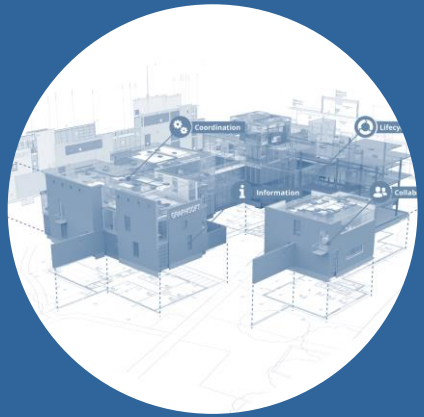
Matematika és építészet

szoftverben elmesélve



Bognár Bálint
bbognar@graphisoft.com

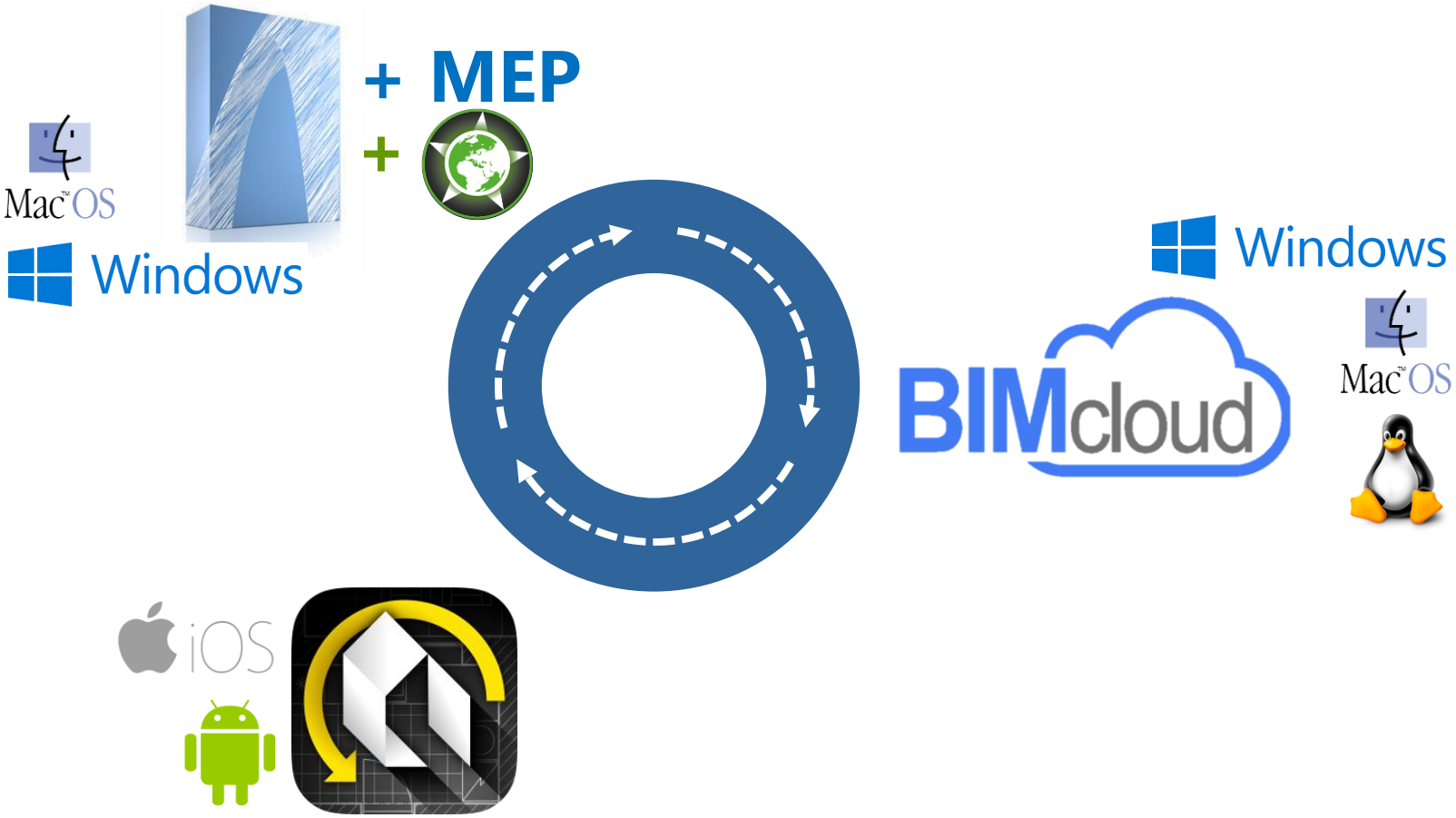
GRAPHISOFT

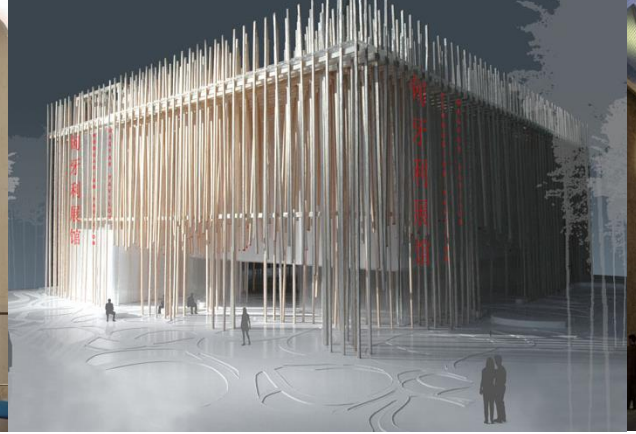
CPU **5 MHz**
RAM **1 MB**
HDD **10 MB**

ARCHICAD

Building
Information
Management

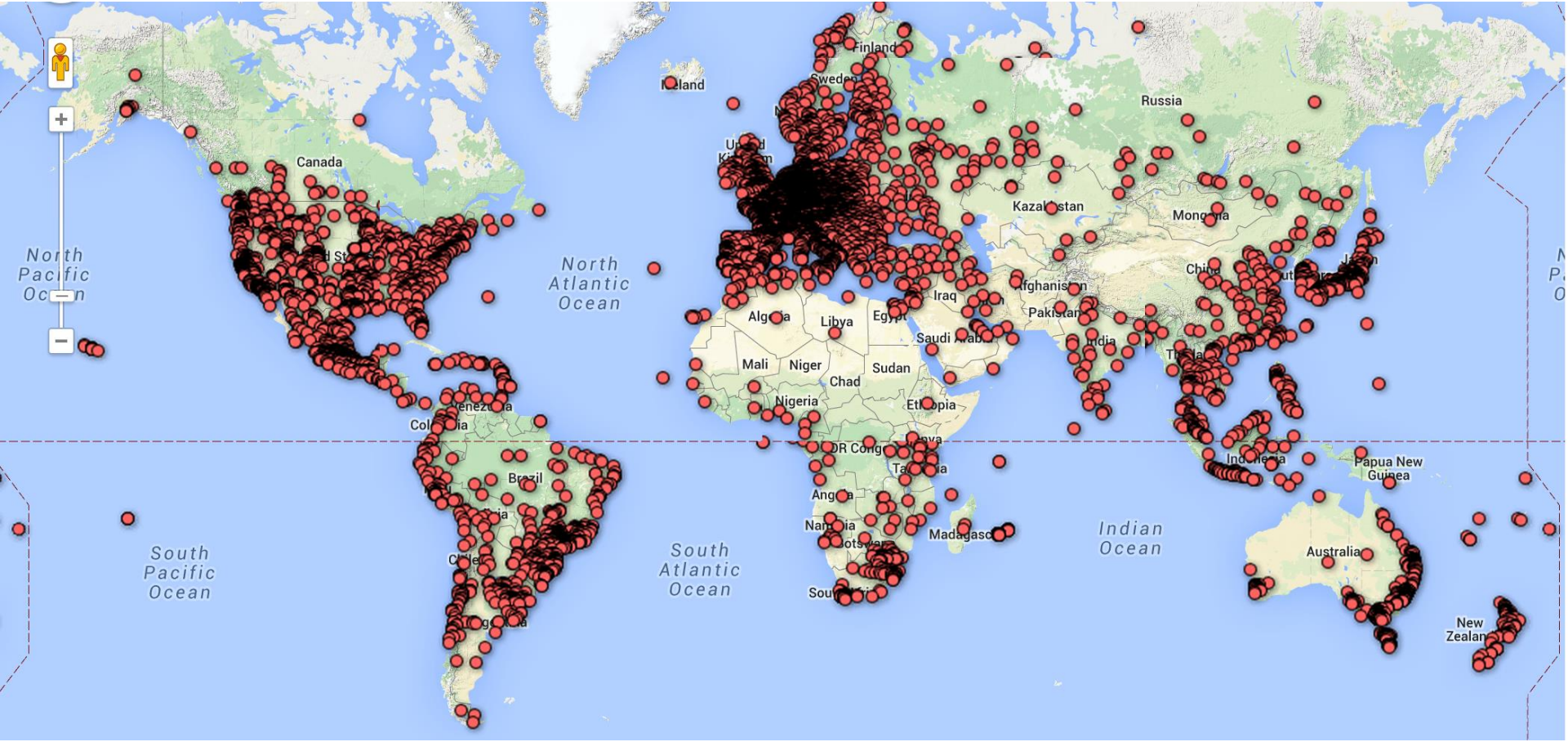
GRAPHISOFT
A NEMETSCHEK COMPANY


+ MEP
+
Mac OS
Windows
Windows
BIMcloud
Mac OS
iOS
GRAPHISOFT
A NEMETSCHEK COMPANY





számokban

- ~600 alkalmazott a világ 15 irodájában
- ~450 Budapesten
- ~150 programozó
- 80 viszonteladó
- 102 piacon
- 26 lokalizált verzió
- 18 nyelv
- 12-13 millió sor C++ kód
- 1M+ tervezett épület
- kétszámjegyű növekedés

GRAPHISOFT
A NEMETSCHEK COMPANY

technológiák

Virtual Trace - US 7936354 B2 - Apr 27, 2007 - May 3, 2011

BIM (Delta) Server - US 8352218 B2 - Jul 8, 2009 - Jan 8, 2013

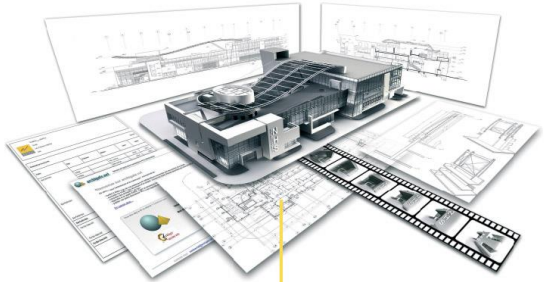
pending

Background Processing - 503291930 (Submission ID) / May 4, 2015 – Pending

BIMx Hyper-model - Not Patented

Predictive Design – 2017 - Pending

díjak



First 3D CAD on Personal Computers

Invention of the Virtual Building™ Concept

"Best New CAD Software"

"Best Architectur CAD Softwar

1982 1986 1990 1992 1993

GRAPHISOFT
A NEMETSCHEK COMPANY


GRAPHISOFT

https://commons.wikimedia.org/wiki/File:A_yellow_house_with_a_sheltering_roof.jpg

https://commons.wikimedia.org/wiki/Category:Sawtooth_roofs#/media/File:Herten_-_Zeche_Ewald_23_ies.jpg

https://en.wikipedia.org/wiki/First_Unitarian_Society_of_Madison

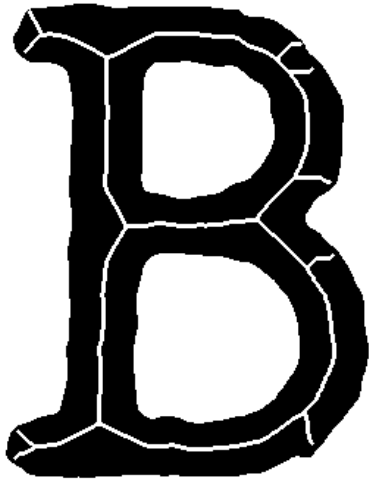
Real-life Roofs

- Different pitches
- Gables
- Flying gables
- Gablets
- Half-hips
- Mazardes
- Bonnet roofs
- Atriums
- Skirt roofs
- Catslides
- Towers
- …

https://en.wikipedia.org/wiki/List_of_roof_shapes

Skeletons for Shapes

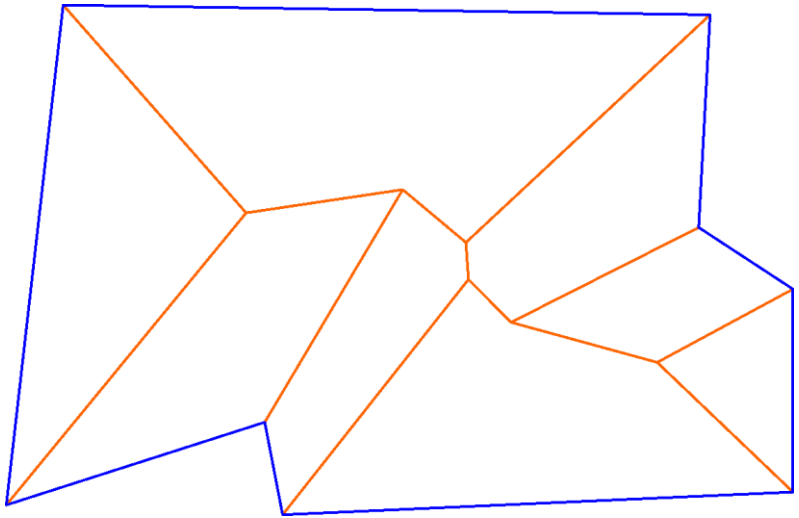
- Pattern recognition
  - Characters
  - Protein folding
  - Fingerprints
- Feature extraction
  - Medical imaging
  - Topography
- Compression



https://en.wikipedia.org/wiki/Topological_skeleton#/media/File:Skel.png

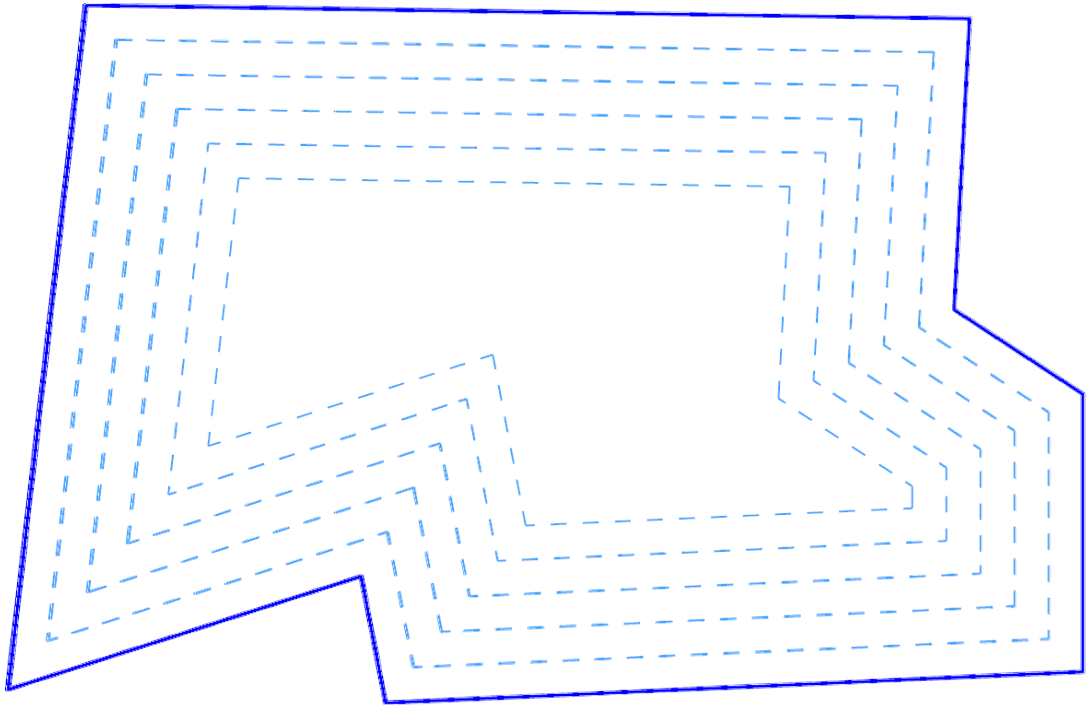
The Straight Skeleton

- From planar, simple polygons
- Straight line segments
- Definition by algorithm

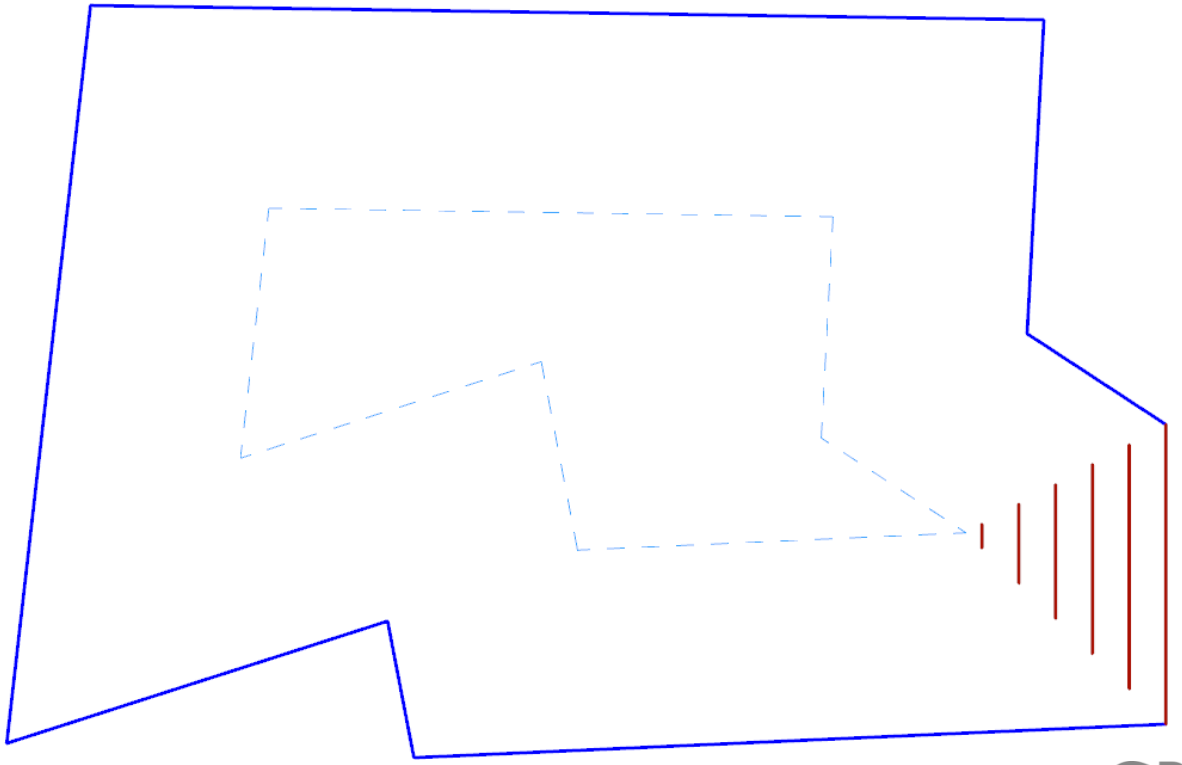


[1] Aichholzer, Aurenhammer, Alberts, Gärtner – A Novel Type of Skeleton for Polygons (1995)

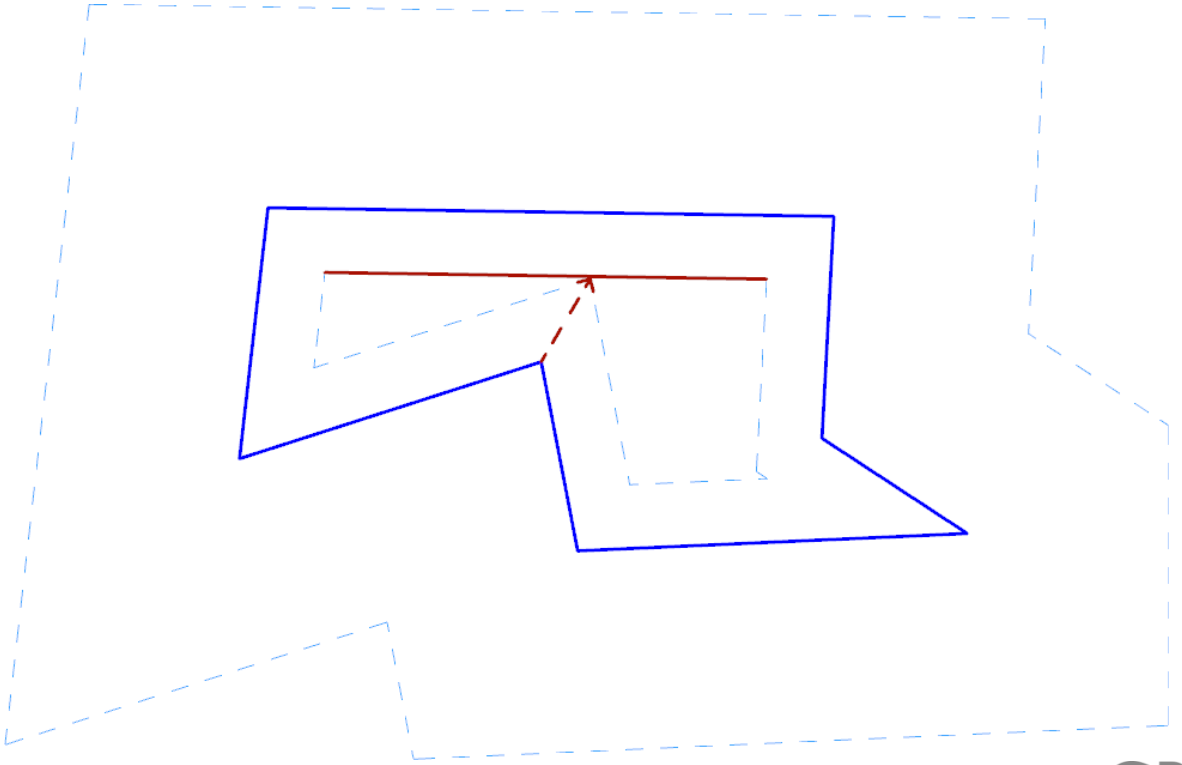
Construction algorithm



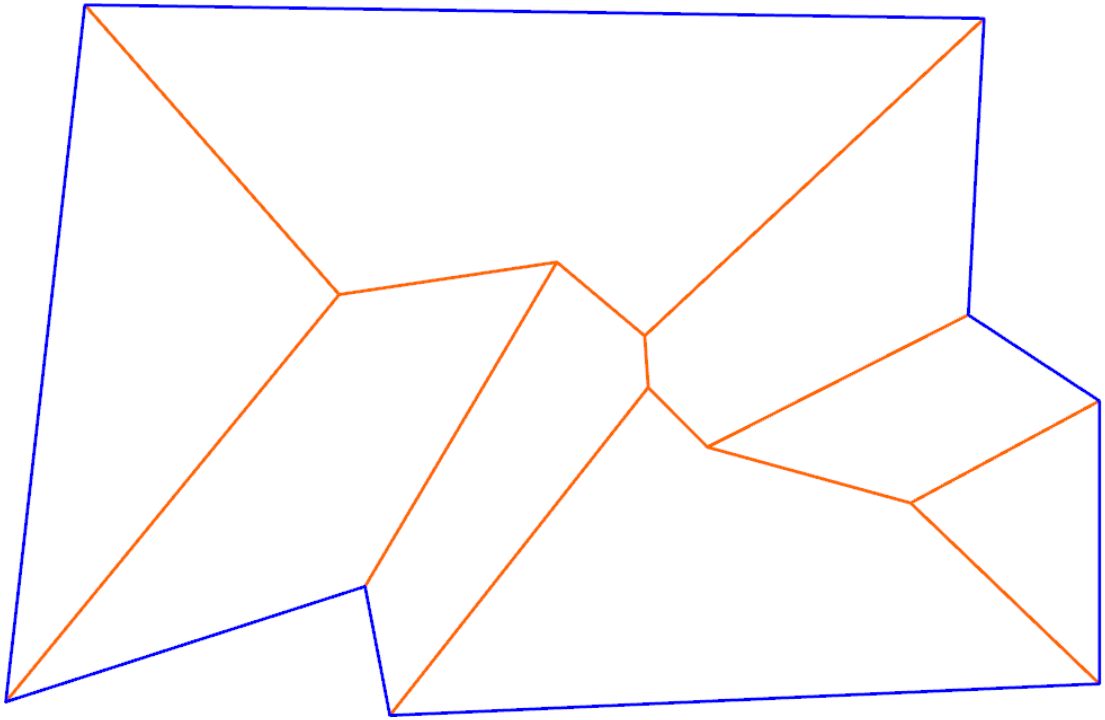
Edge event



Split event

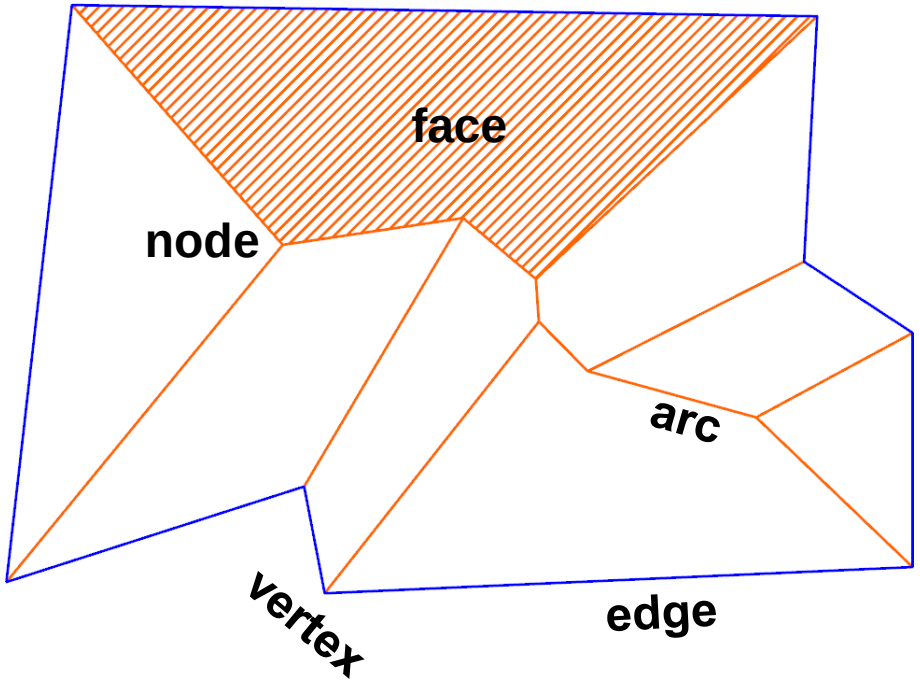


Final Skeleton



Mathematical properties

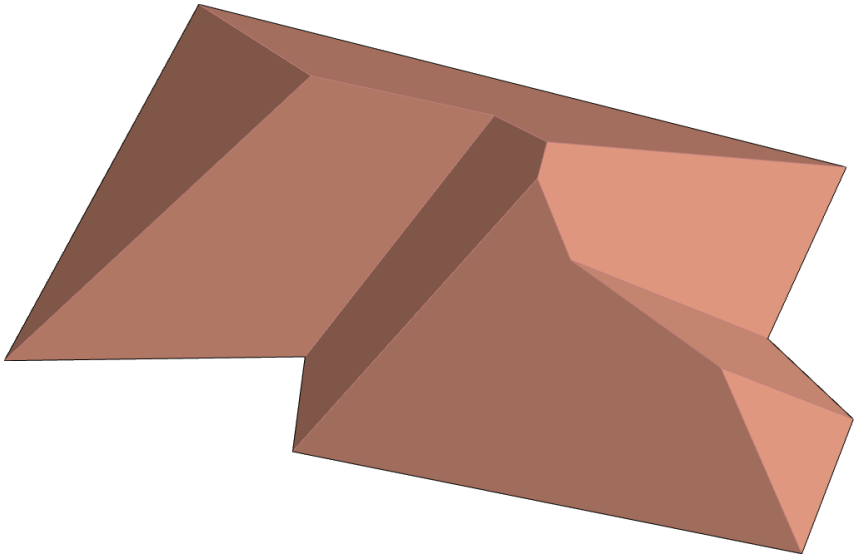
- Straight lines
- Planar tree
- Partitions the polygon
- Faces are monotone
- Possibility of reconstruction



[5] Biedl, Held, Huber - Recognizing Straight Skeletons and Voronoi Diagrams and Reconstructing Their Input (2013)

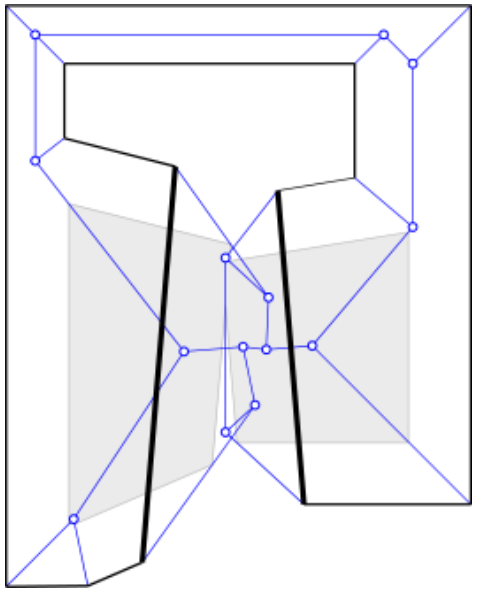
From skeleton to roof

- $t = z$
- Straight ridges
- Water runs off towards the edges



Generalizations

- Base polygon with holes
- Edges with different weights
  - Positive: inward
  - Negative: outward
  - Zero: stays in place

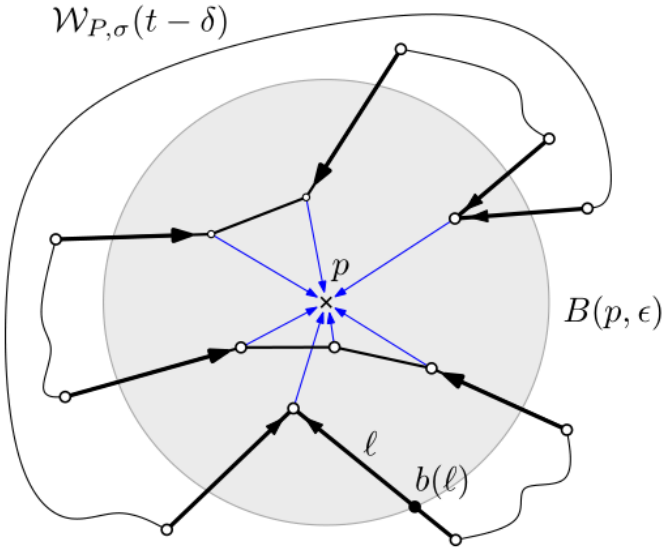


[4] Biedl, Held, Huber, Kaaser, Palfrader – Weighted straight skeletons in the plane (2015)

New event type

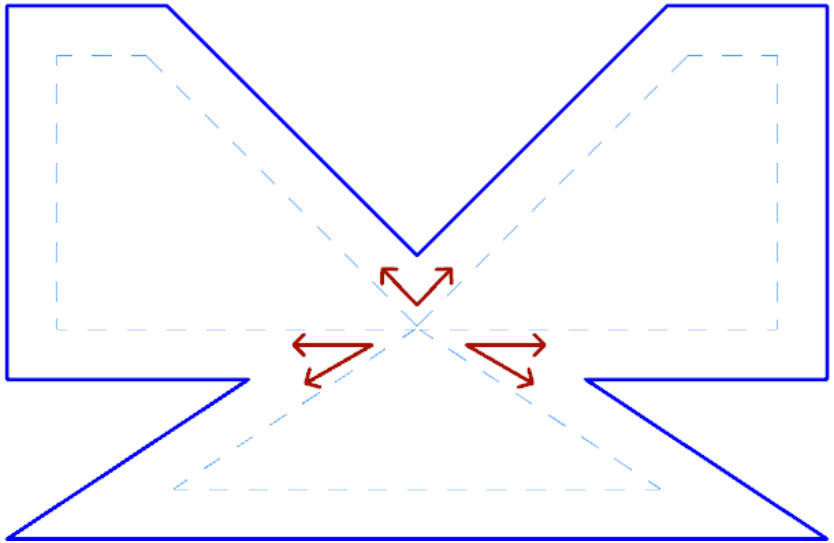
Multi-event: multiple edge or split (or both) events occur at the same time (*t*), in the same location (*p*).

Goal: construct the new topology of the edges so that moving forward, the wavefront remains (weakly) **planar locally.**

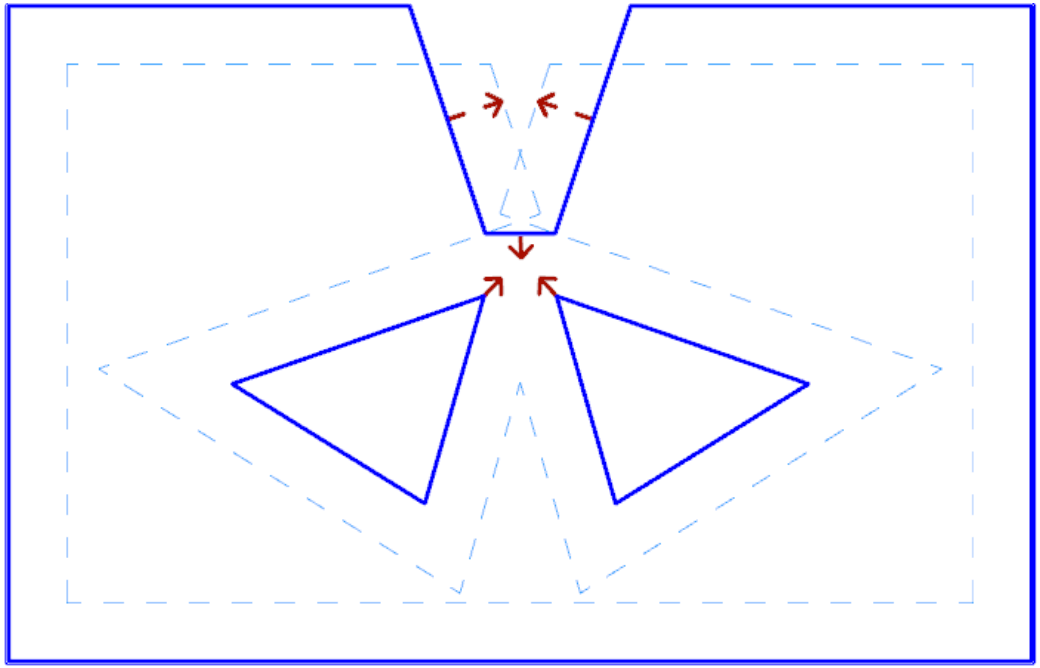


[2] Biedl, Huber, Palfrader – Planar Matchings for Weighted Straight Skeletons (2016)

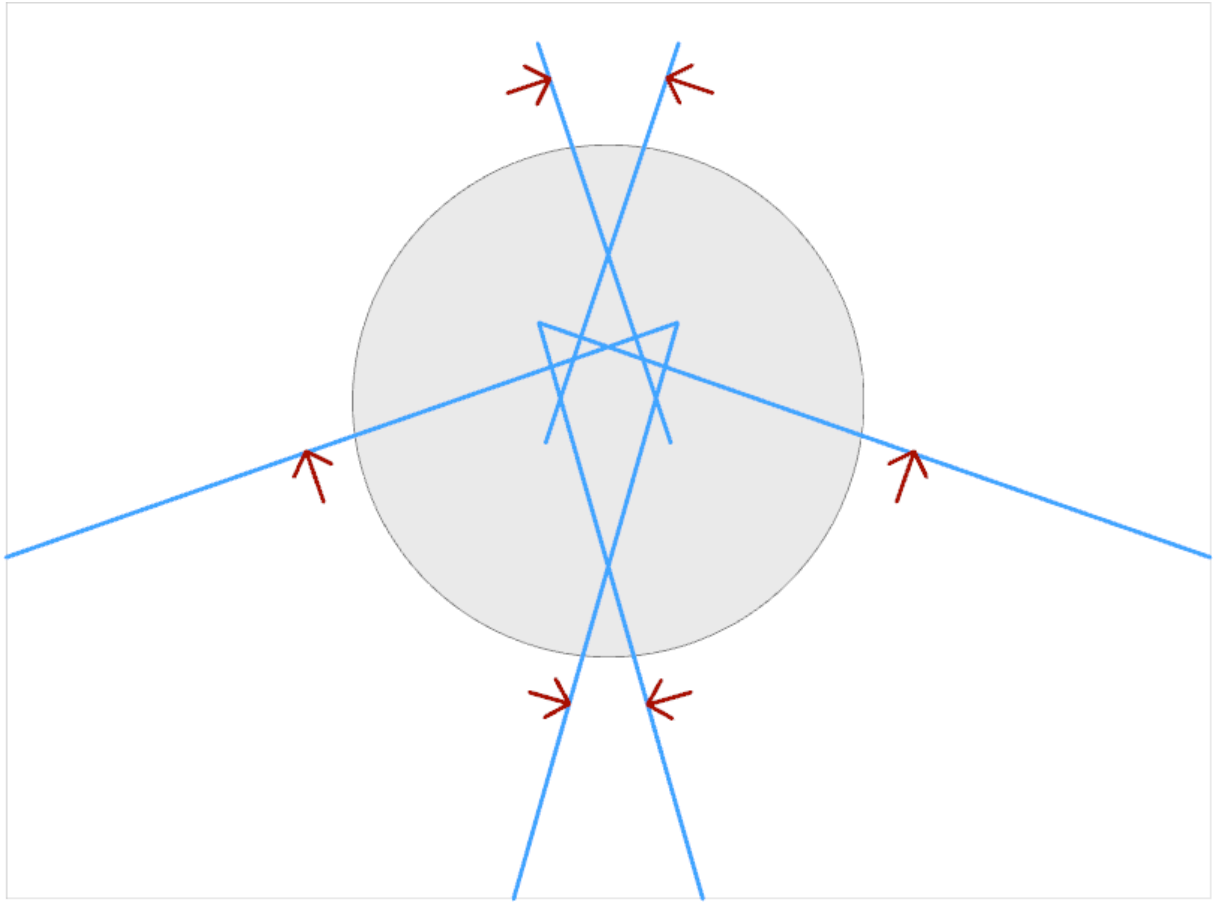
Standard pairing

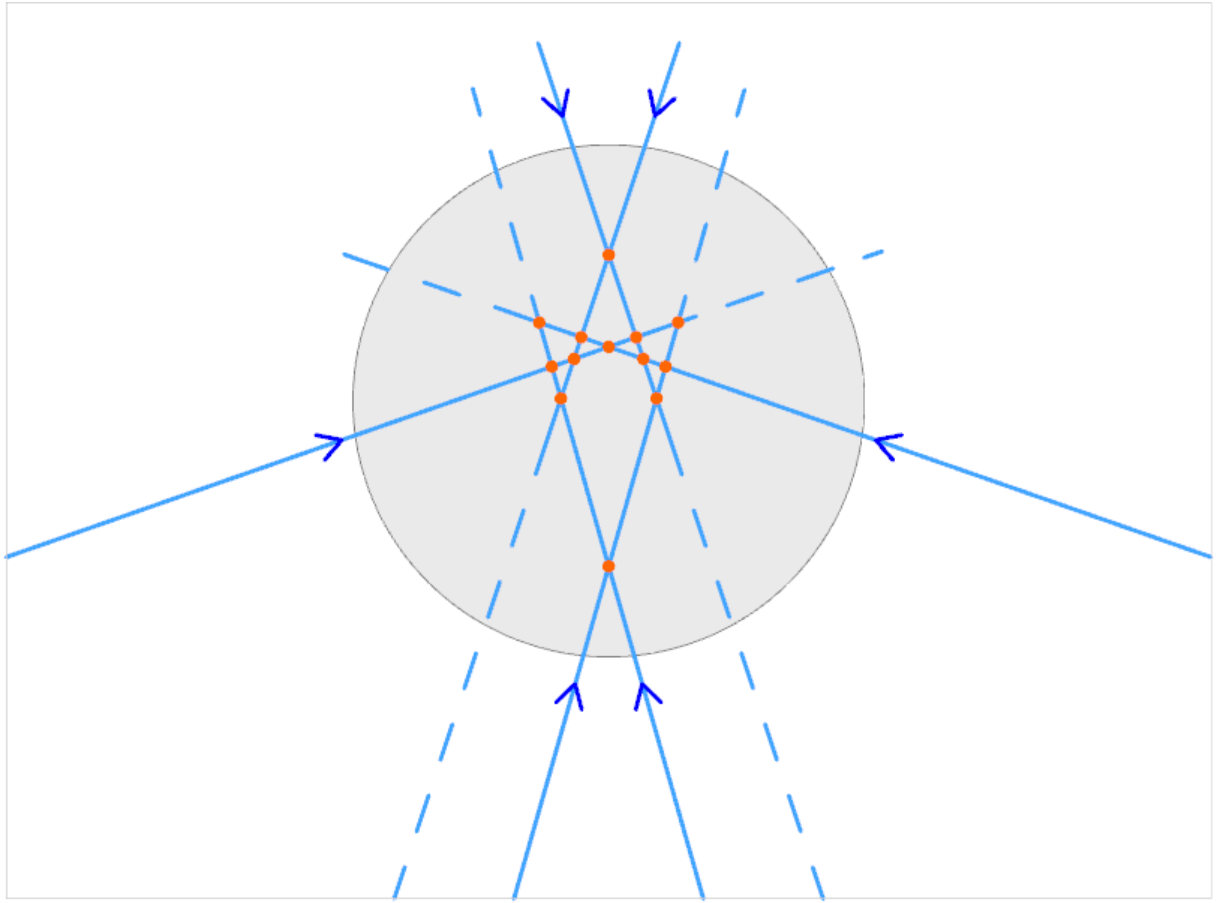


Simulation of the future



GRAPHISOFT®
A NEMETSCHEK COMPANY





The stable roommates problem

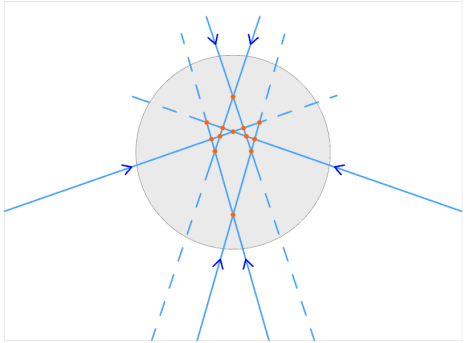
Goal: find a stable matching for an even number of objects.

Stable matching: a pairing where no two objects prefer each other mutually to their pairs.

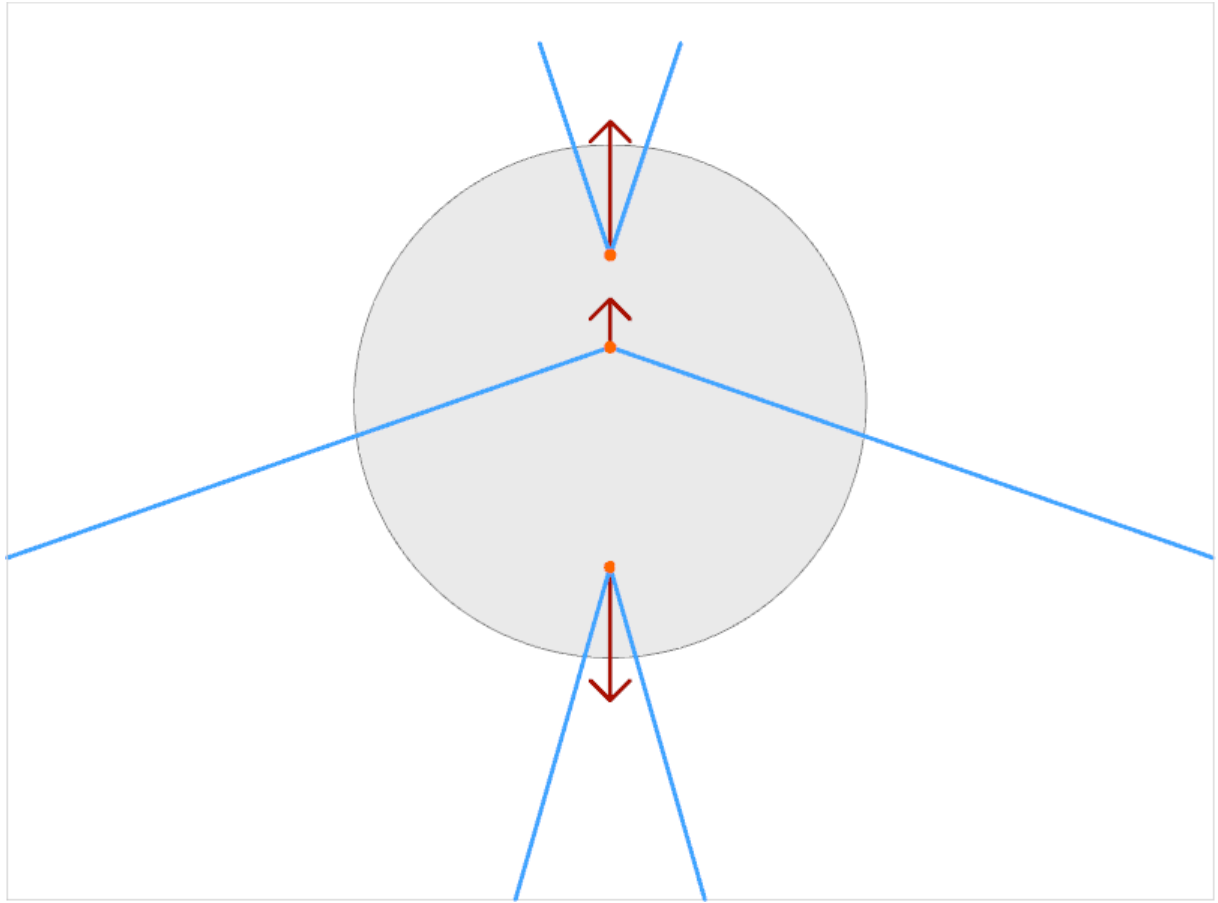
Solution: not guaranteed

[3] *Irving, Manlove – An efficient algorithm for the "stable roommates" problem (2007)*

Preferences: the order of intersections while walking the line of an edge.



Solution: always exists, not necessarily unique.



ARCHICAD specialities

- Preferences are a bit more complicated
  - Collinear edges are less preferred
  - Multi-intersections ordered circularly, starting towards the outside of the wavefront contour
- Instead of Irving's two-phase algorithm
  - Own one-phase algorithm
  - Same time-complexity (n^2)

Improving robustness

- Self-touching input is enabled and handled as an event
- Calculation is done in 2D (+ time)
  - rotated before and rotated back after
- Exact (rational) numerical representation
  - With floating-point aids
- Track the wavefront contour and the „so-far-skeleton” at every event

Further development

- Handle curved edges in the base polygon
- Create skeletons of open polylines
- Create curved roof faces
  - weights change in time continuously

References

[1] Aichholzer, Aurenhammer, Alberts, Gärtner – A Novel Type of Skeleton for Polygons (1995)

[2] Biedl, Huber, Palfrader – Planar Matchings for Weighted Straight Skeletons (2016)

[3] *Irving, Manlove – An efficient algorithm for the "stable roommates" problem (2007)*

[4] Biedl, Held, Huber, Kaaser, Palfrader – Weighted straight skeletons in the plane (2015)

[5] Biedl, Held, Huber - Recognizing Straight Skeletons and Voronoi Diagrams and Reconstructing Their Input (2013)

THANK YOU!

GRAPHISOFT®
A NEMETSCHEK COMPANY