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Research on Process -Resources Dynamic Configuration Model of Digital Inspection Management System

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***Abstract*—Dynamic matching between inspect resources and business processes in digital inspect and MBD (Model Based Definition) environments is a challenging problem. This paper present an approach of building a digital inspection management model based on process-resource dynamic configuration system. Furthermore, the paper described the model from two parts: one was data interaction among inspection, plan and manufacture, the other was process-resource dynamic coupling. It implemented data exchange by the data interaction technology based REST. Then it achieved through the dynamic configuration technology of the process-resource configuration based on the workflow engine. The digital inspection management system was developed to matching process and resource on the basis of the model. Finally, an example of the measurement business management module was provided to validate this model.**

Keywords*—*inspect resource; dynamic configuration; workflow engine; digital inspection management system

I. INTRODUCTION

Today, digital measurement technology has been increasingly applications in the field of modern manufacturing with the rapid development of design and manufacturing technology. Compared with the conventional analog-based and manual measurement mode, a large number of digital inspection equipment such as CMM (Coordinate Measuring Machine) and laser tracker are in the application of the digital detection technology to achieve the automatic acquisition of inspection data, information storage and efficient transmission. Paradoxically, diverse equipment and huge amount of data collected leaded the complexity of the association between inspection resources, such as different types of equipment use different measurement procedures, measurement methods and theoretical data. The above characteristics are not available in the detection technique based manual. It was based on manually collect data, matched inspect resources semi-automatically, determine inspect results to a single criterion. This make detection management system correspondingly not adapt to the transmission mode of the MBD (Model Based Definition) dataset in the collaborative manufacturing system and not solve the problem that feedback digital model defects and configure inspect resources flexibly.

Establish a resource dynamic configuration system with flexible workflow as the center was tried to by many scholars to realize the dynamic coupling between the resources and the business process and to solve the information silos among design, manufacture and detection. There are many attempts to use models or algorithm to fulfill the flexible of the workflow. The multi-autonomic objects flexible workflow based on autonomic computing technology realized the intelligent flexibility of the workflow through the collaborative work of the multi-autonomic objects embedded in each workflow activity [1]. Furthermore, workflow had to adapt to constantly changing business conditions. Establishing a criterion that ensure compliance of in-progress workflow instances with a modified workflow schema can make it true that such changes can be propagated to already running WF instances, but without causing inconsistencies and errors [2]. And leveraged ideas from the Open-Water approach into 3-tier architecture and achieved a workflow support combined with adaptive workflow management to create a flexible workflow support and management system was proposed in [3]. In terms of algorithms, two examples are the component adjustment algorithm based on reconfigurable process model and componentization achieving the separation of process logic and business logic [4], the approach based on SWN(Stochastic Well-Formed Nets) models for formal Modelling of a dynamic reconfiguration on CBS(Component-Based Systems) that allow quantitative analysis [5]. Unfortunately, those attempts only limited to the process itself, however, ignore the significant part that realizing the dynamic configuration of data linking to the process.

The above research results achieved the flexibility of the workflow itself, adapt to the needs of real-time changes in the process of data and achieved dynamic correlation between data and process. However, the scope of the study is limited to a single-system data and processes dynamic configuration, which cannot achieve information exchange among multiple systems. Besides, the dynamic configuration algorithm was highly correlated with the process. And the algorithm logic was quite complicated and was difficult to update for the complex detect resource relationship configuration, which lead to the decrease of flexibility. So it was a good strategy to build a inspect business management system that was suitable for multi-system data interaction and low resource allocation.

II. INSPECTION DATA AND DESIGN DATA, MANUFACTURING DATA INTERACTION MODE

According to the forms and functions of existence, manufacturing enterprise data management model can be divided into physical layer, management layer and data layer.

Inspection data and design data, manufacturing data interaction model was shown in Figure I.

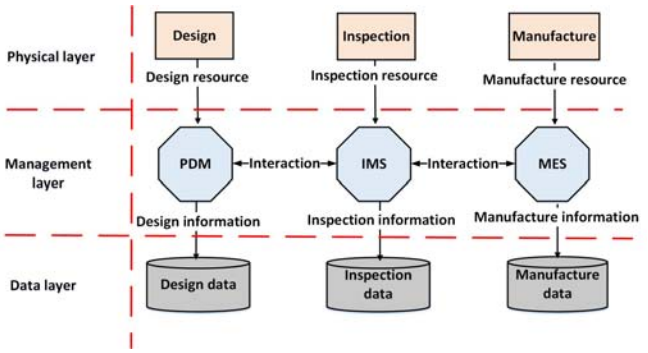

FIGURE I. INSPECTION DATA AND DESIGN DATA, MANUFACTURING DATA INTERACTION MODEL

The physical layer represents the physical department, the management layer represents the information management system corresponding to the physical layer, and the data layer represents the data storage system corresponding to the management system. Design resources produced by design department of the physical layer were transformed into the information resources by management PDM (Product Data Management) data and stored in the data layer as design data; the manufacturing resources generated by the physical layer manufacturing process were transformed into manufacturing information resources and stored in the data layer as manufacturing data through the MES (Manufacturing Execution System); the inspection resources generated by the physical layer inspection process were transformed into the manufacturing data and stored in the data layer by the management layer 's IMS (Inspect Management System), so as to realize the longitudinal data transfer among the design, manufacture, production. At the management layer, real-time information exchange between inspection and design and production was achieved through data exchange between IMS and PDM system, MES system. The detail realization method is as follows: digital design resources such as model data and product data was transmitted through the PDM system to IMS system achieving data exchange between design and inspection; production resources transmission to the IMS system through MES to achieve data interoperability between production and inspection; IMS collected and analyzed the measurement data in the form of XML, TXT, and pictures in inspection resource automatically, and fed back the analysis results and existing problems into the PDM and MES systems to form a complete resource interaction closed loop for design, production and inspection.

III. DATA EXCHANGE BETWEEN DIGITAL INSPECTION SYSTEM AND DESIGN, PRODUCTION

In the enterprise, MBD data was transmitted along the path of design → production → inspection. The key to achieving data transmission completely and rapidly lie in that the data interaction between different systems was Seamless convergence. The data set in MBD was structured in the PDM system. That is to say, the characteristic information such as shape and material of a single part was stored in the database in a form of single data element. In the aspect of data exchange between design and production, we adopt the REST (Representational State Transfer) service architecture based on Resource Oriented Architecture (ROA) to publish the process resources and business entity resources as services to the rest service layer. In REST [6] service, any resource is an entity that can be identified by a unique Uniform Resource Locator (URL), which can be accessed via HTTP (Hyper Text Transfer Protocol) [7]. The service layer assigned a unique URI (Universal Resource Identifier) to each resource. When data interaction was required, the service client send HTTP method information including POST, GET, PUT and DELETE to the target system at the Web layer. Then it requested service to the rest service layer via the Resource Request Handler and get the requested resource based on the URI. Resources will be converted resources into making the browser available through Browser Requester Handler by the server and fed back to the client. The data type of the resource can be JSON (JavaScript Object Notation), XML (Extensible Markup Language) or RSS (Really Simple Syndication). JSON is a lightweight data exchange format. RSS is a format for describing and synchronizing website content. REST operating mechanism was shown in Figure II. The realization process of the data interaction between the digital inspection system and the design and production is that the inspection and management system obtains the MBD model information of the product object in the PDM through the Get service according to the URI and stores the information in its own database. Meanwhile, the MES in the task allocation information were get according to the URI through the Get service and loaded into the task panel. Finally, the inspection management system assigned the measurement results and the data set defect information to a specific URI, so that the PDM and the MES can obtain the corresponding information through the Get service to achieve the complete loop of the data interaction.

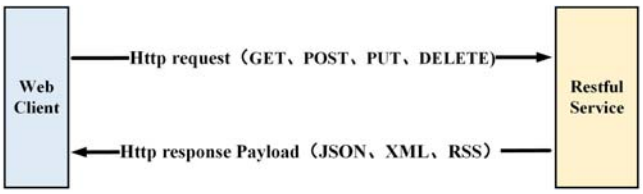

FIGURE II. REST OPERATING MECHANISM

IV. DYNAMIC CORRELATION BETWEEN INSPECTION RESOURCES AND PROCESSES

Inspection resources can be divided into inspection business resources and inspection data resources. Inspection business resources included the inspection object, inspectors, inspection equipment and other related resources. Inspection data resources were consists of forms, data and other related resources. Each resource in the inspection business resource and the inspection data resource was given a unique identifier that make it unique in the resource-process relationship mapping table. Process - resource unique identifier assignment rules was as shown in Table I.

TABLE I. PROCESS - RESOURCE UNIQUE IDENTIFIER ASSIGNMENT RULES

Name	Basic Element	Unique Identifier
Inspection business resources	Inspection object	inspection object number
	Inspectors	Inspectors' ID
	Inspection task	Task's ID
	Inspection equipment	Inspection equipment's number
	Others	URI
Inspection data resources	Form	URL(Uniform Resource Locator)
	Data	Data's number
	Measure programmer	Measure programmer's number
	Measure method	Measure method's number
	Others	URI
Flow	Business flow	Business flow 's ID
	Flow node	Flow node's ID

The description of the process-resource dynamic configuration process was as follows:

1) Obtaining inspection data from PDM and MES through REST service and converting it into the resources in the system as basic data for inspection;

2) Assign the inspection data resources and inspection business resources with a unique identifier and store them into the corresponding resource mapping table;

3) Concrete the inspection business resource mapping table and the inspection data resource mapping table into a dynamic business configuration table and a business service dynamic configuration table in the database, and associating the resources with the process node through the process configuration engine in the process designer;

4) The data resources processed in the system were fed back to the PDM and MES system through the REST service.

V. APPLICATIONS

The application of part measurement business management module of digital inspection management system in the measurement department of a manufacturing enterprise is used to illustrate the realization process of the process - resource dynamic allocation mechanism. This department undertook the whole company's digital inspection tasks, which had a larger of the daily average measuring volume and a wide range of inspection objects. Besides, highly requirements about analysis and feedback was required and the types of measurement equipment selected and types of the same kind of inspection data acquisition equipment were very different in the same process. And at the same time, due to the fact that it is in the process of digital inspection technology being promoted in an all-round way, the business process changes frequently and the inspection resource type has a short update cycle. It is urgent to solve the problem of data transmission in the MBD data model. Therefore, the digital inspection management system based on flexible configuration of resources become the best solution to solve the above problems.

Part measurement business management instance model was illustrated in Figure 3. Delegated measurement information and inspection device information were passed from the PDM and MES systems to the part measurement business management module through the REST service. The measurement data in the part measurement business management module is transmitted to the SPC module for data analysis, and the exception information is fed back to the PDM and the MES in real time. At last, the measurement results were delivered to the MES system through REST services, forming a closed loop of data exchange between inspection and design, production. The workflow engine generates the first version of the part inspection business process according to the requirements, and then couples and associates the process nodes with the corresponding inspection business resources and inspection data resources. This module supports both the process of submitting scan code and the batch operation of process nodes in order to adapt to the requirement of making the testing business digitally and intelligently. The application of this system realized the real-time dynamic configuration of business processes under the condition of business processes and inspection resources' constantly updating and solved the problem of how to achieve the barrier-free transmission and rapid feedback of datasets in MBD environment.

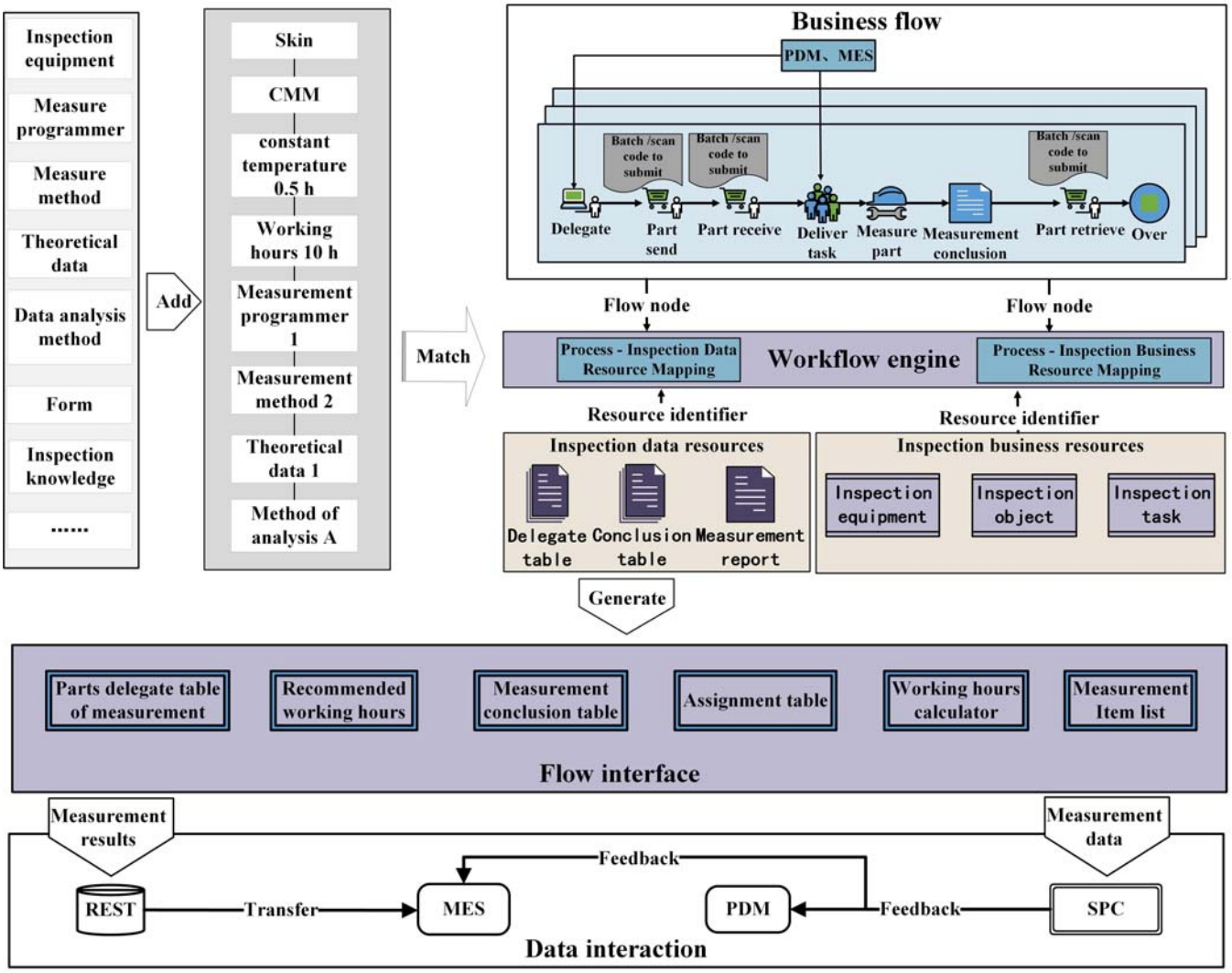

FIGURE III. PART MEASUREMENT BUSINESS MANAGEMENT INSTANCE MODEL.

VI. CONCLUSION

This paper presented a digital inspection management model based on process-resource dynamic configuration, elaborated the operating mechanism of the model, the representation of the model and examples of system application. The model realized the real-time interaction of data between inspection and design, production, and achieved the dynamic coupling of resources and processes in order to adapt to the development of digital detection technology and the continuous advancement of intelligent manufacturing in manufacturing enterprises. Based on the model, we developed a digital inspection management system and achieved good results in the enterprise application.

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