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On a DSML Domain Server for Fluids Transmission Pipeline Design and Modeling

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ABSTRACT
Domain specific modelling languages (DSMLs) are special purpose languages that have been designed and tailored for specific application domains. With domain specific features user of the language can construct with very familiar notations and get desired outcomes. The focus in this paper is on the functionality of a domain server in a domain specific modelling language for modelling oil and gas pipeline design. A domain server is coupled to a range of pipeline physical components by a pipeline context model, each of the components having a variety of pipeline built units, attributes and values. The domain server stores data received from at least one of the range of the pipeline physical components, the data including values associated with one or more attributes of the components. The domain server derives a model type for at least one phase from the life cycle of the pipeline design operation for the first instance of the pipeline built units, based on analytics of information stored in the pipeline built units memory and the component attributes storage, where the model type includes a set of attributes for at least one of the range of pipeline physical components. In addition, the domain server generates an orientation for performance operation of an instance including one or more actions from the pipeline built units corresponding to at least one attribute of the set of attributes

Keywords: Attribute sets, model type, built units, pipeline context model (PCM)

1.0 INTRODUCTION
The example implementations relate to oil and gas pipeline systems, and more specifically, to pipeline systems that convey oil and gas from sources to destinations involving a variety of combination of physical components for a complete pipeline design to enable endorsements for unrestricted oil and gas fluid transmission management. Oil and gas pipelines are purely physical systems that carry crude oil or gas from oil wells and gas storage facilities to tank farms for storage and to points of utilization or to refineries for processing. Such physical delivery system in a pipeline project includes a network of pipes, flanges, fittings and joints, bolting, gaskets, valves, and the pressure containing portions of other piping components. It also includes pipe hangers and supports and other items necessary to prevent over pressurization and over stressing of the pressure-containing components that must be represented as a hierarchy structure [1].

In the correlated system, pipe sections are joined with fittings, valves, and other mechanical equipment resulting into a pipeline system that satisfy operational standards for high quality product delivery, in most instances delays between a supply node and a delivery node are drastically reduced. However, the problem of maximizing output from an input from the stakeholder is not well understood, even with the assistance from conventional modelling systems. The lines of interest and disciplines, and intents of all the stakeholders in terms of data gathered from the fields that concerns physical attributes, loading and service conditions, and environmental and materials-related factors have to be identified and explored.

In one application of the current subject matter as shown in Fig. 1 include the description of concepts, i.e. the salient technical characteristics prevalent in the domain of oil and gas pipeline engineering, which is part of the precise analysis path that moves into the formation of the domain specific framework of the modelling system.

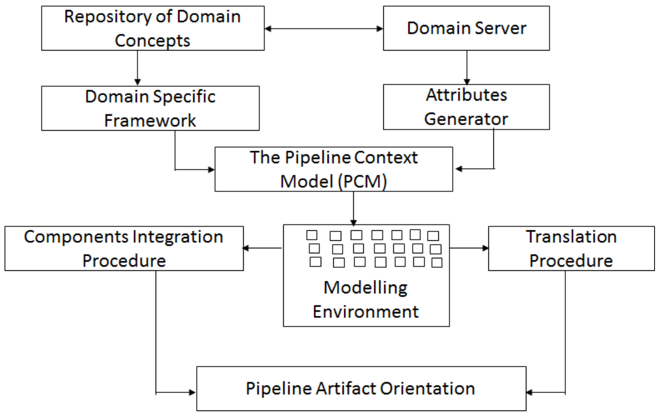

Fig. 1. Framework of the Modelling System

The framework becomes the embodiment of the domain concepts repository, which is a representation of the requirements of the system characterized as design intent and viewpoints of the input parameters of stakeholders or domain experts. The term design intent here refers to identified interests and disciplines of all the stakeholders of the oil and gas pipeline engineering domain as it relates to pipeline design and highlights physical attributes that must be considered in completing a typical modelling process [6].

Some of the key requirements for the system work flow include an abstraction instance, the incorporation of a user interface component, and the fusion of pipeline engineering features. The abstraction instance defines and describes the meaning of the model instances, and the way the model instances relate to the real world examples. The user interface component is to enable users to define the modelling parameters corresponding to the variability and commonalities of the pipeline engineering features that can promote enhanced modelling and be able to interpret artefacts [1]. Whereas the variability indicates precisely what evidence is needed to specify an instance of a feature that could fit into particular design intent; the commonalities define the set of common operations and primitives of the pipeline context model (PCM), which is the core of the instances of any design and modelling activity

2.0 RELATED WORK

In the related art [16], a domain model characterizing the embodiment of the entire relationships and associations of the features and attributes of the pipeline context model where real world concepts of oil and gas fluids are received into a pipeline; a further characterization is the mapping of the pipeline context model (PCM) attributes to the instances of the pipeline physical components; and one or more abstractions characterizing what the system does in order to bring to bear a pipeline design to specifications according to customers or stakeholders needs. The attributes are implemented as information tagged with the pipeline component values, so that in the end they can be transferred into the system sequence [2]. These relationships are user centered and encompasses in its domain model logic sound underlying engineering principles, which illustrates how they are linked to produce a total life cycle approach to pipelines system design and operation.

In the domain model is the model attributes subset consisting of the classes of the events and their relationships with a focus on the user’s perspectives. The domain model also captures all the specifications of the core features of the application behaviour as the overall performance of the modelling system that loads the domain expert design intent. As knowledge changes, the model attributes subset changes to ensure physical components continue to do the users input viewpoint and then produce clear design specifications with pipeline physical assets such as pipes, valves, active equipment (pumps, compressors, etc.,), and insulation and supports [14].

In another interrelated application [20], is a device comprising a translation procedure embedded with a translation processor, a modelling environment, i.e. the user interface, and a components integration procedure as exemplified in Fig. 1; the components integration procedure, which keeps track of the resulting design object once a request triggered by stakeholders design intent is made into the system, serves a useful purpose of mapping the attributes to the abstractions and detailed definitions directly into the strategies in the translation processor [17]. The translation processor having received data signal from the modelling environment a request triggered by stakeholders design intent will produce an input signal specifying symbol substitutions for the major objects in the pipeline model that can be repeatedly performed to generate new modelling sequence.

The translation procedure includes [14], sets of associated attributes such as fitting type, joint type, type name, angle, units, length, and size from the pipeline context model with well-defined rules for mapping the attributes value points(x, y, z), corresponding to the modelling parameters of the physical pipeline design. The master processor implements the translation engine that determines the contents of the pipeline engineering notations of the attributes stream using as inputs the measured values, the machine deducing a total application of the associations of volume in cubic centimeters (cm^3), length in millimeters (mm), fluid density in kilogram per millimeters cube (kg/mm^3), velocity in millimeters/second (mm/s), degrees Celsius (^0C), degrees Fahrenheit (^0F), and others like relative roughness of pipe, fluid static head, fluid specific gravity, minor loss coefficient of flange, inner and outer diameters, and pump head capacity etc. in the attribute stream based on the characteristic repository to bring up the desired designs that fits to the project at hand.

Further, related work [9], has utilized data driven methods for leveraging analytics only in the form of conventional engineering designs modeling where objects are explicitly described, and when one aspect of the model is changed, often several changes have to be made to satisfy design intent or the implicit rules of the design. This is because the system does not keep track of the rules and the designer must decide where and when they are broken. These rules can be used to build a model from scratch, each time using the same parameters, or experimenting with different ones. The parameters [15], can be numeric values, relationships, and can even include graphic parameters already existing in the model. It may allow conditional branching to different sets of instructions until a condition in the model is met.

3.0 METHODOLOGY DESCRIPTION

Details of one or more options of the subject matter described herein are set forth in the associated drawings and descriptions [18]. The following description includes methods, techniques, systems, and structures that may be used to determine oil and gas transmission pipeline domain model properties of attribute stream in real time modeling using translation procedures and one or more parameters that measure pipeline physical component properties of the attribute value stream. Such devices and systems can produce and process all information about the attributes stream necessary to obtain a measurement of the pipeline network without depending on representations of conventional standards.

Domain specific modelling languages (DSMLs) are special purpose languages that have been designed and tailored for specific application domains [8]. Following the focus in this paper on the functionality of a domain server in a domain specific modelling language for modelling oil and gas pipeline design [3]; the approach to the development of the modeling language was derived from Domain-Specific Modeling (DSM) where language specifications focus more on requirements within a particular domain. The approach is therefore directed to utilizing requirements analysis on data gathered from a digital oil field to determine the input parameters as they relate directly to the stakeholder design intent in bringing up pipeline designs that fit the pipeline project at hand [12].

Fig. 2 illustrates a process flow diagram logic showing a method for determining domain expert conceptions for discovering domain knowledge and design intent for productivity at the work place, in accordance with DSM implementation.

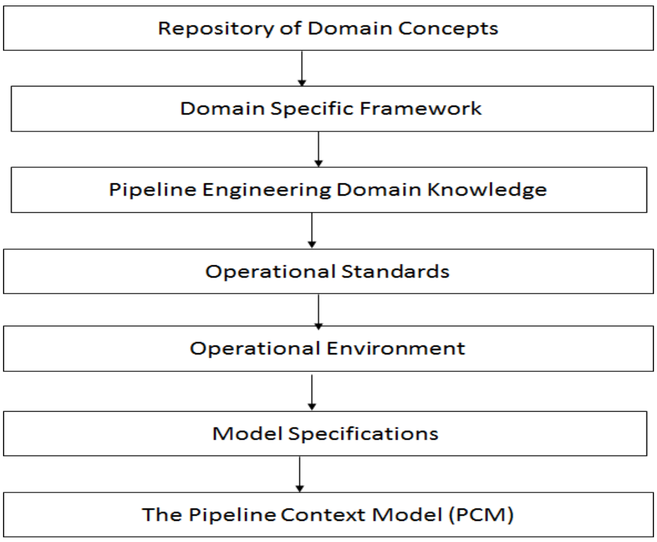

Fig. 2. Utilizing Requirements Analysis

The process [4] involve a corresponding domain analysis and a requirements engineering basic work flow that entails comprehensive pipeline permissibility design and installation and pre-commissioning data

management in pipeline operation situations to describe the application of engineering principles, codes and standards, materials factors that relate to pipeline design and the physical attribute parameters that govern the size, layout, and dimensional limits or proportions of the pipeline. The descriptive systems are connected together to incorporate multiple phases of the requirements engineering operation. These phases include domain concepts exploration phase leading to the building up of the concepts repository, a requirement engineering framework development phase, a domain analysis phase where domain knowledge is carefully elicited and built into the framework, a stakeholder variability management phase where operational standards are considered and built in as design intents, a production phase where the specifications for artefact orientation are fixed, a processing phase where the actual attributes of the pipeline physical components are read into the system to conform with the built in parameters and a pipeline phase where the actual pipeline artefact is designed.
During the domain concepts exploration phase [6], the domain analysis phase, and the requirement engineering framework development phase leading to the building up of the concepts repository, the environment was taken into account because of its strong influence on the elicitation of the domain knowledge. The requirements engineering process then progressed into the acquisition of the qualitative information from pipeline enginneers. This was necessary in order to set the boundaries of the new system. Quite a lot of inputs regarding pipeline components physical attributes and design criteria has to be sequenced through knowledge provided by crew engineers and survey reports generated from their sources of operations. Operations include building pipeline inspection routines and pipeline integrity management and reporting, modelling test tool for hydro testing activities to generate reports for valve interlock installation system design, inclusion of pipeline networking and routing activities in the schedules, and to generate appropriated pipeline designs with the necessary fittings to accomplish oil and gas fluids transmission from sources to points of utilization.
Illustrated in Fig. 3 is a pipeline context model involving a range of pipeline physical component systems with their values and attributes; directed to clearly restructure the domain concepts as a prerequisite step to the definition of a pipeline metamodel. This is [7] the representation of the description of the pipeline physical components and necessary design parameters obtainable in a pipeline network; the pipe model is the major component in the pipeline, linked and connected by other components. Another component is the externally threaded bolts, which are used for fastening joints with nuts, especially to provide bearing connection and slip-critical connections between two components in the pipeline.

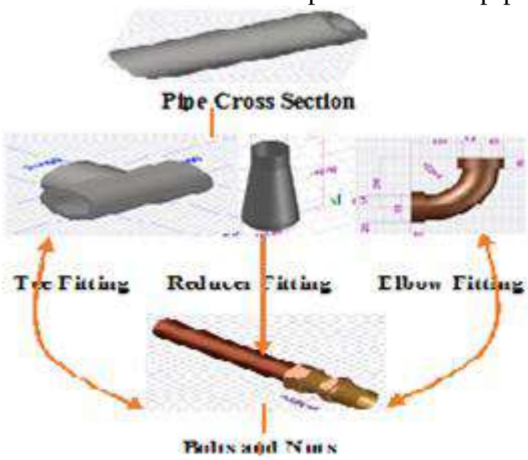

Fig. 3. Pipeline Context Model

A few identified components amongst others are the reducer, and the elbow and tee fittings; a pipe reducer is a fitting that allows for a change in pipe size to meet flow requirements of the system, or to adapt to existing piping of a different size. It is the component in a pipeline that reduces the pipe size from a larger inner diameter to a smaller inner diameter. The elbow is a short length of pipe with a 90-degree or 45-degree bend. It allows pipes to be securely connected at both ends, providing a clean turn, and a change in flow direction. A tee is a short piece of pipe with a lateral outlet, it is a common pipe fitting, used to either combine or split a fluid flow. A tee is used for connecting pipes of different diameters or for changing the direction of pipe runs. They are extensively used in pipeline networks to transport two-phase fluid mixtures [4].
These components have to be related to form the topological structure of a pipeline network as shown in Fig. 4. The piping components can be atomic or compound; the atomic features include pipe size in the form of normal pipe size (NPS) or diameter normal (DN), support types, joint types, fitting types and related ones that does not need to be further refined into sub features when there are no variations among

different products. It is a Parent-Child relationship three logic of the pipeline system with the associated model specifications; the specifications include the modelling primitives and the composition rules. The arc signifies that one and only one of those features must be chosen. The line drawn between a child feature and a parent feature indicates that a child feature requires its parent feature to be present and remain valid.

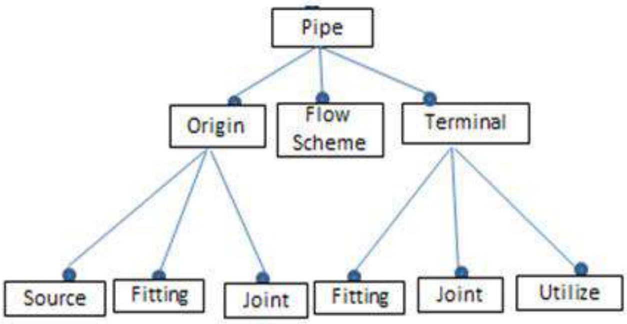

Fig. 4. Parent-Child relationship Tree Structure

All mandatory features of fittings, and joint, whose parent is the pipeline root concept, are common features. Also, the nodes to which these features are attached are the variation points

4.0 DOMAIN SERVER CONFIGURATIONS

The domain server comprise a pipeline built units memory, a component attributes storage, attributes generator processor, and a content valuation network [9]. The processor is configured to execute one or more modules in the memory as illustrated in Fig. 5. The storage is the server to facilitate connections between the memory and the processor. The network facilitates interactions between the processor and the range of operations in the translation engine. Data is aggregated to the memory from the domain server by the network and then subsequently validated for future analytics and processing.

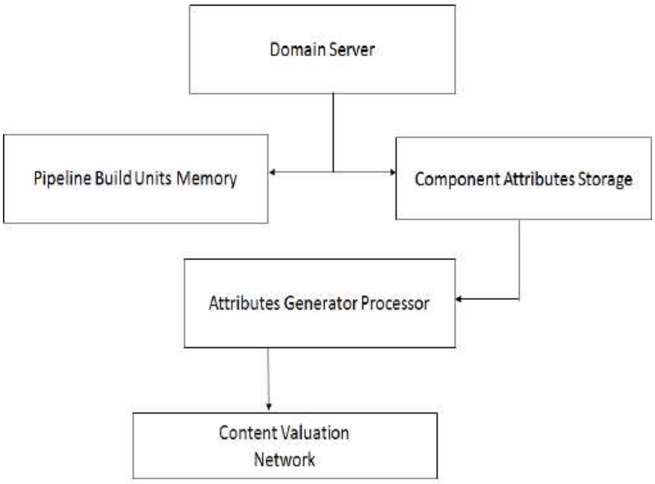

Fig. 5. Domain Server Logical Structure

4.1 Attributes Configuration

The pipeline physical component attributes are stored in the memory of the domain server in accordance with an example implementation. The pipeline built units in the memory, demonstrated the application dashboard facilitates from the user interface for providing references to the attributes of the pipeline physical components along with optional course of actions based on the attributes generator processor as illustrated in Fig. 5. Typically Fig. 6 illustrates an example configuration of attributes of components in the domain server, and stored in the master processor of the translation engine via the valuation network, in accordance with an example implementation [11].

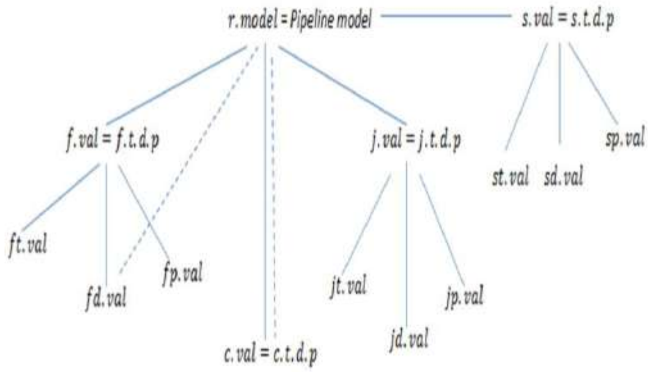

Fig. 6. Attributes of Components

The pipeline built units memory is directed to providing suggestions and courses of actions to the application dashboard through the annotated specifications as illustrated in Fig. 6. The specifications made possible to keep track of domain specific relevant information, which is accomplished by receiving references from the attributes storage server or by receiving an application model package from the pipeline context model via the domain server, and utilizing the application model to provide an application model for the particular pipeline operation.

4.2 High Level Architecture

The high level architecture contain the translation engine, the quality control dash board, a network interface, and the repositories respectively. Fig. 7 illustrates an example high level architecture of data analytics, management and feedback to modelling systems containing the highlighted features. The translation engine, which is the master processor include a translation launcher, the components integrator, an integration processor, an attributes optimizer, the attribute values processor, a pressure or temperature control panel**,** a model selection control panel, the objects tool set, the repository processor, the error approximation control panel, and the productivity report processor [13].

The translation launcher is configured to start the machine to perform one or more operations. The components integrator may generate associated models for each of the components to generate the pipeline system. The integration processor is configured to provide application services to coordinate the orientation procedures as modelling activity is triggered through user input. The attributes optimizer is configured to operate on the rules defined in the metamodel, implicitly or explicitly to generate the target format from the input as set in the domain model, and taking all into account when generating the pipeline design [14]. The attribute values processor captures the metrics of the pipeline engineering field, and connects from the user interface the domain model values and the application services from the integration processor to enable stakeholder interaction with the system.

The pressure or temperature control panel**,** carries sufficient pressure and temperature metrics for the inputted fluid /pipe surface relationships. The model selection control panel is configured to create interactive mechanism with solution notations the end user will utilize to make the artefact orientation very feasible to build the model for production of desired designs. The objects tool set is configured to provide one or more process tools for finding models and forming events. The repository processor enforce internal communication among these phases by utilizing the combination of a repository defined within the architecture [5]. The error approximation control panel, checks for correctness in the master processor. The productivity report processor is configured to generate reports after each development. These phases may contain one or more functions in the architecture as illustrated in Fig. 7.

The master processor compartments include the translation procedure management module, the component integration management module, and the artefact orientation management; the linking and retrievals processing module, and the domain concepts maximization module. The translation procedure management module is configured to perform one or more analytics [13]. The linking and retrievals processing module may generate references to the associated pipeline systems. The domain concepts maximization module is configured to provide one or more information for each of the pipeline systems to generate their own models. Bringing together all these modules into a unified modelling infrastructure produced an architecture covering the scope of the new system [14]. The applicable methodology is that with a quality control dash board and a network interface that enables data aggregation from a digital oil field; the pipeline engineering domain expert can simply bring out desired pipeline designs in any project without being encumbered with third party operational complexities, or the engineer being controlled from needless expertise to get their design intents achieved right at the work place.

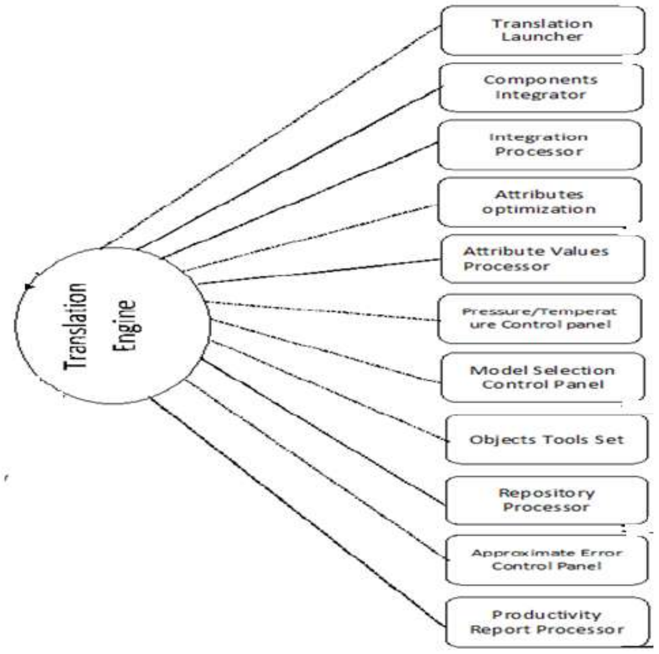

Fig. 7 Data Analytics, Management and Feedback

Common components and related attributes in oil and gas pipeline physical components attributes such as angle, units, length, and size that keeps track of the resulting design object. Taking the form of a domain relationship, the components attributes further connects model elements as instances of the domain class thus providing necessary information fulfilling the goals of the current subject matter; getting a new system specific to modeling pipeline systems.

5.0 DATA PROCESSING MEASURE

Example flow of data processing between the application dashboard of a modelling system and a digital oil field management server, in accordance with the example implementation is illustrated in Fig. 8 [20]. By utilizing the data analytics as described earlier, various output can be possible. For example, through the network interface the pipeline engineering domain expert can gather relevant operational data to improve planning and design of the pipeline based on attributes of a pipeline in both exploration and transportation phases in the oil and gas industry, while analyzing past pipeline designs to determine an appropriate model for the current pipeline project.

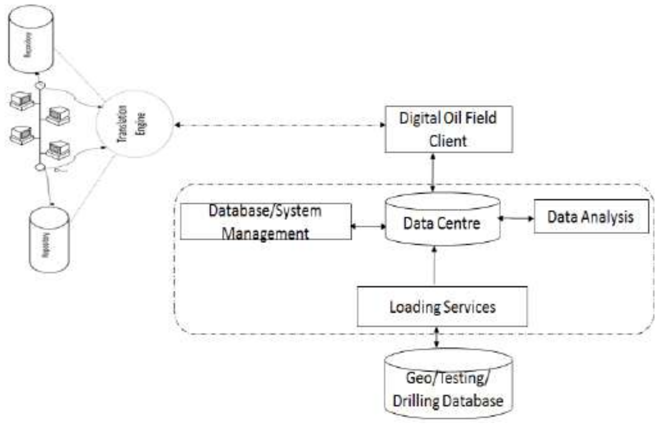

Fig. 8 Flow of Data Processing

The translation engine connected to the digital oil field client as illustrated in Fig. 8, can process industry data to include aspects of the drilling phase and indications of parameters to optimize the pipeline during the drilling phase. It may include capacity and logistics schemes for managing the capacity and logistics during the production and completions phase of the pipeline, providing optimized attributes for the processing of the oil and gas during the production and completions phase, provide decisions for the pipeline throughout the pipeline lifetime, and can be extended to other solutions, depending on the desired implementation [10].

6.0 DISCUSSION

A domain server, comprising: a pipeline built units memory, configured to store: a set of attributes comprising at least one attribute relating to a range of components in the lifecycle of pipeline design operation, each of the range of components representative of a type of operation for a pipeline built unit, the range of components including at least two involving a drilling operation phase, a transmission operation phase and a production completion phase for the entire pipeline built units; pipeline built units data provided from a first built unit unlimitedly merged to the domain server; and information of one or more other built units comprising data of one or more other pipeline built units; a processor integrated into a master processor, configured to: generate an orientation for performance operation of the first instance of the pipeline built units based on the evaluation of: associated models of the first pipeline instance for at least a components of the range of components of the lifecycle of the pipeline design operation for the first instance of the pipeline built units, the component type name of the first instance of the pipeline built units generated from a relationship of the pipeline context model data provided from the first instance of the pipeline built units to the set of attributes including at least one attribute relating to the range of components in the lifecycle of the pipeline design operation for the first instance of the pipeline built units; and a model component type for at least one component of the range of components of the lifecycle of the pipeline design operation, the model component type generated from analytics of a relationship of the data of the one or more other pipeline built units in the memory to the set of attributes including at least one attribute relating to the range of components in the lifecycle of the pipeline design operation; and provide application services to coordinate the orientation procedures as modelling activity is triggered through user input to improve operation of the first pipeline design during the lifecycle of the pipeline design operation for the first instance of the pipeline built units.

The domain server, where the set of attributes are identified as attributes associated to at least one of reducing design time, express and achieve design intents, and increasing production output. The domain server, where the processor is configured to: determine at least one attribute relating to a range of components in in the lifecycle of the pipeline design operation based on the rules defined to generate the target format from the input, and to identify one or more attributes of the set of attributes that are inter-dependent across two or more components of the lifecycle of the pipeline design operation based on a correlation of the first instance of the pipeline built units to one or more other built units.

A more permanent computer readable translation engine containing instructions for a process for a domain server, the instructions comprising: managing a set of attributes comprising at least one attribute relating to a range of components in the lifecycle of a pipeline design operation with a system, comprising: a domain server comprising: a memory, configured to store: a set of attributes comprising at least one attribute relating to a range of components in in the lifecycle of pipeline design operation and provide application services to coordinate the orientation procedures as modelling activity is triggered through user input to improve operation of the first pipeline design during the lifecycle of the pipeline design operation for the first instance of the pipeline built units. A method for a domain server, the method comprising: managing a set of attributes comprising at least one attribute relating to a range of components in the lifecycle of the pipeline design operation. The processor in the domain server is operable to generate the model signature based on the analytics of a relationship of the data of one or more other units in the memory to the set of attributes, compare the component type and the model, and provide the description based on the comparison.

7.0 CONCLUSION

Consideration of the specification and practice of the backgrounds of the current subject matter; other implementations will furthermore be more apparent to stakeholders and domain experts skilled in the art of pipeline engineering in the oil and gas industry; and the various aspects of the described example implementations be considered as examples only, with the true scope and spirit of the current subject matter being indicated. The illustrations depict scenarios of design and modelling of typical oil and gas transmission pipeline models, explaining real life pipeline fitted with the components.

8.0 REFERENCES

A. Khan, C. Kästner, V. Köppen, and G. Saake. Service Variability Patterns in SOC. Technical Report 5, University of Magdeburg, Germany, May 2011.

B. R. Japheth, and P. O. Asagba, (2015), Oil and Gas Pipeline Design Management System: A Case Study for Domain-SpecificModeling, American Journal of Software Engineering and Applications, 4(5): 92-98 doi: 10.11648/j.ajsea.20150405.13

A. Lodhi, V. Köppen, and G. Saake, “Business process improvement framework and representational support,” in Proceedings of The Third International Conference on Intelligent Human Computer Interaction (IHCI), ser. Advances in Intelligent and Soft Computing. Prague, Czech Republic: Springer, August 2011.

Gandomi, Beyond the hype: Big data concepts, methods, and analytics, International Journal of Information Management 35, 2015, pp 137-144.

B. R. Japheth, and O. U. Cyril; (2019), A Domain Specific Modeling Language Semantic Model for Artefact Orientation: International Journal of Cognitive and Language Sciences Vol: 13, No: 2, 2019, Open Science Index, waset.org/abstracts/99162

Upstream Oil and Gas Digital Trends Survey, March 2016; Accenture andMicrosoft; https://www.accenture.com/us-en/insight-2016-upstream-oil-gas-digital-trends-survey.aspx?c=res_acnenrgytwt_10000260&n=smc_0216

Field Automation for Unconventionals: Challenges & Opportunities; Philip Chadney, Field Automation Summit 2015; http://www.upstreamintel.com

B. R., Japheth, and E. E. Ogheneovo, (2013), Supporting Engineering Design Modeling By Domain Specific Modeling Language, American Journal of Software Engineering and Applications 2(3): 86-91, doi: 10.11648/j.ajsea.20130203.11

L. M. Camarinha-Matos, Collaboration in a Data-Rich World, 18th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2017, Vicenza, Italy, September 18-20, 2017, Proceedings.

B. R. Japheth, and P. O. Asagba, (2015), A Framework for Requirements Engineering for Oil and Gas Pipeline SystemsModeling,American Journal of Software Engineering and Applications 4(6): 99-106 doi:10.11648/j.ajsea.20150406.11

A. Long, An overview of seismic azimuth for towed streamers, The Leading Edge, 2010, 29(5), pp. 512-523.

B. R Japheth, and E. E. Ogheneovo, (2015). Model Driven Design of a DSL for Transmission Pipelines: A Roadmap, IEEE African Journal of Computing and ICTs, Vol. 8, No. 1, Issue 2, May 2015, pp. 137-144.

A. R. Brown, Interpretation of three-dimensional Seismic Data, Seventh Edition, AAPG Memoir 42/SEG Investigation in Geophysics, No.9, 2011.

H. Hassani, The role of innovation and technology in sustaining the petroleum and petrochemical industry, Technological Forecasting and Social Change, 2017, 119, pp. 1-17.

Z. P .P1ah , B. R Japheth,, K. T Igulu., and O. M. Georgewill, (2016), A Domain Model Framework for EngineeringDesigns Metamodeling, International Journal of Advanced Computer Technology Volume 5, Number 3, June 2016 *(IJACT)* 21 – 26.

B. R. Japheth, and I. D. Acheme (2017), Defining a DSL for Transmission Pipeline Systems Metamodeling: In the Proceedings of the IEEE Future Technologies Conference 2017 29-30 November 2017 | Vancouver, BC, Canada

K. T Igulu., , Z. P P1ah., B. R.Japheth, and O. M Georgewill,. (2016), Model Interactions in a Domain Specific Modeling Language: An ICT Solution to Transformations in Design of Fluid Supply Systems, *International Journal of Advanced Research in Computer and Communication Engineering Vol. 5,* B, R Japheth, and P. O Asagba., (2015), Design of Transmission Pipeline Modeling Language. *Global Journal of Science and Technology (GJCST) Volume 15 Issue 6 Version 1.0.*

B. R Japheth, and E. E. Ogheneovo, (2013),Domain Specific Modeling of Parameterized Objects, Journal of Physical Science and Innovation, Volume 5, No. 2, 2013, 103 -110 www.cenresinpub.org

G. Carvajal et al., Intelligent Digital Oil and Gas Fields Concepts, Collaboration, and Right-Time Decisions, 1st edition, Gulf Professional Publishing 2017.