Application of MVVM Design Pattern in MES

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***Abstract*—**Manufacturing Execution System (MES) is developed for information requirement of manufacturing enterprises. Because of different requirement of MES in different enterprises, almost all MES are developed customized. Therefor how to reduce modified codes and decrease the coupling between view page and data become the key for system development. MVVM design model separates software structure to view, model and view model by XAML and Data Binding of WPF technology. The number of modified codes is dramatically reduced because of the using of MVVM design pattern. In this paper, MVVM design pattern for MES development is introduced and MVVM Framework, principle and advantage are also studied in detail.

Keywords—MES;MVVM;XAML;Data Binding

I. INTRODUCTION

As developing of manufacturing information, more and more manufacturing enterprises have a high requirement to information system of manufacturing processes. Because of more and more requirement of inner product processes, it is very difficult for MES to be common and portable. Most MES needs to be secondary development. To get the target of high coherence and low coupling, how to reduce the secondary development is the key of MES design.

As the development of .Net Frame Work and widely use of WPF, a new MVVM design model has been applied by most developer. MVVM design model can separate business and logic, increase reusability of code. At the same time, it makes program easy to develop, test and maintain [1]. Developer and page designer can cooperate smoothly. It can improve the efficiency of system development. For the enterprises which have the same business logic but different UI demands, developers only need to modify pages but logic for MES in MVVM model. So MVVM design pattern can reduce code amount substantially because of secondary development. Compare with conventional MVC design model, MVVM design model separates pages and logic of pages clearly. Then connects page and logic by XAML and Data Binding technology of WPF. So MVVM design model has its advantage for MES development and reduce amount of code for secondary development.

II. ANALYSIS OF MVVM DESIGN MODEL

MVVM design model is the extension of MVC design model. It optimizes WPF core attributes, such as binding, data Template, command and behavior. In MVVM design model,

View tier communicates with view model tier by data binding And command binding. View model tier reads data from model tier and translates data to view tier for display [2].
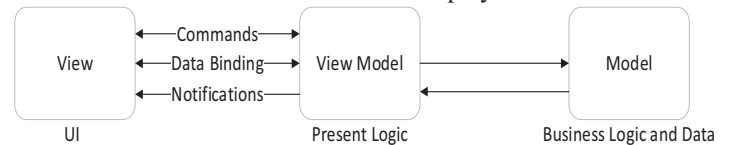

Fig.1 MVVM Class Diagram

MVVM design model can be divided to several tiers as Fig.1.1 shows: model tier, view model tier, view tier.

A. Model tier

Model tier dues with real data and information, records all the business objects and the relations of objects. It mainly realizes secondary package of Business information. By the rule of object-oriented, business information of MES is packaged to business objects which can be read by view model. Such as process objects, workstation objects, staff objects, plan objects, .etc. In a whole MES, model tier is core of system business, and is abstract description of all business. Model tier reduces interconnection of business tier and view model tier. When the business information change, MES can be maintain and update by updating model tier.

B. View tier

View tier is the tier which communicated with customer most frequently, and it displays all the information to customer. Similar to view tier of MVC, users can obtain favorable experience by communication pages in view tier. In MVVM design model, view tier is only for developing pages of foreground. Such as window frame, user control, control style. There is no business and view logic. Therefore, View tier can be designed by those who are only familiar with XAML language. View pages and logic can be developed at the same time. It dramatically increases the efficiency of system development.

UI designer can design initial system model by simple drawing view tier accord to user requirement in MES survey. At the same time, initial system model can be used as final UI of system. View tier is most frequently modified tiers. So view tier is separated in MVVM design model. The influence of UI modification is reduced by this design model.

C. View model tier

View tier's display logic is packaged in view model tier. View model tier don't quote view controls, but bind data and

command of view controls in view tier to view model tier by data Bind technology .it implements loose coupling between view tier and view model tier. The duty of view model tier is coordinating controls in view tier and objects in model tier. So view model tier is the bridge of view tier and model tier. View model tier packages model tier data and supplies interface for data exchanging, makes business data in model tier to display to customer by binding technology. In MES, view model tier meets various kinds of operating commands submitted in view tier. At the same time, process results are feet back to customer and model tier. So we can say that view model tier connects the whole system and separates view tier and model tier. This design model gets the target of high cohesion and loose coupling.

View Model layer is the link layer between View layer and Model layer, in this layer ,the client operating command from View layer is translate to business function which is identified in Model layer, and the business information returning form Model layer is shown to client by View layer. Therefore, View Model layer is the core layer for the whole system performance.

III. OPERATING PRINCIPLE OF MVVM DESIGN MODEL

For MVVM design model, Foreground and background correlate with each other through Binding and Command.

A. Binding

Data Context is a property in view tier control, which is the source of control data. Data Context property assign a background model for control, and the foreground control is banded with background model to insure all data are from the model. View Model provides display data to view. The data source of View Model tier is the business data of Model tier.

B. Command

Routed-Command and Routed0-UI-Command have been established and realized in WPF. For different View event, an ICommand port class need to be redefined. Different events are banged with different View Mode process method. There are two different port: Delegate-Command and Relay-Command.

- Using Raise-Can-Execute-Changed method, Delegate-Command need developer manually trigger control executable judgment, and Relay-Command give the triggered judgment to Command Manager.

- Delegate-Command occupies relatively less resource, but Relay-Command is opposite.

IV. IMPLEMENTATION OF MVVM DESIGN MODEL IN MES

MVVM design Pattern is introduced in MES of discrete industry. Firstly, a MES can be divided to the following models: base data model, quality model, plan model, track model, alarm model, material model, equipment model, data collection model [3]. So there are so many function models in MES, and different enterprises have different requirements for each function model. So design Pattern determines the code amount of redevelopment.

A. Frame design by MVVM design model in MES

Considering scale and modificability of MES, a system is usually developed based on component development. MVVM design pattern is used in components. To reduce coupling of system, and increase reusability of code, we divide the whole system in longitudinal and transverse. The whole function frame is shown as follows.
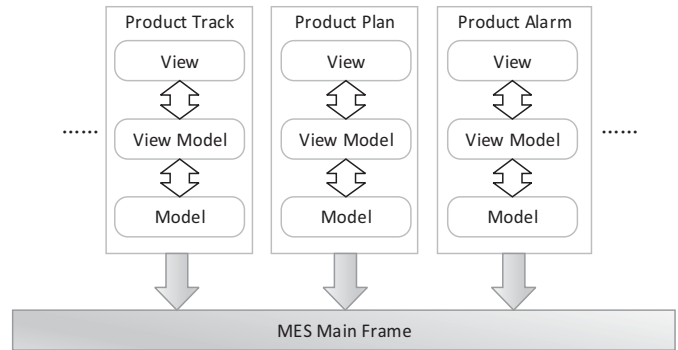

Fig.2 MES Function Structure

As shown in Figure.2, a MES can be divided into several models. Each model can be integrated into system frame dynamically. Each component is designed by MVVM design Pattern. The whole frame can be divided to three level, view tier, view model tier and model tier. By this frame the system is decomposed. Modification can be controlled to a certain tier in a component and scope is narrowed.

B. Realization of MVVM design model

XAML and Data Binding technology are the base of MVVM design Pattern. XAML is basic language of building WPF page file, and Data Binding is a core technology of separating tiers. Those two technologies are introduced as follow below.

XAML is a language which is created by Microsoft for building data and object. In WPF XAML is used to draw view pages [4]. UI designers can directly draw view pages by Microsoft Expression Blend and generate XAML language and import to MES for system view pages.

Data-Binding technology makes MVVM design Pattern can be realized. By this technology view tier and view model tier can be decomposed. Data binding can be divided to one-way binding and two-way binding, one-way binding makes view tier to get data of view model tier, and two-way binding makes data in view tier and view model tier to change simultaneously. Binding process is shown below.
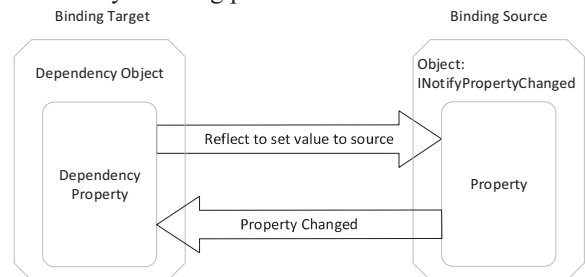

Fig.3 Data Binding Diagram

As shown in Fig.3, Data Binding is communication mechanism between target and source, source notice target to update data by I-Notify-Property-Changed interface. Target attributes denote source attributes by reflection. Binding technology can easily synchronize the data of view tier and view model tier. It only needs to write some XAML sentences.

1) Modeling of model tier:

Firstly, according to requirement analysis results, business processes can be abstracted to different business objects. The business objects are defined in model tier by MVVM design Pattern. Those objects are also the abstract description of base data in database, at last all business data will be stored in MES database. Model tier is a bridge of database and view model tier. It translates gird data with no logic to business objects with business information. It makes view model tier can supply business objects to customer directly.

In different industries production models are different, so business objects are different in different MES. But in different enterprises of the same industry, business is similar. So in MES, model tier reusability is high in the same industry [5]. In discrete industry, business objects such as: staff, department, team, product unit, process, route BOM, equipment, work calendar, product plan, dispatch plan, quality bill, .etc. In model tier, business objects are defined in class. Such as process object is defined in Fig. 2.3. The business objects defined in model tier will be the one binding to UI which is shown to customer. So model tier is core tier of MES data definition
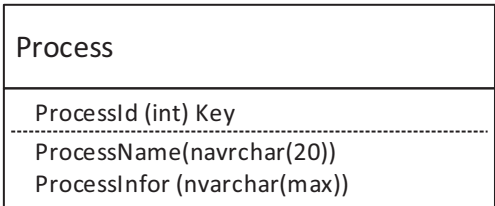
Process
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Fig.4 Process Class

Model layer describes the business object information and achieve business logic for different business objects, and the business processes are different for different business, while business processes at different stage could also be changed. Therefore, Model layer is more likely to be changed. To achieve the loose coupling between business object of Model layer and business logic as well as the loose coupling between Model layer and View Model layer become the key for MVVM design model pattern. In order to meet these requirements, we define business object as abstract class in Model layer, the design pattern for simple factory which belong to establishing design pattern is adapted, and functional operation of the business object class inherits the corresponding business object abstract class. In this way, the dynamic decoupling between business object and business function is achieved. The same business object can be defined as multiple operating function class, operating function class could also be changed according to actual demand for company. As for the link of Model layer and View Model layer, the design pattern for simple factory which belong to establishing design pattern is adapted to achieve establishment

of company business objects. As for View Model layer, design pattern for simple factory is used to achieve uniform calling interface. The Model layer structure is shown as follow:
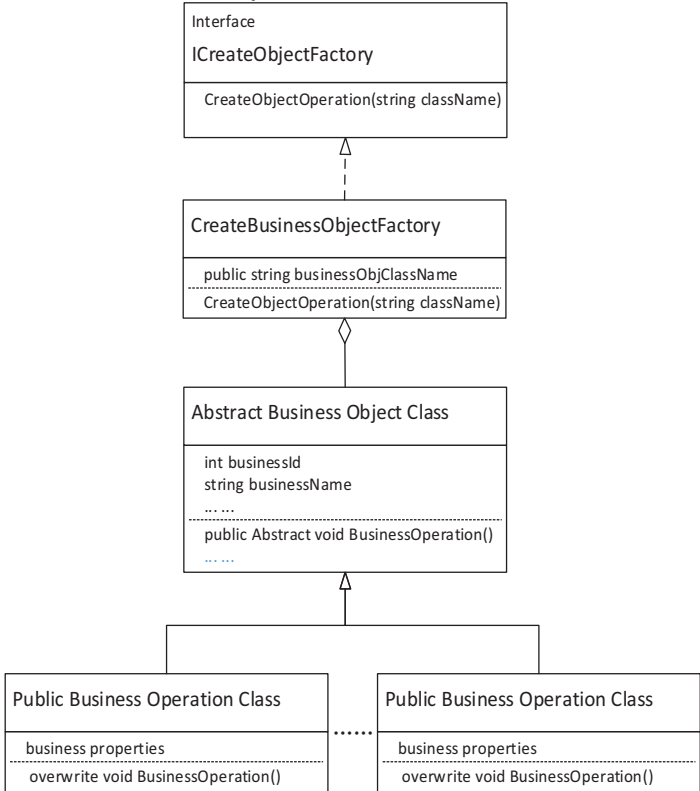

Fig.5 Model Tier Class Diagram

2) Modeling of view tier:

View tier is used to communicate with customer in a MES. First design UI item like window frame, user control with XAML language by UI design tool. Then bind data in view model tier by data binding technology. The optimal code in view page background is only containing construction function: Initialize-Component, without any logic code [6] .When view page changes, background logic don't need to be modified. The view tier create flow as below:

- Analysis customer requirement, create window, page, user control, data complete.

- Define control types in view tier.

- Bind with view model tier by data binding technology.

- Using view model by data context attributes.

In the process of MES system survey and general design, art designer can develop prototype system according to customers' requirement, which is view tier modeling for MES system. The accomplishment of prototype system means the finish of View tier modeling in MVVM design model. After the confirmation of customer's requirement for MES system, prototype system can be imported into MES system as final system interface. By this way, the interface design work are transferred to general design process, the development efficiency is also increased.

3) Modeling of view model tier:

View model just is an abstract view. The logic function of all the controls in view layer are defined in view model layer. View model layer Just have no the really controls. So to the Coders, The finishing of the view model Layer indicate the finish of the view layer. The real view can be pained by view designer. We can user Binding and Command technology to contact the view layer and view model layer.

The function of view model tier is to package display data and operation logic. It contains no visualized elements of view tier. It realizes data binding and commands and denote changing of view state by events. All view models inherit base class of Notification-Object and supply attributes and events by interface of I-Notify-Collection-Changed [7]. Check data by interface of I-Data-Error-Infor. The processes of modeling view model tier are shown below.

- Define view model classes, inherit base class from Notification-Object.
- Define attributes and commands according to visualization elements in view tier.
- Package business data in model tier, translate to data which can be shown in view tier.
- Realize view logic and bind commands to corresponding logic function.
- Supply data checking and error report.

In MES, the real operation and business logic are packaged in view model tier. So the system performance and reasonable of logic are depending on this tier. View Model tier is the core of MES. It needs to receive operations of view pages. At the same time, it needs to communicate with business objects in model tier [8]. In process of MES develop, after understanding requirements of client, developers can directly write codes of business logic in view model tier without waiting develop of view pages.

4) Communication of tiers :

View tier is binding with view model tier by data context attributes. First, define a view model object in an application. Then give the value of data context attributes in application to object of defined view model. Coupling degree between view tier and view model tier is very low. So the current View can be changed by another view if there is no difference between the two Views in Binding and Command. The Communication of tiers like the flowing diagram

All the function operating of business object is packaged in model layer, Model layer provides operation-interface for view model layer, translate relational data of data storage layer to business object, show them to client in view model layer, and translate business information of client to business object and save them in data storage in from of relational data table. The Communication of different layer is shown as flow.

- Client operate the view layer.

- View layer submit the client operation information to the view Model layer.

- View model layer deal with the information and translate them into business object. At last it submit the business information to the model layer.

- The model layer receive the business information and deal with them throw the business functions. Finally, model layer save all information into the data base.

- The information in data base also can be transported to client throw model layer, view model layer and view layer.
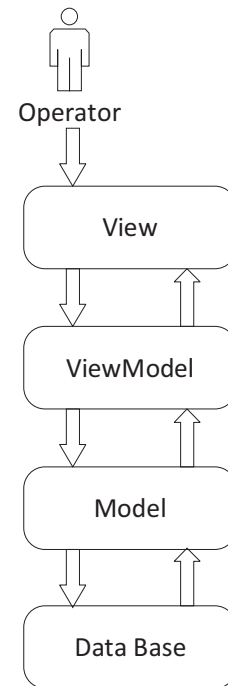

Fig .6 Layers Communication Diagram

5) Advantage of MVVM design model :

For MVVM design pattern, business object and business function operation are in model layer, the loose coupling between company business and system function is achieved, dynamic allocation and load for different company business function is also achieved, and the system is flexible. View layer, View Model layer and Model layer are decoupling in MVVM design pattern, each layer is relative independently developed and tested, and the development efficiency is increased as well as the system performance.

Comparing with MVC design model, MVVM design model divides view tier form view model tier. It makes UI to separate from system. All the logic codes are written in view model tier. It reduces difficult of view tier develop. UI and logic of background can be developed at the same time. When a tier is modified, other tiers don't need to be changed. So the advantages of MVVM model are shown as follows.

- Simplify view tier develop, develop UI and background logic simultaneously, improve develop efficiency.

- Reduce coupling of system, separate UI and logic.

- Improve reusability of system, several view pages can share one view model.

- Hide view code to view model, make system frame more clearly and easy to maintain.

- View layer and Model layer which are most closed to client are separated, so the system modification caused by uncertainty of company client is reduced.

- Simplify test.

V. CONCLUSION

In this paper, MVVM design Pattern is introduced to design MES for discrete industry. MVVM design pattern separates software structure to view, model and view model by XAML and Data Binding of WPF technology. MVVM design Pattern has attributes of high cohesion and low coupling. It reduces secondary development code. So MVVM design model solve th problem of MES must be developed customized [9]. Reduced the effluence of system modification because of the change 0f customer's requirements.

VI. REFERENCES

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