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GPU TECHNOLOGY CONFERENCE

GPU Acceleration of Computational Electromagnetics Methods

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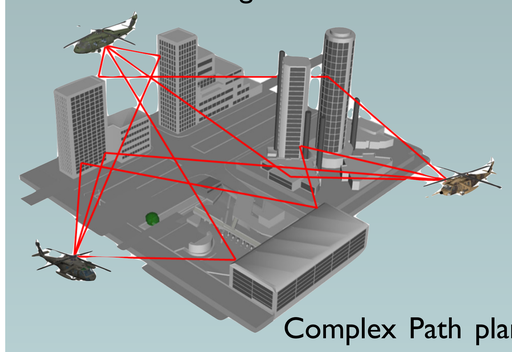
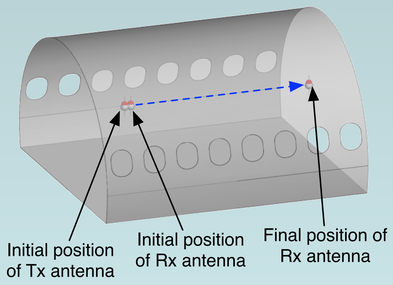
Introduction

- Computational Electromagnetics (EM) is widely used in various aerospace applications.
- Main challenges include: (a) development of a CAD model that captures the physics and material properties of the scene and is useful for simulations, (b) modeling of RF propagation to yield sufficient accuracy, (c) simulations expensive in terms of computational complexity and algorithm latency.
- Different methods widely used for prediction of antenna coverage - our focus on Iterative physical optics (IPO).
- Applications of EM include: (1) antenna coverage prediction of autonomous vehicles in urban environments, (2) wireless propagation modeling in complex environments, e.g. to model the strength and propagation of Wi-Fi signals or critical communication signals within an aircraft cabin.



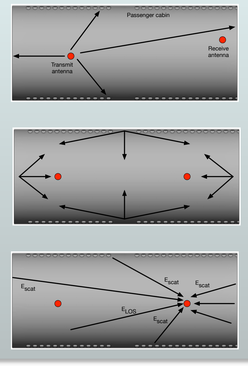
Complex Path planning requires retaining communication while navigating urban environments.

Wi-Fi wireless antenna coverage requires optimal placement of antennae for link budget prediction and less EM interference inside aircraft cabin.

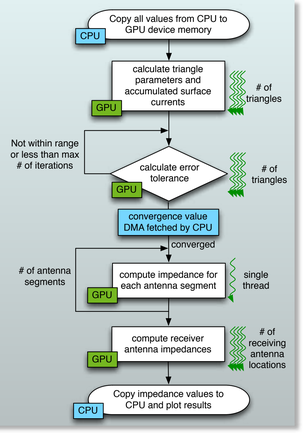


Iterative Physical Optics

- IPO is better suited for wireless propagation modeling in complex environments – does not require a ray tracing or shadowing algorithm.
- IPO is also faster as compared to the MoM based full-wave techniques – no impedance matrix and runs on coarser mesh.
- IPO does not account for surface waves and diffractions and is not guaranteed to converge.
- Computational cost increases when modeling for higher frequencies.



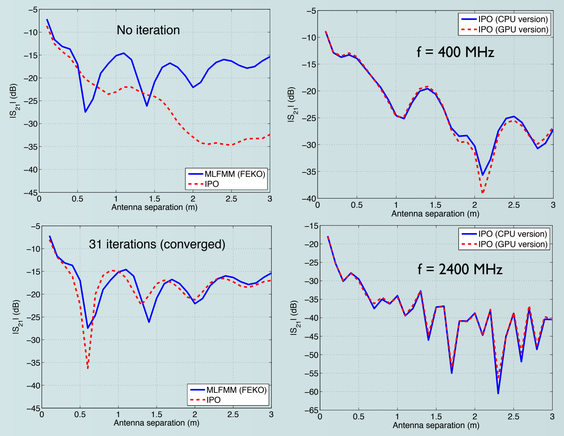
- Assuming a hemispherical antenna radiation pattern, define field points where the antenna coverage is evaluated.
- The scene/location is meshed using triangles and the triangle facets are assigned material properties. Meshes are refined based on wavelength at desired frequency of operation.
- The PO currents are determined and they are reradiated to account for multiple bounces until they converge.

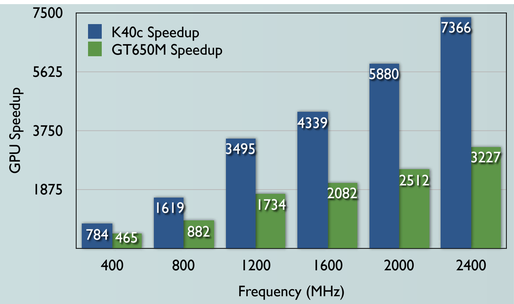


Implementation and Results

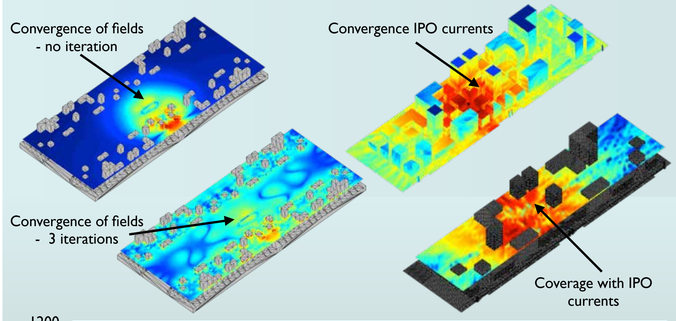
Characteristics	GT650M	K40c
Clock rate (MHz)	700	745
# of cores	384	2880
Global memory (GB)	1	12
L2 cache (KB)	256	1536

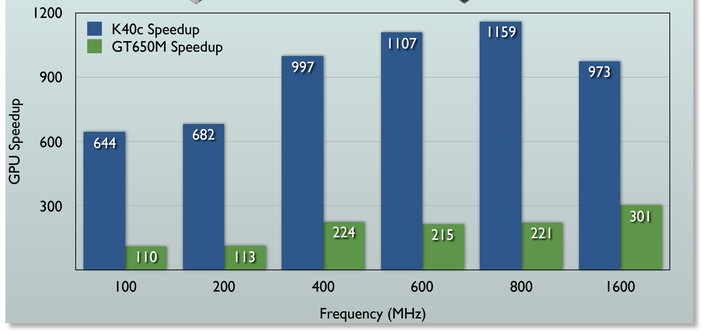
- CPU results - Intel Xeon CPU clocked at 2.67 GHz





- Grid search on the number of iterations for simulations to converge using the IPO vs MLFMM method.
- Number of iterations differed between CPU and GPU as frequency increases.





Conclusion

- IPO methods targeted for two different use cases and accelerated using GPUs.
- Near real-time results obtained using the mobile GT650M - provides a transition path to Jetson GPUs
- GPU implementation of IPO - compute bound or memory bound (denser scenes with more triangles and at higher frequencies do not fit on the GT650M RAM).
- K40c is 2-5x faster than the GT650M - 7.5x increase in the number of cores and 12x increase in device RAM.

Use case	Speedup	
	GT650M	K40c
RF propagation urban environments	110-301	644-973
Antenna placement	465-3227	784-7366

References

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