Outline

• Lab 2 Review
• Overview of locality increasing tools
  – Data partitioning / domain decomposition
• Examples
  – From many sources on the web (quoted on relevant pages)
Sparse Matrix Example
Locality in PDEs

- Smallest: data for single stencil
- Largest: data for entire subdomain
- Intermediate: data for a neighborhood collection of stencils, reused as possible
Locality in PDEs

- As successive workingsets “drop” into a level of memory, capacity (and with effort conflict) misses disappear, leaving only compulsory, reducing demand on main memory bandwidth.

Traffic decreases as cache gets bigger or subdomains get smaller.
Reordering of Water Molecules
Reordering of Finite Element Mesh

The diagram compares the performance of different algorithms for reordering finite element meshes. The x-axis represents the number of elements, while the y-axis shows the performance metric. The different lines and markers denote:

- **METIS**
- **Original**
- **Random**
- **Max**

The performance appears to be better for the METIS algorithm compared to the others, especially at higher numbers of elements.
Reordering of Finite Element Mesh

![Graph showing reordering of finite element mesh]

- **METIS**
- **Original**
- **Random**
- **Max**

The graph compares different methods of reordering for finite element mesh, showing the performance metrics over a range of data points.
Space Filling Curves

- Locality preserving.
- Each point lies a unique distance along the curve.
Space Filling Curves

- Optimal load balance.
- Subdomain boundaries are sub-optimal.
- Recall: Optimizing load and comm is NP-hard.
Space Filling Curves

The main advantages of this partition method are:

- It is fast compared to graph partitioning heuristics,
- It runs in parallel,
- It requires no administration and no storage of processor neighborhoods.
- The knowledge of the separators is enough to compute where to find a node and which processor to ask for it.
Streaming Meshes

• Various reorderings for a mesh for streaming

Figure 6: The dragon mesh reordered by (a) a depth-first compressor, (b) a breadth-first compressor, (c) z-order curve, (d) spatial sort, and (e) spectral sequencing.

From: Martin Isenburg and Peter Lindstrum, "Streaming Meshes", 2005
### Streaming Meshes

From: Martin Isenburg and Peter Lindstrum, "Streaming Meshes", 2005