

ALGEMENE GEGEVENS

1. Projectnummer

027.012.101

2. Titel Project

Massive point clouds for eSciences

3. Gegevens Projectleider (PI)

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DEEL 1: WETENSCHAPPELIJK VERSLAG (MAX. 1 A4)

1. Beschrijving wetenschappelijke vraagstelling en behaalde resultaten (NL of EN)

The main objective of this innovative initiative was to develop an infrastructure for the storage, the management, the visualisation and the manipulation of massive point clouds. The infrastructure enables handling these very large datasets by a large user community. The AHN2 dataset of the Netherlands (640.000.000.000 points) was successfully used to assess the realized infrastructure solutions. In bullet form the main results are:

- Benchmark definition and execution (Mini, medium, full, multi-user) in different software and hardware platforms (pakhuis HP DL380p Gen8, Oracle Exadata, Microsoft Azure)
- Weak/Strong points identified in major point cloud data management platforms
- Many bugs/improvements in tested systems thanks to our work (PDAL, Oracle, MonetDB, LAStools, PostgreSQL)
- Research: Alternative storage structures (based on space filling curve), concept of continuous importance/LoD launched, Parallel querying, Oracle LAZ-perf (PDAL) compression and format
- Events/Publications: papers, ppts, 2 Oracle (Nashua NH) visits, conference stands, very active in PDAL/LAStools forums, few interviews and minor articles in media, many networking meetings
- 3D web based AHN2 viewer and download tool developed (ahn2.pointclouds.nl)
- Facility operational after project (3TU.Datacenter hosting, Fugro functional maintenance)
- Involved (as co-chair) of international point cloud standardization initiative: OGC domain working group (DWG point clouds) started second half of 2015
- 'Community' developed, not only original project partners (RWS, Fugro, Oracle, NLeSc and TU Delft), but also additional 'partners' active in project and present at most consortium meetings (CWI/MonetDB, Het Waterschapshuis, EU FP7 project IQmulus, etc.)
- Sequel research project proposal developed and submitted sept 2015 (to H2020 FET Open RIA): nD-PointClouds by international consortium (lead by TU Delft) and with large number of international supporters; see nD-PC.org.

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2. Deliverables (publicaties, software, demonstraties, video's, etcetera)

Deliverables can be accessed via the project website pointclouds.nl (incl links to github for software).

Publications

5 Reports:

1. P.M. Suijker, I. Alkemade, M.P. Kodde, A.E. Nonhebel, *User requirements Massive Point Clouds for eSciences*, April 2014, technical report, 22 pages:
http://www.gdmc.nl:8080/mpc/documents/reports/user-requirements-massive-point-clouds-for-esciences/at_download/file
2. O. Martinez-Rubi, T.P.M. Tijssen, P.J.M. Van Oosterom, M. Ivanova and E. Verbree. *Mini-benchmark description*, October 2014, technical report, 27 pages:
http://www.gdmc.nl:8080/mpc/documents/reports/mini-benchmark-description/at_download/file
3. O. Martinez-Rubi. *Medium benchmark description*, October 2014, technical report, 24 pages:
http://www.gdmc.nl:8080/mpc/documents/reports/medium-benchmark-description/at_download/file
4. O. Martinez-Rubi. *Medium benchmark (with results)*, August 2014, technical report, 60 pages:
http://www.gdmc.nl:8080/mpc/documents/reports/medium-benchmark-results/at_download/file
5. O. Martinez-Rubi. *Usage guides. Point Cloud Data Management Systems: DBMS and file-based solutions*. October 2015, technical report, 18 pages:
http://www.gdmc.nl:8080/mpc/documents/reports/usage-guides-point-cloud-data-management-systems-dbms-and-file-based-solutions/at_download/file

6 Papers:

1. Peter van Oosterom, Oscar Martinez-Rubi, Milena Ivanova, Mike Horhammer, Daniel Geringer, Siva Ravada, Theo Tijssen, Martin Kodde and Romulo Gonçalves. *Massive point cloud data management: Design, implementation and execution of a point cloud benchmark*. In: Computers & Graphics, Volume 49, 2015, pp. 92-125: <http://dx.doi.org/10.1016/j.cag.2015.01.007>
2. Oscar Martinez-Rubi, Peter van Oosterom, and Theo Tijssen. *Managing Massive Point Clouds – Performance of DBMS and file-based solution*. In: GIM International, September 2015, pp. 33-36: <http://www.gim-international.com/content/article/managing-massive-point-clouds>
3. Oscar Martinez-Rubi, Peter van Oosterom, Romulo Gonçalves, Theo Tijssen, Milena Ivanova, *Benchmarking and improving point cloud data management in MonetDB*, special issue of SIGSPATIAL Newsletter, Special Volume 6, Number 2, July 2014, pp. 11-18 (special issue on Big Spatial Data, guest editor Mohamed Mokbel): <http://www.sigspatial.org/sigspatial-special-issues/SigspatialSpecialJuly2014.pdf>
4. Oscar Martinez-Rubi, Martin L. Kersten, Romulo Gonçalves, Milena Ivanova. *A column-store meets the point clouds*. In proceedings FOSS4G Europe 2014, Bremen, Germany, 15-17 July 2014, 4 pages: http://europe.foss4g.org/2014/sites/default/files/11-Martinez-Rubi_0.pdf
5. Peter van Oosterom, Oscar Martinez-Rubi, Theo Tijssen and Romulo Gonçalves. *Realistic benchmarks for point cloud data management systems*. Keynote at Joint International Geoinformation Conference 2015, Kuala Lumpur, Malaysia, 28-30 October 2015, 23 pages. To be published as chapter in Springer book. Author version at: http://www.gdmc.nl:8080/mpc/documents/papers/realistic-benchmarks-for-point-cloud-data-management-systems/at_download/file
6. Oscar Martinez-Rubi, Stefan Verhoeven, Maarten van Meersbergen, Markus Schütz, Peter van Oosterom, Romulo Gonçalves, and Theo Tijssen. *Taming the beast: Free and open-source massive point cloud web visualization*. Paper presented at the Capturing Reality Forum 2015, Salzburg, Austria, 23–25 November 2015, 12 pages. Author version at: http://www.gdmc.nl:8080/mpc/documents/papers/capturingreality2015-taming-the-beast-free-and-open-source-massive-point-cloud-web-visualization/at_download/file

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Software

- pointcloud-benchmark: Benchmark platform and different point cloud management utilities including tools to load PC data in Oracle, PostgreSQL, MonetDB and a file-base based on LAsTools. The link address is: <https://github.com/NLeSC/pointcloud-benchmark>
- Massive-PotreeConverter: Convert massive point clouds, for example AHN2 to the potree format. The link address is: <https://github.com/NLeSC/Massive-PotreeConverter>
- ahn-pointcloud-viewer: WebGL pointcloud visualization of the Actuele Hoogtekaart Nederland (2) based on <http://potree.org>. The link address is: <https://github.com/NLeSC/ahn-pointcloud-viewer>
- ahn-pointcloud-viewer-ws: Webservice complementary for the AHN2 web viewer: Uses a PostGIS database to approximate number of points in selected area and starts a script to create a laz file of the selection. The link address is: <https://github.com/NLeSC/ahn-pointcloud-viewer>

Other

- 13 Consortium meetings: all very well attended: all agenda's, meeting notes/actions, and presentations achieved at project SharePoint environment
<https://www.edugroepen.nl/sites/pointclouds/SitePages/Home.aspx>
- Many presentations not mentioned above (at publications or consortium meetings): 1. Jan 2013: Introduction to the NWO/SURF project: Massive point clouds for eSciences, 2. Jul 2014: Invited presentation at the IQmulus Workshop on Processing Large Geospatial Data, 3. Oct 2014: Data Science Symposium - Point cloud data management, 4. Nov 2014: Tutorial at 3D GeoInfo - Storage and Management of Large Scale Point Cloud Data, 5. Nov 2014: Netherlands eScience Symposium - Massive point cloud data management: design, implementation and execution of a point cloud benchmark, 6. Dec 2014: SPAR - Databases for Massive Point Clouds, 7. Dec 2014: ELMF - Explorative Point Clouds Maps for Immediate Use and Analysis, 8. Feb 2015: MS Azure cloud basics and first experiences when applied to point cloud data, 9. Feb 2015: Hadoop basics and potential use of Spatial Hadoop for point cloud data, 10. Jun 2015: Visualization of point cloud data (case of Via Apia with key archaeological land marks), 11. Nov 2015: OGH SIG BIWA, Data Science - Oscar Martinez Rubi presents experiences from massive point cloud data management and visualization.
- Point cloud project results included in regular education (esp. MSc Geomatics: GEO1006/Geo-DBMS, GEO1101/Synthesis Project, and several MSc thesis project).
- Organization of final project point cloud symposium 8 dec 2015 (100+ participants expected): 'Management of massive point cloud data: wet and dry (2)', Berlage rooms, Faculty of Architecture and the Built Environment, TU Delft (Julianalaan 134, 2628 BL Delft). In cooperation with: Nederlands Centrum voor Geodesie en geo-informatie (NCG), Oracle Gebruikersclub Holland (OGH), TU Delft and the Netherlands eScience Center.

DEEL 2: FINANCIËLE VERANTWOORDING

1. Financieel Overzicht

Kostenpost	Kostenraming (in proposal)	Werkelijke kosten	FTE (raming)	FTE (werkelijk)
eScience Research Engineer(s)	€ 200.000	€ 200.000	2,0	2,0
Onderzoekspersoneel	€ 252.998	€ 287.067	1,9	2,2
Persoonsgebonden benchfee	€ 0	€ 0	nvt	nvt
Additioneel reisbudget	€ 47.002	€ 6.751	nvt	nvt
Apparatuur/software		€ 32.993	nvt	nvt
Overige kosten	€ 0	€ 0	nvt	nvt

2. Eventuele opmerkingen bij het financiële overzicht

DEEL 3: ACTIEPUNTEN, AFSPRAKEN, CONCLUSIES (NA JAARLIJKSE PROJECT REVIEW)

Note: dit deel (3) dient alléén ingevuld te worden na afloop van een Jaarlijkse Project Review!

1. Actiepunten (indien van toepassing)

N.V.T. (einde project)

2. Afspraken (indien van toepassing)

N.V.T. (einde project)

3. Conclusies (indien van toepassing)

N.V.T. (einde project)

ONDERTEKENING

JA, Ik heb alle informatie compleet en naar waarheid ingevuld.

NAAM van Oosterom, Peter, prof.dr.ir.

PLAATS Delft

DATUM 19 November 2015