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Digital Oilfield: Real-Time Production Data Visualizations (Wells-Testing Operation)

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ABSTRACT

This paper will be representing study of the existing production visualization systems used for monitoring one of the most critical operations in the Oil & Gas stream which called as "Well Test" or "Well Testing" operation. In general, this kind of operation is very expensive but it processing to determine the maximum potential capability during 24 hours of a well to produce main outputs: Water, Oil, and Gas. Where the good result data of this test operation is usually helps a lot to optimizing production. Because of the value of the Well-testing results has arguably begin to be it the most strength business.

1. Introduction

In these days, the use of smart visualizations, monitoring and diagnostics systems for various factors of production has a critical importance to minimize the decision-making manner and accelerate the activities for production enhancement. Throughout the connectivity of various solution applications in Digital-Oilfield technology and the integration of various routines and tasks is normally to automate the calculation of well production rates using well models automatically updated with operational data and optimize production according with the variation of the operational conditions.At the end of these connectivity and integrations of various applications – software's solutions are building real-time dashboards to visualize the high frequency data from oil fields devices such as production drawdown, pressure, flow rate, and productivity index and operations. However, in an Oil & Gas operations business; The Well test is considered as one of the extreme critical operations. Well test is a technique that measure the actual reservoir potential in complete scale level beneath. Where the test results are utilized for predicting, and wells production reconciliation and allocations at the end of month which form number of key inputs to management practices and production decisions. Therefore, the area covers in this paper are: (1) discuss the existing real-time visualizations systems for oil filed production, (2) the data visualizations, (3) proposed model, and (4) critical evaluation and conclusion.

2. Study existing production surveillance systems

A. Scope of study

Studying the exciting systems that used for production surveillance in Oil & Gas firms.

B. Overview of Oil & Gas Upstream Sectors Technologies

The management of big data become as presently challenge for many the industries in different sectors as a whole and in the Oil & Gas domain the management is a bit harder in the same level of this challenge because the Oil petroleum firms are more dealing with high frequency and real-time data. A fit-for-solution Digital-Oilfield Technologies was developed in the last 10 years with different integrations systems to enhance base production over real-time surveillance and effective reservoir controlling [1], [2],[3],[4].Therefore, due to rapid improvement in the technology as overall and in DOF technology specifically that are alien oil and gas sectors which was born different concepts like "smart field", "smart well", "intelligent field", "intelligent well", "digital field" , "digital oilfield" and other intelligent solutions for upstream petroleum sector which was starting in not more than the last 10 years and implemented in many different firms across the world as mentioned in IO conference by Norway[5], and below Fig. 1 displays the Smart Field lifecycle value, over the combination and integration of technologies , workflows and people skills.

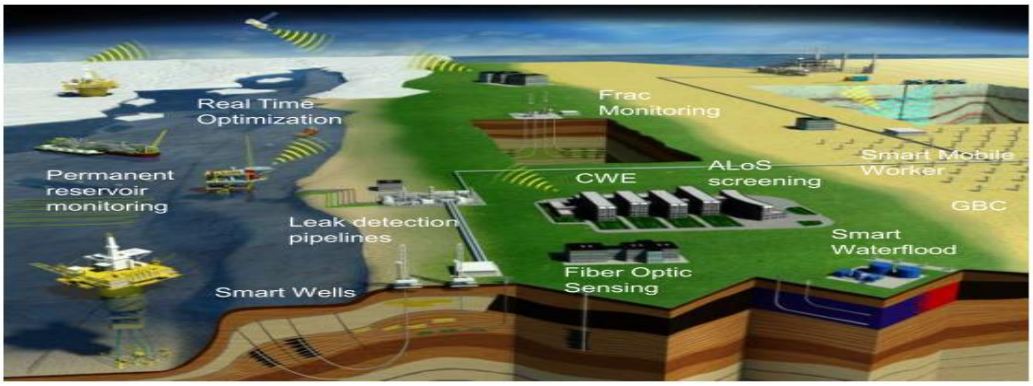

Fig-1 DOF Technologies on the Field location[6].

The DOF or Smart-Field is not solely on computer chips, software and processors. It is about the combining of processes technology with IT and the Internet. It includes a powerful gathering of disseminated network sensors, cloud computing, ubiquitous mobile connectivity, advanced artificial intelligence and big data analytics. It will forecast equipment failure before it occurs and get about “condition-based” rather than “schedule-based” approaches for maintenance.[2].

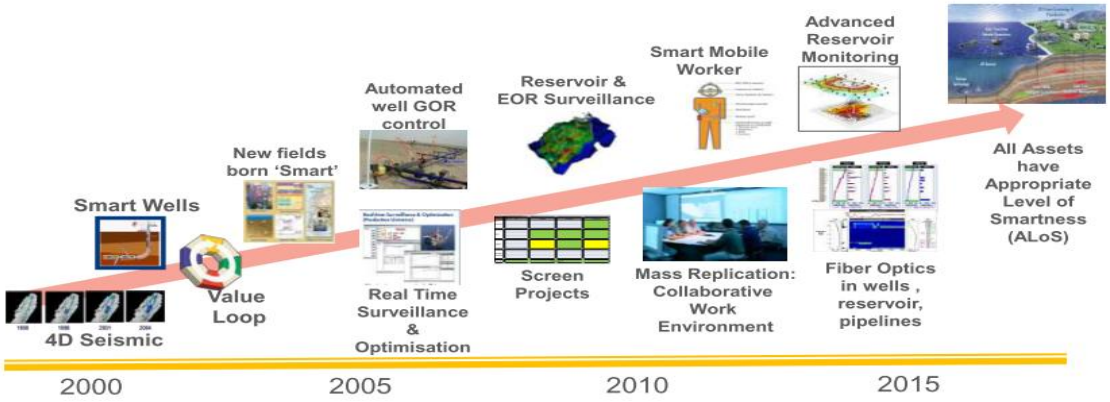

Fig-2 DOF Integration Program[6].[7][7]

The above Fig.2 is showing the time line improvement of implementing theSmart technologies in the oil & gas filed which always enhanced for lifecycle value, over the combination and integration of technologies, workflows and people skills. The connectivity and integration of various applications – software’s solutions are building real-time dashboards for visualizing oilfields data such as production drawdown, pressure, flow rate, and productivity index where the dashboard’s plots or chart data permits engineers and operators to quickly identify wells’ pressure, flowing rates, and performance anomaly and it enables the operators to monitor, control, interpret, take decision and act according to production-associated information which are capture on real time to optimize production, enhance field operation efficiencies[2], [8].The key functionality of these production dashboards is to offer visualizations workflow exact multi-disciplinary KPIs to the filed asset teams over a portal or excel sheet or schematics drawings in the form of graphs, charts, trends, tables and maps[9], [10].

C. Study of Real-Time Production Surveillance Systems

Production surveillance and optimization system IPSO, has become a solution for close observation and optimization challenges with objectives of drive productivity. This system automates routine activities such as data capture, data storage, data manipulation, analysis and visualization. IPSO was mainly designed as a decision-support scheme, with importance and assurance of value-determined the sequence of work for producing assets [10], [11].Due to the integration of different platform operations and technologies in “DOF” or “Smart Filed” , there are different applications used to monitoring all production assets. The following are the most top systems are commonly used in different companies around the world and all having common feature which is the ability to visualize the continuously flowing data from the production field’s floor with assurance to efficiency and productivity to work office:

lowis™ software: it supproted byWeatherford companylowis™ is shortcut for “Life-of-Well information software”[12].Lowis system is also integrated and implementing PI system as aime to retrive realtime data and to visluze the data flow using PI system package sloutions like ProcessBocok , PI AF, and PI DataLinke[12]. In general it has the following Features & Benefits :

A whole optimization tool for wells.
Provides real-time data Monitoring and collectian[12].
Provides remote observing and control for each well
Provides intelligent alarms for production issues[3].
Provides data analysis besides service analysis management capabilities.[13]
reports of forecast equipment failures or production issues.

FieldWare Production Univers(FW PU) software: developed by Shell Production Development Company. It is a data-driven modelling system, used to address basic gaps in the surveillance and management of production operations in oil and gas sectors[14]. This a foundation component for Shell's Smart-Fieldsinitiative ,it has the following Features & Benefits:

track well-by-well production for real-time
Poweful application for Well Testing process.
permitted an increase in period between well tests oprtation and reduced transportable to field locations[15].
fixed hydrocarbon allocation difficulties over real time reconciliation[16].

The Plant Information (PI) system: supported from OSI soft Company. PI is not asoftwaer only but it is afull backge sloution has ability to interconacte with oil and gas complexe environments. Also, it is very powerful solution been used by many companies in different sectors not only in oil and gas sector around the world. PI system is a package module designed solution for monitoring and analysis. It has large capability of integration features with different applications such as Interfaces with Extremely complicated environments, Provides Historical and Real Time Data Access, fully compliant with Microsoft Environment like the WinNT /Win95/ Win98/ architecture, and Offers Data Conveyance across Internet /LANs / WANs. As well PI client system is fully support

Microsoft's object-oriented file structure, ActiveX Automation and Visual Basic Scripting PI systemhas the following Features & Benefits :

provide Historical data.

Provides the ability of visualizing data in different package client solutions like ProcessBocok , PI AF, and PI DataLink [17].

Provide Real-Time Data Integration.

Provide the same available, trustedand updated data.

permittingbest integration amongstManagement and Plant Control Systems, Analytics and Monitoring Systems[18].

Dynamic Surveillance System™ (DSS™) Software: from Halliburton, it has the following Features & Benefits:

powerful and flexible surveillance abilities to improve asset performance.

Manage many assets with less workers[19].

Increase pattern-flood abilities and performance

Built-in wizards and easy to use.

Integrate with third-party software[20].

P2 Well Test Management Software: delivers a web-based UI that permitsengineers and field operators to plan, perform, capture, evaluate, and analyse test data result in a stablemethod, free from outside control system either or bothdata historian. It provied detailed trending of equipment and well and allow field operators withengineers to visualize the high-frequency flowing data develops when execution a test[21]. it has the following Features & Benefits:

Commingled and flow meter Well test opertion.

Approval and Validation.

Manual or automatic multiphase testing.

Default library of test methods and rate calculations for multiphase test unit.

D. Key Findings

There are many tools and solutions in the market either it is build-in system or integrated with third-party software that used for visualizing oil filed production. Also, these solutions can be running as Web-based applications or standalone software and some of them can be integrated with third-party software.Also, the recent study [22]which was presented that; all of Halliburton, Waterford, Honeywell, Schlumberger and ABB petroleum companies are covering well test operation or “Reserves Management” within its own solution’s[22].The following are the common keys findings of this study:

- Many companies use more than one application for monitoring filed assets and visualizing field data for example Petroleum Development Oman (PDO) use LOWIS™, PI system, and FieldWarefor controlling and monitoring well test operation and other activities.
- Some systems have the capability to automate routine activities such as data capture, data storage, data manipulation, data analysis and visualization.
- The connectivity of various applications – software’s solutions are building Real-time dashboards for visualizing multiple data type from different data sources
- Not all software’s are supporting Web based technology because it is build-in systems.
- Some software can’t use by to other companies unless there are some business relationships in between.
- Monitoring and visualizing Well-Testing operations are usually integrated with the full system such as in LOWIS system and FieldWare PU system.
- Most company are building its own solutions for visualizing data production
- PI system is a products has high capability to visualizing high frequency data and most users using it to Creating reports and Trending data and making[23].
- Dashboards in different package solution tools such as process display, spreadsheet

3. Summary well testing operation

Formation of the well testing, which involve taking measurements of flowing fluids that coming from the reservoir, are conducted at wholly phases in the lifecycle of oil and gas fields, beginning exploration finished development over development, injection and production Operators execute these tests toward define whether a formation will produce, or stay to produce, hydrocarbons at an amount that bounces a sensible return on advance investments. Operatorssimilarly use test result data to define the limits or the size of the reservoir besides to plan the furthermost efficient approaches for producing.

A. What is Well Test?

A period of time defined to measure the well production called as "Well Test" or "Well Testing", and this process done either in the production facility, or at the Well head location with portable equipment’s for the test process. Well test is a technique that measure the actual reservoir potential in complete scale level beneath .The greatest extent of well in the test operation can be gathered either as descriptive for reservoir testing or as productivity testing[24].

Test duration is generally between 6 - 24 hours or it maybe longer; the test frequency be able to differal though is normally weekly, monthly or maybe less. Typically, the test result is a set of spot totalized readings or averaged numbers of such parameters like oil production and gas production rates, water-cut (BSW), gas-oil-ratio (GOR) and tubing-head pressure (THP). The production of single well is expected to be homogeneously or equal at the production test rates among well tests, other than at several times while the well is selected to be "closed-in"[14].

B. Well Test Purpose/Objectives

In aim to managing fields in better way, "Well Testing” technique allows Well performance validations during commissioning and cleanup and monitoring the Well reservoir. Wherein the objective of process this technique assists to determination of produced fluids for Well, Identification of reservoir deliverability and forecast of reservoir dimension or size.

C. Well Test Worksflow

The initial step in test operation is identifying which wells need to be tested with a view to comply with testing occurrence needs and to achieve crucial ad-hoc requirements. This schedule should guide test implementation via site-field operations.

After the schedule wells are routed over flow-metering systems for example multiphase flow meters (MPFM) or separators, the data flow processing starts. Finding unchanging periods needs to observe the flow metering tags like oil rate, gas rate and water flow rate though watching temperatures and pressures at the tested well plus flow lines. Then calculations should be made and saved as reports of wells' productivity[11].

D. The Well test Challenge's:

In an Oil & Gas operations business; The Well test is considered as one of the extreme critical operations. Wherein the test results are utilized for predicting, and wells production reconciliation and allocations at the end of month which form number of key inputs to management practices and production decisions. Typically, well test process can be done either by manual process or test manager applications and producing test results or reports are inherently inaccurate due to the manual test practices and the usage of different test equipment and interfaces. In various oil companies the visualization and management of the test results and associated data are limited to the possessions control system (SCADA / DCS) and filed operators can visualize and monitoring data flow during test operation. The exciting real-time monitoring Wells-Testing application used by Daleel site operators has the following challenges and limitations:

- This application is in isolated network and private permissions which can be accessed by one or two site operators only and cannot be accessed remotely. The application is supported by FOXBORO company
- The way of operators used for capturing and saving data are manually process.
- Due to the access limitations permission the engineers in the head office cannot follow-up the real time test process and they have to wait 24 hours till test period end. in other word, there is no public interface for well test process.
- Manual input or storing test result data from pepper to production core database as daily process.

4. The Well testing Proposed Solution

I propose a solution which facilities the process of monitoring, capturing, storing well test data through using PI system form OSIsoft. This solution can be running and functions in either web-based application or Excel Sheet application. The core point is depending on the "Tags" which having the flow rate readings during test operations such as Oil, Gas, Water, Temp…etc. These tags are the main interface needed to bring out all flow data from field location into head office location. The mapping process of tags from DCS system to PI system required MatrikonOPC UA Tunneller server. This solution will focus more in the last layer of any system which is the visualization layer. Therefore, the solution is for developing Well Test Dashboard for monitoring the real-time testing operation and generating testing result reports using Html-5 language and PI Web parts technology under SharePoint platform.

A. Overall Data Flow Architecture

In 2016 Automation & RTO Leader, Al Balushi, was provides conference paper with OSIsoft company in Berlin, Germany about how Daleel is able to Meet the production challenges through using Real-time technologies, the was mentioned through the integration of real-time data and aggregated or non-real-time data, Daleel able to maximize the oil and gas value and improve the decision making[25].So, Fig.3 is shown how the data flow in Daleel from site/filed area to center office in Muscat. An overall network diagram PI System architecture is given in Fig.3. The PI System Design is split into 3 logical layers: Data Collection Layer, Data Archiving Layer, and Data Analysis Layer. The Data Collection Layer is physically located at company field, The Data Collection layer is connected via WAN to the Data Archiving Layer which is physically bound to company headquarters, The Data Analysis and Visualization layer is made up of a group of PI products and or Microsoft Products. The Data Collection Layer and PI Server are part of the same network whereas the Data sources is part of another network and there is a firewall and switch installed for protection of the Process network from intrusions. Below is the data Flow Diagram:

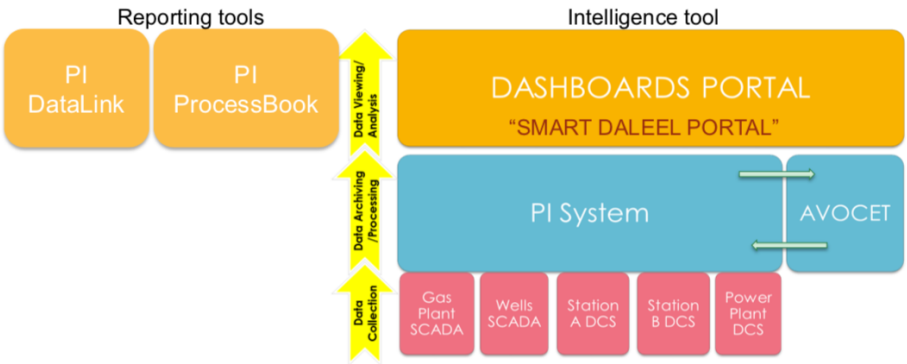

Fig-3 Data Flow Architecture.

B. Proposed Architectural Representation

Following is the solution architecture stack, which provide logical layer to hardware tier mapping along with depiction of

relevant technologies and products used. There are three main tiers, first tier includes the database and file storage and management layer, consist of DBMS, PI archive and PI AF server.

The second tier includes application and reporting layer, consist of core business logic, access control and functions, workflow engine, PI web part and. All the components are exposed using services by the business logic. Actually, the PI web API is connecting directly to AF server to fetch as well as AF sync services for synchronizing real-time data and this service is connected directly to workflow SQL engine.

The third tier includes the web presentation layer, consist of dynamic web pages, forms, controls for user interaction.

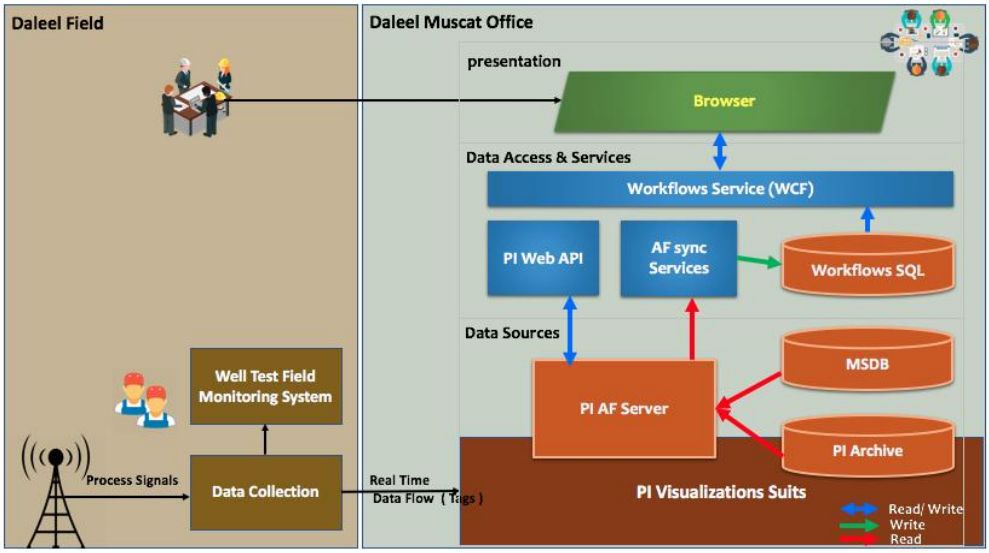

Fig-4 Proposed Solution Architecture

C. Functional Architecture

This section provides overview Functional architecture including details of various functional and solution components and how they will come together to provide a suitable solution to business requirements of Well Test Portal. The table below contains the major functional components for the Portal.

Table-I Table of Proposed Functional Architecture Layers

Component Name	*Component Description*
Infra Layer	Infra Layer consist of IT infrastructure like: server, LAN, Physical/Network Security, Storage for files and Database etc.
Integration Layer	Middleware Integration layer represents external systems and interfacing logic provided for the SharePoint portal. Middleware and SharePoint relying on middleware to interact with external systems
Application Layer	Application Layer consist of core business functionalities; like Registration, Payment model, Document Management, Content Search & Indexing, and User Management. Along with core processing logic it also provides reporting services.
Presentation Layer	Presentation layer provide User Interface compatible to various device types. Being web-based application presentation layer will run on browser on user's device. Also, being first point of interaction, it also handles all authentication and authorization requirements.

The then diagram depicts how these components are layered out to compose proposed solution.

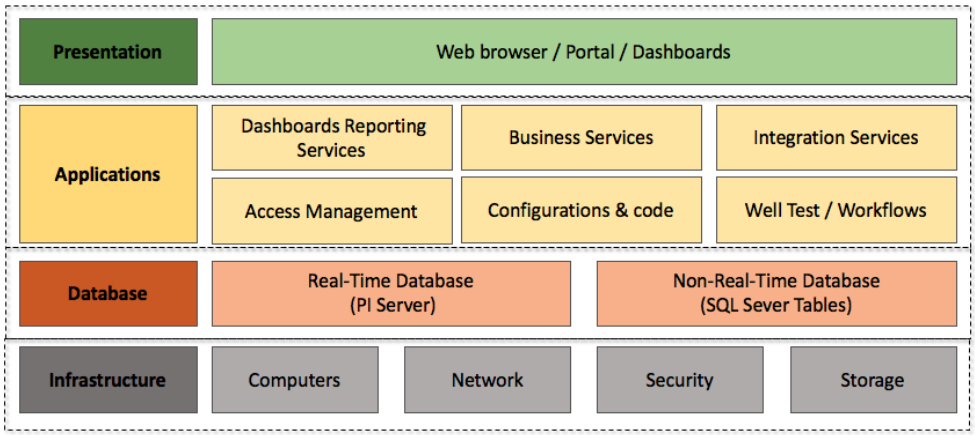

Fig-5 Proposed Functional Architecture Layers

5. Data visualization

A. Data Visualizations Overview

The presentation of records, numbers, and data in graphical or pictorial format called as data visualization which permit decision makers to view, realize and understand analytics obtainable visually, therefore they can identify new model or patterns and grasp hard concepts. Through interactive visualization, users can proceed the conception a step further through using technology toward drill down to graphs and charts for additional detail, interactively altering what data users sees and how it's handled and processed.

B. The Importance of Data Visualizations

Due to the method the human-brain processes data and information, using graphs or charts to visualize huge amounts of difficult and complex data with facts and statistics is easier than poring over reports or spreadsheets. Data visualization is an easy, quick technique to convey concepts and ideas in a universal way and any user can exam and experiment with various scenarios via making slight modifications and adjustments also user can recognize areas that need improvement or attention based on the visualized and the processed data.

The key functionality of these production dashboards is to offer visualizations workflow exact multi-disciplinary KPIs to the filed asset teams over a portal or excel sheet or schematics drawings in the form of graphs, charts, trends, tables and maps[10].The visualization layer in the DOF delivers a visual representation of the fundamental engineering logic, models, and data management to simplify the effective monitoring, controlling, and operation the site field by the company. This layer also offers a coherent view of the oil fields by integrating data collections (e.g. production, economic engineering, etc.) through a visualizations capability in systematized and an organized way. Among visualizations technology, fields data and results are visible to operators, managers, engineers, and any other employers or customers of the system in graphic and visual formats [26].

C. Data Visualizations in Proposed Model Sloution

Developing dashboards for Daleel Production Station (DPS) which using only one type of testing units called "Separators ". So, in the DPS Reports; there are two dashboards, first one is "Online Monitoring" which will be include real-time production data, wells overview information, wells fluid's flow, wells parameters/ behaviors during the test with chart/trend for live testing and second one is "Test Result Reports":

1) ***Online Monitoring Dashboard:*** This dashboard contains one table and three charts. The table content is divided into three sections; (1) Test Unit name must be listed as a parameter for the dashboard. (2) Well Test Details should show main information about real-time well in the test, this information is coming from the PI AF system or SQL server. (3) The data presented in Real Time Reading is related to the selected Test Unit also this information is coming from PI AF system. Where Charts/Trends/Plots must show the data based on the Start Time and End Time.

2) ***Test Result Reports Dashboard:*** This dashboard contains two main tables. (1) Test Validity table shows data for the selected separators during the test time with a specific interval. The total average is the average of the data listed in the test validity table. (2) Previous Well Test Result is divided into two rows; Last Valid test must show information about the last valid test of the selected well, this data can be retrieved from AVM Database. Last Valid Test Current is the difference between Last Valid test and Total Average. Start Time and End Time must retrieve all the well name that are tested during this time.

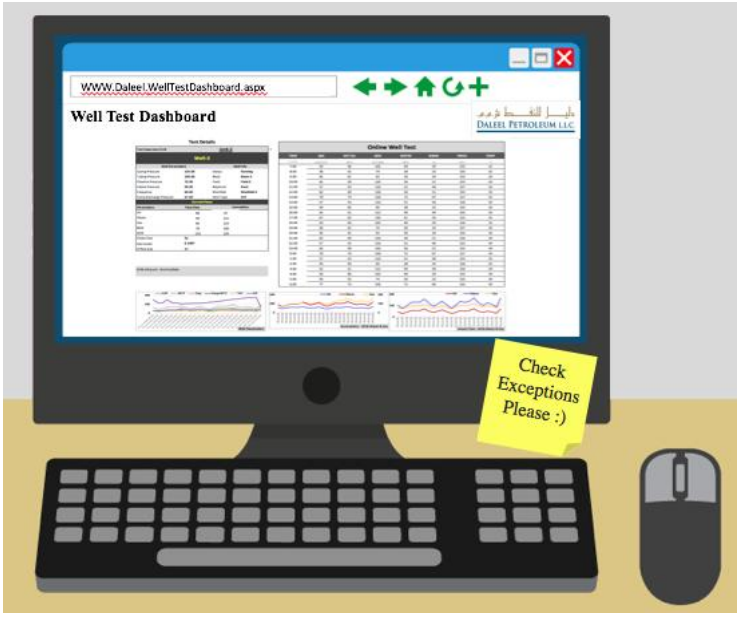

Fig-6. Proposed Well test Dashboard.

6. Critical Evaluation

Developing Well Test Dashboard Web-based solution for monitoring the real-time testing operation and generating testing result reports using Html-5 language and PI Webparts technology under SharePoint platform. The below will be included in this Proposed Model:

a) Create Pages inside the Existing SharePoint Site.
b) Create PI AF Analysis and Tags for the Calculation Purpose.
c) Develop two dashboards; will be developed as Custom WebParts in SharePoint site: Online Monitoring Dashboard and Report Generation Dashboard.

There is one main report that need to be developed as HTML5 dashboards. These dashboards can be linked to the existing Daleel Smart Portal and data will be extracted from PI AF system using PI Web API. In addition to that, these Dashboards will be deployed on the existing SharePoint server.

A. Technology Stack

The below table contain the proposed solution components and their mapping to technologies or applications that will implement them.

Table-II Table of Technology Required

Solution Area	Products/Technology
Server-Side Technologies	C#, Web Part API, MS SQL Server 2012
Client-Side Technology	HTML5, JQuery, Java Script API, High Chart, CSS
Data Storage & Archival	Production database (SQL server)
PI Historian	PI AF & PI -System from OSIsoft

Pi Historian, Asset Framework (AF): is a product form OSIsoft, allow users to add and built all elements and facilities. it is a models and hierarchies consist of elements gathered by specific relations (connectivity, parent-child). An element in AF is refers to an asset or object that can representation a number of properties or attributes AF is counting one or more non-PI sources e.g. external relational databases and PI Data Archives. It used to build calculations, templates, tables, displays, and analyzes data.

AF templates with pre-defined attributes (PI data, non-PI data attributes) and Linked AF tables will be utilized to build the required AF hierarchy. Various AF tables can be created and linked with external Relational databases to get required non-PI attribute values (such as permissible limit values).

Data Storage & Archival: are common DBSM data base that using for archiving data. It includes non-real-time data but a historical data about wells information, wells production and wells test result as an example.

Client-Side Technology: include programing languages that can be used to create the client code, user interface and others for the solution. Different collection of languages is necessary to make solution performance is very high more modern with current programming technologies

Server-Side Technologies: includes different component such as C# which is programing language and usually it used to create the backend sources code to the solution in the server side or some time call as WCF, windows communication undulations.

PI Web API is access layer to PI System, it delivers a cross-platform programmatic interface toward the PI System. It is a rest-full interfaces allow cross-platform development of desktop web, and mobile applications through several programming languages. PI Web API supports to manipulate and retrieve time sequence data from the PI-Data-Archive, besides event frame and asset data from the PI AF server[27].

B. Data Features and Data sources

The below tables contain the proposed solution data sources, features, and frequently change. These the tables description will assist to define; how much of data will be reserved? And what we need to build both dashboards? In order to make these data flowing smooth in-front of end users.

Table-III Table of data features for online dashboard

Online Monitoring Dashboard			
Data Features	***Data sources (App)***	***Data type***	***Data frequently change***
Test Unit Name	Production db. (SQL Server)	Static	non
Well information	Production db. or PI AF	Static	non
Well Parameters	PI AF	Real-Time	Every 1-2 seconds
Plots / Charts/ Trends	PI AF	Real-Time	Every 30-60 mints

Table of dtat feauters for report dashboard

Test Result Reports Dashboard			
Data Features	***Data sources (App)***	***Data type***	***Data frequently change***
Test Unit Name	Production db. (SQL Server)	Static	non
Last Valid Well test	Production db. (SQL Server)	Static	non
Test Validity Report	PI AF	Historian	non

C. Key Capabilities

- Built-in, historical and real-time trending
- Provide automated results for wells test in daily working
- Integration different data sources into one dashboard for different users
- Powerful tool for monitoring production rates behaviors in real-time during test period.

D. Proposed Model Benefits

These Dashboards is a solution that enables the operators and engineers to surveillance the continuously flowing data from the production field's floor with assurance to efficiency and productivity. The dashboards tracks production drawdown, pressure, flow rate (oil, gas & water), and productivity index where the dashboard's plots or chart data permits the production operators to quickly identify wells' pressure, flowing rates, and performance anomaly and it enables the operators to monitor, control, interpret, take decision and act according to production-associated information which are capture on real time during the test period and after test operation finish.

Overall, the proposed dashboards monitoring for well test data in real-time have furthered operators' capability to turn out proactive decisions building on continuously watched wells production[10], [28]. The solution will allow the operators and engineers to monitor, analysis and generate test data report from and for any data along coming years, moths, days. However, the following benefits of the proposed model:

- Reduces a lot of staff manual effort
- Increase staff productivity by automated tasks
- Provide real time data for wells under test
- Enhanced and advanced well test monitoring process
- Helps to forecasting well performance and end with better decision making
- Allows operators to get daily & monthly test result report
- Automated system to monitor the performance of wells, over multiple parameters.
- Very power full tool for monitoring and controlling production assets behaviors in real time
- Easy identification of wells that are performing over or below the expectation. This will help in reducing the operational expenses and thereby increased revenue.

E. Proposed Model Limitations

This solution will not cover the direct control function for generating test scheduled for wells for monthly basis, initialization the test operation form website and will not cover all test units' types like Multiphase Flow Meter (MPFM) which has other report formats.

7. Conclusion

Due to the integration of different platform operations and technologies in DOF, there are different applications used to monitoring real-time production filed assets and filed operations. Many petroleum companies are building its own solution for monitoring real-time production performance and analysis according to its connection structures a technology. Lowis™, Dynamic Surveillance System™, FieldWare(FW PU),P2 Well Test and other build-in applications provides real-time information for all facilities and wells are connected; on other hand, these big systems need some commercial partnerships with supported companies to utilize products or it may require some tendering or budget and a lot of complex process to implemented into any other company. However, Plant Information (PI) system supported by OSI Software,it is very powerful solution been used by many companies in different sectors not only in oil and gas sector around the world. PI system is a package module designed solution for monitoring and analysis. It has large capability of integration features with different applications such as Interfaces with Extremely complicated Environments, Provides Historical and Real Time Data Access, fully compliant with Microsoft Environment like the WinNT /Win95/ Win98/ architecture, and Offers Data Conveyance across Internet /LANs / WANs. As well PI client system is fully support Microsoft's object-oriented file structure, ActiveX Automation and Visual Basic Scripting that will meet the proposed solution in this paper. I propose a solution which facilities the process of monitoring, capturing, storing well test data through using PI system form OSIsoft. This solution can be running and functions in either web-based application or Excel Sheet application.

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