

## Parallelization of the Multilevel Fast Physical Optics Algorithm with Application to Reflector Antennas

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Conventionally, the radiation pattern of a reflector antenna is evaluated in three steps. First, the radiation pattern of the feed is computed or measured. Subsequently, the field is propagated from the feed to the main reflector, either directly or via a sub-reflector. Finally, the radiation pattern of the main reflector is evaluated assuming that the fields on its surface have been pre-computed at the preceding stage. Here, we concentrate on the last step that is often effected by evaluating the Physical Optics (PO) integral over the surface currents, while assuming that these currents are related to the tangential magnetic field on the reflector surface. The PO contribution is often augmented by the Physical Theory of Diffraction (PTD) line integral, in order to improve the far sidelobe accuracy. In all cases, for problems with large electrical dimensions, the computation time is dominated by the (surface) PO integration time. To that end, the radiation pattern evaluation of the main reflector can be efficiently performed using the MultiLevel Physical Optics (MLPO) algorithm recently proposed by the authors (A. Boag and C. Letrou, *IEEE Trans. Antennas Propagat.*, 53(6), 2064-2072, 2005). The MLPO algorithm relies on the divide-and-conquer strategy starting with a multilevel domain decomposition of the reflector surface. At the finest level, the subdomains are roughly one wavelength in size. The radiation patterns of the subdomains at the finest level of the decomposition are evaluated directly on a very coarse grid of directions by performing PO integrals, which are augmented by PTD contributions for subdomains adjacent to the reflector rim. The total radiation pattern is then computed via a multilevel aggregation of the subdomain patterns. The aggregation involves interpolation to finer grids of directions and phase corrections. The MLPO algorithm reduces the complexity of evaluating the PO and PTD integrals to the level comparable to that of the Fast Fourier Transform (FFT)-based computation of radiation patterns of planar apertures.

In this work, we focus mainly on the parallelization of the MLPO using distributed memory architectures. The optimized distributed memory parallel MLPO algorithm starts with distributing the sub-domains among the nodes, based on the geometric proximity, so that the integration process and the first levels of aggregation require no communication between nodes. At each transition between levels, four patterns are aggregated after the interpolation, which increases their size four fold in a binary subdivision scheme. When radiation patterns become too large for the memory available at a node or when the number of patterns becomes roughly equal to the number of nodes, each pattern is cut into four parts that are distributed among four nodes before interpolation. This algorithm appears to be particularly attractive in terms of memory requirements and communication cost: memory requirements remain roughly the same at all levels for a given node, and at a given aggregation step, each node only has to communicate with three other nodes. As a consequence, the scalability of the algorithm was found to be theoretically perfect. Initial results of parallelization on graphics processing units (GPUs) will also be presented.