

# Requirements and Design of RFID based E-Manufacturing System

Gamal Darwish, Ahmed ElShafee, Dina Darwish

**Abstract**—This paper proposes the requirements and design of RFID based system for SFC (Shop Floor Control) in order to achieve the factory real time controllability, Allowing to develop E-Manufacturing System. The detailed logical specifications of the core functions and the design diagrams of RFID based system are developed. Then RFID deployment in E-Manufacturing systems is investigated..

**Keywords**—RFID, E-Manufacturing System, Requirements specifications, Design Diagrams, real time controllability.

## I. INTRODUCTION

E-Manufacturing control is a concept to combine the power of the new Web-based software technologies (SOA, Web Services, ..... etc) and the state-of-the-art. Radio Frequency Identification (RFID) technology to improve the controllability of a factory [ 1-8 ].

The controllability of a factory is highly dependent on the capability of the enterprise system to interact in real time with the data points. A data point is the place where a specific type of data needs to be read or a control data signal needs to be injected (such as identifying the position of material in the manufacturing pipe line, or changing the light indicator of a work center, etc.). Inserting programmable RFID tags at the data-points will enable the real-time controllability. On the other hand integrating the RFID network with ERP systems requires flexible design and development to secure future sustainability and ease of deployment like web-based software technology which offers a sustainable and resilient candidate to implement this integration. A main challenge is to integrate RFID into existing manufacturing systems and to develop RFID middleware, and associated hardware and networking that will link new RFID systems into back-end infrastructure [ 9-17 ].

This paper proposes the requirements and design of RFID based system for SFC (Shop Floor Control) in order to achieve the factory real time controllability, The detailed logical specifications of the core functions and the design diagrams of RFID based system are developed. Then RFID deployment in E-Manufacturing systems is investigated.

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## II. STRUCTURE OF SFC (SHOP FLOOR CONTROL)

Fig. 1 shows the structure of the SFC.

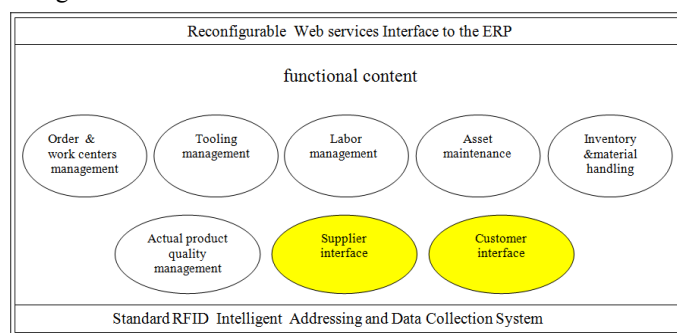


Fig. 1 The SFC logical structure

The structure has two main components [18-21] :

1. The functional content, which will be implemented as software residing on the SFC server
2. The technology content: Reconfigurable Web services Interface to the ERP; Standard RFID Intelligent Addressing and Data Collection System. Such structure takes into consideration the following important priorities:
  1. The core items: orders and work centers management, assets maintenance, tooling management, Finished and semi-finished Inventory, Reconfigurable Web services Interface to the ERP, Automated RFID data collection
  2. Secondary items: Actual product quality management, Labor management
  3. Future upgradability items: Supplier interface, Customer interface. Both are related to the evolution speed of the e-Business and the Supply-Change-Management on the internet

An important concept in the requirement, is that any integration software will be outside the original target functions to be integrated. This is known as business process management/integration. The integration software will reside on the SFC server as an Integration-Hub, as shown in fig. (2).

## III. REQUIREMENTS OF RFID DEPLOYMENT IN E-MANUFACTURING SYSTEM

### A. Introduction

E-manufacturing system combines the power of the new Web-based software technologies (SOA, Web Services, ..... etc.) and the state-of-the-art Radio Frequency Identification (RFID) technology, which offer a unique opportunity to build

a remote integrated systems solving the real time controllability of manufacturing plant. This part of is concerned with defining the requirements for RFID technology and networking to be relevant to pre-defined E-manufacturing system core function requirements.

The four core functions of E-manufacturing system are:

1. The WIP work orders and work center management.
2. The assembly/semi-finished inventory and tracking management
3. Assets maintenance management
4. Tooling management

Each of these functions deploy certain RFID technology some-how to achieve their desired functionality..

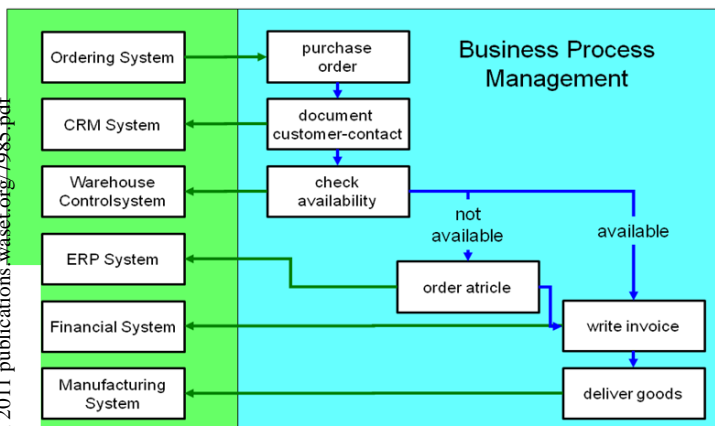


Fig. 2 Illustration of the concept of Integration Hub

### B. Deployment of RFID in E-manufacturing system core factions

#### B.1 The WIP work orders and work center management

This function uses two stages of RFID technology

- Date point
  - RFID fixed reader
  - RDIF tags
  - Touch screen
- Supervisor
  - Hand held RFID Reader/writer

#### B.2 The assembly/semi-finished inventory and tracking management

This function uses three stages of RFID technology

- Date point
  - RFID fixed reader
  - RFID tag
  - Touch screen
- Supervisor
  - Hand held RFID Reader/writer
- Finished/Assembled product tag
  - RFID tags

#### B.3 The assembly/semi-finished inventory and tracking management

This function uses two stages of RFID technology

- Date point
  - RFID fixed reader
  - RFID tag

- Touch screen
- Asset tag
  - RFID tag

#### B.4 Tooling management

This function uses two stages of RFID technology

- Entrance/ Exit RFID gate
  - RFID date reader
- Tooling tag
  - RFID tag

The SFC objects are designed to adopt a Request-action-response model.

## IV. DESIGN OF RFID BASED SFC

The SFC objects are designed to adopt a Request-action-response model.

In this model, Requests are submitted from Business Logic Layer (Represented by Operation manager) that handles Business Operation Process to the RFID Network Layer (Represented by Controller Object) that handle Requests and Create responses as shown in fig. (3).

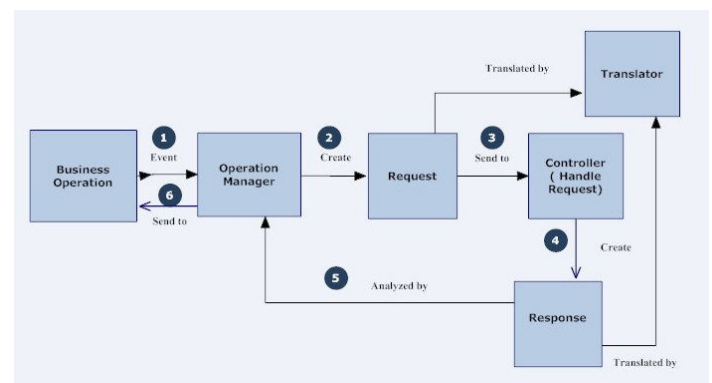
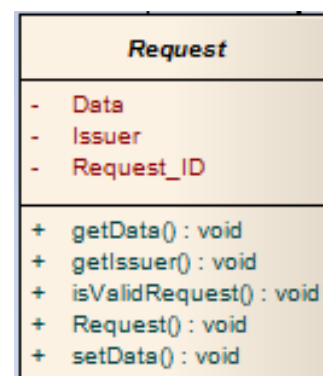


Fig. 3 Proposed design for RFID based SFC

Business Operations (WIP, maintenance, Tolling, and Inventory Tracking) have one or more Operation Process. User Initiates (initiation may be based on pre-set timer on business logic side) Operation Process by initiating an Event. Operation Manager Receives Event From Business operations. Operation Manager creates new object called Request Object to handle the Operation Process. Each operation process of Business Operations has one or more Request objects.

### A. Request Class



This class is an abstract class. The Request contains data sent from Operation Manager, requesting a certain service like;

- Write Daily Dispatch List on Tags.
- Get Dispatch list.
- Get a Machine Status.
- Etc...

Each Request is designed to implement a certain Business Operations Process. Request is formed according to the process type (WIP, tooling, tracking, & maintenance). Each process of Business Operations represented by a Request that contains process details. Operation Manager creates a Request object then sends it to the controller. Controller processes that request then creates a response object which is sent back to the controller. The response can be formed as touch screen or handheld reader.

#### A.1 Attributes

- Data: Holds the data to be processed
- Issuer: Holds request sender identifier. E.g.: Maintenance request, Production Request, ....
- Request\_ID: unique identifier to identify the request, that is used to send a response back to the requester

#### A.2 Methods:

Setters and getters for all class attributes.

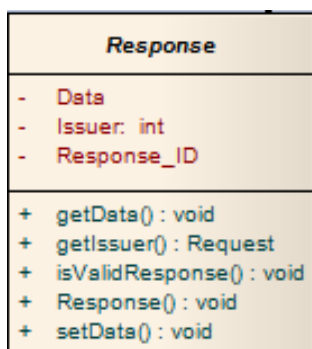
- Get\_issuer(): identify the Business operations process initiator. Knowing the initiator is useful in creating the appropriate response at the other side.
- Is\_validRequest (): validate the structure of request according to its business operation process.

#### B. Response Class

The response is the data sent from the RFID Network Side (Represented by Controller class) to the Business logic Side (Represented by Operation Manager class).

The response object is being created according to the Request. Each response object is a reply to a certain command as mentioned above, that is a Response meets one or more Business Operation Process issued by the Request.

The response also is represented as an abstract class and is inherited by different types of Responses according to types of Requests.



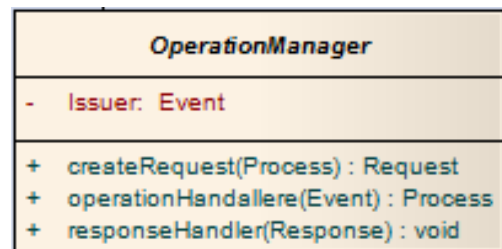
#### B.1 Attributes

- Data: Holds the data to be processed.
- Issuer: Holds an identifier that identifies the sender of the request. E.g.: Maintenance response, Production Response
- Response\_ID: Response unique identifier that is used to send a response back to the requester

#### B.2 Methods:

- Setters and getters for all class attributes.
- Get\_issuer(): identify Request that initiate the event to set the issuer in order to create the appropriate response at the other side.
- Is\_validRequest (): validate the structure of Response according to its Request.

#### C. Operation Manager



Operation Manager has the following Responsibilities:

1. Collect data from Business Operations.
2. Receive Operations Process as Events
3. Create the appropriate Request Object.
4. Send Requests to Controller Object.
5. Receive Responses from Controller
6. Analyze Response and translate it by the appropriate Translator.

#### C.1 Methods:

- Operation Handler (Event):  
Listen to events that come from business Operations and return a process that will be used to create the appropriate request.
- Create Request(Process) :  
Create Response by calling the true type from request types according to the process that produced from operation Handler method.
- Response Handler (Response):  
This method analyze response after receiving it from Controller to extract data from it to send it back to business operation .

#### D. Display class

Responsible of showing tasks on the touch screen for the operator and receive back confirmation from him.

Display can be:

- Touch Screen.
- Mobile Interface.
- Display Object Responsibilities:

- Display Request.
- Display Response.
- Create Response.

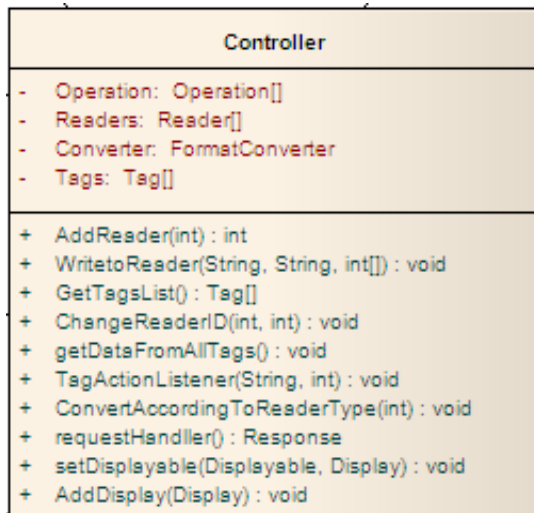
Display Object must have a process logic that helps display to construct a response for each request.

This Processing method must have some methods:

- Construct Response ()  
To build response action from the operator point of view, the deliver it SFC.
- Display request ()  
To display the partial dispatch list on the touch screen.
- Display Response()  
to display response and feedback to operator on the touch screen.

#### E. Controller class

It is the Central controlling component, It is responsible of receiving a request, converting its data to the appropriate format needed by the operation (According to reader type data compatibility).



Controller forwards the request to tags and display screen. Once a response is received, it converts the response into the appropriate format required by the operation requester.

##### E.1 Attributes:

- Converter: Used to convert data of a request or a response from a format to another format according to reader type formats support.
- Readers: Contains a list of the readers whose active is in the system
- Tags: Carries list of tags that belongs to a specific reader

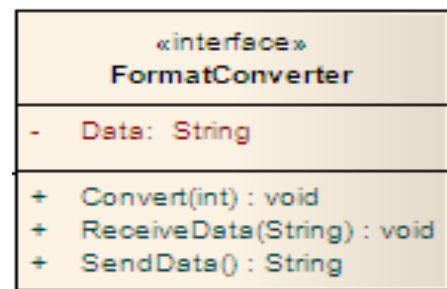
##### E.2 Methods:

- Add Reader (Reader ID): Add a new reader to the system
- Write to Reader(Takes Input: Data, Category, Reader ID List): Send data to one or more readers to be distributed over one or more categories of tags
- Get Tag List: Returns all tags in hold by a specific

reader

- Change Reader ID (Old Reader ID, New Reader ID):  
Change Reader ID of a specific reader
- Get Data From AllT ags: Use readers list stored inside the controller to access every reader and grab the data from every tag under control of each reader
- Tag Action Listener(Tag Category, Reader ID):  
Listen to actions performed on tags and response appropriately
- Convert According To Reader Type (Reader ID):  
Convert incoming data to the format used by the target reader

#### F. Format converter class



An interface to converter data from a format to another format.

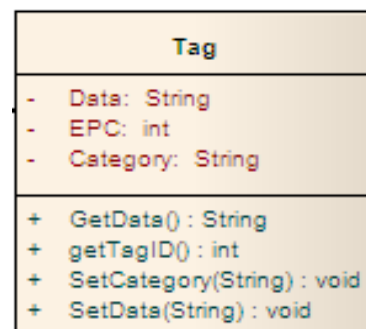
##### F.1 Attributes:

- Data: Used to store incoming data to be converted

##### F.2 Methods:

- Convert (Mode): Converts from the incoming data type to Bytes, Int, etc.. as required by the mode specified
- Receive Data (Data): Takes data and stored it on data attribute as temporary storage for conversion
- Send Data: Send converted data to the controller

#### G. Tag class



A part of a fixed reader, that represents tags being used to store data in different data point.

##### G.1 Attributes:

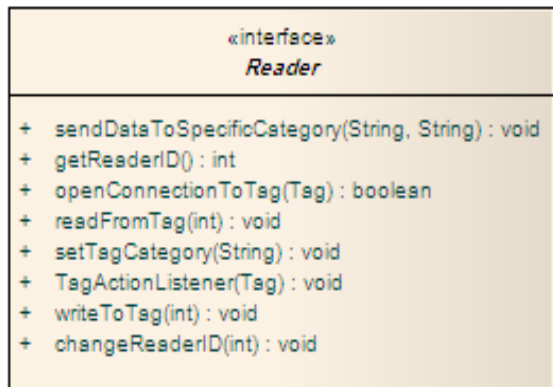
- Data: Carries the information, that stored in the tag memory
- EPC: Carries the tag identification number, a coded number.

- Category: Identify the category of the tag example: Maintenance, Operation, etc..

#### G.2 Methods:

- Get Data: Returns the information stored
- Get TagID: Returns the Tag identification number
- Set Data: write data into the tag data storage
- Set Category: Set the category of the tag

#### H. Reader Class

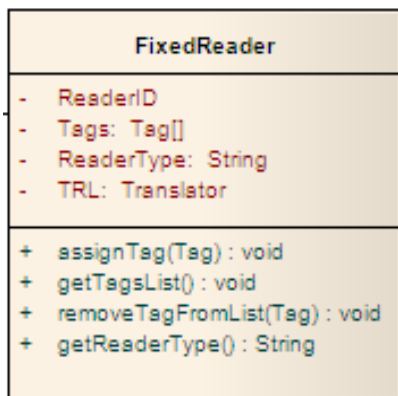


An interface presents Hand held Reader & Fixed Readers

#### H.1 Methods:

- Send Data To Specific Category (Category, String): Save data into tags of specific category
- Create Sensor Session (Tag): Open a session connection with a tag
- Get Reader ID: Return reader ID
- Read From Tag(Tag ID): Read data from specific tag
- Set Tag Category ( Category Name): Set a specific tag into a specific category
- Tag Action Listener (Tag): Actions performed over a specific tag is monitored for immediate response is required
- Write To Tag (Tag ID): Write into a specific tag
- Change Reader ID (Reader ID): Sets a new reader id other than the one created during the creation of the reader.

#### I. Fixed Reader



Represents any fixed reader identifies by its manufacturer, such as Alien, Motorola, etc..

#### I.1 Attributes:

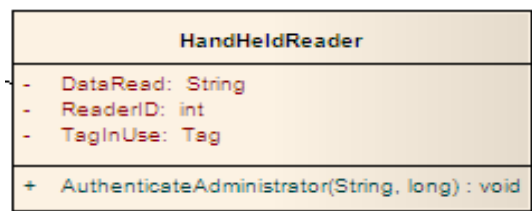
- Reader ID: An reader unique identifier
- Tags: Represents a list of tags under control by a fixed reader
- Reader Type : Indicates the type of the reader which will be used to decide which format conversion is required for the data to be compatible with the reader

#### I.2 Methods:

- Assign Tags (Tag): Assigned specific tag to be under control of the reader
- Get Tags List : Returns tags list controlled by a specific reader
- Remove Tag From List (Tag): Remove a specific from the list of tags under control of specific reader
- Get Reader Type : Returns the reader type e.g.: Alien, Motorola

#### J. Hand Held Reader class

Presents the handheld reader



#### J.1 Attributes:

- Reader ID: An reader unique identifier
- Data: A temporary storage for the data read or data to be written to tag
- Tag In Use : Tag Identifier that is in current session with the handheld reader

#### J.2 Methods:

- Authenticate Administrator (Identifier, Password): Authenticate the administrator to keep intruders outside of the process.

## V. CONCLUSION

This paper proposes the requirements and design of RFID based system for SFC (Shop Floor Control) in order to achieve the factory real time controllability, The detailed logical specifications of the core functions and the design diagrams of RFID based system are developed. Then RFID deployment in E-Manufacturing systems is investigated. The developed requirements and design diagrams presents the bases for developing integrated real time E-Manufacturing system.



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