SPE 112106

Saudi Aramco Intelligent Field Development Approach: Building the Surveillance Layer

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This paper was prepared for presentation at the 2008 SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands, 25–27 February 2008.

Abstract
The Intelligent field is the oil industry's new trend that enables continuous monitoring and optimization of individual wells and overall reservoir performance. This is achieved by integrating fields' real time data in the reservoir management business processes. The results from this integration are anticipated to increase production rates, identify opportunities for higher hydrocarbon recoveries and reduce operating costs and future capital expenditures.

Saudi Aramco has embarked on implementing the Intelligent Field (I-Field) initiative through new pilot projects in Qatif and Haradh increment III fields. The objectives of the pilot projects are to provide real-time diagnostic capabilities, highlight and address implementation challenges, and develop a comprehensive architecture for I-Field implementation in Saudi Aramco fields.

This paper discusses the implementation approach of the intelligent field initiatives in Saudi Aramco. It will shed light on the challenges encountered and will present the process and methodology of developing the roadmap of the "surveillance layer," the first building block of Saudi Aramco's I-Field architecture.

Introduction

The development and implementation of the Intelligent Field (I-Field) initiative is one of Saudi Aramco's key strategic imperatives aimed at optimizing field development and operation strategies. Saudi Aramco's I-Field objectives include:

- Enhancing recoverable HC through in-time intervention and full-field optimization
- Enhancing Health, Safety and Environment (HSE) through remote monitoring and intervention
- Reducing operation cost by reducing manual supervision and intervention

To achieve these objectives, the I-Field initiative is being implemented on two parallel paths, one is of installing in new and old fields fit-for-purpose permanent downhole, well head and surface sensors, and actuators. The objective of this path is to evaluate exploit and drive available intelligent field technologies to address company objectives (Afaleg 2005; Al-Arnaout 2007; Mubarak 2007; Salamy 2007; Saleri 2006). The second path is a structured development approach that captures the challenges, lessons learned and integrates required systems, specifications, processes and procedures for an over all solution that lays out an architecture for large scale implementation and a company-wide role out. This paper will focus on of the later path and specifically on the details of the surveillance layer development; the back bone of the I-Field.

I-Field Structure Overview

I-Field Organization

The Intelligent Field development is an effort that integrates processes, systems and organizations to achieve real-time and/or semi-automated field management. The systems to be integrated are diverse and span various technologies from measurement, data acquisition, control, communication, data management and applications to visualization systems and collaboration environments. In the vast scale of Saudi Aramco operations, these systems are being managed and supported by different organizations. Each organization has its own business set skills, business mandate, business processes and business priorities. To avoid duplication of efforts and ensure company wide coordination, integration, alignment and support, the I-Field initiative implementation is supported by the following setup:

1. The formation of a multidisciplinary team of highly experienced professionals with representation from all concerned organizations.
2. High level management championship and support .Saudi Aramco's I-Field initiative team reports directly to the Chief Petroleum Engineer
3. The formation of I-Field Steering Committee consisting of managers from all involved concerned departments, I-Field Team Leader. The steering committee is chaired by the Chief Petroleum Engineer. The role of the steering committee is to provide oversight, guidance and support for high level cross organization collaboration.

I-Field Development Structure

Saudi Aramco I-Field development structure consists of four major layers as shown in Figure 1, namely Surveillance, Integration, Optimization and Innovation. The surveillance layer provides continuous monitoring of production information and applies data management tools and processes to ensure usefulness of the data. The integration layer interrogates real time data on a continuous basis to detect reservoir behavior trends and anomalies. Reservoir engineers are alerted to such anomalies for further analysis and resolution. The optimization layer provides streamlined full field optimization capabilities and field management recommendations. The innovation layer preserves knowledge of events that trigger the optimization process and corresponding actions throughout the life of the field. This is a knowledge-management and lessons-learned layer that captures and injects "intelligence" into the system. Following are the objectives and a brief description of each layer.

Figure-1 I-Field Development Layers

The Surveillance Layer

The objective of this layer is to provide continuous up-keep and monitoring of all real time data as collected by down-hole, well-head and surface sensors. The surveillance layer provides real-time data acquisition, communication, data management, basic visualization, event detection and alerts. The surveillance layer is the foundation and key enabler for the Intelligent Field. As illustrated in Figure 2, the components of this layer include

- Data Acquisitions & Delivery
- Visualization & Alerting
- Real Time Data Management
- Data Compression, Filtration and Aggregation
- Tags Naming Standard and Configuration Management
- Roles & Responsibilities

The Integration Layer

The objective of this layer is to continuously monitor reservoir behavior patterns, such as higher than expected water cuts or pressure declines. Reservoir regions or groups of wells are examined to study behaviors such as injection efficiencies and inter-well pressure communications. In addition, pressure transient behaviors are triggered and examined in real time. Inconsistencies between observed data and static reservoir models can be detected to trigger model updates. Systems will be provided to analyze reservoir behavior anomalies, examine causes and provide actionable information to the optimization layer. Components of this layer include:

- Static data management
- Detection of actual vs. prediction deviations
- Identify reservoir behavior patters that require intervention
- Provide visualization of reservoir behavior
- Detection of conditions that warrant re-optimization
- Detection of anomalies and the update of static models

The Optimization layer

The objective of this layer is to provide a streamlined environment with "full system" optimization. The optimization covers the entire production system that includes reservoir, well and surface facilities. A key component of this layer is an environment that allows for a plug and play of all applications used within the optimization cycle. This cycle includes geology, integration of data to be used in simulation, up-scaling, simulation, post-simulation and optimization recommendation analysis. Components of this layer include:

- Plug and play environment
- Assisted history matching
- Full Field optimization systems
- Highly sophisticated visualization environments

I-Field Surveillance Layer Development

Qatif & Haradh Increment-III (Al-Arnaout 2007; Saleri 2006) intelligent field implementation served as a pilot and testing ground for defining, developing and implementing the surveillance layer building components through:

- Mapping the data flow path from the fields to the desktop
- Exploiting the interfacing and integration of intelligent field technologies
- Defining I-Field data acquisition & delivery requirement (data, applications, processes and systems)
- Assessing existing data acquisition and delivery implementation
- Assessing existing processes, operations and implementation challenges
- Defining user requirements (data types, frequency, resolution, support)
- Defining surveillance required tools & applications

Surveillance Development Approach

To develop the "Surveillance Layer", the I-Field core team was organized into six sub teams to execute each of the corresponding six surveillance layer components. A team Leader and a team leader backup from the core I-Field team were assigned to each execution team. Each execution team was staffed with component area element domain experts representing all concerned organizations from both I-Field and non I-Field team members. Assigned I-Field core team members identified and nominated required expertise from their corresponding organizations. Ownership of each of the surveillance layer components' elements are kept with the concerned support organization to ensure on going development, maintenance and support.

Rounds of facilitation were conducted with each team to define their area of focus objectives, avoid duplication of efforts and develop short term and long term plans.

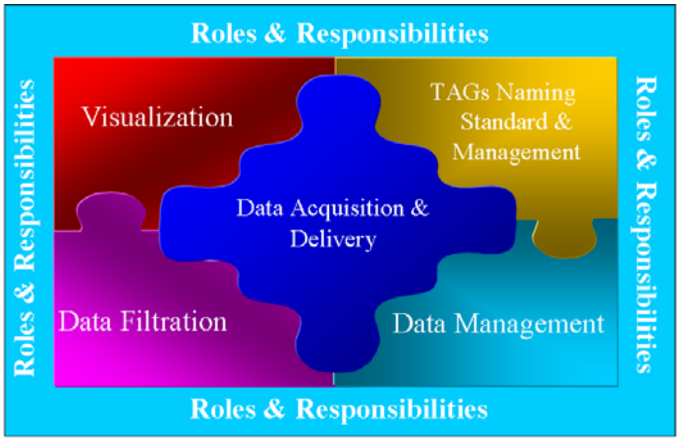

Figure-2: Surveillance Components

Data Acquisition & Delivery Layer

Qatif and Haradh Increment III projects were instrumental in solidifying the I-Field data acquisition and delivery requirement for Reservoir Management and Production Engineering. The requirement specified the data availability, delivery level and the data types with their associated acquisition frequency and resolution. Additionally, the projects also revealed limitations and challenges in the existing data acquisition and delivery infrastructure and the need for developing an I-Field data acquisition and delivery infrastructure architecture. Thus the I-Field Data Acquisition & Delivery execution team was chartered with the following objectives:

- Define and document the I-Field data acquisition and delivery requirement
- Define and document existing fields' to regional and corporate database data acquisition and delivery infrastructure and support structure
- Assess current state of Qatif and Haradh Increment III fields' data acquisition and delivery infrastructure and support structure
- Define an I-Field data acquisition and delivery infrastructure architecture leveraging existing infrastructure investments for upgrading existing fields.
- Incorporate I-Field architecture, specifications and guidelines into existing company fields engineering standards
- Continually explore and evaluate available and emerging data acquisition and delivery industry solution to enhance and optimize developed architecture for use in future fields to enhance/maintain exiting field's architecture
- Perform gap analysis on Haradh and Qatif fields' data acquisition and delivery infrastructure against developed architecture
- Develop scope of work for implementing required upgrade to Qatif and Haradh Increment III fields
- Define and develop data acquisition and delivery data flow monitoring tools
- Define and develop KPIs for monitoring the performance of data acquisition and delivery process
- Develop a road map and execution plan to role out the implementation of the I-Field data acquisition and delivery architecture in all of Saudi Aramco fields

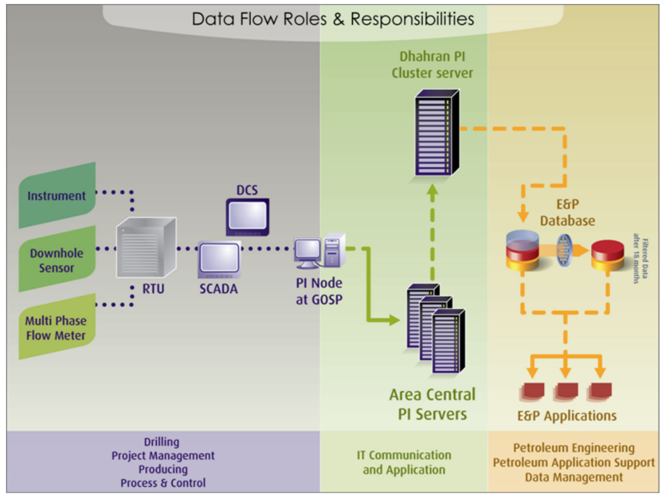

Figure 3 : Field to desktop data flow

Tag Naming Standard & Configuration Management

In the field, instrumentation and equipment data are referenced or named by their associated tag numbers. The tag numbering follows Saudi Aramco Engineering Standard called Instrumentation Symbols and Identification SAES-J004. This standard is used for the purpose of having a uniform means of designating instrumentation symbols and identification standards used in Saudi Aramco.

Field data acquisition and delivery in Saudi Aramco traverses multiple stages of PI Servers before it reaches the corporate database. The first level is the field level, then the area or regional level and last is the central level. At every stage a local standard was applied to name and configure PI tags. Different coding convention was appended to the tags at the various levels, and each organization had its own convention. As a result, different names were used for the same data point at various stages of data collection in PI servers. Figure 3 shows the data path from one field to the corporate database. Furthermore, a configuration management procedure was needed to ensure that required I-Field data are configured in the I-Field real time database. The objectives of the Tag Naming Standard component are:

- Develop an I-Field unified tag naming standard to be used in all PI systems across Saudi Aramco
- Integrate the unified tag naming standard into an existing implementation process for use in new fields and new field's development activities
- Develop a tag configuration management process for the tag names

The team developed Tag Naming Standardization and Configuration Management Guidelines. The guidelines are an extension of Saudi Aramco Engineering Standard Instrumentation Symbols and Identification document SAES-J-004. The I-Field Tags Standardization Guidelines are purely for "Data" tag names on the PI servers and are not for use on the physical device tags.

Data Compression, Filtration and Aggregation

Automated reservoir surveillance requires the collection of engineering data in very small units of time, sometimes as low as every second. As a result, tens of thousands of bits of data can be collected every hour. There is therefore a need to reduce the size of this data for efficient storage and utilization.

The current practice in Saudi Aramco is to compress all data types, based on certain pre-determined criteria, prior to storage in the PI-Server. This process can reduce the data storage requirements by up to 70 per cent in some cases. For some applications, such as pressure transient analysis, which requires high frequency data, especially during the early part of the test, this data compression can be very detrimental, and often renders the data useless. Thus, the method used in the data reduction must take into account the end use and purpose of each data stream.

To address these concerns, a Data Compression, Filtration and Aggregation execution team was formed to accomplish the following:

- Review current practices and develop an I-Field Data Compression, Filtration and Aggregation Guidelines that address the acquisition, sampling, storage and filtration of this high frequency data, in a form that will make it useful for reservoir and production engineering applications.
- Scout for or develop a solution for data cleanup, including noise and outlier removal, as well as data filtration or reduction prior to use by the engineer in reservoir and production applications

Following several meetings and discussions, during which several domain knowledge experts were invited to share their knowledge and insight with the team members, the team came up with guidelines regarding all data types being recorded and their respective sampling frequencies. The team recommended the use of an application that employs a wavelet algorithm for data cleanup, or reduction prior. The team successfully evaluated an off-the-shelf software package that employs a wavelet algorithm which can be applied at PI server and/or database level. Figure 4, illustrates the results of the wavelet application in reducing the volume of the data without sacrificing the underlying information.

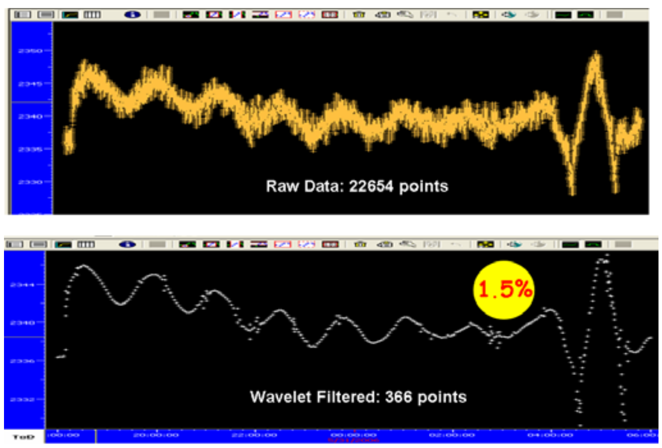

Figure 4: Illustrates wavelet filtration value

Real Time Data Management Layer

The objective of the Real Time Data Management layer is to provide real-time database of high availability and assured quality and develop tools and applications that support the development, enhancement and maintenance of real time data management. The objectives of this layer include:

- Develop real-time database model and create real time database
- Establish real-time database security and accessibility rules
- Configure and connect the database to receive the data from the PI server
- Develop real-time data monitoring and QC tools
- Integrate the real-time database model with other existing data models
- Develop equipment/sensor installation inventory system
- Develop database performance monitoring system
- Develop real-time database capacity planning tool

Most of these objectives are being met and work is in progress to further the development of this components.

Visualization Layer

The objective of this component is to address all I-Field visualization requirements:

1. ***Basic Visualization and Alerting Tools***

To provide basic visualization environment capable of monitoring all aspects of the objective function related to the assets (i.e., a well, a field, an operation and the entire asset) in real time to ensure that performance is being met by providing the required alerts, basic trending and analysis tools. This objective was accomplished by the following:

- Documenting Reservoir Management and Production Engineering basic visualization and alerting requirement
- Carrying out evaluation on several visualization tools
- Acquiring and customizing basic visualization & alerting software
- Devising Key Performance Indicators (KPIs) responsible for tracking and evaluating trends on important parameters

2. Collaboration Center(s)

To develop collaboration environment that facilitates the integration of people, process and technology with focus on high value reservoir management workflows. As the I-Field implementation unfold, petroleum engineers will be dealing with more and more actionable overall field and reservoir data that require integration, visualization and collaboration between multidisciplinary teams for optimal assessment and decision making. Thus, there is a need for the development and implementation of new business environment that is specifically designed to accommodate current and future reservoir management business processes.

Currently work is in progress on developing and implementing two I-Field collaboration centers. The first center is expected to be on-line by end of August, 2008.

Roles & Responsibilities

The objective of the Roles & Responsibilities component is to define a process oriented approach for implementing and maintaining the I-Field layers and components where each participating organization has a clear set of roles and responsibilities to follow.

To achieve this objective, the Roles & Responsibilities execution team worked with all concerned organizations, I-Field execution teams and I-Field core team to:

- Identify, document, complement and communicate key existing and emerging I-Field development and support processes and their associated process owner
- Develop I-Field Rules and Responsibilities document
- Solicit organizations' acceptance and approval on their assigned processes
- Escalate unresolved roles and responsibilities related issues to the I-Field core team
- Develop change management and an approval process for the role & responsibilities document

Here are some examples of new emerging roles and responsibilities

I-Field Guidelines & Specification Administration and Management

- Guidelines & Specifications ever greening process to meet technology, users requirement or organizational changes.
- Guidelines & Specifications change management & administration
- Guidelines & Specifications changes/updates coordination with concerned organizations
- Maintain, publish, communicate and distribute I-field Guidelines & Specifications
- Oversee the implementation of the guidelines on green & brown fields and new field development

I-Field Change Management

- Schedule, document, track and report any required changes in fields' instrumentation including installation or maintenance
- Schedule, document, track and report any required changes in field and area network that may affect the data flow
- Schedule, document, track and report any required changes in field or central servers
- Conduct change management meetings on a regular basis
- Devise a special system for scheduling, tracking and documenting the changes

I-Field Help Desk

- Develop Service Level Agreement (SLA) with all the involved I-Field support organizations
- Receive, log and track related problems and route to the right support organization
- Generate daily/weekly problem resolution reports
- Devise problem resolution KPI's to monitor performance

Acknowledgements

The authors express their appreciation to Saudi Aramco management for their permission to publish this paper. The authors also want to acknowledge the contribution of many of Saudi Aramco professionals of the various organizations on their contribution to development of the I-Field Surveillance Layer. Special thanks go to Abdullatif A Al-Ghanim, Emad H. BuHlaigah, Faisal Shuraidah, and Talal M. Bakri for their valuable contributions.

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