Design Rationale Modeling Representations

EE382V
Software Architecture and Design Intent

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Agenda

- Why Rationale?
- Design Rationale's Roots
- Modeling Rationale
  - IBIS / gIBIS / Tailored IBIS / PHI
  - DRL
  - QOC
- Model Comparison
- Summary

As we know ...

- Requirements are in problem domain terms; architecture often in solution domain terms.
- Rationale determines the mapping between the functional and non-functional requirements and the architecture.
- Requirements → (rationale) → Architecture

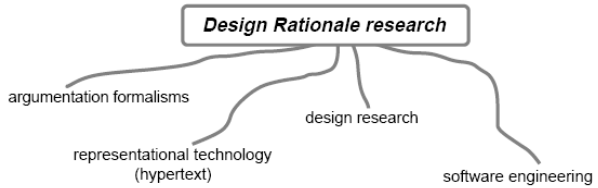
As we know ...

- Rationale tells "WHY"
  - Criteria
  - Plans
  - Alternatives
  - Non-Functional Requirements
- Capturing Design Rationale is a key aspect in effective Communication (inter-organization), effective Documentation (external record), and system evolution

Why Formalize Design Rationale?

- Formalization will/can lead to identification of weak or inconsistent design logic
  - The development of more powerful/succinct SW
- Formalization will provide ideal mechanism for indexing / retrieving the design
  - Without some form of retrieval mechanism, Design Rationale capture in useless
  - Effective retrieval mechanism will reduce future maintenance costs

Design Rationale Roots



DR Roots (Formalizing Argumentation)

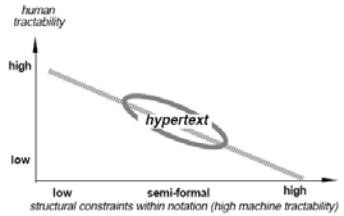
- Goal: A system in which creation and retrieval of trails of relevant information mimics human reasoning & memory
- Key Hypothesis: By making the structures of arguments explicit, they can be more rigorously constructed, explored and communicated

DR Roots (Formalizing Argumentation)

- Formal. (ie. full written documentation)
  - Overly costly
  - Can bog down creative thought & development
- Informal. (ie. memos, email, meetings etc)
  - Created by numerous everyday artifacts
  - Difficult to coalesce into single coherent artifact
- Semi-Formal. (approaches to be discussed)
  - Provides framework without limiting cognitive exploration

DR Roots (Representing Concepts)

- Hypertext capabilities
  - Auto-links, Pop-up Formats, Coloring, etc
  - Strikes a balance between computational needs (a structure) and natural human thought process



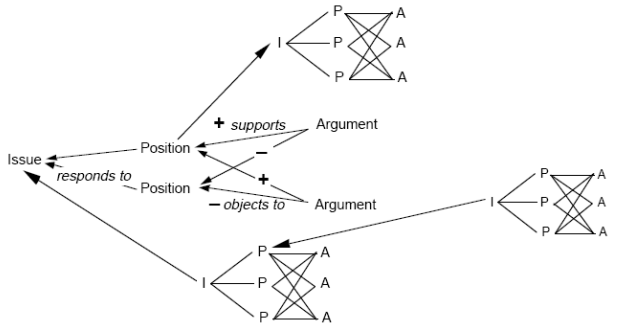
DR Roots (Research and SW Support)

- Research into the development of computational support for reasoned discourse or argumentation
  - Toulmin – (1958) analyzed and depicted the structure of argumentation graphically
  - Engelbert – (1963) one of the first to envision the use of technology for manipulating "concept structures"
  - Kunz and Rittel – (1970) developed argumentative approaches to design (IBIS - Issue-Based Information System)
  - Xerox PARC – (1987) *Argnoter* tool (argumentation spreadsheet) for representing arguments in group design

IBIS - Issue-Based Information System

- First true approach to representing design rationale. (1970's)
- 3 components the model
  - Issues = Design Questions
  - Positions = Answers to the Design Questions
  - Arguments = Either Support or Refute Positions
- Used successfully in a number of non-engineering applications.
- gIBIS, tailored IBIS and PHI : attempts to use IBIS to model engineering design.

IBIS – Structure

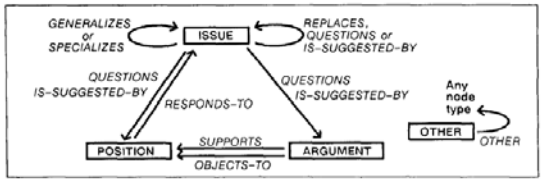


IBIS – Benefits / Drawbacks

- Benefits
  - (+) Captures human reasoning
  - (+) Foundation for numerous other models
  - (+) Highlighted importance of distinctly addressing rationale in a design process
- Drawbacks
  - (-) Extremely complex and hard to parse
  - (-) No mechanism for associating Issues to a design decision
  - (-) No mechanism to control/focus discussions
  - (-) Only models/captures design questions that can be deliberated (directly design related issues)

gIBIS – graphical IBIS

- Hypertext system of the IBIS model
- Simplified the capture of design rationale
- Used the IBIS structure and Link types

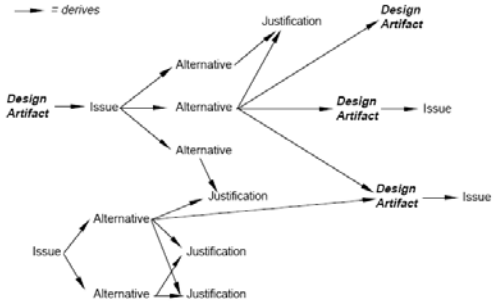


gIBIS – Improvements over IBIS

- Graphical / hypertext interface
- Provides mechanism to stop deliberation
- Provides “other” nodes/links to enable thoughts to be expressed outside of the IBIS framework/rule set
- Provides “external” node to link non-IBIS artifacts (ie. requirement documents, diagrams, code, etc)
- Permits Positions to “modify” other positions; Arguments to “modify” other arguments

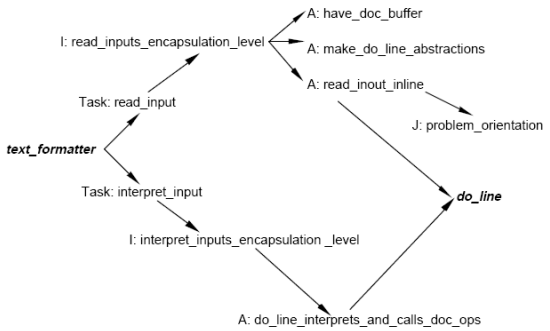
Tailoring IBIS

- Addresses the shortfall of IBIS in not tying Issues to a Design Decision



EXAMPLE: Tailored IBIS-based Notation

- Artifacts are listed in **bold**, I=Issue, A=Argument, J=Justification



PHI – Procedural Hierarchy of Issues

- Offshoot of IBIS and addresses IBIS shortfalls:
  - Lacking a mechanism to focus discussion
  - Lacking ability to model/discuss non-design issues
- Issues can "serve" to resolve another Issue (ie. a hierarchy of issues/work)
- Issues that do not serve the stated aims of the design are (can be) thrown out as irrelevant
  - Also for previous issues that become "stale"

Overview Benefits of IBIS/gIBIS/PHI

- Provides qualitative decision support tool
- Methods do decompose issues into sub-issues
- Can help to tailor conversations
- Provides means to serve as group memory
- Note: care must be taken not to unduly prolong the design process

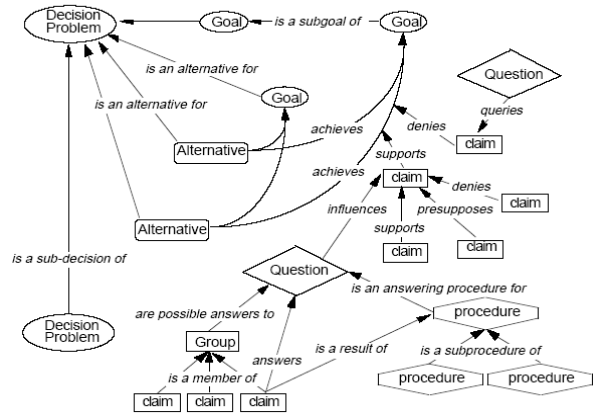
DRL – Decision Representation Language

- Major Components:
  - ISSUE: represents the problem that admits alternatives
  - ALTERNATIVE: represents an option being considered
  - GOAL: represents a desirable property used for comparing the alternatives and is elaborated further in terms of its sub-goals
  - Every relation in DRL is a subclass of a CLAIM
- Possible to manipulate different decisions to see shortfalls/ramifications before commitment
  - Dependency, Precedence, Viewpoint, Plausibility Management

DRL – Decision Representation Language

- Has been used in computer-related applications and implemented in a system called SIBYL
  - Provides graphical user interface for authoring DR
  - Provides computational services such as dependency management, view management, etc.
- Increased vocabulary enables making design deliberation explicit which in other models were handled with exceptions to the language
  - Therefore, is significantly more complex model
- Meant to be constructed asynchronously (ie. historical record of deliberations/rationale)

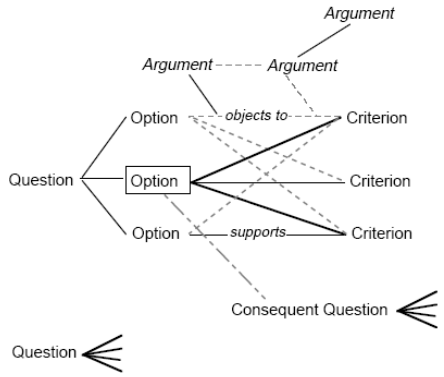
DRL - Structure



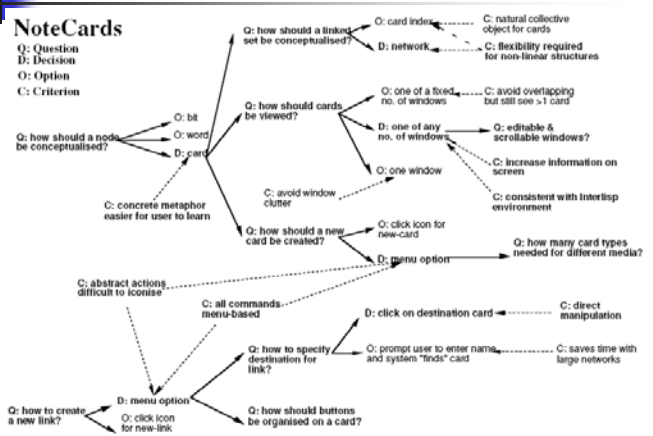
QOC – Questions, Options, Criteria

- Similar to IBIS
  - Questions = Design Questions
  - Options = Various Answers to Design Questions
  - Criteria = Provides way to weigh various Options
- Clarifies how a particular design decision sits with respect to alternatives (defines the Design Space)
- Constructed synchronously with design process
- * Develops a logically coherent representation
- * Depicts “HOW” the design space was explored

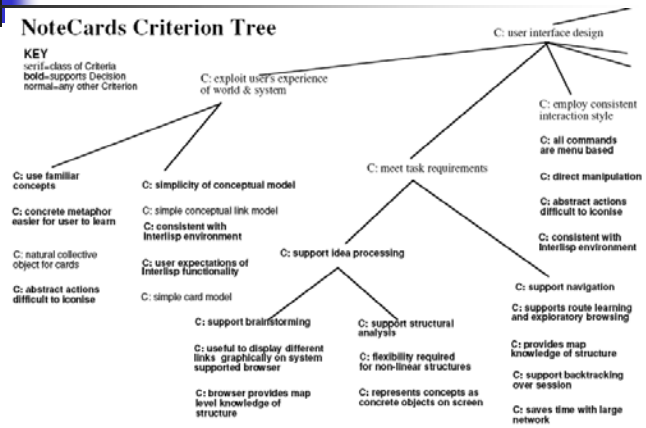
QOC - Structure



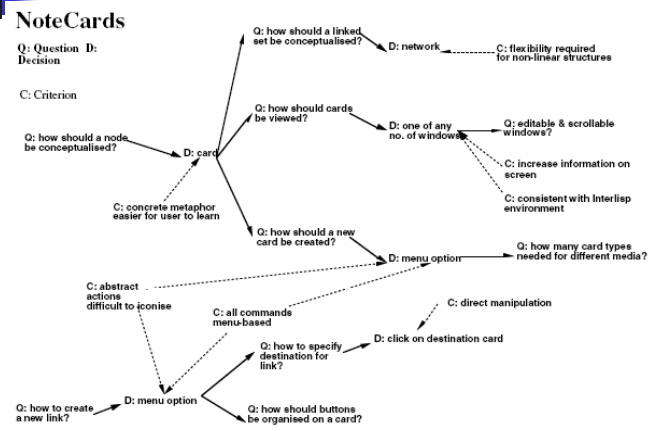
QOC – Example (High Level Model)



QOC – Example (Criterion Tree)



QOC – Example (Decision View)



Observed Benefits of QOC

- Serves as a record of what's been discussed
  - Includes both constructive and "deadend" ideas
- Encourages greater completeness in evaluating options
- Structure identifies task-relevant information (and missing assessments as dangling links)
- The process of constructing QOC model helps clarify vague, unarticulated ideas
- Having all the rationale (the complete process) laid out helps in final decision making
- A relatively simple model

QOC vs ...

- vs IBIS / gIBIS
  - IBIS arguments only implicitly refer to “Arguments”
  - QOC Options are specifically design options
- vs DRL
  - QOC maps closely to DRL
  - Much simpler and composed at “run time”

Comparing the Models

- Reusability
  - How generic (reusable) is the captured Rationale to other designs
- Design Process Capture
  - How well does the captured Rationale reflect the actual design process
- Computational Support
  - Operations/language supported by the model
- Authoring Overhead

Comparing the Models

Approach	Reusability	Process Capture	Computational Support	Authoring Overhead
gIBIS	(-) Capture of design only; little abstraction of issues	(+) Constructed synchronously with design process	(ok) Small vocabulary yields simplicity	(ok) Structuring conversations IAW IBIS rhetoric is not natural
Tailored IBIS	(ok) Improved rationalization over gIBIS	(+) Most types of arguments are able to be represented	(+) Representations of design artifacts can be easily integrated	(-) More expressive notation may take longer to construct
DRL	(+) Can assess decisions tradeoffs (+) Precedence Management	(ok/-) Can represent most arguments BUT too slow to be done in real time	(+) Services for managing, linking, and retrieving design rationale	(-) Large/expressive notation may take long to construct
QOC	(+) Design Space Analysis relates multiple designs in comparable form	(ok/-) Capture filters out narrative elements of the design process	(ok) Small vocabulary yields simplicity	(ok) Simple but capturing complete design space analysis can take much effort

General Issues with DR Models

- In order for a model to be useful a balance must be maintained between human usability, machine usability, and expressiveness
- There is a tradeoff between expressiveness and real-time demands
- It is important to makes clear what the intended use of the model is
- A representation must allow the users to say exactly what they want to
- Users must be immediately motivated to record design rationale

Why has Design Rationale not caught on?

- Successes in capturing design rationale have been few and usually associated with a sole DR champion
- Capturing design Rationale is “costly”
  - Requires a large investment of time
  - Serves no immediate need
- Capture often results in loss of info/subtleties
  - Must divide rationale into discrete “chunks”
  - Categorize and assign attributes to the “chunks”
  - Relate “chunks” to each other

Modeling Design Rationale

Questions ?

(Hopefully, that we can answer)