SoundTracing: Real-time Sound Propagation Hardware Accelerator

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Motivation (1)

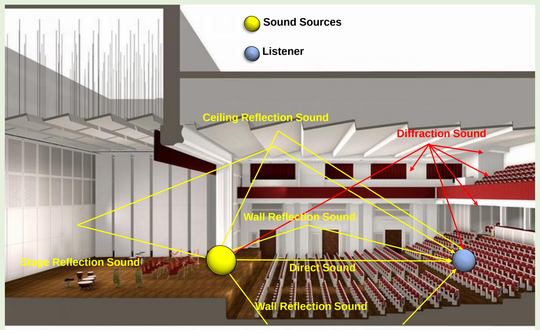
- **High expectation on VR – the future and the final of ICT technologies**
- **High-quality visual + acoustic technologies are must-have item for reality-like VR implementation**
  - Visual and acoustic immersion are the two most important senses for true VR experience

<Reality-like visual experience>

<Reality-like acoustic experience>

What is the SoundTracing? (2)

- **SoundTracing** : An Immersive VR Technology
  - ***Sound-rendering technique*** that tracks sound propagation paths between sound source(s) and listener to produce life-like three dimensional sound
  - High-quality sound implementation based on physically-based 'path-tracing' algorithm



Load the scene inform. & SoundTracing option

Perform the simulation of sound propagation (Direct, early reflection, late reverberation)

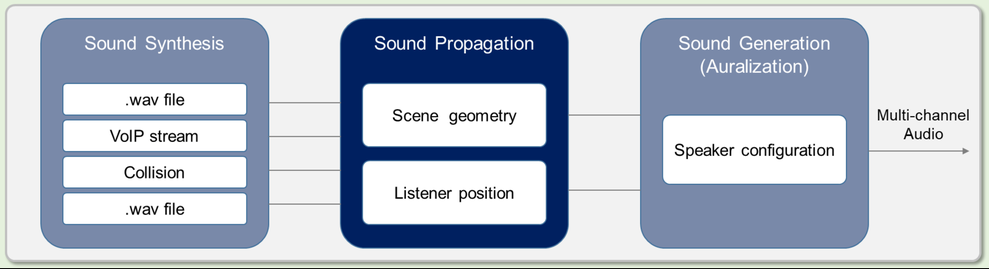
Output rendered sound using dry sound and impulse response

Enjoy immersive VR environments

<An example of SoundTracing and processing flow>

SoundTracing Pipeline flow

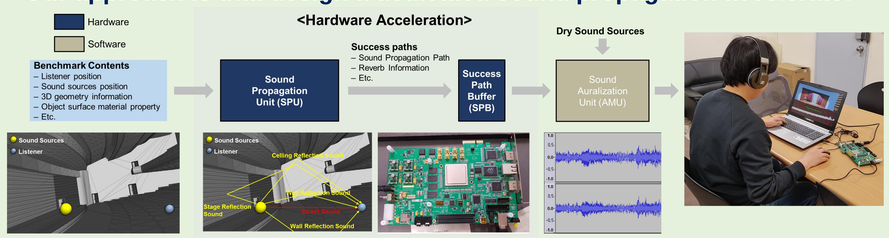
- ***Synthesis***: sound emitted from sound sources is propagated in 3D geometry setting
- ***Propagation***: sound bounced and traced against 3D geometry data (of readily-modifiable material properties). Effective sound paths simulated and collected based on listener's position and orientation
- ***Generation***: simulated sound delivered to Auralization process for speaker output



SoundTracing Architecture & Implementation (3)

The Proposed SoundTracing System

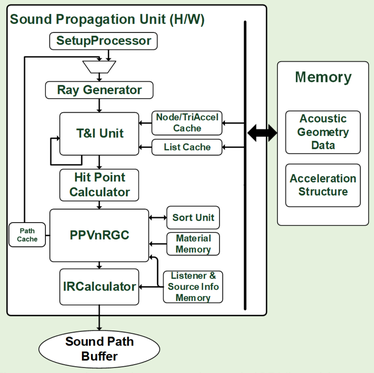
- The **sound propagation step is a major bottleneck** in SoundTracing pipeline
- **Our approach is that design a dedicated sound propagation accelerator**



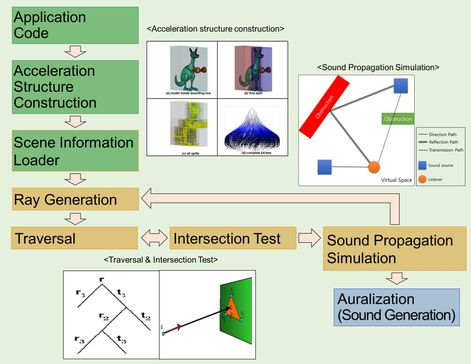
<The sound rendering system based on sound propagation hardware accelerator>

Sound Propagation Unit

- **The datapath**
  - Ray tracing parts: Setup Processor, Ray Generator, Traversal & Intersection Test Unit (TnI), Hit Point Calculator
  - Sound processing parts: Propagation Path Validator & Reverb Geometry Collector, IR Calculator
- **External memory interface**: TnI cache memory (acceleration structure data)
- **The internal memory**: Material memory, Listener & Sound Source info. memory, Path Cache

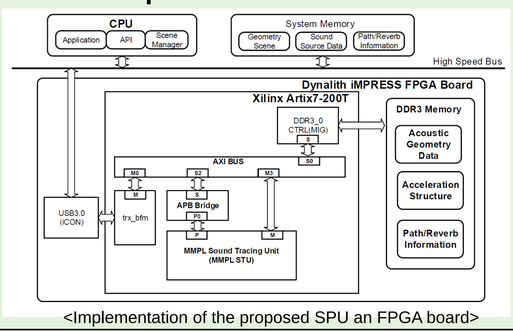


<The proposed sound propagation unit (SPU) architecture>



<Processing flow of the SPU>

FPGA Implementation



<Implementation of the proposed SPU an FPGA board>

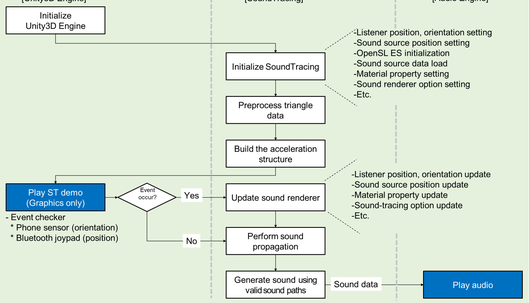
<Dynalith's iMPRESS FPGA board>

Features/ Highlights (4)

Features

SoundTracing HW Technology	FPGA v2.1	IP v0.9 (Est.)
Process / Clock Freq.	RTL v2.1 (@100MHz)	T 28nm (@400MHz)
Performance	30 FPS	90 FPS
Gate count	-	7M (incl. cache memory)
Scene Complexity	3D geometry data **up to 512K triangles**	
Sound Sources	Dynamic, multiple sound sources **up to 16 sources**	
Material Properties	**Up to 16 materials** including concrete, gypsum board, metal, tile, wood, etc.	
Sound Effects	Reflection, absorption, reverberation, occlusion, attenuation, doppler effect, directional sound	
Spatial, Positional, Sensor-related	Supports all spatial, positional, head tracking/sensor-oriented audio processing	
Demo Kit	SW – Samsung Galaxy S6 mounted Gear VR HW – Xilinx Artix7-200T FPGA (@100MHz)	
SDK	Proprietary SoundTracing SDK Supported platform: Windows, Android, unity, Apple, Unreal Coming soon	

SDK Framework Example



<SDK framework processing flow with Unity3D game engine>

Live Demos

<'Concert Hall'>

<'Bootcamp' FPS>

References

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[5] D. Hong, T.-H. Lee, Y. Joo, W.-C. Park, "Real-time sound propagation hardware accelerator for immersive virtual reality 3D audio," in Proceedings of the 21st ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D 2017), San Francisco, CA, USA, 25-27 Feb. 2017.

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