Virtual Reality Visualization System for Virtual Nuclear Reactor

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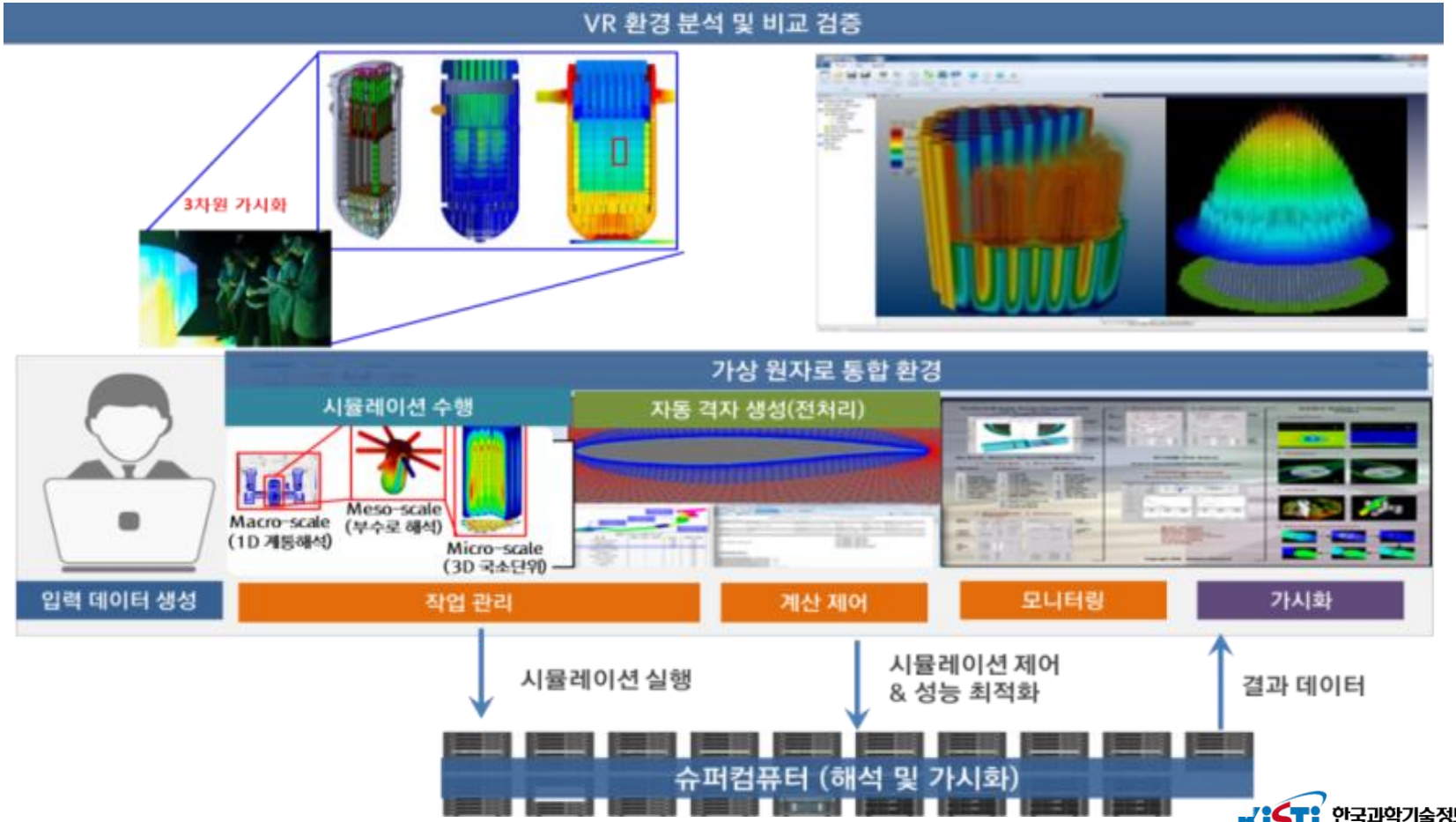
Introduction

1.1 What is Virtual Nuclear Reactor?

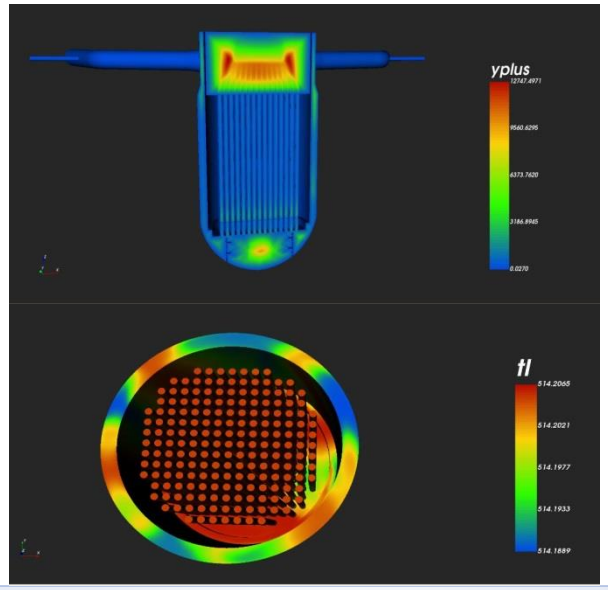
- What is “Virtual Nuclear Reactor?” in broad sense

  Whole process being required for nuclear reactor simulation by computation and analysis.



1.2 Visualization System based on Virtual Reality

- VR visualization hardware + VR visualization software



Display Cluster for Tiled Display

GLOVE Remote User Interface

GLOVE VR User Interface

Interconnection network

Computing Cluster for Parallel Visualization

VR Visualization Hardware

2.1 VR Visualization Hardware Components

명칭	용도 및 특징	규모	예산
출력장치	가시화 결과 출력 필요에 따른 입체영상 지원	환경에 따른 편차가 매우 큼	~ 30억 원
입력장치	6자유도 사용자 입력 장치		~ 1억 원
디스플레이 클러스터	출력장치 운용 화면 출력이 가능한 GPU 장착	~ 16 노드	~ 5억 원
가시화 계산 클러스터	해석 데이터 가공 및 가시화에 필요한 연산 수행 계산에 특화된 GPU 장착 대용량/고속 병렬 파일시스템 포함	~ 256 노드	~ 40억 원

가시화 시스템 구축사례(KISTI)

가시화 시스템 구축사례(KAI)

해외사례

2.2 Output Devices

- 출력장치

구분	Tiled display	Wall screen	CAVE	HMD
특징	(–) 모니터 패널 / 프로젝터 큐브 (–) 넓은 가격대 (품질 편차) (–) 입체영상 : 선택 (O) 확장성 : 쉬운 고해상도 구현 (O) 높은 공간효율 (O) 동시 사용자 다수 (X) 모니터 프레임(bezel)으로 인한 이미지 연속성 훼손(2) (X) 색상 보정의 어려움	(–) 프로젝터 + 스크린 (–) 넓은 가격대 (품질 편차) (–) 입체영상 : 선택 (O) 높은 색상품질 (O) 색상 연속성 보장 (O) Geometry 연속성 보장 (O) 동시 사용자 다수(3) (X) 확장성 낮음 (X) 블렌딩 영역 → 해상도 손실 (X) 낮은 공간효율	(–) 프로젝터 + 스크린 (–) 입체영상 : 필수 (O) 높은 색상품질 (O) 색상 연속성 보장 (O) Geometry 연속성 보장 (O) 높은 몰입감 (X) 동시 사용자 소수 (X) 낮은 확장성 (X) 높은 가격 (X) 블렌딩 영역 → 해상도 손실 (X) 낮은 공간효율	(–) 입체영상 : 필수 (–) 1인용 (O) 높은 몰입감 (O) 낮은 가격 (X) 낮은 색상품질 (X) 낮은 해상도 (X) 무게
구축 사례				

(1) Tiled display와 wall screen의 결합, Tiled display와 CAVE의 결합 등 혼합형 출력장치 구성 가능
(2) 프로젝터 큐브로 구축할 경우 bezel이 아예 존재하지 않는 형태도 가능 (가격 상승)
(3) 소규모 회의실, 극장, 강당 등 다양한 규모의 출력장치 구축 가능

2.3 Input Devices and Visualization Cluster

- 입력장치


wand


joystick


haptic


motion capture


force plate


speech

- 클러스터

구분	디스플레이 클러스터	가시화 계산 클러스터
GPU	비디오 출력 지원 노드 당 2개 전후 장착 GPU 당 2~4개의 영상 출력	비디오 출력 미지원 노드 당 2~8개 장착
메모리	노드 당 256 GB (권장)	노드 당 512 GB (권장)
노드 수	~ 16 노드	~ 256 노드
기타	오디오, 입력장치 운영	
외장 스토리지	공유	


가시화 클러스터(KISTI)

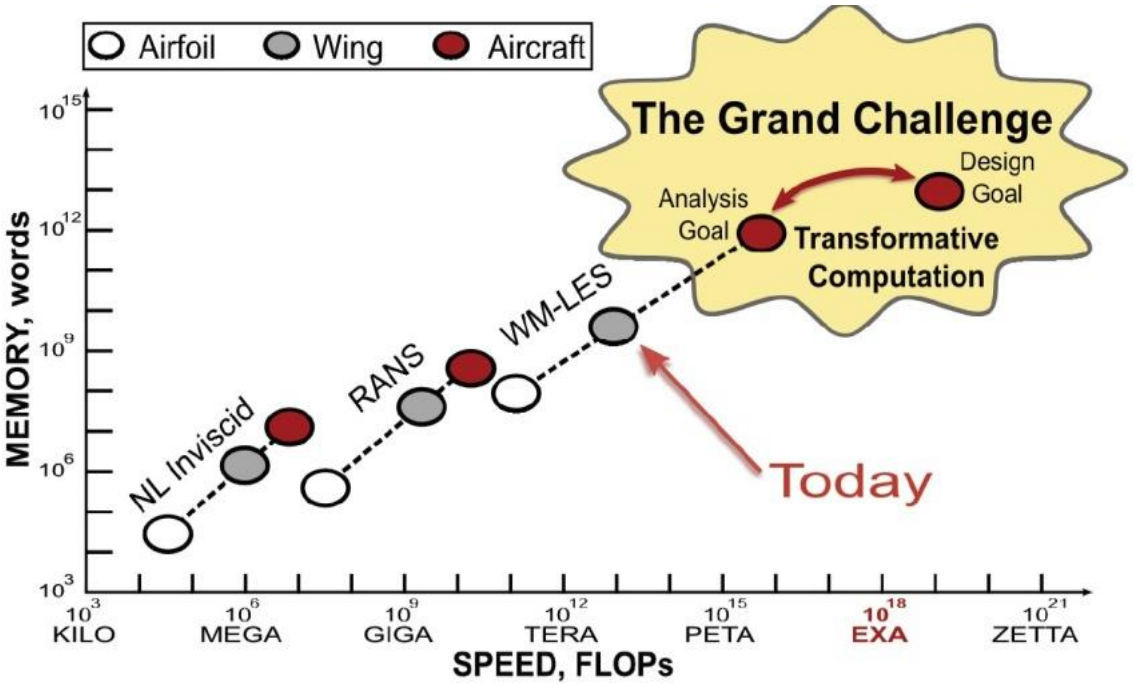

가시화 클러스터(TACC)

가시화 클러스터(ANL)

VR Visualization Software

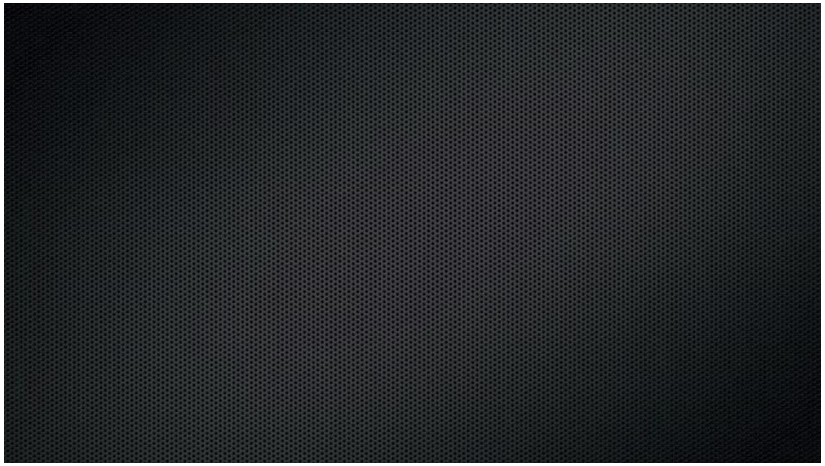
3.1 VR Visualization Software Requirements (1)

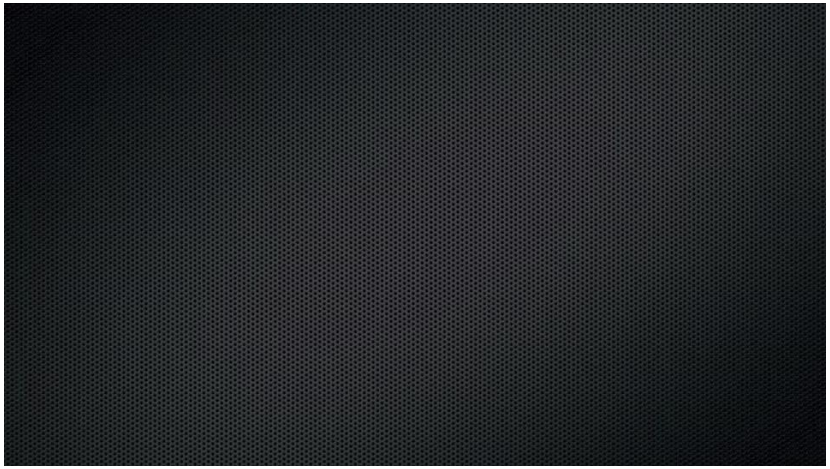
- High-precision CFD data size has been dramatically increasing for designing and developing products with CFD simulation.
- However, it takes a considerable time to analyze the massive data.
- The visualization for analysis is one of the most important, time-consuming factor.



3.1 VR Visualization Software Requirements (2)

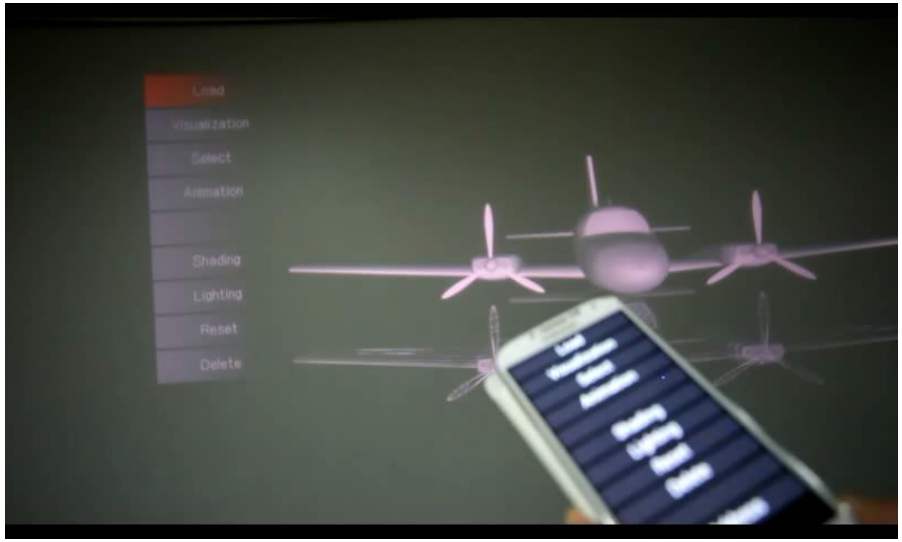
- Massive data manipulation for extracting features that users want to visualize.
- The effectiveness of parallel algorithm for real time visualization and rendering
- Time varying data visualization
- Scalability

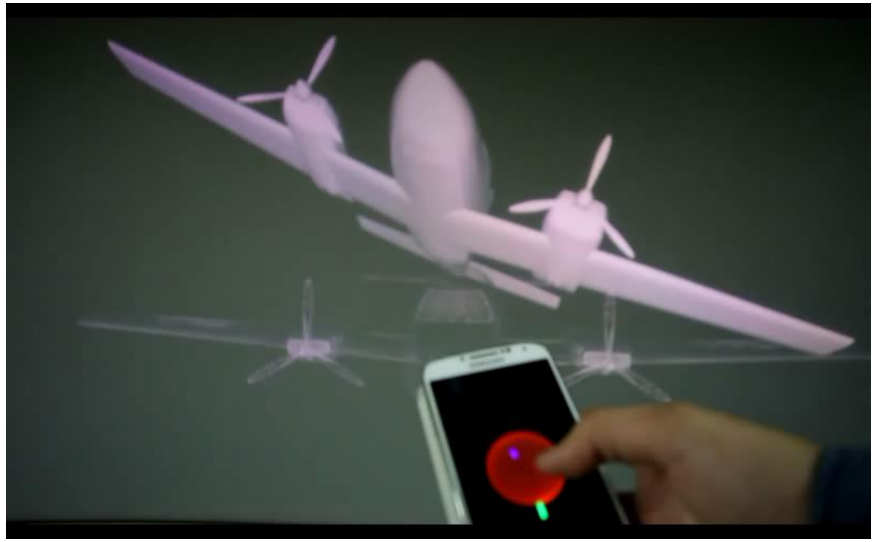




3.1 VR Visualization Software Requirements (3)

- It has to support various types of display environments (including high-resolution tiled display, immersive VR environments, etc.) for high-end users
- It has to support a 3D monitor and a 3D mouse.
- It has to various types of 3D input devices have to be supported(IS-900, smart phone, haptic device, etc.)

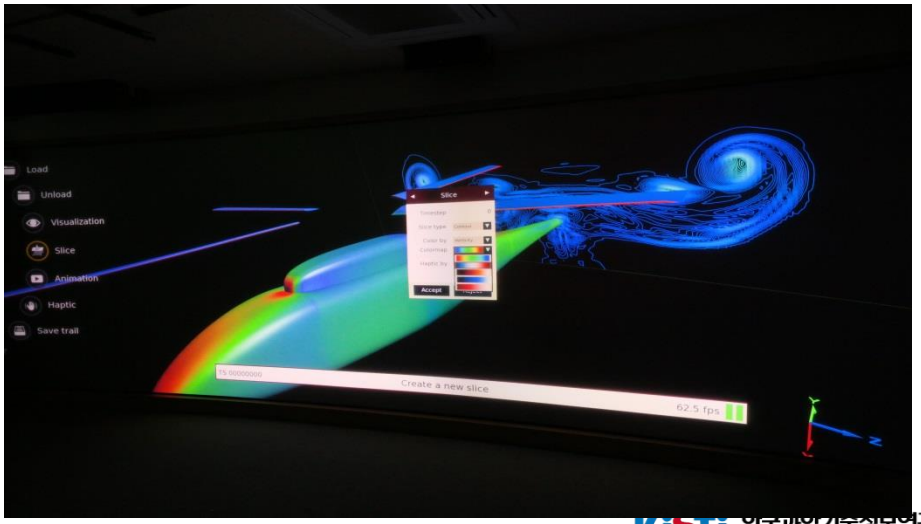




3.2 Open Source VR Visualization Software

	GLOVE	ParaView	VisIt
개발 기관	KISTI	Kitware, LANL, SNL	LLNL, ORNL, LBNL, UC Davis
예산, 인력	4 man/year	85 man/year	25 man/year(Initial version)
개발 기간	2009 ~	2000 ~	2000 ~
우수성	뛰어난 가시화 성능	범용 가시화, 설치의 편리함	탁월한 병렬 확장성, 병렬 렌더링
차별성	다중사용자 지원 가상현실 인터페이스 Customized GUI	웹 환경 지원 통계 분석 기능 (그래프 등)	동적 플러그 인을 통한 기능 확장
VR 장비 지원	Tiled display, VR 입출력장치 지원	VR 사용자 인터페이스 지원	지원하지 않음
VR 사용자 인터페이스	VR 상에서 Operation 가능	VR 상에 View 만 지원	-

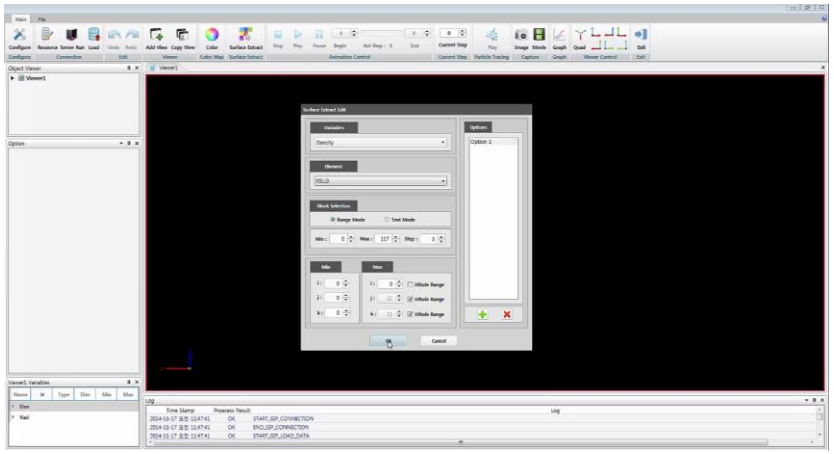
<Paraview VR>



<GLOVE VR>

GLOVE

4.1 GLOVE



Display Cluster for Tiled Display

GLOVE Remote User Interface

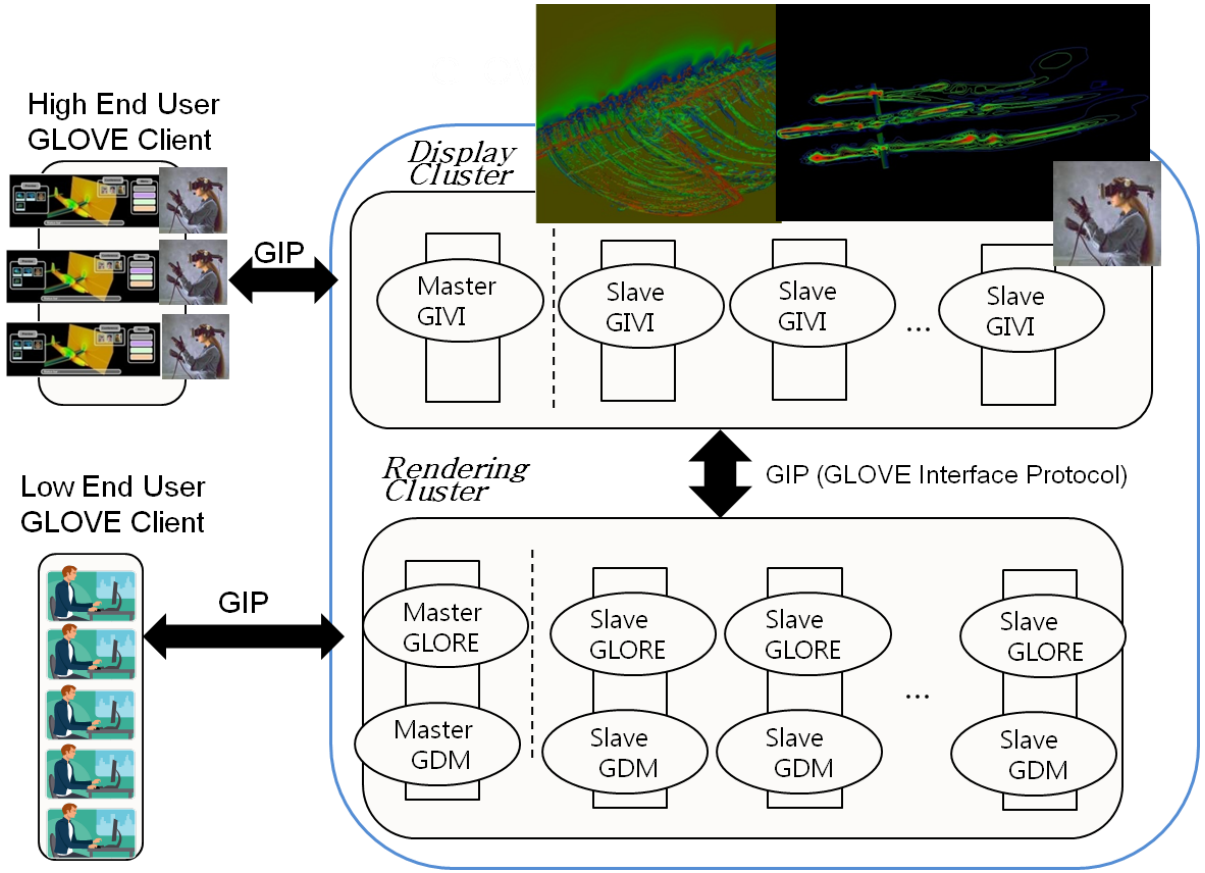
GLOVE VR User Interface

Interconnection network

Computing Cluster for Parallel Visualization

4.2 GLOVE Software Architecture

- GLORE is a daemon server and GIVIs operate as clients for visualization request.

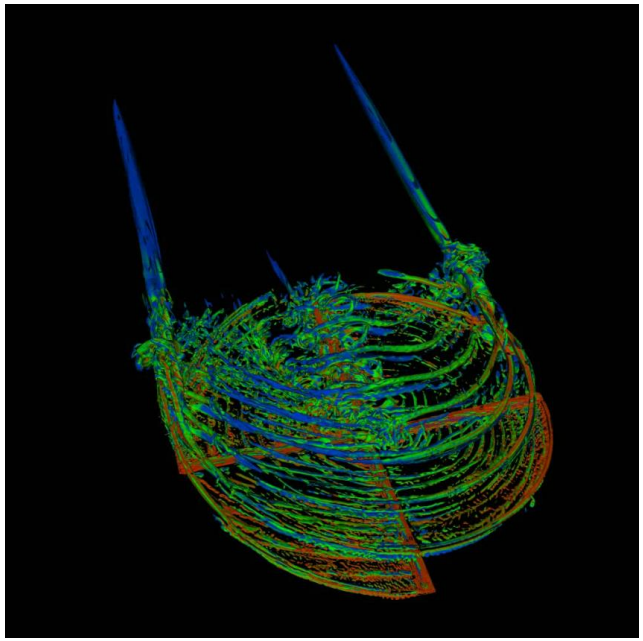


GLORE : GLOve Visualization Server
GIVI : GLOVE Integrated Visualization Interface
GIP : GLOVE Interface Protocol

4.3 GLOVE Performance Test(1)

Total # of points	size / time step	# of time steps	Total size
135M	12.64GB	98	1.21TB

Total number of nodes		64	
CPU		Xeon X5450 3.0 GHz	
Memory size / node	32GB	Total memory size	2TB

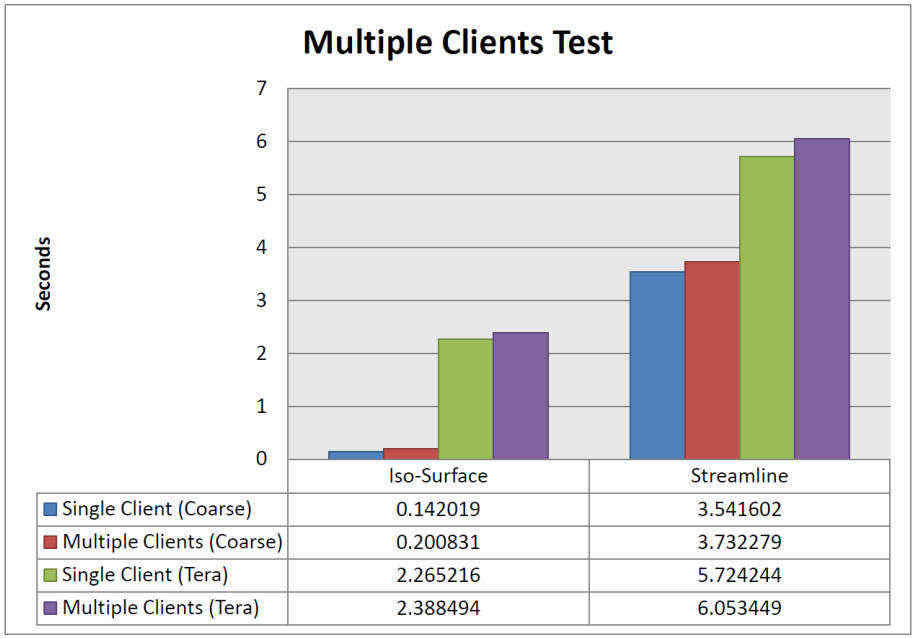


Tool	Ensight (sec)	ParaView (sec)	GLOVE (sec)	Ensight : ParaView : GLOVE
Slice	1.5	1.79	1.80	0.83 : 0.99 : 1
Iso-surface	4.8	10.11	2.12	2.26 : 4.76 : 1
Animation	307	274	2.12	144.8 : 129.2 : 1

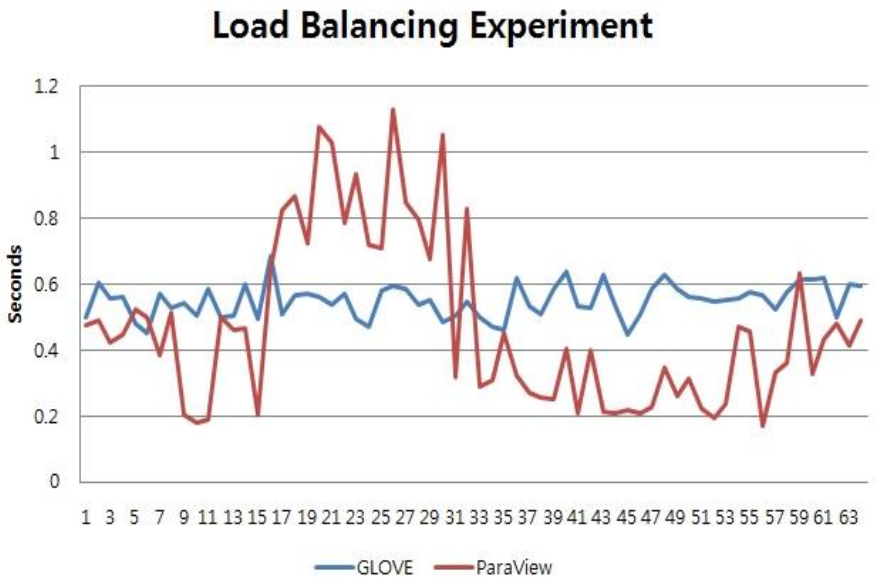
	Streamline	Pathline
GLOVE	71.02	85.12
Ensight	79.74	3906.91
Ensight/GLOVE	1.12	45.90

4.3 GLOVE Performance Test(2)

- The user with small datasets do not suffer heavy time loss from the user with large data sets when GLOVE process their requests at the same time
- The load balancing test shows GLOVE is more balanced than Paraview.

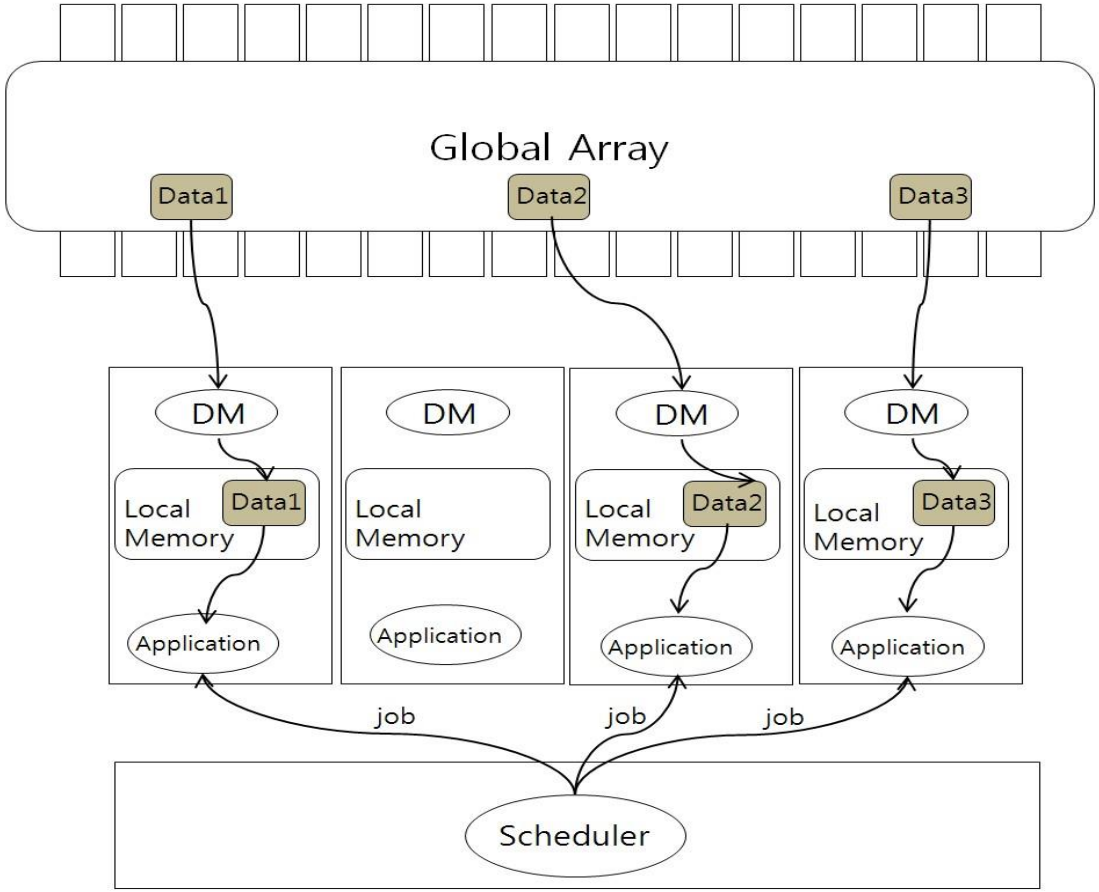


	Iso-Surface	Streamline
Single Client (Coarse)	0.142019	3.541602
Multiple Clients (Coarse)	0.200831	3.732279
Single Client (Tera)	2.265216	5.724244
Multiple Clients (Tera)	2.388494	6.053449



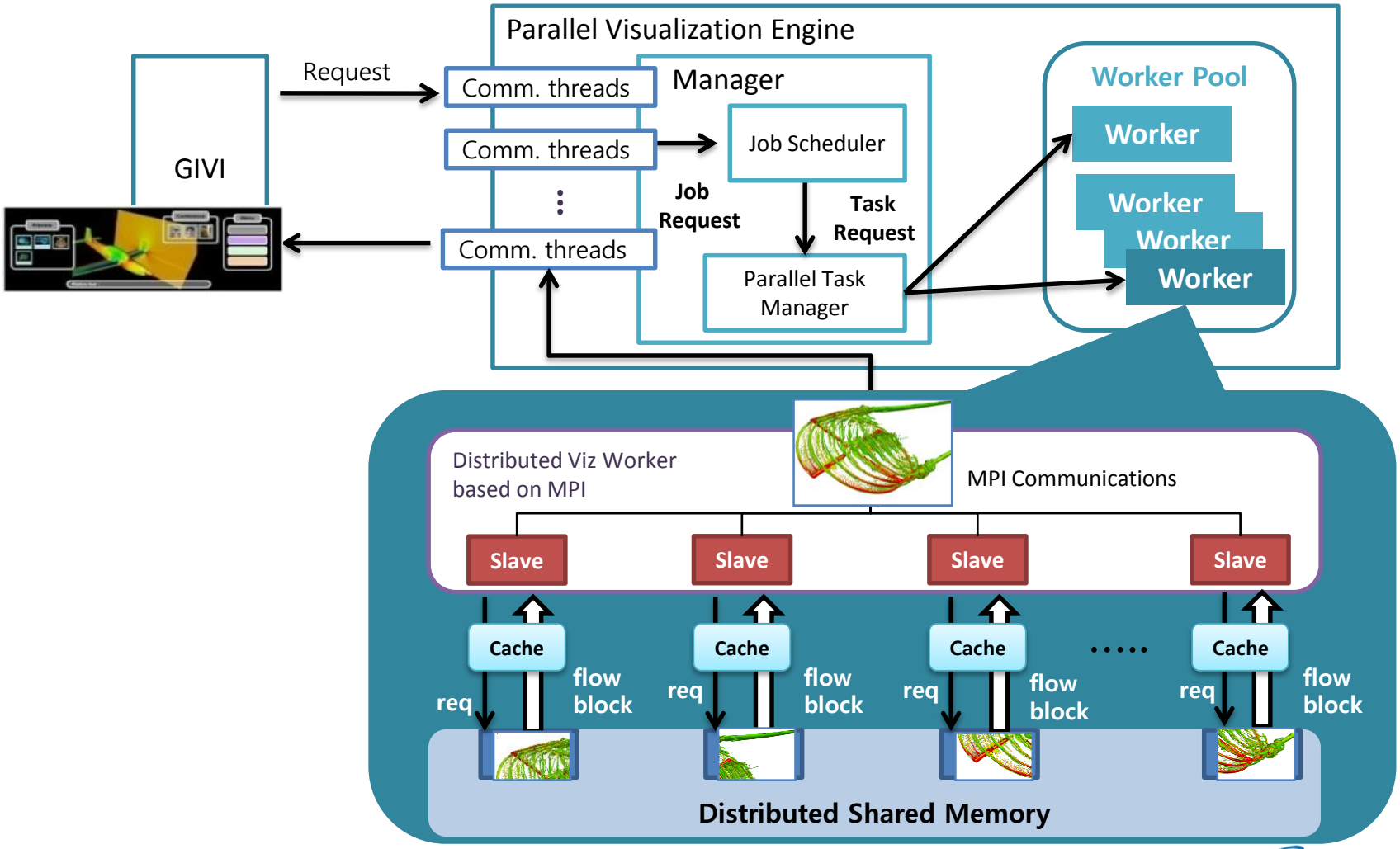
4.4 HPC technology in GLOVE (1)

- Massive data manipulation using distributed shared memory and job distribution for parallel data processing.



4.4 HPC technology in GLOVE(2)

- Job scheduling and task managing



4.5 Related Project – Virtual Wind Tunnel(1)

Goal

- Developing a real-time scientific visualization software that can handle CFD simulation results of a full-scale ship model in VR environments

Budget

- $ 2,130,000 (3 years, Aug. 2016~Jul.2019)
  funded by NST (National research council of Science & Technology)

4.5 Related Project – Virtual Wave Basin(2)

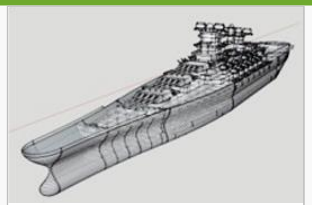
Goal

- Developing a real-time scientific visualization software that can handle CFD simulation results of a full-scale ship model in VR environments

Budget

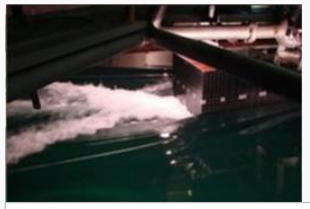
- $ 2,130,000 (3 years, Aug. 2016~Jul.2019)
  funded by NST (National research council of Science & Technology)

Ship Model Test



Design

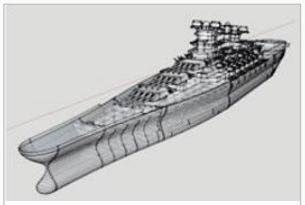
Model



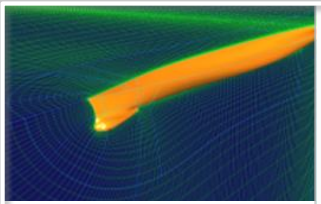
Test in wave basin facility

- Reduce verification cost
- Speed development cycles

Virtual Wave Basin



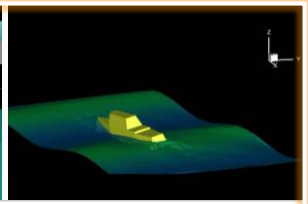
Design



Mesh Generation

Simulation

CFD Simulation



Realistic visualization in VR environment

Q & A