# Leveraging web technologies for rapid visual debugging

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### **Debugging mesh problems**

#### State of the art

#### Need to locate the problem

- 1. Logging
  - Sprinkle printf statements throughout code
  - Compile, run, inspect, repeat, ..., [clean up]
- Vislt/Paraview
  - Load entire mesh / set of meshes
  - Filter, focus, render, ...
  - Tool might not support your new feature

Difficult and time consuming for users and developers



## Add lots of printf statements...

```
0:
                Side + id: <PolygonalRZSide 0x105ed7e0> 11108
0:
                Side vertices (R,L,z) (0.29750000000000,0.58000000000000)
                                                                                   (0.315000000000000, 0.5800000000000000)
                                                                                                                            (0.312812500000000,0.57...
                Side neighbors: 11270 11109 11111
0:
0:
          Fragment 12
                <C PolygonalRZTracerSurfaceFragment instance at 50e0ed1000000000 c TracerSurfaceFragmentTMCMeshRZTGeometry MeshBaseTGeometry RZ ...</p>
0:
0:
                Vertices:
0:
                        Vert 0: (0.328499997939130,0.572000000525481)
                                                                           Barvcentric: 0.804081422340462
0:
                        Vert 1: (0.314999998251136,0.579999996802077)
                                                                           Barycentric: 0.000000000000078
0:
0:
                Area -- computed: 0.031723893335204
                                                           -- analytic from verts: 0.031723893335204
                Length -- computed: 0.015692352659859
                                                           -- analytic from verts: 0.015692352659859
                Side + id: <PolygonalRZSide 0x105cea80> 11109
0:
0:
0:
0:
                Area -- computed: 0.000000002127504
                                                           -- analytic from verts: 0.000000002127504
0:
                Length -- computed: 0.00000001030755
                                                           -- analytic from verts: 0.00000001030755
0:
                Side + id: <PolygonalRZSide 0x10eedd50> 11110
0:
                Side vertices (R,L,z)
                                         (0.328500000000000, 0.5720000000000000)
                                                                                   (0.310250000000000,0.57200000000000 (0.312812500000000,0.5760000000...
0:
                Side neighbors: 10948 11111 11109
0:
        Sorted verts:
0:
                0.0 (0.3150000028069416, 0.5799999985408756) Frags: [2]
0:
                2.77567624633e-14 (0.3150000057225042, 0.5799999985408755) Frags: [0, 2]
0:
                7.76450475364e-14 (0.3149999982511359, 0.579999996802077) Frags: [11, 12]
0:
                1.00054413663e-13 (0.31499999741255247, 0.5799999972990151) Frags: [11]
                0.80408142234 (0.32849999793912954, 0.5720000005254811) Frags: [12]
0:
                0.80408142234 (0.3284999979391296, 0.5720000005254811) Frags: [13]
0:
```

## ... search for connectivity information

```
0:
                Side + id: <PolygonalRZSide 0x105ed7e0> 11108
                Side vertices (R,L,z) (0.29750000000000,0.58000000000000)
                                                                                   (0.315000000000000, 0.5800000000000000)
                                                                                                                            (0.312812500000000, 0.57...
0:
                Side neighbors: 11270 11109 11111
0:
0:
          Fragment 12
                <C PolygonalRZTracerSurfaceFragment instance at 50e0ed1000000000 c TracerSurfaceFragmentTMCMeshRZTGeometry MeshBaseTGeometry RZ ...</p>
0:
0:
                Vertices:
0:
                        Vert 0: (0.328499997939130,0.572000000525481)
                                                                           Barvcentric: 0.804081422340462
0:
                        Vert 1: (0.314999998251136,0.579999996802077)
                                                                           Barycentric: 0.000000000000078
0:
0:
                Area -- computed: 0.031723893335204
                                                           -- analytic from verts: 0.031723893335204
                Length -- computed: 0.015692352659859
                                                           -- analytic from verts: 0.015692352659859
0:
                Side + id: <PolygonalRZSide 0x105cea80> 11109
0:
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0:
0:
                Area -- computed: 0.000000002127504
                                                           -- analytic from verts: 0.000000002127504
                                                           -- analytic from verts: 0.00000001030755
0:
                Length -- computed: 0.00000001030755
0:
                Side + id: <PolygonalRZSide 0x10eedd50> 11110
0:
                Side vertices (R,L,z)
                                         (0.328500000000000, 0.572000000000000)
                                                                                   (0.310250000000000,0.57200000000000 (0.312812500000000,0.5760000000...
0:
                Side neighbors: 10948 11111 11109
0:
        Sorted verts:
0:
                0.0 (0.3150000028069416, 0.5799999985408756) Frags: [2]
0:
                2.77567624633e-14 (0.3150000057225042, 0.5799999985408755) Frags: [0, 2]
0:
                7.76450475364e-14 (0.3149999982511359, 0.579999996802077) Frags: [11, 12]
0:
                1.00054413663e-13 (0.31499999741255247, 0.5799999972990151) Frags: [11]
                0.80408142234 (0.32849999793912954, 0.57200000005254811) Frags: [12]
0:
                0.80408142234 (0.3284999979391296, 0.5720000005254811) Frags: [13]
0:
```

...

```
Totals: 2231489 244942 9.11
                                                                                                                                                                                                                                                              Generating IA data structure... (took 0.024300 seconds.)
There are 16001 vertices, 47616 edges and 31616 triangles.
Comparing the two representations...
   Generating Diamond data structure... relation file loc is: ../tables/labels20.cmy
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *** Closing file.
Imported mesh: ../models/bais_2k_0.0000.trl with 2231489 vertices, and 6458219
triangles
                                                                                                                                                                                                                                                              Shortest edge is: Edge Vertices:
[0]:Index: 1189 Coordinates: (252,260,7.44445) Associated triangle: 972
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     0:
computed: 0.024250000000000
                                                                                                                                                                                                                                                         with length: 2
1: SDI2
2: 22208 (07.98278 of total; 32.1573 cumulative)
(07.98278 of total; 180 cumulative)
//wettopsus
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Vertices:
                                                                                                                                                                                                                                                            chistogram type='Diamond ET'>
Details of histogram:

1:384 (0.80663% of total; 0.80663 comulative)

2:4722; 180 (0.80663% of total; 0.80663 comulative)
Averaged in the comulative of total; 180 comulative)
Averaged comulative of total and total an
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             Ama - computed:

.03172889335204 -- analytic from verts: 0.03172389335204 -- length -- length -- length -- analytic from verts: 0.0160325269859 -- analytic from verts: 0.0160325269859 -- Side + 16:
Level: Size | Sucket count (max) | load factor (mon zero lf) | max lf
e: 1 ···|·· 17 (1) ···|·· 0.6588285 (1) ···|·· 1
1: 1 ···|·· 17 (1) ···|·· 0.6588285 (1) ···|·· 1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        olygonal#25ide @x111f42b@> #3
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             *** diamond stats
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             Area - computed:
.83172389335304 -- analytic from verts: 0.83172389335304 -- legth -
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         PolygonalRZSide @x105cea80> 11100
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                lygonal8251de 0x10eedd50> 11110
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     0:
Frags: [0, 3]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     u:
0.492) Frags: [2, 3]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 1.0 (0.95, 0.5)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         8:
18948 11111 11309 Sorted verts:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     0:
0.492) Frags: [1, 2]
                                                                                                                                                                                                                                                              :
8.3158888828868416. 0.579999985488756) Frags: [2]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             r:
:PolymonalRZSide 0x105cea80> 11109
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           8.35499999741355367, 8.5799999972998155) Frags: [15] 8.38489542234
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0.00000002127504 -- analytic from verts: 0.00000002127504 b:
Length -- computed: 0.000000001030755 -- analytic from verts: 0.000000001030755 b:
Side + 1d:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (0.315000021000115, 0.75000001600175) Frage: [2]
(0.315000007225042, 0.75000000500175) Frage: [0, 2]
(0.315000001251350, 0.75000006002077) Frage: [11, 12]
(0.316000001251350, 0.75000006002077) Frage: [11, 12]
(0.31600001251350, 0.75000006002077) Frage: [11, 12]
 chistogram type="Diamond ET">
Details of histogram:

1:384 (0.86652% of total; 0.886652 comulative)

Norage cordinality is: 1.9928 (60.2920% of total; 200 comulative)
Norage cordinality is: 1.9928 (
                                                                                                                                                                                                                                                                B:
:PolygonalRZSide BxiBeeddSB> 1111B
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 <snip 500K
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf lines>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      chistogram type='18.ET'>
Details of histogram:
(8.886452% of total; 8.886452 comulative)
21.2222
(98.9352% of total; 388 comulative)
Amerage cardinality is: 1.99394 (out of a total 49414)
(vihitogram)
                                                                                                                                                                                                                                                              (0.3150808057225042, 0.579909096588255) Frage: [0, 2]
0: 7.76450475364e-14
(0.3140909082513159, 0.579909096802877) Frage: [11, 12]
0: 1.080545366e-13
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               .31499999741255247, 0.5799999972998151) Frags: [11]
                                                                                                                                                                                                                                                            chistogram type="diamond ET";
Devails of histogram:
(0.806652 of total; 0.806652 comulative)
2: 4722 (06.95055 of total; 380 comulative)
//wherege cardinality is: 1.90204 (out of a total 47614)
//histograms
   Mesh has: 1425 supercube vertices, and 4394 supercube diamonds.
                                                                                                                                                                                                                                                         Chickegram type: 'Giasod wertex depths' )
Details of biologram:

(00.0568 of total; 00.0556 camulative)

1: 64 (0.15008 of total; 00.058 camulative)

1: 64 (0.17008 of total; 00.058 camulative)

Finding the sin and max depth and total conductive)

Finding the sin and max depth and their EX relations for Diamond structure...

(00.000 0.00100.000 camulative)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             *** Counting number of triangles
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Chitagram types "Elamond VI")

World of Villageau.

Facility of Villageau.

1: 28 (6.8802766 of test); 8.090036 comistive)

1: 28 (6.8802766 of test); 8.090036 comistive)

1: 10814 (4.80276 of test); 8.090036 comistive)

1: 10404 (4.80276 of test); 8.090036 comistive)

1: 10404 (4.80276 of test); 8.0900 comistive)

1: 10404 (4.80276 of test); 8.0900 comistive)

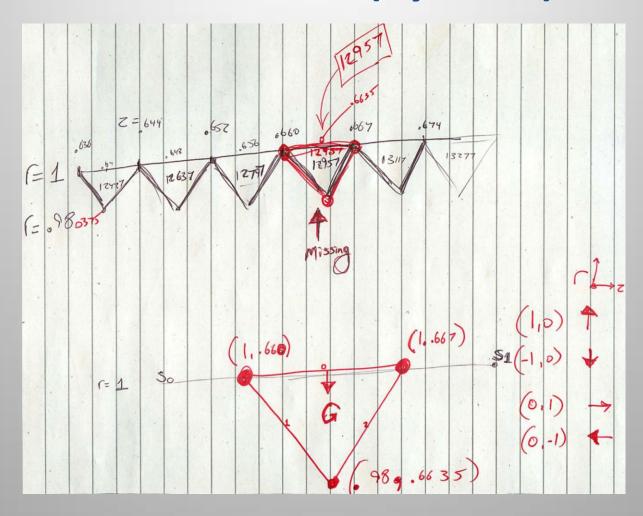
1: 10406 (7.80276 of test); 8.0900 comistive)

American confidently in: 5.9006 (out of a test); 8.0000 comistive)
                                                                                                                                                                                                                                                         Longest edge is: Gap on vertex: ((128,18), (136,24))
with length 1882 15 K relation:

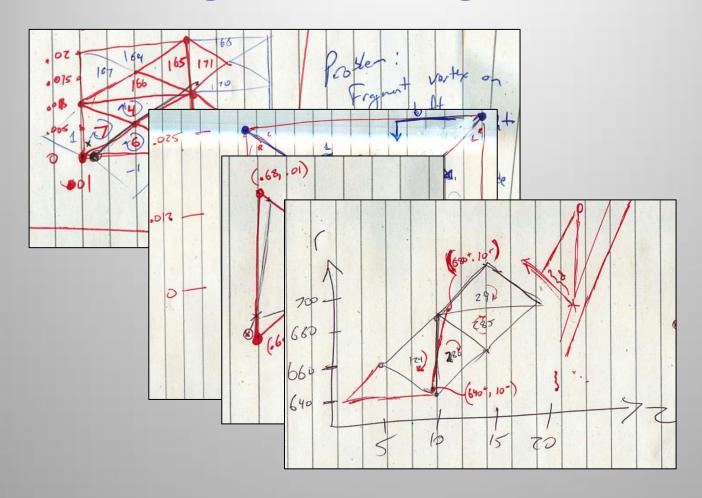
From www.15 (188,20) 15 K relation:

1889 on vertex: ((128,18), (136,14))
1899 on vertex: ((128,20), (136,14))
1899 on vertex: ((128,20), (136,14))
1899 on vertex: ((128,20), (136,14))
1899 on vertex: ((136,20), (136,20))
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Generating Diamond data structure... relation file loc is:
../tables/labels2b.csv
(took 0.407313 seconds.)
There are 223460 vertices, 202005 diamonds.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        chistogram type='18.57'>
Details of histogram:
1: 4757 (8.0712092% of total; 0.0712092 cumulative)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 *** diamond stats
```

# **Reconstruct local mesh (by hand)**



## Mesh changed ... start again



# Lightweight visual debugging tool

- Output small subset of local mesh from simulation
  - with desired geometric and topological features
  - simple text based representation of local mesh
- Leverage existing web technologies to visualize and interact with this information
  - reconstruct local geometry and connectivity
  - 'free' GUI
    - [practically] no new tool to maintain
    - firefox available on all platforms

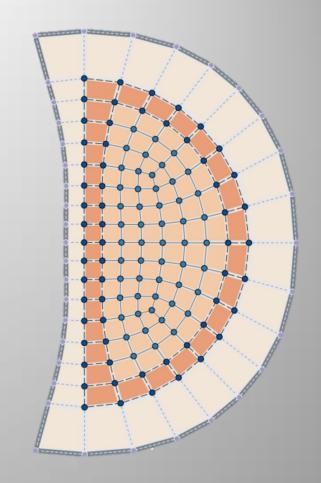
## **Text output mesh (JSON format)**

```
"zones": [
                                            {"idx":0, "position":{"x":0.027,"y":0.205}, "classification":["owned","send"], "domainID":0,
                                             "connectivity": \{"n": [3,24,53,12],"e": [0,1,2,3],"f": [0,1,2,3],"s": [0,1,2,3],"c": [0,1,2,3],"z\_n": [1,4,5,32,36,96,97,104]\}\}, and the property of the pro
                                            {"idx":1, "position":{"x":0.083,"y":0.201}, "classification":["owned"], "domainID":0,
  6
7
8
                                            "connectivity":{"n":[12,53,54,13],"e":[2,4,5,6],"f":[4,5,6,7],"s":[4,5,6,7],"c":[4,5,6,7],"z_n":[0,2,4,5,6,32,36,40]}},
                                            {"idx":2, "position":{"x":0.137,"y":0.194}, "classification":["owned"], "domainID":0,
                                             "connectivity":{"n":[13,54,55,14],"e":[5,7,8,9],"f":[8,9,10,11],"s":[8,9,10,11],"c":[8,9,10,11],"z_n":[1,3,5,6,7,36,40,44]}},
  9
 10
                             "nodes": [
                                            {"idx":0, "position":{"x":0.5,"y":0.0}, "classification":["owned","send"], "domainID":0,
                                             "connectivity":{"e":[199,200,201,243],"f":[365,504,507],"z":[91,92,112,126],"s":[365,366,504,507],"c":[366,369,451,504],"n_n":[41,52,131,146]}},
 13
                                            {"idx":1, "position":{"x":0.0004,"y":-0.499}, "classification":["owned","send"], "domainID":0,
 14
                                            "connectivity": \{"e": [112,115,240,267], "f": [192,500,501], "z": [48,111,124,125], "s": [192,195,501], "c": [192,446,498,501], "n_n": [15,44,145]\} \ \},
 15
                                            {"idx":2, "position":{"x":-0.0005,"y":0.499}, "classification":["owned","send"], "domainID":0,
                                             connectivity":{"e":[86,87,231,251],"f":[468,469],"z":[35,107,116,117],"s":[142,143,469],"c":[143,429,466,469],"n_n":[136,137]}},
 16
18
                              "edges": [
 19 🖨
                                            {"idx":0, "position":{"x":-0.00059,"y":0.2061}, "classification":["owned","send"], "domainID":0,
 20
                                            "connectivity":{"n":[3,24],"f":[0,386],"z":[0,96],"s":[0,386],"c":[0,1,386,387]}},
                                            {"idx":1, "position":{"x":0.0266,"y":0.1734}, "classification":["owned","send"], "domainID":0,
                                            "connectivity":{"n":[24,53],"f":[1,19],"z":[0,4],"s":[1,19],"c":[1,2,19,16]}},
23
                                            {"idx":2, "position":{"x":0.05545,"y":0.2040}, "classification":["owned","send"], "domainID":0,
24
25
                                             "connectivity":{"n":[12,53],"f":[2,4],"z":[0,1],"s":[2,4],"c":[2,3,4,5]}},
26
27 <del>-</del>
                             "views": [
 28
                                           {"name":"ownedView", "xMin":-0.000856344631497, "yMin":-0.499999773836, "xMax":0.5, "yMax":0.499999651374 },
 29
                                            {"name":"domainView", "xMin":-0.149575632365, "yMin":-0.643248713534, "xMax":0.643076796639, "yMax":0.643232259745},
30
31
32
                                            {"name": "problemView", "xMin":-1.0, "yMin":-1.0, "xMax":1.0, "yMax":1.0}
```

- Output is arrays of javascript objects (JSON)
- Uses desired set of properties with actual mesh values
- Bonus: can diff against when changing mesh features

# Visual output

- Transform JSON to 2D vector graphics (SVG) in browser
  - d3 visualization library (javascript)
  - Custom functions (javascript)
  - Mesh elements styled in CSS
- View and interact in browser
  - Pan, zoom, shrink, hover to get details



# Transforming the mesh with the d3 javascript library

```
//// Functions to setup the various element types
function setupZones(){

    // Generate the zones (closed polyline paths)
    d3.select("#zoneGroup").selectAll(".zone")
        .data( visualCMI.model.zones ).enter()
        .append("path")
        .attr("id", function(d,i) { return elementID("z", d.idx, d.globalID); } )
        .attr("class", function(d) { return classificationClasses("zone", d); })
        .attr("d", function(d) { return svgPathFunction(d, true); } )
        .attr("title", function(d,i) { return generateElementTooltip(d,i,"Zone"); })
        .on("mouseover", function(d,i) { onElementHover(d,i,"Zone"); })
        .on("mouseout", function(d) { onElementUnhover(d); })
        .on("click", function(d,i) { onElementClick(d,i,"Zone", this); })

        addElementsToMap("z", visualCMI.model.zones);
}
```

```
/************

* Zone styles *

*****************

.zone.owned { fill: rgba(253, 174, 107, 0.5);}

.zone.owned.selected { fill: rgba(43, 43, 43, 0.5);}

.zone.owned.clicked,.zone.owned:hover { fill: rgba(250, 255, 233, 0.5);}

.zone.owned.send { fill: rgba(230, 85, 13, 0.5);}

.zone.owned.send.selected { fill: rgba(0, 0, 0, 0.5);}

.zone.owned.send.clicked,.zone.owned.send:hover { fill: rgba(237, 248, 123, 0.5);}

.zone.receive { fill: rgba(254, 230, 206, 0.5);}

.zone.receive.selected { fill: rgba(142, 142, 142, 0.5);}

.zone.receive.clicked,.zone.receive:hover { fill: rgba(255, 255, 255, 0.5);}

.zone.externalSurface { stroke-width: 20; stroke: rgba(1, 25, 49, 0.5);}

.zone.externalSurface.problemBoundary { stroke-width: 30; stroke: rgba(25, 1, 49, 0.7);}

.zone.externalSurface.selected { stroke: rgba(0, 0, 0, 0.5);}

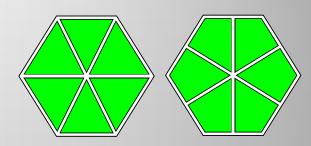
.zone.externalSurface.clicked,.zone.externalSurface:hover { stroke: rgba(46, 4, 174, 0.5);}
```

# Transforming the mesh with the d3 javascript library

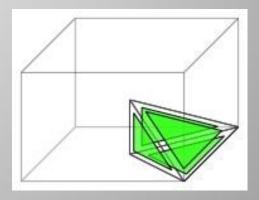
```
function setupZones(){
    d3.select("#zoneGroup").selectAll(".zone")
         data( visualCMI.model.zones ).enter()
         append("path")
           .attr("id", function(d,i) { return elementID("z", d.idx, d.globalID); } )
           .attr("class", function(d) { return classificationClasses("zone", d); })
           .attr("d", function(d) { return svgPathFunction(d, true); } )
           .attr("title", function(d,i) { return generateElementTooltip(d,i,"Zone"); })
           .on("mouseover", function(d,i) { onElementHover(d,i,"Zone"); } )
           .on("mouseout", function(d) { onElementUnhover(d); })
           .on("click", function(d,i) {    onElementClick(d,i,"Zone", this);    })
                 <path id="z_44_140" class="zone owned send" d="M-8.072351821603153,440.71406464995L-</pre>
    addElement
                 8.155464771921501,494.4...645366499,483.98271494520003L-86.53911350515,432.4634424669Z" title="[44] Zone 44 GID 140"></path>
                 <path id="z 45 141" class="zone owned send" d="M-100.858008282985,429.45011408399995L-</pre>
                 115.6476012315,480.96...18529997,453.5614589605L-172.10471292745,407.25834488289996Z" title="[45] Zone 45 GID 141"></path>
                 <path id="z_46_142" class="zone owned send" d="M-184.6009637059,401.90678954515L-</pre>
                 209.81875896374999,448.209....9911303983,409.3827685343L-246.75533165035,369.03170044495Z" title="[46] Zone 46 GID 142"></path>
                 <path id="z_47_143" class="zone owned send" d="M-257.3708265445,361.84645096779997L-</pre>
                 288.60662529245,402.197...817584995,354.1397176974L-310.39888855034997,318.7408217025Z" title="[47] Zone 47 GID 143"></path>
                 <path id="z_48_144" class="zone owned selected" d="M-209.50099524670003,204.22566568825L-</pre>
                 235.326857909,230.0039...060762285,187.4286701895L-219.15716420459998,168.9283878283Z" title="[48] Zone 48 GID 144"></path>
                 <path id="z_49_145" class="zone owned" d="M-221.9256837954,161.42059801135L-</pre>
.zone.owned.se
                 264.70912721365,179.920880...83919556,130.9189640871L-231.10961110735002,118.11849840985Z" title="[49] Zone 49 GID 145"></path>
.zone.owned.se
                 <path id="z_50_146" class="zone owned" d="M-233.0447354635,109.62706259701L-</pre>
                 283.94351631175.122.427528...8057448186,69.316291406855L-239.5621336413,62.569770259645Z" title="[50] Zone 50 GID 146"></path>
.zone.receive.clicked,.zone.receive:hover {    fill: rgba(255, 255, 255, 0.5);}
.zone.externalSurface {    stroke-width: 20;    stroke: rgba(1, 25, 49, 0.5);}
zone.externalSurface.problemBoundary { stroke-width: 30; stroke: rgba(25, 1, 49, 0.7);}
zone.externalSurface.clicked,.zone.externalSurface:hover { stroke: rgba(46, 4, 174, 0.5);}
```

# **Example: Visual CMI**

- We have a complicated mesh
  - Unstructured polygonal/polyhedral mesh
  - Subzonal geometry
  - Ghost layers: send, receive, external surface
- Difficult to learn
  - Documentation not always consistent w/ implementation
- Visual CMI is a way to interact with our actual mesh
  - ...as seen by the code

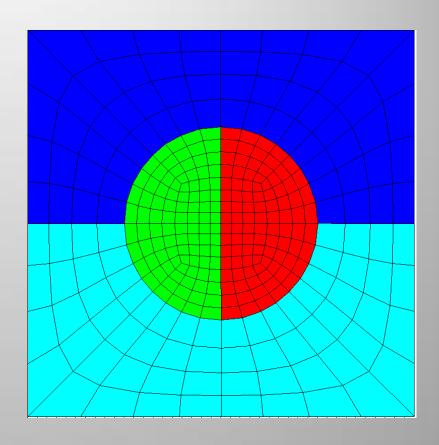


Sides and corners of a hexagonal zone

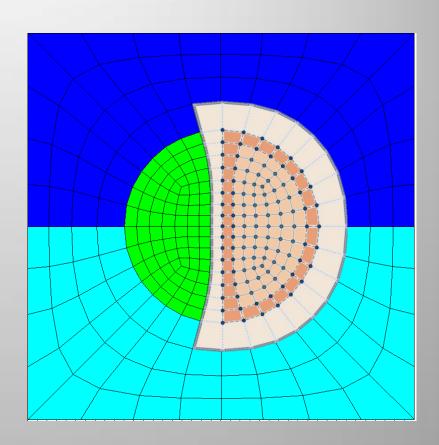


Facelets of a side of a hexahedral zone

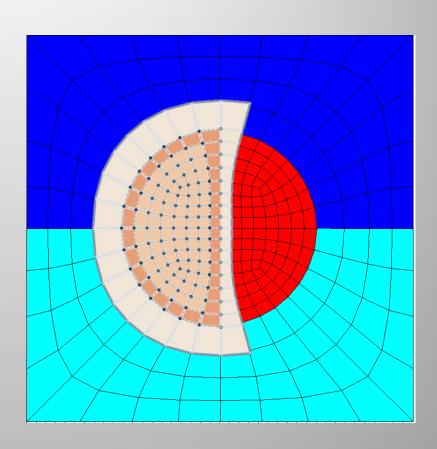
- Simple mesh: circle embedded within square
- Four domains
  - Right of circle
  - Left of circle
  - Upper square
  - Lower square



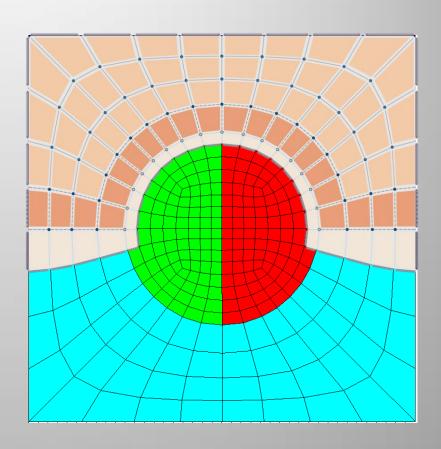
- Simple mesh: circle embedded within square
- Four domains
  - Right of circle
  - Left of circle
  - Upper square
  - Lower square



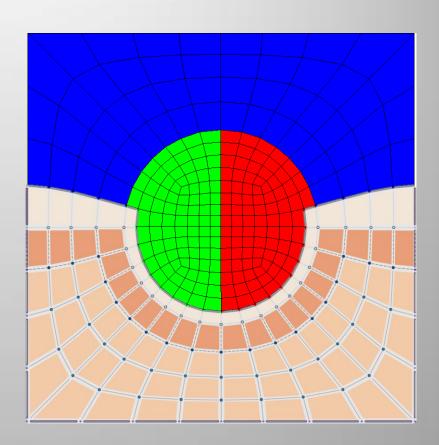
- Simple mesh: circle embedded within square
- Four domains
  - Right of circle
  - Left of circle
  - Upper square
  - Lower square



- Simple mesh: circle embedded within square
- Four domains
  - Right of circle
  - Left of circle
  - Upper square
  - Lower square

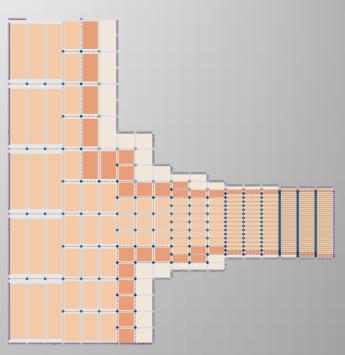


- Simple mesh: circle embedded within square
- Four domains
  - Right of circle
  - Left of circle
  - Upper square
  - Lower square



# Benefits when modifying mesh API or implementation

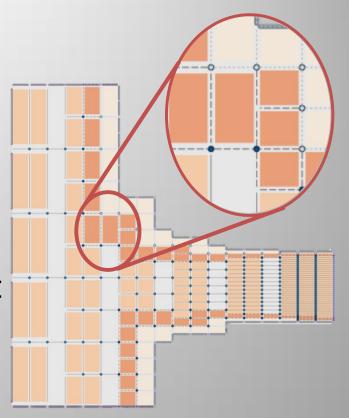
- Add support for dendritic elements to mesh
  - Elements with hanging nodes
    - increase resolution while maintaining good aspect ratios
  - Marked with per element bitflags
- Tool showed problems with ghost elements
  - Logic error in my code!
    - When setting classification tags,
       I accidentally overwrote
       all other tags, including dendritic



demo: bug | fixed

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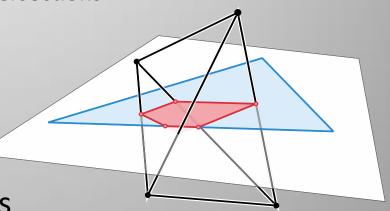


demo: bug | fixed

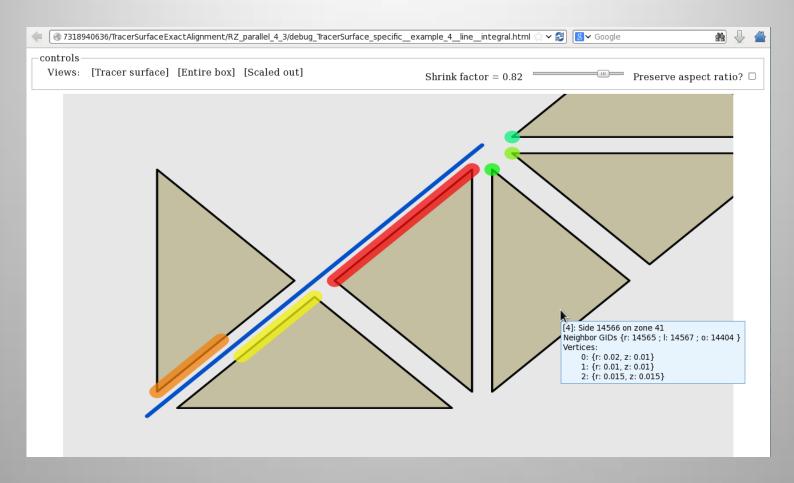


# A second example: Tracer Surfaces

- Project: Improve efficiency of fragmentation algorithm
  - Diagnostic tool measuring flux through dynamic arbitrary surfaces
    - Integrated via decomposition of tracer surface {segments,triangles}
       into fragments intersecting a single mesh element
    - Decomposition based on only local intersections
  - Output mesh contains
    - Set of tracer surface simplices
    - Set of intersected mesh elements
    - Set of tracer surface fragments
- Code had some robustness issues
  - When surface elements almost coincident with mesh edge/face



### **Tracer Surface visualization demo**



Fragmentation demo: problem | fixed

#### Conclusion

- Lightweight, flexible tool for visual debugging
- KISS
  - Use available tools
  - Don't duplicate functionality in existing powerful tools
    - Visualization tools: VisIt, paraview, silex
    - Debugging tools: totalview, gdb, ...
- Quickly pinpoint local problem in the mesh
  - reconstruct geometry and connectivity
  - along with some field data
- Only for small regions of mesh

## **Ongoing and future work**

- Visualizing tangled zones
  - output problematic zones and all incident neighbors
  - along with field data
  - can be automatically triggered based on local conditions
- Extend tool to handle our regions and field data
- Visualization of polyhedral (3D) meshes using webGL
- Visualize data layout/locality

# Thank you.

Questions?
Comments?
Suggestions?



# Complicated mesh setup 3D Element Types

**Primary elements** Half-faces Nodes Zones Secondary elements Edges **Tertiary elements** 

Nodelets