KNOWLEDGE & INFORMATION MANAGEMENT THROUGH LIFE

Towards a Curation and Preservation Architecture for CAD Engineering Models

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Outline

The Product-Service Paradigm

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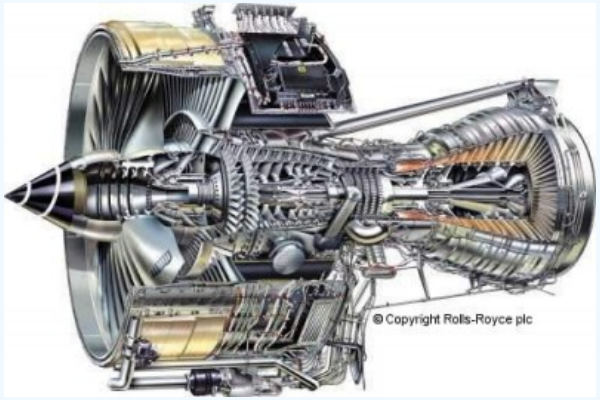


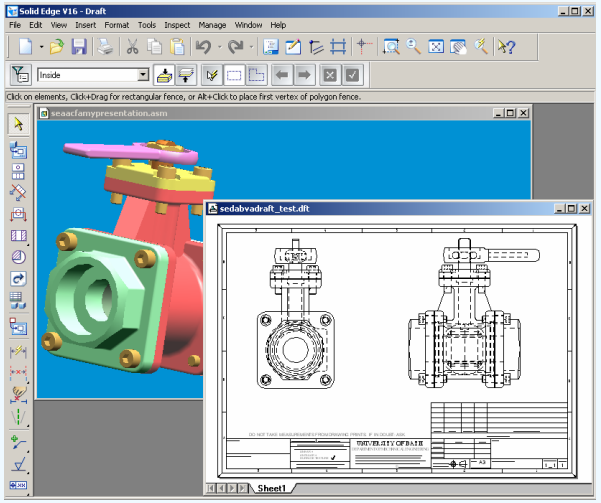
EPSRC

iPRES 2008
29 September 2008

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Computer-aided design (CAD)

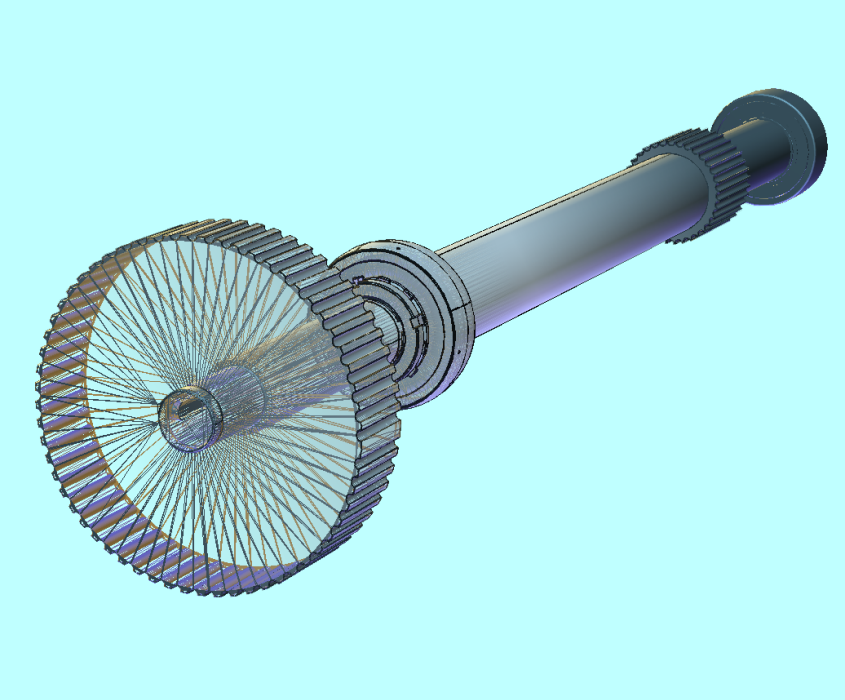
- Increased integration with downstream tools
  - Manufacturing (CAM)
  - Analysis and simulation (CAE)
  - Enterprise Resource Planning (ERP)
  - Customer Relation Management (CRM)
  - Supply Chain Management (SCM)
- Increasingly complex representations
- Mostly proprietary, mutually incompatible, ephemeral formats



Inside a CAD model

CAD models typically contain:

- geometry
- dimensions and tolerances
- construction history
- ‘features’ – predefined parts
  - more meaningful than ‘raw’ geometry



Lightweight formats

Lightweight visualization formats are:

- simpler formats dedicated to a single purpose e.g. design review)
  - approximate or exact geometry
  - sometimes product manufacturing information
- usually well documented to encourage wide support
  - standard formats
  - formats with freely available specifications
- supported by free software
- supported on many platforms
- small in file size

Product Lifecycle Management

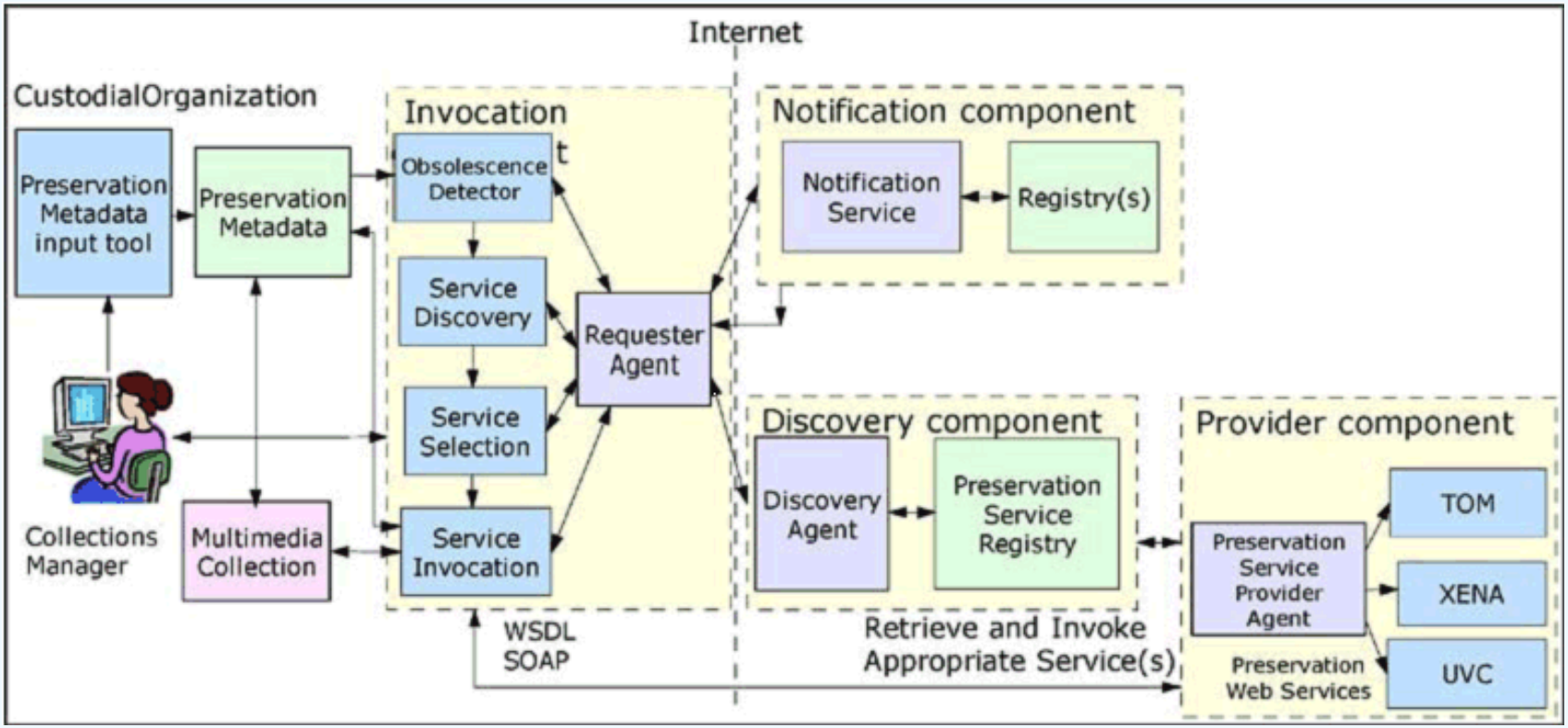
Product Lifecycle Management (PLM) systems offer the following facilities:

- versioning
- access control
- cross-file linkages
- cross-system linkages
- portals for activities and collaboration

But

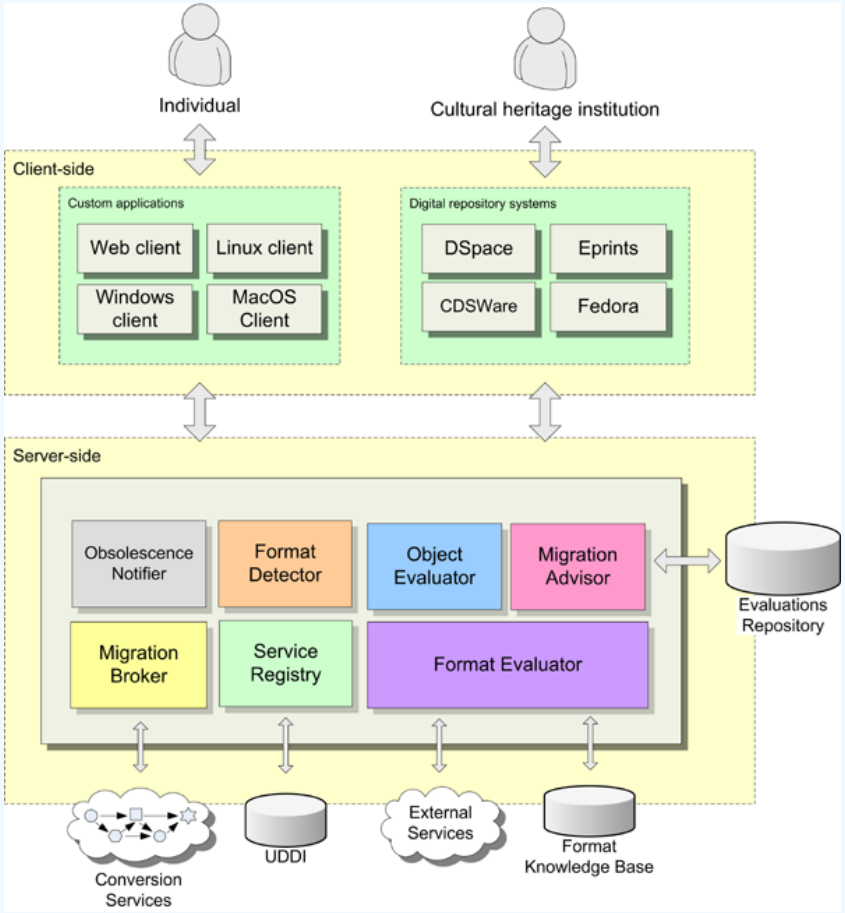
- limited channels for information flow
- no preservation planning tools

PANIC



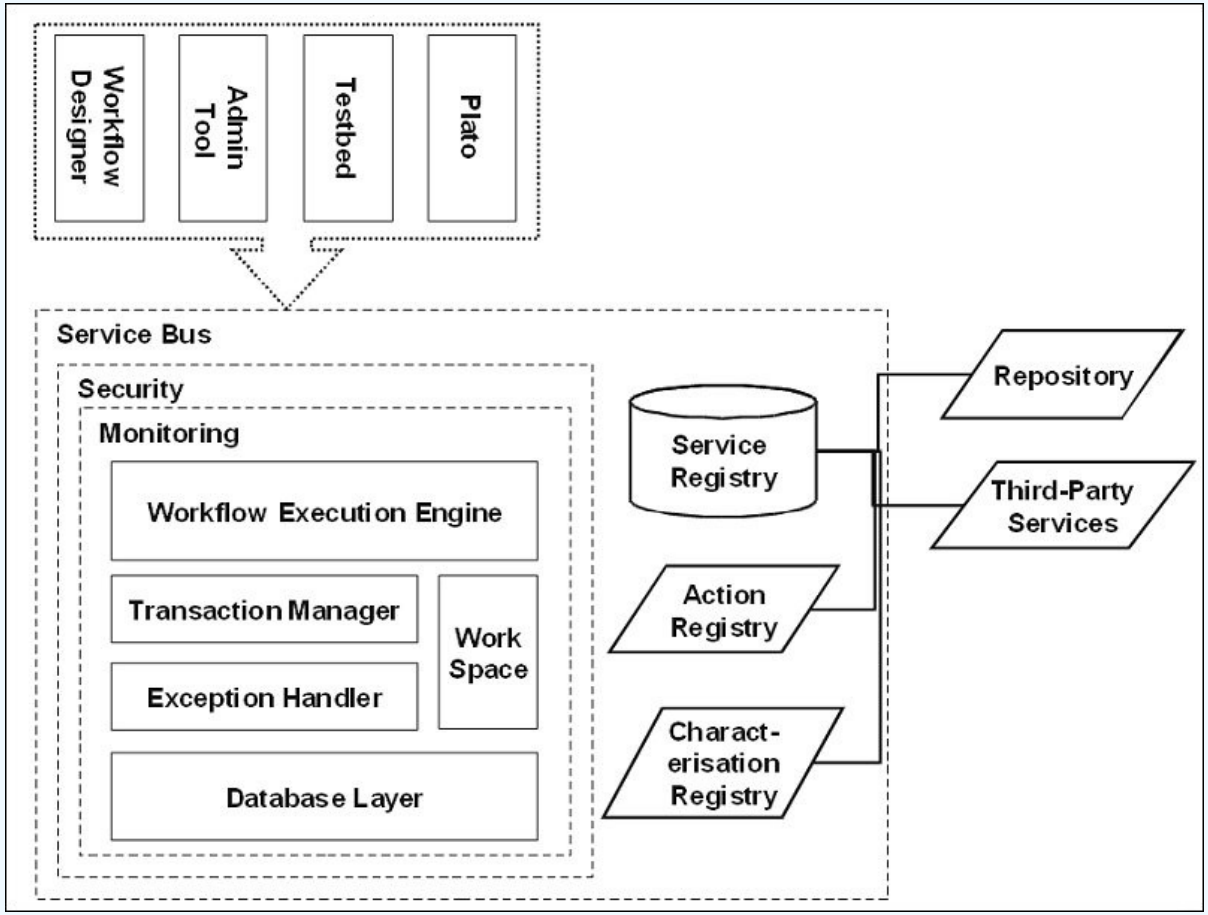
J Hunter, S Choudhury. 2006. 'PANIC: an integrated approach to the preservation of composite digital objects using Semantic Web services.' *International Journal on Digital Libraries* 6(2): 174–183.

CRiB



M Ferreira, A A Baptista and J C Ramalho. 2006. 'A Foundation for Automatic Digital Preservation.' *Ariadne* 48. `http://www.ariadne.ac.uk/issue48/ferreira-et-al/`

PLANETS



A Farquhar, H Hockx-Yu. 2007. 'Planets: Integrated Services for Digital Preservation.' *International Journal of Digital Curation* 2(2):88–99.

Desiderata for PLM

- Flexible, modular and consistent approach to communicating design information
- Preservation planning:
  - registry of format characteristics
  - registry of format migration services
  - registry of evaluations of preservation actions

- How can we add these?

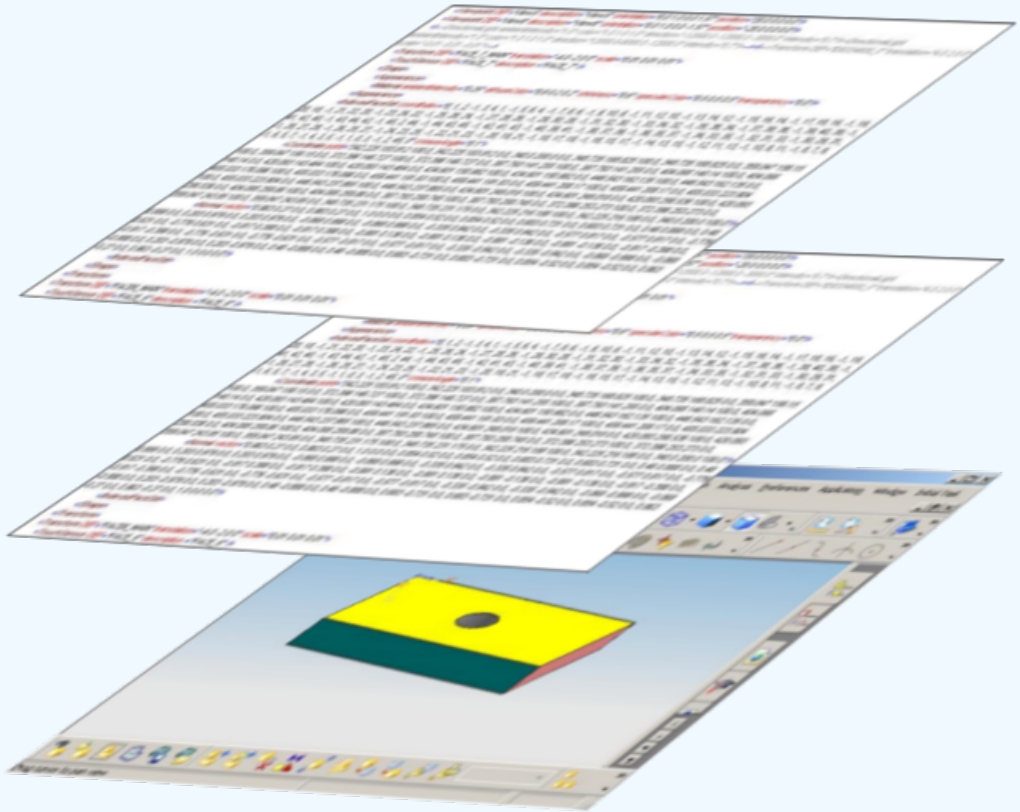
Lightweight Models with Multilayered Annotations

- Geometry held in lightweight visualization formats (as well as the original CAD model)
- Everything else held in one of a number of sets of annotations layered on top the model

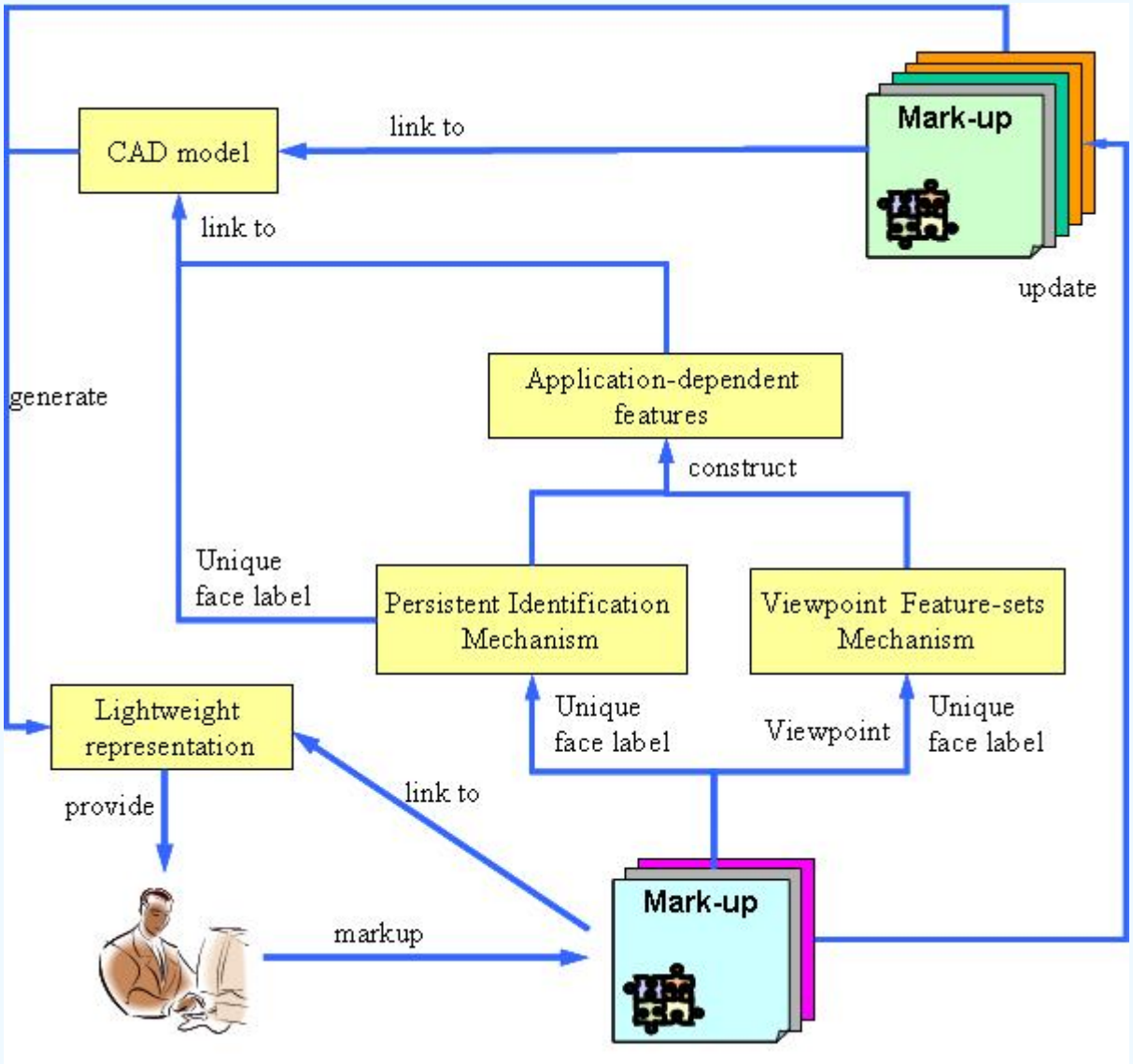
Layering annotations

Different annotation layers for different **viewpoints** (design, manufacture, service) and for different **security levels** (internal, public)

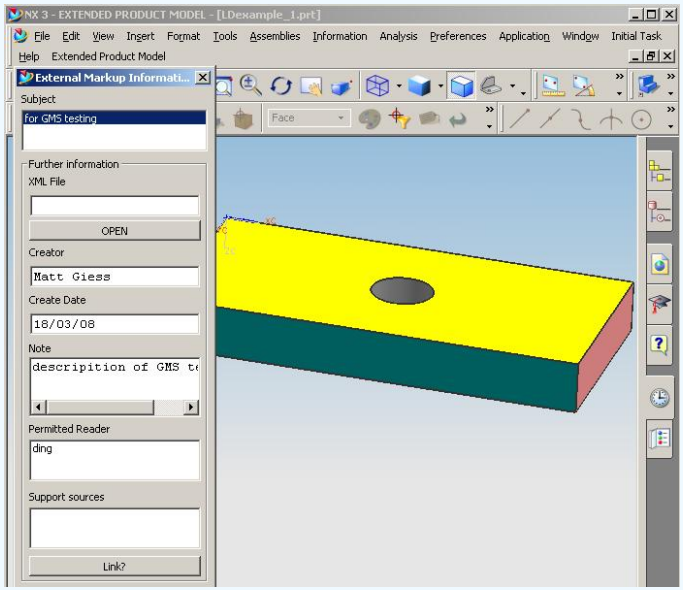
Geometry layer



Workflow

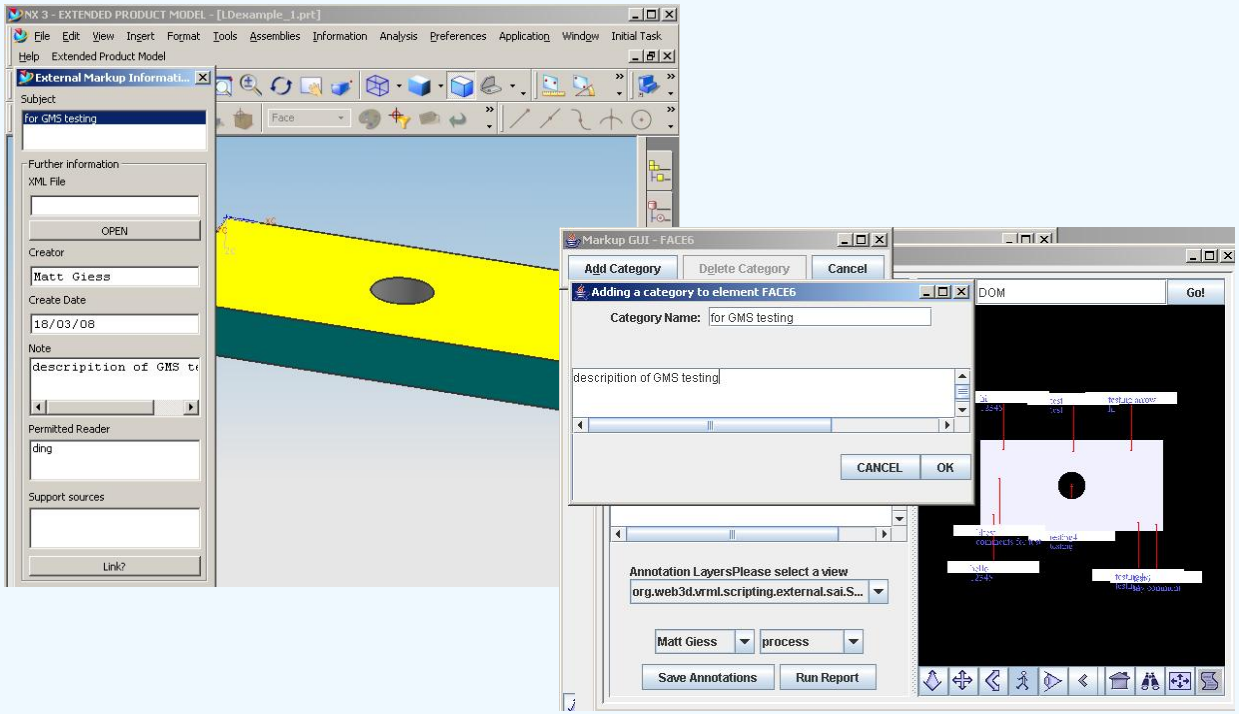

CAD model
link to
Mark-up
link to
update
generate
Application-dependent features
construct
Unique face label
Persistent Identification Mechanism
Viewpoint Feature-sets Mechanism
Lightweight representation
Unique face label
Viewpoint
Unique face label
provide
link to
markup
Mark-up

LiMMA tools



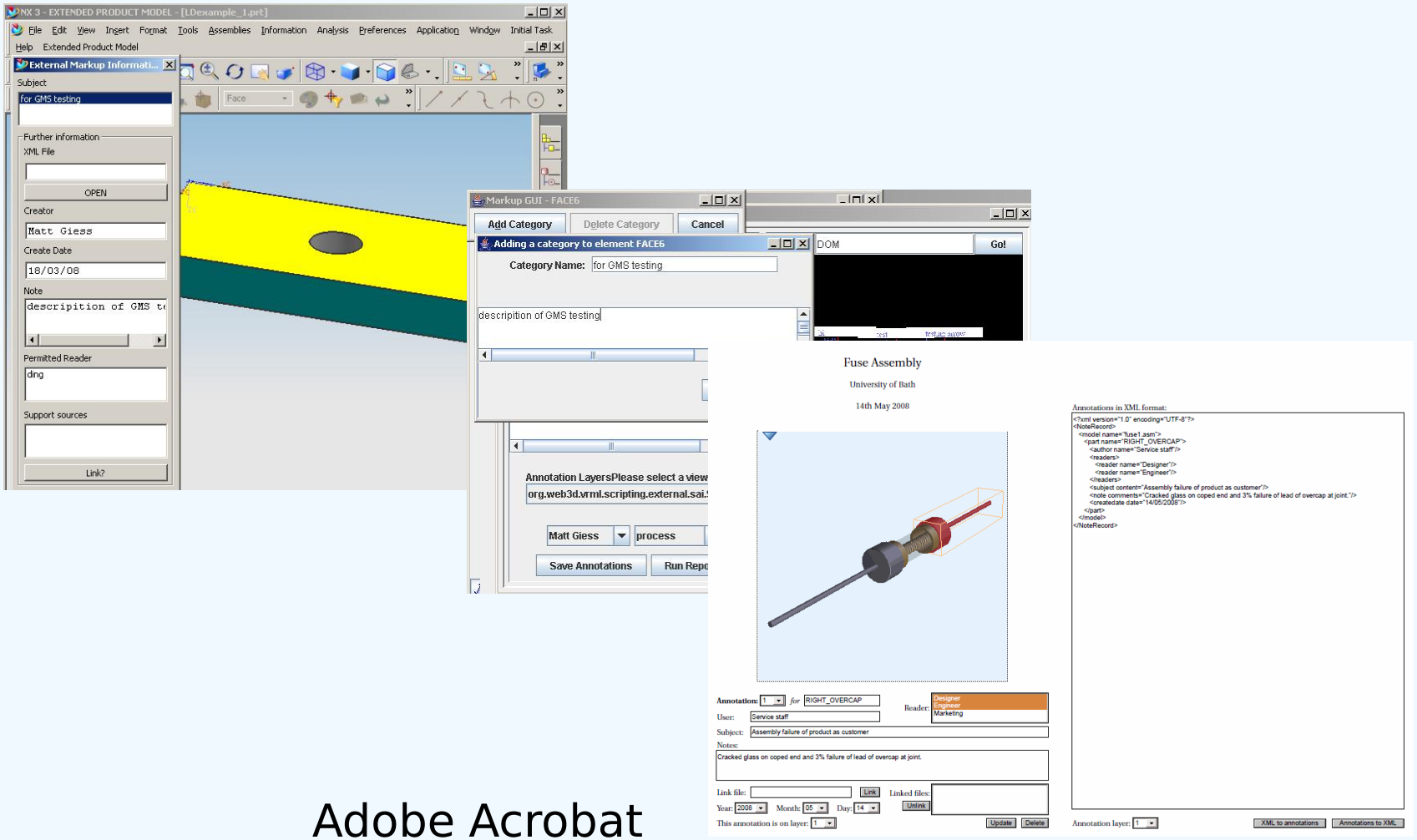
NX3 CAD system

LiMMA tools



X3D lightweight viewer

LiMMA tools



Adobe Acrobat

Registry/Repository of Representation Information for Engineering

- Holds information about format characteristics and migration services
- Uses custom XML format for storage

RRoRIfE

- Searches for formats suitable for a given purpose
- Searches for migration paths suitable for a given purpose

Significant Properties

- Definition: those aspects of a digital object which must be preserved over time in order for it to remain accessible, usable and meaningful

  (A Wilson. 2007. *InSPECT Significant Properties Report.* AHDS/National Archives.)

  - Relative to object
  - Relative to purpose
- Working definition for RRoRIfE: those aspects of a digital object which any new expression of that object must exhibit in order to fulfil its intended function while being faithful to the original

Types of requirement

- Exact geometry versus approximate geometry
- Construction modelling history
- Geometry-related metadata (tolerances, finishes, etc.)
- Transmission of the model over the Internet
- Persistent identification of (subsets of) geometry

2D Geometry

- Point
- Polyline
  - Line
- Conic arc
  - Elliptical arc
    - Circular Arc
- Open composite curve
- Ellipse
  - Circle
- Polygon
  - Triangle
  - Rectangle
    - Square
- NURBS curve
  - Rational Bézier curve
    - Non-rational Bézier curve
      - Cubic Bézier curve
        - Quadratic Bézier curve
- Closed composite curve

3D Geometry

- Point cloud
- Helix
- Plane
- Ellipsoid
  - Sphere
- Cylinder
- Cone
- Cuboid
  - Cube
- Torus
- Translation surface
- Normal swept surface
  - Polylinear swept surface
    - Extrusion surface
  - Swung surface
    - Rotation surface
- Lofted surface
  - Ruled surface
- NURBS surface
  - Rational Bézier surface
    - Non-rational Bézier surface
- Mesh of surface segments
  - Mesh of tessellating triangles

Geometric construction techniques

- Constructive Solid Geometry
- Boundary representation
- Trimmed surfaces
- Parameterized re-use of instances
  - Simple re-use of instances
- Construction history modelling
- Multiple alternative representations
  - Levels of detail

Geometry-related metadata

- Feature semantics
- Material metadata
- Geometric dimensioning and tolerancing
  - Dimensions
- Assembly node metadata
- Assembly hierarchy

Compression and identification

- Field-wise compression
- Stream-wise compression
- Whole-file compression
- Streaming
- Identification of subassemblies
- Identification of parts
- Identification of surfaces
- Identification of edges
- Identification of vertices

Applications

File formats: levels of support

- Full
- Partial
- None

Processing software: levels of preservation

- Good
- Fair
- Poor
- None

Further work

LiMMA

- Automatic extraction of CAD information to annotations
- Recombination of annotations and geometry into CAD model

RRoRIfE

- Synchronization with standard registries
- Extension beyond significant characteristics
  - openness of formats
  - price, availability and customizability of software
  - evaluations of previous preservation actions

Conclusions

- PLM systems need more components and more modular systems for curation and preservation
- LiMMA provides flexible information flows throughout the lifecycle
- RRoRIfE provides preservation planning capabilities
- Still a lot of work to do before being ready for use.

Thank you for your attention

Any questions?