nD-PointCloud continuous level representation for spatio-temporal phenomena in Open Point Cloud Maps, plans for year 2

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Results year 1

- see previous presentations: Theoretic foundations, use case analysis, initial software development, hardware platforms
- Publications:

  - Haicheng Liu, nD-PointCloud Data Management - continuous levels, adaptive histograms, and diverse query geometries, PhD thesis, Delft University of Technology, pp. 207, 2022.
  - Peter van Oosterom, Simon van Oosterom, Haicheng Liu, Rod Thompson, Martijn Meijers, Edward Verbree, Organizing and visualizing point clouds with continuous levels of detail, In: ISPRS Journal of Photogrammetry and Remote Sensing, Elsevier BV, 194, pp. 119-–131, 2022.
  - Martijn Meijers, PCServe – nD-PointClouds Retrieval over the Web, In: ISPRS - Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 17th 3D GeoInfo Conference, Sydney, Australia, Copernicus GmbH, X-4/W2-2022, pp. 193-200, 2022.
  - Vitali Diaz, Haicheng Liu, Peter van Oosterom, Martijn Meijers, Edward Verbree, Fedor Baart, Maarten Pronk, Thijs van Lankveld, Point clouds and Hydroinformatics, 2022 (Abstract from EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022).
  - Zhenyu Liu, Peter van Oosterom, Jesús Balado, Arjen Swart, Bart Beers, Detection and reconstruction of static vehicle-related ground occlusions in point clouds from mobile laser scanning, In: Automation in Construction, Elsevier BV, 141, pp. 104461, 2022.
  - Haicheng Liu, Rodney Thompson, Peter van Oosterom, Martijn Meijers, Executing convex polytope queries on nD point clouds, In: International Journal of Applied Earth Observations and Geoinformation, Elsevier, 105(102625), pp. 1-11, 2021.
  - Guan-Ting Zhang, Edward Verbree, Xiao-Jun Wang, An Approach to Map Visibility in the Built Environment From Airborne LiDAR Point Clouds, In: IEEE Access, Institute of Electrical and Electronics Engineers (IEEE), 9, pp. 44150-44161, 2021.
  - H. Liu, P. Van Oosterom, B. Mao, M. Meijers, R. Thompson, An efficient nD-Point Data Structure for Querying Flood Risks, Chapter in: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Copernicus GmbH, XLIII-B4-2021, pp. 367-374, 2021.

Some reflections

- Conceptual model:
  on-track (80%)

- Datamanagement:
  in progress (45%)

- HPC/HTC, webservices:
  good start (20%)

- Visualization:
  bit false start (10%)

- Proof-of-concept:
  cases defined, initial focus
  monitoring changes

More reflections

- Not an easy start, kick-off became hybrid, followed by distance working

- Markus Schütz visit to Delft, in 'early post-covid' times, week of 21 March 2022: some TUD staff got Covid in week before and did go online, despite this Markus got infected…

- Maarten van Meersbergen, NLeSc Computer Graphics expert, could join for limited time (and now left NLeSc)

- Peter (PL) was on sabbatical from April-August 2022, limited efforts

- Learning curve Vitali was non-trivial

Table 1: Time table

| Work Package	Year 1		Year 2		Year 3	
WP1: Organization, Communication	██	██	██	██	██	██
WP2: Conceptual Model	██	██				██
WP3: Data Management Technologies	██	██	██	██		
WP4: HPC/HTC Web-services		██	██	██	██	
WP5: nD-PointCloud Visualization			██	██	██	██
WP6: Proof-of-Principle water management	██			██	██	██

On the bright side

- Martijn and Thijs explored nD-PC organization (with cLoI) in resp. DBMS and files, and good results obtained
- Vitali explored and cleaned spatio-temporal point cloud data, and analyzed in detail the possible change detection options
- PL applied for support from the TU Delft Digital Competence Centre (DCC) and received this: Manuel Garcia helped us by getting started with the Delft Blue super computer
- Nauman Ahmed from NLeSc joined the project with HPC/HTP expertise and continues exploiting Delft Blue
- New hardware: ipad with laser scanner, Zeb horizon laser scanner, successor of our own server (pakhuis) with a lot of SSD
- Weekly semi-structured project meetings
- Geomatics/GIMA students doing thesis projects with point clouds

Plans year 2

- Instead on only yearly meeting, may be meet more often (2 or 3 times per year), open for discussion
- Be more active in international organizations (OGC), events, publications
- Next to nD-PC basis, also move to OPCM, with point clouds:
  - different scales
  - different CRS
  - different attributes
  - different density distributions
  - different times
  - different servers
  - different clients
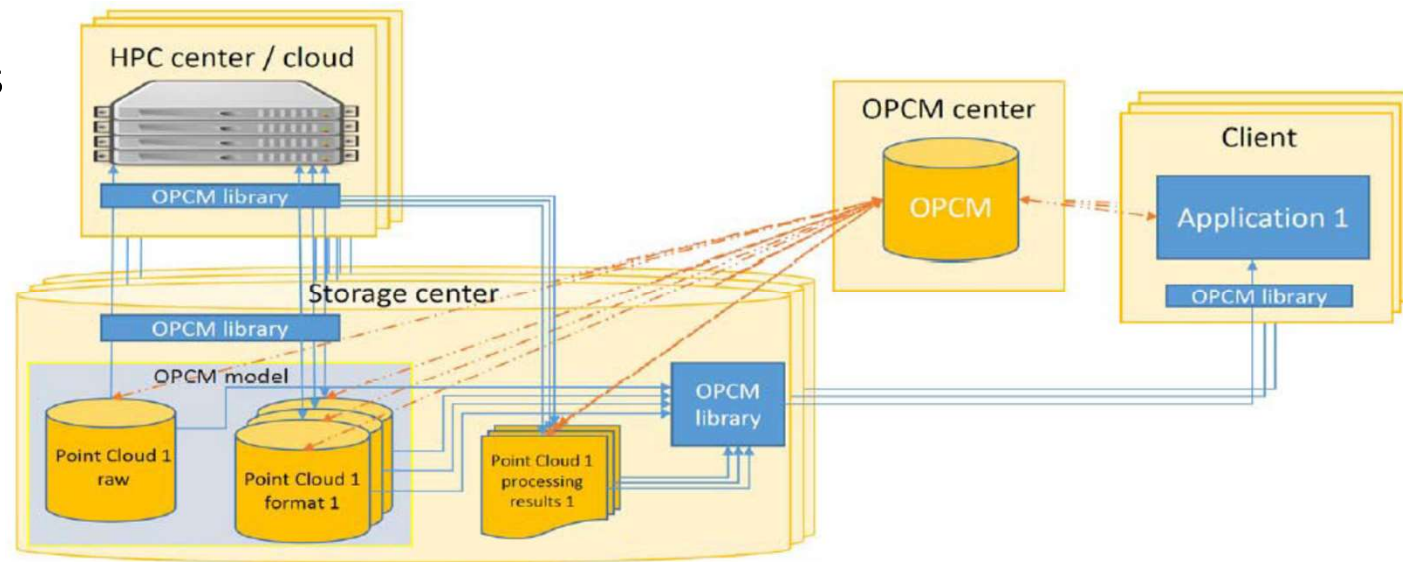
These plans imply…

- Publication plan (e.g. AGILE, ICA, ISPRS journals and events)
- Standardization of format and protocols (binary Parquet / COPC files)
- cLoI aware viewers and other clients (computations), investigation of selection with flat hyperplanes (convex polytope)
- On-the-fly CRS transformations of selections, or pre-computing of everything (on HPC/HTC)
- Explore cLoI to integrate datasets from different scales (after geo-referencing/CRS transformation)
- Change detection in the nD-PC model by adding 1 dimension (just vertical) or 3 dimensions (all directions) to represent differences with previous epoch: massive preprocessing (on HPC/HTC), but fast use