Multi-Frame Rate Rendering for Standalone Graphics Systems

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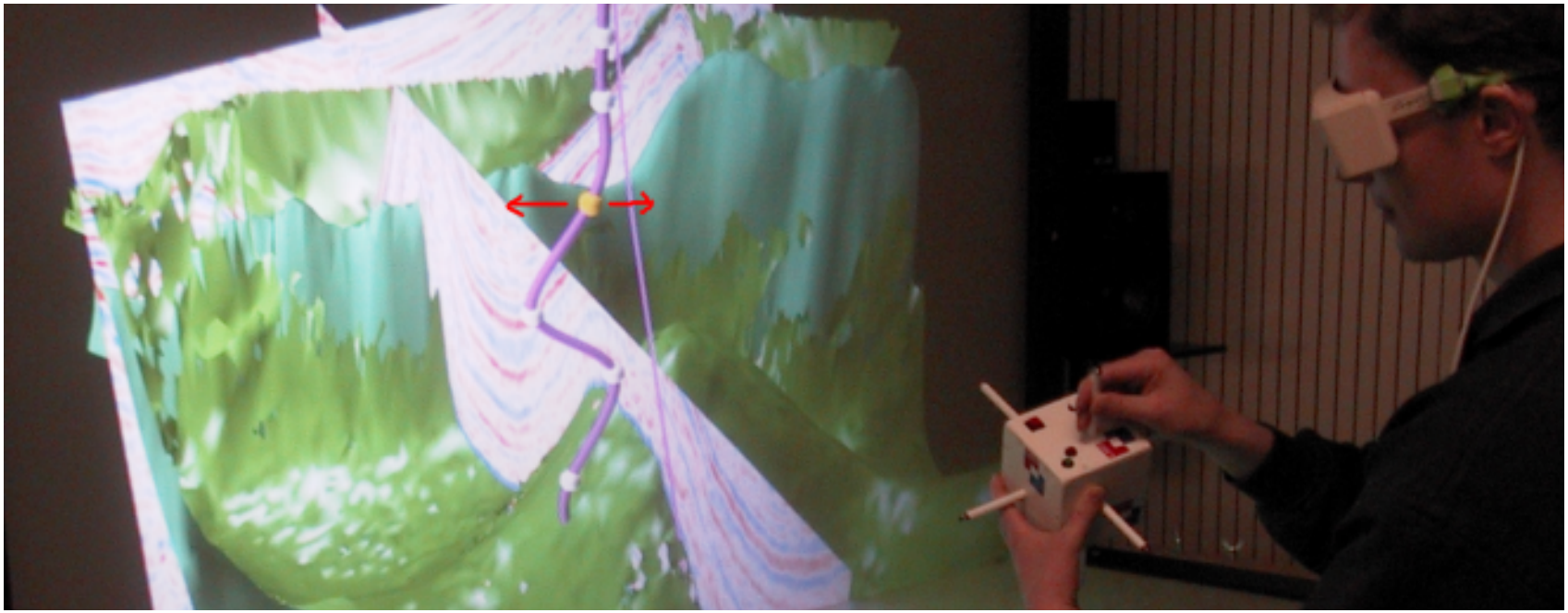
Observations for Complex Applications



High frame rates:

- Object manipulation
- System control

Low(er) frame rates:

- Head tracking
- Navigation

Multi-Frame Rate Rendering and Display

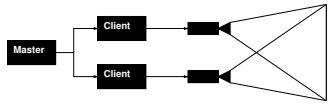
Asynchronous rendering

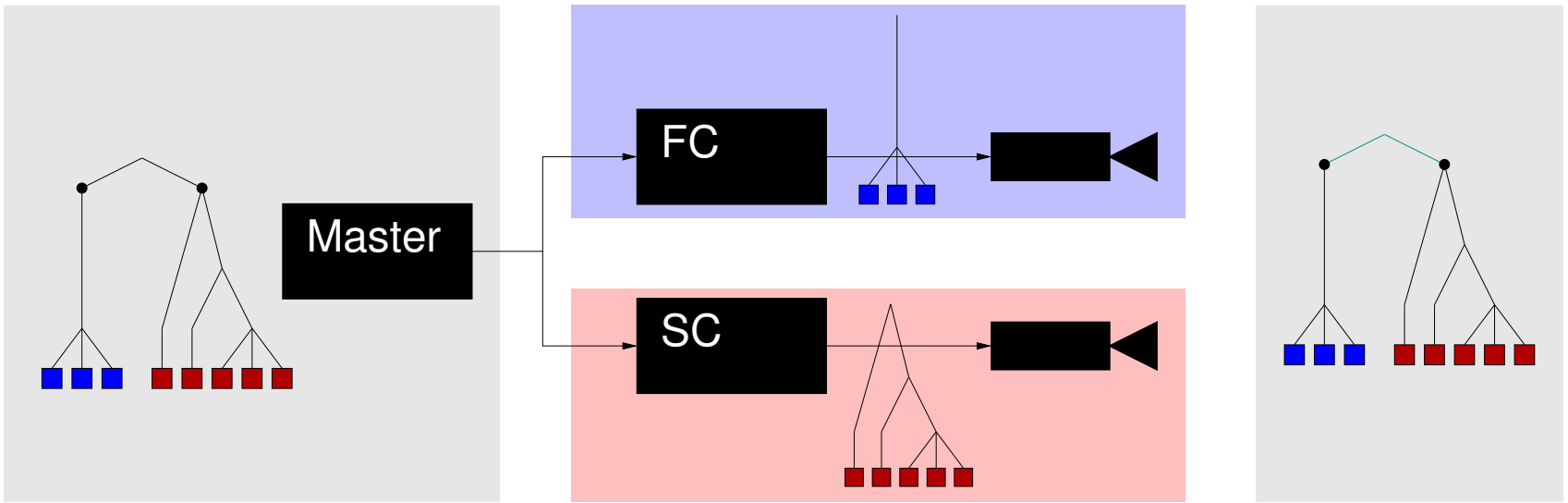
- Distribute scene to two clients (graphics cards / computers)
- Fast client will render:
  - manipulated/active objects
  - system control
- Slow client will render:
  - rest of the scene

Results combined into multi-frame rate display

- Optical superposition
- Digital composition

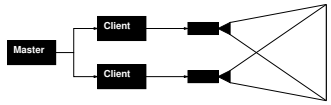
Optical Superposition



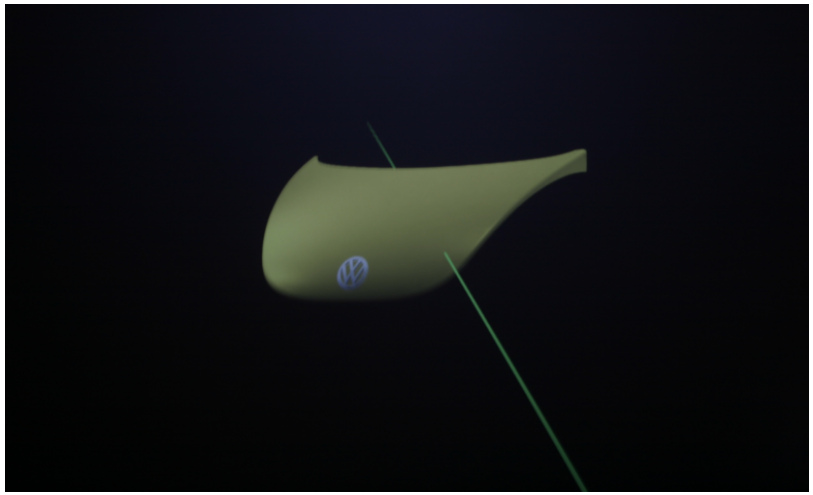


Inspired by Majumder and Welch, *Compter Graphics Optique: Optical Superposition of Projected Computer Graphics*, IPT - EGVE 2001

Optical Superposition



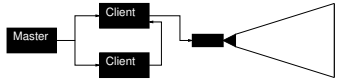
Slow client (SC)

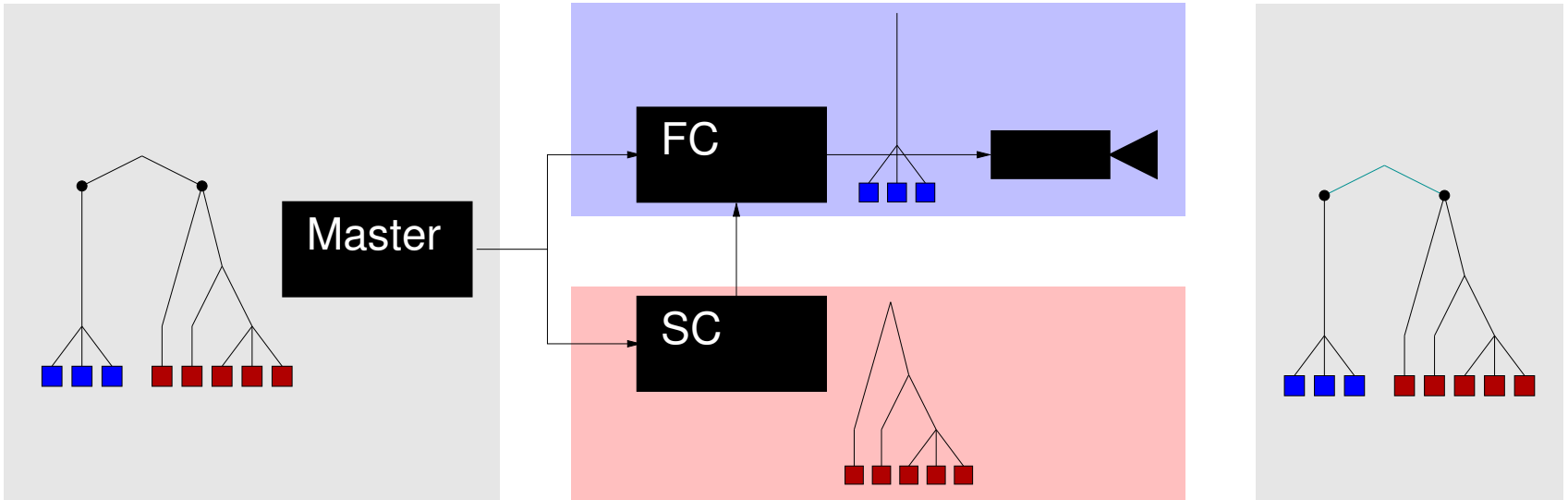


Fast client (FC)

Optically combined image on display

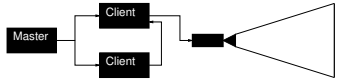
Digital Composition



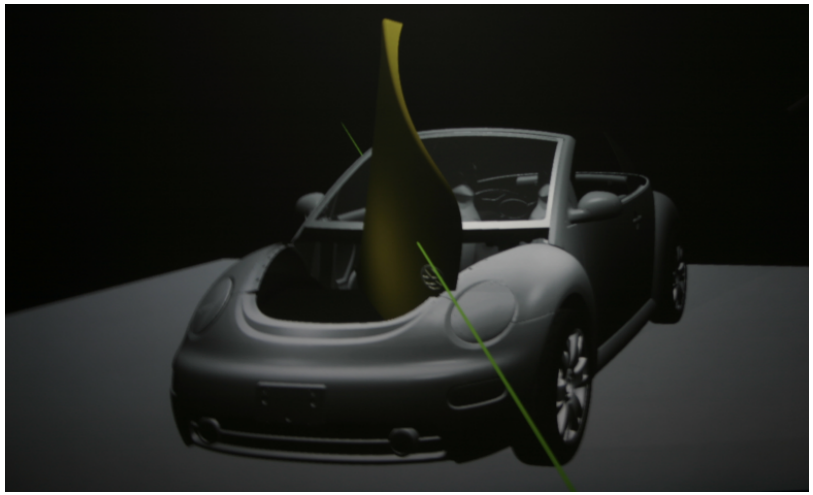


Inspired by Sort-Last parallel graphics

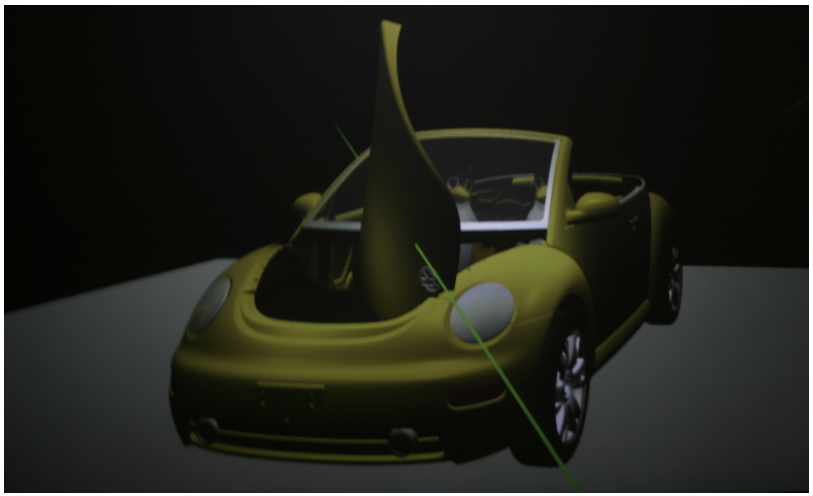
Digital Composition



Slow client

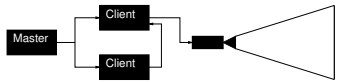


Fast client



Digitally composited image on display

Digital Composition

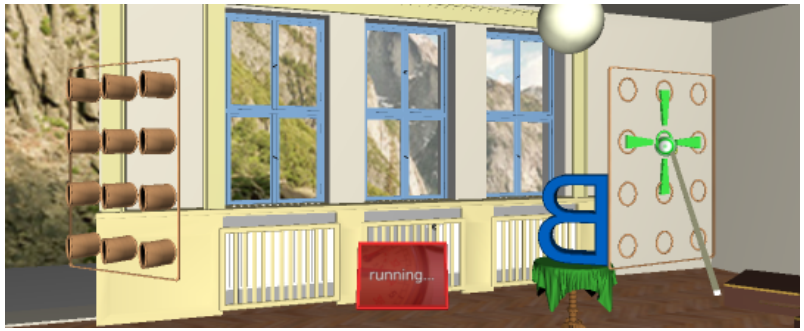


Properties and issues

+ Fast interaction and object manipulation
+ Correct occlusion between objects on fast and slow client

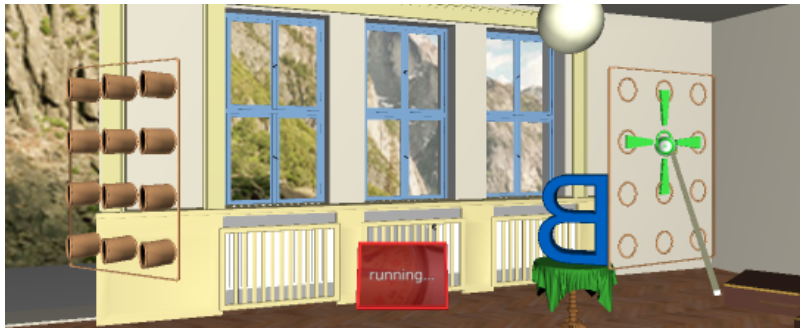
– Implementation more difficult
  - Transfer of depth/color buffer from SC to FC
  - Transfer of view transform from SC to FC (for head tracking)
– Increased latency for images generated by SC
– Network bandwidth limits update rates of SC
– Popping artifacts during selection and deselection of objects

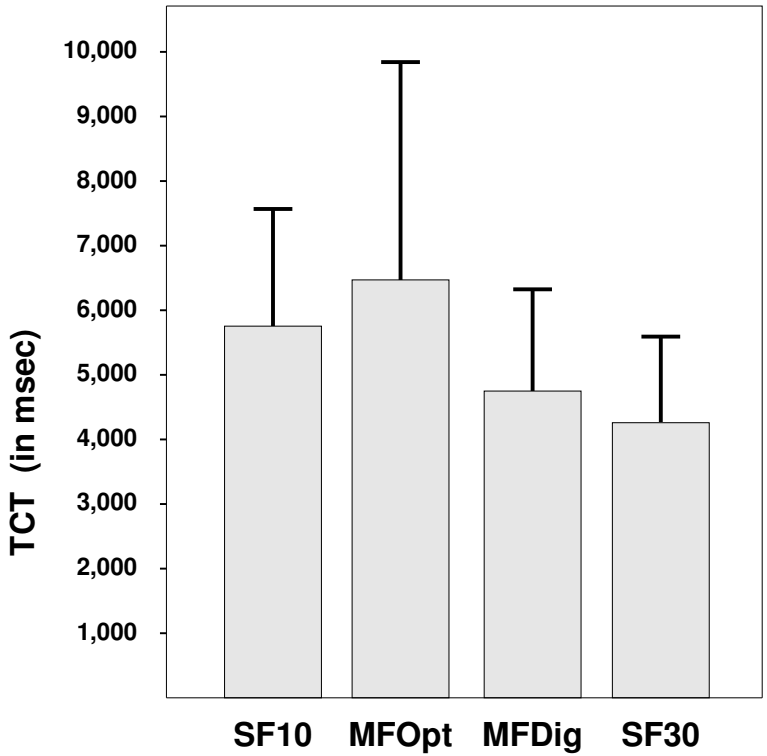
User Study



User Study

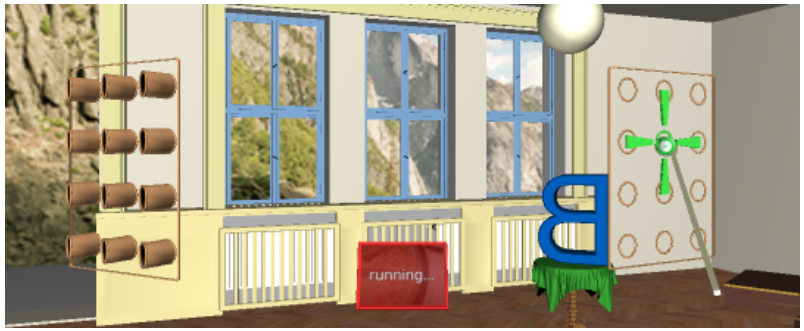

next
try

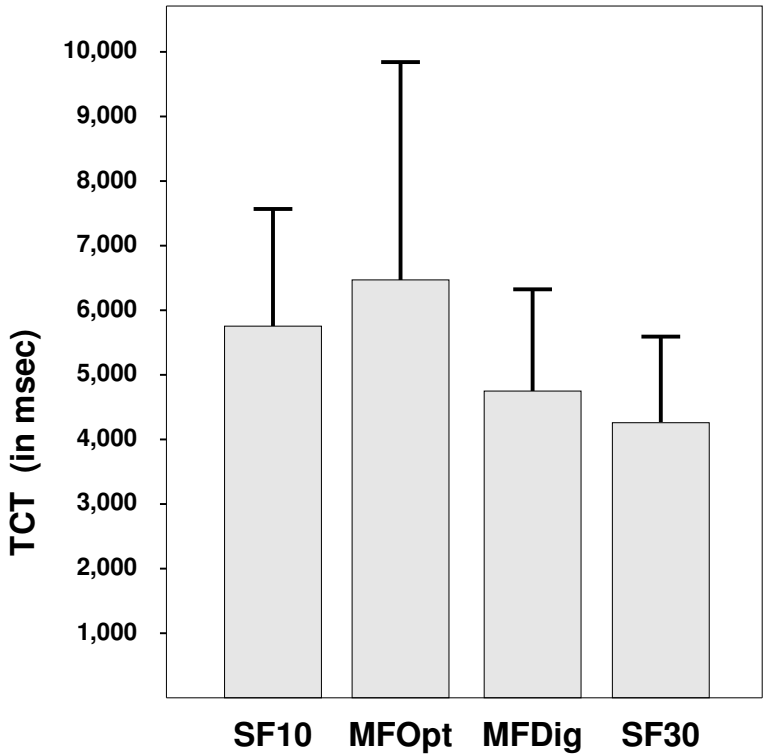

running...


TCT (in msec)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
SF10
MFOpt
MFDig
SF30

User Study


next
try


running...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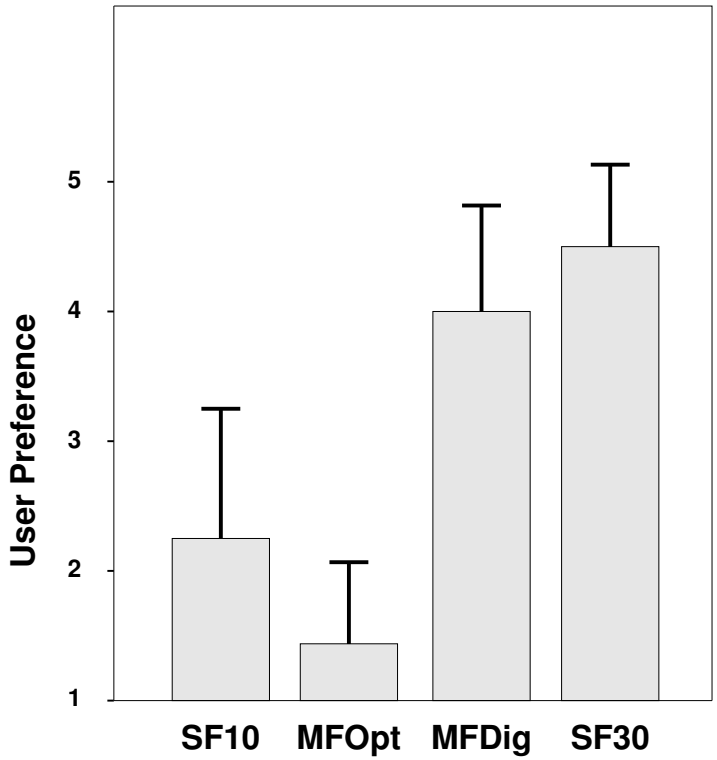
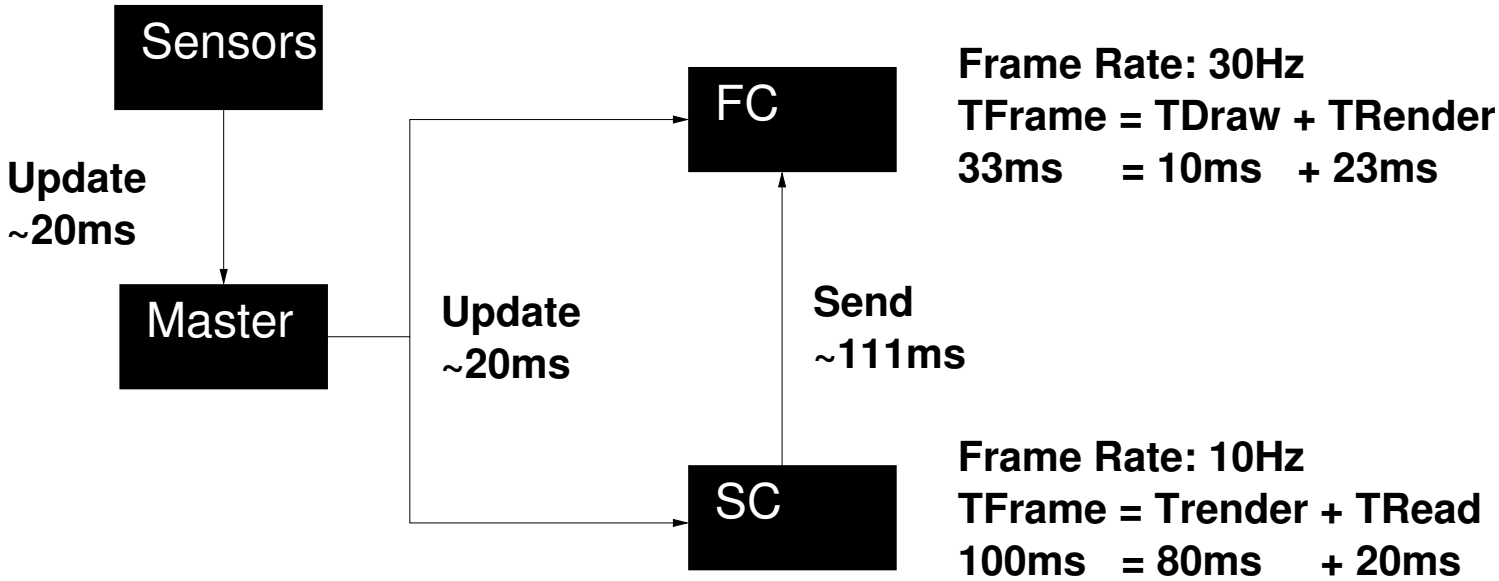
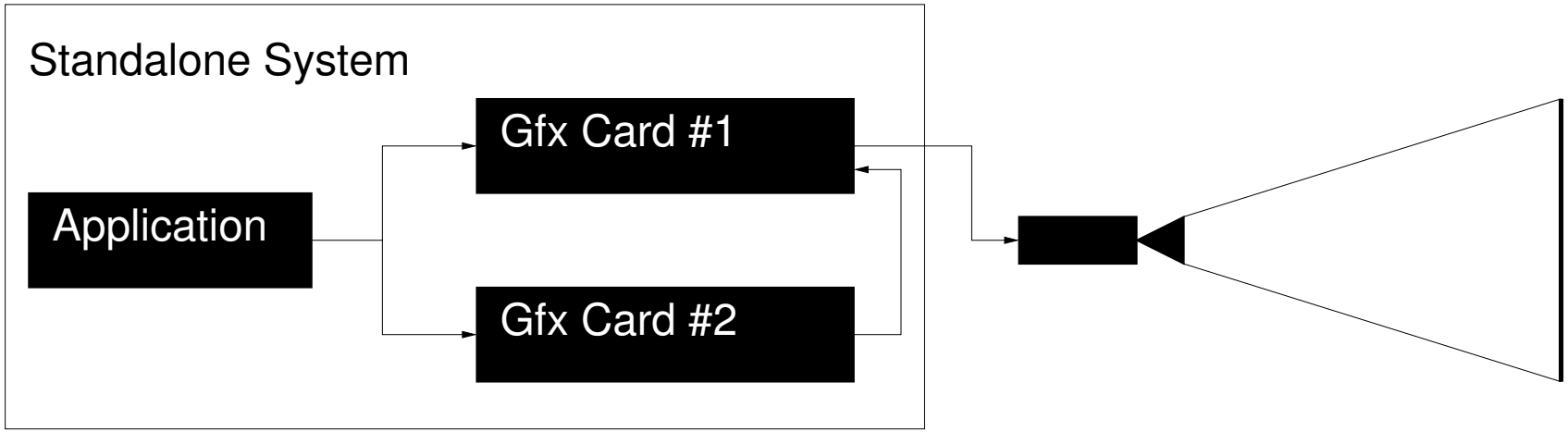

User Preference
5
4
3
2
1
SF10
MFOpt
MFDig
SF30

End-to-End Latency



- Resolution: 1280×1024
- Image compression may not decrease network latency
  see Roth and Reiners, *Sorted Pipeline Image Composition*, EGPGV06

Multi-GPU System Support



Properties

+ Completely avoids network latency
+ Simplified application structure

– Scalability

Multi-GPU System Support: Implementation Strategies

- Cluster application on single host
  - by send/receive over loopback device
  - by reading/writing to process shared memory
- Process memory shared by multiple threads
  requires asynchronous graph traversals in one application
- Shared resource on all GPUs
  update on SC "automagically" triggers transfer to FC

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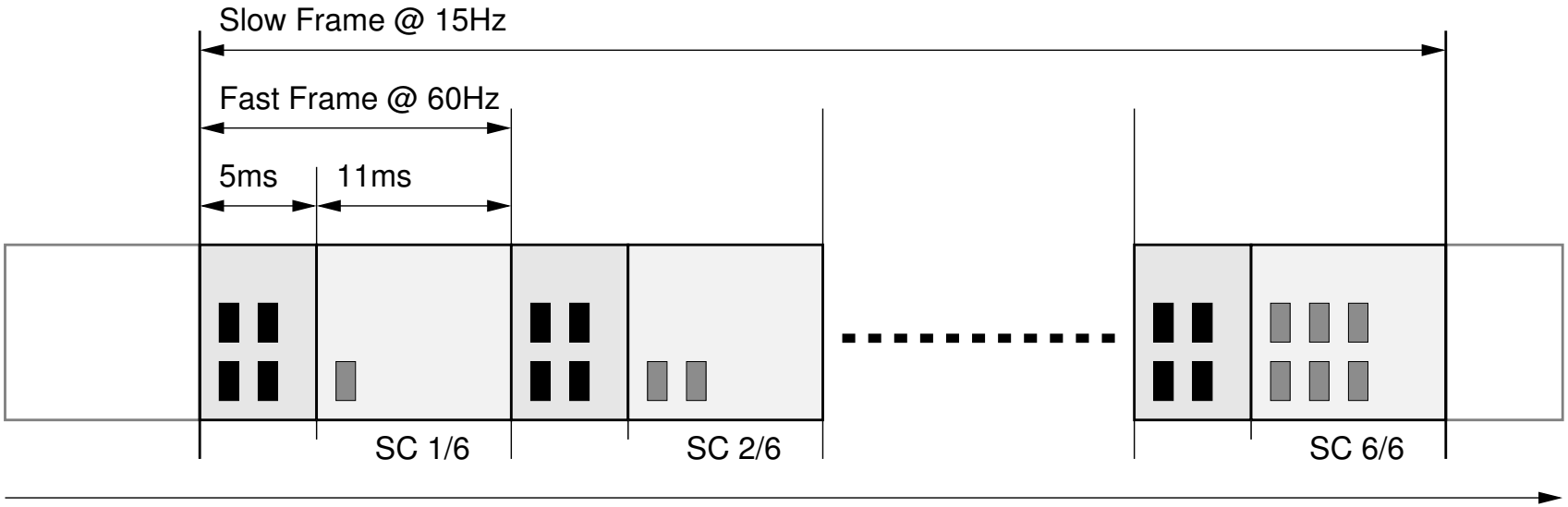
Multi-GPU System Support: Experiences

- Loopback device 2 GBit bandwidth limit
- Shared memory access w/ full system bandwidth
- Quad-core CPU better than dual-core CPU
- Concurrent read/write on multi-gpu systems does work

Single-GPU System Support

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Single-GPU System Support: Experiences

- Scene segmentation vs. scheduling (`GPU-INTR`)
- Extends range of usable devices (e. g. cell phones, PDAs)

Summary

- Multi-frame rate rendering
  - Improves object manipulation and system control
  - Does not improve navigation
  - Works with stereo and head tracking
- Standalone system support
  - Supports both optical superposition and digital composition
  - Minimizes transfer latency between SC and FC
  - Extends range of usable devices

Future Work

- Refine digital composition approach
- Develop multi-frame rate artifact fixes

- Further user studies
  - Lowest limit for head tracking update rates?
  - Which frame rate ratios for SC and FC work well?

- Combine with other parallel rendering strategies
  - Resource (re-)allocation/balancing

Thank you for your attention.