Parallel Graphics Programming with Equalizer

Latest version at http://www.equalizergraphics.com/documents/ParallelGraphicsProgramming.pdf

Outline

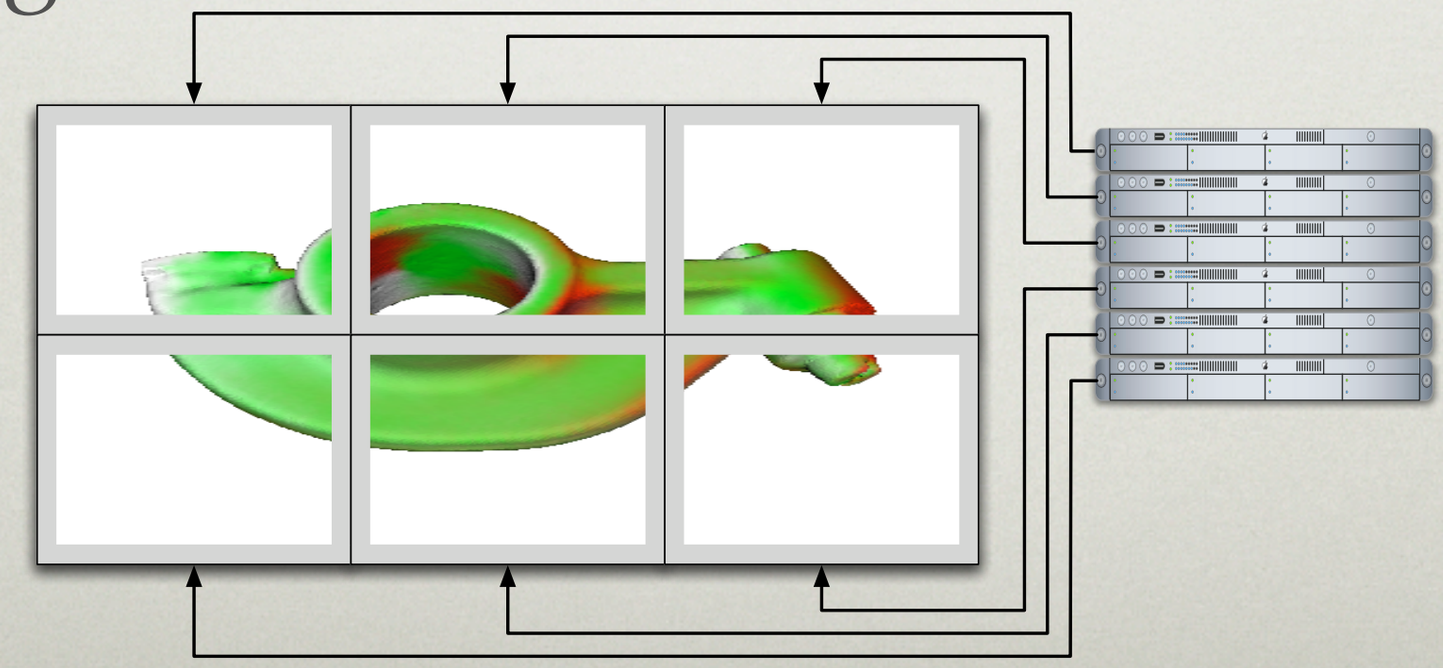
- Application Environments
- Scalable Rendering
- Multipipe Programming with Equalizer

Environment

- Display Walls
- Virtual Reality
- Remote Rendering
- Scalable Rendering

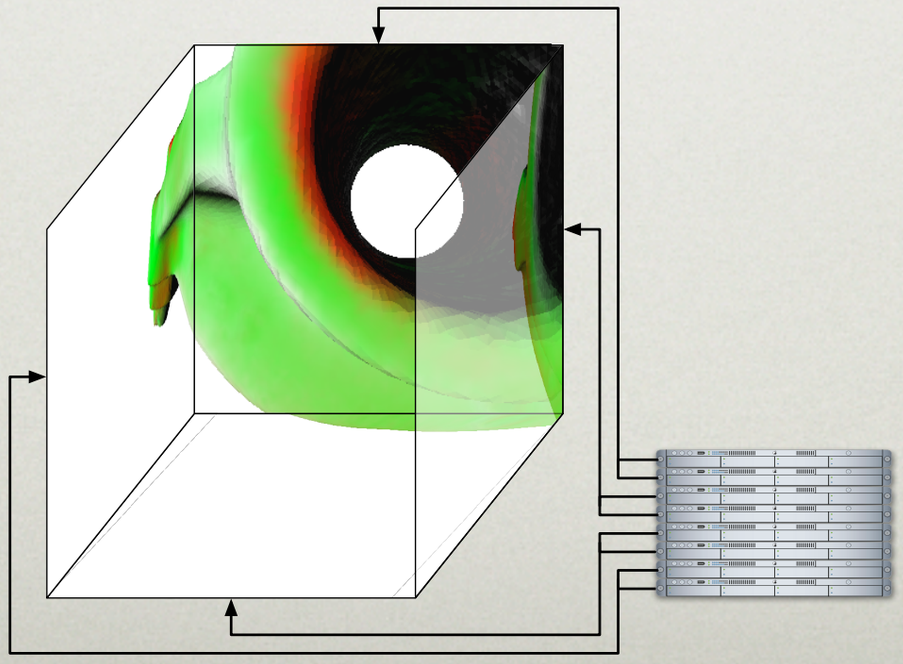
Display Walls

- Group collaboration
- Better data understanding
- One to four displays per computer
- High resolution: 10-100 MPixels



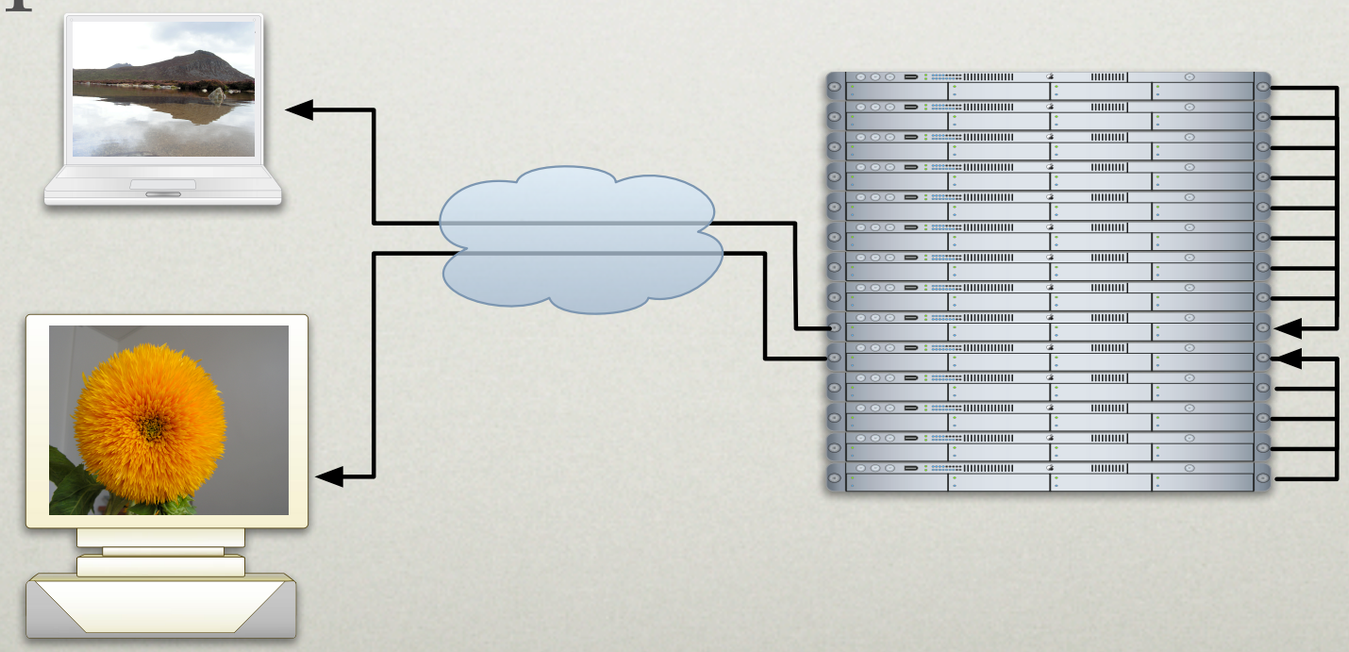
Virtual Reality

- Stereo rendering, head tracking
- High frame rates
- Up to two computers per wall with passive stereo



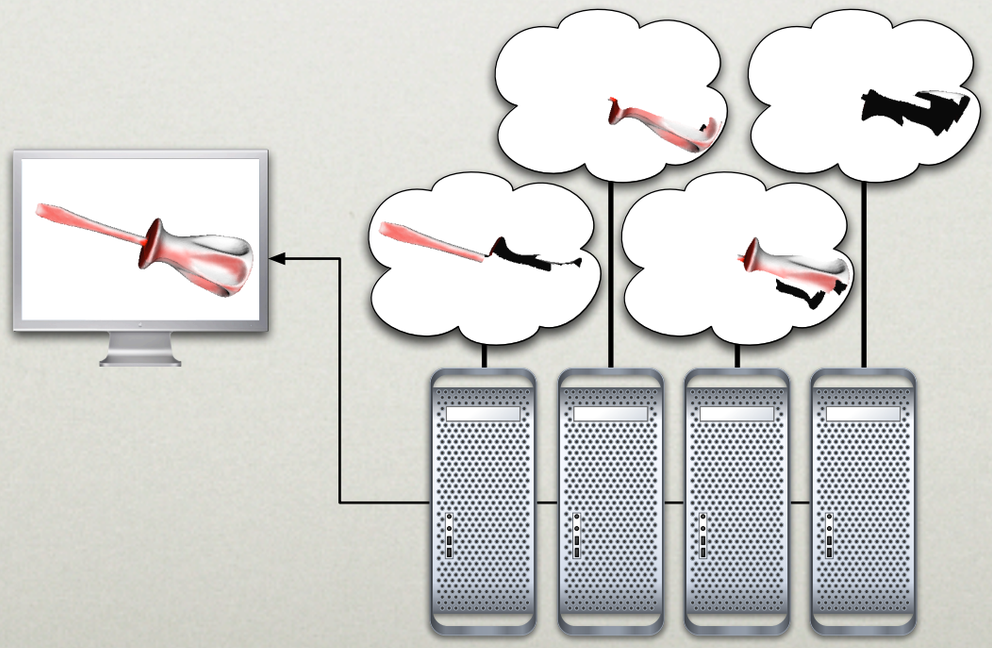
Remote Rendering

- Centralize data, software and hardware
- Combined with scalable rendering
- Avoids copying of HPC result data
- Simplifies administration



Scalable Rendering

- Render massive data sets faster
- Use multiple graphics cards and processors per display
- Different algorithms for parallelization

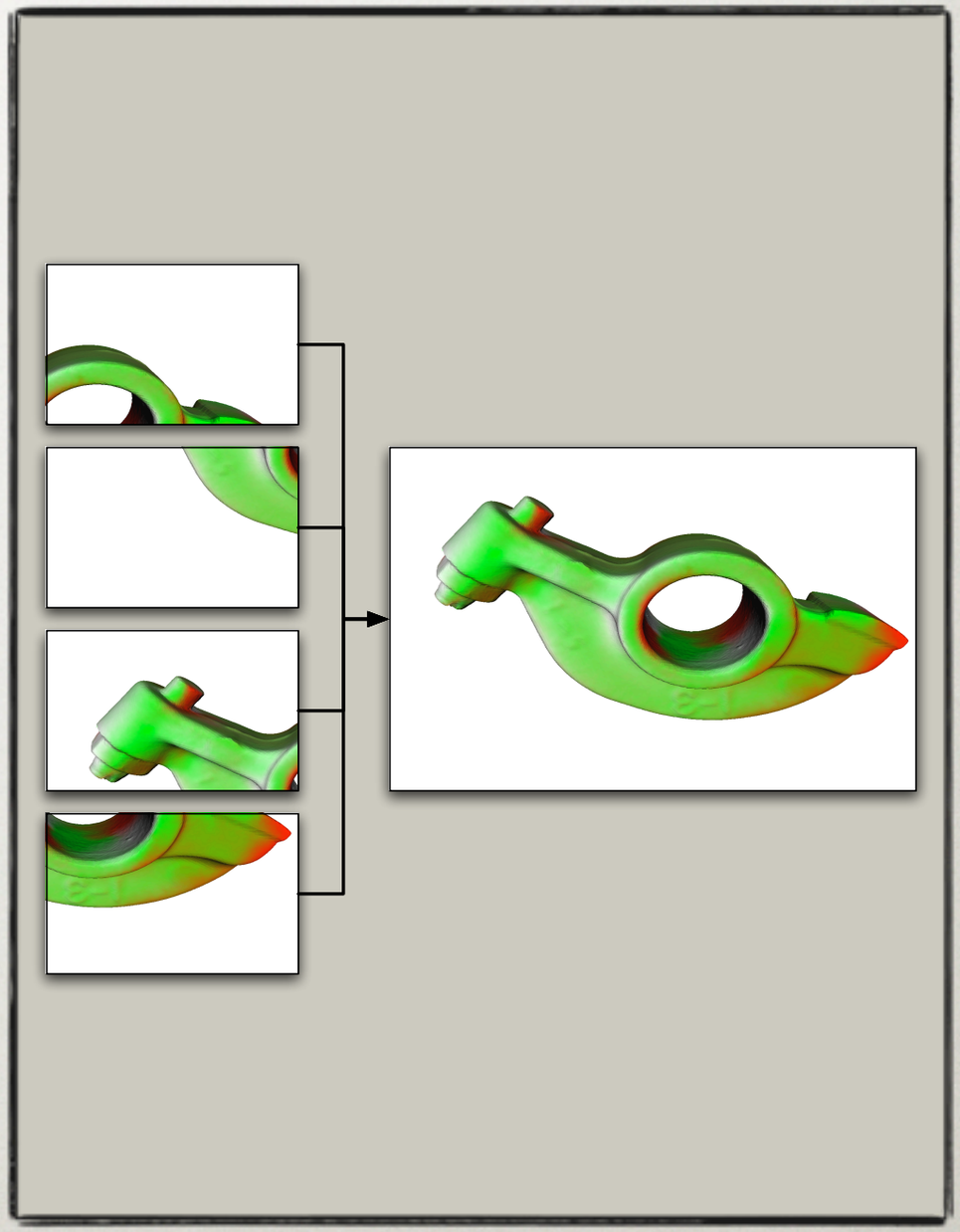


Scalable Rendering

- Single frame decomposition
  - sort-first: screen-space partition
  - sort-middle: only practical on GPU
  - sort-last: database partition
- Entire frame decomposition
  - DPlex: time-multiplex
  - Eye: stereo passes

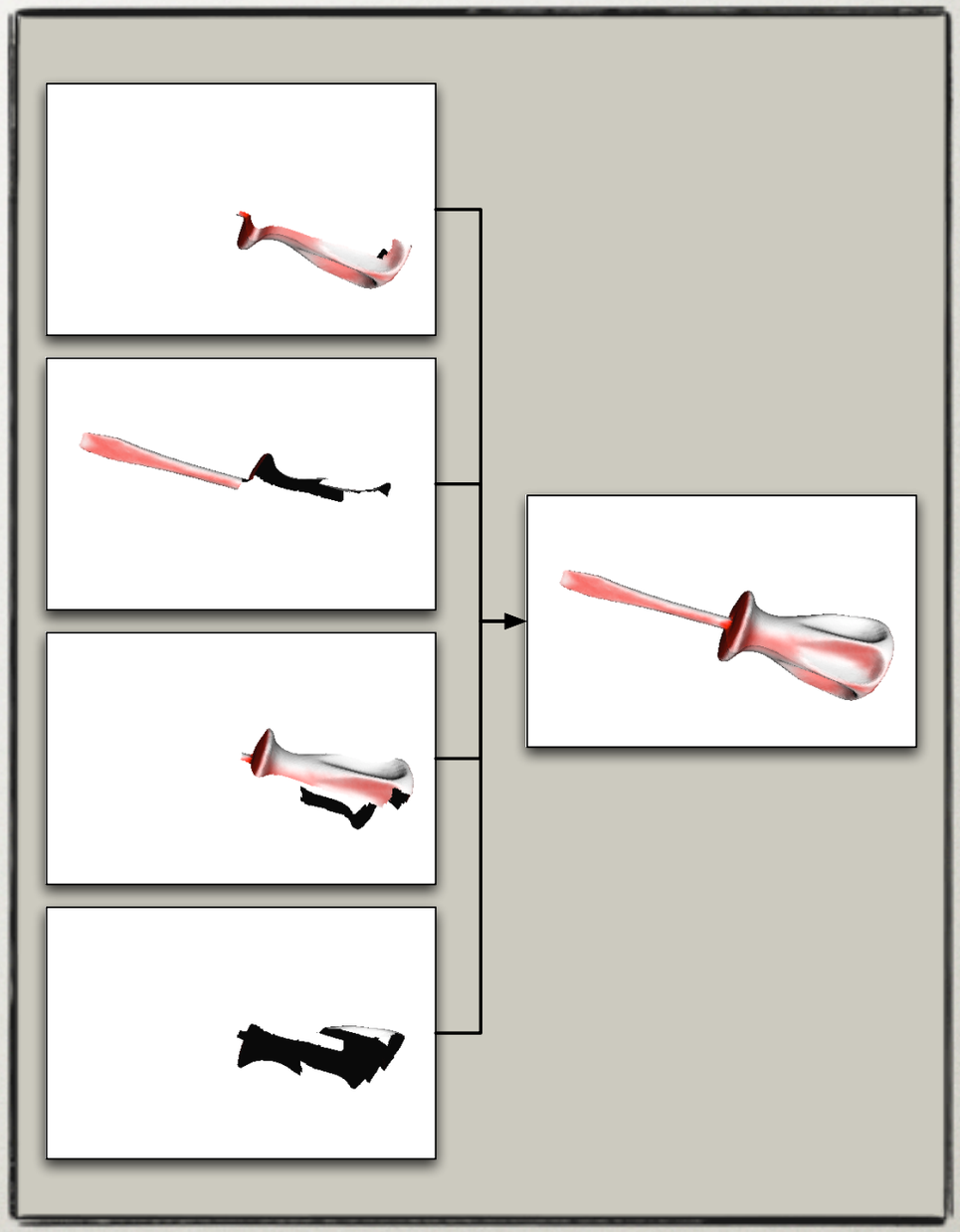
2D / Sort-First

- Scales fillrate / fragment processing
- Scales vertex processing with view frustum culling
- Parallel overhead due to primitive overlap limits scalability



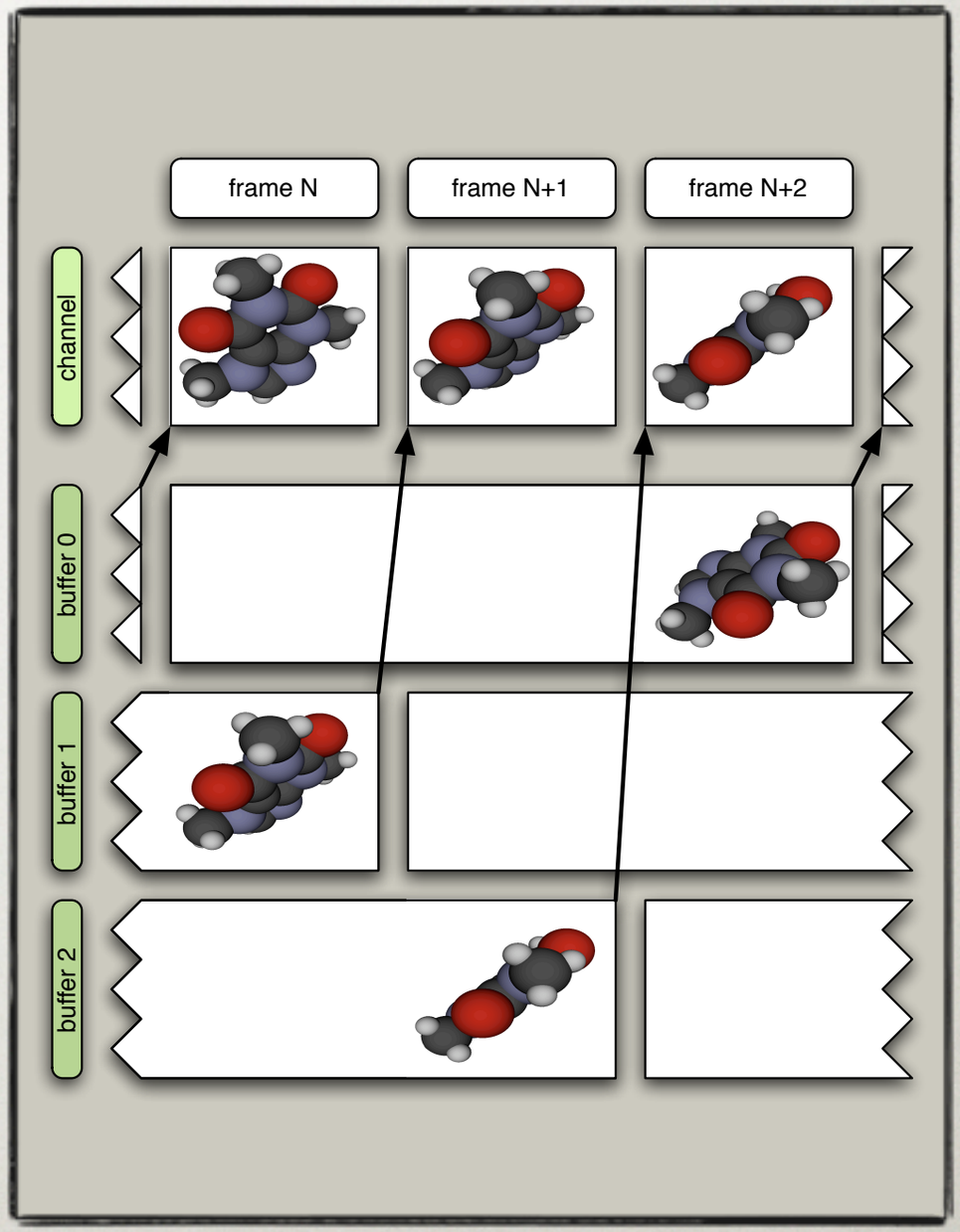
DB/Sort-Last

- Scales all aspects of rendering pipeline
- Application needs to be adapted to render subrange of data
- Recomposition relatively expensive



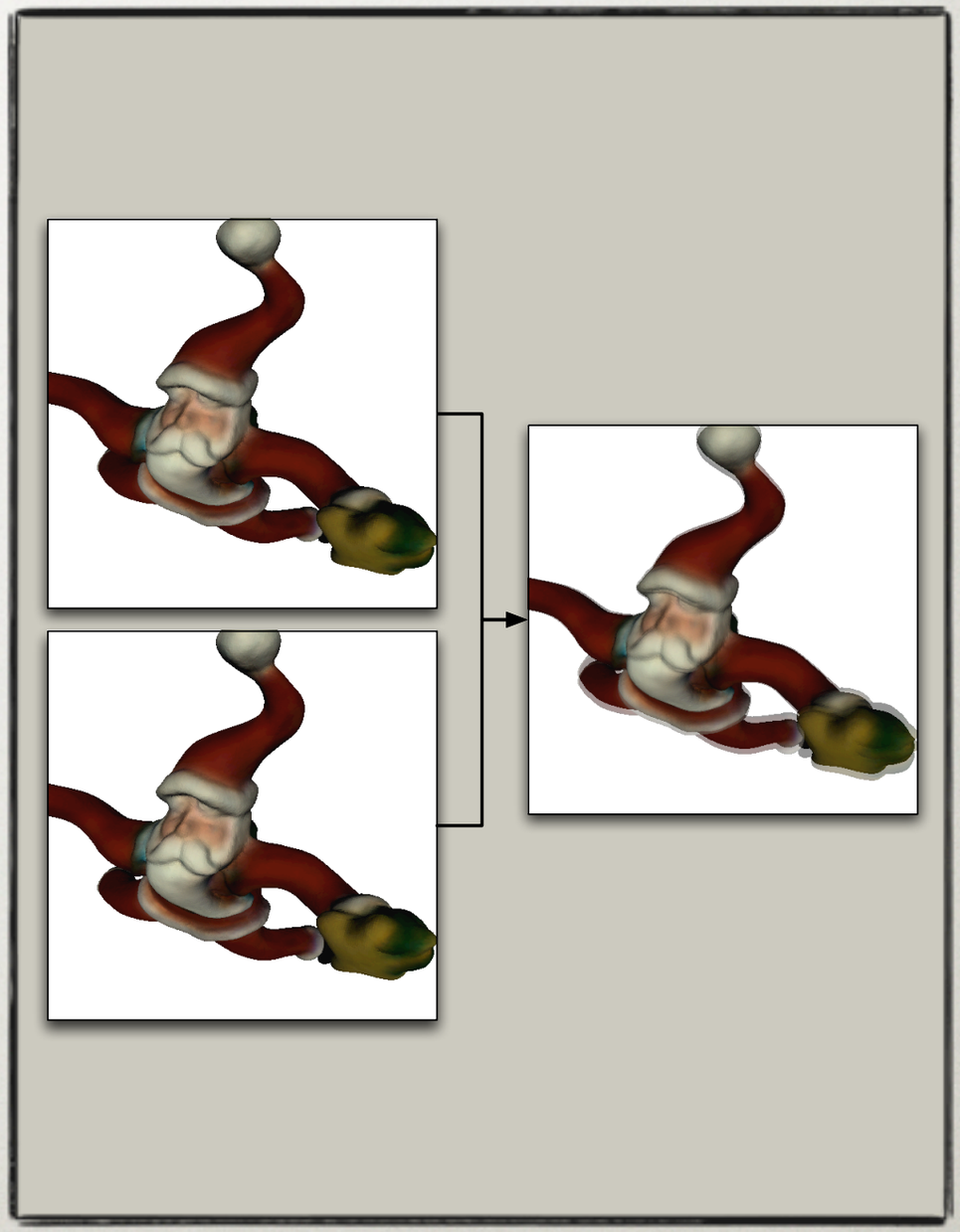
DPlex / Time-Multiplex

- Good scalability and loadbalancing
- Increased latency may be an issue



Eye/Stereo

- Stereo rendering
- Excellent loadbalancing
- Limited by number of eye views



Conclusion

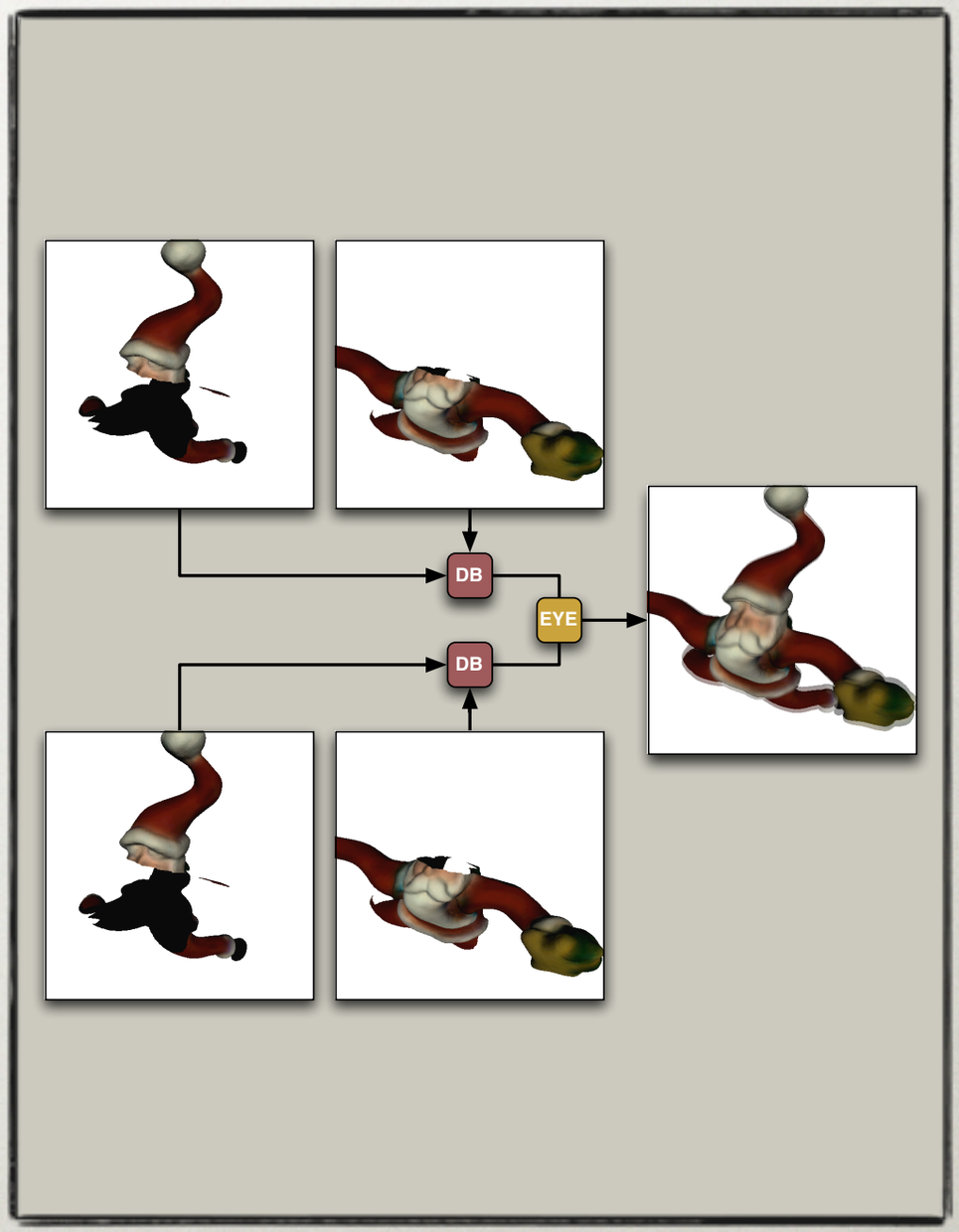
- No ‘magic bullet’
- 2D is ideal for up to eight pipes
- Use Eye if running in stereo
- DB scales best

➡ Combine modes

	2D	DB	DPlex	Eye
Fillrate	++	++	++	++
Vertex Processing	0	++	++	++
Memory Usage	0	++	0	0
Load Balancing	0	+	++	++
Latency	++	++	-	++
Re-assembly	+	-	+	+

Multilevel

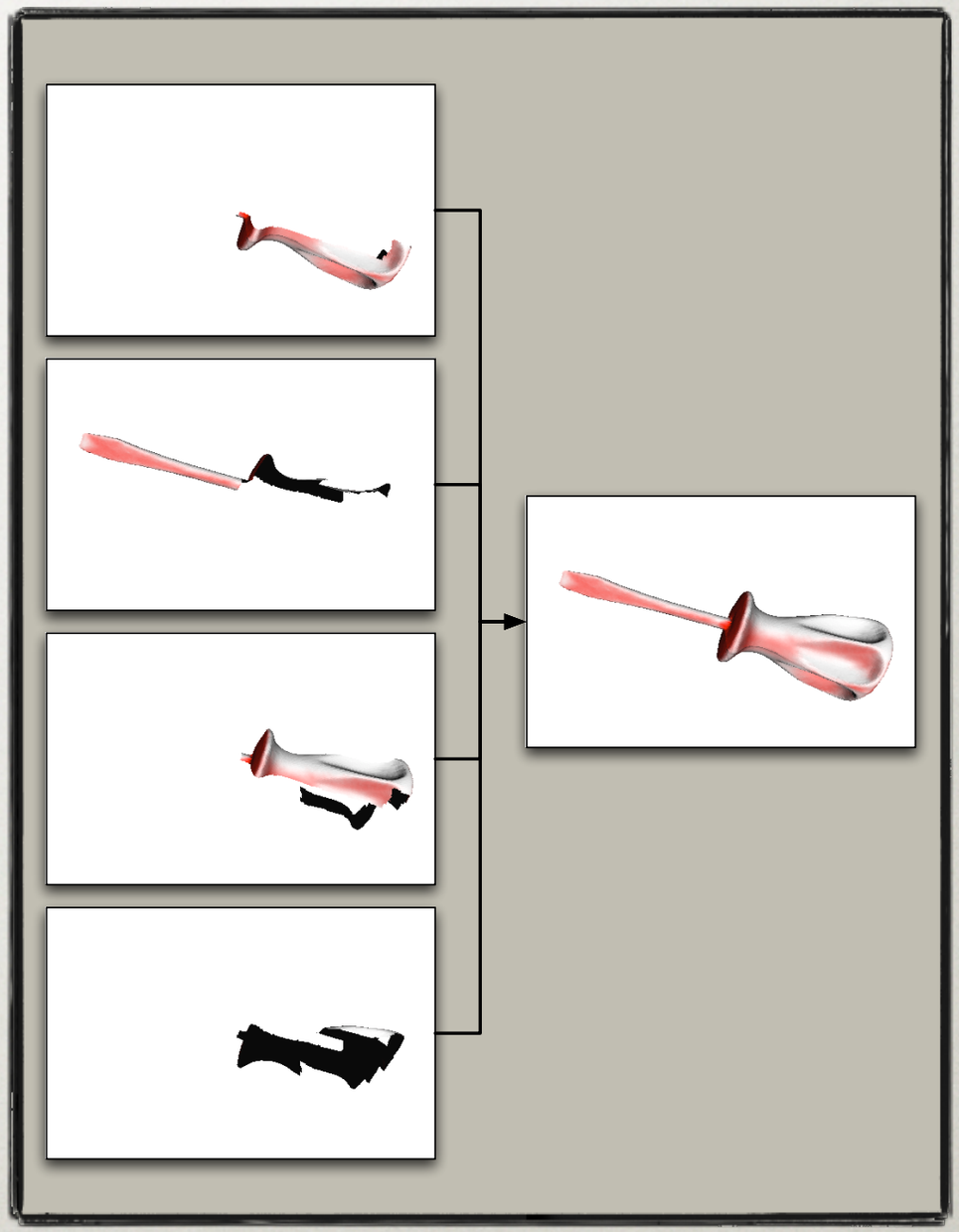
- Combine different algorithms to balance bottlenecks
- Flexible configuration of recomposition algorithm



Sort-Last Compositing

- Naive approach composites everything on final view
- O(n) IO requirements
- ≈ 6MB / node / frame

➡ Parallelize compositing

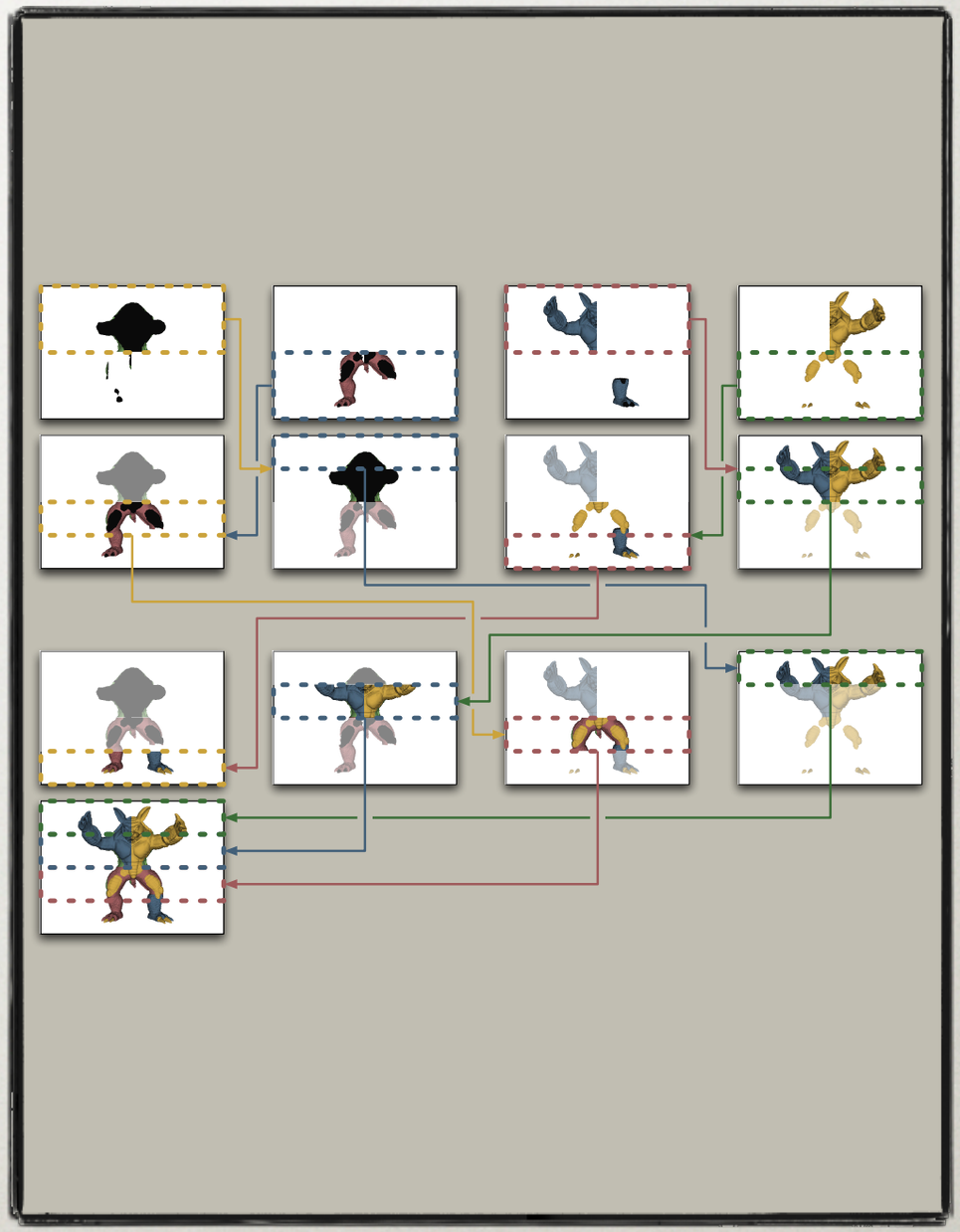


Binary Swap

- Power-of-two nodes

1. Swap half with partner
2. Composite
3. Repeat 1. & 2. until own tile is complete
4. Gather tiles

- O(1), but $O(\log_n)$ steps

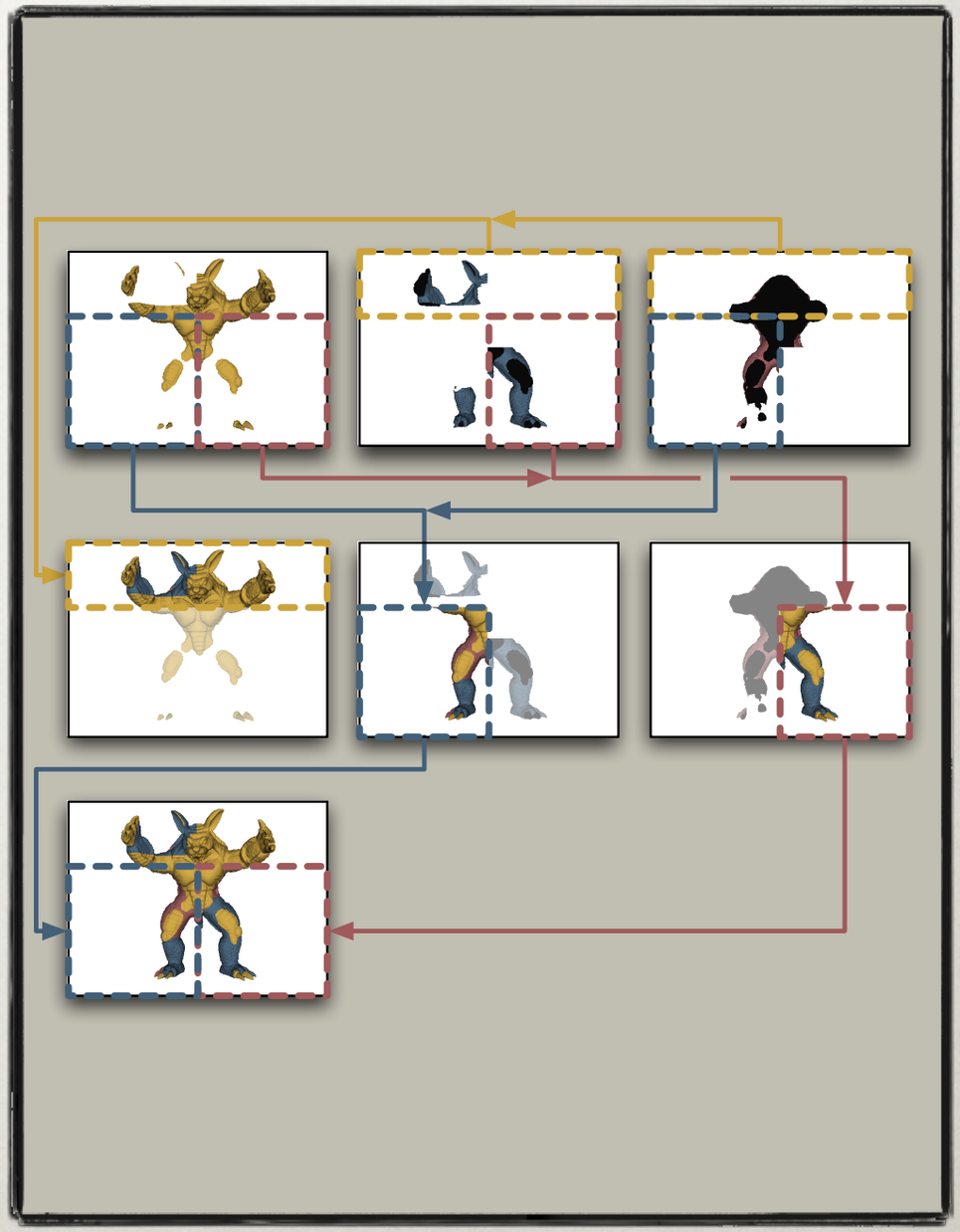


Direct Send

- Any number of nodes

1. Composite full tile
2. Gather tiles

- O(1)

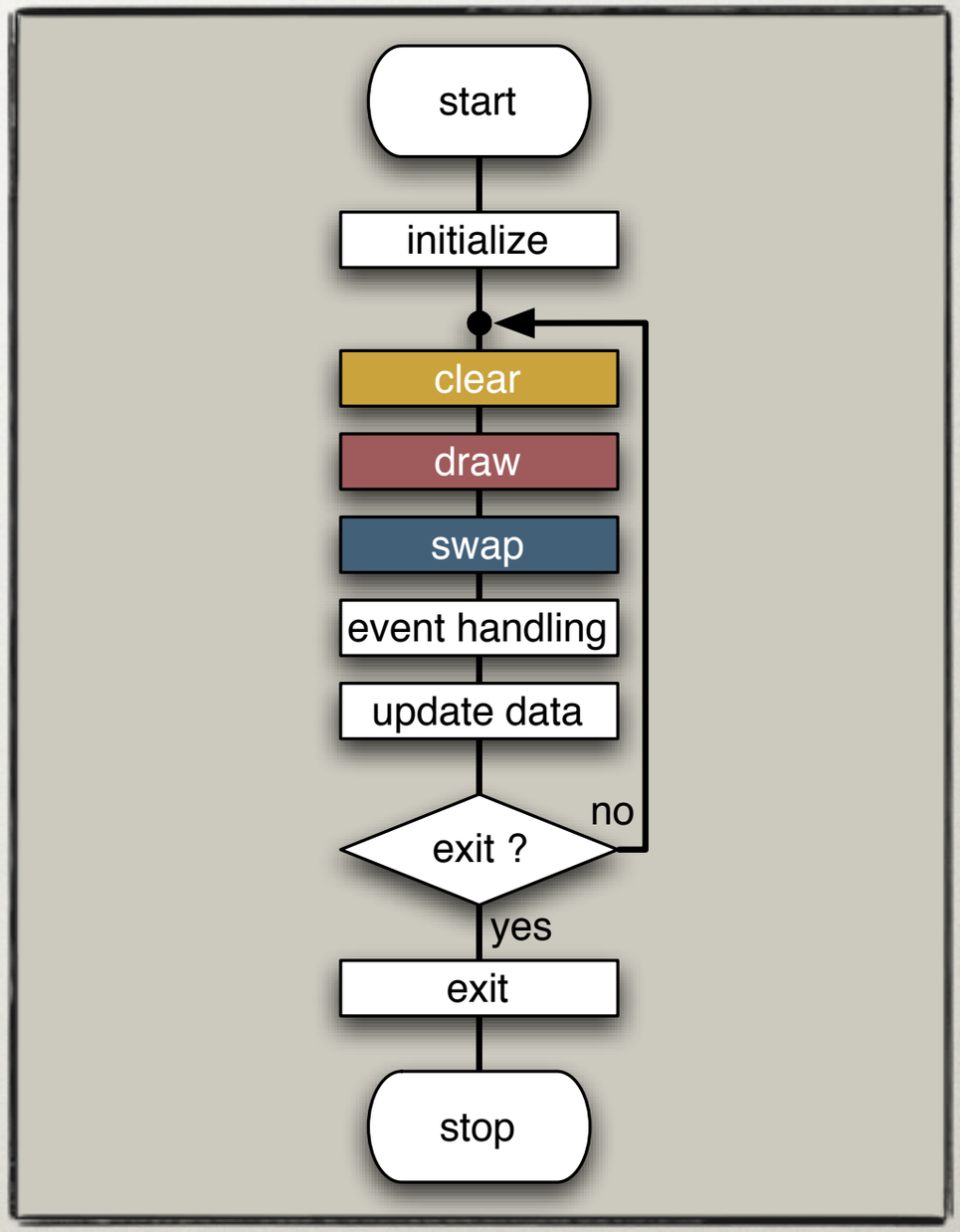


Multipipe Programming

- Single pipe application
- Multipipe porting
- Equalizer API
- Porting details

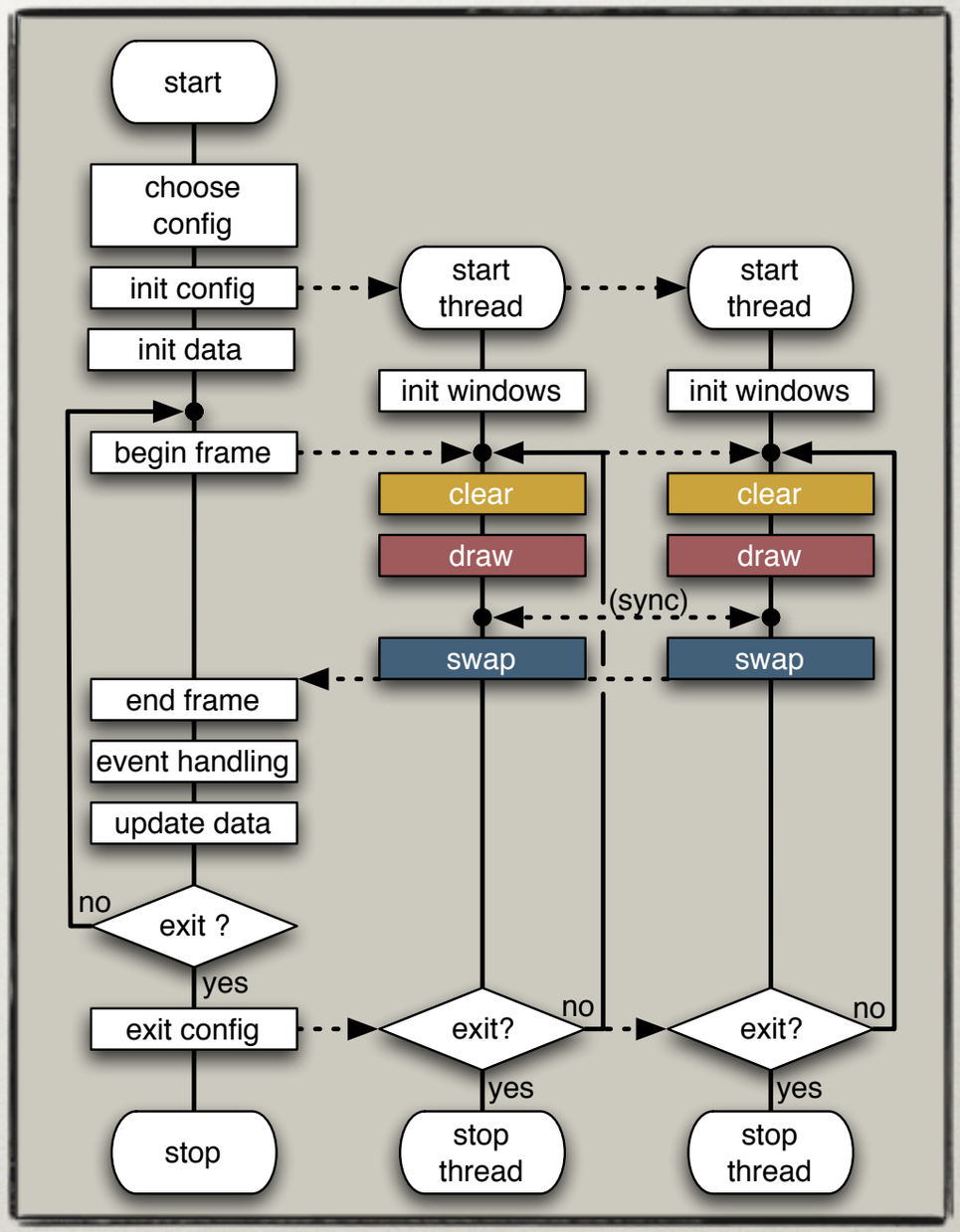
Single Pipe Rendering

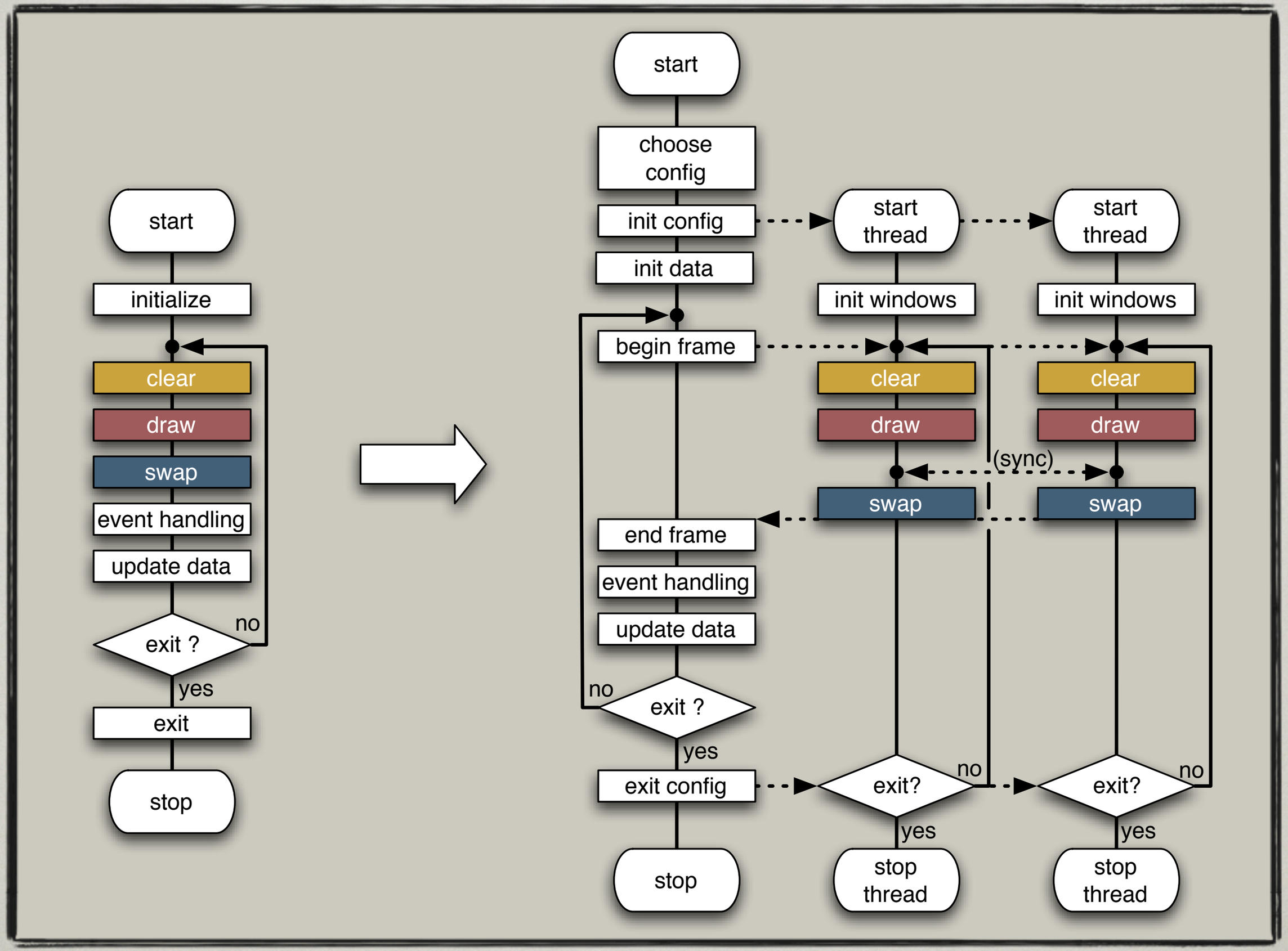
- Typical rendering loop
- Stages may not be well separated



Multipipe Rendering

- Separate rendering and application
- Instantiate rendering multiple times
- Synchronize parallel execution




start
initialize
clear
draw
swap
event handling
update data
exit ?
no
yes
exit
stop
start
choose config
init config
init data
begin frame
end frame
event handling
update data
no
exit ?
yes
exit config
stop
start thread
init windows
clear
draw
swap
exit?
no
yes
stop thread
start thread
init windows
clear
draw
swap
exit?
no
yes
stop thread
(sync)

Equalizer Programming

Applications are written against a *client library* which abstracts the interface to the execution environment

- Minimally invasive programming approach
- Abstracts multi-processing, synchronization and data transport
- Supports distributed rendering and performs frame compositing

Equalizer Programming

C++ classes which correspond to graphic entities

- **Node** is a single computer in the cluster
- **Pipe** is a graphics card and rendering *thread*
- **Window** is an OpenGL drawable
- **Channel** is a viewport within a window

Equalizer Programming

Application subclasses and overrides “callback” methods, e.g.:

- **Channel::draw** to render using the provided frustum, viewport and range
- **Window::init** to init OpenGL drawable and state
- **Pipe::startFrame** to update frame-specific data
- **Node::init** to initialize per node application data

Default methods implement typical use case

Porting Details

- Configuration
- Multithreading
- Synchronization
- Rendering decomposition
- Data distribution for clusters

Configuration

- Display environment
- Rendering resources
- Rendering mode (stereo, mono)
- Equalizer provides:
  - Simple ASCII configuration files
  - Central resource management

Multithreading/Synchronization

- Threading model
- Display synchronization
- Data synchronization
- Equalizer provides:
  - Abstraction of threading library
  - Swapbarrier, lock, sema, barrier, ...

Rendering Decomposition

- Task computation
- Result recomposition
- Equalizer provides:
  - Automatic task generation based on config
  - Flexible decomposition and recomposition
  - Task-specific callbacks

Data Distribution

- Who needs which data?
- Equalizer provides
  - Versioned, distributed objects
  - ‘Userdata’ mechanism, e.g.:
    - Config::beginFrame(**id**) is input parameter to Channel::draw(**id**)
    - ID identifies object or object version

Last Words

- LGPL license
- Open standard for scalable graphics
- User-driven development
- Alpha version on www.equalizergraphics.com
- Get in touch!