Conservative Rasterization and Raster Order Views

Rahul Sathe, Evgeny Makarov
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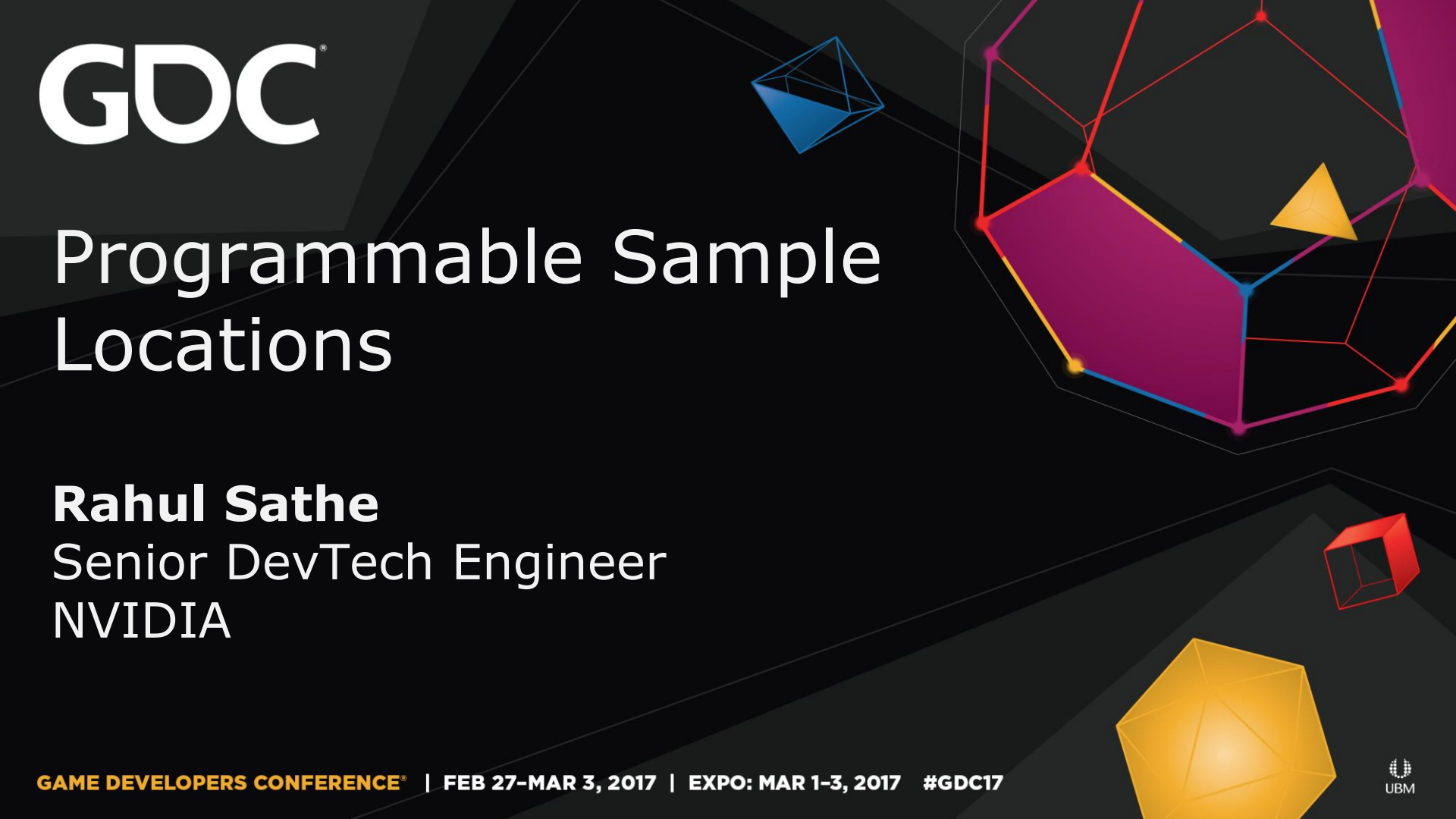
NVIDIA



Programmable Sample Locations

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Agenda

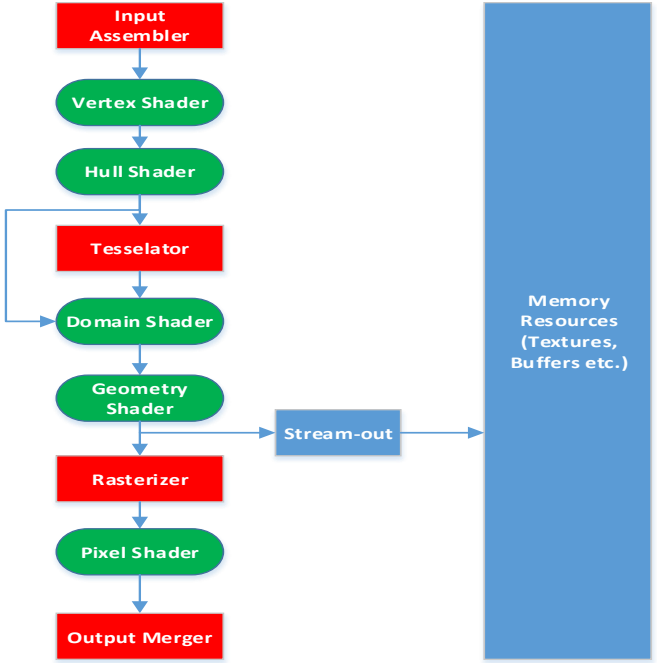
- Motivation: Programmable Sample Locations
- Rasterization Basics
- Conservative Rasterization
- Algorithm
  - Pull mode interpolation
- Clipper Issues and the work-arounds
- Temporal super sampling/TAA
- Future

Motivation

- Samples layout: Uniform Grid
  - Aliasing : Geometric, shader and texture
- Temporal super-sampling
  - Desired feature to tackle flickering
- Ray tracing requires richer sample patterns
  - Halton (2, 3), 0-2, Sobol Sequence etc.

Rasterization Basics

- Rasterizer
  - Fixed Function
- Rasterization:
  - Is P(x,y) inside



Rasterization Basics

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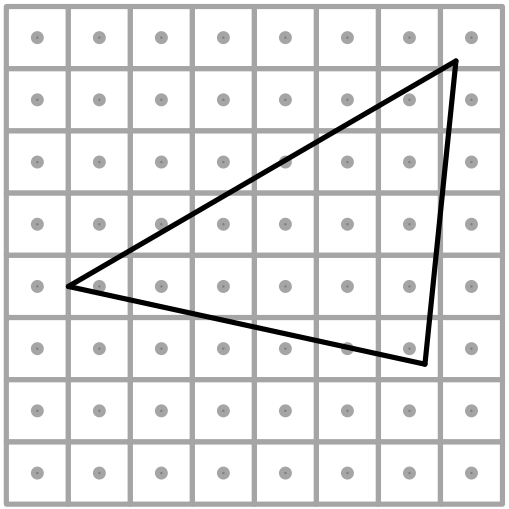

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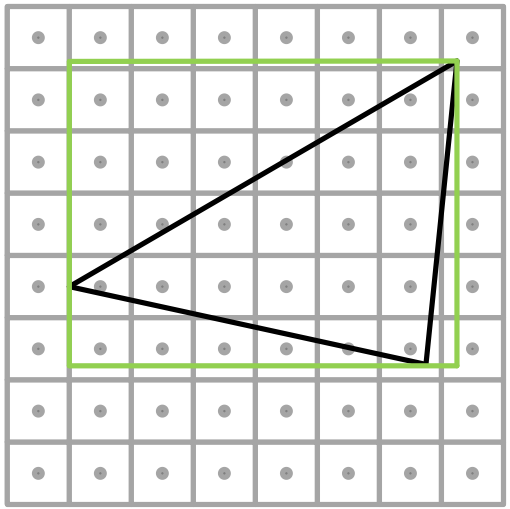

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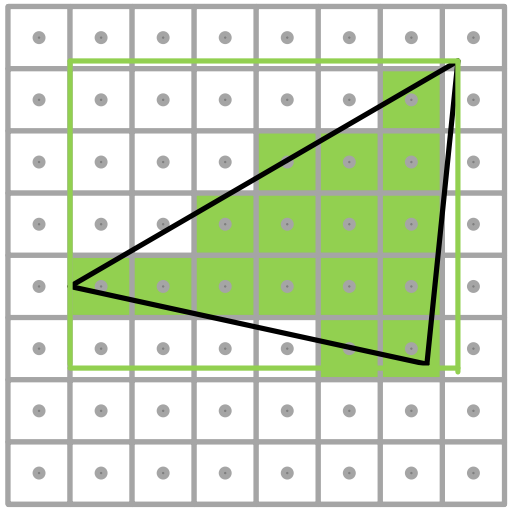

- Edge Equations in Screen Space
  - Ax+By+C < 0 : Inside
  - Ax+By+C > 0 : Outside
  - Ax+By+C = 0 : On the edge
- Top-left rule when on the edge
- Hierarchical rasterization

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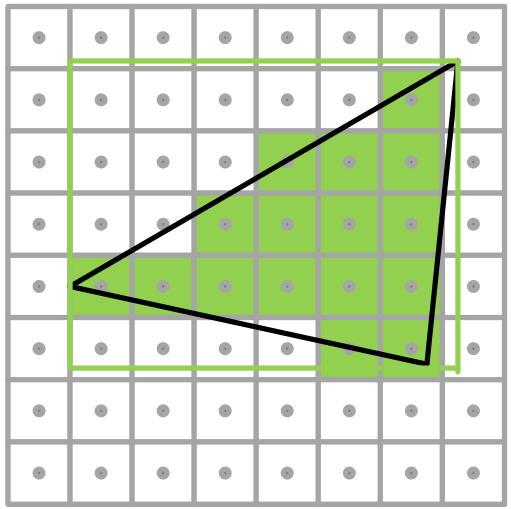

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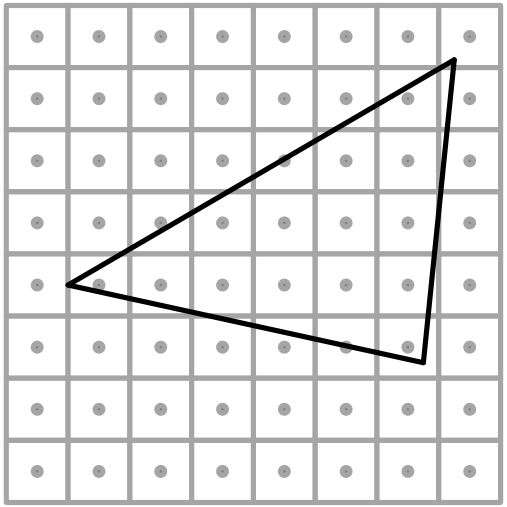

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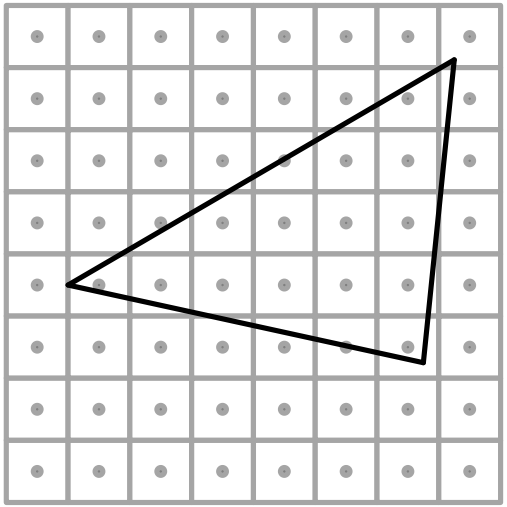
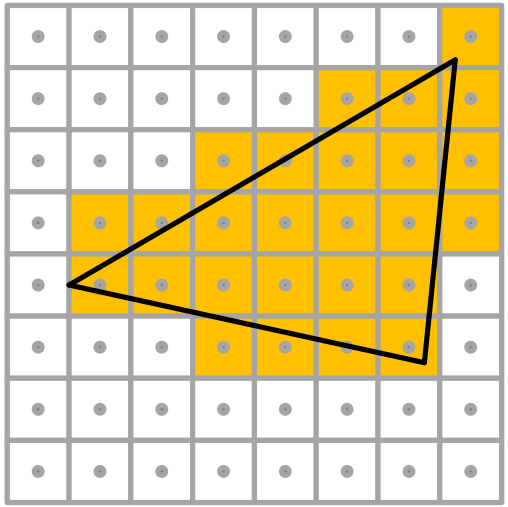


- Rasterizes pixels if their extents overlap the primitive
- Feature Level 12_1
- APIs : D3D12 and D3D11.3
- Tier 3 : SV_InnerCoverage

Conservative Rasterization



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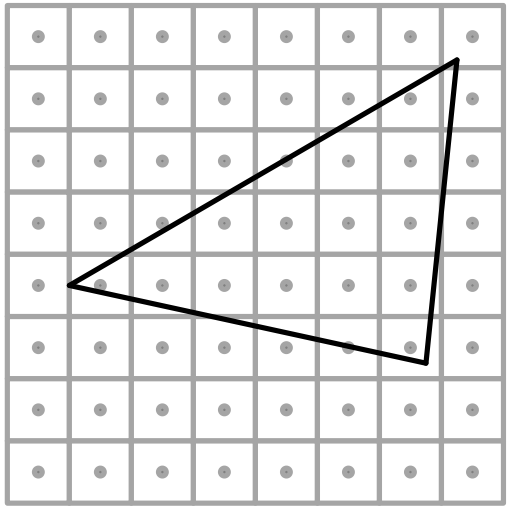

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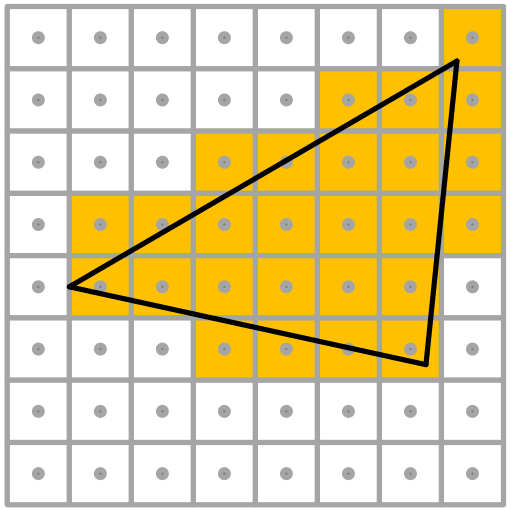

- GS
  - edge equations
- Conservative Rasterizer
- PS
  - Random offsets
  - If outside discard
  - If inside interpolate
  - Output the depth

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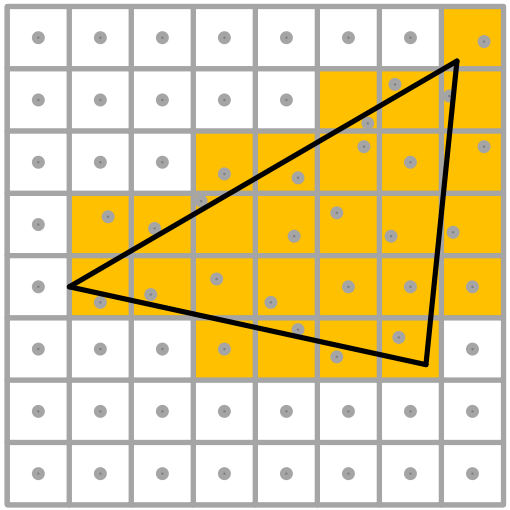

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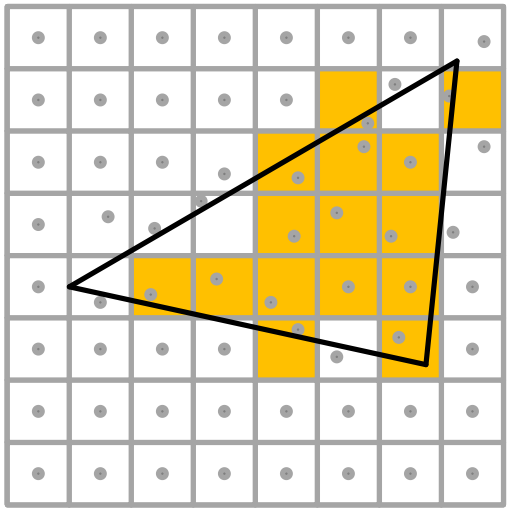

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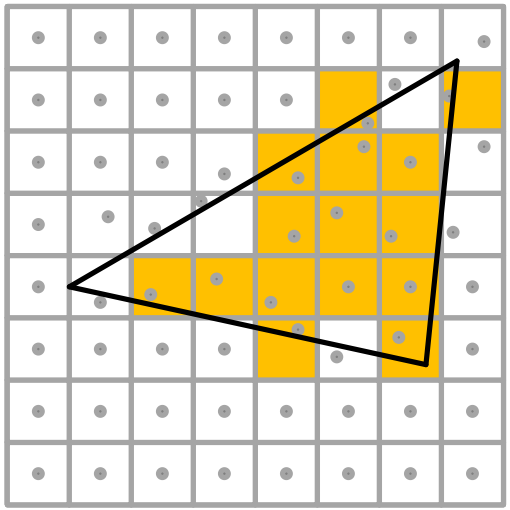

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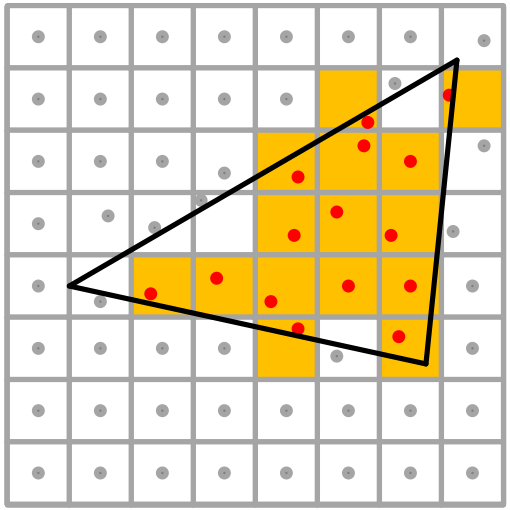

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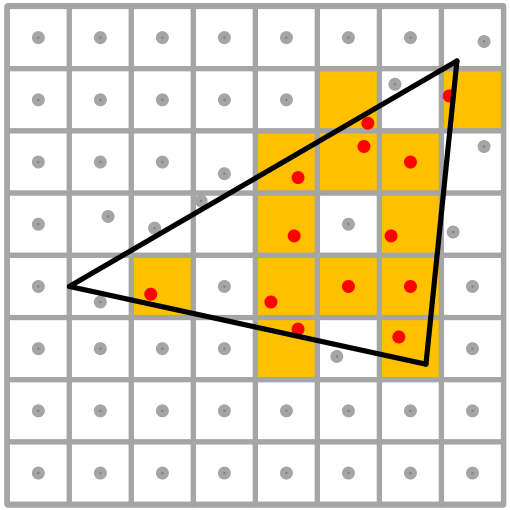

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Pull mode interpolation

- Interpolation is done in the shader
  - EvaluateAttributeAtCentroid
  - EvaluateAttributeAtSample
  - EvaluateAttributeSnapped
    - 16x16 possible discrete offsets

Other Interesting Details

- SV_Depth output forces the late Z/stencil
- Consistent offsets from a given viewpoint
- SampleCount > 1
  - PS should generate per sample output depth
  - Pass SV_SampleIndex as input to the PS

Clipper

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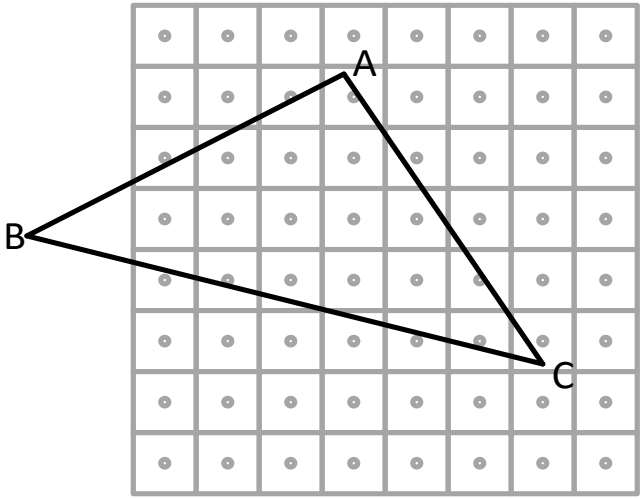

- Clips large triangles
- 1.f – (1.f – t) ≠ t
- Must use fixed point math
- But the GS sent the original triangle’s edge equations
- Pixels along shared edges get shaded multiple times

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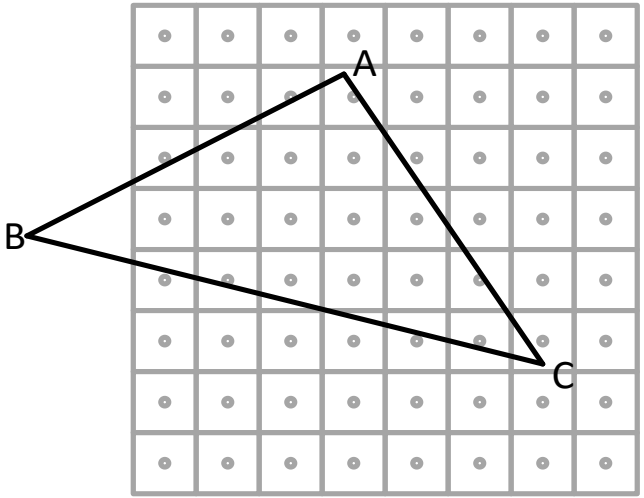

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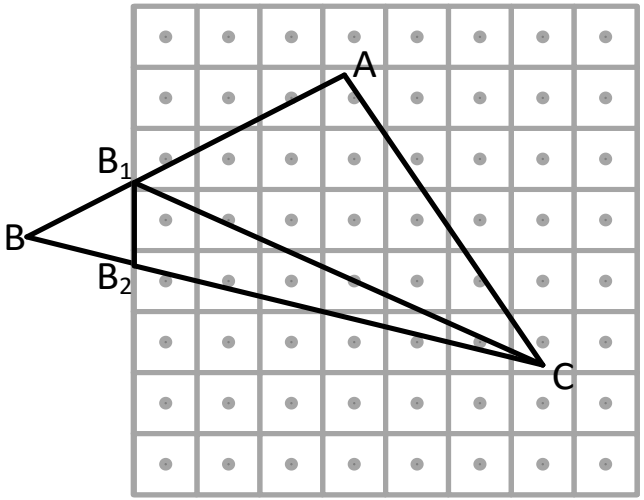

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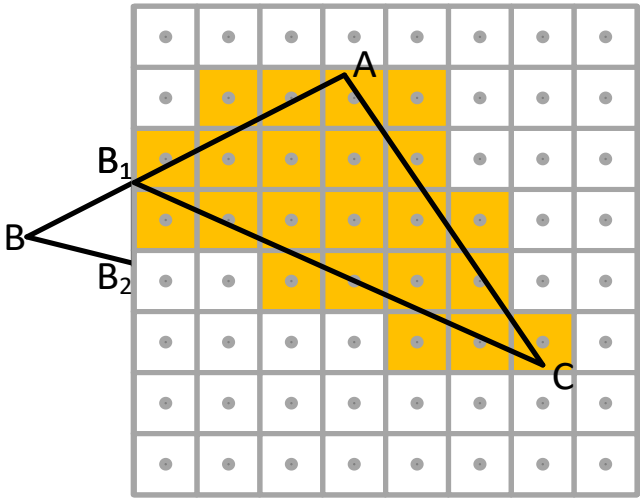

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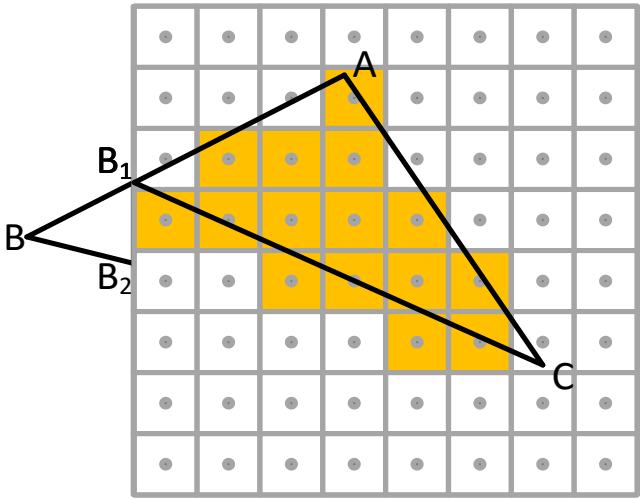

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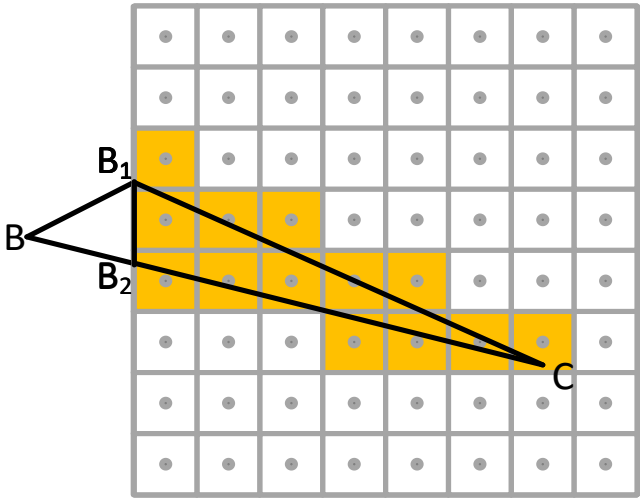

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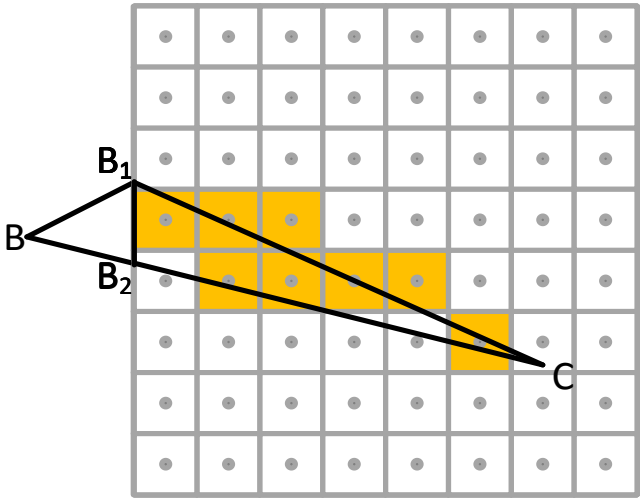

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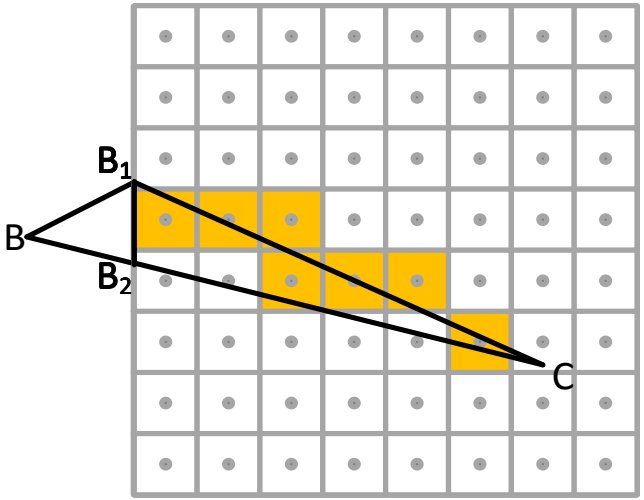

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- Similar to UAVs, but
- Impose API ordering

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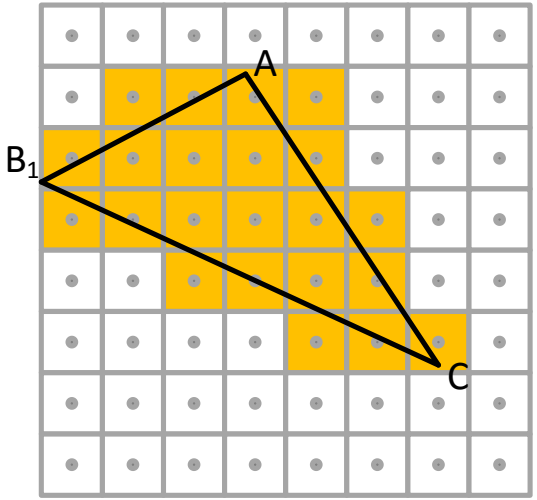

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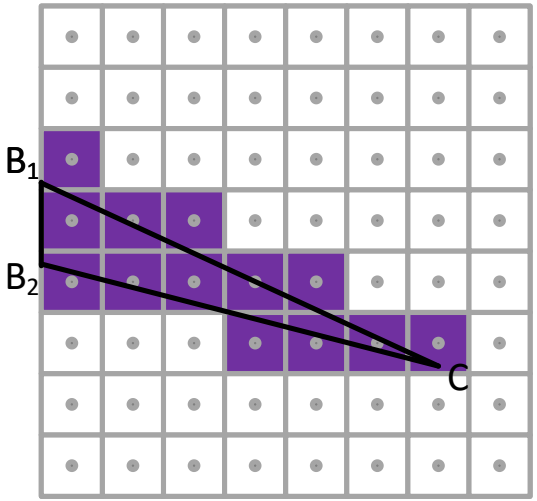

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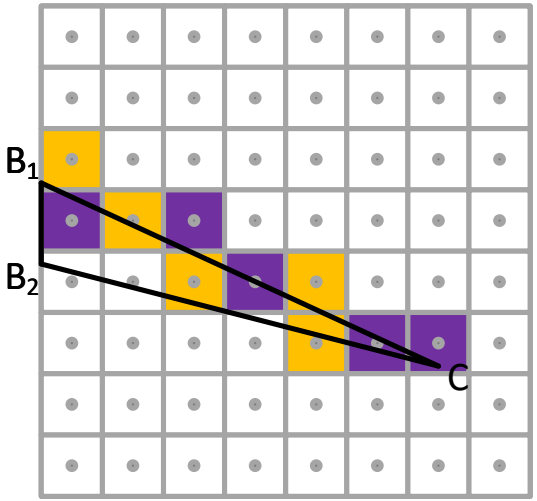

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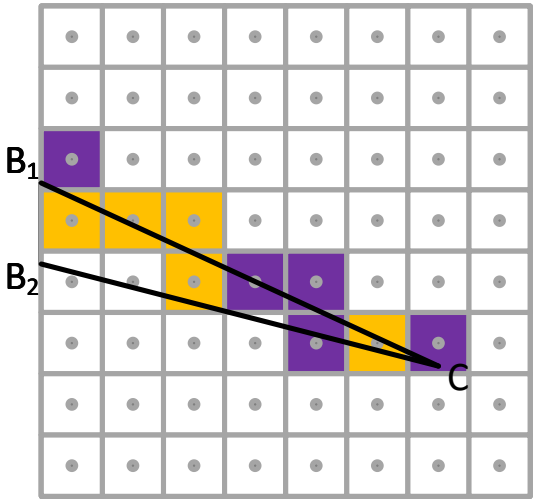

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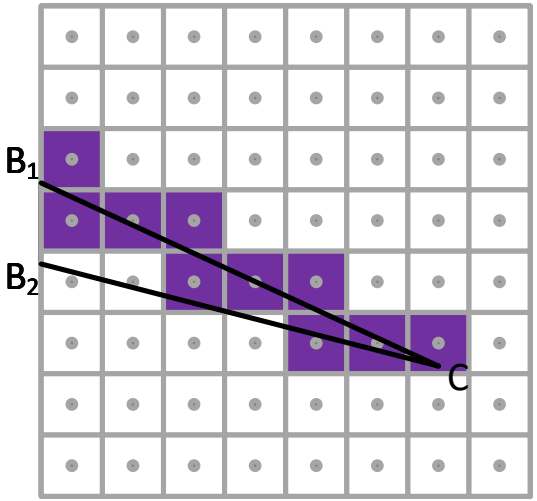

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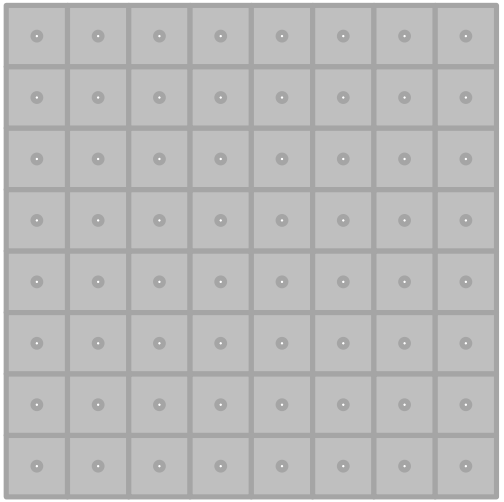
Handling clipped triangles



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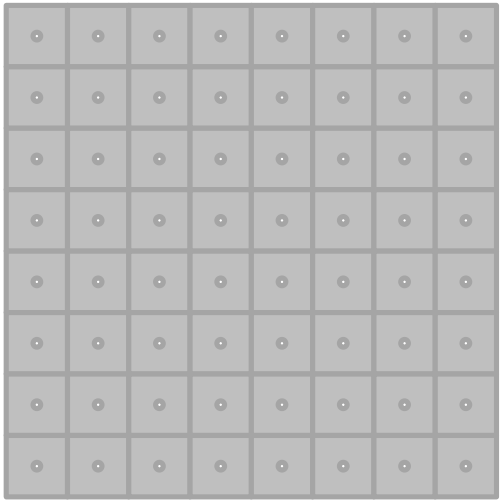

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- GS assigns primId
- PS

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} else
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- SV_Innercoverage

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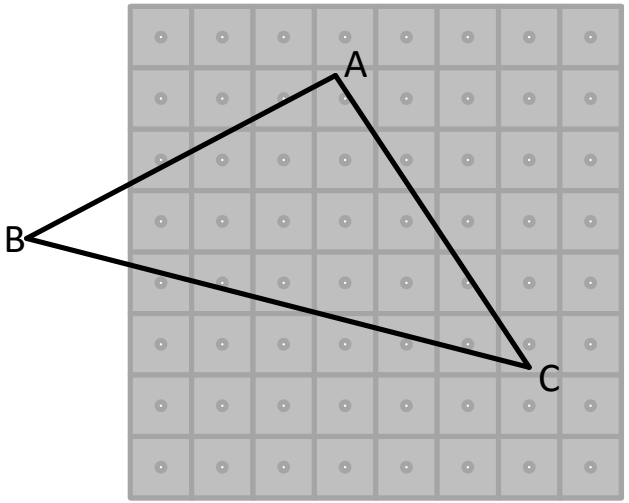

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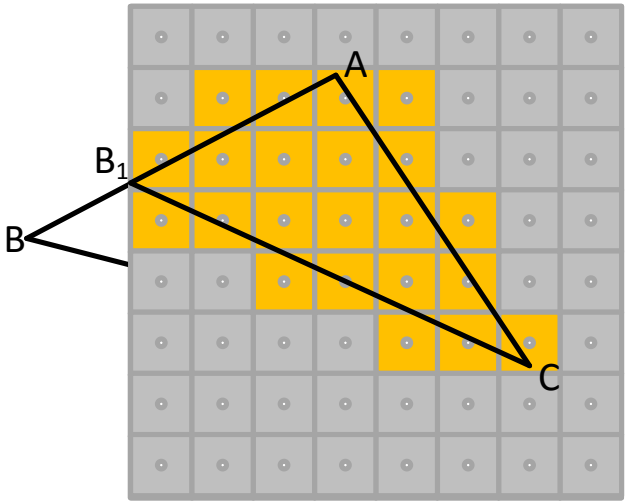

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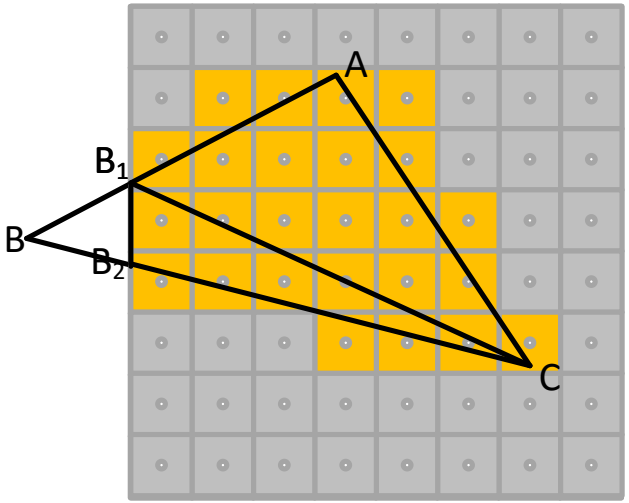

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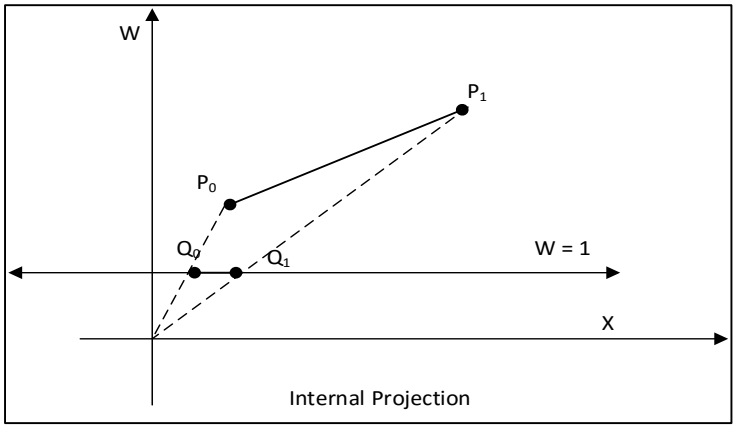
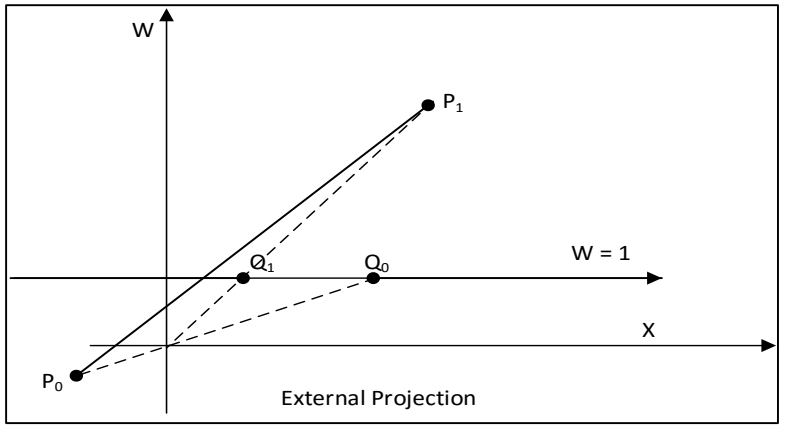
Clipping when w < 0

- Produces external projections on w=1
- Cannot use edge equations ☹





http://www.gamasutra.com/view/news/168577/Indepth_Software_rasterizer_and_triangle_clipping.php

Clipping when w < 0

Clipping when w < 0

- Clip against the front plane in the GS
  - Might produce inconsistent vertices
  - But they are on the same edge ➔ same coefficients
- When both the vertices are behind the eye
  - Mark as invalid edge
  - Skip in-out tests in the PS

Temporal Super-sampling

- Plays well with the Temporal AA
- Filter Weights must be calculated per pixel
- Rest of the algorithm stays same
- Tends to have less flickering

Future

- Avoid Geometry Shader and late Z/stencil
- Shade @ pixel rate when SampleCount > 1
- Foveated rendering

References

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Acknowledgement

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Q/A