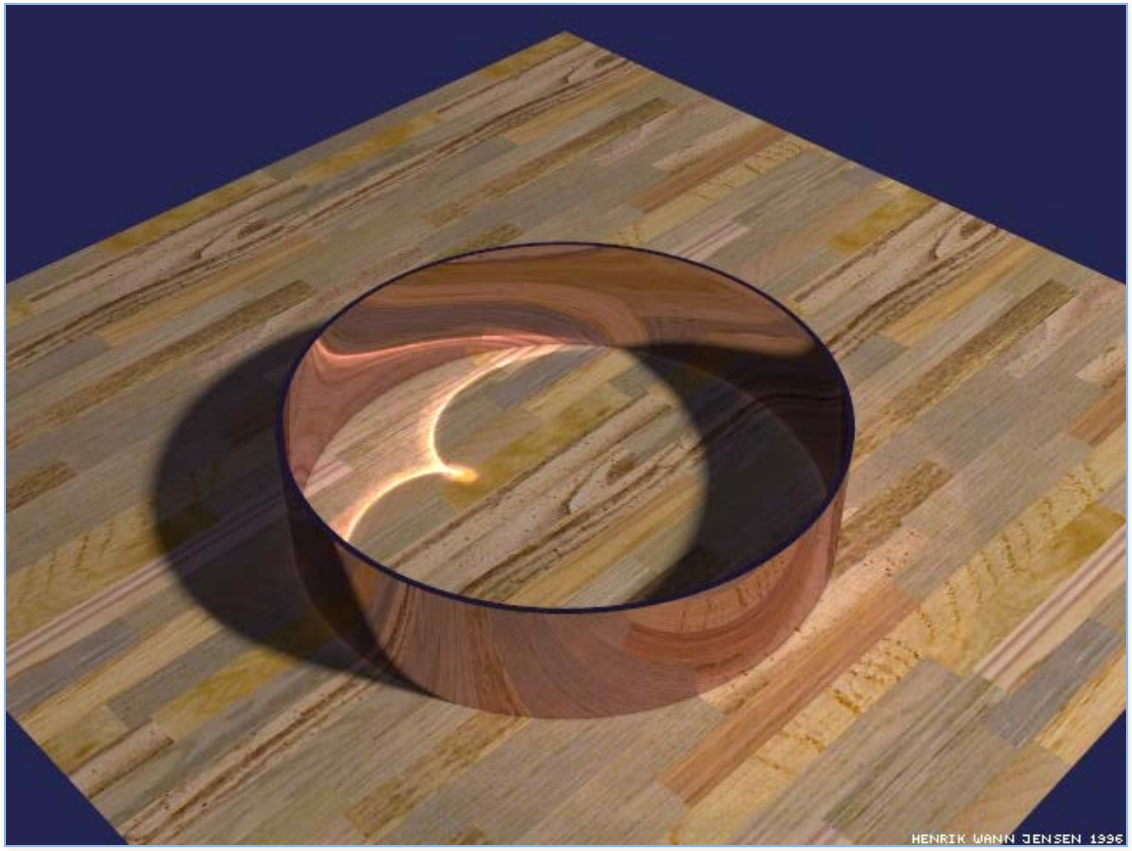
Global Illumination

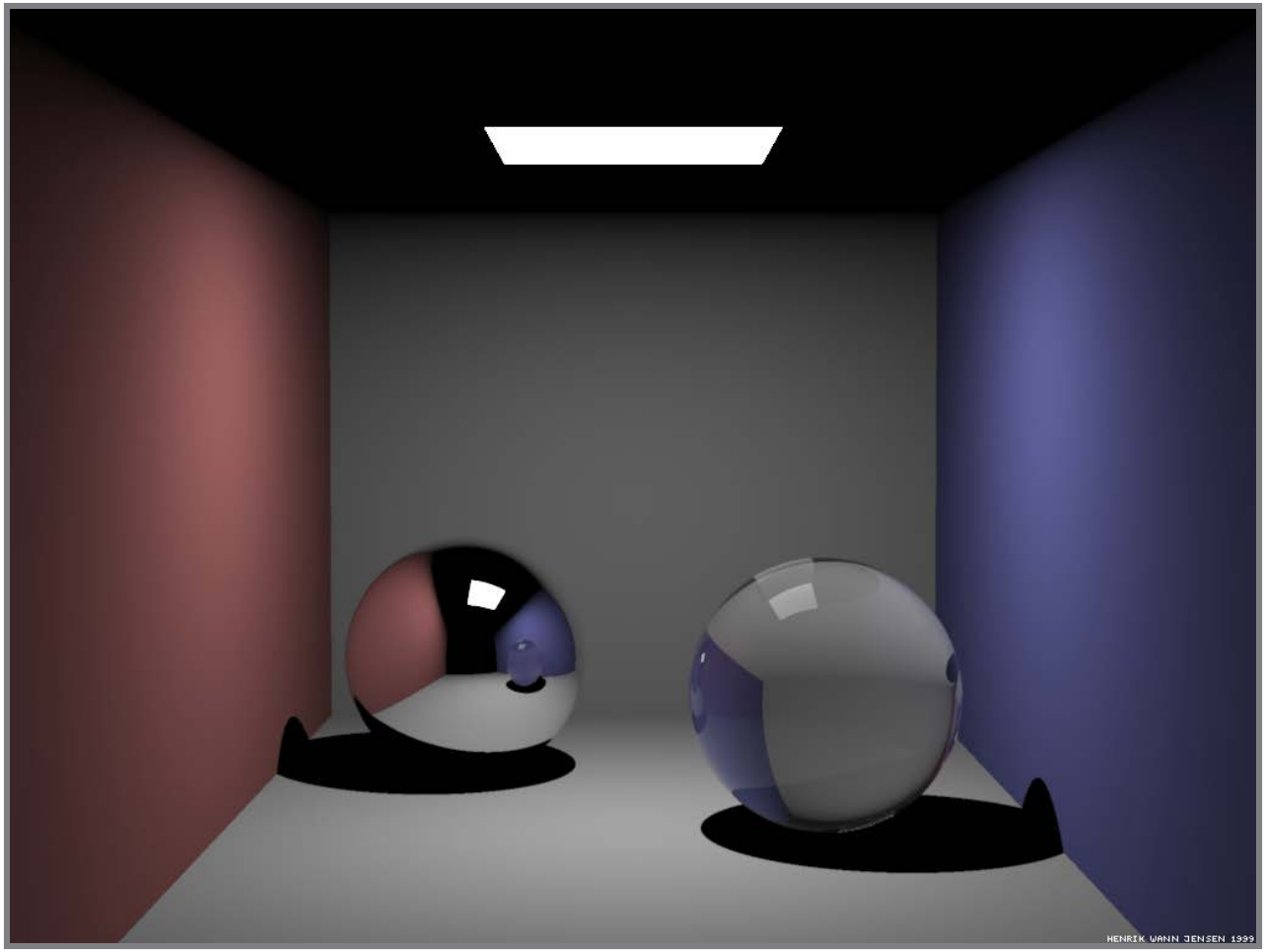
COS 526: Advanced Computer Graphics

Global Illumination

Synthesize image of a 3D scene accounting for all light transport (including indirect illumination)



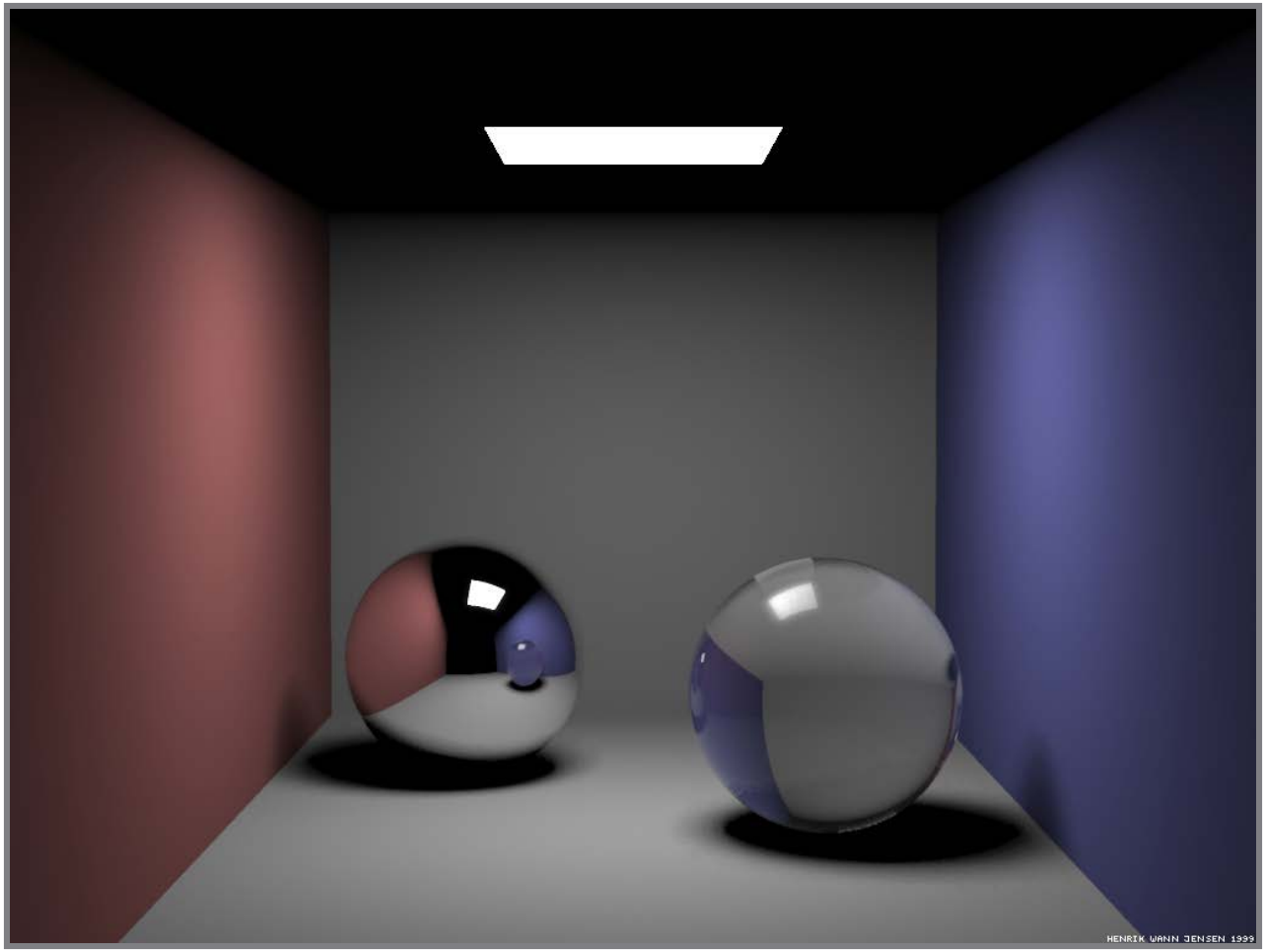
Path Types



Ray tracing

Henrik Wann Jensen

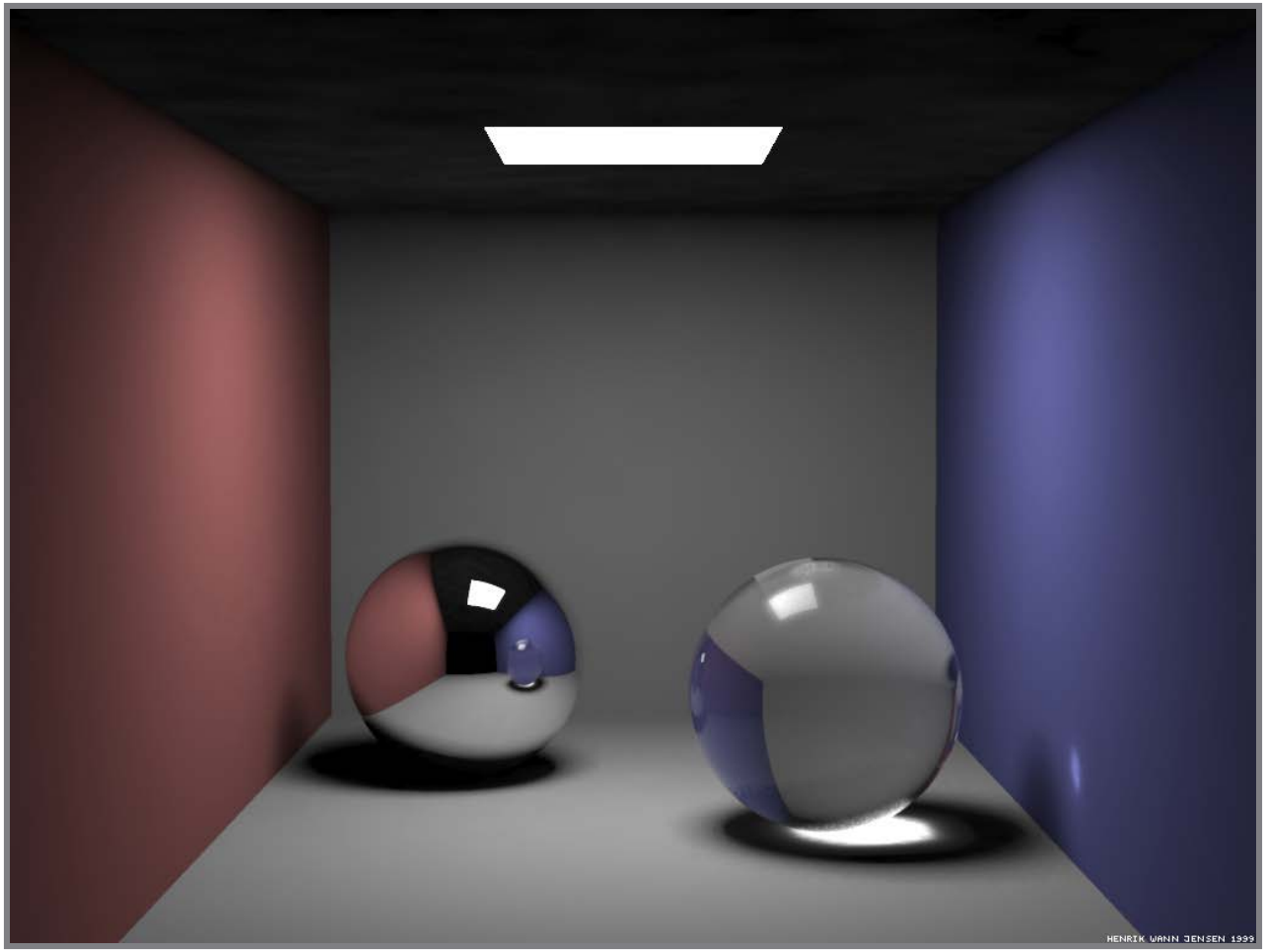
Path Types



+ soft shadows

Henrik Wann Jensen

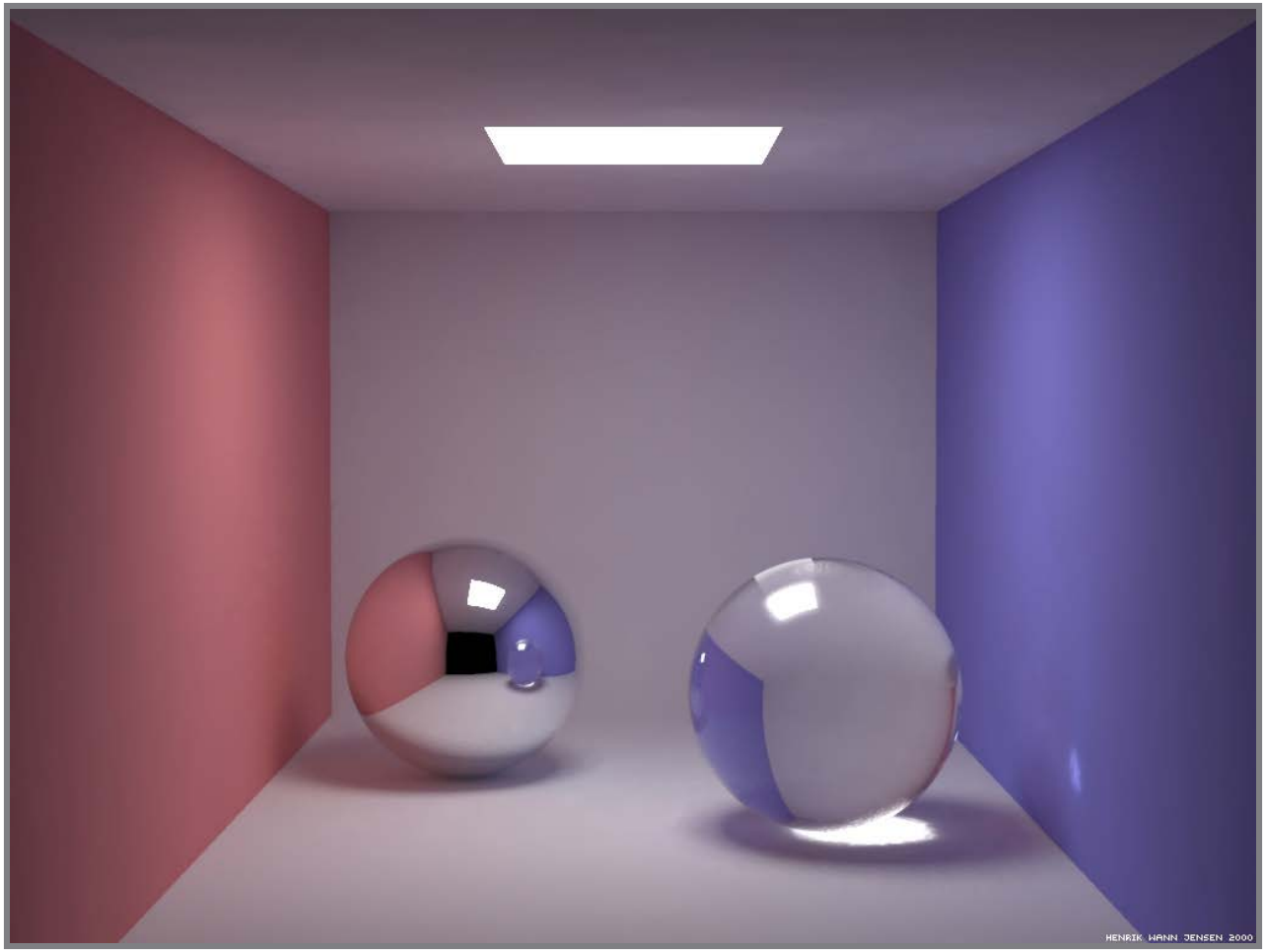
Path Types



+ caustics

Henrik Wann Jensen

Path Types



+ indirect diffuse illumination

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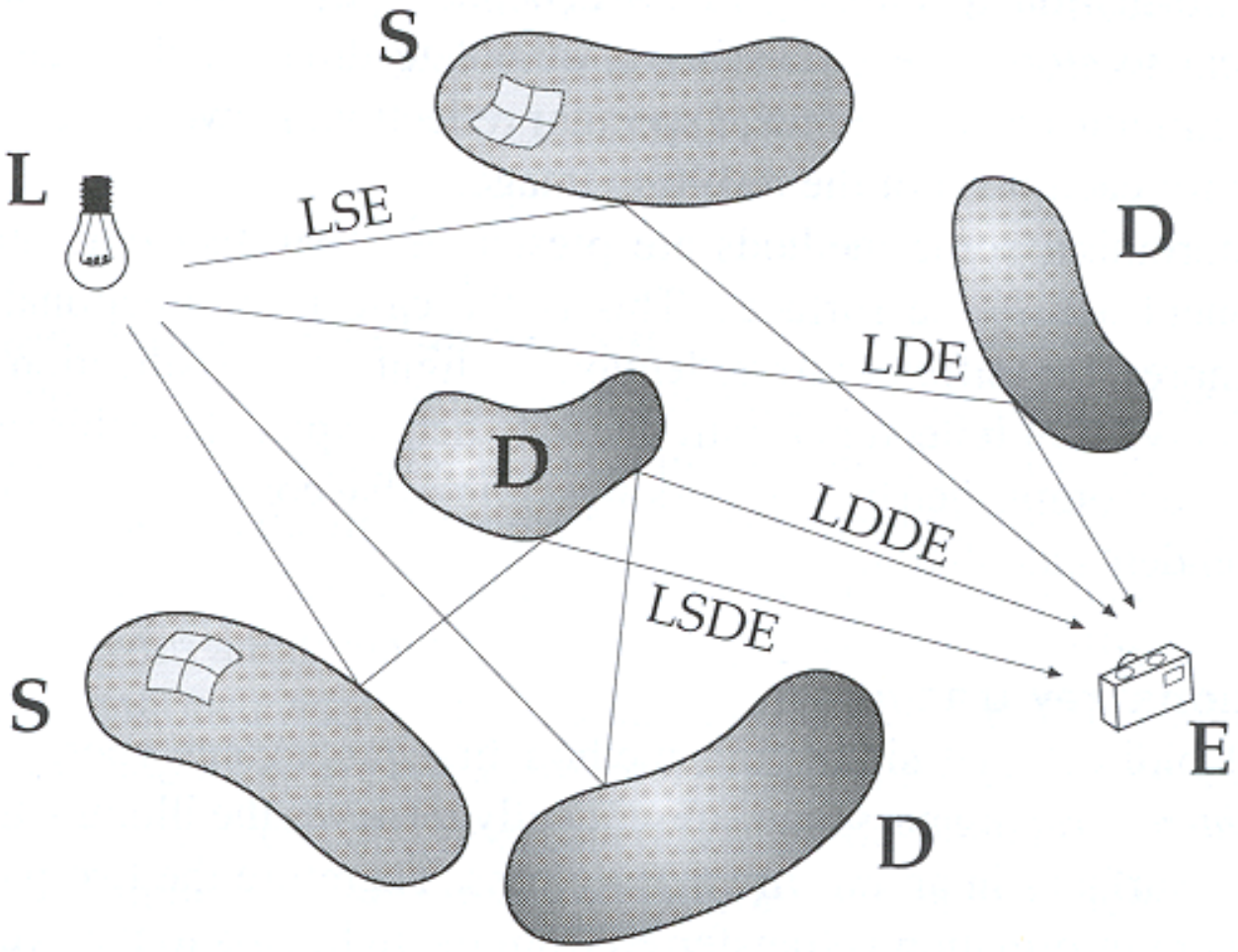
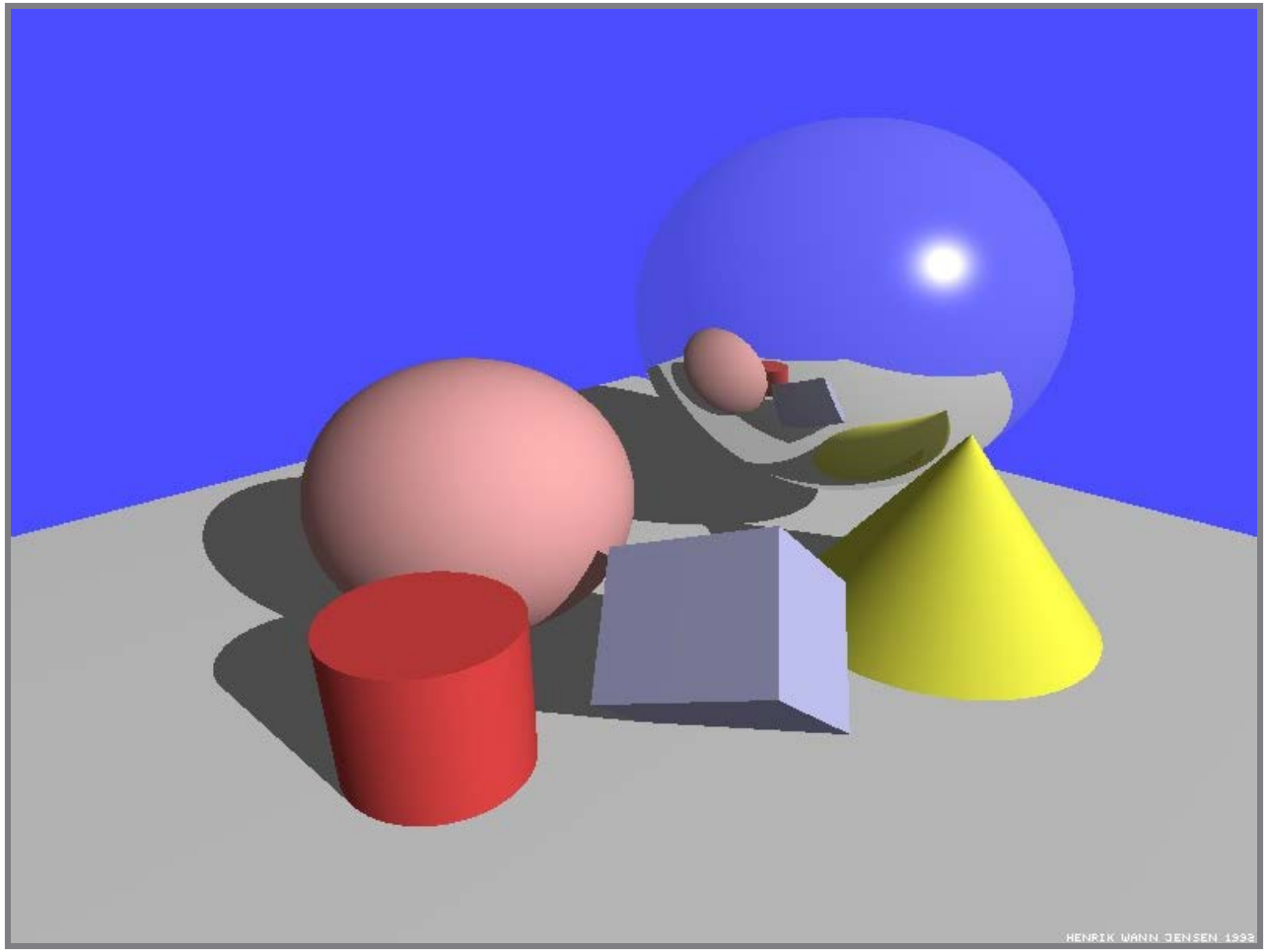
Path Types



Path Types?



Henrik Wann Jensen

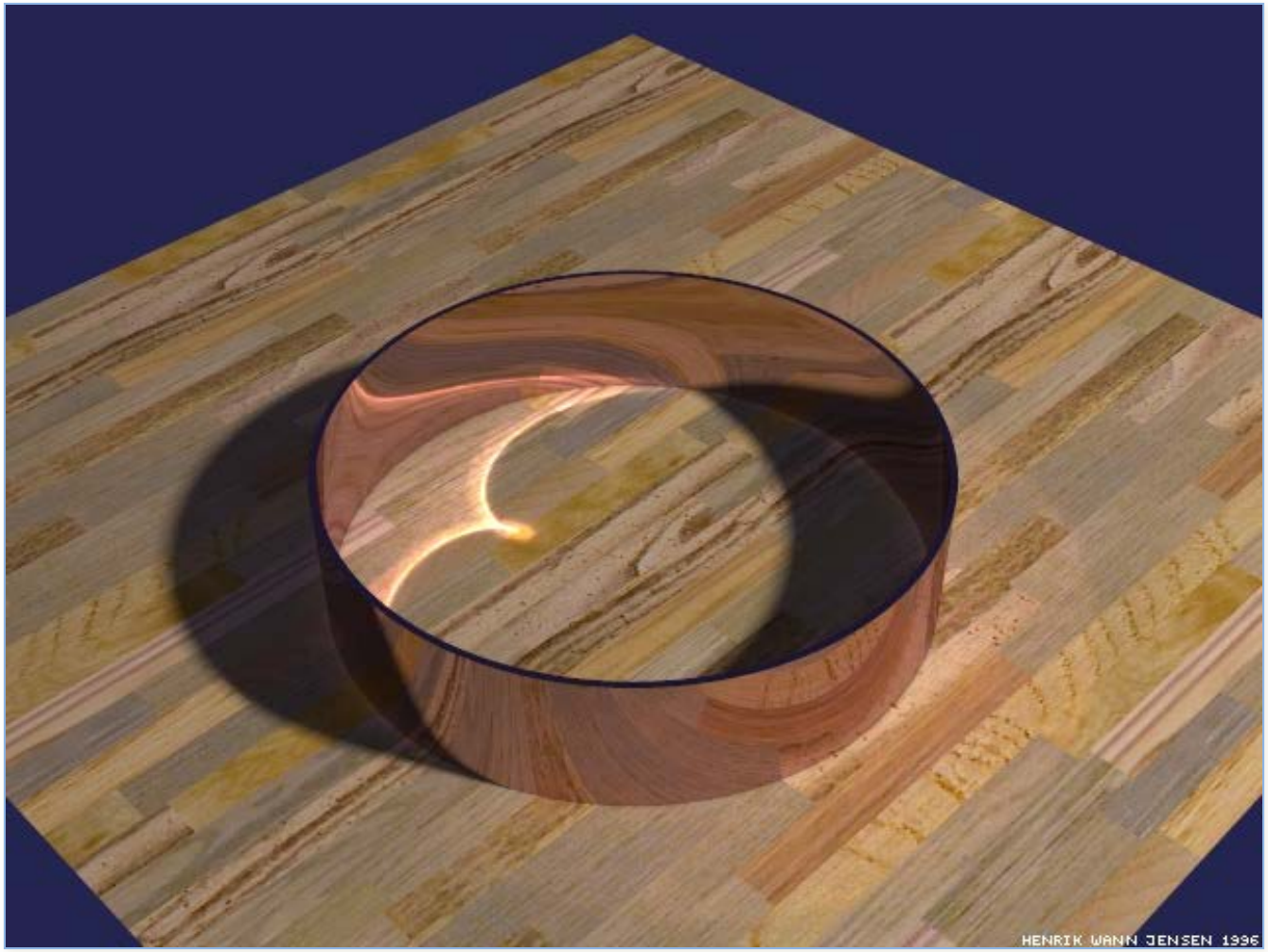
Path Types?

Herf

Path Types?

Paul Debevec

Path Types?



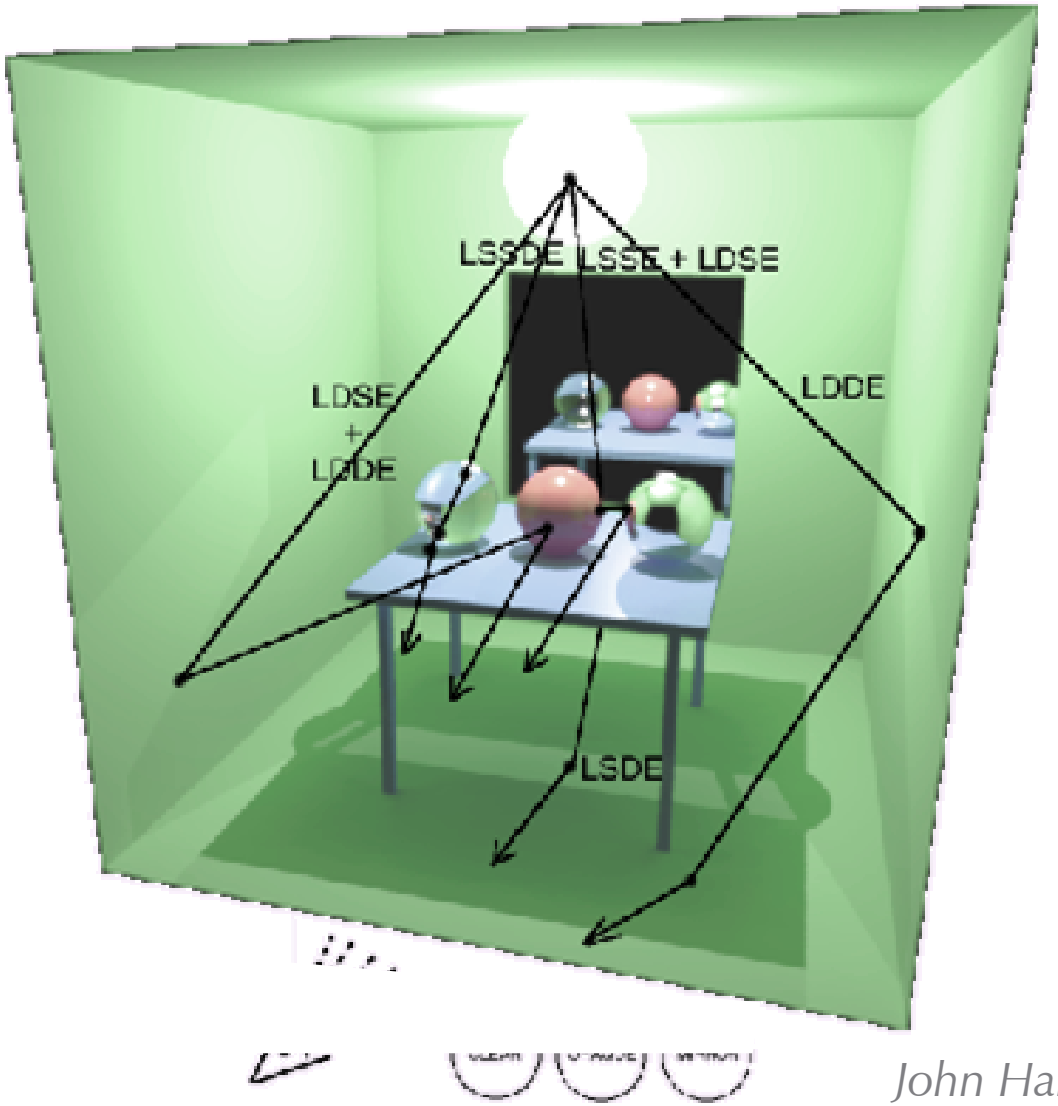
Henrik Wann Jensen

Path Types?

RenderPark

Rendering Methods – Path Types

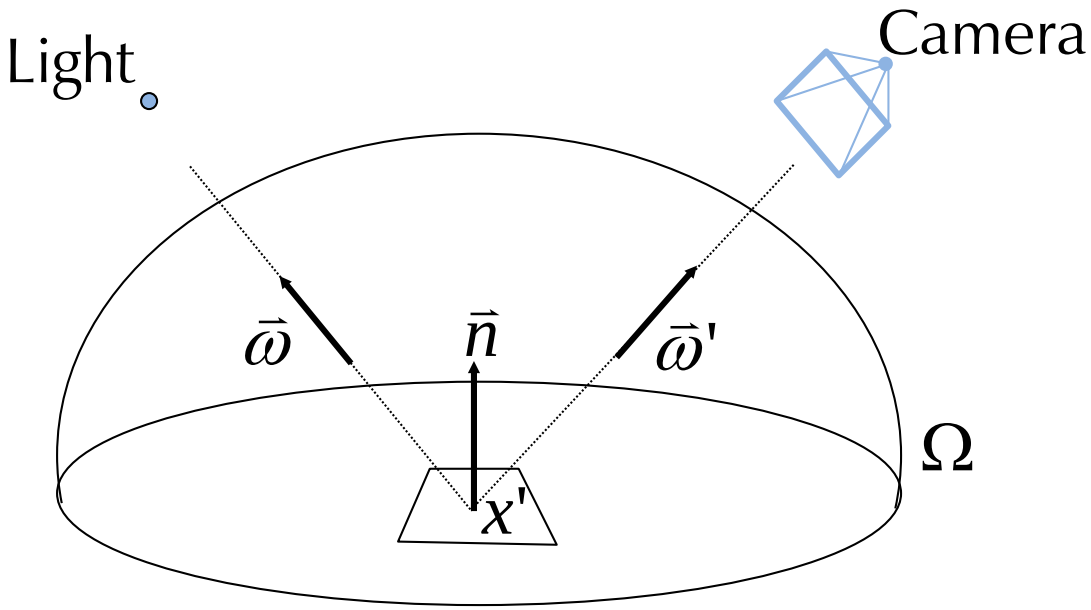
- OpenGL
  - LDE
- Ray tracing
  - LDS*E
- Path tracing
  - L(D|S)*E
- Radiosity
  - LD*E



OpenGL

$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \int_{\Omega} f_r(x',\vec{\omega},\vec{\omega}')L_i(x',\vec{\omega})(\vec{\omega}\bullet\vec{n})d\vec{\omega}$$

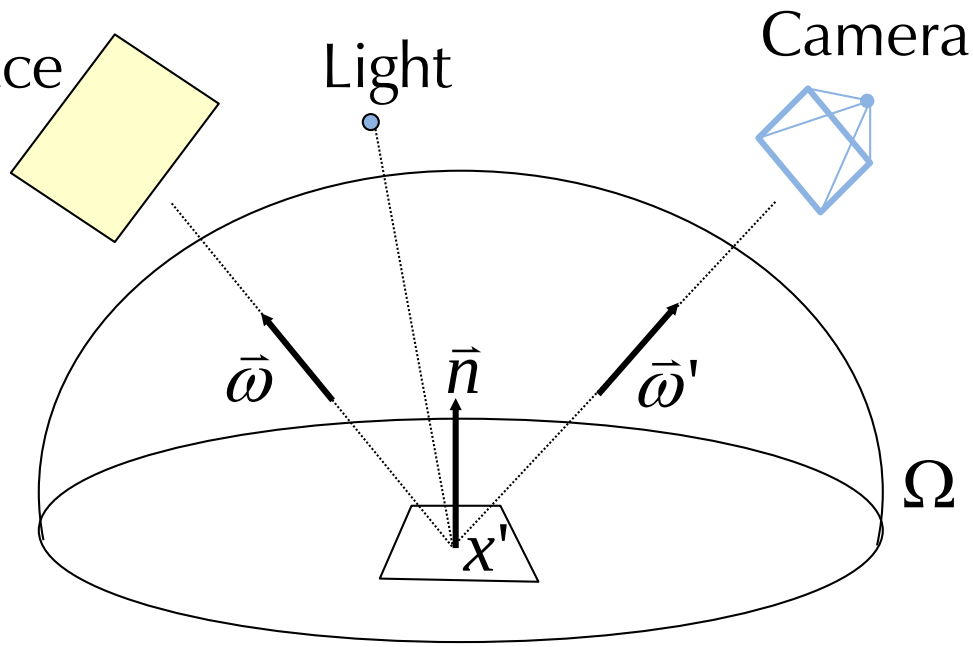
Assume direct illumination from point lights and ignore visibility



$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \sum_{i=1}^{nlights} f_r(x',\vec{\omega},\vec{\omega}')L_i(x',\vec{\omega})(\vec{\omega}\bullet\vec{n})$$

Recursive Ray Tracing

$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \int_{\Omega} f_r(x',\vec{\omega},\vec{\omega}') L_i(x',\vec{\omega})(\vec{\omega} \bullet \vec{n}) d\vec{\omega}$$



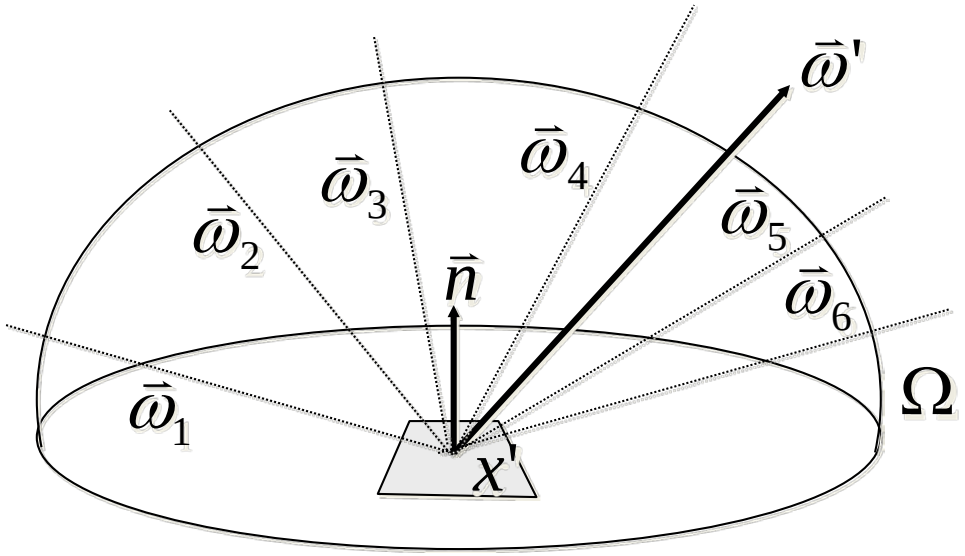
Assume only significant indirect illumination due to perfect specular reflection and refraction

$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \sum_{i=1}^{nlights} f_r(x',\vec{\omega},\vec{\omega}') L_i(x',\vec{\omega})(\vec{\omega} \bullet \vec{n}) + specular$$

Distribution Ray Tracing

$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \int_{\Omega} f_r(x',\vec{\omega},\vec{\omega}') L_i(x',\vec{\omega})(\vec{\omega} \bullet \vec{n}) d\vec{\omega}$$

Estimate integral for each reflection by random sampling

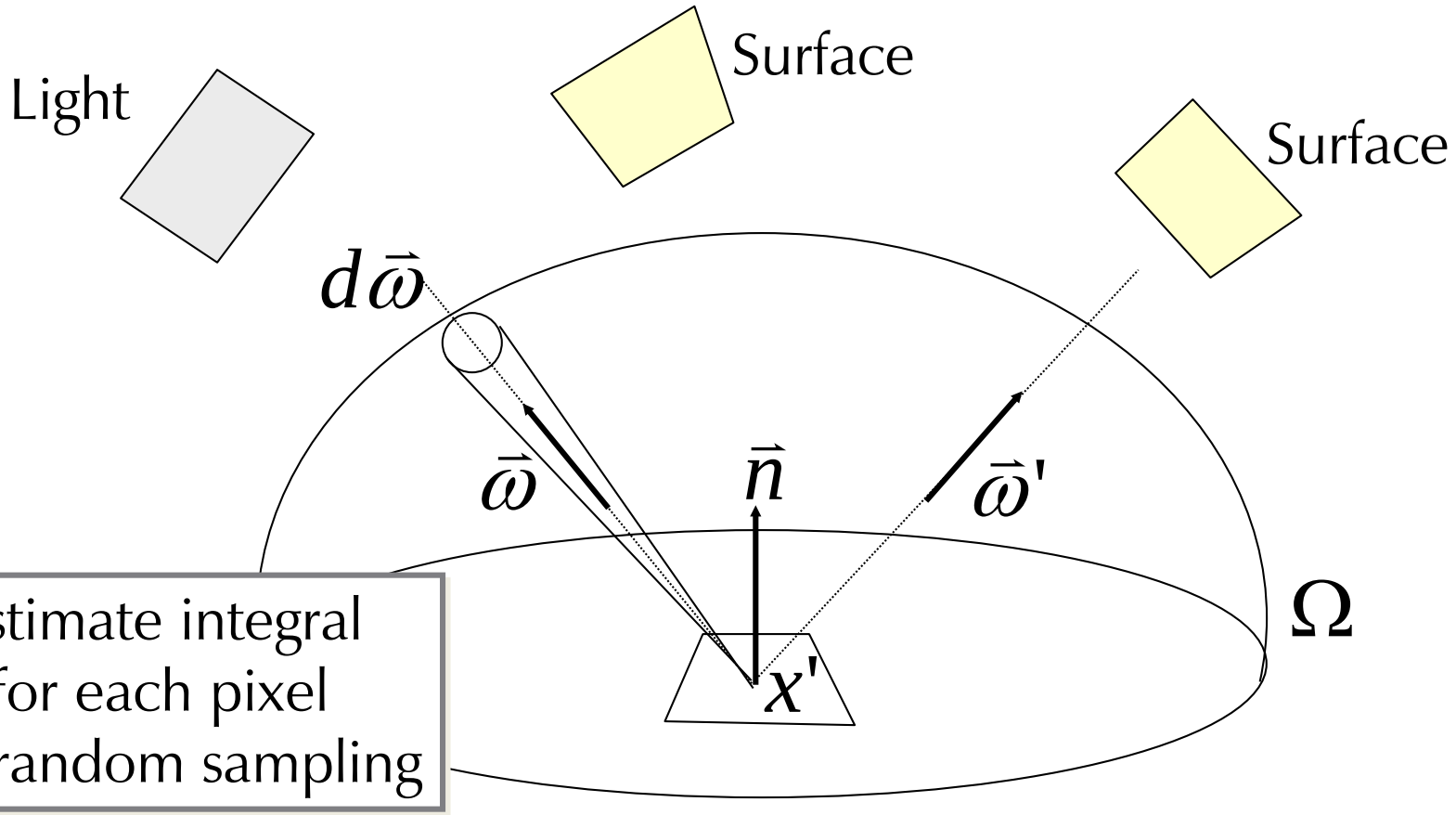


Also:

- Depth of field
- Motion blur
- etc.

Path Tracing

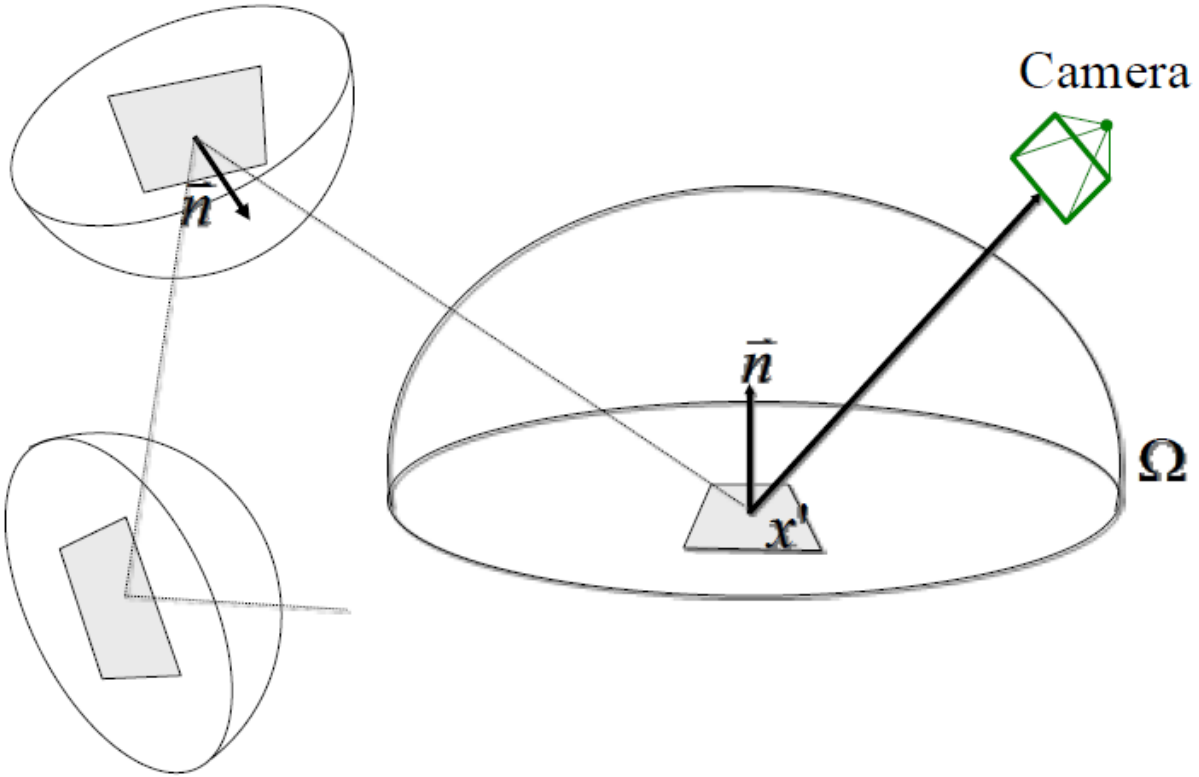
$$L_o(x',\vec{\omega}') = L_e(x',\vec{\omega}') + \int_{\Omega} f_r(x',\vec{\omega},\vec{\omega}') L_i(x',\vec{\omega})(\vec{\omega} \bullet \vec{n}) d\vec{\omega}$$



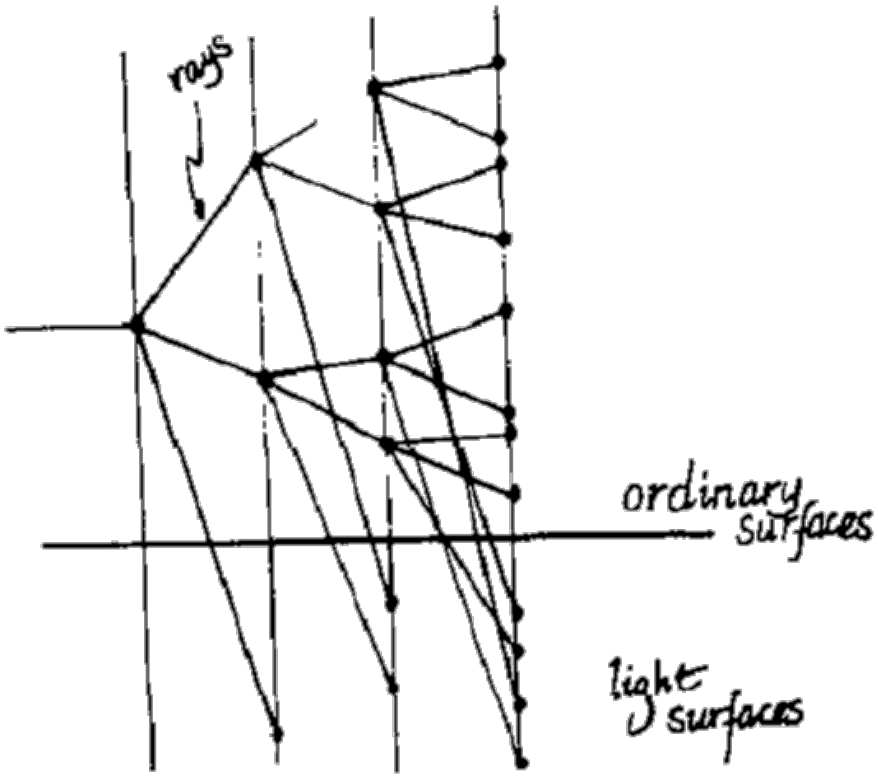
Estimate integral
for each pixel
by random sampling

Path Tracing

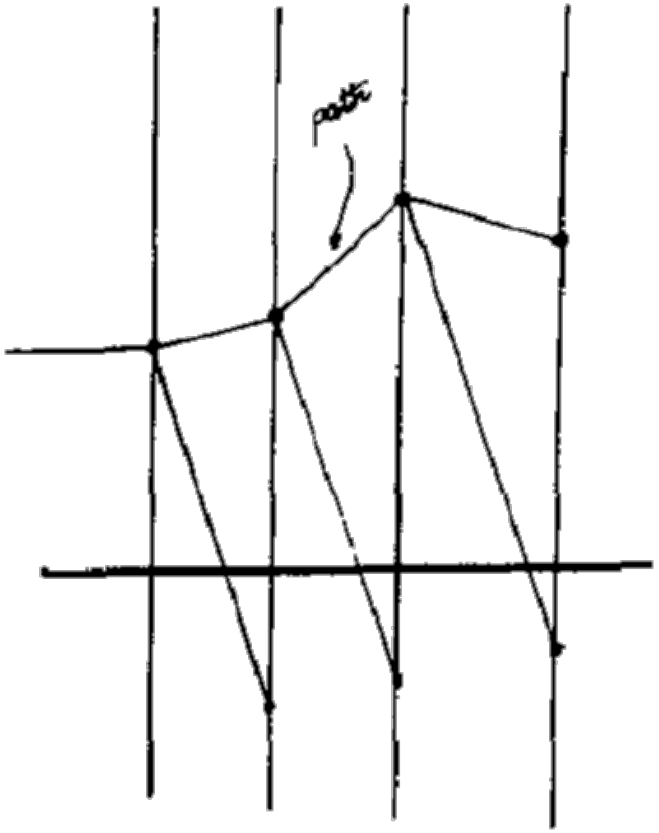
Estimate integral for each pixel by sampling paths from the camera



Ray Tracing vs. Path Tracing



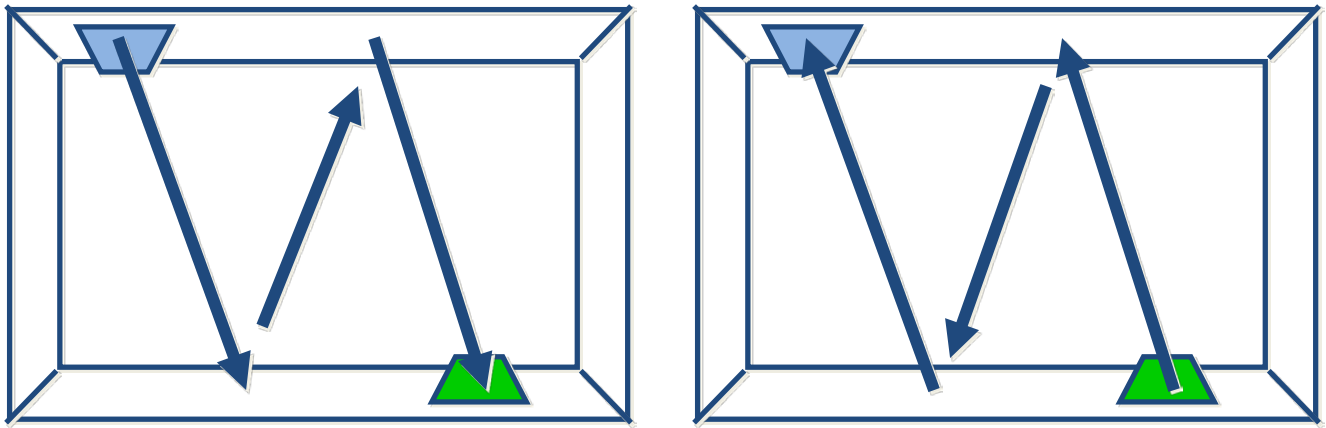
Ray tracing



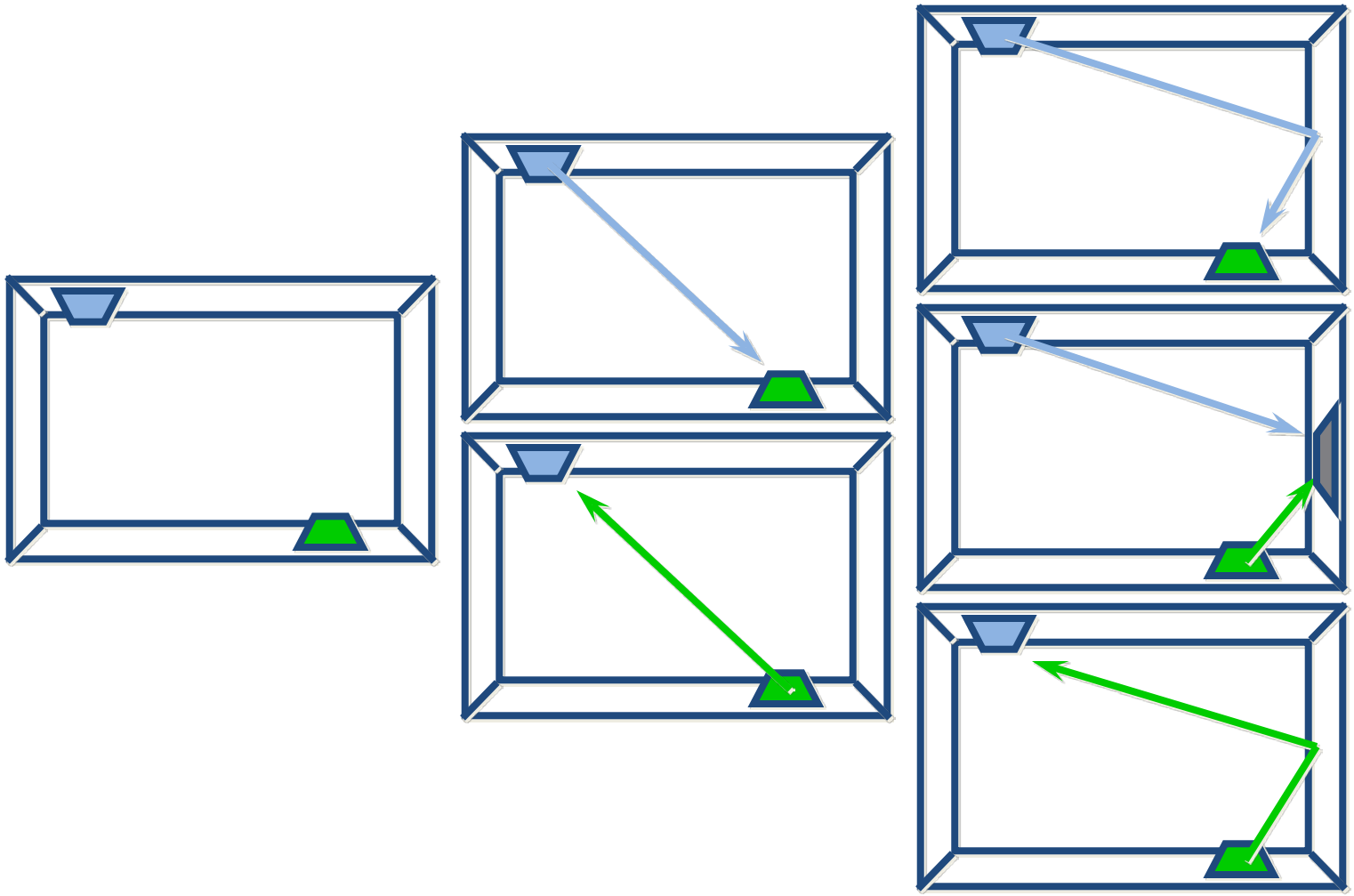
Path tracing

Bidirectional Path Tracing

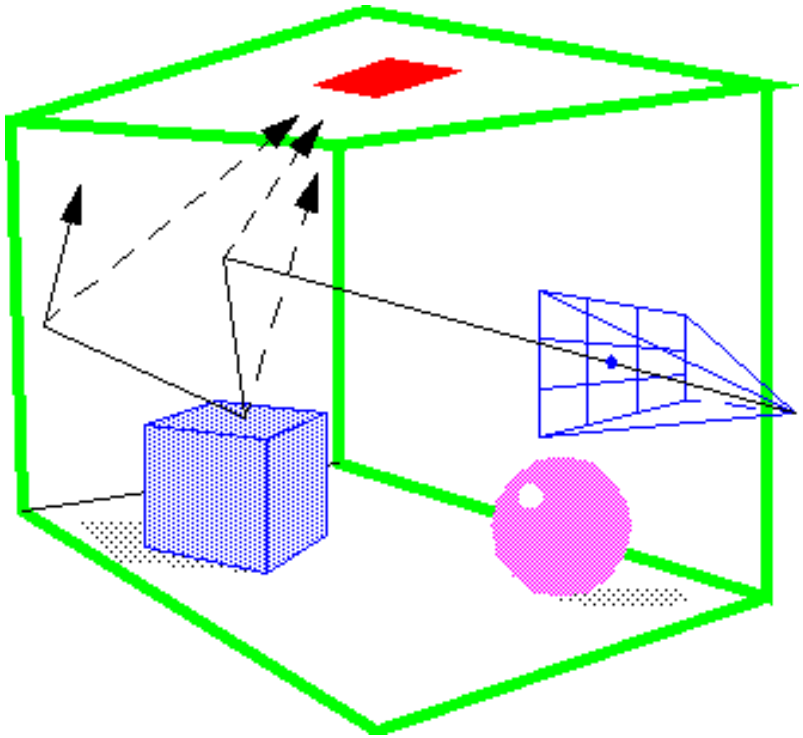
- Role of source and receiver can be switched, flux does not change



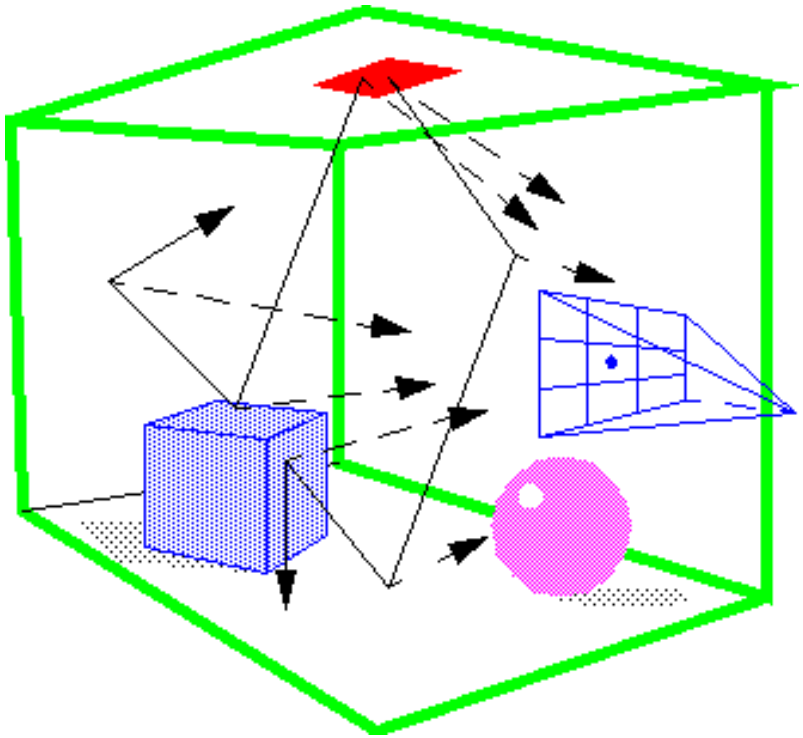
Bidirectional Path Tracing



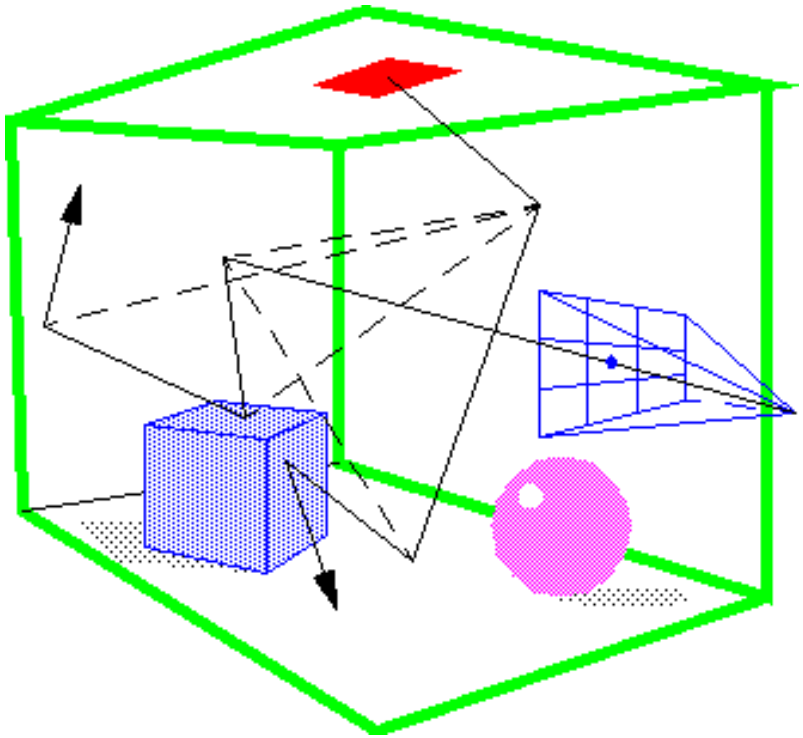
Tracing From Eye



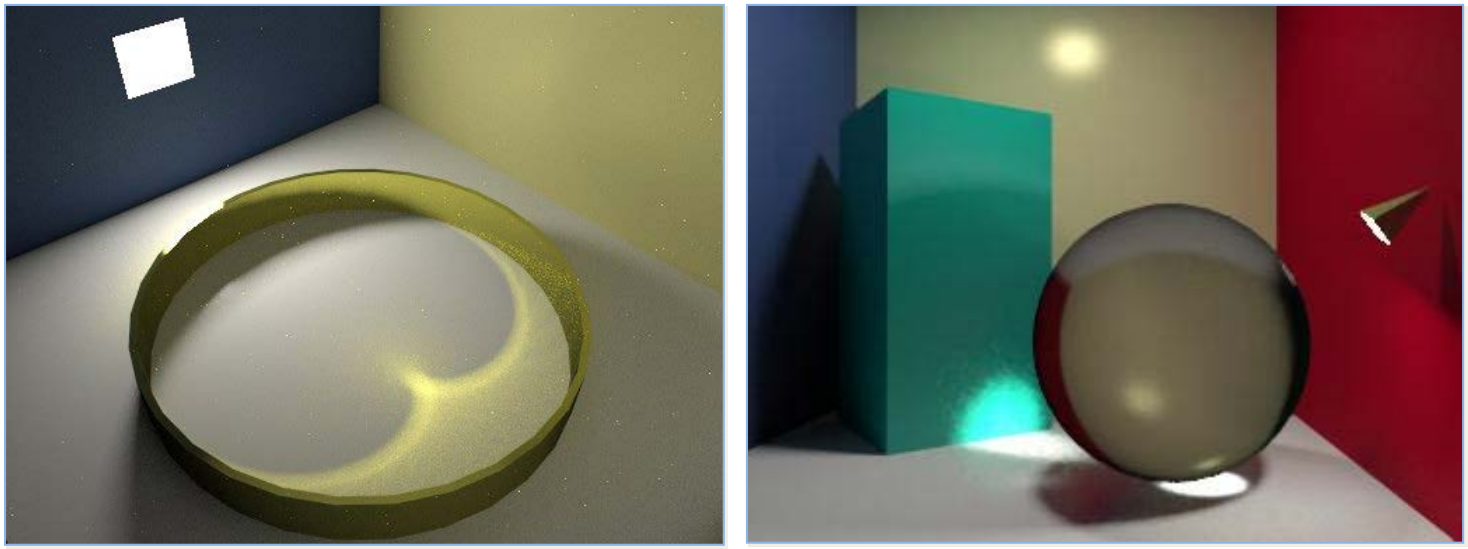
Tracing from Lights



Bidirectional Path Tracing



Bidirectional Path Tracing



(RenderPark 98)

Summary

- Global illumination
  - Rendering equation
- Overview of solution methods
  - OpenGL
  - Radiosity
  - Ray tracing
  - Distribution ray tracing
  - Path tracing