Spatial Data Management for Virtual Product Development

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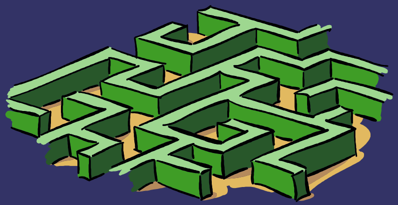
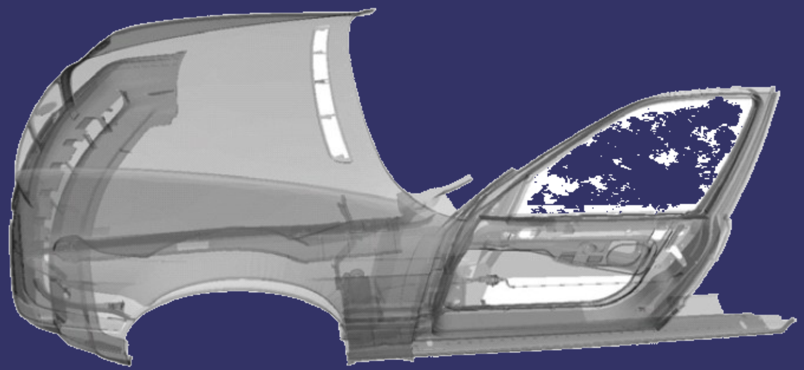
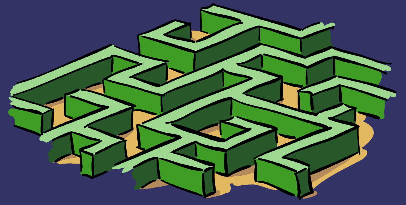


CAD

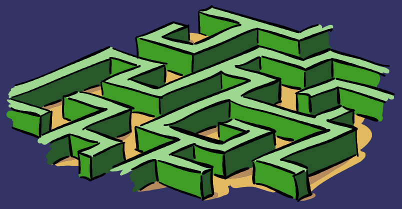
- Computer Aided Design
- Used for
  - Cars
  - Buildings
  - etc.





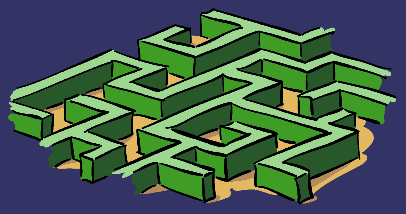
Intro

- New possibilities with CAD files
- New requirements of databases
- Solutions



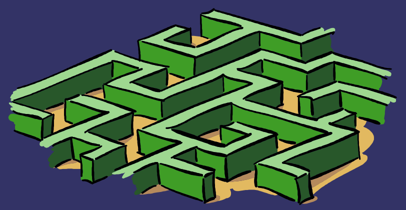
Spatial engineering

- Mechanical engineering
- Possible to test models without physical product
- New requirements for databases



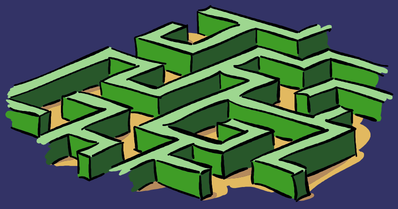
Engineering Data Management

- Old system of databases
- Hierarchal
- DIVE



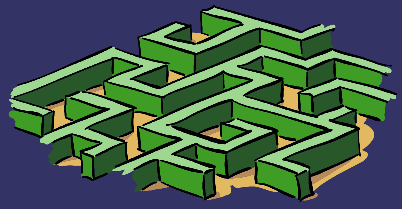
Digital Mock-Up

- Often late changes
- DMU enables fast detection of collisions
- Main memory
  - well-assembled list
  - few parts
- Earlier manually selection of parts



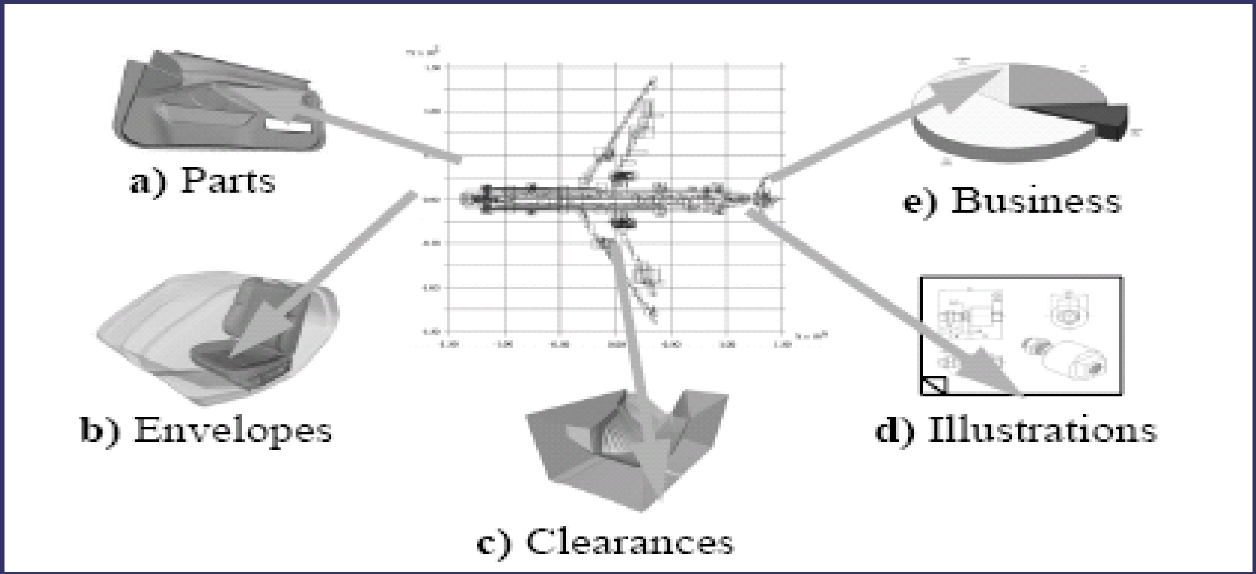
Haptic rendering

- Emulate forces towards CAD objects
  - To prevent parts from colliding
- Fast database is important



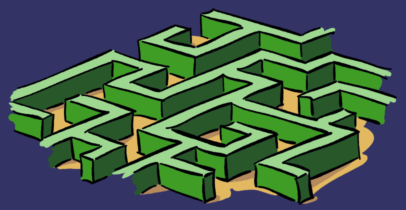
Spatial document management

- Files besides CAD files will be changed
- References to data
  - free space around hot parts
  - number of passenger
  - costs



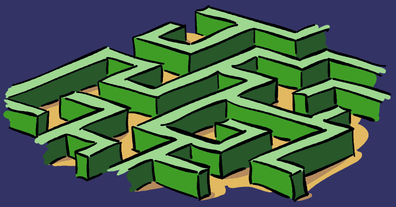
Operations on Spatial Engineering data

- Product = Collection of 3d-parts
- 3d-part = High precision complex geometric shape
- Geometric data models for representation:
  - Triangle meshes (Visualization, interference detection)
  - Voxels (Spatial keys)
  - Point Shells (RealTime Haptic Rendering)



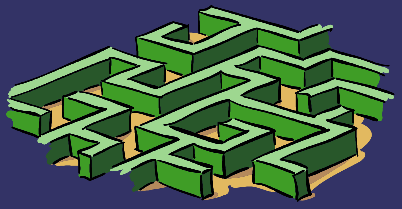
Triangle Meshes

- Accurate representations of original surfaces often implemented by bicubic surfaces
  - Too complex for efficent spatial computations
- Triangle mesh (Polygons) can be derived from original representations
  - Allows efficient spatial computing



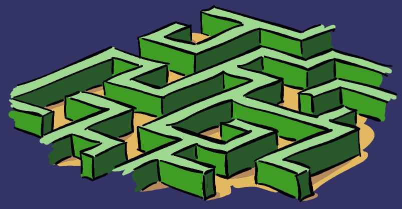
Collisions Queries

- Important database primitive
- Three different actions:
  - Collision detection
  - Collision determination
  - Collision response



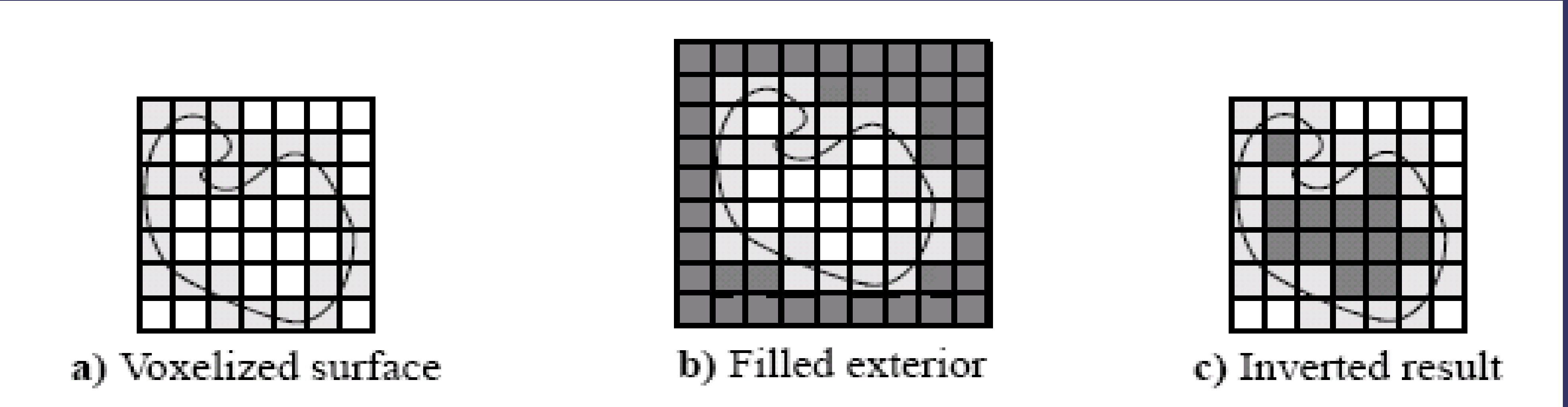
Voxels

- “3D-pixels”, atomic unit (cube) in 3D-space
- Algorithm for transfering triangle meshes to voxelobjects
  - Runs in O(N), N = number of voxels
  - Produces an approximation of the surface



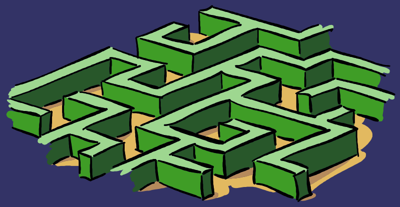
Problems in conversion

- Triangle meshes often contain gemeometric and topological inconsistencies (gaps, overlaps)
  - Robust reconstruction of original interior becomes very laborious



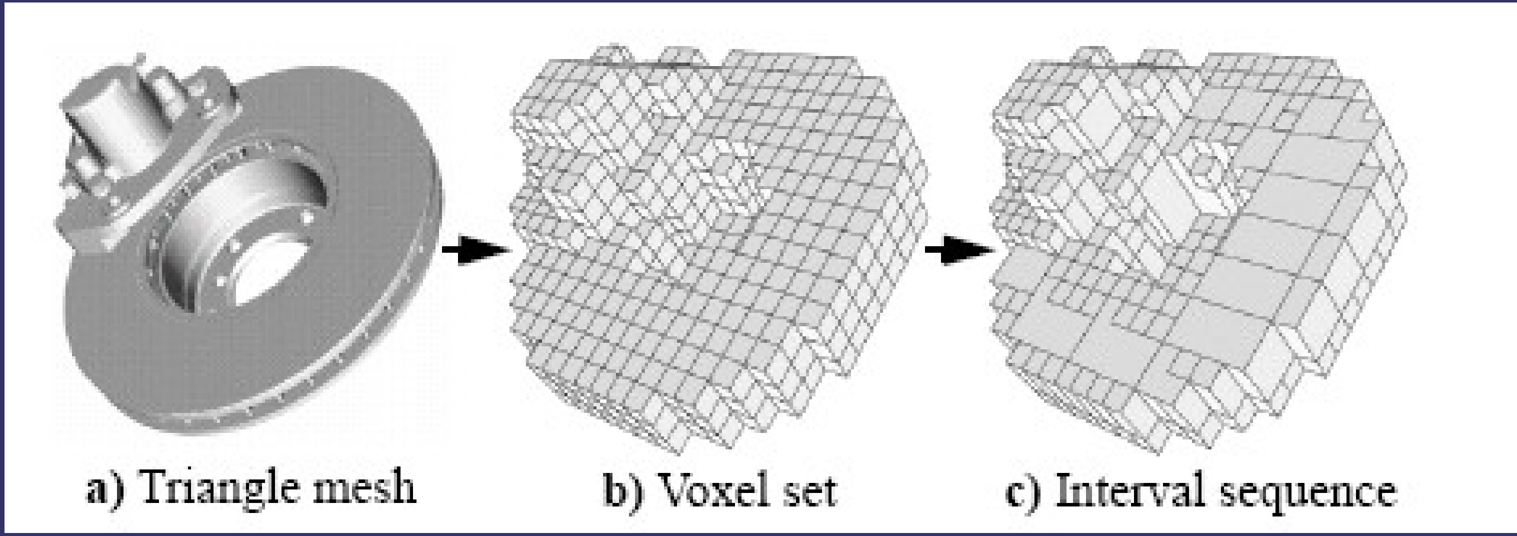
Interval sequences

- Grid covering complete data space
- Voxel corresponds to one cell
- Each cell encoded by single integer
- Object = set of integers
  - Adjacent cells presented by contigous integers, an interval

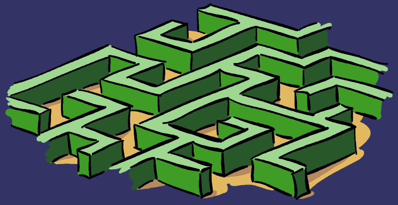


Pipeline process

- Triangle mesh -> Voxel set – Intervals

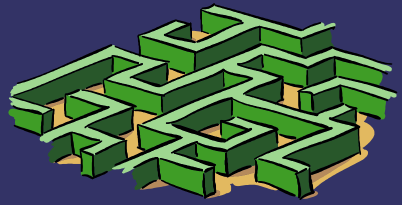


- Hilbert Algorithm



Point Shells

- Realtime interference detection requirements:
  - Efficient geometric transformation (1)
  - Efficient intersection tests (2)
- Tringle meshes fails (2)
- Voxel fails (1)
- Point shells solves the problem



Creation of Point Shells

- Triangle mesh
- Voxelize
- Centerpoints of boundary voxels
- Interpolate closest surface point to voxel-center
- Compute normal vector for each point, pointing inwards

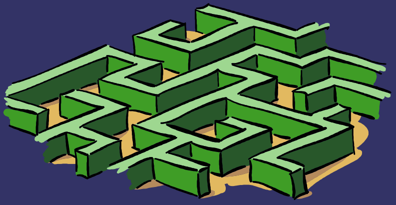
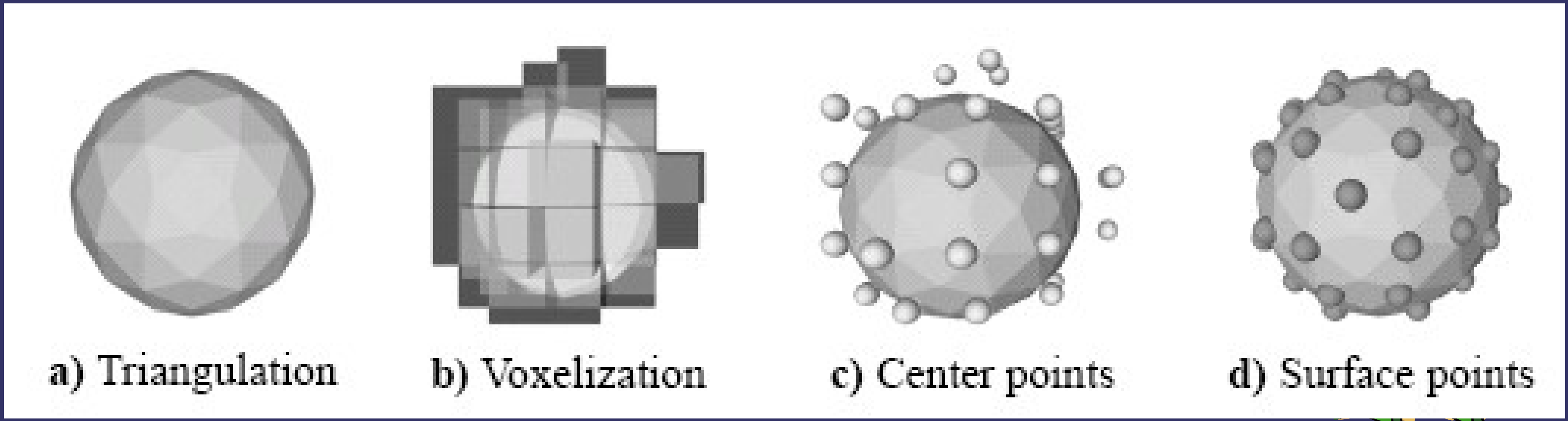


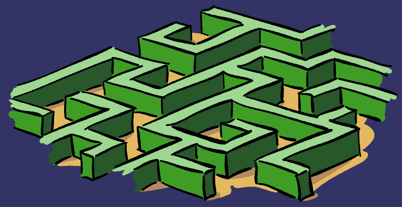
Illustration and use

- Voxels used for static environment
- Point Shell used for moving object



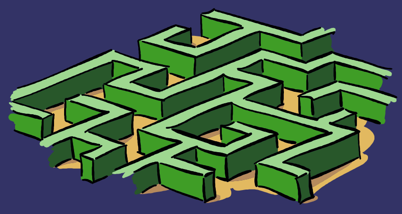
Relational Interval Tree

- Storing and indexing intervals
- Virtual binary tree
- One tree for each axis in space (?)
- Possible to find intersections in log(N)



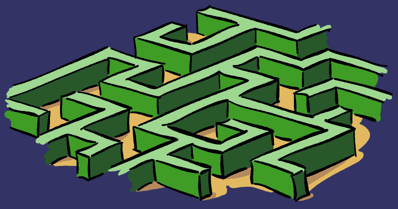
DIVE

- Database integration of Virtual Engineering
- Architecture for integrating mentioned techniques into existing EDM-systems
- Spatial data management – use a region of space as a key
  - Reference documents, CAD-files spatially
- Main problems:
  - Store spatial data in convetional databases
  - Efficient geometric queries



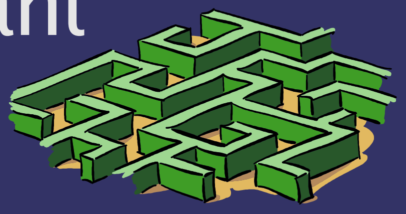
Solution

- Use conversion pipeline for objects -> inter-vals and store in RI-trees
- Spatial part of queries works on RI-trees
- Non-spatial part works on EDM
- Current version supports 3 spatial queries:
  - Volume query
  - Collision query
  - Clearance query

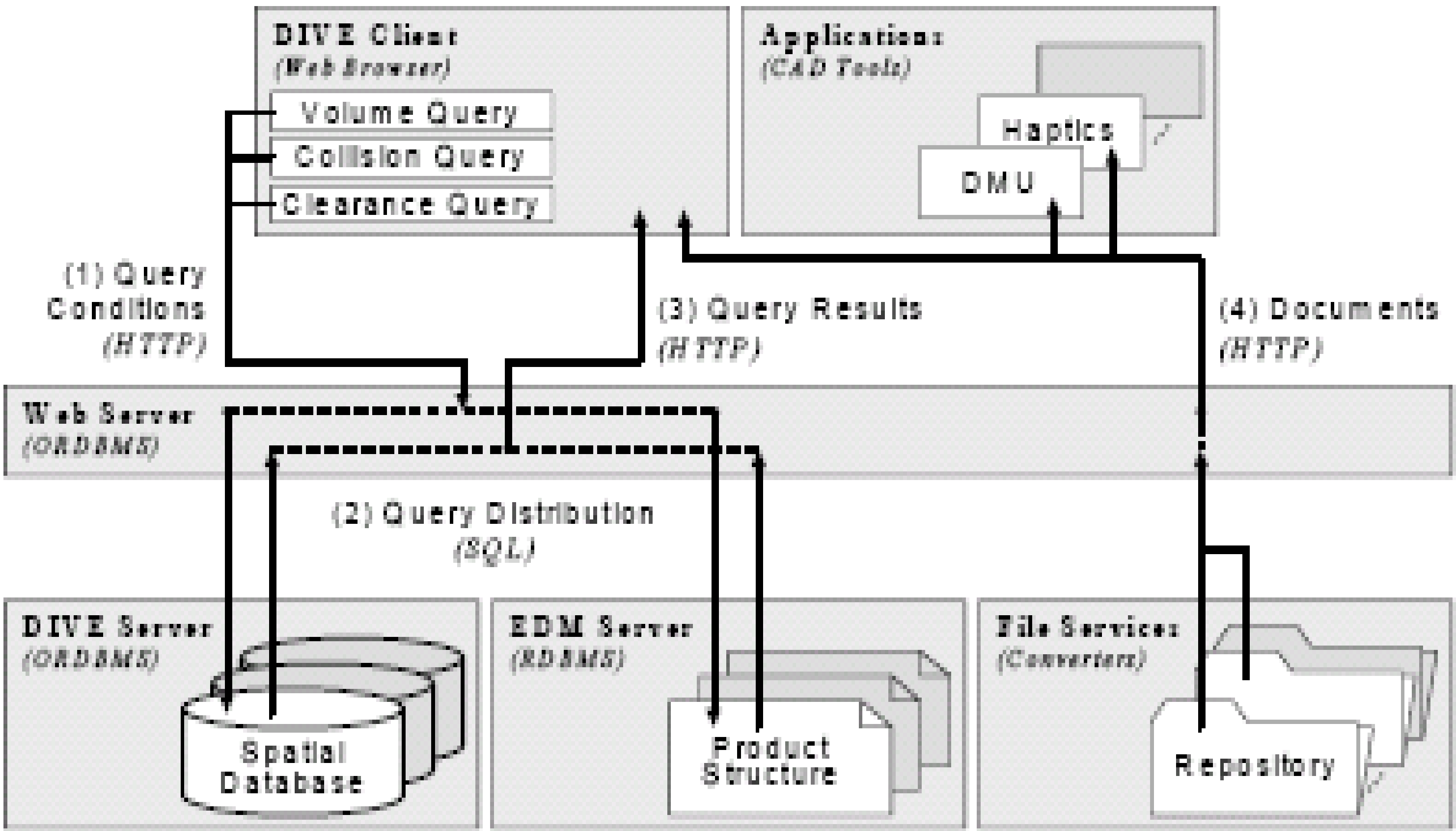


Refined DMU

- Used for demonstrating capabilities of DIVE
- Results from spatial queries can be used in next query
  - Enables user to spatial browse large databases with interactive response times
- Supports ranking of query results according to e.g. intersect volume
  - Can be used to detect most relevant problems



System Architecture



Industrial Evaluation

- Athlon 750
- IDE Harddrives
- 11,200 Spatial keys
- Volume / Collision queries avaraged 0,7s
- Logaritmic scale up make interactive respones times possible for much larger databases