Generalisation via tGAP structure

MobiMaps project (RGI-233)

Guest lecture at LBS/Geomatics

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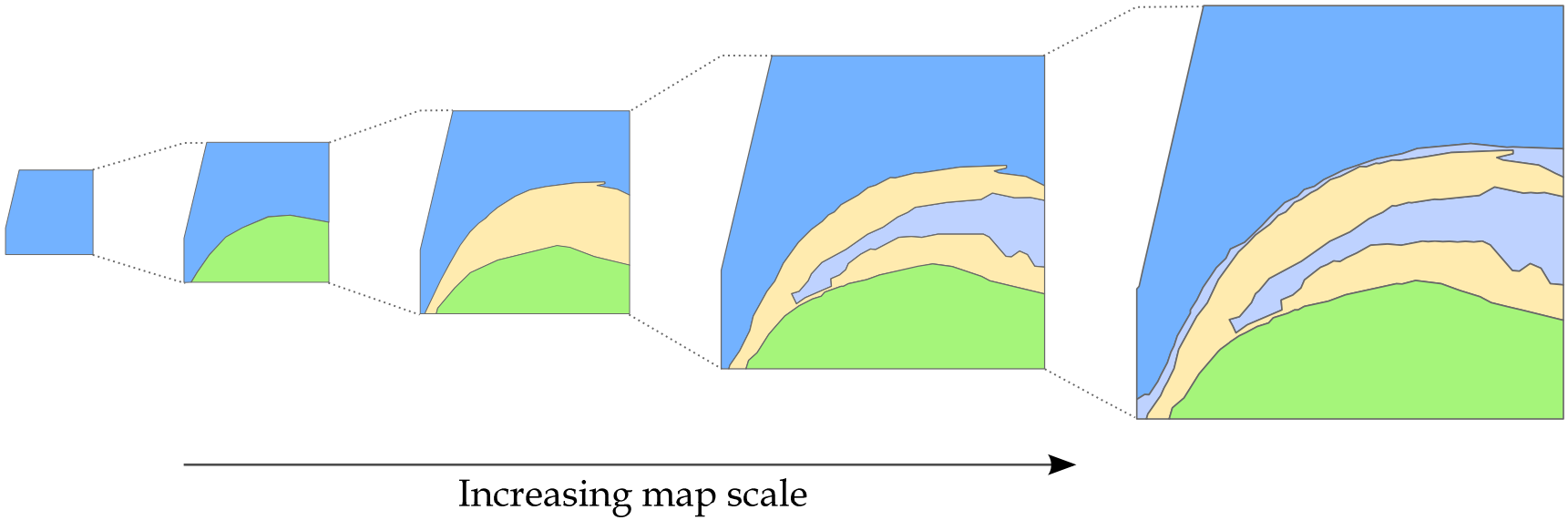
Content

- Few words on generalisation
- Theory of tGAP (topological Generalised Area Partitioning)
  - How tGAP is filled (off-line)
  - How tGAP is used for (online) feature selection
- Implementation of tGAP in Oracle Spatial
  - New data types
  - Tables storing the structure
- Further research

Why generalisation?

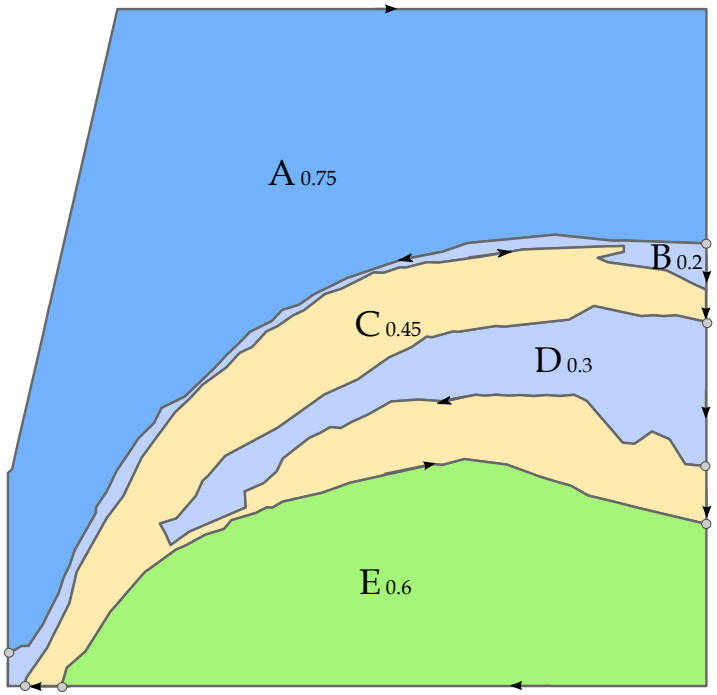


Generalisation methods & operators

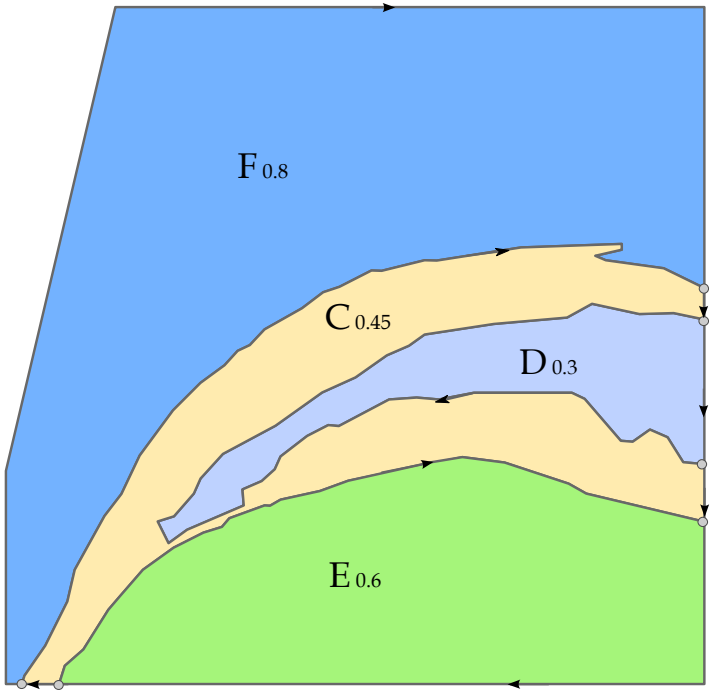
- Generalisation methods:
  - Multiple representation databases
  - On-the-fly generalisation
  - tGAP structure
    - Off-line generalisation
    - On-the-fly feature selection
- Generalisation operators:

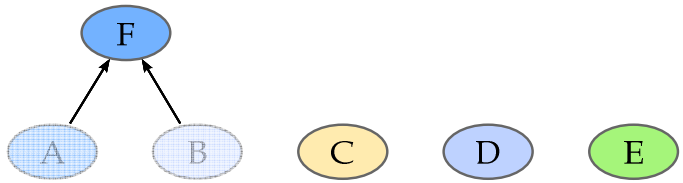
  reclassification, elimination, collapse, simplification, …

Offline generalisation of tGAP

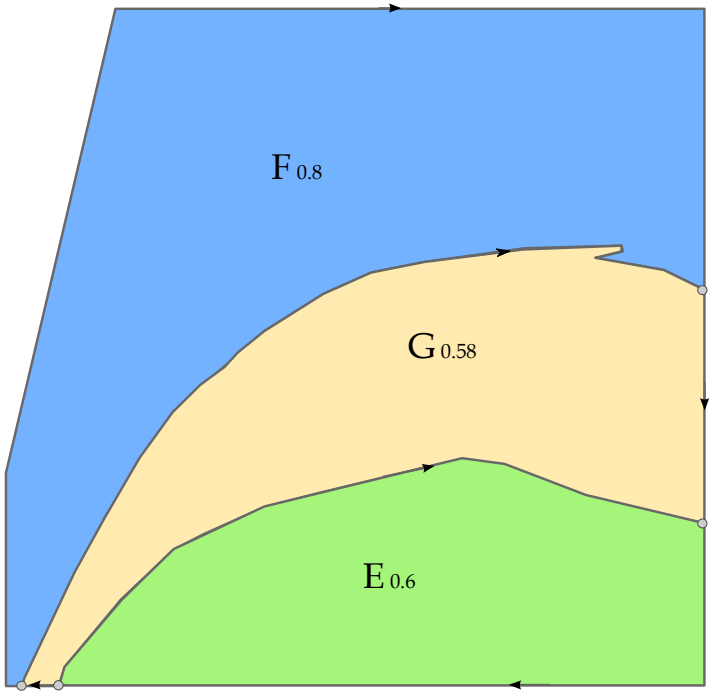


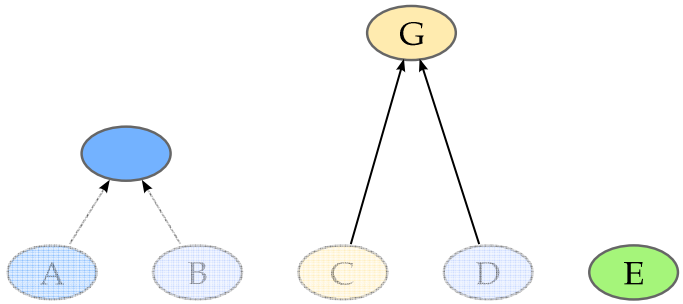
Offline generalisation of tGAP



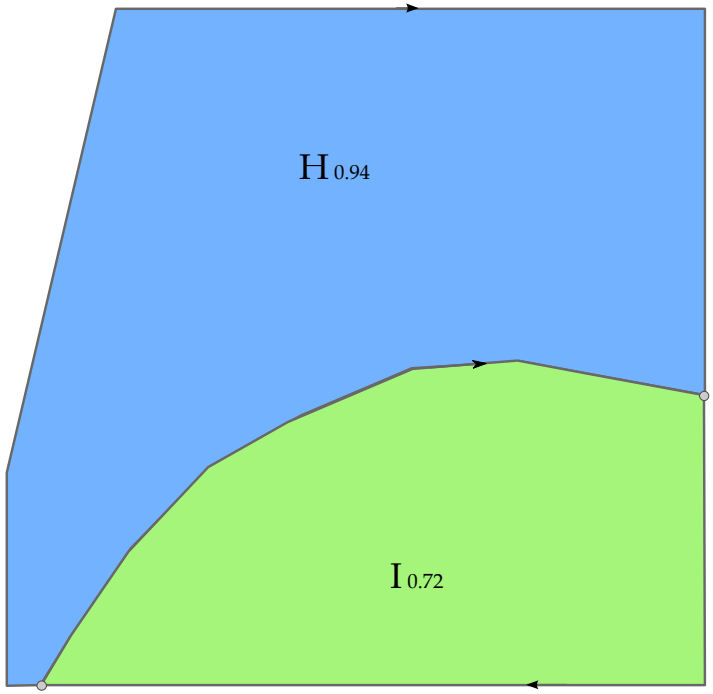


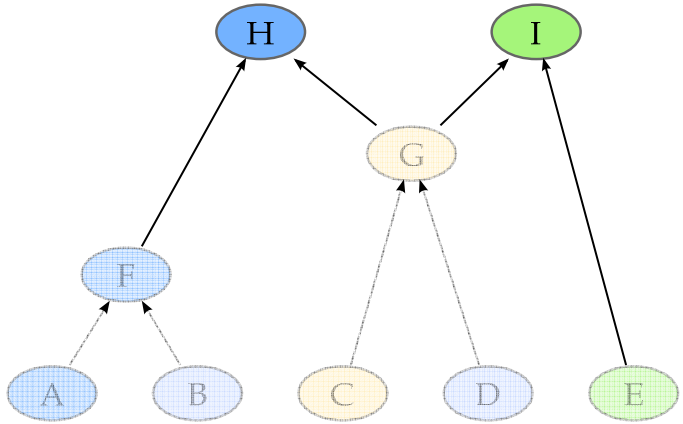
Offline generalisation of tGAP



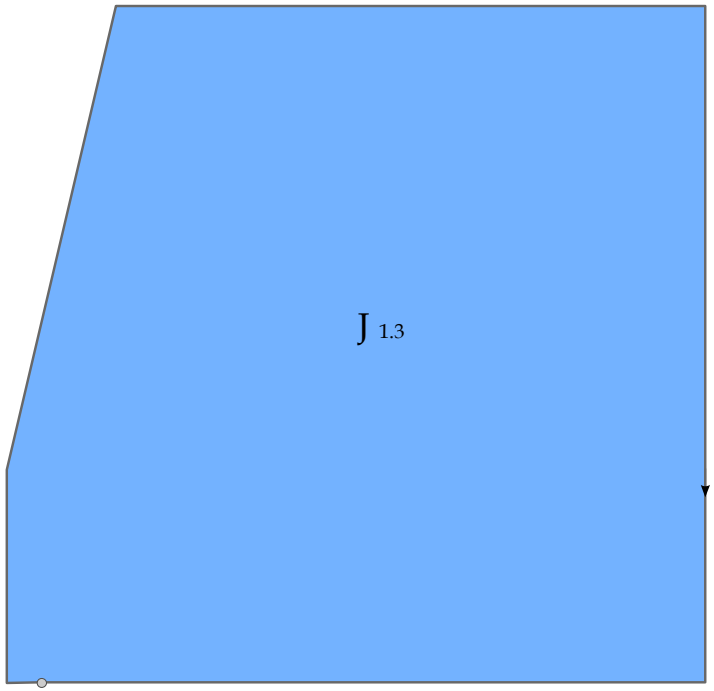


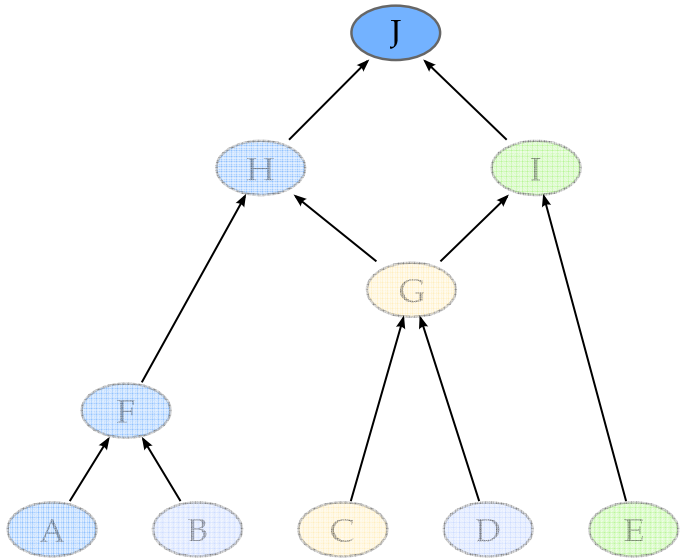
Offline generalisation of tGAP





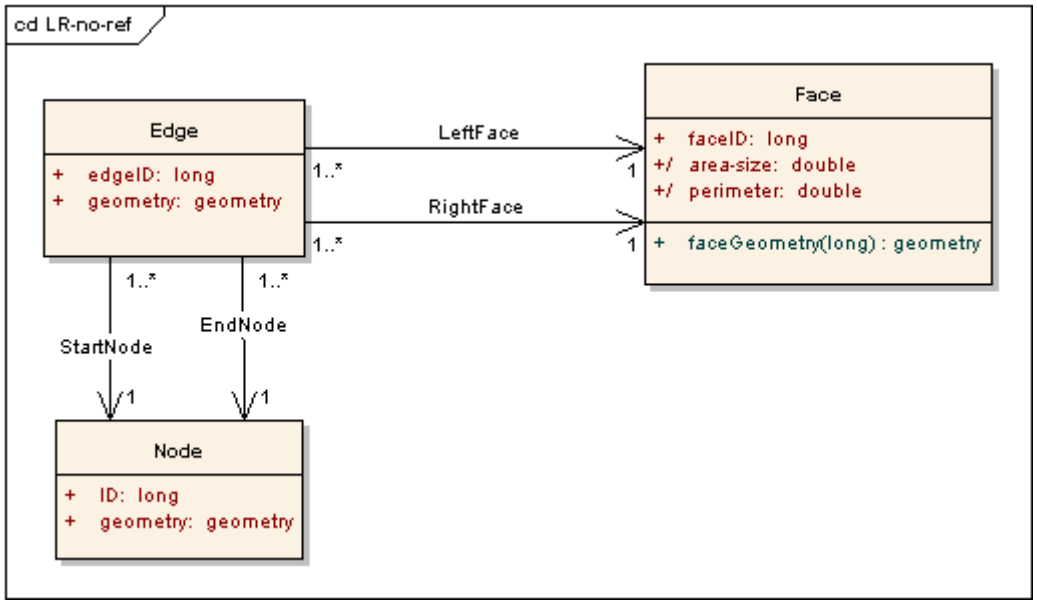
Offline generalisation of tGAP





Topological model for data storage

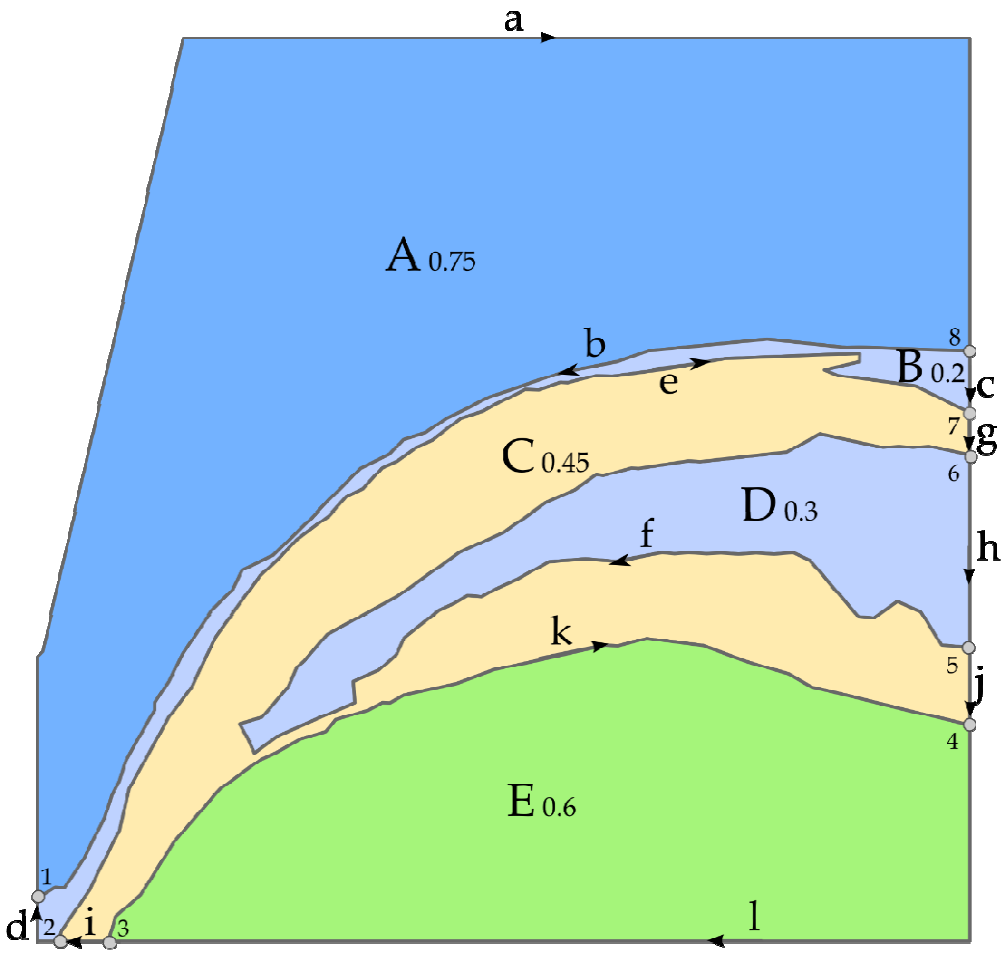
- Left-Right topology without edge references



tGAP structure composition

- tGAP structure is composed of
  - Hierarchy of faces: DAG (Directed Acyclic Graph)
  - Hierarchy of edges: edge forest
  - BLG (Binary Line Generalisation) trees for edge simplification; one BLG for each edge

Building DAG hierarchy of faces: step 0

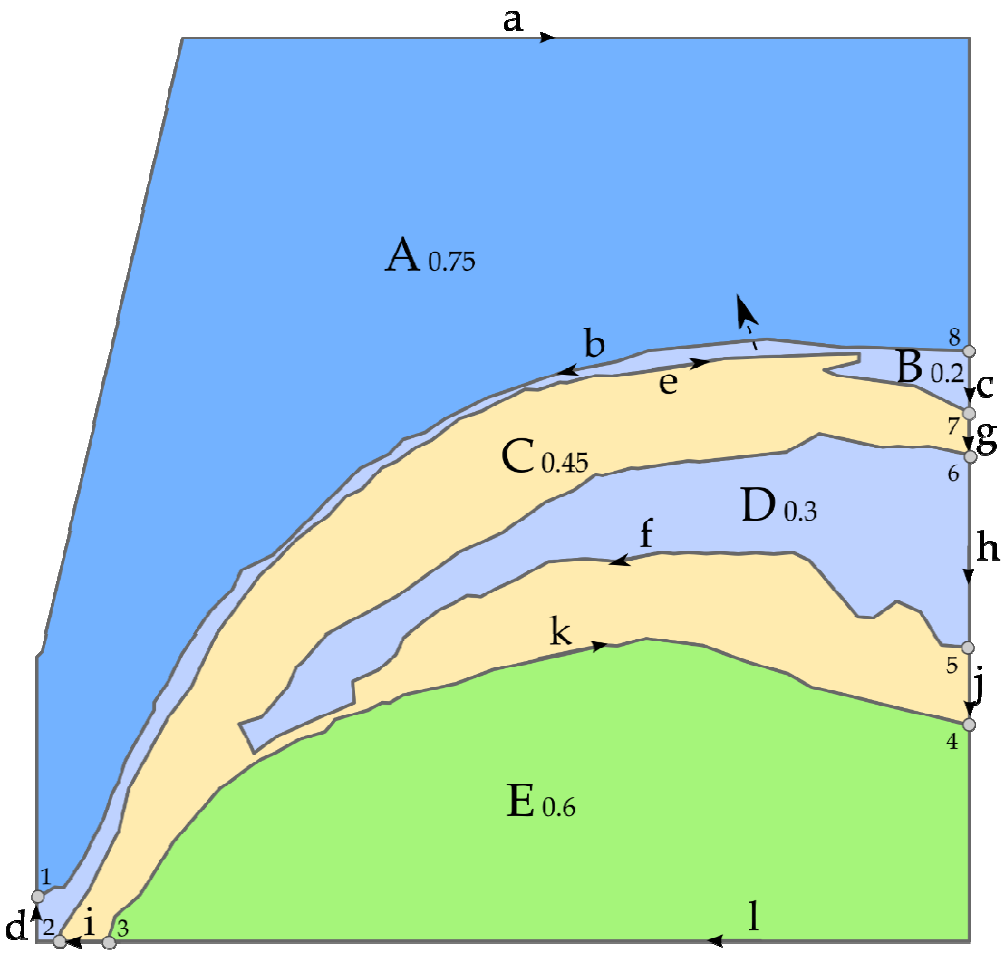


Calculate importance values:

Importance(F) = Area(F)*Class-Weight(F)

A	B	C	D	E
0.75	0.2	0.45	0.3	0.6

Building DAG hierarchy: step 1

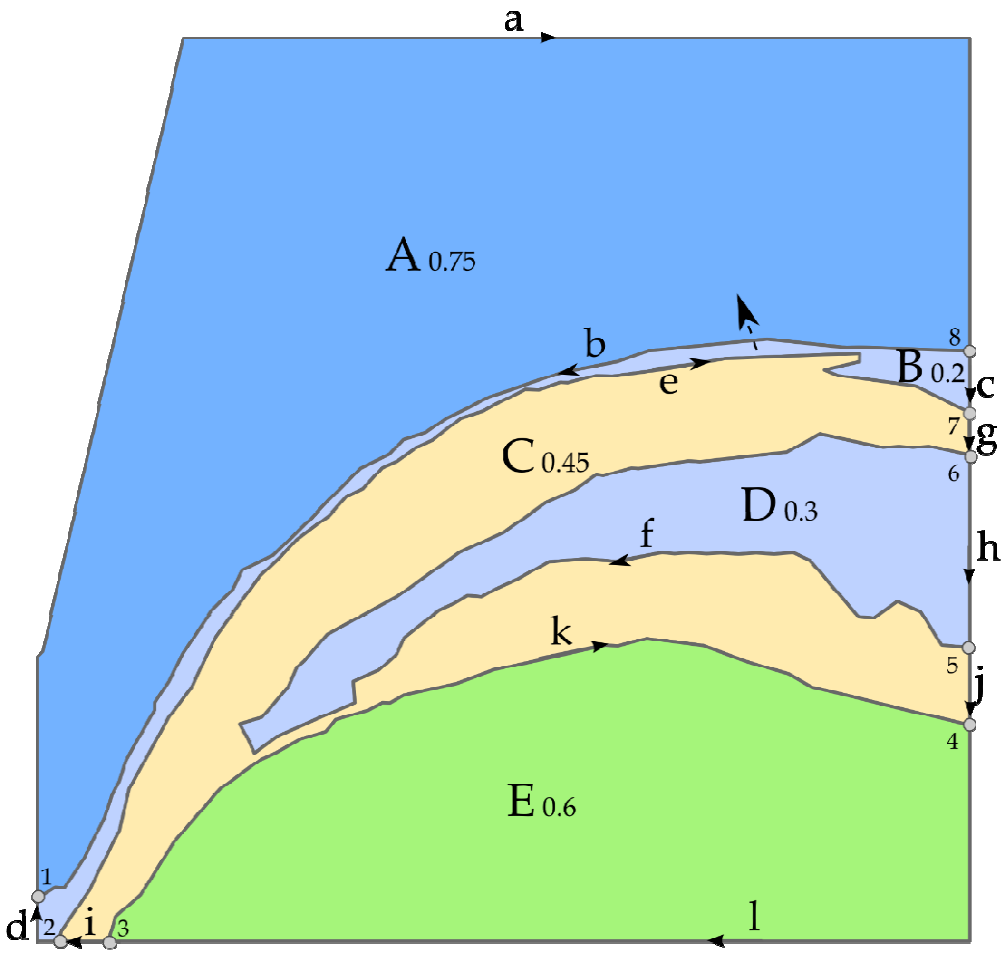


Find least important face;
Find its most compatible neighbour:

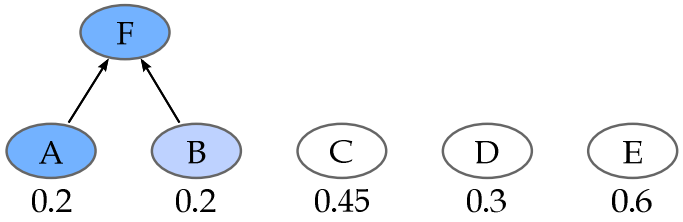
Comp(F,G) = Len(Bnd(F,G)) * Class-Similarity(F,G)

A	B	C	D	E
0.75	**0.2**	0.45	0.3	0.6

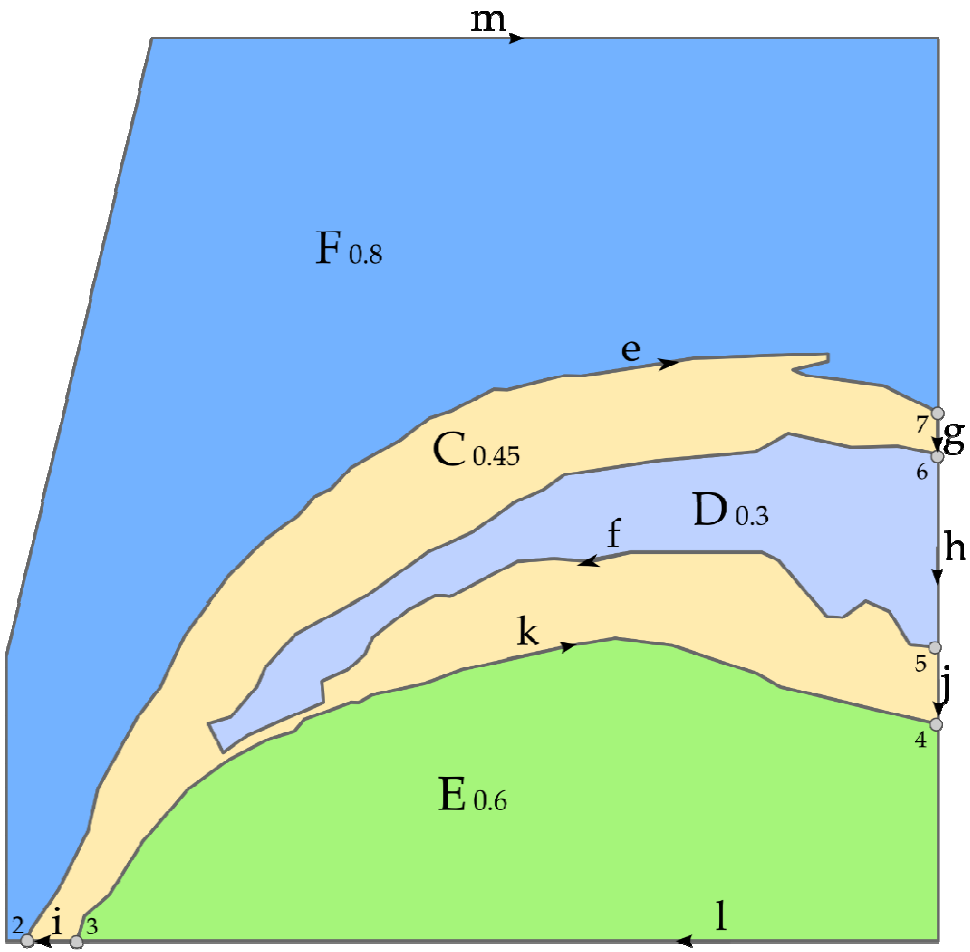
Building DAG hierarchy: step 1



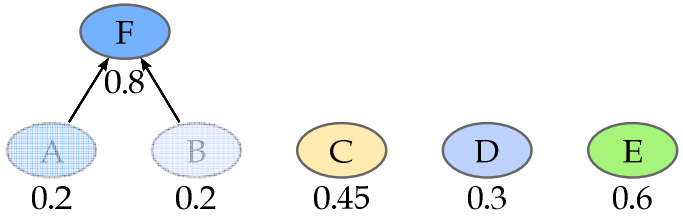
Merge faces



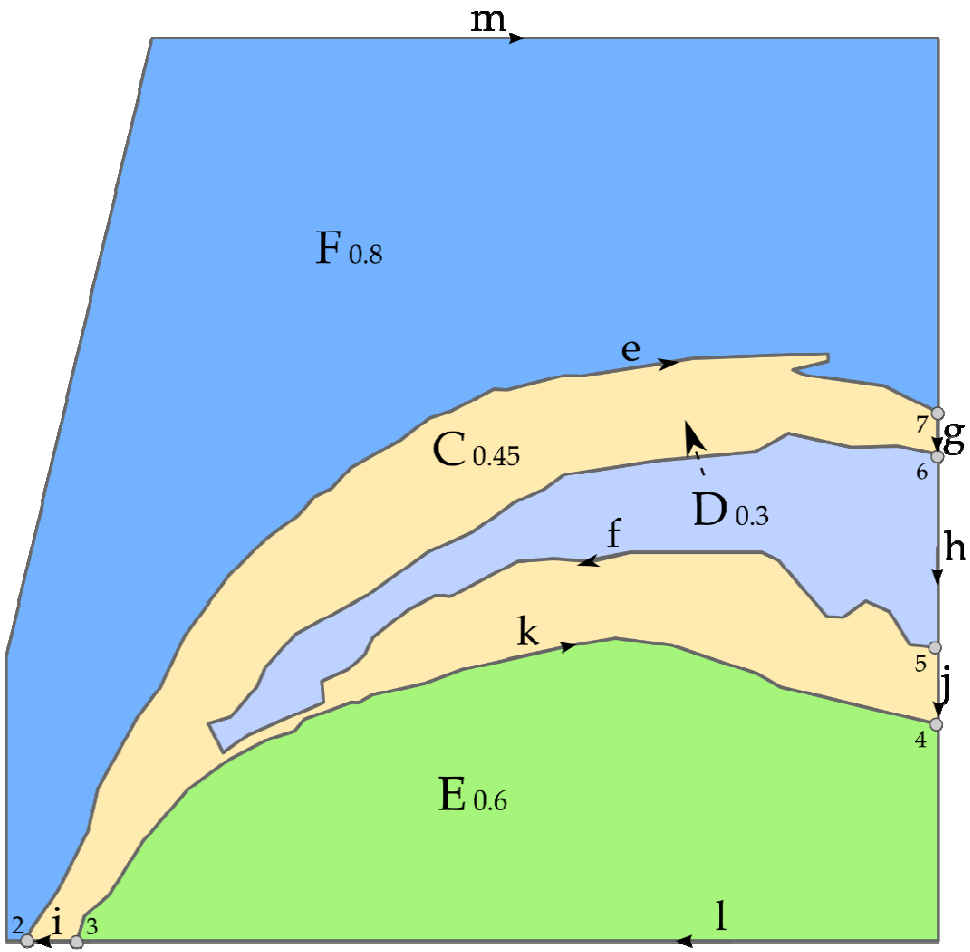
Building DAG hierarchy: step 1



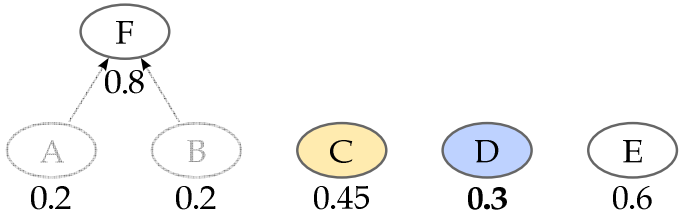
Calculate importance of the new face



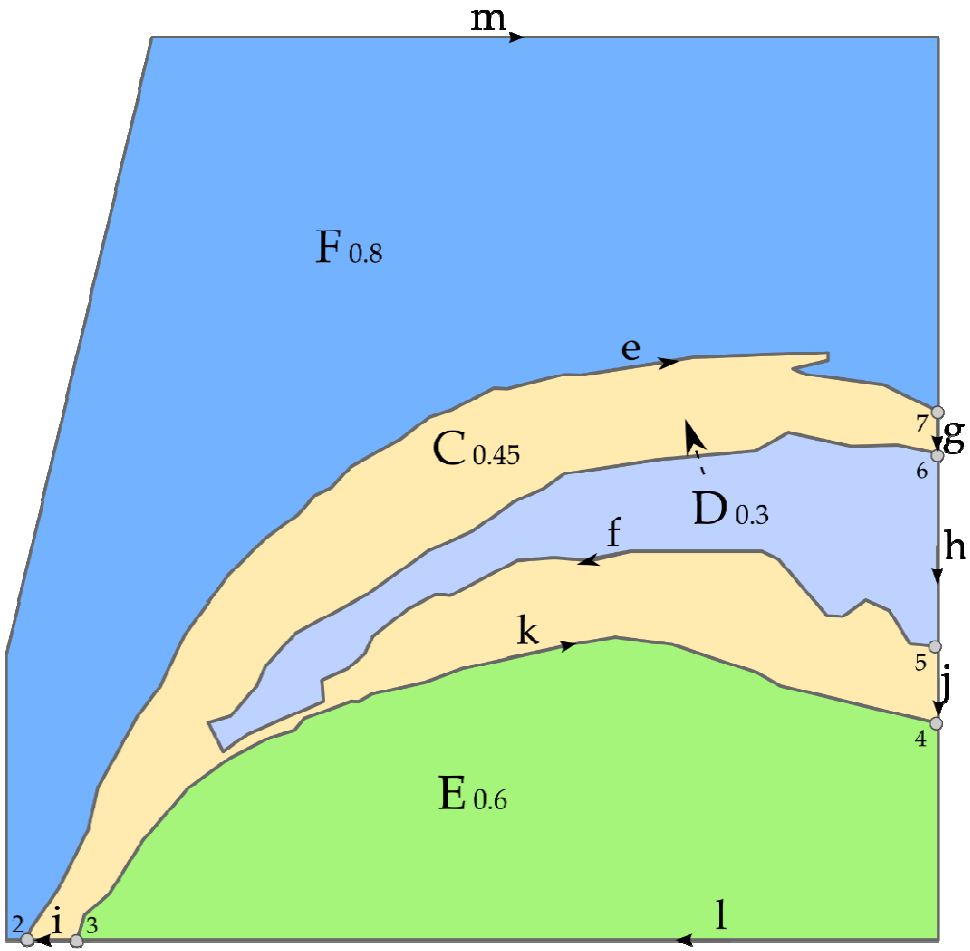
Building DAG hierarchy: step 2



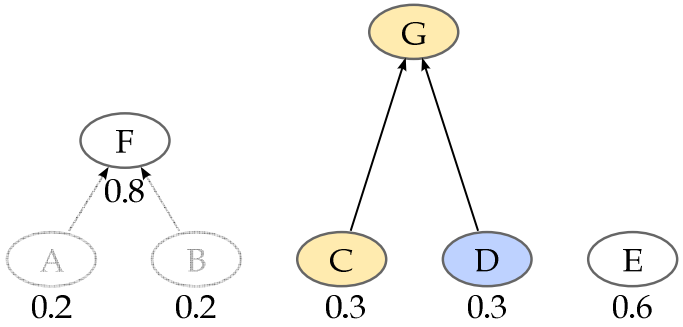
Find least important face;
Find its most compatible neighbour



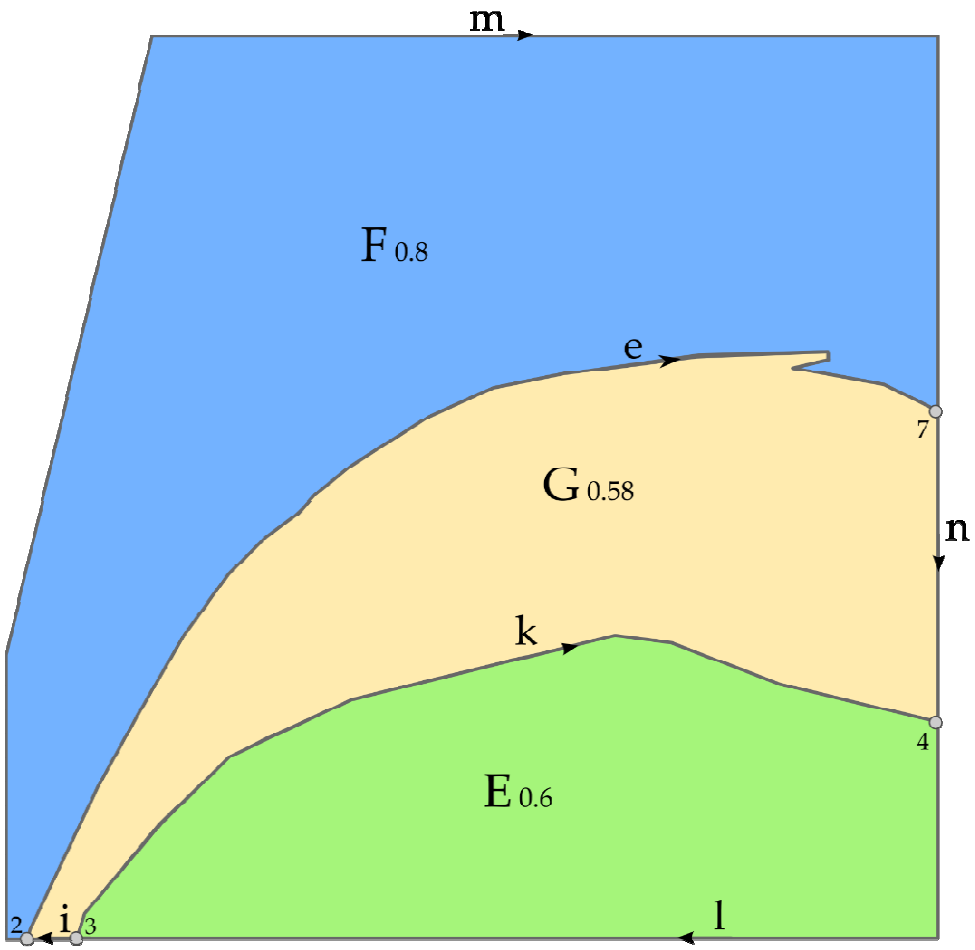
Building DAG hierarchy: step 2



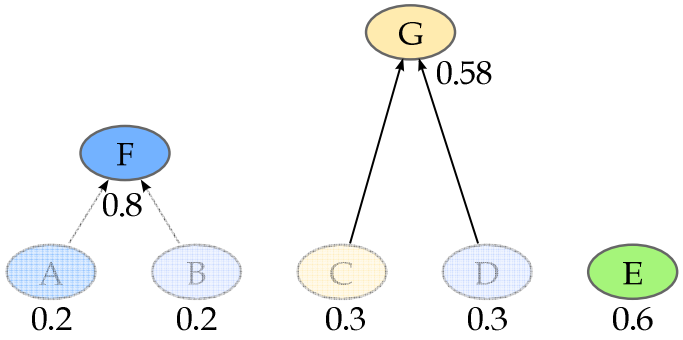
Merge faces



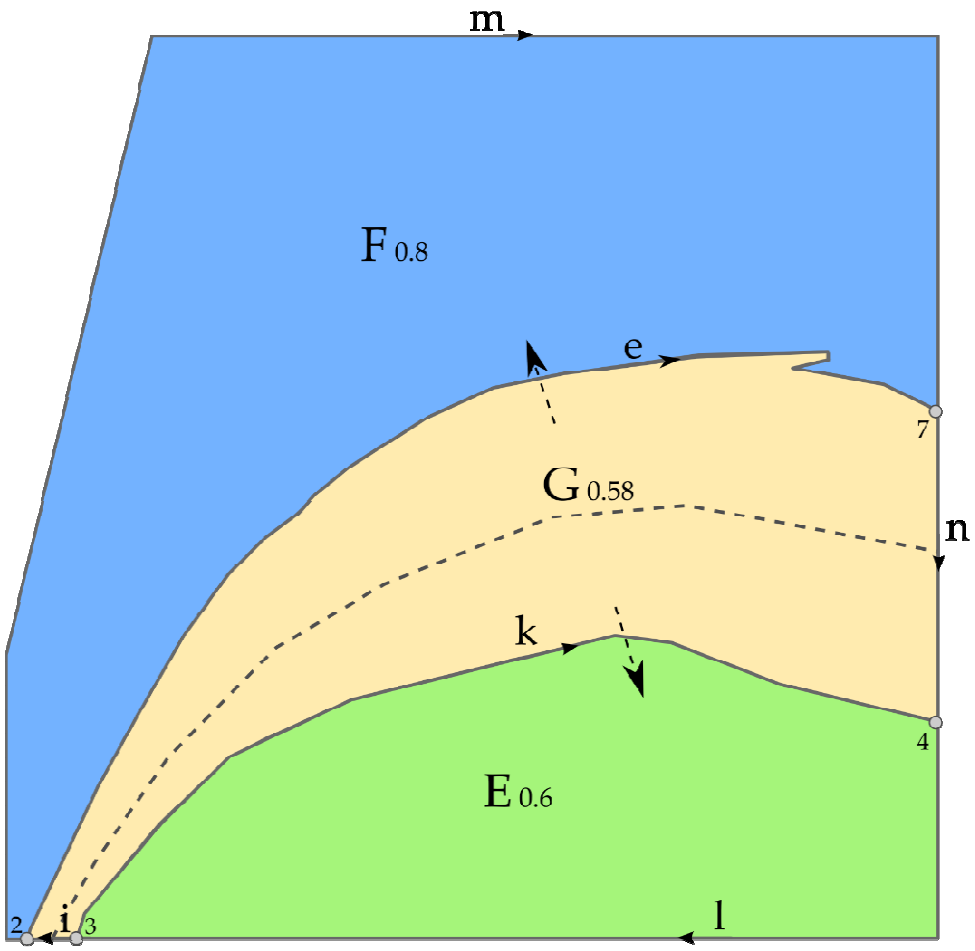
Building DAG hierarchy: step 2



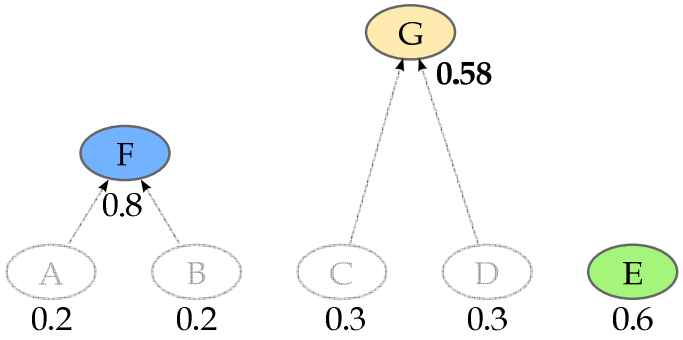
Calculate importance of the new face



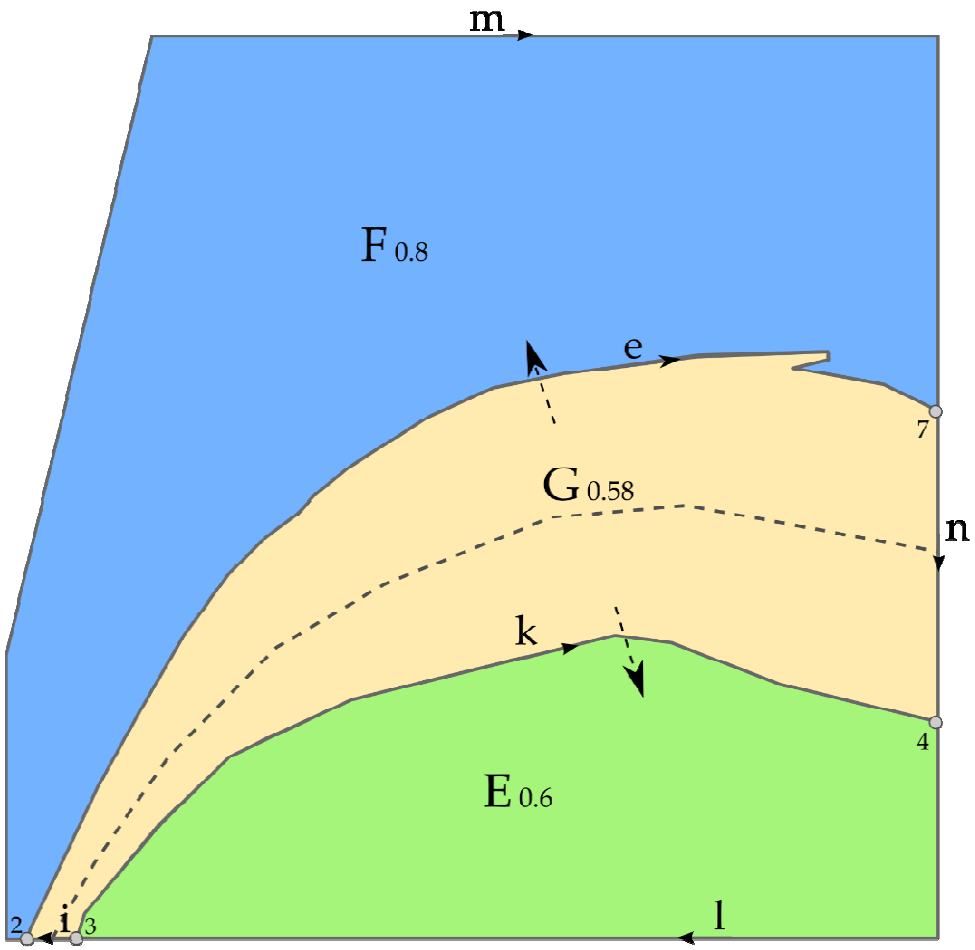
Building DAG hierarchy: step 3



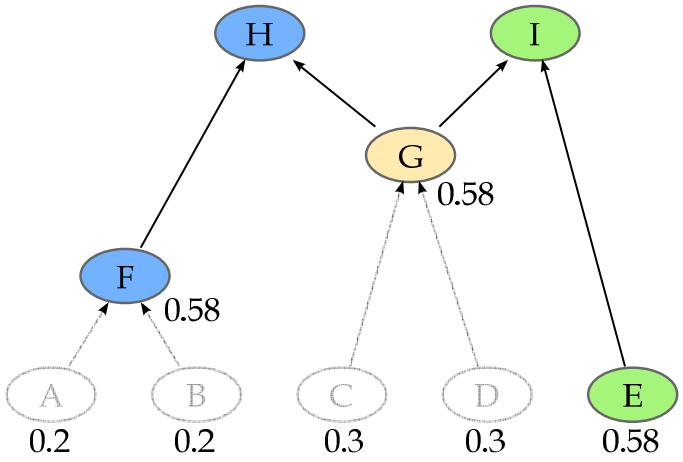
Find least important face;
Find most compatible neighbours



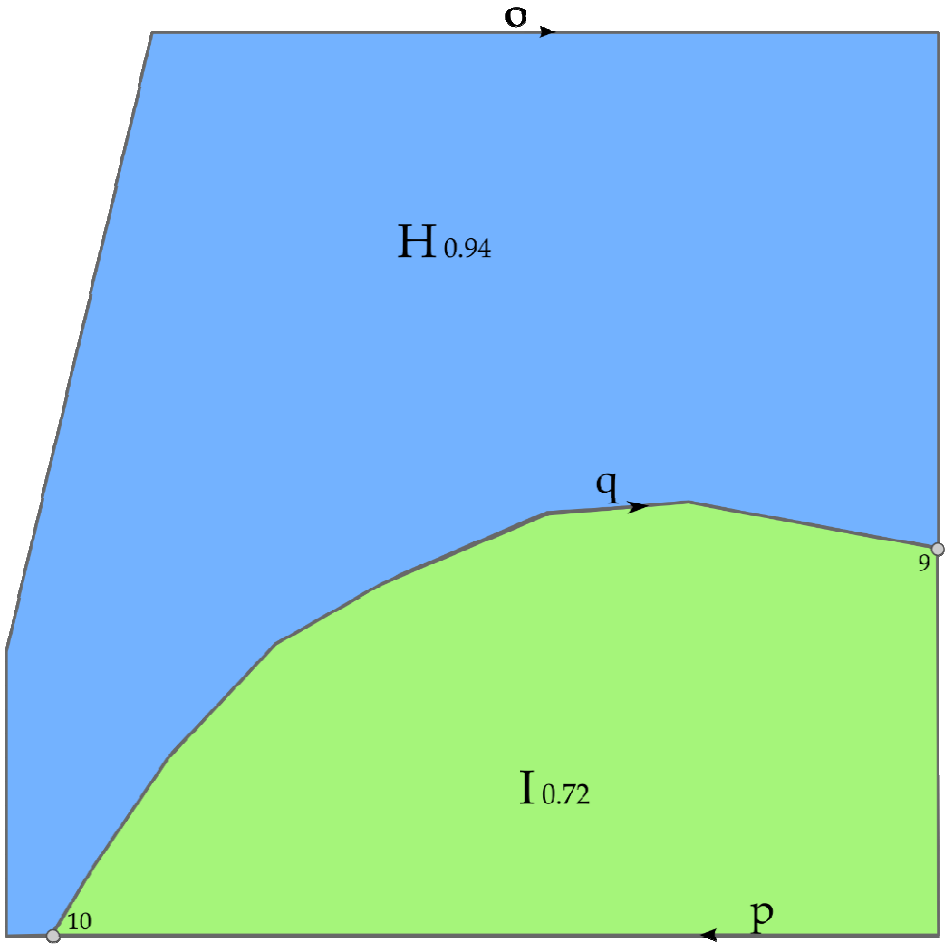
Building DAG hierarchy: step 3



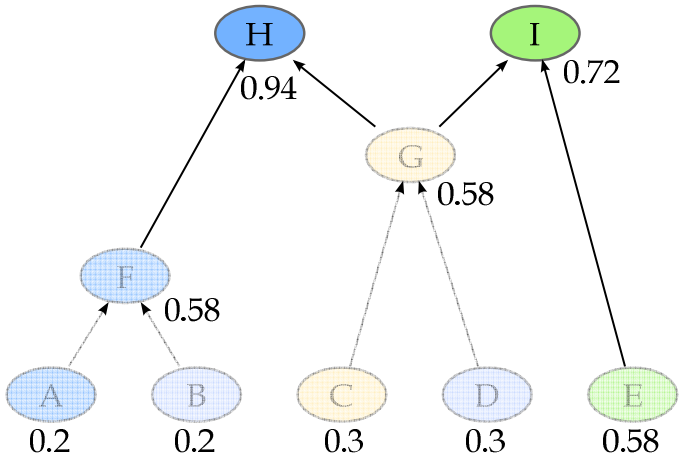
Split to an axis;
Merge parts to neighbour faces



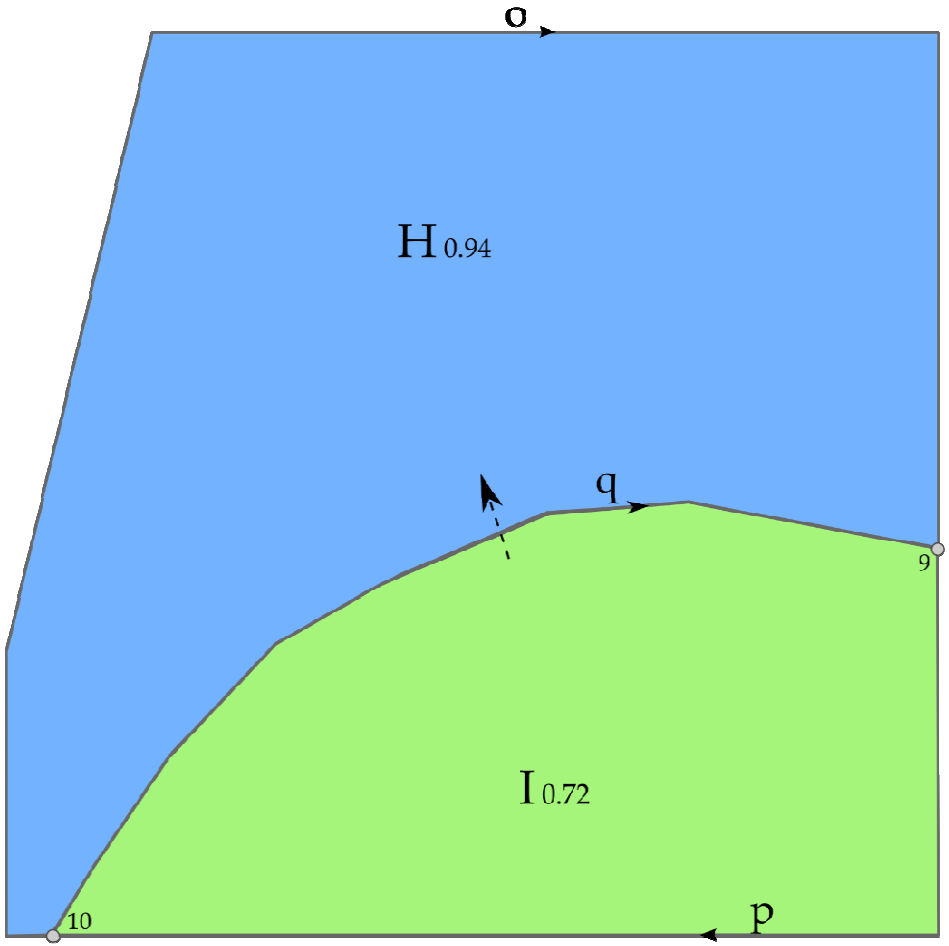
Building DAG hierarchy: step 3



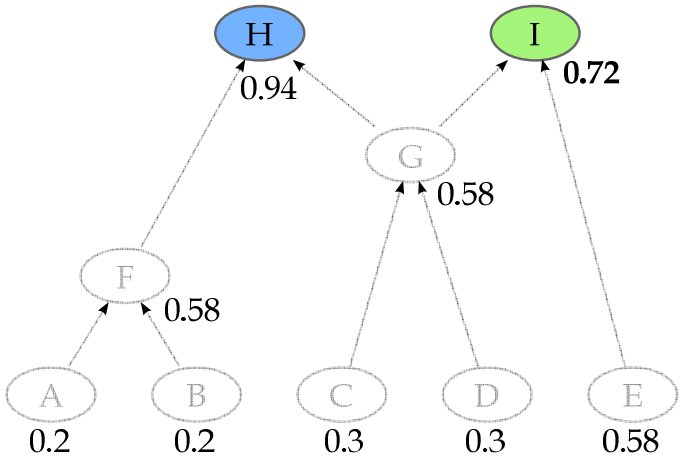
Calculate importance of the new face**s**



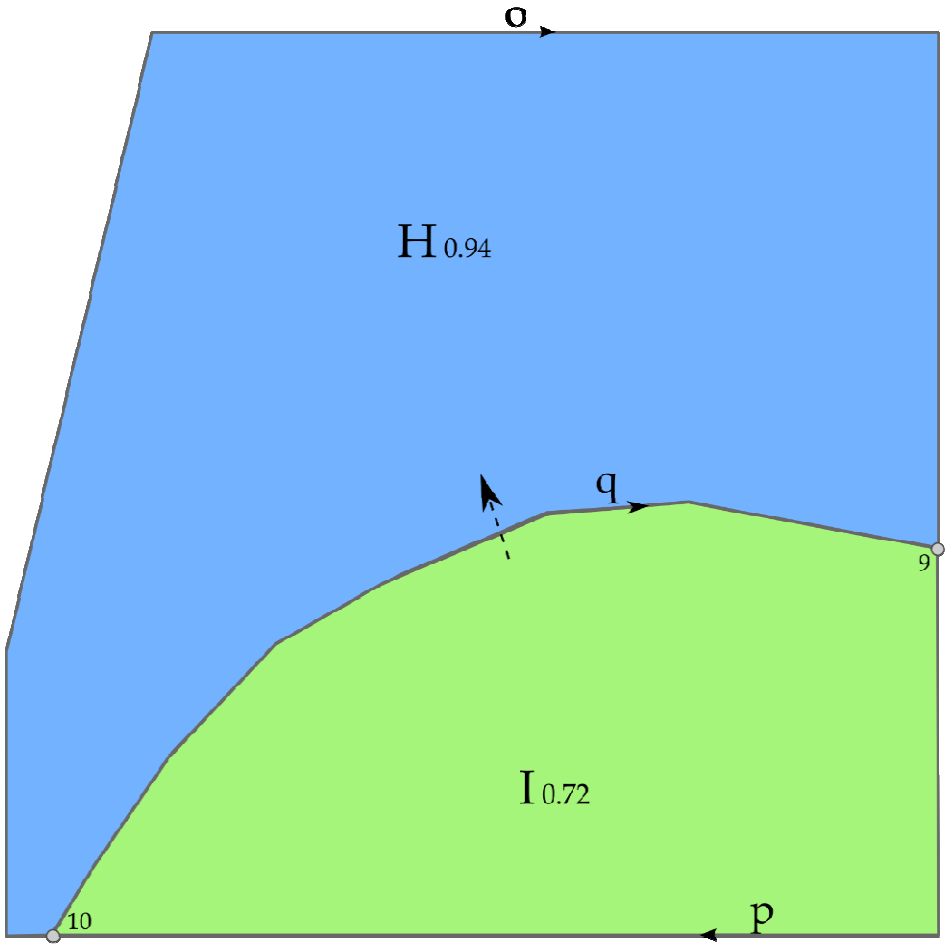
Building DAG hierarchy: step 4



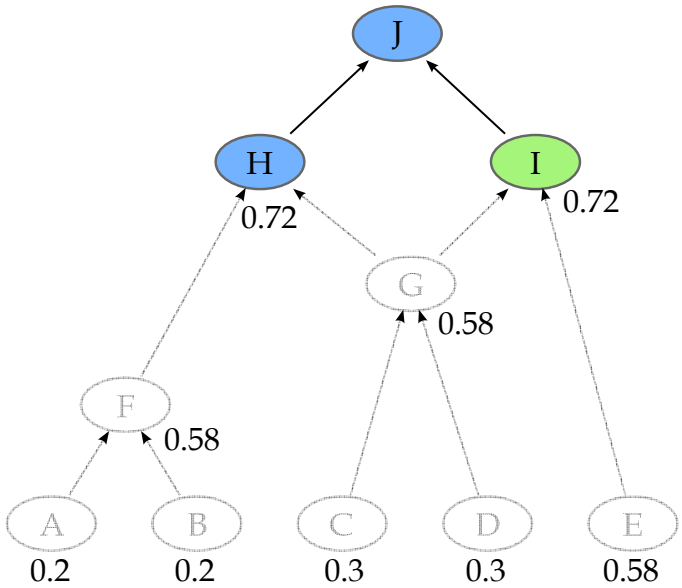
Find least important face;
Find most compatible neighbour



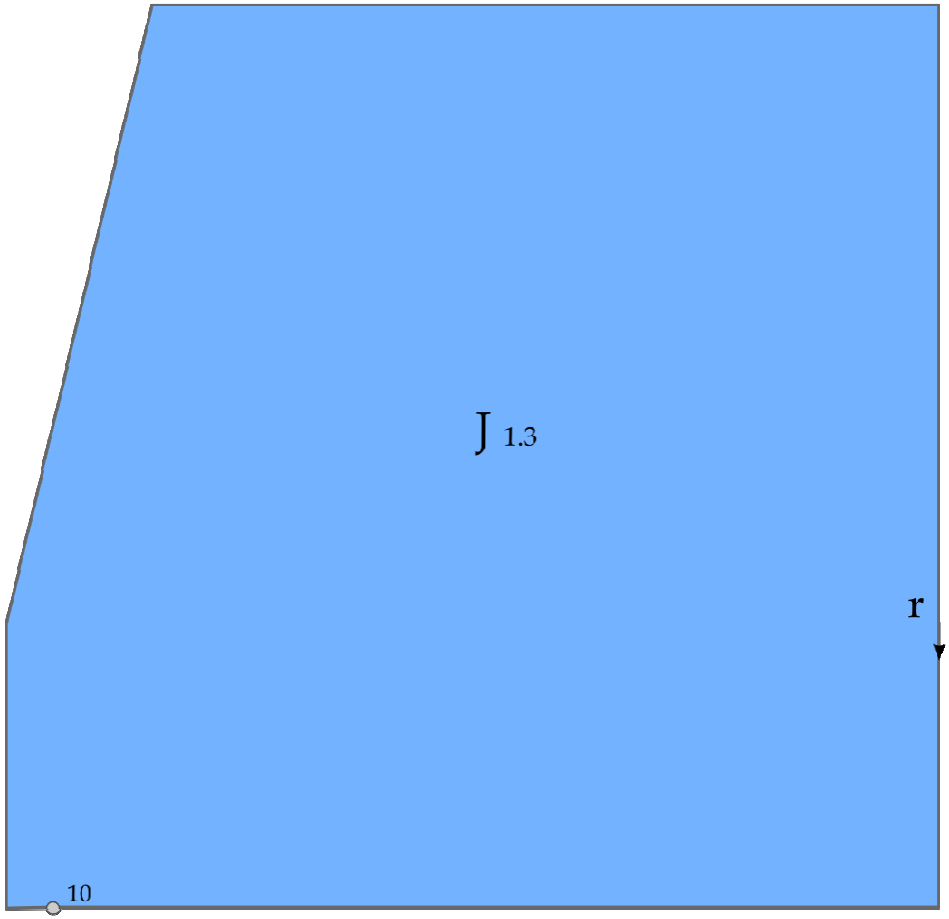
Building DAG hierarchy: step 4



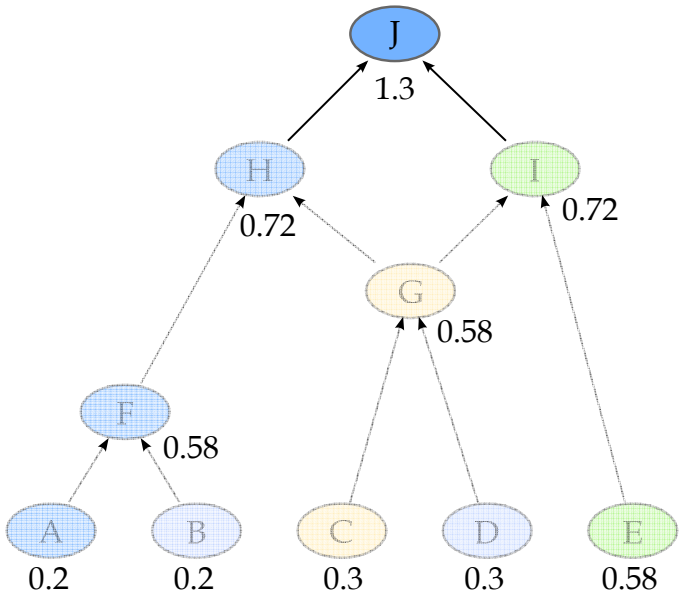
Merge faces



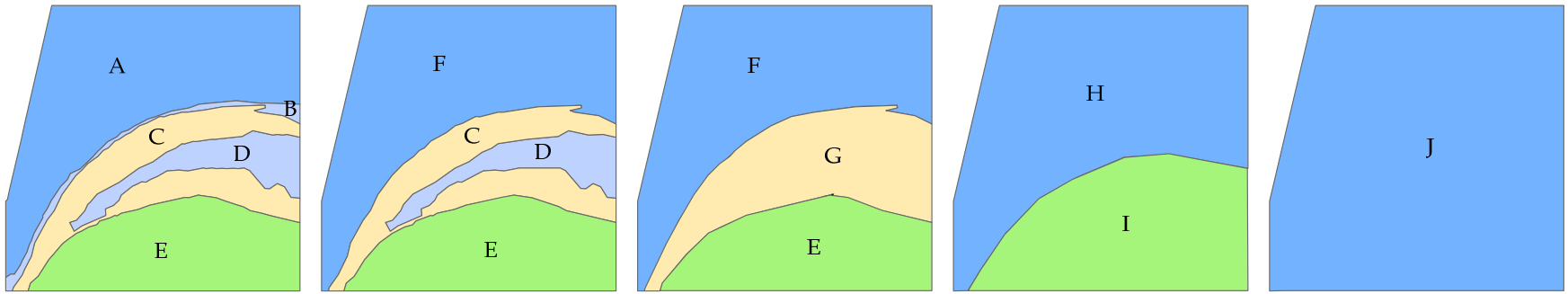
Building DAG hierarchy: step 4

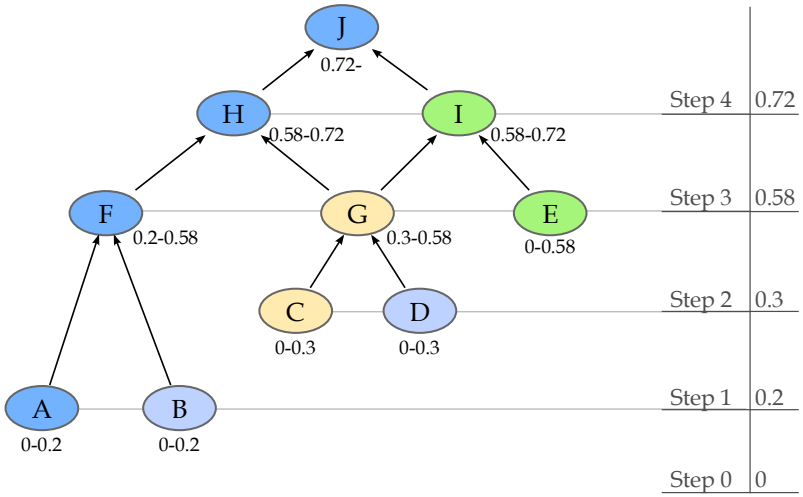


Calculate importance of the new face

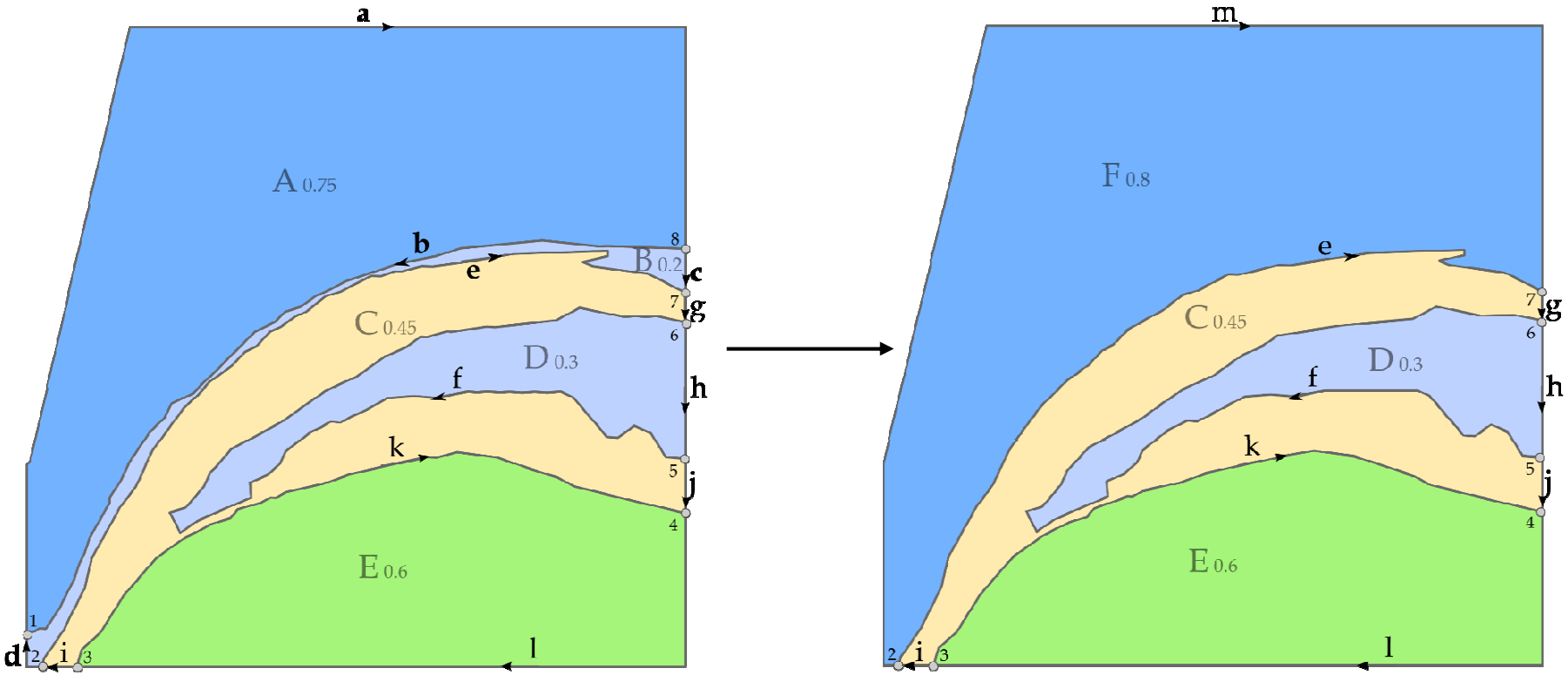


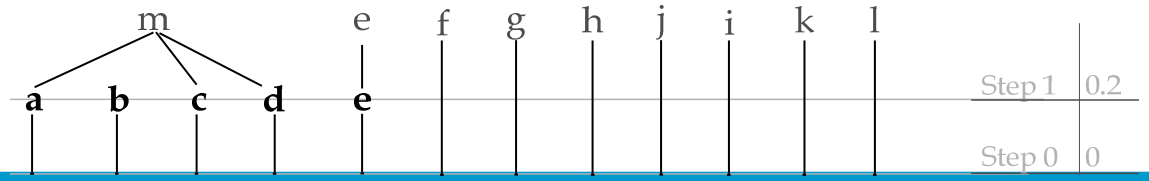
DAG hierarchy of faces



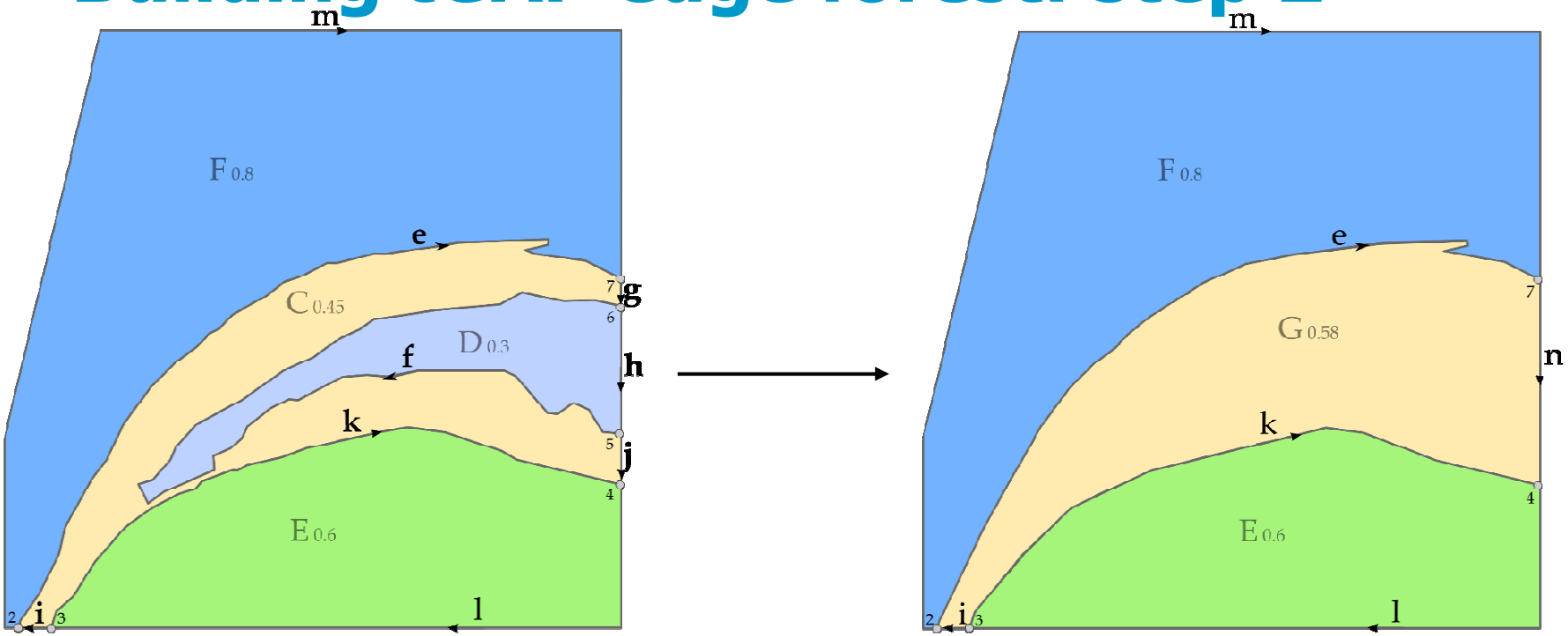


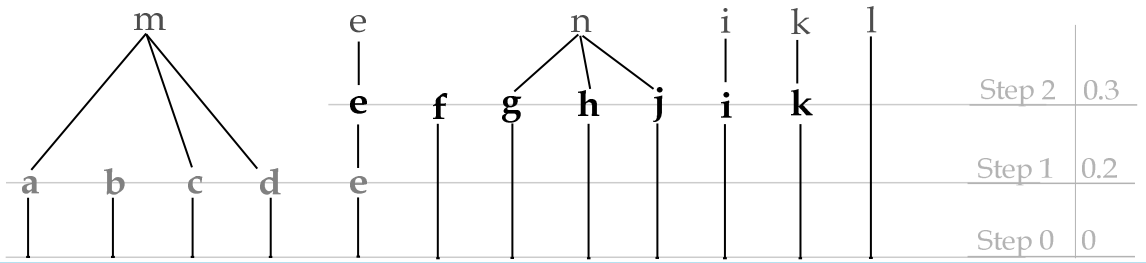
Building tGAP edge forest: step 1



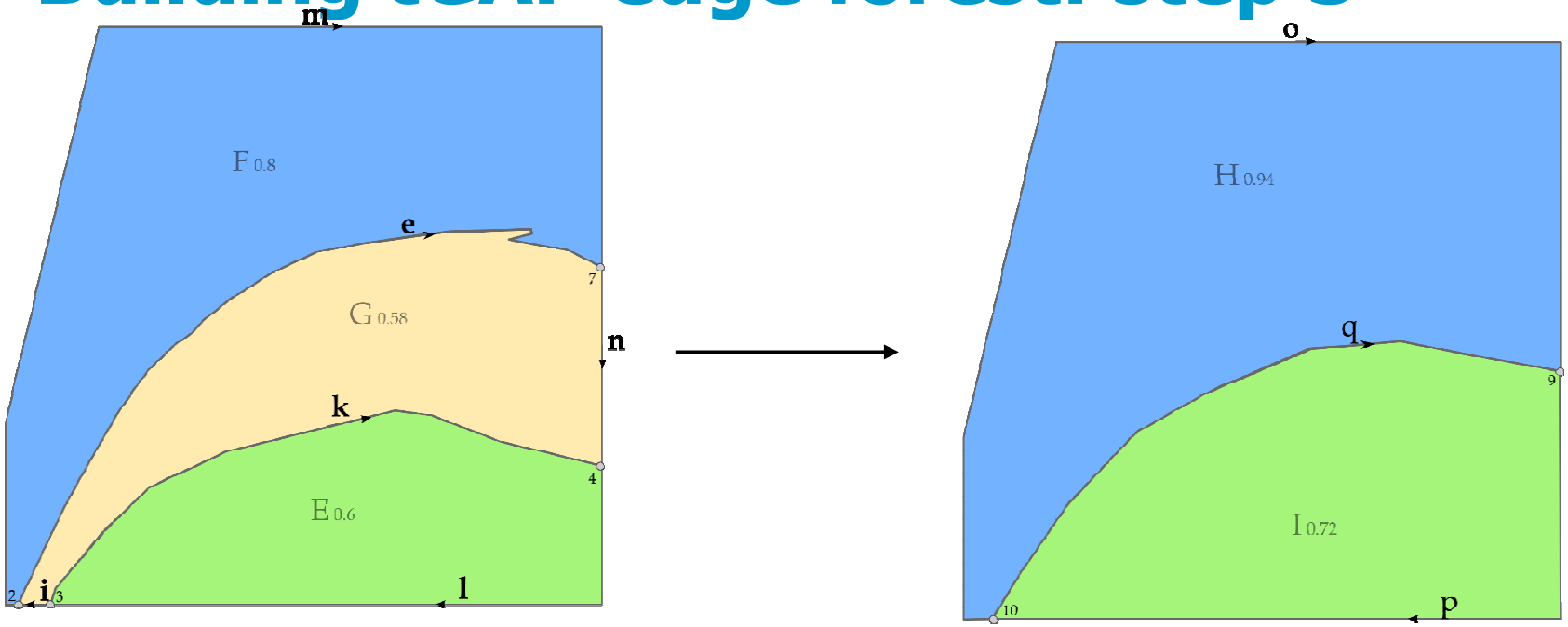


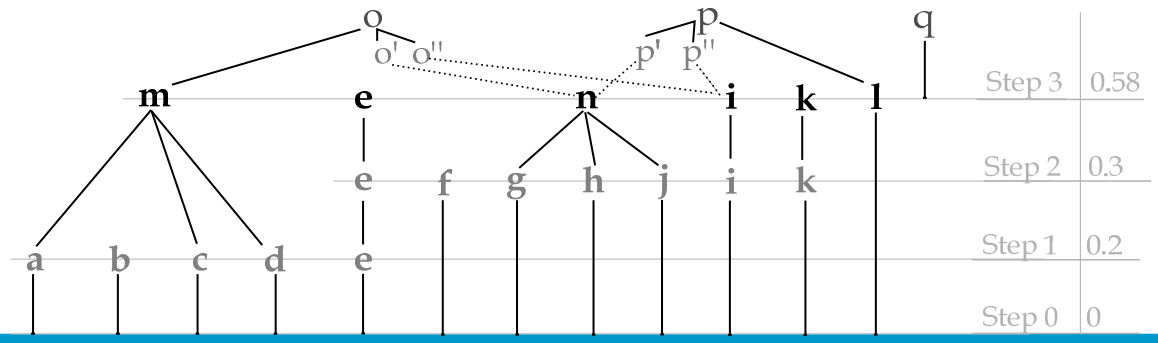
Building tGAP edge forest: step 2



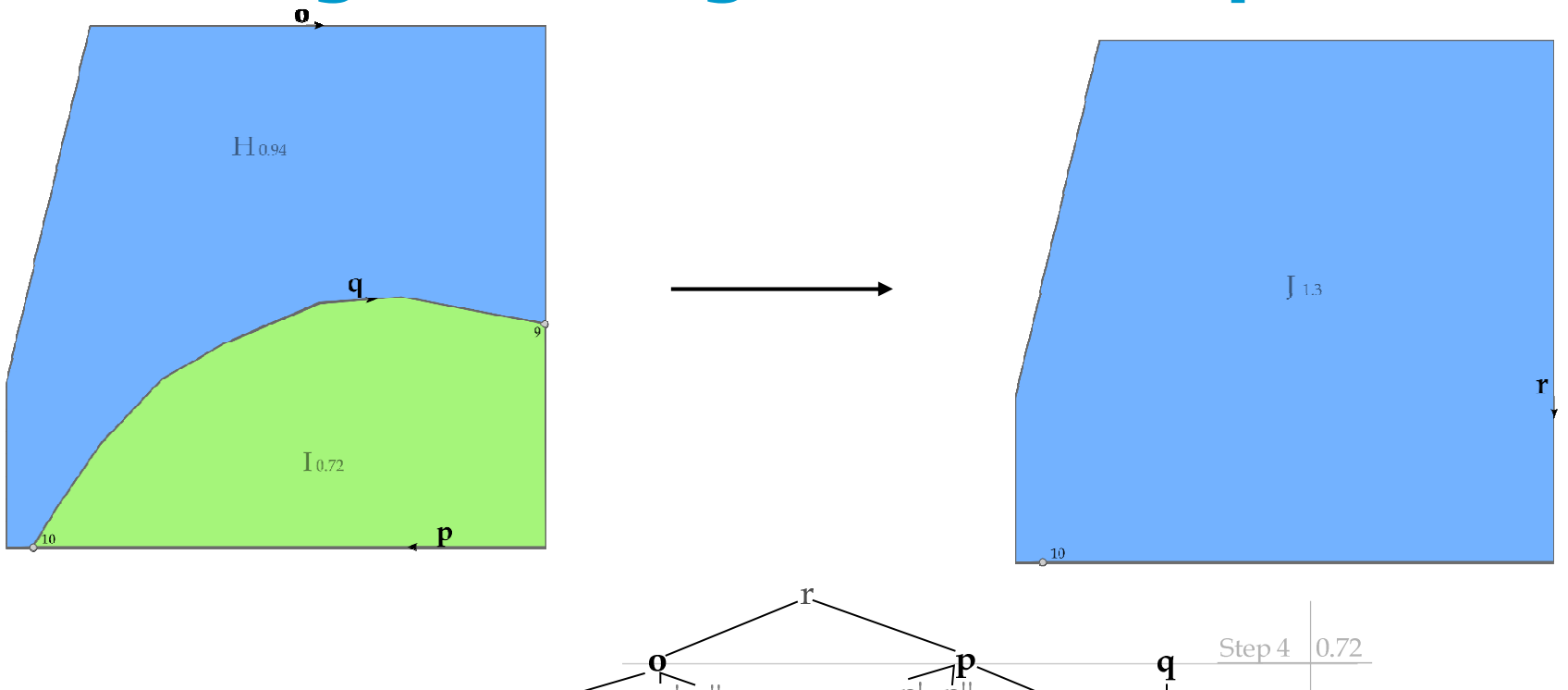


Building tGAP edge forest: step 3

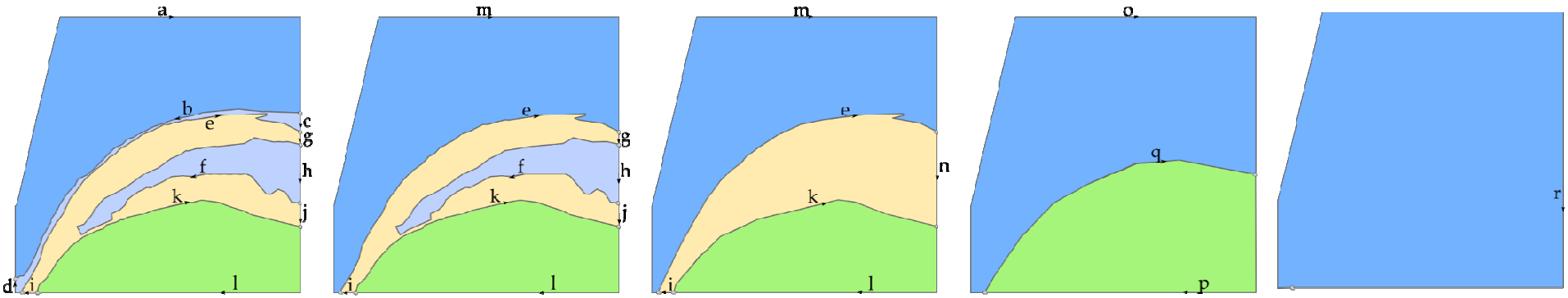


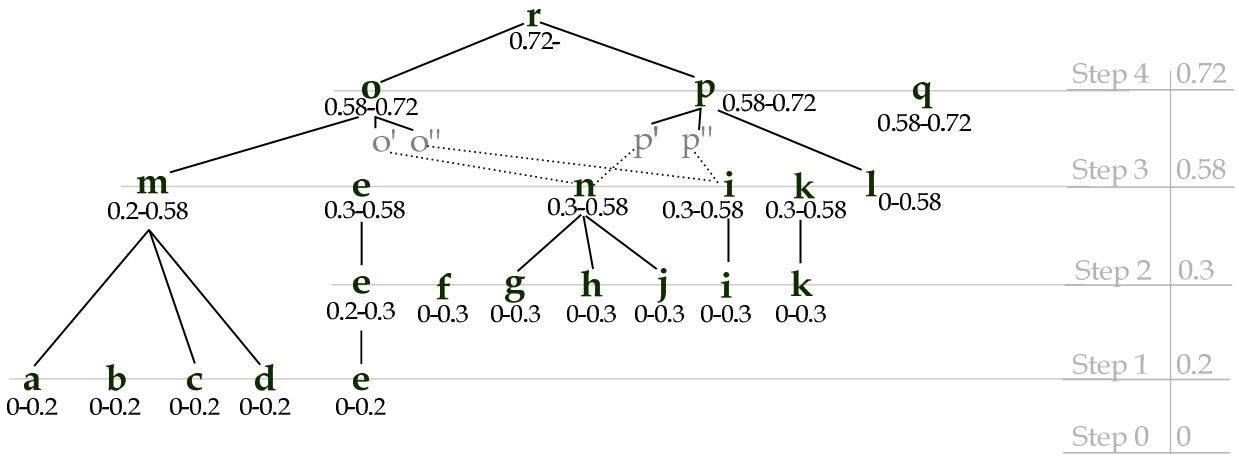


Building tGAP edge forest: step 4



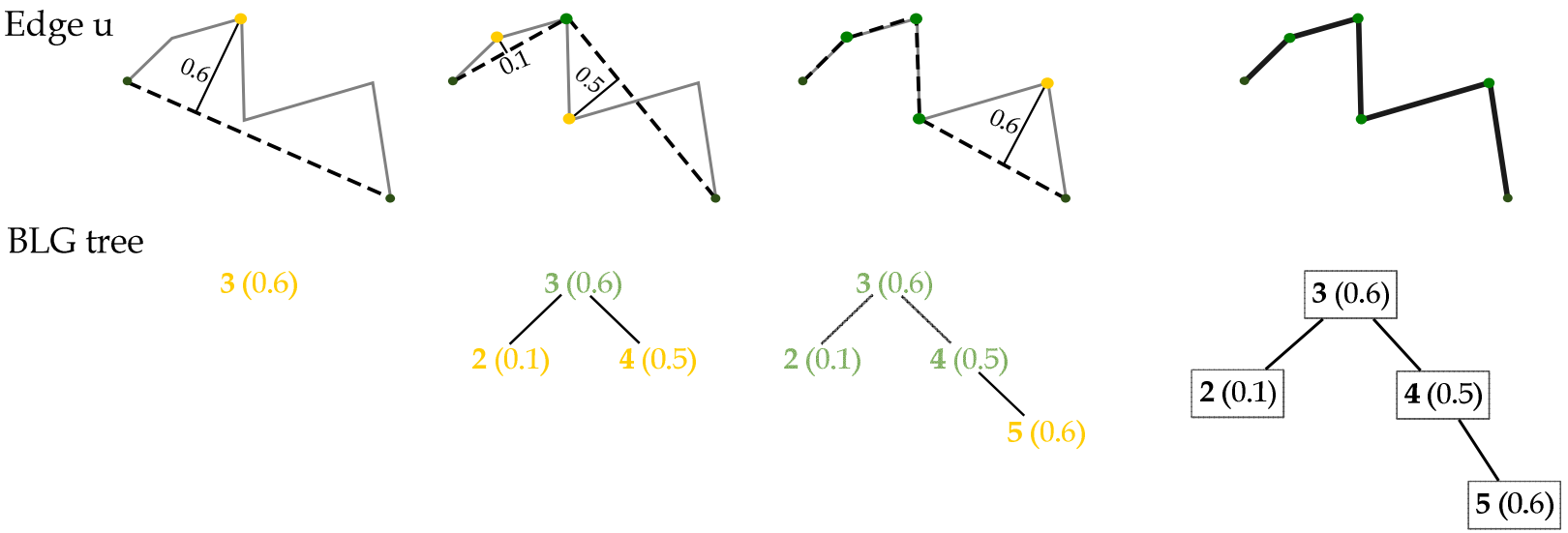
Complete tGAP edge forest





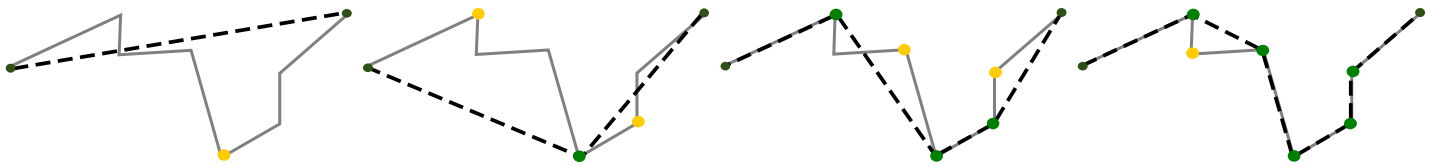
BLG edge trees

- Douglas-Peuker algorithm for edge simplification
- Results stored in a BLG tree

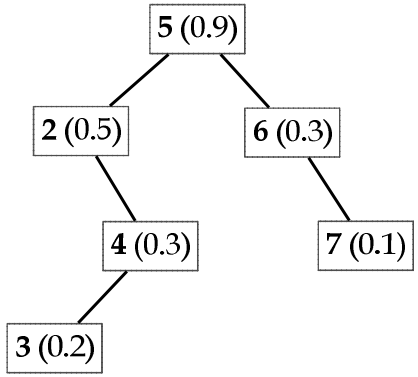


BLG edge trees

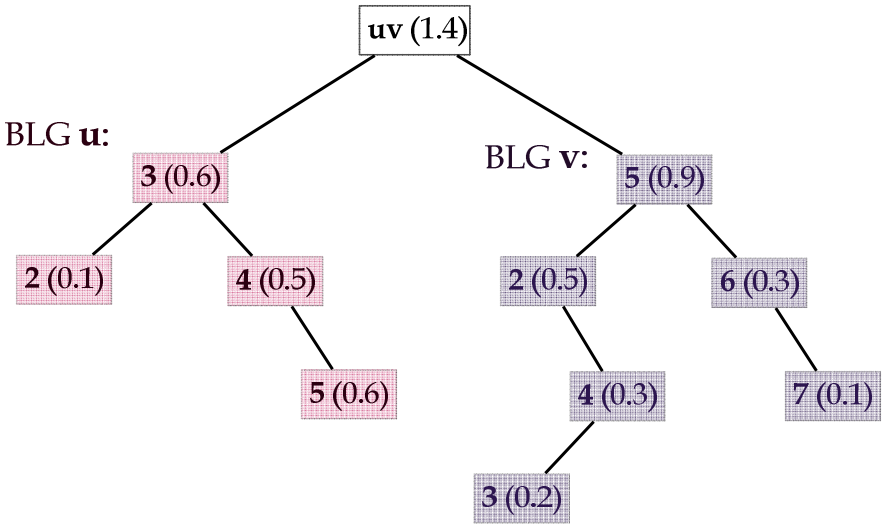
•BLG tree of another edge, **v**:

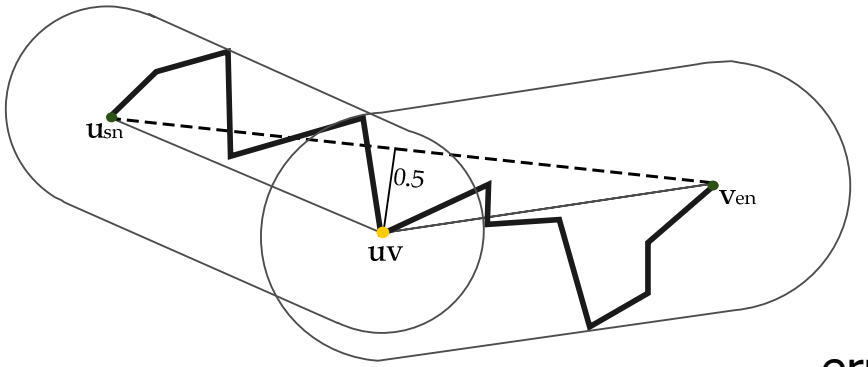


v: BLG tree



Joined BLG trees



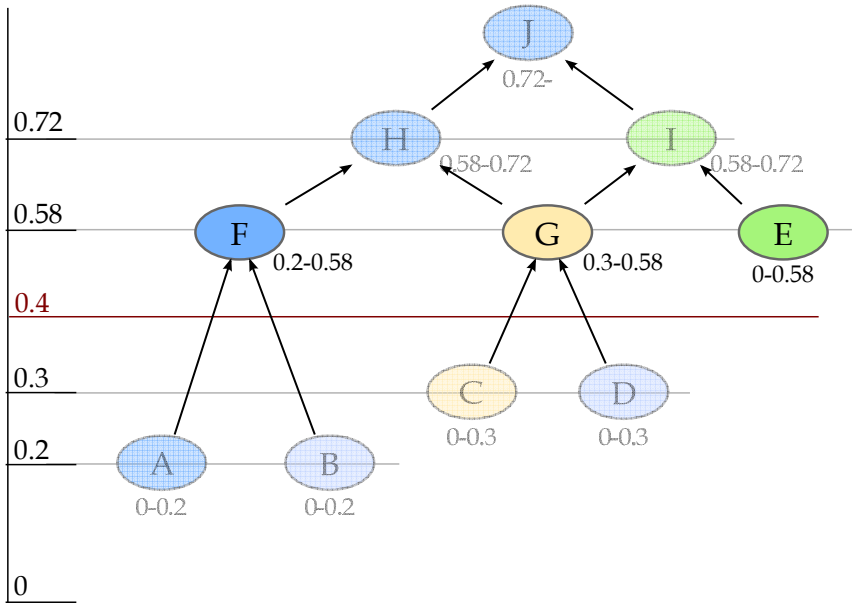


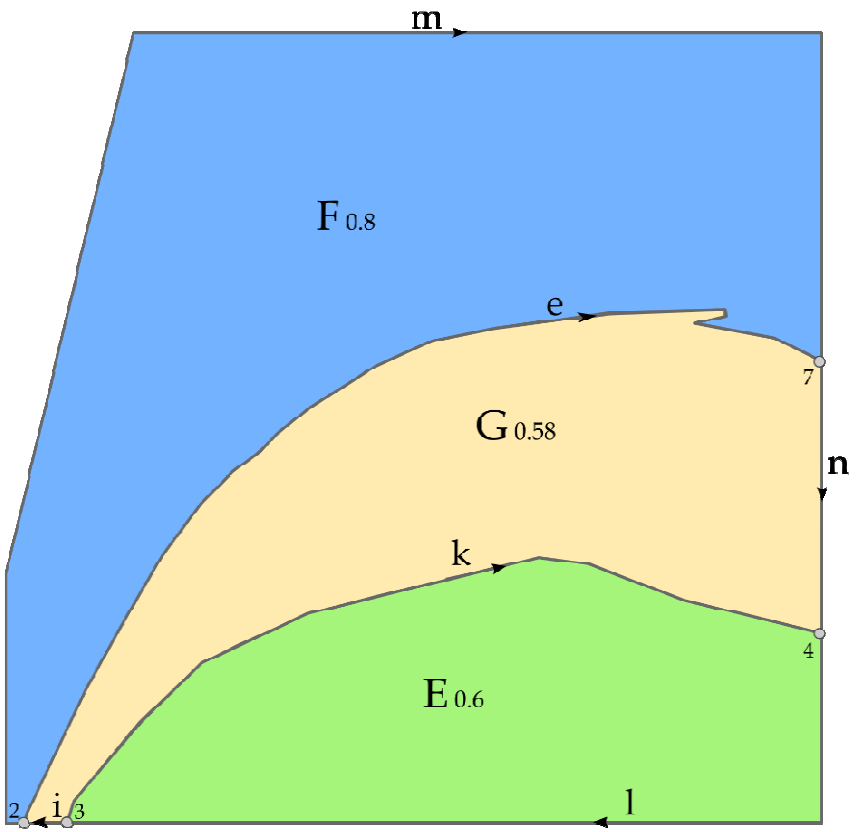
err_uv = dist(point(uv), line(u_{sn},v_{en})) +
max{err_u, err_v}=

0.5+max{0.6,0.9} = 0.5 + 0.9 = 1.4

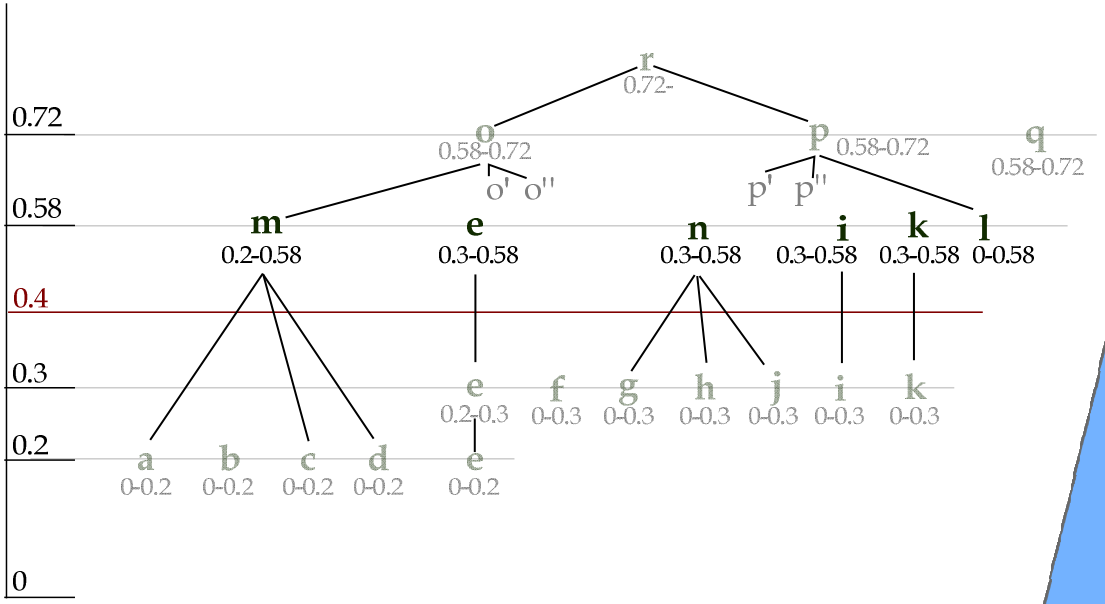
Using DAG hierarchy for selection

Importance = 0.4

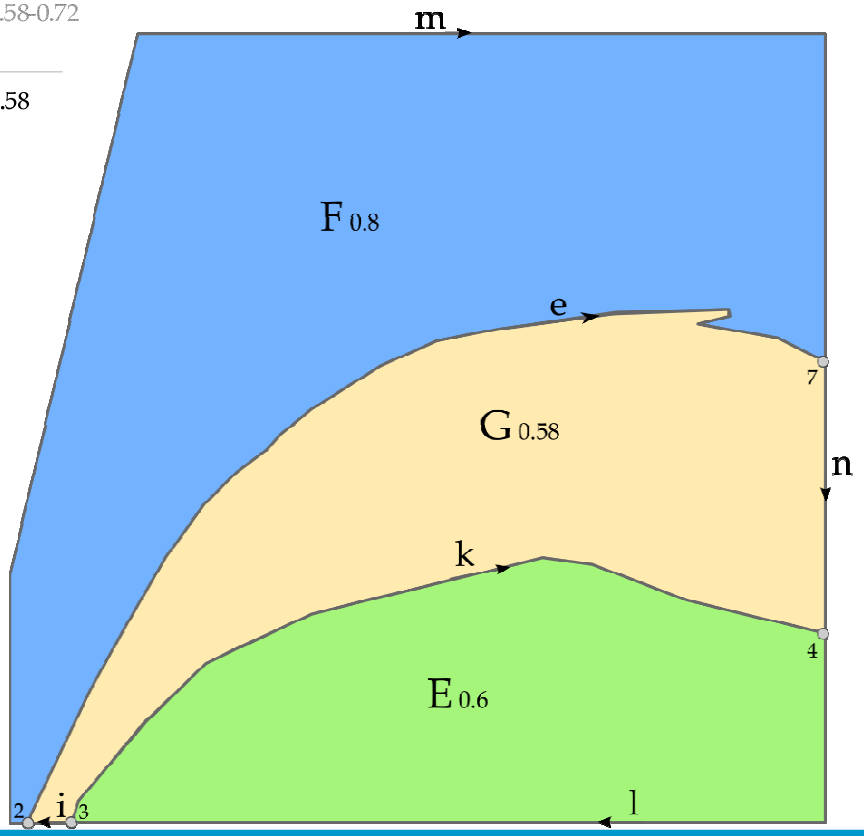




Using edge forest for selection

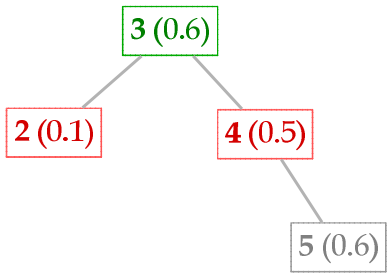


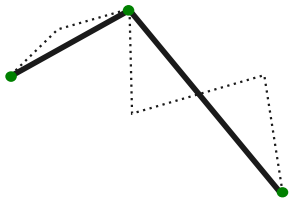
Importance = 0.4



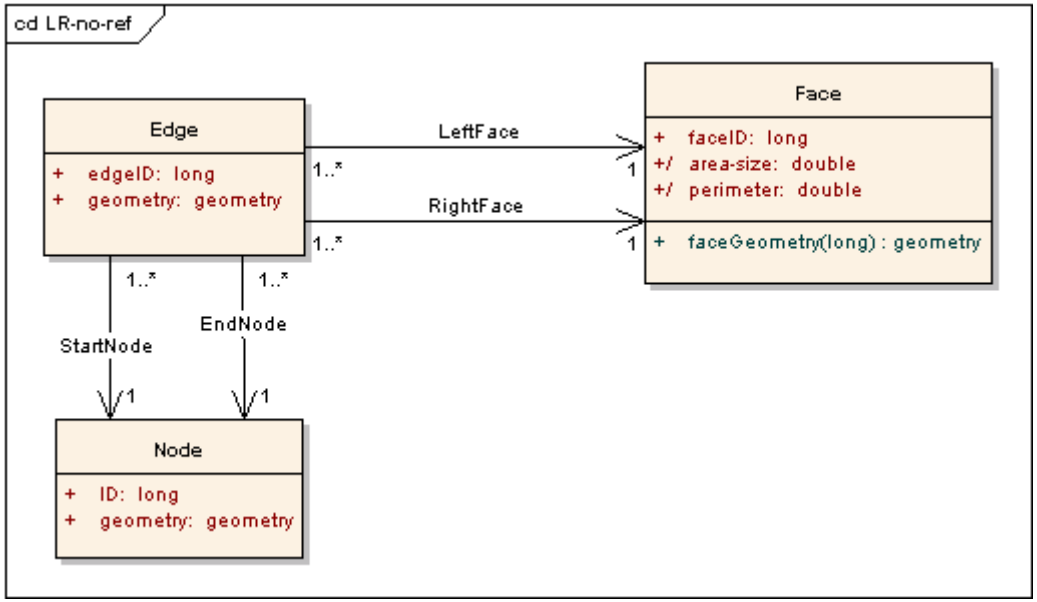
Using BLG trees for edge simplification

•Selecting vertices of BLG tree **u** for tolerance = 0.52

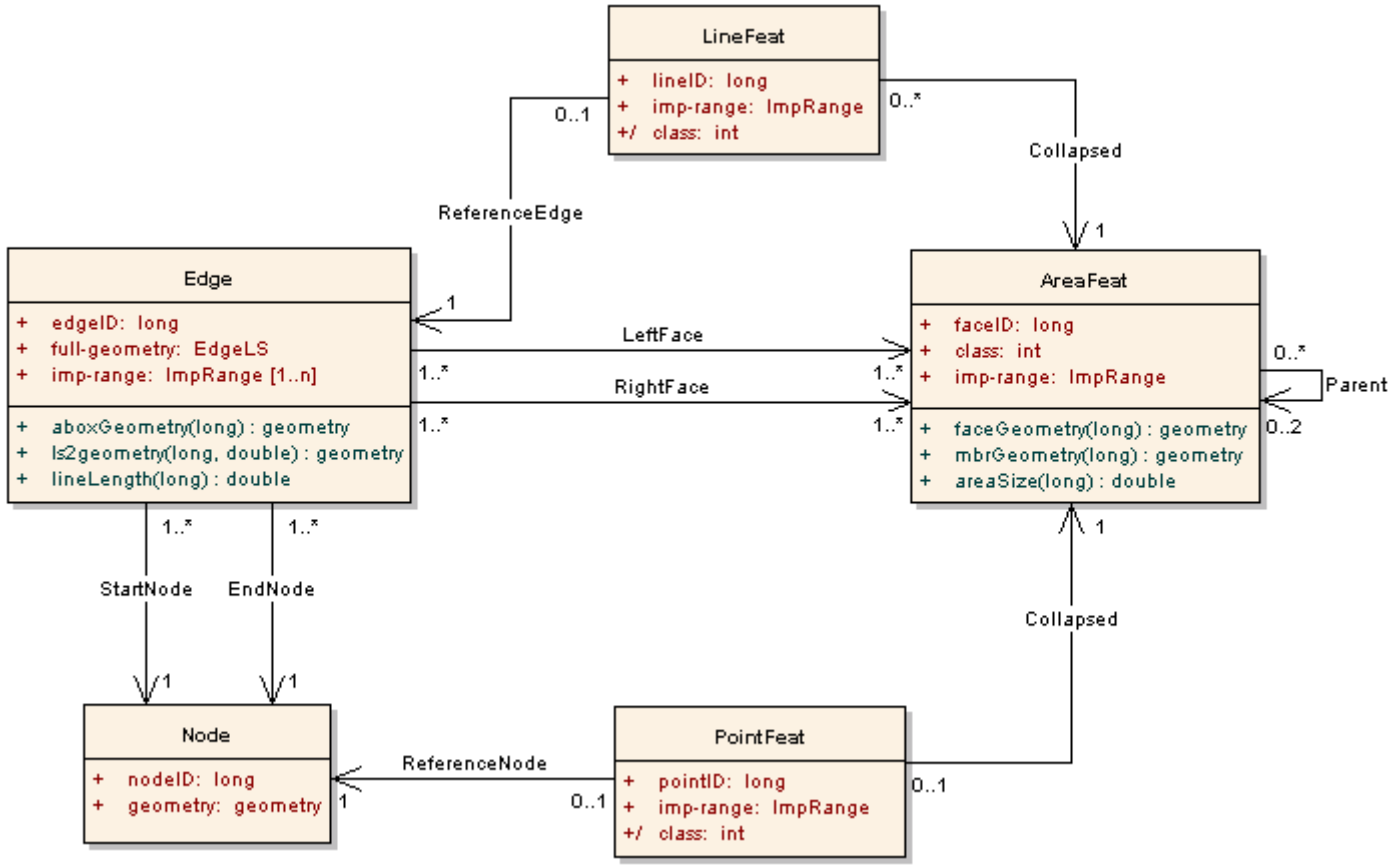




Implementation
Left-Right topology without edge references



Implementation: tGAP classes



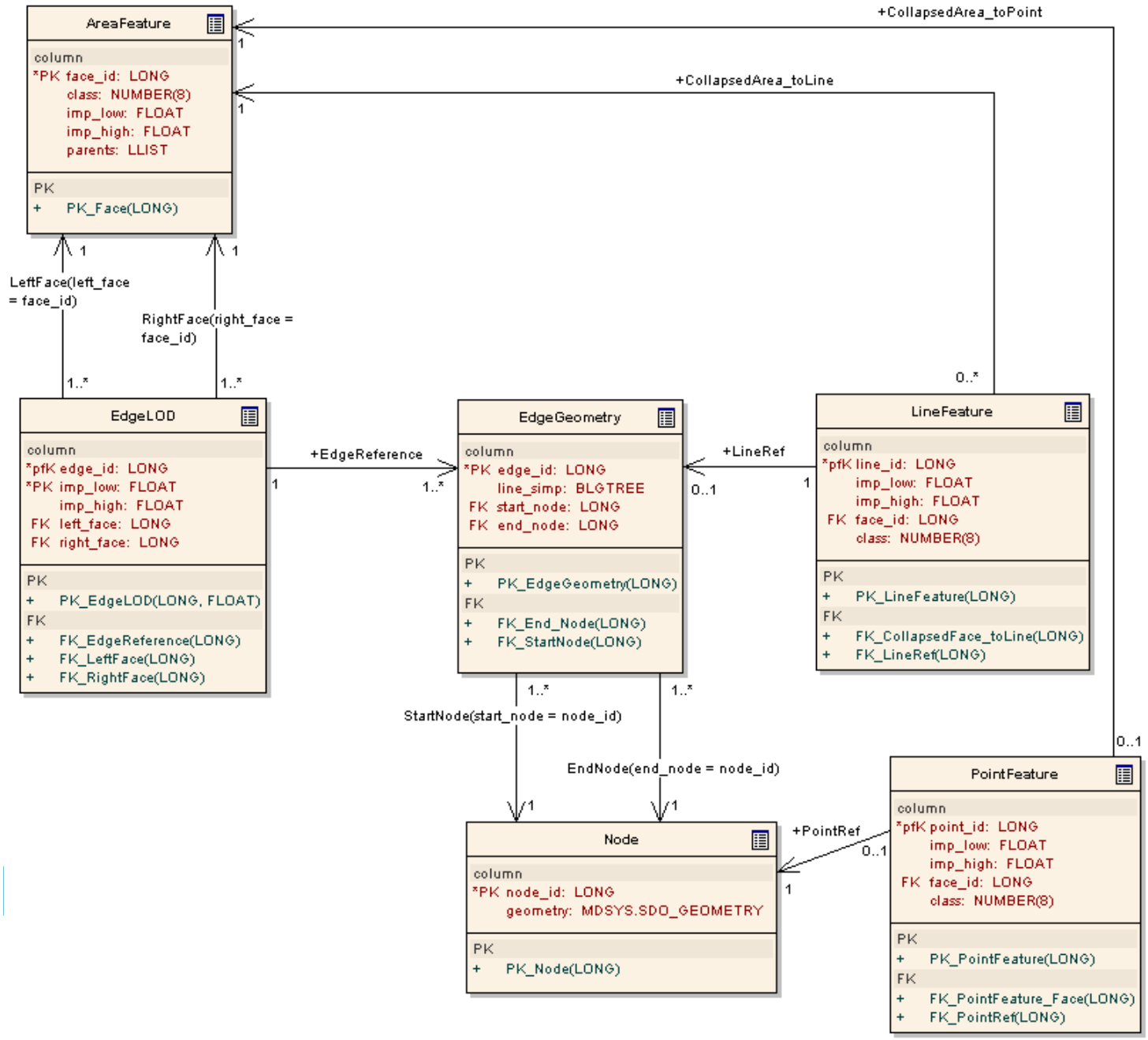
Implementation: new data types

- Data type for (variable detail) edge geometry

```
struct BLGTREE {
    double x_coord;
    double y_coord;
    float tolerance;
    struct BLGTREE *left_node;
    struct BLGTREE *right_node;
}
```

For joined BLG trees left & right_node refer to left & right BLG trees

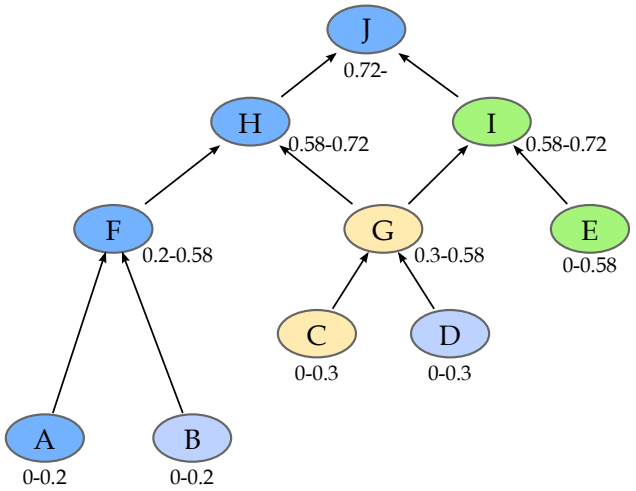
Implementation: tGAP tables



TU Delft

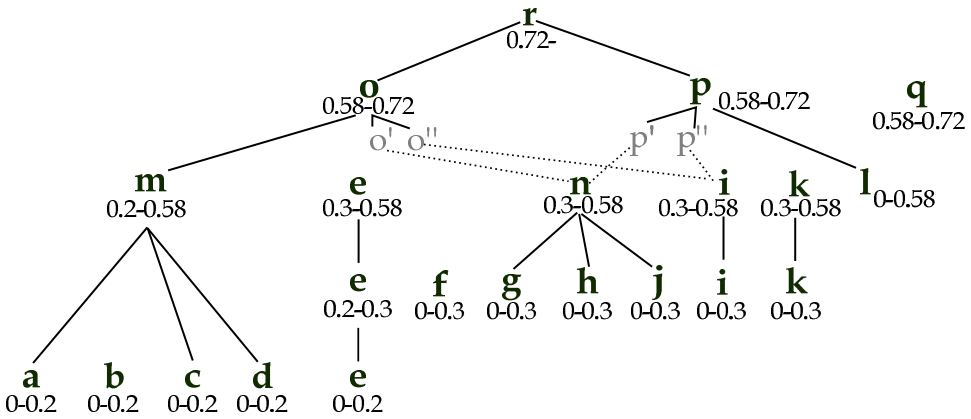
Implementation: AreaFeature table

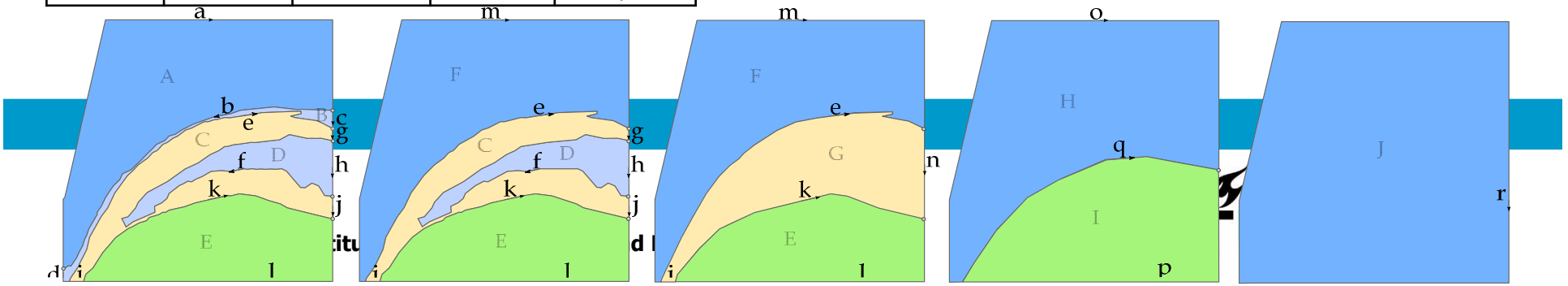
AreaFeature				
face-id	class	imp-low	imp-high	parents
A	1	0	0.2	F
B	3	0	0.2	F
C	2	0	0.3	G
D	3	0	0.3	G
E	4	0	0.58	I
F	1	0.2	0.58	H
G	2	0.3	0.58	H, I
H	1	0.58	0.72	J
I	4	0.58	0.72	J
J	1	0.72		



EdgeLOD table

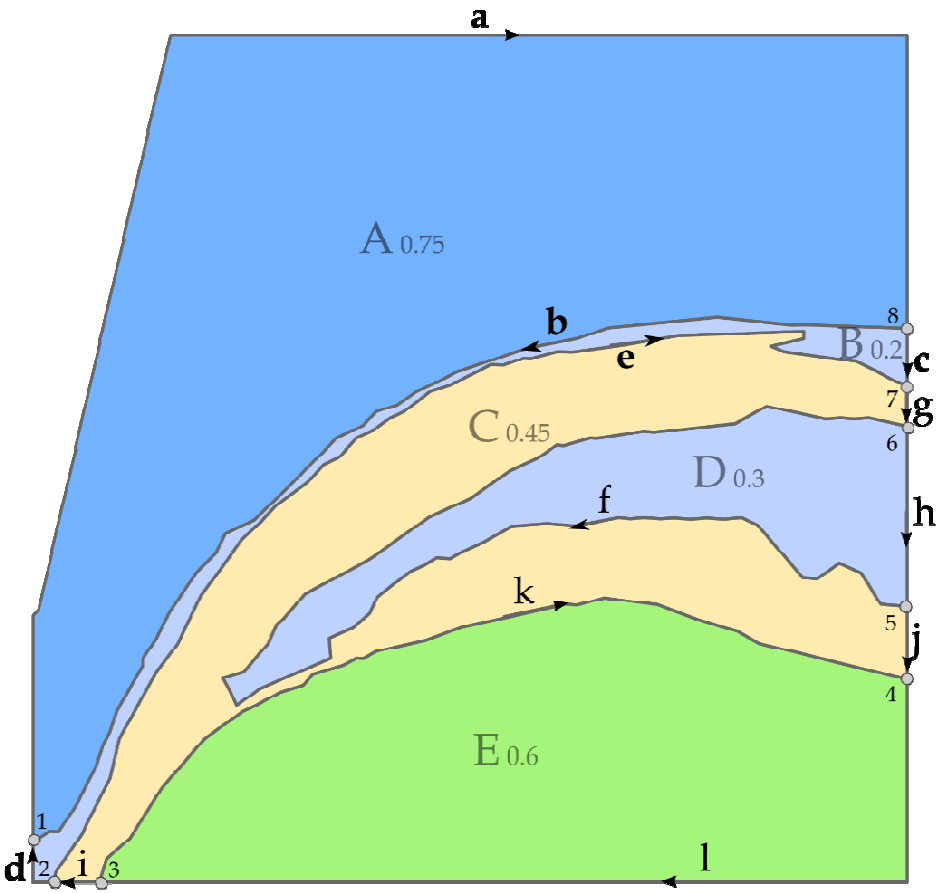
EdgeLOD				
edge-id	imp-low	imp-high	left-face	right-face
a	0	0.2	0	A
b	0	0.2	B	A
c	0	0.2	0	B
d	0	0.2	0	B
e	0	0.2	B	C
f	0	0.3	C	D
g	0	0.3	0	C
h	0	0.3	0	D
i	0	0.3	0	C
j	0	0.3	0	C
k	0	0.3	C	E
e	0.2	0.3	F	C
l	0	0.58	0	E
m	0.2	0.58	0	F
e	0.3	0.58	F	G
i	0.3	0.58	0	G
k	0.3	0.58	G	E
n	0.3	0.58	0	G
o	0.58	0.72	0	H
p	0.58	0.72	0	I
q	0.58	0.72	H	I
r	0.72		0	J





Implementation: EdgeGeometry table

EdgeGeometry			
edge-id	line-simp	start-node	end-node
a	<blgtree>	1	8
b	<blgtree>	8	1
c	<blgtree>	8	7
d	<blgtree>	2	1
e	<blgtree>	2	7
f	<blgtree>	5	6
g	<blgtree>	7	6
h	<blgtree>	6	5
i	<blgtree>	3	2
j	<blgtree>	5	4
k	<blgtree>	3	4
l	<blgtree>	4	3
m	<blgtree>	2	7
n	<blgtree>	7	4
o	<blgtree>	10	9
p	<blgtree>	9	10
q	<blgtree>	10	9
r	<blgtree>	10	10



More tGAP issues & further research

- Algorithm performing the off-line generalisation
- Mobile (or web) application
  - Progressive transfer
  - Visualisation on client
- Include other operators in generalisation process
- Updating tGAP structure
- …

References

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2. Peter van Oosterom. *Reactive Data Structures for Geographic Information Systems*. PhD thesis, Department of Computer Science, Leiden University, December 1990.
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5. Martin Galanda. *Automated Polygon Generalization in a Multi Agent System*. PhD thesis, University of Zürich, 2003.