Chapter 6 From Urban Knowledge to Spatial Metainformation

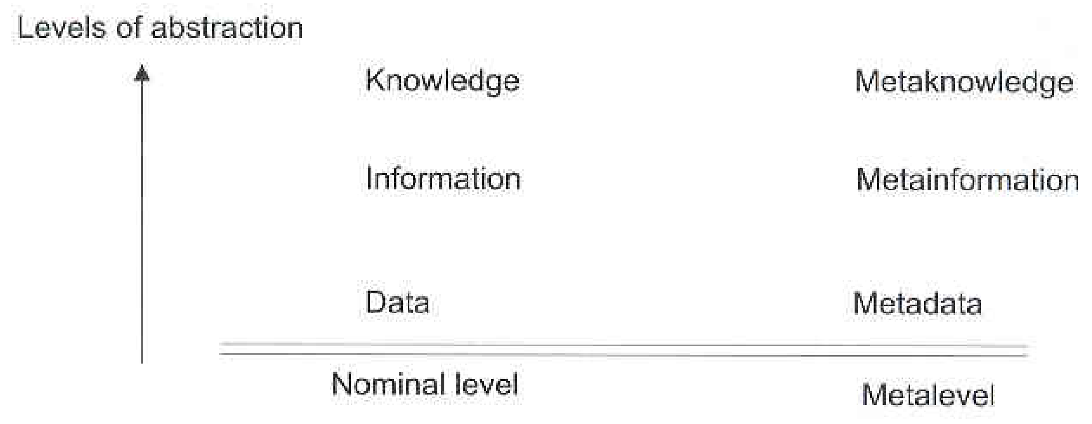

Figure 6.1 Scale of information levels, scale of levels of information about information.

6.1 Generalities

- scale of info level corresponds to scale of meta level

6.2 Knowledge

- knowledge can be decomposed into facts + rules

  facts : single events (e.g. vehicle collision) or single features

  rules : statements that establish a regulation, a process, a method, a principles, a code of conduct, a law ..

  can be written w/ IF-THEN statement
  (e.g. IF a zone is a marshland THEN prohibit construction)

Table 6.1 Knowledge versus data engineering. From Turban and Aronson 1998, p. 205

Dimension	Based on knowledge	Based on data
Processing	Primarily symbolic	Primarily algorithmic
Nature of input	Can be incomplete	Must be complete
Search	Heuristic (mostly)	Algorithms
Explanation	Provided	Usually not provided
Major interest	Knowledge	Data, information
Structure	Separation of control from information (data)	Control integrated with information (data)
Nature of output	Can be incomplete	Must be correct
Maintenance and update	Easy because of modularity	Usually difficult
Reasoning capability	Limited but improving	None

- knowledge vs data engineering

Table 6.2 Comparison of conventional systems and expert systems (Turban and Aronson 1998)

Conventional systems	Expert systems
Information and its processing are usually combined in one sequential program	Knowledge base is clearly separated from the processing (inference) mechanism (that is, knowledge rules are separated from control)
Program does not make mistakes (programmers do)	Program may make mistakes
Do not (usually) explain why input data are needed or how conclusions are drawn	Explanation is part of most Expert Systems
Require all input data. May not function properly with missing data until planned for	Do not require all initial facts. Typically can arrive at reasonable conclusions with missing facts
Changes in the program are tedious	Changes in the rules are easy to make
The system operates only when it is completed	The system can operate with only a few rules (as for the prototype)
Execution is done on a step-by-step (algorithmic) basis	Execution is done by using heuristics and logic
Effective manipulation of large databases	Effective manipulation of large knowledge bases
Representation and use of data	Representation and use of knowledge
Efficiency is a major goal	Effectiveness is the major goal
Easily deal with quantitative data	Easily deal with qualitative data
Use numerical data representations	Use symbolic knowledge representations
Capture, magnify, and distribute access to numeric data or information	Capture, magnify and distribute access to judgement and knowledge

6.3 Expert systems

- a common way of programming

  (different from conventional programming systems)

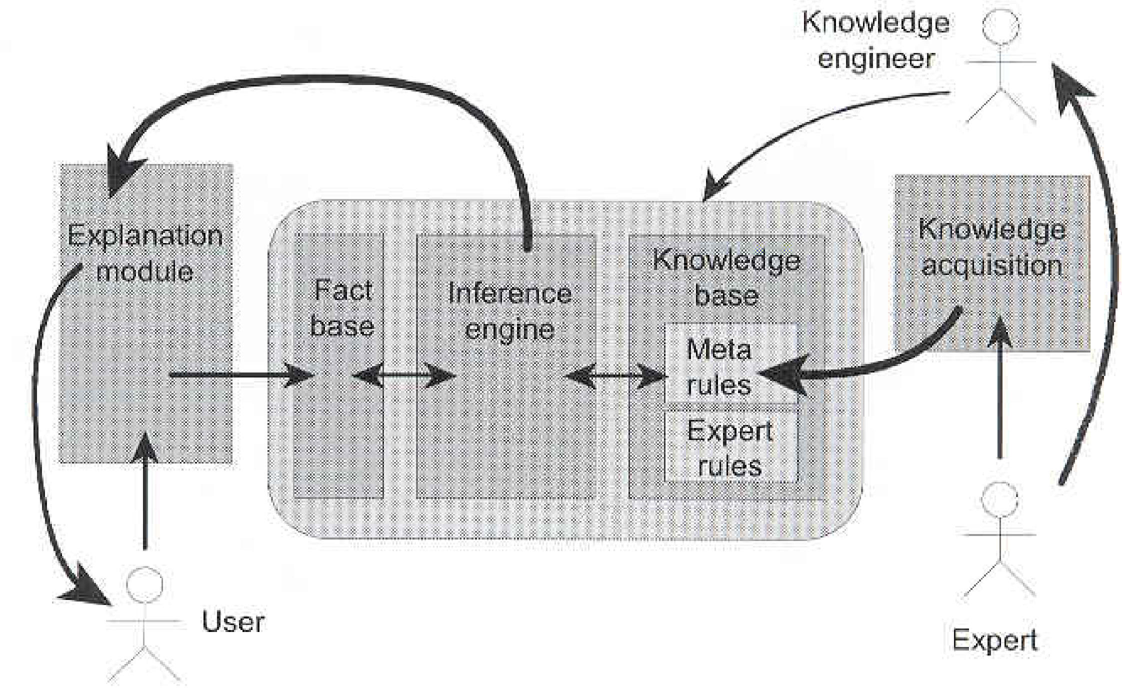

Figure 6.2 General structure of an expert system.

General structure of an expert system

- ES is an integration: a set of rules + a set of facts + inference engine

- three categories of persons are usually involved in the design & use
  * knowledge engineer : access human knowledge & codify

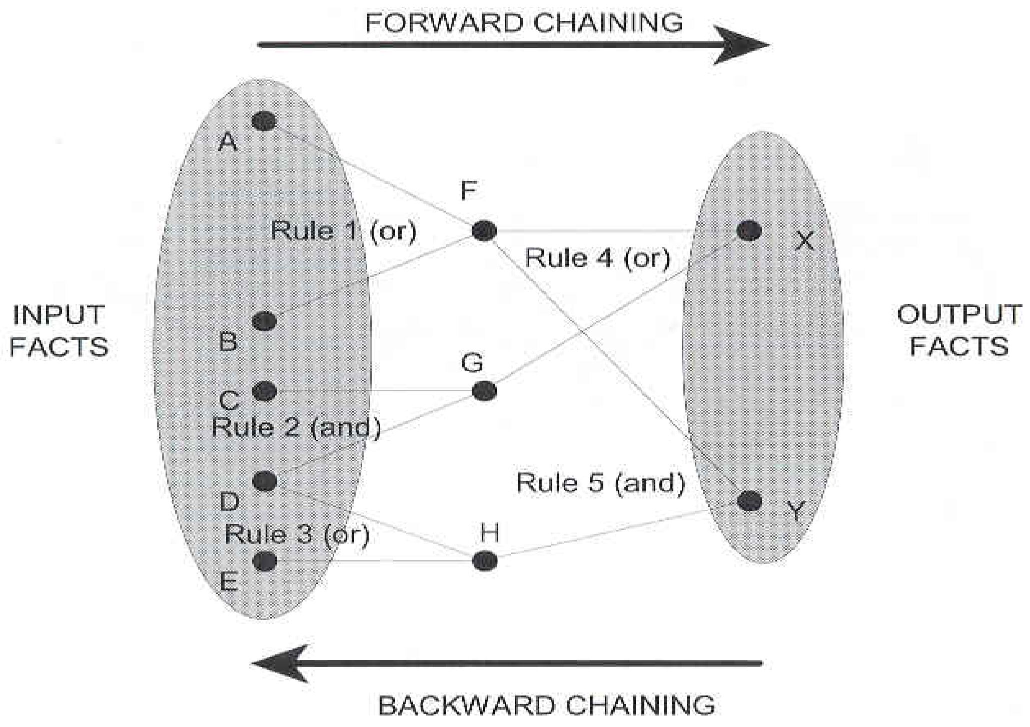

Figure 6.3 Diagram illustrating a set of facts linked with rules.
Laurini and Thompson, 1992.

<u>Inference engine</u>

- role is to reduce some output from facts & rules

- several methods of reasoning can be used

  a. deduction : (P; P→ R) ⇒ R
  if P is true, then P→ R is true, then R is true

  b. abduction : (R; P→ R) ⇒ P
  if R is true & rule P→ R is true, then P is true

  c. transitivity : (P→ Q; →QR) ⇒ (P→R)
  if two rules are true, then P→R is true

- set of deductions : forward chaining
  used for testing the consequences of some starting context
  e.g. what-if reasoning

- set of abductions : backward chaining
  good for diagnosis – to discover the reasons
  generating the observed situations

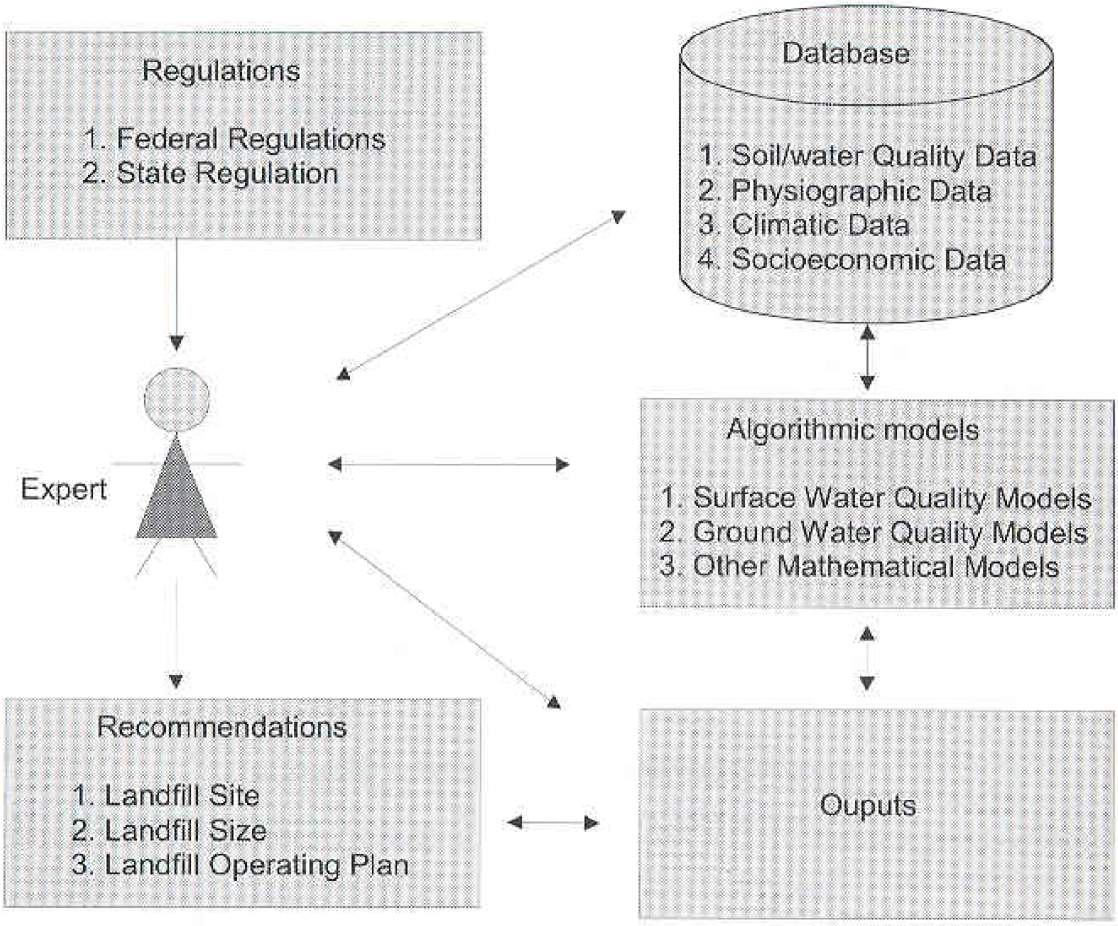

Figure 6.4 Example of the structure of a specialised expert systems.
Rouhani and Kangari 1987.

- example for landfill site selection (figure 6.4)

Use of the expert systems in urban planning

- little use to now
  because the knowledge & rule extraction is difficult,
  integration of spatial geometry & topology into the system is difficult

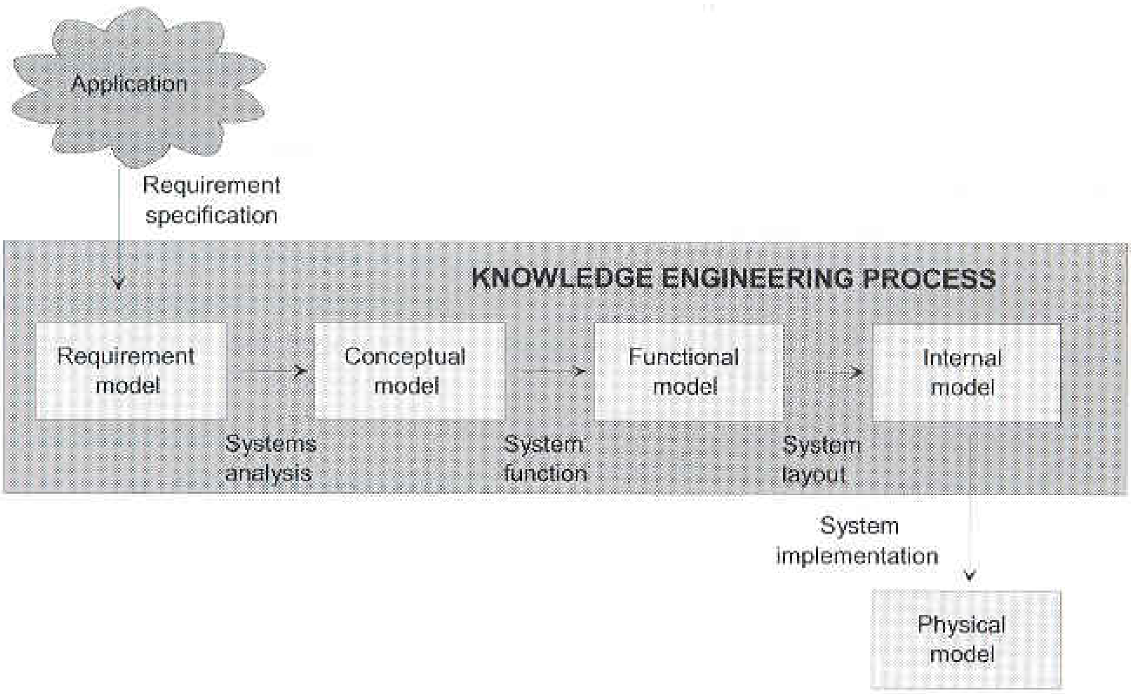

Figure 6.5 The knowledge engineering process.
According to Debenham 1998.

6.4 Knowledge bases

- failure of the ES causes the knowledge engineering
  : design & maintenance of the knowledge based systems

- knowledge in geographic & spatial systems
  a. primitive knowledge : identification of primitives (e.g. point, line)
  b. relationship knowledge : relationship between primitives
  e.g. proximity, orientation, degree of overlap

  c. assembly knowledge : used to define collection of objects
  d. non-visual knowledge : helps to refine classifications
  e. consolidation knowledge : used to resolve & evaluate conflicting info
  f. interpretation knowledge : used for understanding or reasoning

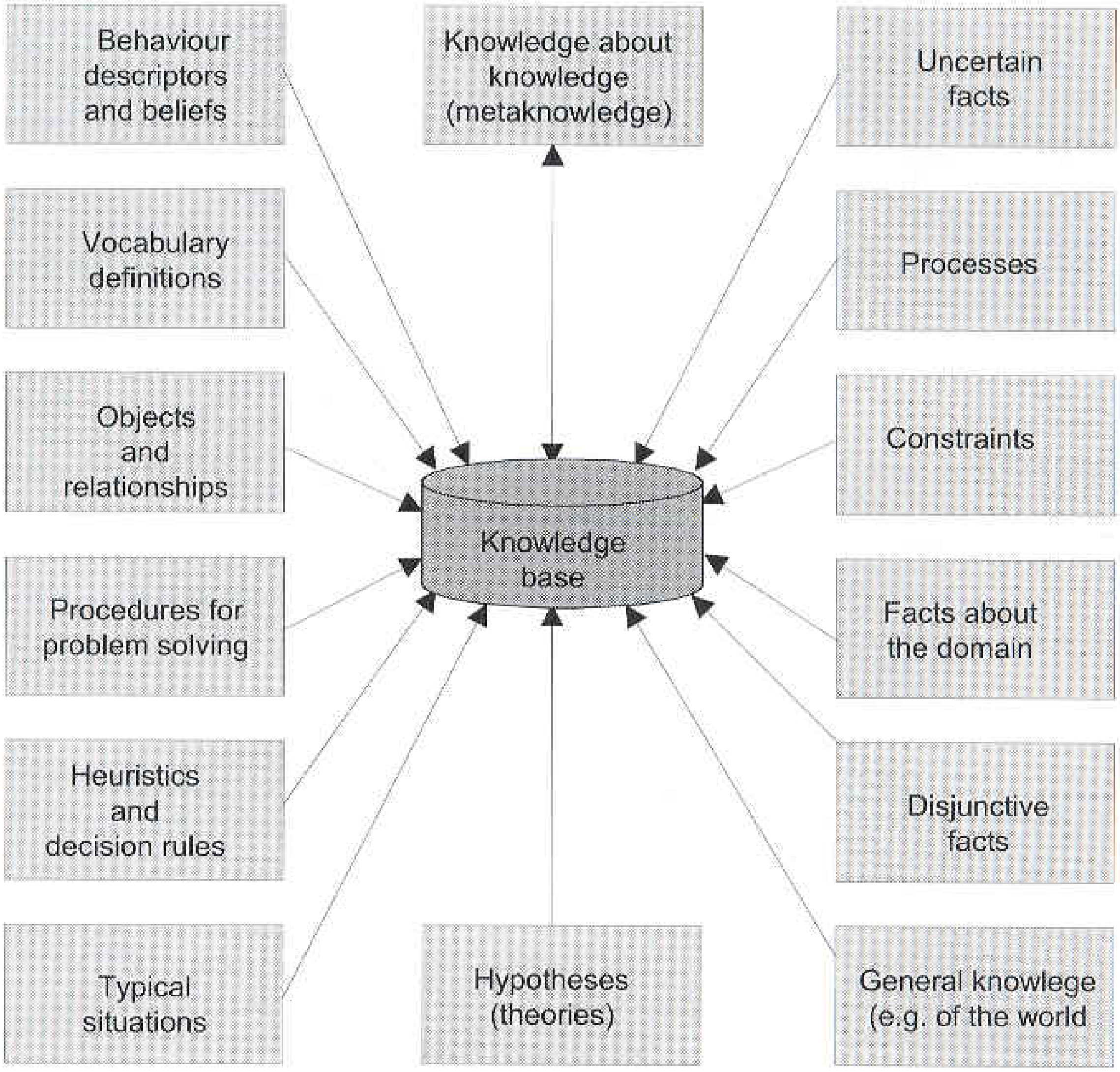

Figure 6.6 Type of knowledge to be represented in the knowledge base. According to Turban and Aronson 1998.

- various origins of knowledge

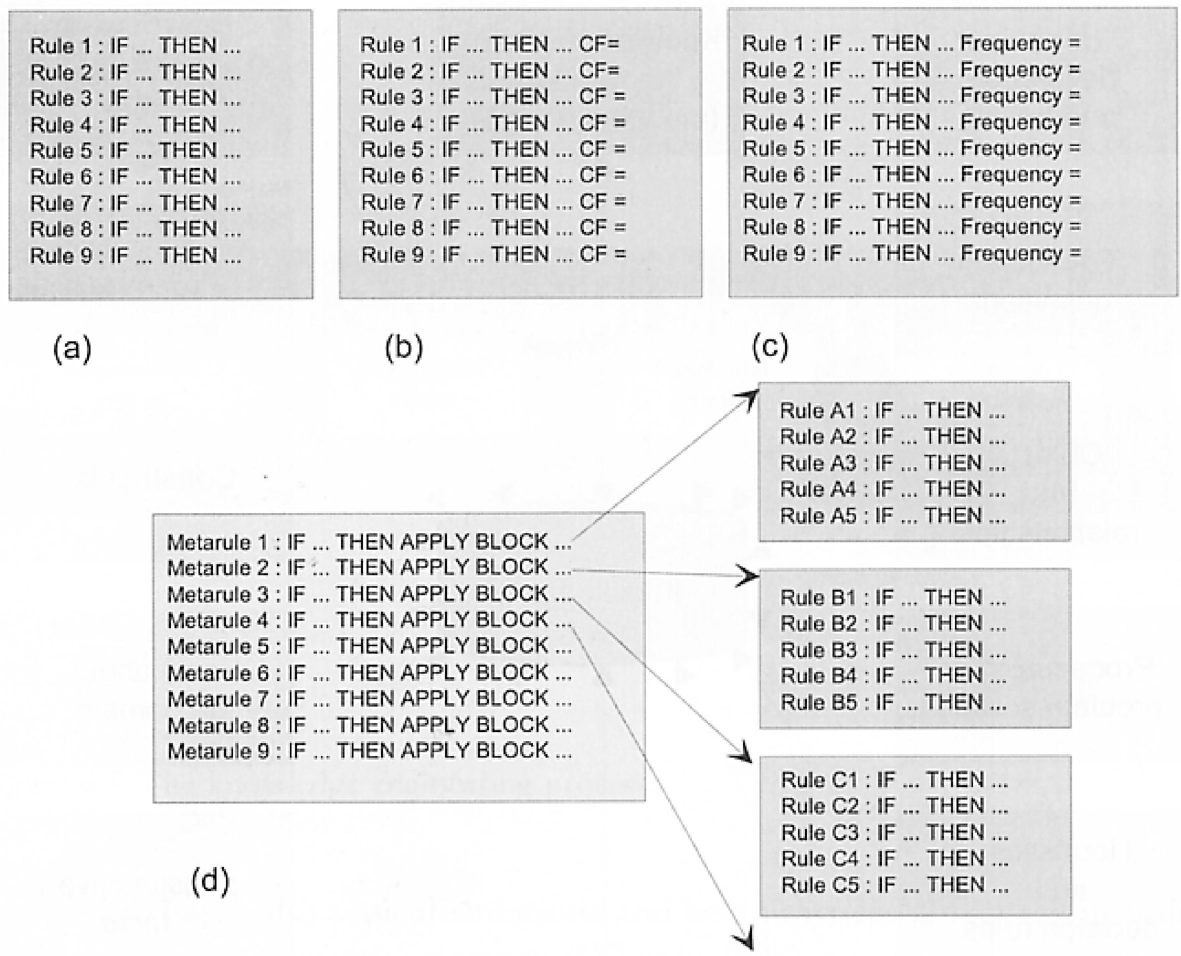

Figure 6.7 Several organisations of a rule base. (a) The sequential organisation. (b) The sequential organisation with certainty factors. (c) The sequential organisation in which rules are sorted by frequency. (d) The metarule organisation.

Metarules

- an expert system can possess metarules

- metarules : rule concerning knowledge

  e.g. a procedure for selecting other rules

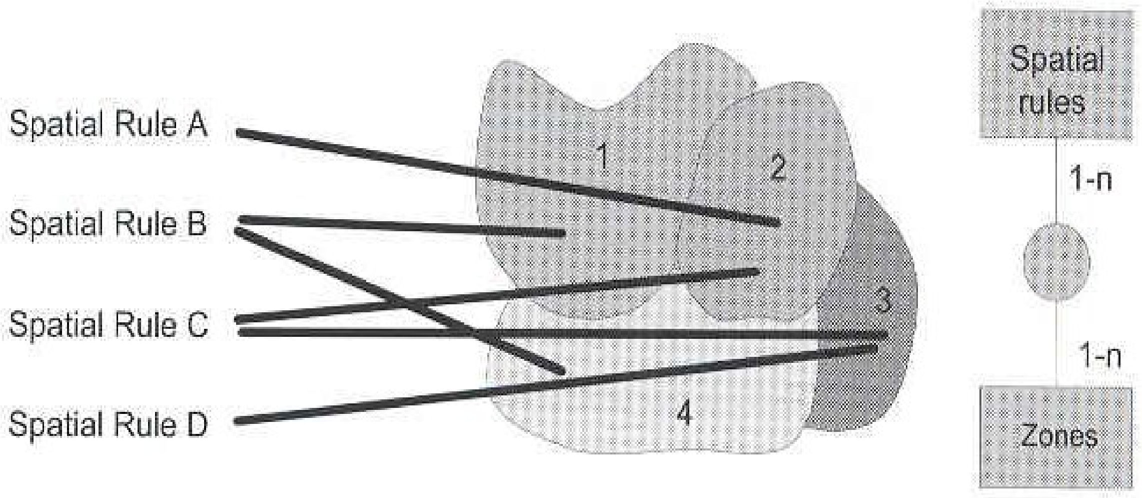

Figure 6.8 Correspondence between spatial rules and zones.

Spatial metarules

- using the areal units, spatial rules can be applied to several zones
- this task requires point-in-polygon query to be solved
  e.g. IF(x,y) belongs to Zone1 THEN rule B is applicable

Table 6.3. Measures of validation of a knowledge base (Turban and Aronson 1998 p. 516)

Measure (criteria)	Definition
Accuracy	How well the system reflects reality, how correct the knowledge is in the knowledge base
Adaptability	Possibilities for future development changes
Adequacy (completeness)	Portion of the necessary knowledge that is included in the knowledge base
Appeal	How well the knowledge base matches intuition and stimulates thought and practicability
Breadth	How well the domain is covered
Depth	Degree of the detailed knowledge
Face validity	Credibility of knowledge
Generality	Capability of a knowledge base to be asked with a broad range of similar problems
Precision	Capability of the system to replicate particular system parameters, consistency of advice, coverage of variables in knowledge base
Realism	Accounting for relevant variables and relations, similarity to reality
Reliability	Fraction of the expert system predictions that are empirically correct
Robustness	Sensitivity of conclusions to model structure
Sensitivity	Impact of changes in the knowledge base on quality of outputs
Technical and operational validity	Quality of the assumed assumptions, context, constraints and conditions, and their impact on other measures
Turing test	Ability of a human evaluator to identify whether a given conclusion is made by an expert system or by a human expert
Usefulness	How adequate the knowledge is (in terms of parameters and relationships) for solving correctly
Validity	Knowledge base's capability of producing empirically correct predictions

Knowledge consolidation & validation

- knowledge can come from totally different sources

  -> needs some consolidation & validation procedures

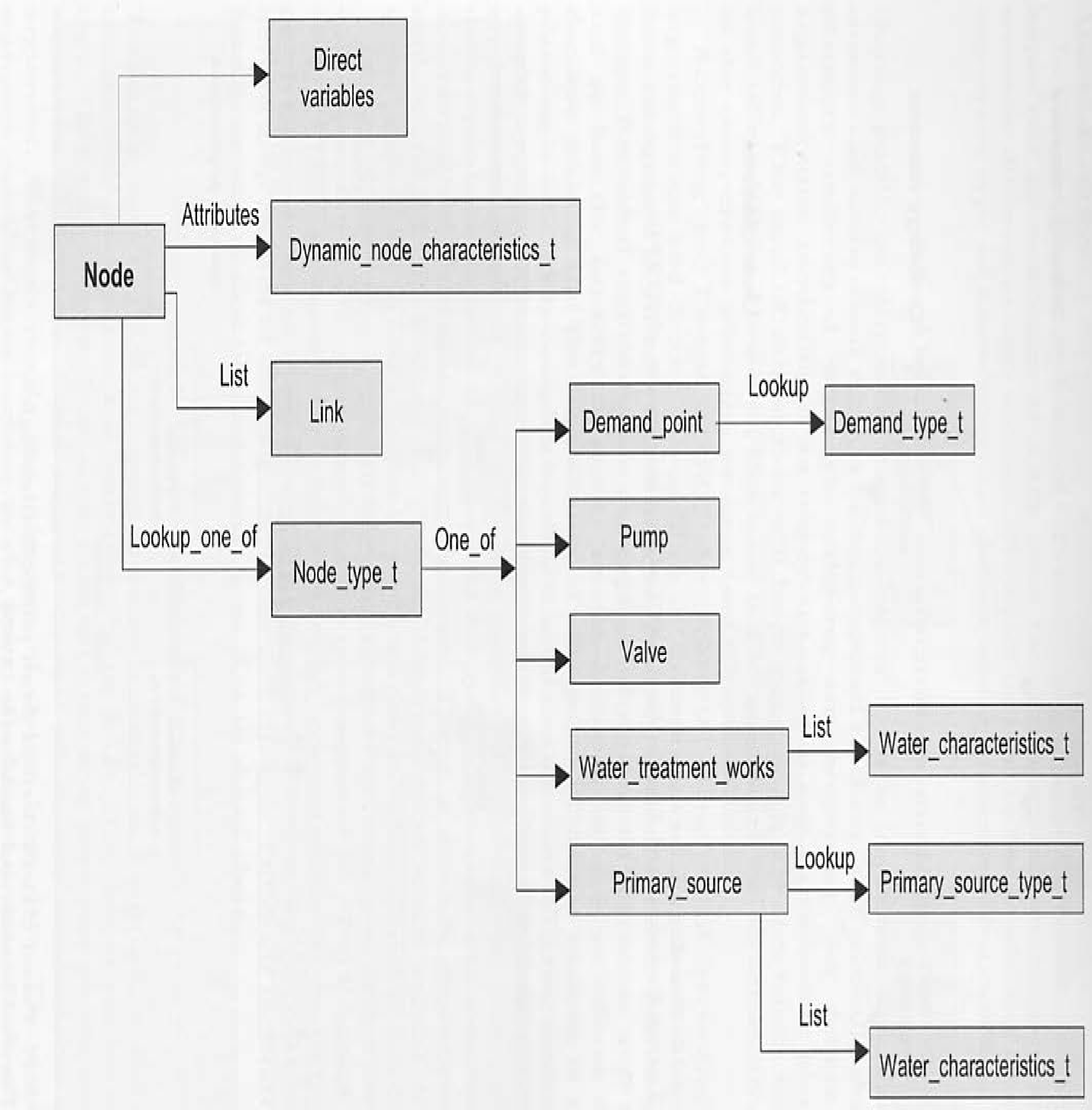

Figure 6.9 An excerpt from an ontology approximation on underground water resources. From Hadzilacos *et al.* 2000.

6.5 Ontologies

- description of the concepts & relationships
- ontological commitment – an agreement to use a vocabulary – is required to guarantee consistency

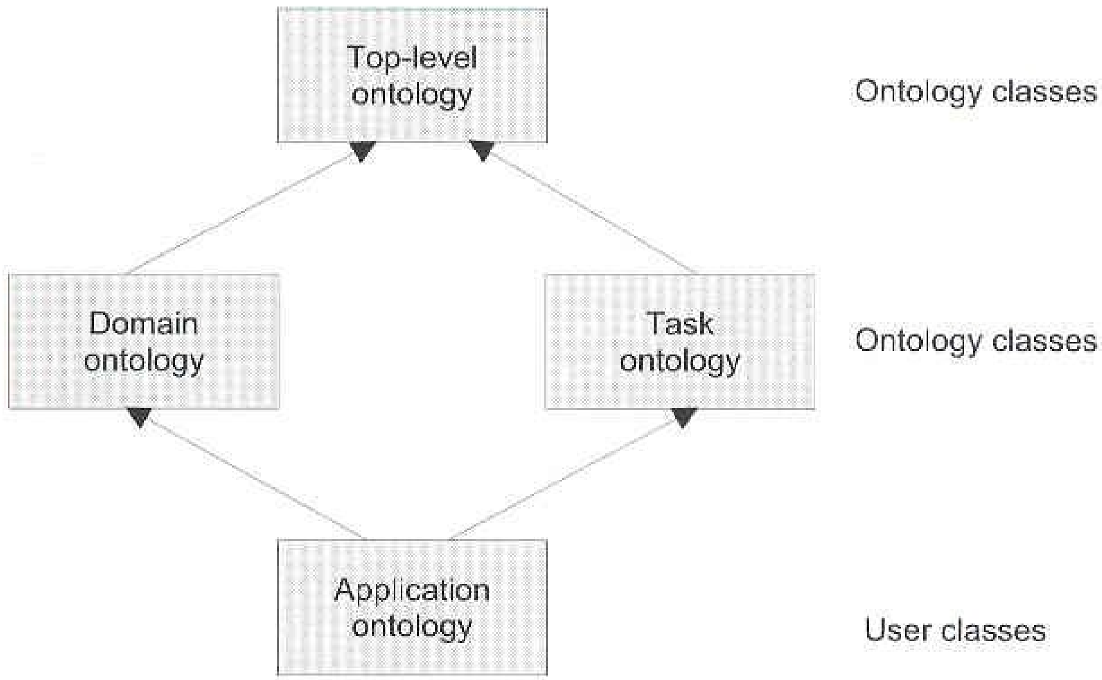

Figure 6.10 Ontologies organisations.
From Torres-Fonseca and Egenhofer (2000) after Guarino *et al.* (1994).

- relationship between several types of ontologies

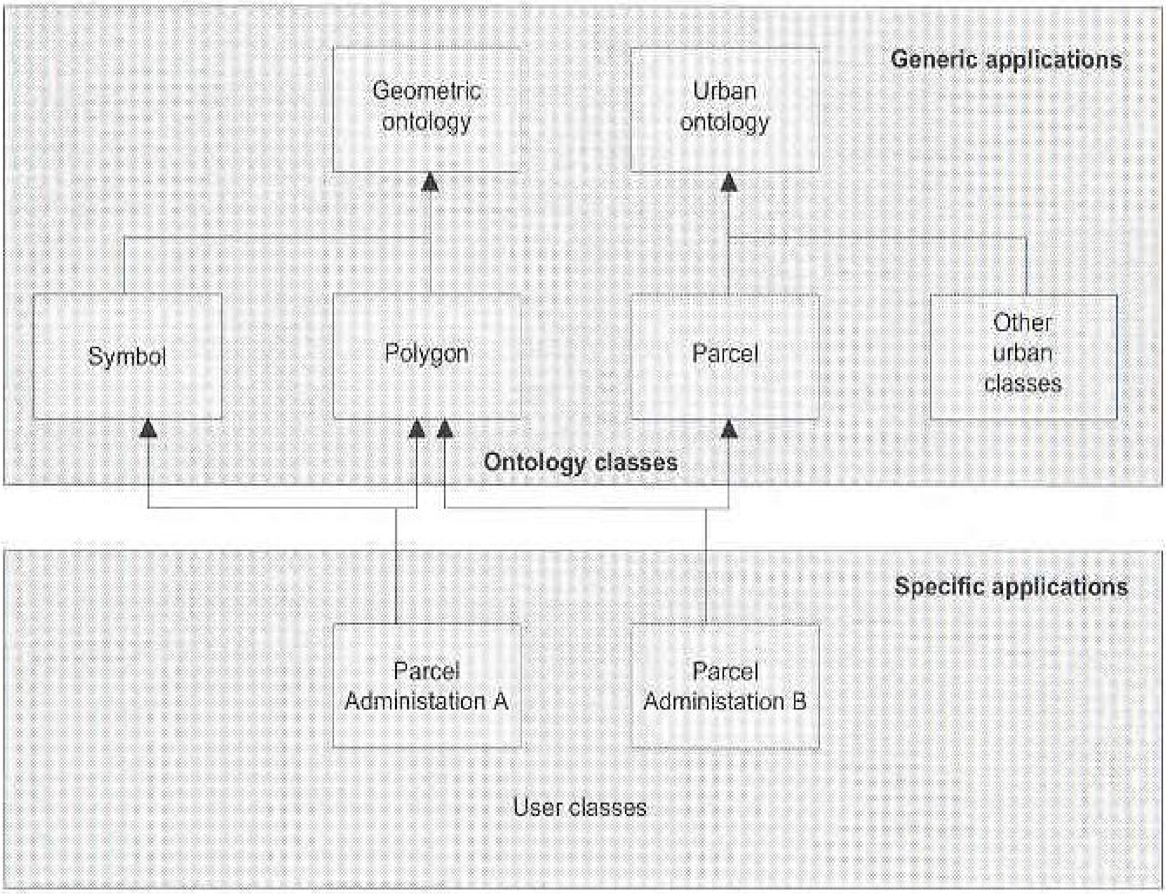

Figure 6.11 Parcel classes derived from multiple ontologies.
After Torres-Fonseca and Egenhofer (1999).

- example : two applications need different definitions of a parcel

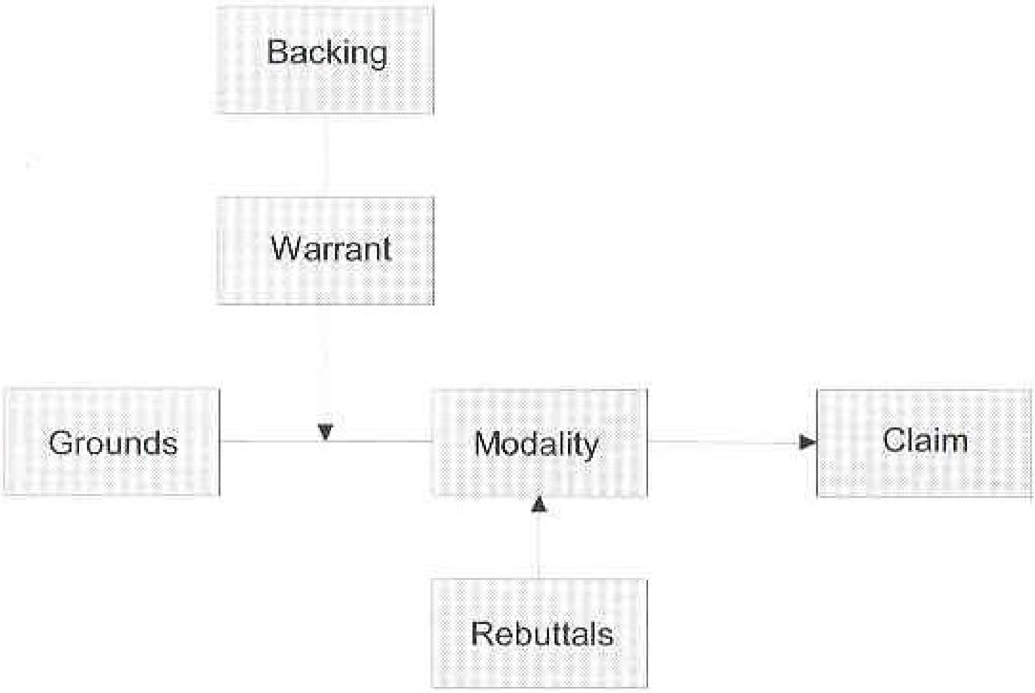

Figure 6.12 Toulmin's structure for representing argumentation.

6.6 Debates & argumentation modeling

- important issue in any participative planning process

- Toulmin's model of argumentation

  : simple in structure – claims, data, warrants

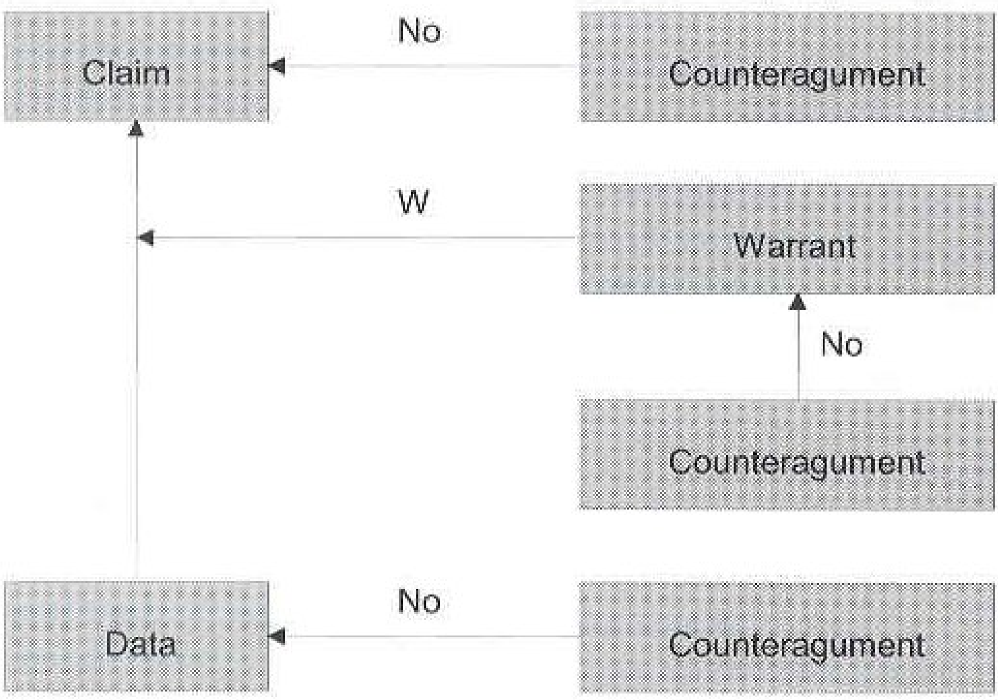

Figure 6.13 Gottsegen's model with counterarguments (Gottsegen 1998).

- Gottsegen's model w/ counterarguments

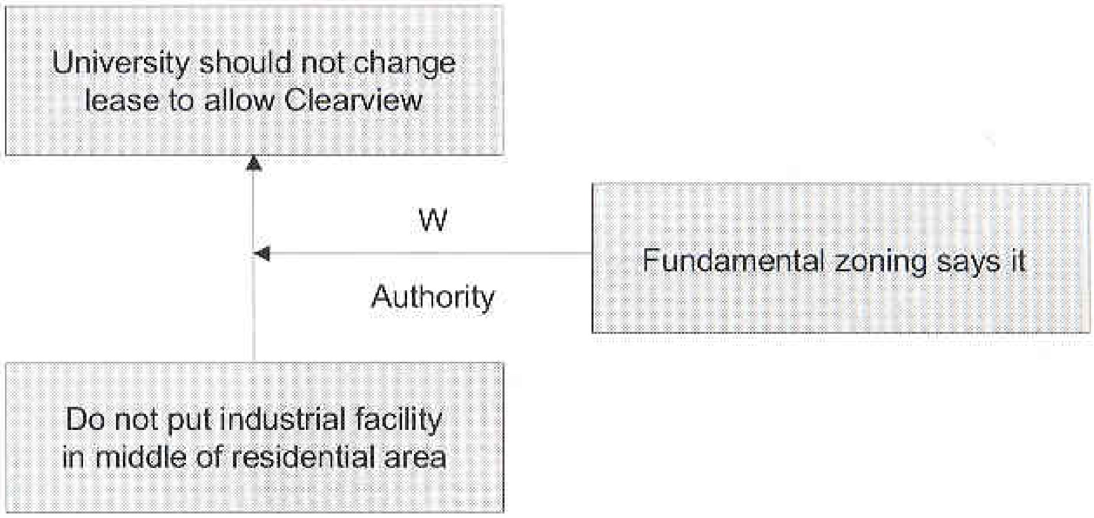

Figure 6.14 Example of subargument.

- subargument : data-warrant-claim units

  e.g. UC-Santa Barbara : construction of a slant drilling facility for oil retrieval in campus

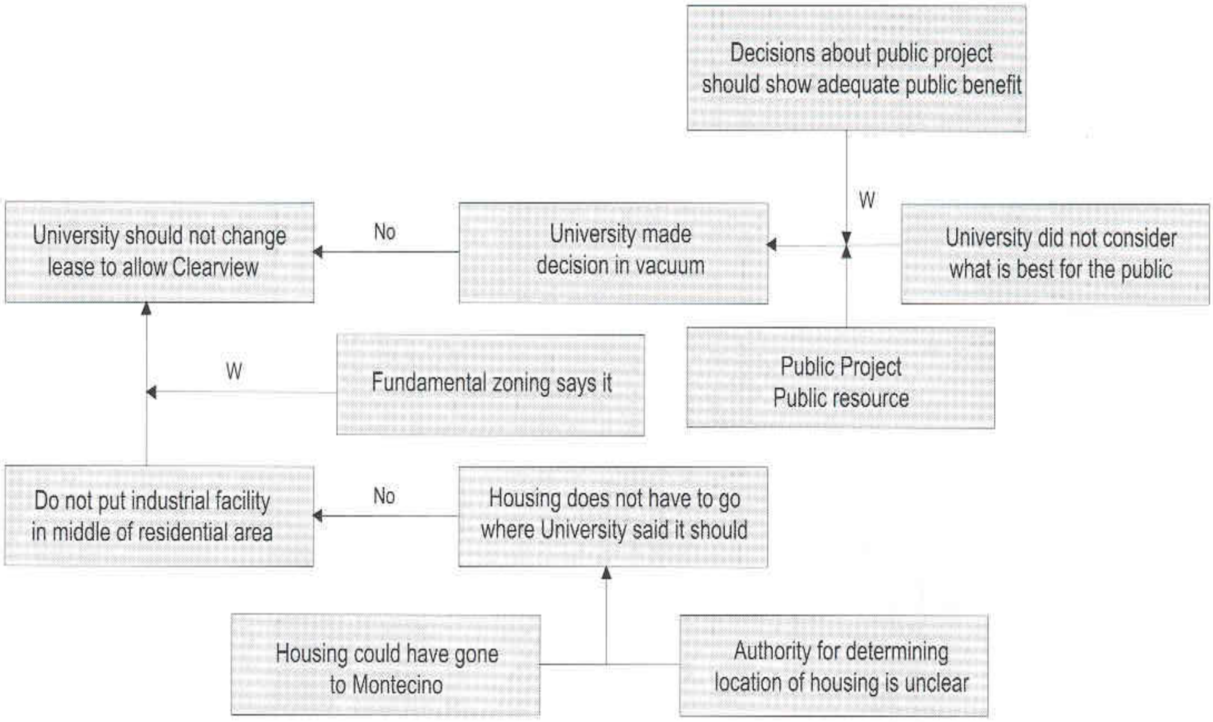

Figure 6.15 Representation of a debate (Gottsegen 1998).

- more detailed explanation of the subargument

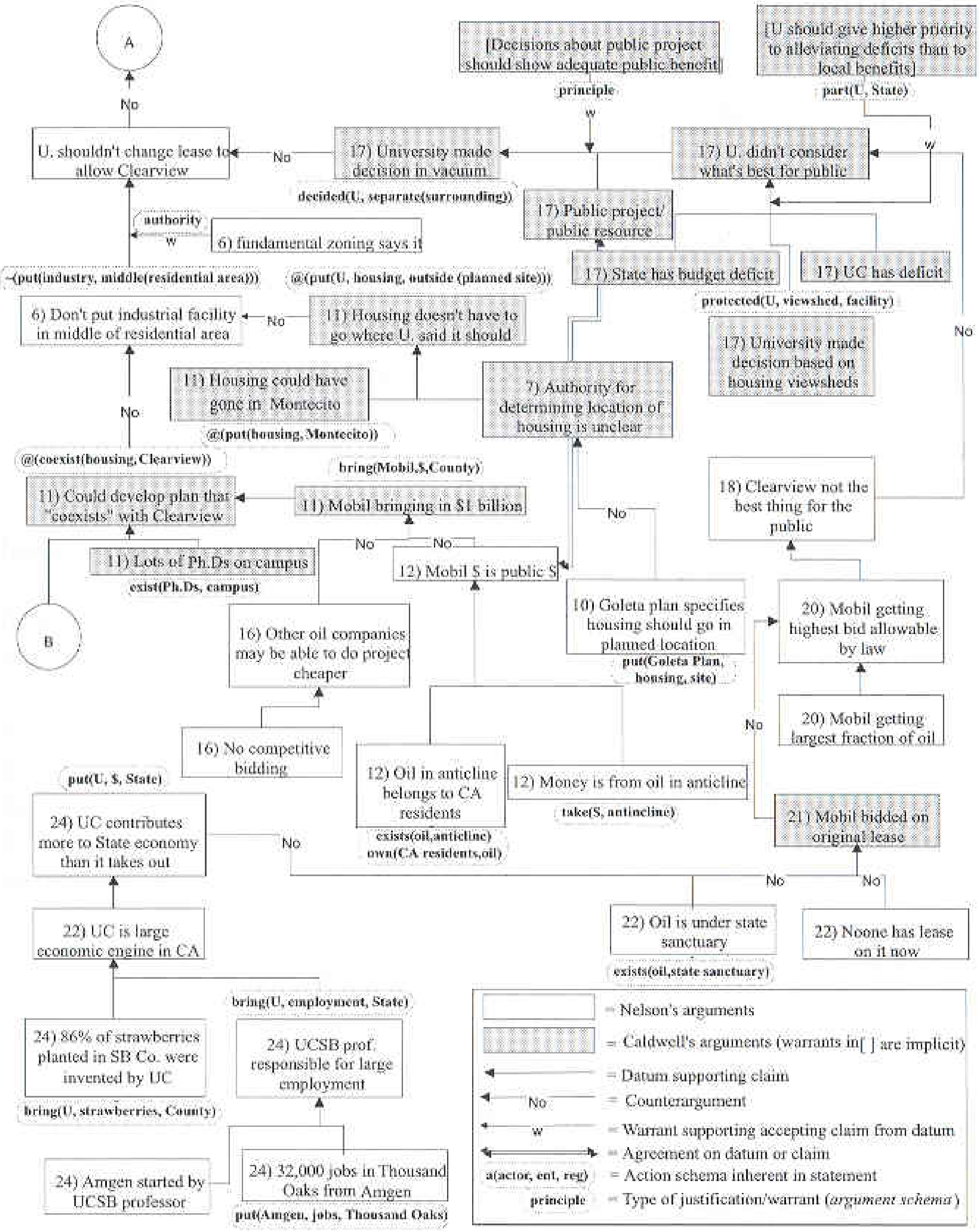

Figure 6.16 Analysis of portion of Clearview Debate (Gottsegen 1998).

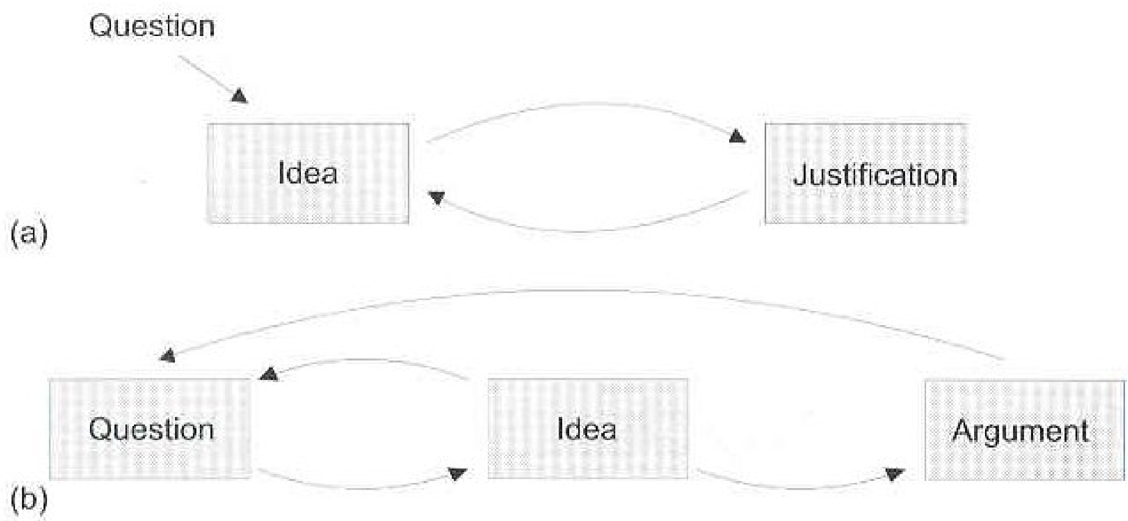

Figure 6.17 Basics of IBIS. (a) Feedbacks between ideas and justification. (b) Links between question, idea and arguments.

<u>From IBIS to Tweed</u>

- IBIS (Issue-Based Info Sys)

- all conversations / issues in IBIS consist of
  a. 'question' states a question
  b. 'idea' proposes a resolution for the question
  c. 'argument' states an opinion / judgement

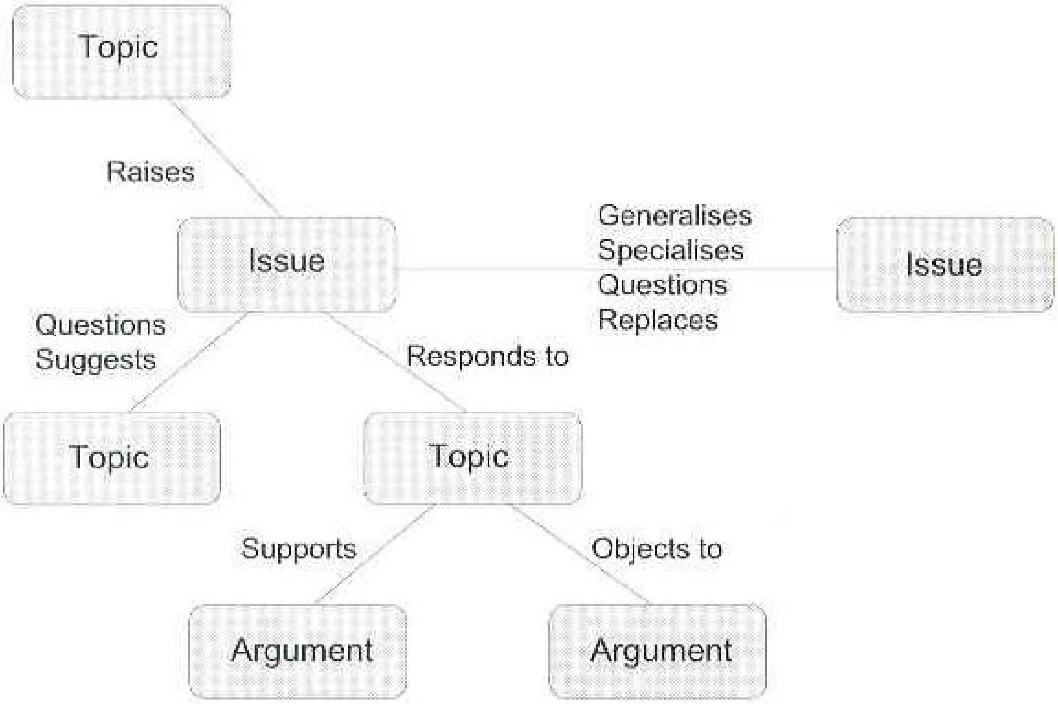

Figure 6.18 IBIS representation of issues.
According to Tweed (1998).

- IBIS provides a set of nodes & links to construct networks of argu

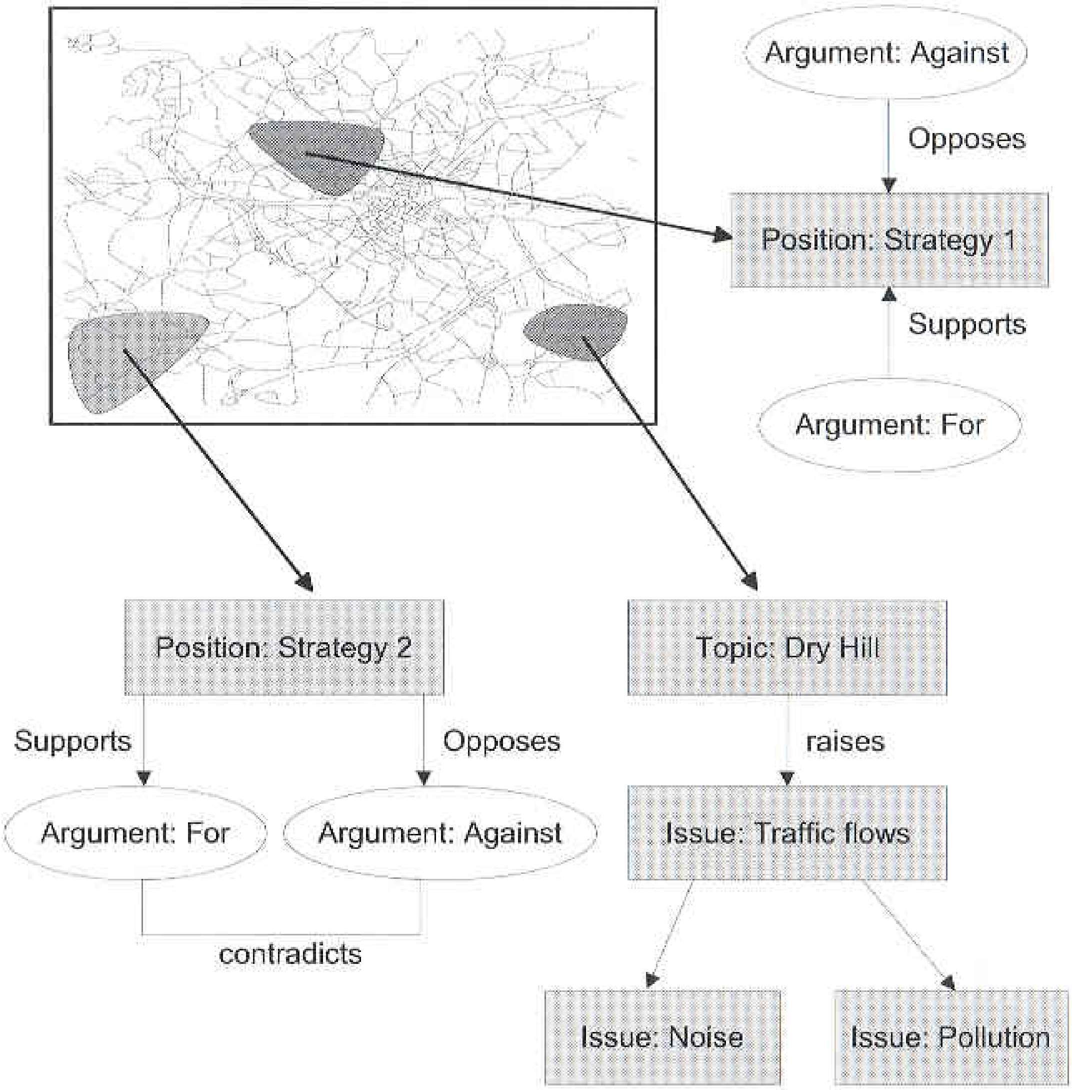

Figure 6.19 Part of an argumentation network for road development strategies.

- gIBIS system : graphical browser + structured index + inspection window + control panel
  -> networks of argu are displayed as graphical elements

- Tweed(1998) combined gIBIS w/ hypermaps

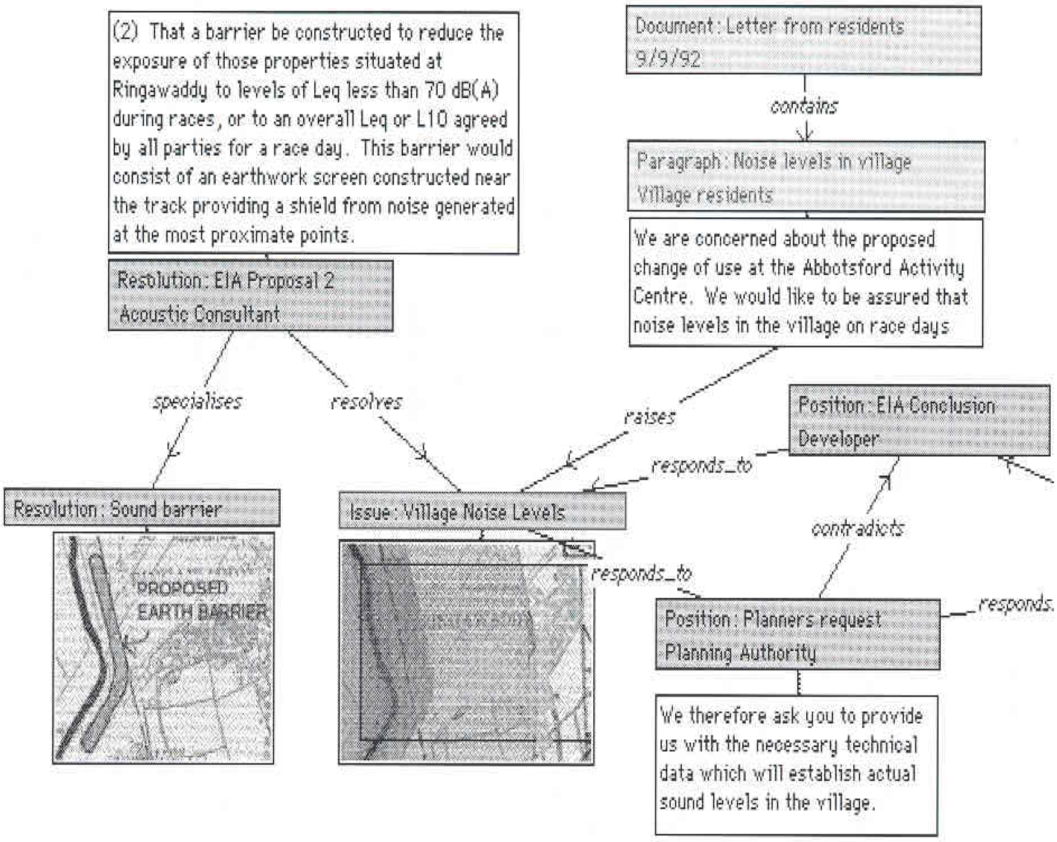

Figure 6.20 Example of an argumentation network with the hybrid model.
Reprinted from *Computers, Environment and Urban Systems* 22 4, C. Tweed 'Supporting Argumentation Practices in Urban Planning and Design' 351–63 © 1998, with permission from Elsevier Science.

- argumentation network

  e.g. motor sport racetrack construction vs noise level increase

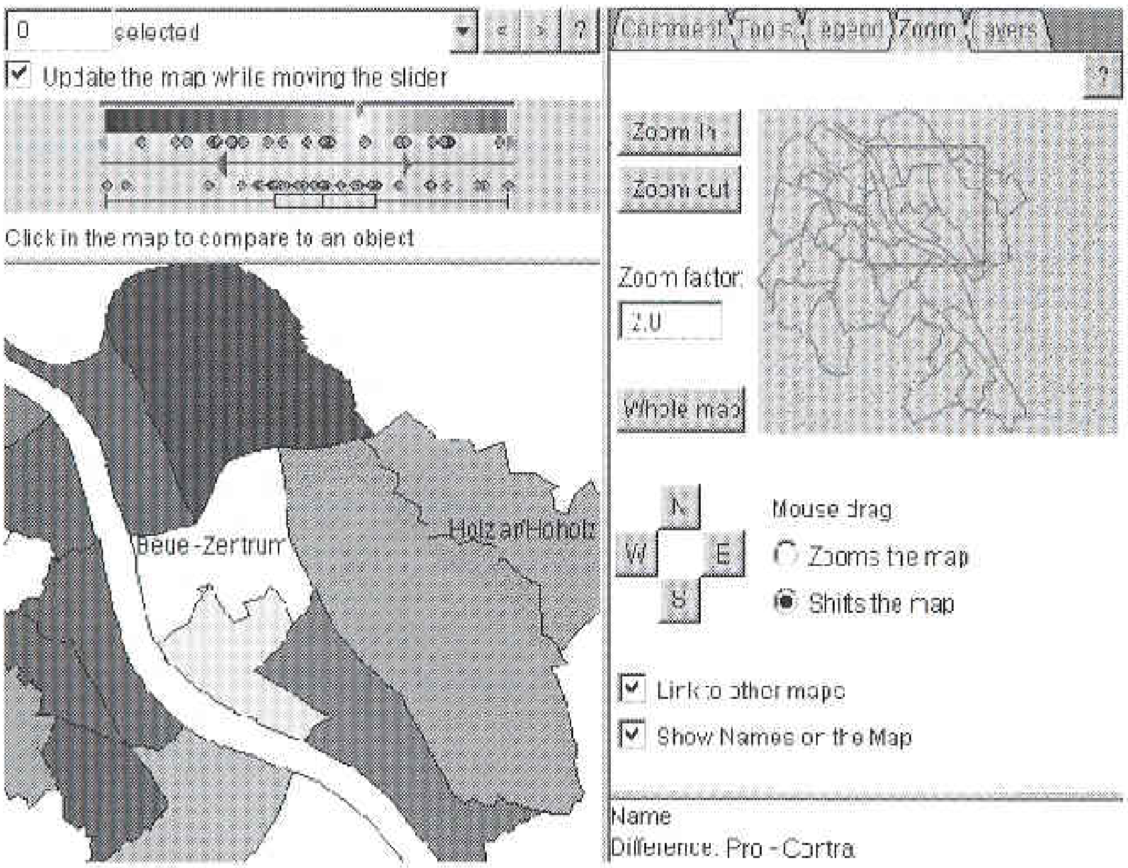

Figure 6.21 Argumap exploration with Descartes (Rinner 1999). Published with permission.

<u>Argumaps</u>

- based on argumentation & hypermaps
- advance the level of integration & utility of electronic discussion forum

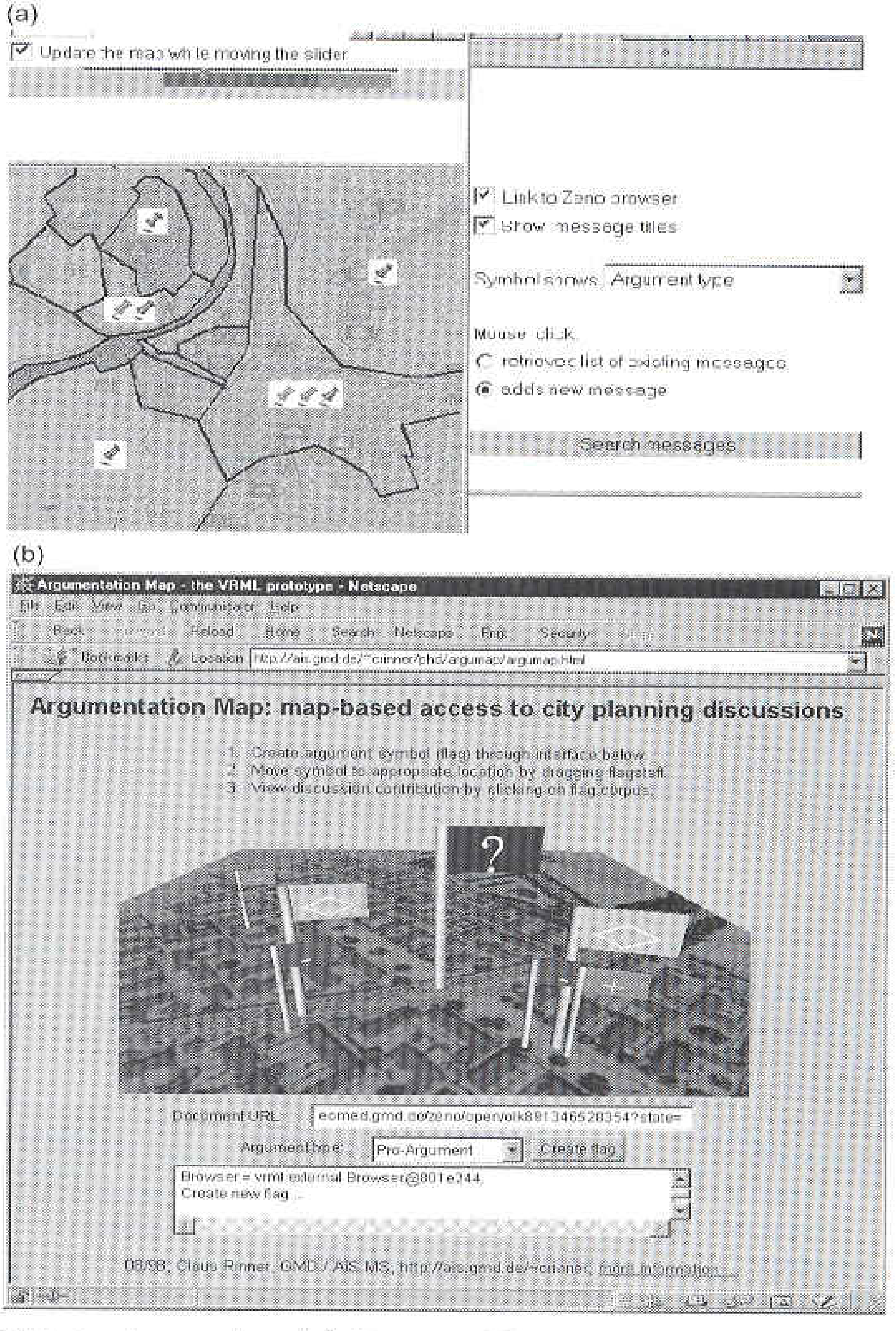

Figure 6.22 Navigation session with Descartes (Rinner 1999). (a) By pin-pointing arguments. (b) With flags.
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- two modes of locating the arguments

Table 6.4. The Metadata environment (O'Brien 1999)

		Catalogue	Where Within datasets	Historical records	Textual reports
Applications	Discover Evaluate Access Exploit				

6.7 Metadata & metainformation

- Devlin(1997) defines metadata as

  data that describe the meaning & structure of business data

  describe how it is created, accessed, used

- three types of metadata

  a. build-time metadata

  : created & used in the process of application / DB design & const

  b. control metadata

  : used to control the operations related to the DB / data warehouse

  timeline metadata – info about the timeliness of planning data

  utilization metadata – mostly related w/ security & authorization

  c. usage metadata

  : support enduser's use & understanding of the planning data

- environment of metadata

  : detailing the kind & location of description

  e.g. there are multiple ways of storing metadata

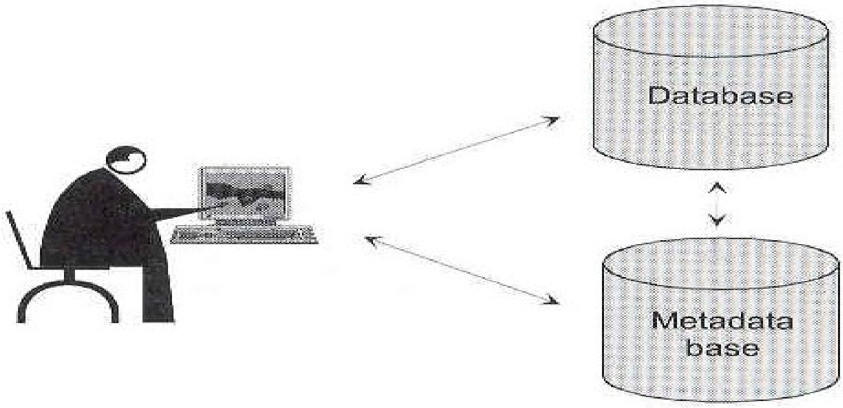


Figure 6.23 Relationships between the user, the database and the metadatabase.

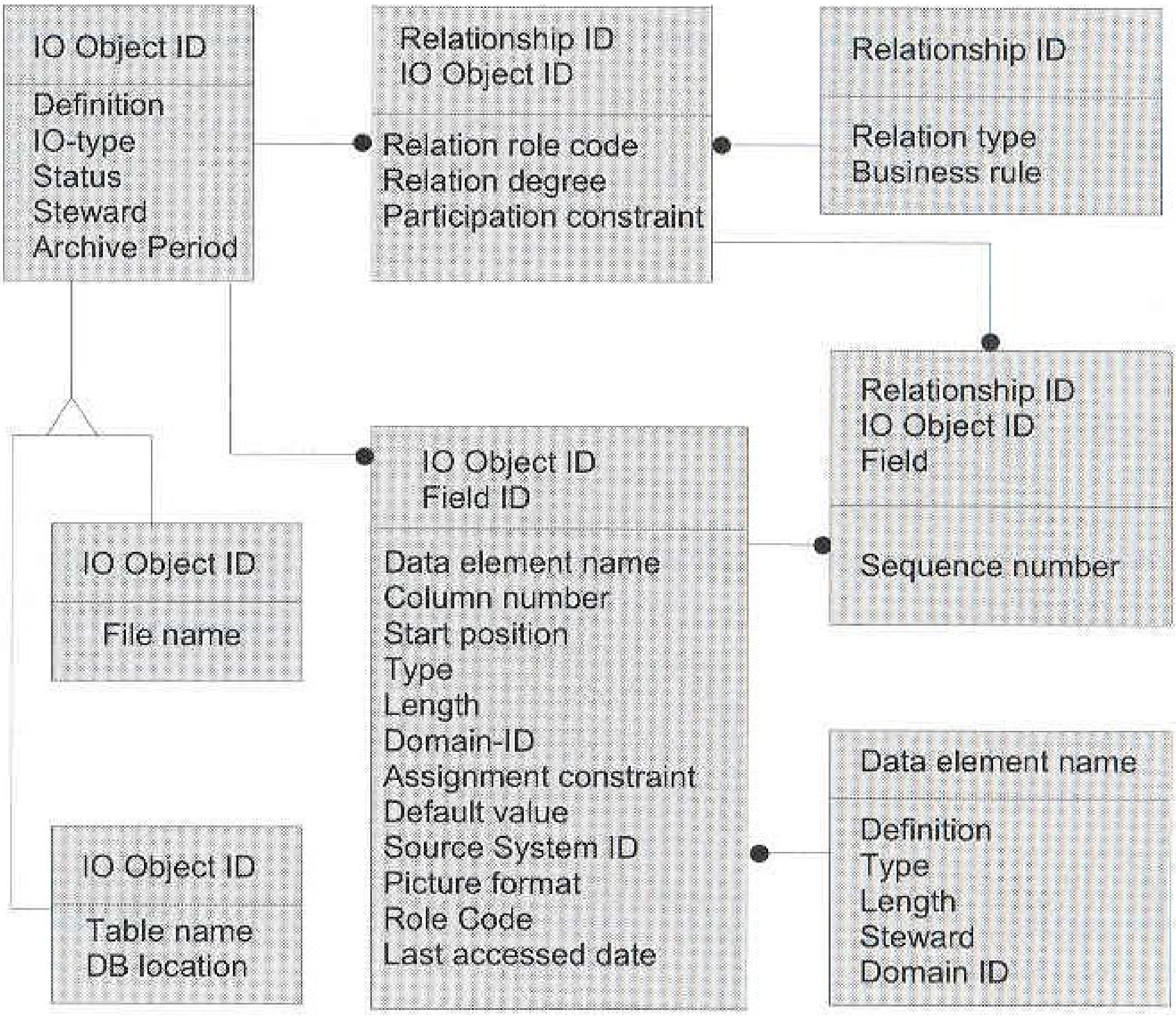


Figure 6.24 Metadata model describing the contents of the datawarehouse. After Barquin and Edelstein (1997) with modifications.

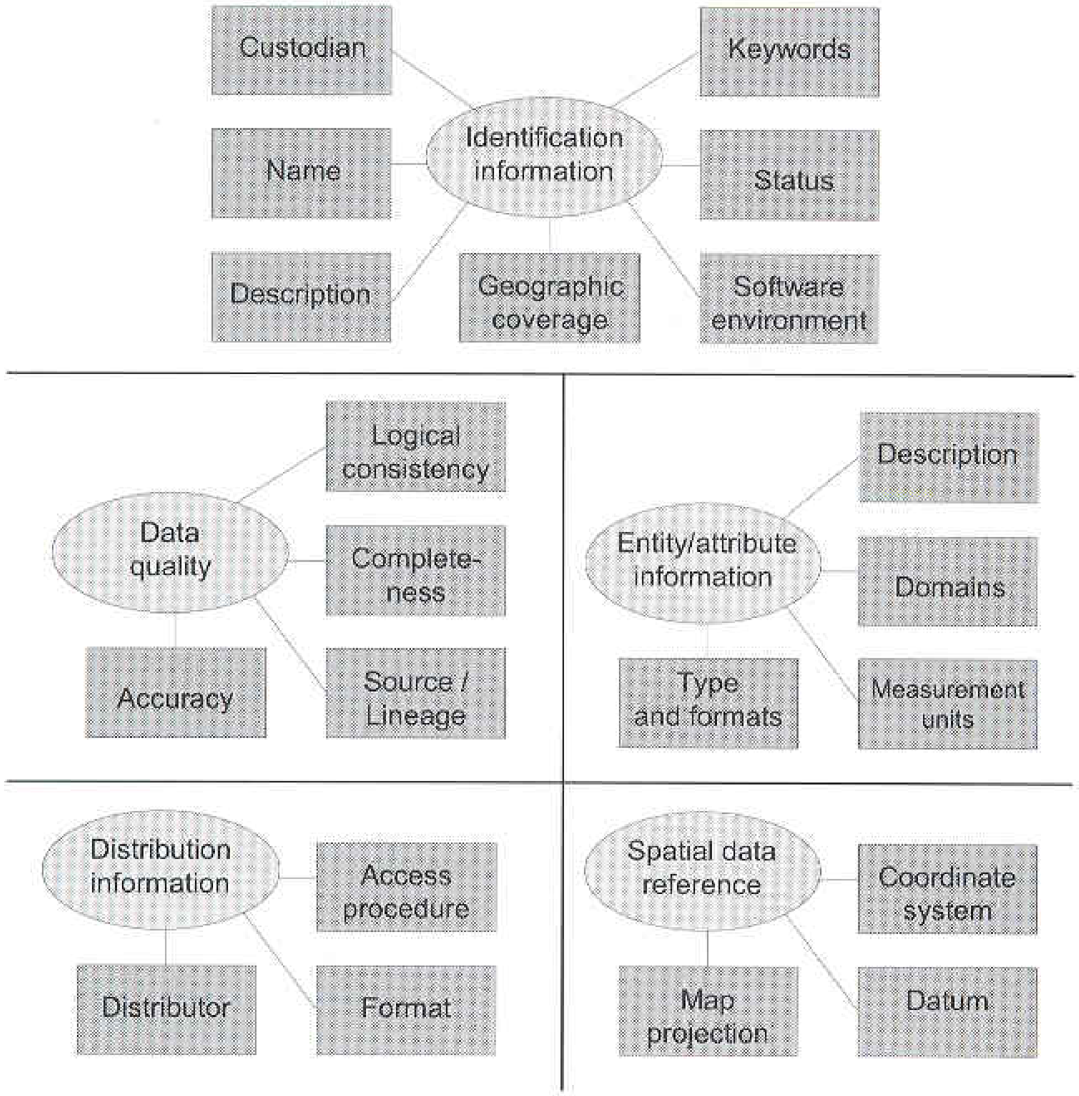


Figure 6.25 Overview of the FGDC Metadata Content Standard.

6.8 Spatial metainformation

- USA : FGDC metadata standard

  -> CSDGM (Content Standard of Digital Geospatial Metadata) v.2

  -> used for draft for the development of ISO TC211 standard

- ISO & OGC set up class A liaison

- Europe : CEN/ENV (European standard)

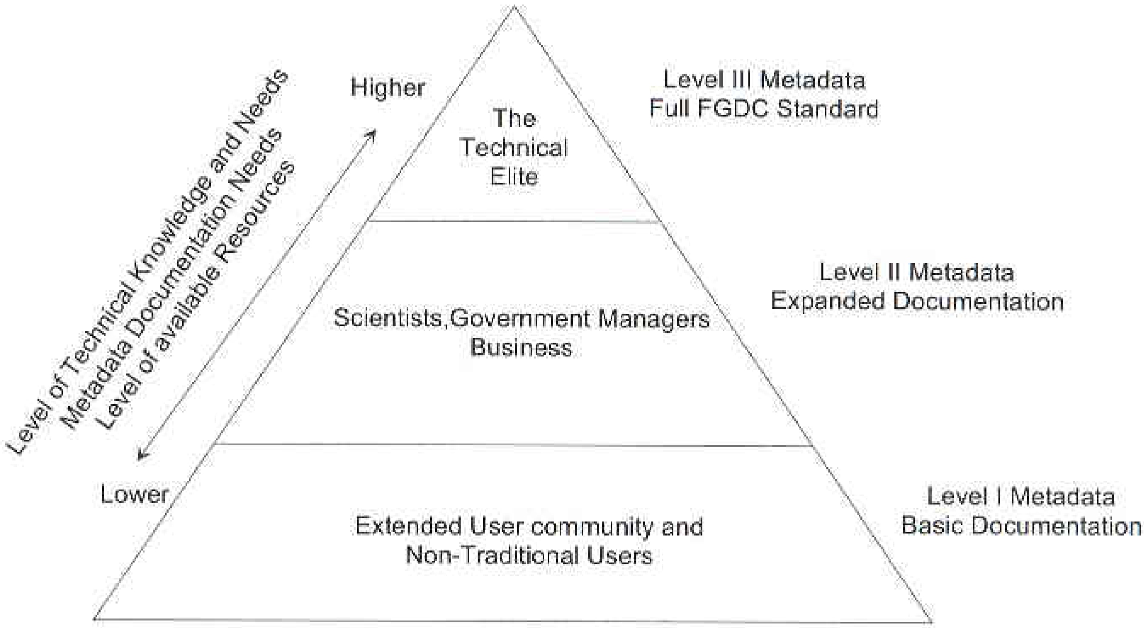


Figure 6.26 Levels of metadata.
Introduced by Foresman *et al*. (1996).

- different user profiles according to some expertise level
  a. simple users who do not need very detail info
  b. decision makers who have a very broad knowledge of the domain
  c. experts who master the specifications & structure of info

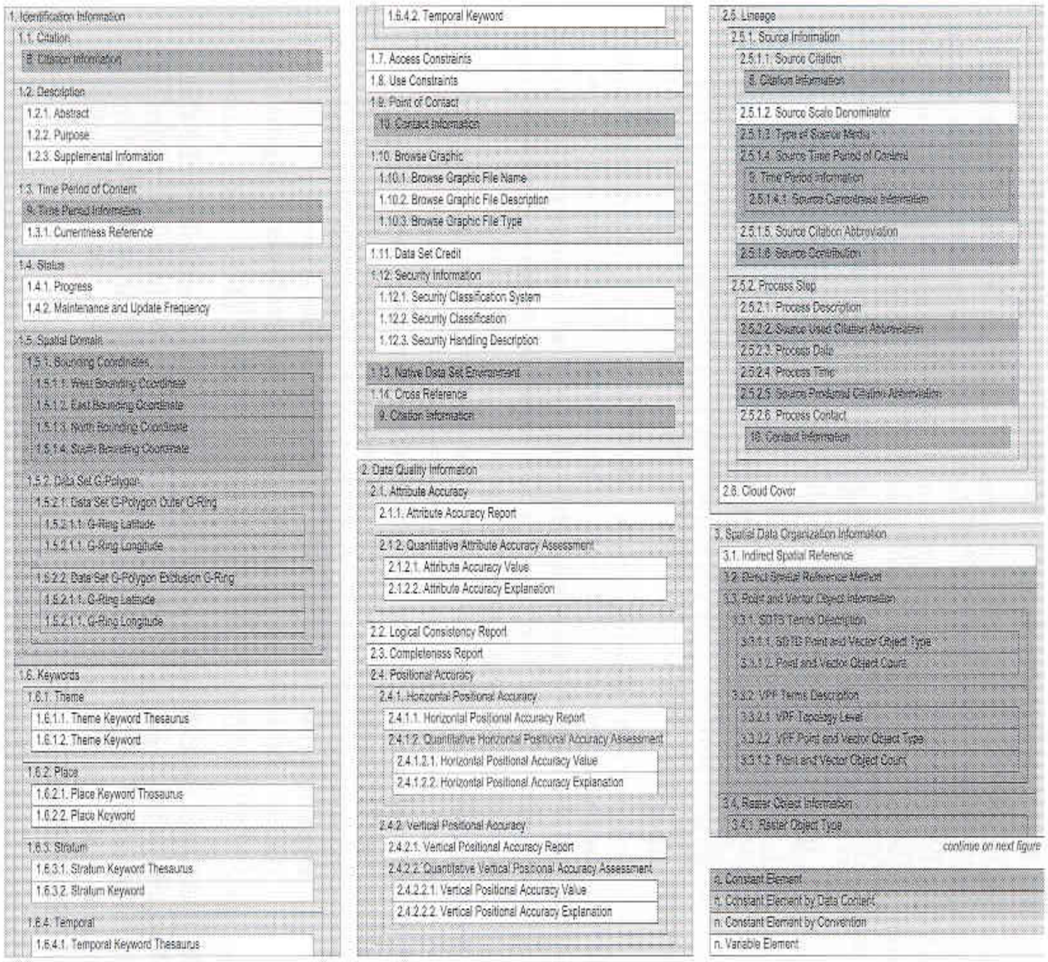
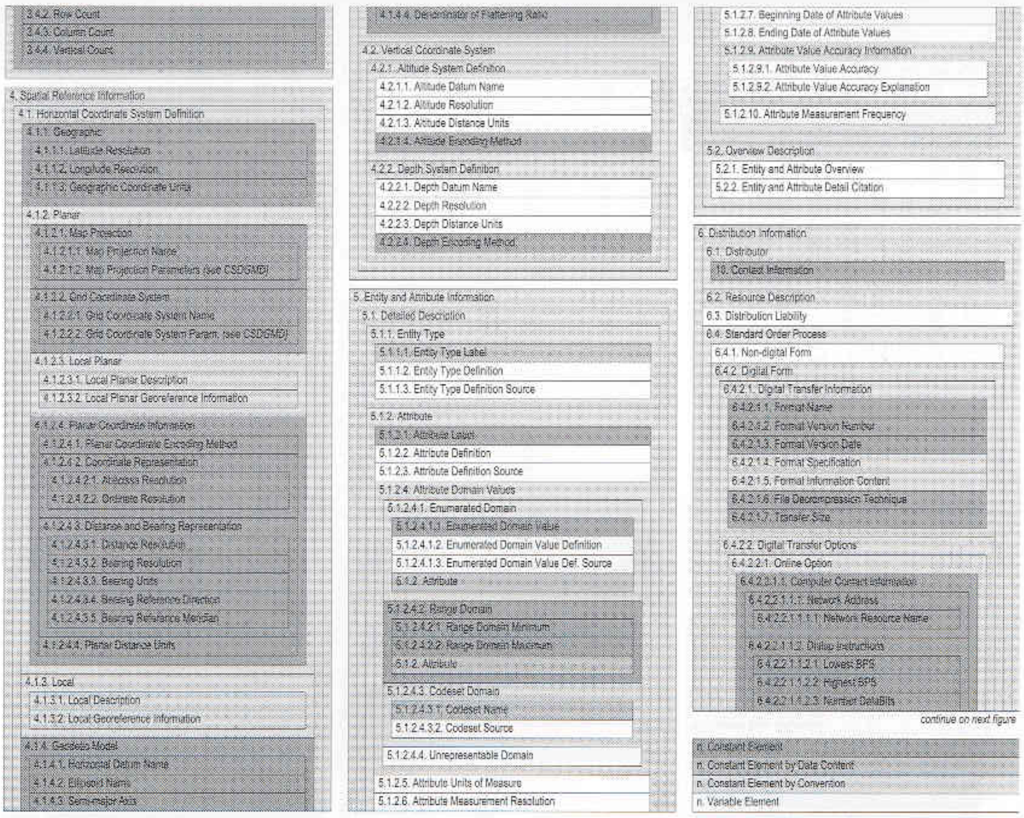


Figure 6.27 Classification of constants and variable element of the American standard for metadata. According to Hedorfer and Bianchin (1998).



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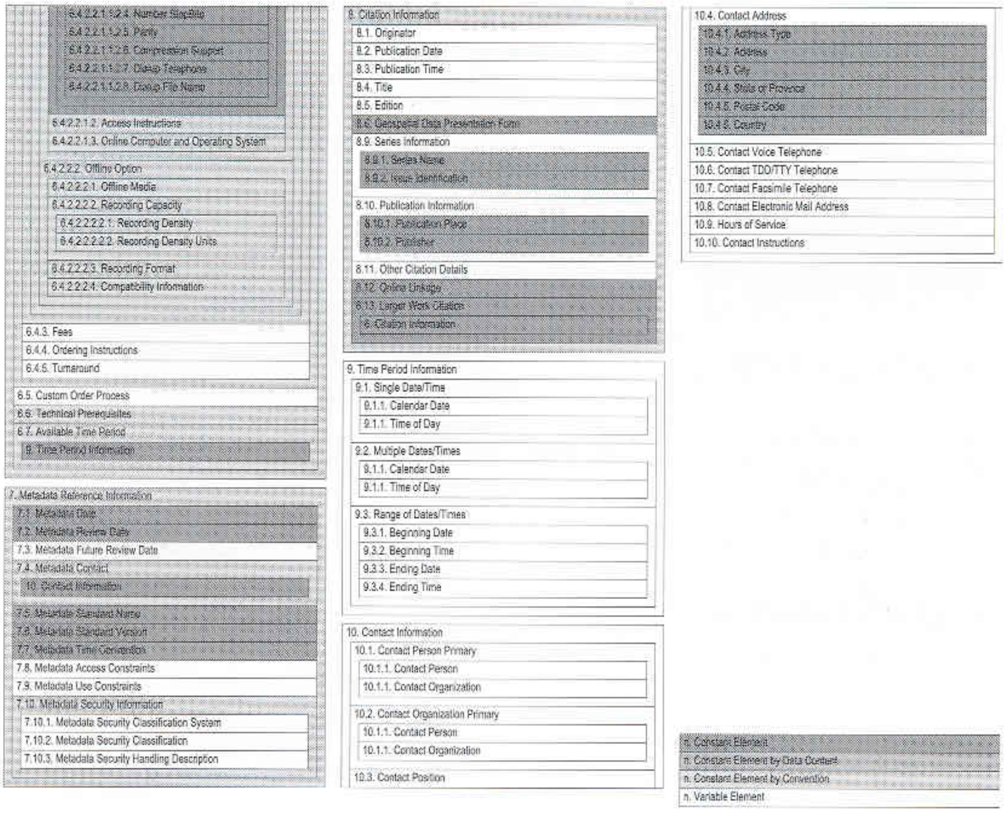

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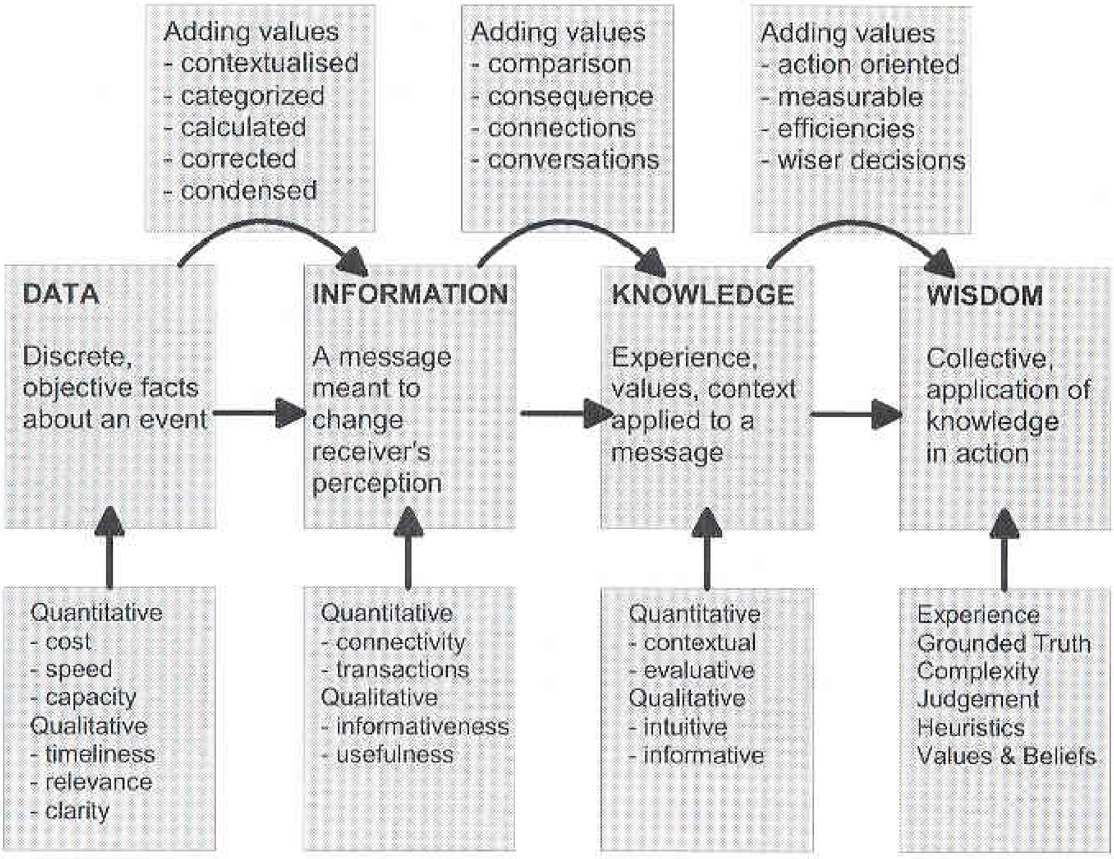

Figure 6.28 The knowledge progression, from data to wisdom.
From Sena and Shani (1999).