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Numerical Simulation of Some Antenna Systems for the Square Kilometer Array Project—Challenges and Successes

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In this paper we discuss the problem of rigorous simulation of some of the potential candidates for the antenna designs being considered for the Square Kilometer Array (SKA) project. These include large arrays of wide-band elements, such as Vivaldis that are mounted on complex structures, as well as reflector antenna systems with patch array feeds and support systems, e.g., struts. Accurate prediction of the impedance characteristics as well as of the radiation patterns—including the wide angle sidelobe levels—is extremely important in the design stage, when many options must be weighed in and factored into the process of developing optimal configurations from the point of view of overall performance.

Because of the large electrical size of the overall system, whose dimensions are in the range of tens or even hundreds of wavelengths, rigorous calculations of the near and far field parameters require extensive computing resources, equipped with a large number of processors, access to substantial memory and adequate CPU time. Hence, such problems can only be handled on a parallel computing facility. However, computing resources alone are not adequate for the task, and availability of the "right" CEM code, which scales well on parallel platforms is the key to successful modeling of the large and multiscale type of problems that need to be analyzed for the SKA project. We should also mention that most of the available commercial CEM tools are found to be woefully inadequate for the task, because they do not scale well when parallelized.

For the problems at hand, the simulations are typically carried out on a supercomputer with more than 3000 compute nodes, each consisting of 4 cores and 2GB of memory. The parallelized Finite-Difference Time-Domain (FDTD) software package GEMS, which is enabled with the Message Passing Interface Library, has been adopted to carry out the simulations, since it is capable of handling electrically large and complex systems with very high accuracy and numerical efficiency, and it exhibits excellent scaling properties on large computer clusters. Extensive results will be included in the presentation to illustrate both the challenges and successes encountered in the course of the studies of SKA antennas that we have carried out during the last four years.

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