Parallel Rendering

Molnar, Cox, Ellsworth, and Fuchs. "A Sorting Classification of Parallel Rendering." ***IEEE Computer Graphics and Applications*****. July, 1994.**

Why Parallelism

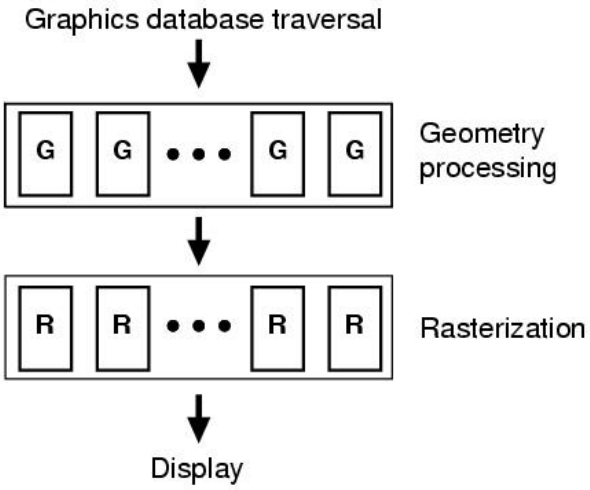
Applications need:

- **High frame rates**
- **High resolution**
- **Large geometric models**
- **Stereo**
- **Antialiasing**
- **etc.**

Performance implications:

- **Hundreds of MFLOPS compute power**
- **Gigabytes per second memory bandwidth**

Stages of Parallelism



Processing Tasks

Geometry Processors

- **Each processor gets a subset of primitives**
- **Transformation**
- **(Lighting)**
- **Set-up for Rasterization**

Rasterization Processors

- **Each processor gets a subset of pixels**
- **Visibility computation**
- **Shading**

Rendering as Sorting

- **Primitives may lie anywhere on or off screen**
- **Determine effect of each primitive on each pixel**
- **Primitives are “sorted” onto screen**
- **Sorting affects distribution of data on geometry and rasterization processors**

Primitives in Screen-space Regions

Where to sort

Sort Middle

- **Sort between geometry processing and rasterization**

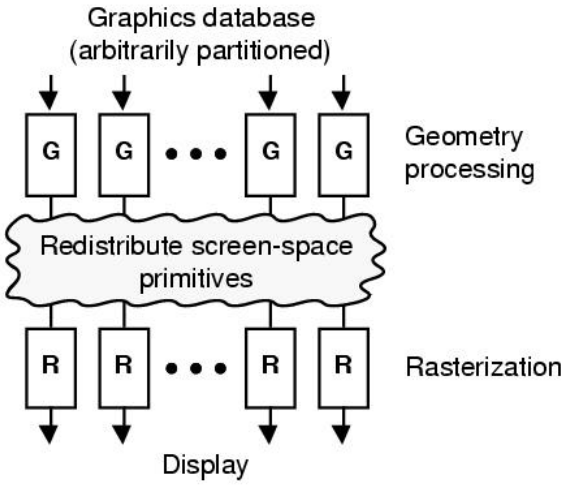
Sort First

- **Sort during geometry processing**

Sort Last

- **Sort during rasterization**

Sort Middle



Sort Middle: Data Arrangement

Geometry processors

- **Arbitrary (random) distribution of primitives**
- **Good for load balancing**

Rasterization processors

- **Screen-space distribution of primitives**
- **Load balancing difficult**

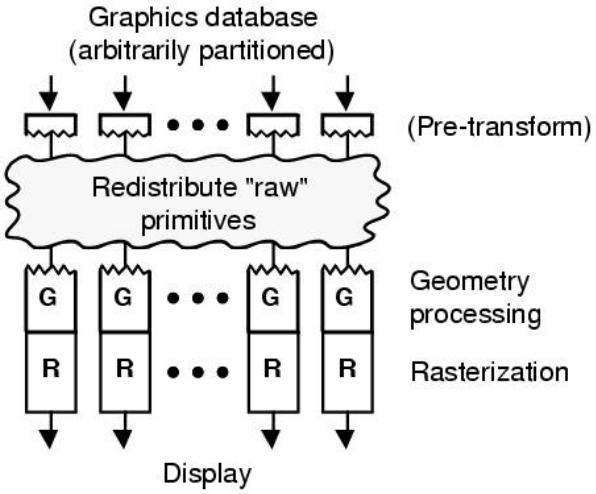
Sort Middle: Communications

All geometry transformed primitives must be communicated every frame

All geometry processors must communicate with all rasterization processors

- **$O(n^2)$ communications paths**

Sort First



Sort First: Data Arrangement

Distribute both geometry and rasterization work according to position of primitives on screen

Load balancing difficult

- **Different screen regions of equal sizes may contain different numbers of primitives**
- **May need dynamic region sizes**

Sort First: Communications

Must determine primitive screen coverage before full transformation

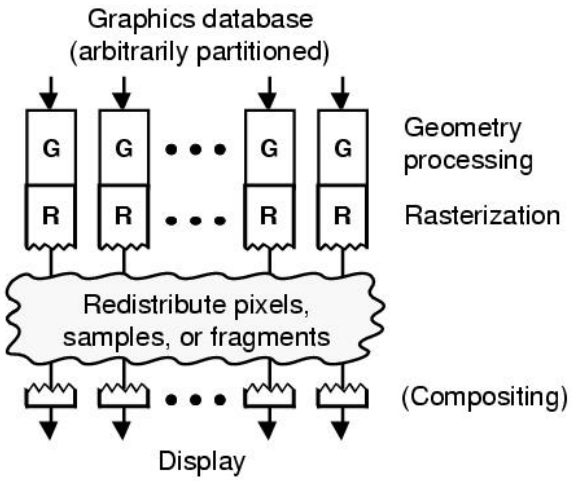
Exploit frame-to-frame coherence

- **Shuffle primitives between geometry processors only if screen coverage changes**

Possibly employ primitive clustering and bounding volumes

- **Pre-transform bounding volumes for small groups of primitives**

Sort Last



Sort Last: Data Arrangement

Arbitrary (random) arrangement of data on both geometry and rasterization processors

Great for load balancing

Each rasterization processor makes image of entire screen, with subset of primitives

Sort Last: Communications

Rasterization processors must communicate final pixel data

Composition of pixel data may take place along linear or tree-shaped network

Requires high bandwidth, assuming pixel data is much larger than primitive data

Advantages and Disadvantages

	Advantages	Disadvantages
SF	• Low communications when good coherence • Each processor implements entire pipeline	• Susceptible to load imbalance • Retained mode and complex data handling
SM	• General and straightforward • Natural communications placement	• High communication cost • Rasterizer load imbalance
SL	• Each processor implements entire pipeline • Easier load balancing • Linear scalability	• Large communication cost, especially for high resolution or multisampling

Video

Mueller. "Hierarchical Graphics Databases in Sort-First." ***Proceedings of 1997 Parallel Rendering Symposium*****.**