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The detection of objects using acoustic waves is a crucial issue in the marine and aeronautical fields. This is based on the principle of acoustic diffraction, also called scattering: an acoustic wave is emitted from a device, such as a sonar, and is then reflected, either partially or totally, by the obstacle we wish to detect. It is this diffracted wave that is then detected by sensors.

We focus on time-harmonic acoustic wave propagation, which is modeled by the Helmholtz equation. However, the domain in which the wave propagates is usually unbounded, so that its direct discretization is not possible. Assuming that the domain is homogeneous, i.e. the wavenumber is constant, we can circumvent this issue by reducing the problem to another one formulated on the boundary of the domain, using Boundary Integral Operators.

In practice, a domain is not homogeneous everywhere, but can often be split into a homogeneous subdomain and a heterogeneous one. In order to exploit this knowledge, we want to solve the heterogeneous problem with the Finite Element Method (FEM) and the homogeneous one with the Boundary Element Method (BEM): it is known as FEM-BEM coupling. The linear system of the discretized problem involves a block matrix with sparse and dense blocks: for such a problem, there is no known efficient preconditioner.

In this talk, we show how to use the recent functionalities implemented in FreeFEM to deal with FEM-BEM coupling in a user-friendly way, with underlying distributed memory parallelism (MPI).
After recalling some theory of Boundary Integral Equations, we establish a comparative study of several FEM-BEM coupling techniques using GMRES, and explore some first preconditioning strategies. In particular, we examine the number of iterations with increasing wavenumber for different types of obstacles and incident angles.