Visualization, storage, analysis and distribution of massive aerial LiDAR point clouds

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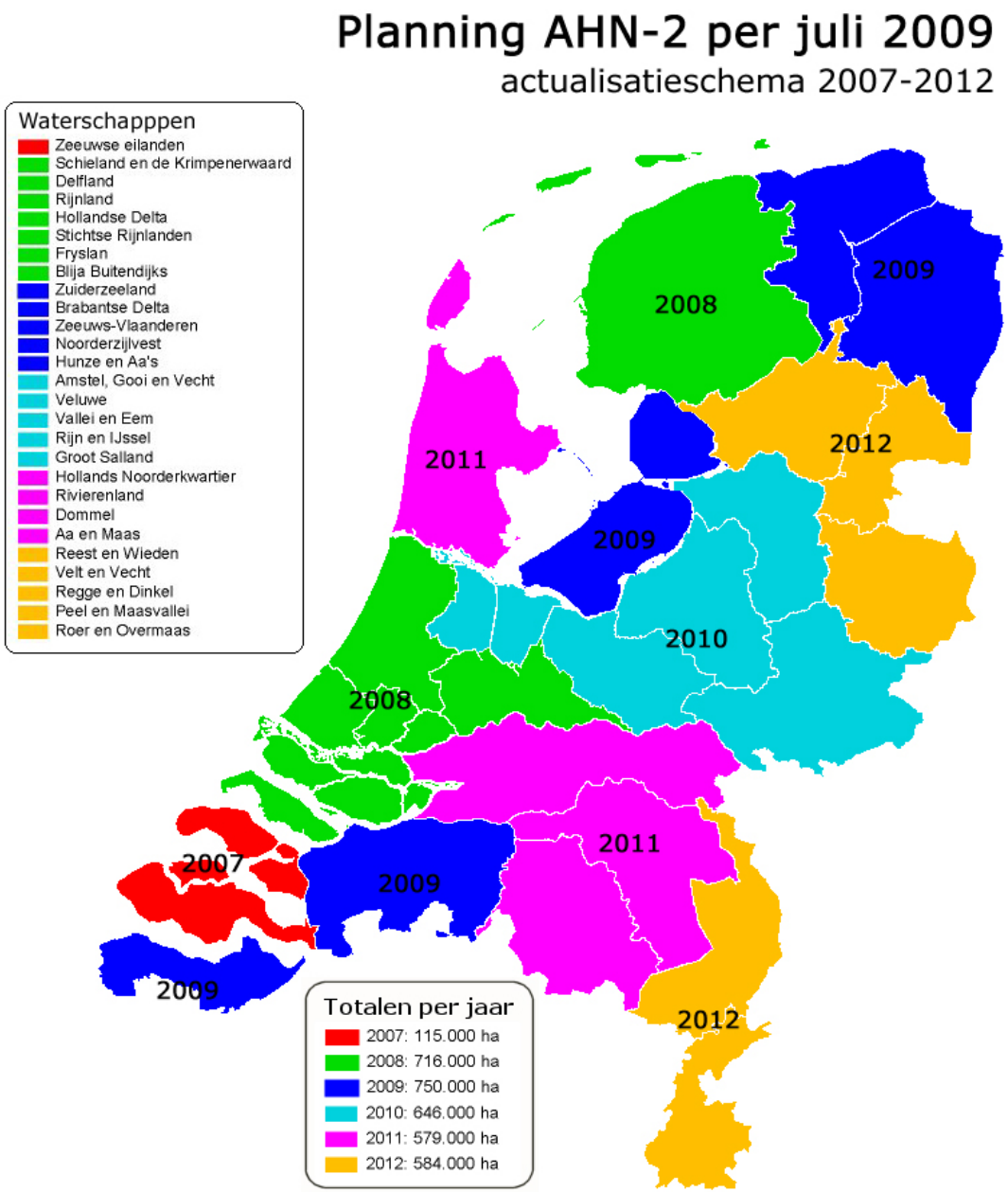
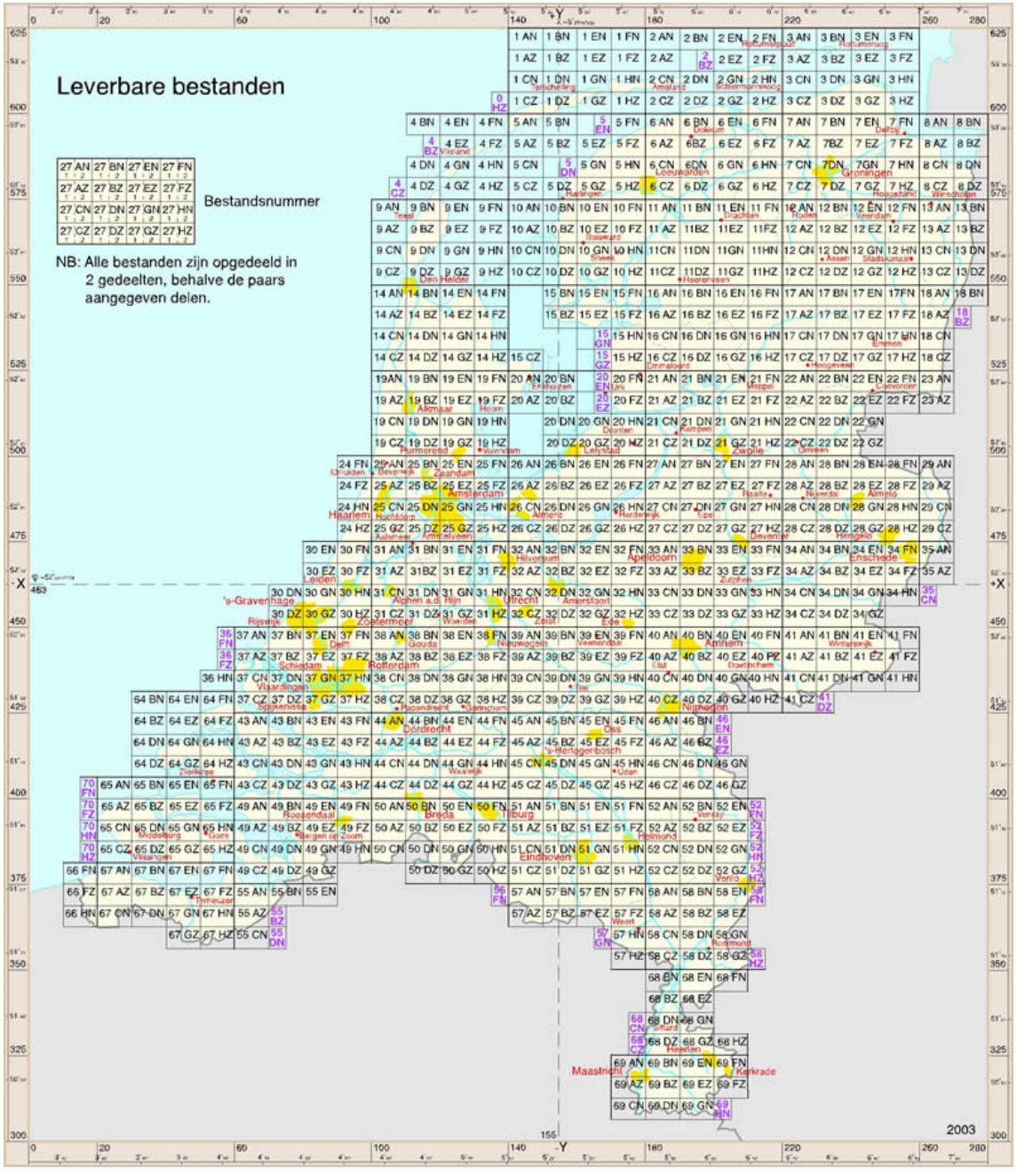
GeoWeb 2010, Vancouver
July 28 2010

AHN^2: A dataset covering totally the Netherlands

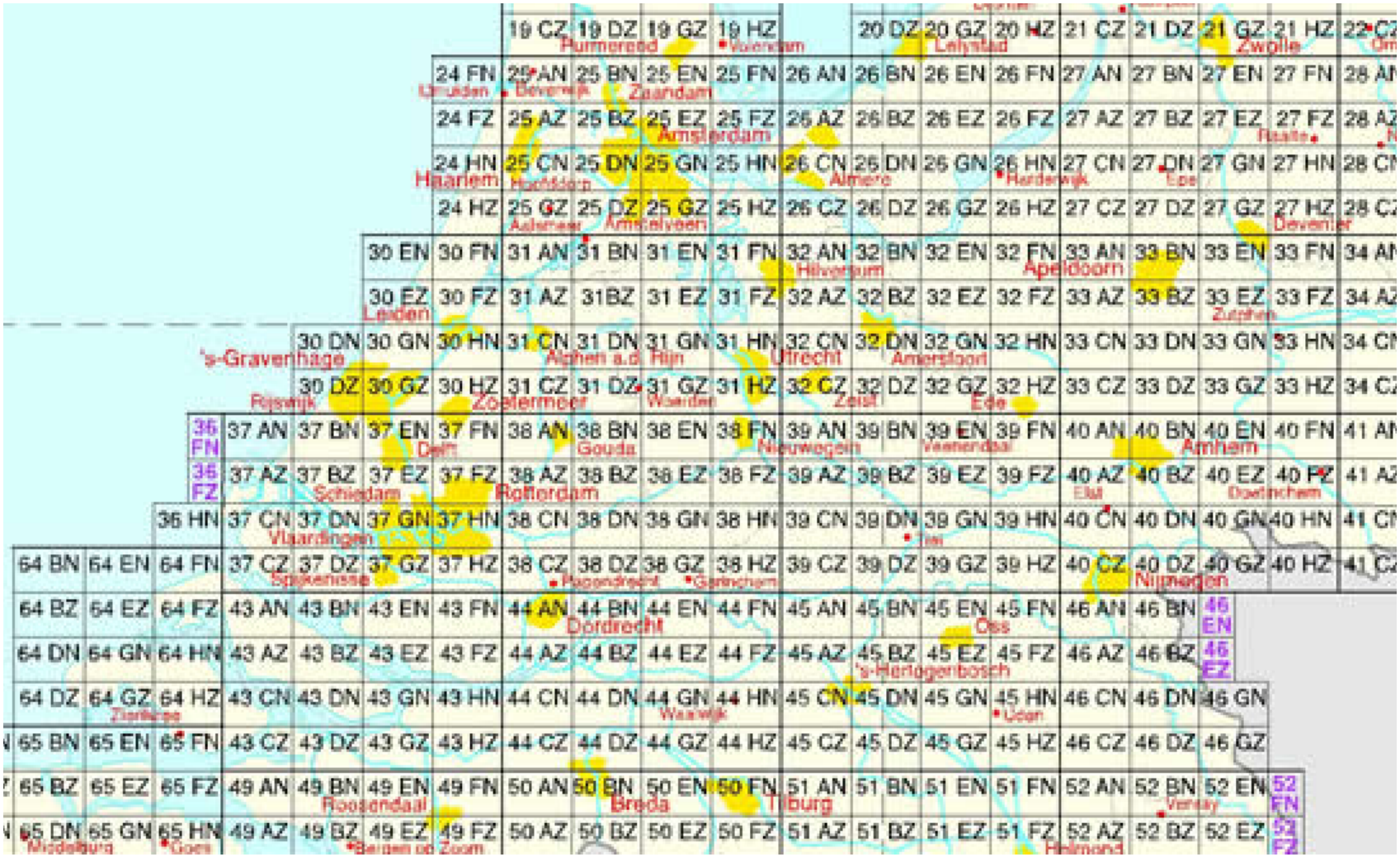


- compiled by the government
- (x, y, z) points
- raster (50cm grid available)
- at least 4 pts/m^2
- $>$ 150 billions points

AHN^2: A tiled dataset



AHN^2: A tiled dataset



File “g37en1_08.xyz”

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82993.334,447517.102,-0.042
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82992.494,447517.148,-0.005
82992.788,447516.682,-0.044
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82994.576,447513.770,-0.070
82994.884,447513.247,-0.012
...
...
...
```

Our challenges when dealing with massive point clouds

1. Real-time visualisation
2. Storage + spatial analysis
3. Distribution of such datasets

Can our tools/workflows scale to **massive** datasets?

Real-time Visualisation

Why visualise point clouds?

- Because it's a nice challenge!
- Because we need to:
  - Perform visual inspection of raw measurements
  - Gain insights from numbers

Rendering $\longrightarrow$ Visualisation $\longrightarrow$ Interaction

From DEM terrain...

(AHN^2 DEM 0.5m grid)

... to point cloud

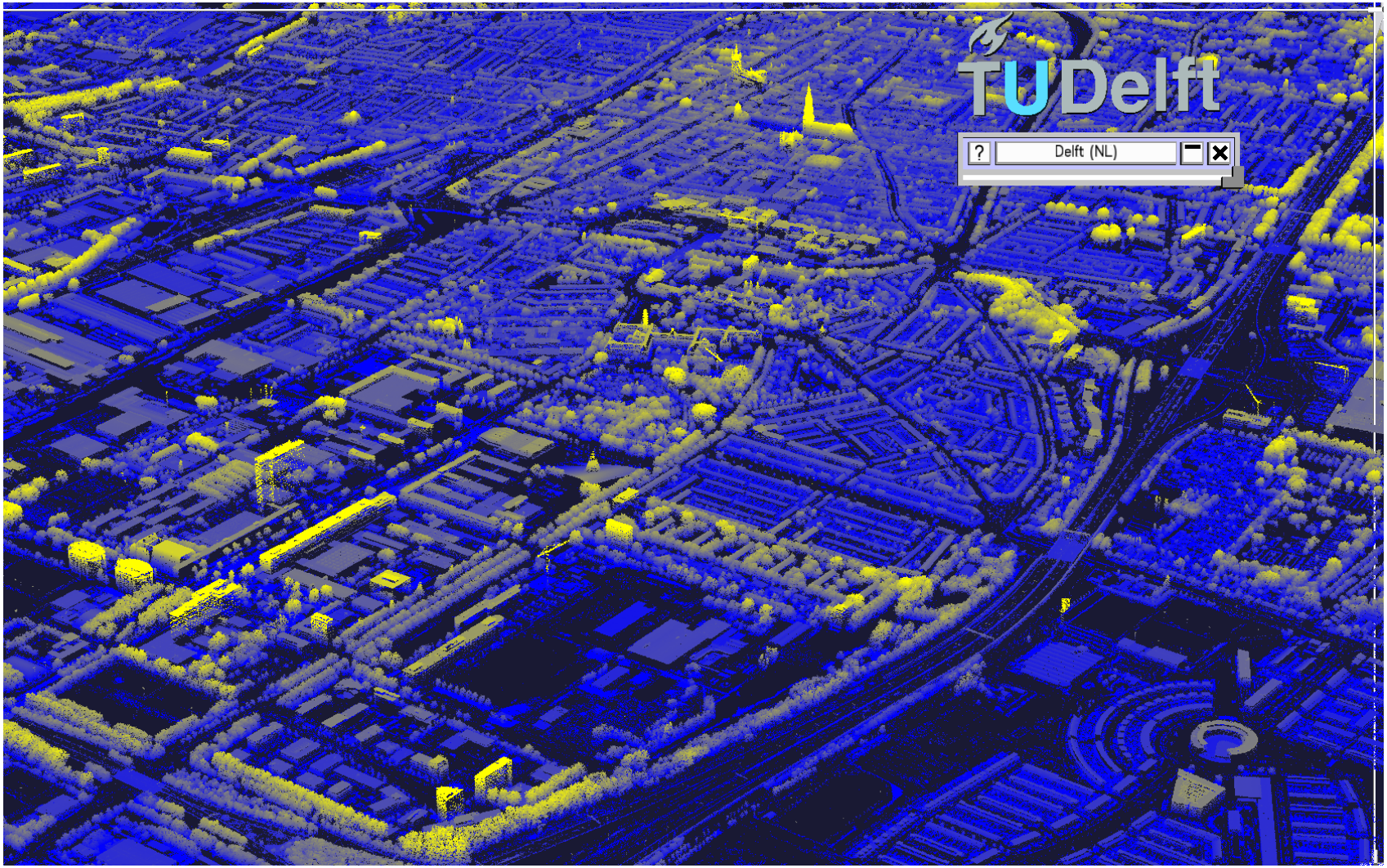
($\sim$ 2 millions points from AHN^2)

Our tools of choice

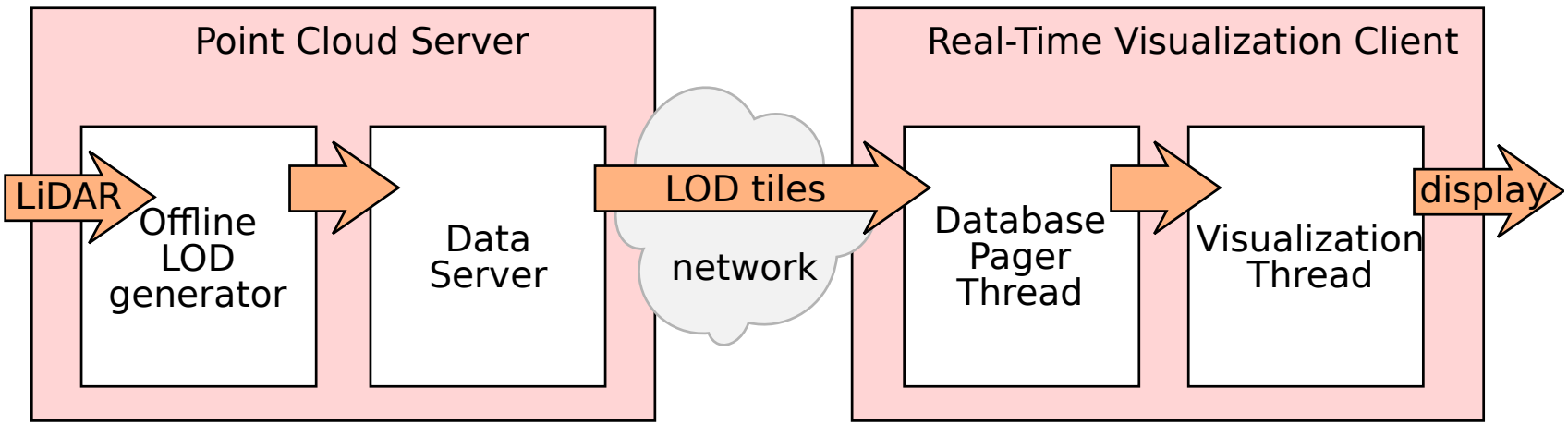
- OpenSceneGraph
  - most popular FOSS scene graph engine
  - based on flight-simulator software (not GIS)
- OpenSceneGraph-based VRMeer software
- Python abstraction layers

  `http://code.google.com/p/osgswig`

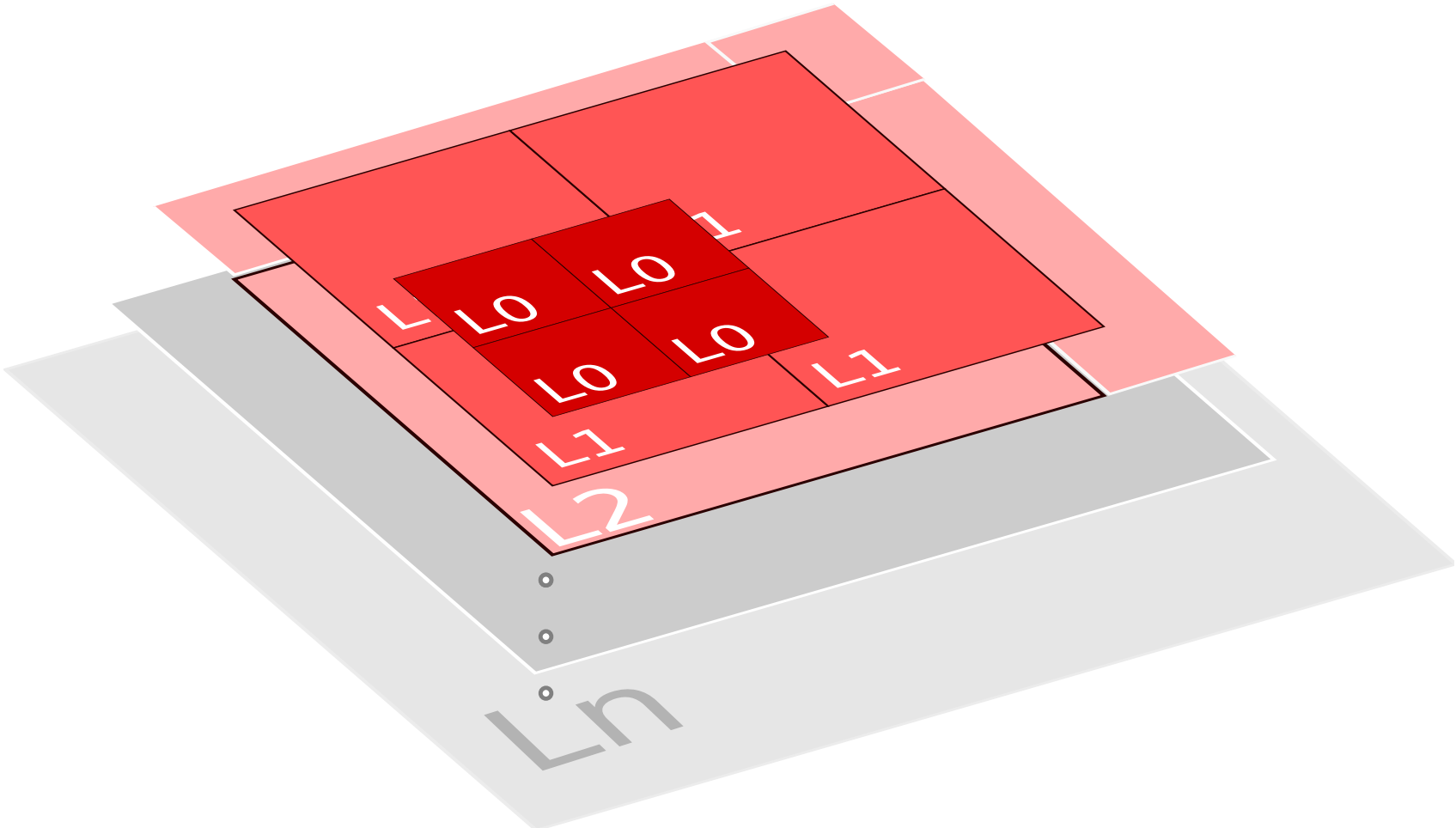
Demonstration video



Visualisation pipeline overview



Multi-resolution data struture



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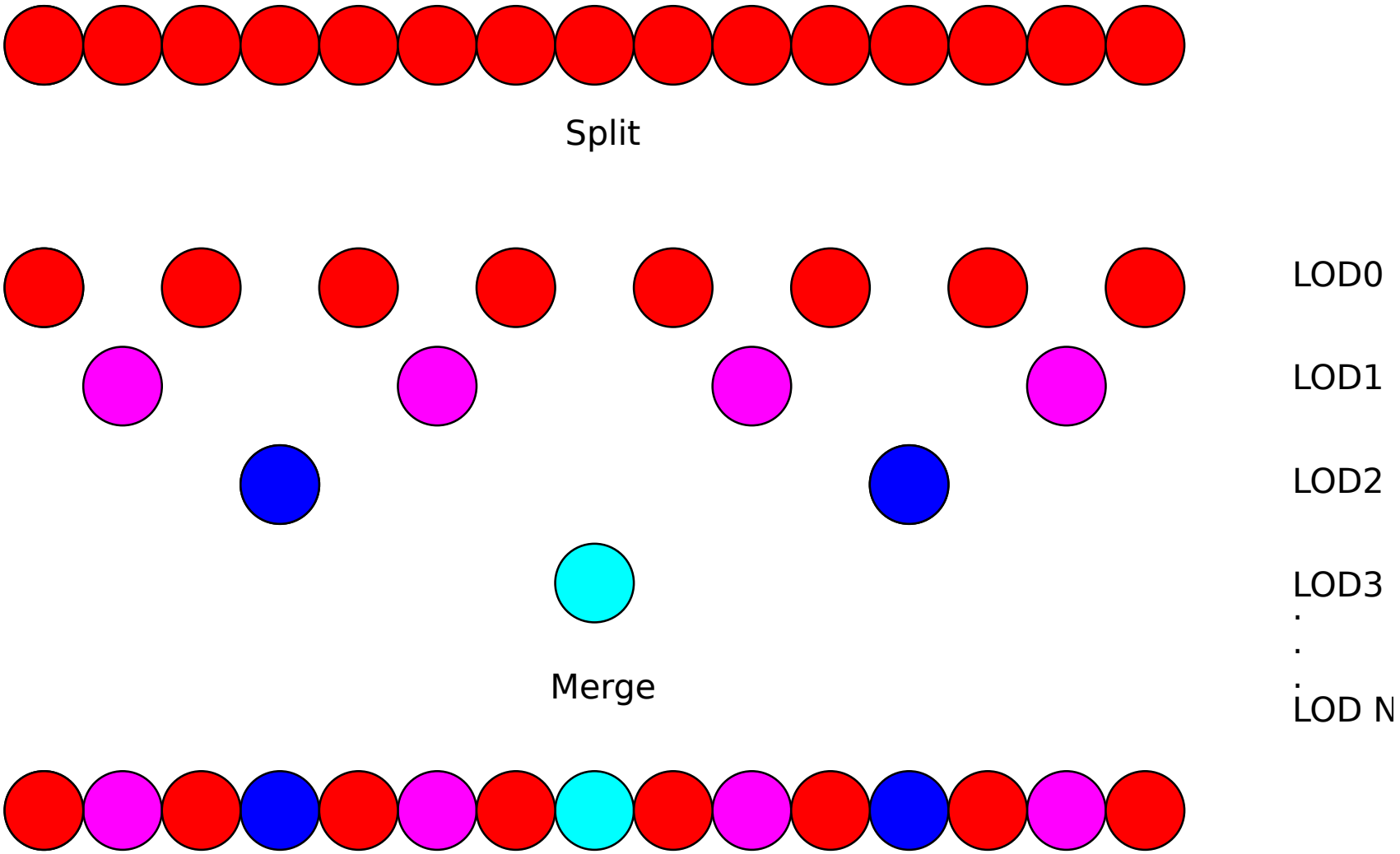
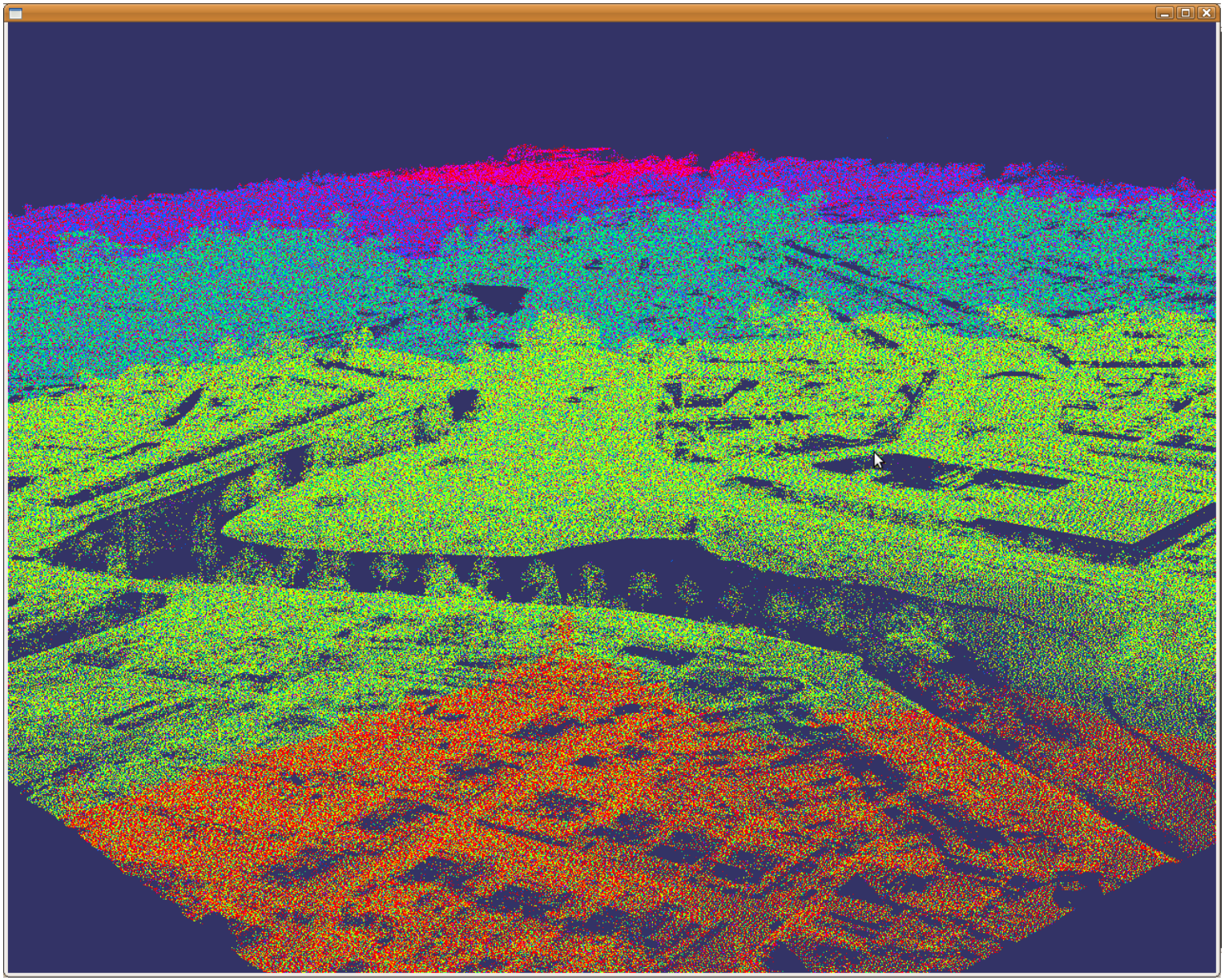
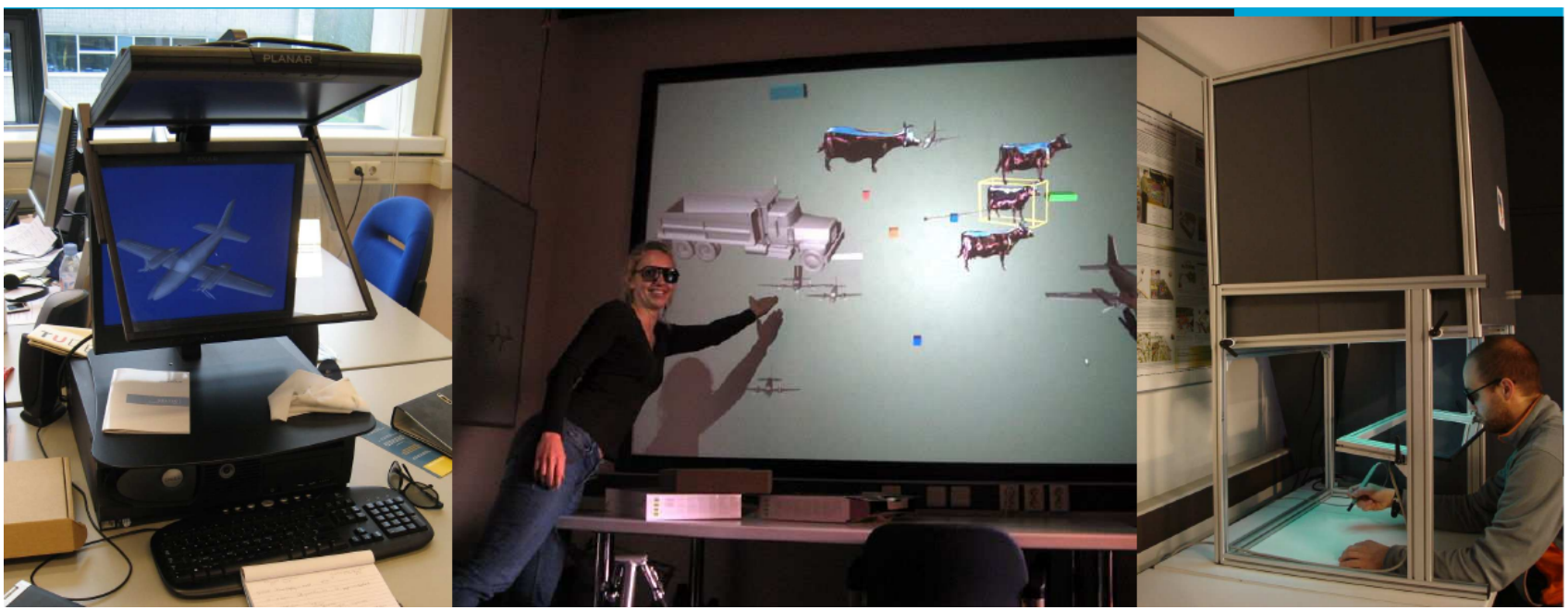


LOD effects



Interaction

- Stereoscopic display
- 3D interaction with space-mouse, Wii balance board interaction
- More info: PhD thesis *Techniques and Architectures for 3D Interaction*, Gerwin de Haan, TU Delft, 2009.

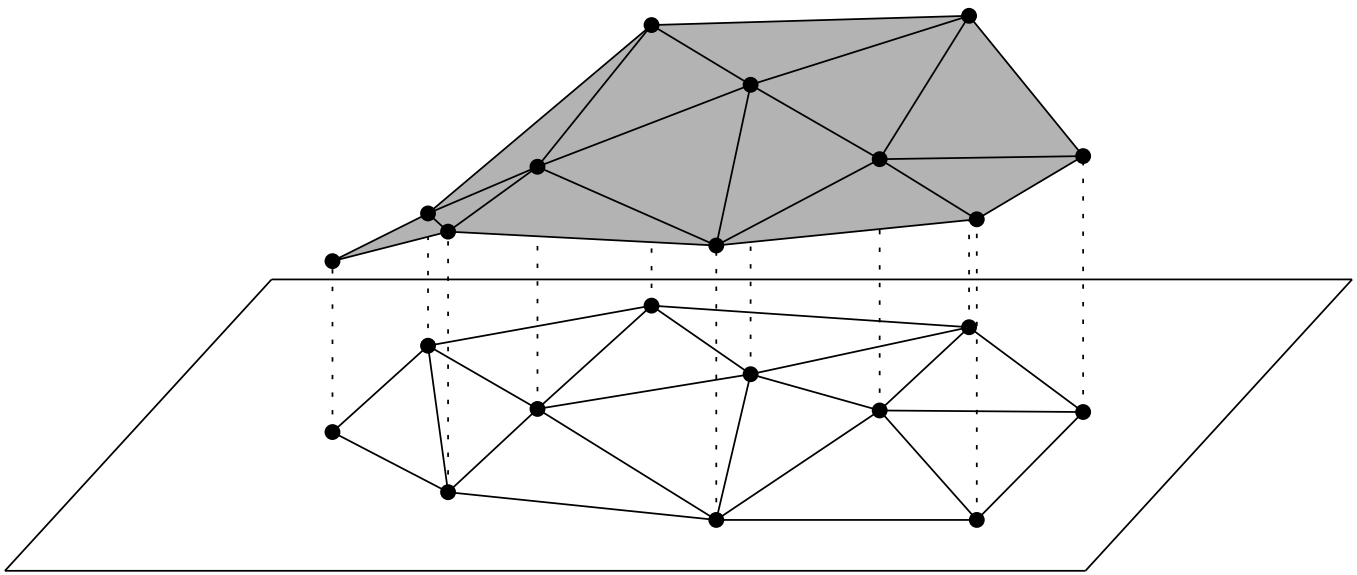


Interaction

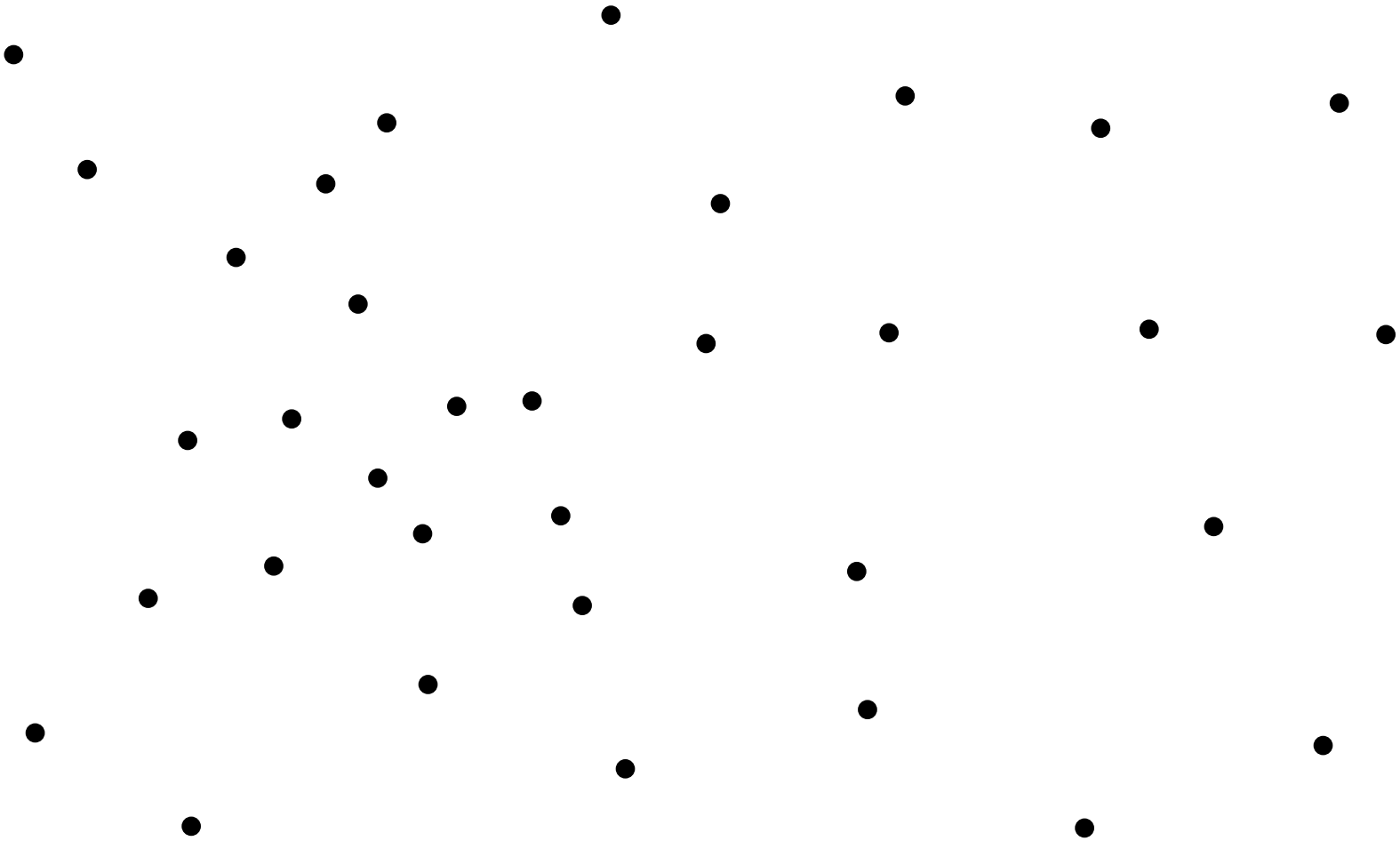
Analysis & Storage

Point clouds are often "2.5D surface"

LiDAR datasets are formed by scattered points in 3D space, which are the samples of a surface that can be projected on the horizontal plan.

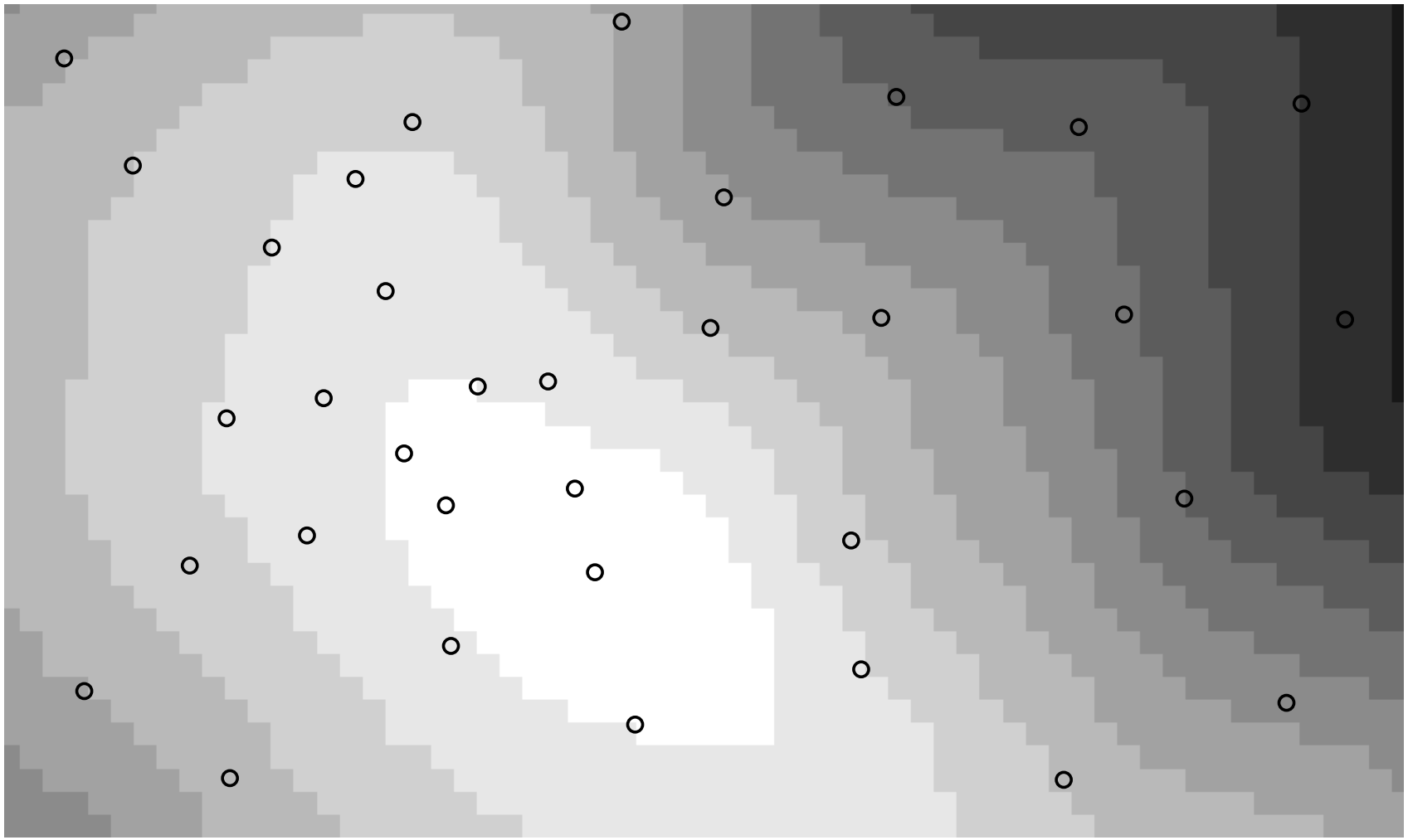


Reconstruction of the surface



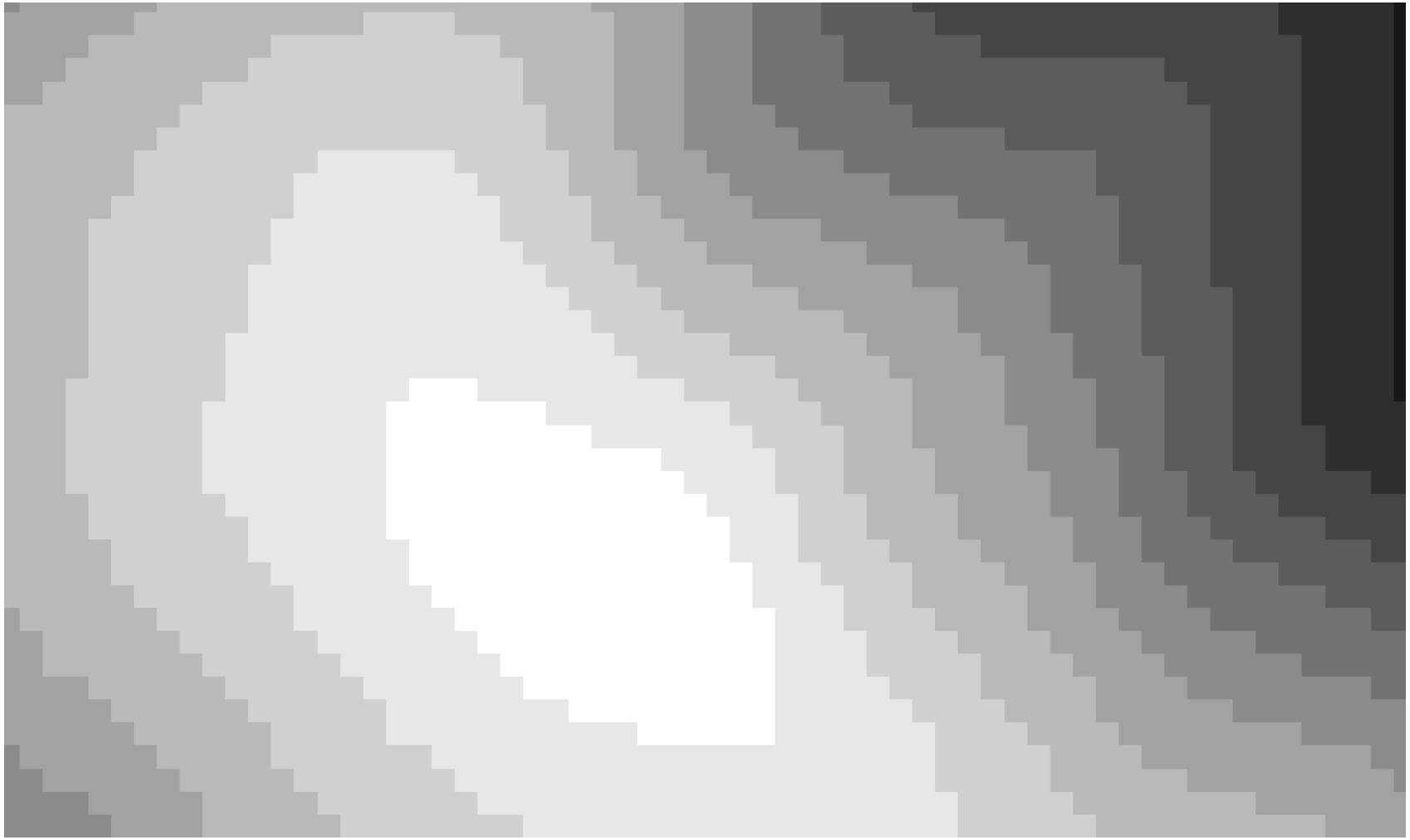
Original LiDAR points

Reconstruction of the surface



Raster representation

Reconstruction of the surface



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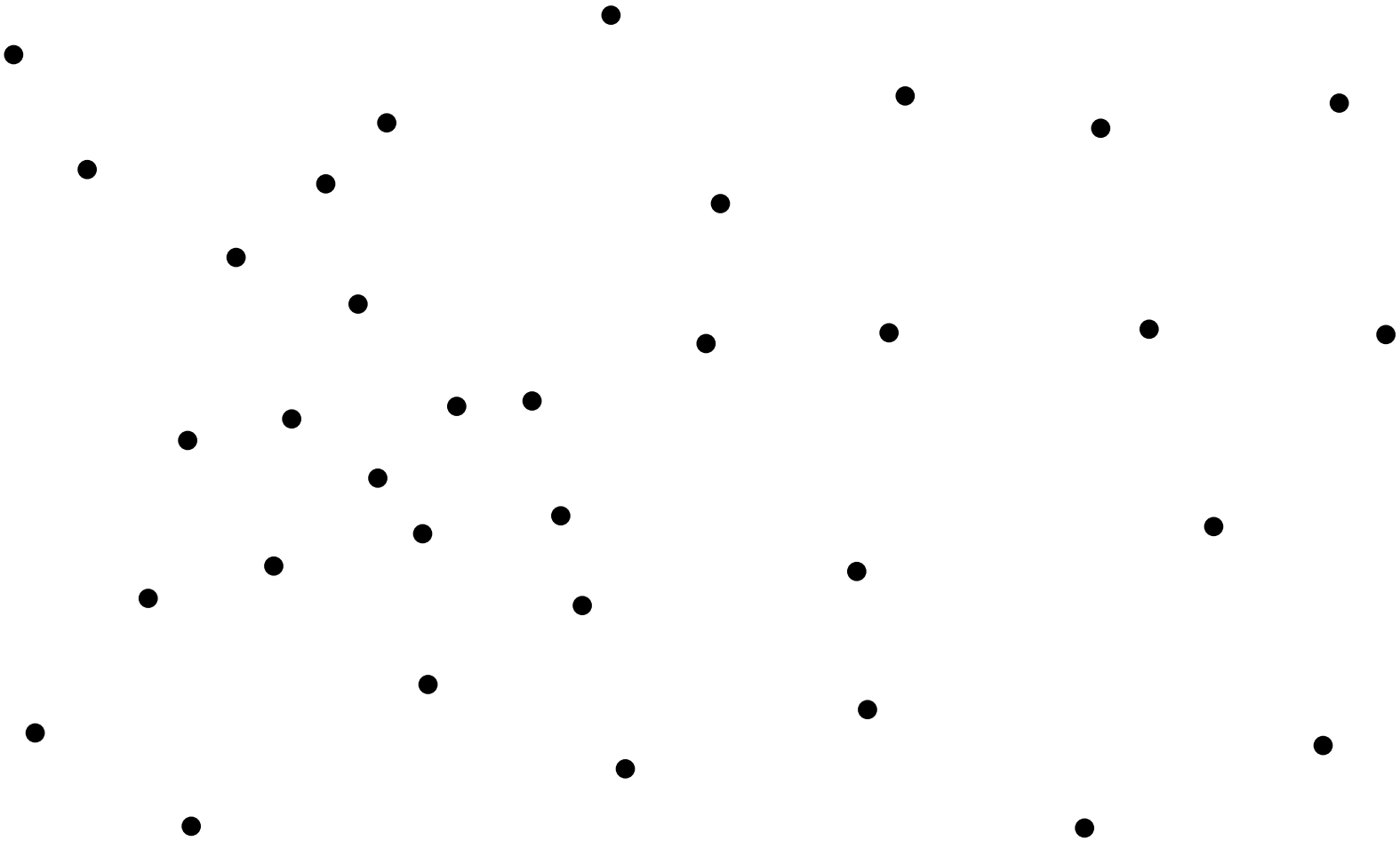

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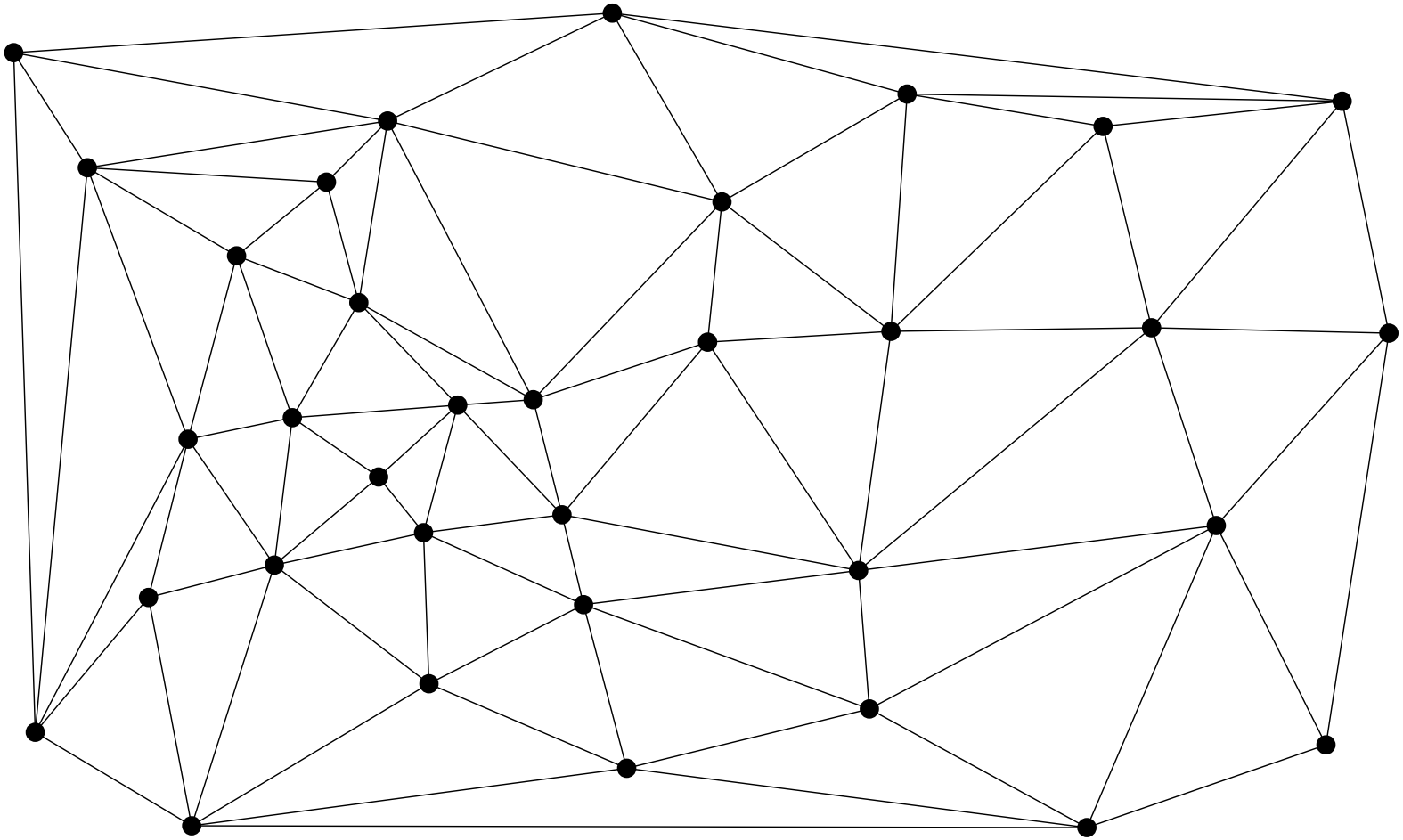
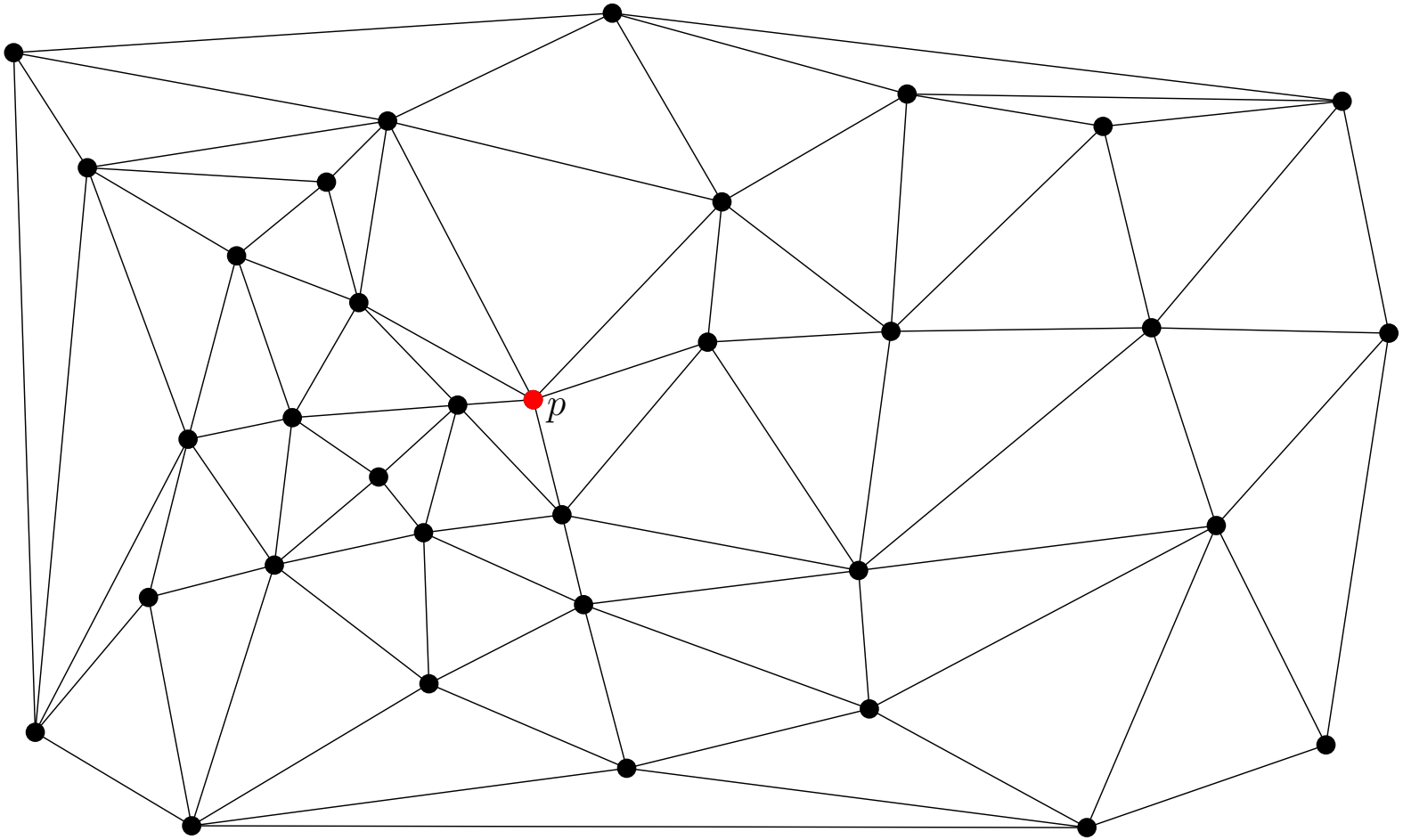


TIN (with Delaunay triangles)

Reconstruction of the surface



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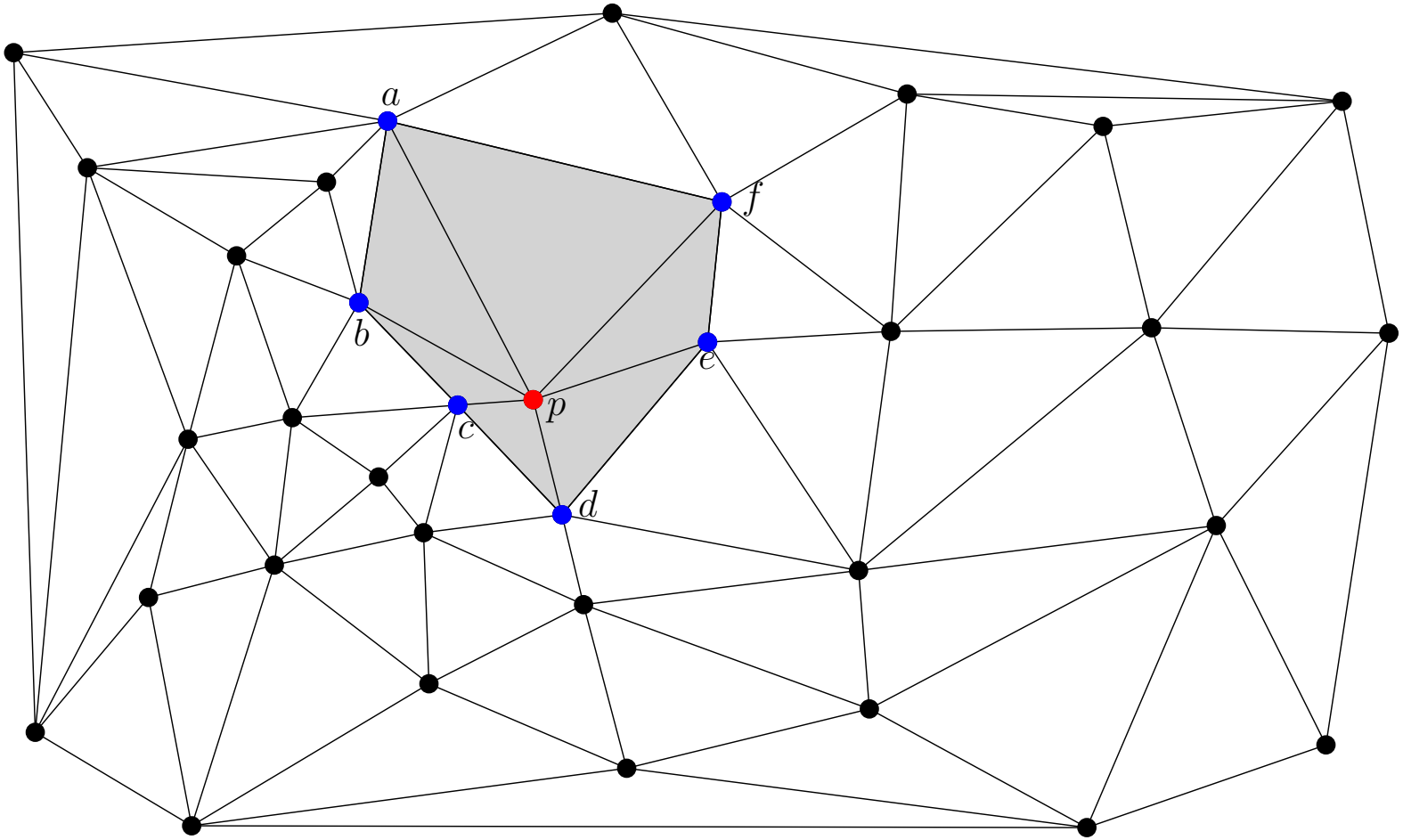
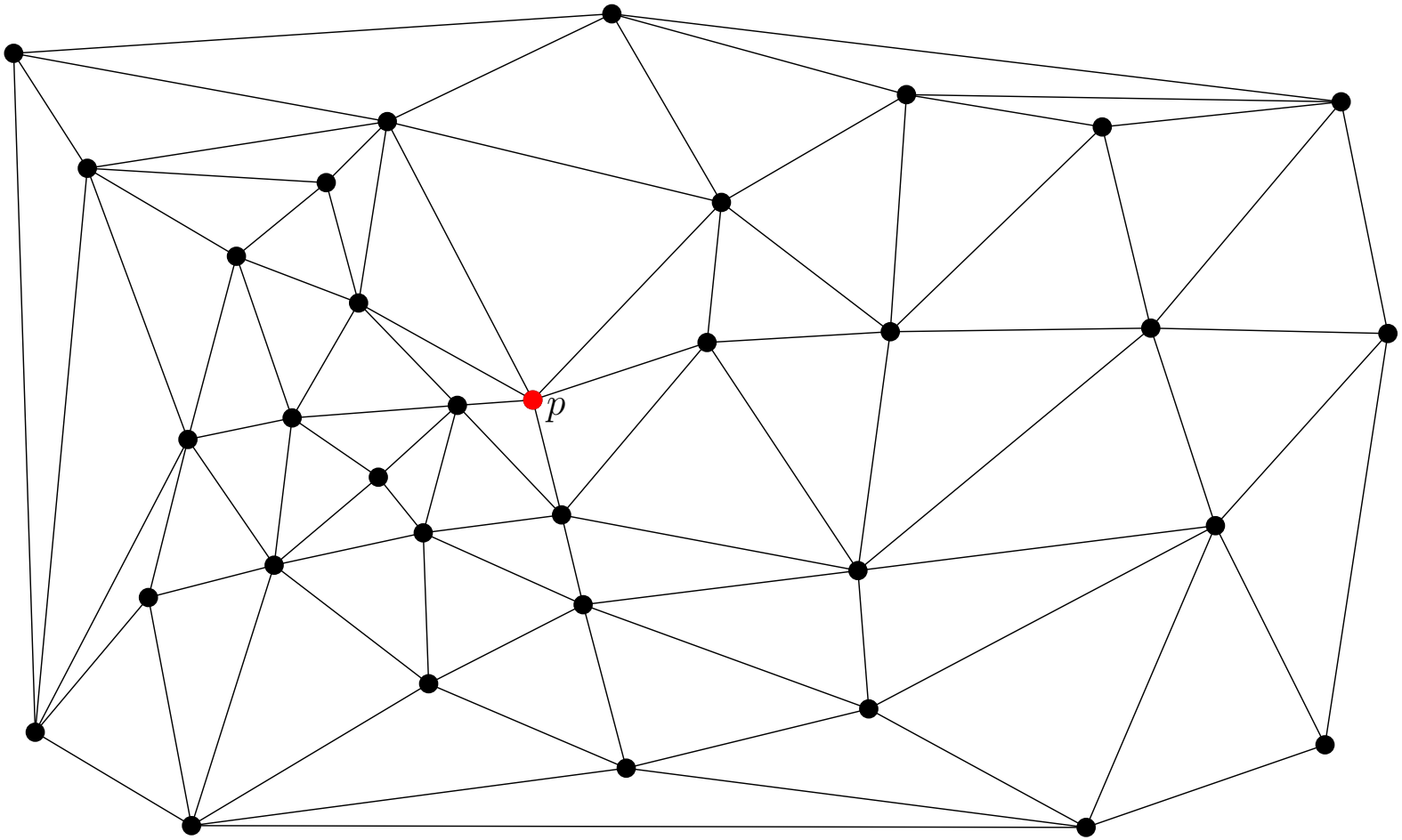


TIN (with Delaunay triangles)

A star-based data structure

- Goes beyond the usual "store points and edges/triangles"
- Ideas come from data structures for compression of graphs



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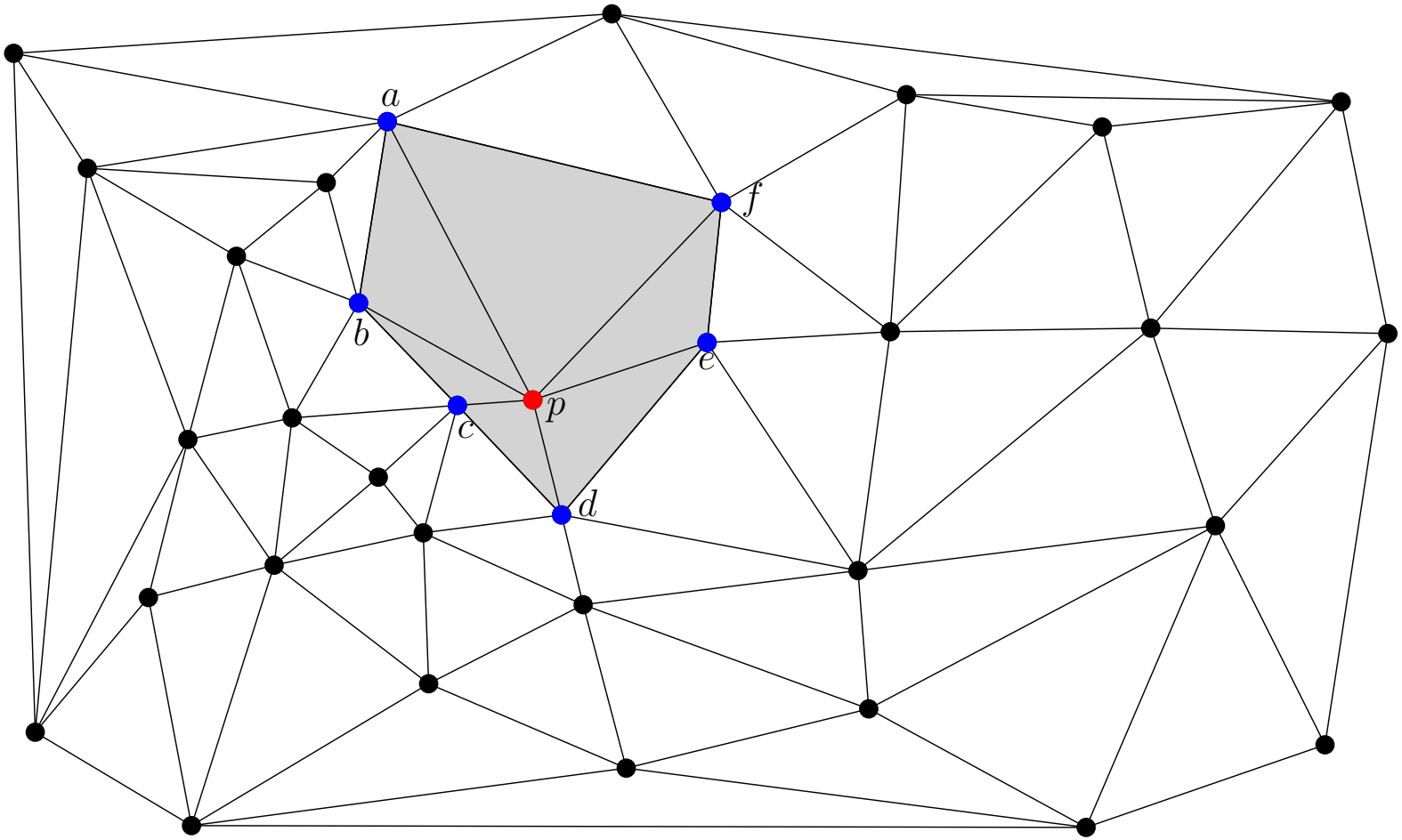

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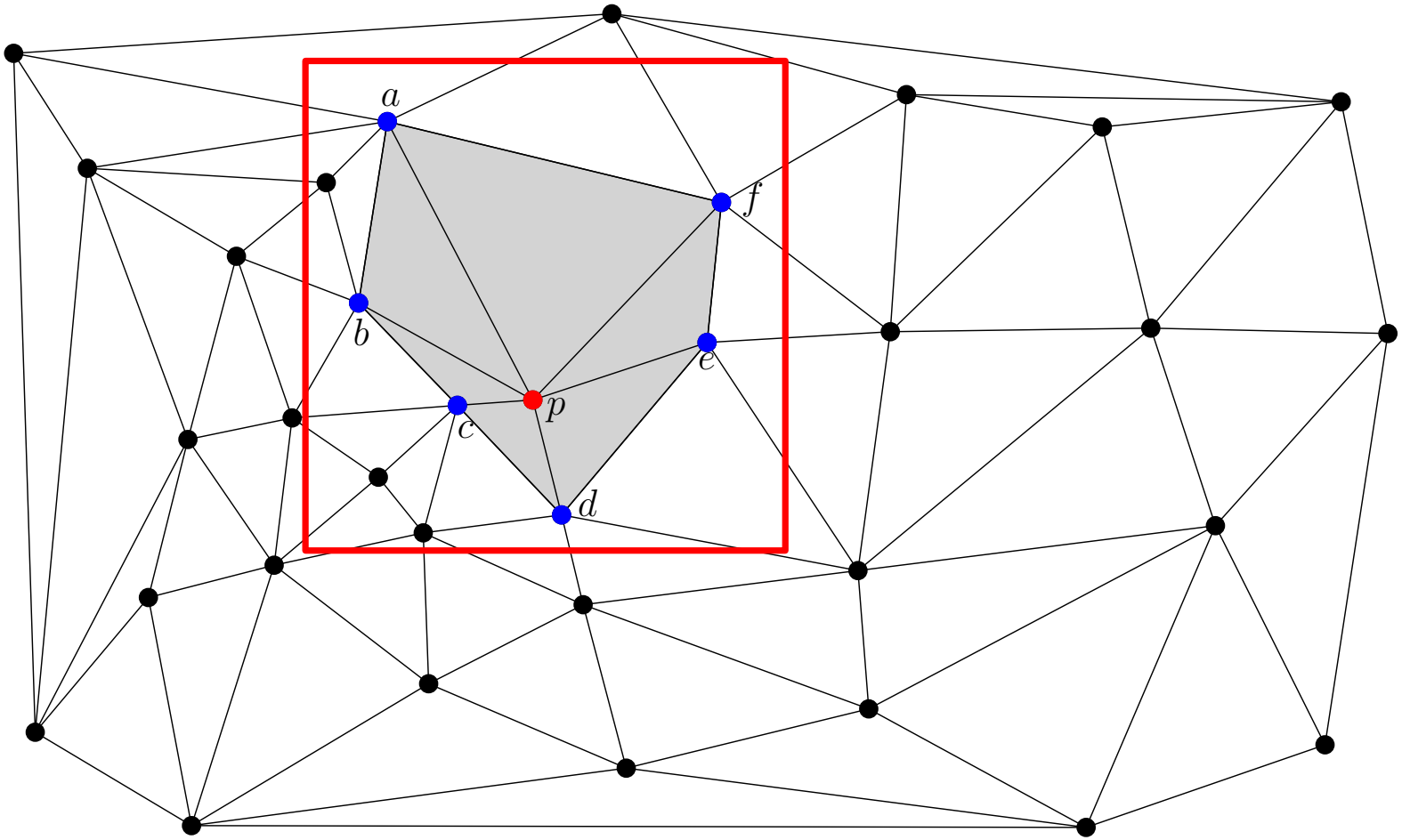

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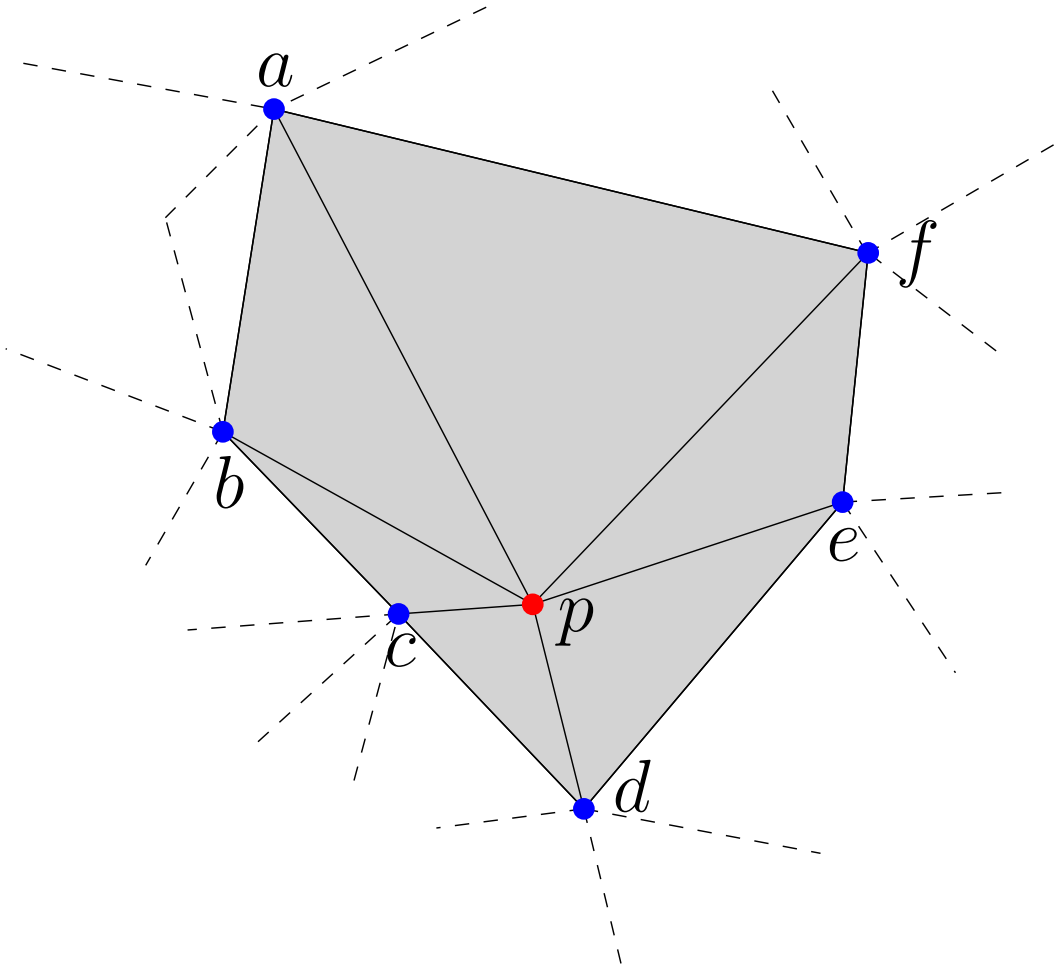
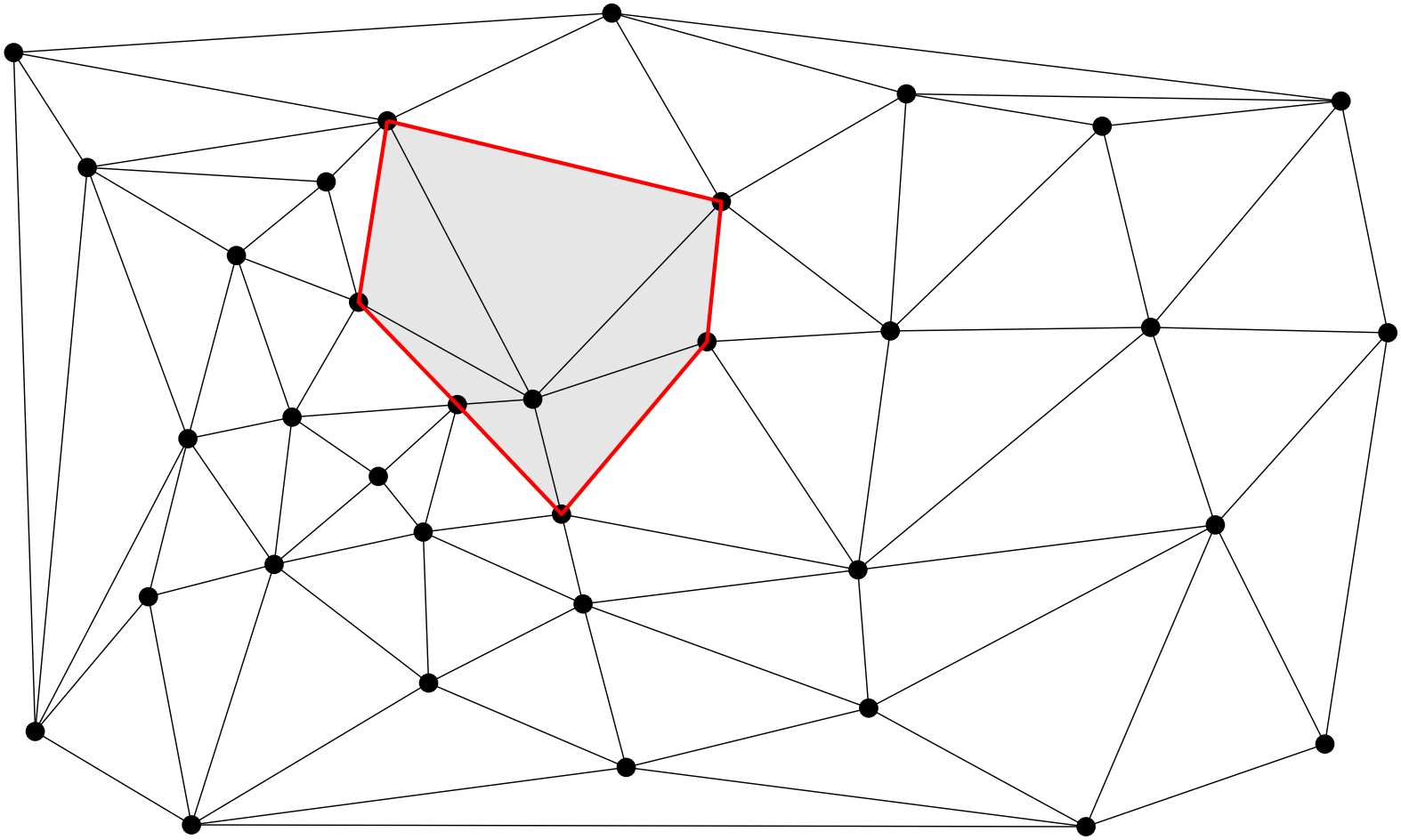


$$star(p) = abcdef$$

Every star(v) is stored $\longrightarrow$ implicit triangles



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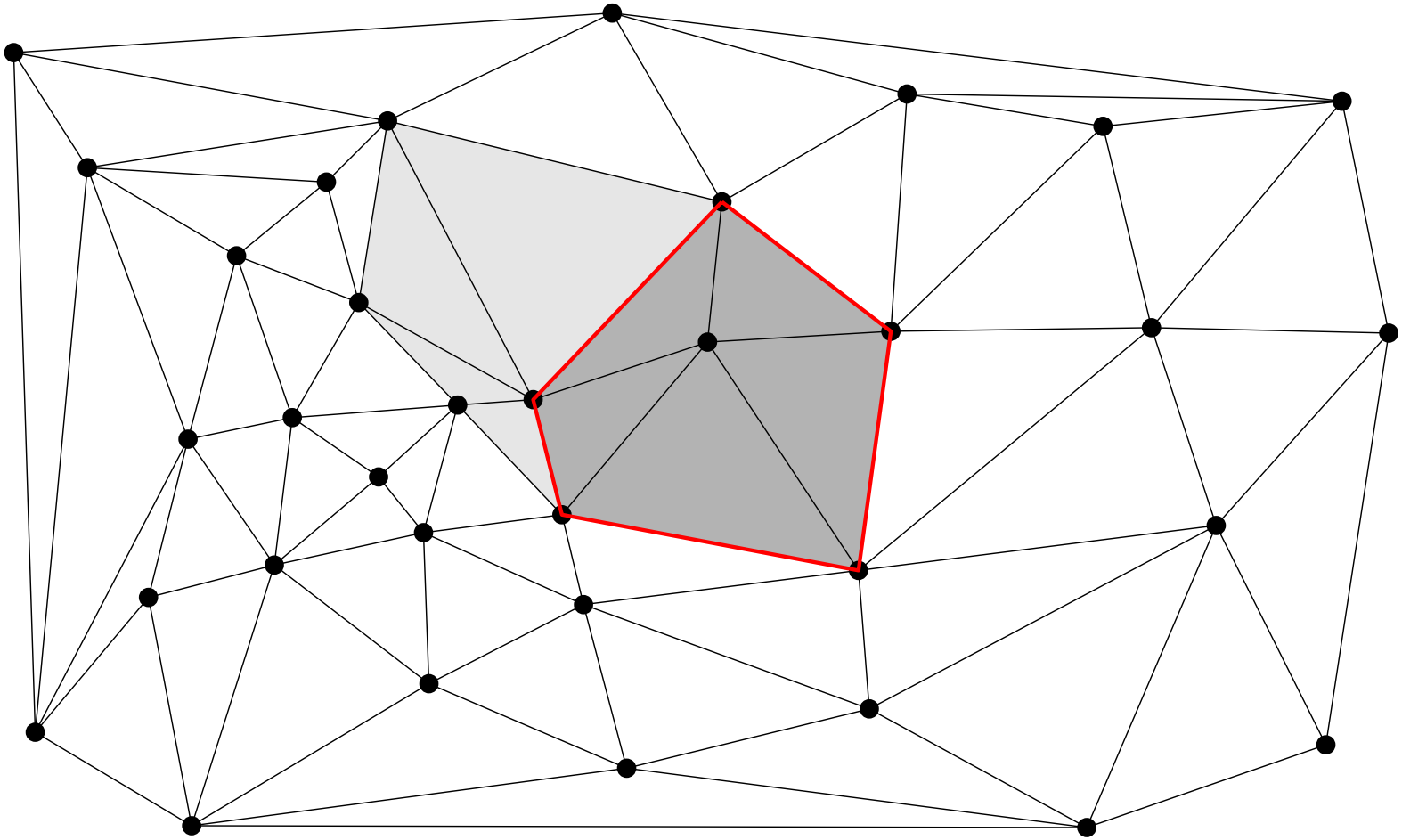

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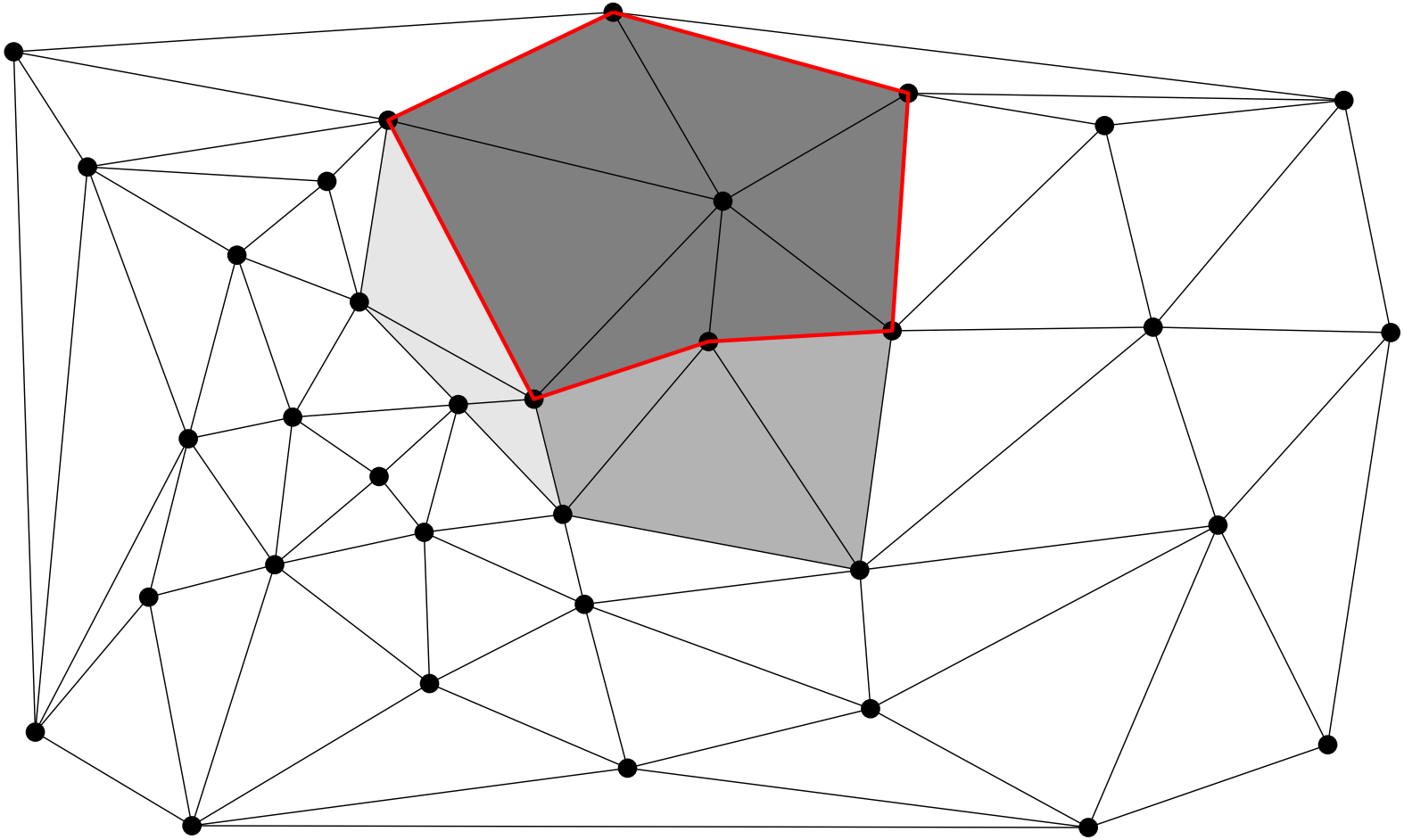

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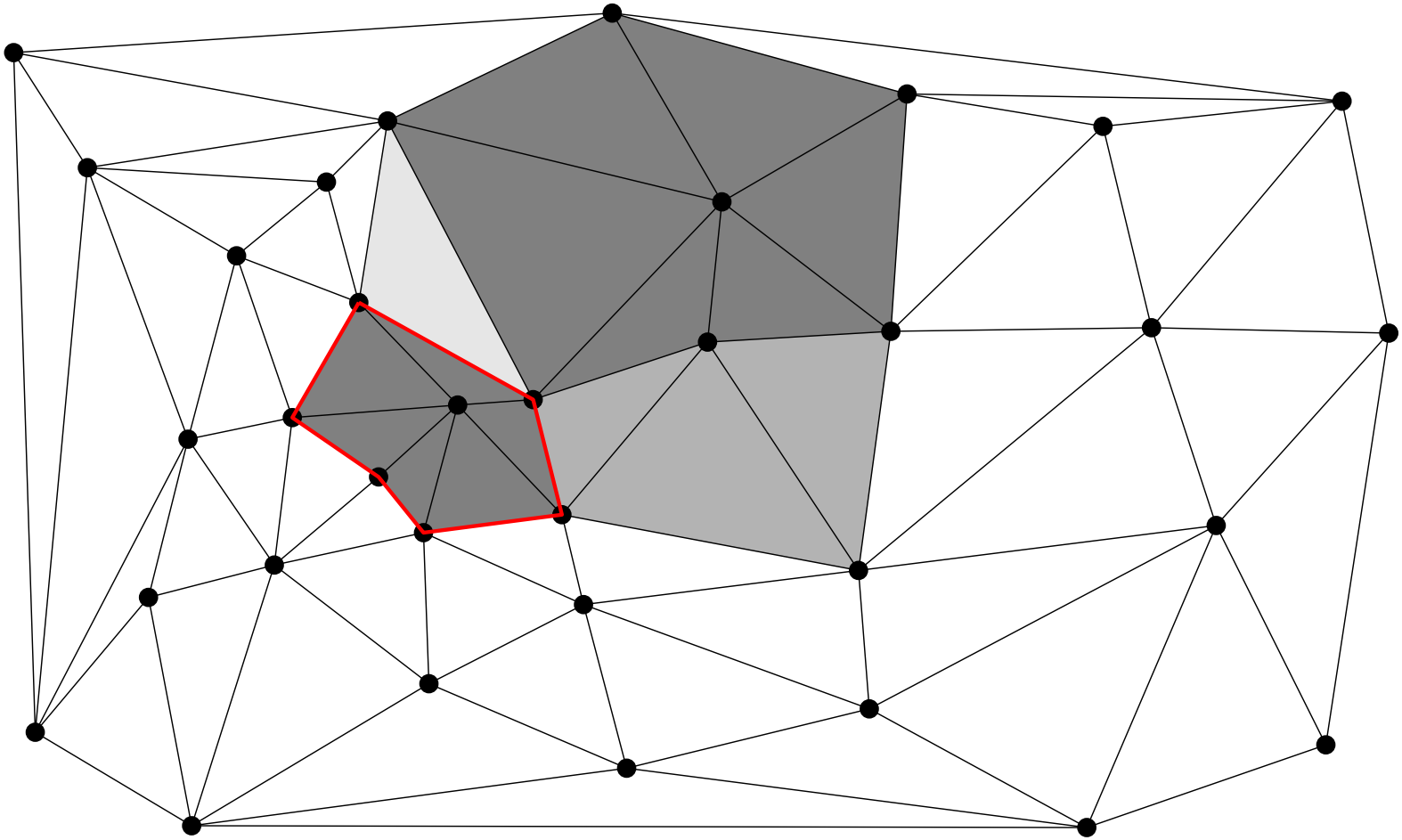


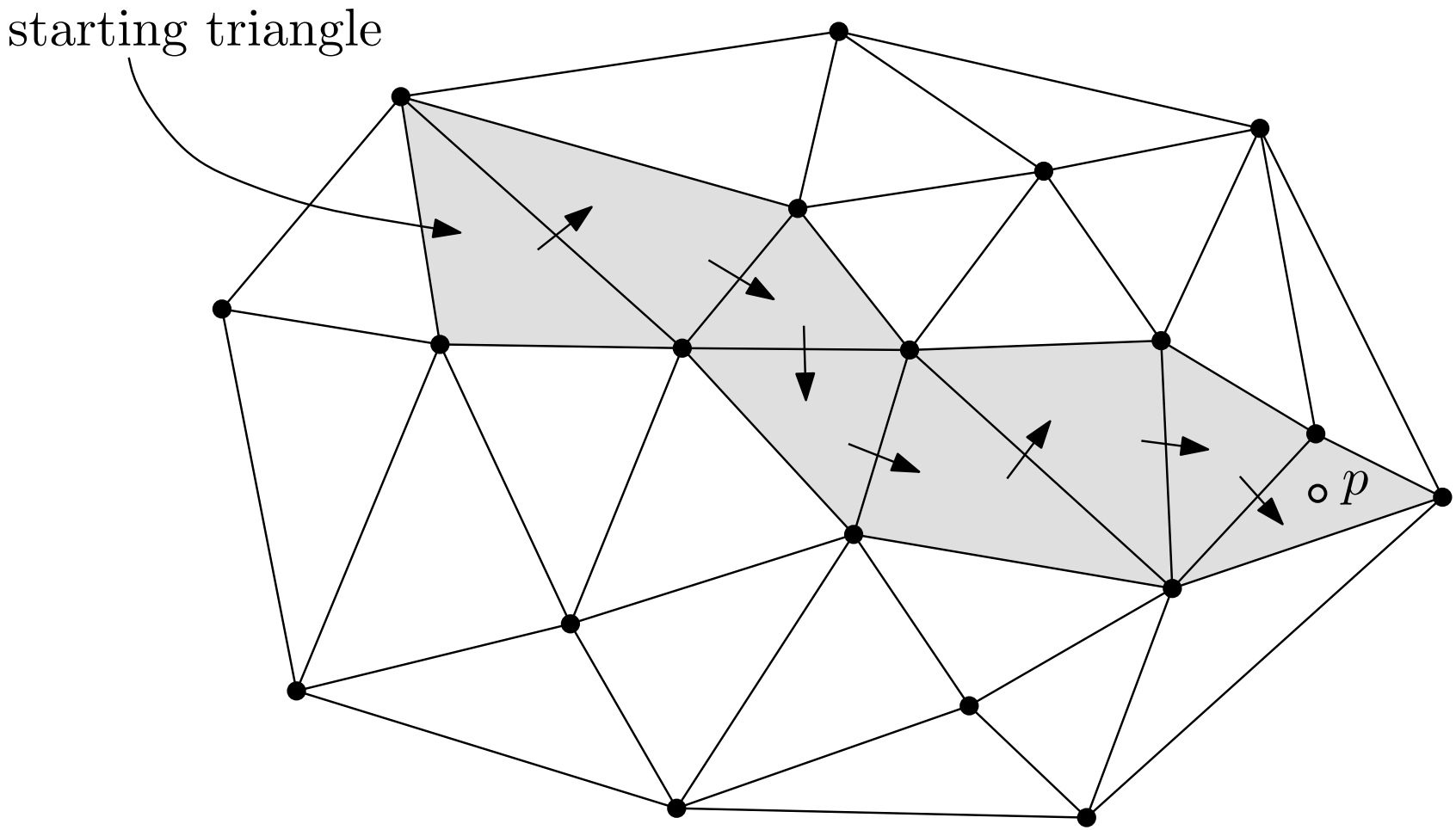
Stars in a DBMS

ID	x	y	z	star
1	3.21	5.23	2.11	2–44–55–61–23
2	5.19	29.01	4.55	7–98–111–233–222
3	22.43	15.99	8.19	99–101–73–23
...	...	...	...	...
5674	221.19	15.23	37.81	309–802–793–1111

Advantages:

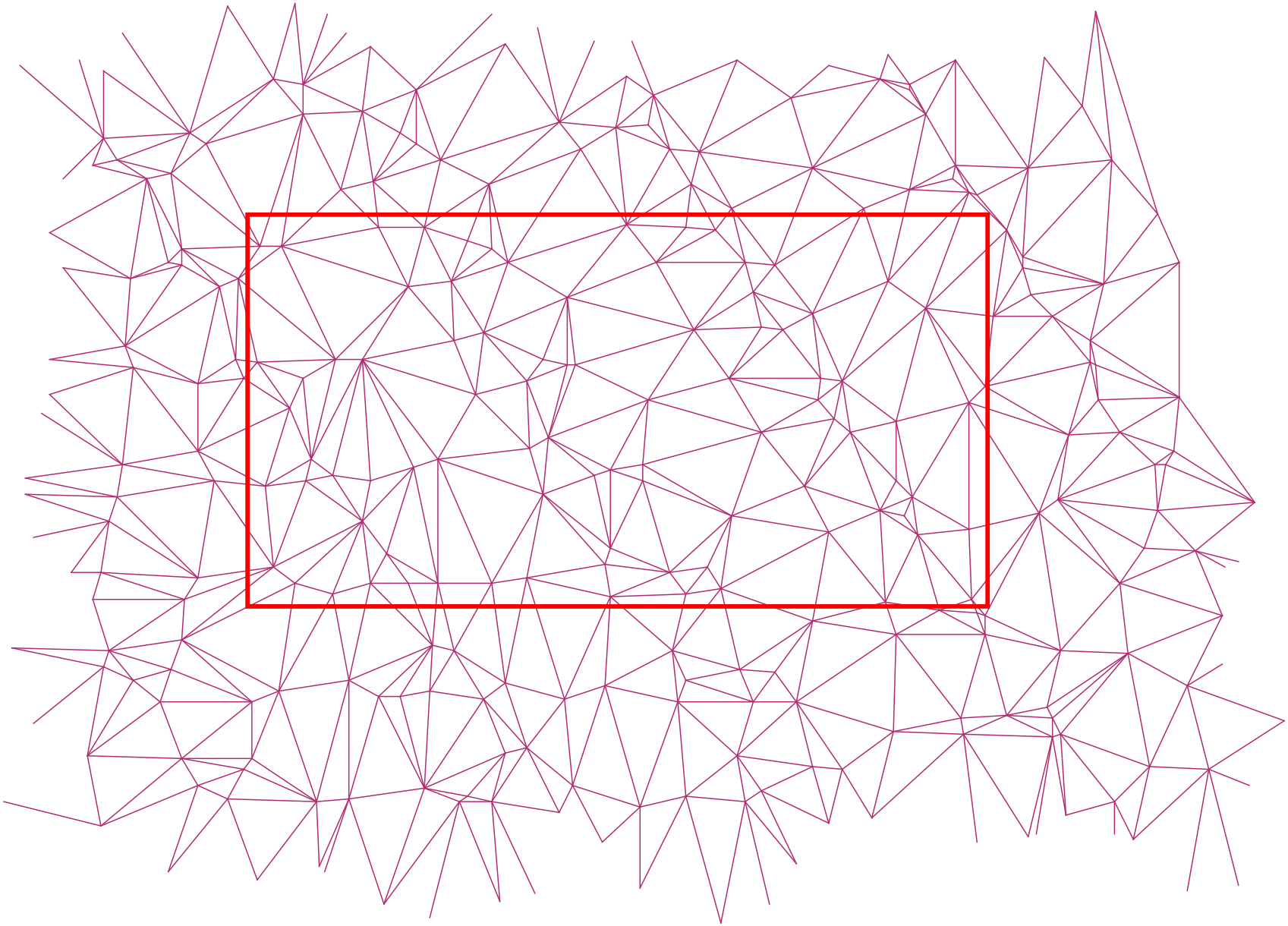
1. Only one table with $id - x - y - z - star$
2. No spatial index needed: fetching of triangles based on "walking"
3. Star column need not be filled ($\sim$ Simple Features)
4. Local updates are possible (insertion and removals)
5. Ideas are readily extensible to 3D for storing manipulating tetrahedra

Point Location = "Walking" in the triangulation



(Can be made efficient with some tricks [MSZ99])

Range Queries: also uses the triangulation



One problem: how to create that DT in the first place?

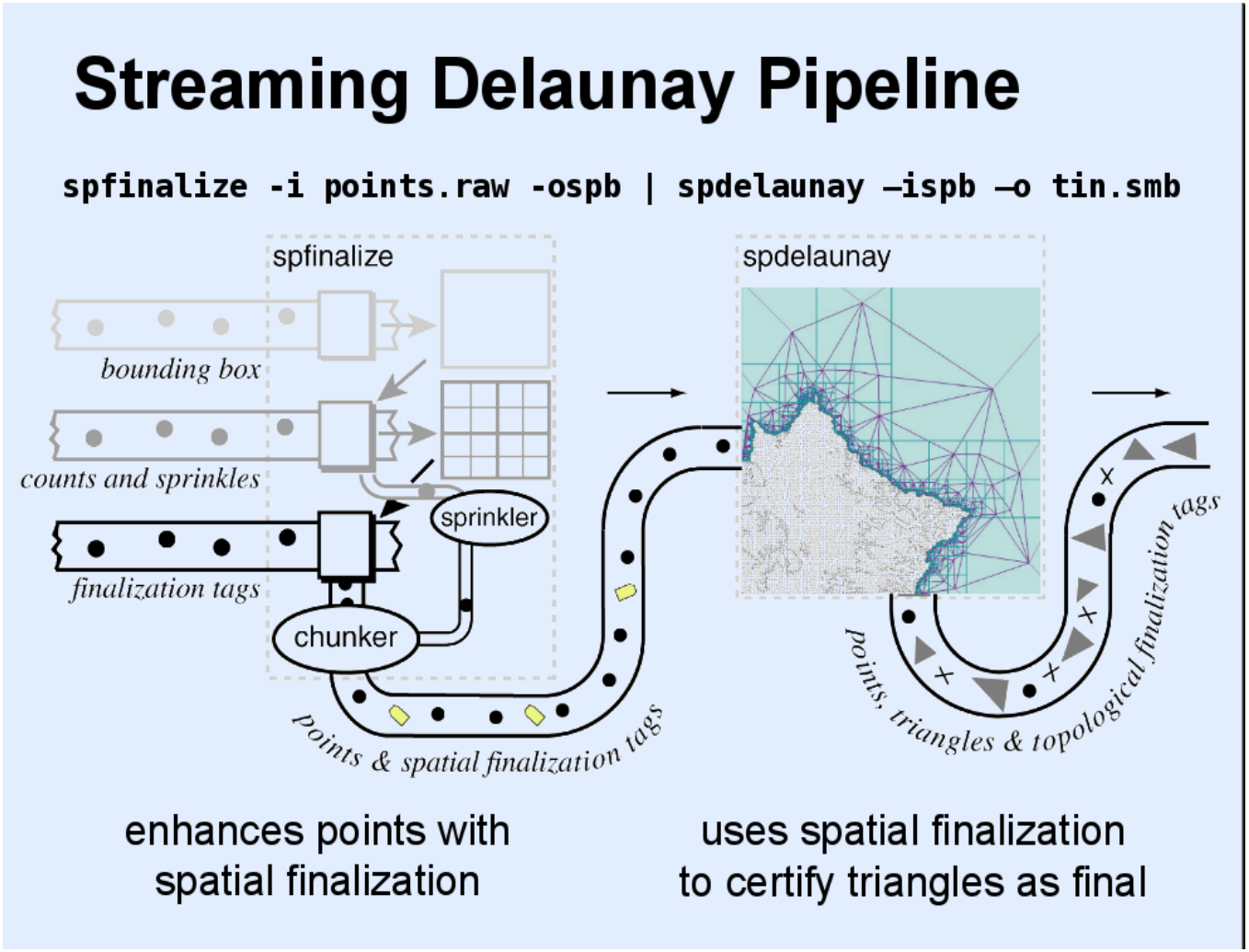
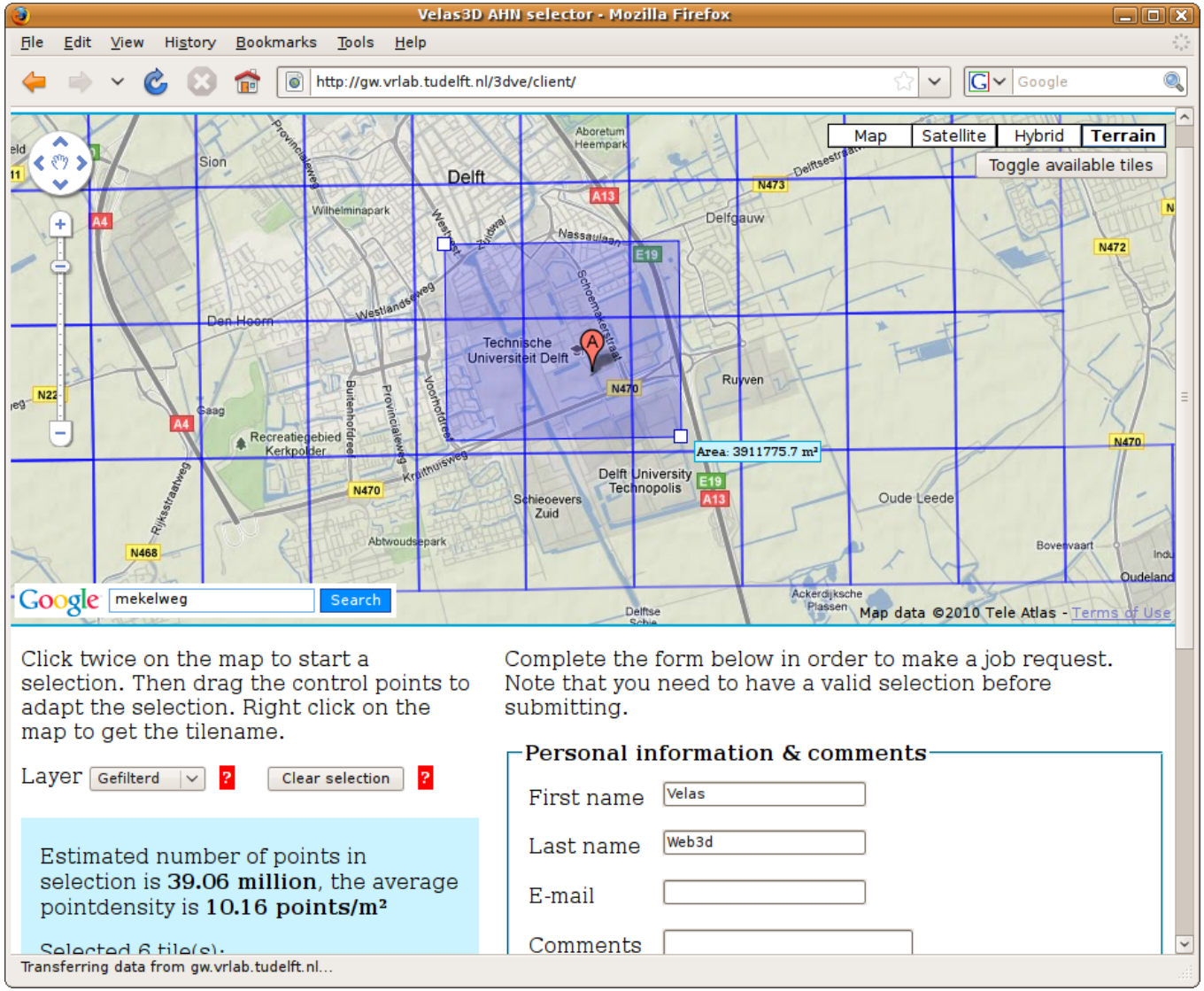


Figure from Martin Isenburg's presentation at GIScience 2006 [ILSS06]

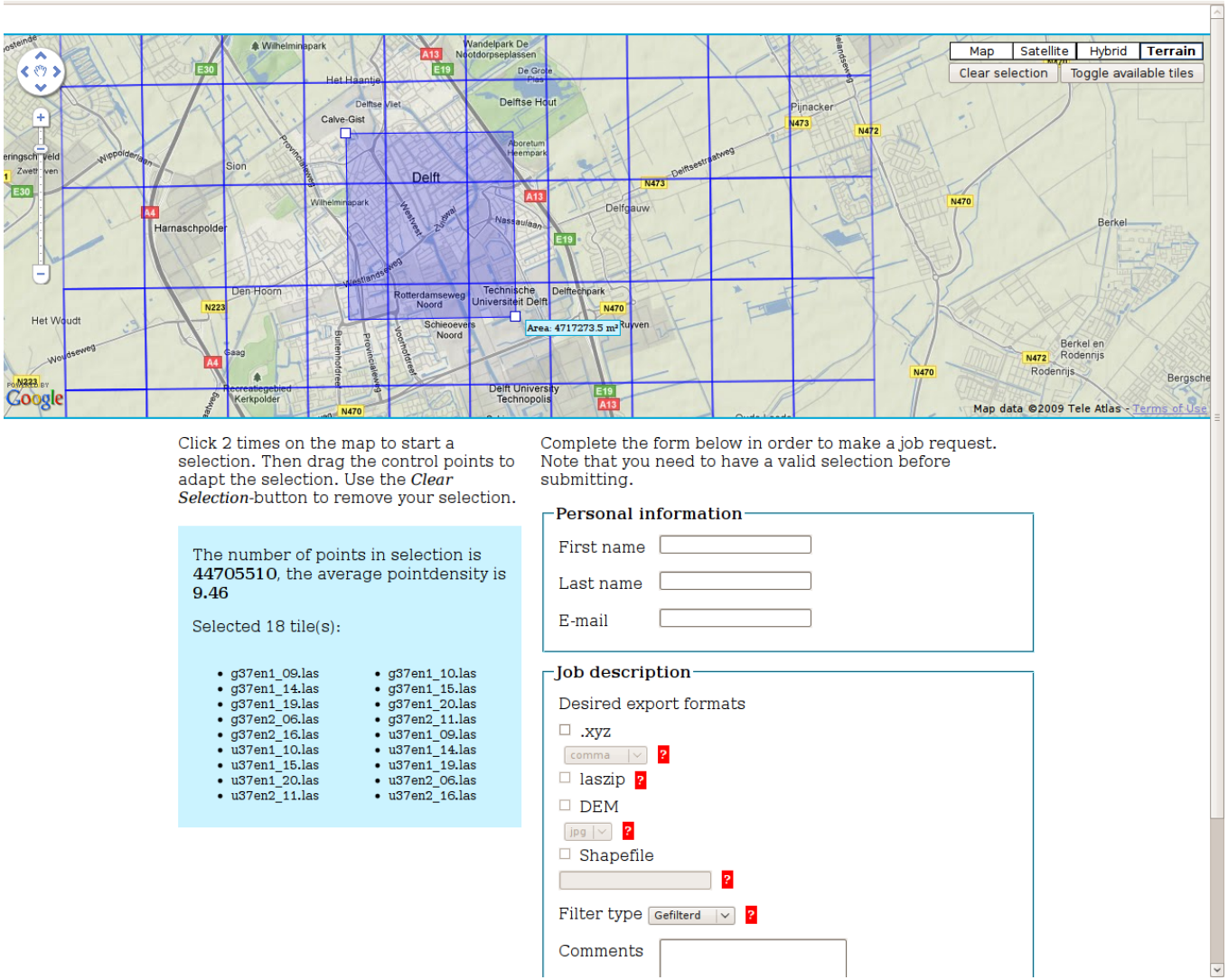
Distribution of the Data

Velas3D: An online AHN^2 selector



http://gw.vrlab.tudelft.nl/3dve/client

Velas3D: An online AHN^2 selector



Click 2 times on the map to start a selection. Then drag the control points to adapt the selection. Use the ***Clear Selection***-button to remove your selection.

The number of points in selection is **44705510**, the average pointdensity is **9.46**

Selected 18 tile(s):

- g37en1_09.las
- g37en1_10.las
- g37en1_14.las
- g37en1_15.las
- g37en1_19.las
- g37en1_20.las
- g37en2_06.las
- g37en2_11.las
- g37en2_16.las
- u37en1_09.las
- u37en1_10.las
- u37en1_14.las
- u37en1_15.las
- u37en1_19.las
- u37en1_20.las
- u37en2_06.las
- u37en2_11.las
- u37en2_16.las

Complete the form below in order to make a job request. Note that you need to have a valid selection before submitting.

Personal information

First name

Last name

E-mail

Job description

Desired export formats

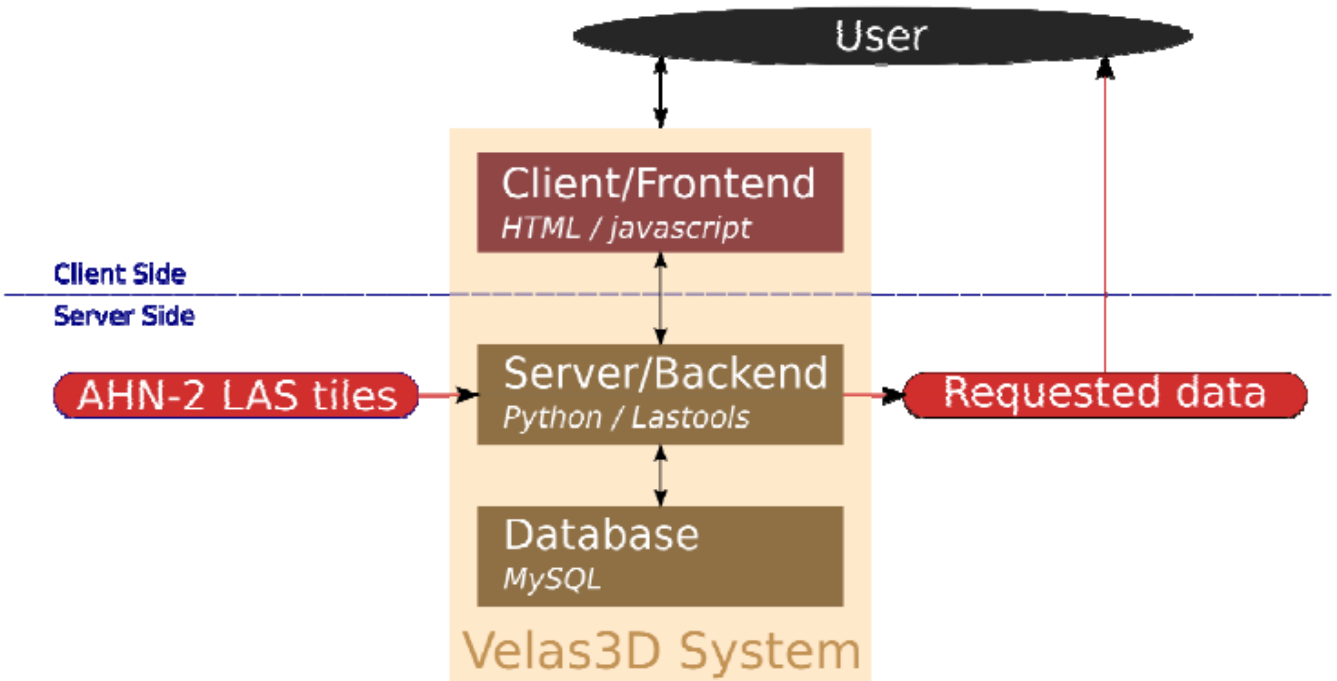
- .xyz (comma)
- laszip
- DEM (jpg)
- Shapefile

Filter type: Gefilterd

Comments

`http://gw.vrlab.tudelft.nl/3dve/client`

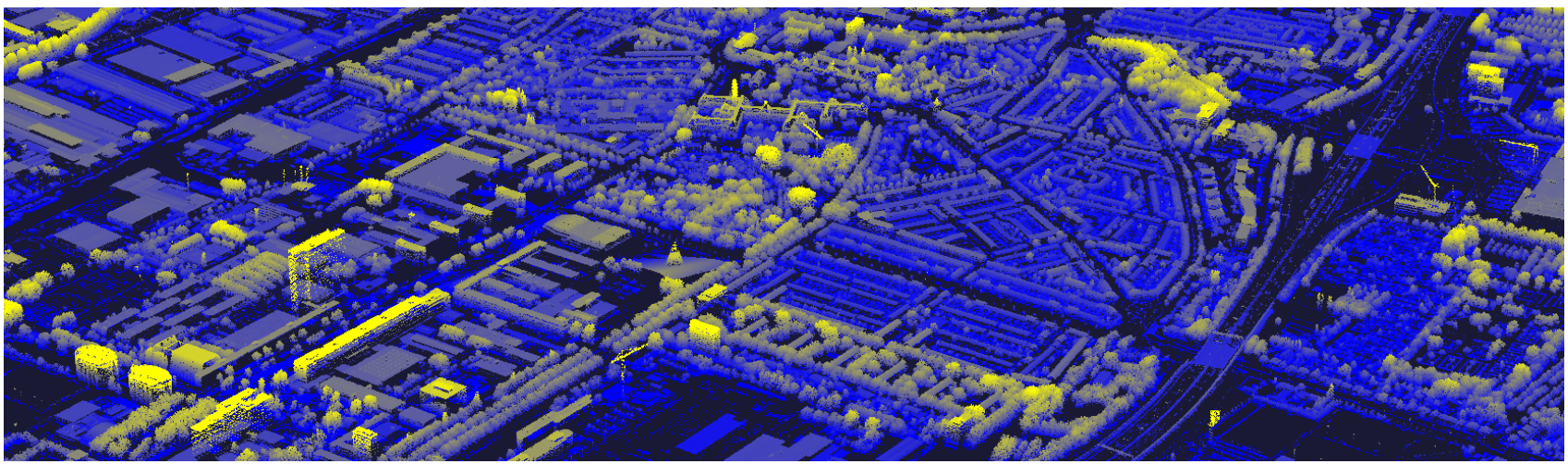
Velas3D: An online AHN^2 selector



Thanks for your attention

Hugo Ledoux
h.ledoux@tudelft.nl

Gerwin de Haan
g.dehaan@tudelft.nl



References

Martin Isenburg, Yuanxin Liu, Jonathan Richard Shewchuk, and Jack Snoeyink.
Streaming computation of Delaunay triangulations.
ACM Transactions on Graphics, 25(3):1049–1056, 2006.

Ernst P. Mücke, Isaac Saias, and Binhai Zhu.
Fast randomized point location without preprocessing in two- and three-dimensional Delaunay triangulations.
Computational Geometry—Theory and Applications, 12:63–83, 1999.