PARALLEL IMPLEMENTATION OF NUMERICAL SIMULATION OF ELASTIC WAVES ON THE BASE OF LAGUERRE TRANSFORM FOLLOWED BY DOMAIN DECOMPOSITION

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Currently a common way to perform full scale numerical simulation of seismic wave propagation in heterogeneous media is to use explicit in time finite-difference schemes. This approach is easy for implementation and provides a natural way for parallelization on the base of domain decomposition when each elementary subdomain is assigned to a single Processor Unit (PU). At the same time, along with the obvious advantages of this approach it has some serious drawbacks, one being the need of data exchanges between the adjacent processors at each time step, which significantly reduces the efficiency and scalability of the software, especially in elastic media with considerable variability of the velocity of wave propagation. A new class of problems produced by necessity of modeling of wave propagation in multiscale media has led to the need not only to exchange data between neighboring processors, but also to couple different grids used to describe background and cavernous/fractured reservoir. This further worsens the efficiency and scalability of the method.

We develop another approach to numerical resolution of this class of problems, based on successive application of separation of time in the elastic wave equations, domain decomposition and organization of iterative process on the base of Schwartz alternations (Chan and Mathew, 1994). The key point of this approach is the use of integral Laguerre transform with respect to time, which provides strict negative definiteness of an elliptic operator (Konyukh, Mikhailenko and Mikhailov, 2001) that ensures exponential convergence of Schwartz iterations. It must be emphasized that the separation of time by Fourier transform leads to a sign-indefinite system of elliptic equations, for which the iterative process based on Schwartz alternation, generally speaking, does not converge. It is worth mentioning that this elliptic system does not depend on the parameter of separation. Therefore, the matrix, which arises after its finite-difference approximation in each subdomain needs to be inverted only once.

The parallel software is developed and tested. Results of numerical experiments performed for 2D Gullfaks synthetic model (Fossen and Hesthammer, 1998) are presented and discussed.

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References

Chan T., Mathew T.P., 1994. Domain decomposition, *Acta Numerica*, **3**, 61-143.

Fossen H., Hesthammer J., 1998. Structural geology of the Gullfaks Field, northern North Sea, Geological Society, London, Special Publications, **127**, 231-261.

Konyukh G.V., Mikhailenko B.G. and Mikhailov A.A., 2001. Application of the integral Laguerre transforms for forward seismic modeling, Journal of Computational Acoustics, **9**, 1523-1541.