**SAMR**: Structured Adaptive Mesh Refinement
- Multiscale algorithm for Cartesian meshes

**Pros**:
- Less grid points, less compute time.
- Preservation of numerical accuracy.

**Cons**:
- Load Balancing problems.
- Lack of scalability.

**The Problem**: Algorithms ensuring efficient resolution and numerical accuracy may not be scalable. Scaling analyses of SAMR simulations are rare.

**The Objective**: Identify the non-scalability sources.

**Methodology**:
1. Choose a test problem where the initial and final states of the computational domain are vastly different so that:
   i. It poses a challenge to domain partitioning.
   ii. The quality of the partitioning affects scalability.
2. Analyze timing measurements and domain decomposition specifics to identify the causes of lack of scalability.

**Problem Statement**:
- Global problem size is held constant.
- Virtual machine expanded in steps of two, starting with 7 processors.

For more than 28 processors experimental results deviate a lot from the linear scale up behavior. What are the possible causes?
- Excessive transfer times caused by network saturation.
- Synchronization costs due to non-optimal domain and load partitioning.

**Results-Analysis**:
We pick two processor topologies, 28 and 112, and analyze.
We have a dynamically adaptive algorithm. Are all intermediate states equally scalable or non scalable? No they are not.

**Unscalable State (Timestep 80)**

The average communication radius is 3.2 for p=28 and 8.1 for p=112. By comparing their communication patterns we see that as the number of processors increases they communicate further in the virtual machine.
As the communication pattern radius approaches 8 nodes and substantial communication occurs over tier-1 switches the communication times increase.

Note: T_{com} >> T_{comint} so Timestep 40 is scalable.

**Scalable State (Timestep 40)**

The synchronization bound model only holds for p=7 and p=14. For p > 28, \( \sigma_{com} / T_{com} > 0.25 \) and the non-linear effects of \( \sigma_{com} \) dominate. This analysis will be part of future work.