DESIGNING PRODUCTION SYSTEM USING SERVICE ORIENTED ARCHITECTURE (SOA) CASE STUDY IN AUTOMOTIVE MANUFACTURING

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ABSTRACT

Management system development in a manufacturing company is very complex, this is because the business conditions in the company is very flexible, so it requires the concept of developing a flexible and reusable system. The concept of enterprise architecture is now entering a level that can be considered very tough to apply to manufacturing companies that business looks very volatile. In addition to highly competitive business issues, another problem is the very high investment infrastructure that requires an infrastructure service that expenses the cost in accordance with its use. The concept of enterprise architecture using SOA is a method that can accommodate the development of existing systems in manufacturing companies based on service oriented. Then, viewed from the side of the production system concept, generally the automotive company uses the TPS concept, namely the Toyota Production system, this concept in general is to develop products based on continuous improvement, so that the production process will continue to evolve to adjust customer needs. to support sustainable improvement, the concept of developing a flexible and effective system is needed. This SOA architecture can be used to support such production system concepts, so companies can continue to develop the production process without being hindered by the development of a complex system.

Keywords: *Enterprise Architecture, Manufacture Production System, Service Oriented Architecture.*

1. INTRODUCTION

Automotive manufacturing companies generally have almost the same process and the products are 4-wheeled vehicles of various types. Automotive manufacturing companies generally has 5 factories that move according to their functions. The first factory produces vehicle frames, the second factory produces the raw material for making machinery, the third factory is the place for assembling machines, the fourth and fifth factories are assembling all components of the vehicle so that the product can be operated. In business, the vehicle production process is supported by various functions or divisions and other departments that are interrelated with each other. Among them are production planning, logistics, quality and the production division itself.

Each function in the production process is supported by various kinds of information systems, both starting from the production planning process to the product sales process. All information systems in each of these functions refer to the same core system, namely the production system. But the current condition of each division is focused on developing an information system individually or in other words, wanting to develop an information system in its own way. The result is the different in platform between information systems, diversity of programming languages, different database platforms, and other fundamental differences. Case studies on the writing of this study are focused on the processes that occur in production systems and production supporting information systems at Automotive manufacturing companies where production systems are core systems or data sources that will be used by supporting information systems to make the production process more effective and efficient. The main function of the production system is to record all production activities and provide instructions to the machine to make production. Other positions, supporting information systems have the main function of providing additional references to the production system for production. Current conditions, there is a connection between the production system and supporting information systems, but it is not well integrated, so that when a system develops, it is necessary to make major changes to each related system, both from the production system as the core system and the system supporting information that you want to develop. This is considered to be less effective and has considerable risk in the production process. So it is necessary to change the paradigm to change the mindset of functions or divisions from the beginning of individual development into integrated development. Service Oriented Architecture (SOA) aims to harmonize business processes with the use of IT, in this way can making it possible to integrate between several Information Systems in an organization [1]. SOA can help organizations develop logic and share data between software developed on different platforms easily. SOA can break down the complexity of the application into the components that have been standardized so that it can be combined and reused to deal with changing business situations, and give business opportunities to be flexible and agile [1].

I. Literature Review

Service Orientation Architecture (SOA) is an architectural style that supports service orientation. This definition focuses on the architectural style, service orientation, service and features that stand out in SOA. Organization for Advancement of Structured Information Standards (OASIS). Defines SOA as a paradigm that is used to regulate and utilize distributed capabilities that might be under the ownership control of a different domain. The definition mentioned by OASIS includes something called a "reference model". The reference model in question is the details of the definition that is expanded and formalized ([1]. The Service Oriented Architecture (SOA) approach does not have the standard principles used for the development of the SOA. Some of the principles often used in connection with the SOA approach are found in the discussion below [2]:

Principle 1*: Service can be used again*

Development of systems that use the SOA approach, services are designed specifically to support reuse according to their needs.

Principle 2*: Service provides a formal contract*

Service does not require any division in development that uses the SOA approach to be able to interact with services. Service requires a formal contract that can describe each existing service and determine the requirements needed for the exchange of information that occurs.

Principle 3*: Service is a free partner*

Service specifically in the SOA approach is designed to be able to communicate between services without the need for interdependence.

Principle 4: *The essence of service is underlying logic*

The only part of the service seen in the outside world in the application of the SOA approach is the things displayed through the service contract. The basic logic beyond this is stated in a description consisting of contracts that are not real and irrelevant to the request of the service.

Principle 5: *Service can be described*

The use of SOA causes services to be able to arrange other services. This allows logic to be described at different levels of granularity and promotes its use again and the arrangement of the essence that is in the layer.

Principle 6*: Service is autonomous*

Logic that uses the SOA approach is influenced by a service placed on a boundary that cannot be seen. The service will control this limit and to execute it does not need to depend on other services.

Principle 7*: Service is stateless*

Service based on SOA does not have to require state information settings. This is because the state can block the service's ability to join or integrate.

Principle 8*: Service not detected*

The service designed must be able to allow a description of the service itself within the system that has implemented SOA to be able to find the service and can be understood by humans and the service applicant who can use logic in the service.*Cloud Computing*

A. Relationship between Components in Service Oriented Architecture

The discussion of the relationship between components owned by a service orientation can be explained as follows [3]:

[1] An operation will send and receive a message to do a certain job
[2] An operation can be determined by a message process that is related to the capabilities described in the statement above
[3] An operation classifies a collection of operations that have interrelated relationships
[4] Ability above causes a service to be determined by certain operations associated with it.
[5] An instance process can arrange a service.
[6] An instance process that is considered not important can be determined by the service. This is caused by the need for some of the functionality offered by the service.
[7] An instance process calls a group of services that are unique to a particular operation to be able to complete the related automation process.
[8] Ability above causes each instance process to be determined by part of the service operation used by it.

B. SOA benefits

1. **Speed**

In SOA, business processes are broken down and simplified in the form of smaller services. Dependence that exists between services must be minimized. So that if there is a change in a business process, enough related services are subject to change, no need for the whole system. In this way, the system can respond to change quickly [3]

2. **Real-time responsive**

In the services stored business rules and restrictions in business. And these services are stored and managed on an application server called ESB. So that various types of applications can access the business rules. If there is a change to the business rules, ESB will manage it automatically. So that new business rules will apply at that time [3].

3. **Savings**

Although initially the implementation requires a large amount of money, the implementation of SOA enables the development of a centralized system, so that there are many resources that can be reduced. Thus reducing costs [6].

4. **Independent channels**

Business deals with many parties, both customers and suppliers. Various parties that relate to the organization of course allow for different types of applications. With service and ESB, it is possible for various applications to access defined business rules. So that the parties related to the organization no longer depend on a particular application [3].

5. **Shorter development time**

In SOA, business processes that are broken down in the form of smaller services allow for changes and development in certain services. Because development is carried out in a focused manner, less time is needed [3].

6. **Reducing duplication**

Service in SOA is managed on an application server called ESB. Because the service is managed centrally, this will reduce the possibility of system duplication. In addition, service forms that allow reusability also reduce the presence of the same functions that exist in a system [3].

C. Service Oriented Modeling and Architecture (SOMA)

SOMA is a software development life-cycle method that was discovered and developed by IBM to design SOA-based applications. SOMA defines key techniques, as well as the role in an SOA project and its work breakdown structure (WBS). This WBS contains tasks, input and output products for these tasks, as well as instructions needed to deeply analyze, design, implement, also when the service deployment, components, and flow are needed in building strong SOA solutions and reusable[4]. The SOMA method focuses on how an application is made based on the business side that runs. Broadly speaking, SOMA consists of seven main phases as shown in the figure below [4]. SOA implementation using web services has been proposed by [5].

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2. RESULTS AND DISCUSSION

Step 1 : Business Modeling & Transformation

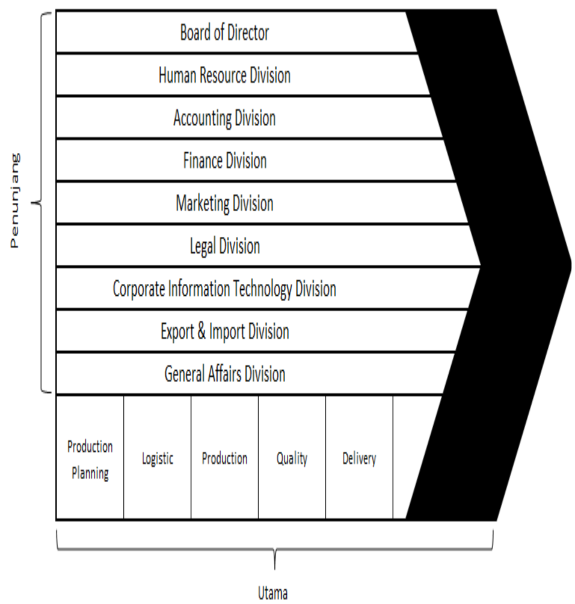

Figure 3. Business Modeling & Transformation

From the picture above it can be seen that Company X has main functions and supporting functions, but supporting functions function as complementary main activities such as BOD, HRD, Accounting and others, each function has a different role according to its interests. there are major processes in business modeling and transformation are production. this process is also supported by the production sub-process. in this paper the author does not discuss all processes, but only focuses on the main processes and sub-processes of production.

To focus more on the main processes in company X, a component business model needs to be made, so that all the main functions can be mapped properly. The following is the component business model of company X :

	Production Planning	Logistic	Production	Quality	Delivery
Direct	Production planning & Schedule	Part Order planning	Production Process Planning	Quality Target Planning	Target Delivery
Control	Production Achievement Monitoring	Part Delivery Control	Achievement control	Defect monitoring	Delivery Achievement Control
Execute	Fulfill production target with less problem	Part Supply to production	Production Process	Quality Inpection Process	Delivery Process

Figure 4. Component Business Model

Figure 4 explain about business components at Company X is derived from the previous value chain diagram. Based on the CBM diagram above, the Achievement Control process is the focus of this paper, of course it will be integrated with monitoring defects in the quality checking area. Based on field studies, control defects are still limited to data in the quality area, whereas actually the defect data in the unit needs to be matched by the ongoing process in the production area to help parties related to the defect easily analyze the causes of defects.

Step 2 : Solution Management

In the second stage is a solution management which is the stage where the stabilization of the solution is determined by defining the solution used, the application involved in it and the part that participates in solving the solution. The results of this stage will be in the form of a Solution Template.

Based on ongoing business processes and has been described in previous Business Modeling and Transformation It can be seen that there are problems that occur in both of these systems, namely the unintegrated two systems, which makes it difficult to maintain data on these two systems, and requires a very large effort if you have to display data in an integrated manner. Besides that the

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difference in database platforms is very influential in the data management process. Then the very basic thing is the difficulty in developing a system for quality information systems. Therefore SOA will be used as the basis of architecture to provide data that is integrated between the production system and the quality information system available at Company X, so that the data management process becomes easier. In addition, the SOA method can eliminate dependencies between applications with other applications. Then from the basics above comes the solution to realize the system integration architecture for each platform, as follows:

No	Nama System	Bahasa Pemrograman	Basisdata
1	Production System	VB .NET	SQL Server 2008
2	Quality Information System	Delphi	Oracle
3	Web Service	PHP (RESTful)	-

Figure 5. Solution for Production System Integration and Quality Information System Templates

Based on field studies at Company X, has obtained an overview of the main activities at Company X. This company has the main activity, namely the production of car units where the production system records every process that has been passed by the unit. The flow of business processes produced by Company X starts with doing production planning, namely division planning doing planning about the number of units that will be produced, then divided into months, then divided into days. From the planning, the logistics party can already plan the part that will be ordered. The following figure 6 below is a rich picture of the production system that is running.

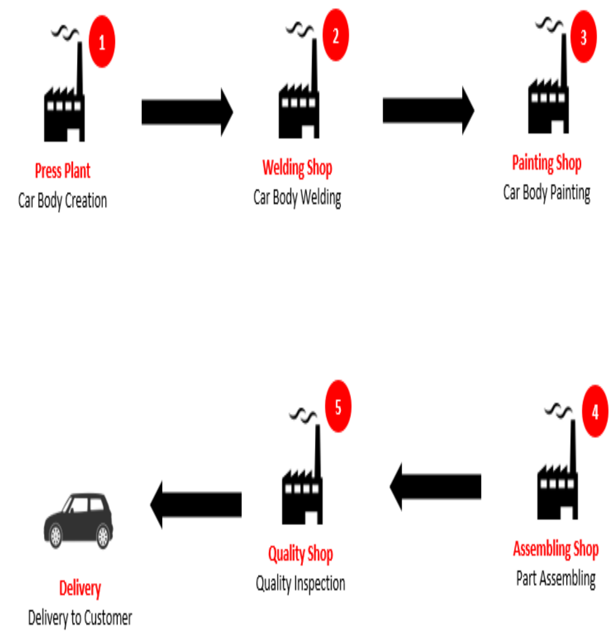

Figure 6. Business Process

Then the next process is the assembling process, where in this shop the assembly process begins. Starting from small parts to large parts mounted on the body unit. In this shop the system starts to record the body frame number and time of entering the shop, this is also similar to the previous process, but there is one difference namely, in this shop, in addition to recording the order number and time of entering the shop, also conducted reordering the unit, which aims to adjust the availability of parts, so that production does not stop if the required parts are not available.After all the parts have been installed then the quality checking process begins. This shop quality will be the subject of discussion in this thesis, where the shop quality check will not only record the order number and time of shop entry, but also record defects or defects in the quality of the unit, both in body and parts attached. in the unit. In this shop there are two systems that have interdependence but different systems, namely the production system and the quality information system.

Following is the flow of the quality checking process at PT. XYZ

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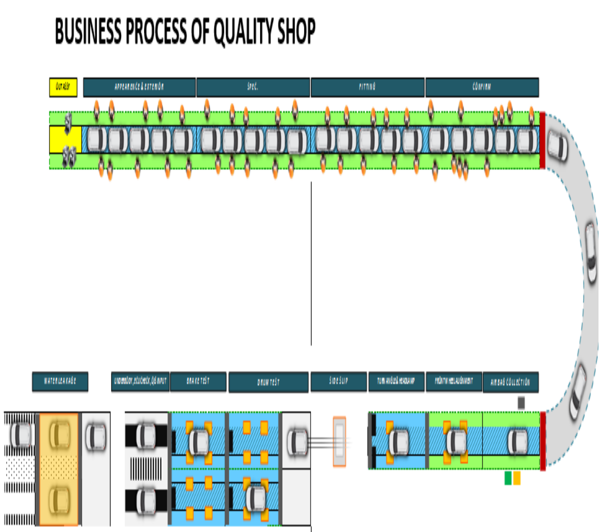

Figure 7. Business Process of Quality Shop

In the picture above explains that the quality checking process at PT. XYZ has several main processes namely at the beginning of the process, the unit is recorded order number and time of entry, then check appearance or check the appearance of defects in the body unit, currently the checking process is done with paper, namely by recording defects if there are defects in the unit being checked. Then the next process is the exterior and interios unit checking process, in this process also carried out by using a checksheet that has been provided by the quality department, this checksheet certainly meets the quality checking process standard. After checking the exterior and interios, the next process is checking the unit specifications, whether the units in the area are in accordance with their respective specifications. This process is also carried out using a standard checksheet. Then the next process is checking the function of the features that exist in the unit, this process is also done using a standard checksheet, in this process in addition to being carried out by the operator, this process also requires assistance by standardized tools, for example i for checking machinery, brakes, and checking safety. After all processes are completed, the quality information system will input the data. In the data input process, the operator scans the unit number and then input the defect according to the existing checksheet. Next is the display of the quality information system.

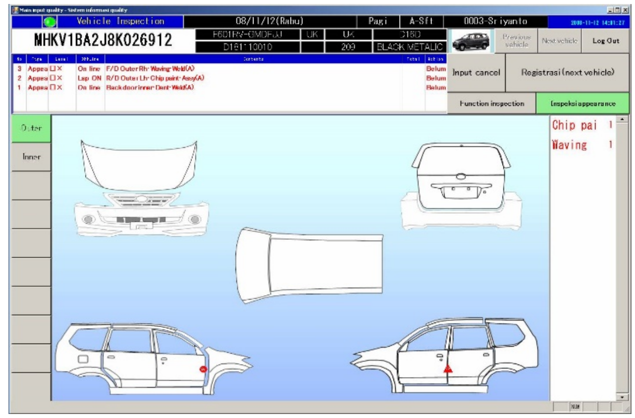

Figure 8. Information System Quality XYZ

At this stage the production system is interpreted into a use case diagram that illustrates what processes occur and relates to the user who is the actor. Here is a use case diagram of the production system at PT. XYZ:

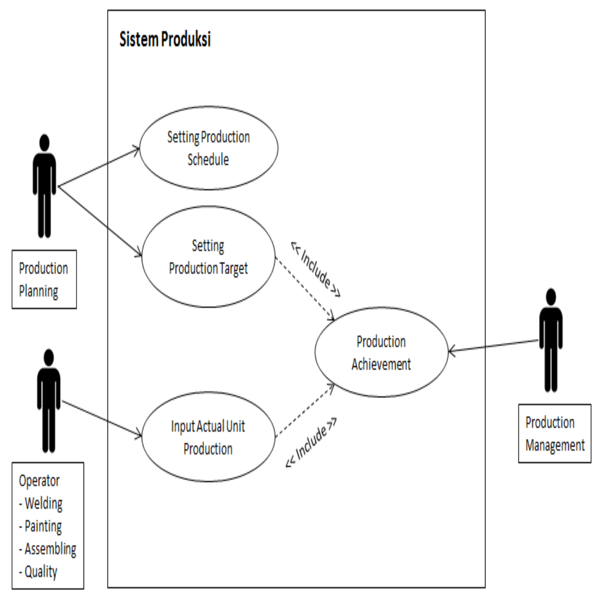

Figure 8. Use Case Diagram Production System

In the picture above it is known several actors in the production system. Each actor has their respective functions. The picture above is the core activity of the production system currently running at PT. XYZ Other activities are not the focus and are not explained in this picture. The first actor is production planning, which is the person doing production planning, starting from determining the number of units produced to setting production targets per day. The production target, of course, was agreed upon by top management. Then the second actor is the operator, the operator here is the actor who acts as the motor of production, meaning that without the production operator it cannot run normally. In the production system that is run at PT. XYZ, the operator's role as input to the actual unit data so that it can know the actual number of units to be produced. Then from the target determined by production planning, the number is compared by the actual data that has been inputted by the operator in each shop. The data is processed so as to create a production achievement that will be seen by management as a reference for further production planning.

Step 3 : Identification

At this stage the three main techniques used are Conduct Goal-Service Modeling, Decompose Domains, Refactoring and rationalize services because at this stage the top down approach is used.

a. Goal Service Modeling

Goal service modeling in the case study design of production systems based on service oriented architecture (SOA) is to provide convenience for the process of processing data produced by production systems and production support systems. In addition, using the SOA method is expected to facilitate the ongoing system development process

b. Decompose Domains

At this stage decomposition of the previous business process is carried out, namely in the process (Business Process and Transformation). Every business process will be decomposed to produce service components that will be used

Figure 9. Deomposition Modeling at Production Domain

In the picture above explained about the decomposition process in the production domain, namely the main process of Company X. In the process there are several processes that support the production process, including production planning, where the division planning will make production planning according to the number of orders set by the top management, then the planing division prepares a production schedule that has been approved by management.

In addition to the production planning process, there are also production activities themselves, where there are 4 main processes in this process, namely: the process of making a car body, then welding the body that will form parts into one whole, then the body is given color according to the customer's request, and installed parts that support the formation of a vehicle, both small parts and large parts in the assembling process. Then the no less important is the quality checking process so that the products produced are truly standard and of high quality.

In the production process there are several processes including: actual data input, so that the production results can be reported, then the unit tracking process, so that if a problem occurs in the unit, the production team can easily find the location of the unit in which the problem occurred. Then to support the running of the production process, the operator requires an instruction to install parts that are in accordance with the specifications of the car

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to be built, this process is supported by the instruction process. Then the next process is the production process reporting process, the top management wants reporting in real time, as well as summary, to be able to make decisions on production planning in the long term.

Domain decomposition on domain quality is as follows:

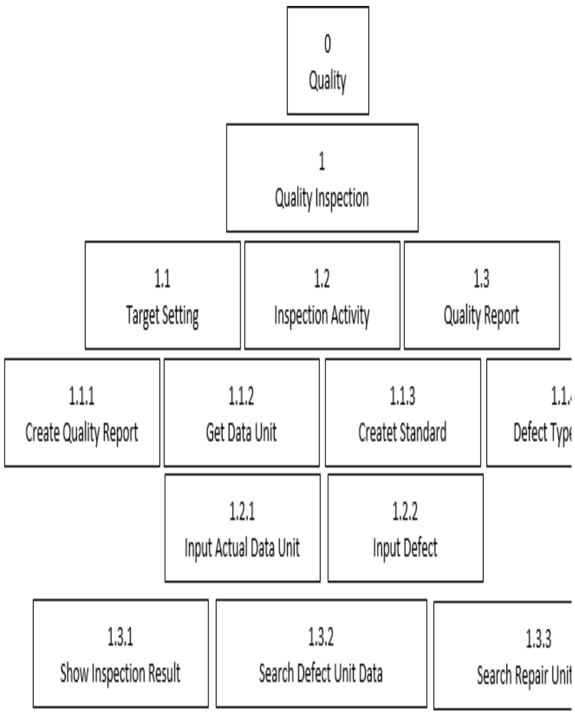

Figure 10. Decomposition Modeling at Quality Domain

c. Refactoring and Rationalize Service

This stage is the final stage of the identification process which functions to define any services from the information needed by the current application which will later form a service portfolio.

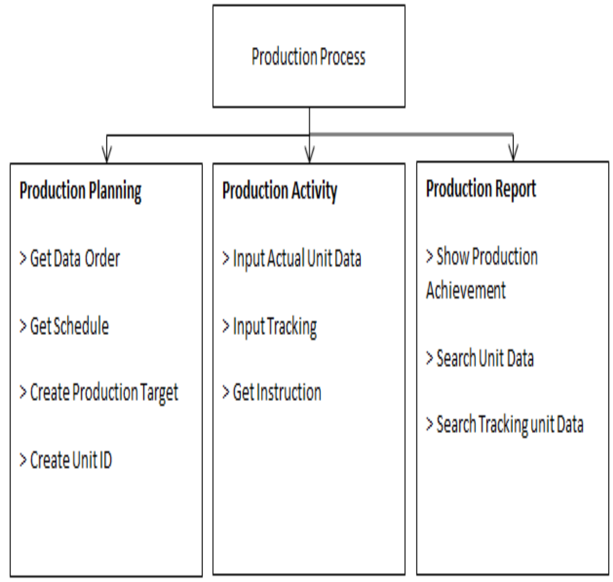

Figure 11. Service Identification at Production Process

In the picture explains the service identification of the production process of Company X, the service that will be built is Get data order, Get Schedule, Create production target, make unit number, actual data unit input, tracking unit input, get instruction, display production results, search unit data, search unit tracking data.

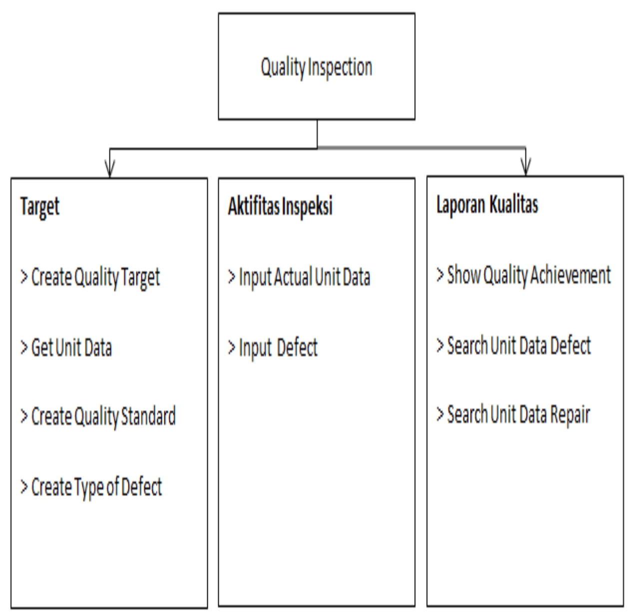

Figure 12. Service Identification at Quality Process

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In figure 12 describes service identification on quality inspection, where the service to be built is to create quality targets, get data units, create standards, set types of defects, actual data input units, input defects, display inspection results, search unit data defects, search data unit repair.

From the two images, then the service is mapped by forming a service layer. Next is the service layer from the results of the two processes above:

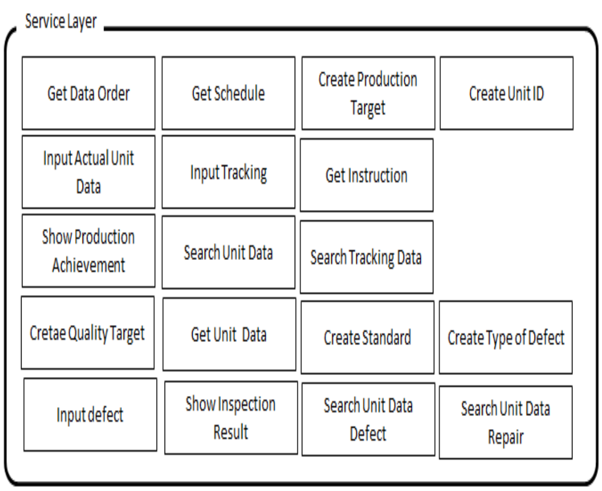

Figure 13. Service Layer

Figure 13 describes the service layer that has been built by adopting two business processes, namely the production process and the quality inspection process while the service that can be re-used is:

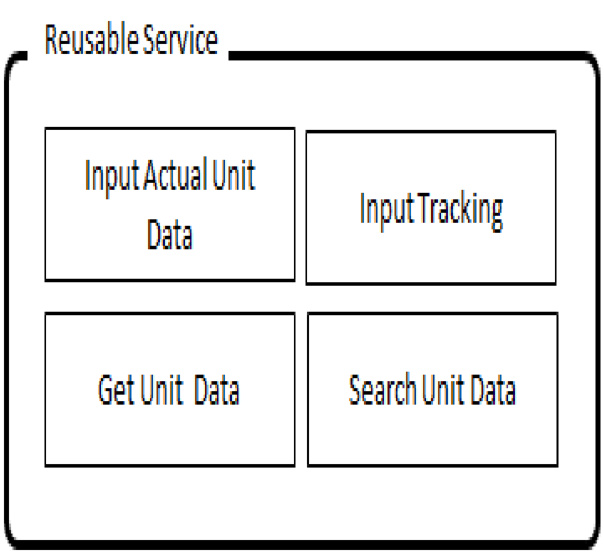

Figure 14. Reusable Service

Figure 14 is a service that is re-usable, meaning that the service can be used by other services. This service is very useful because it is common use, so that both other systems and other services can access the same data without creating a new service

Step 4 : Specification

At the specification stage includes the design of components to be carried out based on the results of identification that have been carried out at the previous stage. The results of this stage include the composition of services and also the design of the architecture of the process of exchanging data between applications. This stage is divided into 2 main stages, namely Domain Model for mapping the contents of object services and Component Specification for mapping components in each of the main applications and the use of services by these components.

Step 5 : Realization

At this stage, it functions to define or connect various predetermined services with components to be implemented in the implementation that are reflected in SOA References Architecture. The SOA Reference Architecture will describe in detail each layer of the architecture formed to be applied during implementation

- Refine Component Details

At this stage the process of defining the components that will be used is connected to the service layer and business process layer to form a unified relationship that starts from the Operational process layer, component layer, and also service layer as it will look like the image below :

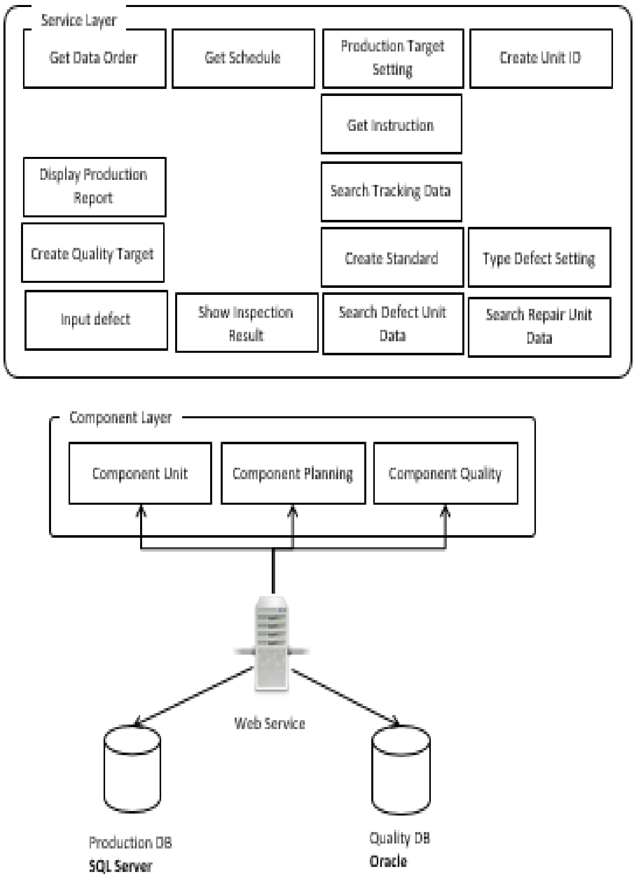

Figure 15. Service Layer

Figure 15 describes the unity of relations starting from the Operational layer, component layer, and also service layer where in the business process layer there are several servers for the system created and the database used.

Step 6 : Implementation

In the implementation phase, the hardware and software specifications are used, there are software and hardware specifications as follows :

List of software used in web service development:

1. Windows 10 Pro as the operating system used
2. Microsoft SQL Server 2014 as an IDE for database integration
3. Notepad ++ as an editor in restful web service development
4. Php as a programming language for web services and frontend / backend

While the hardware used in the process of designing and implementing web services is as follows

1. OS: Windows Server 2012 Standard
2. CPU: Intel (R) Xeon (R) CPU E5-2640 v3 @ 2.60GHz, 64 - Bit
3. Ram: 4.00 GB
4. Hard drive: 100 GB

In the process of building a web service in a production system consisting of 2 parts, namely service provider and service consumer, the service provider is all services that move to call the data needed, while the consumer service is the end user who will use the application to call services that will provide data . In general the concept of this system looks like the picture below:

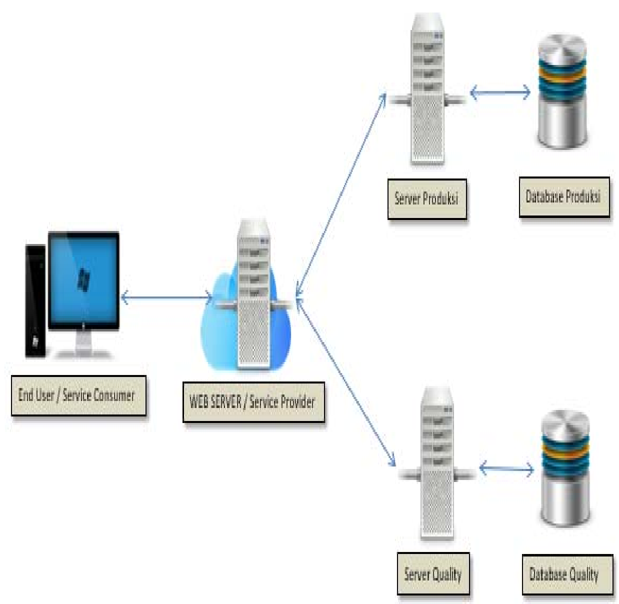

Figure 16. RESTful Web Service architecture

The picture above explains the web service architecture that can integrate several different applications and databases where the function functions needed are made in the form of services or services that are stored on the web server. If other applications require functions from other applications, then just call the defined function from the web server in the form of xml or json with the RESTful method. For the implementation of the web service or service provider consists of several

Controller components which will later become several services that are ready to be consumed by the client application

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In the service provider, it contains services that can later be called by other applications by entering the required parameters, in this case the parameters that can be used for example is the VIN number (Vehicle Identification Number) or commonly called the vehicle frame number.

```
<?php

  public function getDataUnit($vin)
  {
     $q_unitinfo = sqlsrv_query($conn,"exec Sp_GetUnitInfo '$vin'");
     $d_unitinfo = sqlsrv_fetch_array($q_unitinfo , SQLSRV_FETCH_ARRAY);
     $data = array(
        'vin' => $d_unitinfo['vin'],
        'katashiki' => $d_unitinfo['katashiki'],
        'suffix' => $d_unitinfo['suffix'],
        'color' => $d_unitinfo['color'],
        'engine_number' => $d_unitinfo['engine_number'],

     );
     echo json_encode($data);

  }

?>
```

Figure 17. Function get data unit

The function in the picture above functions to retrieve information from the unit, general information displayed is VIN (vehicle identification number), then katashiki, suffix, color, engine number, tracking data can also display tracking history by entering the vin parameter in the following function:

```
<?php

  public function getDataTrackingUnit($vin)
  {
     $q_trackinginfo = sqlsrv_query($conn,"exec Sp_GetTrackingUnitInfo '$vin'");
     $d_trackinginfo = sqlsrv_fetch_array($q_trackinginfo , SQLSRV_FETCH_ARRAY);
     $data = array(
        'vin' => $d_trackinginfo['vin'],
        'shop_id' => $d_trackinginfo['shop_id'],
        'wip_id' => $d_trackinginfo['wip_id'],
        'scandate' => $d_trackinginfo['scandate'],
        'lifting_number' => $d_trackinginfo['lifting_number']

     );
     echo json_encode($data);
  }

?>
```

Figure 18. Function get data tracking unit

The function above is a function to call the tracking unit data. Its function is to see where the position of the unit is currently being worked on. This function is very important because when a problem occurs, the search process becomes easier because the system can detect the presence of the unit and then make improvements. Then from this data can also be added to the functions that exist in the quality information system, for example in the function below, which is to collect data units and defect the unit. This is very important, because when you want to do a root cause analysis, the quality inspection team needs to check unit information and tracking data units, then start to collect data on the possibility of defects in which process

The following is a function to retrieve defect data with parameter vin, namely vehicle identification number:

```php
<?php

  public function getDataDefectUnit($vin)
  {
    $q_defectinfo = sqlsrv_query($conn,"exec Sp_GetDefectUnitInfo '$vin'");
    $d_defectinfo = sqlsrv_fetch_array($q_defectinfo , SQLSRV_FETCH_ARRAY);
    $data = array(
      'vin' => $d_defectinfo['vin'],
      'defect_name' => $d_defectinfo['defect_name'],
      'level_defect' => $d_defectinfo['level_defect'],
      'scandate' => $d_defectinfo['scandate'],
      'inspection_seq' => $d_defectinfo['inspection_seq']

    );
    echo json_encode($data);
  }

?>
```

Figure 19. Function get data defect unit

3. CONCLUSION

Based on the results of the research in this study, conclusions can be obtained as follows:

1. Production systems and production support systems in this case quality information systems are two systems with different platforms that can be integrated using the Service Oriented Architecture (SOA) approach. Functionally it becomes more complete because the data generated from the results of the integration becomes easier and can be accessed using a RESTful web service.
2. Communication between platforms is no longer a problem, because if there is another support system that wants to consume data from the results of integration, it is enough to call the web service that has been built. So that the process of developing production support systems becomes easier without having to depend on a particular programming language or platform
3. Looking at system and data maintenance, using a web service is easier, because the service can be reused, so it can save additional support systems that are functionally the same as the systems that are already available. Then maintenance data becomes more valid, because data is taken from a centralized source without being fragmented.

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