Optimizing Designs with High Throughput Computing

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Abstract :
In this talk, we discuss how JMAG software is being run at the UW-Madison campus in a High Throughput Computing (HTC) environment powered by the open source Condor software. By coupling JMAG with Condor, we were able to improve optimization turnaround by an order of magnitude. We present HTC principles and an introduction to Condor, as well as an overview of the UW Center for High Throughput Computing (CHTC), which serves, among others the Wisconsin Electric Machines and Power Electronics Consortium. For more than two decades the CHTC has been serving the computational needs of a broad range of research and production domains, including scientists and engineers from a wide spectrum of disciplines ranging from semi-conductor test harnesses to turbine blades and electrical machines. We conclude with direction for future joint work.

CENTER FOR HIGH THROUGHPUT COMPUTING

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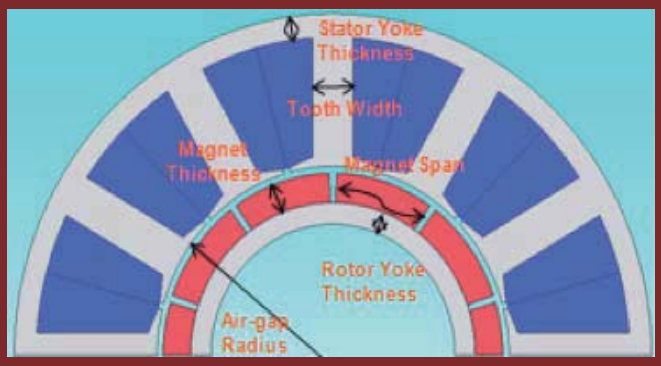
A Problem



Many parameters impact performance:

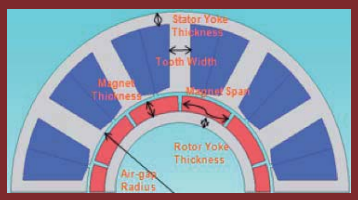
- Stator Yoke Thickness
- Tooth Width
- Magnet Thickness
- Air-gap radius
- Etc…

JMAG can simulate performance of motor, given a set of parameters.

But, what *combination* of parameters provides *optimal* solution for:

Cost – Performance – Weight

One Solution



Vary each parameter, thus:

- Tooth width to slot pitch ratio [0.1 to 0.8 by 0.1]
- Stator yoke thickness to tooth width ratio [0.1 to 0.8 by 0.1]
- Magnet span to rotor pole pitch ratio [0.5 to 0.95 by 0.05]
- Rotor yoke thickness to rotor pole pitch ratio [0.1 to 0.6 by 0.1]
- Magnet thickness to air-gap thickness ratio [1 to 7 by 1]
- Air-gap radius to stator outer radius ratio [0.3 to 0.75 by 0.15]

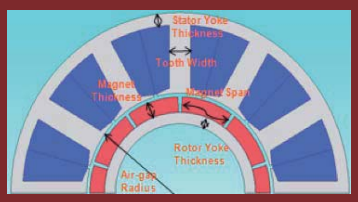
8 x 8 x 10 x 6 x 7 x 4 = 107,520 simulations!!!

Running 107,520 serial simulations not feasible:

107,520 * 30 seconds for 2-D static analysis > 1 MONTH!

107,520 * 10 minutes for 2-D transient analysis > 2 YEARS!

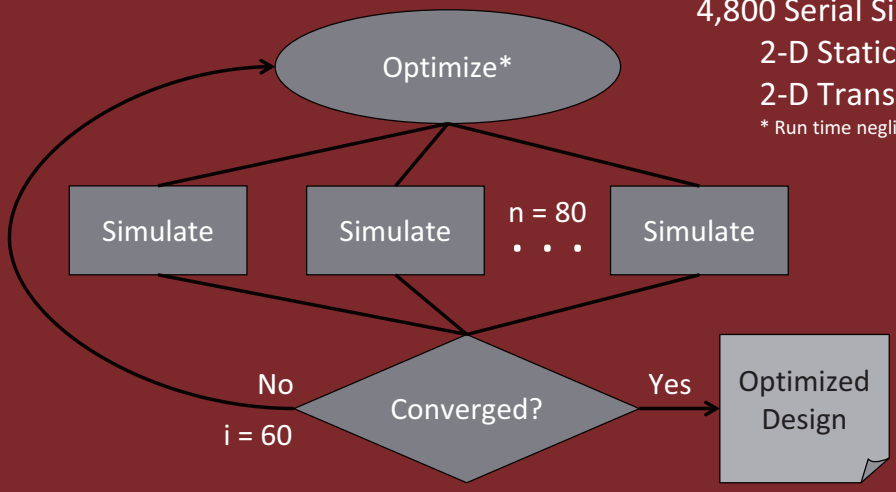
Better Solution



Reduce number of simulations needed:

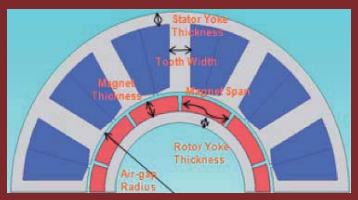
- Use optimizing 'wrapper'
- Could be Simulated Annealing or Genetic Algorithm
- Can be written in Matlab and use VBS[1] to set simulation parameters
- Stop after some convergence criteria

4,800 Serial Simulations:
2-D Static: ~1.5 days
2-D Transient: ~1 month
* Run time negligible



1. Visual Basic Scripting

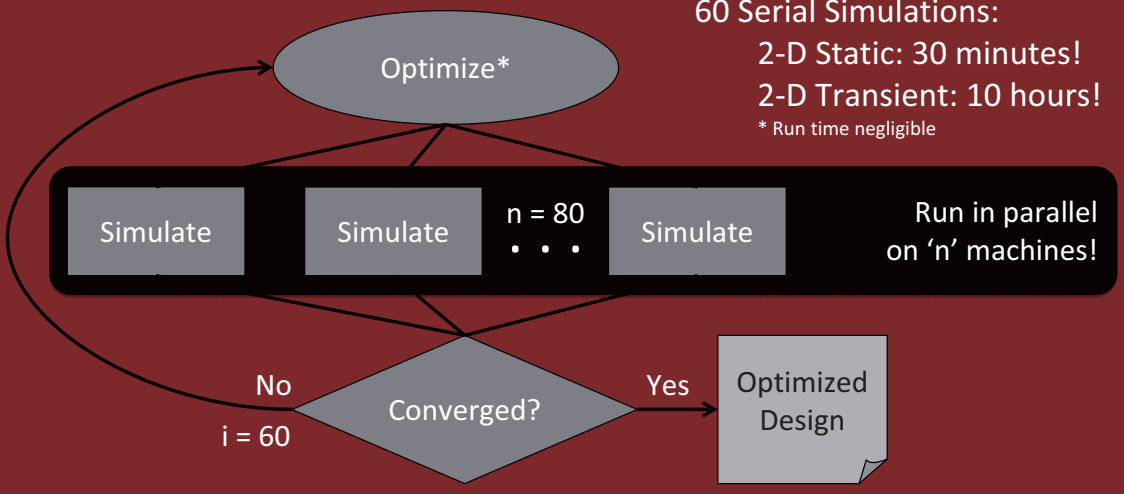
Best Solution



Reduce serial simulation runtime:

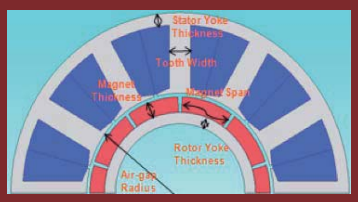
- Use optimizing 'wrapper'
- Could be Simulated Annealing or Genetic Algorithm
- Can be written in Matlab and use VBS[1] to set simulation parameters
- *Run simulations in parallel*
- Stop after some convergence criteria

60 Serial Simulations:
2-D Static: 30 minutes!
2-D Transient: 10 hours!
* Run time negligible



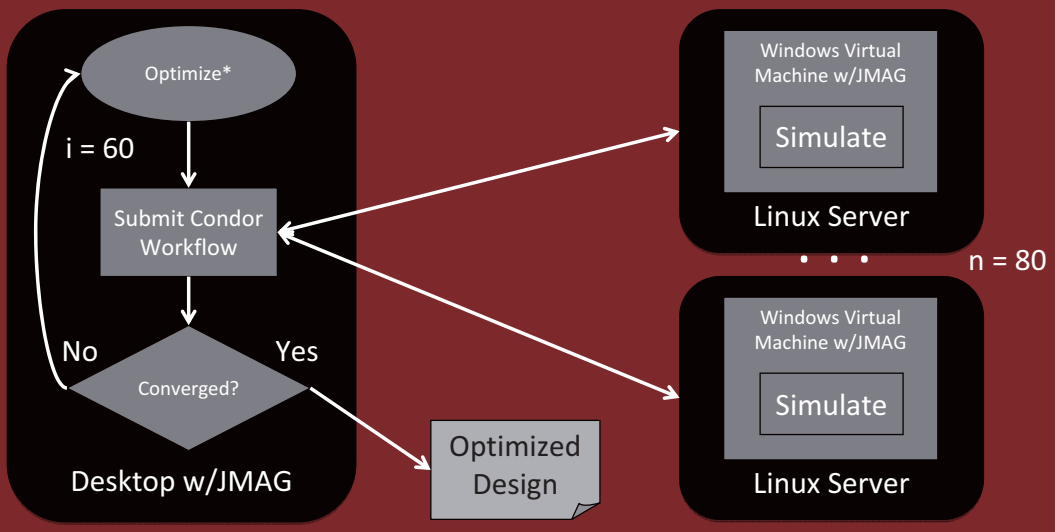
1. Visual Basic Scripting

Running JMAG in parallel



Use Condor *High Throughput Computing* Software:

- Start optimizing 'wrapper' from desktop
- Wrapper submits Condor workflow
- Condor starts Virtual Machines on Linux Server to run parallel simulations
- Workflow synchronizes simulation results
- Optimization continues or converges



Condor enables High Throughput Computing

http://condorproject.org

Condor features:

- Open Source from University of Wisconsin - Madison
- Runs on Linux, Macintosh and Windows
- Matches jobs to available resources
- Transfers required data to and from remote resources
- Enables workflow execution

Status and Future Work

Status:

- JMAG software enabled to run in parallel on Windows virtual machines, executing on Linux servers
- Optimization wrapper developed to search problem space without using brute force approach
- Optimization run time was reduced by order of magnitude
- Optimized Finite Element Analysis (FEA) designs provided to Wisconsin Electric Motor and Power Electronics Consortium

Future work:

- Continue improving optimization wrapper and scaling parallel simulation
- Provide more complete multi-physics optimal design by integrating electro-magnetic, structural *and* thermal elements

In Conclusion…supporting concepts behind JMAG

Precise analysis	High speed processing
Running more simulations in less time provides better optimized designs.	Leveraging High Throughput Computing enables many simulations to run in parallel.
High Productivity	**Open interface**
The JMAG interface that users are familiar with did not have to change.	The Visual Basic Script interface enabled another level of Optimization.

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