The CALCULEMUS Research Training Network

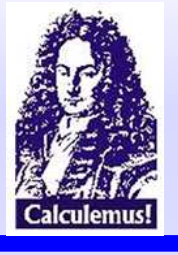
(HPRN-CT-2000-00102)

Christoph Benzmüller

Saarland University, Saarbrücken, Germany

QPQ Workshop, Miami, USA, July, 2003

CALCULEMUS



Interest Group

since mid 90s

`www.calculemus.org`

EU Research Training Network

09/2000 – 09/2004

`www.eurice.de/calculemus/`

Scientific Motivation

New generation of (mathematical) assistant systems

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- Integration of symbolic reasoning and symbolic computation

- Applications in mathematics, maths education, formal methods

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- Integration of symbolic reasoning and symbolic computation
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- Integration of heterogeneous specialist reasoners
- Open system architectures and mathematical services
- Applications in mathematics, maths education, formal methods

Scientific Motivation

New generation of (mathematical) assistant systems

- Integration of symbolic reasoning and symbolic computation
- Interoperability with mathematical knowledge bases
- Knowledge exploration, maintenance, management of change
- Integration of heterogeneous specialist reasoners
- Expressive representations; human-oriented user interfaces
- Support for representation transformations
- Open system architectures and mathematical services
- Preparation and validation of mathematical texts and publications
- Applications in mathematics, maths education, formal methods

Sociological Goal

Early stage training of young researchers

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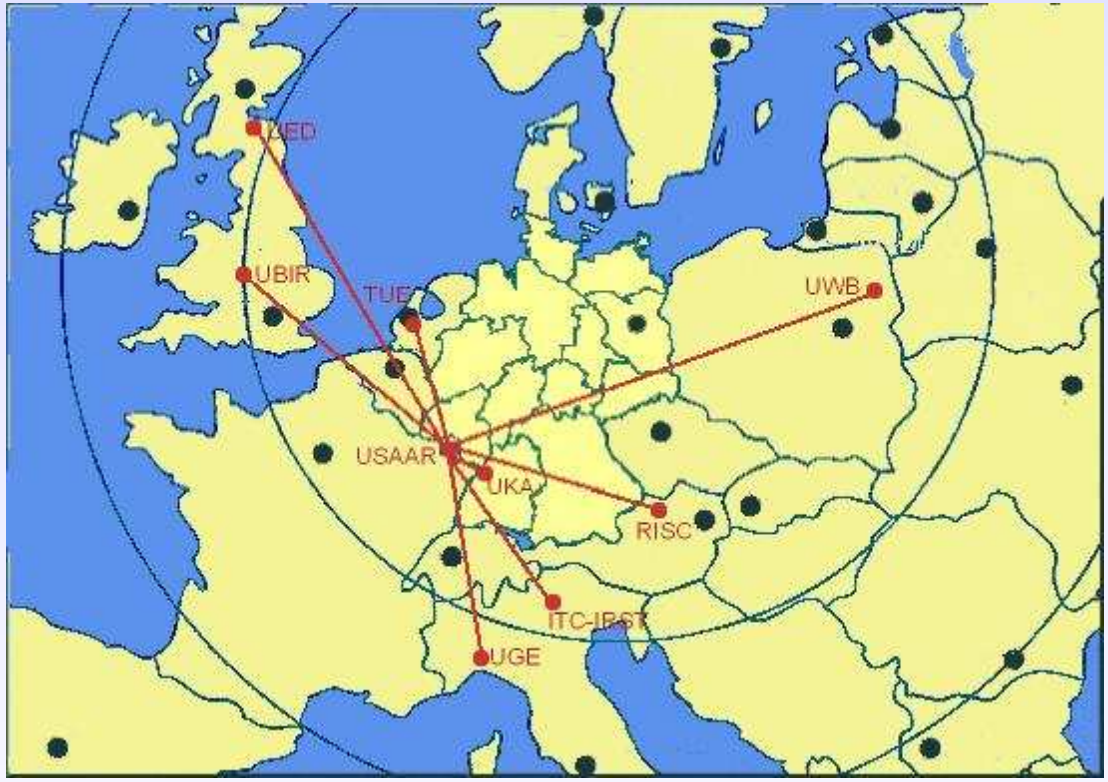
Measures:

- The CALCULEMUS Autumn School 2002
- CALCULEMUS Symposia and Network Meetings
- Training at an Individual Level at the Network Nodes
- Local Courses, Workshops, Talks, and Seminars
- Exchange of YVRs between Network Nodes
- Industry Internships

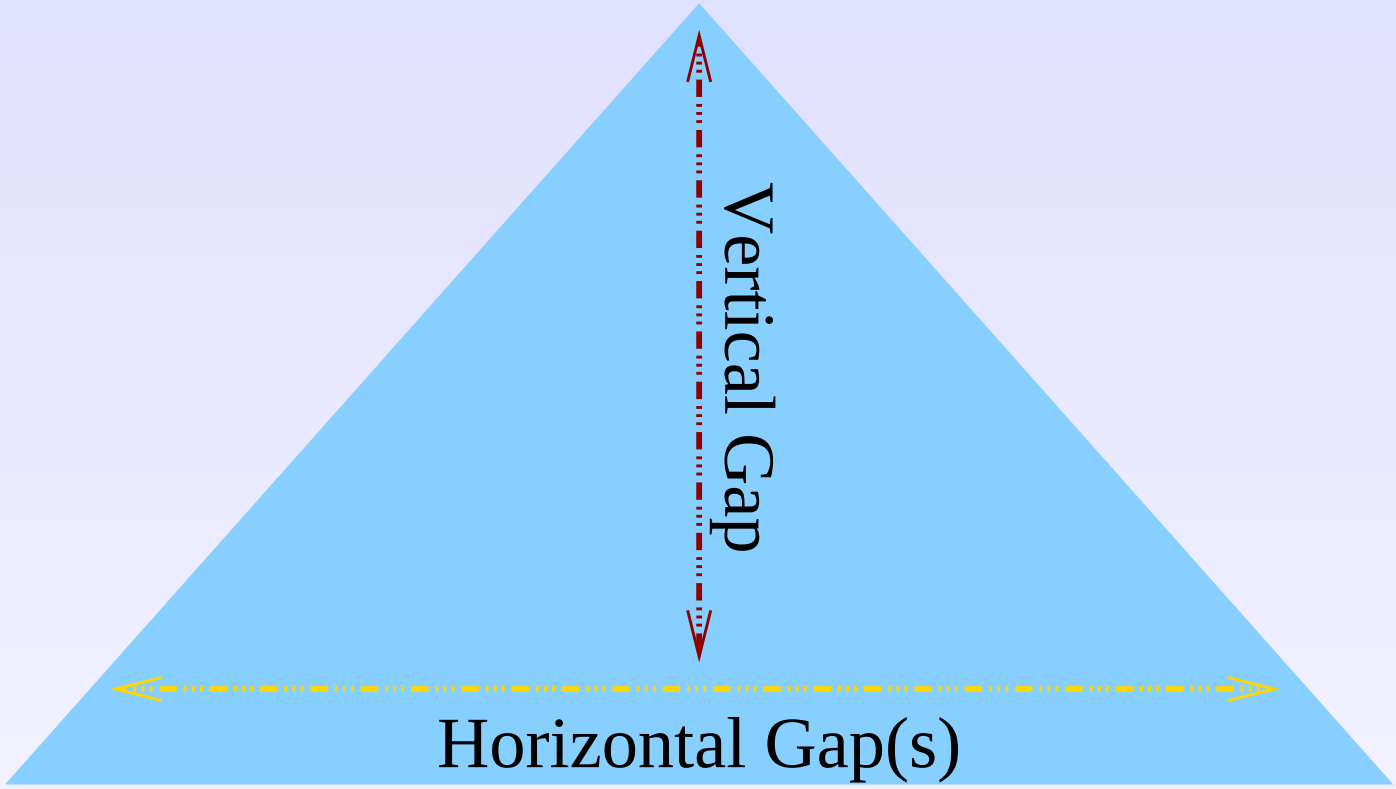
The CALCULEMUS RTN

USAAR	Saarbrücken *Siekmann*
UED	Edinburgh *Bundy*
UKA	Karlsruhe *Calmet*
RISC	Linz *Buchberger*
TUE	Eindhoven/Nijmegen *Cohen/Barendregt*
ITC-IRST	Trento *Giunchiglia*
UWB	Bialystok *Trybulec*
UGE	Genova *Armando*
UBIR	Birmingham *Kerber*



CALCULEMUS **Methodology**

Vision: Powerful Mathematical Assistant System(s)



Reality: heterogeneous frameworks, systems, and tools

individual strengths and weaknesses

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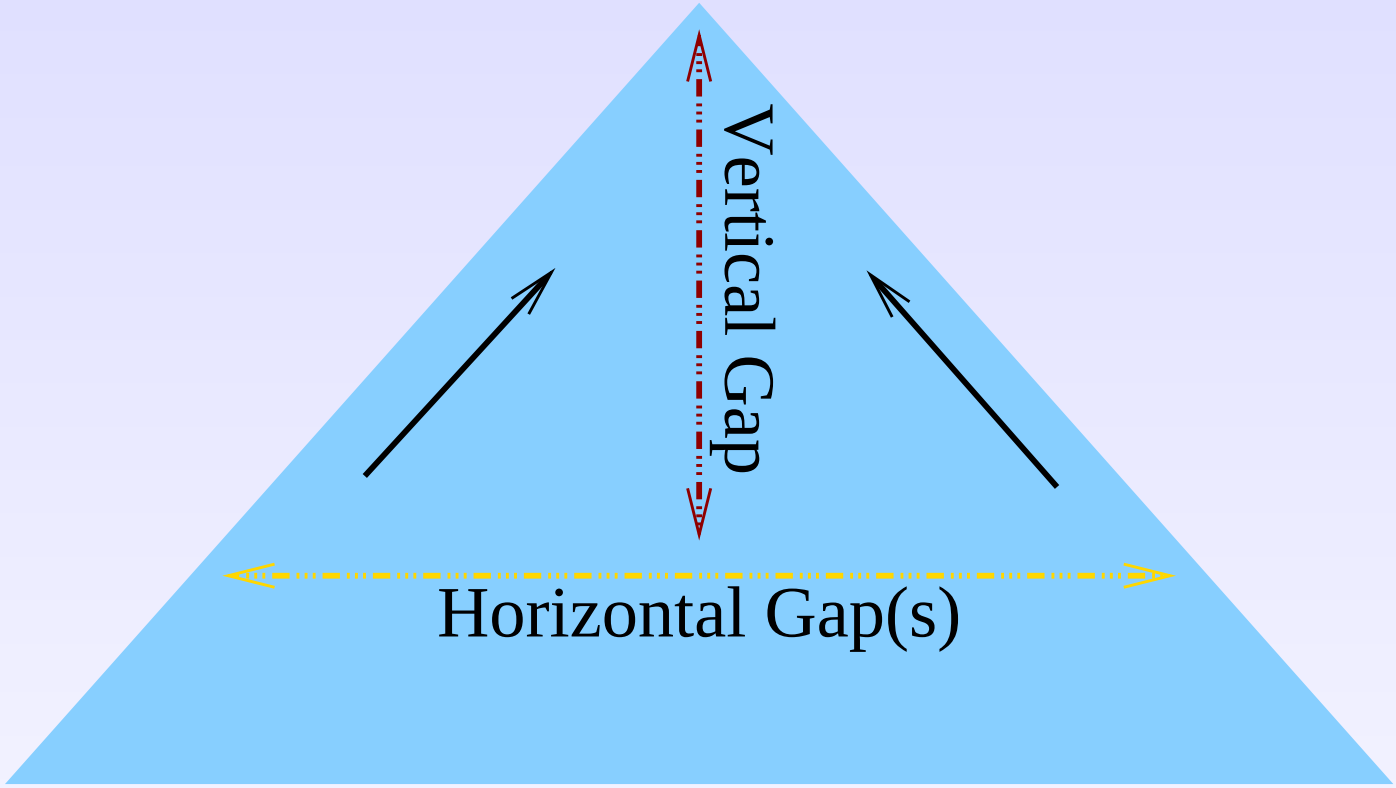
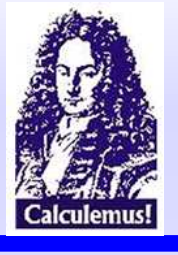


Bottom-up from: CAS DS Math-KBs …

Possible cooperation with: QPQ?

CAS & DS: The Map



DS $\subseteq$ CAS:	■ - THEOREMA $\subseteq$ *Mathematica* ■ - HR uses OTTER for MAPLE
CAS $\subseteq$ DS:	■ (tight coupling: - T-unification, constraint resolution, T-resolution) ■ loose coupling: - reflection approach as used in Coq - proof planning ($\lambda Clam$, ΩMEGA)
CAS $\equiv$ DS:	■ protocol, e.g. á la Calmet ■ common interface: - top down: OMRS, MathWeb-SB, LBA, MathBroker - bottom up: CCR, MathSat

Experiences

Bad news:

- no single predominant approach for CAS & DS

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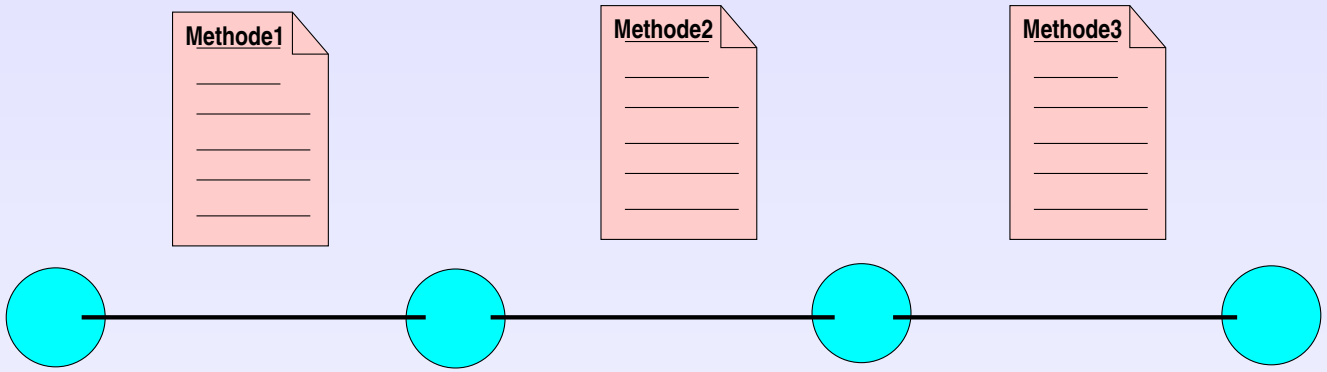
Good news:

- heterogeneity is not necessarily bad
- challenge is to support heterogeneity
- frameworks supporting the integration of heterogeneous tools are in development ($\mathrm{CAS} \equiv \mathrm{DS}$)

CAS and ATP in Proof Planning

Proof Planning (as an example for $CAS \subseteq DS$):

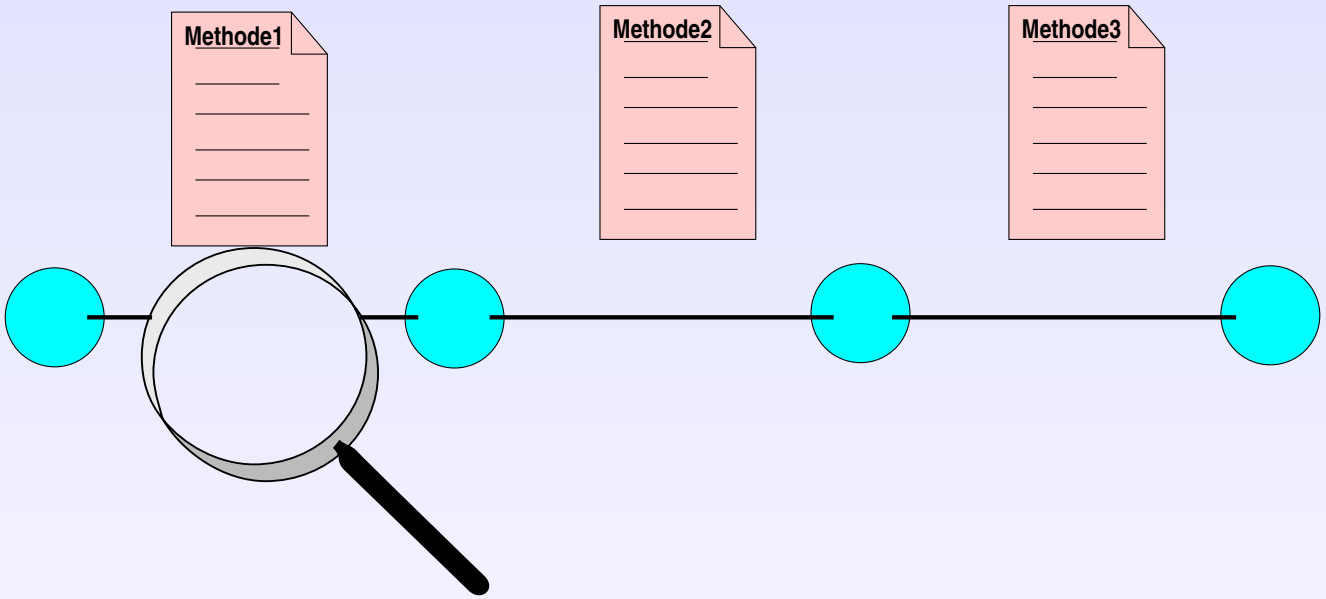
domain specific, heuristic reasoning at abstract layer



Integration of Specialist Reasoners (CASs and ATPs):

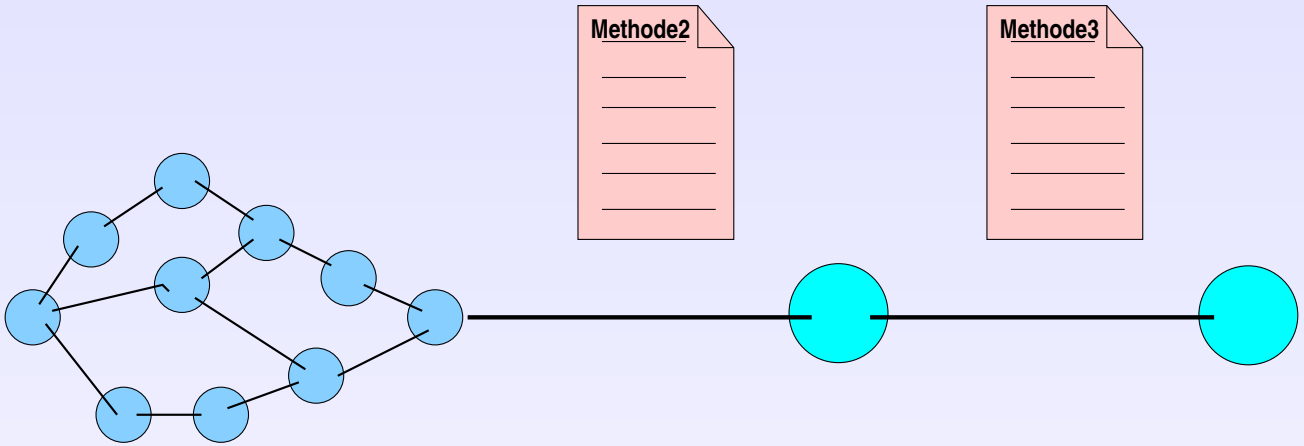
- at method layer
- at the heuristic meta-reasoning layer

CAS and ATP in Proof Planning



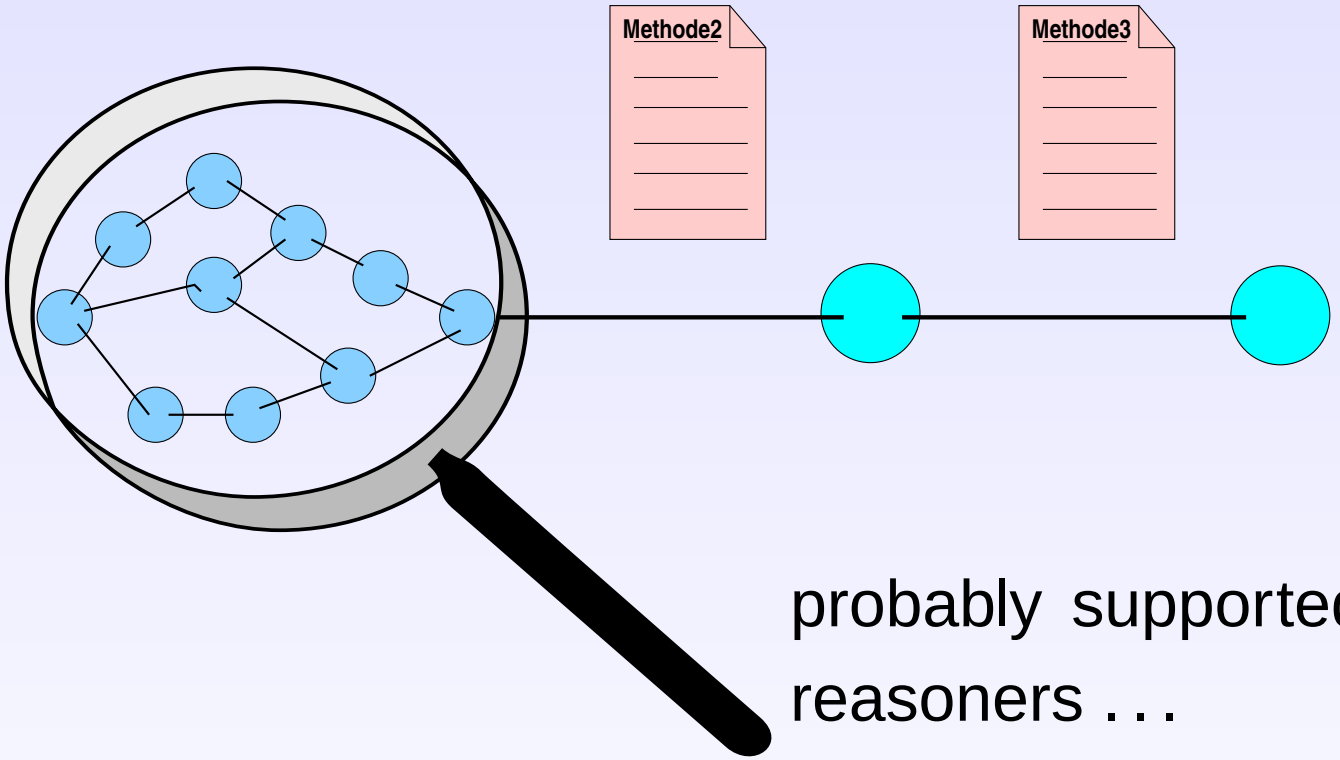
soundness is evaluated by . . .

CAS and ATP in Proof Planning



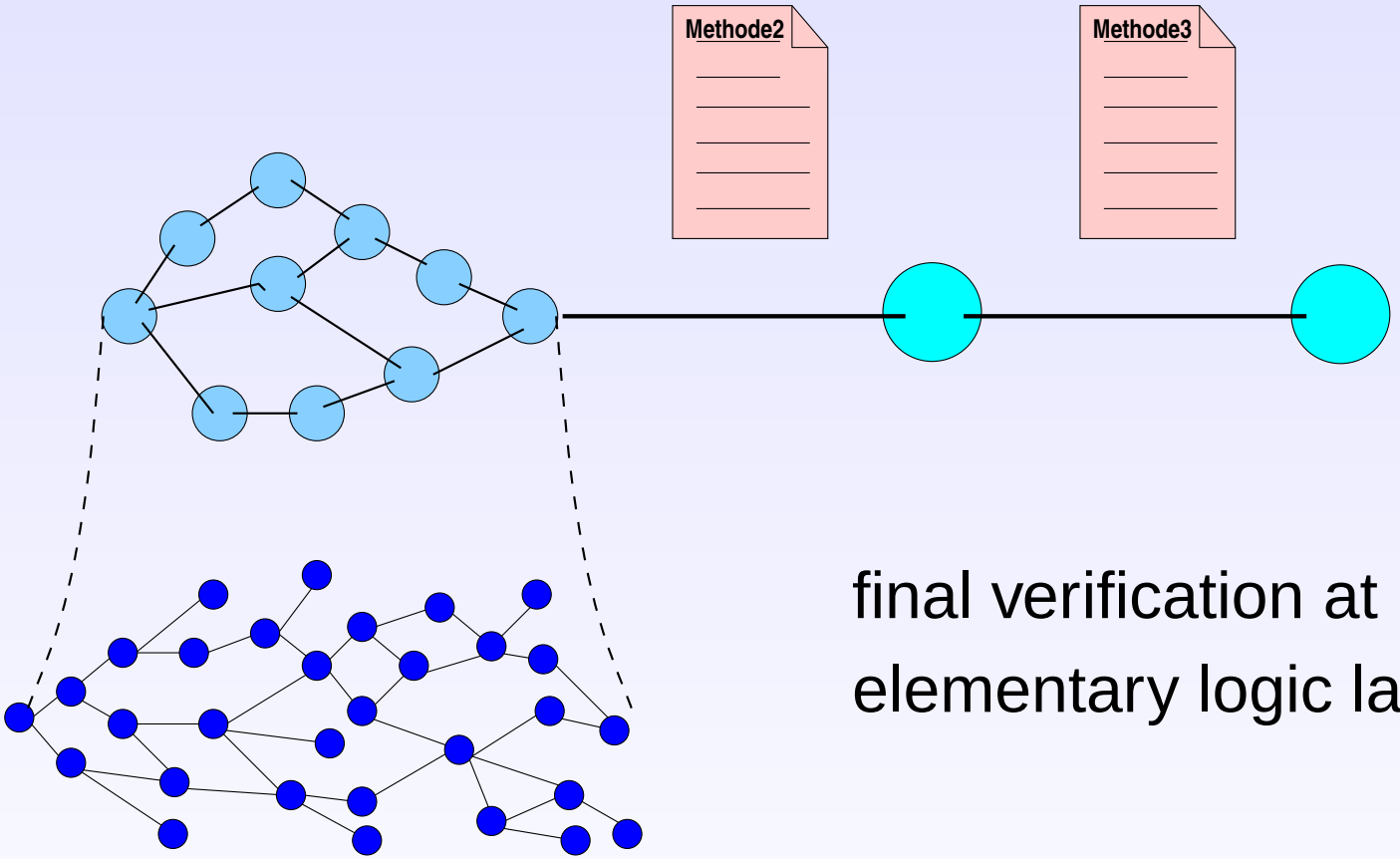
refinement (expansion)
over several layers
...

CAS and ATP in Proof Planning



probably supported by external reasoners . . .

CAS and ATP in Proof Planning

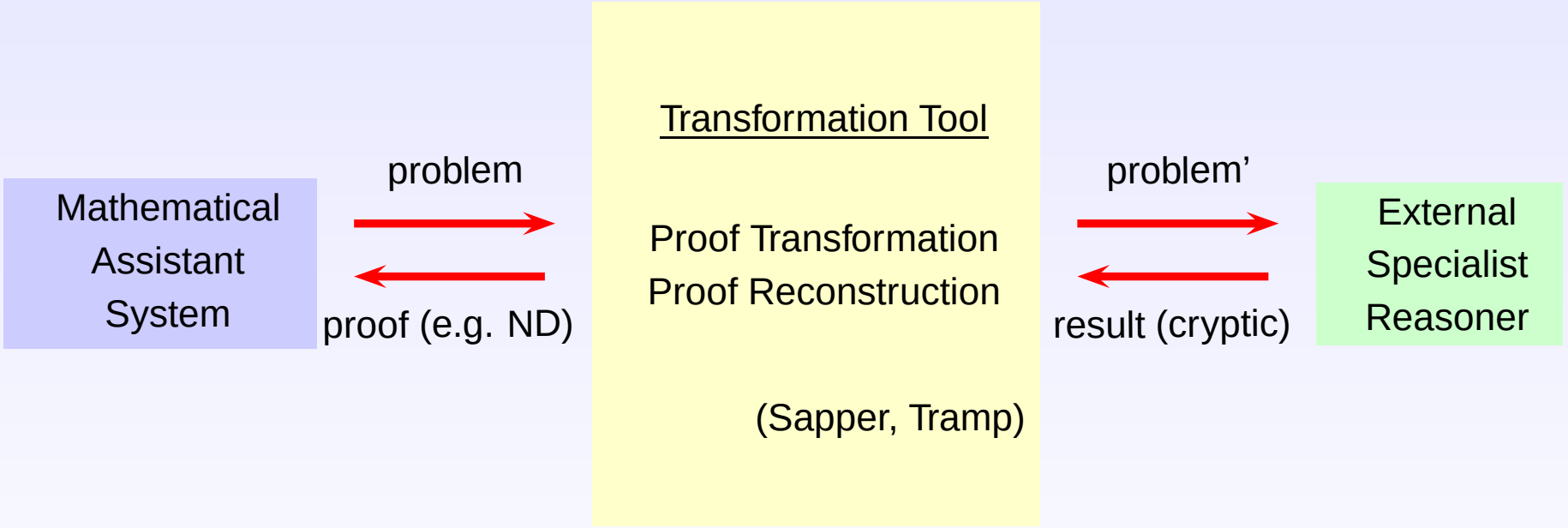


final verification at
elementary logic layer

CAS and ATP in Proof Planning

Required/Useful for $CAS \subseteq DS$:

- white box integration of external specialist reasoners
- tools for extraction and transformation of results



QPQ and CALCULEMUS?

Short-term

- central repository for tools
- foster uniform (problem and proof) representations
- provide (problem and proof) transformation tools

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Long-term

- foster semantical descriptions of tools
- cooperate with emerging semantic brokering mechanism

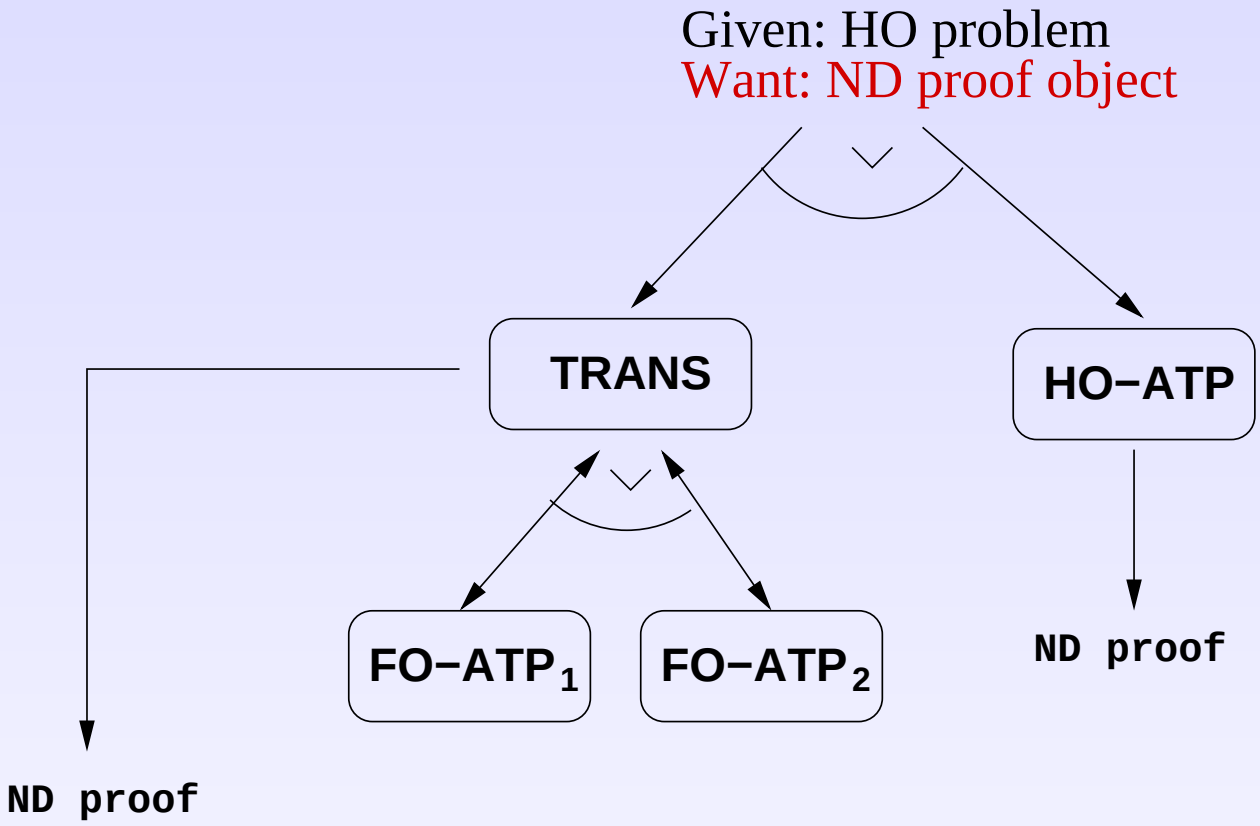
An ATP Service in MSDL

Source: Jürgen Zimmer (Edingurgh/Saarbrücken)

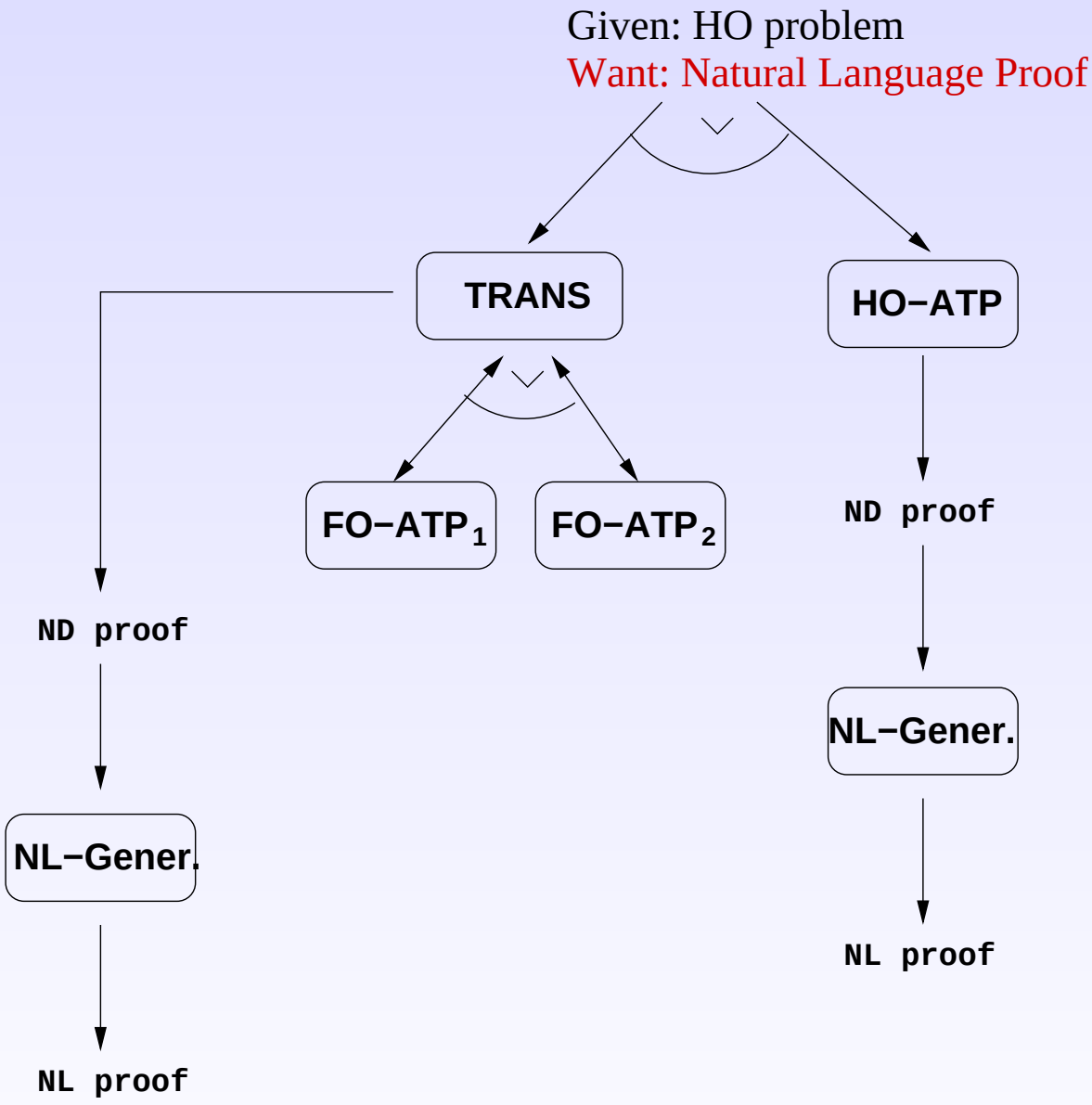
Service: SpassProver	
classification:	Classification with Taxonomy of services or link to Ontology (→ QPQ) • → **first-order problem description**
service interface:	→ `fo-prover.wsdl`
implementation details:	Information about hardware, software (calculus, etc.)

first-order problem description	
input parameters:	name: $problem$, signature: ATP-Problem (DAML-S Class)
output parameters:	name: $result$, signature: ATP-Result (DAML-S Class)
pre-conditions:	$equational\_reasoning(problem)$ $\wedge\ Ax = axioms(problem)$ $\wedge\ C = conjecture(problem)$ $\wedge\ \forall a \in Ax.first\_order(a)$ $\wedge\ first\_order(C)$ $\ldots$
post-conditions:	$Ax \vdash_{FOL} C : has(result, proof\_object)$

Semantic Brokering of Mathematical Services



Semantic Brokering of Mathematical Services



Related (EU) research initiatives

- MONET: Mathematics on the Net

  offering mathematical algorithms through web services

- MOWGLI: Mathematics on the Web: Get it by Logics and Interfaces

  from machine-readable to machine-understandable representations of mathematical information

- OpenMath:

  standard for representing mathematical objects with their semantics

- MKM: Mathematical Knowledge Management Network

  from paper-oriented and presentation-oriented view to a semantics-oriented view of mathematical knowledge

- . . .