Application of Parallel Processing - A Case Study on Oil Exploration

Siti Nurhidayah binti Zul [#1], Mohamed Faidz Mohamed Said [#2]

 # Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA
70300 Seremban, Negeri Sembilan, MALAYSIA
[1] sitinurhidayahzul9@gmail.com
[2] faidzms@ieee.org

Abstract—**The oil and gas industry is certainly never out of the technology business. Since both oil and gas is not far from production problems and increased reserves, they are synonymous with technology. Without adequate technology, it would not be possible for oil and gas to be drained properly. Especially with the characteristics of national oil blocks that are already old. The Enhance Oil Recovery or EOR is a term commonly used in oil and gas exploration. However, it is one of the incorrect technologies used to maximize the rate of dewatering. Not only the technology requires a lot of investment, it is also dangerous to the environmental health since EOR is known to pump out large amounts of toxic water to the surface thus contributes to the natural pollution. Oil exploration is defined as a research done by an expert in geology to discover the oil and gas underneath the earth. To enhance the process of exploring the oil and natural gas, several methods of parallel processing is utilized in order to increase the manufacture of oil while decrease the pollution made during the exploration process.**

Keyword: **oil, electromagnetic, HPC, CSEM, MPD**

I. INTRODUCTION

In this paper, studies are carried out to look into the application of parallel processing on a case study of oil exploration. Parallel processing is the brain potential to process several things all at once. In other word, when a person sees a problem, they do not just find one solution to solve the problem but rather look for many different perspectives to solve the problem. Oil exploration is also called as hydro carbon exploration. Hydro carbon exploration is one of the categories under the application of reflection seismology. A high resolution map that can read deeper in subsurface area is provided by many oil companies using the research on oil exploration. The subsurface area can be enhanced when the resolution is united with the seismic analysis study and more geophysics application. Oil exploration is an expensive, high-risk operation thus the oil and gas industry is facing severe challenges, such as rising production costs and international political turmoil. This complicates the exploration and drilling of new oil reserves. To reduce the costs and effect on environment, many energy companies are choosing to use technology and supercomputer help to discover the oil and gas exploration. Therefore, using an application of parallel processing in oil exploration, users could identify whether the cost of oil discovery will be reduced as well as whether the production oil exploration will be increased.

A. Definition

In this research study, there are several definitions and terms used to describe the method of approach defined in the literature. Below is the list of definitions with their respective descriptions:

- Parallel Processing: It is a computer mode where the operations carry out simultaneously by splitting the process into several parts on different processors [1]
- Oil Exploration: It is a research study done by geoscience experts in searching beneath the Earth's surface for hydrocarbon deposits [1]
- CSEM: Controlled Source Electromagnetic (CSEM) method is an deep-water searching technique, where the electromagnetic remote-sensing approach is implemented to designate the existence and magnitude of hydrocarbon level under the ocean floor [2]
- GA: The genetic algorithm (GA) is a technique to solve optimized problems originated in a natural selection theory and biological evolution process [3]

B. Technology

According to the numerous paper reviews done during the research, there are several definitions of technologies used in this modern area. This technology helps enhance the process of gathering and exploring the oil and gas thus provides many benefits. The list of some technologies used in oil exploration as mentioned in the papers reviewed is shown below:

- A field-programmable gate array (FPGAs): an integrated circuit (IC) that can be programmed in the field after manufacture. FPGAs are similar in principle to programmable read-only memory (PROM) chips [4], but have vastly wider potential application
- Petro-Mod: a software system that uses C++ programming language suited for petroleum systems model [5]
- Managed pressure drilling (MPD): is used to strengthen the pressure control adjustability, an amount of drilling technologies, proficiency and security as a whole
- High performance computing (HPC): is the operation technique based on super computers for solving advanced application programs effectively [4]

II. HISTORICAL BACKGROUND

History of hydro-carbons started in the 19th century when the purification process of paraffin from crude oil takes place. Since then, many researches and studies are done in order to increase production while the demand in oil usage also increases. In oil exploration, the districts thought to accommodate hydrocarbons are originally dependent on the gravity survey, magnetic survey, and passive seismic or seismic reflection surveys by region to uncover the extensive component of the geological subsurface of Earth. Oil exploration is also categorized under the section of the science petroleum geology. There are three main geophysical methods used in petroleum exploration which are magnetic, gravity and seismic. The methods of magnetic and gravity are used only in the pre-drilling phase. However, seismic survey is used in both exploration and development phases.

III. PAPER REVIEW

In this section, a collection of paper review is being analysed regarding the topic of this research paper. Each paper is discussed in detail as in several categories as stated below:

A. Application of parallel processing in oil exploration

A stochastic approach is used in the hydrocarbon resource estimation [3]. The main idea of this approach is genetic algorithm (GA), which is based on the selection of fitness scaling, crossover probability and mutation of new populations. GA is a technique to resolve all stated constraints. GA also repeatedly modifies a population of individual solutions.

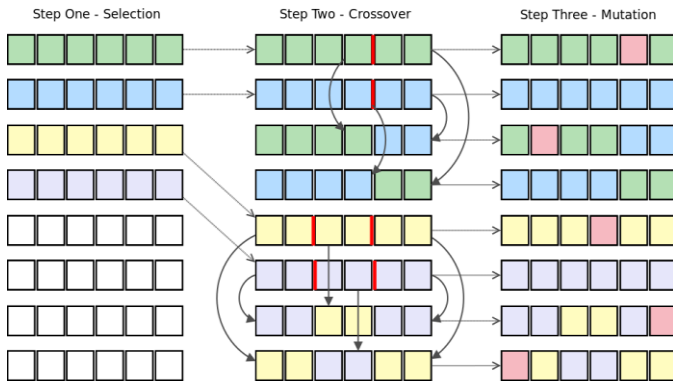Fig. 1 displays the step-by-step example of genetic algorithm.

Fig. 1. Example of genetic algorithm steps [6]

Other application of parallel processing is through an incremental technique where it is used for parallelization of PetroMod using OpenMp [5]. This technique is applied to minimize the workload for both software evolution and management. However, in other direction, a more advanced parallel computer can overcome the conflict regarding shared-memory system. Using Blue Gene/L supercomputer, an

electrical application implements the use of conductivity mapping for potential deep shore on natural gas reservoirs within short time [7]. This method also resolves the problem involving the 3D CSEM image.

B. Advantages of using parallel processing in exploring oil and gas

Several advantages were discovered when using parallel processing method in exploring both oil and gas. The stochastic approach can be utilized to optimize the mass-production of oil and gas condensates [3]. The GA has been implemented in order to grow more dependable interactions to foresee the outcome for the life of oils.

In certain cases, an electromagnetic (EM) technique assist seismic survey to discover a potential hydro-carbon reservoir and enhance the favourable outcome of drilling [8]. The EM and seismic survey is a good tool in solving complex problems. This tool helps reduce time requirement and increase productivity of exploring oil and gas.

The parallel adaptive finite element algorithm presented is used for brisk and precise simulations of 2D EM mishap [9]. The algorithm can be used to test large and complex data model and return the results in short time.

C. Computing aided in resolving oil exploration problems

With the aid of computing, many oil exploration problems can be solved using computing solution. Here is the list of some of computing aided technologies. In recent event, heterogeneous networks of workstations (NOWs) has been acknowledged as the solution for computing problems and the use of this network is quite favourable among the user [10]. This network enables the use of existing data, provides wide degree of performance isolation, offers low cost at wide range of applications, provides services for huge system and also gives aid to a variance of contradict task namely sequential, parallel and interactive task with a variety of computing implementation.

Nevertheless, there are two instances of computer-aided process engineering which are MPD (Managed Pressure Drilling), where it is used to manufacture shale into natural gas and implement deep-offshore approach [11]. These instances help acquire economical production from unsafe and harsh areas.

Moreover, based on hybrid intelligent system, an implementation of CI (Computational Intelligence) method has affected the characteristic of petroleum reservoir and outlook model positively [12]. This technique has the capability to execute several data sets at the same time even if these datasets have a high number of dimensions.

D. Important use of computing in oil exploration

In this paper, data is transmitted by underwater acoustic modems installed on the sensors, platforms and vessels used for logistic support of the oil exploration. Based on the simulator ONE (Opportunistic Network Environment), analysis performance is created to explain the detail of deep shore communication. The process which involves time

management control and proportion between messages time delivery become more organized when the number of vessels in the network increased [13].
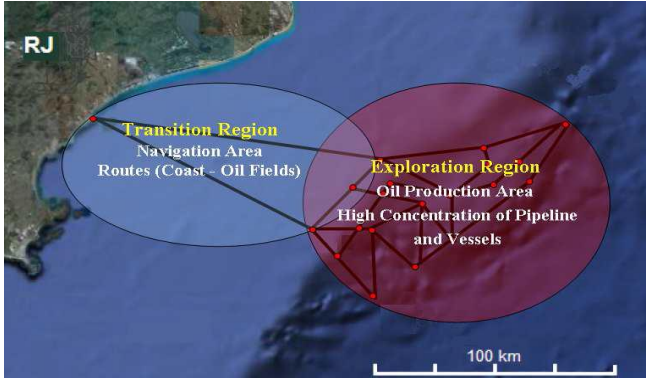

Fig. 2. Exploration region of oil production area [13]

Fig. 2 shows the exploration region of oil production area with high concentration and transition region of navigation area routes (coast-oil fields).

Compare with MT approach, the marine method, CSEM show that it can perform the best because of it capability to produce more hydrocarbons in deep water [2]. Given the great computational cost of 3D inversion, the fact that most marine CSEM data are collected as individual lines of radial component data or a small number of parallel or intersecting lines, and the observation that 2D inversion has become an effective workhorse for MT interpretation even as 3D inversion has become tractable, one could ask what the relative gains of 3D inversion might be. In spite of said that, computing is an important factor in reducing the risk of oil spills while extracting them from the resources [14] as shown in Fig. 3.
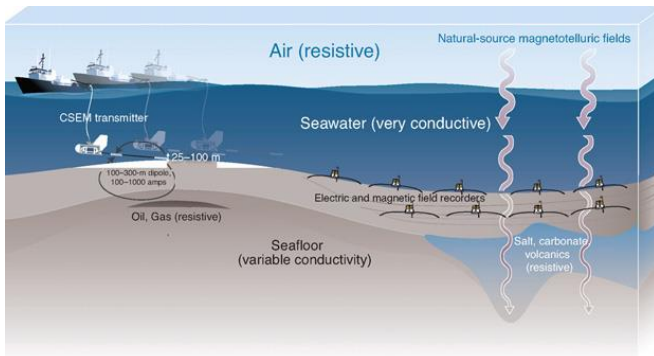

Fig. 3. Example of marine controlled-source electromagnetic (CSEM) method in deep water [2]

E. Brief overview of the use of technology

In the research of oil exploration, different methods are studied to discover whether it can achieve parallelism in computing, and presents how parallelism can be identified compared to serial computing methods [15]. Figure 4 and 5 describes the different methods of computing methods;
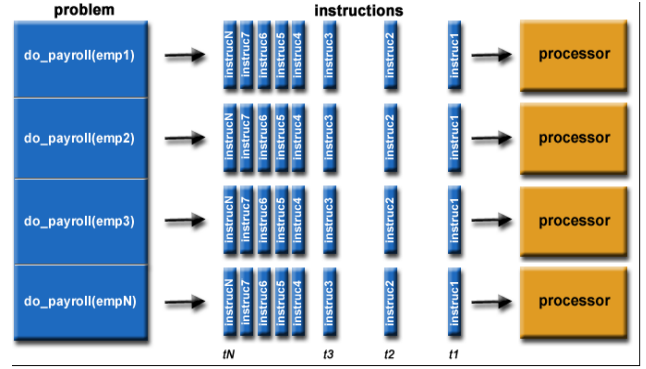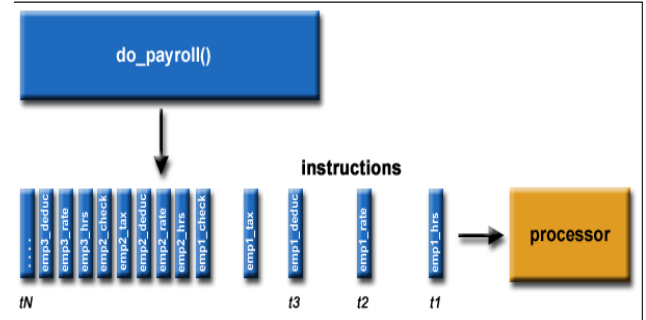

Fig. 4. Parallel computing methods [15]

Fig. 5. Serial computing methods [15]

Parallel computing characteristics are architecture, taxonomies and terms, memory architecture, programming and multicore processors. Parallel computing hardware includes graphics processing units, open computing language, GPU architecture, Streaming Multiprocessor (SM) operation and computer network storage for high capacity systems.

Despite having used HPC technology to enhance the demands, it is doubtable to rely only on one technology. Thus, the acceleration of the most demanding application is analysed using field-programmable gate array (FPGA) technology [16]. FPGA offer more advantage where it can reduce the power use compared to GPU and CPU solution.

Extension of highly complex and subdue deep shore for environment friendly is due to the research study on hydrocarbons using technology such as improvised CSEM on the exploration of natural gas. To overcome this environment, Acoustic Sensor Networks are used. However, time synchronization algorithm is necessary in the application of the sensory networks [7, 13].

IV. CONCLUSION

Each research paper has come to a similar conclusion. By using parallel processing in the study of oil exploration, the cost of oil discovery can be reduced. There are also several advantages when using high performance computing in discovering oil and gas. When the industry needs to leverage the high performance data analytics, accessibility of data flows can be easily conducted and utilized in dealing with excretion, welfare, water, regulations and other issues. Other advantages of using super computer in oil exploration are to exceed the production of oil, accomplish workloads, develop

subsurface hydrocarbon, observe pipeline data and fluid dynamics, save time management and money, as well as to enhance efficiency.

REFERENCES

[1]   Wikipedia. "Hydrocarbon Exploration." https://en.wikipedia.org/wiki/Hydrocarbon_exploration (accessed June 11, 2017).
[2]   S. Constable, "Ten years of marine CSEM for hydrocarbon exploration," *Geophysics,* vol. 75, no. 5, pp. 75A67-75A81, 2010.
[3]   B. Thander, A. Sircar, and G. P. Karmakar, "Hydrocarbon Resource Estimation: A Stochastic Approach," *Journal of Petroleum Exploration and Production Technology,* vol. 5, no. 4, pp. 445-452, 2015.
[4]   P. Sundararajan, "High performance computing using FPGAs," *Xilinx White Paper: FPGAs,* pp. 1-15, 2010.
[5]   H. M. Bücker, A. I. Kauerauf, and A. Rasch, "A Smooth Transition from Serial to Parallel Processing in The Industrial Petroleum System Modeling Package PetroMod," *Computers and Geosciences,* vol. 34, no. 11, pp. 1473-1479, 2008.
[6]   T. Finance, "Using Genetic Programming to evolve Trading Strategies," n.d.
[7]   M. Commer *et al.*, "Massively Parallel Electrical-Conductivity Imaging of Hydrocarbons using The IBM Blue Gene/L Supercomputer," *IBM Journal of Research and Development,* vol. 52, no. 1.2, pp. 93-103, 2008.
[8]   Z. He, W. Hu, and W. Dong, "Petroleum electromagnetic prospecting advances and case studies in China," *Surveys in Geophysics,* vol. 31, no. 2, pp. 207-224, 2010.
[9]   K. Key and J. Ovall, "A Parallel Goal-Oriented Adaptive Finite Element Method for 2.5-D Electromagnetic Modelling," *Geophysical Journal International,* vol. 186, no. 1, pp. 137-154, 2011.
[10]   A. J. Plaza, "Parallel Techniques for Information Extraction from Hyperspectral Imagery Using Heterogeneous Networks of Workstations," *Journal of Parallel and Distributed Computing,* vol. 68, no. 1, pp. 93-111, 2008.
[11]   M. Nikolaou, "Computer-Aided Process Engineering in Oil and Gas Production," *Computers & Chemical Engineering,* vol. 51, pp. 96-101, 2013.
[12]   F. A. Anifowose, J. Labadin, and A. Abdulraheem, "Hybrid Intelligent Systems in Petroleum Reservoir Characterization and Modeling: The Journey So Far and The Challenges Ahead," *Journal of Petroleum Exploration and Production Technology,* vol. 7, no. 1, pp. 251-263, 2017.
[13]   F. c. J. L. Ribeiro, A. de Castro Pinto Pedroza, and L. s. H. M. K. Costa, "Underwater Monitoring System for Oil Exploration using Acoustic Sensor Networks," *Telecommunication Systems : Modelling, Analysis, Design and Management,* vol. 58, no. 1, pp. 91-106, 2015.
[14]   A. Jernelöv, "The threats from oil spills: Now, then, and in the future," *AMBIO: A Journal of the Human Environment,* vol. 39, no. 6, pp. 353-366, 2010.
[15]   L. A. Clevenger, H. Eng, K. Khan, J. Maghsoudi, and M. Reid, "Parallel Computing Hardware and Software Architectures for High Performance Computing," May 1, 2015 2015.
[16]   O. Lindtjorn, R. Clapp, O. Pell, H. Fu, M. Flynn, and O. Mencer, "Beyond traditional microprocessors for geoscience high-performance computing applications," *Ieee Micro,* vol. 31, no. 2, pp. 41-49, 2011.