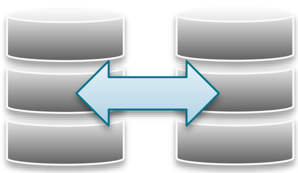
Advanced Compression Methods

for Simulation Models in SDM Systems



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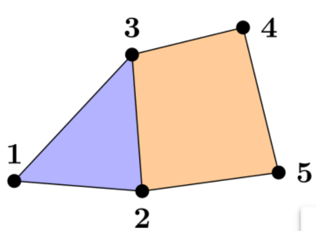
SCALE GmbH

Data deduplication



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Mesh compression

SCALE

Today’s global, large-scale car production incurs immense complexity to SDM.

Motivation: *SDM dimensions of complexity*

- Requirements
  - Legislation
  - Consumer tests
  - Customer comfort requirements

Environment diversity

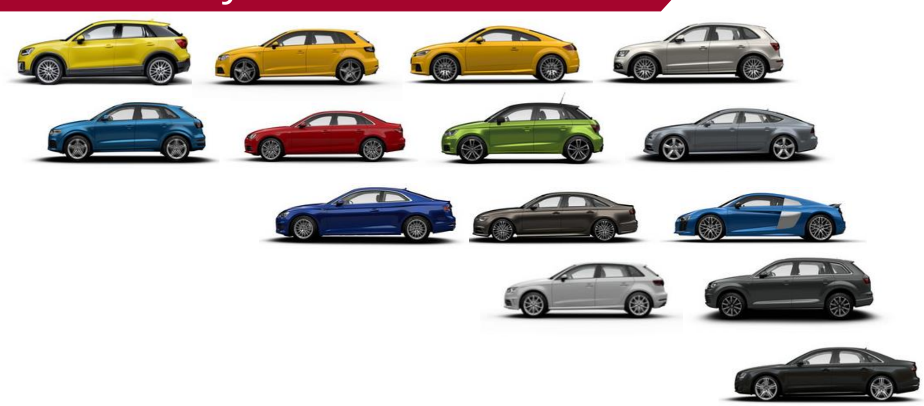
- Projects and derivatives
  - Body variants
  - Engine variants
  - Interior configuration
  - Region specifics

- Job Split
  - VW Group – Audi - Suppliers
  - KeyUsers - Project engineers
  - Multiple Disciplines
  - Ext. CAE services

Product diversity

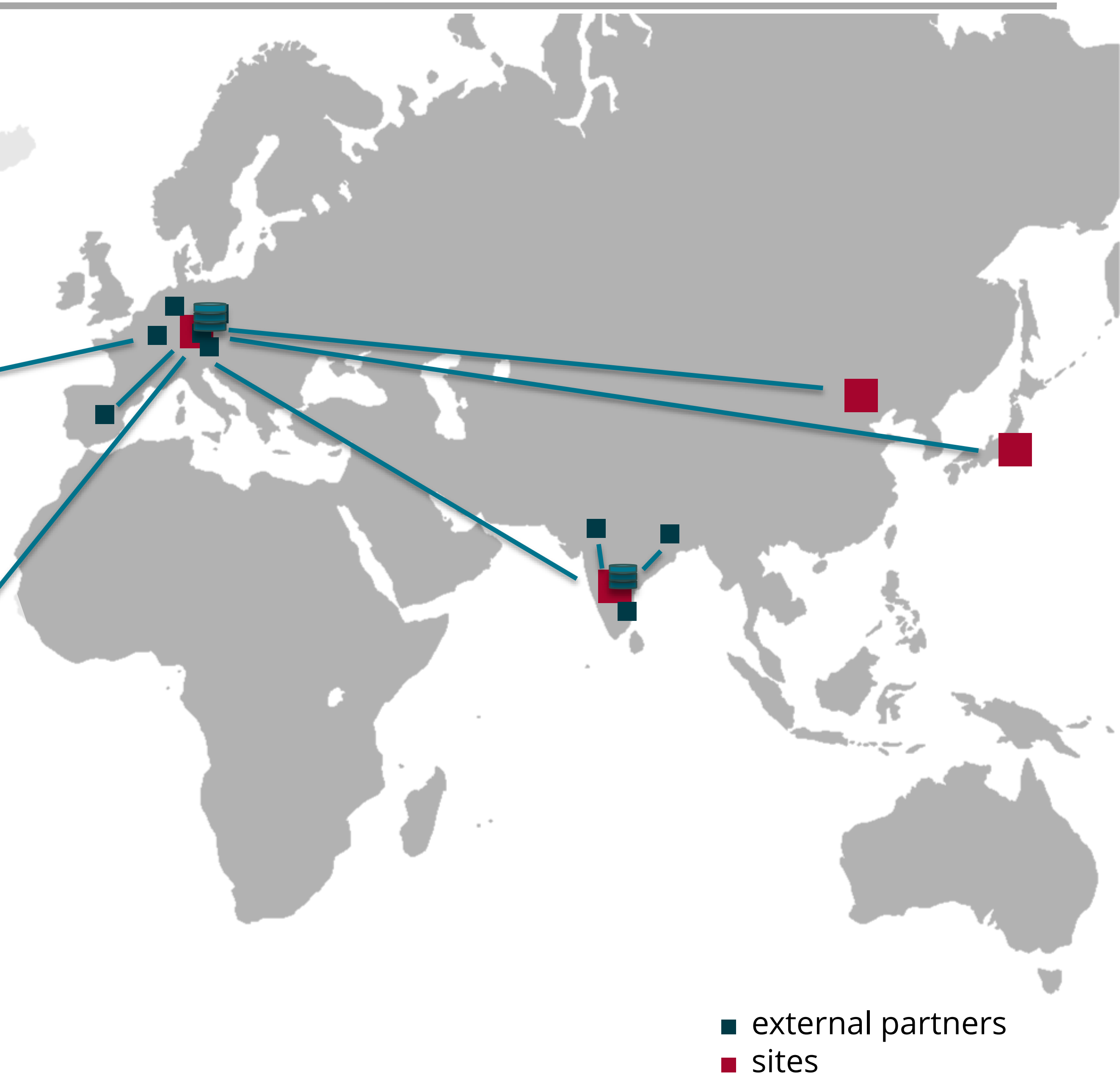
Discipline diversity

Audi



Motivation: *location diversity*

- **Collaboration**
  - Teams are distributed all over the world
  - Products share data over multiple sites
  - Many engineers are working together on the same problem
- **Availability**
  - Users expect data to be instantly available
  - Bandwidth and latency are critical
- **Security**
  - Encryption is essential



Today’s global, large-scale car production incurs immense complexity to SDM.

Good SDM systems shield you from this complexity as much as possible.

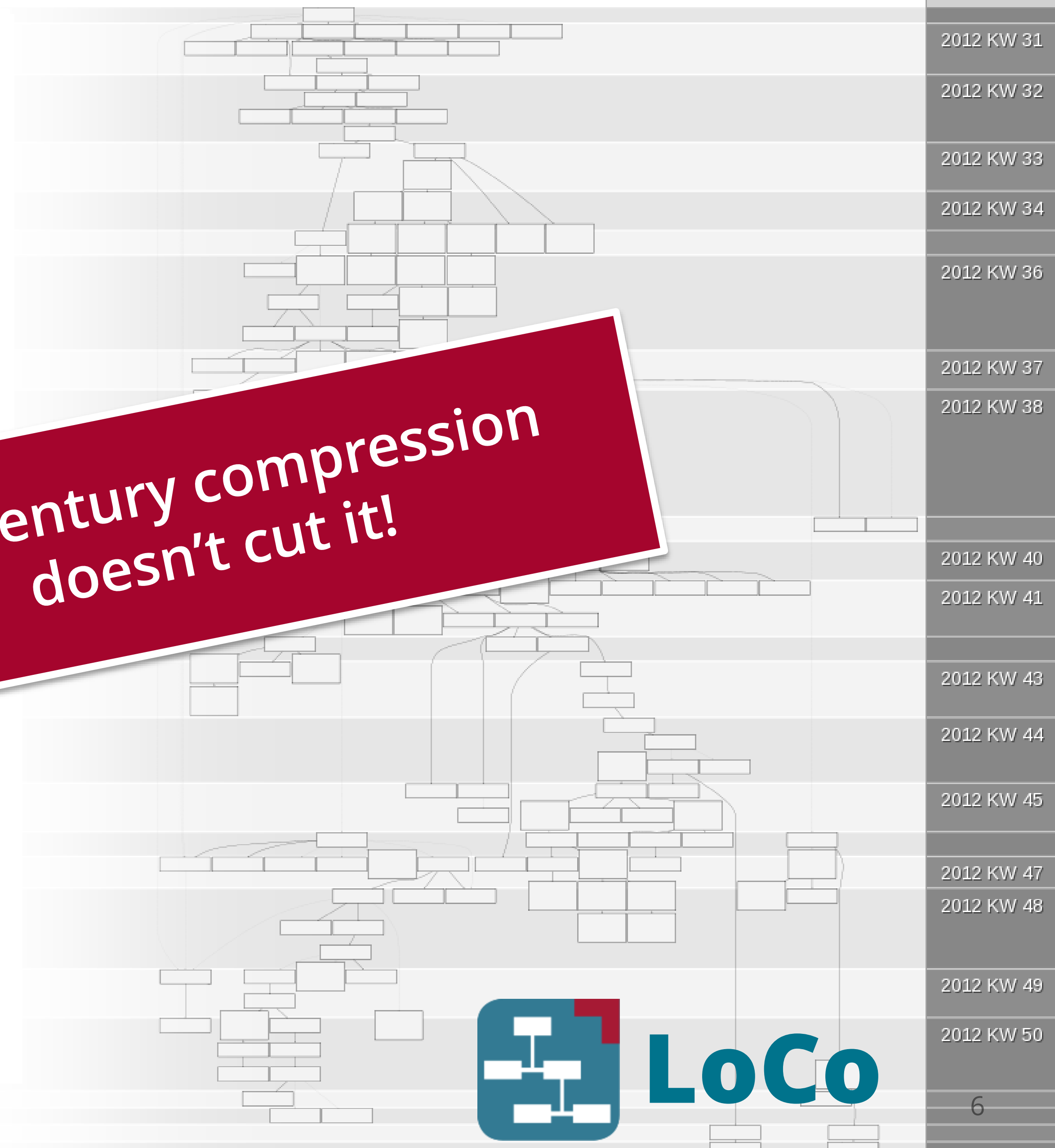
This is a hard task!

SCALE

SCALE.sdm

LoCo

Motivation: Growing amounts of data/simulations



20th century compression doesn't cut it!

LoCo

SCALE

Today's global, large-scale car production incurs immense complexity to SDM.

Good SDM systems shield you from this complexity as much as possible.

This is a hard task!

So, how do we do it?

SCALE

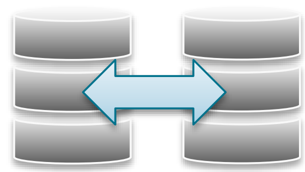
SCALE.sdm

LoCo

Motivation: Broad problem → concrete problems

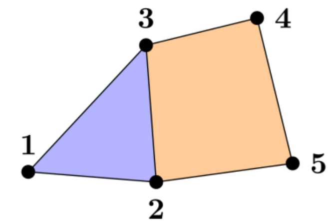
Input data

- **Problem: storage, transfer**



  - Many variants: high redundancy
  - Data deduplication
  - Format **independent**
  - Compression ratio: > **3**

- **Problem: mesh visualisation**



  - High mesh resolution vs. preview
  - Mesh compression
  - Format **specific**
  - Compression ratio: > **10**

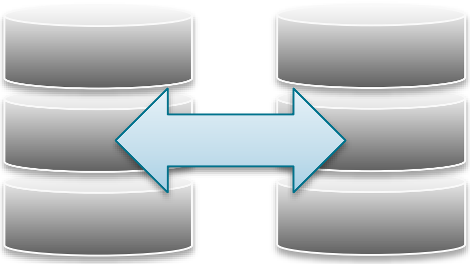
Output data

- **Problem: storage, transfer**

SIDACT

  - see Stefan Mertler's talk
  - Compression ratio: > **3**

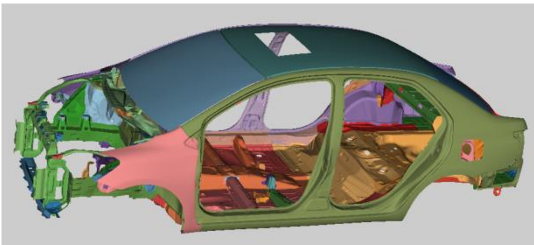
Data Deduplication



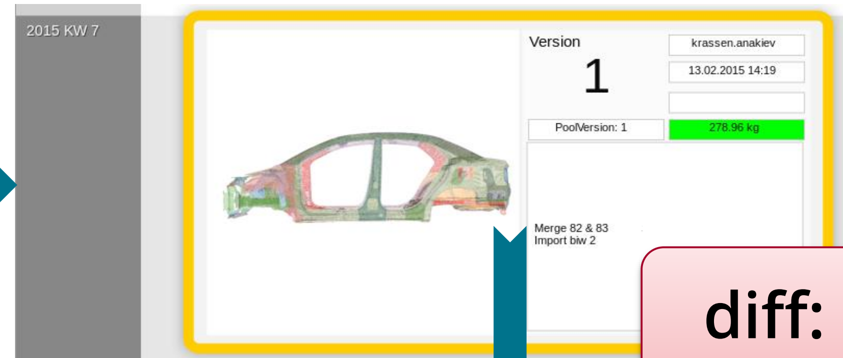
Simulation Data Management workflow

server

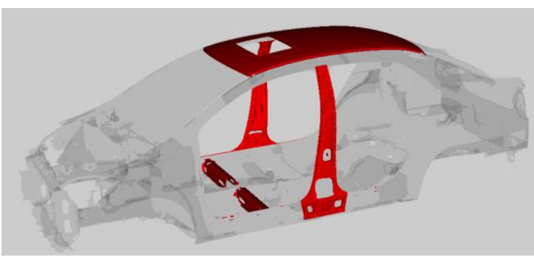
client (LoCo)



140 MiB



**diff:
8 KiB**



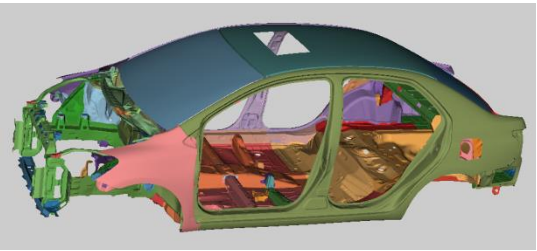
140 MiB

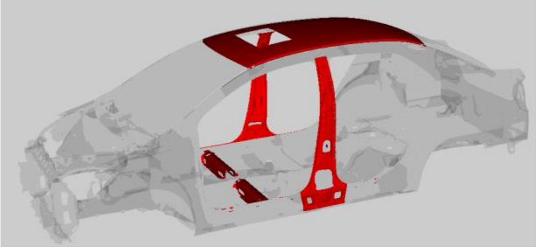
storage 280 MiB

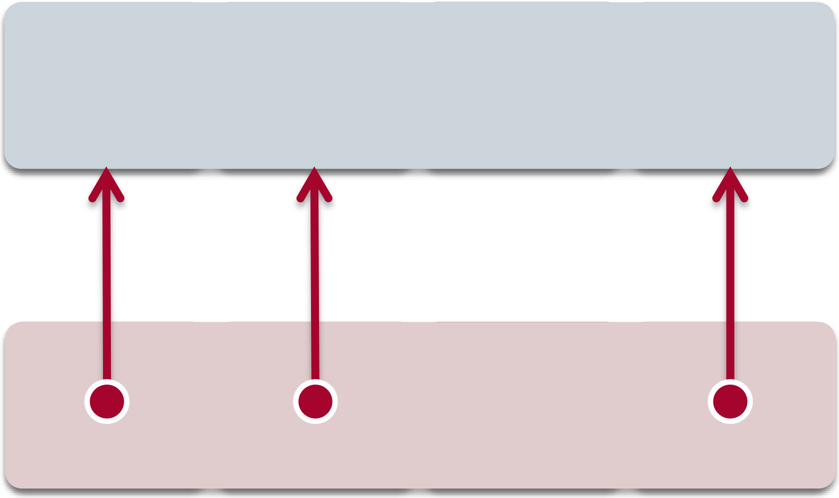
storage 280 MiB

transfer 280 MiB

Data Deduplication: Approach

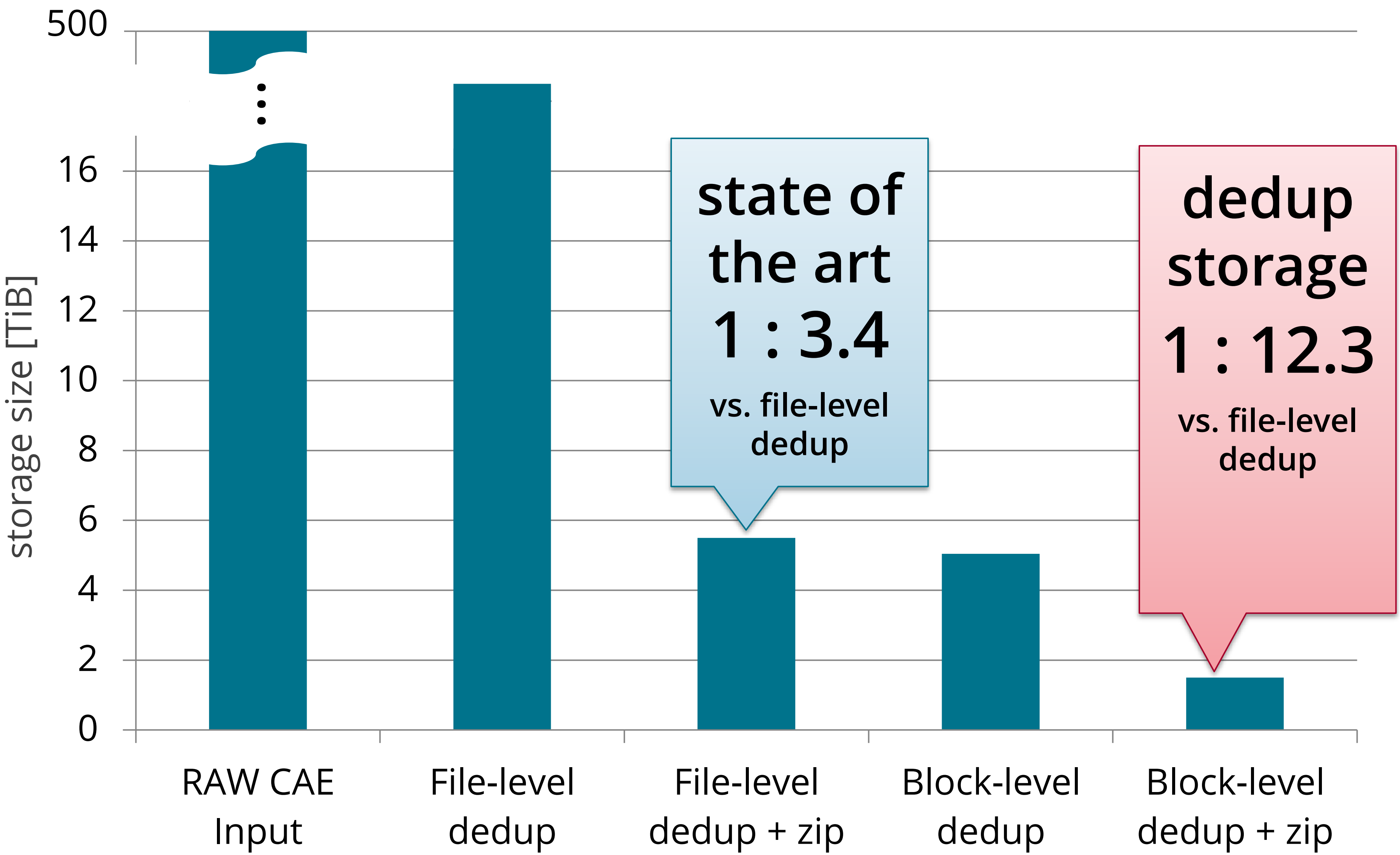






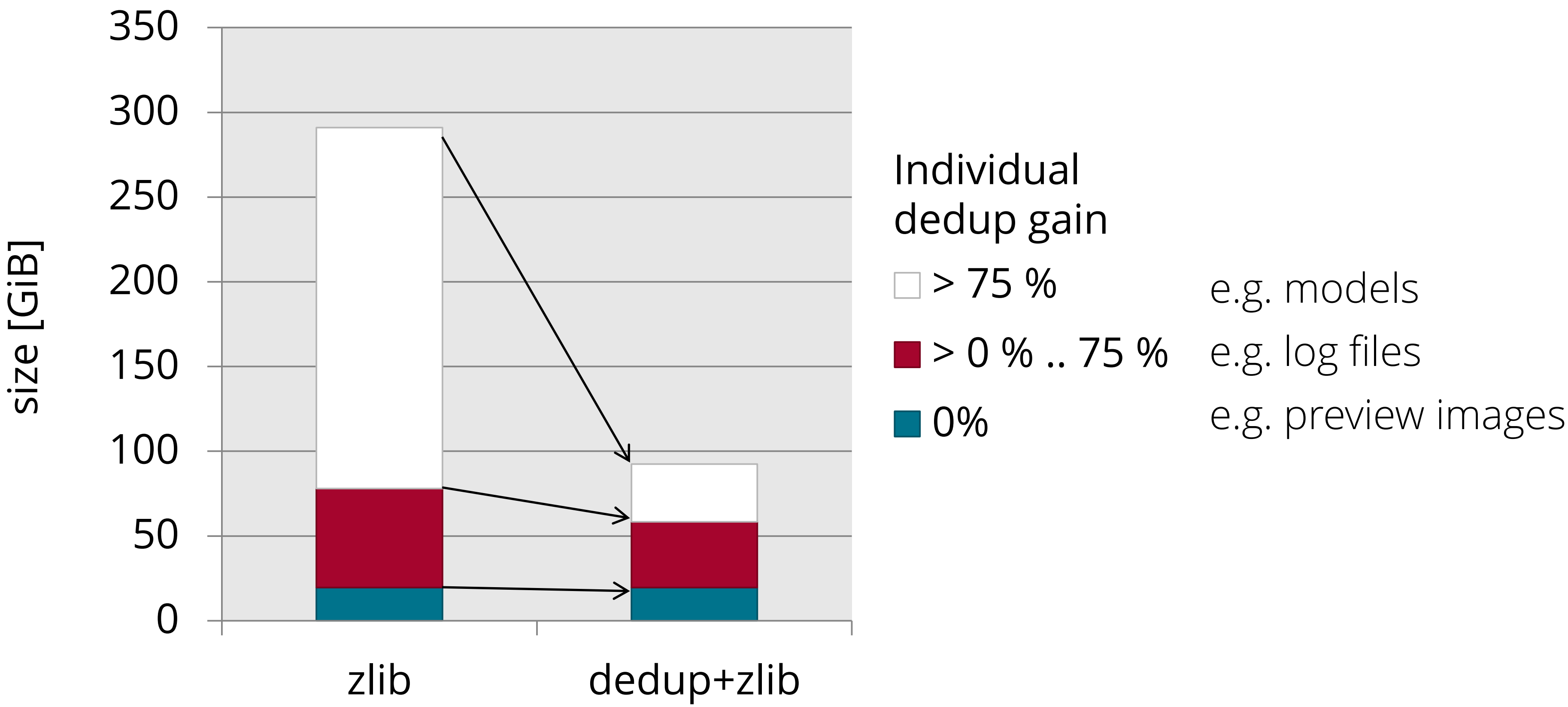
Chunking: find block boundaries via rolling checksum
Indexing: identify each block with cryptographic hash

Data Deduplication: Results



Data Deduplication: Results

- **Deduplication rate**
  - **980 GiB** real-world SDM data
  - Total deduplication ratio: **1 : 4**



Data Deduplication: Requirements & Challenges

- **Requirements**
  - Minimized Storage
  - Minimized Transfer
  - Performance
  - Scalability
  - Deletion
  - Encryption
- **Challenges**
  - Choice of parameters
  - Storage organization
  - Data integrity
  - Concurrency

Roadmap

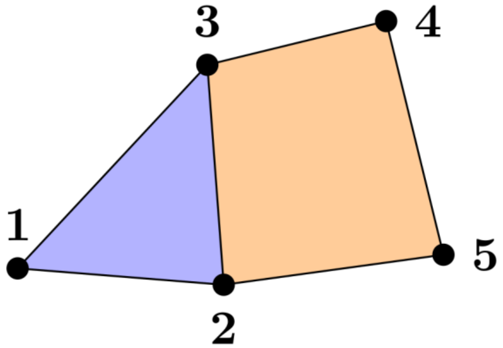
- **Done**
  - Incorporated data deduplication into SCALE's SDM client *LoCo*

LoCo

- **Work in progress**
  - Incorporate into SDM server (2017)
  - Test deduplicated transfer (2017)

Mesh Compression

→ Justus Richter



Objective

visualisation of simulation results via web interface

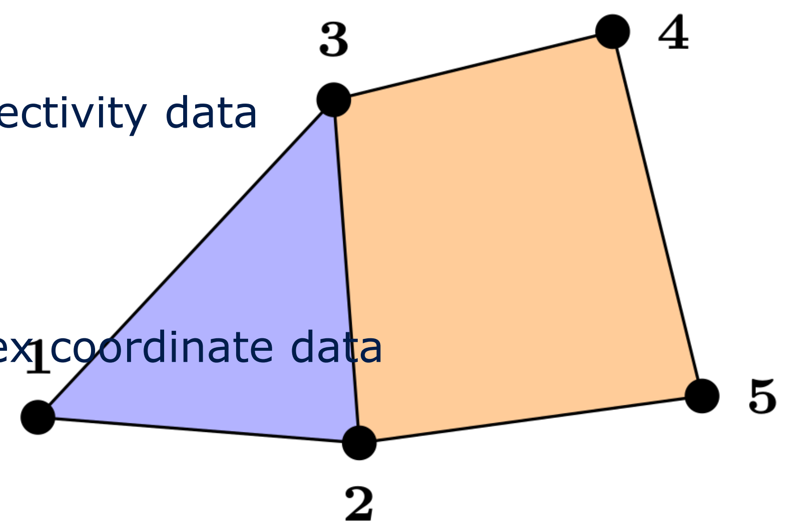
→ mainly transfer of meshes and related data

conventional: storage in plain text, e.g. LS-DYNA Keyword file

```
*KEYWORD
*ELEMENT_SHELL
1, 1, 1, 2, 3
2, 1, 2, 3, 4, 5
*NODE
1, 0.00, 0.21, 0.00
2, 1.51, 0.09, 0.00
3, 1.39, 1.70, 0.00
4, 2.70, 2.02, 0.00
5, 3.12, 0.31, 0.00
*END
```

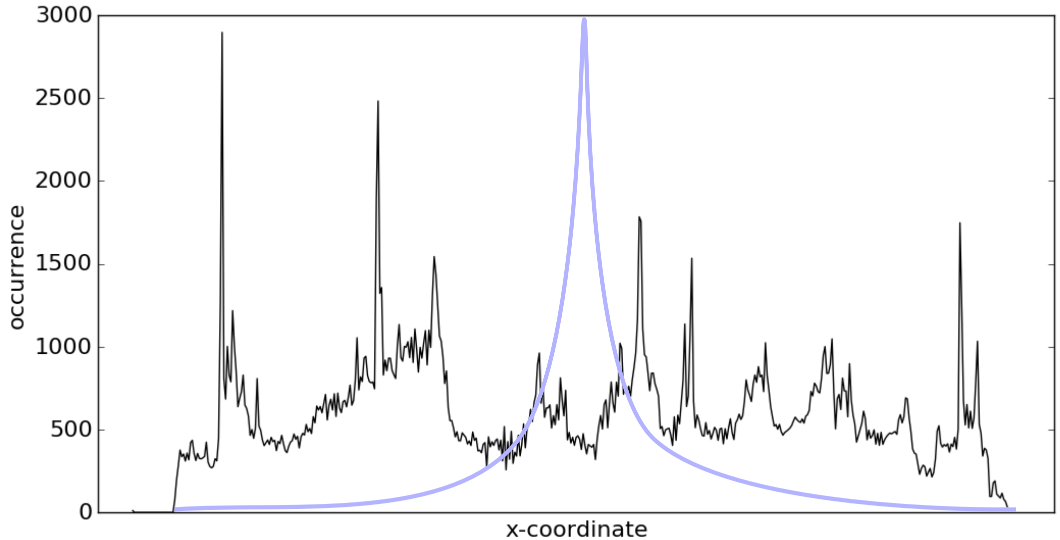
connectivity data

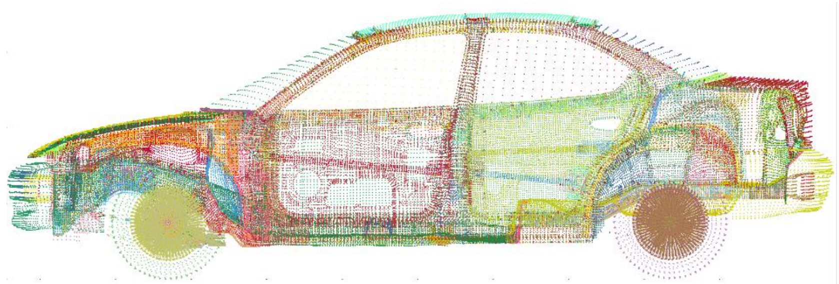
vertex coordinate data



Compression of Vertex Coordinates

entropy encoding works fine with predictable distribution





Compression of Vertex Coordinates

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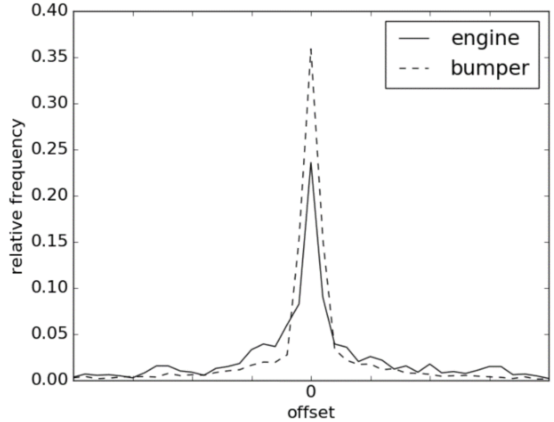


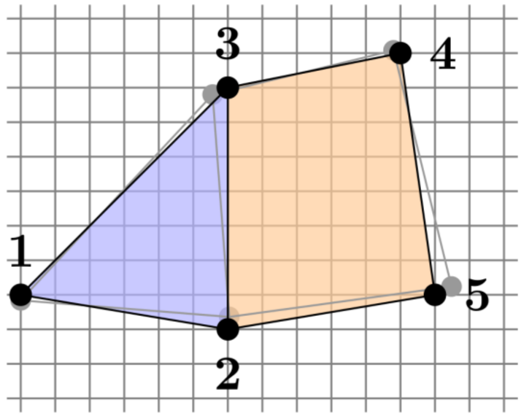
Geometry Prediction

e.g. parallelogram rule

storing offsets instead of original coordinates

Quantisation q_n

$$q_n : [x_{\min}, x_{\max}] \to \{0, 1, \ldots, 2^n - 1\}$$

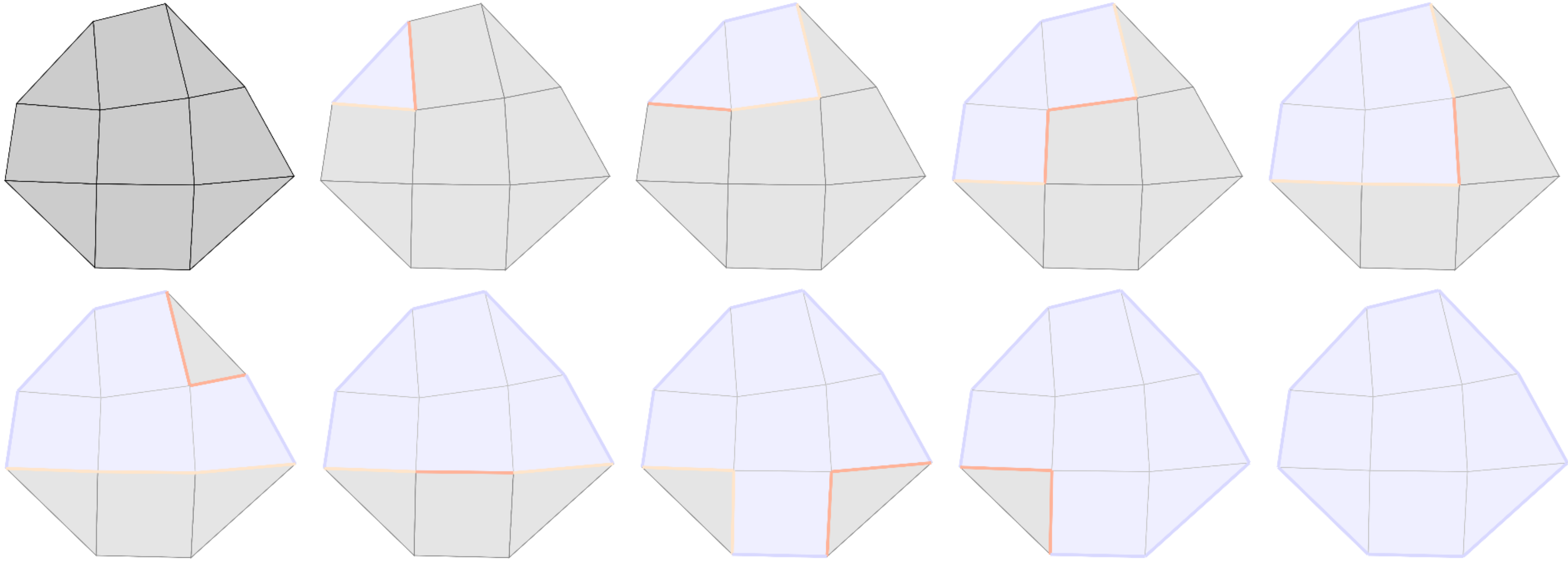


information loss dependent on bit size n

Compression of Connectivity

Degree Encoding

→ traversal algorithm

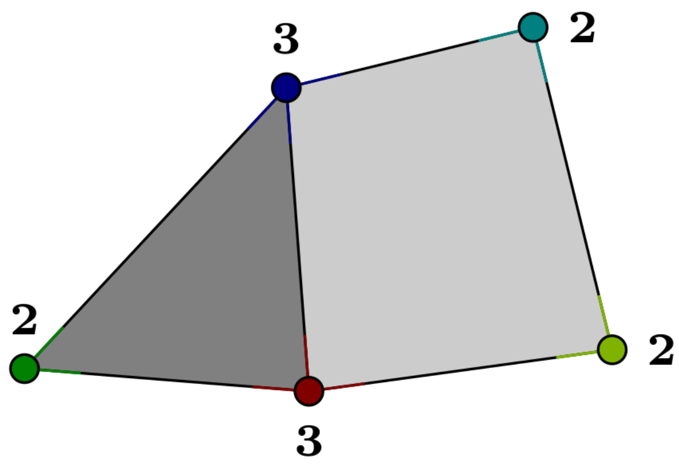


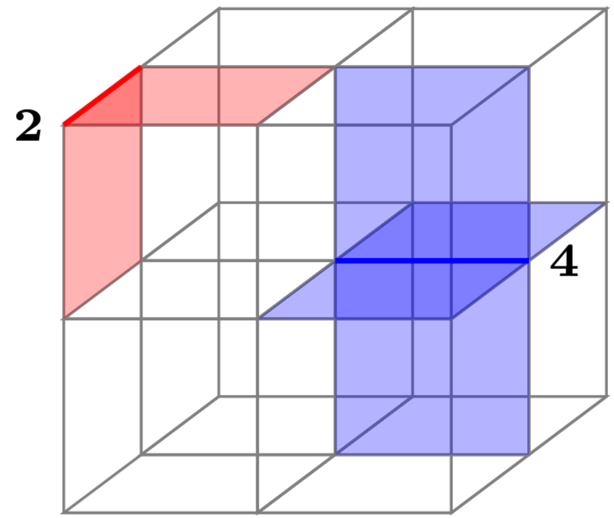
Compression of Connectivity

Degree Encoding

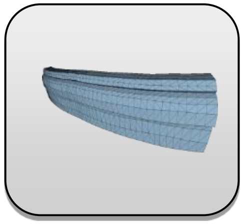
→ traversal algorithm

shell meshes based on vertex degree
solid meshes based on edge degree
→ different algorithms

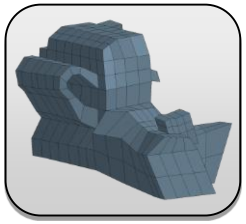




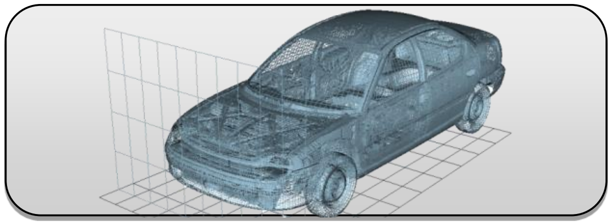
Results



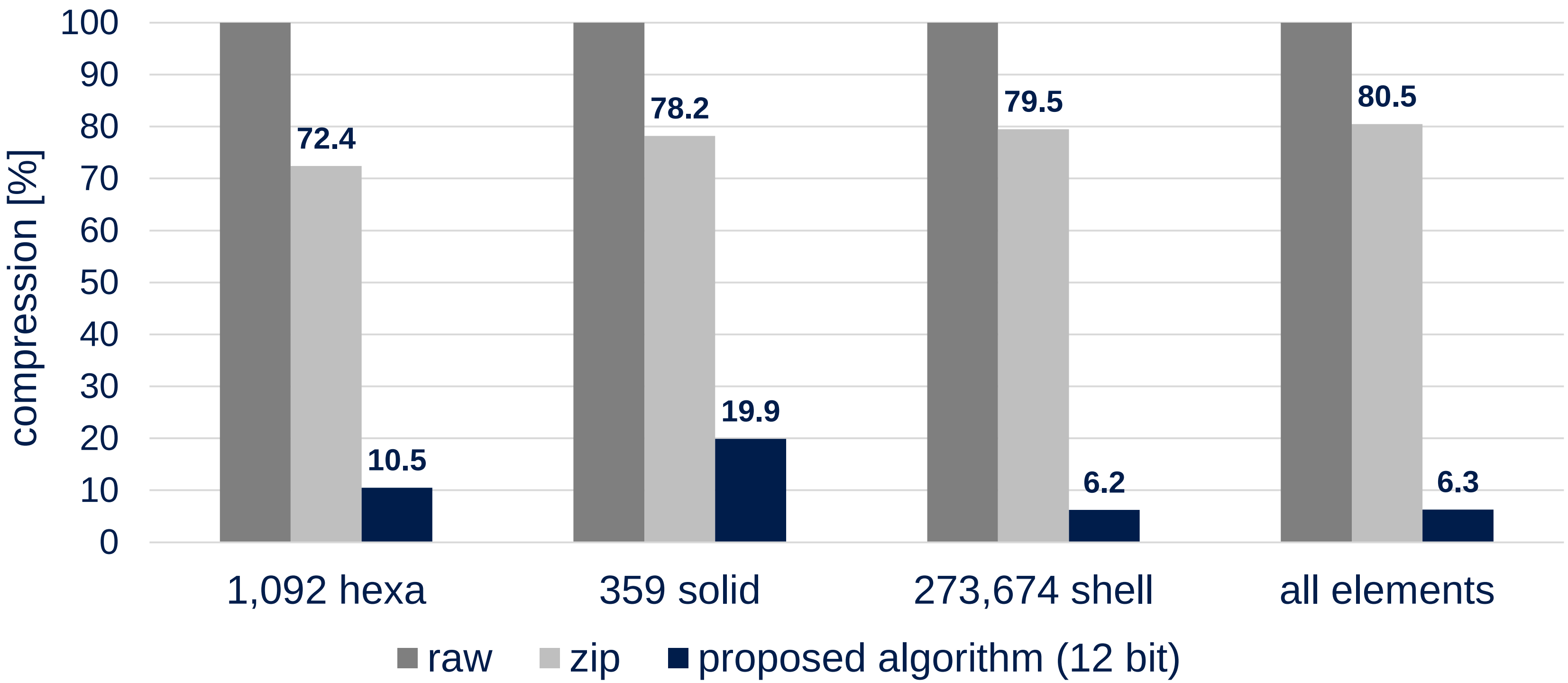
bumper



engine



full model



Conclusion

satisfactory compression ratio up to 15, dependant on mesh regularity

implementation supports all common element types

→ shells, hexahedra, tetrahedra, wedges

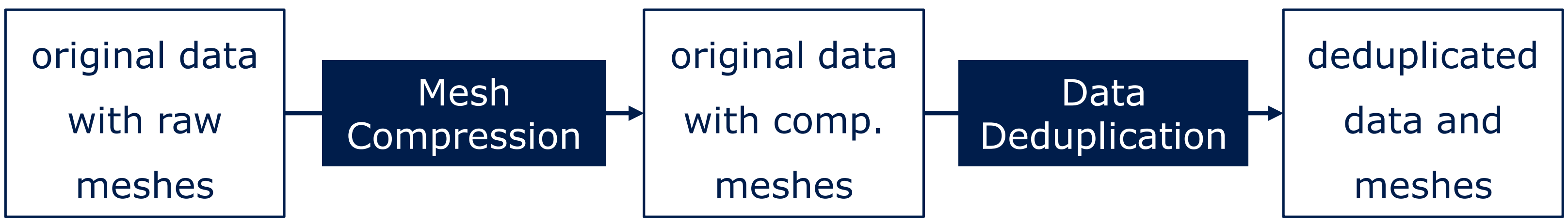
loss in coordinate resolution chosen by bit size of quantisation (optional)

Outlook

consideration of vertex and element properties (e.g. stresses and strains)

integration in SDM and post-processing systems

combination with data deduplication



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Institut für Statik und Dynamik der Tragwerke

Advanced Compression Methods

for Simulation Models in SDM Systems

Thank you!

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