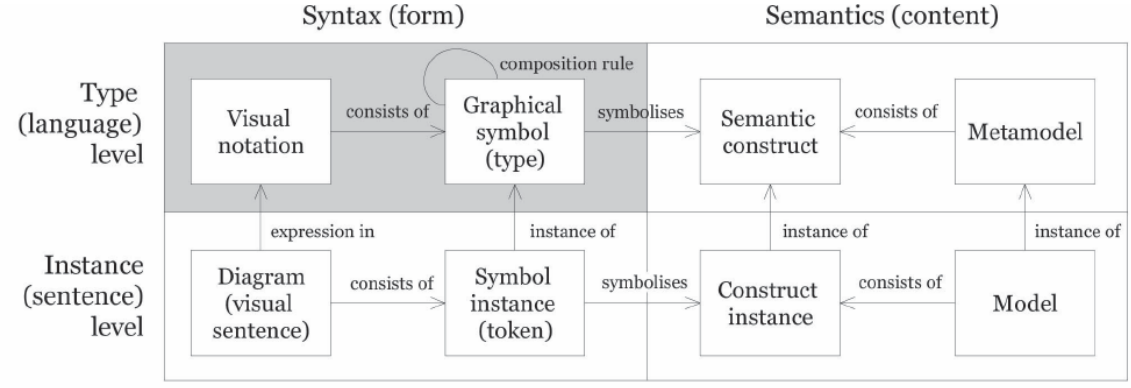
COMPSCI 732 Software Tools
Visual Languages: Design and Evaluation

- Topics:
  - Elements of a visual language solution
    - Surface notation
    - Meta model and meta modelling
    - Semantic processing (see later in Karen's section)
  - Design and evaluation of visual languages
    - Techniques for designing "good" VLs
    - Cognitive dimensions
    - Physics of notations

Elements of a visual language solution

Surface VL defn

Meta model/information model defn



A VL diagram

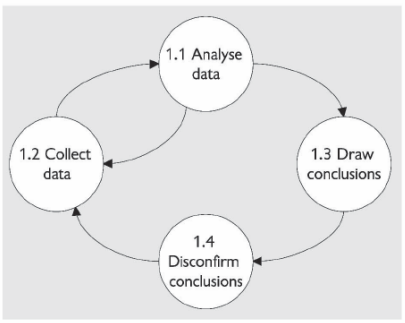
"Execution" of the diagram

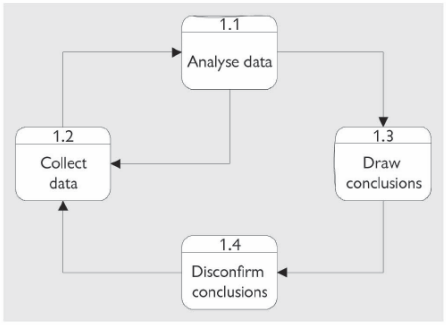
From Moody "Physics of Notations"

Surface notation

- The surface form of the language
- May be variants/dialects

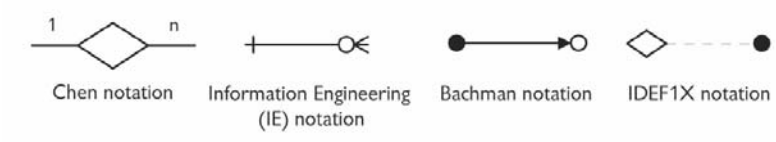
DeMarco DFD





Gane & Sarson DFD

ER Variants

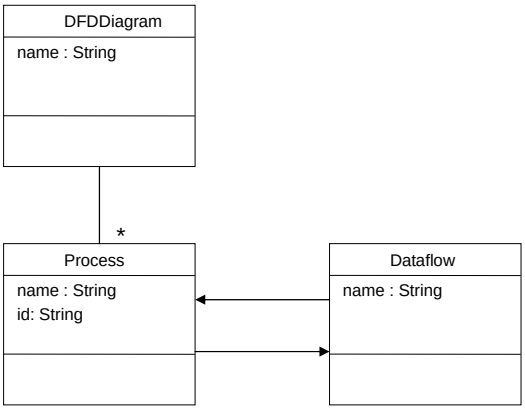


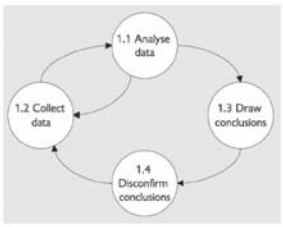
From Moody

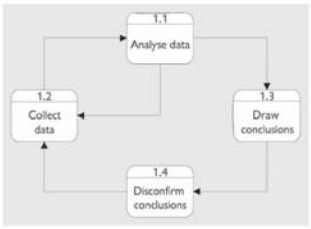
Meta model

- Describes underlying information model of the language
  - It's abstract syntax
  - "A metamodel is a precise definition of the constructs and rules needed for creating semantic models" Ernst
- Want to be able to describe precisely in the same way as we can describe formal models for textual languages
- Need mappings from visual syntax to meta model
  - From these define the equivalent of parsers

Simple DFD Meta Model







Meta modelling

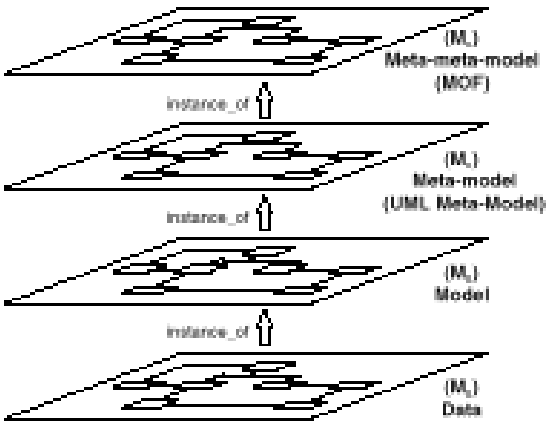
- Methodologies and techniques for deriving a meta model
  - Meta modelling deals with modelling of models
  - Bottom up – derive modelling needs in the form of a meta model (eg to configure a framework or product line) then a VL to express that
  - Top down – have a VL (eg one familiar to end users) and derive a meta model from this to build a tool to support modelling in that VL
- So what are metamodels good for:
  - As a "schema" for semantic data that needs to be exchanged.
  - As a schema for semantic data that needs to be stored, in a repository, for example.
  - **As a language that supports a particular methodology or process** - a metamodel allows a language designer or methodologist to better capture, analyze and understand what they are actually writing about in all those methodology books.
  - As a language to express additional semantics of existing information.

Meta modelling

- Need a notation for expressing the meta model!
  - Has both structural aspects (eg generalisation) and behavioural (constraints of various sorts)
  - Typically use a constrained form of UML class diagrams plus OCL
    - eg the Meta Object Facility MOF
    - eCore is a commonly used variant of MOF
    - eCore support provided in Eclipse
  - But how do you define that?
    - Meta meta model using MOF itself

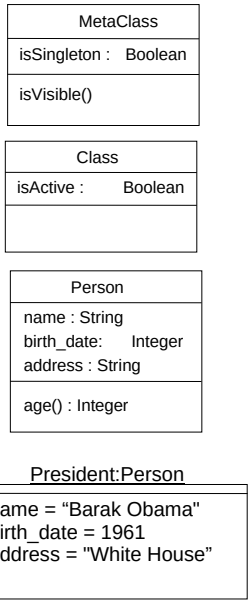
4 layer model – eg for UML

- This approach leads to a four layer approach to the modelling
- meta-meta-model (M3): defines the MOF notation
- meta-model (M2): defines UML notation using MOF
- user model (M1): a UML model of a particular problem domain
- data (M0): typical objects instantiating the UML model
- Note: could use M3 instead to define M2 for ER modelling; M1 a typical ER model; M0, typical ER data.



Examples

- Typical examples of elements at each level:
- M3: MOF MetaClass
- M2: UML Class, instance of MOF Class; very similar to MOF concept of a Class
- M1: Person, a typical instance of UML Class
- M0: President:Person, a typical instance of Class Person
- From C. Atkinson, Supporting and applying the UML conceptual framework.



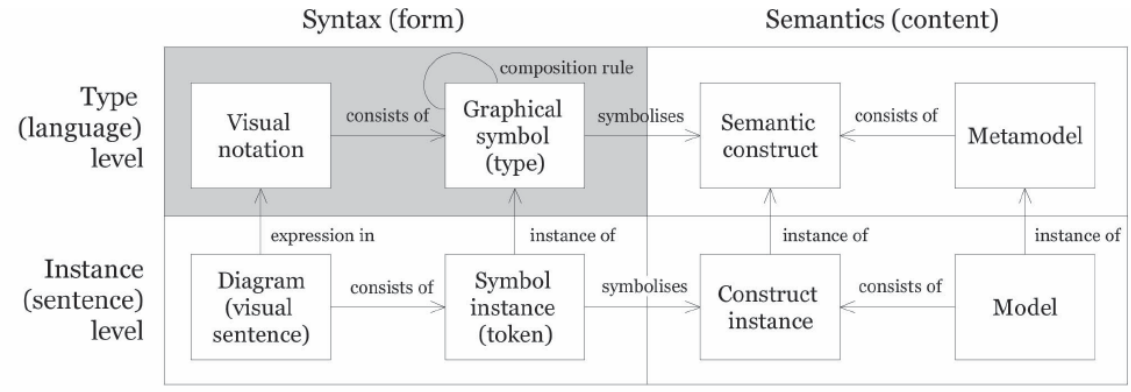
Most people don’t model at this level

If defining a UML tool model this

People using the tool model this

At “runtime” may result in these

VL design and evaluation



Cognitive Dimensions Framework

- Green and Petre 1996 (since developed by Blackwell)
- Establishes a set of "dimensions" to think about the tradeoffs made in implementing visual programming environments
  - Has had very strong influence on the VL community
  - Means of explaining effects of design decisions
- Comes out of cognitive psychology community
- Lightweight – doesn't need large usability studies to get useful insight
- Can be used for evaluation and also as a design aid

Cognitive Dimensions

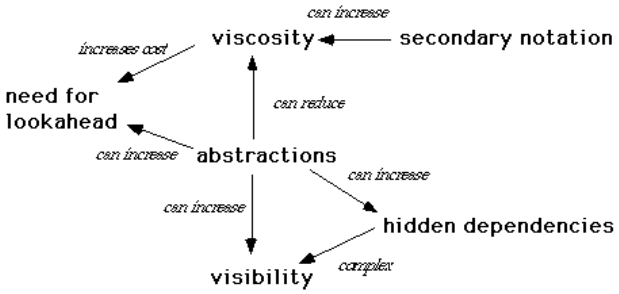
- **Abstraction gradient What are the minimum and maximum levels of abstraction? Can fragments be encapsulated?**
- **Closeness of mapping What 'programming games' need to be learned?**
- **Consistency When some of the language has been learnt, how much of the rest can be inferred?**
- **Diffuseness How many symbols or graphic entities are required to express a meaning?**
- **Error-proneness Does the design of the notation induce 'careless mistakes'?**
- **Hard mental operations Are there places where the user needs to resort to fingers or penciled annotation to keep track of what's happening?**
- **Hidden dependencies Is every dependency overtly indicated in both directions? Is the indication perceptual or only symbolic?**

Cognitive Dimensions

- **Premature commitment Do programmers have to make decisions before they have the information they need?**
- **Progressive evaluation Can a partially-complete program be executed to obtain feedback on "How am I doing"?**
- **Role-expressiveness Can the reader see how each component of a program relates to the whole?**
- **Secondary notation Can programmers use layout, color, or other cues to convey extra meaning, above and beyond the 'official' semantics of the language?**
- **Viscosity How much effort is required to perform a single change?**
- **Visibility Is every part of the code simultaneously visible (assuming a large enough display), or is it at least possible to compare any two parts side-by-side at will? If the code is dispersed, is it at least possible to know in what order to read it?**

Use of Cognitive Dimensions

- Note the tradeoffs that occur
  - May add an abstraction that makes it easier to change things (reduced viscosity) but increases the difficulty of understanding (increased abstraction gradient and increased hidden dependencies).
  - See Green and Petre paper for several examples illustrating tradeoffs made



- Burnett provides a set of representation benchmarks that assist in operationalising the use of the CD framework.

Exercise

- CD evaluation of UML class diagrams
- Look at tradeoffs made
- Look at how designing appropriate tool support could mitigate problems

Cognitive Dimensions provides vocabulary

Verbatim transcript from a newsgroup discussion (real words from real users).

NB: this discussion referred to a version of Framemaker that is now obsolete.

- *A:* ALL files in the book should be identical in everything except body pages. Master pages, paragraph formats, reference pages, should be the same.
- *B:* Framemaker does provide this ... File -> Use Formats allows you to copy all or some formatting categories to all or some files in the book.
- *A:* Grrrrrrrrr …….. Oh People Of Little Imagination !!!!!!
- Sure I can do this ... manually, every time I change a reference page, master page, or paragraph format …..
- What I was talking about was some mechanism that automatically detected when I had made such a change. (…..) Or better yet, putting all of these pages in a central database for the entire book ……
- *C:* There is an argument against basing one paragraph style on another, a method several systems use. A change in a parent style may cause unexpected problems among the children. I have had some unpleasant surprises of this sort in Microsoft Word.

Improved Discussion

- *A:* Framemaker is too viscous.
- *B:* With respect to what task?
- *A:* With respect to updating components of a book. It needs to have a higher abstraction level, such as a style tree.
- *C:* Watch out for the hidden dependencies of a style tree.
- *(further possible comments)*
- The abstraction level will be difficult to master; getting the styles right may impose lookahead.

From: An Introduction to the Cognitive Dimensions Framework, T R G Green

http://homepage.ntlworld.com/greenery/workStuff/Papers/introCogDims/index.html

Attention Investment

- Theory to explain why people spend time doing programming
- Programming defined very broadly
- Defines “attention units”: nominal amount of “concentration” applied
- Applies a cost benefit analysis approach to programming activities
  - Programming => automation to save time in the future
  - Has Cost: attention units to do the job
  - Investment: attention units expended towards a potential reward
  - Pay-off: reduced future cost from investment
  - Risk: probability that no pay-off or –ve pay-off results
- See: First steps in programming: a rationale for attention investment models, Blackwell.

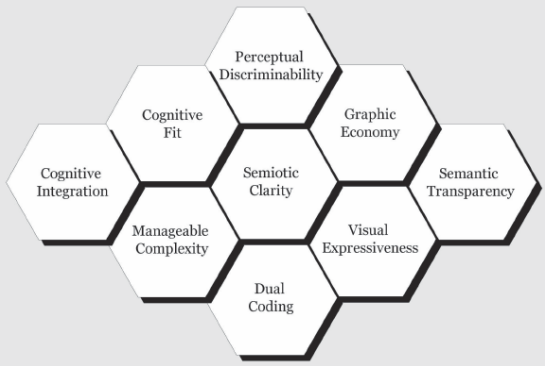
Champagne Prototyping

- A “cheap” method for early design evaluation
- Combines:
  - simple prototyping
    - used overlays and “look don’t touch” approach
  - cognitive walkthroughs with credible participants
  - cognitive dimensions & attention investment for analysis

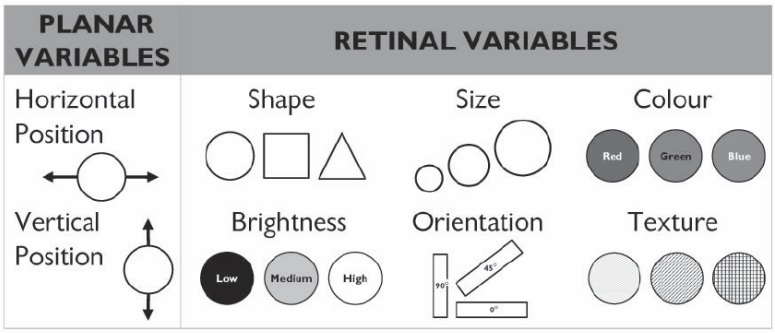
  to assist in answering questions at early design phase of visual environments
- Blackwell, Burnett and Peyton Jones, Champagne Prototyping: a research technique for early evaluation of complex end user programming systems, IEEE VL/HCC, 2004, 47-54

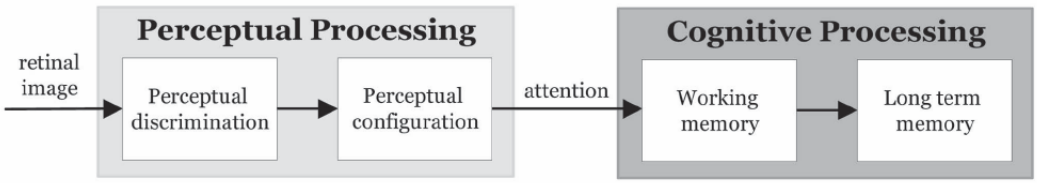
Physics of Notations: Moody

- Claims to be a "theory" that allows you to predict qualities of a visual notation
- A "meta study" – set of principles derived from synthesising multiple empirical results that others have reported
- New work, but will have significant influence in VL design



Design and solution space





Nine principles

- Principle of Semiotic Clarity: There should be a 1:1 correspondence between semantic constructs and graphical symbols
- Principle of Perceptual Discriminability: Different symbols should be clearly distinguishable from each other
- Principle of Semantic Transparency: Use visual representations whose appearance suggests their meaning
- Principle of Complexity Management: Include explicit mechanisms for dealing with complexity
- Principle of Cognitive Integration: Include explicit mechanisms to support integration of information from different diagrams
- Principle of Visual Expressiveness: Use the full range and capacities of visual variables
- Principle of Dual Coding: Use text to complement graphics
- Principle of Graphic Economy: The number of graphical symbols should be cognitively manageable
- Principle of Cognitive Fit: Use different visual dialects for different tasks and audiences

Examples

- Principle of Semiotic Clarity: There should be a 1:1 correspondence between semantic constructs and graphical symbols

  Symbol redundancy UML

  Symbol overload ArchiMate

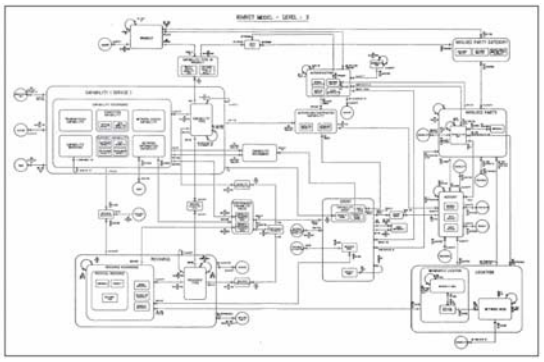
Examples

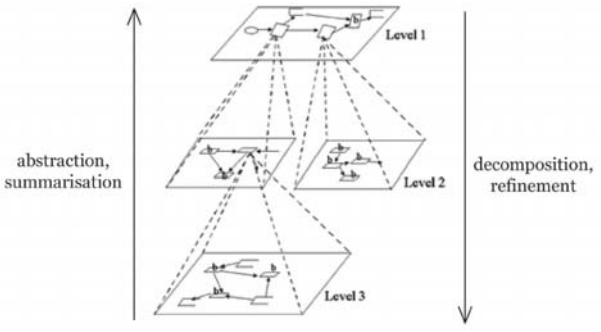
- Principle of Perceptual Discriminability: Different symbols should be clearly distinguishable from each other

  Visual distance important – shape, redundant coding important (cf visual expressiveness)

Examples

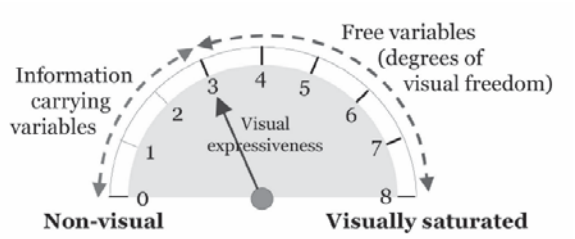
- Principle of Complexity Management: Include explicit mechanisms for dealing with complexity

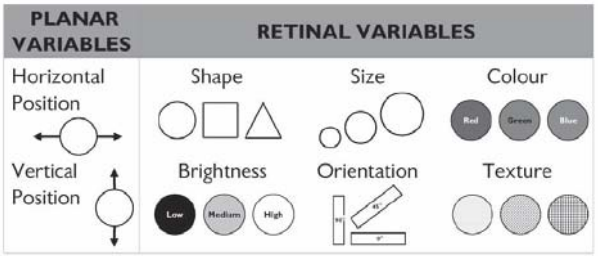


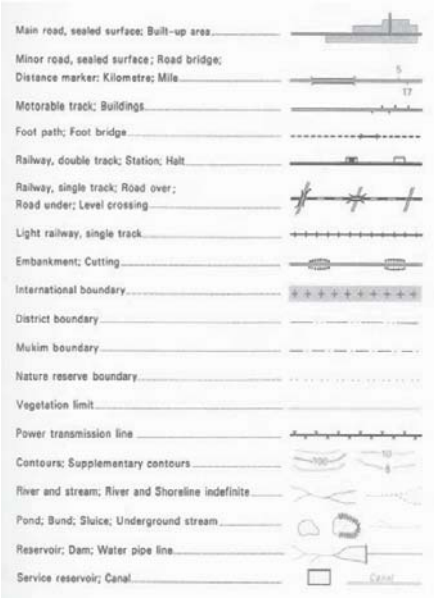


Examples

- Principle of Visual Expressiveness: Use the full range and capacities of visual variables







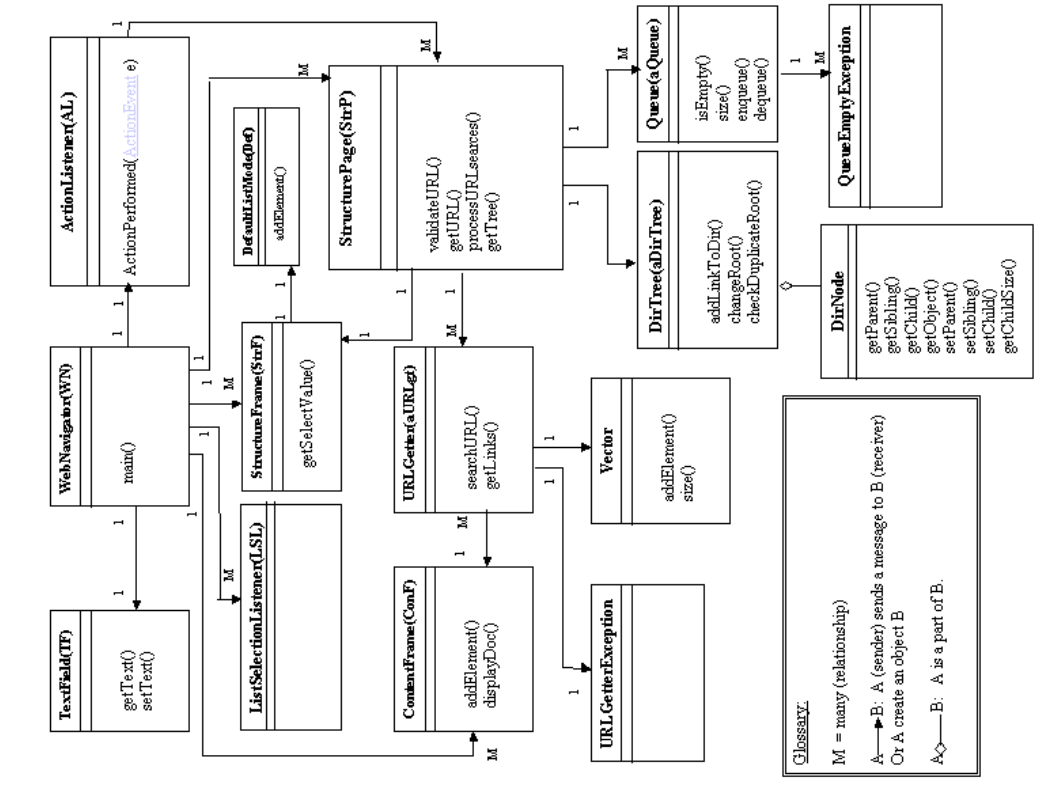
Exercise

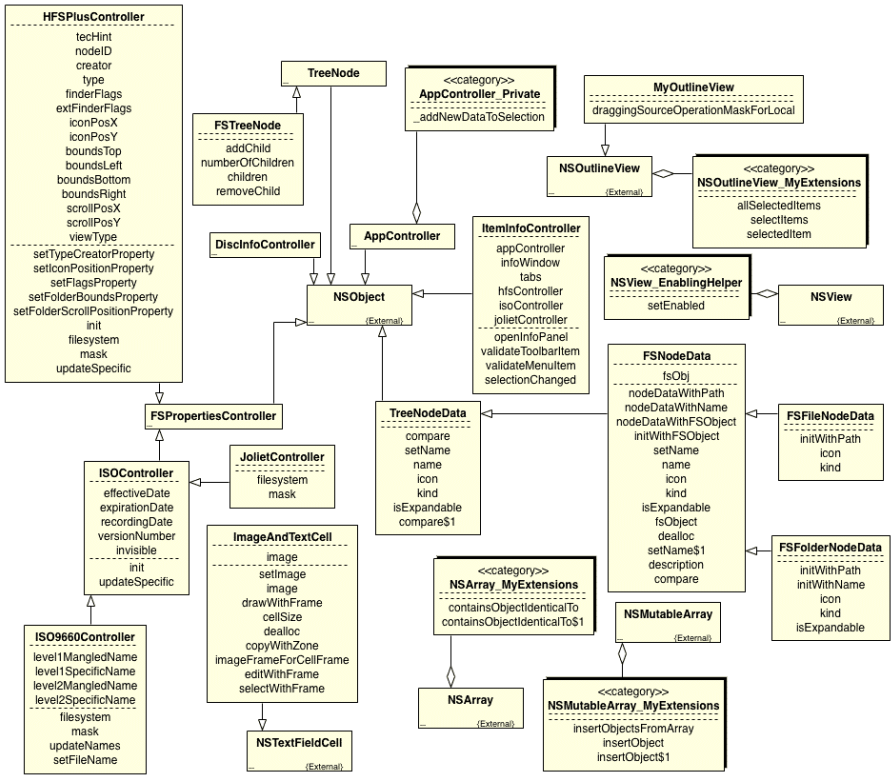
- Look at 2-3 of the principles applied to UML class diagrams
- Look at how changing design of UML surface notation could improve the language
- Look at how designing appropriate tool support could mitigate problems

Homework

- Thursday group activity will be in 279
- Undertake a CD and PON analysis of a visual language
- Will look at Swenson's Regatta
  - A Visual Language to Describe Collaborative Work, Swenson – see Resource page
  - Read this – make some preliminary notes about CD and PON wrt Regatta
  - Bring a copy of the paper plus CD and PON papers to class
  - Be prepared to argue your points

    - NB: if you are interested in Regatta, also look at our extensions of it: Low-level and high-level CSCW support in the Serendipity process modelling environment, Grundy et al.

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