Content, Metadata & Flexible Reuse within the MatDL Transport Archive

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Outline

- Background
  - MatDL Overview
  - Transport archive
  - Metadata
  - Ontology
- Course Composer

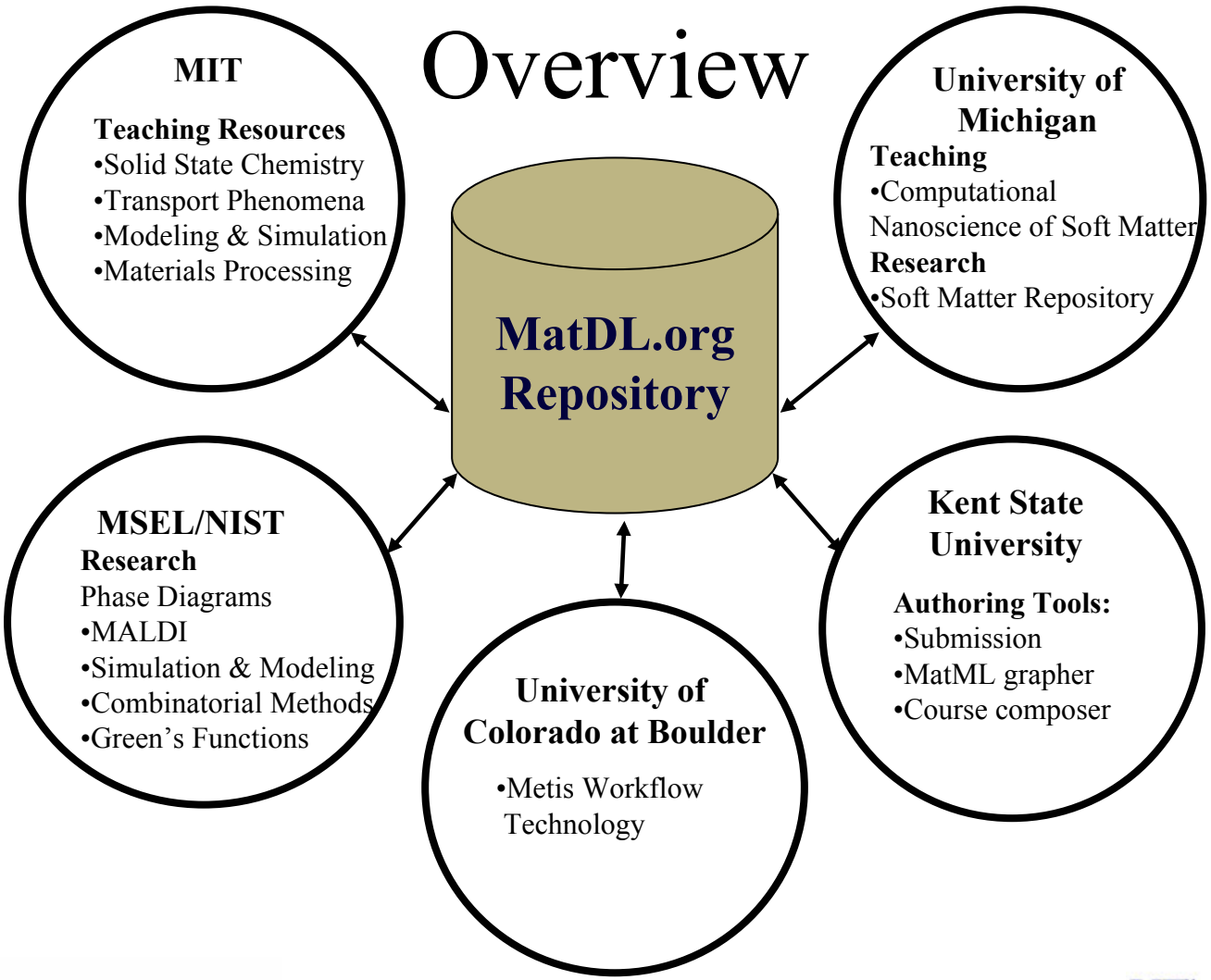
Materials Digital Library

MatDL.org

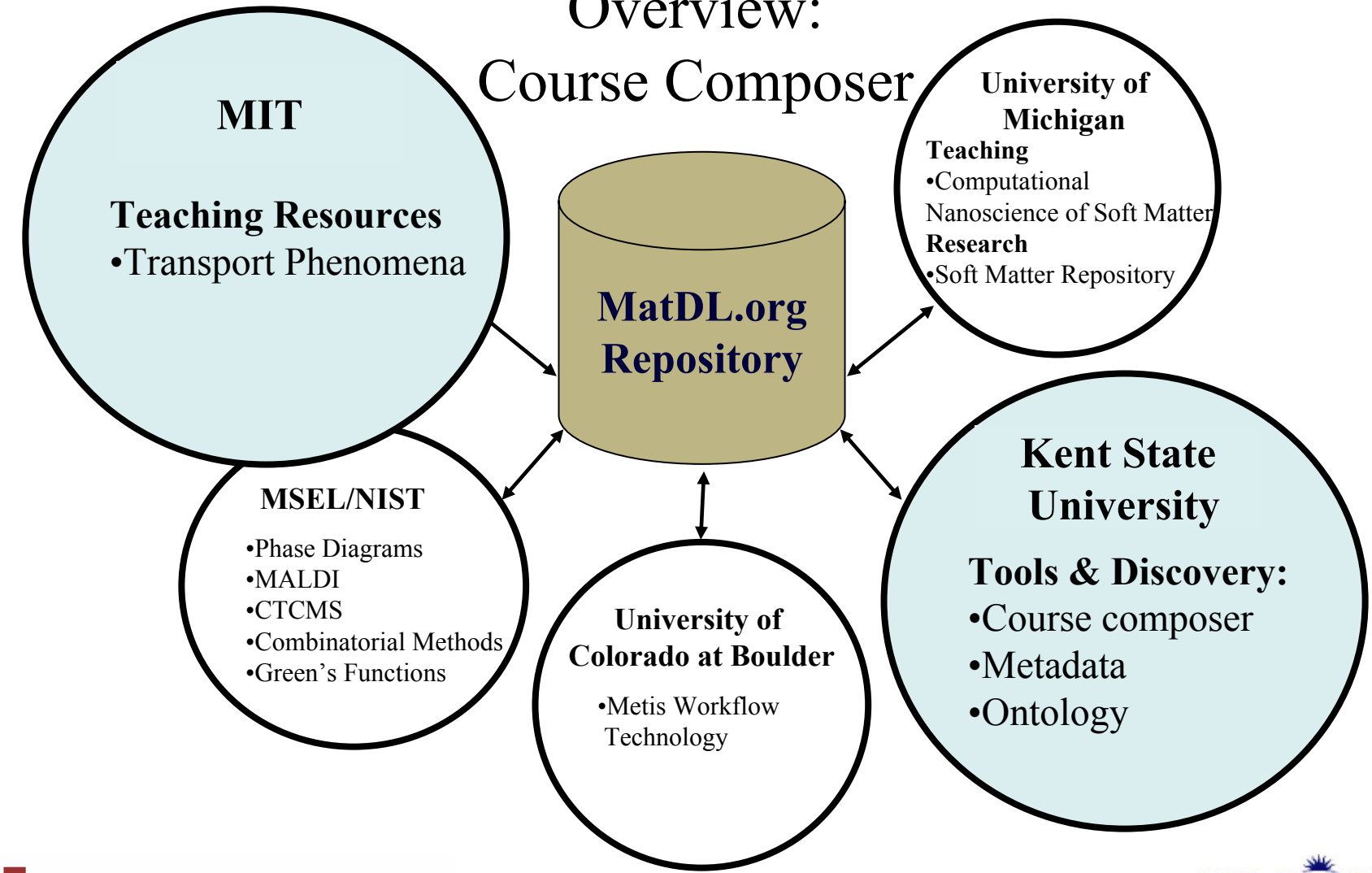
NSDL

NIST National Institute of Standards and Technology

Overview



Overview: Course Composer

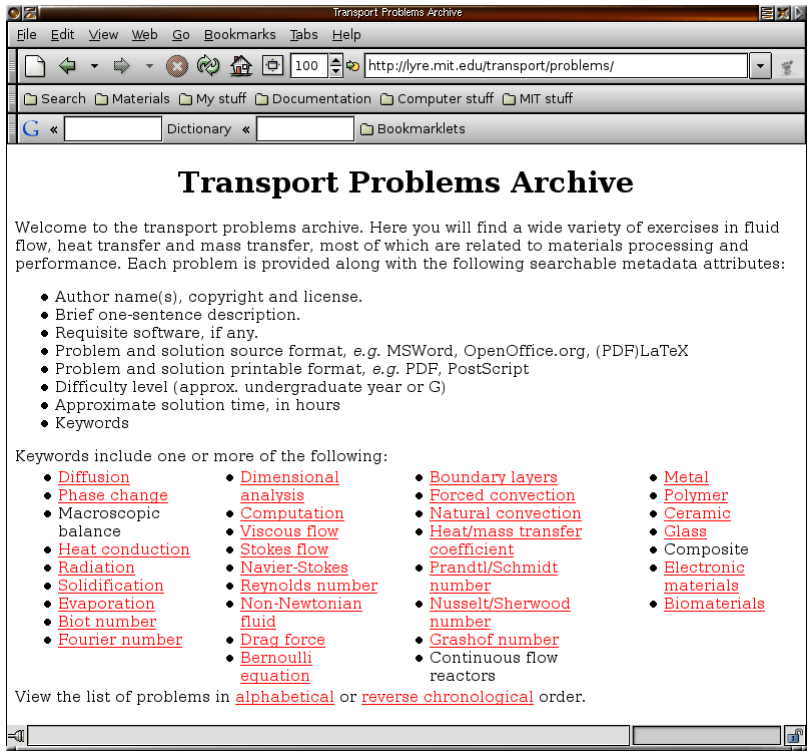


MatDL Transport Archive

- Online space for collaborative development of transport educational resources
- Transport phenomena: fluid dynamics, heat and mass transfer
- Content: readings, lecture notes, handouts, exercises, courseware, pedagogical mat'ls
- Metadata: currently ad-hoc, later IEEE LOM
- Initial focus on materials processing cases
- Four contributors, sixteen users (USA, Canada, Mexico, Japan, Sweden)

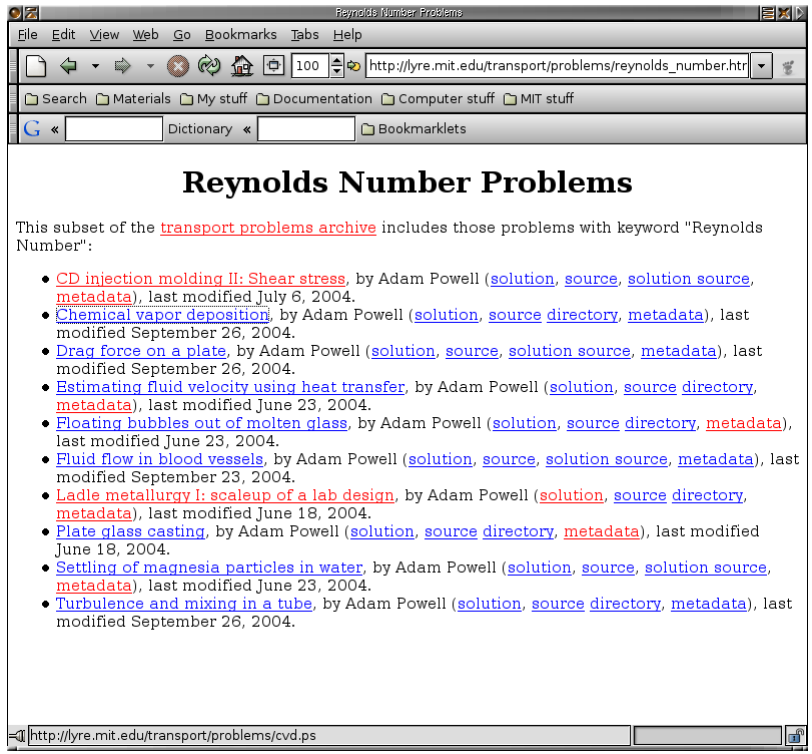
Transport Archive Content

- Resource content:
  - Author, copyright
  - Brief description
  - Source (.tex, .doc)
  - Printable (.pdf, .ps)
  - Checksum(s)
  - Problems and solutions
  - Student level
  - Solution time
  - Key words



Resource Listing

- Gives title, author, links to source etc.
- Problems include qualitative (sketch), quantitative (calc), design components
- Designed for easy modification, reuse



Transport Archive Impact

- Free high-quality resource for educators
- Forum to rapidly transfer research results in this area to educational use
- Quickly build a course, including ABET objectives/outcomes
- Timely launch: many materials departments cutting classes in processing/transport
- Online case studies help to compensate for this trend

Transport Archive Future Plans

- Metadata format: ad hoc to standard compliant
- Advisory board, review process
- Migrate version control, workflow software to Fedora, Metis
- Content: mechanical, chemical engineering
- Content: structure formation
- Content: nanofabrication, manufacturing
- Resource links to transport ontology
- New courseware: property graphs and selection, flow past sphere, etc.

Metadata

- Dublin Core (DC)
  - Used by MatDL repository (DSpace)
    - Fields stored in database
- Learning Object Metadata (LOM)
  - Used by Course Composer
    - XML files

LOM Metadata: Educational

- <interactivityType>
  - <value>active</value>
- <learningResourceType>
  - <value>exercise</value>
- <context>
  - <value>higher education</value>
- <typicalLearningTime>
  - <duration>PT1H30M</duration>

Materials Digital Library

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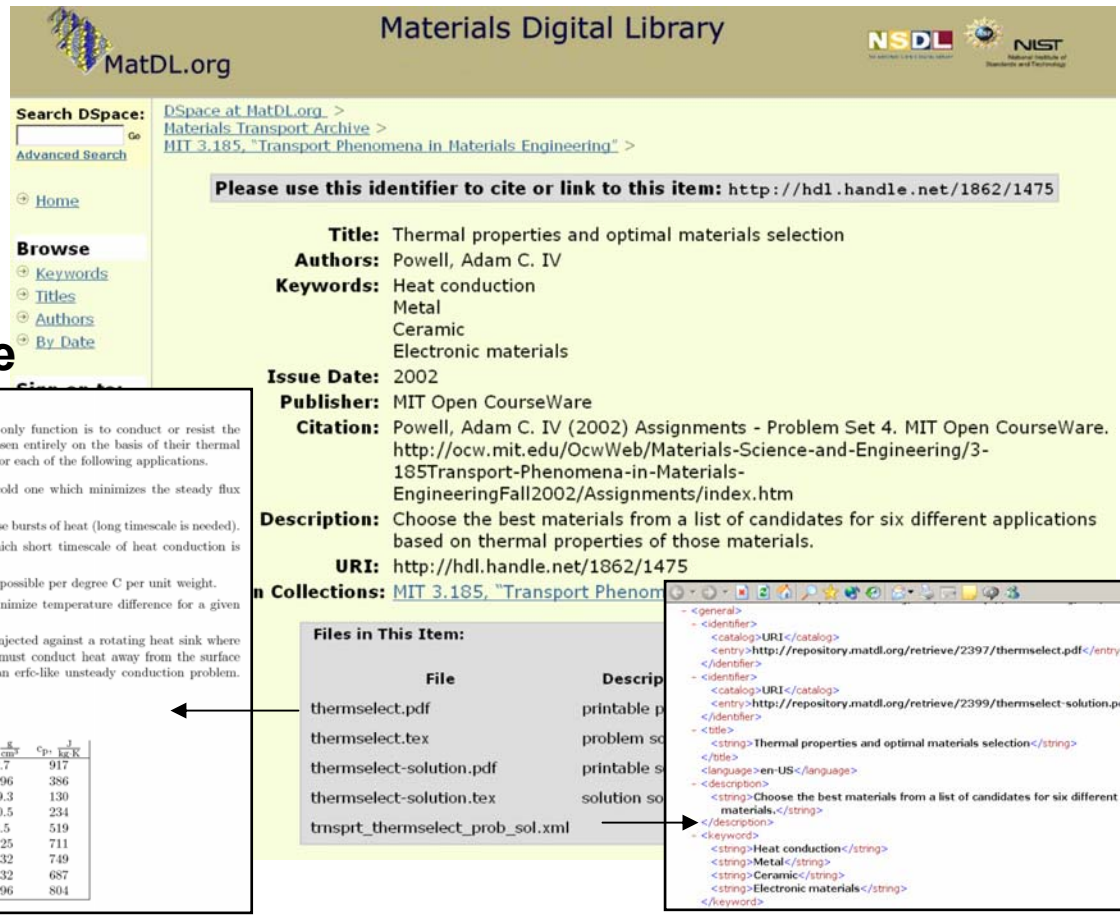
Transport Resource Viewed in MatDL



Problem/Exercise

1. Thermal properties and optimal materials selection

In many situations, product designs include parts whose only function is to conduct or resist the conduction of heat. Materials for these parts are thus chosen entirely on the basis of their thermal properties. Select the best material from the list provided for each of the following applications.

(a) Heat shield sandwiched between a hot body and a cold one which minimizes the steady flux between them.

(b) Heat shield which protects something from short, intense bursts of heat (long timescale is needed).

(c) Cheap (i.e. not diamond) temperature sensor, in which short timescale of heat conduction is necessary for rapid response.

(d) Light heat reservoir which must hold as much heat as possible per degree C per unit weight.

(e) Heat sink for a semiconductor device, which must minimize temperature difference for a given flux.

(f) Heat sink for melt spinning, in which liquid metal is injected against a rotating heat sink where it is solidified as rapidly as possible, so the material must conduct heat away from the surface quickly. (Hint: evaluate the flux through $x = 0$ in an erfc-like unsteady conduction problem. Diamond is not an ecomonically viable option.)

Candidate materials:

Material	k, $\frac{W}{m\,K}$	ρ, $\frac{g}{cm^3}$	c_p, $\frac{J}{kg\,K}$
aluminum	238	2.7	917
copper	397	8.96	386
gold	315.5	19.3	130
silver	425	10.5	234
diamond	2320	3.5	519
graphite	63	2.25	711
lime (CaO)	15.5	3.32	749
silica (SiO_2)	1.5	2.32	687
alumina (Al_2O_3)	39	3.96	804

LOM Metadata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      materials.</string>
    </description>
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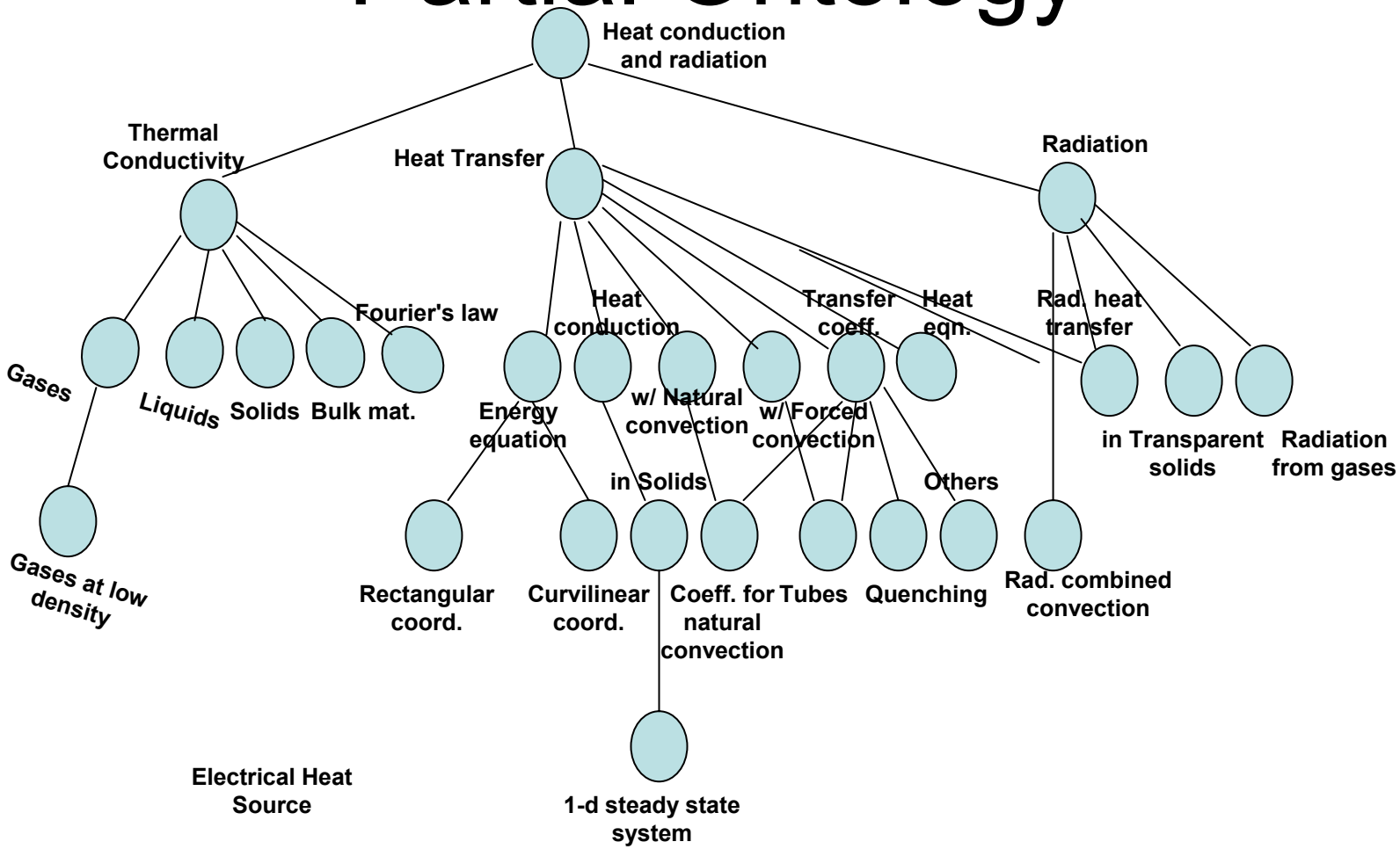
      <string>Metal</string>
      <string>Ceramic</string>
      <string>Electronic materials</string>
    </keyword>
```

Transport Phenomena Ontology

- MSE perspective
- Developed from:
  - Course syllabus
  - Textbook

Partial Ontology



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Thank you!

Questions?

Course Composer

Course Composer

- A framework under which teaching materials can be creatively shared by a community.
- Currently there are substantial amount of “digital elements” made available in electronic format and some in course web-site in ad-hoc manner by self-motivated volunteers.
- But the goal of “reusability” seems to be still illusive!
- The course composer is a metaphor targeted to create a framework which attempts to push the depth to which course materials can be contributed, searched, repurposed for creative, customized and automated composition.

Main Features

- Human composer (user) can specify a thematic outline of the course and expect the system (Course Composer) to complete the conceptual design.
- A user can expect the Composer to find deeply targeted and intelligently related course materials.
- A user can expect the Composer to help in automatically creating high level composed objects such as lecture plan, lecture notes, handout, even exams!

Sample Capabilities

Sample Capability-1

- **Question:** I would want to know more about "Thermal Diffusion". Would you find some reading material?

- **Course Composer:** Yes. But to know about 'Thermal Diffusion" also one needs to know about "Flick's law" and "Phase Transformation". How much time would you like to spend on them??

Course Composer

Sample Capability-2

- **Question:** Help me creating a "Quiz" on thermal conductivity. Can you find some questions?
- **Course Composer**: How hard you want them to be?
- **Question:** I think about one or two should be of simple complexity but one must be quite hard.
- **Course Composer:** OK! I have found three questions- one multiple choice- testing the area of "gases at low density", one narrative type question testing the area "liquid", and another mathematical type testing the area of "solid" area. The last one is quite hard as it would require knowledge about all four prerequisite areas. I think roughly it will take 25 minutes to answer them.

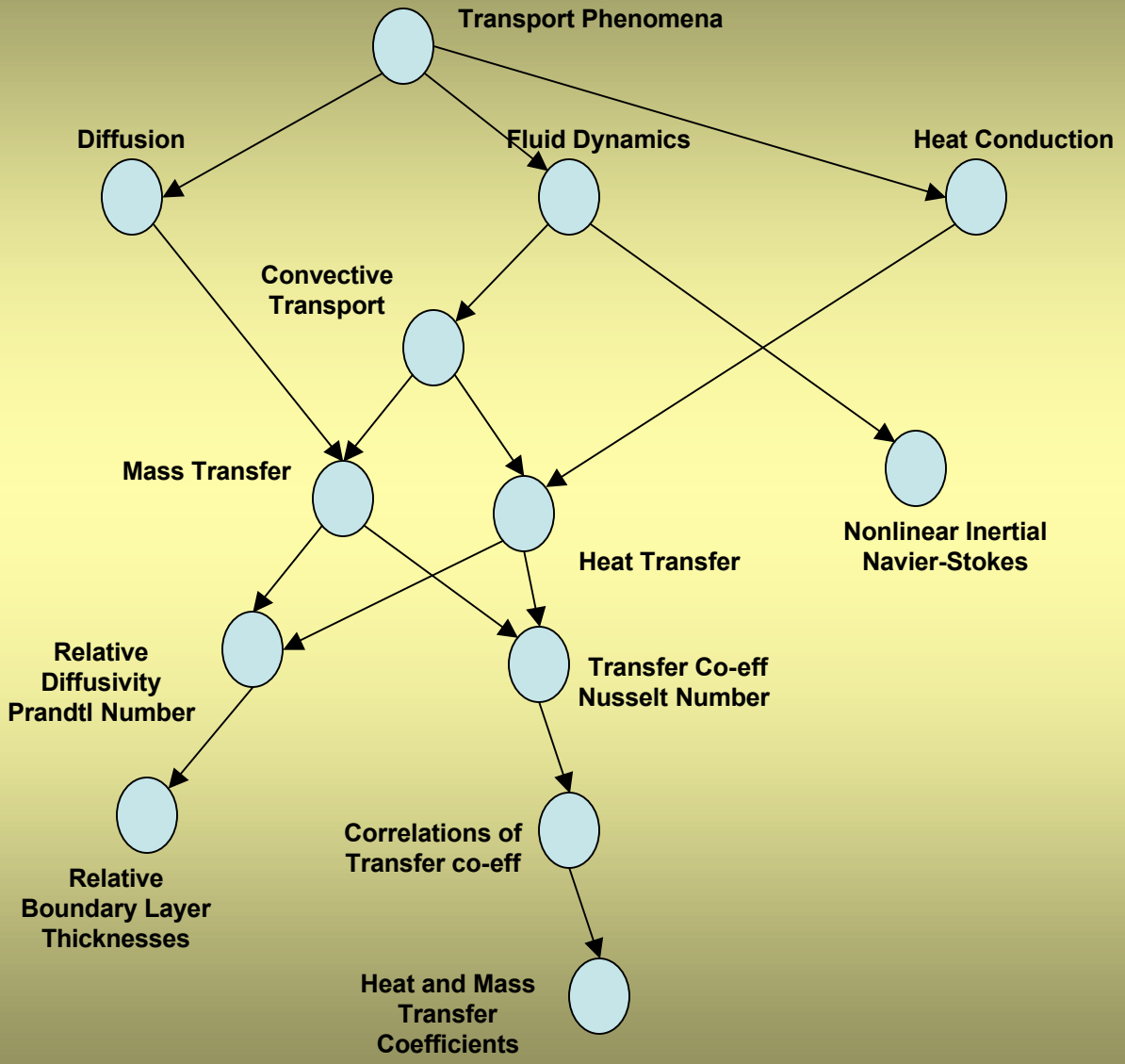
Sample Capability-3

- **Question:** I would like to know what topics I should cover for a new transport phenomena course I am developing specially for Biology majors. What preparatory topics to be added to current topics?

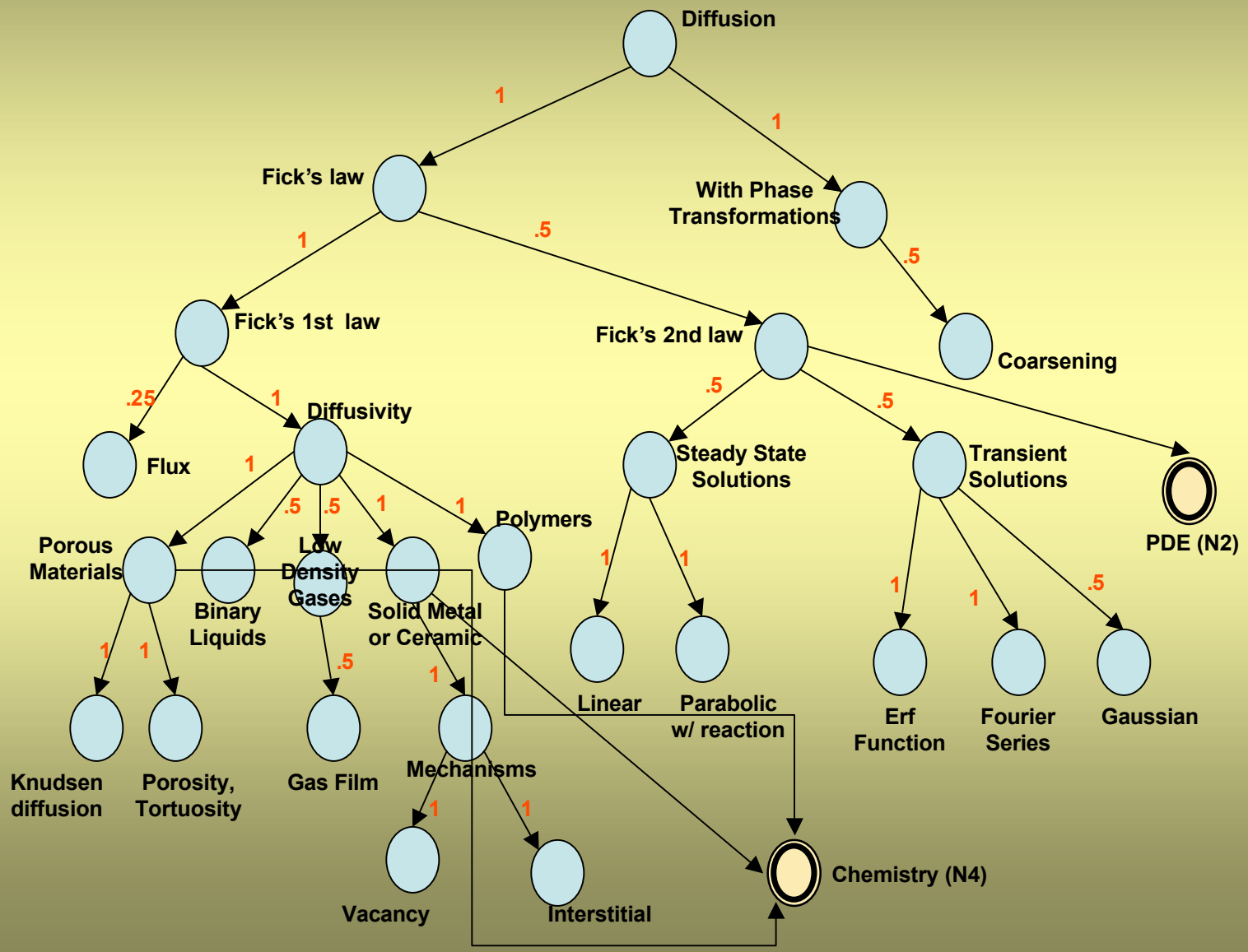
- **Course Composer:** I would suggest that you add a review discussion on “partial differential Equation” and “numerical solution approaches”. Also I suggest that you include discussion on “vascular wall” and “blood biochemistry”.

Composition Process

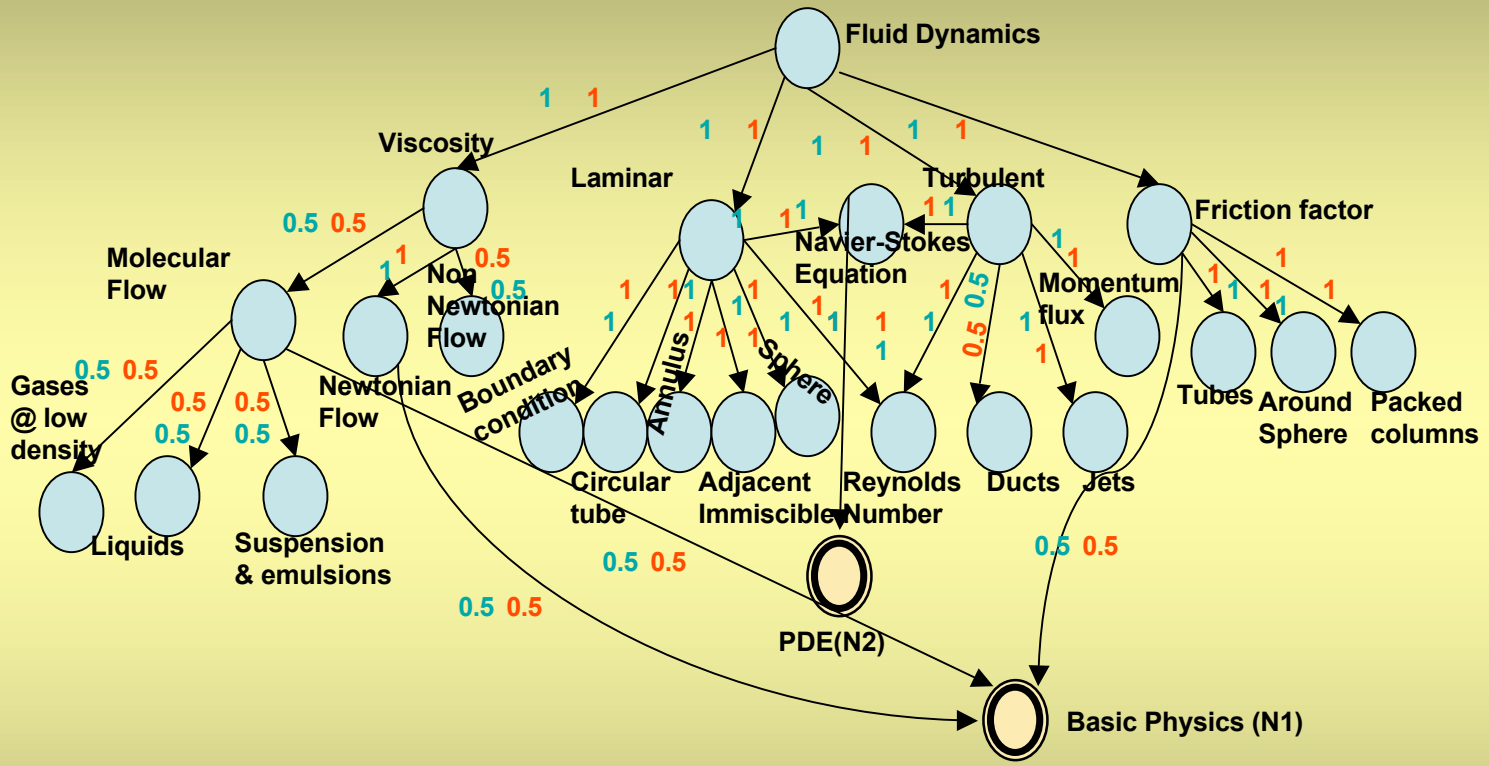
Concept Space: Transport Phenomena



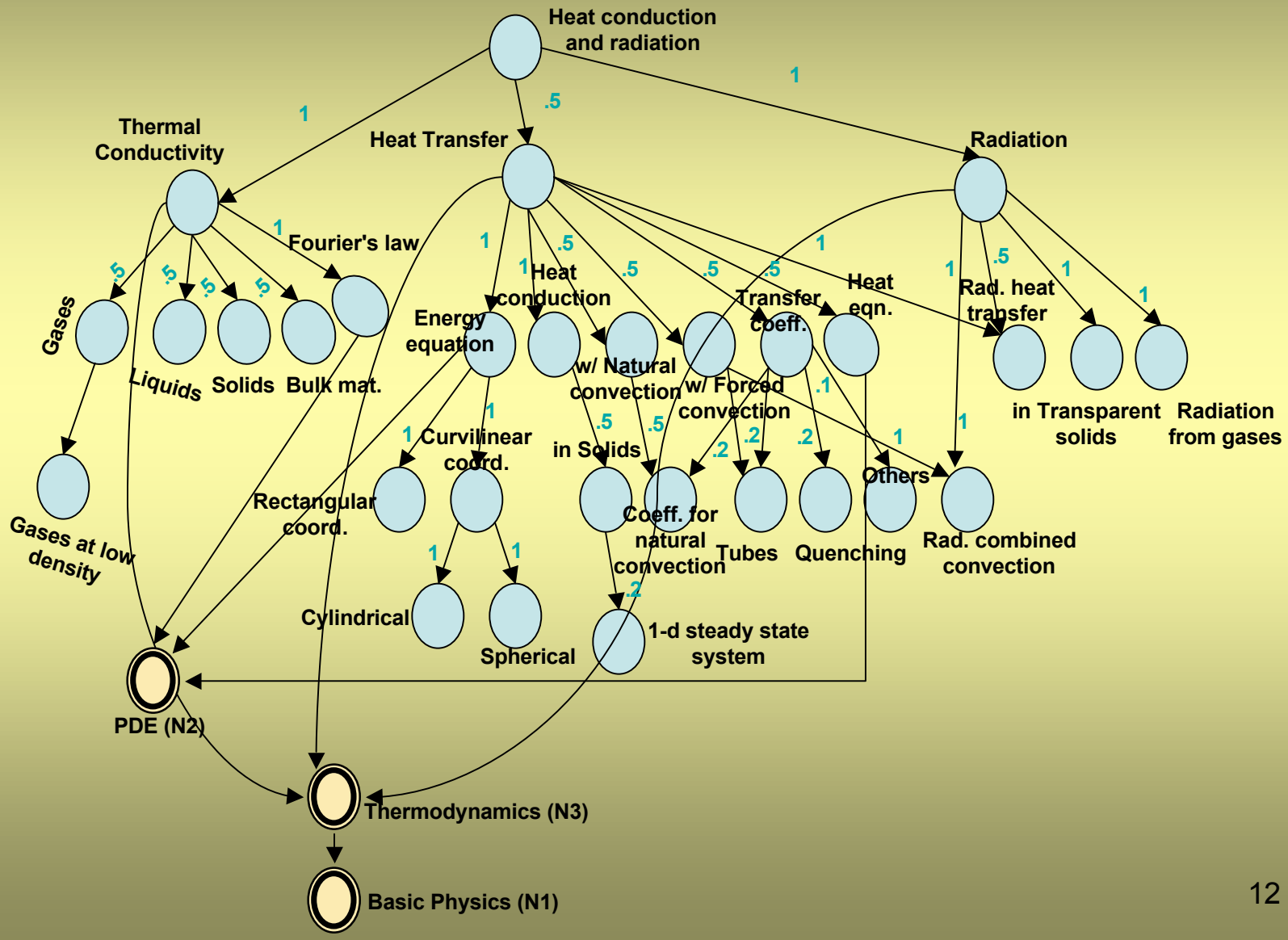
Semantic Topic Graph (part-1)



Semantic Topic Graph (part-2)



Semantic Topic Graph (part-3)



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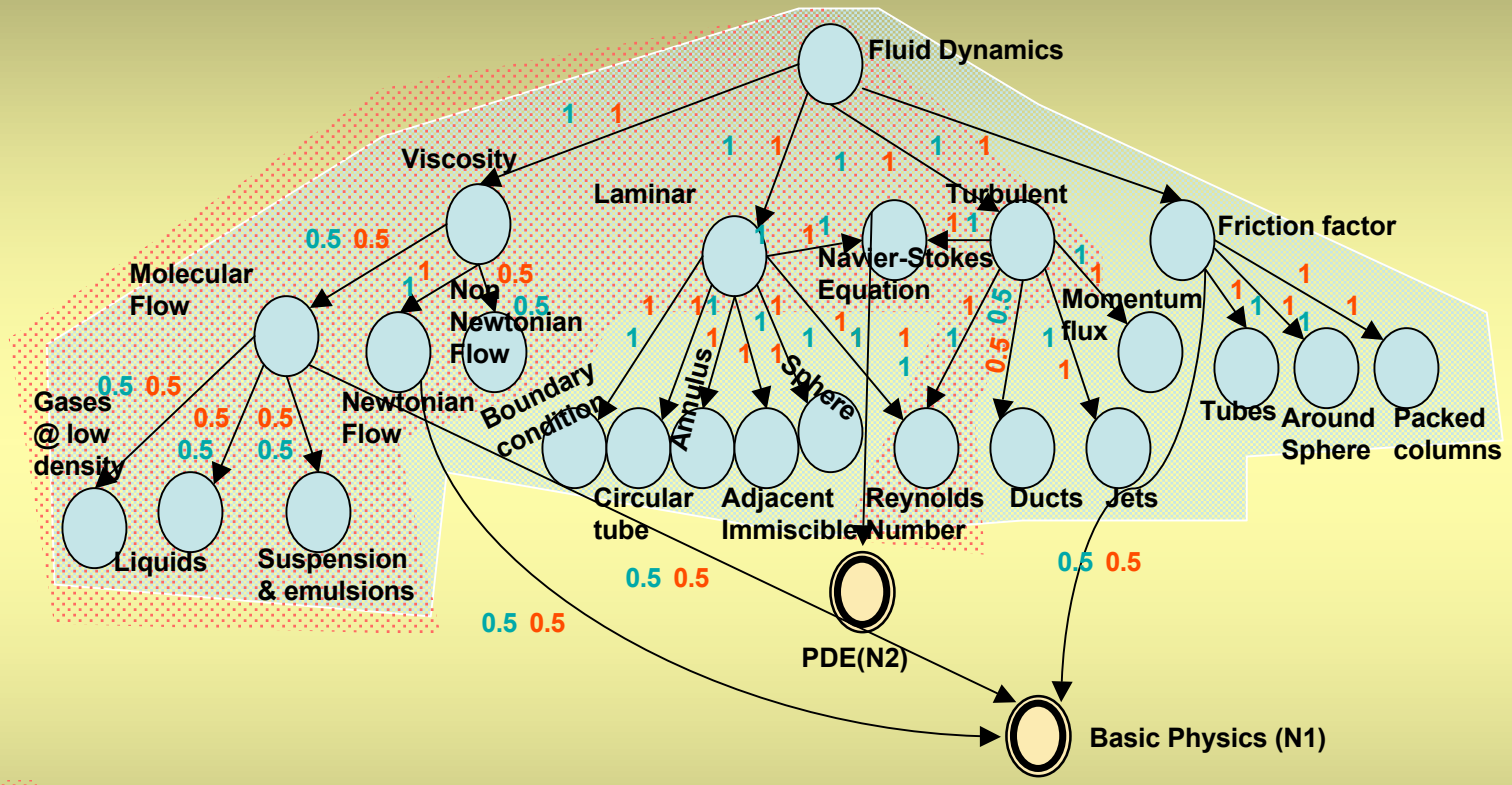

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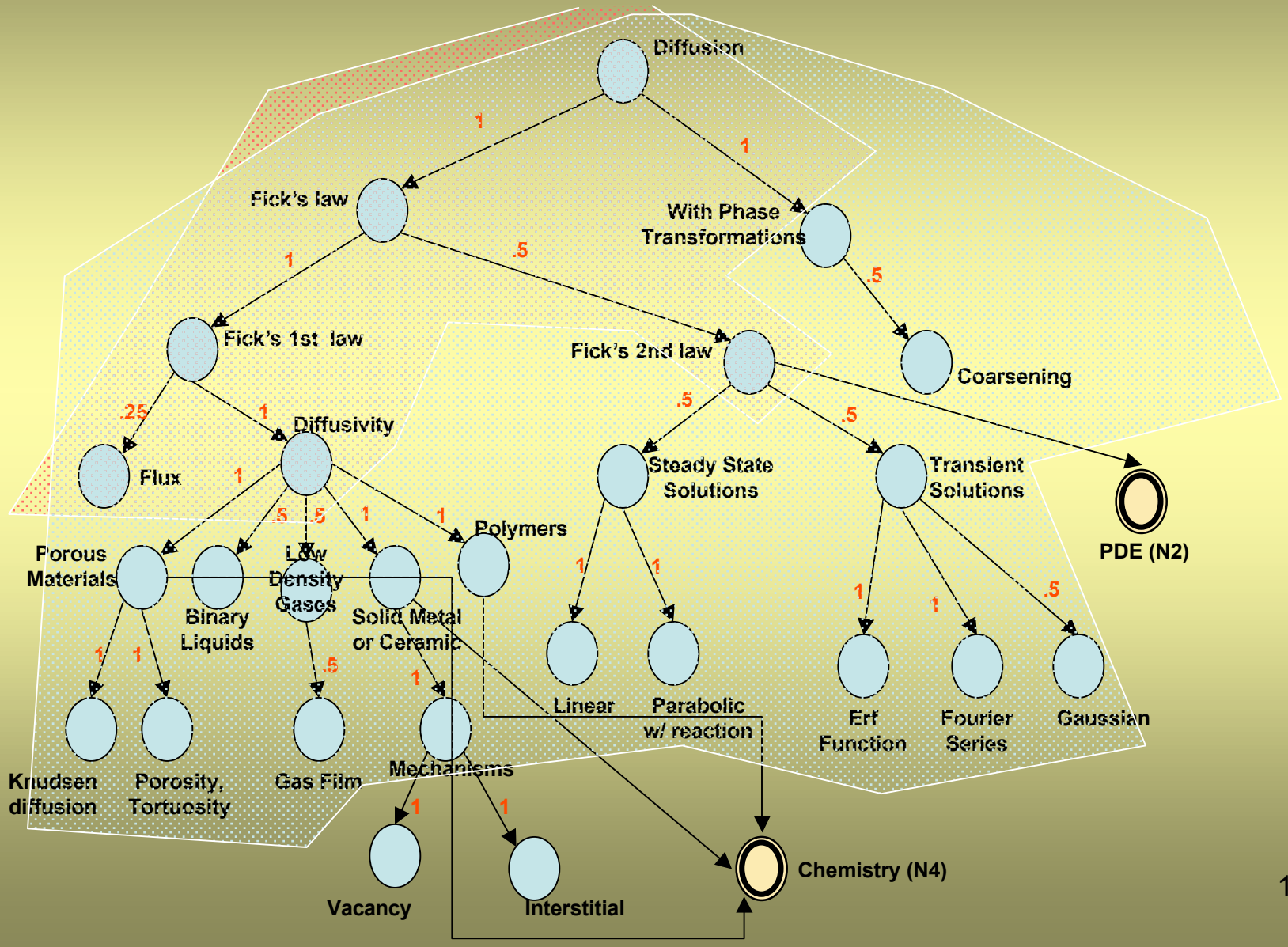
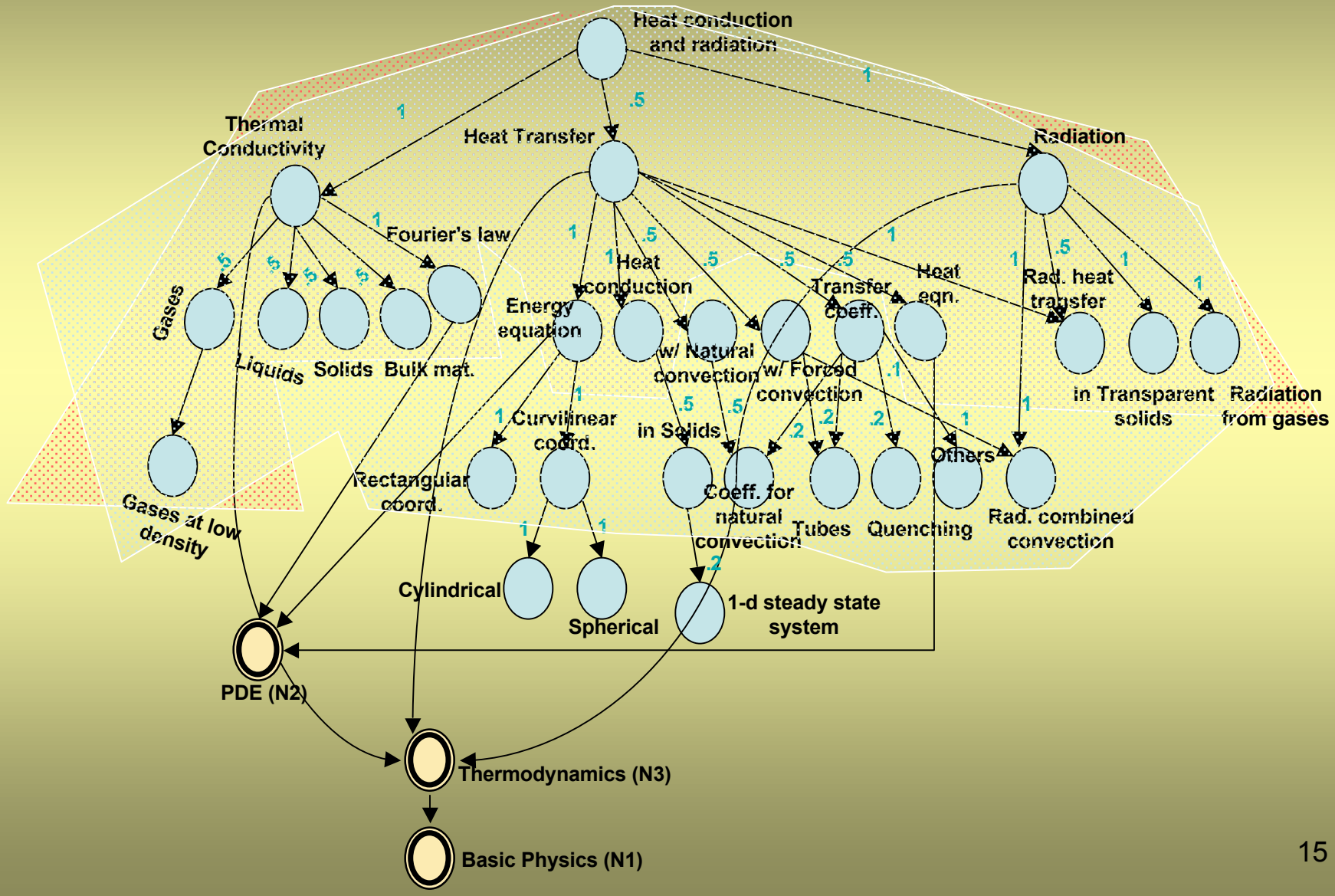
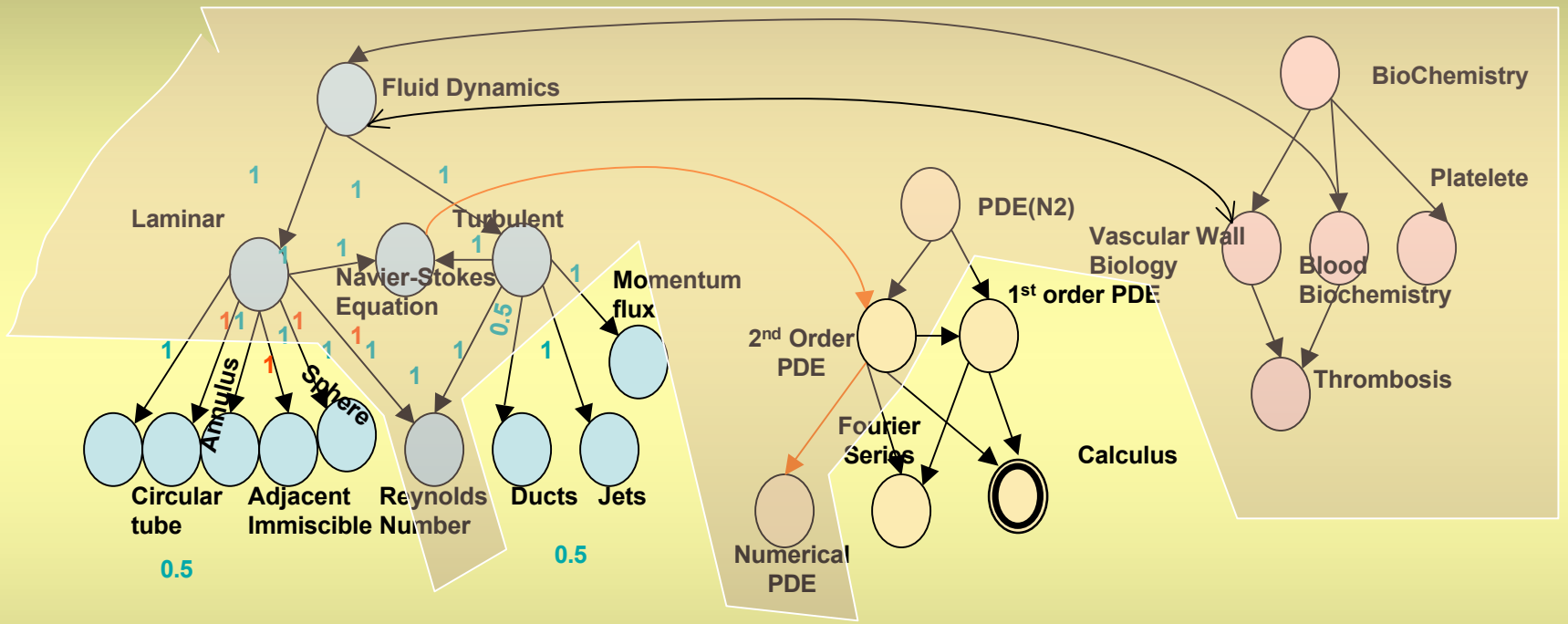


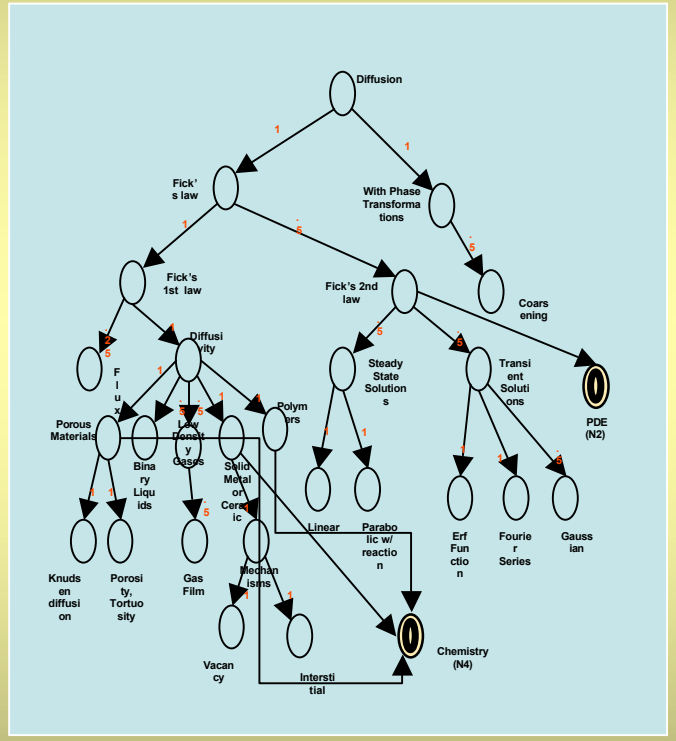
Semantic Topic Graph (part-3)

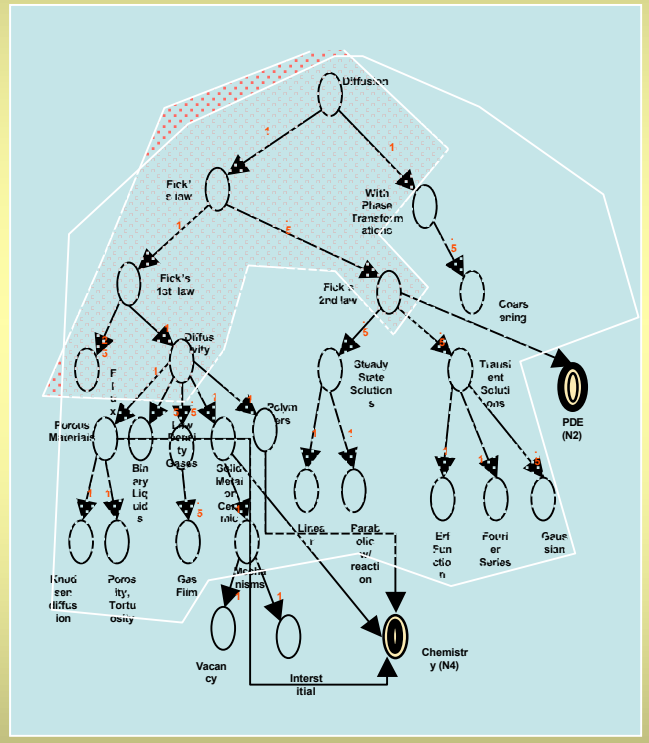


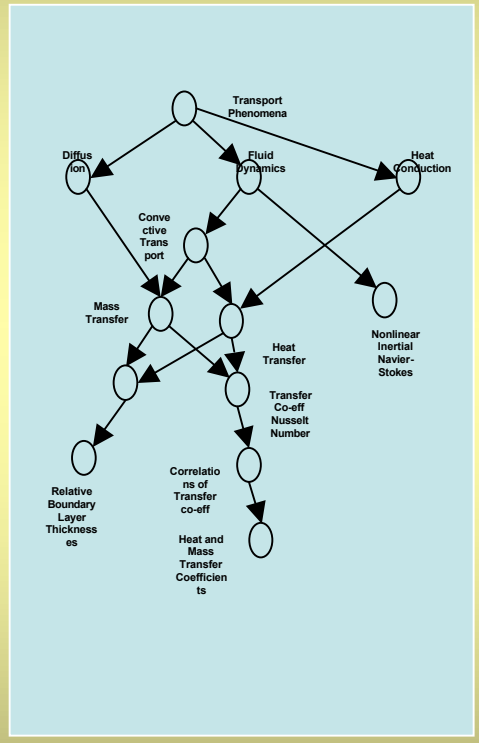
Semantic Topic Graph (Bio-X)



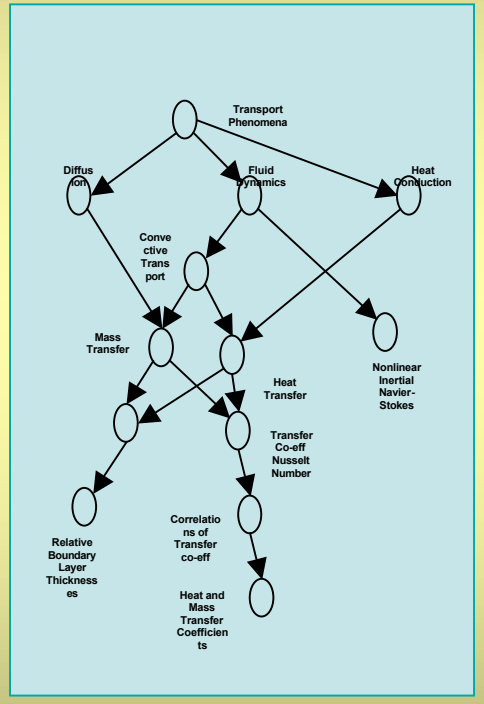
Concept Composition

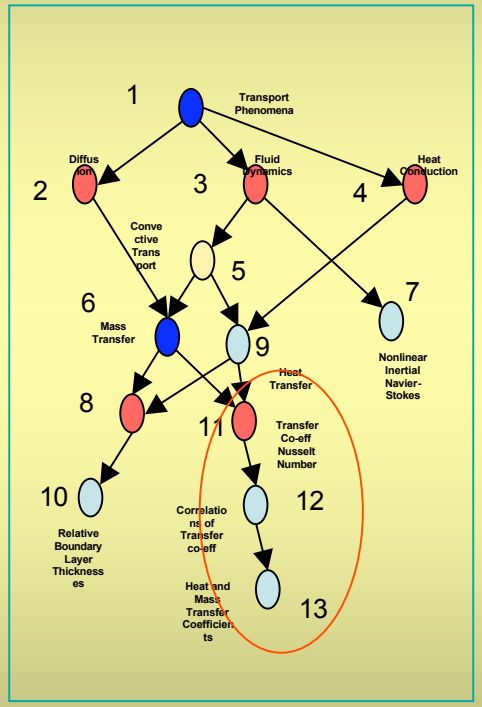






Linearization





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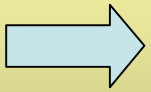
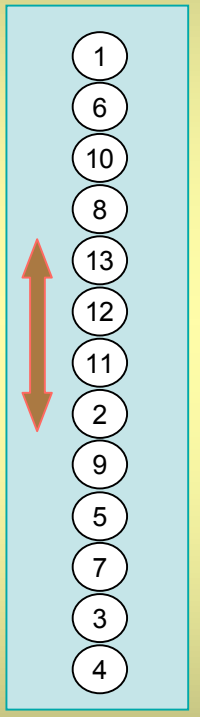
2→=(6→),2
6→=6,(8→),(11→)
8→=10,8
11→=13,12,11
3→=(5→),7,3
5→=9,6*,5
4→=4,9*

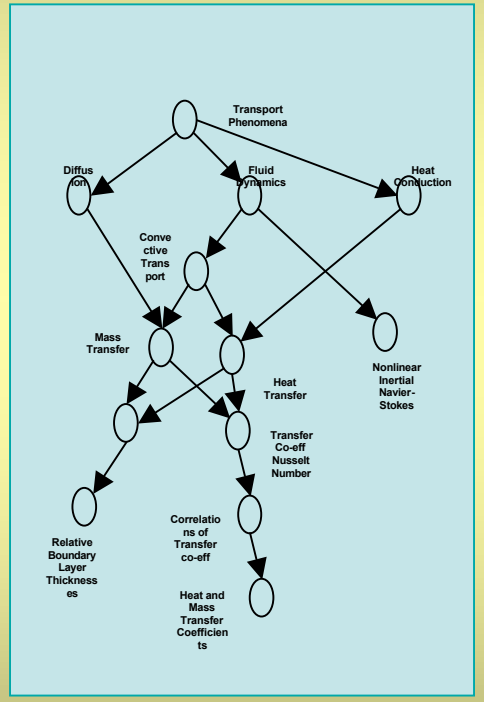
1→=(1,6,10,8,13,12,11,2,
9,6*,5,7,3,4,9*)

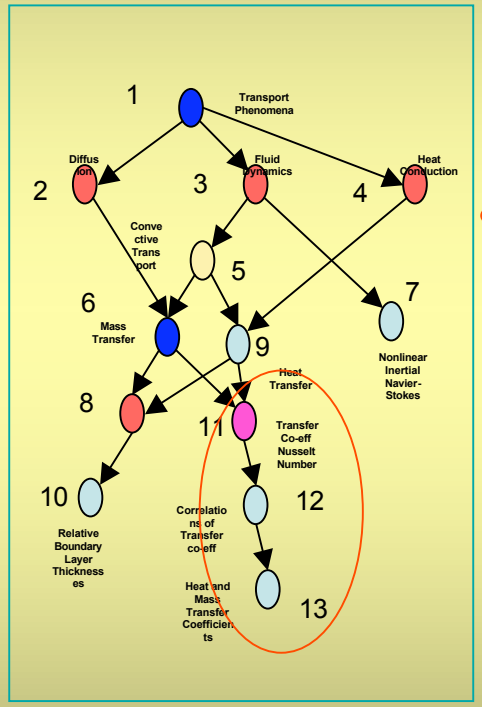




P,L→R P, R→L L→R, P R→L, P

Linearization





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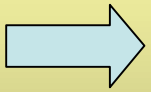
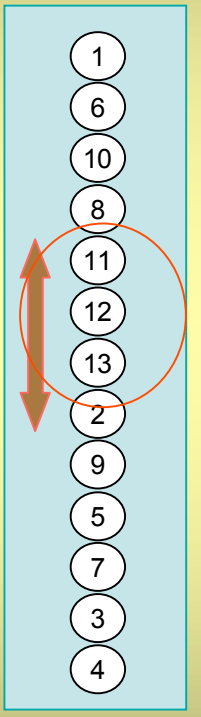
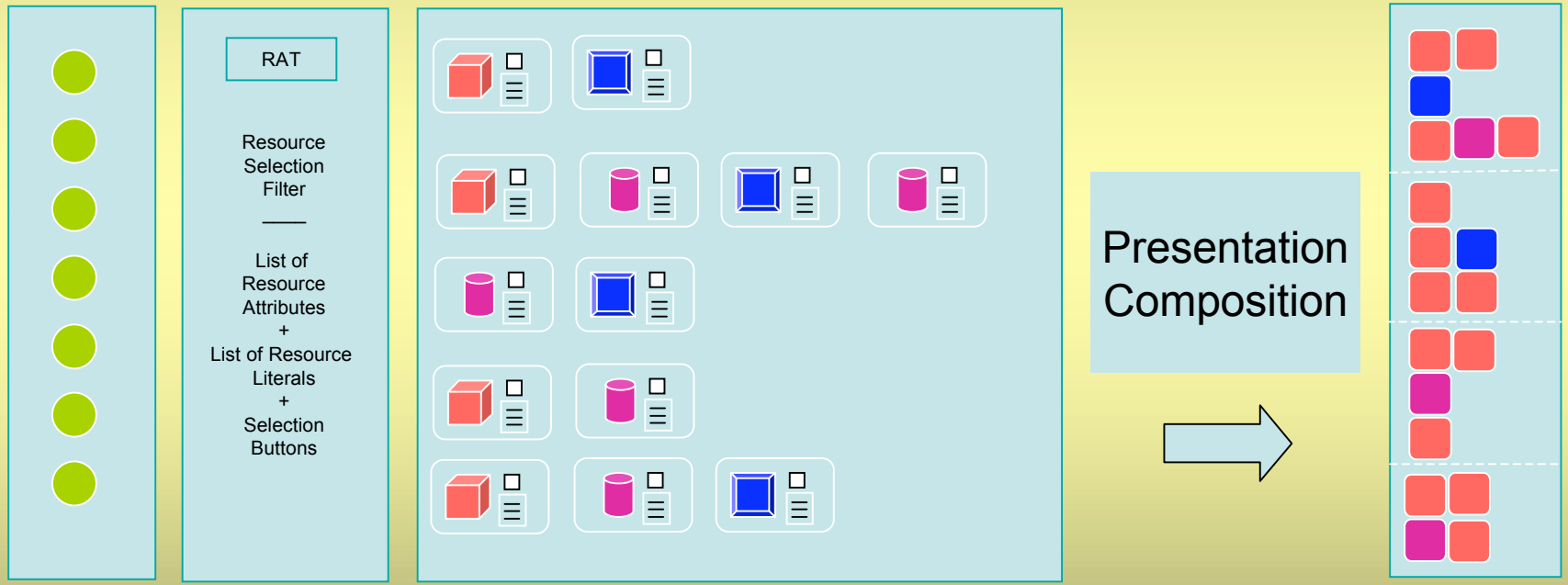




P,L→R P, R→L L→R, P R→L, P

Resource Composition



Challenges

- Flow
  - Pedagogical uniformity
    - Ontological uniformity
    - Seamless use of examples
- System
  - Access to document fragments
  - Third party value added annotation
    - We envision the translation/ conversion onsite. It is scalable in global sense only if the services can be integrated instead.
- Evolution
  - Capturing user's act of design for reuse
- Evaluation
  - How good is a composition?

Course Composer

Future Work

- By April..
  - Topic Composition
  - Linearization
  - Complete Lecture Plan
  - Homework Composition
- What's Possible
  - Creation of all lecture materials!
    - Customized text book
    - Lecture notes
    - Hand notes
    - All tests, exams and assignments
    - Course portal
    - Customized course material for special students (gifted, handicapped, blind)

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Thanks!

Question? Feedback? Ideas?