What’s New in ML?
New Features in Trilinos 8.0

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Outline

- Performance Improvements.
- RefMaxwell: A New Solver for Maxwell’s Equations.
- Parameter List Validation.
- What’s next?
Performance Improvements

- Scalability improvements: SA, Maxwell (Jonathan Hu).
- NSSA now works in parallel (Ray Tuminaro).
- Bugfixes, incremental improvements (Everybody).
RefMaxwell

- Required Packages: Epetra, EpetraExt and Teuchos.
- Location: src/RefMaxwell
- Is not part of MultiLevelPreconditioner.
Eddy current Maxwell’s equations:

\[ \nabla \times \left( \frac{1}{\mu} \nabla \times \mathbf{E} \right) + \sigma \mathbf{E} = \mathbf{f} \]

Use discrete Hodge decomposition:

\[ \mathbf{E} = a + \nabla \phi \]

where \( \nabla \cdot a = 0 \).
RefMaxwell: Mathematics (2)

- Since $\nabla \cdot a = 0$, add $\nabla \nabla \cdot a$ to 1st equation:

$$\begin{bmatrix}
\nabla \times \nabla \times + \nabla \nabla \cdot + \sigma & \sigma \nabla \\
\nabla \cdot \sigma & \nabla \cdot (\sigma \nabla)
\end{bmatrix}
\begin{bmatrix}
a \\
\phi
\end{bmatrix}
= 
\begin{bmatrix}
f \\
\nabla \cdot f
\end{bmatrix}$$

- Implicitly block-diagonally precondition with two AMG preconditioners.
RefMaxwell: Mathematics (3)

\[
\begin{bmatrix}
\nabla \times \nabla \times + \nabla \nabla \cdot + \sigma & \sigma \nabla \\
\nabla \cdot \sigma & \nabla \cdot (\sigma \nabla)
\end{bmatrix}
\begin{bmatrix}
a \\
\phi
\end{bmatrix} =
\begin{bmatrix}
f \\
\nabla \cdot f
\end{bmatrix}
\]

- Idea: Reformulate $\nabla \times \nabla \times$ to Laplacian.
- Nodal Laplacian $\Rightarrow$ standard AMG good.
- Edge Laplacian $\Rightarrow$ standard AMG not good.
- Idea: Special grid-transfer, so Edge Laplacian $\Rightarrow$ vector nodal Laplacian.
- SISC paper in review (w/ Bochev, Hu and Tuminaro).
Why RefMaxwell?

- Decouples edge/node hierarchies on coarse levels.
- Uses MultiLevelPreconditioner(SA) on both subproblems.
- Avoids complexities of existing Maxwell solver.
- Allows rapid deployment of new SA technology.
- Better parallel scalability.
Scaling: Maxwell vs. RefMaxwell

- **EddyMMS**
  - Field Solve Time vs. Number of Processors
  - Old Solver vs. New Solver

- **Liner**
  - Field Solve Time vs. Number of Processors
  - Old Solver vs. New Solver

- **LinerF**
  - Field Solve Time vs. Number of Processors
  - Old Solver vs. New Solver

- **Sphere**
  - Field Solve Time vs. Number of Processors
  - Old Solver vs. New Solver
Parameter List Validation

- Motivation: Make sure options on the Teuchos ParameterList are correct.
- This is on by default in Trilinos 8.0.
- Option names and types are checked to ensure correctness (not silently ignored).
- Used by MultiLevelPreconditioner and RefMaxwell.
Sample Output

Error, the parameter \{name="this option should fail"\,type="int"\,value="1"\} in the parameter (sub)list "ANONYMOUS" was not found in the list of valid parameters!

The valid parameters and types are:

\{
    "ML debug mode" : bool = 0
    "ML output" : int = 0
    ...
    ...
    "z-coordinates" : double* = 0
    "zero starting solution" : bool = 1
\}

Throw number = 1
ERROR: ML’s Teuchos::ParameterList contains an incorrect parameter!
What’s next in ML?

- Enhanced dropping capabilities in aggregation.
- Continued scalability improvements.
- Use of sublists rather than (level x) parameters.
- More RefMaxwell performance enhancements.