Chapter 10

COOPERATIVE COMPUTER AIDED ENGINEERING OF ANTENNA ARRAYS

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Abstract: In this chapter, the problem of Computer Aided Engineering (CAE) of rectangular aperture arrays is attacked taking advantage of grid computing technologies. This allows an implementation of the CAE environment in a service oriented framework, where CAE components are encapsulated into services and exploited remotely through the grid. We also propose an ontology for CAE of aperture antennas. The ontology allows the identification and localization of remote services and their orchestration for CAE problem solving. It is demonstrated that the strong need of cooperation tools in CAE of microwave circuits and antennas is perfectly fulfilled by these emerging information technologies.

Key words: CAE; Cooperative Engineering; Grid Computing; Aperture Antenna Array; Semantic Grid; Ontology.

1. INTRODUCTION

Microwave (MW) engineering and research must often and often face the problems implied by the growing complexity of applications and services. One of the most frequent consequences is the increase in the peak demand of computing power for the computer-aided-engineering (CAE) of large circuits and antennas. One typical example is represented by the CAE of aperture arrays. Indeed, the accurate modeling of the radiating behavior is not trivial even for simple apertures and becomes nearly unaffordable when medium-sized aperture arrays must be dealt with, as periodic approximations cannot be adopted.
Another issue is the need of integration of heterogeneous knowledge and design skills: a research project in the CAE of aperture arrays often deserves a joint effort of several groups, each with its own favorite numerical approaches, programming methodologies, etc. In other words, a strong need of cooperative engineering strategies arises. This goes along with another key-point: the importance of avoiding reinventing the wheel, when possible. Indeed, in many cases the MW researcher could take substantial advantage from existing solutions; unfortunately, it often happens that existing solutions are not easily accessed or integrated in the framework of a more complex application.

In conclusion, interoperability, portability and compatibility are crucial issues, along with the development of very efficient numerical software.

Now, in this chapter we demonstrate that grid computing technologies, and semantic grids more specifically, are suitable to fulfill the above mentioned requirements.

In Section 2, the basic properties of a CAE framework are summarized. Section 3 is an overview on semantic grids, whilst Section 4 focuses on the relative architectures. Section 5 describes how the CAE environment can be set up thanks to grids and ontologies, and finally conclusions are drawn.

2. CAE OF APERTURE ANTENNA ARRAYS

The analysis of an antenna array starts from the study of the physical elementary structure (i.e. the geometry of the single radiator) and gives at the end a full insight into the properties of the whole device (the antenna array). As usually happens when dealing with complex problems a sort of schematization must be introduced in order to simplify the problem and divide it into various sub-problems. In such a perspective, the problem of CAE of an array of rectangular flange-mounted apertures (we concentrate on such devices since now on), can be considered as composed of four main tasks, namely: 1) analysis and design of the feeding waveguide section (AFS) 2) analysis and design of the aperture over the flange (AMC) 3) analysis of the overall behavior of the system (ESM) 4) analysis of the consequent radiating properties of the system (ERP).

The study of the basic radiating structure, namely the elementary radiator opening over the flange, can be faced by employing different numerical techniques, basically mentioned in some pioneering works enumerated in [Mongiard et al., 2000], whilst the study of the mutual coupling arising in small arrays was pioneered by Mailloux [Mailloux, 1969a, 1969b], and, subsequently, by Hockam [Hockam and Walker, 1973].