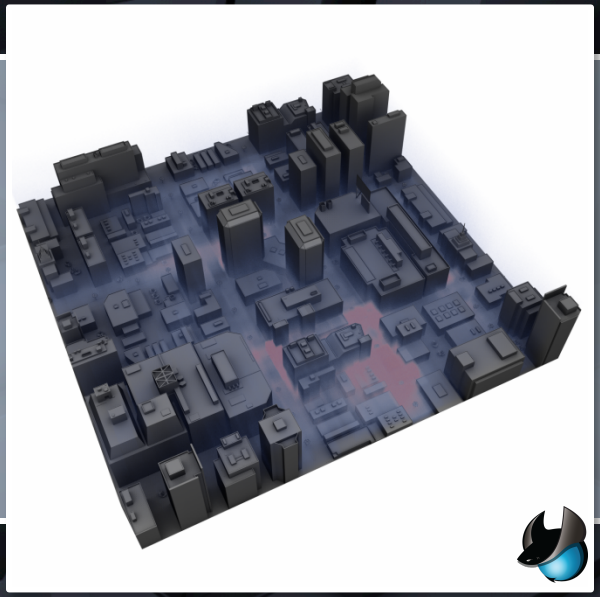
High Performance Radio Frequency Ray Tracing with Embree

Christiaan Gribble & Jefferson Amstutz
Applied Technology Operation
SURVICE Engineering Company

Intel HPC Developer Conference
16 November 2014

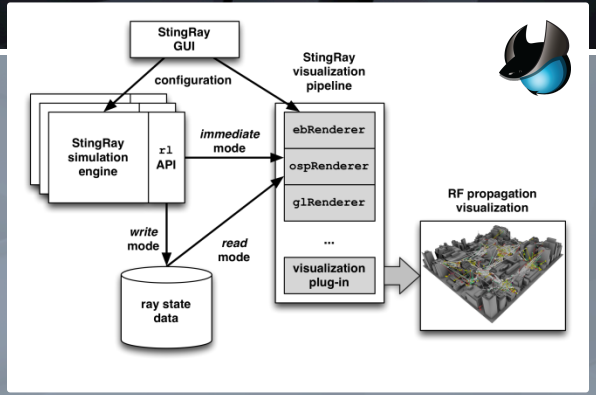
Agenda

- Introduction
  - Radio frequency simulation
  - RFRT : radio frequency ray tracing



Agenda

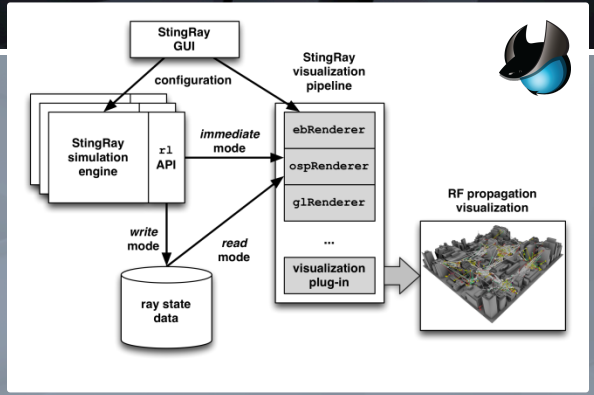
- Introduction
  - Radio frequency simulation
  - RFRT : radio frequency ray tracing
- StingRay
  - Architecture & core components
  - Live demonstration



SURVICE

Agenda

- Introduction
  - Radio frequency simulation
  - RFRT : radio frequency ray tracing
- StingRay
  - Architecture & core components
  - Live demonstration
- Wrap-up

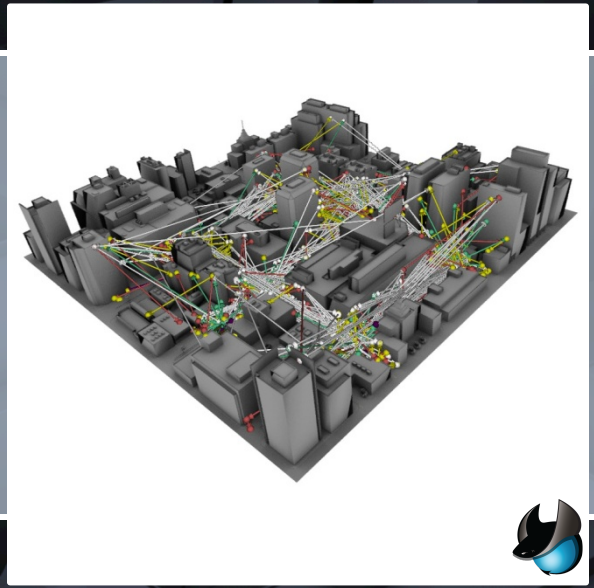


SURVICE

Introduction

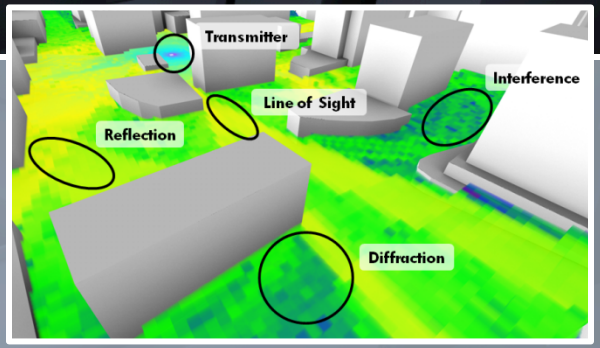
Radio frequency simulation

- Radio frequency (RF) propagation
  - Transmission of radio waves
  - Behavior affected by various phenomena
- Possible methodology
  - Empirical models, FEM, 2*N*-ray models, …
  - Monte Carlo path tracing

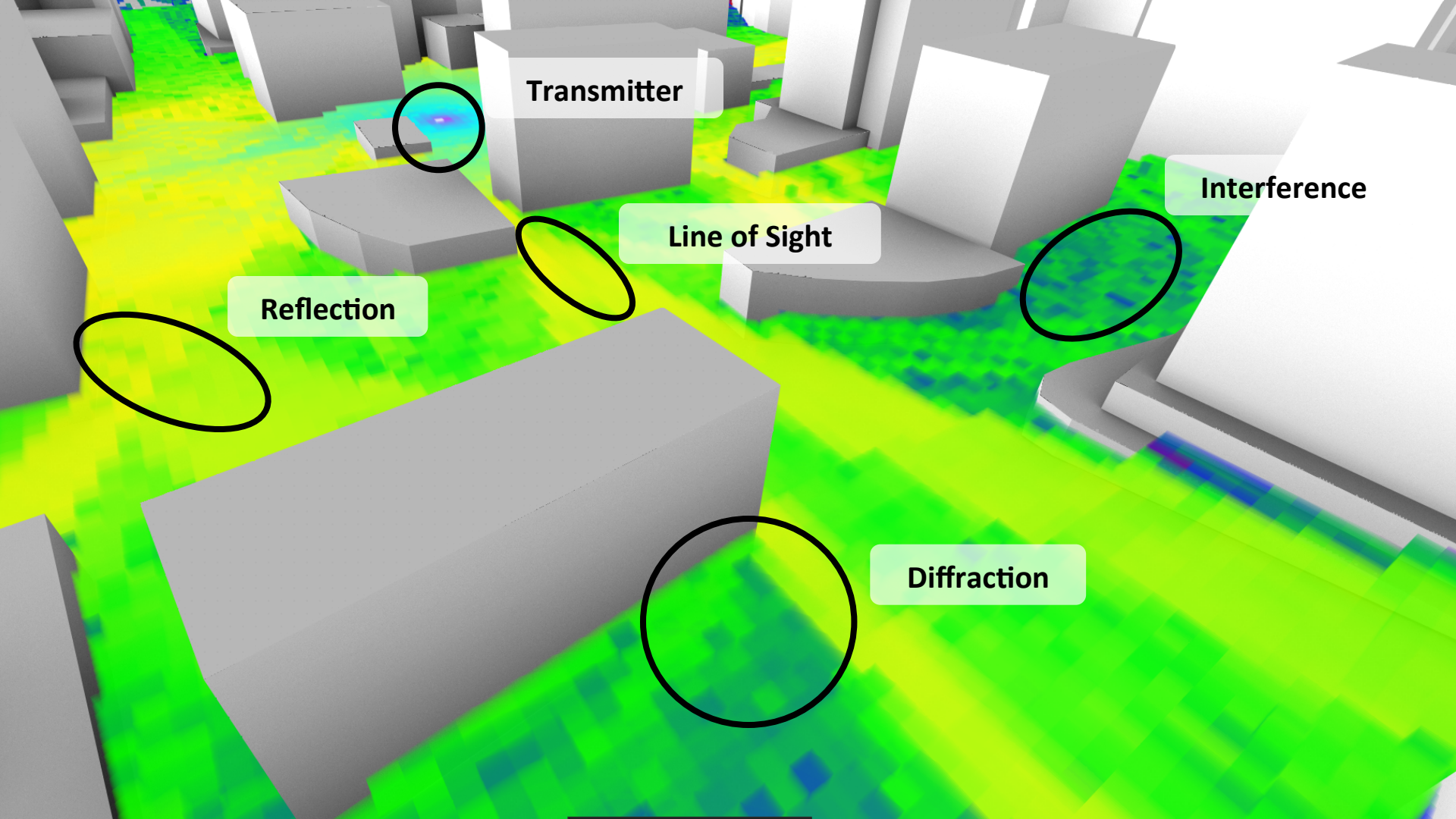


RFRT – radio frequency ray tracing

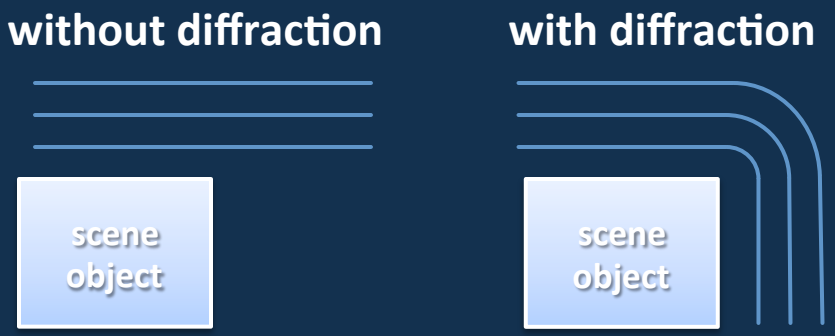
- Ray representation
  - EM wave, same direction of travel
  - Direction perpendicular to wavefront
- Ray behavior
  - Graphics : reflection, refraction
  - RF simulation : +diffraction, +interference



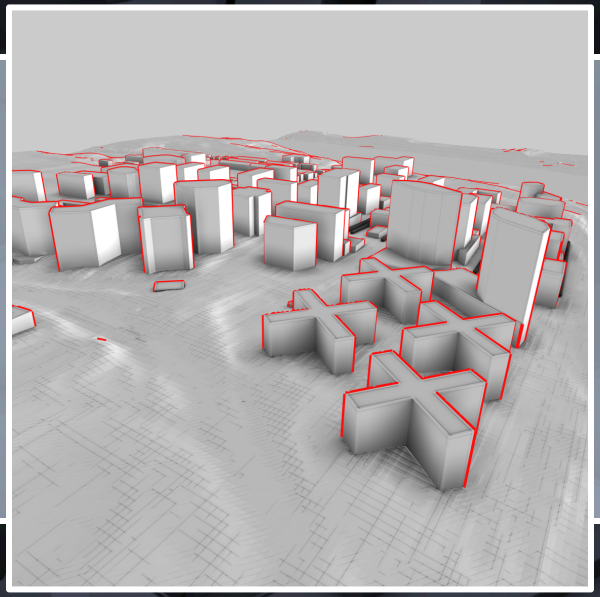
SURVICE


Transmitter
Interference
Line of Sight
Reflection
Diffraction

RFRT – diffraction



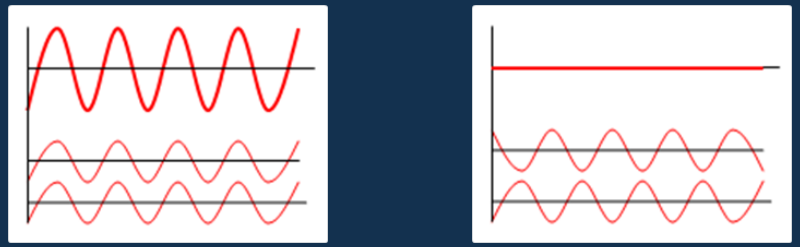
- Wedge diffraction
- Diffraction edge proxy geometry



SURVICE

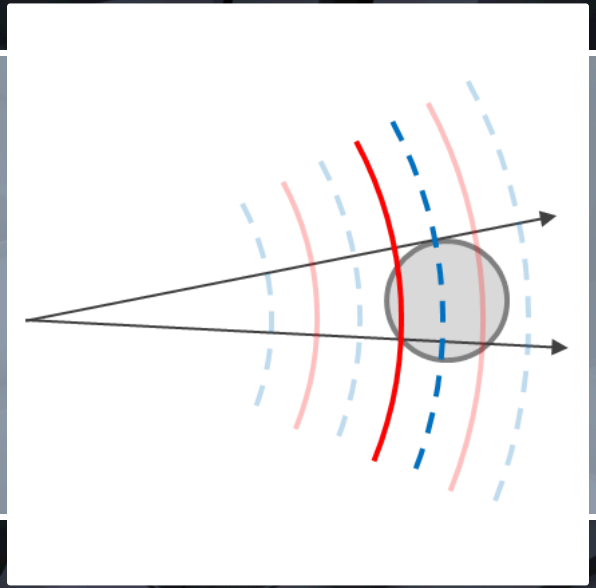
RFRT – interference

constructive **destructive**



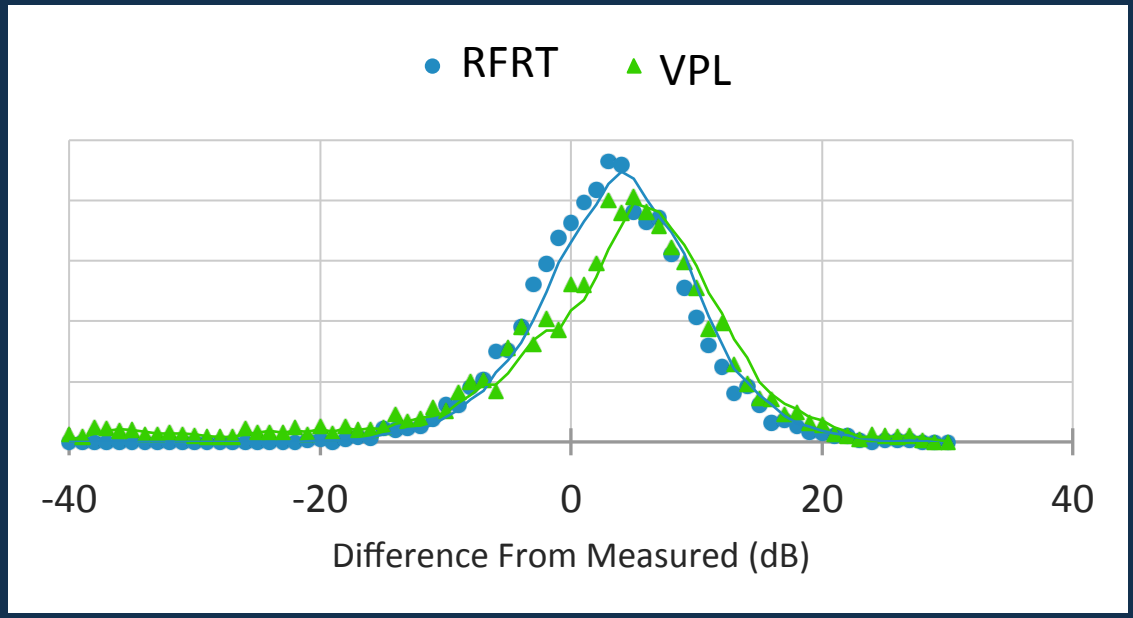
[image source: Google images]

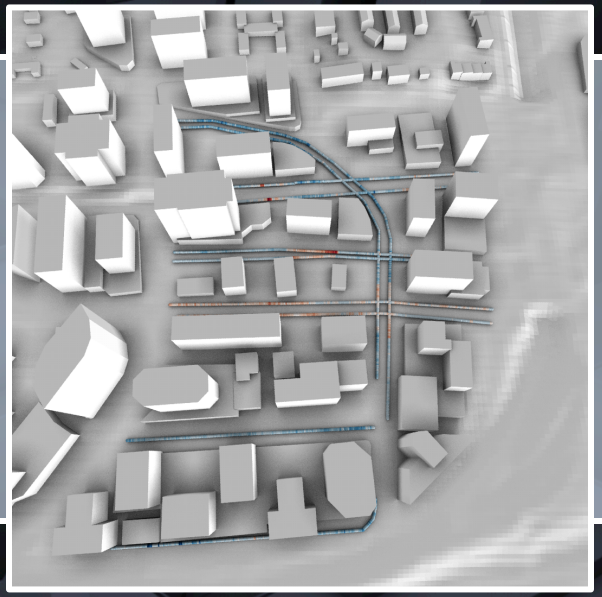
- Constructive v. destructive
- Ray/sensor interaction



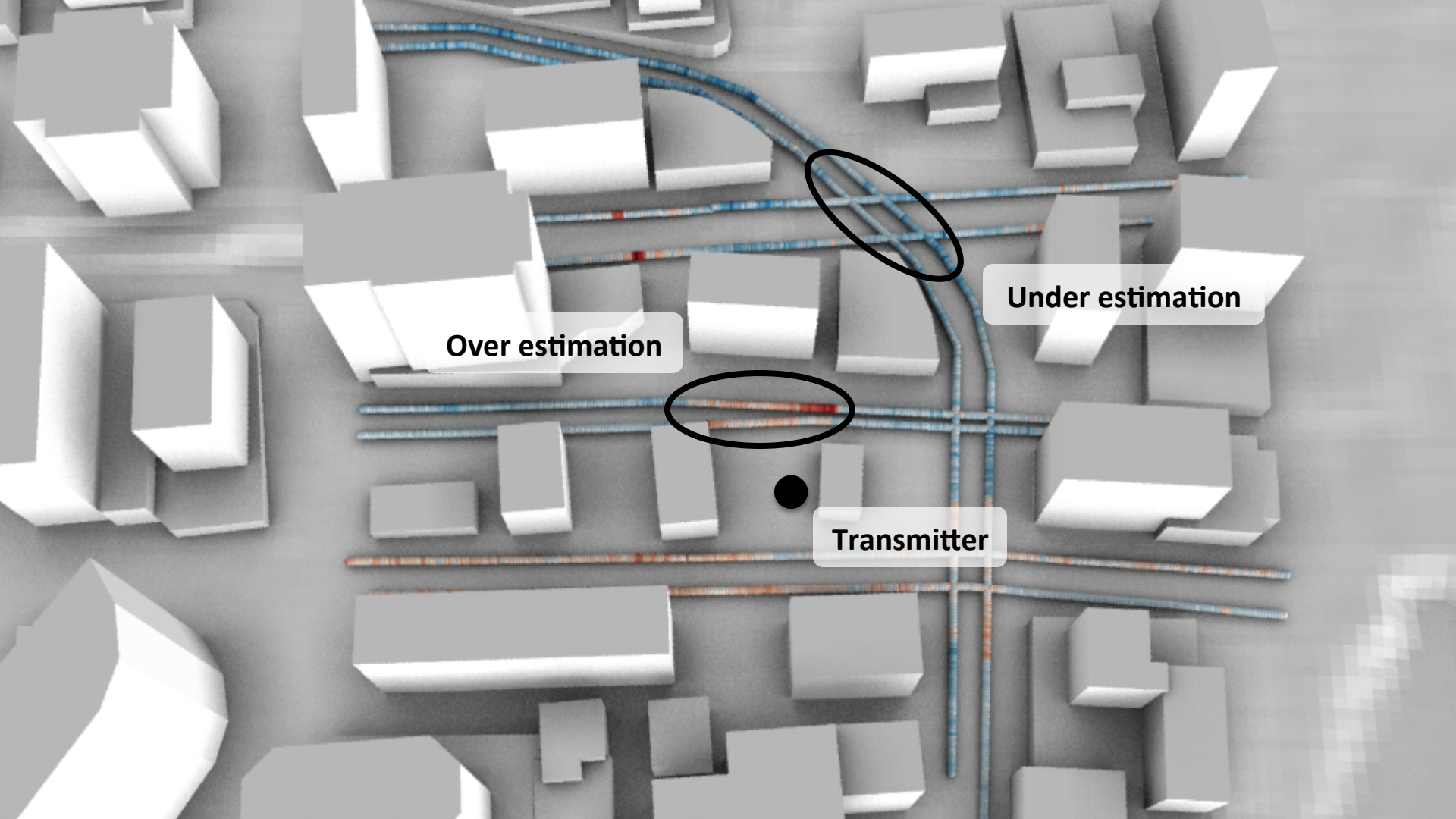
SURVICE

RFRT – validation





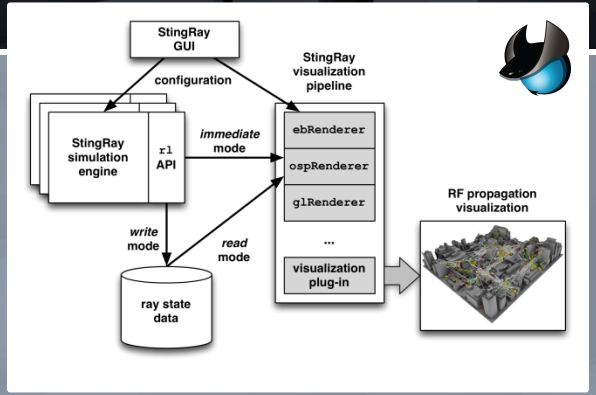
SURVICE


Under estimation
Over estimation
Transmitter

StingRay

StingRay – combined RF sim/viz

- Loosely-coupled components
  - Simulation : Embree
  - Visualization : OpenGL, Embree, OSPRay, …
  - GUI : Qt5
- Open source release
  - Fully interactive sim/viz environment
  - Cross-platform support
  - Coming winter 2014

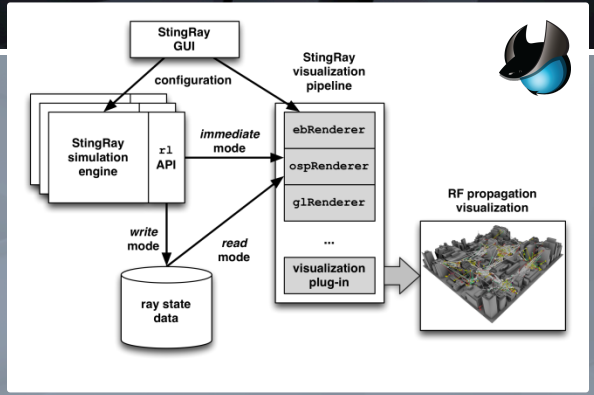


SURVICE

Simulation engine

StingRay – simulation engine

- Ray-based RF wave propagation
  - Dominant RF propagation phenomena
  - Full simulation : Monte Carlo path tracing
- C++ library with straightforward API
  - Asynchronous multithreaded ray logging
  - Embree : intersection engine



SURVICE

StingRay – core components

scene geometry

- Defines objects & materials in physical environment

StingRay – core components

scene geometry

edge geometry

- Defines objects & materials in physical environment
- Captures & generates diffraction events

StingRay – core components

scene geometry

edge geometry

ray logger

- Defines objects & materials in physical environment
- Captures & generates diffraction events
- Collects completed paths & RF propagation state

StingRay – core components

scene geometry

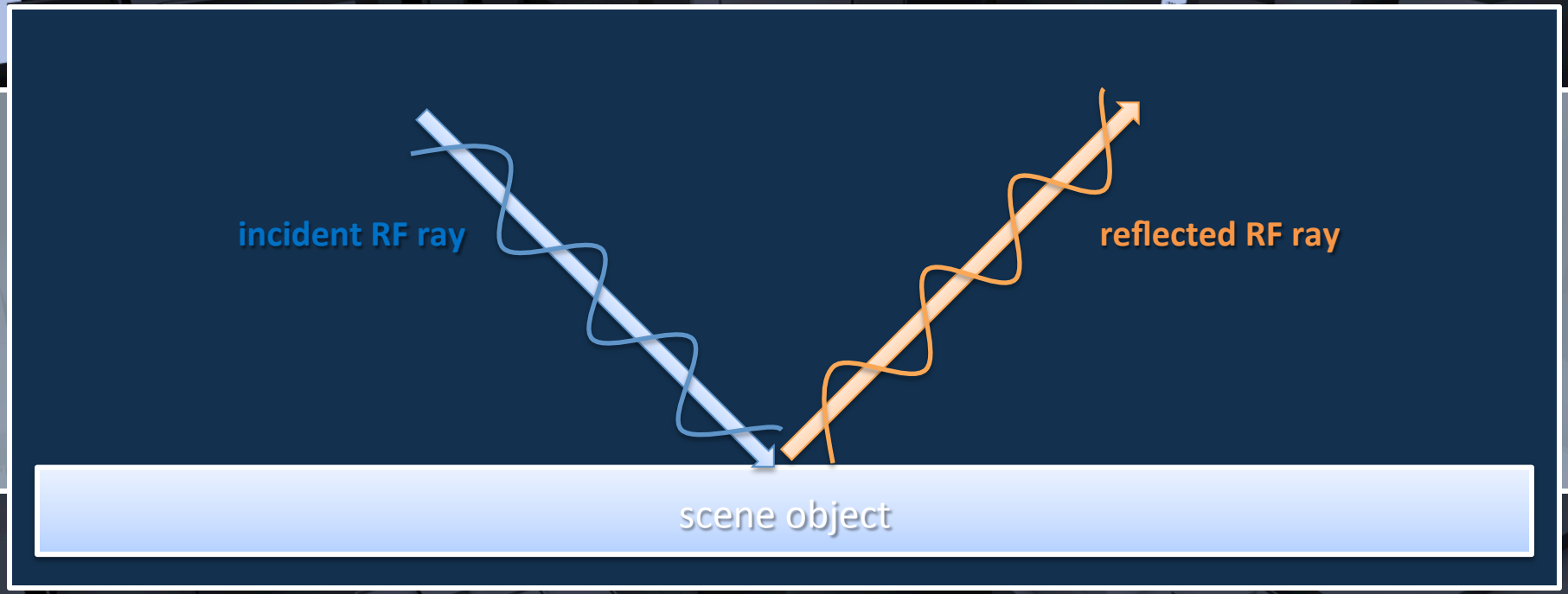
edge geometry

ray logger

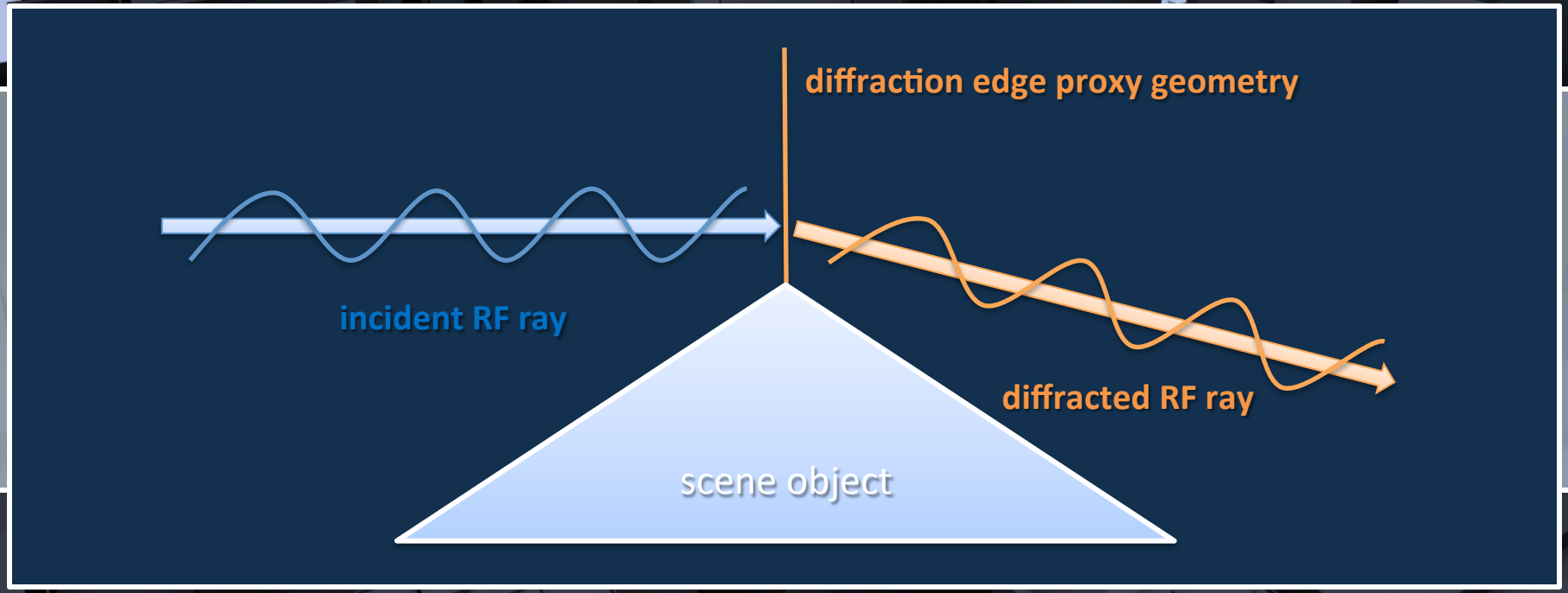
simulation controller

- Defines objects & materials in physical environment
- Captures & generates diffraction events
- Collects completed paths & RF propagation state
- Governs execution & interfaces with client programs

StingRay – specular reflection



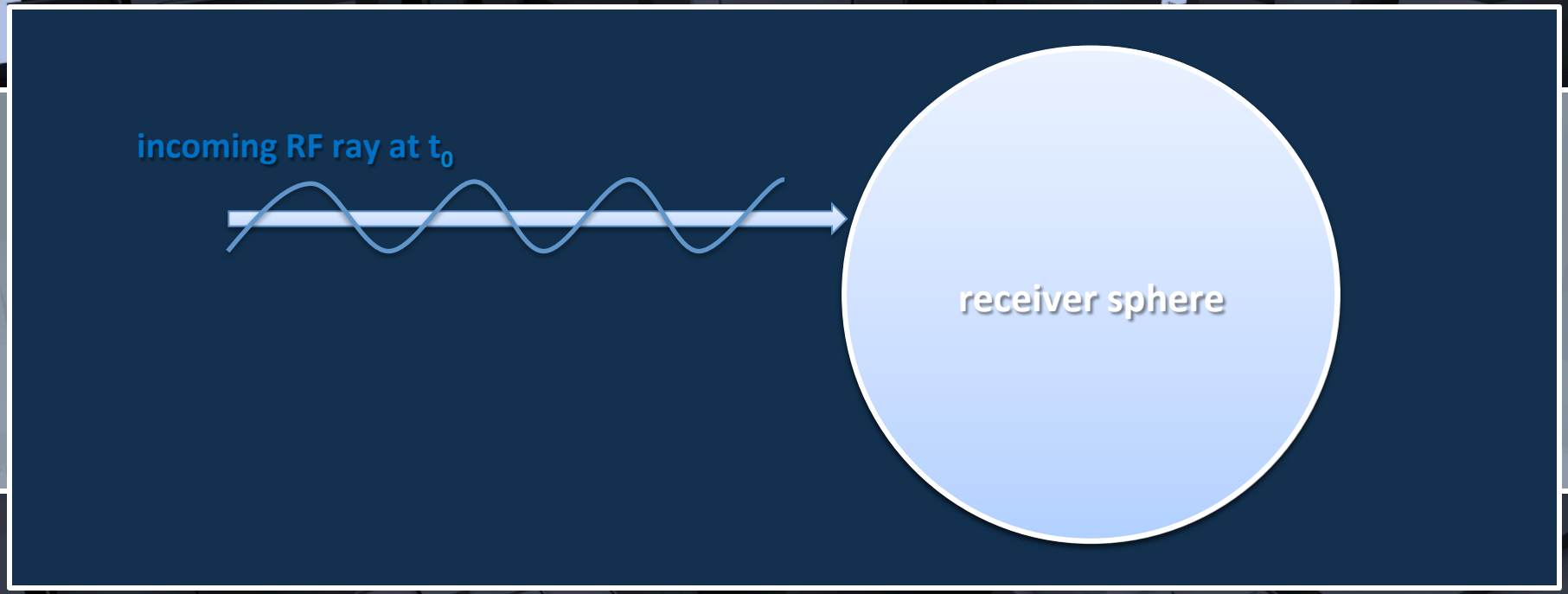
StingRay – wedge diffraction



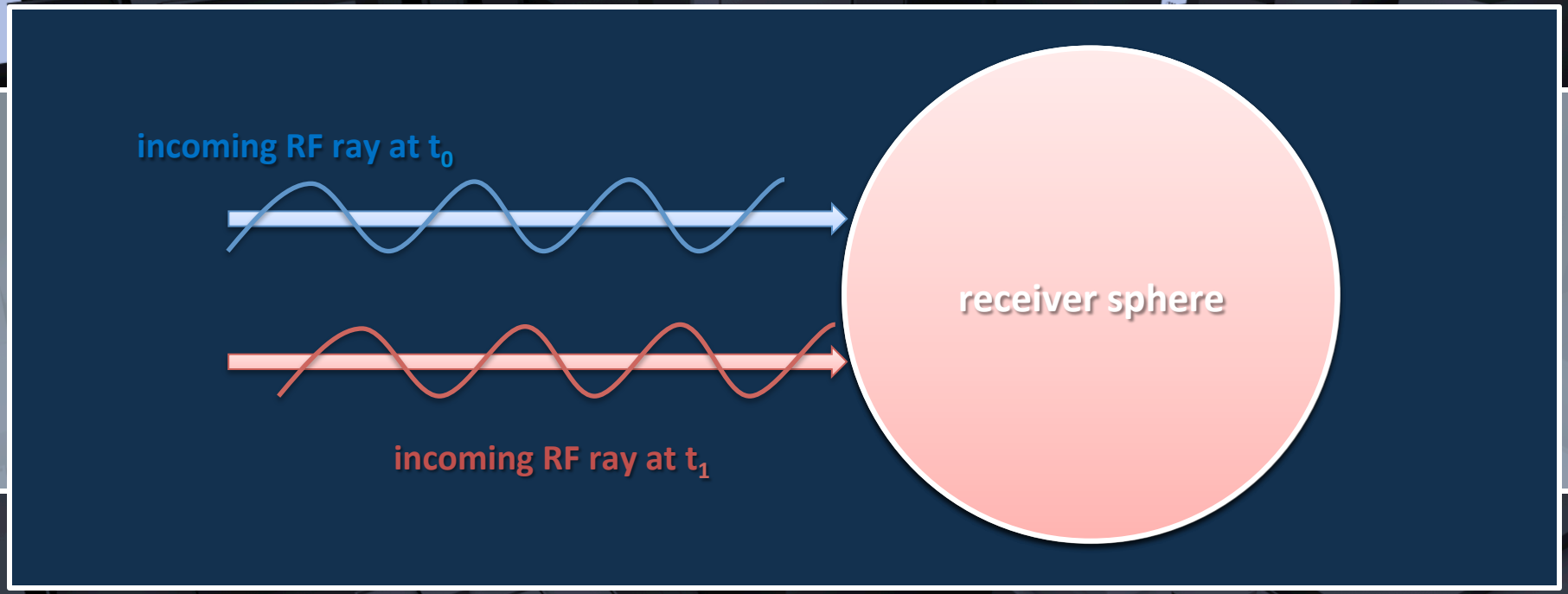
StingRay – interference

SURVICE

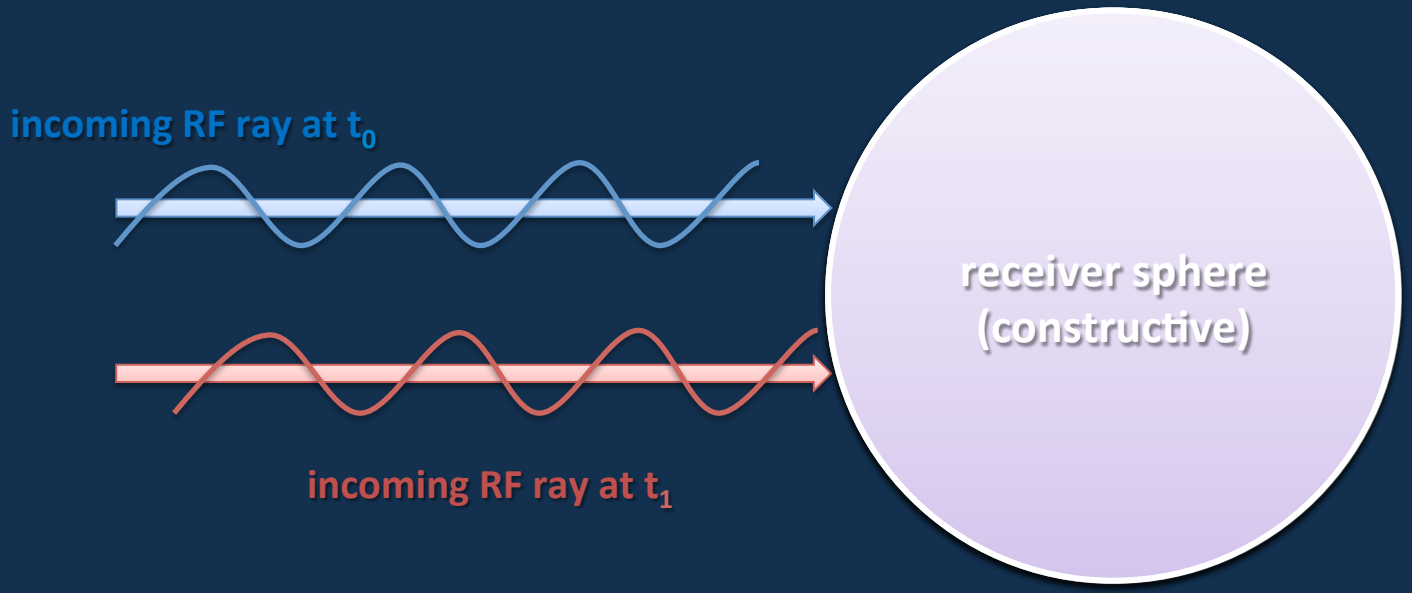
StingRay – interference



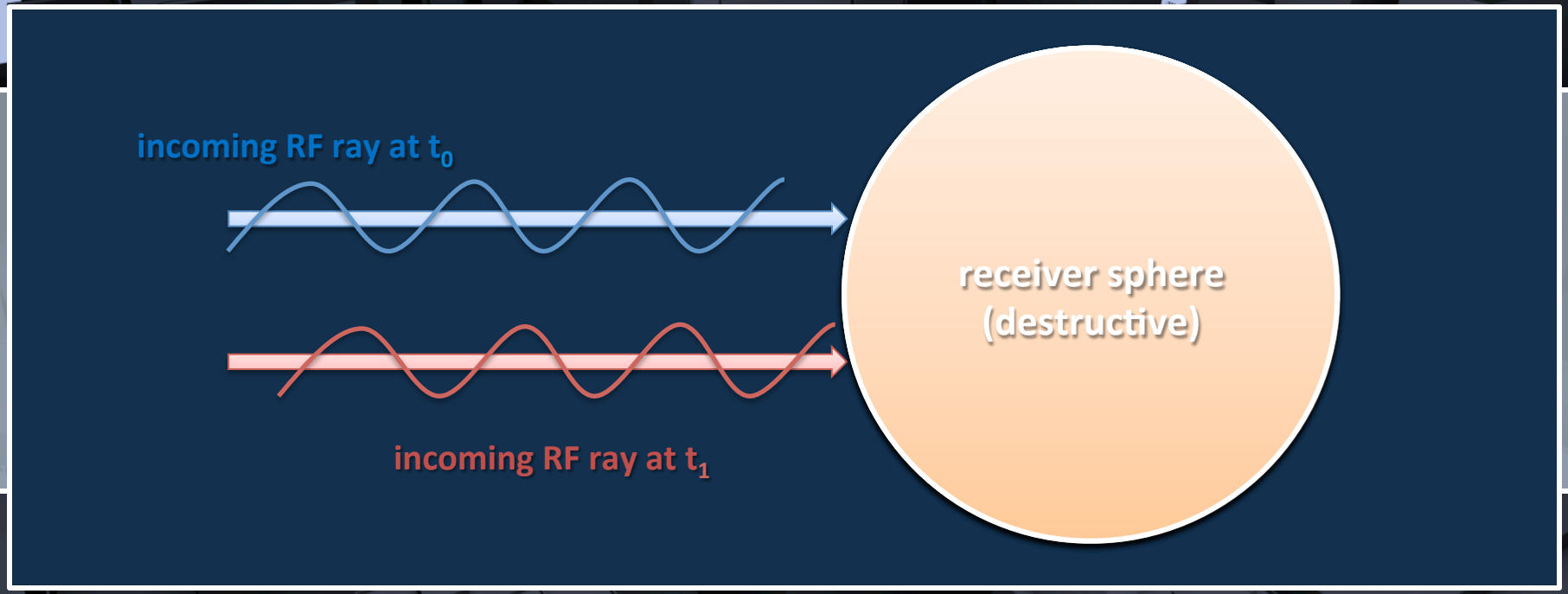
StingRay – interference



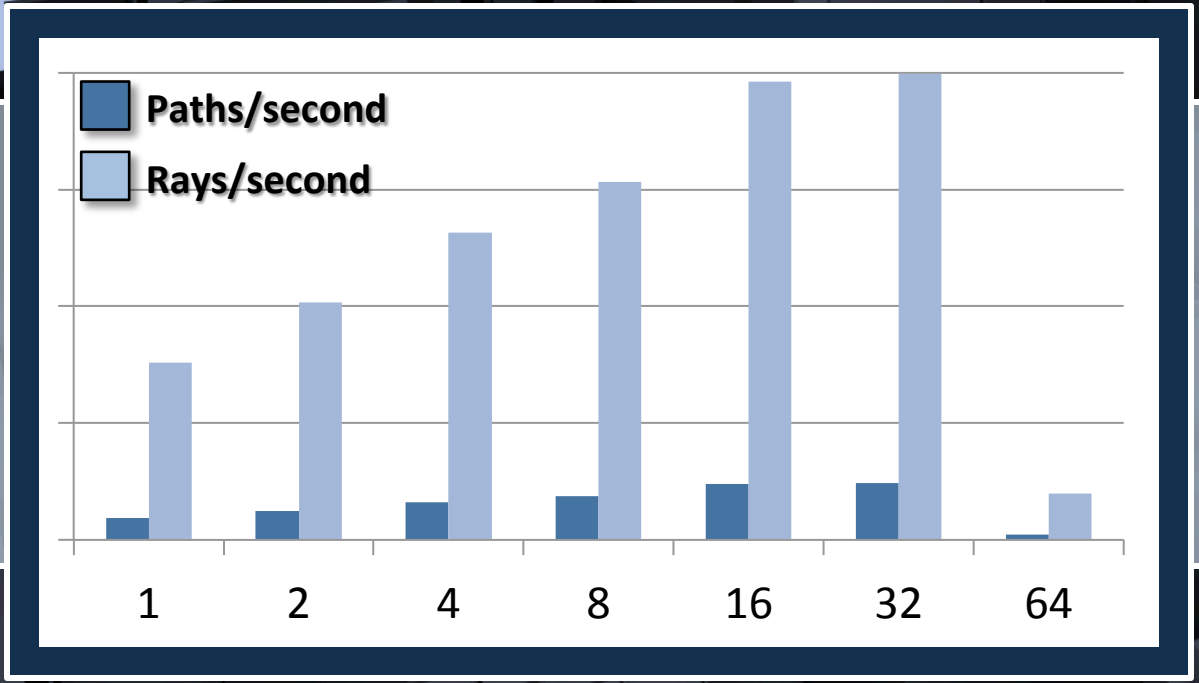
StingRay – interference

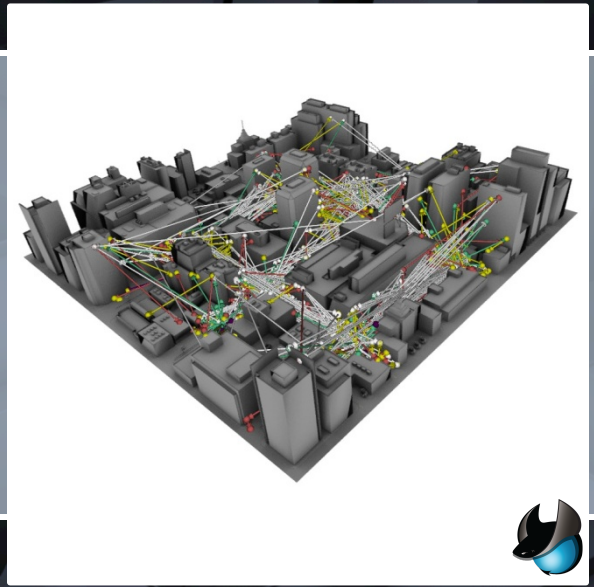


StingRay – interference



StingRay – performance



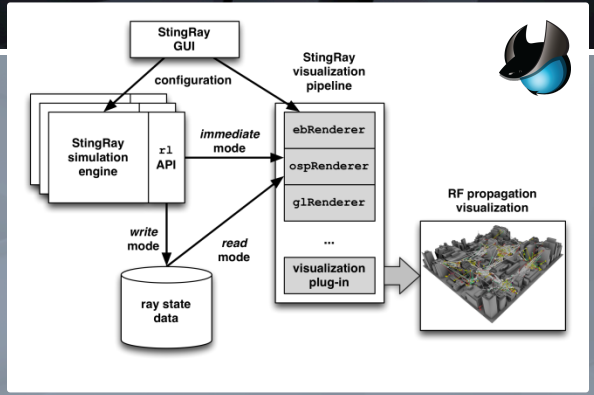


SURVICE

Visualization pipeline

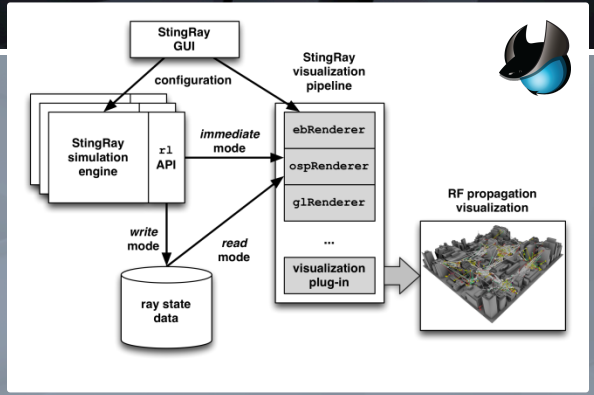
StingRay – visualization pipeline

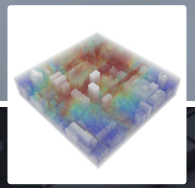
- Loosely-coupled visualization plug-ins
  - Producer/consumer API
  - Frame-oriented I/O
  - Extensible hierarchy of visual elements
- Interactive exploration of results
  - Online queries of underlying data
  - OpenGL, Embree, OSPRay, …

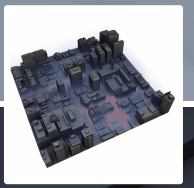


StingRay – visualization capabilities

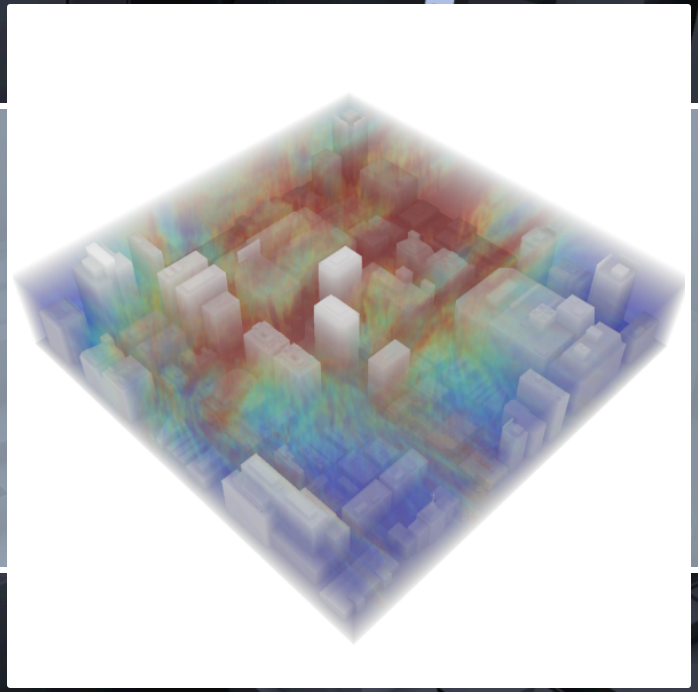
- Scene geometry
- Diffraction edges
- Ray glyphs
- Scalar volume data
  - Traditional volume rendering
  - Participating media



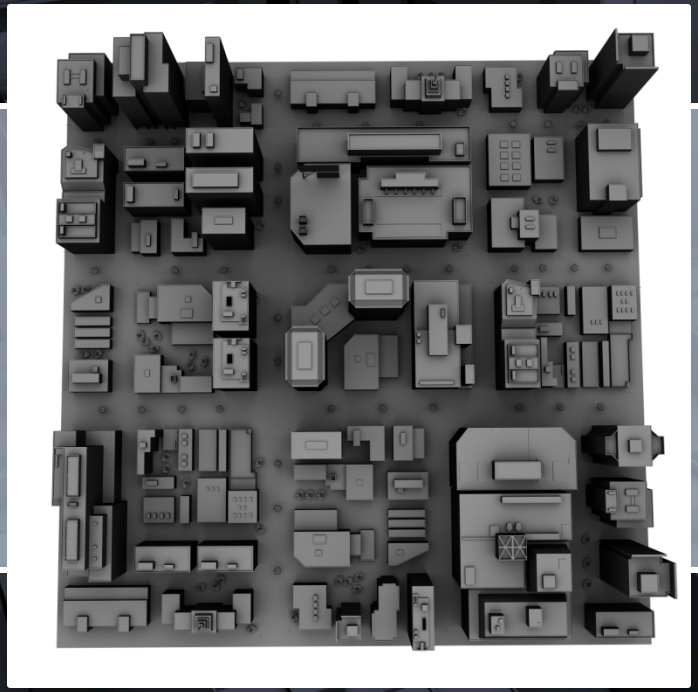


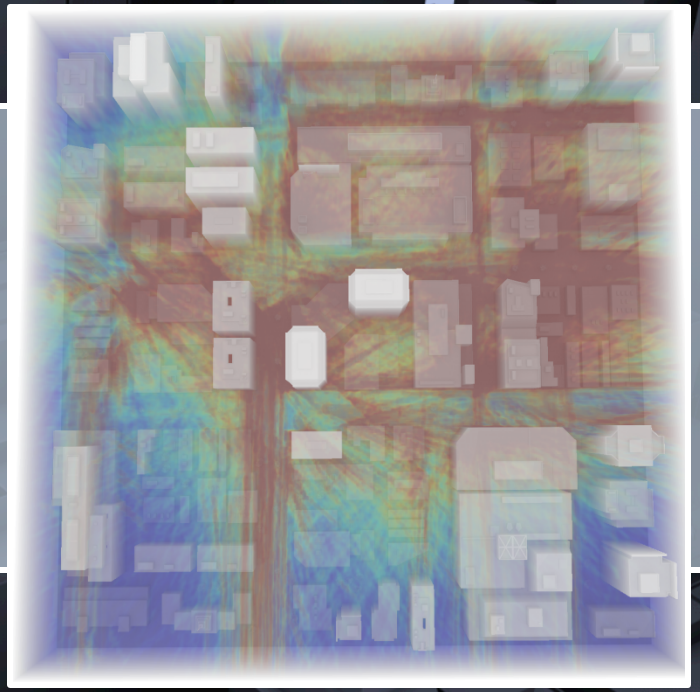


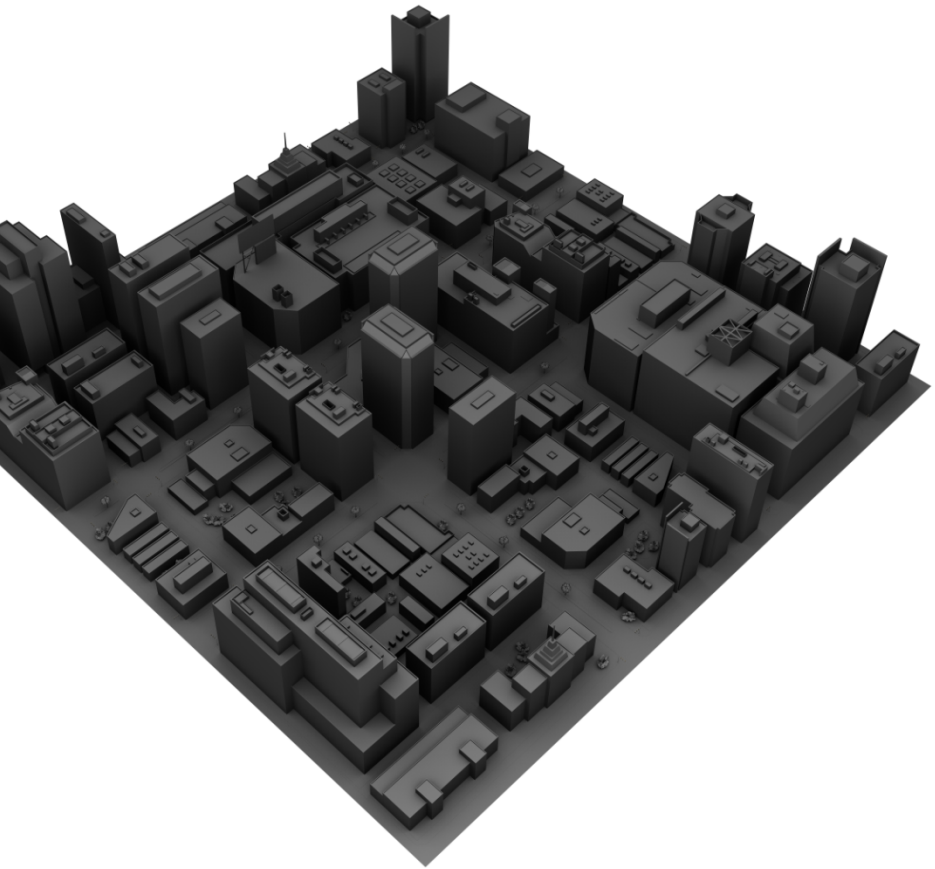
StingRay – examples

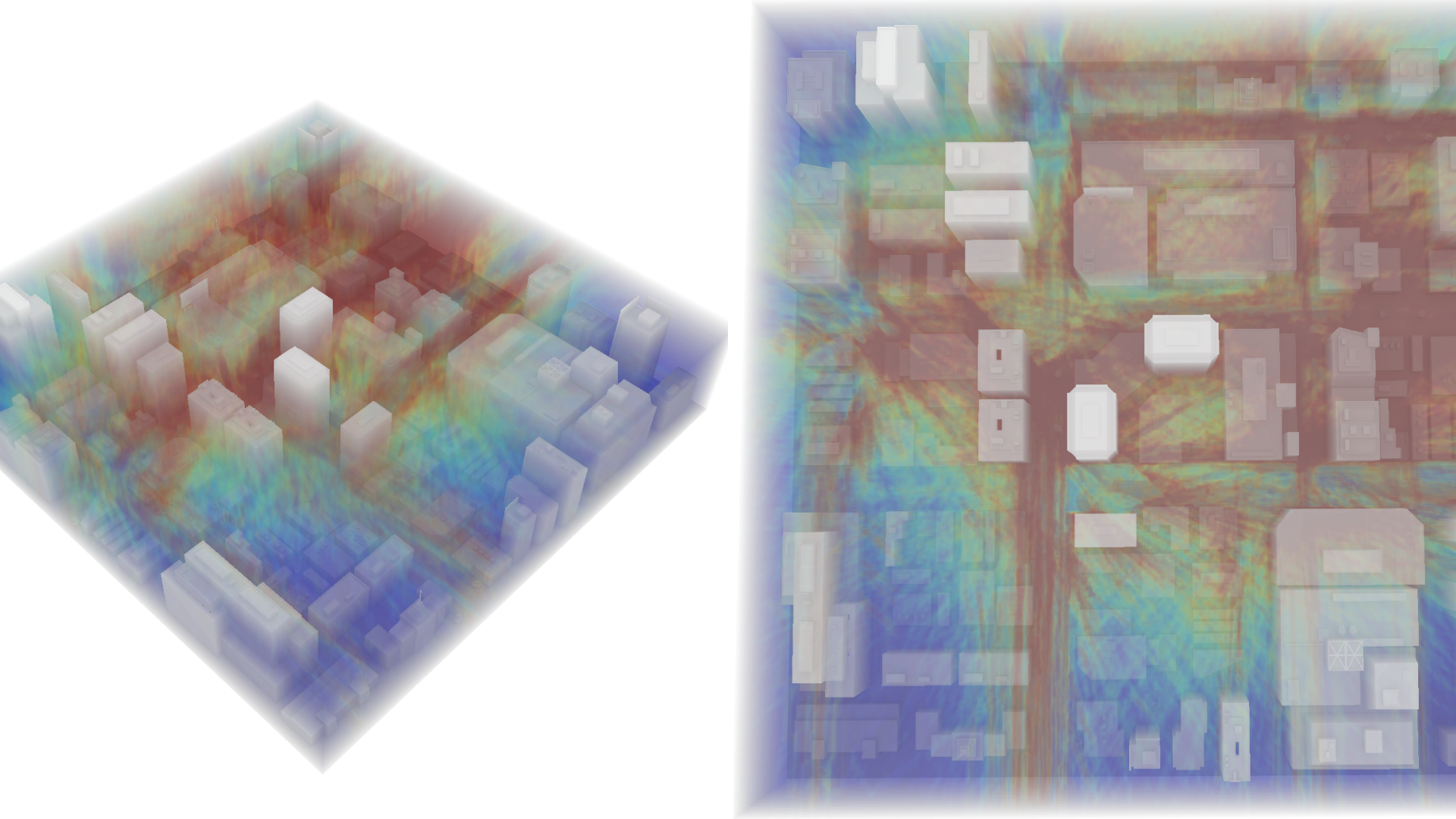


StingRay – examples

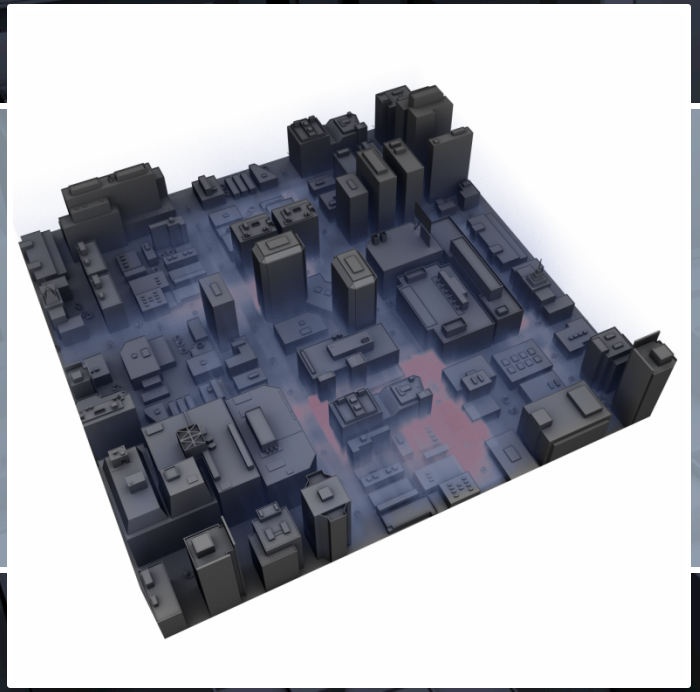


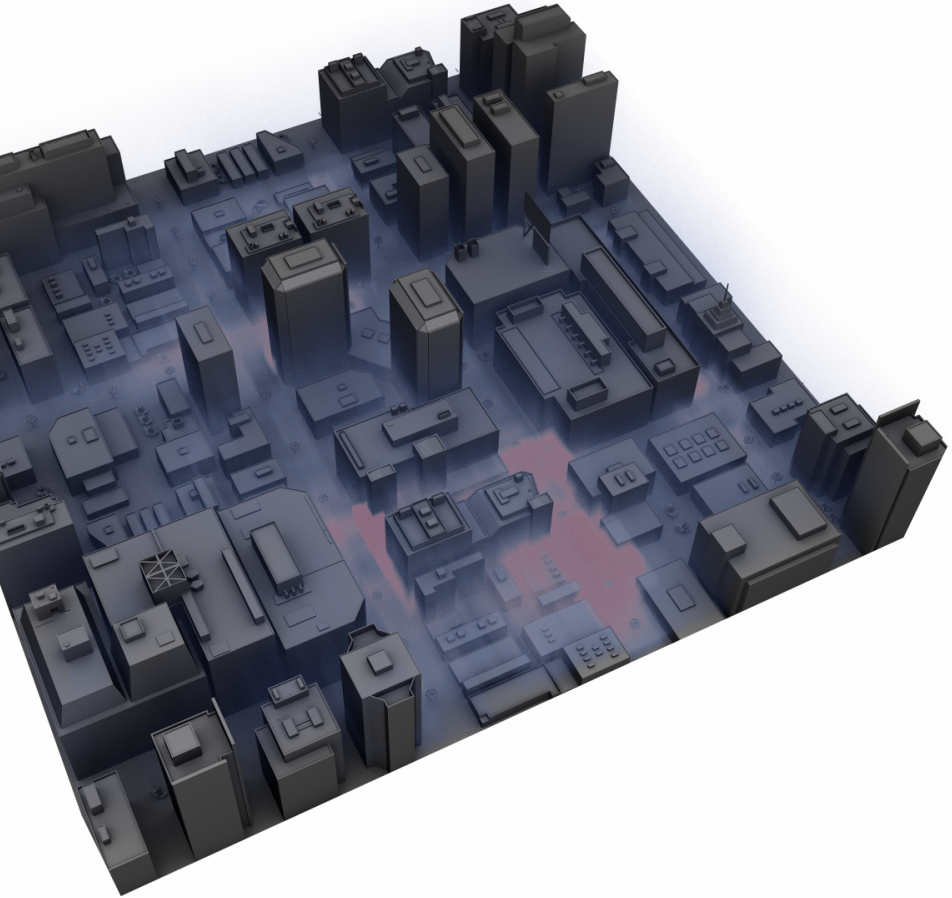


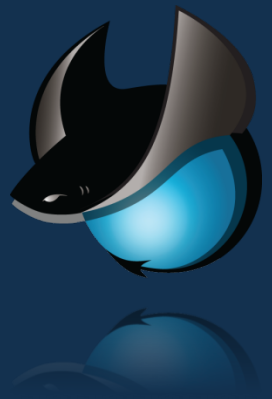




StingRay – examples







Live demonstration

Wrap-up

Take-home messages

- RF simulation : critical to planning, analyzing, & optimizing communication networks

Take-home messages

- RF simulation
- RF ray tracing : high performance alternative to traditional RF simulation methods

Take-home messages

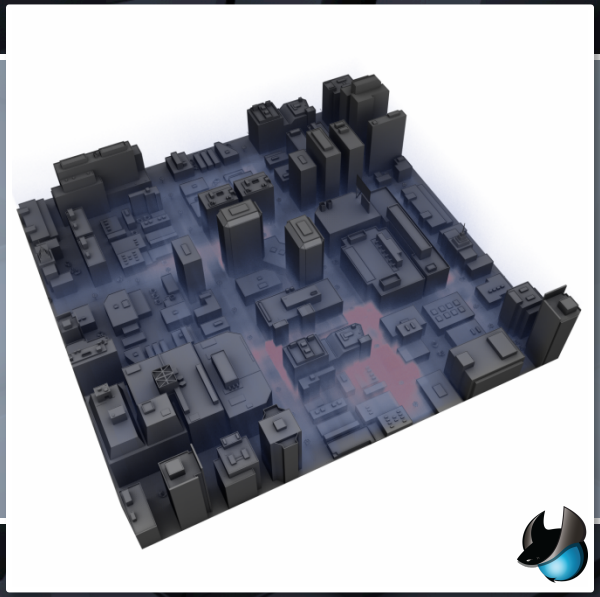
- RF simulation
- RF ray tracing
- StingRay + Intel hardware & software : enables a combined simulation/visualization approach

Take-home messages

- RF simulation
- RF ray tracing
- StingRay + Intel hardware & software
  - Intel® Xeon® product family : HP compute for physics-based simulation
  - Embree : HP ray tracing for optical & non-optical rendering
  - OSPRay : HP visualization for understanding RF propagation

Acknowledgements

- Intel
  - Jim Jeffers, Ingo Wald, & PVE team
  - Nicole Grieve
- SURVICE
  - Mark Butkiewicz
  - Gideon Ludwig



SURVICE

Contact information

Address

Applied Technology Operation
SURVICE Engineering Company
1362 Brass Mill Road, Suite 5
Belcamp, MD 21017

E-mail

christiaan.gribble@survice.com
jeff.amstutz@survice.com

Web

http://www.survice.com/


STINGRAY