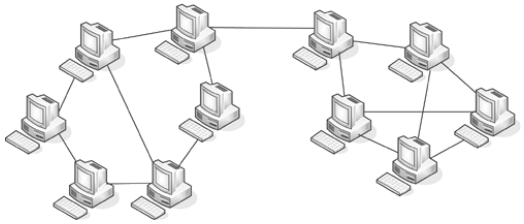
Decentralized query reformulation in DL-Lite
(IJCAI 2009)



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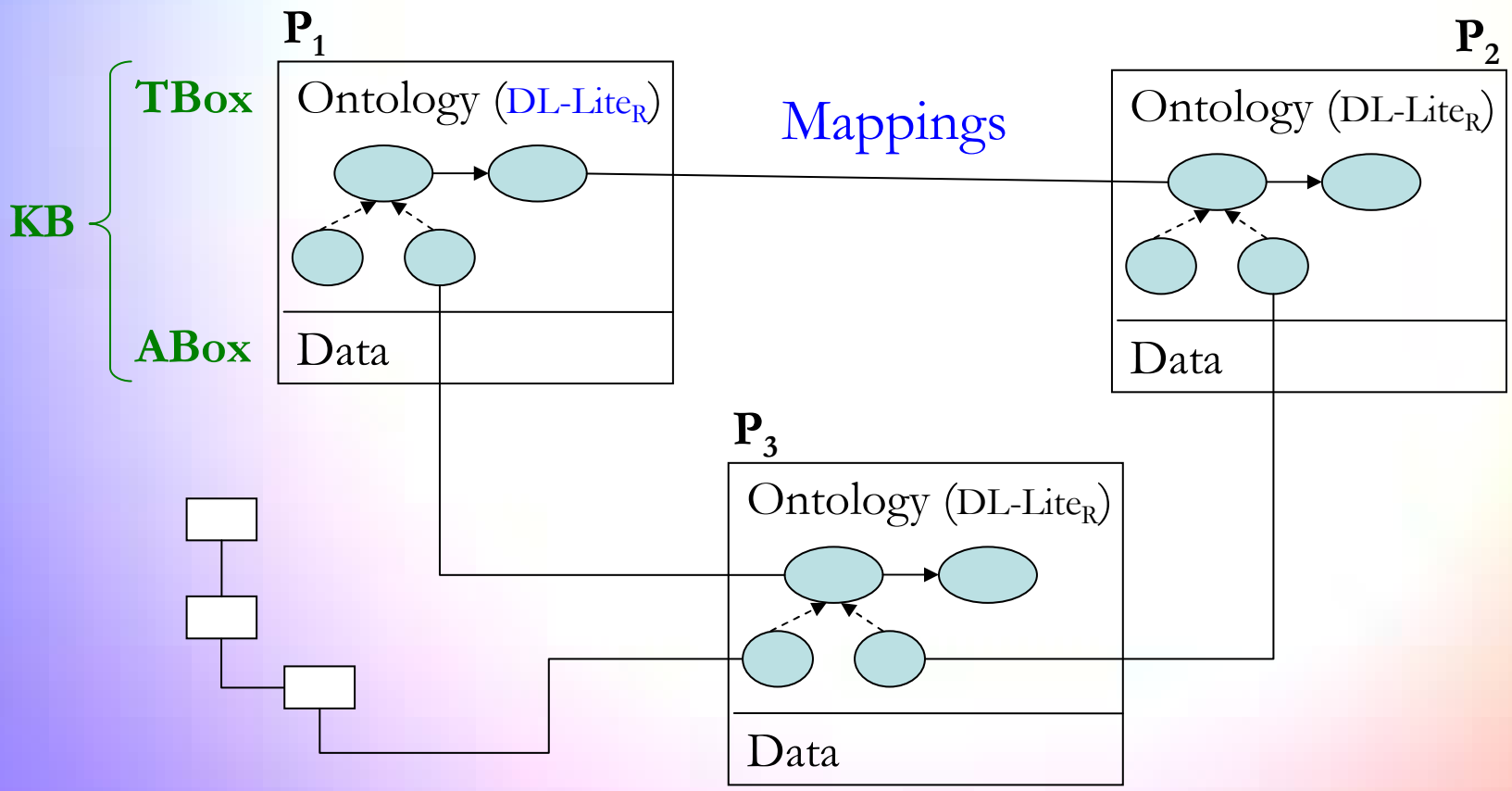
Setting Decentralized data management for the Semantic Web

Decentralized: Dynamic network of collaborative peers

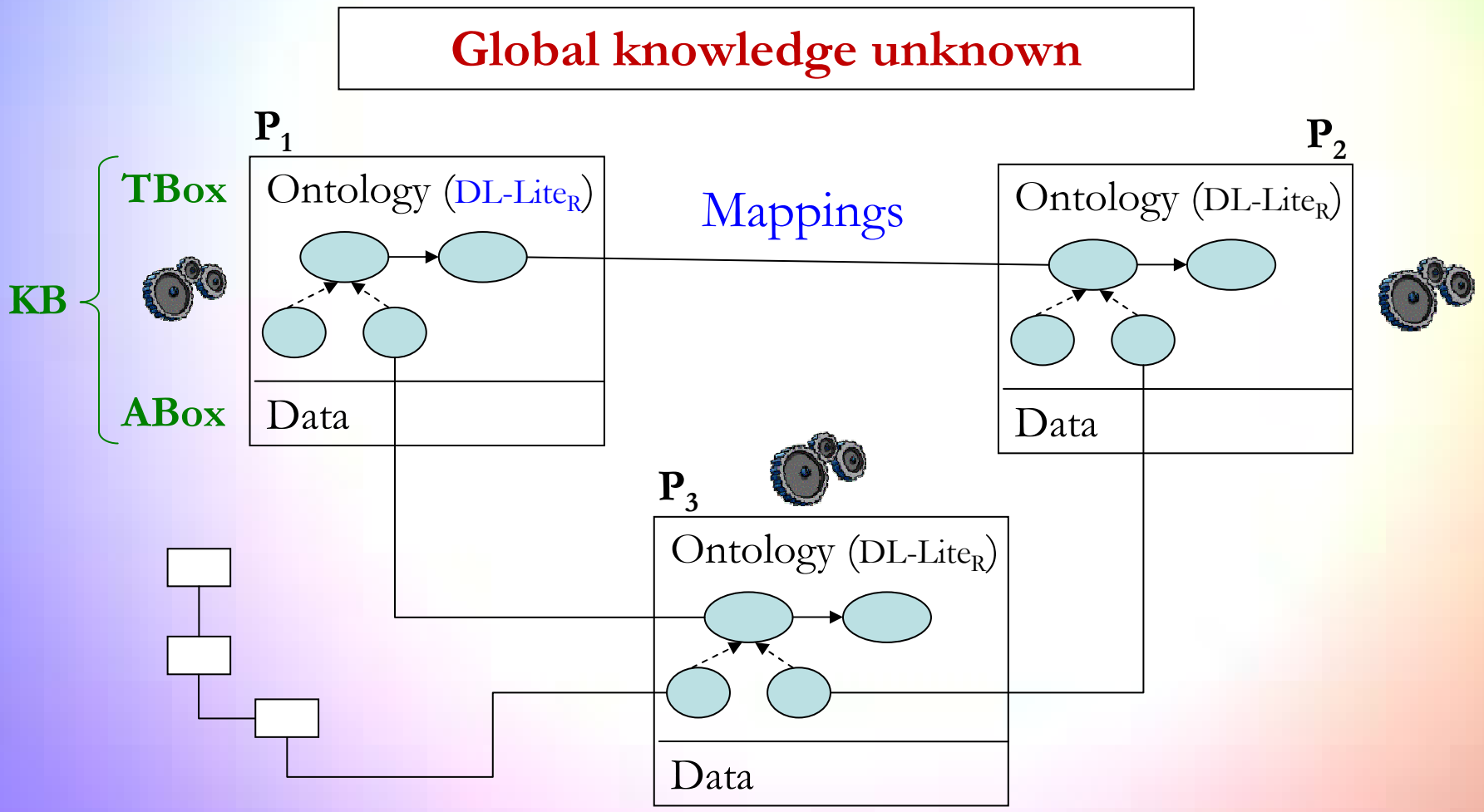
Semantic Web: Data are described with ontologies (OWL2)



Context Decentralized Data management system for the Semantic Web

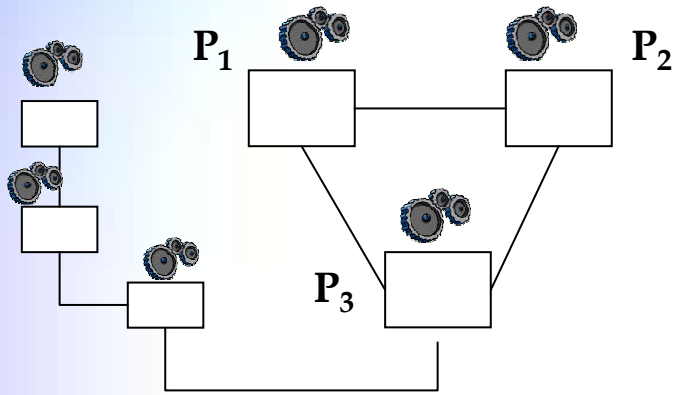
Decentralized: Dynamic Network of collaborative peers

Semantic Web: Data are described with ontologies (OWL2)



Contributions

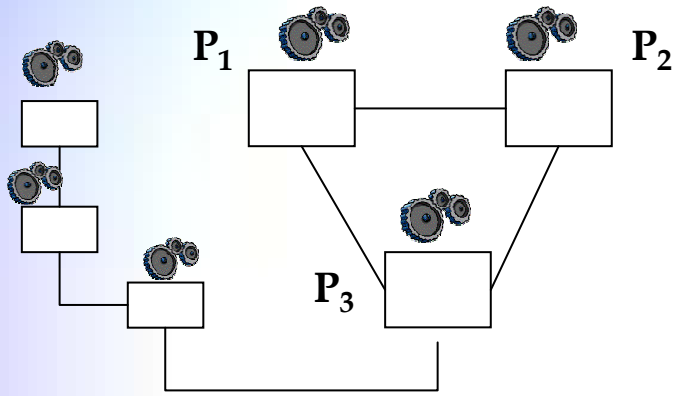
1. DL-Lite$_R$ decentralized data model



2. Decentralized Algorithms for:
   - ✓ Data consistency checking
   - ✓ Query Answering

Contributions

1. **DL-Lite$_R$ decentralized data model**



2. **Decentralized Algorithms for:**
   - ✓ **Data consistency checking**
   - ✓ **Query Answering**

State of the art

- D.Calvenese and al. (JAR 07) "Tractable reasoning and efficient query answering in description logics"

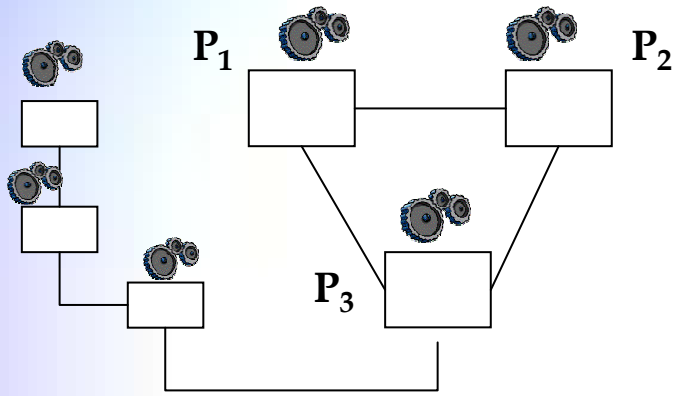
Centralized DL-Lite$_R$ KB

Centralized Algorithms for:

- ✓ **Data consistency checking**
- ✓ **Query Answering**

Contributions

1. **DL-Lite$_R$ decentralized data model**



2. **Decentralized Algorithms for:**
   - ✓ **Data consistency checking**
   - ✓ **Query Answering by reformulation**

State of the art

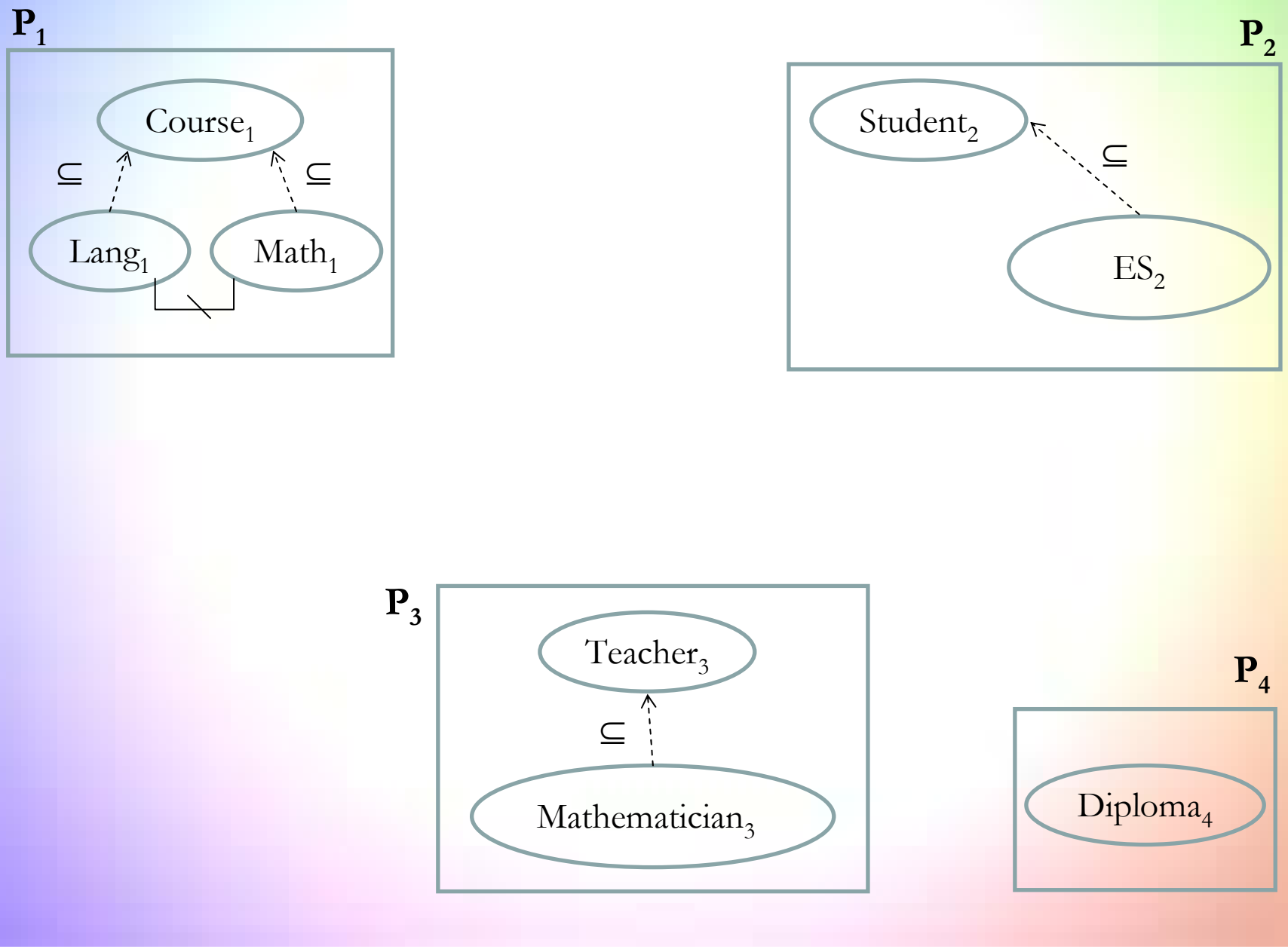
- D.Calvenese and al. (JAR 07) "Tractable reasoning and efficient query answering in description logics"

Centralized DL-Lite$_R$ KB

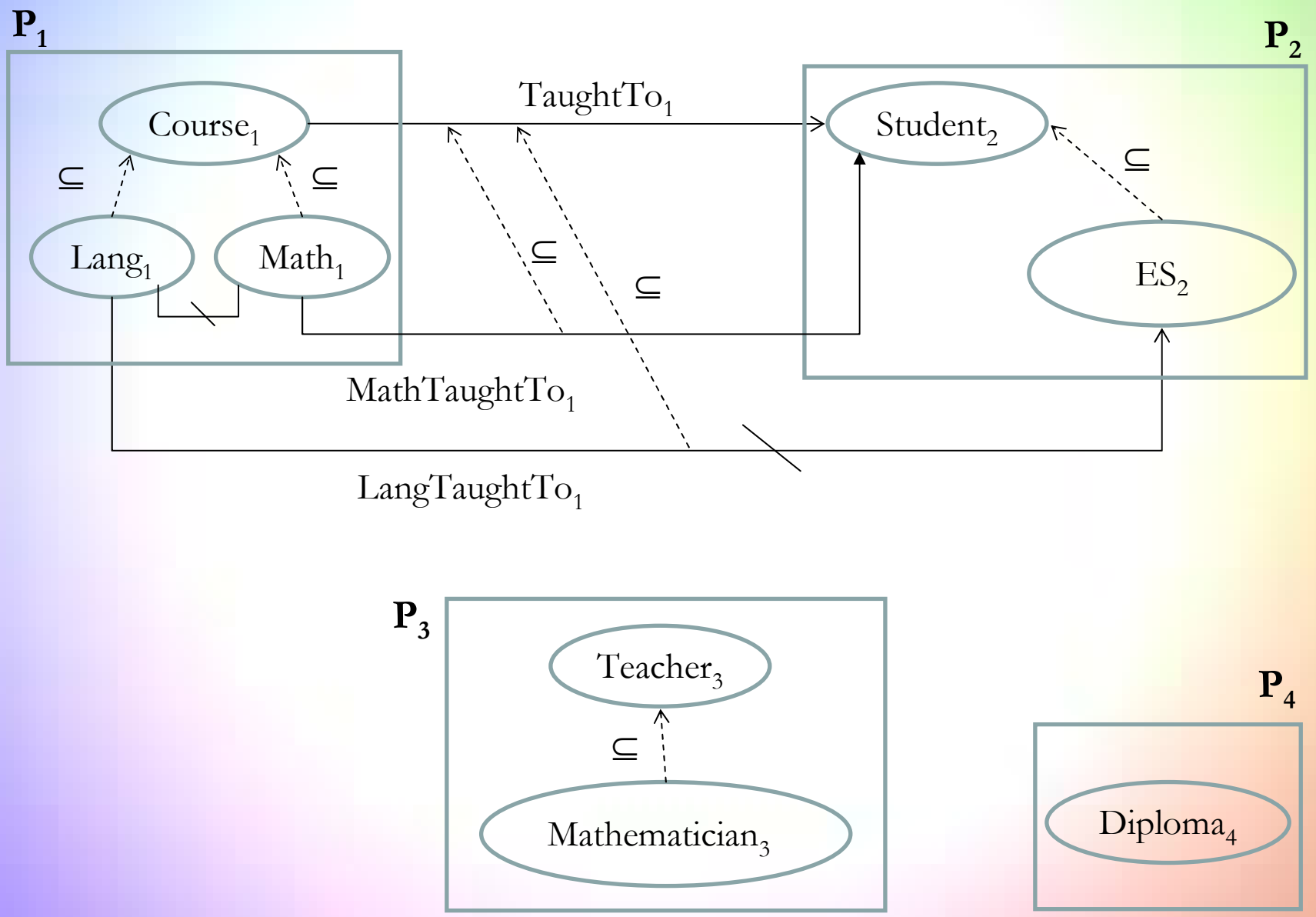
Centralized Algorithms for:
- ✓ **Data consistency checking**
- ✓ **Query Answering by reformulation**

3. **Decentralized & Centralized Algorithms for:**
   - ✓ **View consistency checking**
   - ✓ **Query Answering using views**

DL-Lite$_R$ decentralized data management: illustration



DL-Lite$_R$ decentralized data management system



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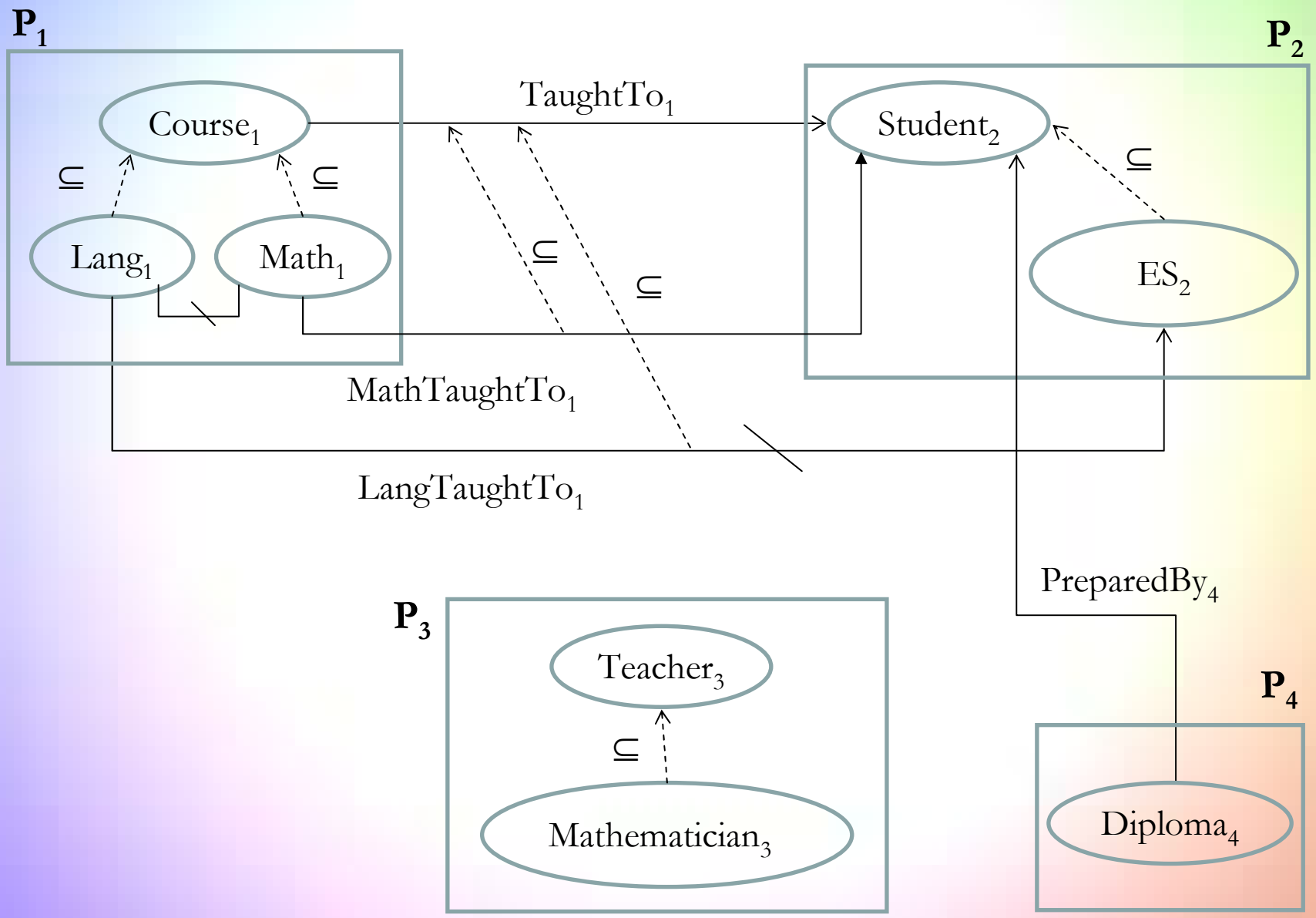

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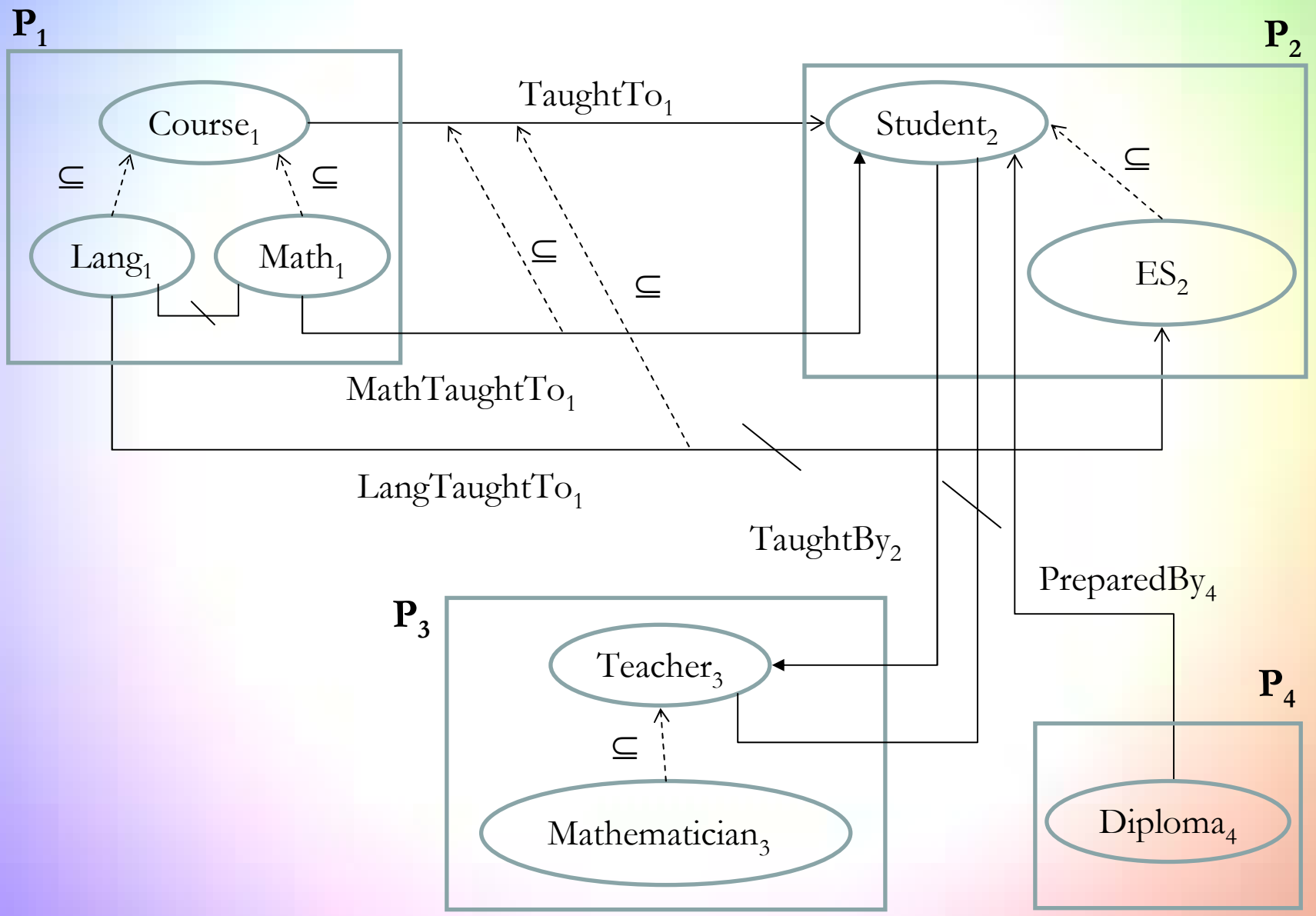

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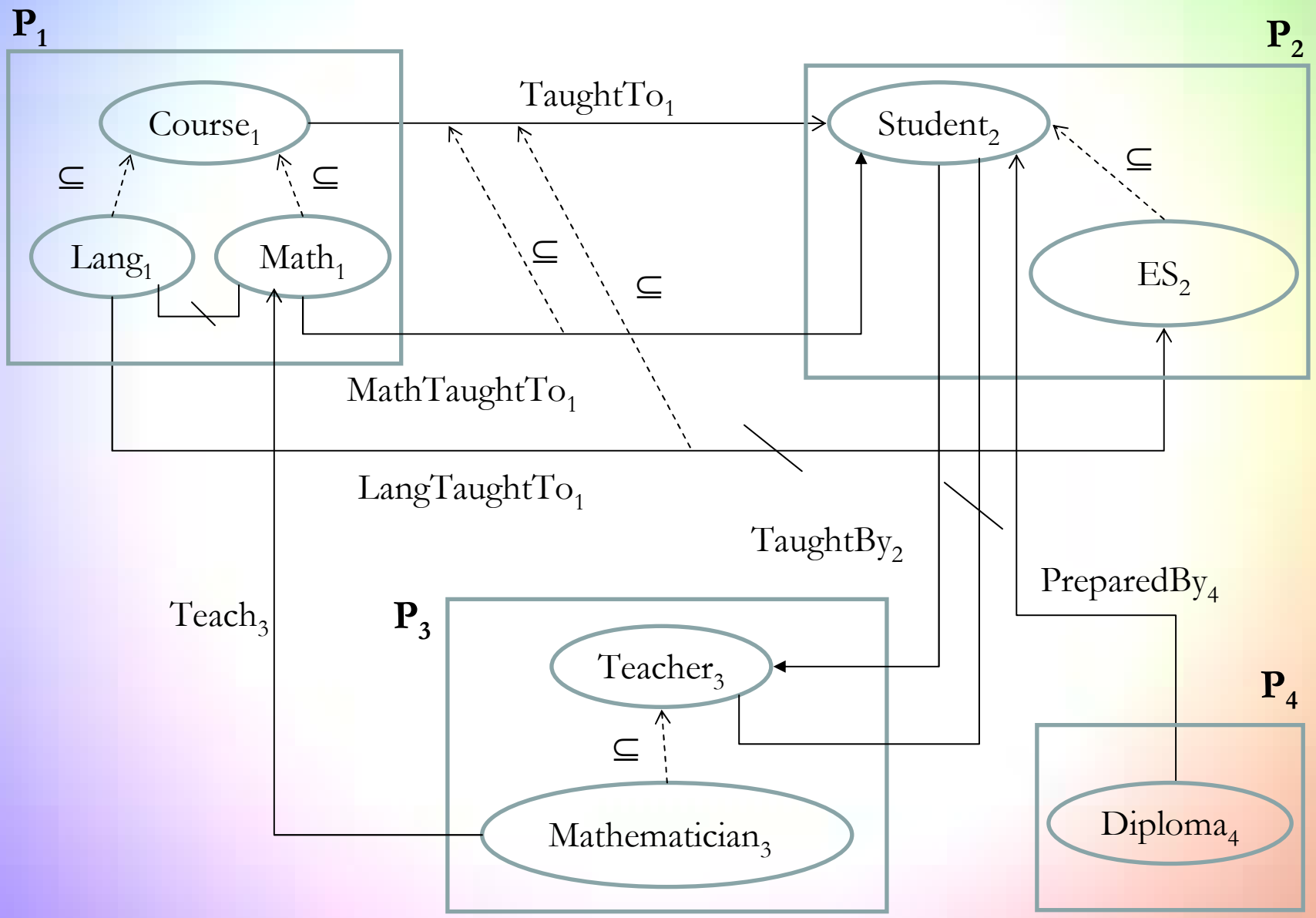

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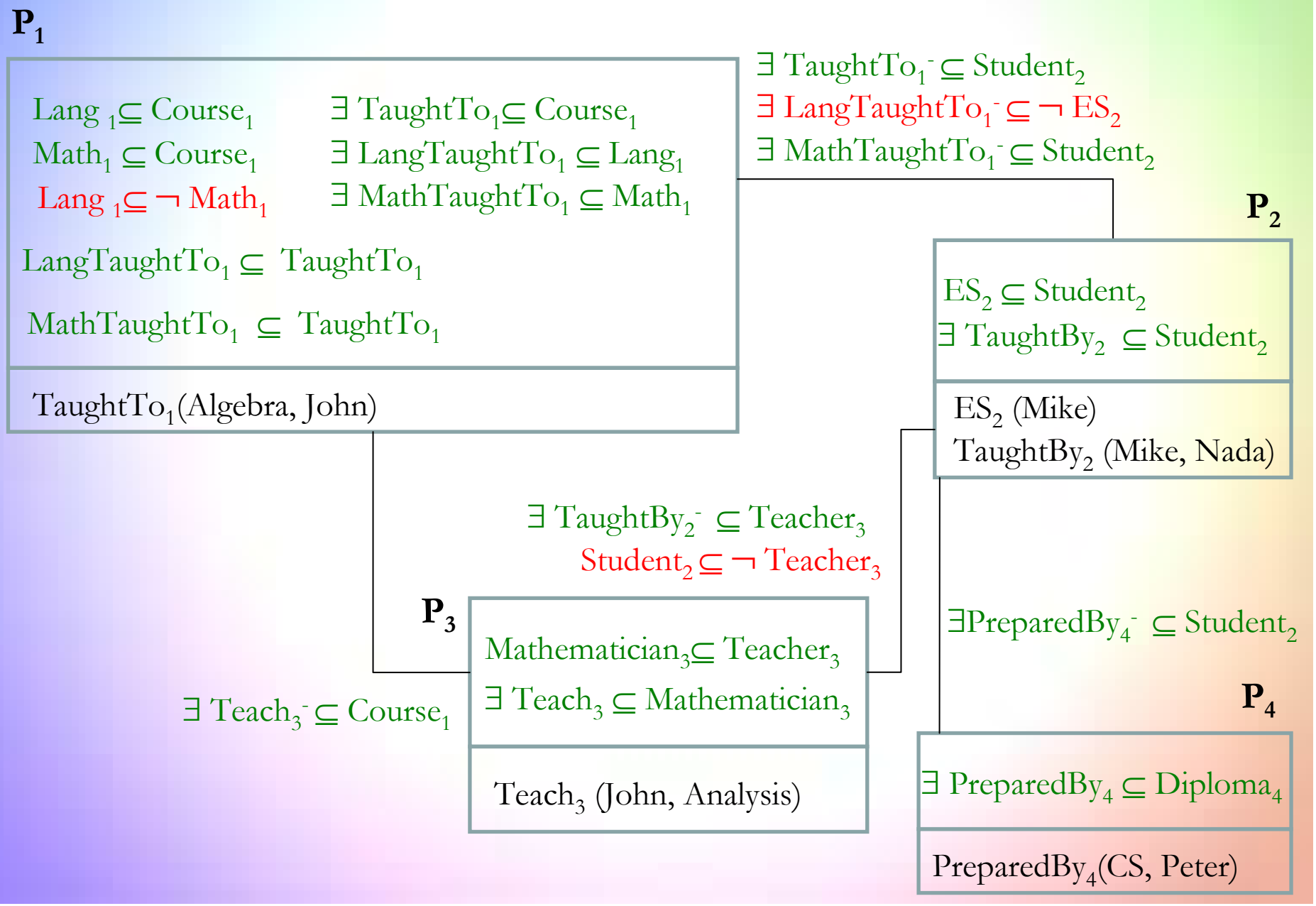


Data consistency Checking

- Consistency problem:

  A data management system is consistent iff its KB (Tbox + Abox) is satisfiable.

- In DL-Lite$_R$:
  - ✓ Tbox is always satisfiable
  - ✓ Tbox + Abox may be insatisfiable

- Example :

TBox

$\exists$ TaughtTo$_1^-$ $\subseteq$ Student$_2$

Student$_2$ $\subseteq \neg$ Teacher$_3$

Mathematician$_3$ $\subseteq$ Teacher$_3$

$\exists$ Teach$_3$ $\subseteq$ Mathematician$_3$

Implicit Negative Inclusion

$\uparrow$

TBox $\models \exists$ TaughtTo$_1^-$ $\subseteq \neg \exists$ Teach$_3$

ABox

TaughtTo$_1$ (Algebra, John)

Teach$_3$ (John, Analysis)

KB $\models \exists$ y TaughtTo$_1$ (y , John)

KB $\models \exists$ y Teach$_3$(John , y)

$\bot$

Data consistency Checking

- Centralized case

Existing Algorithm Consistent :

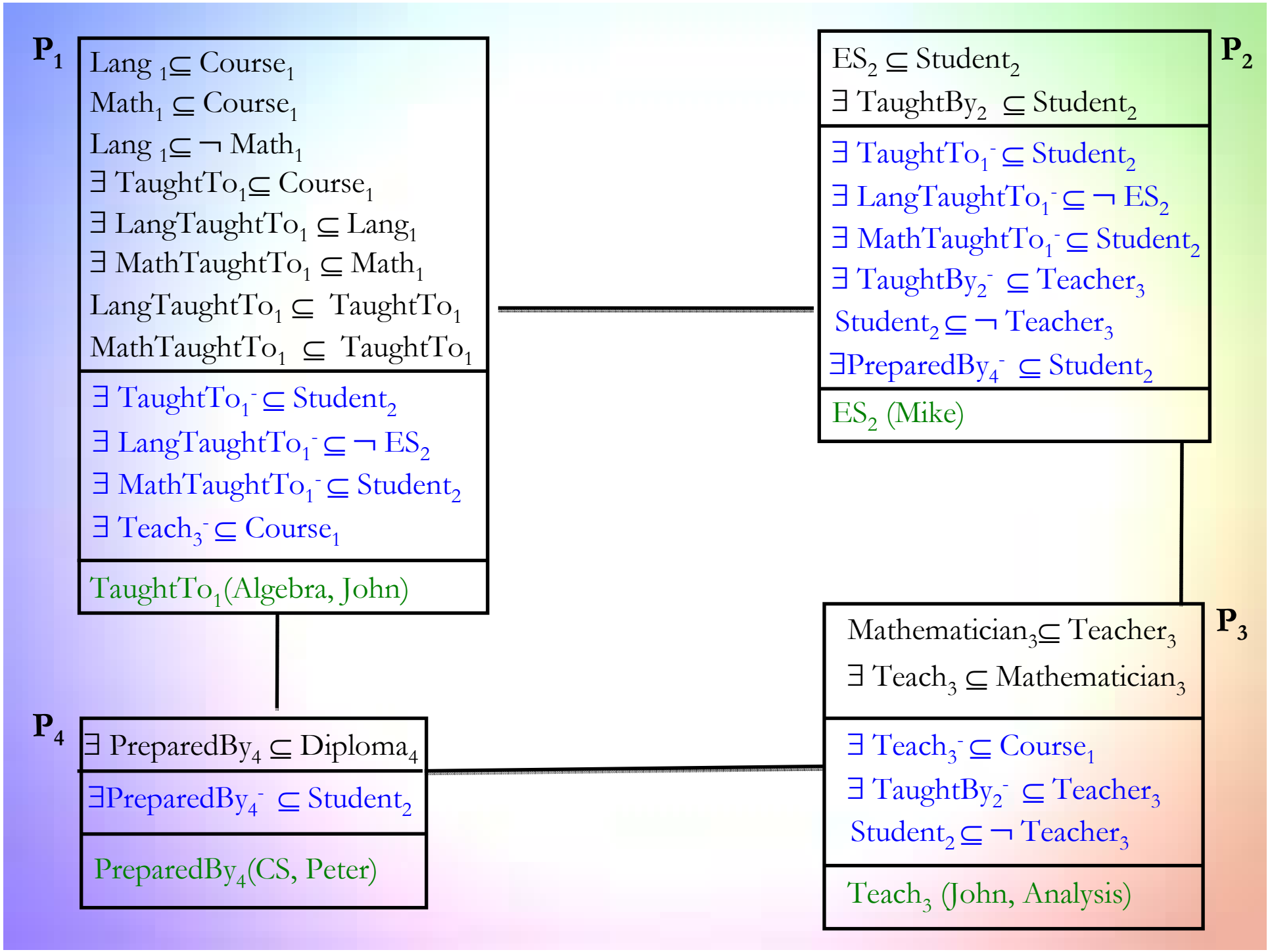
D.Calvenese and al. (JAR 07) :"Tractable reasoning and efficient query answering in description logics"

- Computes all the Negative Inclusions entailed by the Tbox.
- Checks if the computed negative inclusions are violated by the Abox.

Checking if the DL-Lite$_R$ formulae that must be disjoint according to the TBox, indeed have disjoint instances in the Abox

Data consistency Checking

- Decentralized case
  - Decentralized Data consistency Checking w.r.t a peer
    - ✓ Each peer propagates over the network each of its positive or negative inclusions and collects in return all the negative inclusions of the network the entailment of which uses the Tbox of the peer.
      - All Negative Inclusions entailed by the network are not necessarily computed.
    - ✓ Each peer checks if the negative inclusions that he has collected are violated by the Data by sending queries to the corresponding peers.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Lang 1⊆ Course1
Math1 ⊆ Course1
Lang 1⊆ ¬ Math1
∃ TaughtTo1⊆ Course1
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LangTaughtTo1 ⊆ TaughtTo1
MathTaughtTo1 ⊆ TaughtTo1
∃ TaughtTo1- ⊆ Student2
∃ LangTaughtTo1- ⊆ ¬ ES2
∃ MathTaughtTo1- ⊆ Student2
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TaughtTo1(Algebra, John)
P2
ES2 ⊆ Student2
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ES2 (Mike)
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P4
∃ PreparedBy4 ⊆ Diploma4
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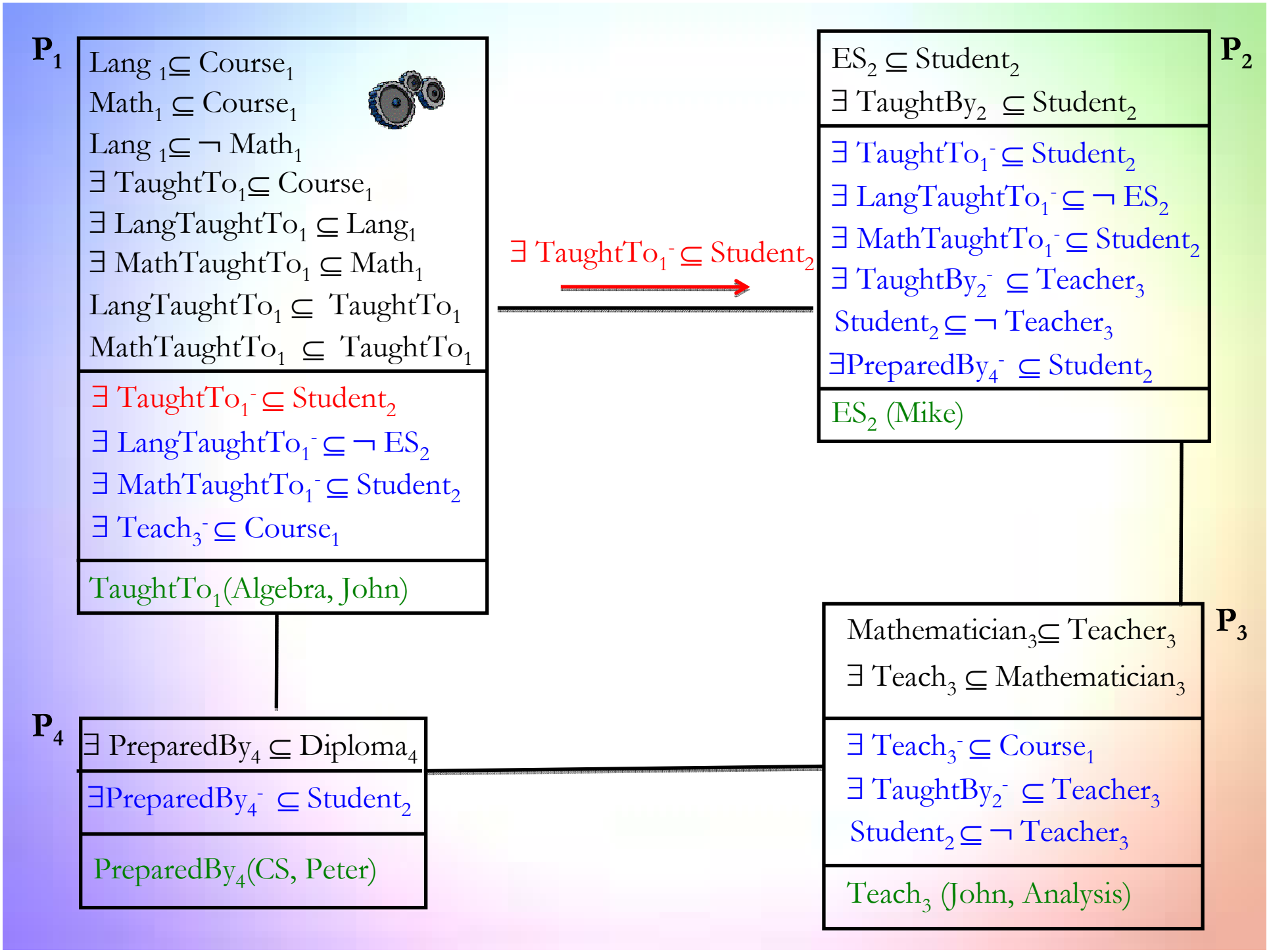
PreparedBy4(CS, Peter)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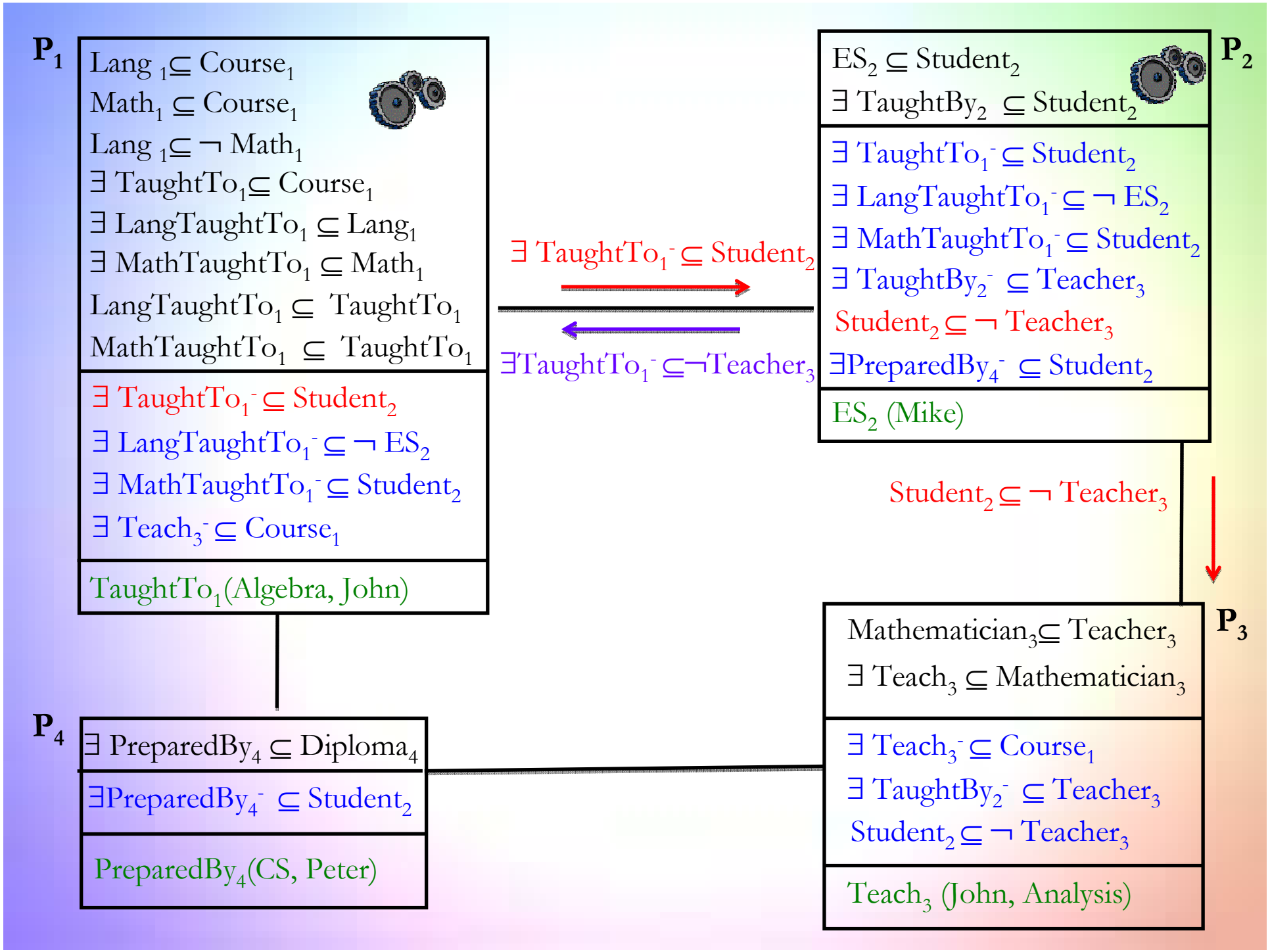
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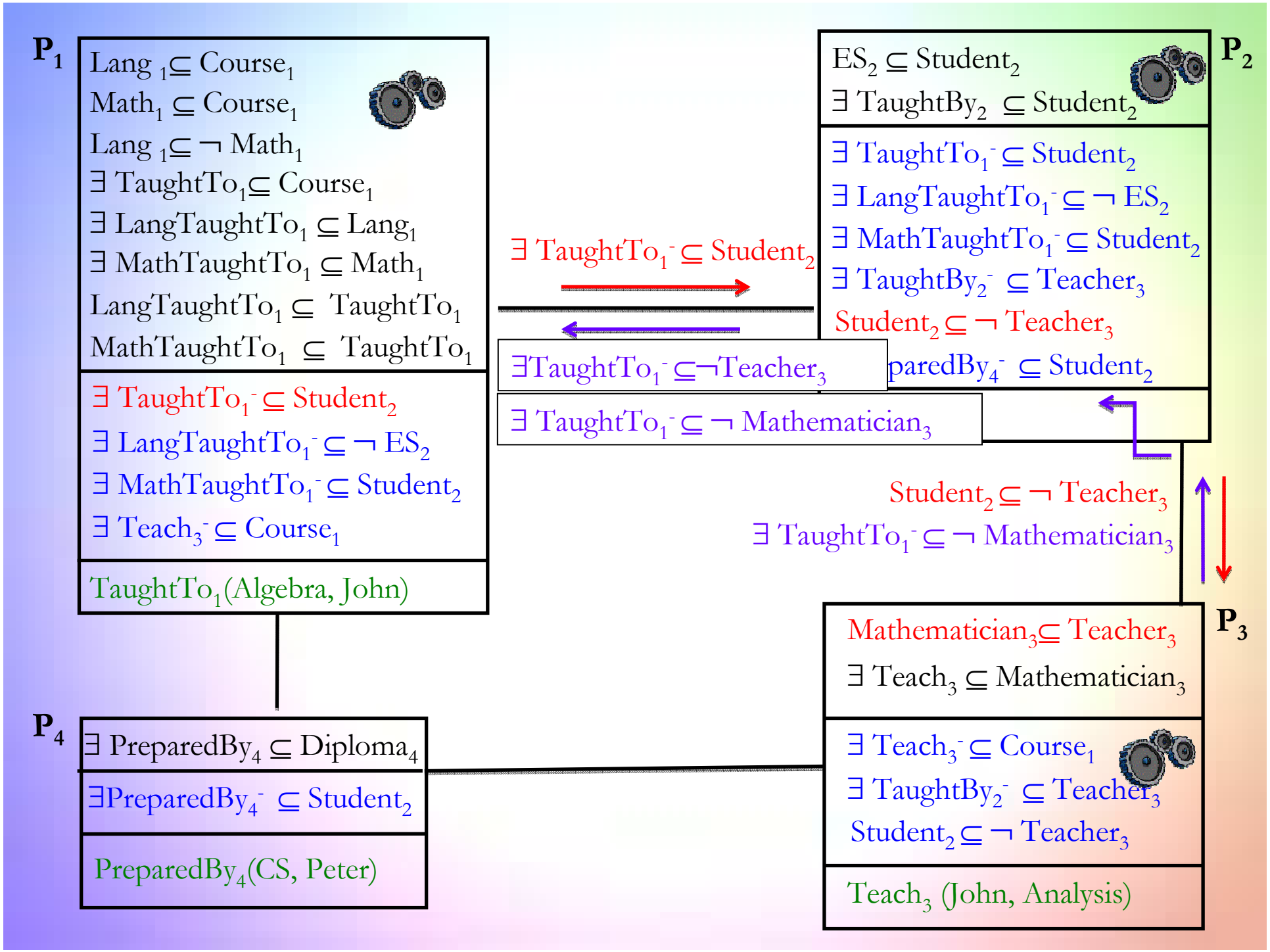
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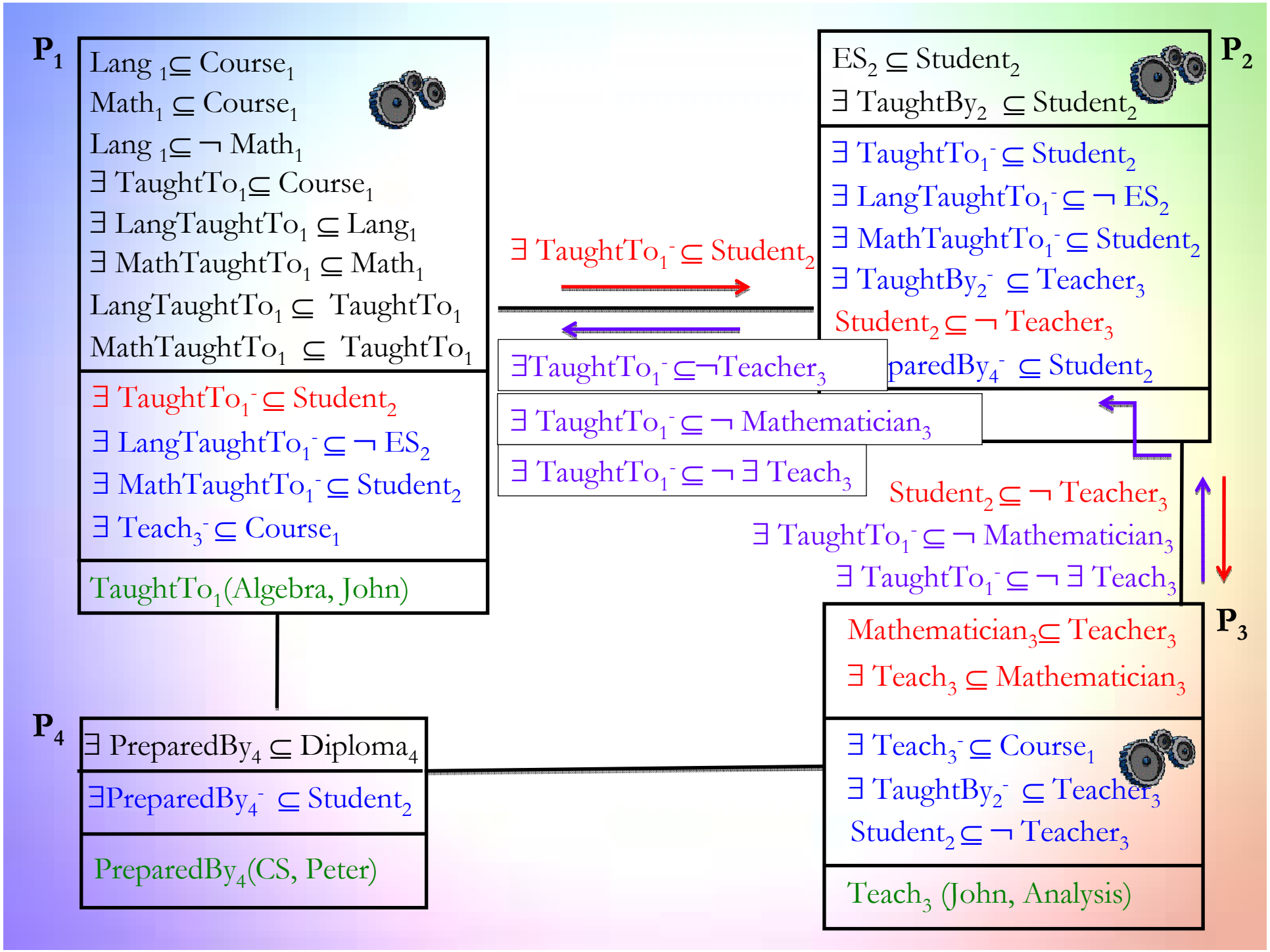
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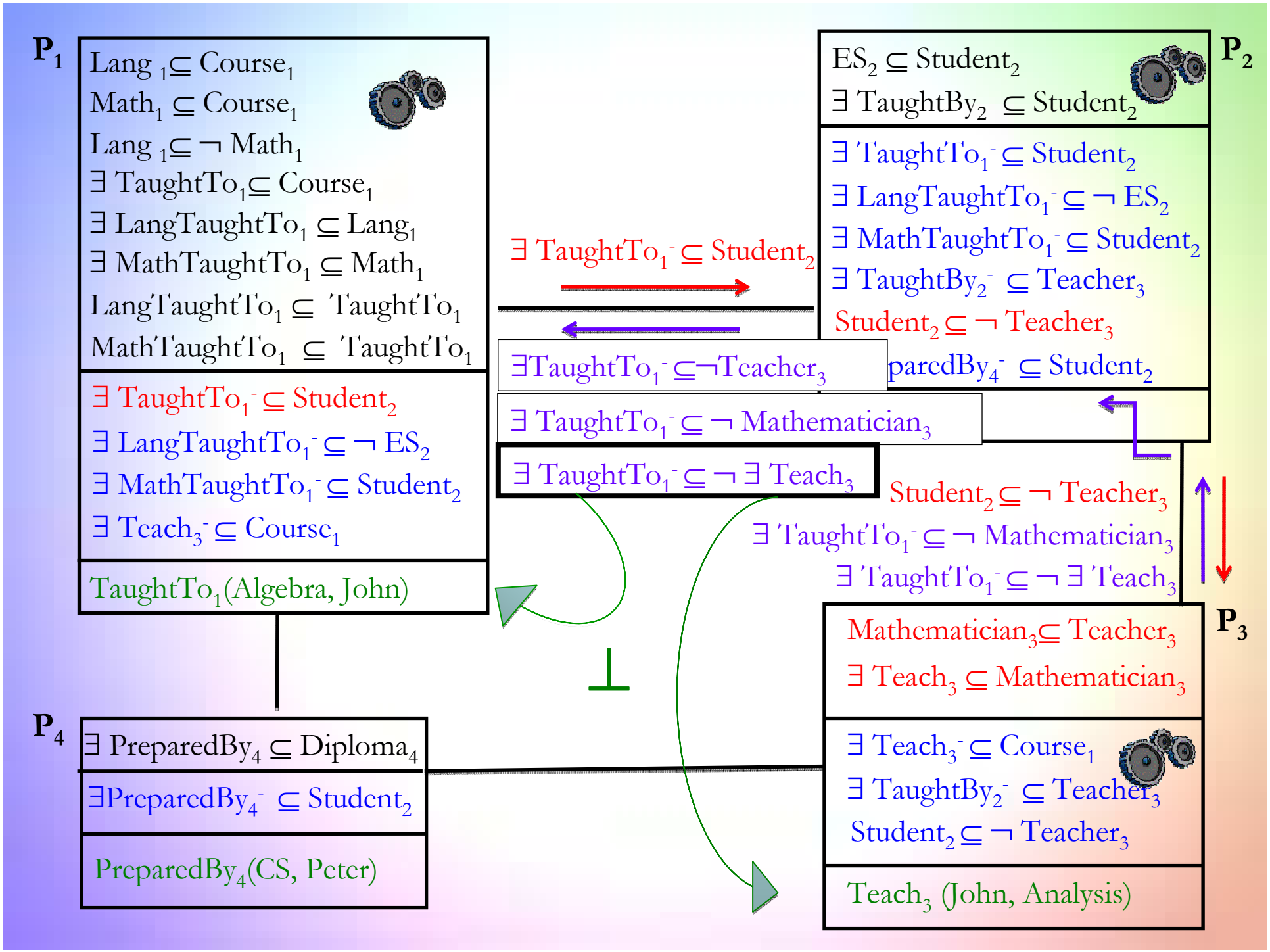
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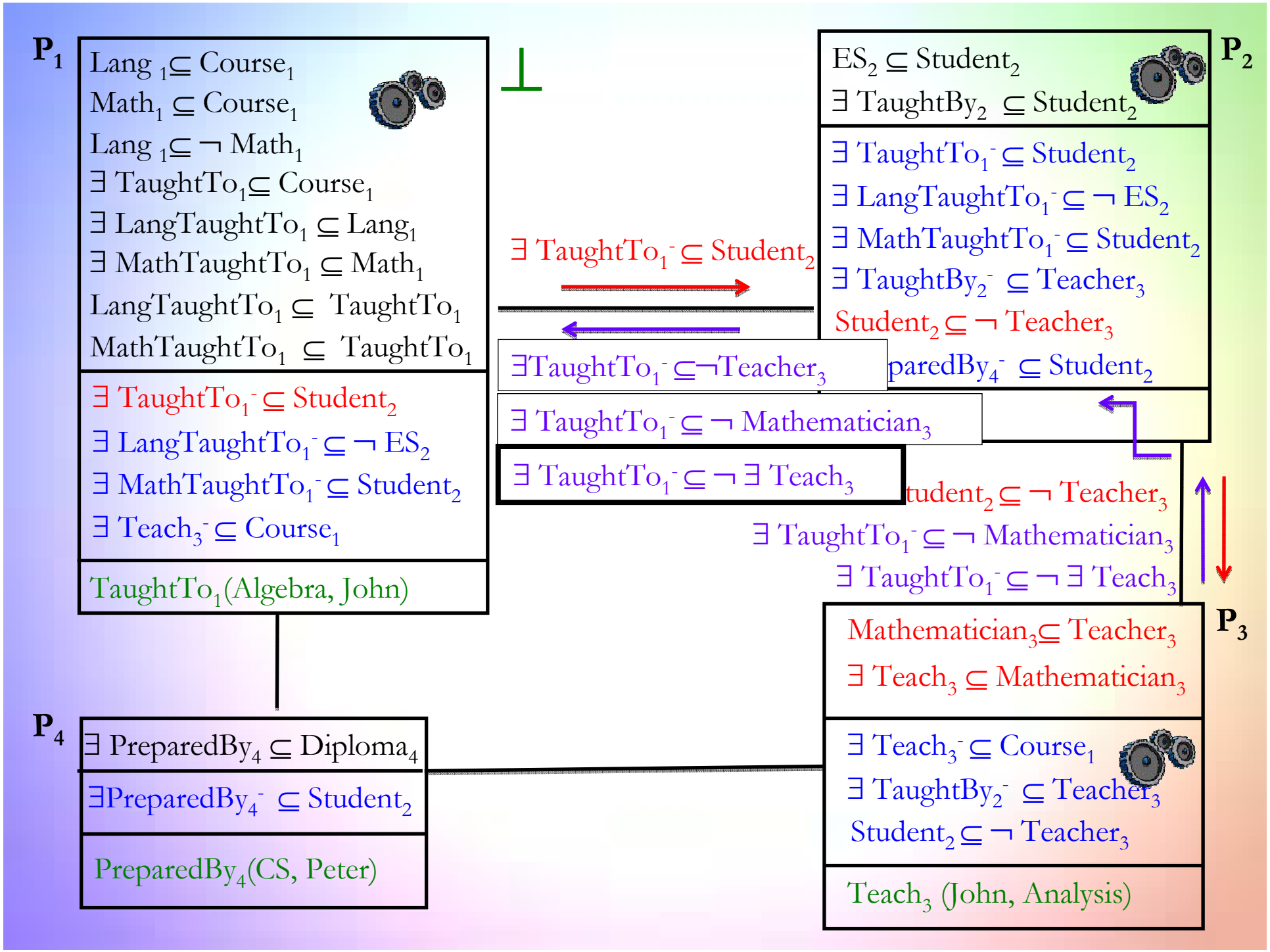
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⊥
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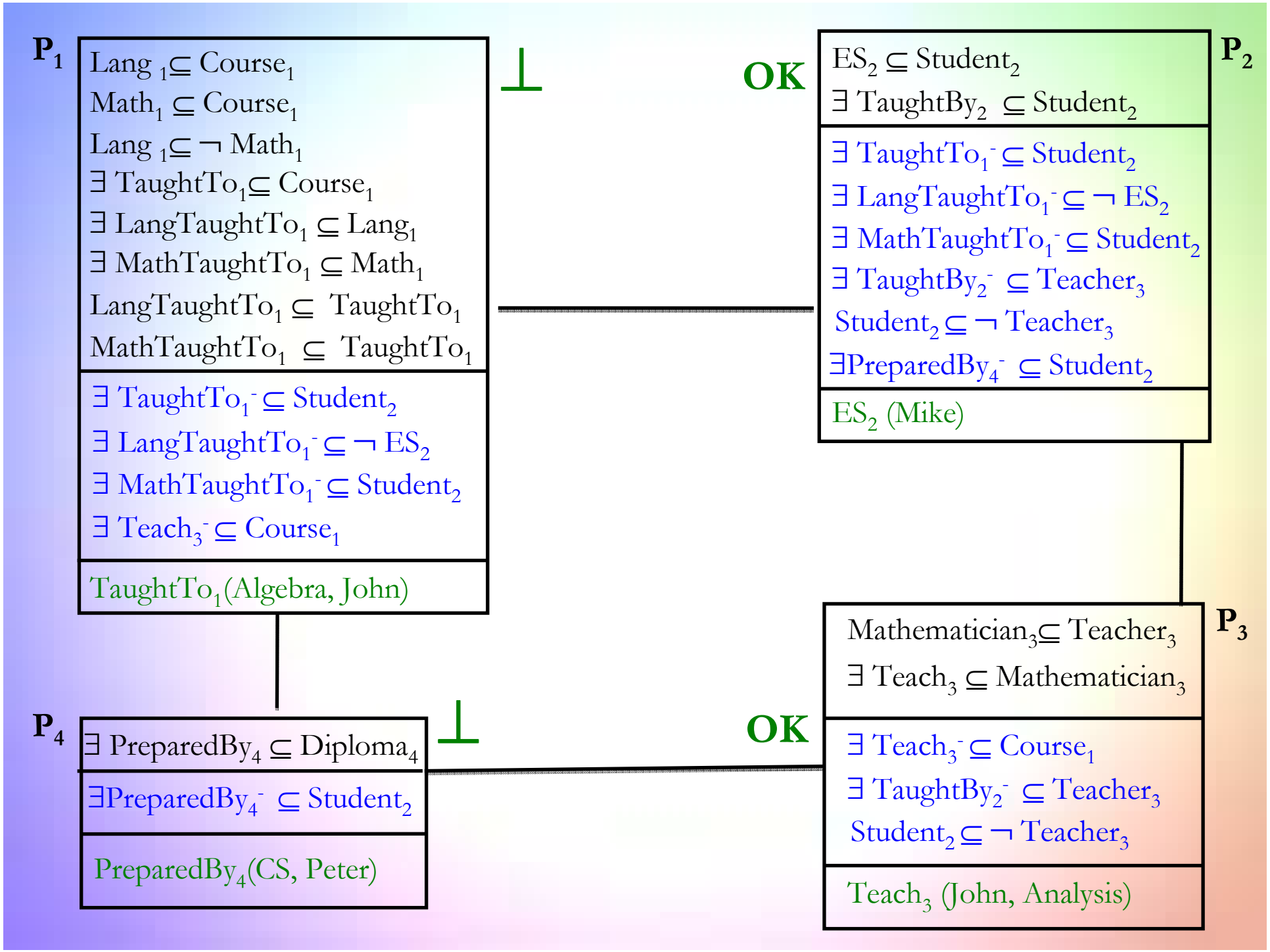
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TaughtTo1(Algebra, John)
⊥
OK
ES2 ⊆ Student2
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Student2 ⊆ ¬ Teacher3
Teach3 (John, Analysis)
OK
⊥
P4
∃ PreparedBy4 ⊆ Diploma4
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PreparedBy4(CS, Peter)

Query Answering

- Query Answering problem:

Given a conjunctive query q, compute the answers of q over the system.

- (Certain) Answer :

A tuple t of the constants appearing in KB such that:

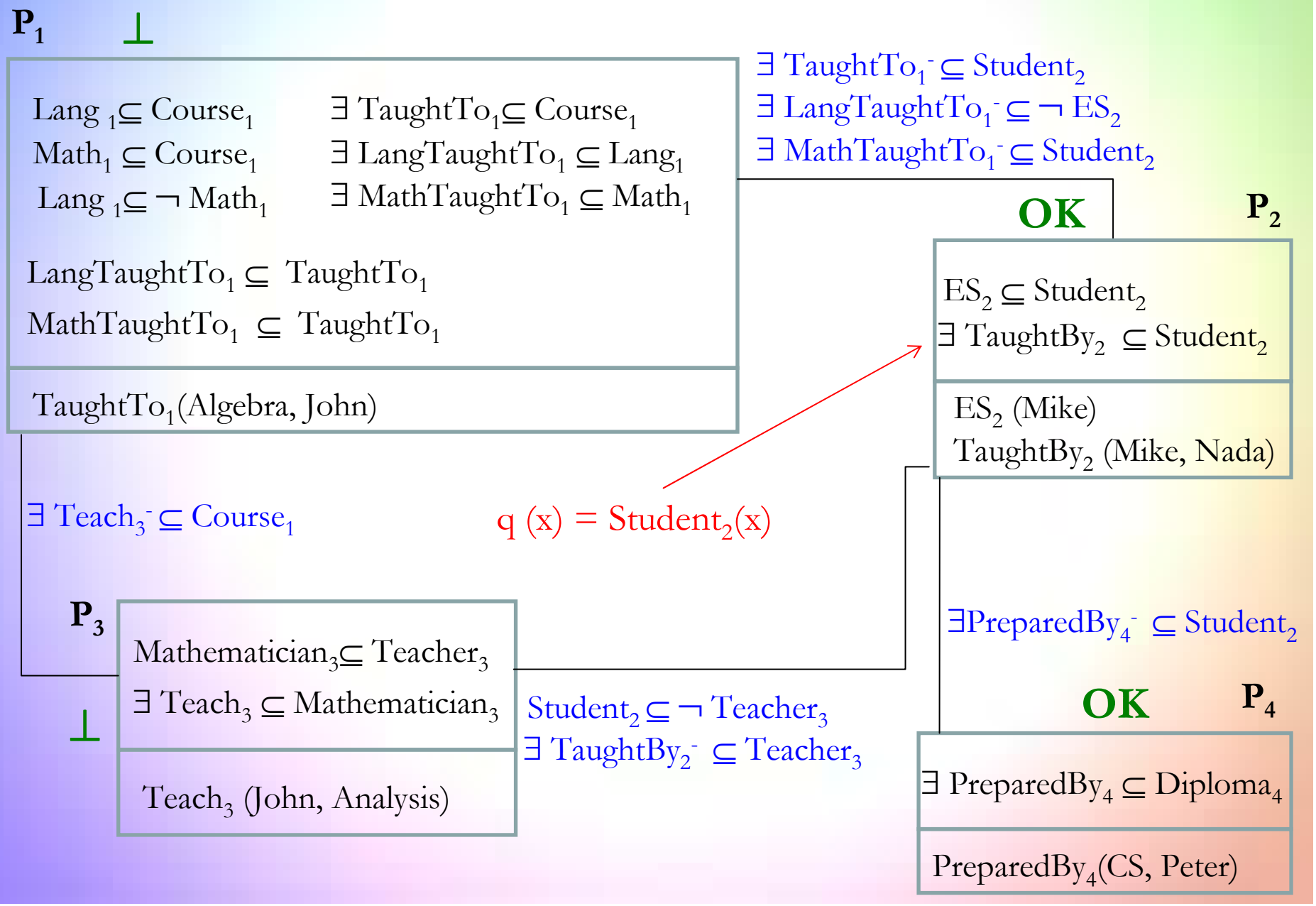
$KB \models q(t)$

- In centralized case:

Algorithm PerfectRef: D.Calvenese and al. (JAR 07)
"Tractable reasoning and efficient query answering in description logics"

Data consistency checking
Query Answering
- Query Reformulation
- Reformulation Evaluation

Decentralized Query Answering



Decentralized Query Answering

- Contribution:
  - Decentralized algorithm for query answering.
    - Well Founded Answers even in globally inconsistent Networks

      1. Decentralized Query Reformulation
      2. Checking data consistency w.r.t the peers involved in each reformulation
         - We keep only sound reformulations
      3. Evaluation of the sound reformulations
         - Well founded answers

Decentralized Query Answering

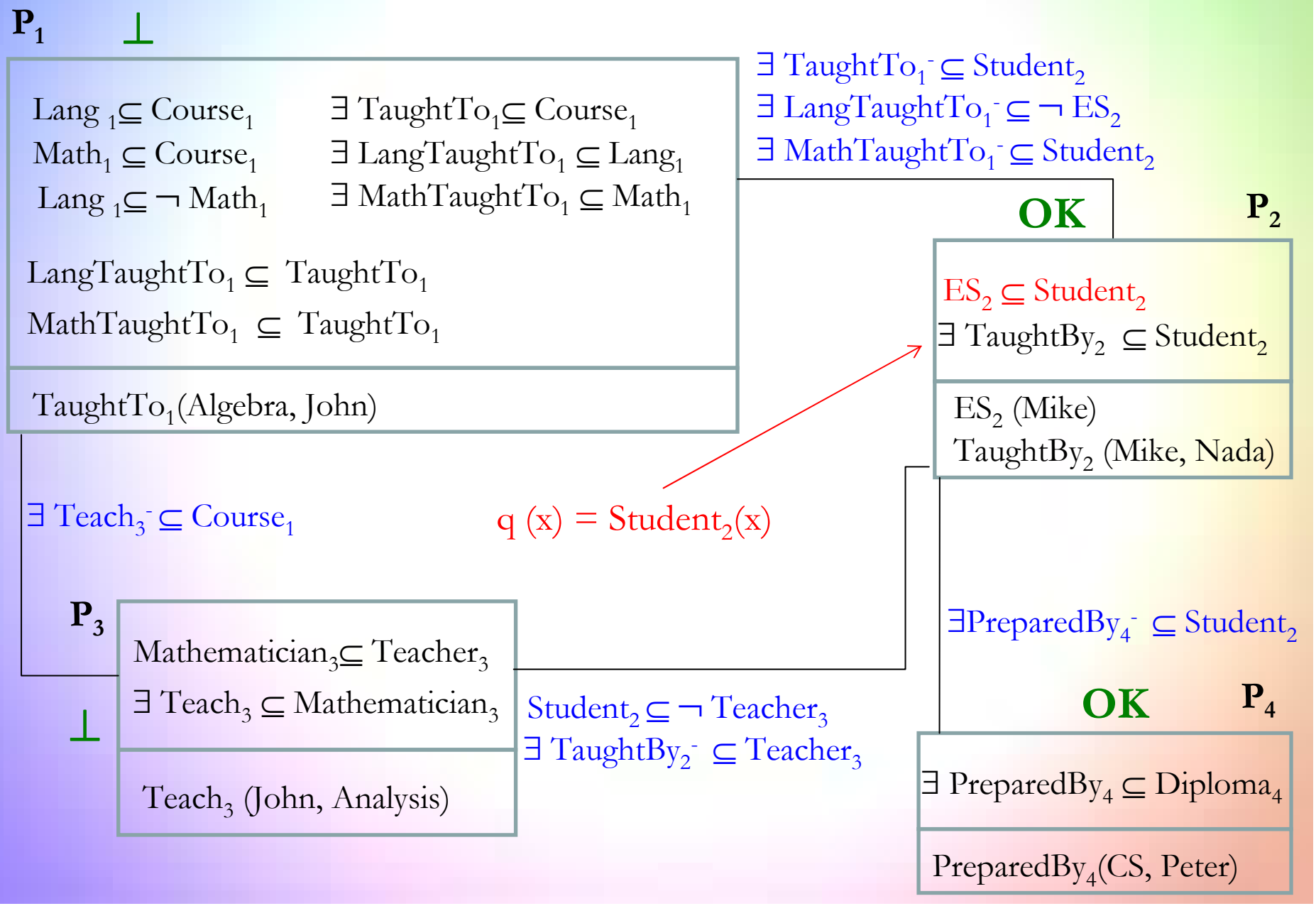
- Contribution:

  - Decentralized algorithm for query answering.

    - Query reformulation

      $q(x) = \text{Student}_2(x)$

Decentralized Query Answering



Decentralized Query Answering

- Contribution:

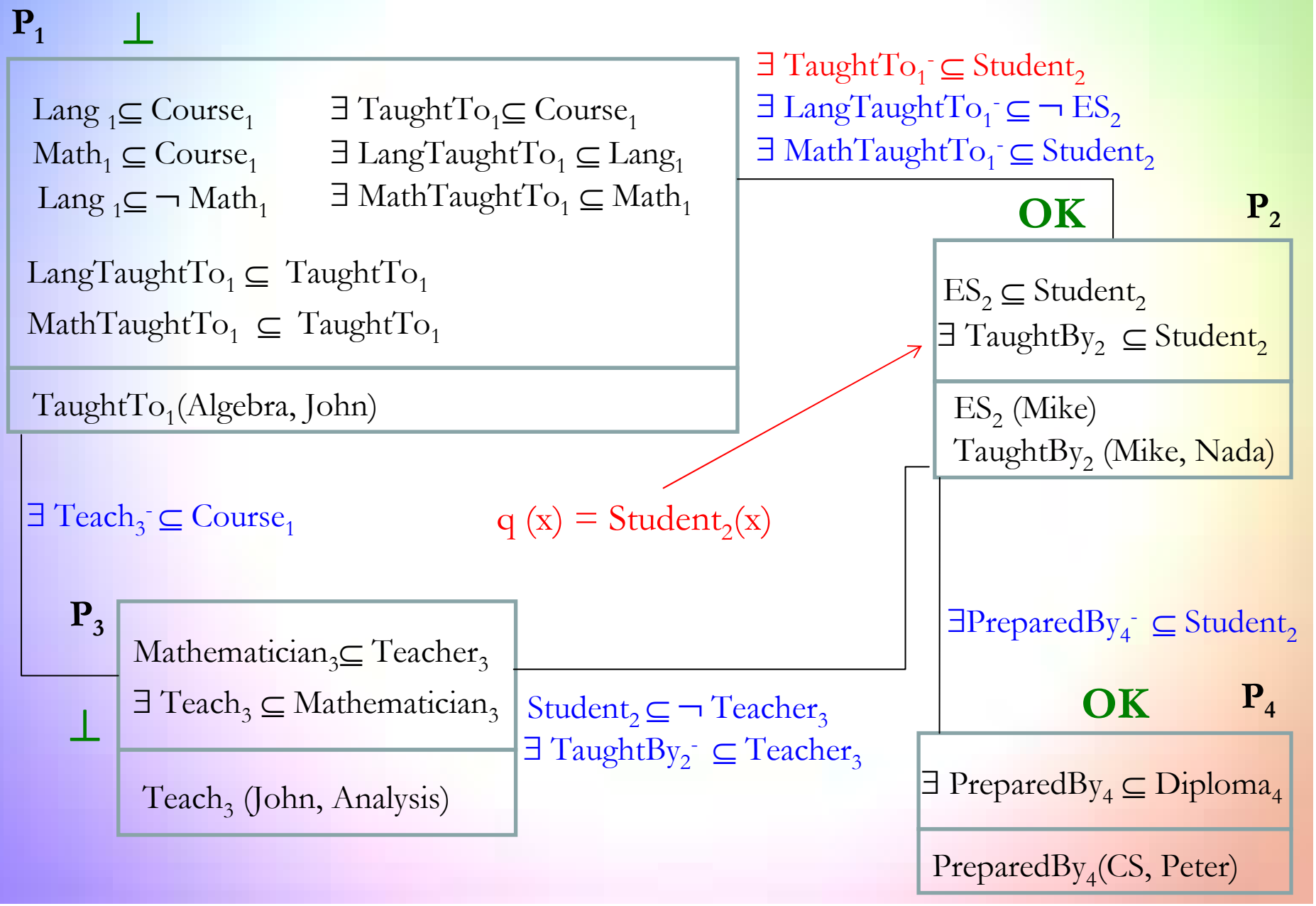
  Decentralized algorithm for query answering.

  - Query reformulation

    $q(x) = Student_2(x)$

    $q_1(x) = ES_2(x)$

Decentralized Query Answering



Decentralized Query Answering

- Contribution:

  Decentralized algorithm for query answering.

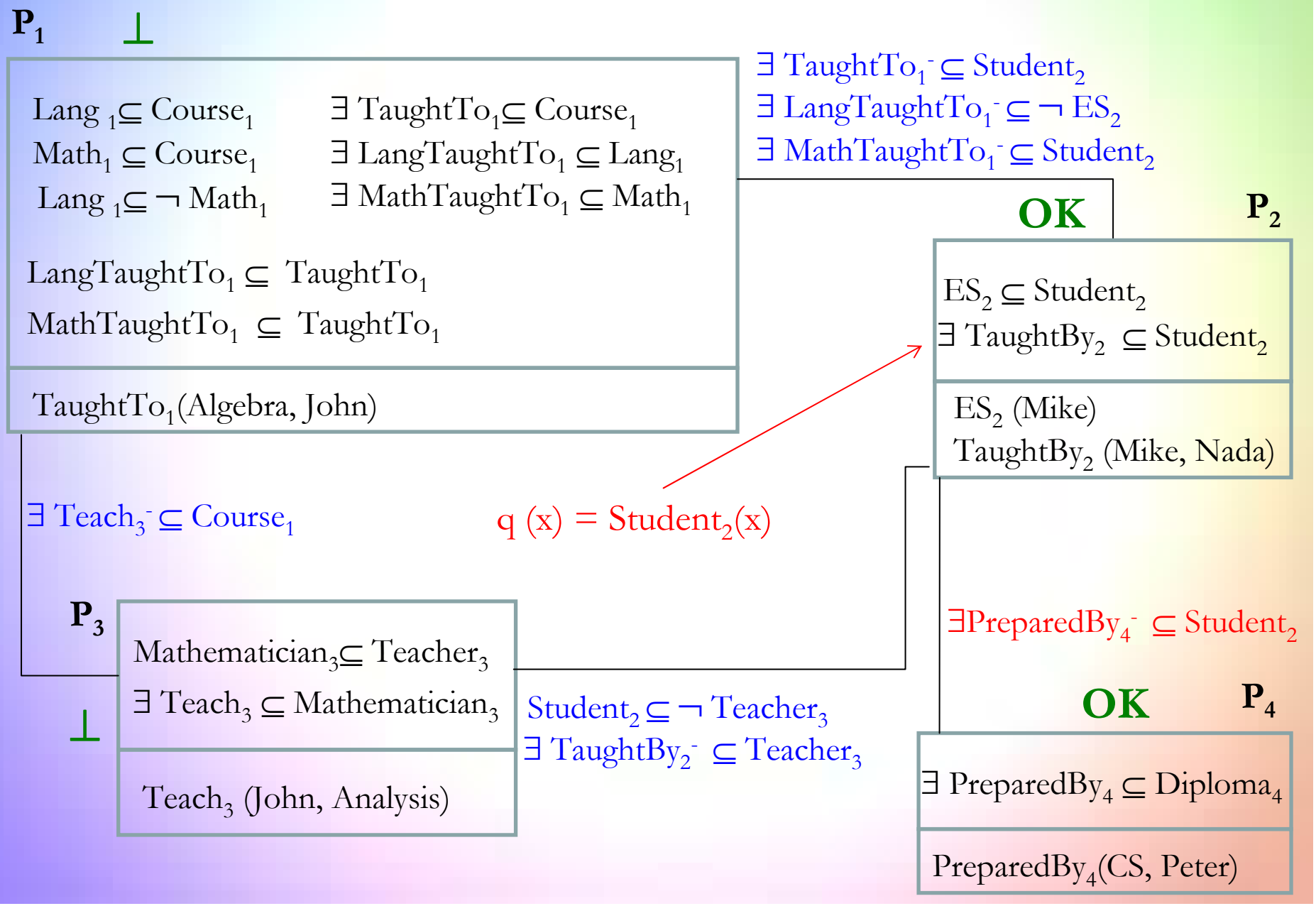
  - Query reformulation

    $q(x) = Student_2(x)$

    $q_1(x) = ES_2(x)$

    $q_2(x) = \exists z\ TaughtTo_1(z, x)$

Decentralized Query Answering



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Decentralized Query Answering

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  - Data consistency checking

    Consistent algorithm on P_1, P_2 and P_4

    On P_1: $\perp$

    On P_2: OK

    On P_4: OK

Decentralized Query Answering

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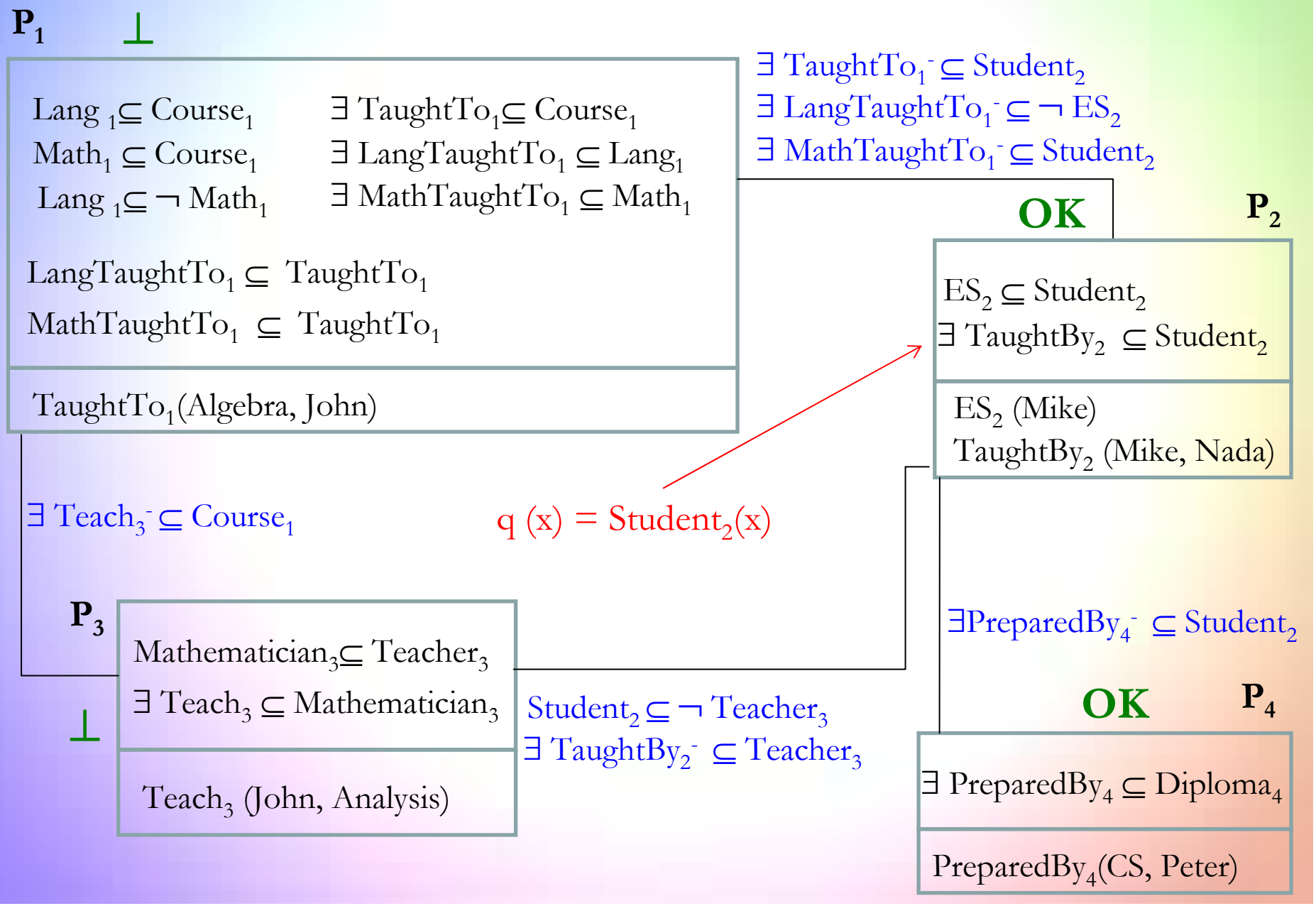
Query Evaluation

Decentralized Query Answering



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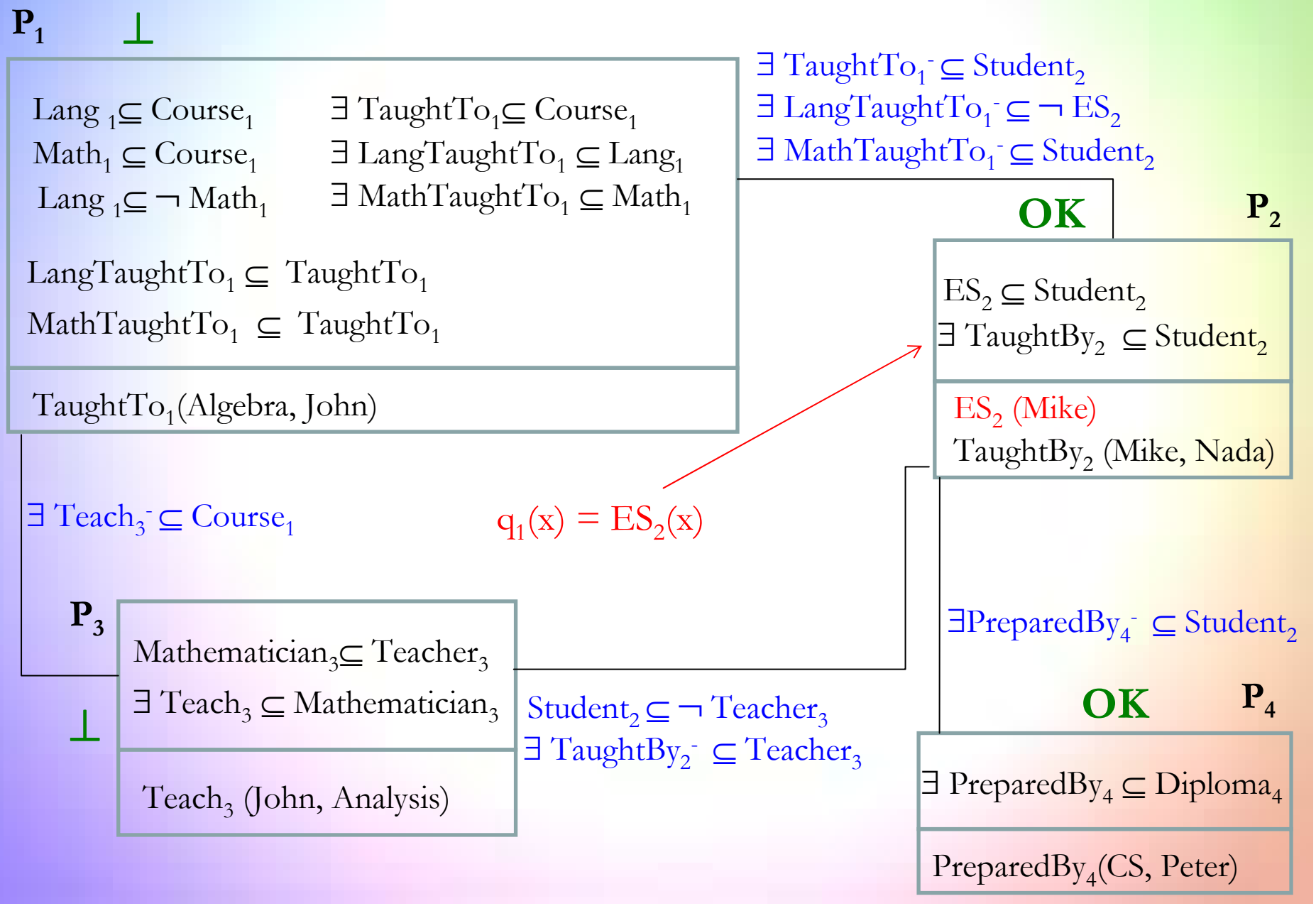
On P_2 : OK

On P_4 : OK

Query Evaluation

No answer

Decentralized Query Answering



Decentralized Query Answering

- Contribution:

  Decentralized algorithm for query answering.

➢ Query reformulation

$q(x) = Student_2(x)$ ⟶ No answers

$q_1(x) = ES_2(x)$ ⟶ Well founded Answer= {Mike}

$q_2(x) = \exists z\ TaughtTo_1(z, x)$

$q_3(x) = \exists y\ PreparedBy_4(y, x)$

Query Evaluation

➢ Data consistency checking

Consistent algorithm on P_1, P_2 and P_4

On P_1 : ⊥

On P_2 : OK

On P_4 : OK

Decentralized Query Answering

- Contribution:

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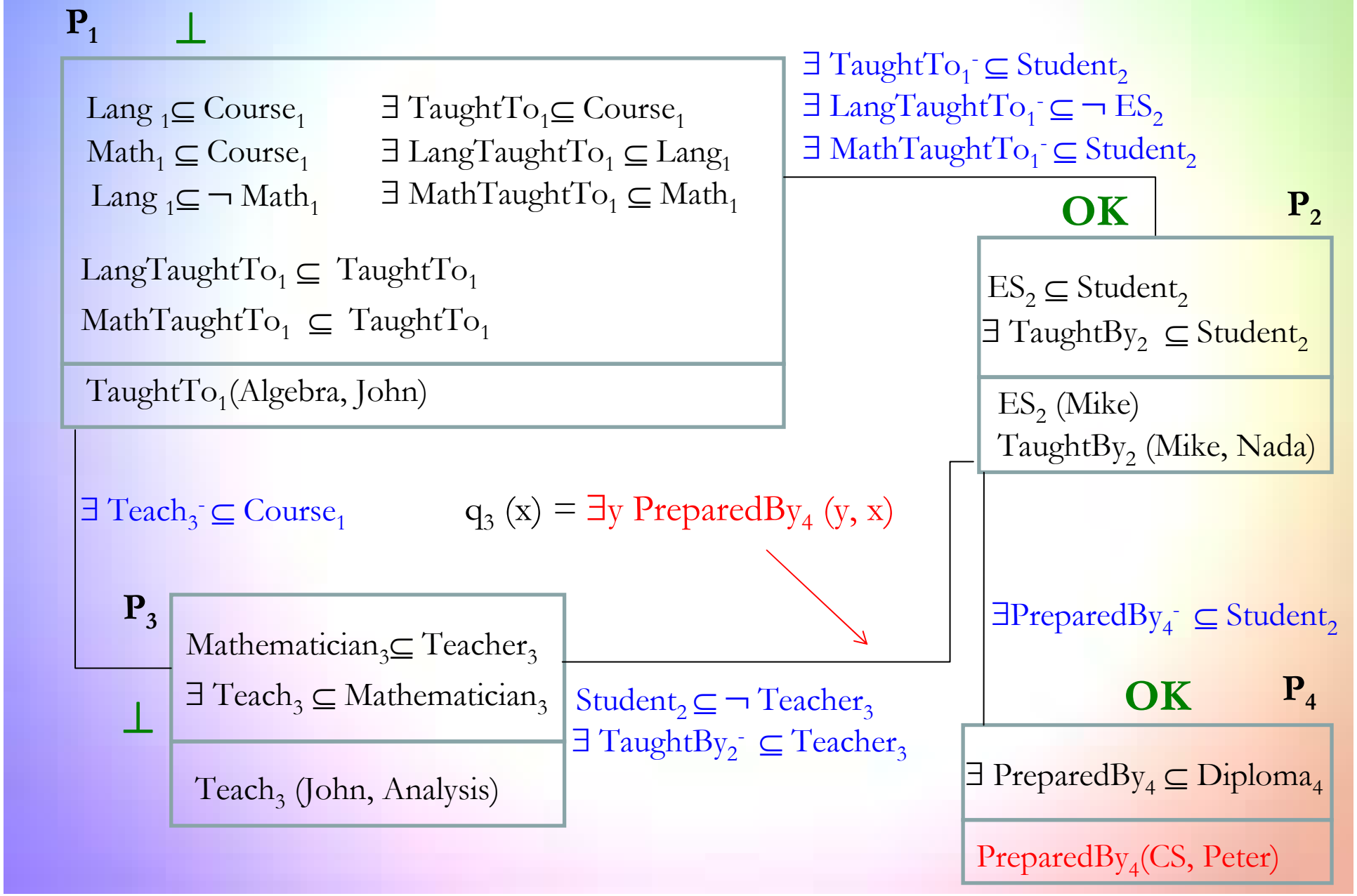
Query Evaluation

Decentralized Query Answering



Decentralized Query Answering

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➢ Query reformulation

➢ Data consistency checking

Consistent algorithm on P_1, P_2 and P_4

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On P_2 : OK

On P_4 : OK

	Query Evaluation
$q(x) = Student_2(x)$ →	No answers
$q_1(x) = ES_2(x)$ →	Well founded Answer= {Mike}
~~$q_2(x) = \exists z\ TaughtTo_4(z, x)$~~	
$q_3(x) = \exists y\ PreparedBy_4(y, x)$ →	Well founded Answer= {Peter}

Decentralized query reformulation by using SomeWhere

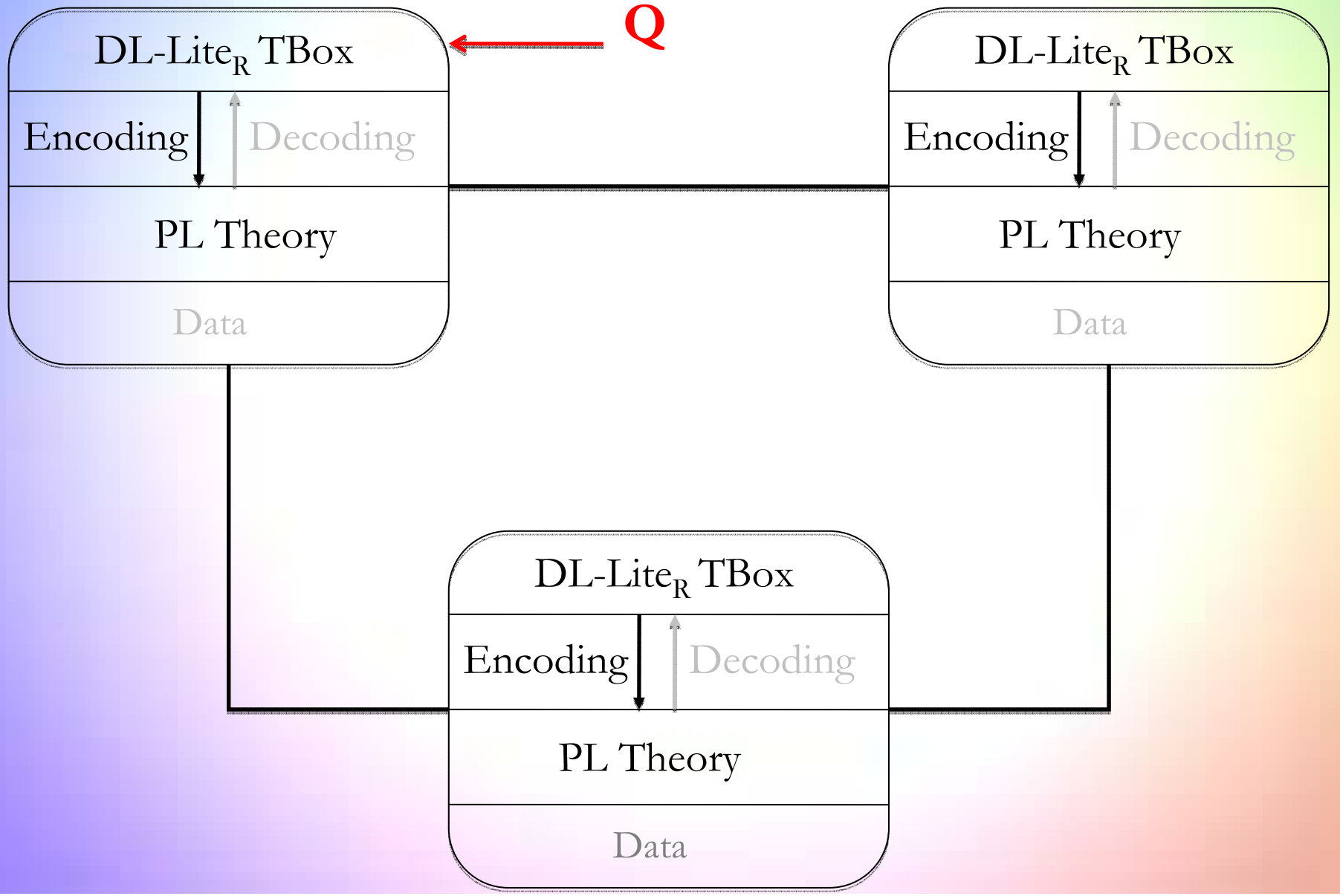
- ✓ An existing Decentralized Infrastructure "SomeWhere" for reasoning in propositional logic and for which the experiments have demonstrated the scalability.

  P. Adjiman and al. (IJCAI 05) : Scalability study of peer-to-peer consequence finding"

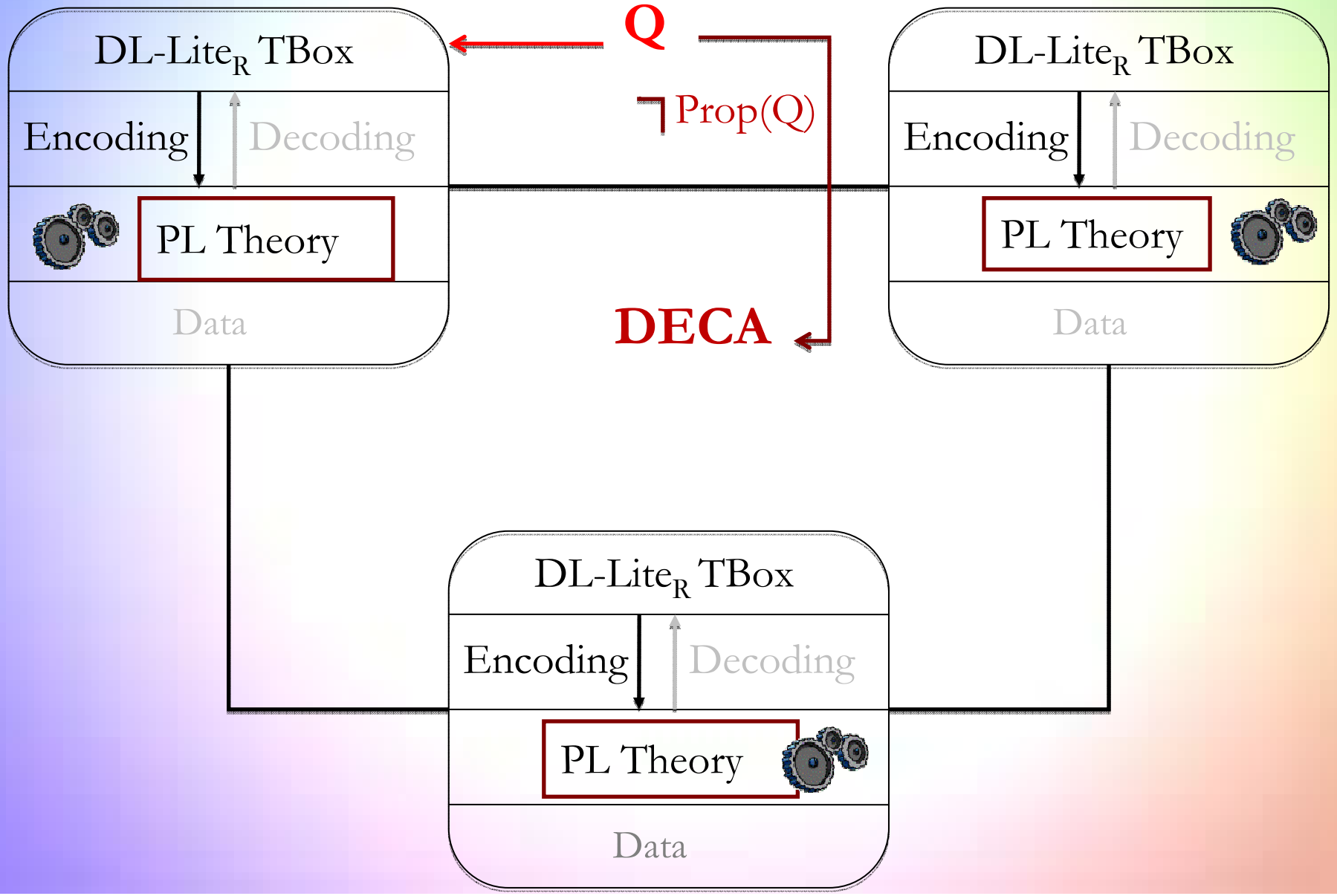
- ✓ An existing Decentralized Consequence finding Algorithm in propositional logic (DECA)

- ✓ A propositional encoding of the DL-Lite$_R$ TBox.

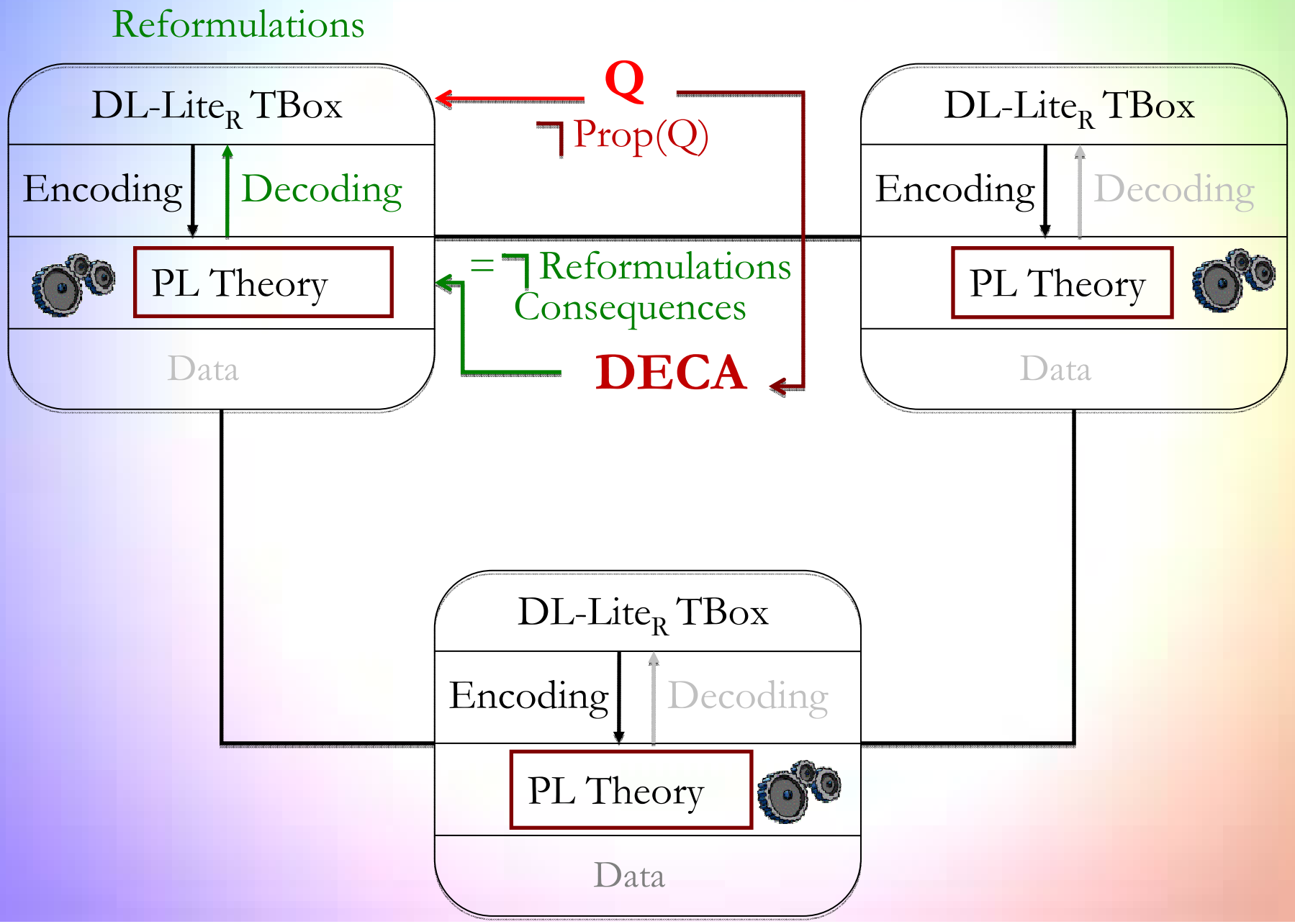
Decentralized Query Reformulation by using SomeWhere



Decentralized Query Reformulation by using SomeWhere

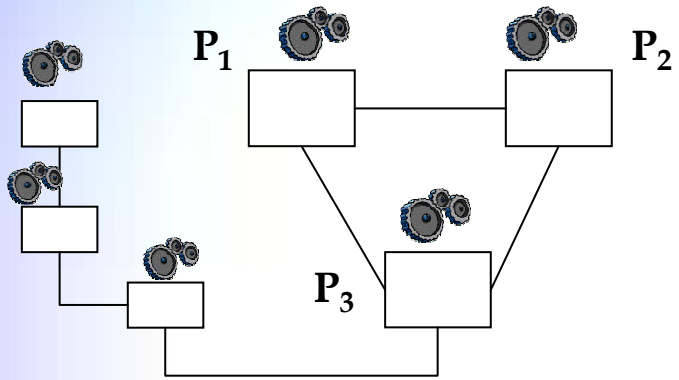


Decentralized Query Reformulation by using SomeWhere



Conclusion & future work

1. DL-Lite$_R$ decentralized data model



2. Decentralized Algorithms for:
   - ✓ Data consistency checking
   - ✓ Query Answering

3. Decentralized & Centralized Algorithms for:
   - ✓ View consistency checking
   - ✓ Query Answering using views

Other Applications

- Mapping discovery:

Rémi Tournaire'sPhD 2010

- Data reconciliation:

Extension of Fatiha Sais' PhD

- Explanation of answers to queries

Feasibility of the approach with other dialects of DL-Lite and with Datalog+-