Pakistan Journal of Hydrocarbon Research
Vol. 8, No. 1 (January 1996). p. 59-61. 4 Figs

Seismic and its Super Computing Challenges

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ABSTRACT

Seismic methods are widely used for exploration of hydrocarbons. In the last two decades there has been remarkable advancements in the seismic techniques which are mostly attributed to the need for exploration of complex, deep reservoirs. To fulfill these requirements seismic processing has grown to a major super computing challenge. This paper reviews the developments in various technologies behind seismic, like top of the line digital computers, storage media and data acquisition systems and then explores various options available for seismic data processing.

INTRODUCTION

Seismic, an acoustic imaging technique, is a major tool for hydrocarbon exploration. Seismic processing is not only compute-intensive but is also noted for data volume and I/O requirements. This can be visualized from the fact that an average seismic dataset, contains 40 million traces and has a size of 320 Gbytes. Such a large data volume has to undergo extensive signal processing such as, demultiplexing, sorting, digital filtering, convolution, correlation, and several other mathematical operations involving complex integrals. Thus seismic processing has gone far beyond the range of mainframes and has emerged as a global super computing challenge. The oil industry is therefore the largest market for super computing systems and thus the leading manufacturers, like CRAY and Fujitsu, are mostly concerned about the development of seismic software for their systems.

DEVELOPMENT REVIEW

In the last two decades the seismic industry has advanced exponentially. This advancement is mainly due to two major factors; the growing complexity of exploration targets and parallel advancements in various technologies forming the backbone of seismic techniques. These two factors (Figure 1) are discussed below.

I. From the early days of seismic, due to continuous exploration and production all major near surface reservoirs have been explored and consumed. The new hydrocarbon targets are complex and deep and therefore require much more sophisticated technologies for delineation. To accomplish these challenges there has been revolutionary advancements in seismic techniques such as; increase in CDP coverage, increase in resolution, 3D seismic surveys and finally 4D (or time elapse 3D) seismic surveys.

II. Due to the above advancements, in seismic techniques, there has been a considerable increase in the volume of seismic data. In addition more complex and compute intensive algorithms have been developed, to process such large volumes of data, for signal enhancement. These requirements have forced seismic techniques to become a continous challenge to the supporting electronic and computer industry. To cope with these requirements, various technologies behind seismic methods have progressed to a great deal. Advancements in the three major supporting technologies are discussed below.

Data Acquisition Systems

With the increasing needs of seismic surveys there has been considerable advancements in seismic data acquisition systems. The main areas of improvement in this regard are increase in the sampling rate, dynamic range and the number of channels. The new systems now offer unlimited channel capability. In addition other advancements like radio telemetry system, fiber optic cables and on-line workstation based controller have also been incorporated. Figure 2 shows the increase, over the years, in the number of channels practically used in seismic surveys.

Storage Media

To store large volumes of seismic data there has been an exponential increase in the storage capacity of magnetic tapes. Compact disks with compressed storage technology have also been introduced in the seismic industry. Figure 3 shows the increase in the storage density of magnetic tapes in the last 25 years.

Computer Systems

Seismic data processing demands very fast computational engines. With the advent of VLSI technology, fast circuitry and parallel architecture there has been a continuous increase in the computational speed of computers. Figure 4 shows the

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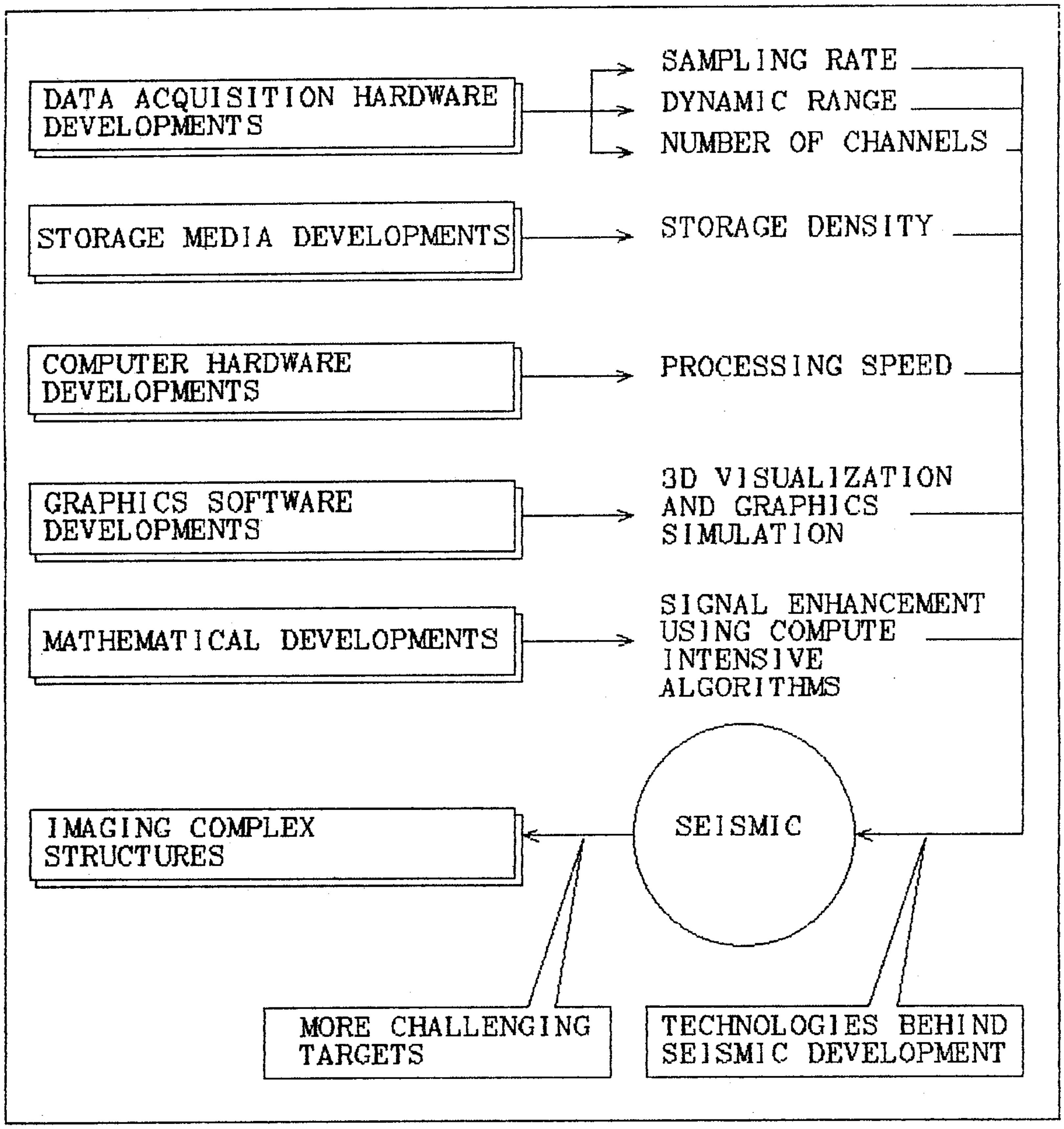

Figure 1 - Schematic approach showing various technologies behind the advancements in seismic methods and the exploration targets which demand advancements in these technologies.

increase in the peak computational speed of computers (based on the fastest computers).

From the above review it can be observed that there has been considerable advancements in electronic and computer technologies, supporting the seismic methods. The seismic, on the other hand, due to its ever changing trends and increasingly complex targets has always been a challenge even to the latest supporting technologies.

COMPUTATIONAL OPTIONS

We now explore some new trends in the computing industry and focus on some economical choices which can solve the seismic challenge.

In 1992 SEG mini-workshop, entitled "New Trend in Computing", emphasis were laid on bringing parallel computing into the mainstream, particularly in the oil industry. In this regard some computational experiments were performed at MIT, Earth Resources Lab (Charrette, 1993). A

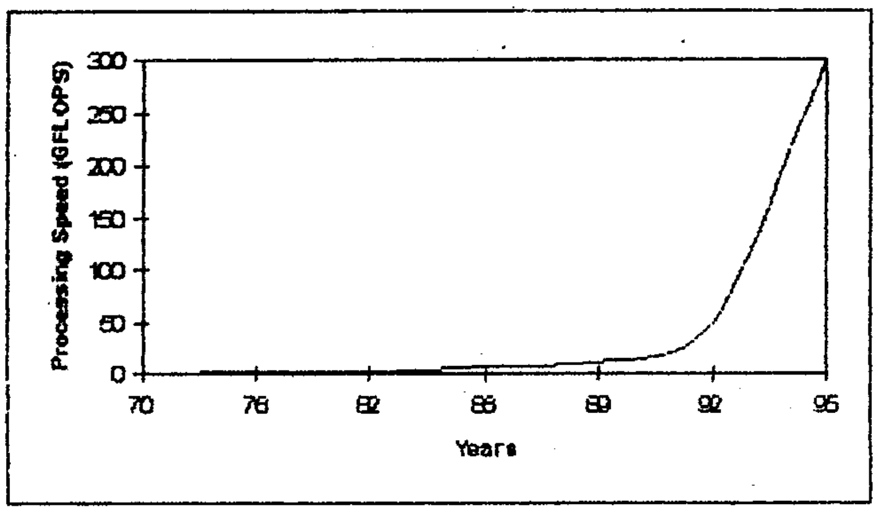

Figure 2 - Increase in the number of channels, supported by data acquisition systems and practically used in seismic surveys. (traces per record = number of channels)

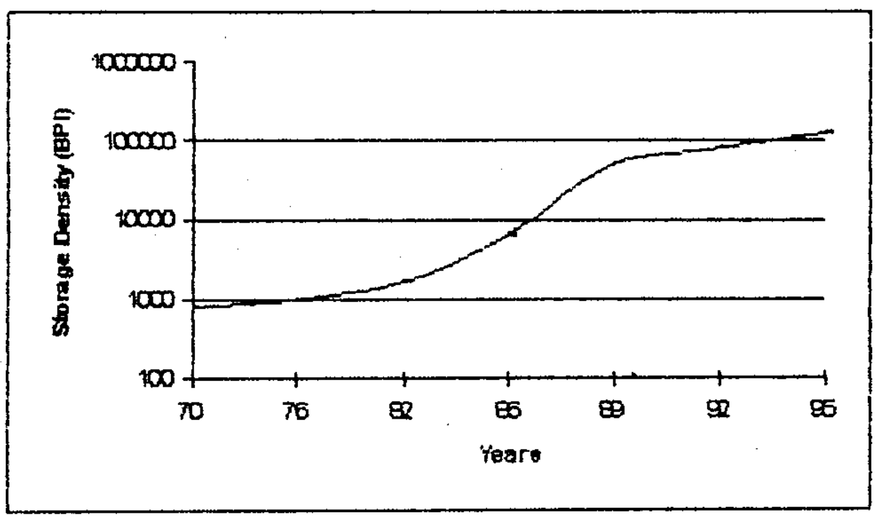

Figure 3 - Increase in the storage density of magnetic tapes in the last 25 years. (BPI = Bits per Inch)

sample program was analyzed on two parallel topologies, an nCUBE 2 parallel computer with eight processors each having a sustained compute rate of 2 MFLOPS and a network of four DEC 5000 workstations each having a sustained rate of 5 MFLOPS. It was found that the total run time for the network of workstations was much higher than for the nCUBE 2, a high performance parallel computer (HPPC). This difference was mainly due to the speed of the network communications. The workstations were connected through an ethernet which has a peak bandwidth of 10 Mbits/sec, but it generally performs at 25% efficiency. On the other hand the HPPCs have inter-processor bandwidths of 20-100 Mbits/sec and are capable of performing at nearly peak speed. This suggests that the workstation network is more useful for problems where the ratio of computation to communication is large.

Another economical configuration is the parallel distributed workstation system in which several workstations are

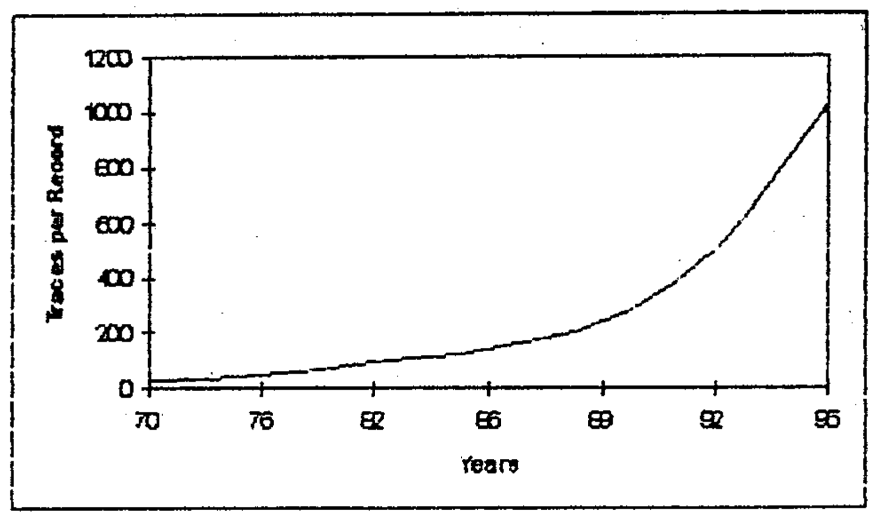

Figure 4 - Increase in the peak computational speed (starting from less than 0.1 GFLOPS in 1970), based on the fastest computers over the last 25 years. (FLOPS = Floating point Operations Per Sectond)

connected to a mainframe. In this case the ideal choice would be the IBM Enterprise System (ES/9000) connected to eight IBM RISC System (RS/6000) workstations through parallel channel adapter (PCA) cards. The performance of PCA cards is much higher than the ethernet, thus this configuration can be useful for seismic applications.

Finally the most effective solution for seismic applications is the Cray Research Inc's (CRI) Massively Parallel Processor (MPP) Product , T3D which is multiple-instruction multiple-data (MIMD) in architecture. It has 2048 processing elements (PEs) with a potential peak performance of 300 GFLOPS (Koeninger, 1992). On the programming side the global addressing feature of CRAY MPP Fortran Programming Model (Pase, 1992) can be used for optimized load balancing and minimized communications. Such facilities are useful for writing parallel algorithms used in solving complex seismic problems.

The above discussion provides a wide range of computational options for seismic data processing. The appropriate system can be chosen according to the data volume and processing requirements.

REFERENCES

Charrette, E.E., J.R. Matarese and M.N. Toksoz 1993, A portable parallel finite difference benchmark, 55th Meeting, European Association of Exploration Geophysicists, Extended Abstracts, paper p. 17.

Koeninger, K., 1992, Massive parallel performance a Cray Research: CRAY CHANNELS, Fall.

Pase, D., P. MacDonald and A. Melzer 1992, CRAY MPP Fortran Programming Model: Cray Research, Inc. report.