



Building A Digital Great Wall with A New Game Engine

YingPeng Zhang

Technical Expert, Tencent Games



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01 *Video Show*

Photo Scanning, 3D Reconstruction, PCG, In-House Engine

02 *Digital Great Wall*

Purpose, Challenges, and Technology

03 *CROS Game Engine*

Architecture, Rendering, and Optimization

01 Video Show

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02 *Digital Great Wall*

Purpose, Challenges, and Technology

Introduction to "Digital Great Wall"



GDC



- *Non-profit and Digital Heritage Conservation Project*
- *Digital Twin with 1km section of the Great Wall*
- *Photogrammetry and Procedural Generation*
- *In-House Game Engine with Next-Gen visual quality*
- *Realism, Large-Scale, and High-Definition Rendering*
- *Cloud Game*

Introduction to “Digital Great Wall”

This project is a game about repairing the Great Wall ...

Everyone can experience this mini-game at the exhibition in the next few days (Booth NO.S963).



What technologies are utilized in the project?

Variety of cutting-edge digital technologies are used in this large-scale and the millimeter-level high-precision digital scene reconstruction and rendering.



Photogrammetry,
Through laser measurement, high-definition image acquisition and UAV shooting and recording, the Xifengkou Great Wall is accurately measured at millimeter level.

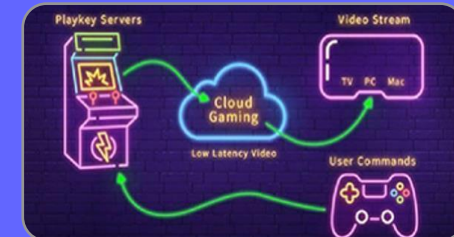


PCG, Self-developed PCG tool controlled by algorithms and parameters, super-efficient to realize the true reproduction of complex terrain and vegetation.

How Game Engines Work



In-House Game Engine,
Achieve real-time, high-definition, large-scale and super-realistic digital Great Wall through various technical breakthroughs of the in-house engine.



Cloud game, Through the original transmission flow control algorithm, it breaks the limit of computing and realizes the 3A Visual effect and interactive experience on the mobile terminal.

1. High-precision Photo scanning and 3D Reconstruction technology was used to restore the model of Great Wall



Nearly 50,000 high-definition pictures and 1 billion patches were utilized to meticulously reconstruct every detail of the Great Wall in Xi Feng Kou.



It took half a year for the in-house engine to develop rendering and streaming technologies like Nanite Lite, Udim, and Virtual Texture, which support real-time rendering of ultra-detailed models with massive textures.

2. The Best Practices for Procedural Generation Techniques



By utilizing pictures and plant illustrations from the local county annals, a meticulously arranged vegetation landscape was recreated.



With a self-developed PCG tool set, 250,000 trees were planted all at once for the Digital Great Wall.

3. In-House Game Engine + Cloud Game Technology

Create a hyper-realistic accessible interactive experience



Advancements in game engine technology, including GPU-Driven Forest, Hybrid Dynamic Shadow, Physical Sky Lighting, Physical Atmospheric Effects, Realtime Global Illumination, and other cutting-edge features, enable us to present a breathtaking digital Great Wall in the virtual world



Thanks to the advancements in cloud rendering and codec technology, the threshold of user experience in cloud gaming is continuously being lowered, making it possible to create high-quality 3A effects even on mobile platforms.

03 CROS Game Engine

Architecture, Rendering, and Optimization



Tencent IEG CROS
Tencent IEG Common R&D and Operation System



CROS Game Engine Architecture

Local Engine

Cloud Service

Foundation

Lighting

HD
Rendering

Large-
Scale
Rendering

Visual Effects

Post Process

Runtime PCG

Asset
Generation

Other

ECS

Job System

Frame Graph

Streaming

Deferred Plus

Smart GI

Virtual Geometry

Virtual Texture
& Udim

Forest, Building

Hybrid Shadow
Tech

Atmosphere

HFog / VFog

Volumetric
Clouds

HDR Color
Grading

Local
Tonemapping

Bent Normal AO

FSR 2.x

City Generation

Differentiable
rendering

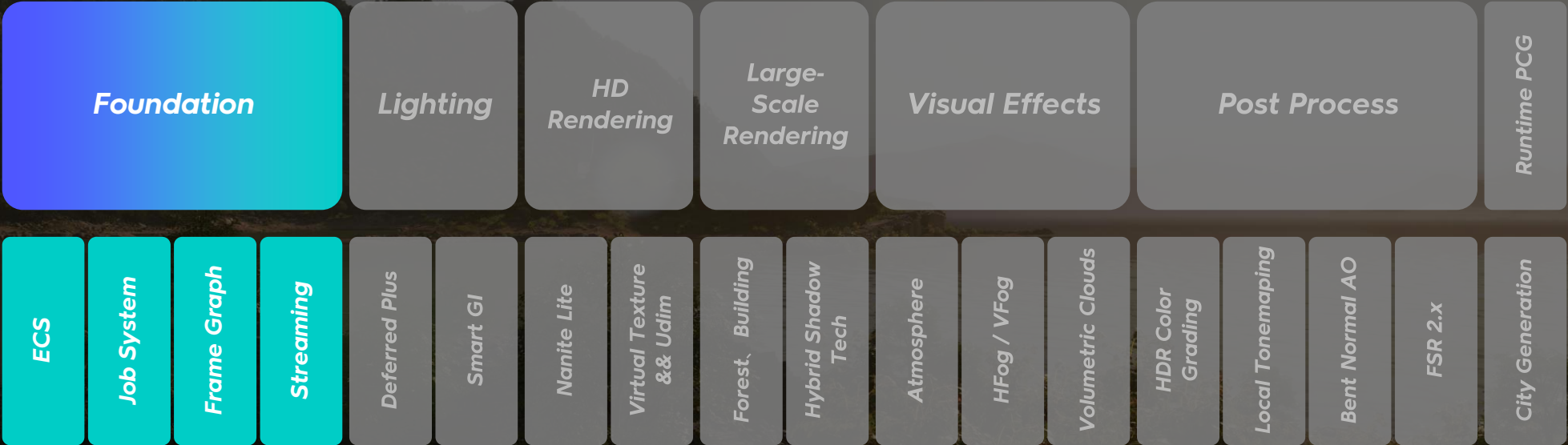
Nerf

PCG

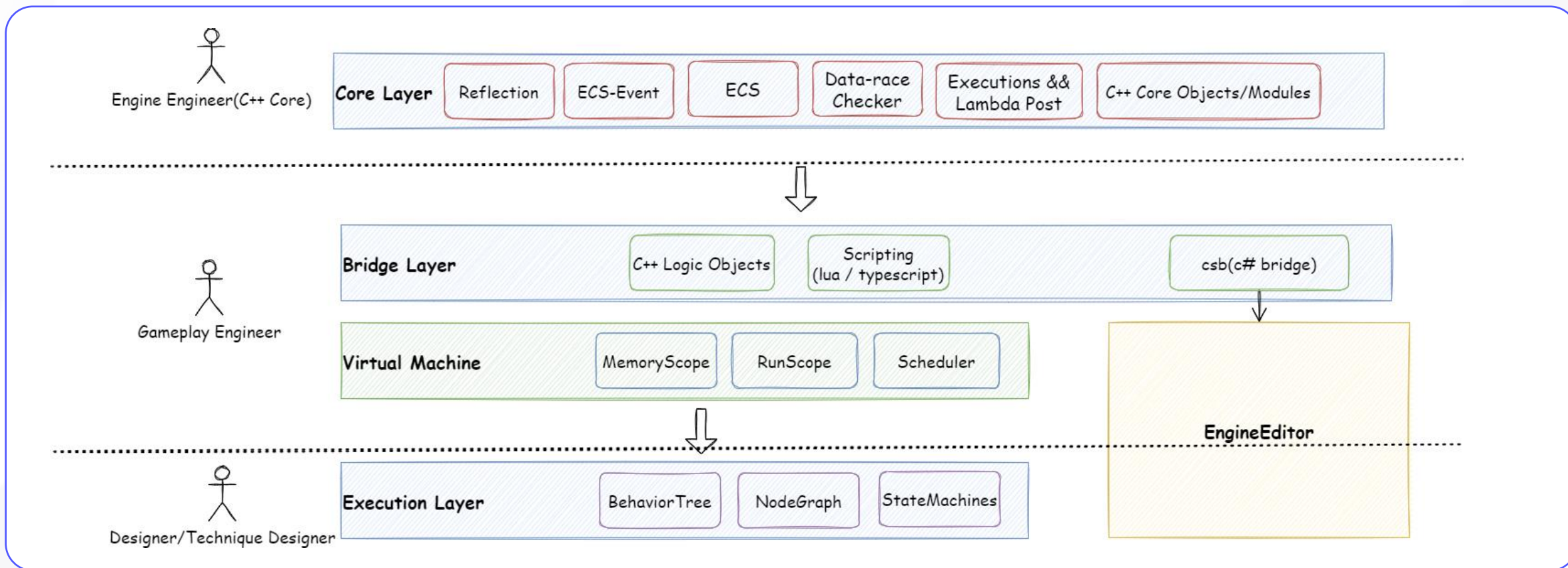
Lighmap, PRT
Baker

Occlusion Baker

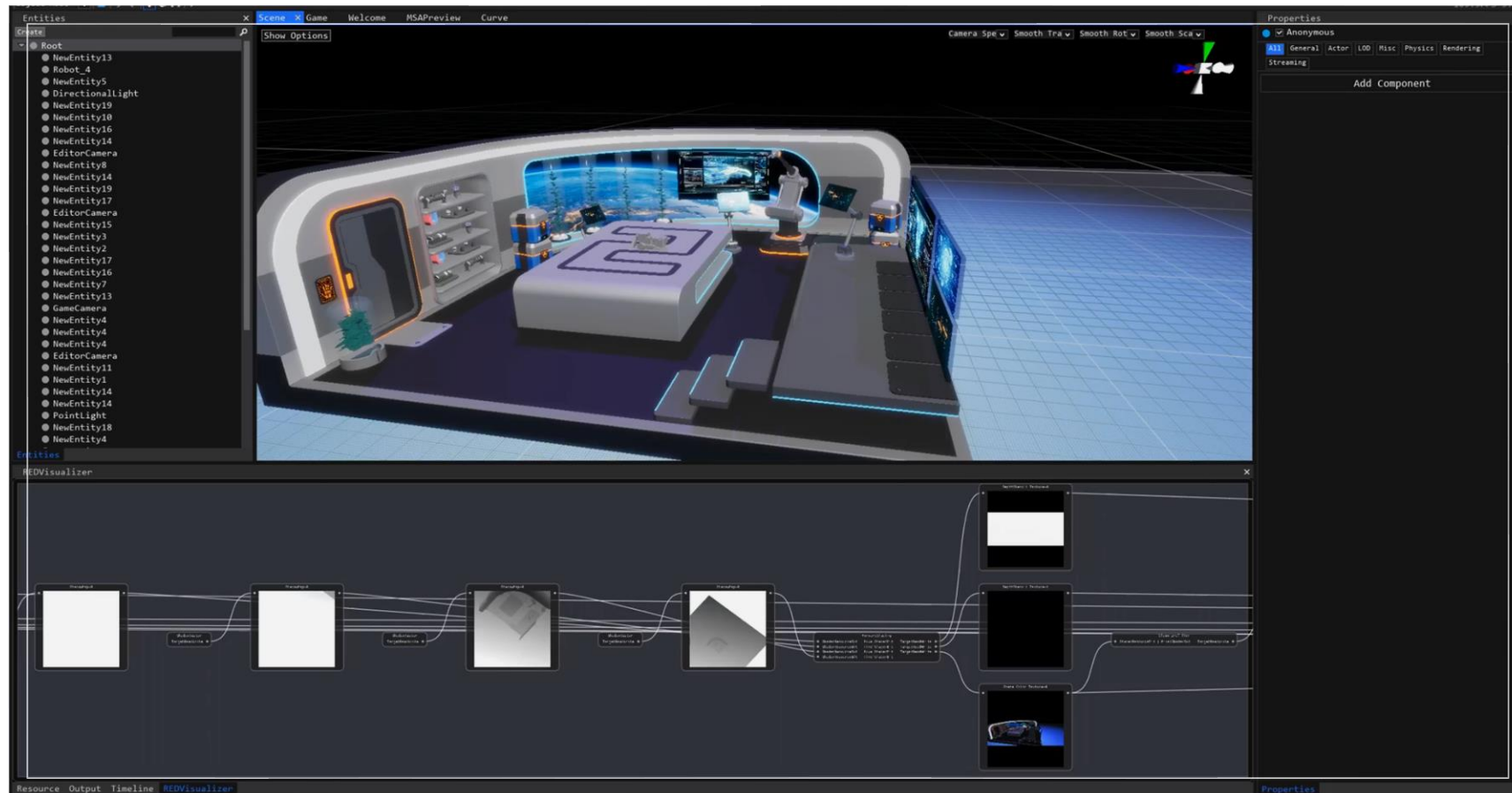
Local Engine



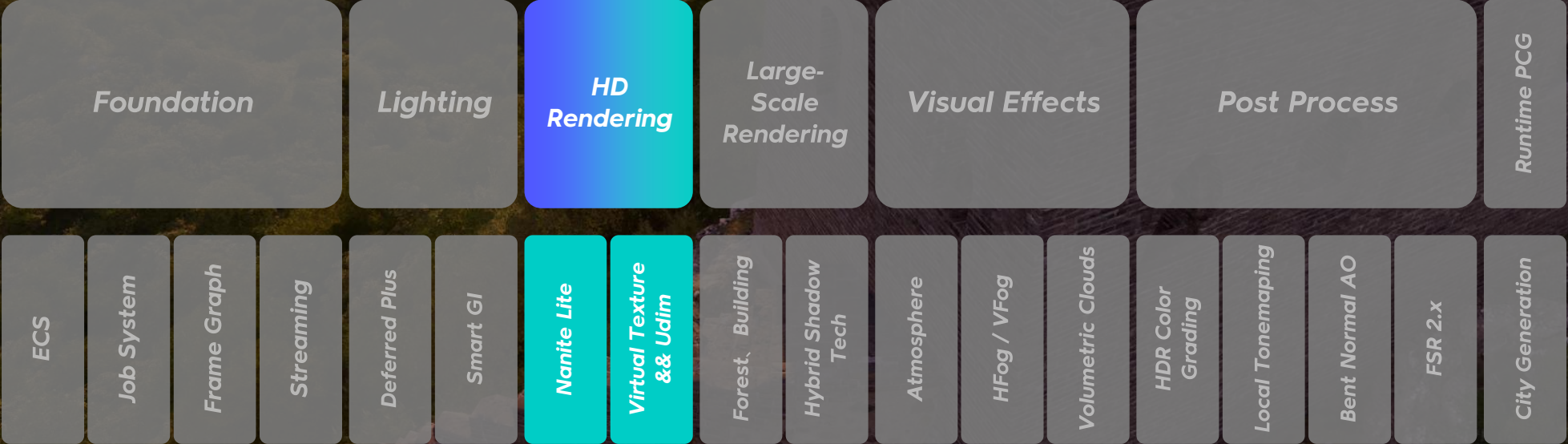
- High performance ECS data storage and efficient event architecture.
- High flexible job-system for parallel rendering, resource streaming and simulation.
- Natively support data competition checker.
- By using C++ bridge layer, Provide a general GameObject abstraction with Reflection, GC, Serialization etc.



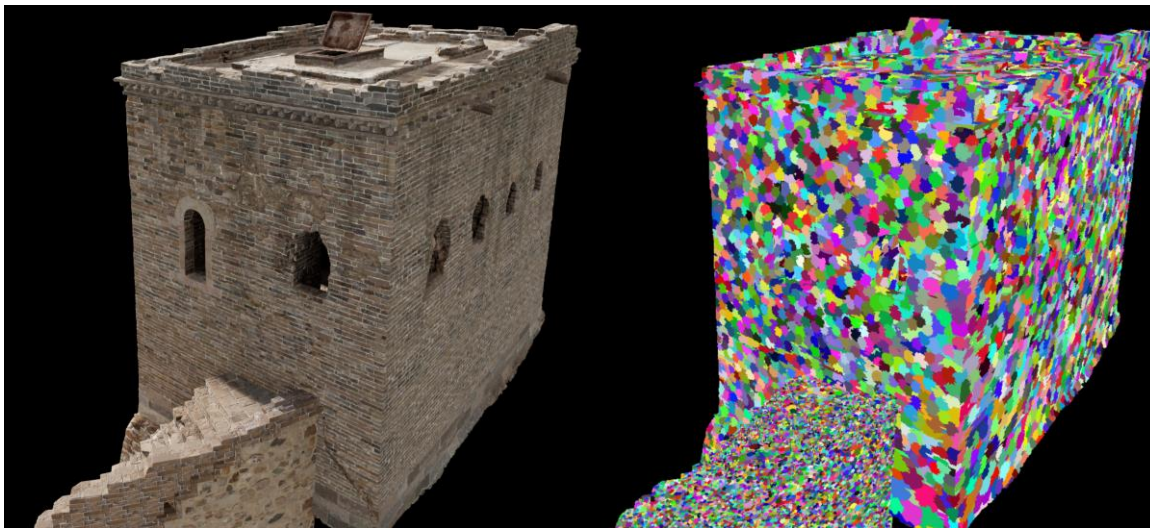
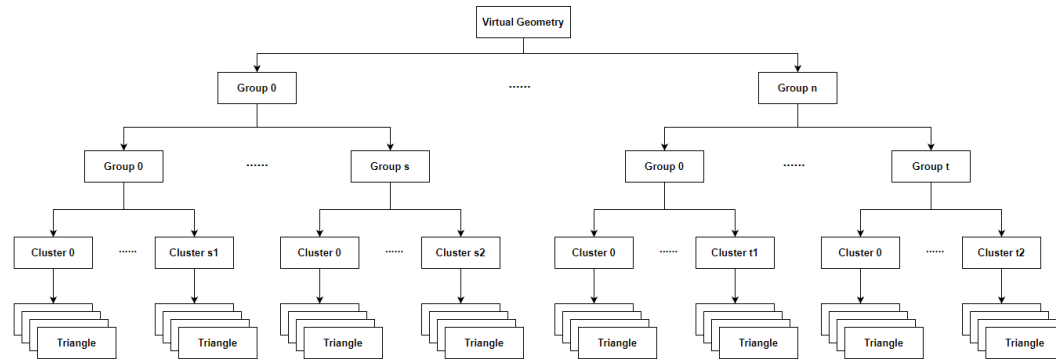
- Runtime visualization
- Support SubPass and Tile Memory management
- Support nested parameter and extending temporary resource lifetime



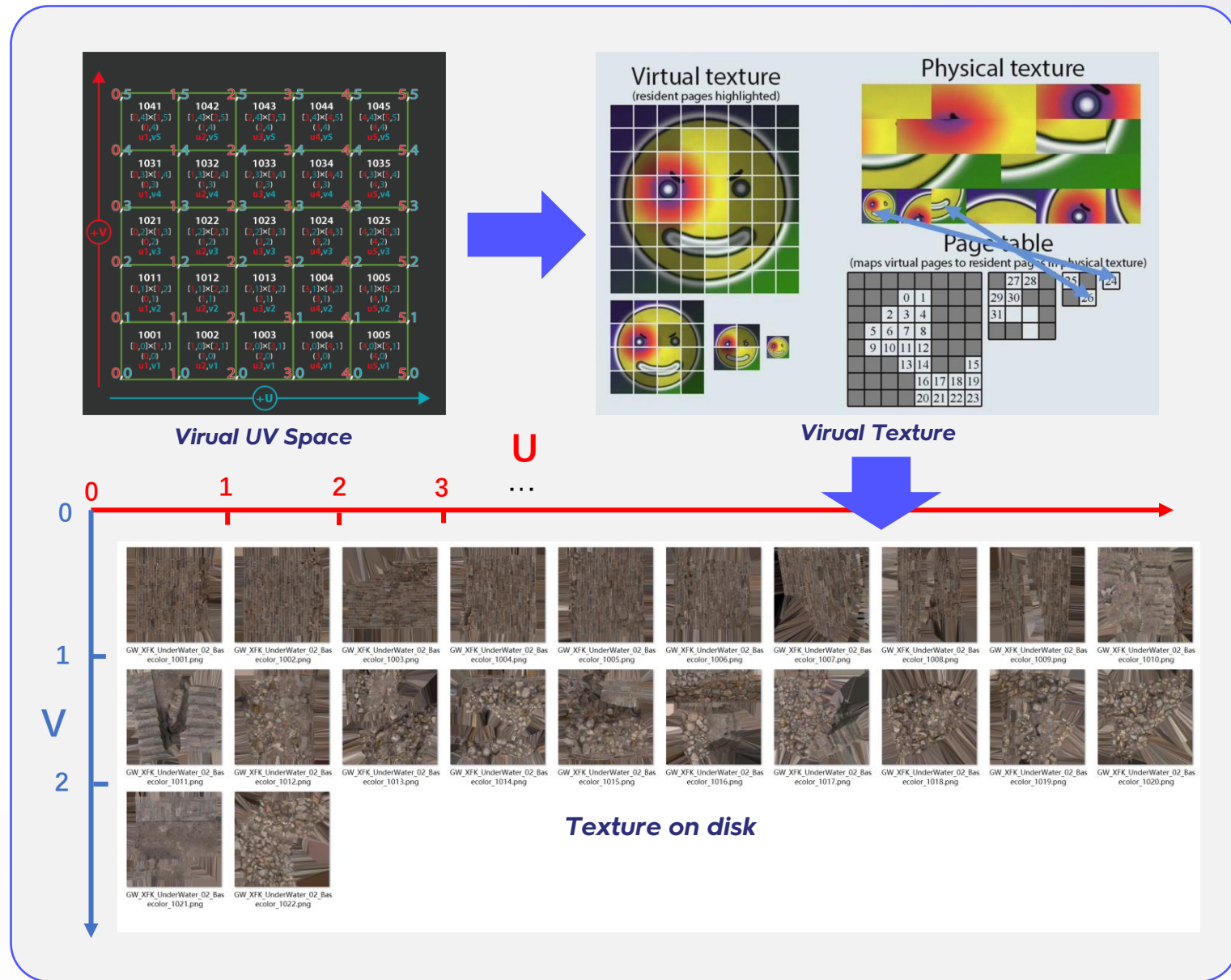
Local Engine



- **Challenge:** 200 million triangles in Digital Great Wall.
- **Solution:** Nanite Lite (GPU Driven, Cluster Quantization, Cluster Hiz Culling, etc.)

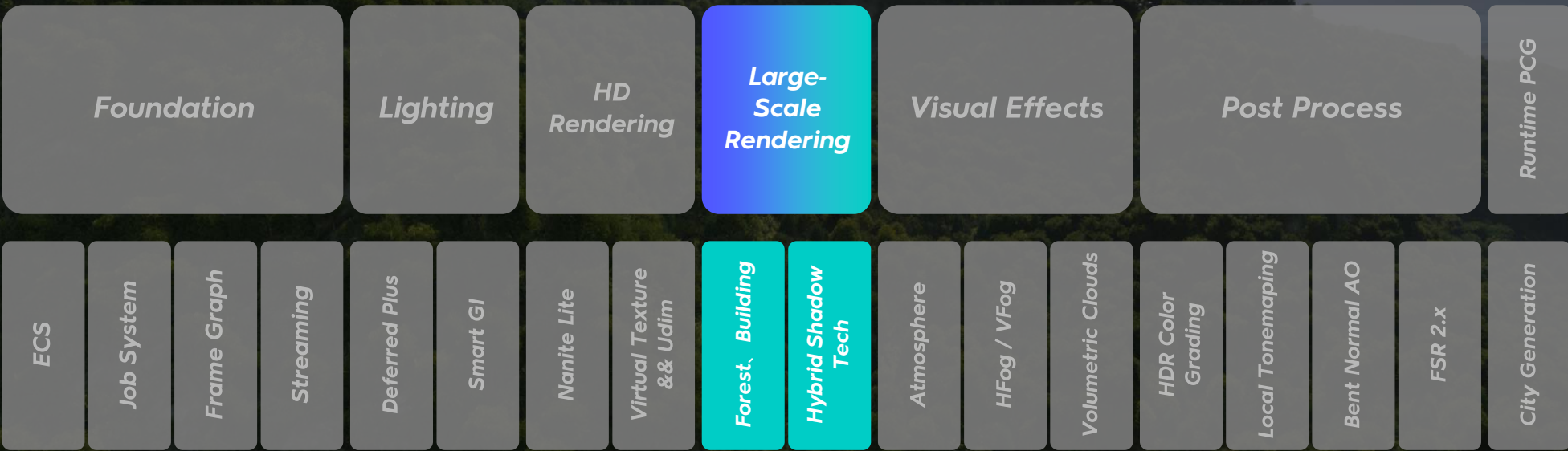


- **Challenge:** Nearly 2,000 8K textures and Total size is 370GB for Digital Great Wall.
- **Solution:** UDIM、Virtual Texture



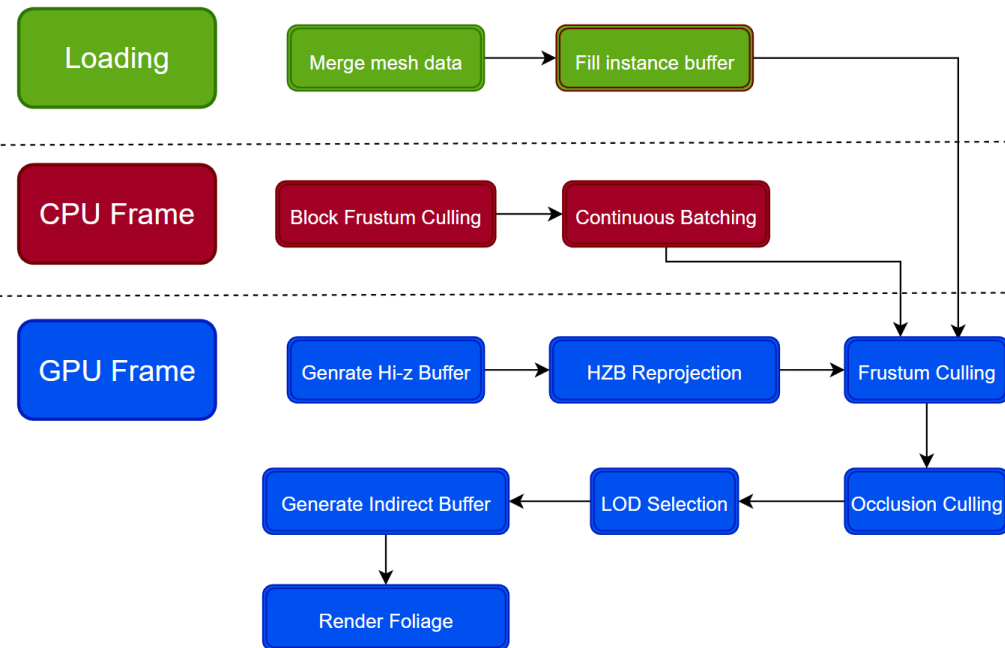
- **Multiple Layers support**
 - BaseColor, Normal, RMO maps
- **Massive Assets**
 - 2000+ 8K images
 - Raw Asset: ~370GB
 - Engine Asset: ~40GB

Local Engine



Large-Scale Rendering: Forest

- **Challenge:** 250,000 pieces of vegetation on one screen.
- **Solution:**
 - CPU and GPU hierarchical culling technology to reduce the draw call.
 - GPU Scene greatly reduces the interaction between the CPU and GPU.
 - GPU-Driven Draw Call and Lod Selection.



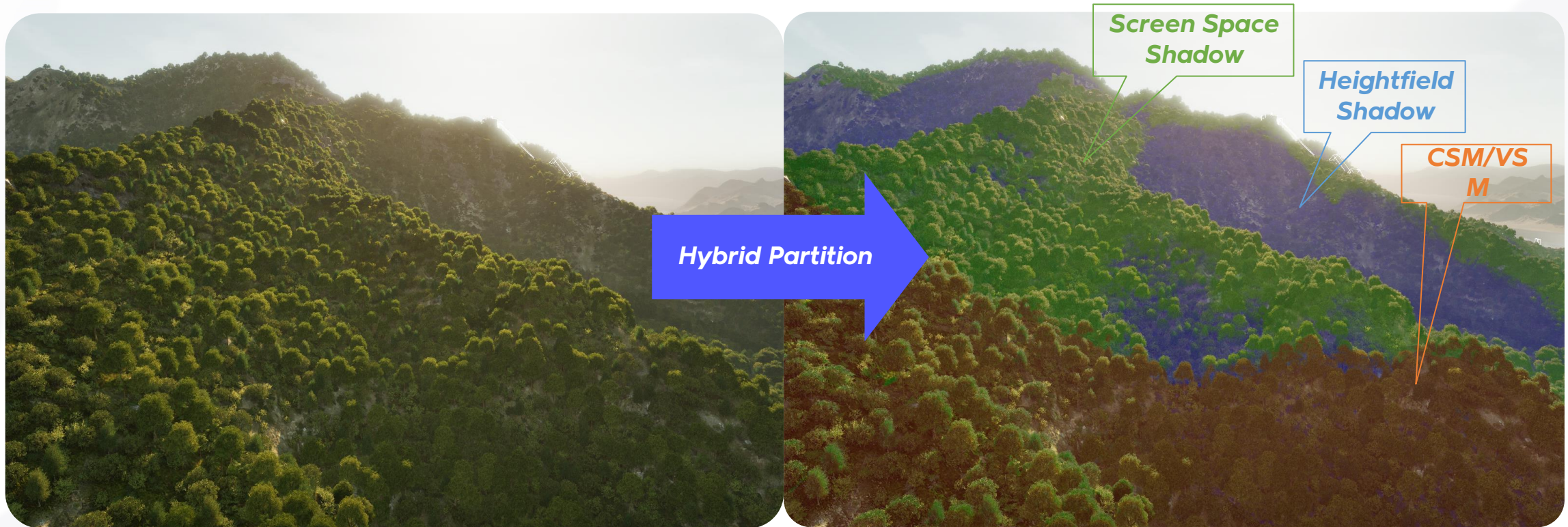
Large-Scale Rendering: Hybrid Shadow Tech

- **Challenge:** Large-Scale, High-Quality, Fully-Dynamic Shadows
- **Solution:**
 - Hybrid Shadow tech, Compose CSM/VSM, Screen Space Shadow and heightfield shadow.
 - Scene complexity independent.
 - Get very good performance and displayment at the same time.

Shadow Tech	Quality	Runtime Performance	Dynamic	Baker	Transmission
CSM	Medium	Low	High	No	Yes
VSM	High	Low (too many triangles)	High	No	Yes
Screen Space Shadow	Low (nearby)	High	High	No	No
Lightmap	Medium	High	Low	Yes	No
SDF Shadow	High	High	Medium	Yes	Yes
Hybrid Shadow Tech	High	High	High	No	Yes



- CSM/VSM shows the most accurate and best results at close range.
- Screen Space Shadow plays the leading role in the medium and long-range scene.
- Heightfield shadow complements the information outside the screen space.



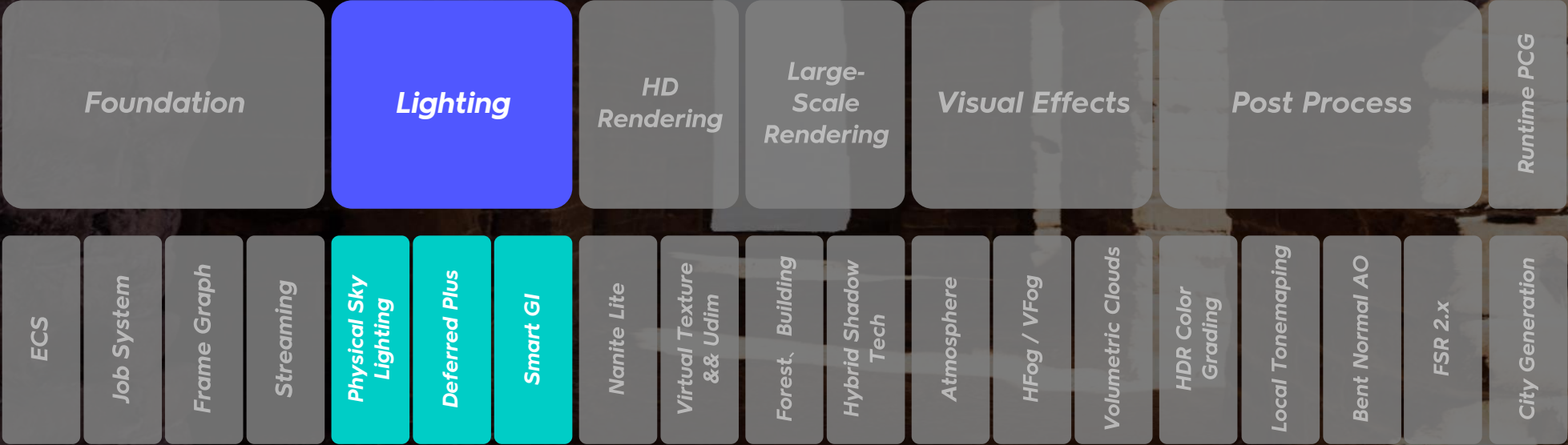
Support full-scene transmission effect.



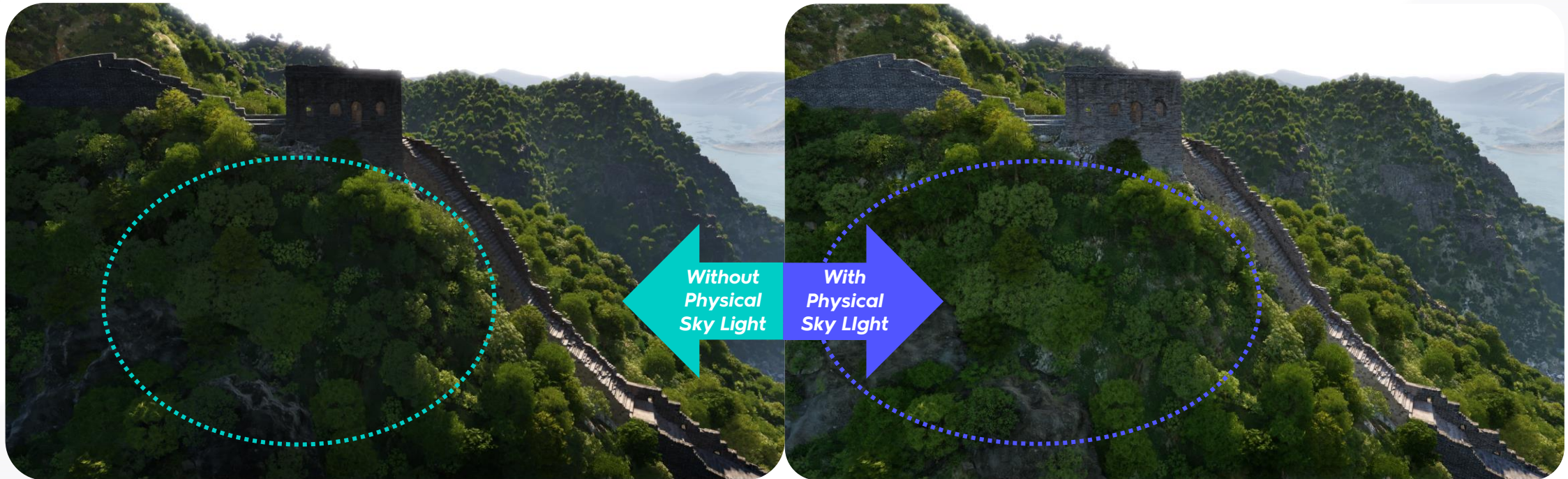
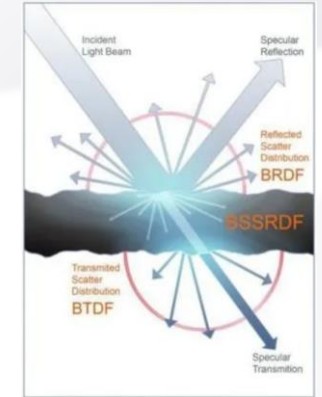
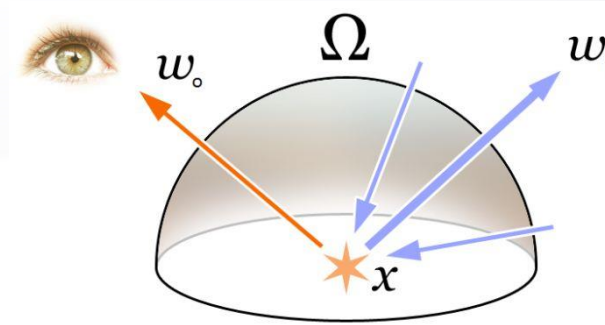
Large-Scale Rendering: Hybrid Shadow Tech



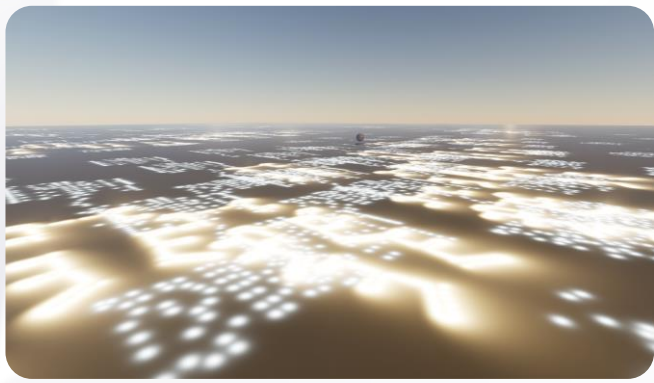
Local Engine



A more physical lighting model for skylight, including BRDF, BSDF, BTDF and multi-bounces

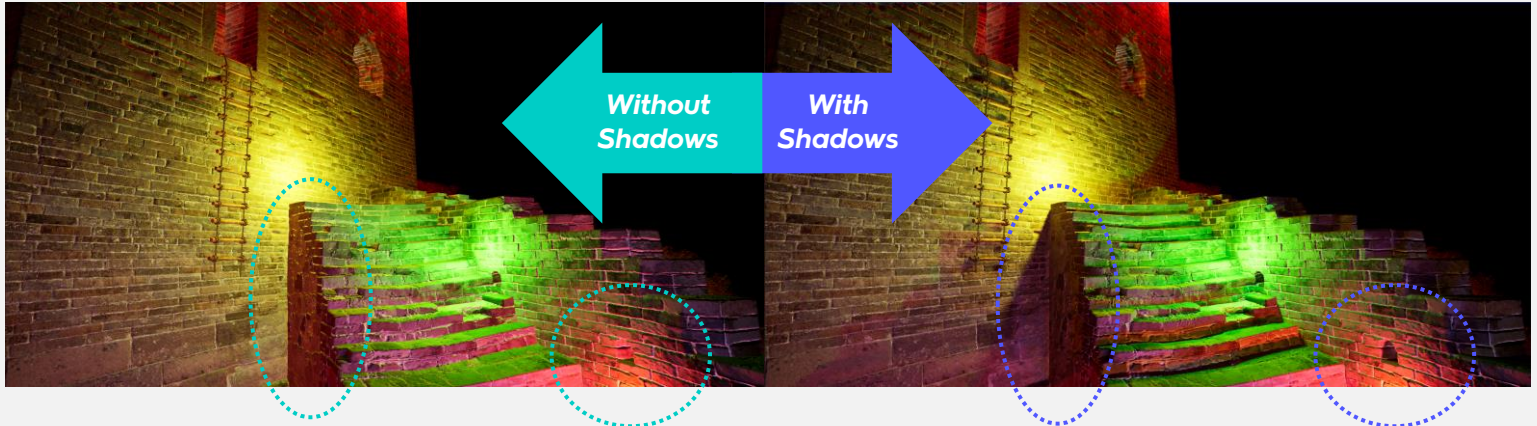
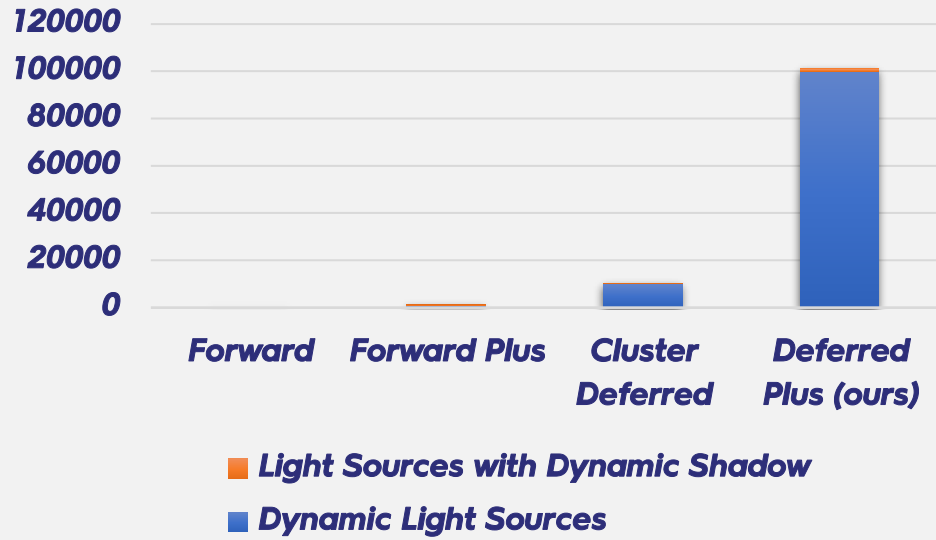


- A new multi-light source technology, which we call Deferred+. Using GPU Driven technology, the number of light sources has increased from thousands to 100,000 in one screen.
- In addition, A new multi-light source shadow technology has been developed, which increased the number of real-time shadow from about 100 to more than thousands in one screen.

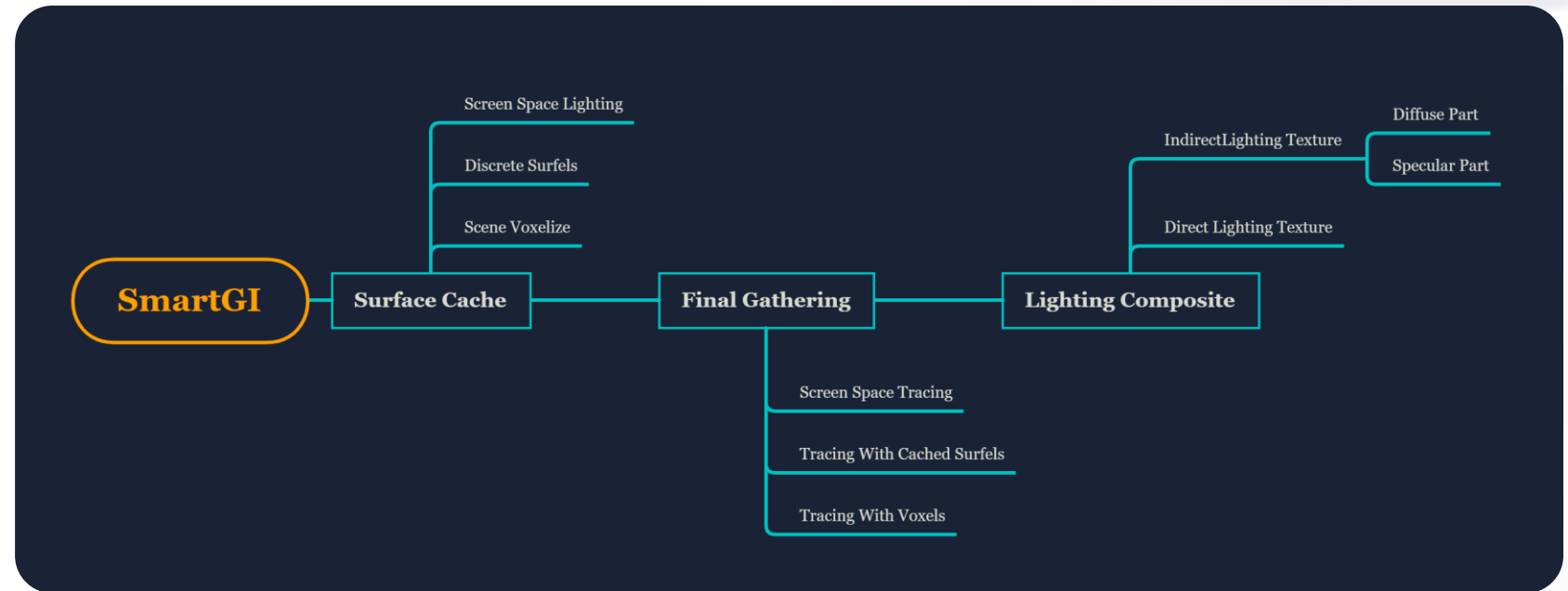


100,000 Dynamic Light Sources in one screen

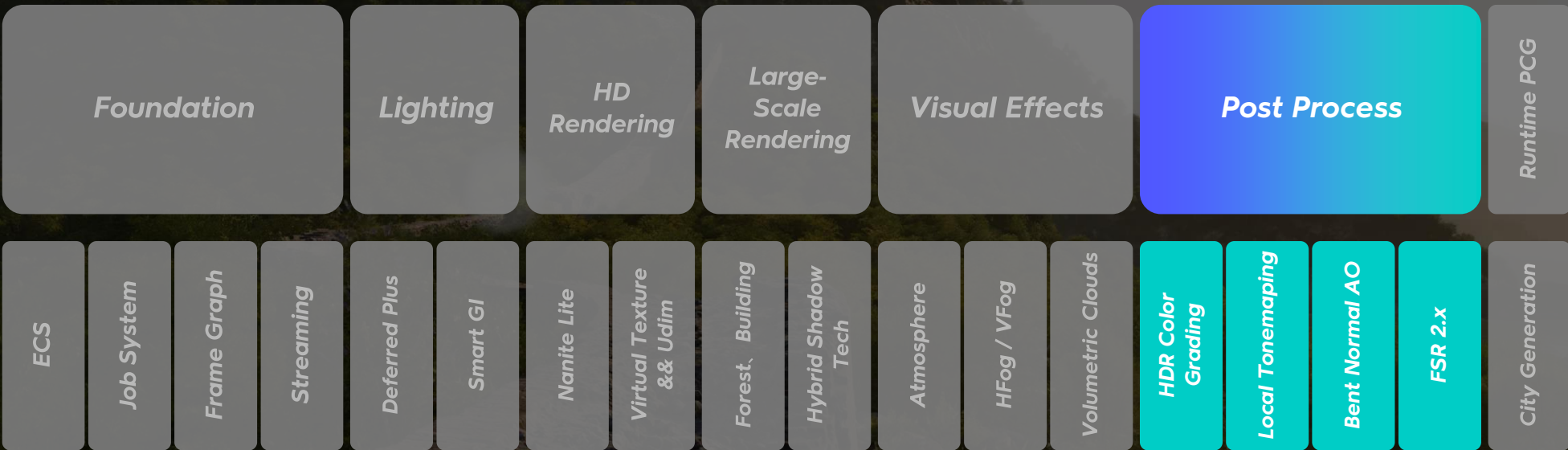
Dynamic Light Sources & Dynamic Shadows Limitation



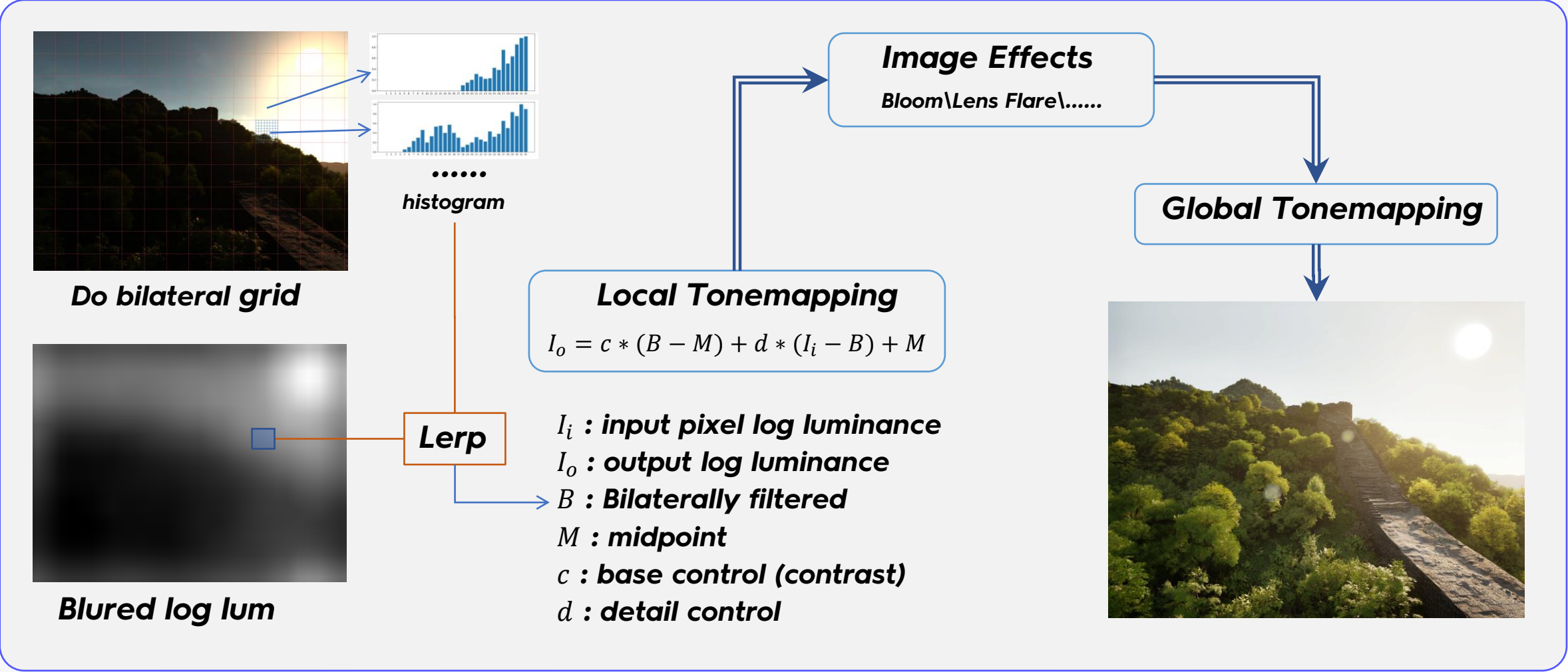
- **Hybrid GI**
 - **Surface Cache**
 - **Screen Space Lighting**
 - **Discreted Surfels**
 - **Voxelized Scene**
 - **Final Gathering**
 - **Screen Probe (Integration)**
 - **Scalable**
 - **Hardware Raytracing**
 - **SDF/HIZ Ray Marching**
 - **Cone Tracing**
- **Archivement**
 - **Reference With PT**
 - **High Performance (1-2ms)**
 - **All Platforms Support**



Local Engine



Local Tonemapping can avoid dead black and overexposure at the same time



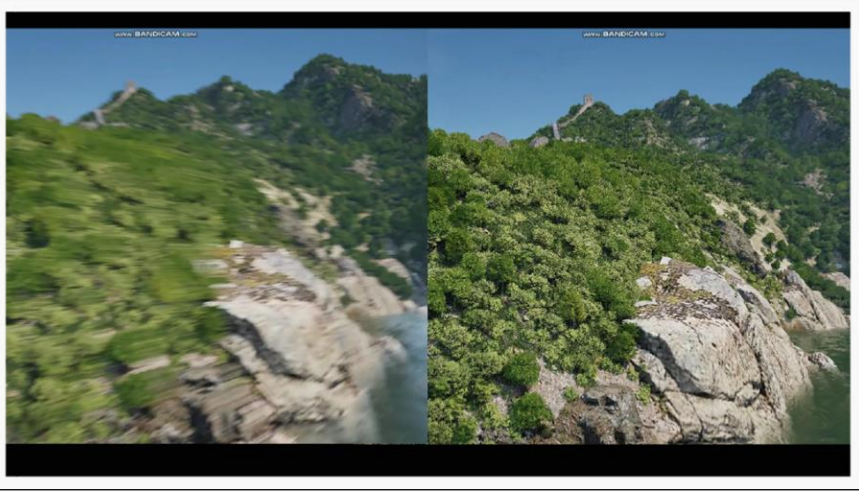
We have made many improvements to *fsr2* based on the idea of *SVGF* (Spatiotemporal Variance-Guided Filter), so that it better balances the sharpness, anti-aliasing effect and Ghost Problem.



super-resolution + anti-aliasing



Optimized the blur problem caused by movement



Thank You



GDC

Welcome to Booth NO.S9633