Implementation of parallel processing in BCE seismic analysis software to decrease CPU requirements

The BCE seismic analysis software contains various algorithms that can result in significant processing time (such as the Time Variant Blind Seismic Deconvolution, which is described in Technical Note 9, and the Normal Move Out Tomography, described in Technical Note 17). In the past considerable efforts were made to optimize the algorithms as much as possible, but more recently the software was modified to take full advantage of multi-core processors and the Hyper-Threading (HT) technology.

The Central Processing Unit (CPU) in a computer carries out the computational work. While a traditional single-core CPU can only carry out one task at a time, the Multi-core CPUs allow multiple tasks to run concurrently. In general terms, a multi-core processor is a single CPU component with two or more independent physical processing units ("cores"). Each core can carry out calculations independently from the other, and the HT technology takes this one step further by creating two virtual processing cores for each physical core present in a CPU, which enables the CPU to delegate tasks between cores in real time. While many computers contain multi-core CPUs and implement HT technology, the software needs to (re)designed to take full advantage of these features and actually have computations performed in parallel.

BCE designs software utilizing the Embarcadero RAD studio development environment. Embarcadero has recently provided a parallel programming library, which allows developers to readily design software with tasks running in parallel using the TTask class function. In addition the so-called TParallel.For class function allows for the replacement of the sequential *for-loop* provided the loop is not recursive (i.e. the next loop iteration does not depend on values calculated in the previous iteration). TParallel.For executes two or more iterations in parallel rather than sequentially as in the standard *for-loop*, and this function was found to be ideally suited for the tomography algorithm where numerous iterations of forward modeling are carried out utilizing Monte Carlo techniques to vary the initial simplex. Unfortunately the same function could not be used for the blind seismic deconvolution algorithm as this requires extensive recursive loops

After these features were implemented in the 2017 version of the SC3-RAV software test bed analysis was carried out on the same set of data outlined in Technical Note 17. The analysis was carried out on a Dell Latitude E6520 with a quad-core Intel i7-2760QM CPU @ 2.40 GHz. Figure 1 illustrates the CPU[1] usage output from the Windows™ *Resource Monitor* utility when running the standard (32-bit) version of the tomography algorithm provided in the 2016 version of SC3-RAV™. As is evident from Fig. 1, the usage of the CPUs is minimal to moderate.
Figure 2 illustrates the same output with the (64-bit) version of the tomography algorithm included in the 2017 version of SC3-RAV. Clearly the usage of all eight CPUs has been increased substantially, resulting in a reduction in the processing time of some 60%.

[1] 8 CPUs for four multi-cores utilizing HT technology (two virtual cores for every physical core (i.e., 2x4 = 8 CPUs)).

Figure 1. Output from Windows™ *Resource Monitor* utility when implementing the 32-bit version of 2D NMO tomography algorithm provided within SC3-RAV™.

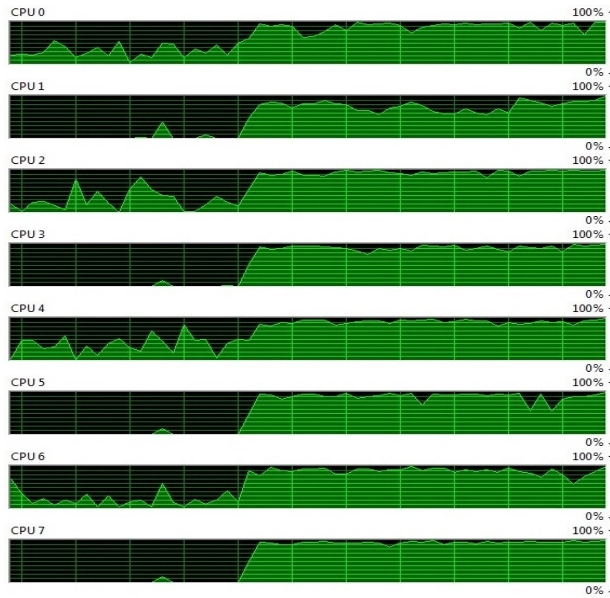

Figure 2. Output from Windows™ *Resource Monitor* utility when implementing the 64-bit version of the 2D NMO tomography algorithm provided within SC3-RAV™.

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