Electrically Large Structures in WIPL-D

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Abstract: In this paper, an electrically large structure, a 50-λ (where λ is the wave length) long airplane and a dual-polarized 60-element Vivaldi array are run in 64-bit version WIPL-D® software on the Intel® Itanium2® platform with 64GB physical memory. The scattering electromagnetic parameters (the RCS, the surface current, and the near field) and the radiation pattern are shown. The memory usage and the CPU times for different number of unknowns larger than the limit of 32-bit PCs are listed. We also show that this 64-bit version of WIPL-D can go beyond the 64GB physical memory and the speed is not significantly decreased when the virtual memory is used.

Keywords: WIPL-D, electrically large structures, more than 2GB RAM, 64 bit computing, Vivaldi

1. Introduction

Nowadays there are increasing demands for solutions of electrically large structures on computational electromagnetics. However, these demands are restricted by two technical bottlenecks: the 2GB memory limit for 32bit platform and the long CPU time for large number of unknowns. In this presentation, we show that using the 64-bit version of WIPL-D, we can go much further beyond the 2GB limit and the CPU time spent on large structures is moderate. A scattering example of a 12-meter-long airplane is used to demonstrate the large capacity of 64-bit platform. Results of the RCS, the surface current and the near field at 1.25 GHz are shown. A radiation example of a large dual-polarized Vivaldi array is also shown. The CPU time for different number of unknowns are listed.

2. Simulation Setup

The structure used in this presentation is shown in Fig. 1. It's a perfect electric conducting (PEC) surface with the symmetry in YOZ plane. The plane incident wave comes from –*y* direction and polarized in *z* direction. The structure is 11.6 meters long. Although we simulated this structure at different frequencies, in this presentation, we only provide the electromagnetic responses at 1.25 GHz. The corresponding wavelength at 1.25 GHz is 0.24 m, hence the structure is around 50-λ long.

WIPL-D 64-bit version in Windows is used to run the simulation. The hardware platform is a server of 4 Itanium2 1.5 GHz processors with 6MB cache for each. It has 64 GB physical memory and 120 GB hard disk.

Fig. 1 shows the amplitude of the induced current at one phase. Fig. 2 shows the RCS in dB on YOZ plane along θ direction. One cut of the near field at the symmetry plane is shown in Fig. 3.

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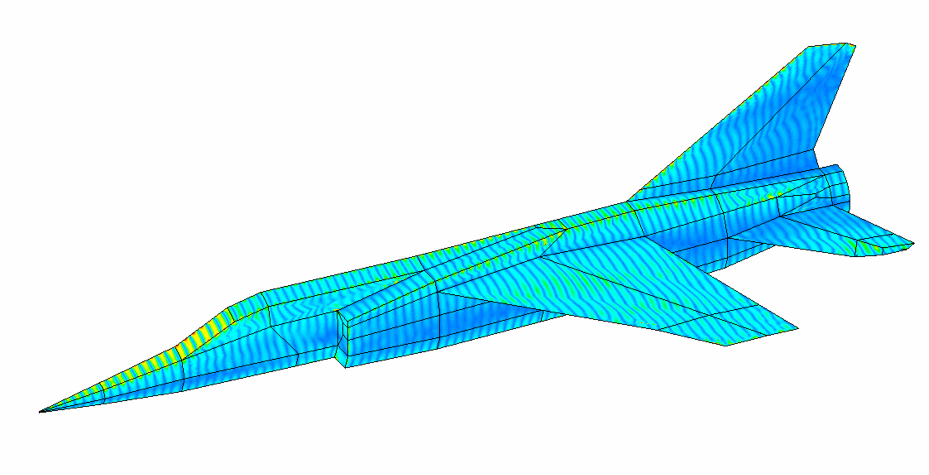


Fig. 1. Induced surface current

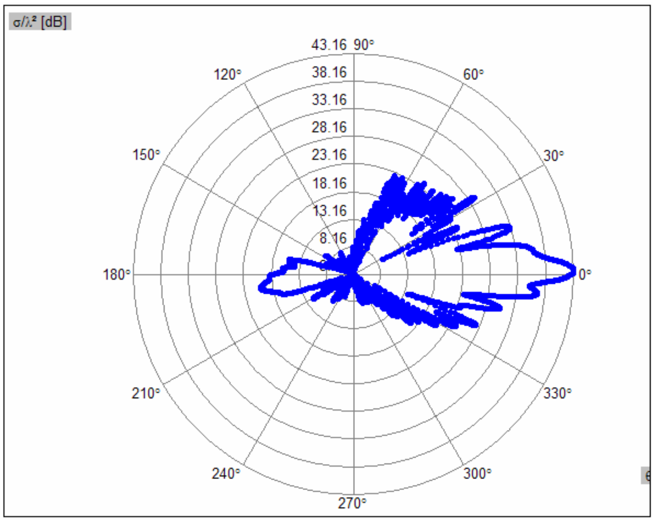


Fig. 2. RCS at YOZ plane in dB

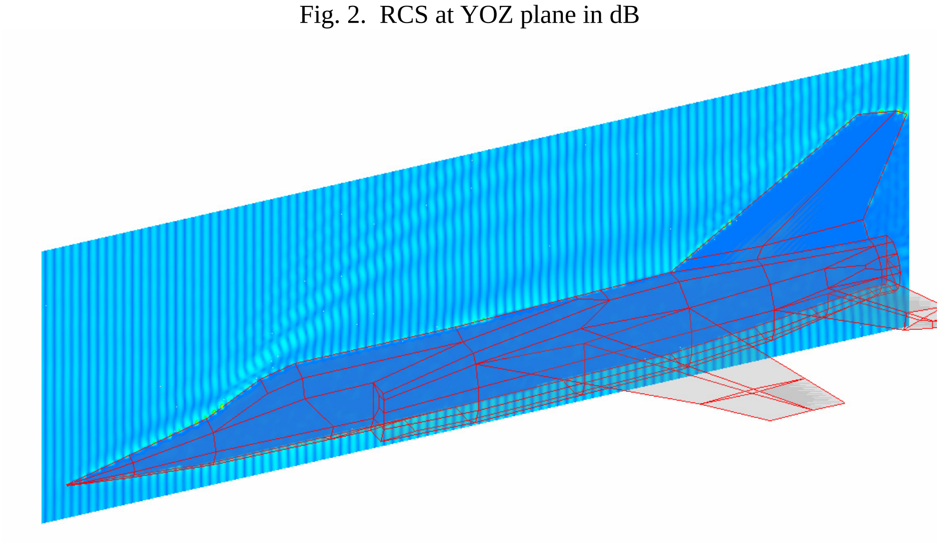


Fig. 3. One cut of the near field at YOZ plane

3. Performances for Different Sizes

In this section we discuss the memory usage and the CPU time of WIPL-D® in Itnanium2® platform for the same airplane structure. The dominant part of memory is assigned to the $N \times N$ complex impedance matrix of the Method of Moment, where N is the number of unknowns. For single precision, the required memory is $8N^2$ in bytes. The CPU time is proportional to N^3. The structure in this example is metallic, hence the impedance matrix is symmetric and we can use the option "reduced" to halve the computational time of the LU factorization. Table 1 shows the number of unknowns, the memory usage and CPU time for different frequencies for large structures. Notice that the CPU time listed here includes the matrix filling, equation solving and the calculation of the results. The results calculated in this example are the currents, the 480×80 points of near field and 3601 degrees of far field.

From Table 1 we can see that when the number of unknowns goes higher, the CPU time goes up approximately in the order of N^3.

Frequency (GHz)	Number of Unknowns	Memory Used (GB)	CPU Time (Hours)
1.25	24993	4.65	5.8
1.85	50806	19.2	37.3
2.05	60653	27.4	61.7
2.20	70470	37.0	95.1
2.33	80705	48.5	141.4
2.47	92002	63.1	212.8
2.60	99973	74.5	293.2

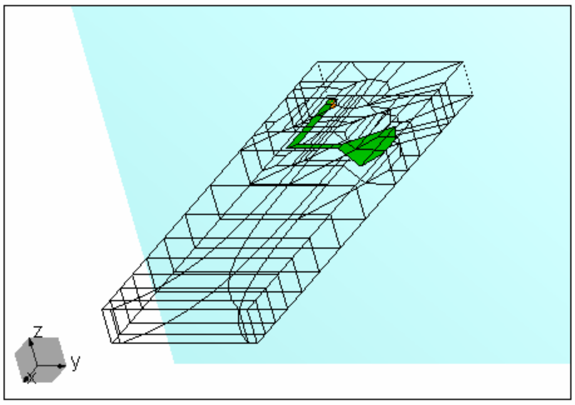
Table 1. Performances for different frequencies.

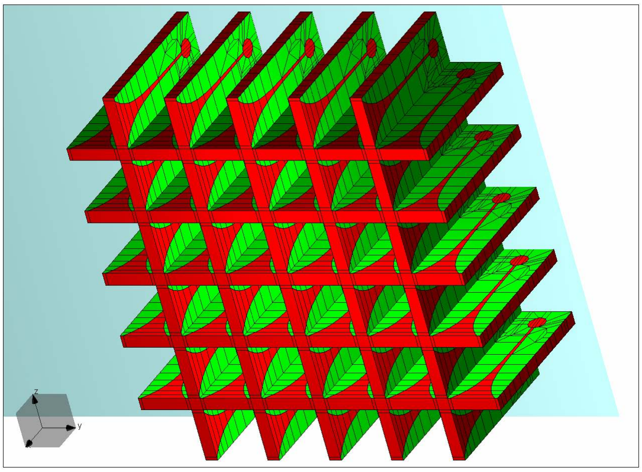
4. Simulation of a large dual-polarized Vivaldi array

In this section we simulated a large dual-polarized Vivaldi array shown in Fig. 4. The size for a single element is 76 mm × 25.6 mm × 6 mm. The relative permittiviy of the dielectric substrate is ε_r = 2.2. One cut of the radiation pattern of this array is shown in Fig. 5. The number of unknowns for this problem is 49820.

5. Conclusions

An electrically large airplane is analyzed by 64-bit WIPL-D on Itnaium2 base platform. The scattering problem is simulated and reasonable results of induced currents, near field and far field are shown when the airplane is 50 wavelengths long. From the results we can see that the 64-bit mode of WIPL-D can go beyond the limit of 2 GB memory in 32-bit platforms while the CPU time is moderate. Furthermore, we show the performances of WIPL-D running for the same structure with different number of unknowns. The relationships of memory usage as N^2 and CPU time as N^3 are stable even with virtual memory.





(a) (b)

Fig. 4. (a) The structure of the single element of the Vivaldi antenna. The shaded part is the feeding strip. (b) The structure of a 60-element dual-polarized Vivaldi array. The green (light) color is for metallic plate and the red (dark) color is form dielectric material.

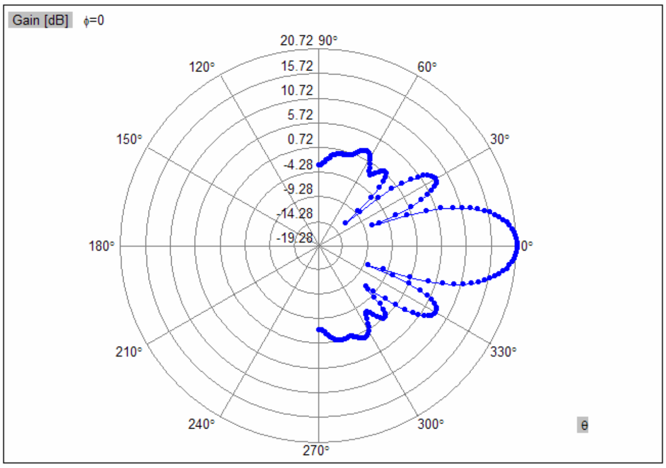


Fig. 5. Radiation pattern of the Vivaldi array

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