

# Partitioning Screen Space 1

(An exciting presentation)

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A New Algorithm for Interactive Graphics on Multicomputers

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The Sort-First Rendering Architecture for High-Performance Graphics

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Hierarchical Graphics Databases in Sort First

## A New **Algorithm** for Interactive **Graphics** on **Multicomputers**

David A. Ellsworth

- Multicomputer: non-shared memory multi-cpu system
  - Then: Touchstone, iWarp, Paragon
  - Now: commodity clusters

- Mueller uses first person singular
- Hughes Hoppe doesn't

## Sort-first

- Primitives initially assigned arbitrarily
- *Pre-transformation* is done to determine which screen regions are covered
- Primitives are then redistributed over the network to the correct renderer
- Renderer performs the work of the entire pipeline for that primitive from that point on

this slide shamelessly stolen from cliff's presentation

# Granularity Ratio

*Number of screen regions per processor*

Higher granularity ratio =

- Higher probability of being able to assign regions equitably
- Increase in required communication and per-primitive rasterization overhead

# Load Balancing

- **Between Regions**
  - Processor asks for regions on the fly
  - Each assignment individually broadcasted
- **Between Stages**
  - Wait for transformation completion, then assign regions all at once (single broadcast)
- **Between Frames**
  - Processors immediately begin rendering based on last frame's primitive counts
  - Frame-to-frame coherence is key

## “A New Algorithm”

## “A New Algorithm”

- Transformation and Rasterization not overlapped (it was *too* efficient and caused the computer to overheat)
  - But previous frame’s primitive counts used
    - Single processor computes and then broadcasts region assignments for next frame
- Fixed granularity ratio: 8 regions/processor

## “A New Algorithm”

*“All-to-all communication does not scale very well”*

## “A New Algorithm”

- Two-tier'd communication system
  - Optimal when  $x$  routers for  $x^2$  total processors
- Implemented on 512 node Touchstone Delta
  - Only 17MB/s because it's 1994
  - Primary bottleneck: collection of region primitive counts limits framerate
    - *(Why not re-use last completed region distribution if new assignment not ready yet? Anything is better than a suffering framerate...)*

## Future Work

- Try statically assigning regions to processors instead
  - *(Would it have been that hard to test this when the dynamic assignment tests were performed?)*
- High hopes for big iron multicomputers

## The Sort-First Rendering Architecture for High-Performance Graphics

Carl Mueller

“millions of polygons for  
zillions of pixels”

## **WANTED:** Interactivity

(Low Latency and 30fps)

- Sort-last: too much bandwidth required
- Sort-middle: many-to-many communication -> limited scalability
- Sort-first: load balancing hard

## Coherence

- Htha wast yugli jix mallie nop sequin
- Sudden view changes also make for bad coherence
- The faster your framerate, the better your frame-to-frame coherence

## Offscreen Primitives

- Keep on the processor where they were on-screen
  - Can lead to overload
- Send to neighboring processors
  - Still leads to overload or redundant communication
- Send to underloaded processor
  - Requires broadcast of load information
- Send to a random processor
  - Randomness is cool
- When to get rid of them?
  - (popping in and out of view)

## Load Balancing

- Static assignment
- Adaptive methods
  - Roble's Method
    - split high-primitive regions, join low-primitive ones
  - Whelan's Method
    - split according to primitive centroid distribution
  - Whitman's Method
    - use uniform grid to tally primitive distribution
  - MAHD
    - use uniform grid, weight primitive tallies by inverse of size

## Results

- Using previous frame's region assignment has little detrimental impact
- Static method requires 9-25 regions/proc and 3-5 times communication bandwidth to get same load-balance as adaptive 1 region/proc

## Results

- Static method
  - requires no per-primitive overhead
  - fixed-size regions
  - fixed processor-to-framebuffer mapping
- Static method suitable for low-end system (few processors = little overhead)
- To get around screen subdivision scalability limitations, use sort-last compositing on top of sort-first rendering
  - Good enough of an idea to score Mueller a citation in the wiregl paper

## Hierarchical Graphics Databases in Sort-First

Carl Mueller (again)

- HGD (scenegraph)
  - Sort-middle / Sort-last
    - Divide primitives equally among processors
  - Sort-first
    - Can divide structures among processors
    - But requires state replication or resolution

## Database Representation

- Minimal view
  - “Connectivity” information only, no instances
- Maximal view
  - Explicit instancing

## Min-set method

- Processor knows connectivity information, but must check bounding volume of each structure against processor's region to determine whether to render it or not
- Primitive migration: Push vs. Pull
  - Push wins – less communication, less latency, less computation

## Max-set method

- Given min-set representation, processor is assigned a pointer into a structure in min-set for each primitive it needs to render
- Primitive migration
  - Harder - no shared memory
    - pointers into min-set must use global IDs to be able to find address of structure on new processor

# Results

- Max-set slightly better than min-set in terms of transformations
  - Due to bounding-box calculations in min-set method
  - Instancing is a natural application of pointers into the min-set
    - For little or no instancing, min-set pulls ahead

- How many total equations in all three of these papers?

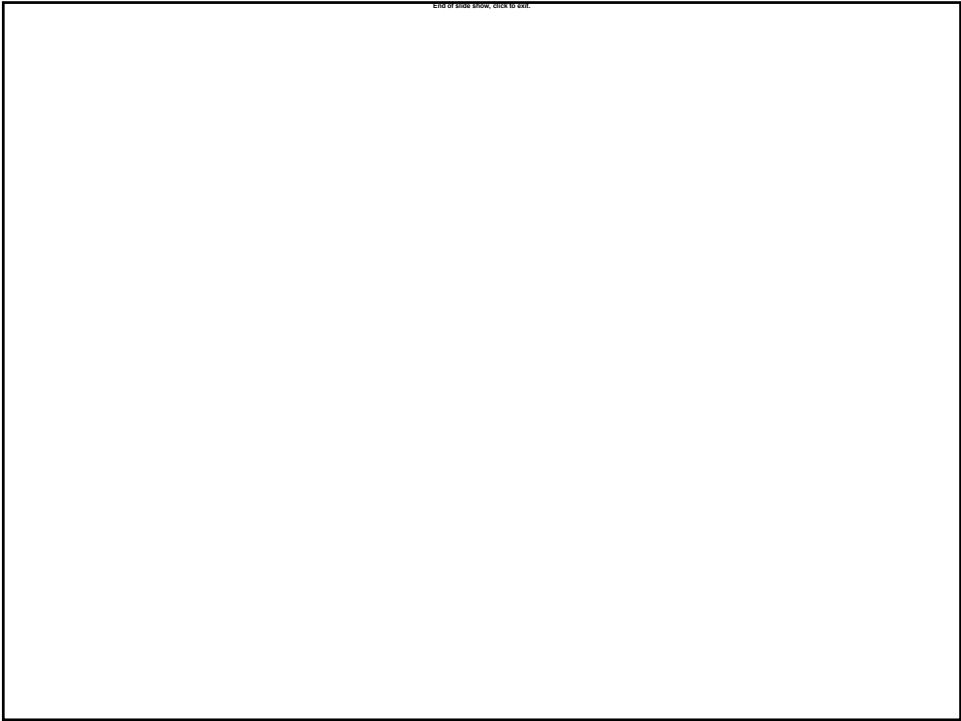
- How many total equations in all three of these papers?

–1

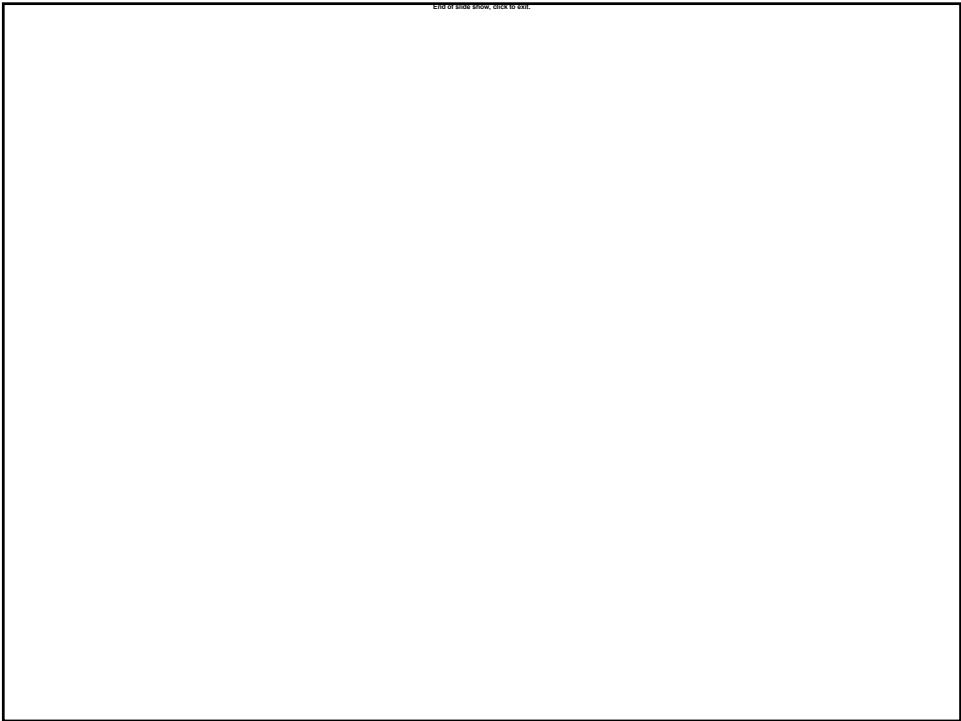
- (for optimal number of routing groups in 2-tier communication network in Ellsworth paper)

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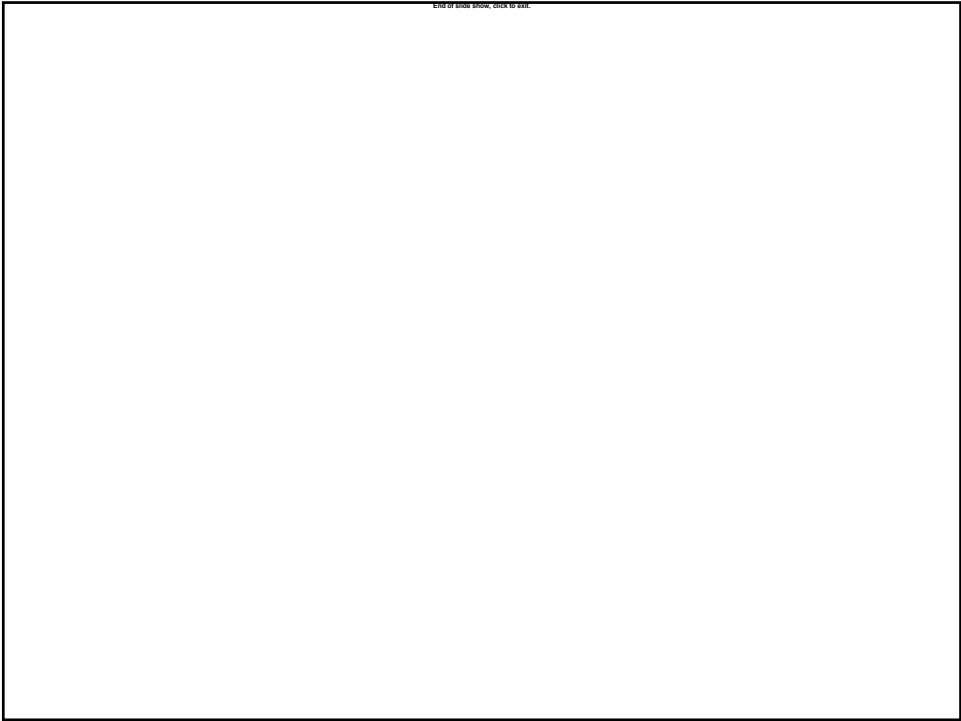
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