### Formal Information Modeling for Standardization in the Spatial Domain

adapted by Damir Medak credits to Andrew U. Frank

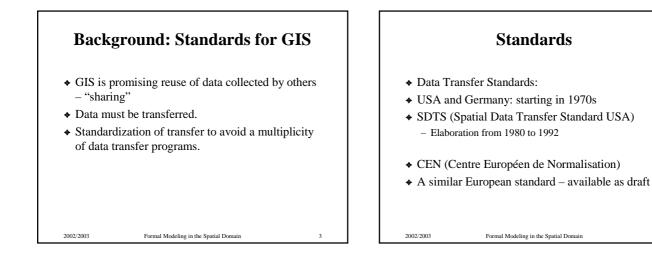
### Overview

- ✤ Standardization for GIS
- ✤ Open GIS standards
- Problems with current standardization methods

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- Try to use Functional Programming
- Conclusions

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# Industry standards The major vendors have defined formats which work and are widely used. AutoCAD, Intergraph, ESRI The elaboration of national standards, especially for small countries is a questionable effort.

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### **Open GIS Consortium**

- Geographic Data on the web does not require transfer of datasets, but access to the 'live' data.
- Open GIS : open with respect to vendors, proprietary formats
  - avoiding of 'locking in' of organizations
- Elaboration of industry standards: the topics of importance to industry at the time they are necessary.

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### Standardization of Interoperability

- ✤ Not standardization of data transfer.
- Description of operations which can be executed on another machine, including the interpretation of the results.

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Specification of operations
 not description of data!

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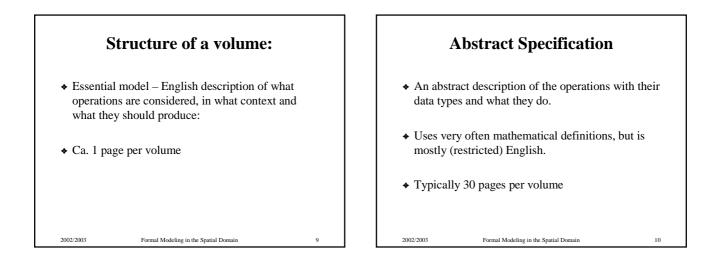
### **Open GIS Consortium Standards**

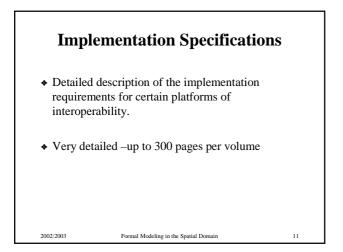
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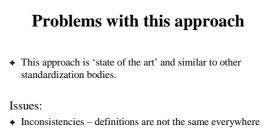
- Subdivision of the field of GIS in several 'volumes' which are worked on.
- Completed first: feature geometry
- ♦ Currently 16 volumes

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\* A very substantial body of material!







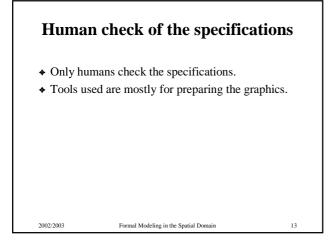
Contradictions –

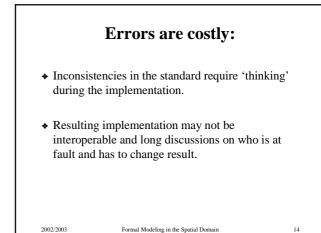
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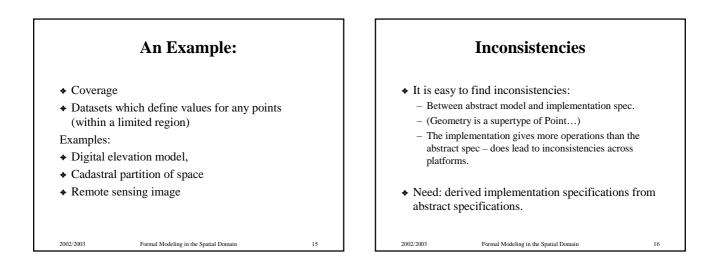
- + Holes: some important points are not described.
- + Abstract and implementation specifications do not agree

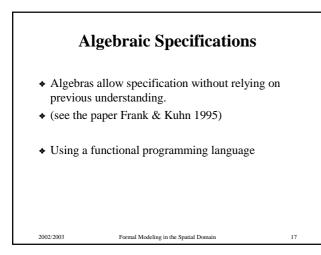
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# Translation of abstract specifications to Haskell

- Class in specifications becomes algebras (class in Haskell).
- Operations become functions (with all parameters)

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• A very simple implementation is described as a model. It uses only lists of data elements.

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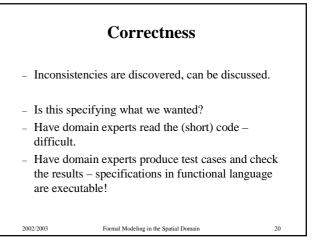


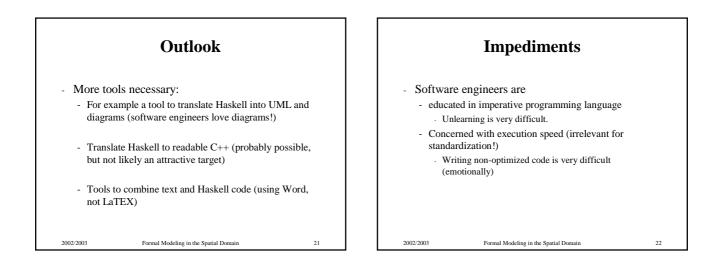
- The algebra can be described simply in terms of operations and thus become independent of the model.
- The model is important:

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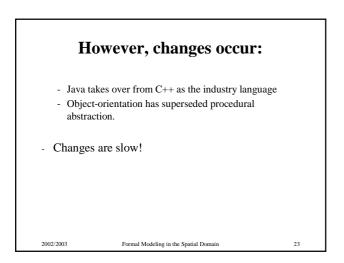
- to create the specification and understand it.
- to be able to execute the specifications.
- The abstraction is important:
  - to demonstrate that the specification is independent of the model.

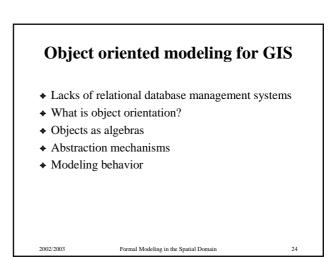
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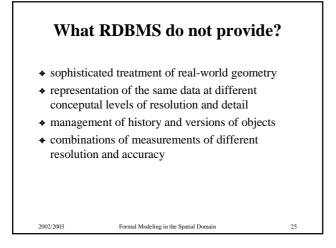




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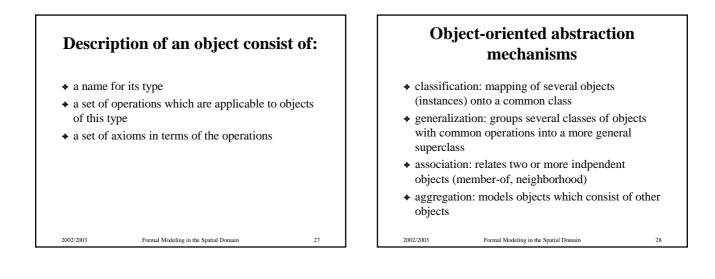
### **Object-orientation**

 a design method that focuses on modeling objects as humans perceive them in reality

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- it combines modeling of the structure and the behavior of the objects
- corresponds with multi-sorted algebras



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### Modeling behavior

- Inheritance is a method to define a class in terms of one or more other, more general classes.
   Properties which are common to a class and its subclasses are defined only once and inherited to all objects of the subclass
- Propagation describes how a *value* of a property of one class is derived from values of properties of another class.

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### Seven-steps method

- 1. Candidate classes
- 2. Define classes
- 3. Establish associations
- 4. Expand many-to-many associations
- 5. Attributes
- 6. Normalization
- 7. Operations (behavior)

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- ◆ a *thing* (entity) i represented in English as a *noun*
- a list of *nouns* that *might* name classes we are interested in
- four ways to generate a list:
  - client interviews

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- requirements model and other documentation
- brainstorming (generating ideas)
- the Delphi method (brainstorming by mail)

### 2. Define classes

- ♦ checking the importance of candidate classes
- ♦ three checks:

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- real-world identifier
- definition
- sample attributes and behaviors
- + objects have identity
- ✤ if a class matters, its instances must have identity

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### 3. Establish associations

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- association is a relationship expressing the interactions between instances of two classes, represented by the verb that describes what they do to each other
- discovering the verb
- capturing all possible associations (matrix method)
- establishing the multiplicity (the number of instances of each class that can participate in an occurence of an association)
- Sentence = Subject + Verb + Number + Object An owner owns many Parcels
- difference between identifiable and quantifiable objects
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# 4. Expand many-to many associations

- 1:M associations are simple to implement (foreign keys in RDBMS or pointers in OODBMS)
- M:M associations (a parcel owned by several owners, an owner having several parcels)
- placing event data attributes
- solution: intersection (associative) class
- every M:M association breaks out into a pair of 1:M associations with the M-ends pointing at this new intersection class

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### 5. Attributes

- ✤ a lot of work to do, but simple concept
- for each class: list all the attributes the users can think of
- in larger models boxes will be cluttered record just the key attributes
- + use dictionaries to provide good definitions

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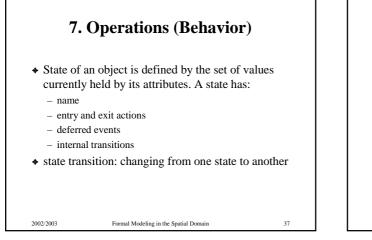
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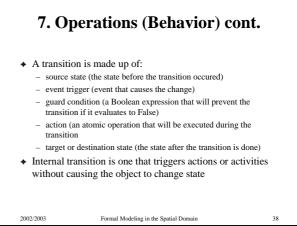
### 6. Normalization

- Normalization is a proces of ensuring that every attribute is attached to the class of objects that it truly describes.
- primarily a database design technique, but valuable at all stages in systems development
- 1NF no repeating fields
- ◆ 2NF all the nonkey attributes are *fully* functionally dependent on the key
- ♦ 3NF there are no transitive functional dependencies
- a list-valued attribute violates all normal forms
- denormalizing reduce complexity and improve response times, but makes it more difficult to extract the data later

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### 7. Operations (Behavior) cont.

- statechart diagram: a map showing all permissible states and permissible transitions for a class of objects, along with events that cause these transitions and the actions and activities that result from them
- object life cycle consists of the various states an object may transition through, the set of permissible transitions and sequencing of those states and transitions, as it progresses from its initial creation to its eventual disposal

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## Geographic information – Methodology for feature cataloguing (ISO/DIS 19110)

- "functional language programming language in which abstract data types are defined in terms of operations on the types, and in which algebraic axioms specify the results of each of the operations for each of the types.
  - NOTE: In a functional language, feature types may be represented as abstract data types"
- "The use of functional language specifications to help define feature types is recommended." (ISO/TC:211, 2001)

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