Protégé as Professor:

Development of an Intelligent Tutoring System With Protégé-2000

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Outline

- General requirements for a tutoring system in Pathology
- Practical aspects of Protégé integration into SlideTutor
- Further use of Protégé

Medical Training System Needs

- Large medical image libraries (VHL)
- Digital knowledge libraries (FMA)
- Knowledge structuring, sharing, utilizing to teach the decision-making process
- Very few good examples in medicine
- Reuse knowledge representation and acquisition in other fields: paradigms, methodology, ideas
- Create system that incorporates empirical knowledge and theories about how people learn
- Build system with reusable components
- Design adaptive, revisable system that can incorporate any new observations

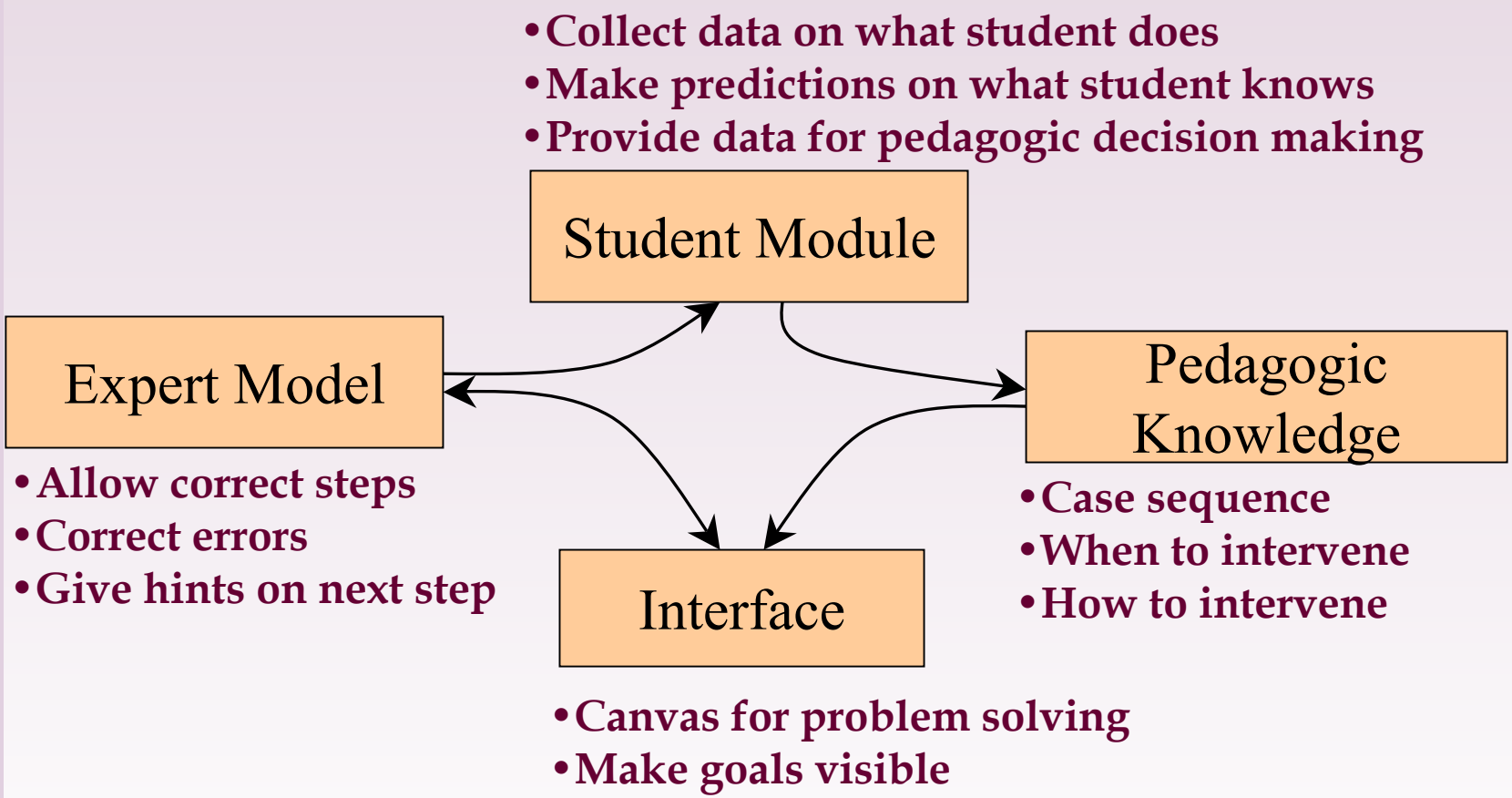
Intelligent Tutoring System

- Systems that use AI formalisms to offer interactive computer-based instruction
- Represent and model knowledge
- Actively monitor and encode student's progress through a problem/case, and/or across problems/cases
- Offer instruction and provide feedback that is adaptive, flexible, *individually tailored*

Intelligent Tutor System With Model Tracing

- Cognitive Tutor based on ACT-R theory of learning (*Anderson, Corbett, and Koedinger*)
  - Expert Model – problem solving and decision making cognitive domain
    - Declarative – "factual" knowledge
    - Procedural knowledge - how to do things
    - Proceduralized declarative knowledge in the rules(*step instructions*)
  - Model Tracing – every user action is checked against the Expert Model

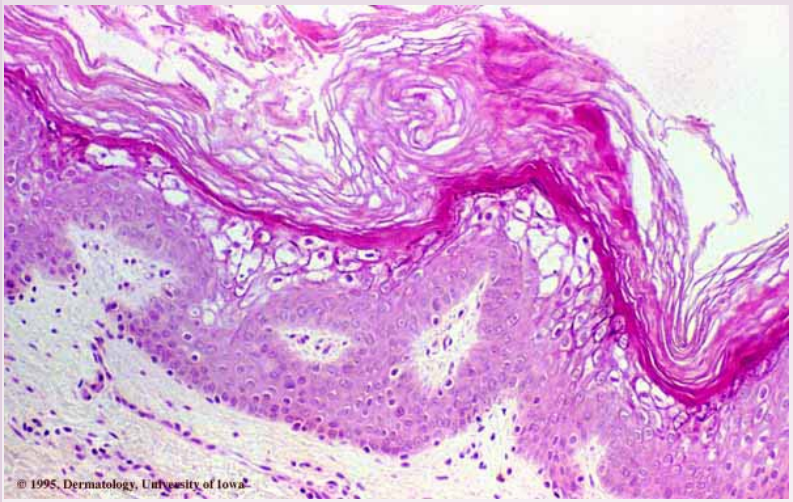
Intelligent Tutor System Structure



Dermopathology as an ITS Domain

- Extremely difficult
- Residents have little time to learn
- False positives and false negatives; errors associated with significant impact to patient
- Some areas are highly algorithmic, seemed straightforward to model with rule system
- Diagnosis more deterministic in Pathology when compared with other domains

Dermopathology Domain

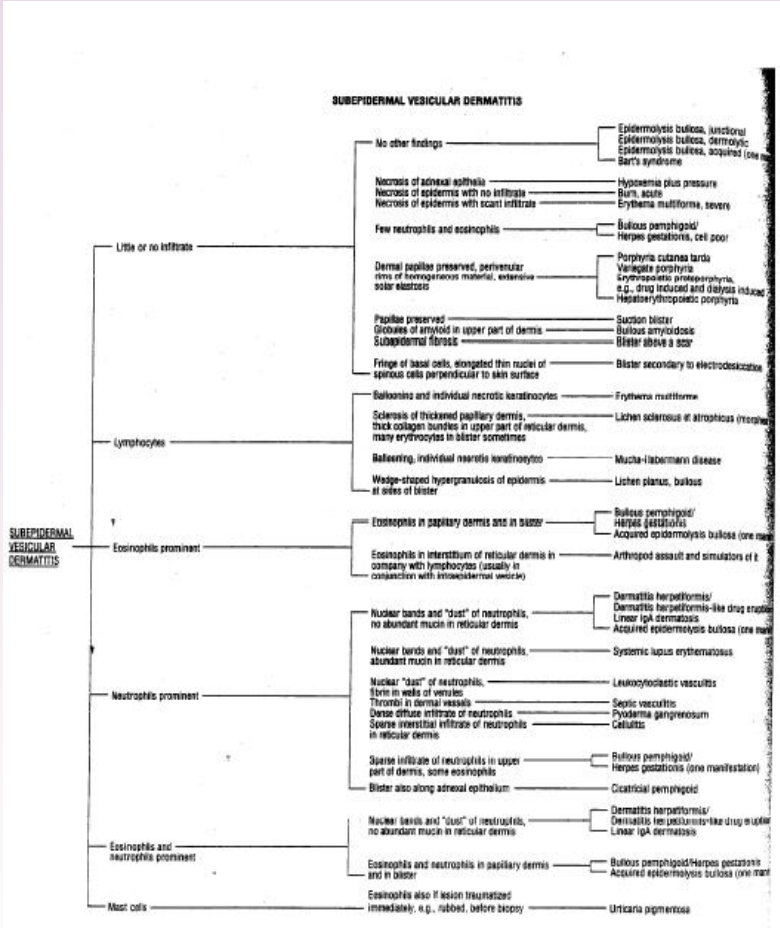


- Visual diagnostic
  - Use of the microscope
  - More precise, visual criteria for reasoning
  - Visual criteria depend on microscope power, can be hierarchically classified

Dermopathology Domain

- Visual diagnostic
- Study of expertise in microscopic diagnosis (*Crowley et al., JAMIA 2003*)
  - Identified reasoning steps, goals
  - Physical search, identification, hypothesis testing and refinement
  - Knowledge transformation from novice to expert

Dermopathology Domain

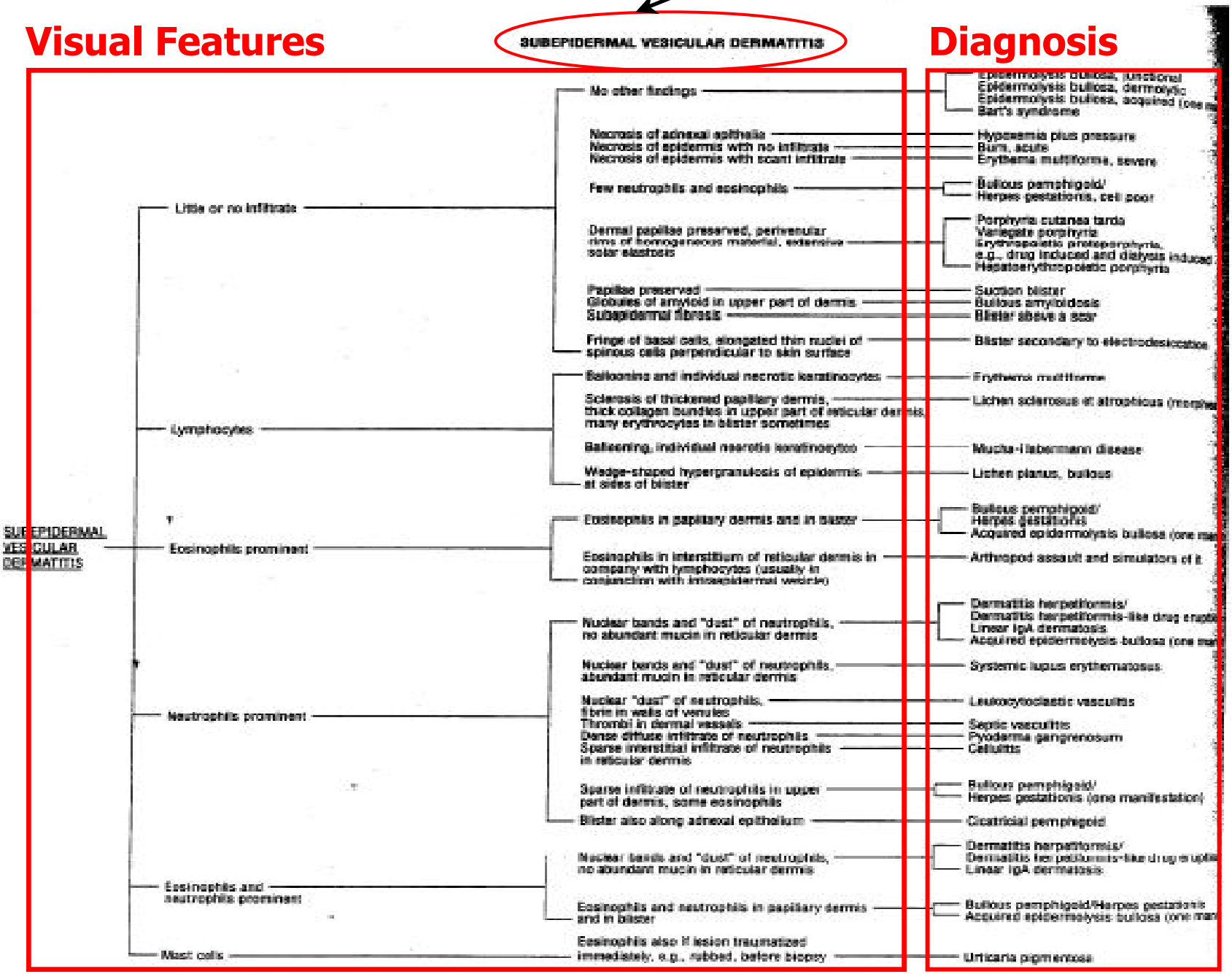


- Visual diagnostic
- Study of expertise in microscopic diagnosis
- Dermopathology domain algorithms

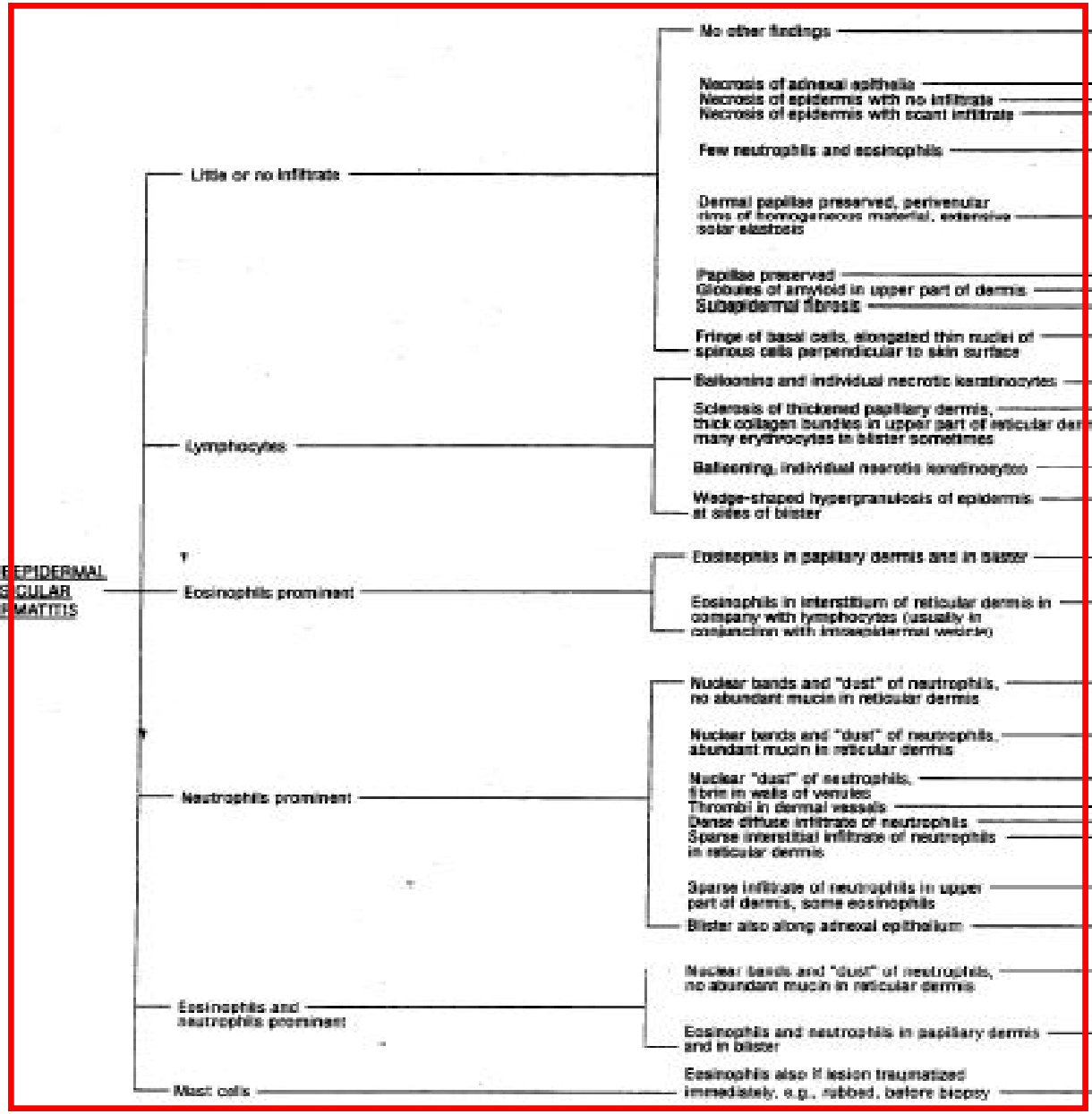
1/11 pattern

Visual Features

Diagnosis



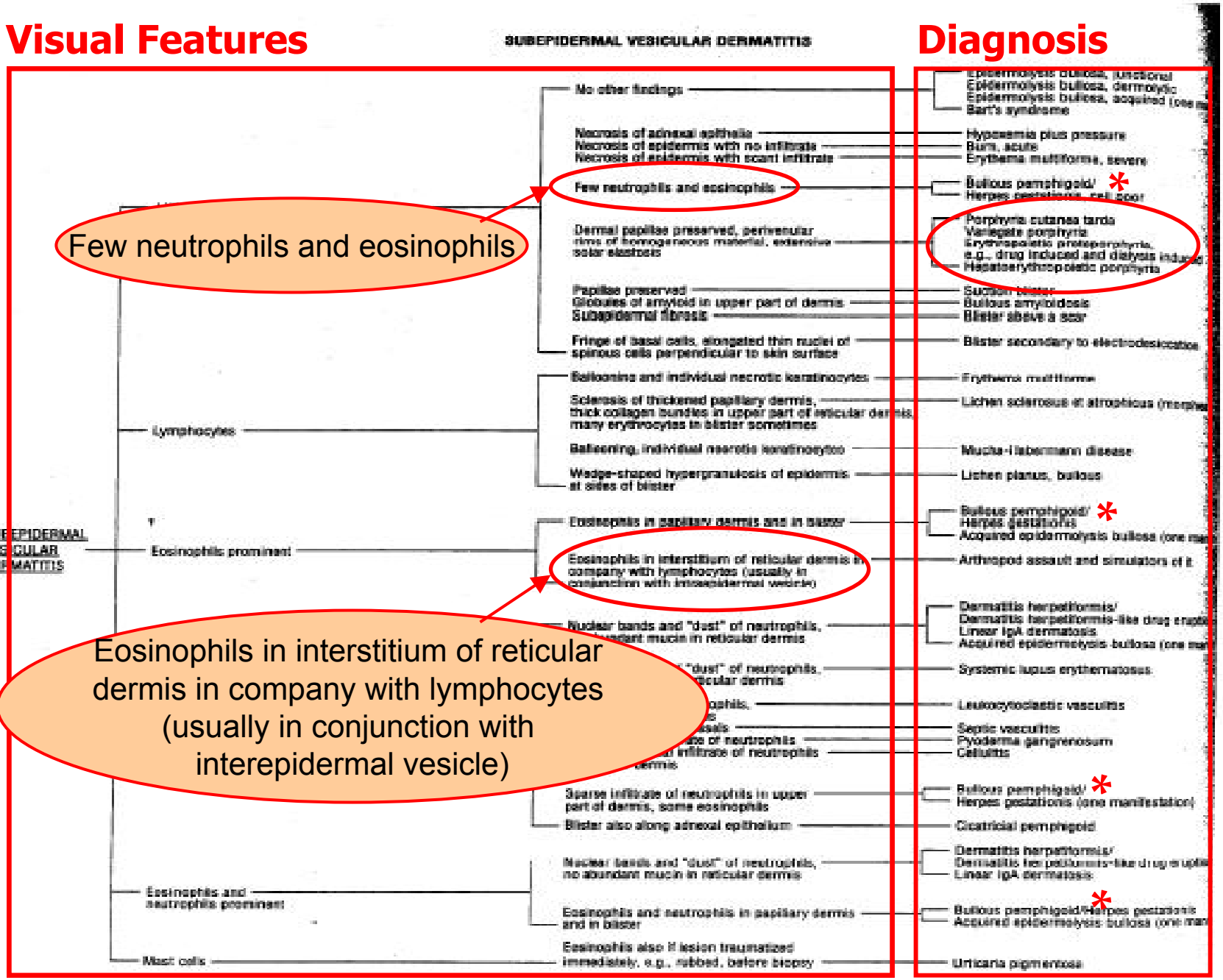
Visual Features



Diagnosis

Visual Features

Diagnosis



Few neutrophils and eosinophils

Eosinophils in interstitium of reticular dermis in company with lymphocytes (usually in conjunction with interepidermal vesicle)

Medical Intelligent Tutoring Systems

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- Individualized instructional system
- Multiple paths for problem solving
- Multi-dimensional decision space
  - Expert, Student, and Pedagogic models

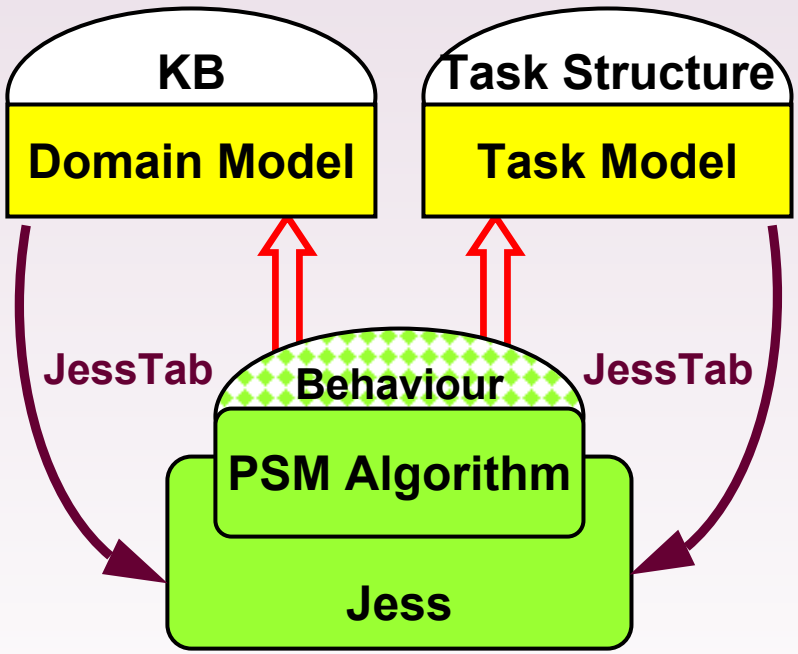
(-)

- Large complex dynamic declarative knowledge
- Formalism of production rule knowledge representation is domain specific (Nx100 rules)
- Maintenance is difficult and time consuming
- Knowledge modification alters the rules

SlideTutor Approach

- Use KBS approach to separate static (declarative) and dynamic (procedural) knowledge
- Complicated domain structure exactly fits Protégé knowledge representation paradigm
- In KBS PSMs serve as its *reasoning part* that can be used by tutor procedural rule based expert system

SlideTutor Approach

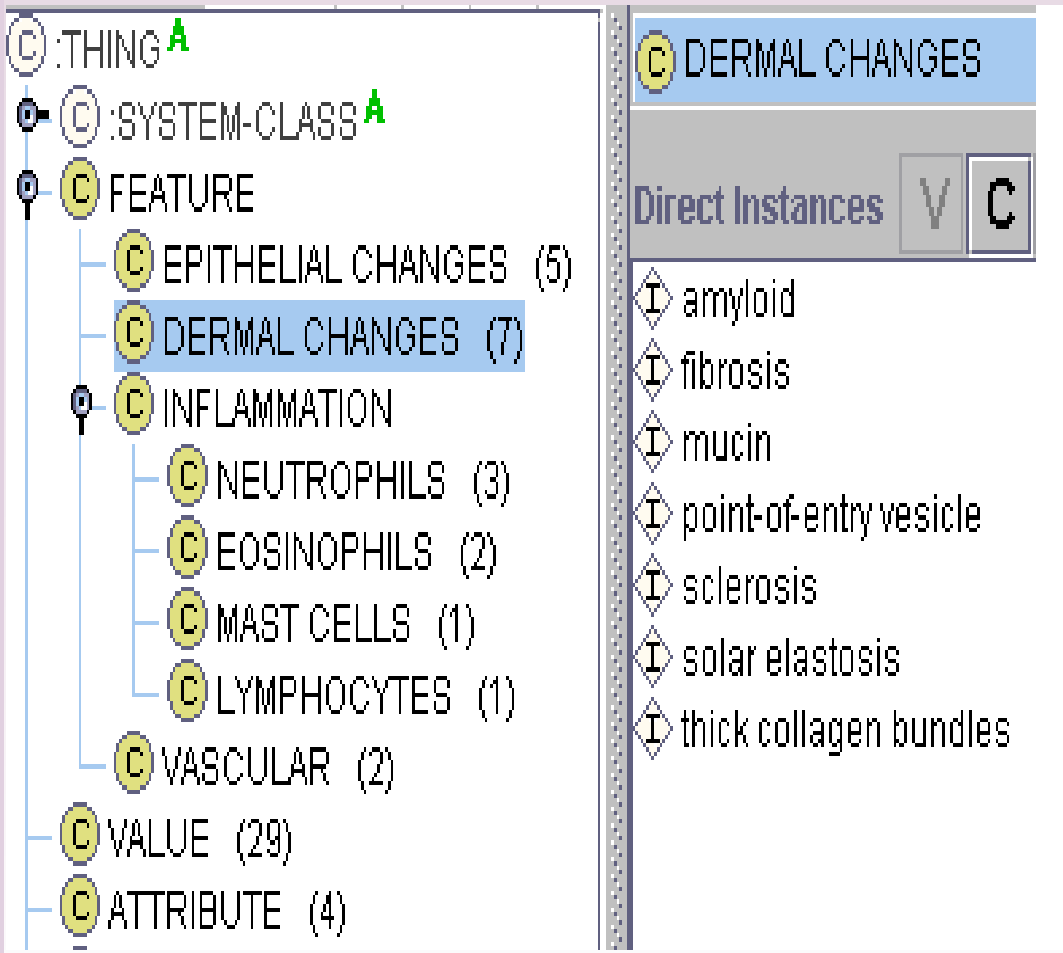


- Protégé for declarative knowledge
- Jess Expert System as PSM base
- JessTab bridge (Eriksson, 2003), slightly modified
  - reflect hierarchical Protégé structure
  - work with multiple projects
- Separate abstract graph PMS algorithm and specific behaviour

Expert System KB Implementation

- Parametric design approach for classification problem solving (Motta, 1999):
  - find the *solution* class that best explains certain set of *observables* for unknown object
    - Solution = Domain KB - finite set of feature specifications
    - Observable = Case Representation - set of facts
- Extended
  - Redefined Feature to be an object with its own properties
    - Solution - {***f*** {***a*** {***v***}}}
    - Observable - (***f***, {***a***, ***v***})
  - Added abstract Feature-Attribute-Value ontology

Feature Ontology

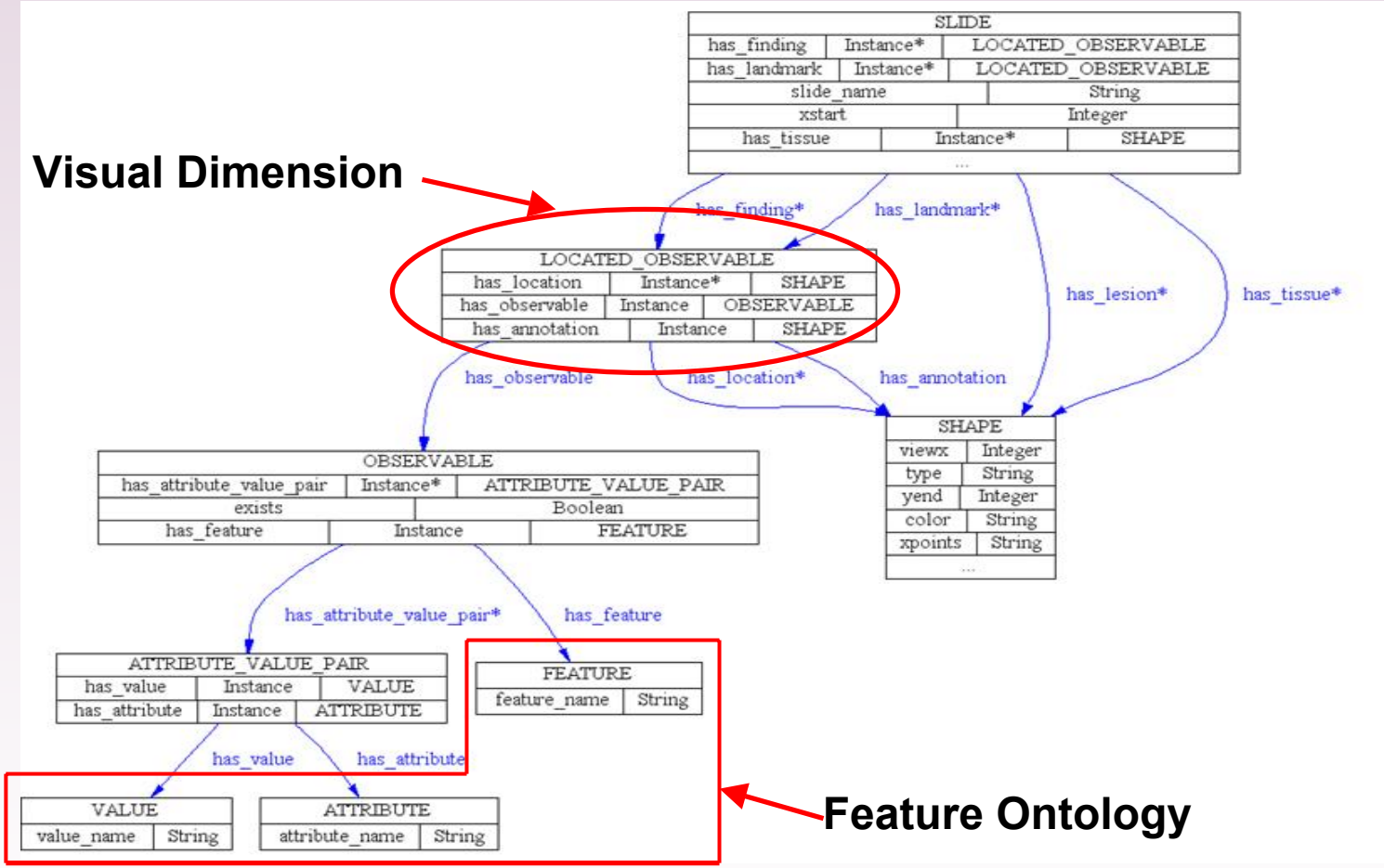


- Hierarchical Feature structure
- Feature – Attribute – Value independence
- Reused by Domain KB and Case Representation

Domain KB

- Hierarchical diseases representation with allowed multiple inheritance
- DISEASE has FEATURE_SPECIFICATIONs, built up from range of features, attributes and values – multiple disease paths
- FEATURE_SPECIFICATION can have any number of associated DISEASEs – multiple disease set for a particular path
- DISEASE can be extended by tests, UMLS content
- Reusable, not connected to any problem solving environment

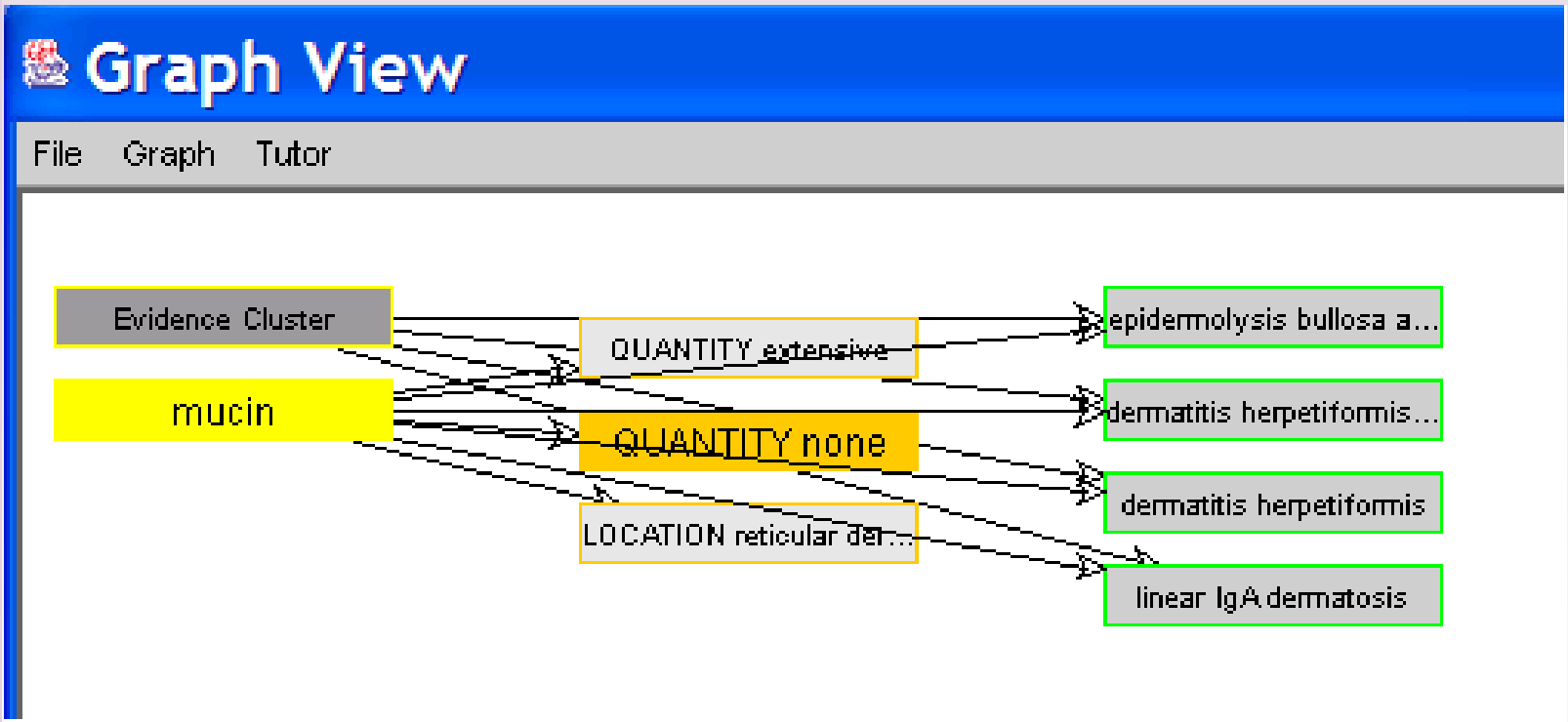
Slide Representation



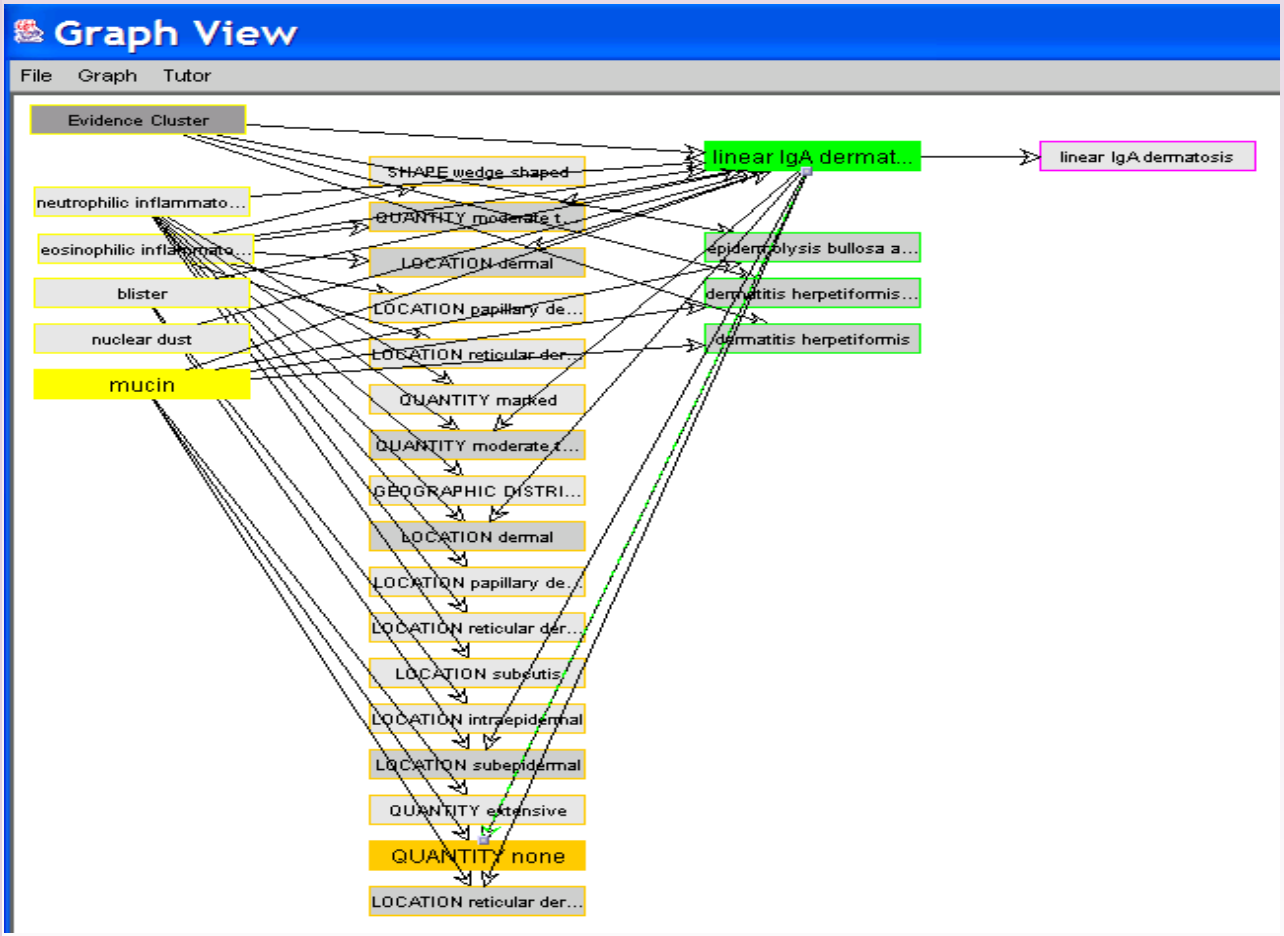
Dynamic Solution Graph (DSG)

- Generates valid path through problem state based on combination of expert model ontologies, case and pedagogic knowledge within abstract PSM
- Dynamic – incremental problem state and valid next steps generation system
- DSG state depends on the order of input reasoning events
- Abstract, task-independent, allows any conceptually correct node, makes no decision
- Node type specific response to a triggered event encapsulated in the behavior structures
- DSG visualization (JGraph, www.jgraph.org)

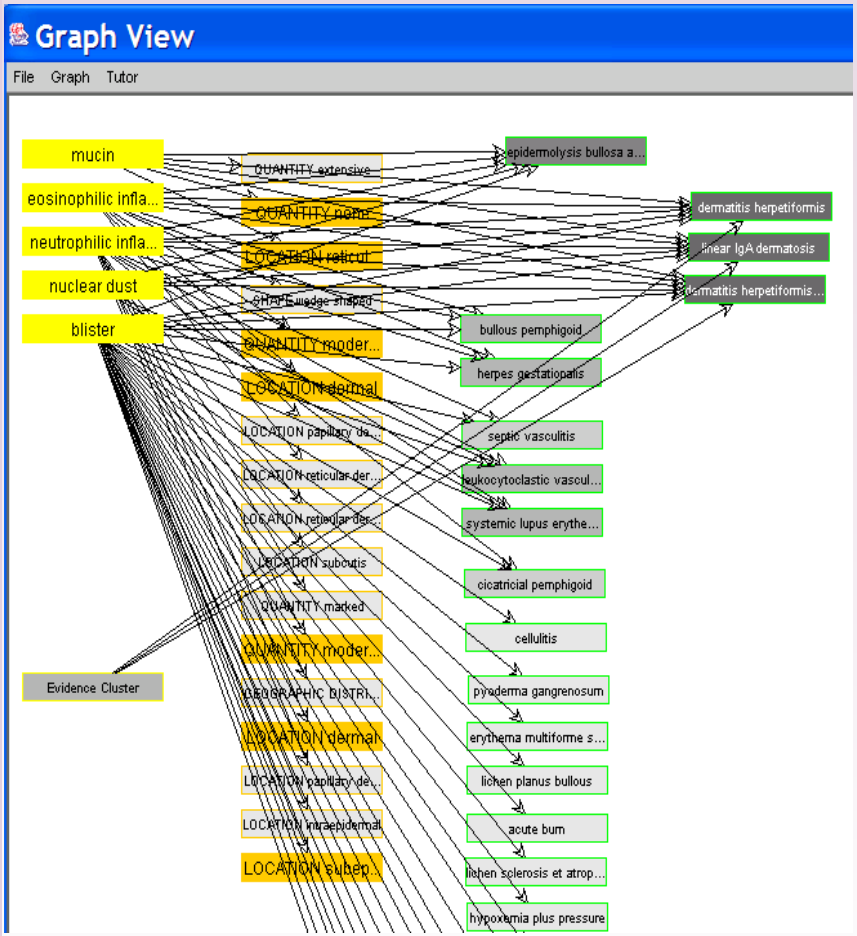
Forward Reasoning and Negation



Backwards Reasoning



Cluster Concept



- Evidence Cluster – integrated relation between the state of its elements and nodes outside the cluster
- Serves as disjunction element that forms the problem solving path
- Allows multiple pedagogic strategies for hypothesis formation:
  - Based on single piece of evidence
  - Consistent with all evidences

Protégé Advantages

- Redefine a knowledge role of shared procedures as a static knowledge
- Knowledge decomposition and inclusion (Feature, Domain and Case ontologies)
- Modularity and extensibility allows independent rules and models development
- Reusable domain for classification problem solving
- Domain neutral for many *search - identification – interpretation* reasoning systems
- More Protégé – more flexibility

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