Real-time Sound propagation in video game

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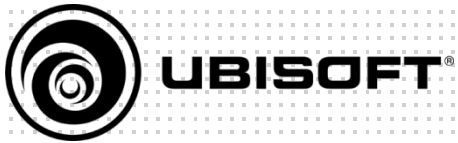

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Realistic rendering can increase immersion of the player

But what about sound?

Agenda

- Physics of wave interaction
- What others have done
- Limitations of the game industry
- Our way of doing it
- Problems we faced
- Real examples

A bit of Physics

- Wave interaction effects
  - Reflection
  - Absorption
  - Diffraction
  - Refraction

A bit of Physics

- Audible sound is between 20Hz and 20 KHz
- Corresponds to a wave length between 17 m (low frequency) and 2 cm (high frequency)

Wave interaction

Reflection

Sound	Light
Reverb, echo	Specular reflection

Wave interaction

Absorption

Sound

Occlusion by a door or window

Light

Semi-transparent material

Wave interaction

Refraction

Sound

Rare: Sound that can be heard farther over a lake in the morning

Light

Broken straw in a glass full of water

Wave interaction

Diffraction

Sound

Hearing sound not in line of sight

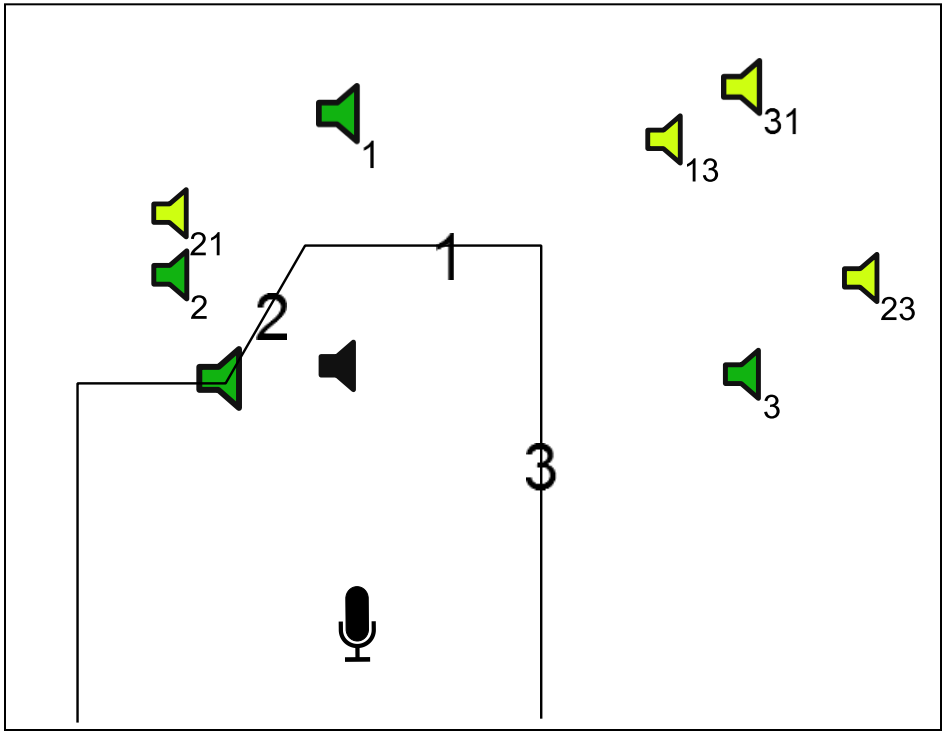
Light

Rare:

iridescent cloud, color on a CD

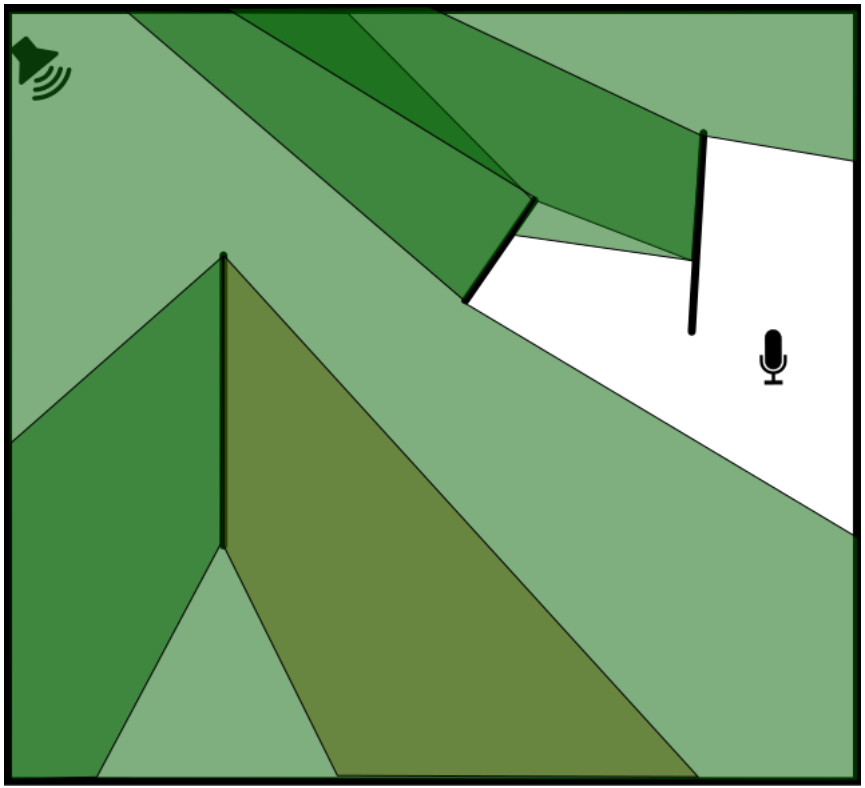
Different way to render virtual soundscape

Virtual source method



Different way to render virtual soundscape

Ray Tracing and
Beam Tracing



Limitations of game industry

- Game wants to run between 30 and 60 FPS
- Cannot "downgrade" the game for sound propagation
- Limited memory (2 to 50 MB for audio)
- Limited CPU (around 10% of the total CPU for audio)
- Up to 64 simultaneous sounds playing
  - At 60 FPS, that gives 250 μs per sound

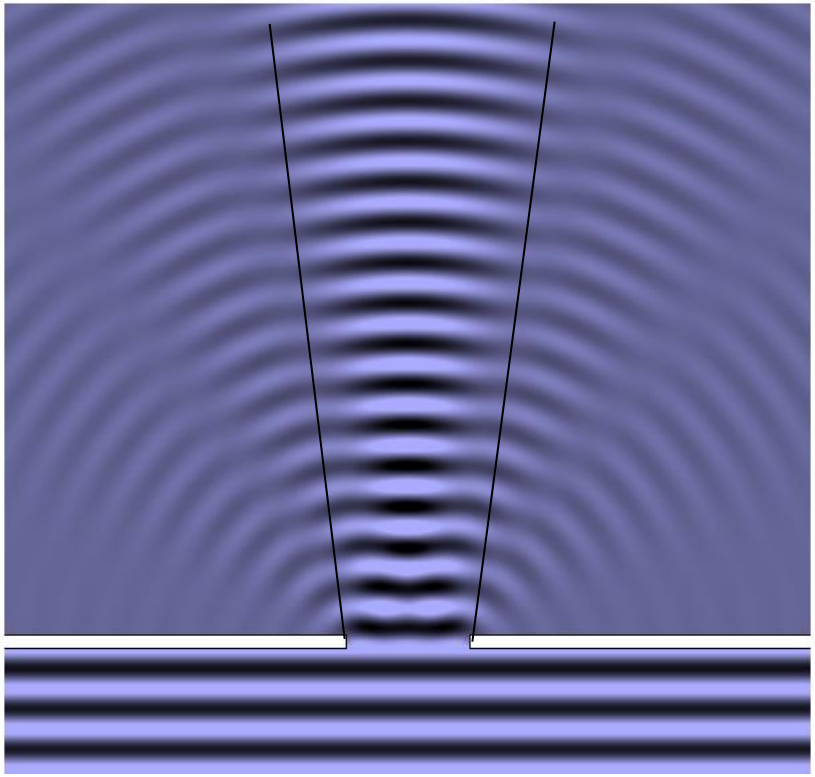
Goals we want to achieve

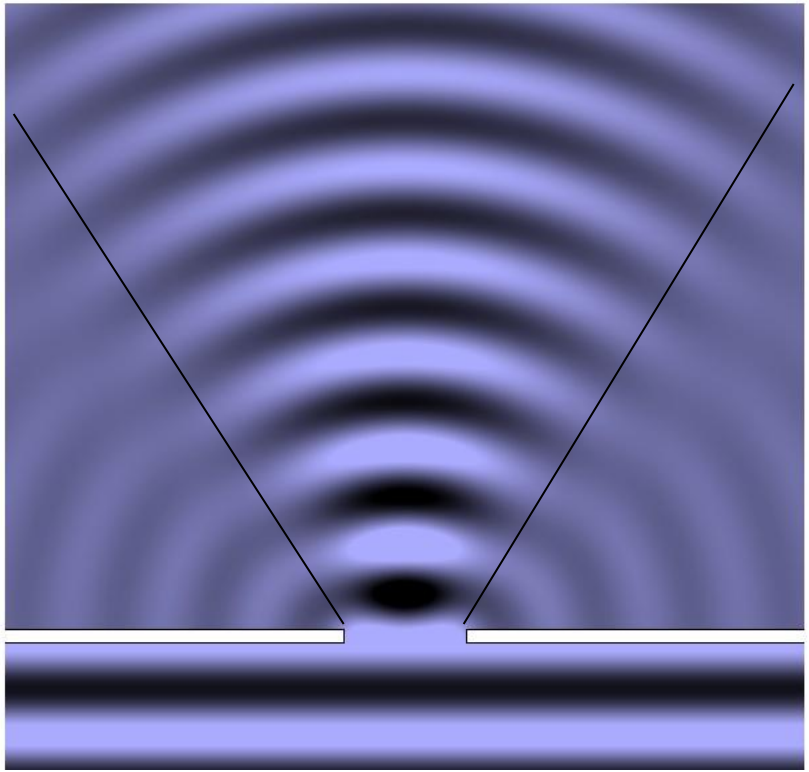
- Immersive result, not really interested in a physically exact result

Goals we want to achieve

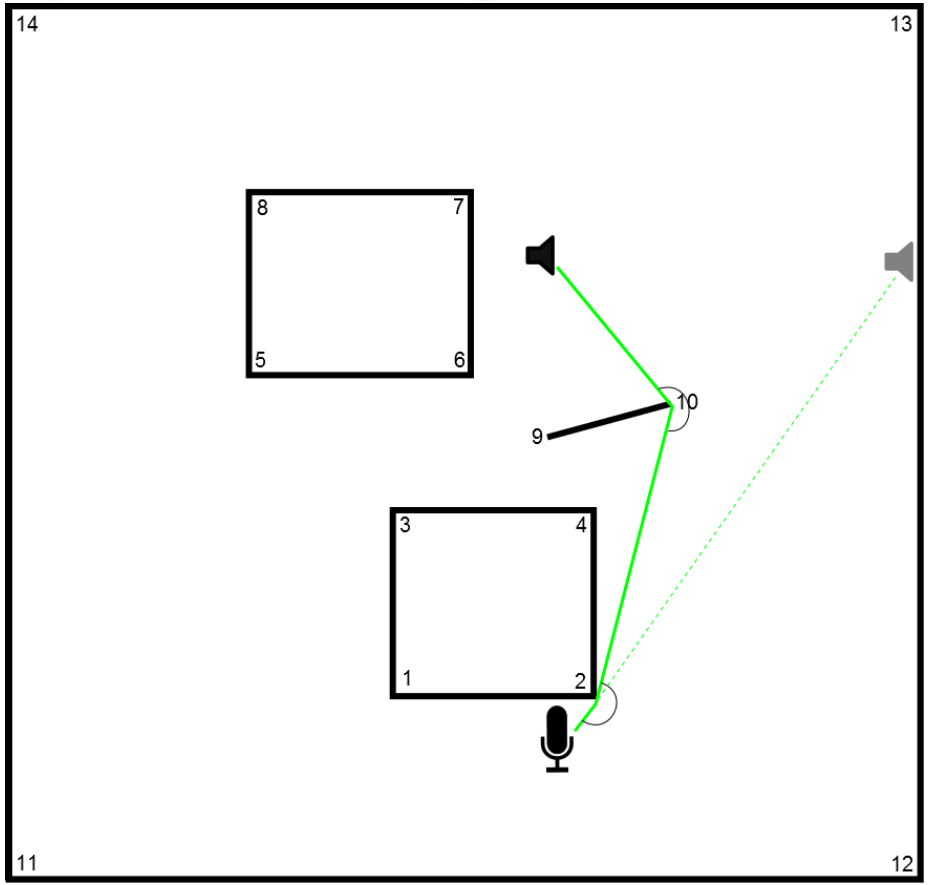
- Immersive result, not really interested in a physically exact result
- Current reverb algorithm already correctly simulates reflection of sound in the room
- Wanted to focus on diffraction, absorption and getting the general direction from where the sound is coming

Diffraction



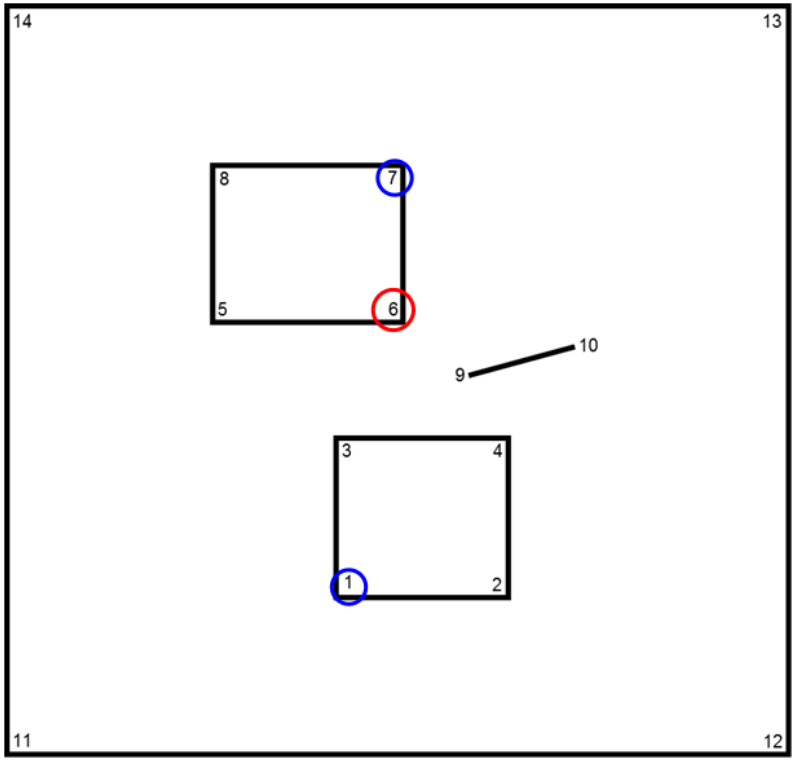


Our way of doing it



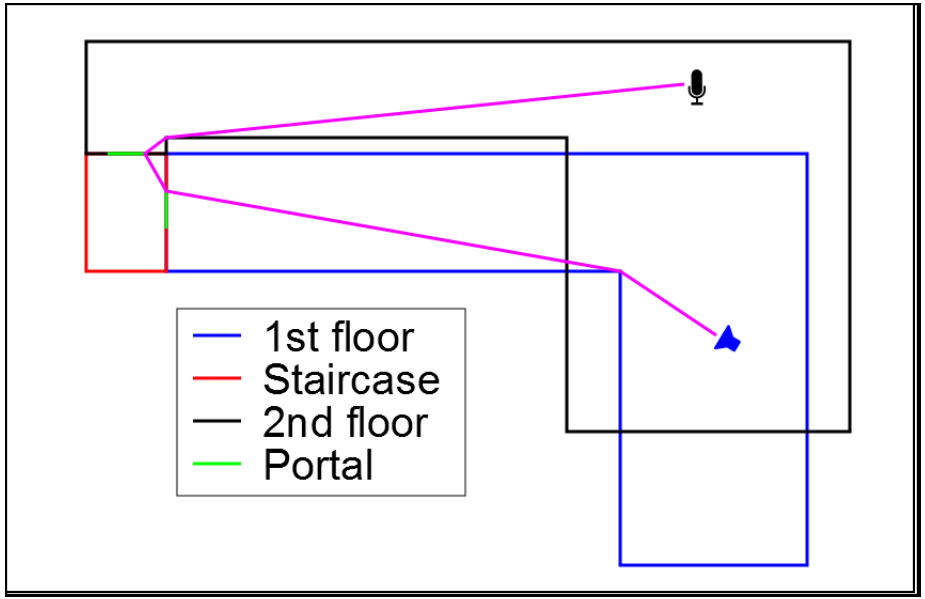
Our way of doing it

Edge dist	1	2	3	4	5	6	7
1	-- -	2 10	3 10	2 20	5 23	3 17	3 27
2		--	1 20	4 10	1 35	4 21	4 36
3			--	4 10	5 13	6 7	6 17
4				--	5 17	6 11	9 3
5					--	6 10	6 20
6						--	7 10
7							--



Optimization

- Zoning to remove irrelevant geometric data
- Computation done in 2D + height



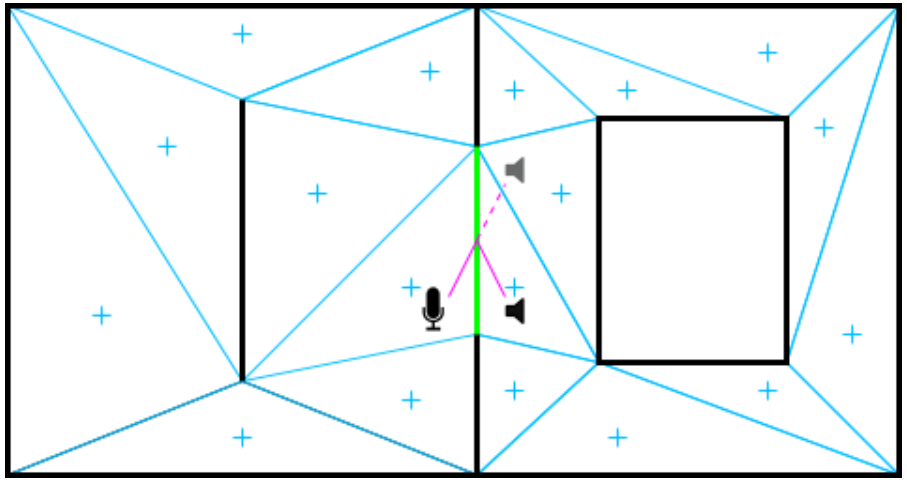
Optimization

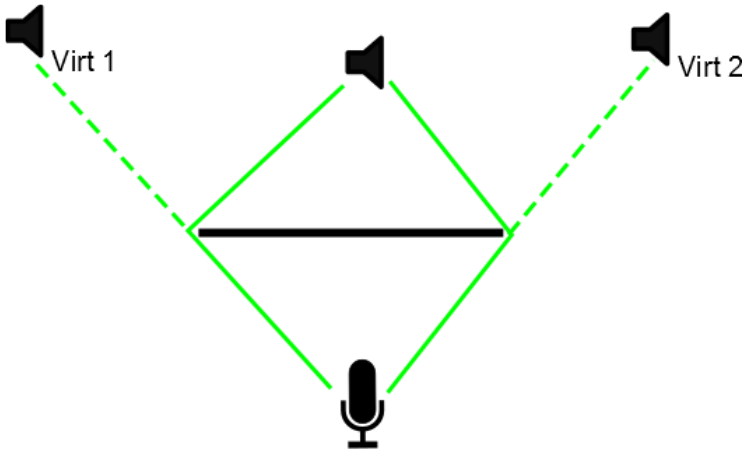
- Zoning to remove irrelevant geometric data
- Computation done in 2D + height
- Added a “microphone reception distance” that results in ignoring walls outside this range
- Frame rate of the algorithm is independent of the game frame rate
  - FPS between 5-10 is normally sufficient
  - We first compute objects that have moved the most

Problems we faced

Not the same as AI Path finding

Discontinuity





Problems we faced

Dynamic loading

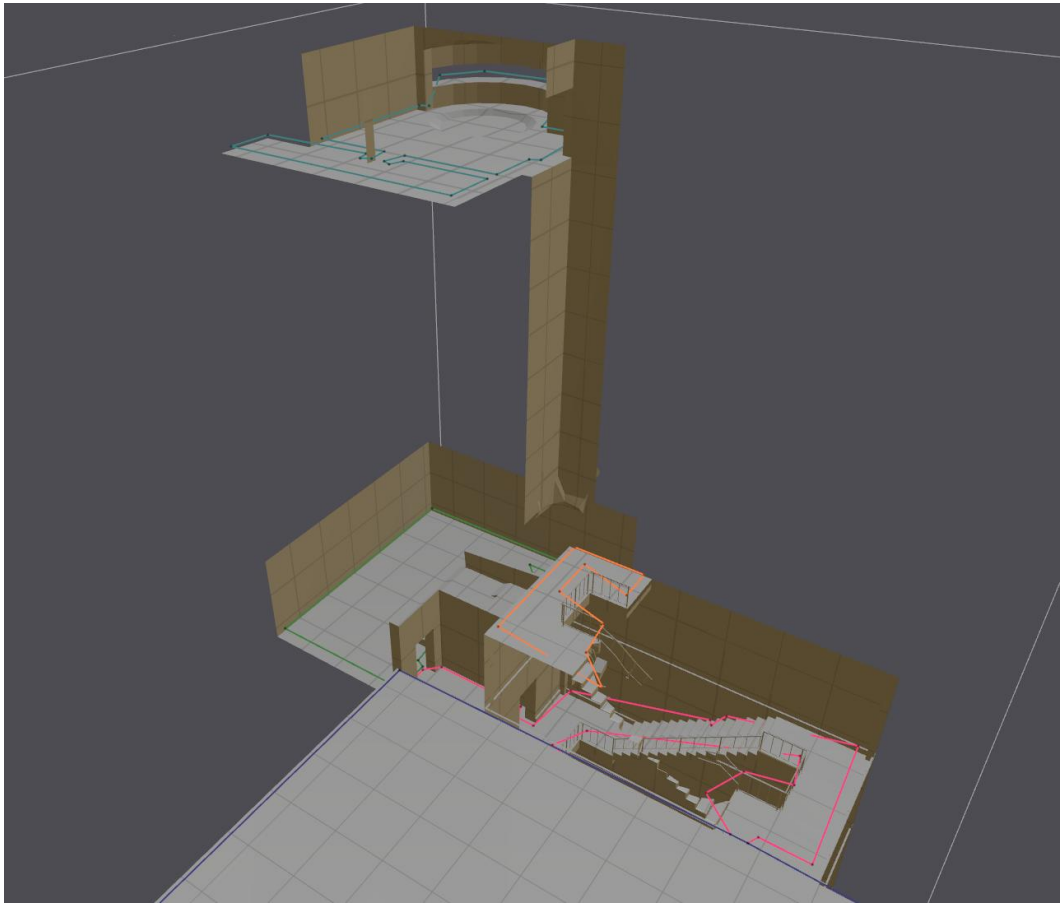
- Had to reorganize data structure for pre-computed shortest paths

Problems we faced

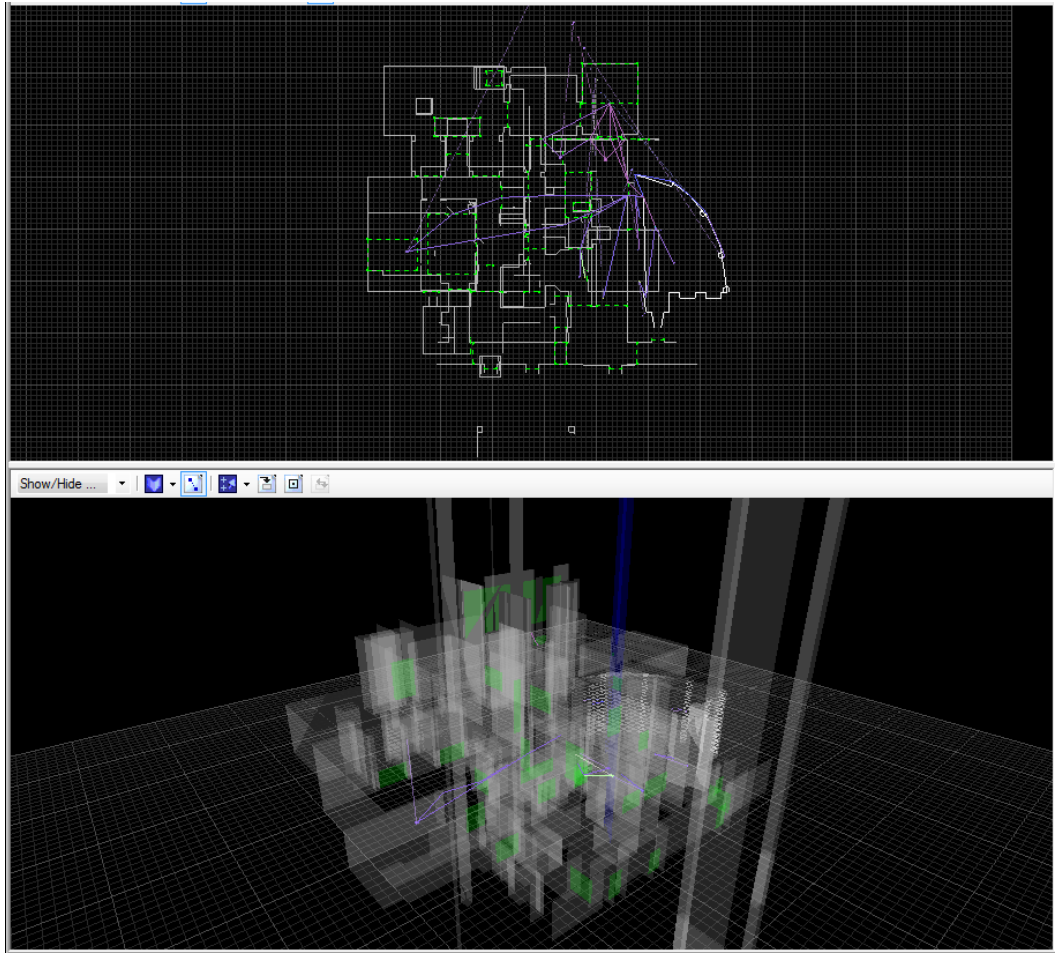
Data creation

- First version needed to flag walls individually
- Was hard to have a comprehensive, 100% automatic solution
- Ended up with 2 automatic generation algorithms
  - One optimized for complex interiors
  - One optimized for exteriors with small buildings

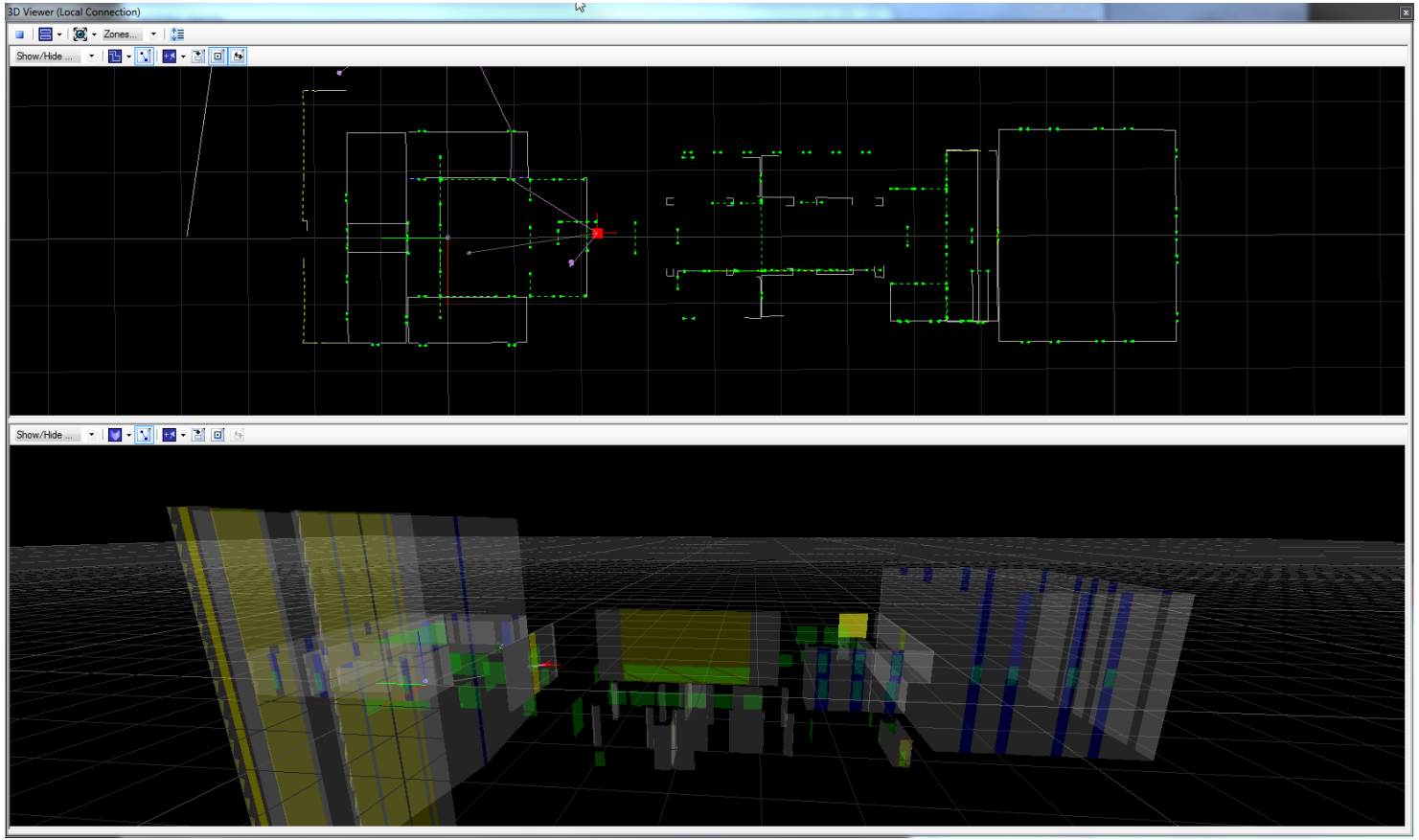
Data creation



Data creation



Data creation



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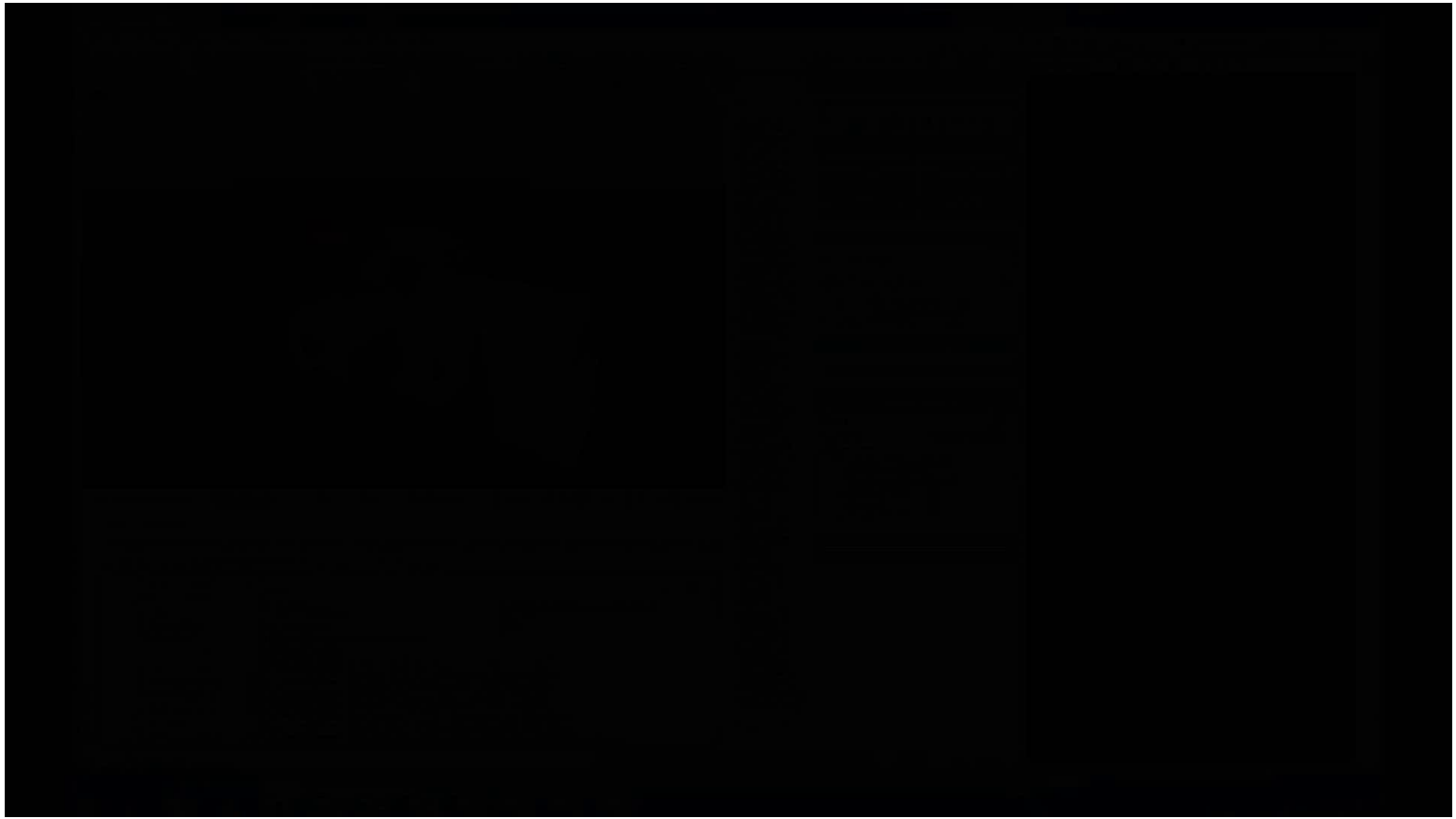
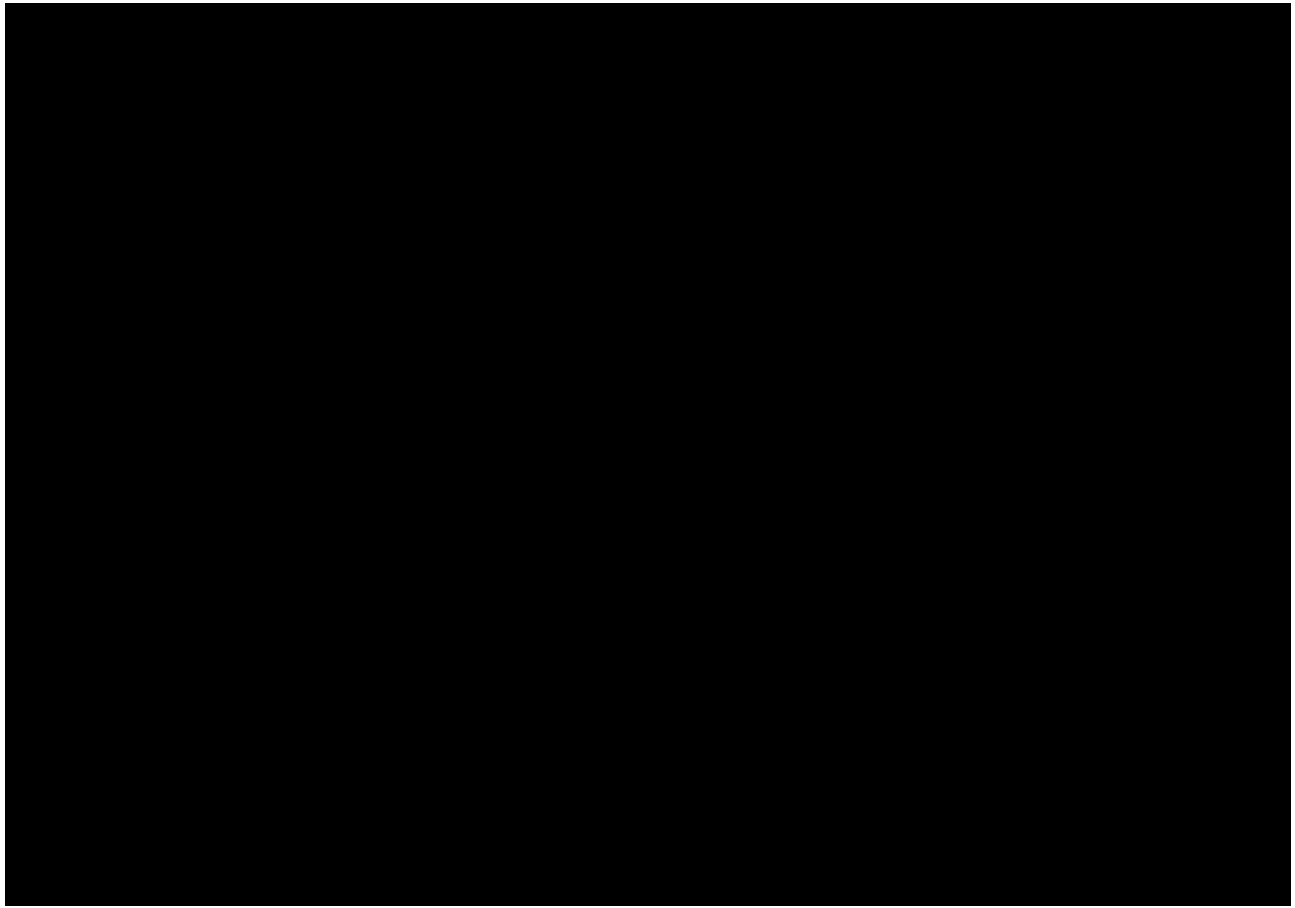


Some real examples (diffraction)

Some real examples (absorption)



Splinter Cell Conviction

Sound Propagation integration

Future developments

- Dynamic/destructible environments
- Improve automatic generation

Conclusion

- Needs to be simple to use and fast
- Should not have discontinuity
- Audio designer needs to have control on how it will be rendered
- Propagation is a good way to increase player's immersion
- Even possible to do game play with propagation

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Questions ?

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