frequency, Reader power, Number of slots, Reader type, Reader kill password.

5.3 RFID Readers (Interrogators)

It is the third level of the proposed infrastructure. Each group of readers is distributed in a special manner to cover a dedicated area; these

interrogators receive embedded information from tags and send this information to the responsible

EMC. On the other hand, they take their setting from the EMC.

5.4 RFID Tag (Transponder)

In the proposed infrastructure, every physical object will be identified by an RFID tag attached to it. The tag ID is embedded inside the tag, and all other information related to that object is stored in the main database (tag information table).

6. DESIGN THE CORE MODULES OF IRFID

The proposed IRFID can be described as a set of interconnected structural modules that provide a framework supporting the entire structure of an RFID network based applications. These modules are: Main module, Main Database module, Web server module, MMC Backup server module, Communication modules, Utility module and Application module as shown in Figure (4). Each of these modules has its own functionalities in supporting the IRFID.

The key module is the Main module that has its own sub modules inside it. These sub modules are shown in Figure (5). The modules of EMC module are similar to the sub modules of main module but there are additional modules which are: read tag ID, EMC database and RFID reader communication modules as shown in Figure (6). Since backup server is considered as a copy of the MMC server, the modules of the whole IRFID that work inside the backup server are similar to the modules in the MMC server. But it has two additional modules to support its work. The additional modules are: MMC Monitor Module and Database MMC Copier Module as shown in Figure (7).

7. MAPPING IRFID REQUIREMENTS TO CORE MODULES

Summing up, the entire modules of the IRFID can be classified according to their interrelated work with the server and their functionalities into three types:

- MMC server modules (Figure 4).
- Backup server modules (Figure 7).
- EMC modules (Figure 6).

7.1 MMC server modules

The entire modules of IRFID that work with MMC server are explained as follows:

- *Main module*

The Main Module is responsible for making remote setting, initialization, synchronization, acquisition, logging and communication with other modules. It has the following sub modules:

1- GUI Module: This module is responsible for the interfaces between the user and the IRFID. Usually, any command is excuted via GUI module.
2- Job Assignment Module: This module receives the commands and data that arrive from the GUI or the communication modules and then classifies this information to the intended modules to perform the required job.
3- Initialization Module: This module is responsible for starting the communication process between the MMC and EMC.
4- Clock Synchronization Module: This module is responsible for clock synchronization between the MMC and EMC(s).
5- EMC Setting /Acquire Parameters Module: - this module is responsible for performing two actions. The first action is the remote setting of the EMC's parameters. The second action is acquiring the EMC data automatically.
6- Log Module: This module provides the flexibility of displaying any event that happened in the system with its time.
7- Reader Setting/Acquire Parameters Module: This module is responsible for two actions. The first action is the remote setting of the parameters of RFID reader. The second action is acquiring the RFID reader data automatically.
8- Acquisition Module: This module does two actions. The first action is to send an acquire command to send tag IDs to main database (in the case of EMC is in Poll mode, by using the Poll command from the MMC). The second action is asking about the quantity of tag IDs in case a specific application needs this information.
9- MMC Database module: This module is resposible for transferring data from MMC to main database.

- *Web Server Module*

This module is responsible for delivering pages content that can be accessed through network by an authorized user; therefore, any authorized user

has the ability to make a remote tracking and a concurrent tracking of objects.

- *Main Database Module*

This module represents the main database used in IRFID and contains five tables. It is connected to MMC database module, EMC database module, Web server module, MMC Backup communication module and application module. This module is responsible for storing tables of data, displaying and providing a copy of these tables by opening a connection with other modules. In this module, the updating of tables occurs automatically.

- *Utility Module*

This module acts as a tool to support specific functions in the proposed IRFID. These functions involve universal time synchronization, finding available com port and checking the availability of network devices in the IRFID.

- *Application Module*

This module represents the application software. The IRFID is supposed to handle multiple applications. Hence, the reusability could be achieved.

- *MMC Backup Module*

This module works on the basis of a message called the heartbeat messages. This message is sent to the backup server to inform it that the main server is still working. Therefore, if anything happened to the MMC server the backup server is working instead of it.

- *Communication Module*

This module is responsible for the communication among the modules.

7.2 Backup server modules

The entire modules of IRFID that work with the backup server are similar to the modules of IRFID that work with the MMC server; in addition, there are two other modules:

- *MMC Monitor Module*

This module operates on the basis of heartbeat messages which are sent from MMC server to the backup server. Receiving these messages by this module to ensure that the MMC server is still working; therefore, the continuity of work will be accomplished due to the fact that the Backup server will operate instead of the MMC.

- *Database MMC Copier Module*

This module operates periodically and automatically to get an updated copy of database from the main database and store it in the backup server. Therefore, there is a continuous data backup.

7.3 EMC Modules

EMC modules are similar to the sub modules of the main modules; in addition there are other modules:

- *Read Tag ID Module*

The functionality of this module is to deliver the information arrived from RFID readers to the job assignment module. This module works automatically.

- *RFID Communication Module*

This module is responsible for the communication between EMC(s) and RFID readers.

- *EMC Database Module*

This module is responsible for transferring Tag IDs to the main database directly through a dedicated communication module.

8. THE IMPLEMENTATION OF IRFID

These sections give the implementation of the proposed IRFID. In doing so, these sections explain the implementation of RFID tags (Level 4), RFID Reader (Level 3), and finally the GUI activities for both EMC (Level 2) and MMA (Level 1).

8.1 RFID Equipment

The RFID equipments needed by the IRFID are as follows:

- *RFID Tags (Level 4)*

The tags that are used in the proposed system are passive RFID tags which are programmed to store the identities of the system related objects. Every tag represents single object, which is programmed by the RFID reader/writer device to contain one unique identity. The shapes of tags used in the implementation are shown in Figure (8).

- *RFID Reader (Level 3)*

The type of RFID reader used in the implementation is a passive tagsense Nano-UHF RFID Reader; it is a very smal, low-power and low-cost RFID reader. Figure (8) shows tagSense Nano-UHF RFID Reader.

For hardware installation**,** tagsense reader is connected with the other components. The power

connection is connected to an adapter with a voltage of 3.3 V (regulated). The RFID reader is connected to the PC (EMC) using a simple 3-wire serial technique; the 3 data lines are: Ground, Data Transmit (TX) and Data receive (RX). The RS-232 serial adapter includes a DB-9 connector which is attached to a standard serial cable **(Tag Sense, Inc, 2013)** as shown in Figure (8).

- *Antenna*

Tag sense half patch antenna are used in the implementation and the reader connected via Sub Miniature version A (SMA) connector.

8.2 The Implementation of IRFID

The MMC which is the main management controller server must have the ability to control and monitor almost all the stations beneath its level, so the capability of MMC is implemented by using GUI which is the user-visible interface. The main program window of the MMC is shown in Figure (9). EMC is the edge management controller that is making control on the levels beneath it. The GUI of the EMC is shown in the Figure (10). When backup server starts working, the window shown in Figure (11) will appear. The IP address of MMC must be set in its filed in the first time, and when the connection is established between MMC server and backup server the heartbeat message begins transmitting from MMC to the backup and the counter shown in Figure (11) begins counting every 10 seconds. All data is organized and displayed faster by using MySQL databases. MySQL is used because it is a relational database system, fast, supporting large databases, and customizable **(Glass M. et al, 2004)**. In order to create a new record in a specific table, login as an administrator user account with the appropriate privileges is needed.

The tables that are created for the proposed system are shown in Tables 1, 2, 3, 4 and 5. Apache Web Server is responsible for accepting HTTP requests from clients and serving them as HTTP responses, usually in the form of web pages containing table's content of the main database. The language used for designing webpage is PHP that used to create web pages. The types of interface used between EMC and RFID reader are serial (RS232).

9. APPLYING SYSTEM FEATURES

The applying of each property will be demonstrated in the following sections. *Applying of Remotely Setting* is accomplished through using a remote main management control server (MMC), which controls every device setting (EMCs, RFID Readers) from remote distance, by installing the proposed software in MMC. *Applying of Scalability* is implemented by using multiple PCs (MMC, multiple number of EMCs) and RFID readers also the system expand in a chosen dimension without major modifications to its software. *Applying of Automation* is efficiently improved, throughout controls the automatic initialization and terminates acquisition processes also the automated dealing with RFID equipment and MySQL commands, updating the database accordingly and website updating. *Applying of Remotely Power Saving* is done by making MMC controls the mode of reading tag ID. If the RFID reader is in polling mode (i.e. power saving mode or standby mode), it will automatically turn off the power to all its radio circuitry when it is not transmitting. *Applying of Reusability* is achieved by implementing two applications practically as case studies for small scale applications .The case study can be implemented by installing only small external software in the user's PC, and when this software runs, the GUI in Figure (12) will appear. As seen in Figure (12), two applications can be selected, and each one represents a case study: Case Study one (*Tracking System*): In the College of Engineering / the University of Baghdad the proposed system can be implemented for tracking the employees. The MMA can be installed in the administrative building of the College of Engineering and 32 EMCs can be distributed in the College of Engineering departments to cover the area of the college. Therefore, the RFID readers can be distributed in every (entry, exit) gate in all partitions as shown in Figure (13). every employee has a tag ID which contains the ID of this person. All other information related to this person is stored earlier in the main database. The illustration of tracking will be displayed on the map and on the GUI fields as shown in Figure (14). As a proof of system reusability, a second case study (*Attendance System*) was implemented on a small scale application to take the attendance of employees, and by the same manner. The application can be implemented in the college's department and the same EMC used in the previous application can be used here, but the readers are putting in the staff member room. The GUI of this application is shown in Figure (15). *Applying of Remotely and Concurrent Tracking* is done by using website dedicated for this purpose; the generated tables will be browsed. *Applying of Continuity in work* is achieved through the using of a backup server. Also, there is a continuous backup of data by taking a copy of data from the main database and storing this data in the backup server.

10. COMPARISON BETWEEN IRFID AND RELATED WORK

As a summary of the foregoing features evaluation, Table 6 demonstrates the main functionalities of the IRFID compared with related work discussed before.

11. CONCLUSIONS AND FUTURE WORK

This paper presented a fully scalable, automated, reusable, remote setting, power saving RFID infrastructure system called IRFID. Existing RFID systems are embedded in this research, in which the investigations involved evaluating the performance of each one of these systems in terms of chosen characteristics**.** There are some points that might be taken into consideration in further work such as using other types of connections such as, Ethernet, and/or Wireless connection using towers, and/or VSAT (very-small-aperture terminal) the extendibility feature can be improved, on the other hand, it is highly desired to integrate other modules into the IRFID like LF, HF, and active RFID. Also the security feature and mobile module must add in the infrastructure to serve mobile devices facilities and increase the ability of IRFID to use in many applications.

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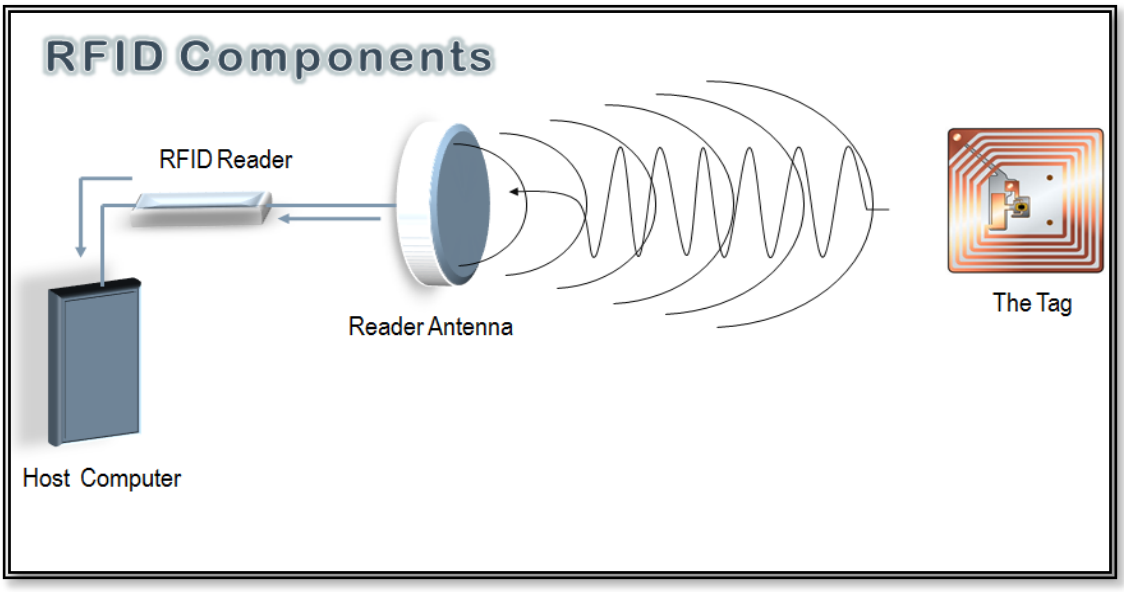


Figure (1) Data Communication between Parts of an RFID System

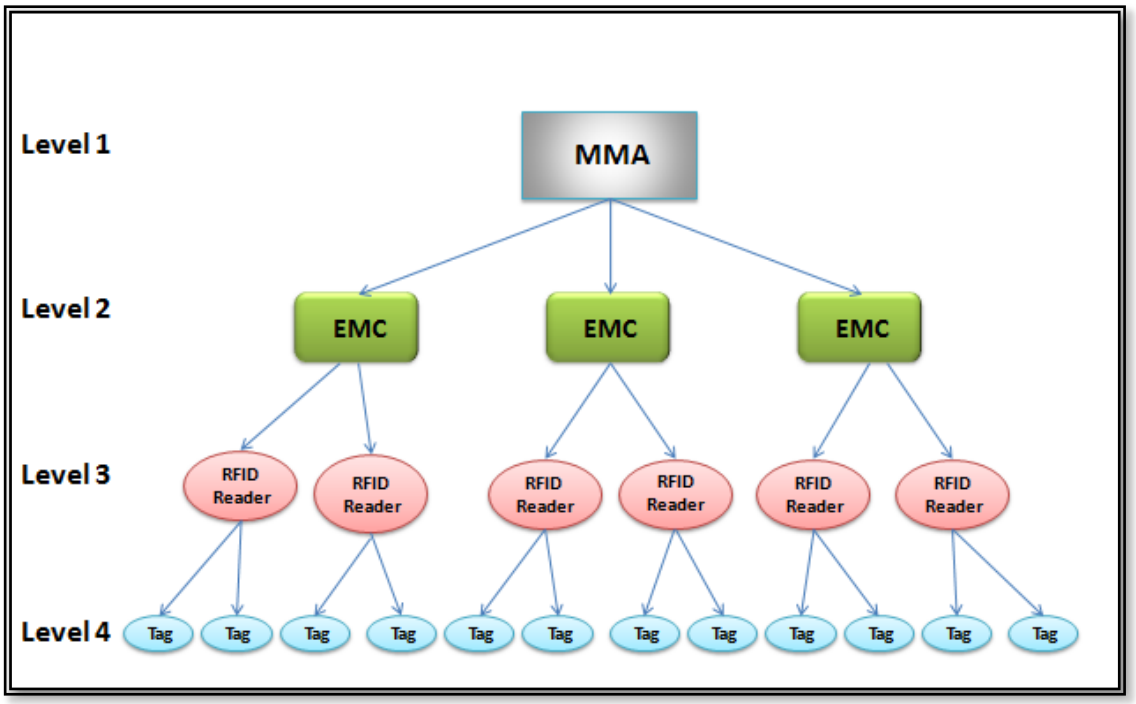


Figure (2) The Hierarchical Tree Organization of the IRFID

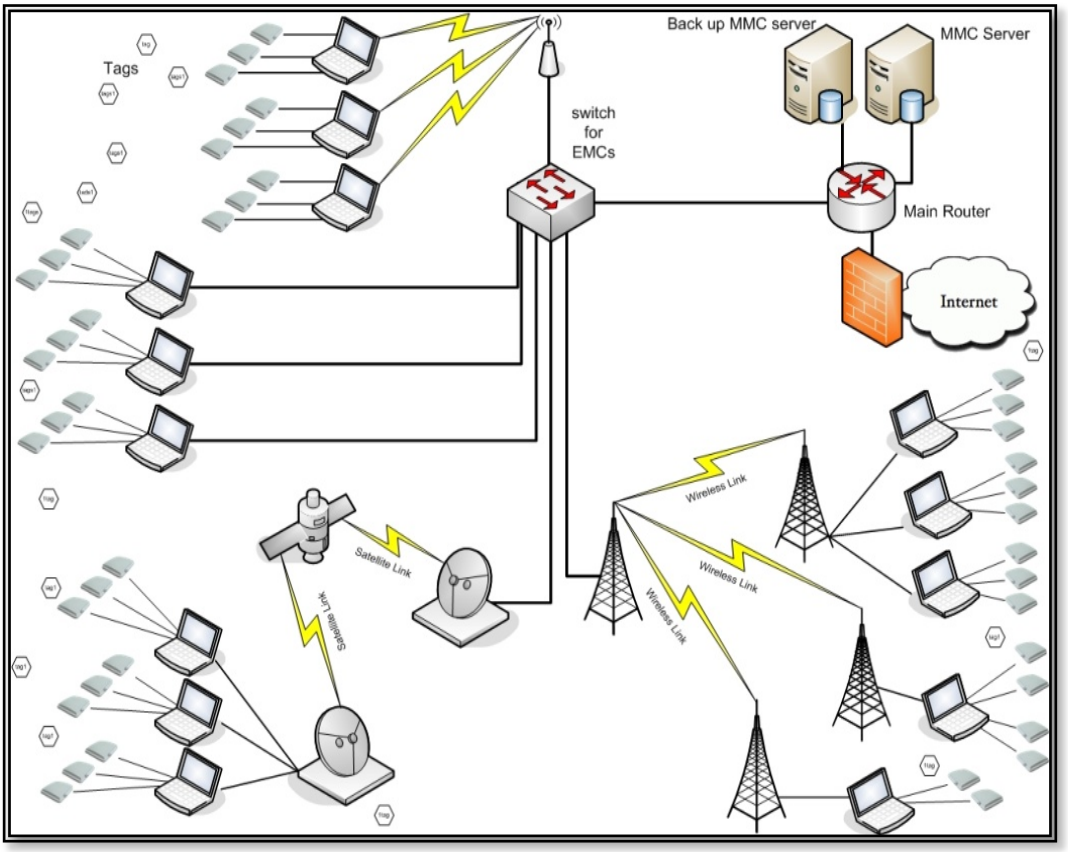


Figure (3) The Schematic Diagram of IRFID

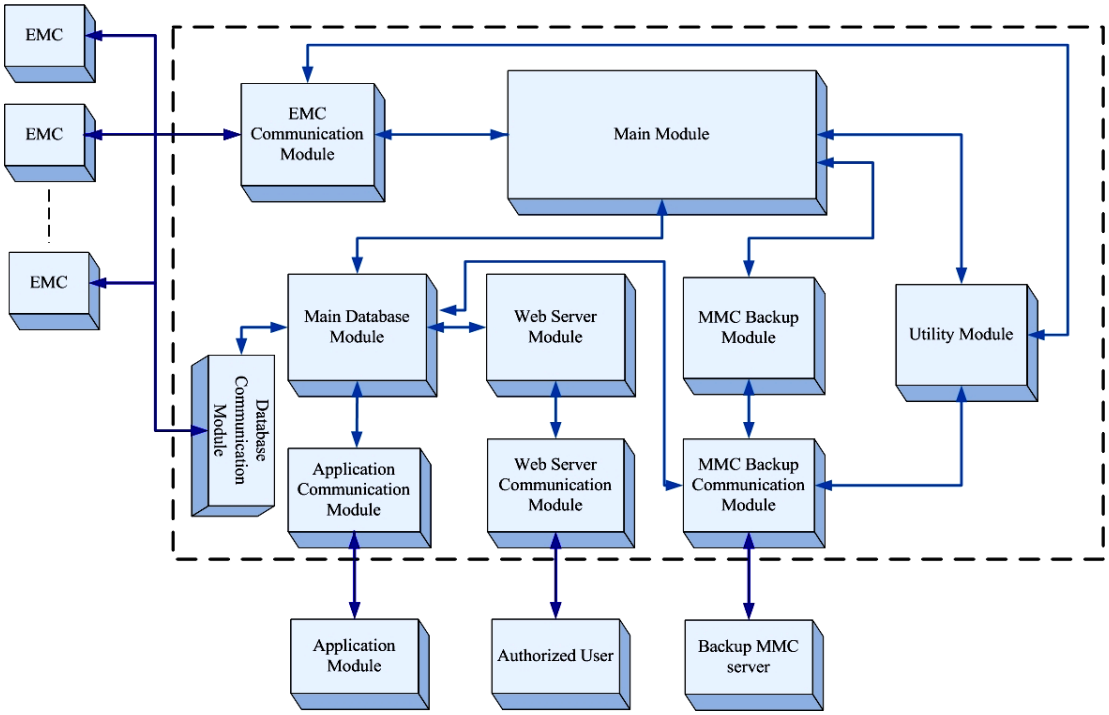


Figure (4) The Entire Modules of the IRFID Dedicated to MMC Server

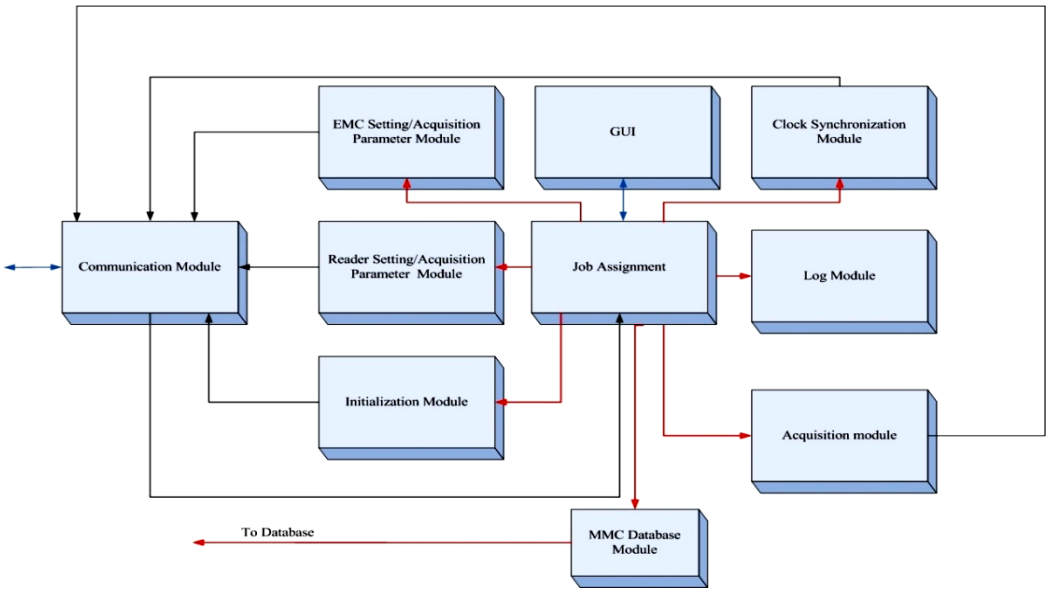


Figure (5) The Entire Sub Modules of the Main Module

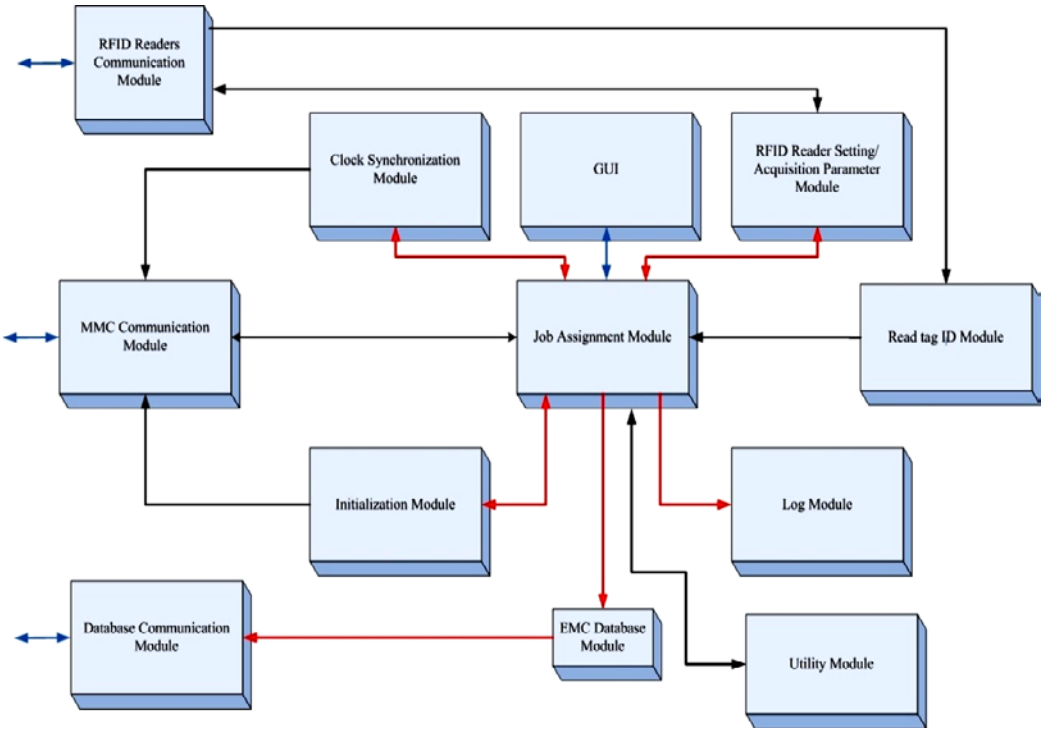


Figure (6) The Entire Modules of EMC

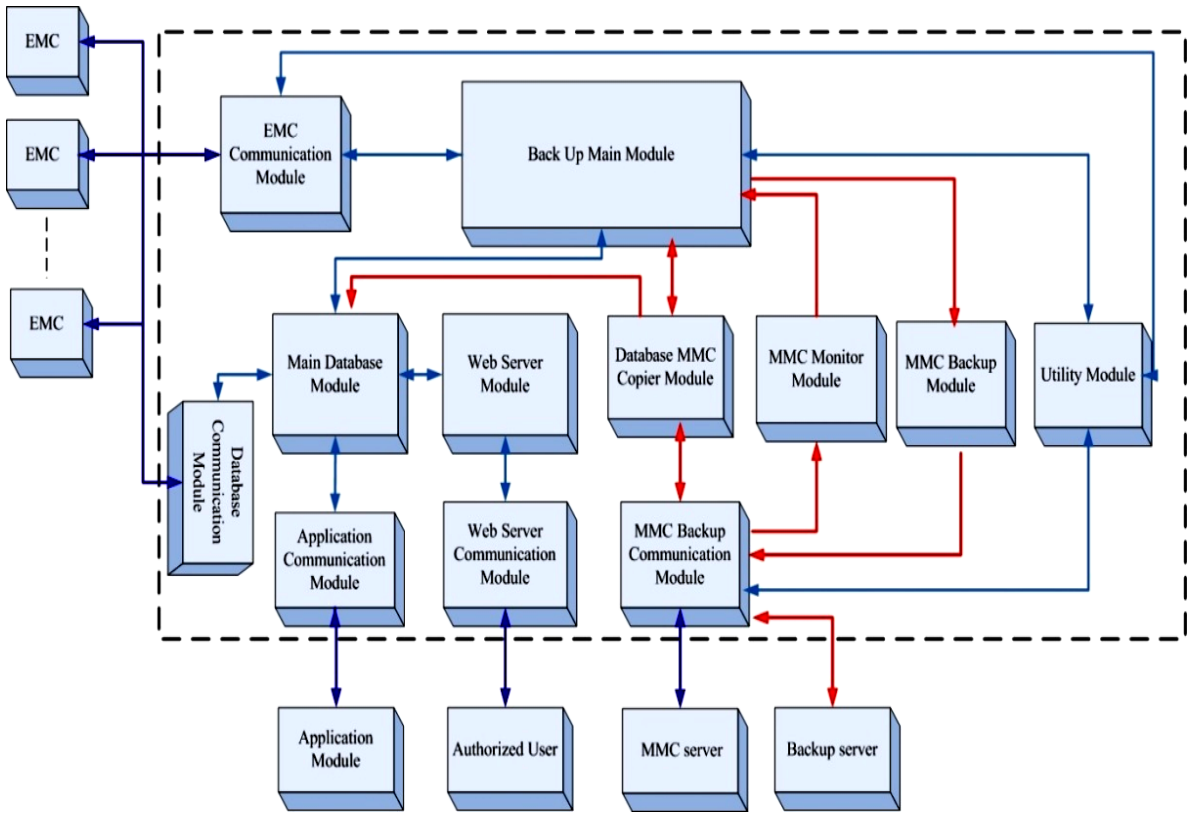
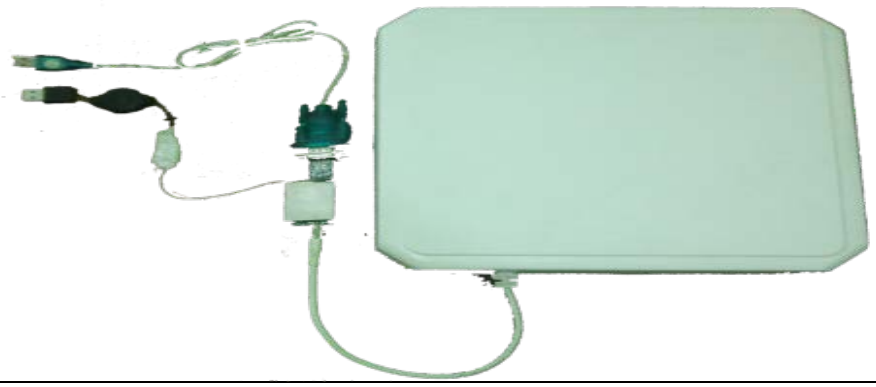


Figure (7) The Entire Modules of the IRFID with Back Up Server

The types of tags used in the implementation of IRFID

The type of RFID reader used in the implementation of IRFID



The combination of RFID reader with the antenna used in the implementation of IRFID

Figure (8) RFID Reader, Tags and the Antenna

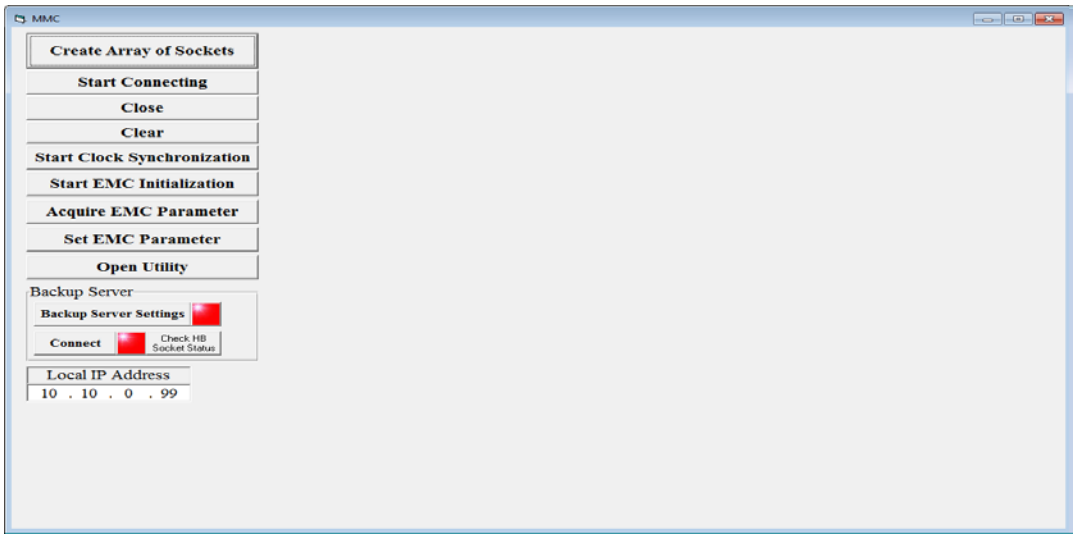


Figure (9) The Main Program Window of the MMC

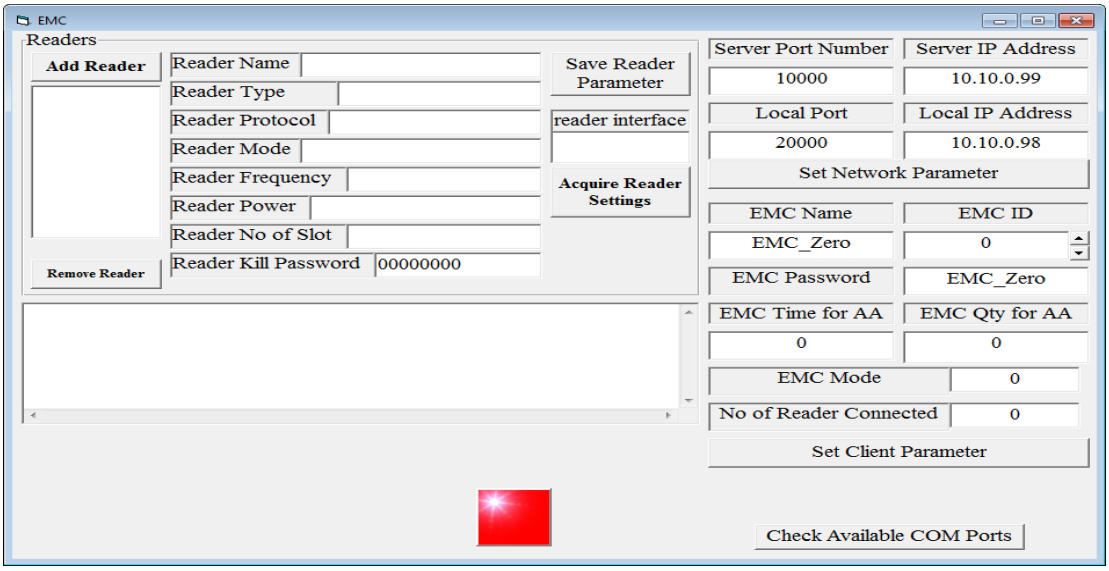


Figure (10) EMC GUI Window

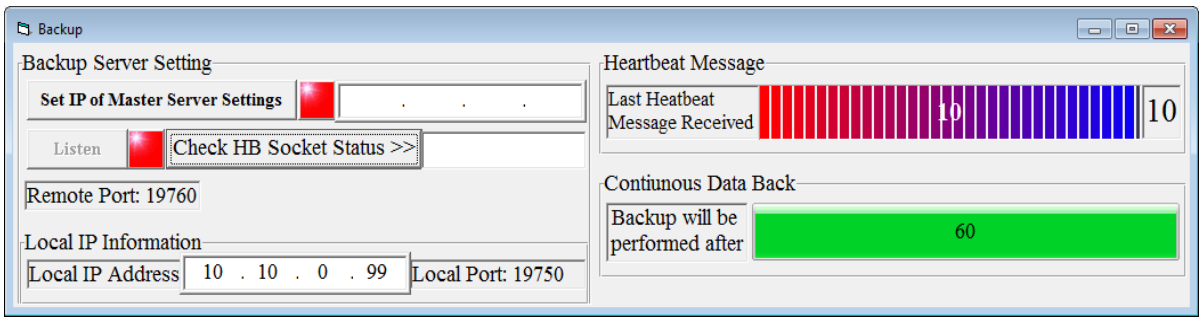


Figure (11) Backup Server Startup Window

Table 1 The Construction of the RFID Readers Parameters' Table

Logout

readerparam | syssubcontparam | systemevent | tagid | taginfo

ID	EMC ID	Reader ID	Reader Name	Reader Type	Reader Protocol	Reader Mode	Reader Frequency	Reader Power	Reader NOS	Reader Kill Password	State of Parameter	Time

Table 2 The Construkction of the EMC Parameters' Table

Logout

readerparam | syssubcontparam | systemevent | tagid | taginfo

ID	EMC Name	EMC ID	EMC Password	EMC IP	MMC Port	EMC Local Port	EMC QTY FAA	EMC Time FAA	No of Readers	EMC Mode	State of Parameter	Time

Table 3 The Construction of the 'System Events' Table

Logout

readerparam | syssubcontparam | systemevent | tagid | taginfo

ID	Log Event	Event Time

Table 4 The Construction of the 'Tag ID' Table

Logout

readerparam | syssubcontparam | systemevent | tagid | taginfo

ID	Tag ID	EMC ID	Reader ID	Time

Table 5 The Construction of the 'Tag Information' Table

Logout

readerparam | syssubcontparam | systemevent | tagid | taginfo

ID	Tag ID	Tag Password	Tag Image	Tag Information1	Tag Information2

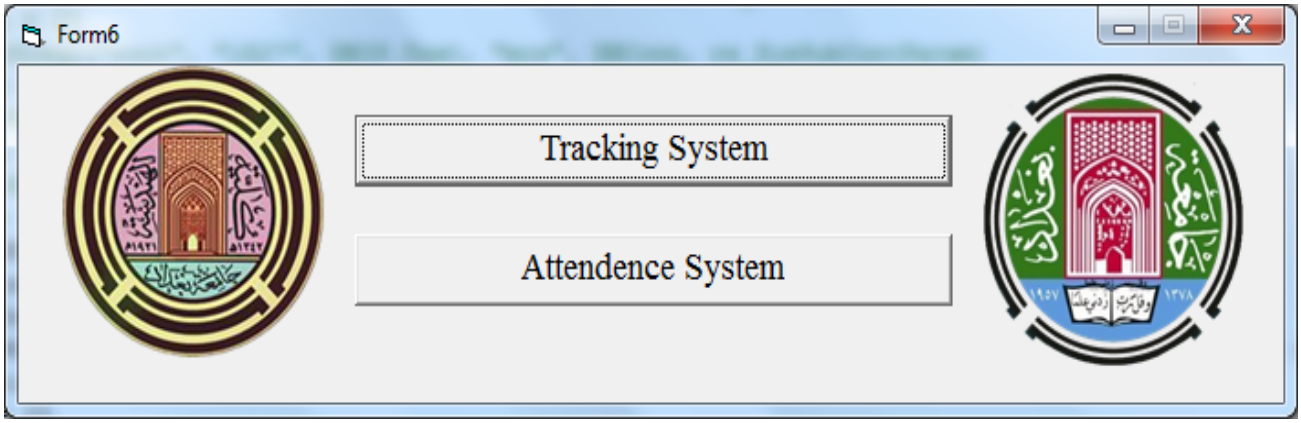


Figure (12) The Applications' GUI

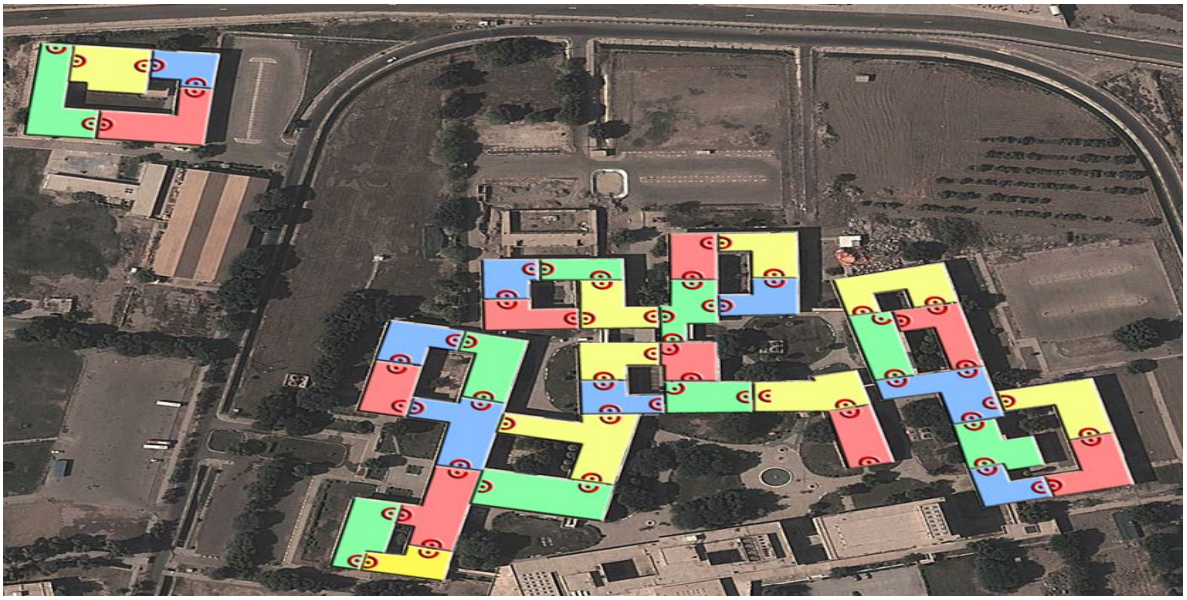


Figure (13) The Distributing of RFID Reader on the College's Map

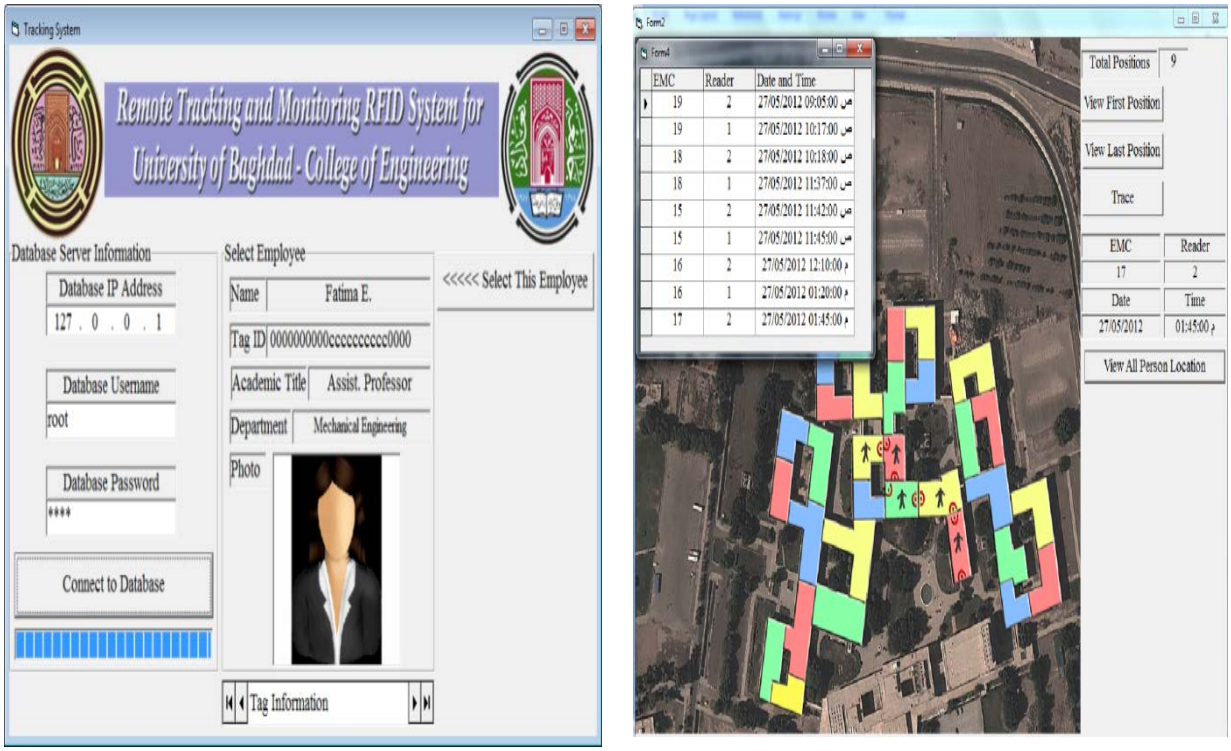


Figure (14) GUI of Remote Tracking and Monitoring Application

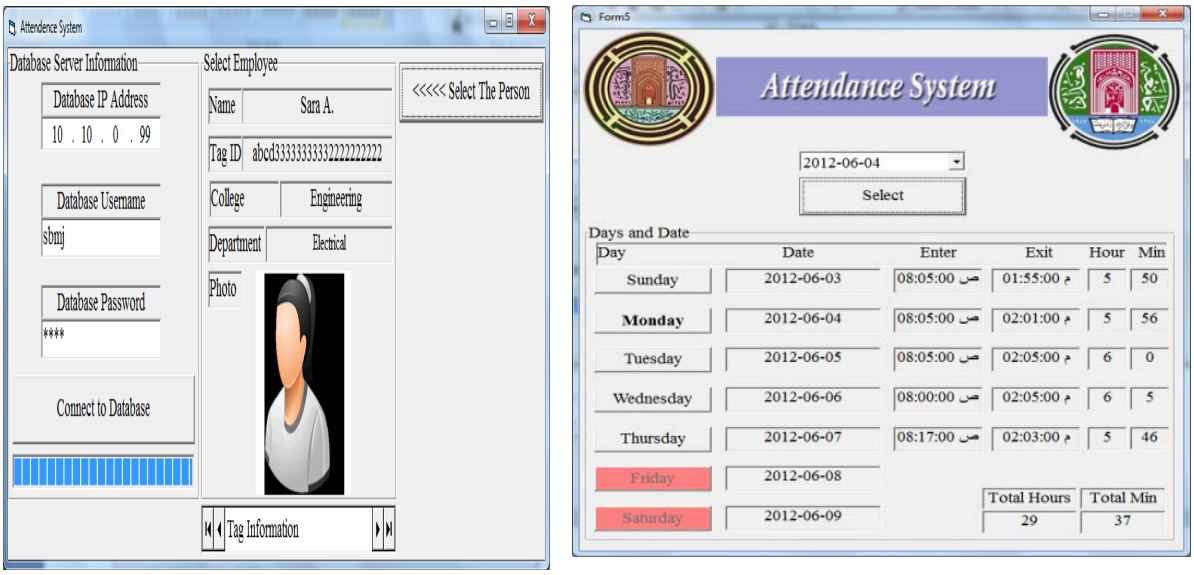


Figure (15) The Attendance of the Selected Employee

Table 6 Comparison between Proposed IRFID and Related Systems

Implemented feature (√) Not supported feature (X) Limited supported feature (L)	**RFID-based Systems**								
Functionalities	**ATAS**	**BAS**	**AAS**	**VTS**	**RFIDTM API**	**SAAS**	**RFIDBMUC**	**SLMS**	**Proposed IRFID**
1- Remotely setting	X	X	X	L	L	X	X	X	accepted
2- Scalability									
❖ **Networking and management**	X	X	X	X	L	√	√	√	accepted
❖ **System extendibility**	X	X	X	X	X	√	√	√	accepted
3- Tracking									
❖ **Remotely tracking**	√	X	√	X	√	√	√	√	accepted
❖ **Concurrently tracking**	X	√	√	√	√	√	√	√	accepted
4- Reusability	X	X	X	X	√	√	√	X	accepted
5- Automation	L	L	L	L	L	√	√	√	accepted
6- Power saving	X	X	X	X	X	X	X	X	accepted
7- Continuity in work	X	X	X	X	X	X	X	X	accepted