research & innovation

Automation: Kick Detection Solutions Example

Abdullah Al-Yami
Saudi ARAMCO

Poll Question

Are you an SPE member?

Poll Question

Which Geographical area are you from ?

Poll Question

What is your affiliation?

Poll Question

What is your main Job Interest?

Expert Systems

Expert systems are knowledge processing which enable computers to do certain tasks similar to humans or some times better than human experts.

The real motives of such type of research are the following:

- Shortage of expertise,
- Shortage of working memory, and
- Biased opinions

After Hayes-Roth (1987) and (Pandey and Osisanya 2001).

Bayesian Equation

- Smith has a routine chest X-ray required of all new employees. The test shows that he has cancer. He panics and becomes certain that he has lung cancer. But should he? He learns that 1 out of 1000 employee has cancer.
- The test is not absolutely conclusive; It has uncertainties. That is a false negative rate of 0.4 and a false positive rate of 0.02.

Lung Cancer

Has Cancer	0.001
Does not have Cancer	0.999

Test

Lung Cancer	Has Cancer	Does not have Cancer
positive	0.6	0.02
negative	0.4	0.98

Bayesian Equation

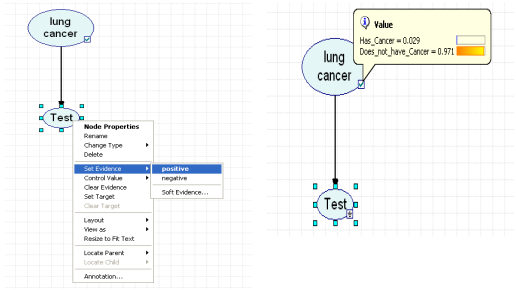
$$P(A_j|B) = \frac{P(B|A_j)P(A_j)}{\sum_{i=1}^{m} P(B|A_i)P(A_i)}$$

$$P(\text{Has Cancer}\,|\,\text{Positive}) = \frac{P(\text{Positive}\,|\,\text{Has Cancer})\,P(\text{Has Cancer})}{P(\text{Positive}\,|\,\text{Has Cancer})\,P(\text{Has Cancer}) + P(\text{Positive}\,|\,\text{He does not have Cancer})\,P(\text{He does not have Cancer})}$$

$$= \frac{(0.6)(0.001)}{(0.6)(0.001)+(0.02)(0.999)} = 0.029$$

Richard, E.N.: "Learning Bayesian Networks," 2004 by Pearson Education, Inc. pp. 23-24.

Bayesian Network



Proposed Solution

- The objective of this research is to propose a set of guidelines for the optimal design of different drilling specialties, by integrating current best practices through a decision-making system based on Bayesian Intelligence. Best practices collected from **experts' opinions**, are integrated into a Bayesian Network.
- The term *Bayesian* derives from Thomas Bayes (1702-1761), who was a British mathematician. Bayes introduced *Bayesian equation*, which I used in my research.

Bayesian Network

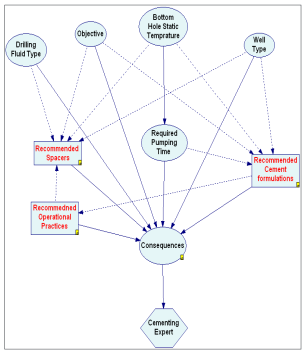
- For this study, GeNIe (Graphical Network Interface) was used for calculations of the uncertainty propagation to build up the expert systems.
- The approach we followed was to deal with all factors that effect our practice selection as uncertainties.

SPE 135183

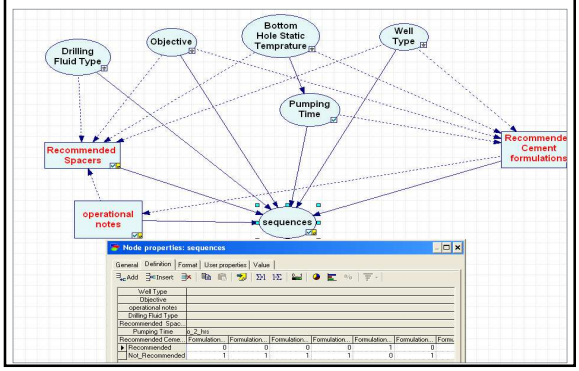
Cementing Model

Cementing Expert Model

- To develop a model that can be used to assist in performing successful cementing operations, a comprehensive model is needed, as the one presented here

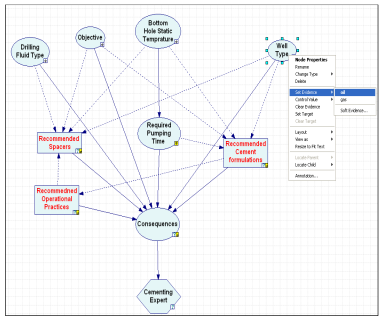


Cementing Expert Model

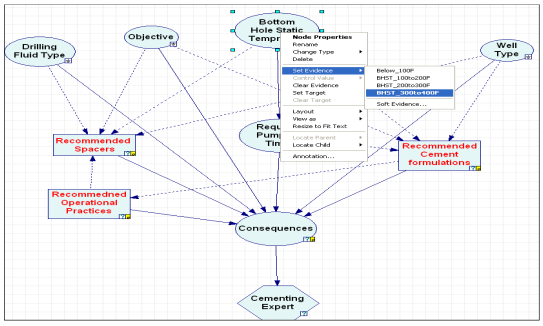


Example: Cementing Oil Production Liner (Selection of Well Type)

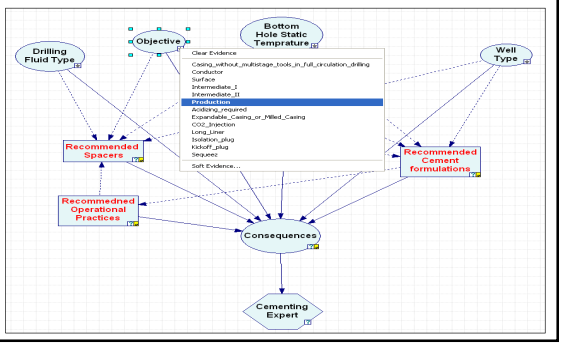
- This section shows the use of this model in one scenario where the user select his conditions



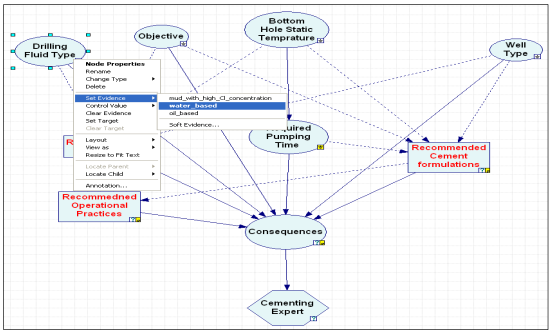
Example: Cementing Oil Production Liner



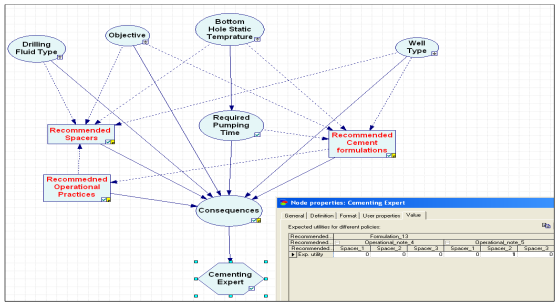
Example: Cementing Oil Production Liner



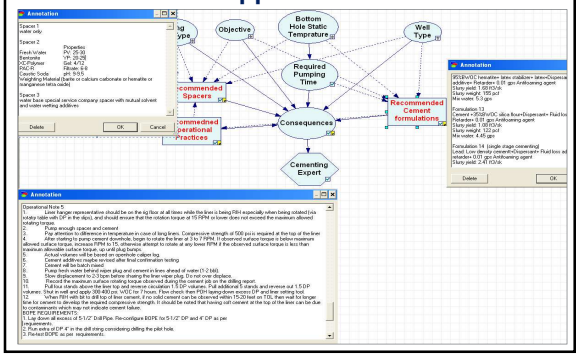
Example: Cementing Oil Production Liner



The Cementing Expert System Recommends Formulation 13, Operational Note 5 and Spacer 2 to Be Used in This Application



The Model Showing More Details for This Application

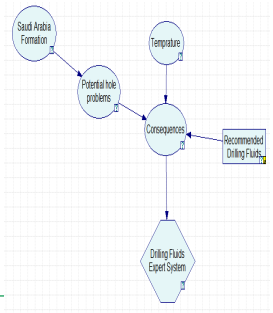


SPE 152098

Drilling Fluids Model

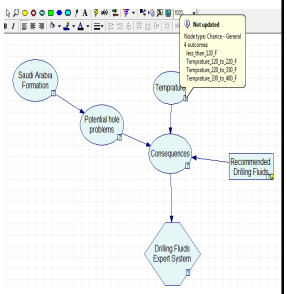
Drilling Fluids Model

- Variable nodes allow the user to input desired well conditions that allows for generating the corresponding best drilling fluids practices. Three uncertainty nodes are defined for this model to determine best practices in one decision node (recommended drilling fluids). The model has one decision which has uncertainties and one consequence node.



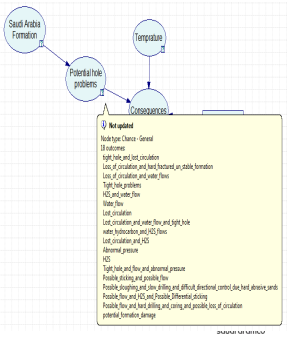
Drilling Fluids Model

- The first uncertainty node is the temperature range. Temperature is divided into 4 ranges since different polymers used in drilling fluids are affected by temperature.



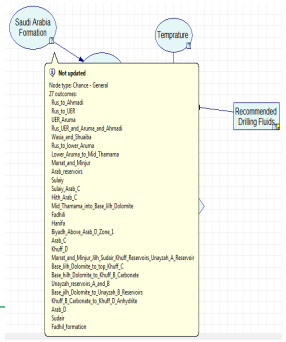
Drilling Fluids Model

- The second node is the potential hole problems uncertainty. These problems are considered to be general problems that need to be considered when designing drilling fluids. The consequences node depends on the temperature range and potential hole problems probabilities selected.



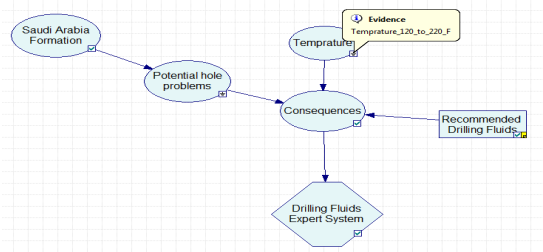
Drilling Fluids Model

- The last uncertainty node in the model is the Saudi Arabia formation, The objective of this node was to utilize the use of this model in Saudi Arabia fields.

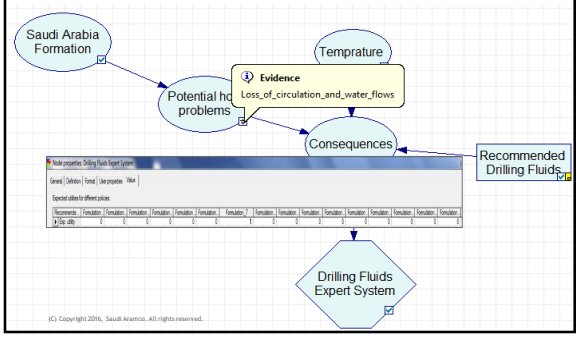


Drilling Fluids Model Example

- Selection of 120 to 220 °F range and loss of circulation and water flows can lead to another example of drilling fluid recommendation, Formulation 7.

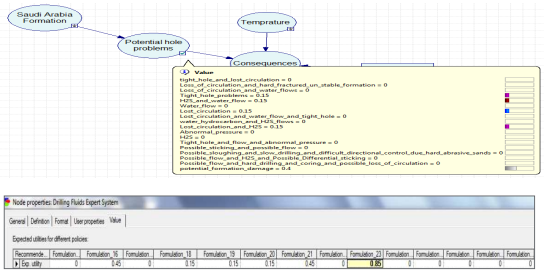


Drilling Fluids Model Example

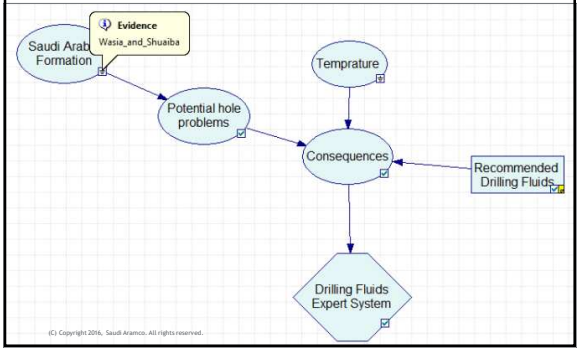


Drilling Fluids Model Example

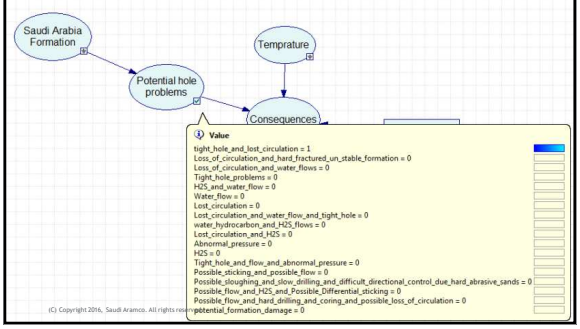
- Selecting Arab-D formation leads to five potential hole problems probabilities. Different drilling fluids formation can be used in this case.



Drilling Fluids Model Example

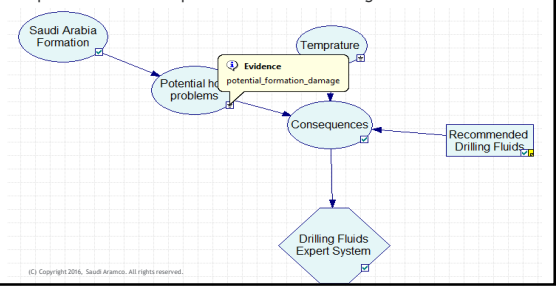


Drilling Fluids Model Example



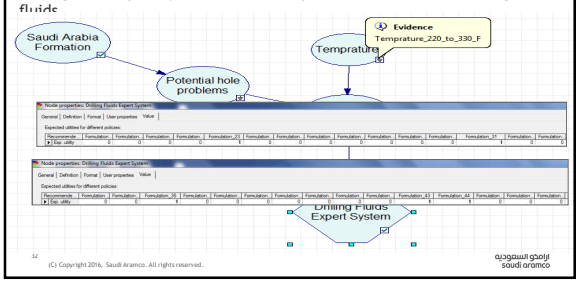
Drilling Fluids Model Example

- The user can select the potential hole problem that might be faced by assigning a probability of one to any of the available probabilities. For example the user selects potential formation damage.

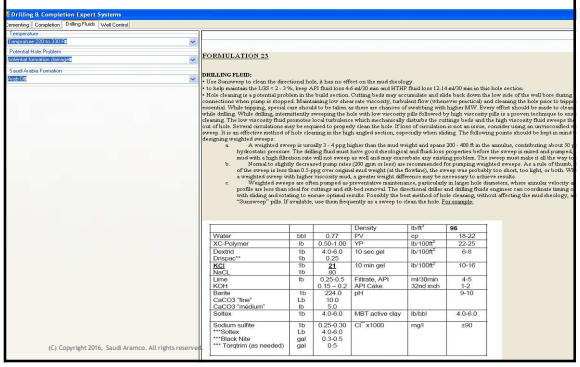


Drilling Fluids Model Example

- A temperature range of 220 to 330 °F was selected. The utility node named drilling fluid expert system shows examples of recommended drilling fluids



Drilling Fluid Expert Software

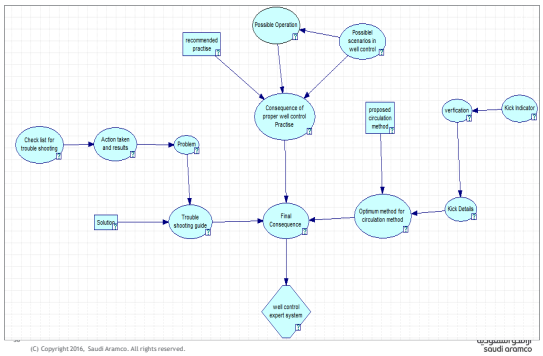


OTC 22882
Well Control Model

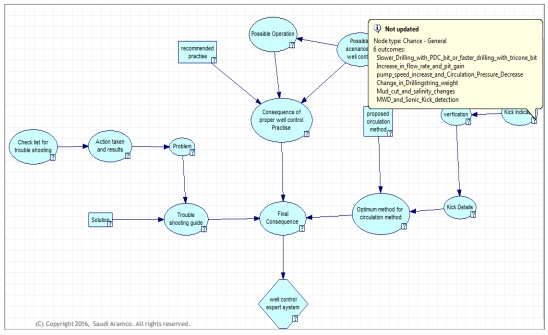
Well Control Expert Model

- The model is divided into three parts or decisions. Each decision has uncertainties and consequences nodes.
- The consequences node combines the uncertainty nodes where well control expert opinions were used to assign and define the conditional probability distribution. The model then calculates the optimum practices decision.

Well Control Expert Model



Well Control Expert Model



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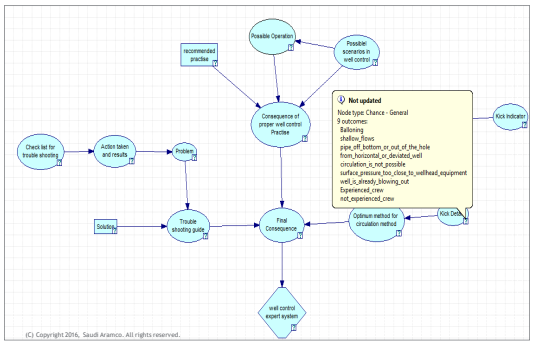

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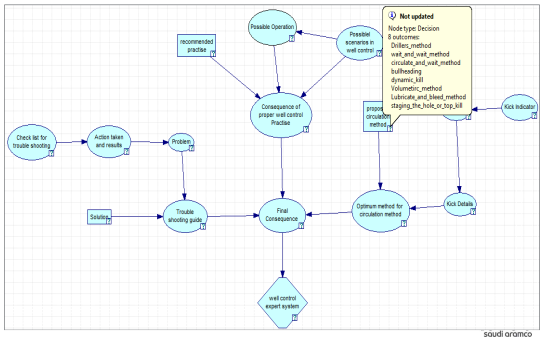

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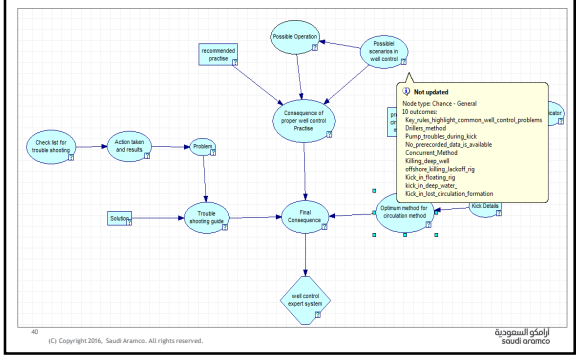

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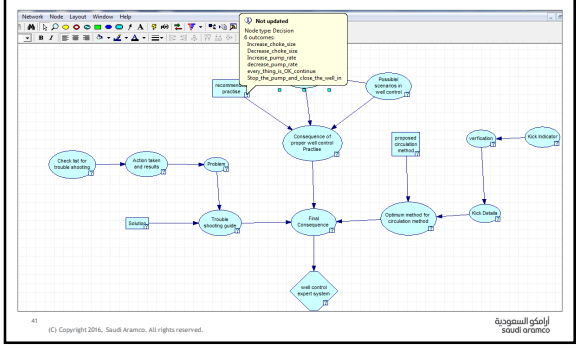

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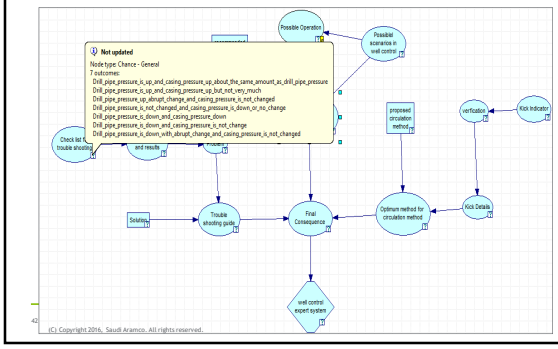

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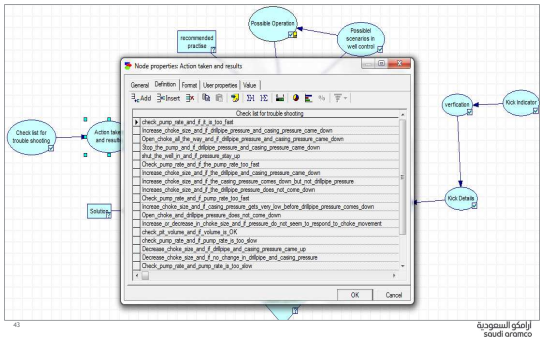

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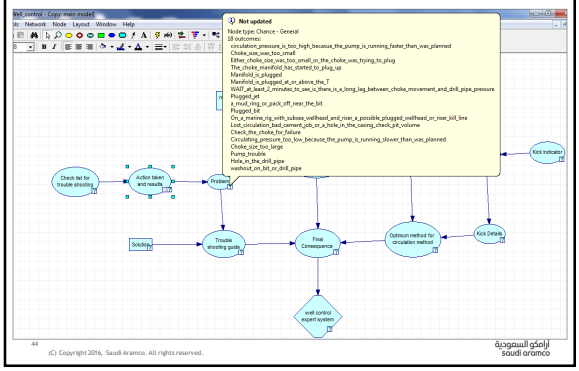

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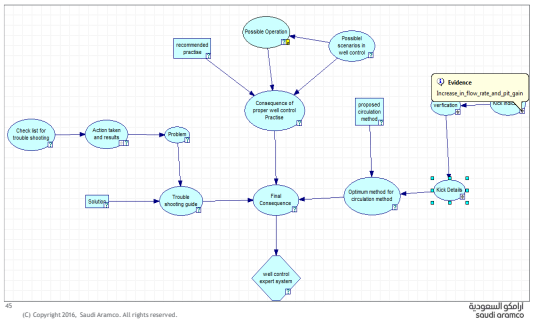

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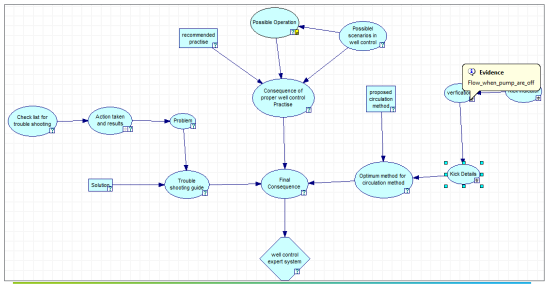

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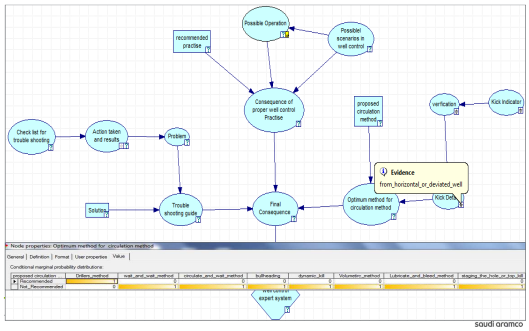

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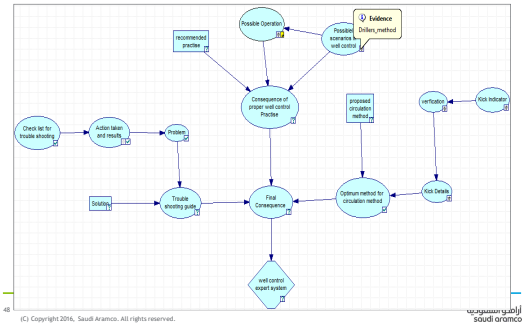

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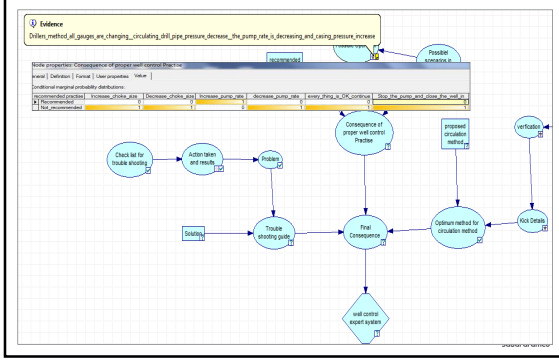

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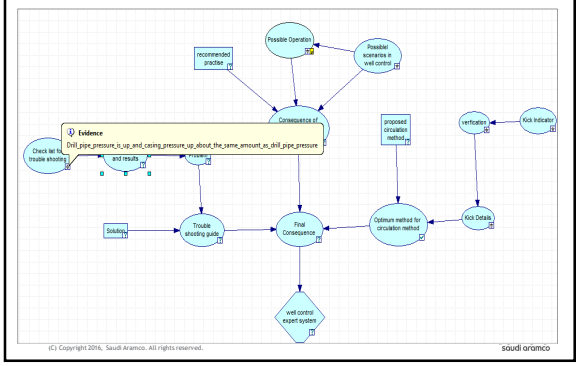

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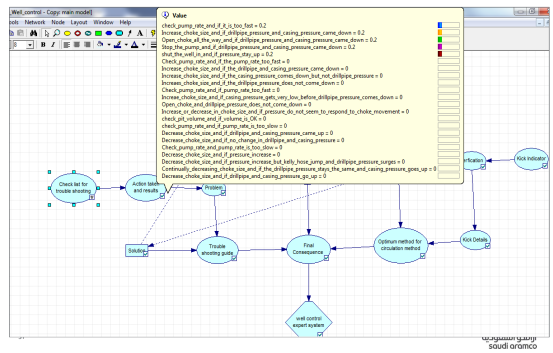

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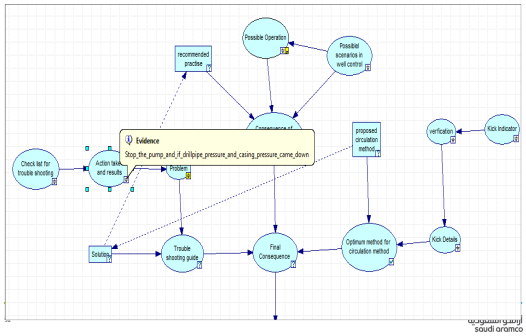

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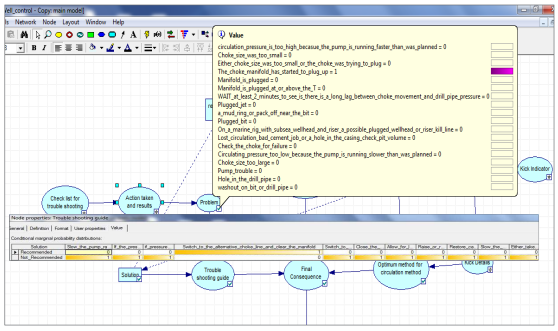
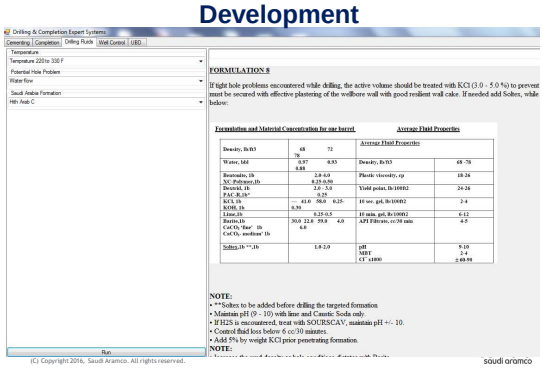
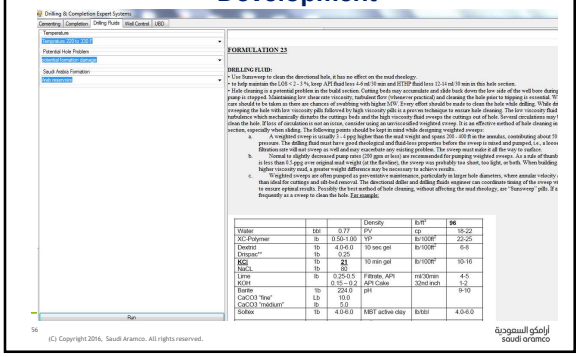


Updating Network

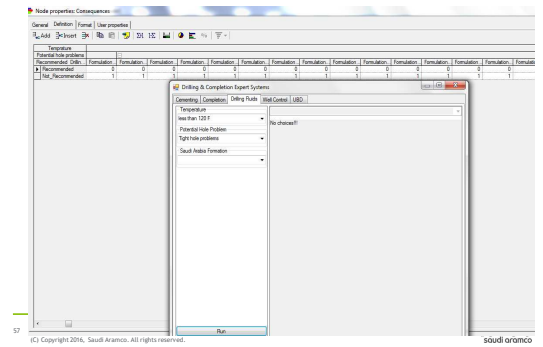
Drilling Fluids Expert Software Development



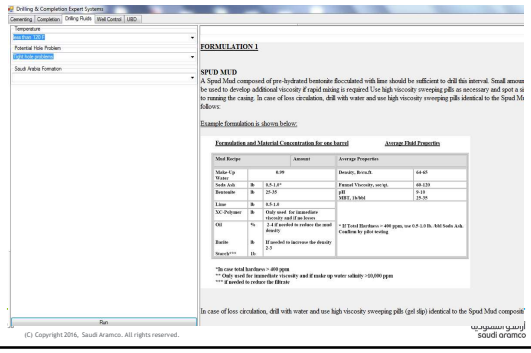
Drilling Fluids Expert Software Development



Drilling Fluids Expert Software Development



Drilling Fluids Expert Software Development



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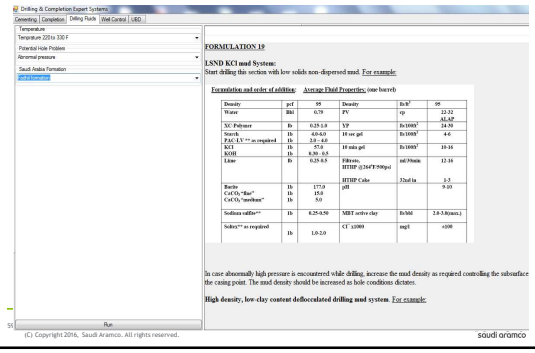
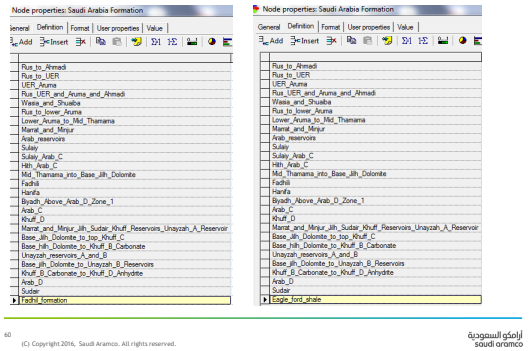


Drilling Fluids Expert Software Development



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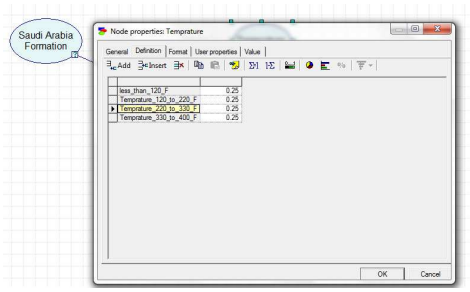

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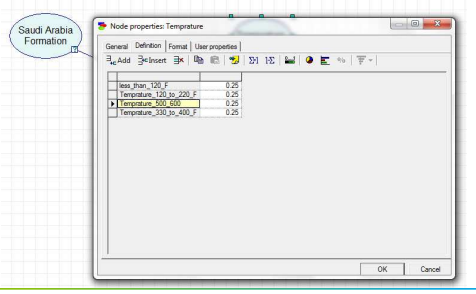
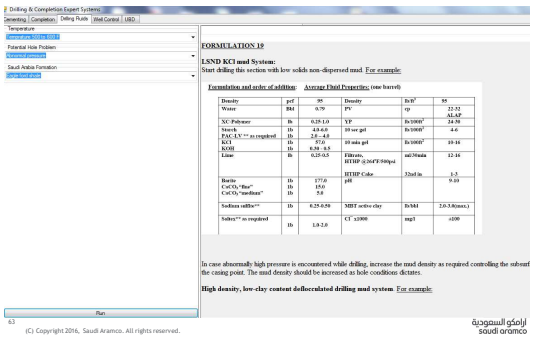
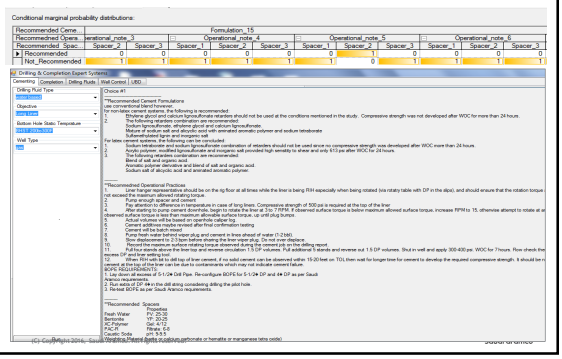


Drilling Fluids Expert Software Development



Cementing Expert Software Development



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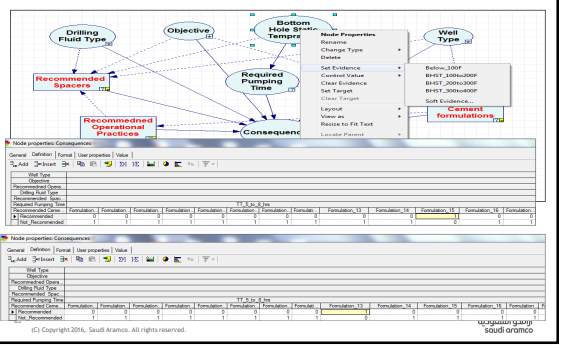

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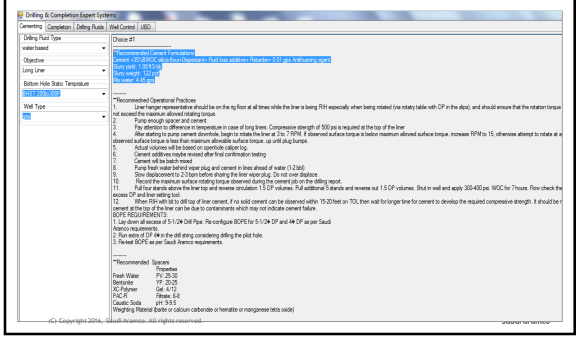
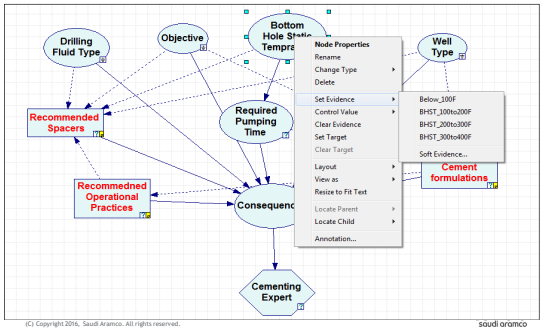


Cementing Expert Software Development



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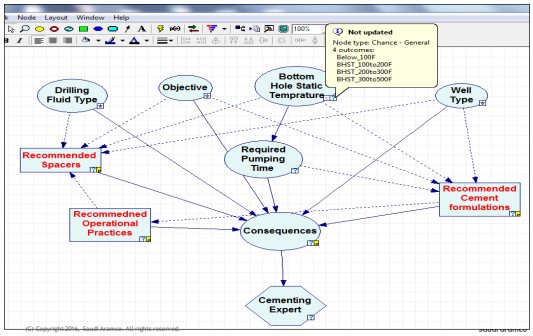
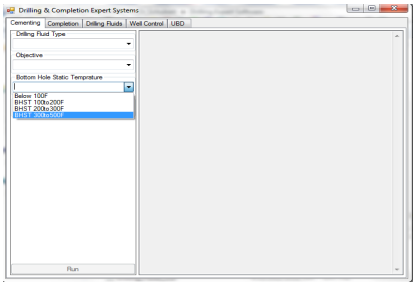
Cementing Expert Software Development



Cementing Expert Software Development



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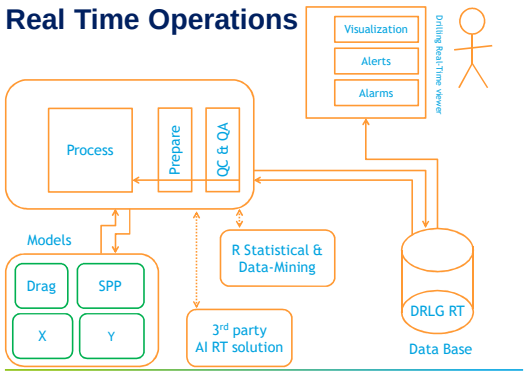
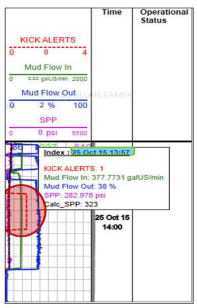
Real Time Operations

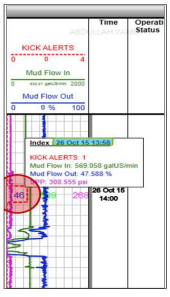


Real Time Operations

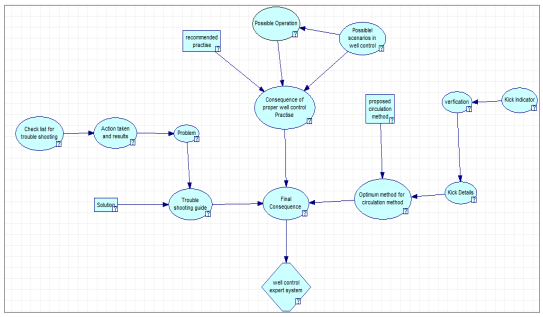
- Ability to monitor +200 wells simultaneously in 365/24/7 basis
- Aggregate, transmit and process 50,000 data points/sec
- Run eight (8) Artificial Intelligence (AI) prediction and correlation modules

Well Control (Automated)





Well Control (Automated)



Drilling Automation

- Recently attracting research area
- New sensors are being manufactured
- Models are being developed
- Real time operations center
- Huge data capturing

Drilling Automation Problem

- Automation in Drilling are being done in silos without consideration to:
  - All drilling parameters; for example ROP optimization is not considering wellbore stability nor hole cleaning
  - To any other science; for example production, geophysics, and geology, statistics, etc.

Part 1: What are the Available Real Time Data? What can we do with it?

- Dynamic Data (Surface)
  - Weight on bit
  - Flow Rate (in/out)
  - RPM
  - Stand Pipe Pressure
  - Pit Volume
  - Flow Line Temperature
  - Mud Properties (not really)

Do we have accurate sensors and good quality Data for our discussion today?

Part 2: What are the Available Real Time Data? What can we do with it?

- Dynamic Data (Downhole)
  - Directional Survey, when is it available?
  - Formation logs (LWD), when is it available?
  - Temperature logs,?
  - Pressure logs, when is it available?

Do we have accurate sensors and good quality Data for our discussion today?

Part 3: What are the Available Real Time Data? What can we do with it?

- Static Data (Geologic Pre-well, not real time?)
  - Lithology?
  - Rock Properties?
  - Fracture Prediction?

Do we have accurate sensors and good quality Data for our discussion today?

Part 4: What are the Available Real Time Data? What can we do with it?

- Static Data (Geophysics, not real time?)
  - Seismic?
  - Offset analysis?
  - Minimum/Maximum horizontal stress?

Do we have accurate sensors and good quality Data for our discussion today?

Part 5: What are the Available Real Time Data? What can we do with it?

- Static Data (Production, not real time?)
  - Production records?
  - Decline Analysis?
  - Casing Pressure?

Do we have accurate sensors and good quality Data for our discussion today?

How Can We Combine Previous Parts to Improve Drilling Performance?

- Well Control, which parts?
- Hole Cleaning, which parts?
- ROP Optimization, which parts?
- Losses, which parts?
- Stuck Pipe Incidents, which parts?
- Wellbore Stability, which parts?
- Formation Damage, which parts?
- **How can we get all parts working together real time handling all drilling activities?**

What Do We Want to End up With?

- Additional Curves and Alarm Systems?
- Who is really the end user of such work?
- Will this cause additional confusion?
- How many fields/wells/rigs are we targeting?
- Do we need to build expert system to give instruction and recommendation or just signal the abnormal performance?
- Will this create new responsibilities and tasks and additional load of work? Is it needed?

Conclusions

- The Bayesian approach was found suitable for designing expert system based on the factors mentioned above. The model can work as a guide to aid drilling engineers and scientists to design and execute optimum drilling practices.
- Using Bayesian network allows us to update our industry practices by updating (automate) the probabilities states mentioned earlier.
- Building platforms and validating them using offset data is basic requirements prior automation
- Future of automation is machine learning not physics driven (opinion)
- Kingdom of Saudi Arabia is a good place for Automation

Thank You