A story of an initiative to extend the X3D Cadprofile adding BREP solid representation

An issue of semantic vs. structural expression

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What about ?

- A story happened in 2007 at Electricité de France,
  - that is a large Utility involved in energy production, transport and distribution of electricity,
  - that is designer of its own **nuclear, thermal, hydraulic,** power plants,
  - that use CAD technology for a long time, (started in the end of seventies),
    - Schematic System design,
    - AEC mock-up,
    - Equipments and concrete buildings CAD design.
  - that has a long experience on all kind of computation based on 3D models.

Which issues ?

- A question came during a discussion with a leader at EDF :
  - I know that you were involved in CAD domain sometime ago, didn't you ?.
  - Yes, but it was a very long time ago...
  - Well, we have a problem of "CAD" with our multiphysics computing platform . Could you help us ?
  - Ah, maybe. What is it?
  - "The modeler of our platform is really just a data integrator before meshing. It has not the ergonomic features of a real CAD software. Users prefer to use other softwares they use for other purposes. Retrieving data from these other sources is a recurring problem ".
  - Do you use any standard exchange?
  - Yes, for some we use STEP, and CSG, but that does not work very well. Models need often to be fixed... for some sources we have to use specific converters. All this is expensive to maintain ...
  - And for output?
  - For output we look at X3D as a language for results publication.
  - May be you can use it for input as well, don't you ?

Then...

Then one of the domain experts came to me:

- You mentioned the idea of using X3D to express CAD data :
  do you know that there is expected a "CAD profile" in the standard ?
  But it is very incomplete.
  I have some ideas to introduce the description of BREP solids.
  Could we study this together?
- Why not ? To work on BREP is a good idea, as we might also describe solid convolutions in CSG trees.
- We need to take care of BREP first. Then we will look to CSG trees.
- OK. I propose to do that through a kind of modelling interview.
  I have some new ideas of methodology to manage that.

To old questions try new approaches

- In my past, after a long time in an engineering company,

  I worked at EDF on the design of 3D CAD systems,

  then I was pragmatically concerned with 2D CAD Schematic, that were more important for plant enginnering,

  Then, logically I went back down to 1D CAD, (as to my experience Word® is the most used CAD software in industrial engineering !)

  Finally the aim of all this was similarly to reduce the entropy of descriptions.

  Then again, from Document structuration (SGML and XML)
  I switched to the study of the used terminologies
  and then to thesaurus,
  and then to formal ontologies...

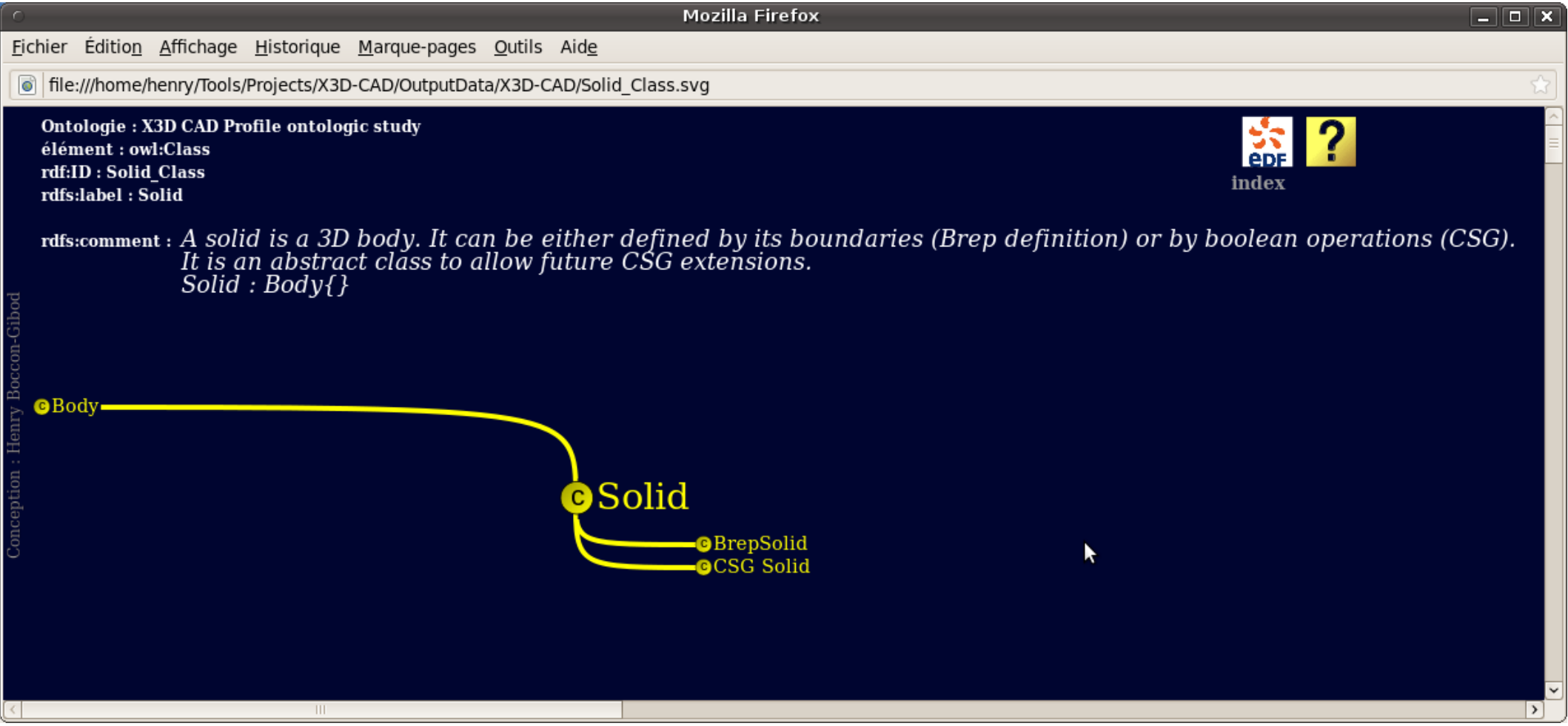
  The study of formal ontologies, because of their description efficiency, led me to rethink everything I've studied, and many other things.

So...

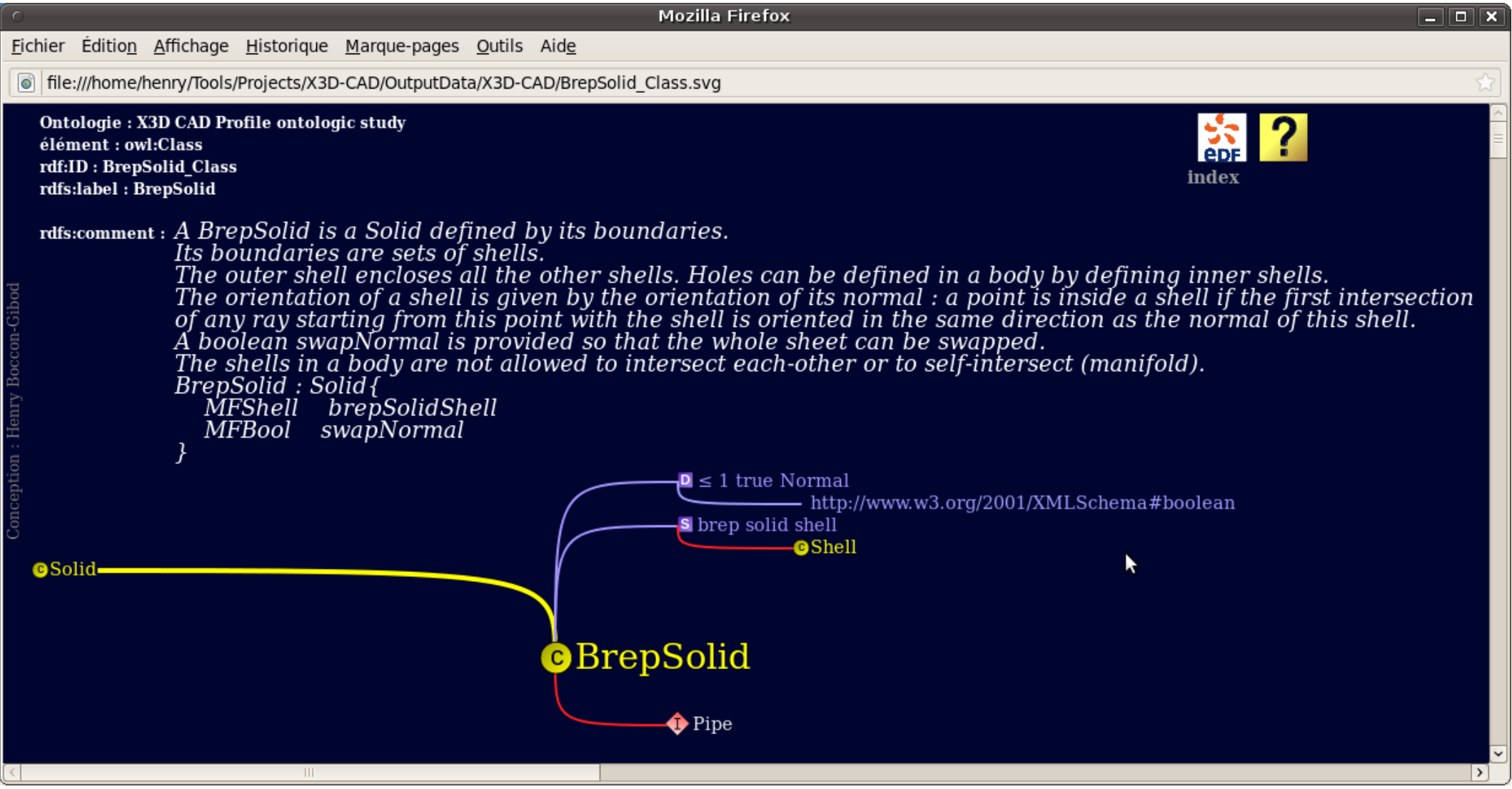
- We started to formalize our formal BREP model as an OWL ontology. In order to do it, we recorded our conversation via a popular rdf editor.
  - What is (a BREP) ?
    - We need to look at its components :
    - A BREP is a solid, that has a shell... what are solid and shell ?
    - A shell has edges... what is an edge ?
    - An edge has vertex... what is a vertex ?
    - A shell has faces... what is a face ?
    - A face has a loop... what is a loop ?
    - (…)

… so we went to a complete consistent description, committed we were to let nothing implicit.

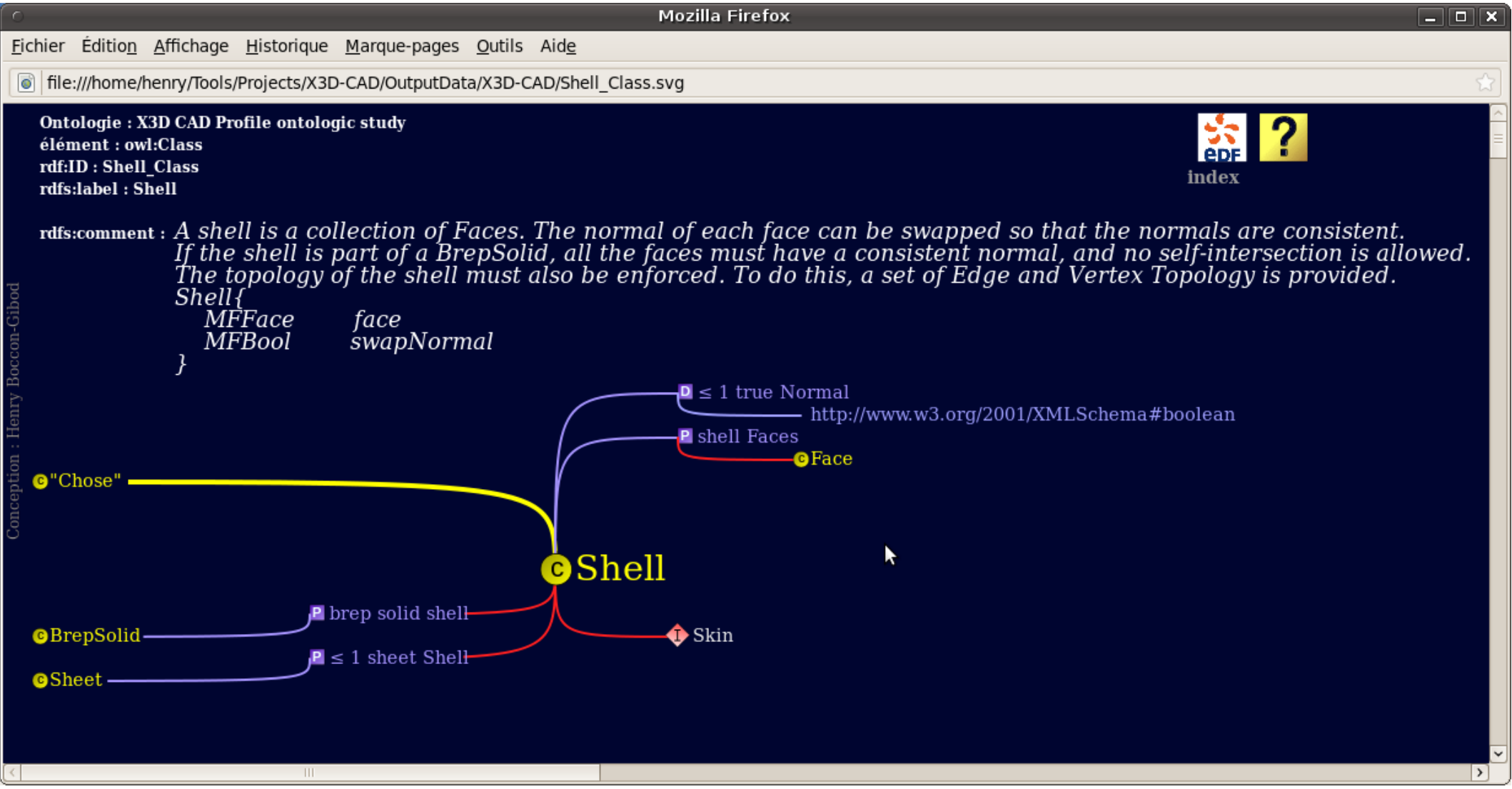
Two kind of solids : BREP and CSG



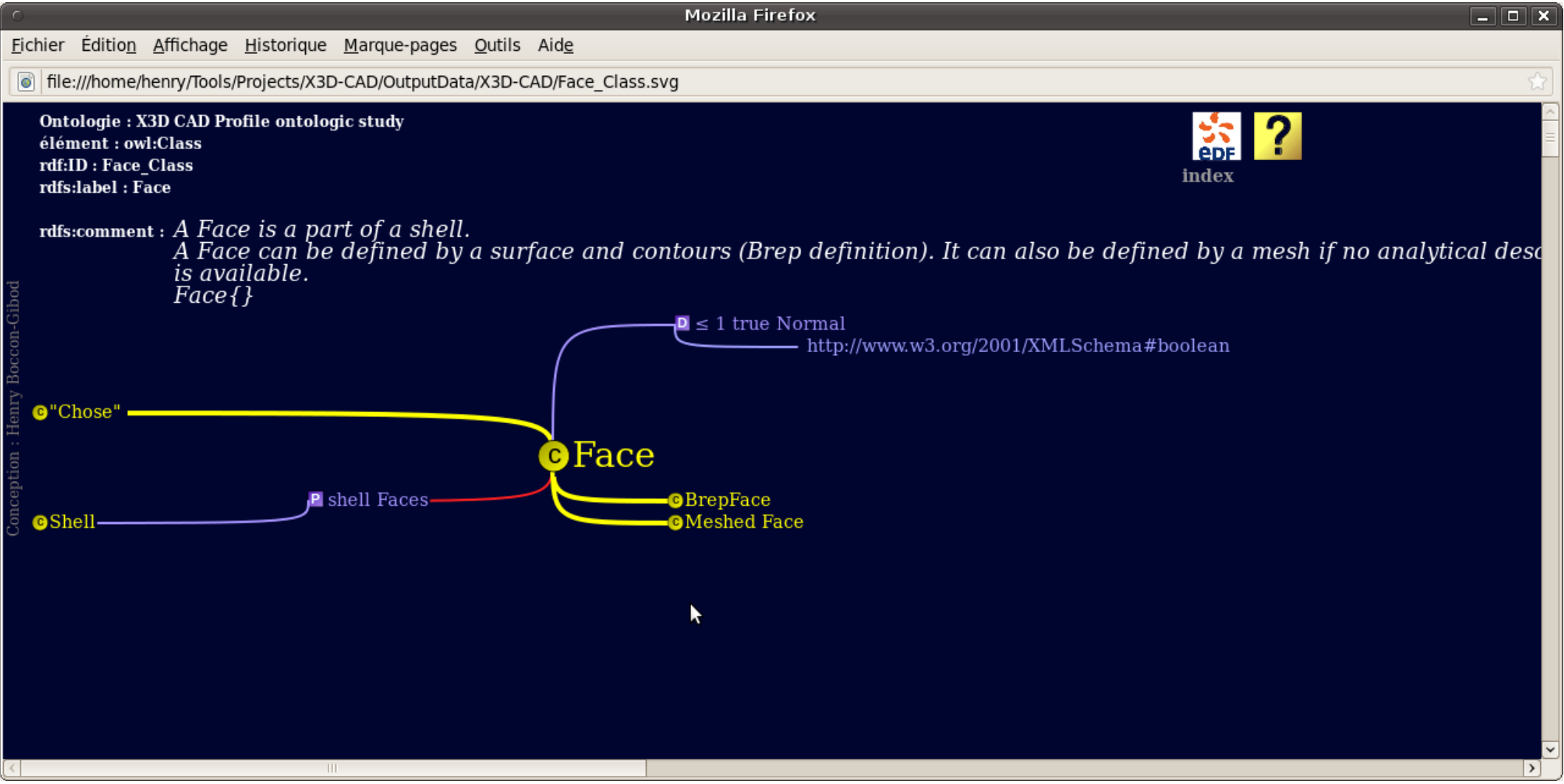
BREP Solid has a shell...



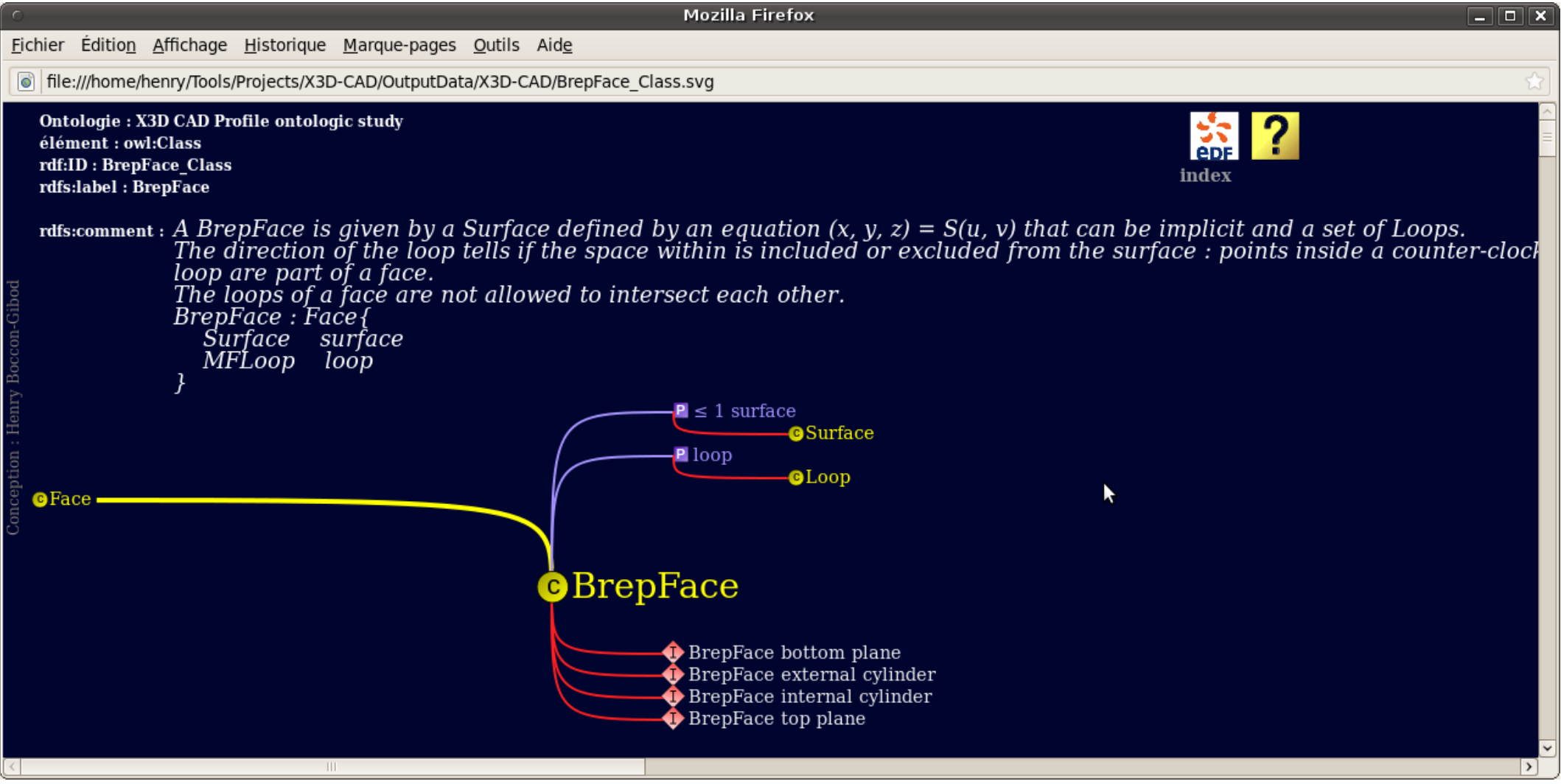
Shell has faces...



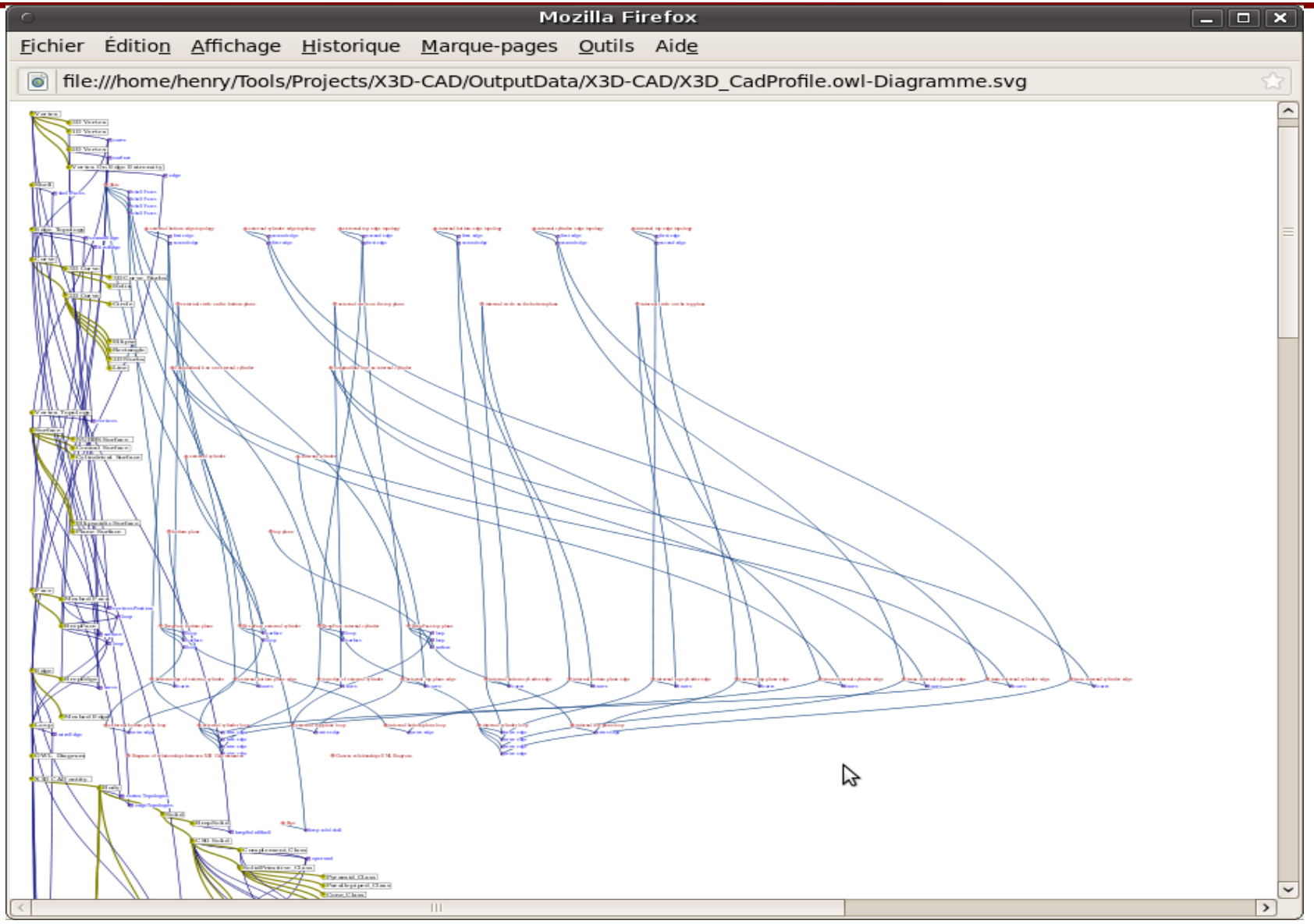
Faces may be BREP or meshed...



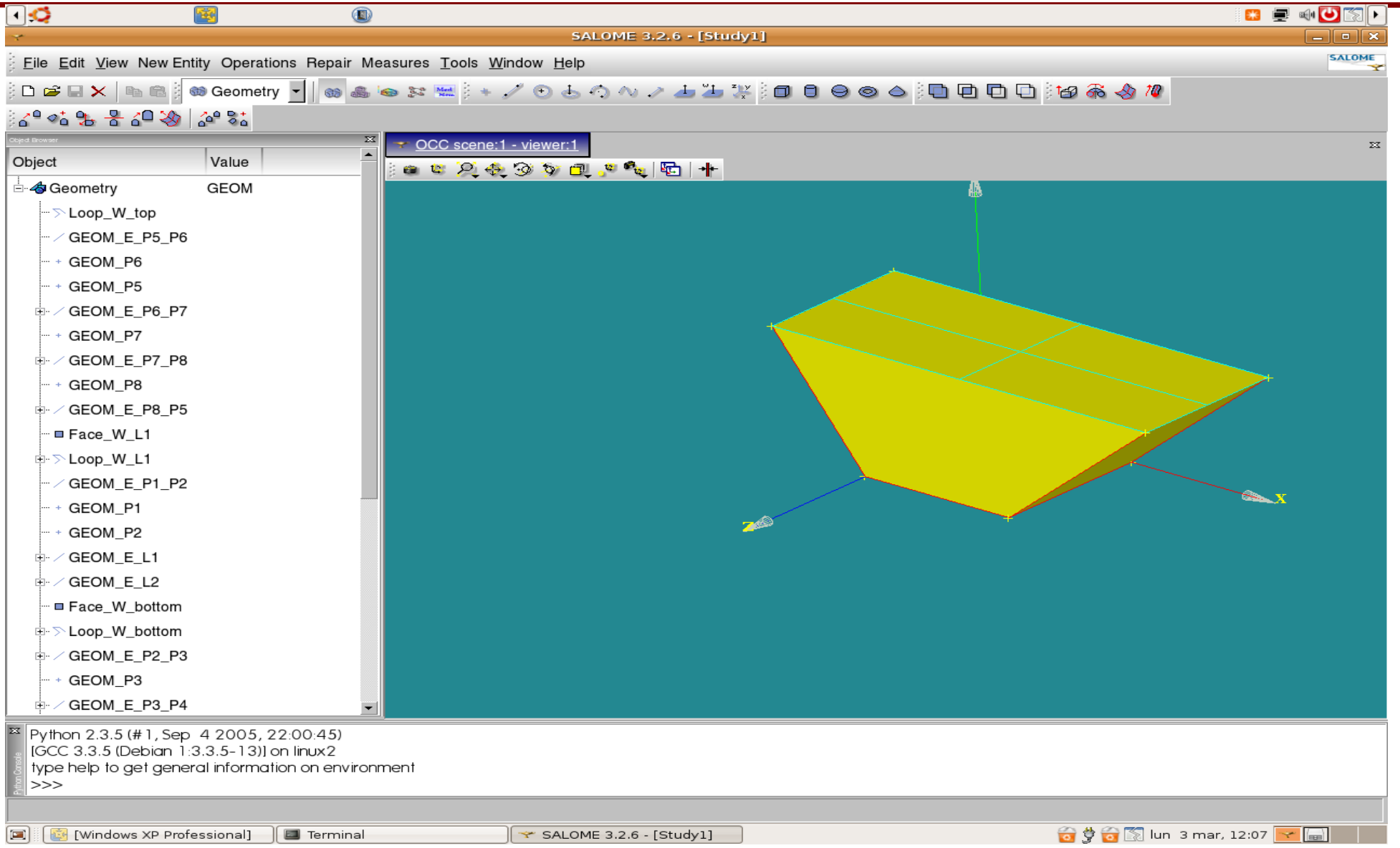
BREP faces has surface and loop...



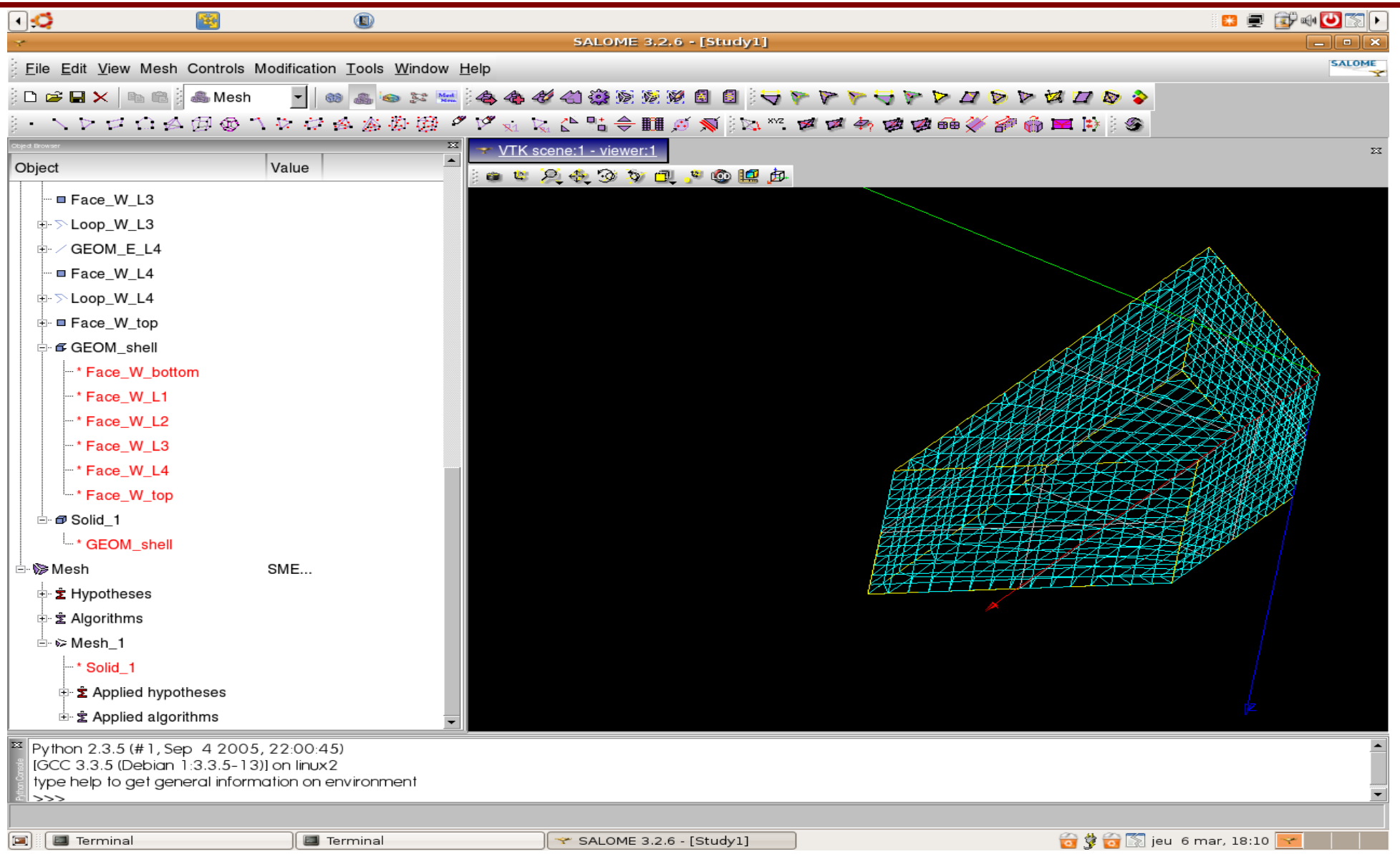
A consistent populated model...



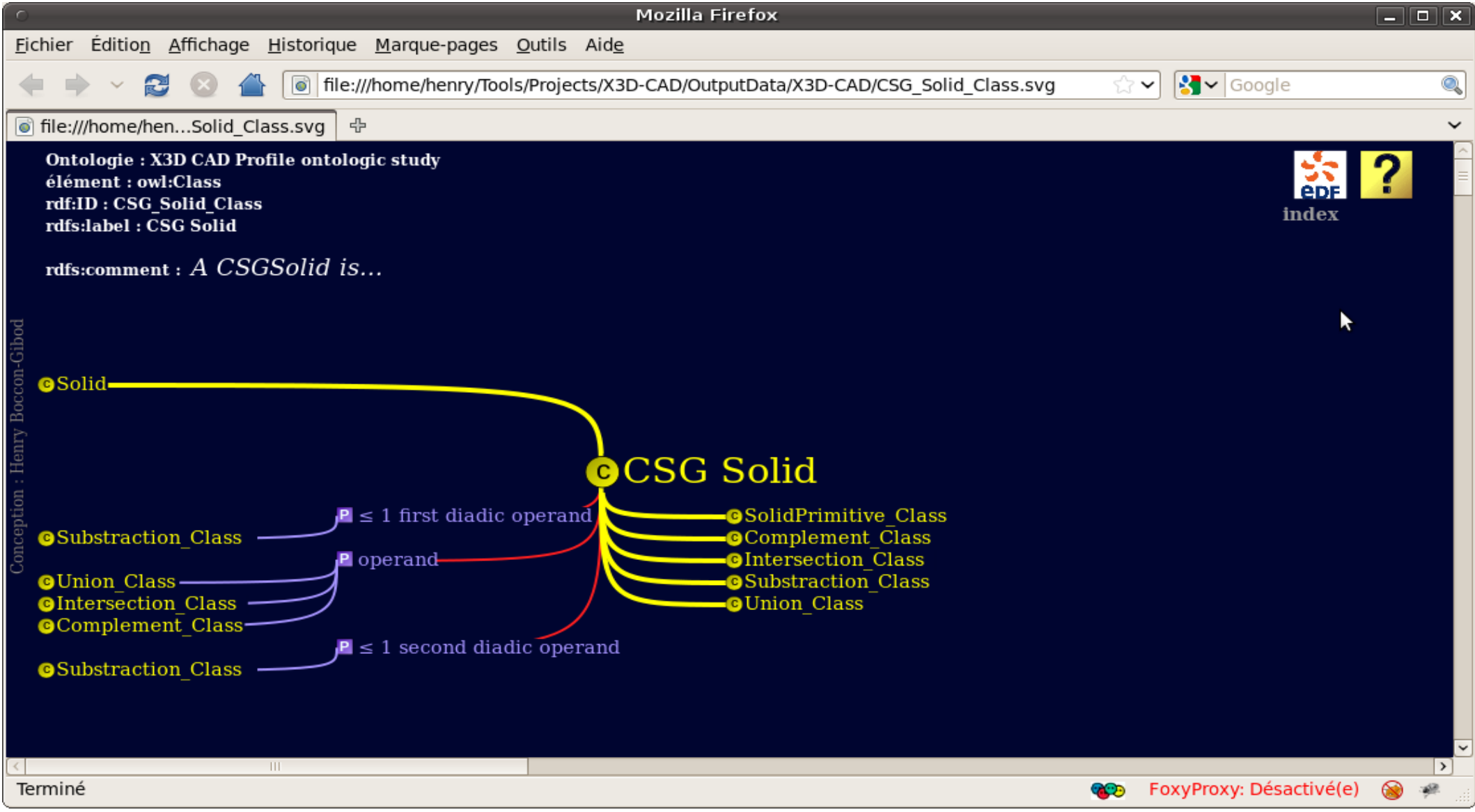
Input in a CAD system after a simple xsl data conversion



Check model consistancy



We may have continued modelling CSG trees...



Then, we had to build a proposal for the X3D CAD profile

- Simple issue :
  - As most of (but not all) standards based on XML, X3D is defined by an XML schema.
  - Our prototype is based on RDF, using a metamodel defined in OWL.
- Prior to propose our extension of X3D we needed to convert the metamodels, through an XSL transformation from semantic OWL to structural XSD.
- Some rules we state :
  - Define new Nodes (complextypes) from OWL classes,
  - Transform subclass trees into inverted composition trees,
  - Transform DataTypeProperties into attributes,
  - Transform ObjectProperties into Xlink cross references,

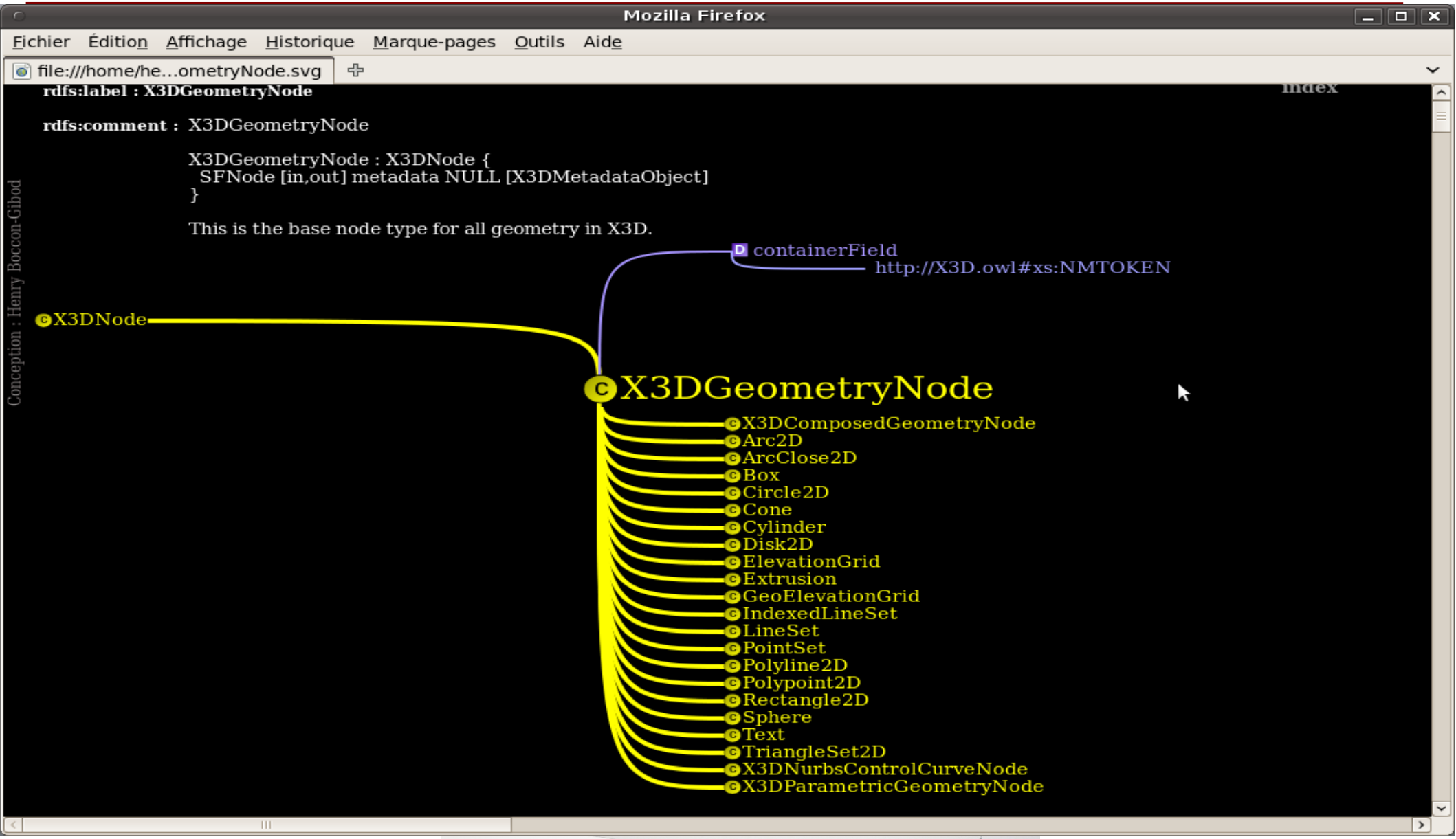
Need of implementation(s)

- EDF missionned Alexandre Frouard, a young, brilliant, developer, at Yumetech, in order to build a first implementation of BREP in X3D.
  - The proposal was discussed, as we did in EDF...
  - Some modification were suggested and tried... but at the end the result was quite similar to what we designed.
- The first implementation were demonstrated at the 2009 Web3D conference in Darmstadt.
- ...but to day, a second implementation is still waited !

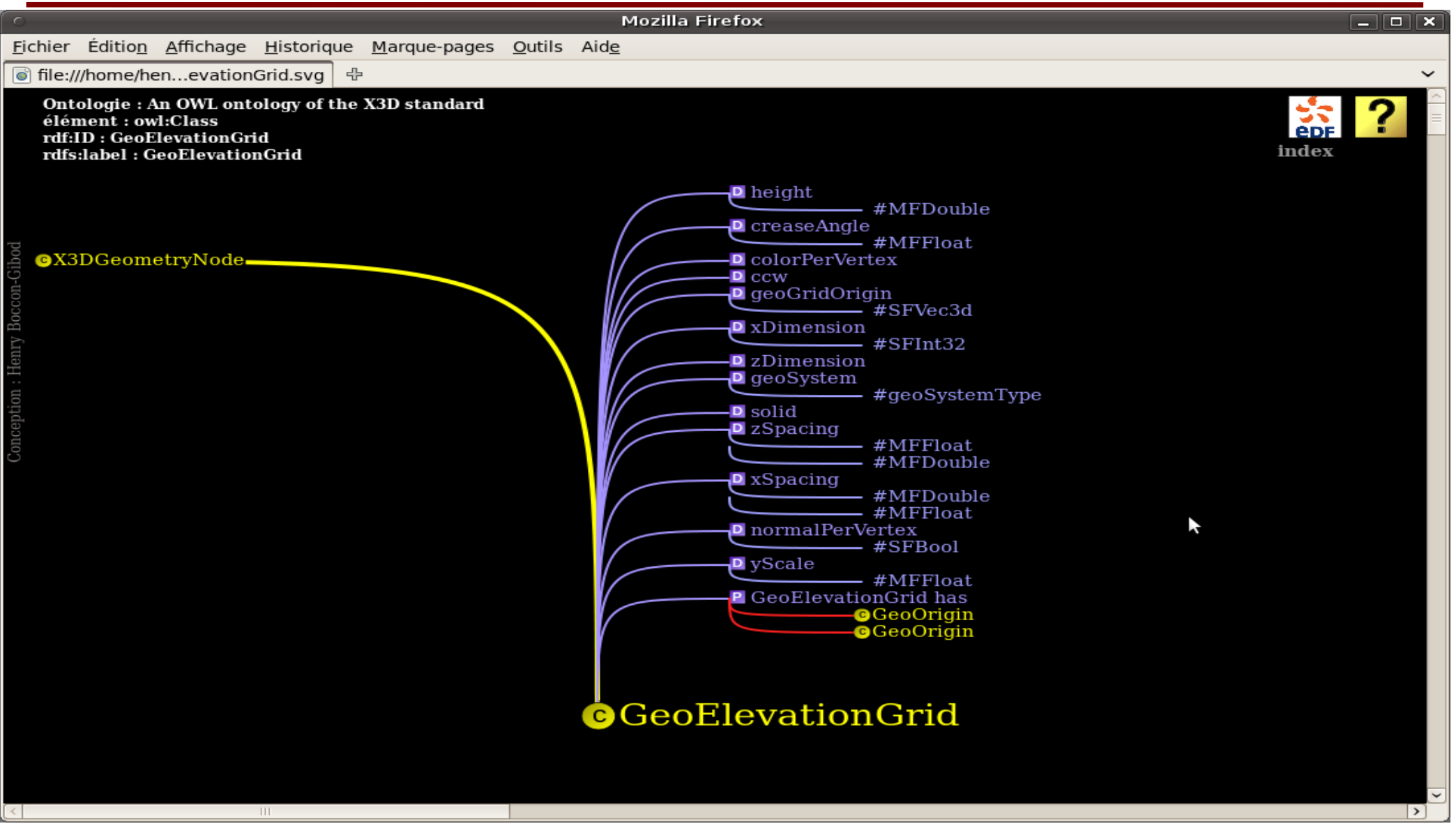
An emerging idea

- Some time ago, I was working on some protocols of extension of ISO 10303 STEP standard.
  - STEP standards are based on metamodels defined in EXPRESS language, that now appear to be a kind of ontology language.
  - At least one of STEP standard (ISO 15926, about AEC) has moved from EXPRESS to an RDF/OWL expression.
- Would it be possible to get an RDF expression of the X3D standard ?
  - So I tried to build it using an inverse transformation of the whole edition of the X3D XML schema from XSD to OWL, using same rules as the previous one, inverted.

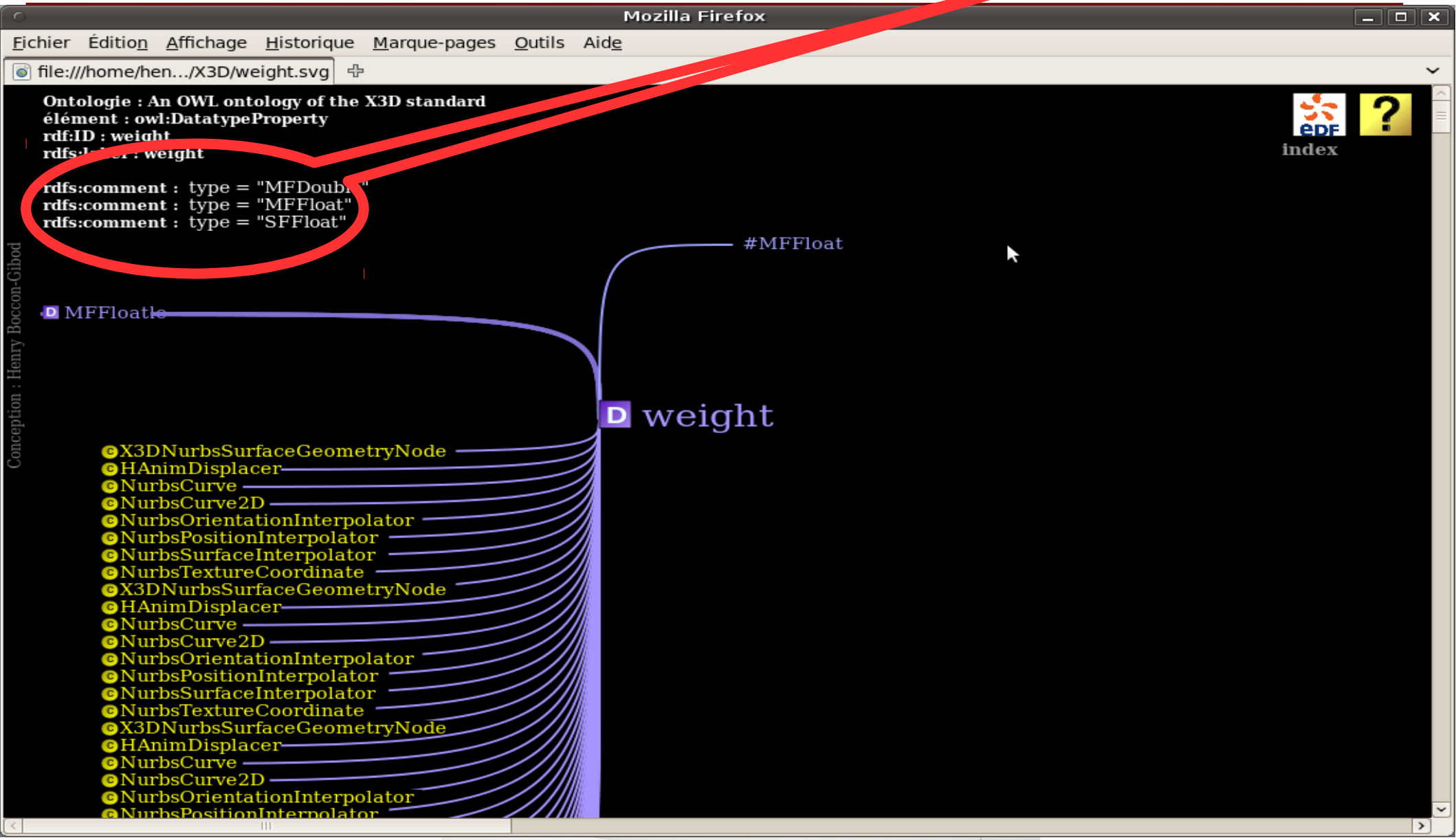
So an owl expression of X3D may be something like that



All concepts semantically linked

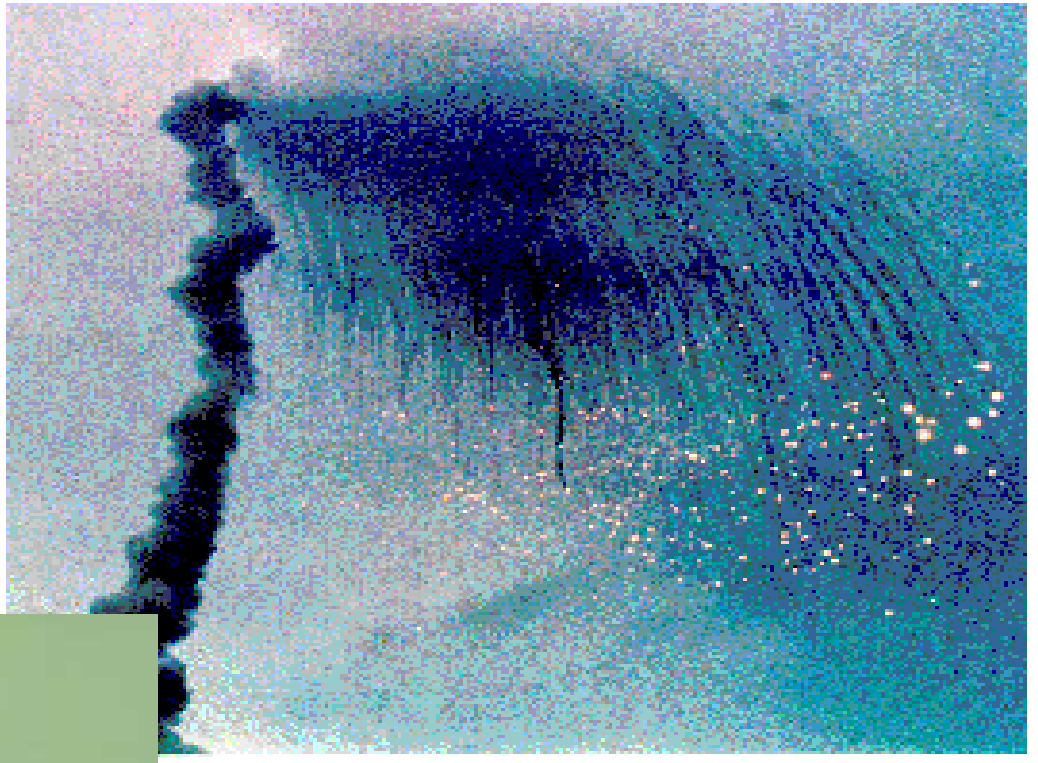


But some (in fact a lot of) things appear iconsistent..



That remind me an experimental result of some kind of data type discrepancies...

That was the first flight of Ariane 5,



Questions

- Issues :
  - What are compared advantages/disavantages of semantic (OWL) versus structural (XSD) expression ?
    - easier extensibility and consistancy of OWL expression ?
    - easy semantic extension of any kind ?
    - possible benefits of rule languages attached to owl ?
      - Model consistancy checking ?
    - Possible lack of efficiency issues due to OWL APIs ?
      - (Jena, OWLAPI etc.)
  - To change expression kind, would it be a revolution ?

Thank you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