Semantic modeling and vario-scale geo-information

4-11-2011

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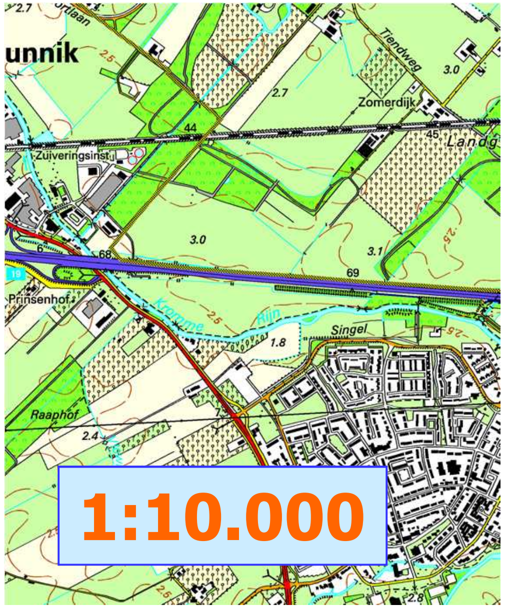
Keynote presentation at SeCoGIS 2011, 1 November 2011, Brussels
5th International Workshop on Semantic and Conceptual Issues in GIS

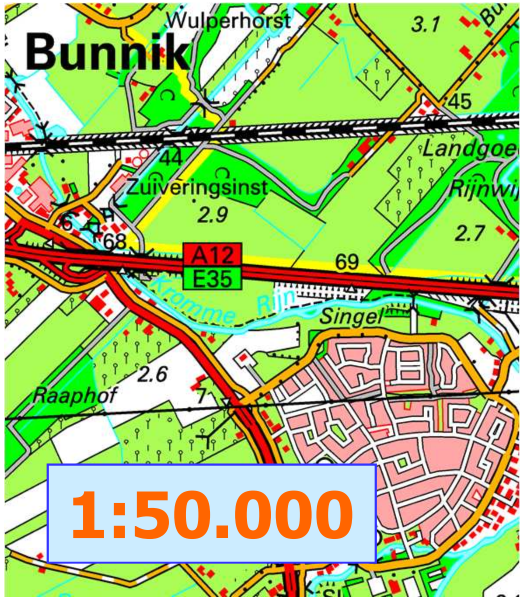
Two steps, two parts in presentation

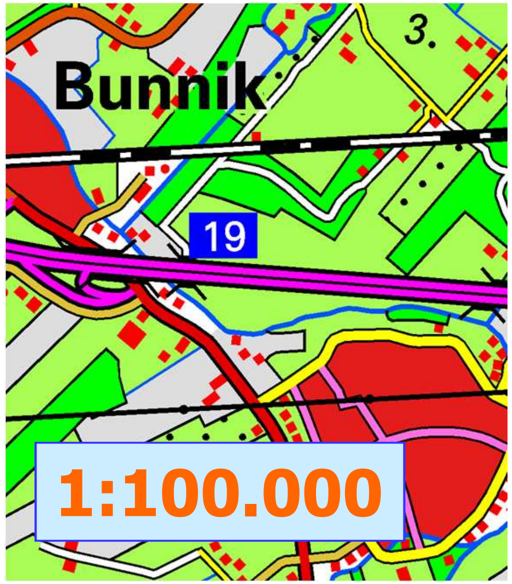
1. Multi-scale modelling (and attention to DLM-DCM)

2. Vario-scale modelling

Context of the research







Applying DLM and DCM concepts in a multi-scale data environment

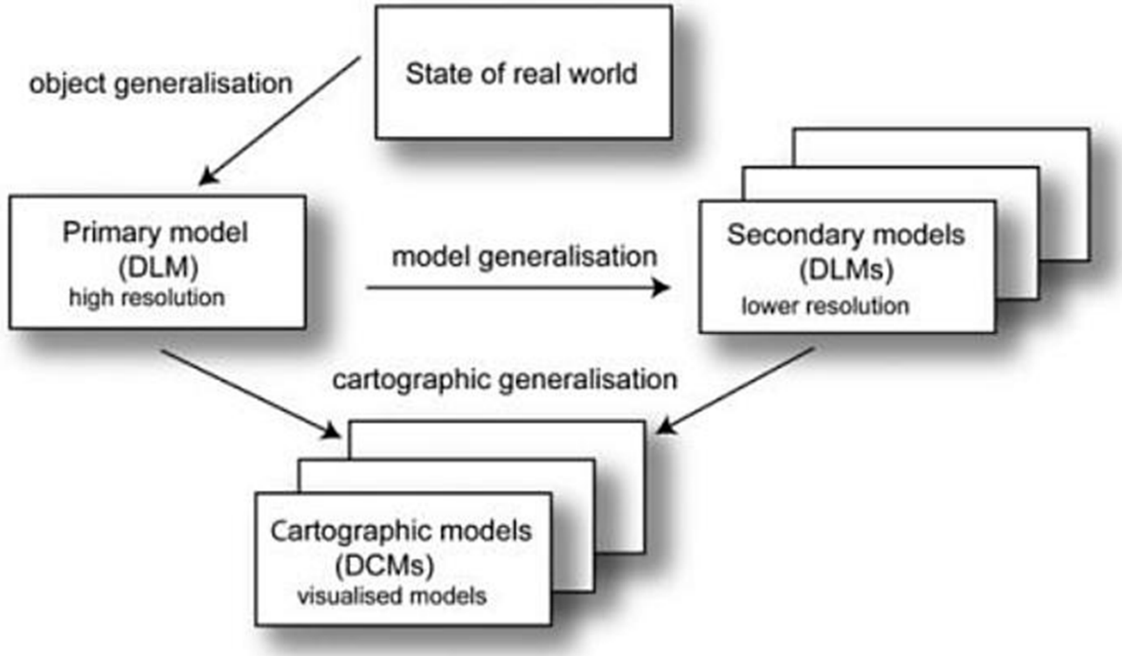
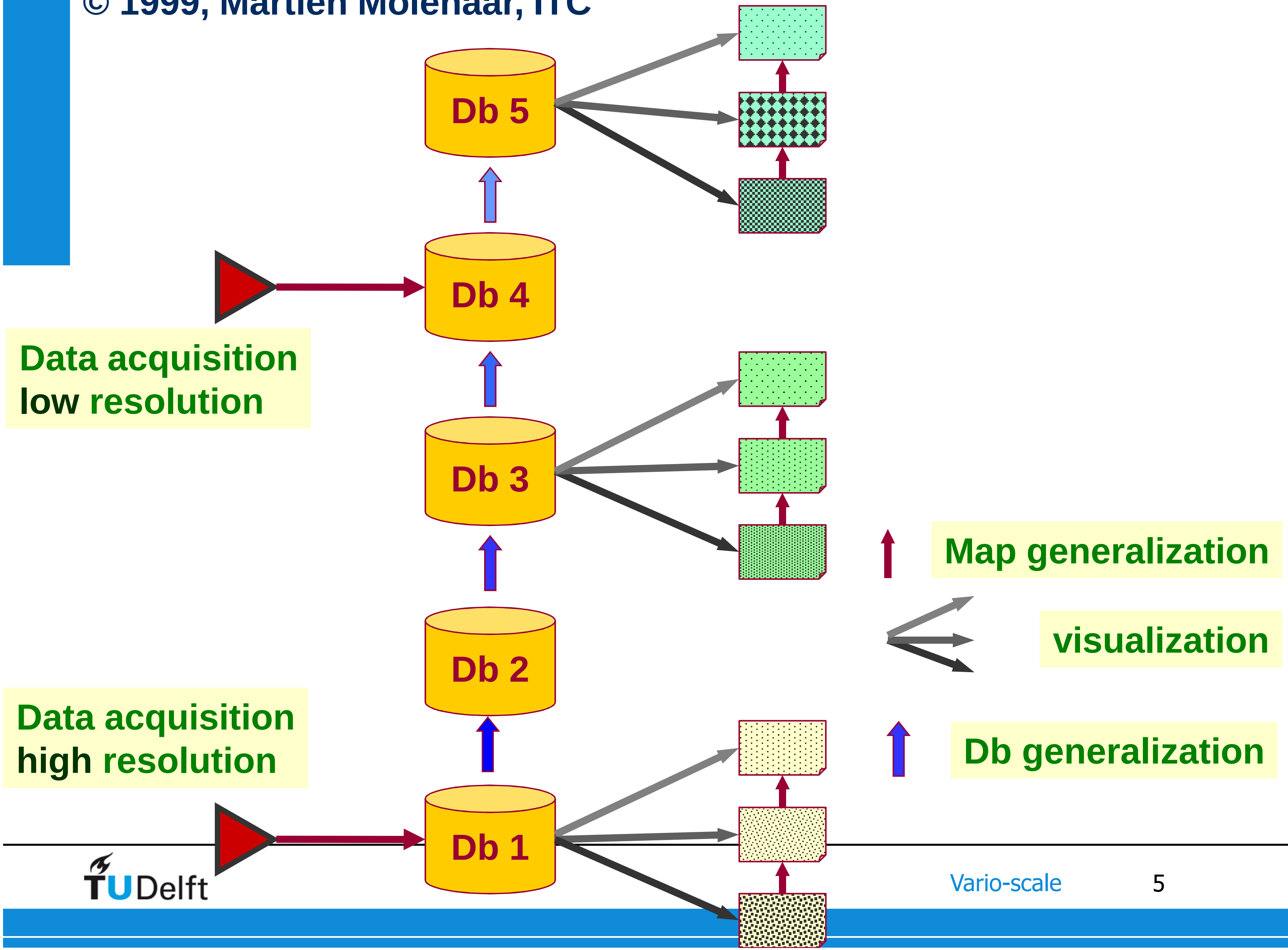


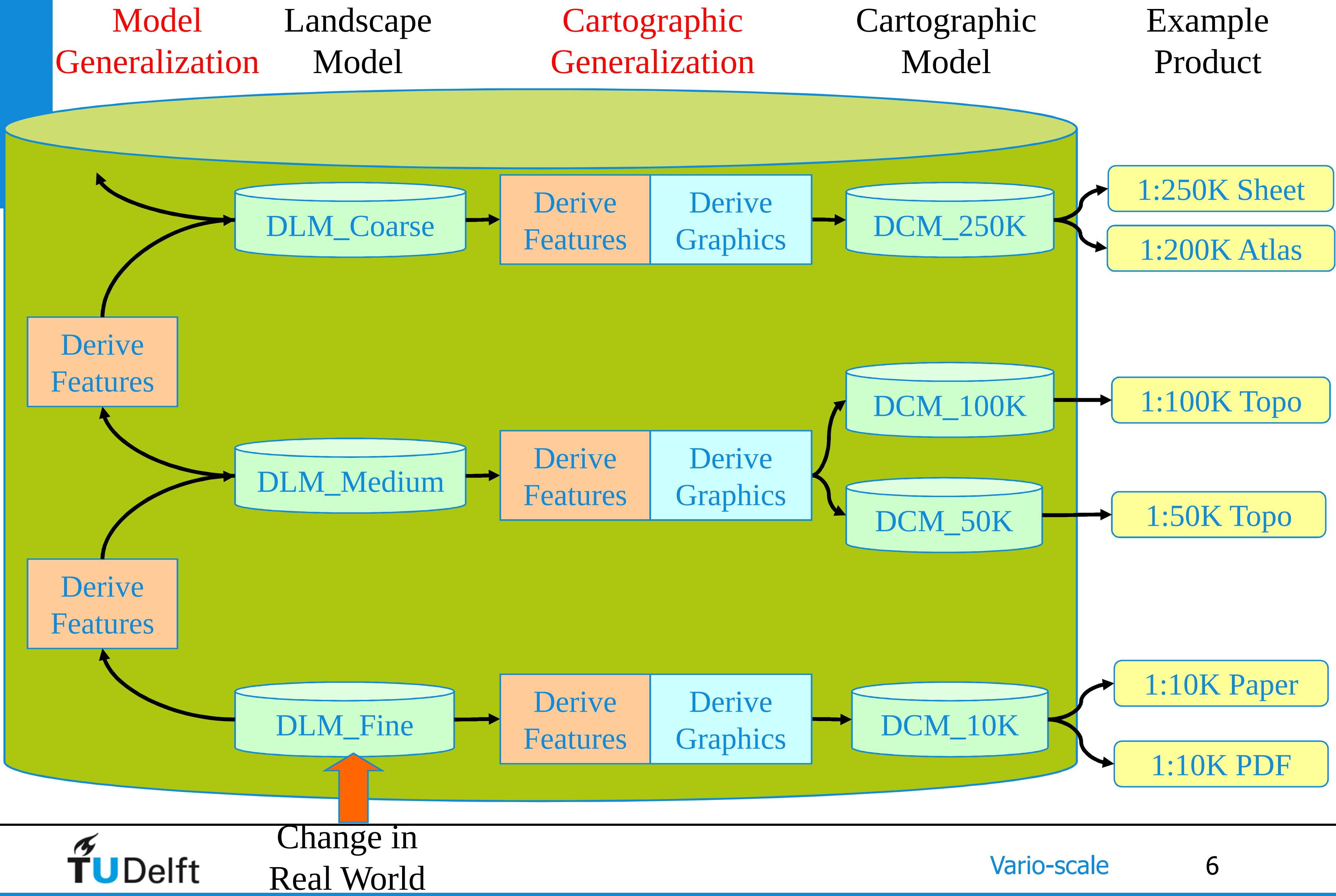
Fig. 2.3. The ATKIS model (after Grünreich, 1985). Printed by permission.

Joint work with Martijn Meijers (TU Delft) Jantien Stoter (TU Delft/Kadaster)
Dietmar Grünreich (BKG, Germany), Menno-Jan Kraak (ITC, Univ Twente)

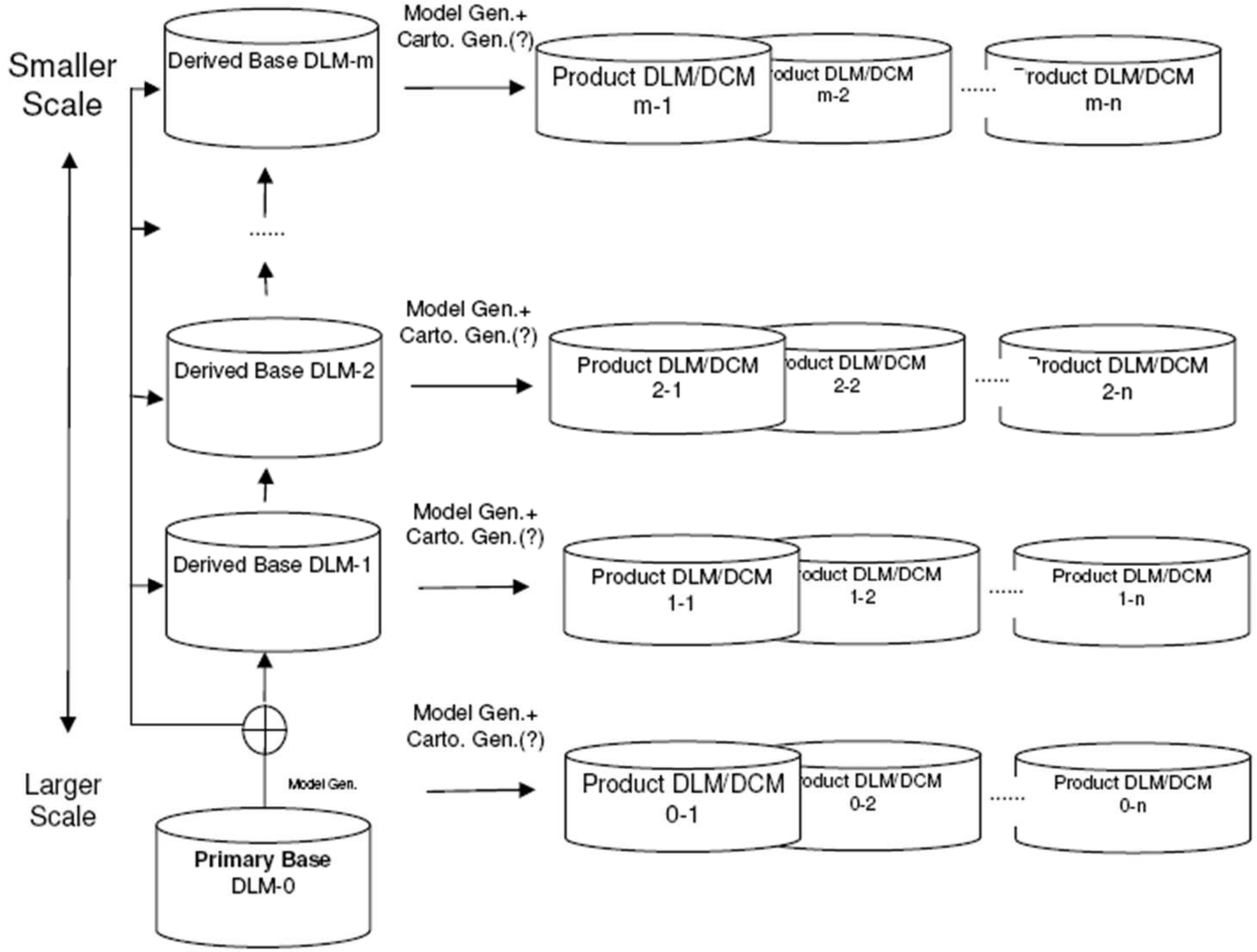
GDI 2010: Generalization and Data Integration, 20-22 June 2010, Boulder USA


Db 5
Db 4
Db 3
Db 2
Db 1
Data acquisition
low resolution
Data acquisition
high resolution
Map generalization
visualization
Db generalization

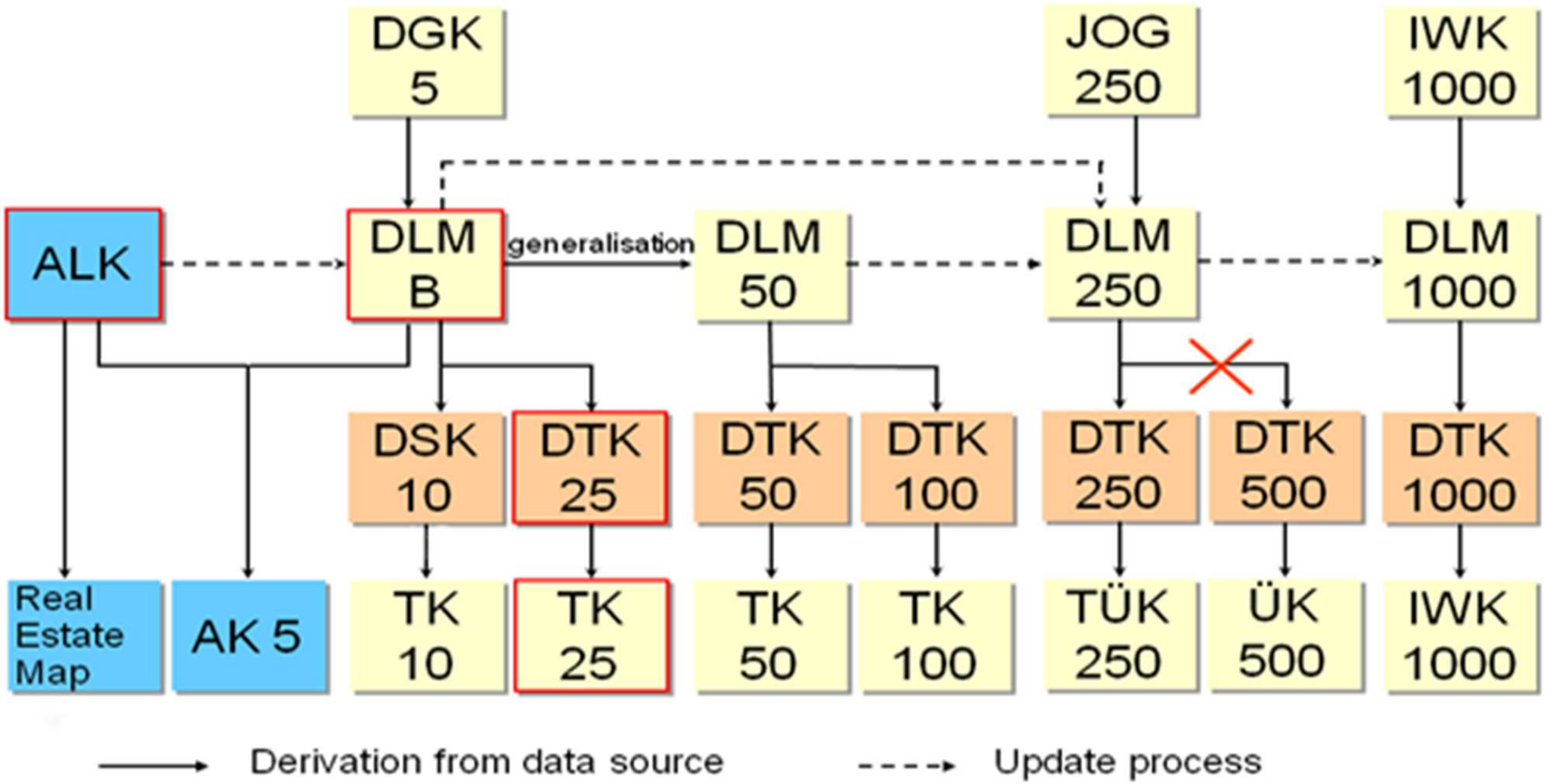
Thierry Kressmann, ESRI Int. User Conf 2004
Landscape Models, Cartographic Models, and Products



An example of Multi-Version MR-DLM/MR-SDB



Applied in Germany



DLM-DCM balancing

- DLM contains captured object according to specs
  → geographic objects

- DCM contains transformation of objects for visualization
  - depends on symbology
  - may be non-trivial transformation
  → map objects

- What should data producers store and maintain?

4 DLM-DCM balancing options

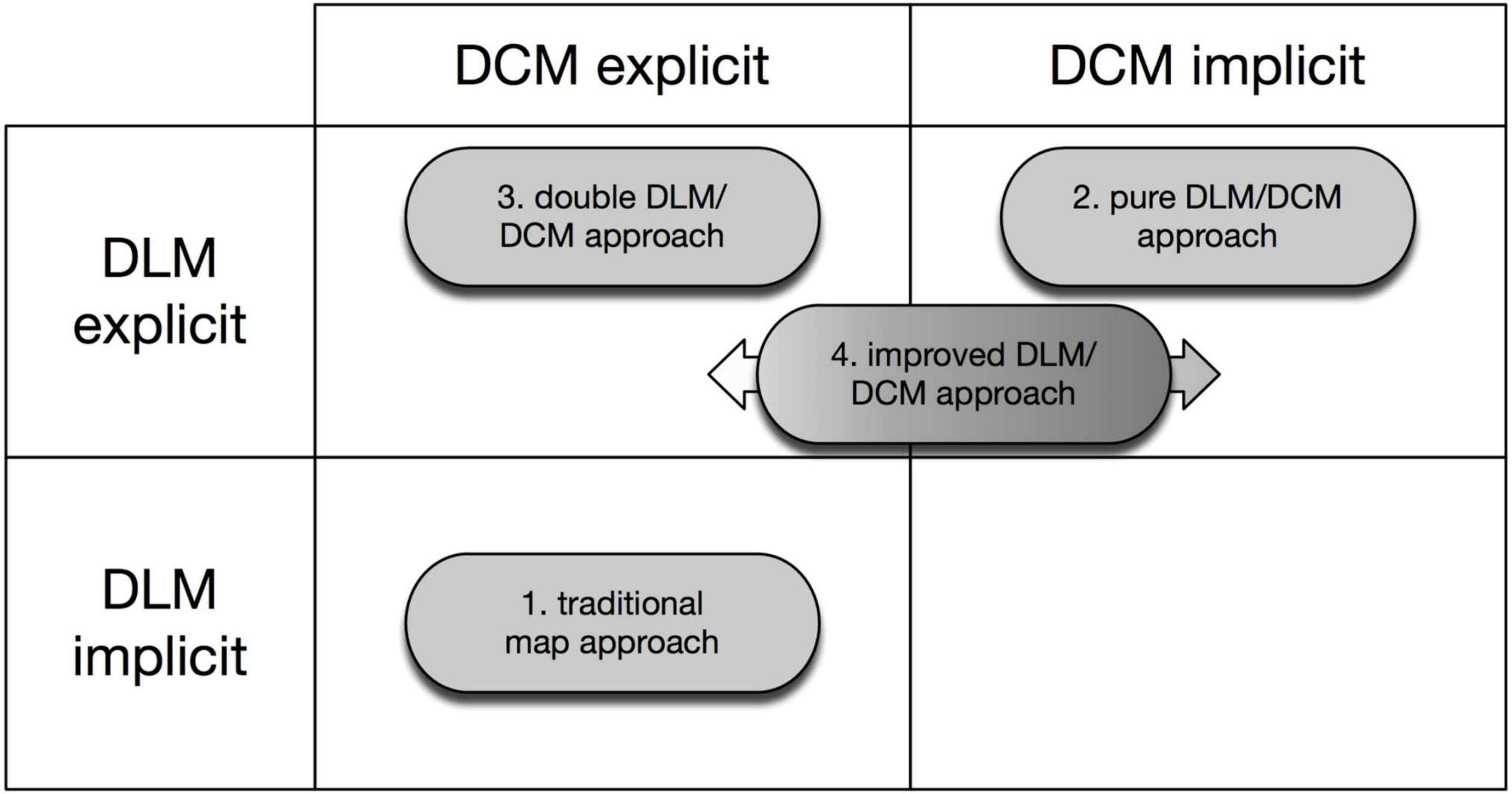
1. Only store map objects
   → mixes real world and map (bad for analysis?)

2. Only store geographic objects, derive map objects when needed
   → full automation difficult, non-optional quality

3. Store both map and geographic object (multi-representation)
   →for update also explicit links (somewhat redundant)

4. Adapt geographic object for default efficient visualization
   → no changes for needed easy visualization, but harder cases (displacement) might change geographic object within specs

Implicit-explicit storage of DLM-DCM



DLM-DCM in multi-scale database

- The DLM-DCM balancing question re-occurs per scale
- Assuming 5 scales and option 3 (both geographic and map objects)
  → 10 models to be stored, maintained and kept consistent
- Trend to provide higher rates of updates, so becomes challenge...
- Explicit links between corresponding DLM-DCM objects and between DLM object at adjacent scales (and perhaps even between DCM objects) might this easier
  → prize is now also maintaining many references

DLM modified approach, option 4

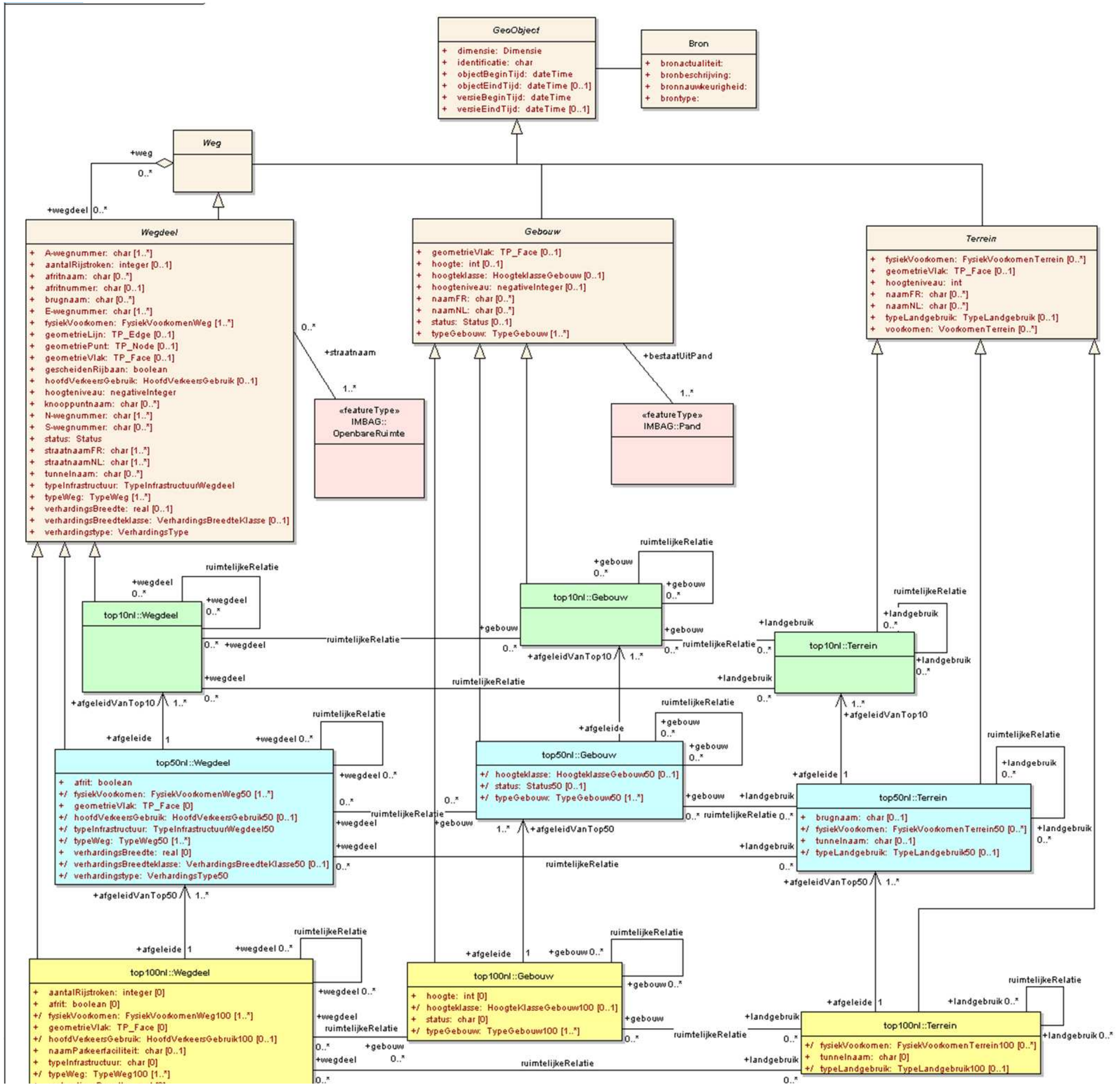
- In multi-scale environment, the DLM_{i+1} does deform the objects from the scale below DLM_i (via aggregate, remove, simplify,…) within limits as in specs for this scale.
- Why not allow changes (within spec) effective for easier visualization (e.g. displace)?
  - this would save half of the instances: 10→5 (and links)
  - assures never inconsistencies between DLM-DCM
- But…
  I want to do analysis on my DLM and changes distort the result
  → true, but within bounds given by spec and if you need more accuracy then go to the next more detailed DLM (digital world)

The multi-scale IMTOP (NL)

DLM-DCM separation was tried

→ model and cartographic generalization rules, constraints and optimization goals attached to resp. DLM and DCM object classes, but often classification was hard/impossible

→ multi-scale model already quite complicated without DLM-DCM separation



Roads Buildings Terrain

Part of the abstract layer (NEN3610)

Top10 layer

Top50 layer

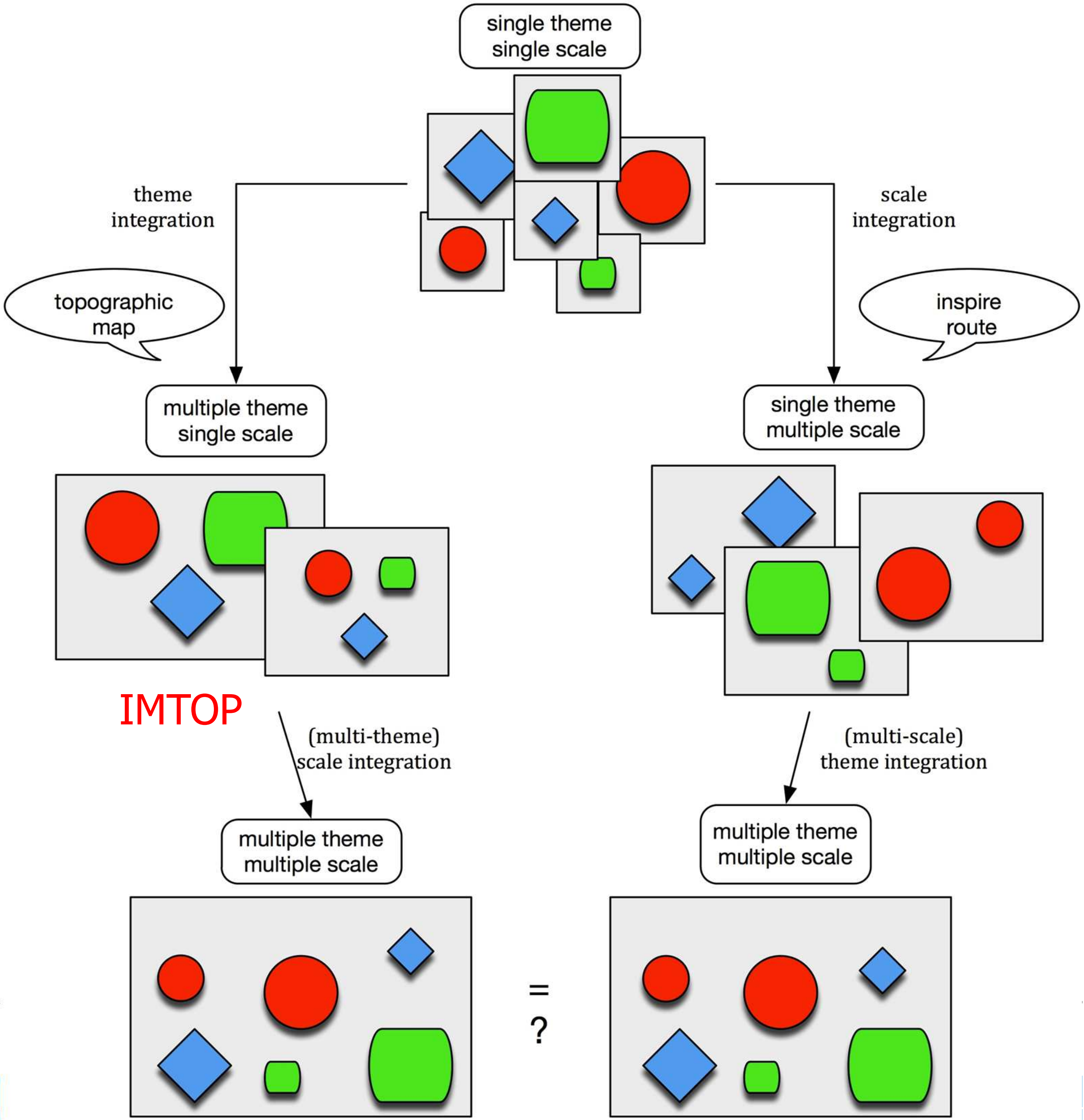
Top100 layer

Themes

Integrate themes and scales

Best order?

Same result?



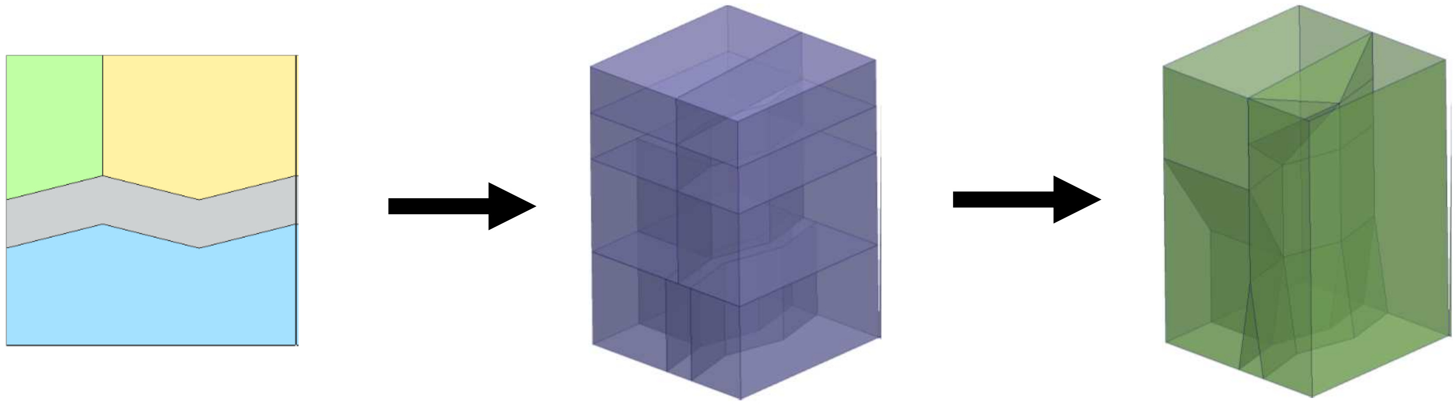
TU Delft

Vario-scale as ultimate solution?

- Still the ‘multi-scale (adapted) DLM only’ has some drawbacks → why redundant store same feature at multiple scales?

- Vario-scale is option, that avoids redundancy and also offers in-between scales (e.g. to support smooth-zoom) → tGAP

- However, improvements needed (and possible):
  1. Road collapses to line (kind of multi-rep)
  2. Certain concepts do not exits at largest scale but can only be introduced and medium/smaller scales (roundabout)
  3. Certain types of changes (again difficult to compute with simple structure; typify, displace,…), add second representation



Towards a true vario-scale structure supporting smooth-zoom

Joint work with Martijn Meijers (patent pending nr. OCNL 2006630 prepared by Dirk de Jong, European Patent Attorney, Vereenigde)
ICA 14th Generalisation Workshop, 30 June-1 July 2011, Paris, France

Contents

This is not 'yet another tGAP story'…
(generalized area partitioning)
Because… SSC, space-scale cube

Early use of additional dimension for scale (importance) representation

- Alternative Reactive-tree (van Oosterom, Auto-Carto 10, 1991)

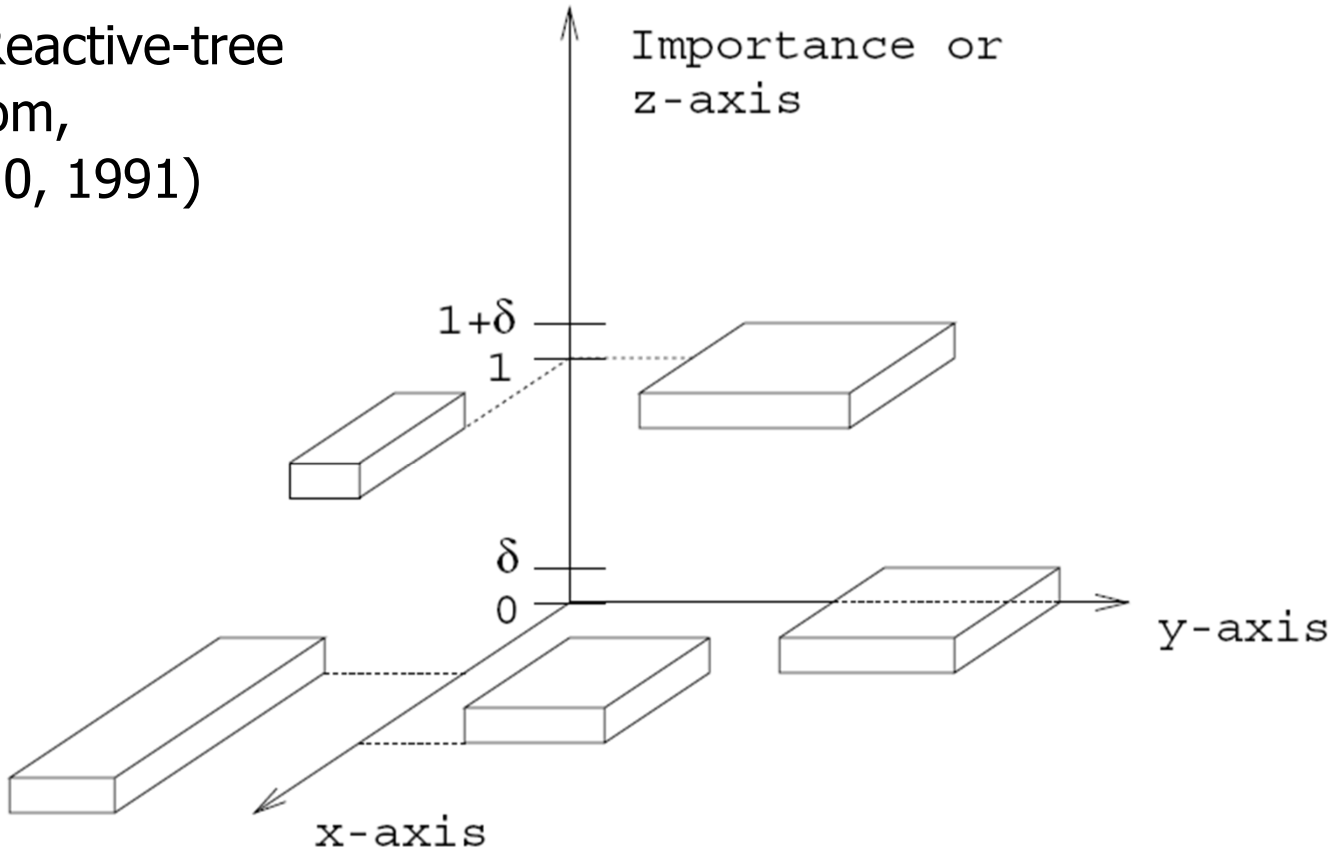
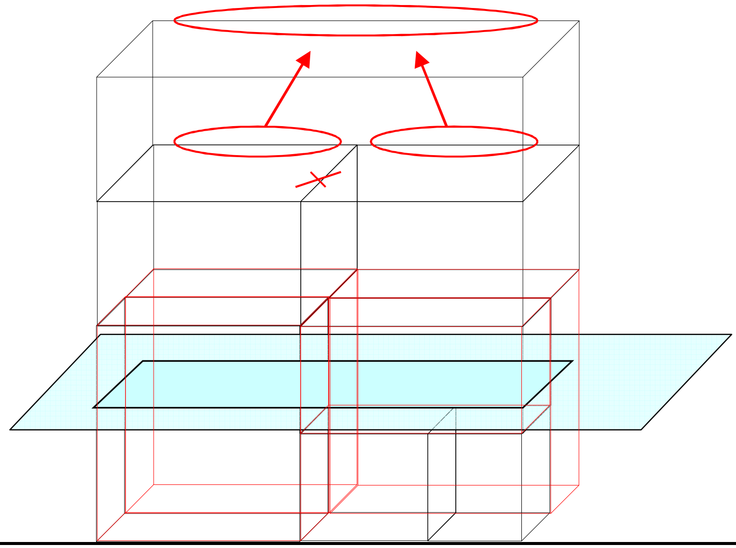


Figure 8: The 3D MBRs of the Alternative Reactive-tree

Generalized Area Partitioning-tree (GAP-tree) history

- Normal GAP-tree (van Oosterom 1993) areas are stored as independent polygons → computed redundancy (both at given scales and between scales)

- Vermeij et al. 2003 proposed topological GAP-tree: edges and faces (with importance range, consider as height), reduced redundancy between neighbors
  → scale/imp with 3D prisms



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- Smooth tGAP → SSC
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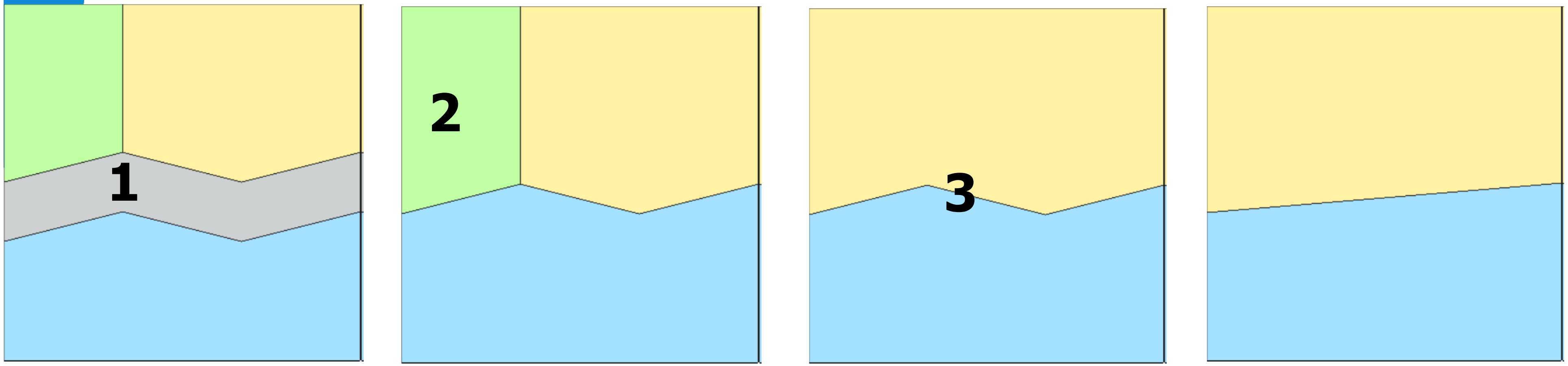
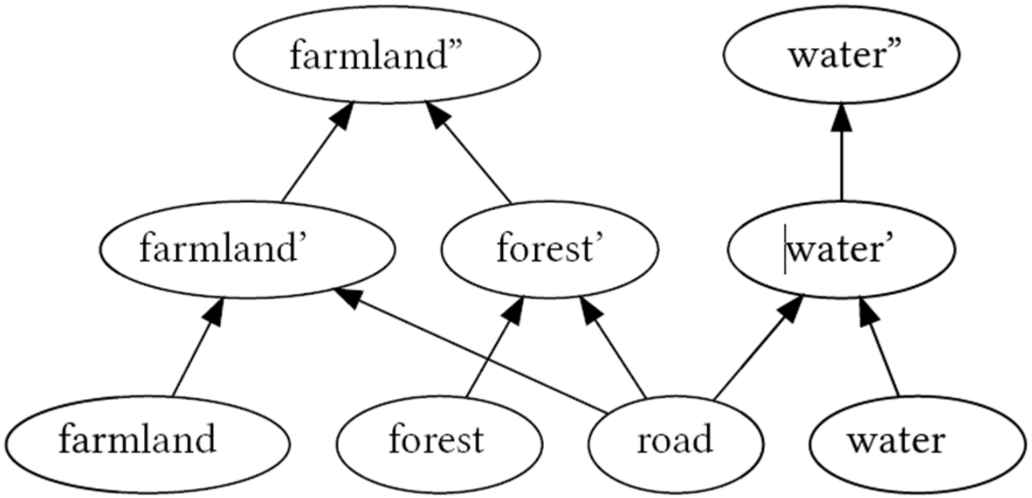
- Conclusion

tGAP example

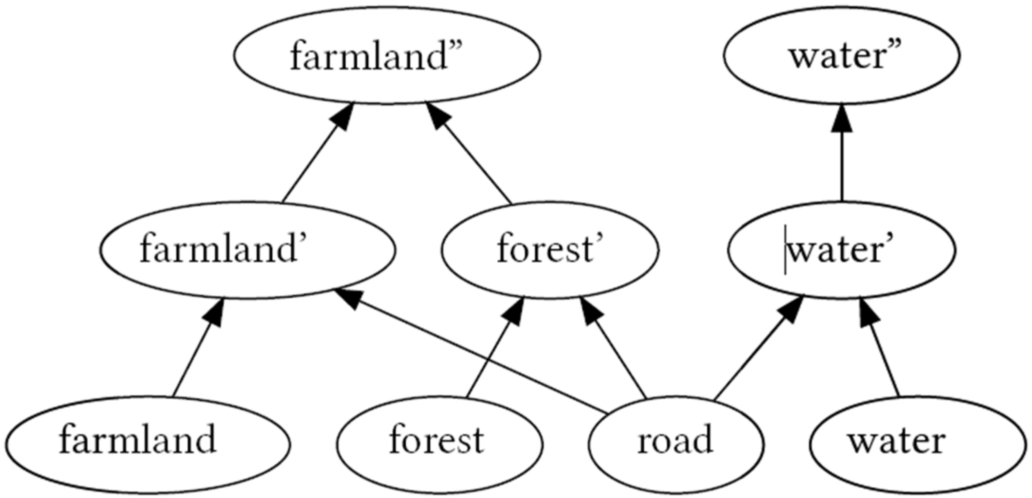


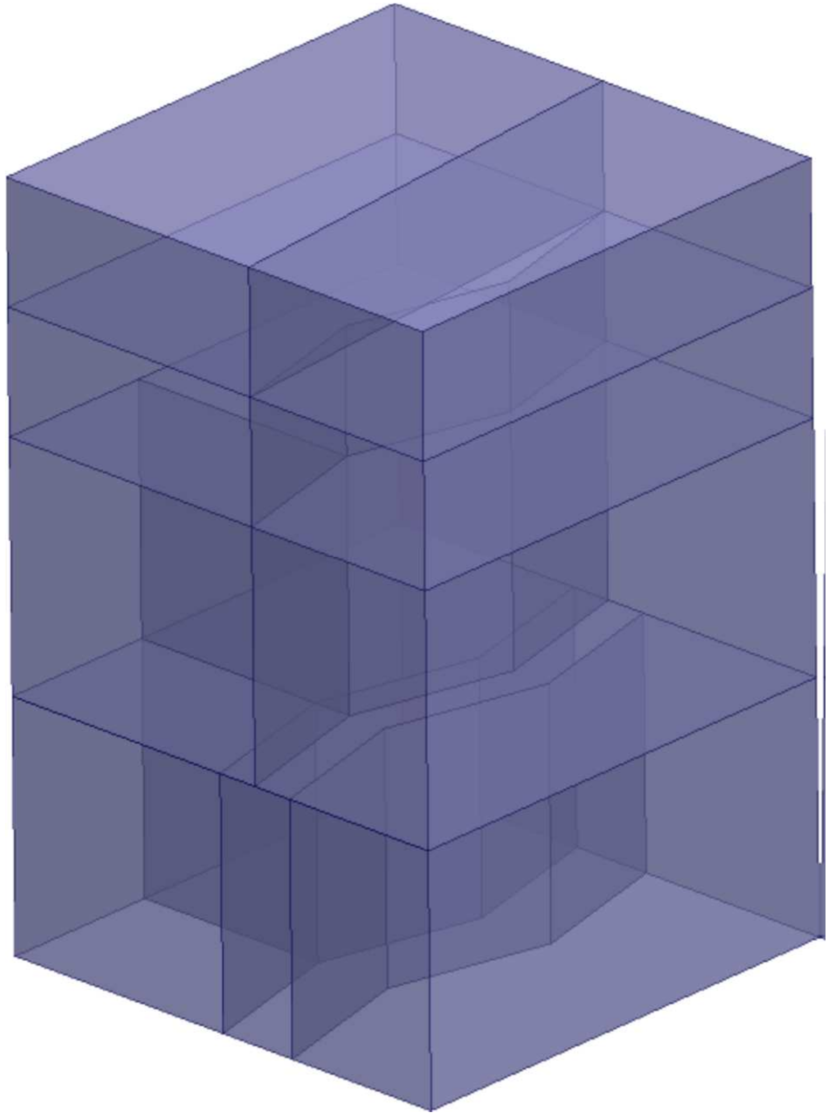
1. Collapse road
   (split area, merge neighbours)
2. Delete forest
   (merge with farmland)
3. Simplify boundary
   (between water/farmland)



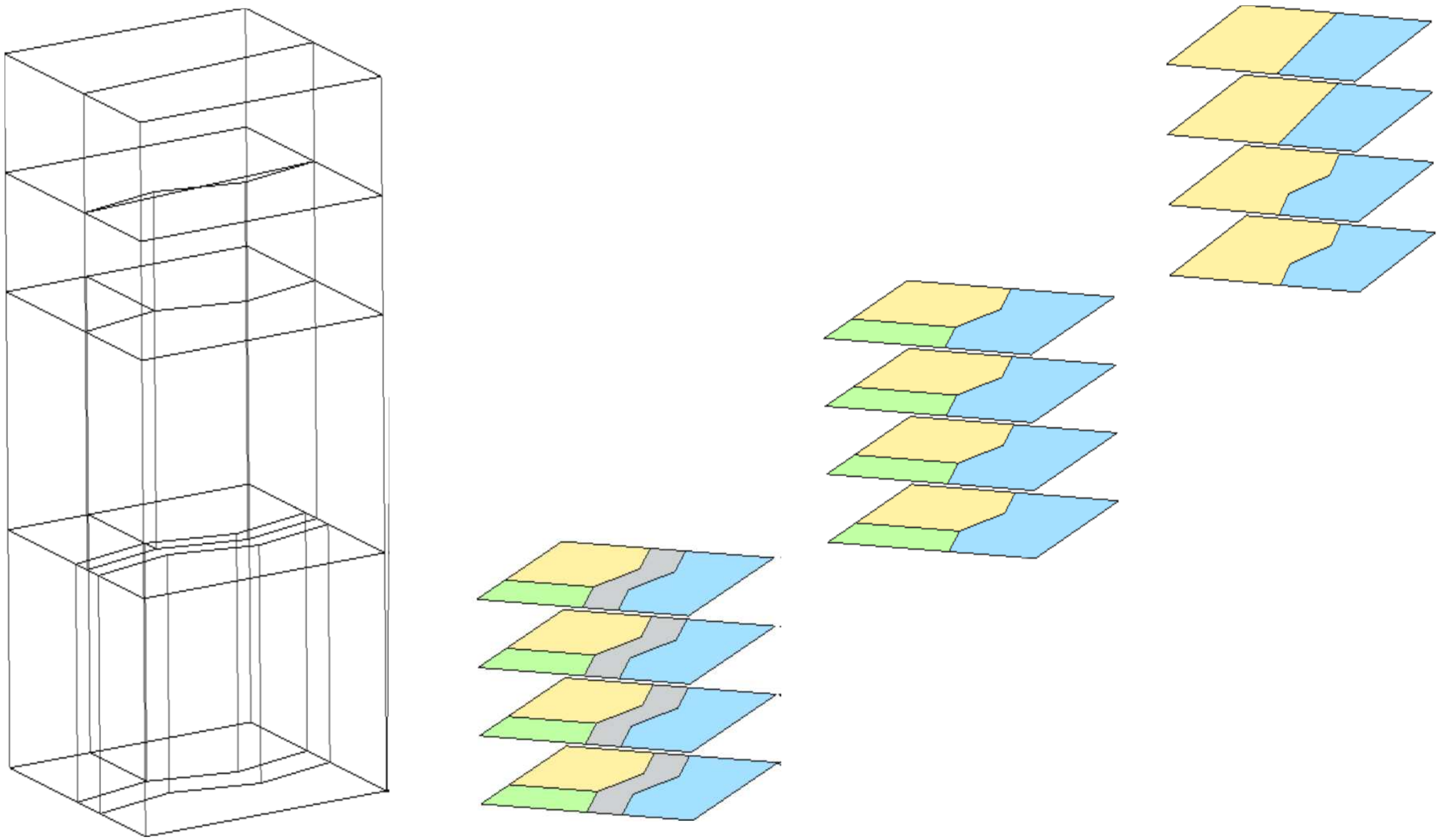
2D+scale → 3D integrated

- tGAP DAG to 3D structure
- Parent-child:
  →neighbour above-below





Delta scale
→ no change at all or local shock



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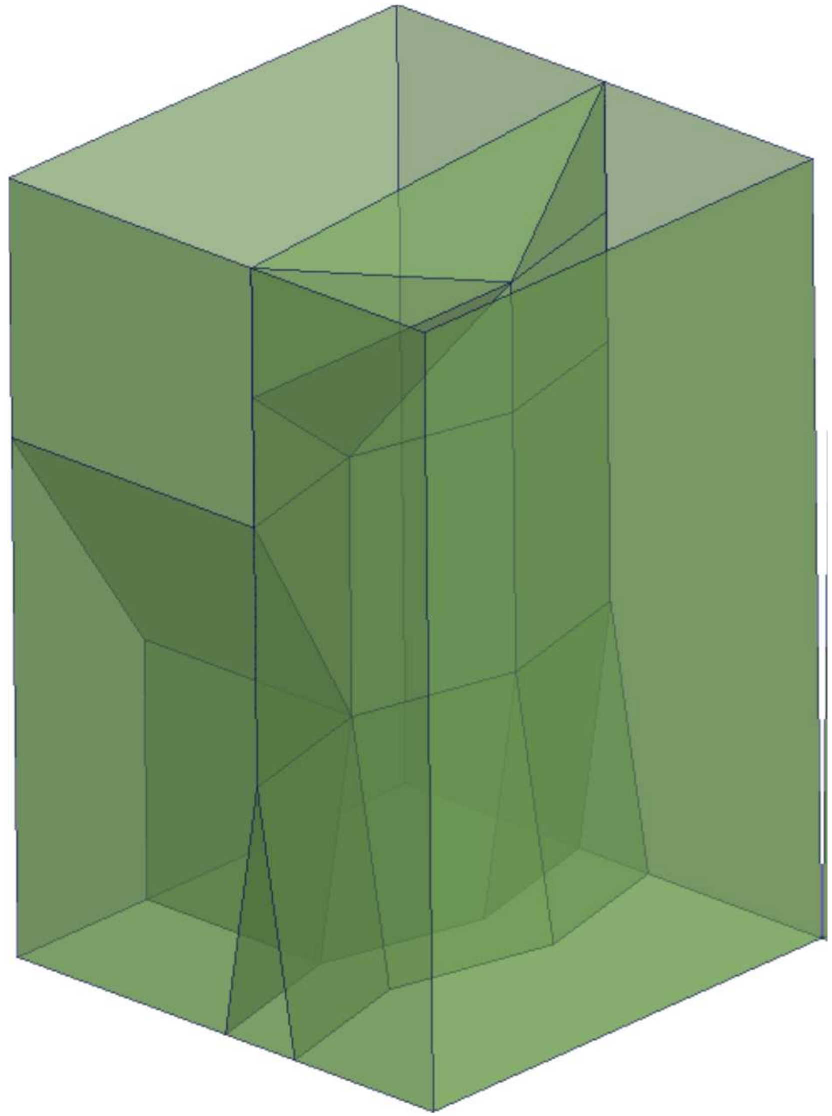
Smooth tGAP

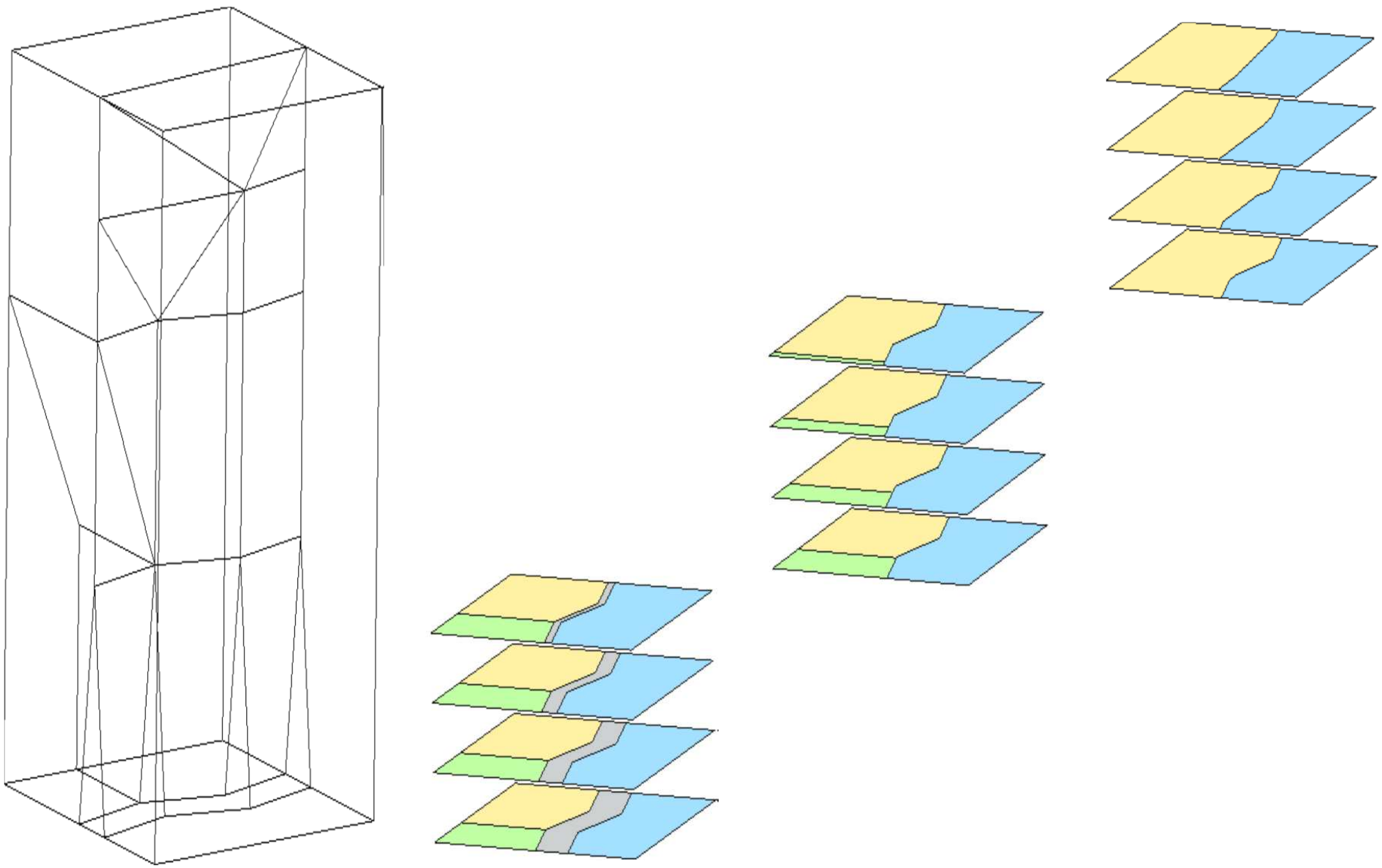
- Remove local shock
  → no horizontal faces

- Gradual changes
  → less vertical faces

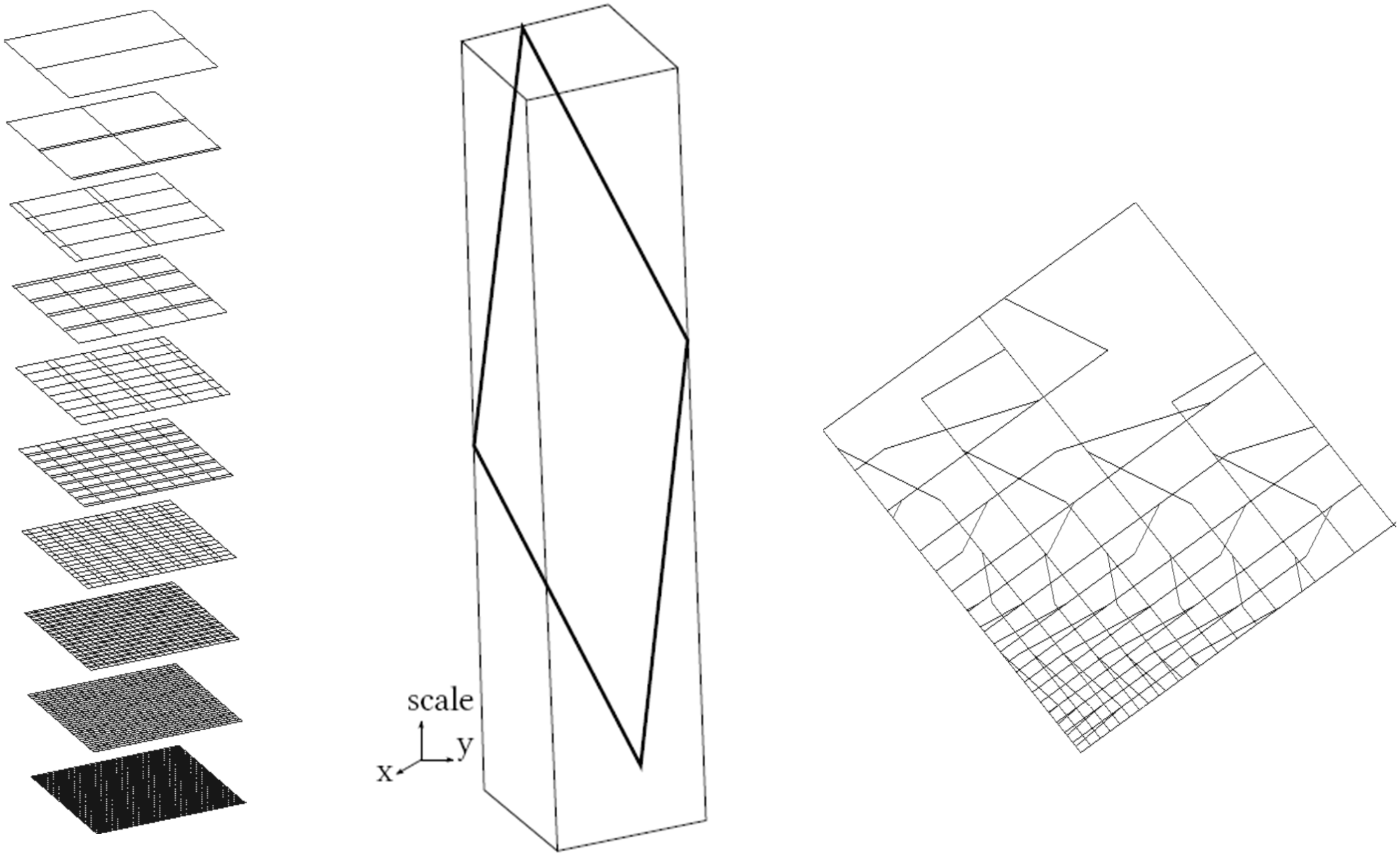
- Resulting polyhedron
  → representation of single
  object for all its scales



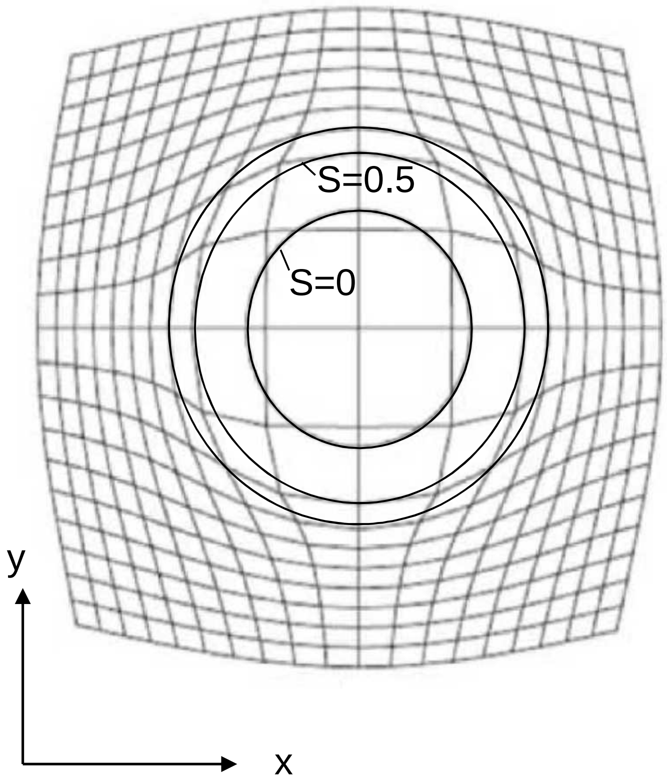
Delta scale → delta map

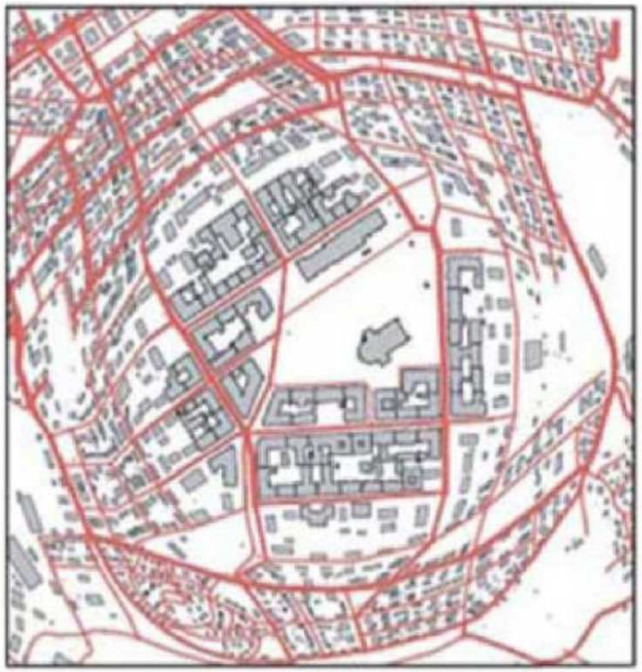


Non-horizontal slice → mixed scale map



Non-flat slice → mixed scale map (fish-eye example)



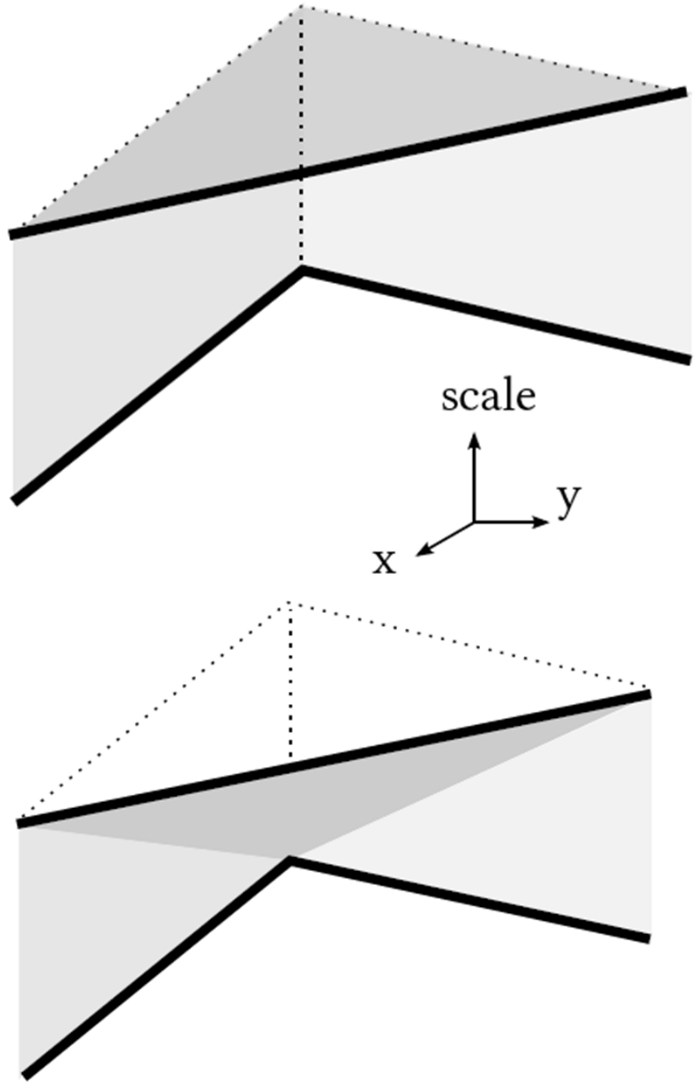


source: Harrie et al, 2002, ISPRS Archives 34(4):237–242

Contents

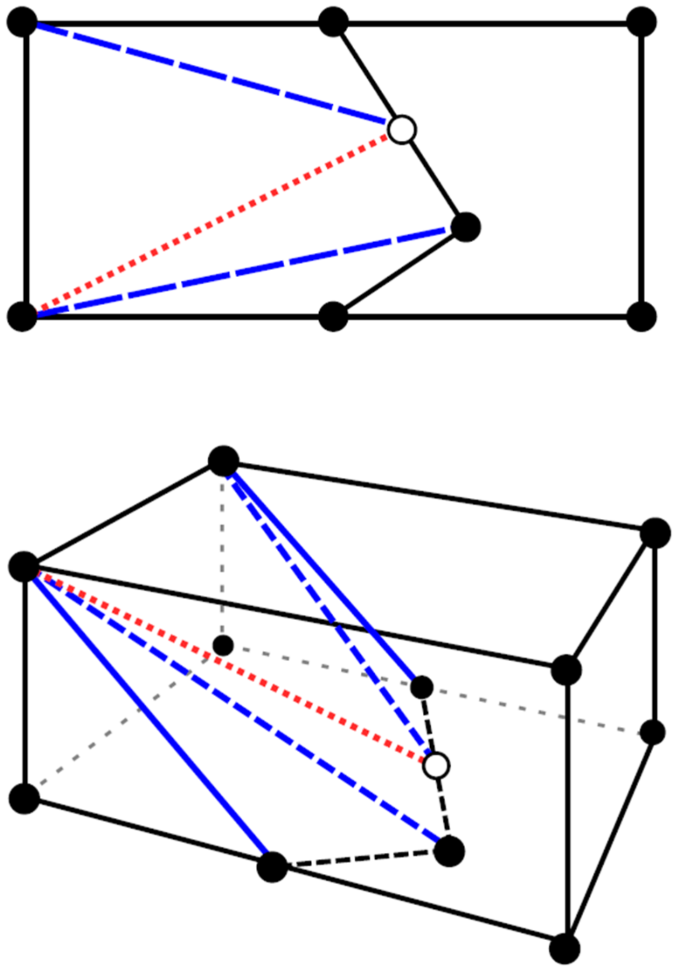
Smooth simplify

- Shock change:
  - 2 rectangles
  - 1 triangle
- Smooth change:
  - 3 triangles



Smooth merge for convex neighbour

1. make #nodes shared and target bnd equal (n)
2. connect node pairs
3. 2 triangles + n-3 quadrangles
4. if non-flat → split quadrangle into 2 triangle
5. Merge planar neighbours

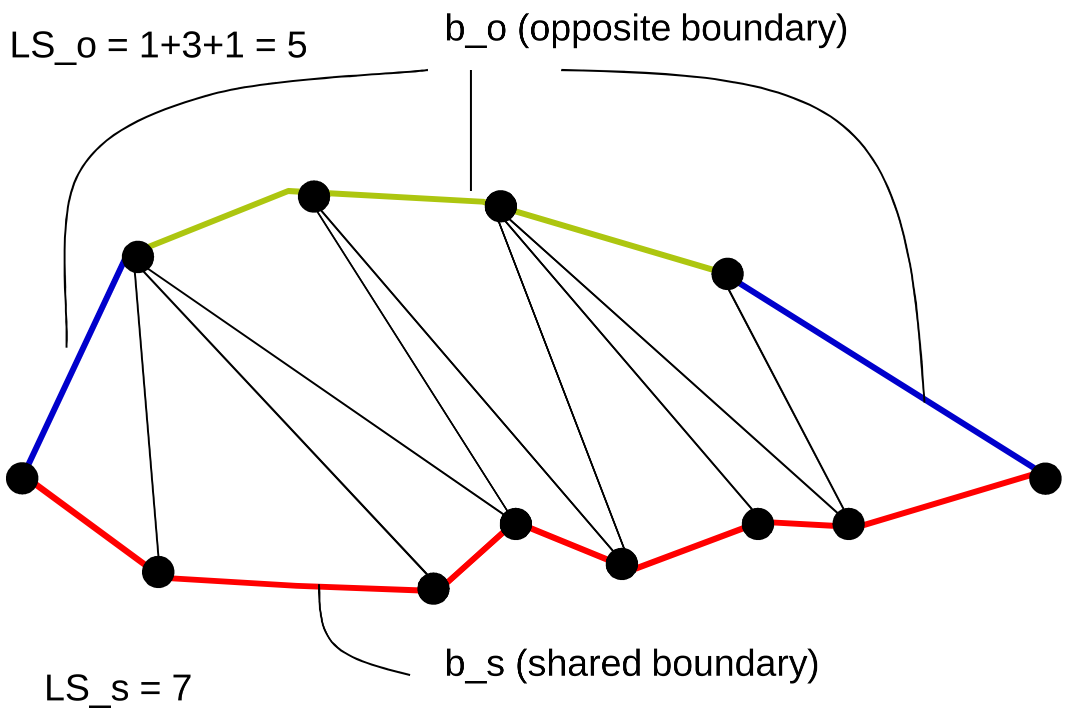


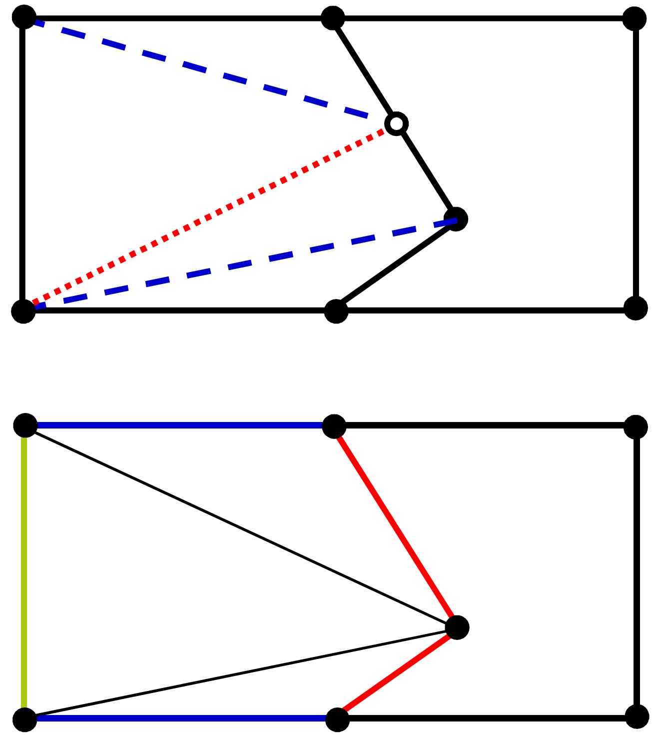
top view

space-scale view

Alternative (without adding nodes)

Create triangle base at one side
and top at other side

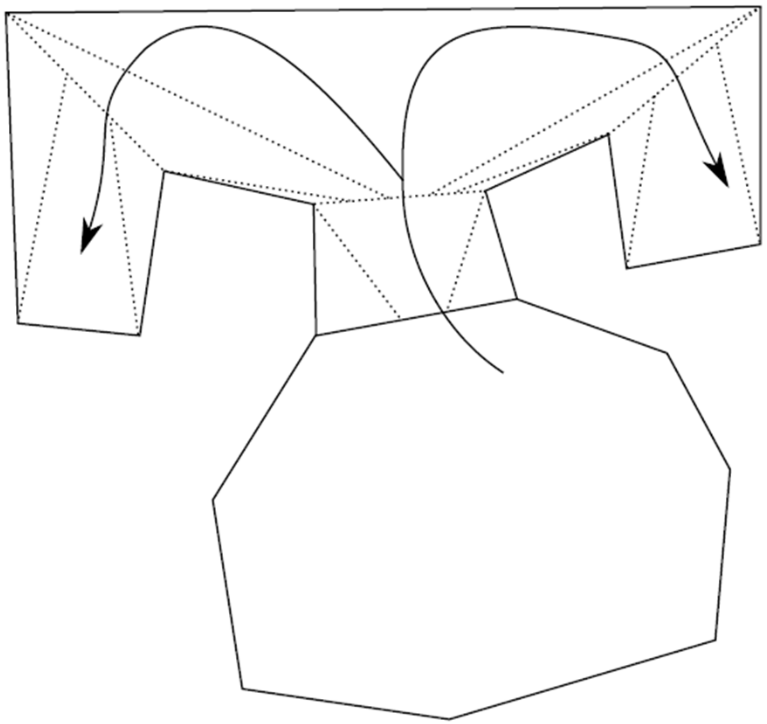




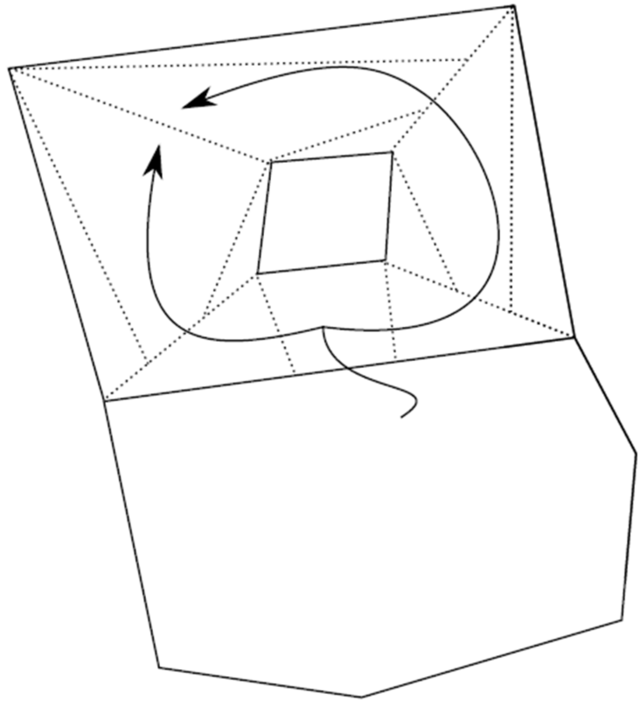
at scale s2, from s1 to s2, at scale s1

Non-convex neighbour
→ subdivide in convex parts

m-shaped neighbour



neighbour with hole



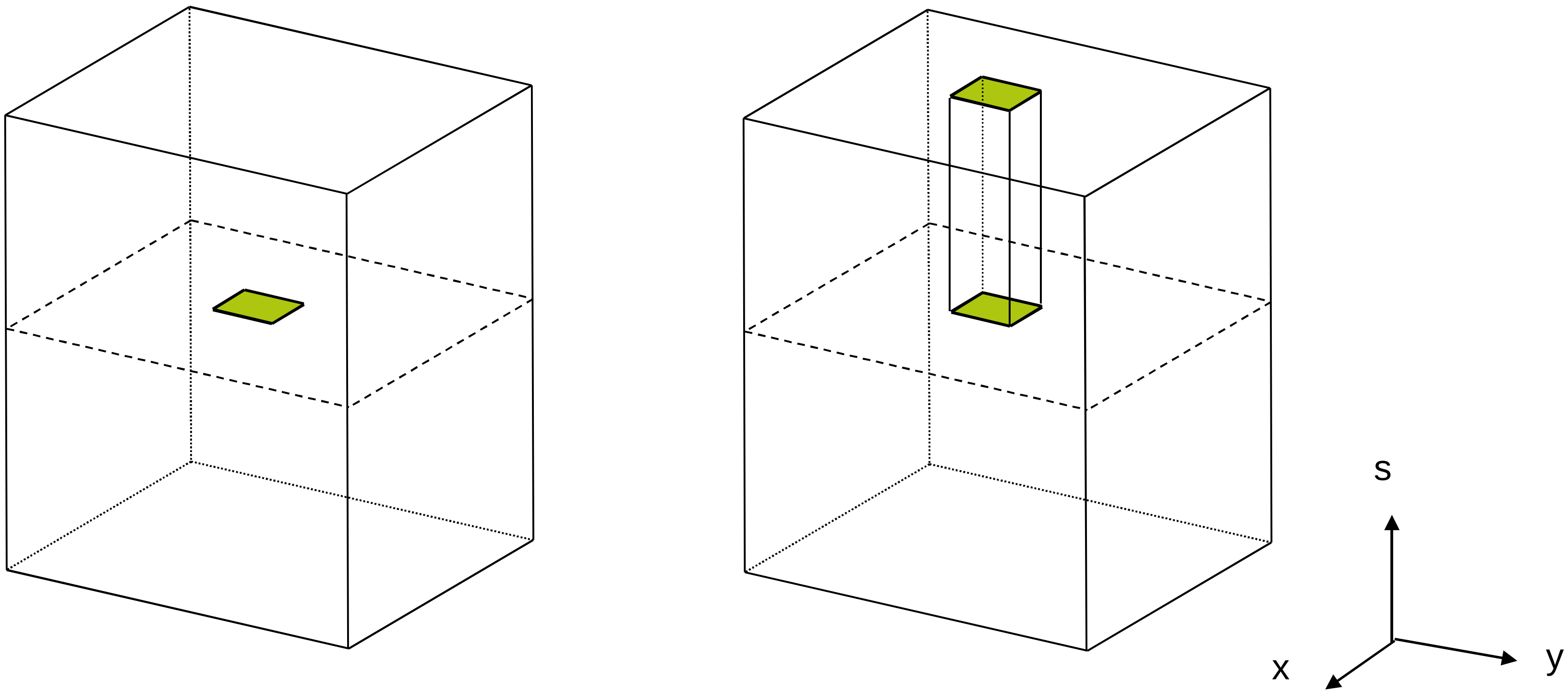
(note: smooth collapse/split similar to smooth merge)

Contents

Selection based on (n+1)D overlap from space-scale cube

Simple initial map

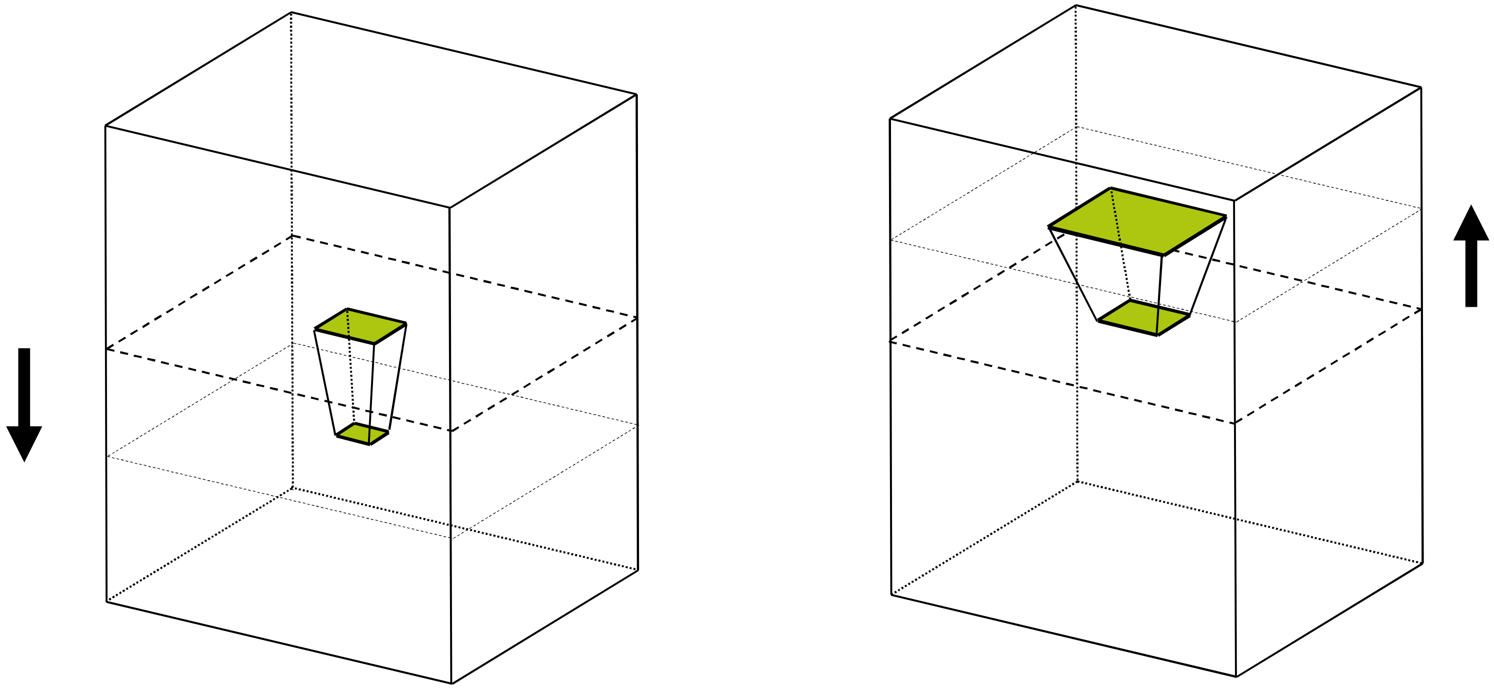
Progressive initial map
(sorting lower→higher detail)



(n+1)D overlap selection for zooming

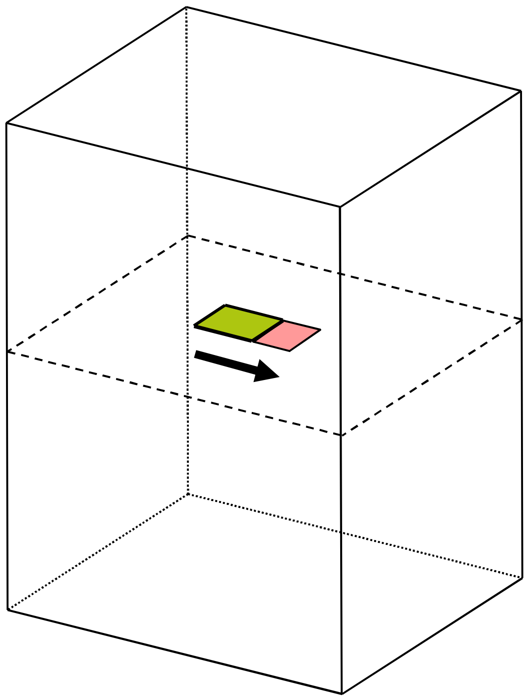
Progressive zoom-in
(normal sorting order)

Progressive zoom-out
(reverse sorting order)

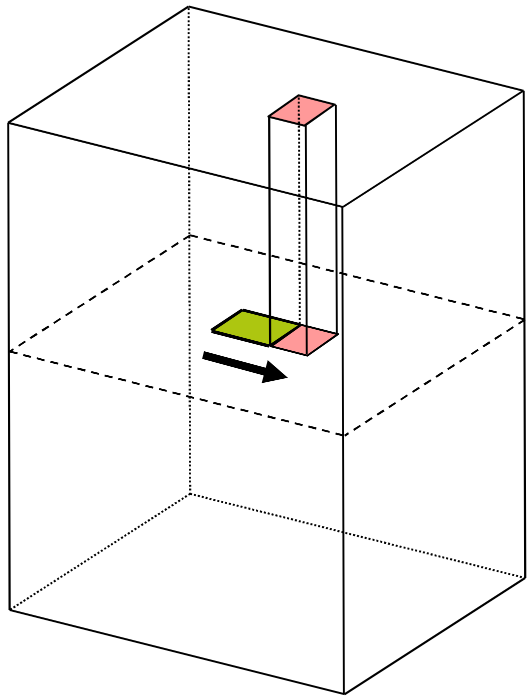


(n+1)D overlap selection for panning

Normal panning



Progressive panning
(normal sorting order)



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Some future work

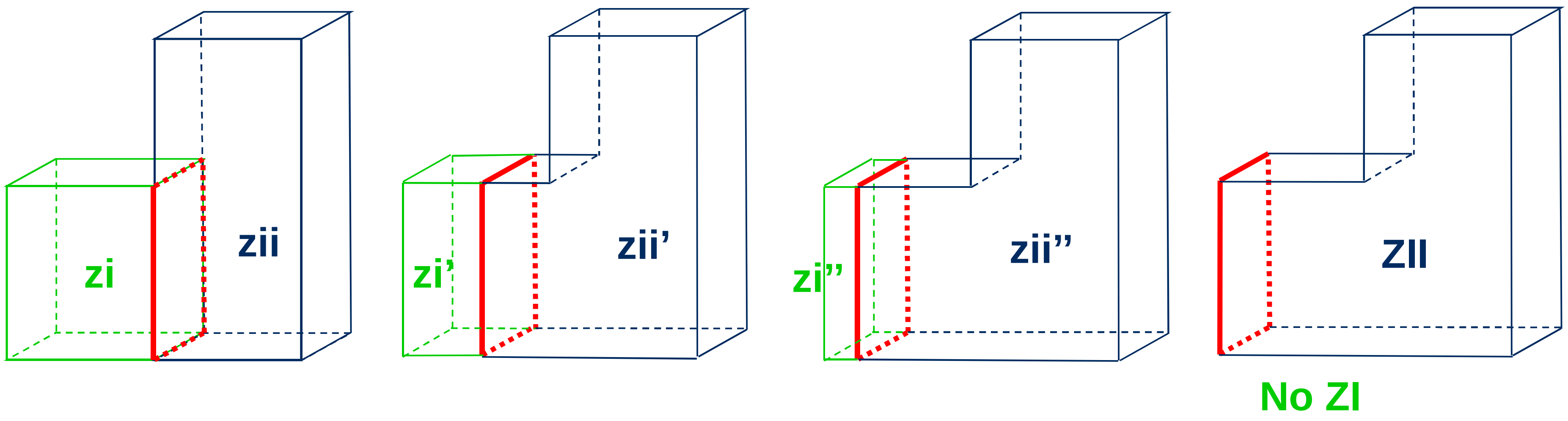
- Semantic aspect (incl. attributes) needs further attention
- Lower dimension primitives (lines, points) do also fit in the structure, but need further investigations
- Not per se object by object creation (but multiple objects in parallel → see paper)
- Sliver before disappearing
- Lot of implementing and testing needed

Conclusions, true vario-scale

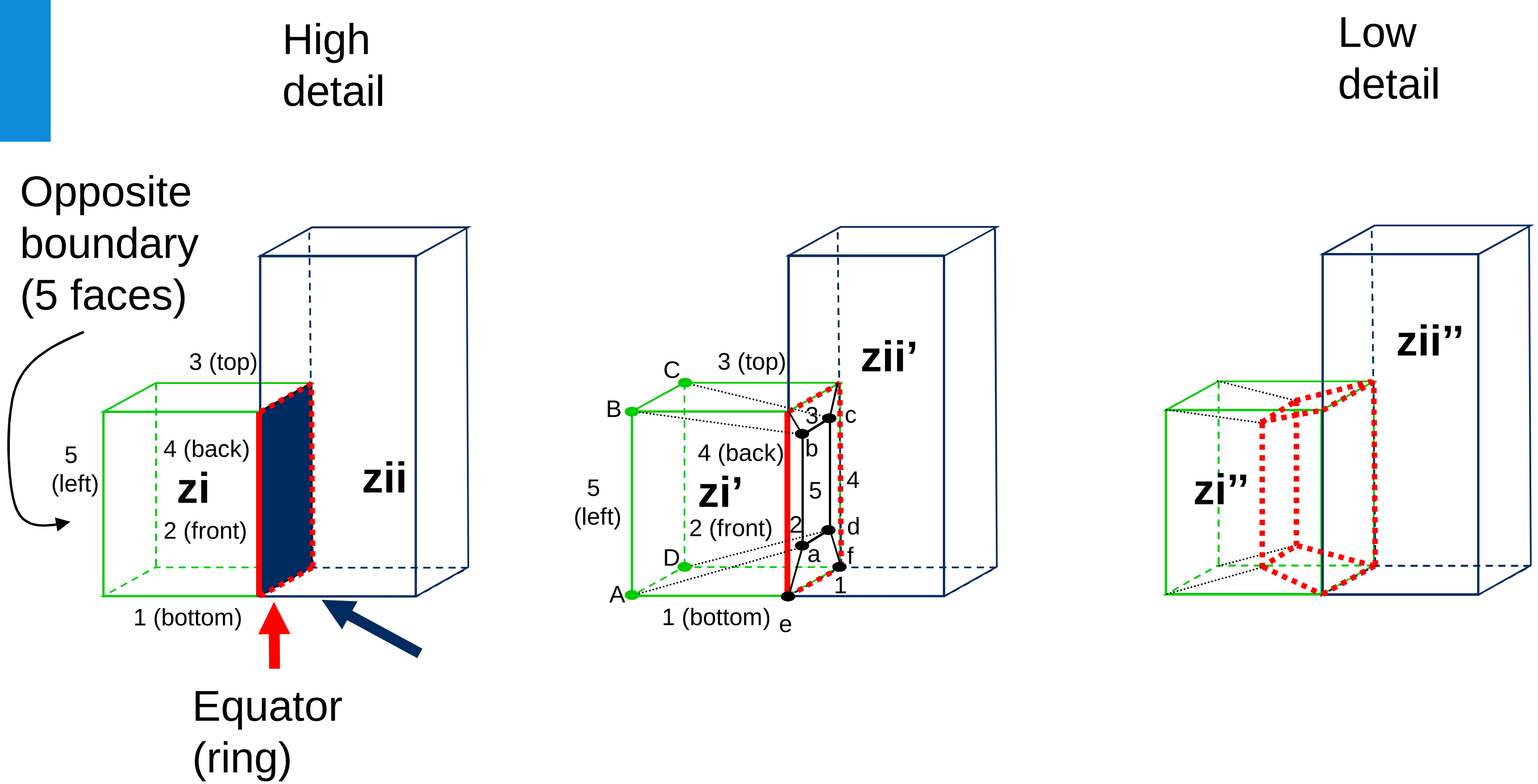
- tGAP is well suited for web environment (progressive)

- True vario-scale nD maps based on
(n+1)D representations and
slicing (selecting) with hyperplanes:
  - tGAP structure translates 2D space and 1D scale in an integrated 3D topological representation: no overlaps and no gaps (in space and scale)
  - Starting with 3D space and adding scale results in 4D
  - Starting with 3D space and time (history) and adding scale results in 5D topological structure (again no gaps/overlaps in space, time or scale), well defined neighbors in space, time and scale directions

3D smooth merge (more details in patent claim)

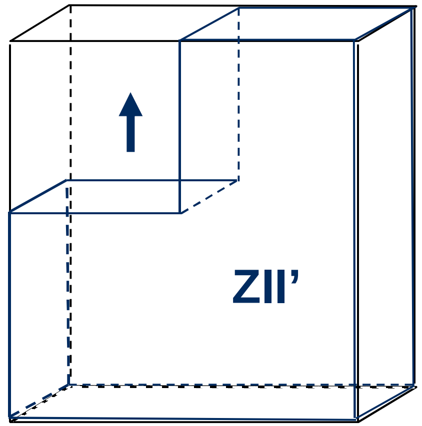


Generic 3D smooth merge

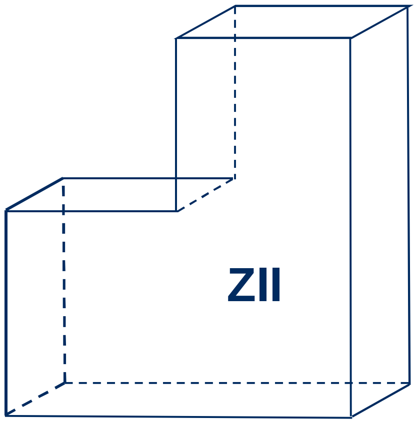


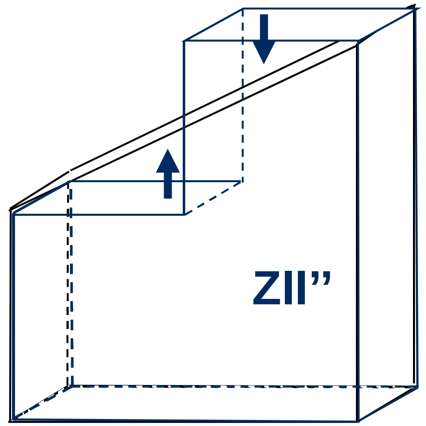
3D Smooth simplify

Simplify boundary of merged object,
two options:



1. Keep block shape





2. Tilted roof shape

Pseudo 4D-view

Zone zi shown for reference purpose