SFB 378
Ressourcenadaptive
Kognitive Prozesse

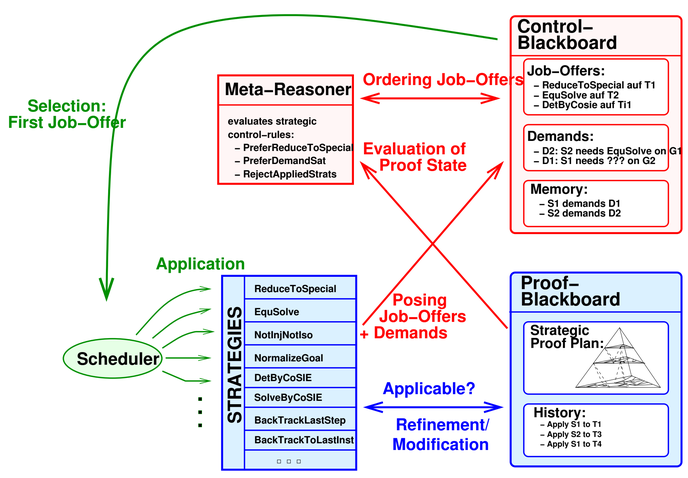
# Resource-adaptive Proof-Planning (Period 2001-2004)

Project MI 4 OMEGA: Siekmann, Autexier, Benzmüller

## Multi-Strategy Proof Planning

The MULTI Proof Planner is a general framework for the incorporation of heterogeneous and parameterized algorithms for proof planning

MULTI supports a flexible combination of proof plan refinements guided by strategic control rules




Strategic control rules realizing meta-reasoning patterns, for instance,

- reasoning about failure
- reasoning about integration of constraint solver
- reasoning about meta-variable dependencies

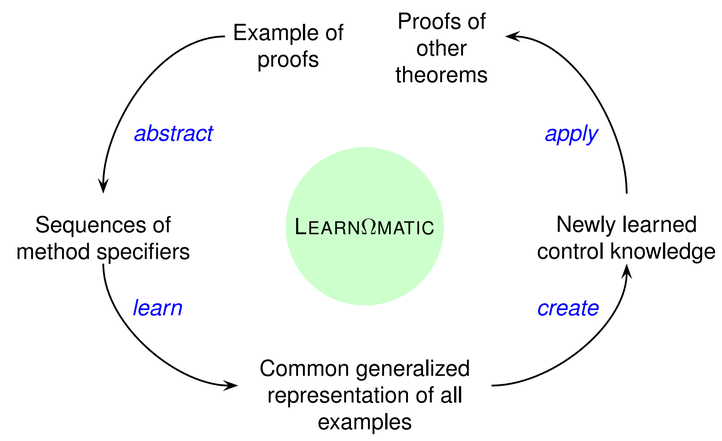
Case studies in limit theory, irrationality of $\sqrt{2}$, permutation groups, residue classes

[PHD-Meier-2004]

## Learning of Control Knowledge

LEARNΩMATIC is a hybrid system consisting of learn engine and proof planner.

The learn engine is available as MATHWEB service.




*abstract:* proof abstracted to sequences of method identifiers

*learn:* generalization of method sequences

*create:* interpretation mechanism for generalized sequences guides proof search

*apply:* strategies enhanced by learnt control knowledge

Case studies in set theory, group theory, residue classes:
⇒ more theorems provable, proof search more directed, and shorter proofs

Successful automatic generation instead of manual modeling of proof planning strategies

[J-IGPL-03,ECAI-02,CADE-02a]

## Case studies

$\varepsilon$-$\delta$-proofs

- Application of multi-strategy proof planning and meta-reasoning.
- Use of constraint-solver and computer algebra system
- 60 theorems from *Bartle & Sherbert: "Introduction to Real Analysis"*

[PHD-Meier-2004]

Automatic analysis of residue class properties

- Proof-planner MULTI orchestrating the combination of computer algebra systems and theory formation system HR
- Proof-plan data structure adequate for integration of different reasoning and computation tools
- Different proof planning strategies implementing different reasoning techniques
- Automatic classification of ∼18.000 structures [JSC-02]

Verification of GAP computations on permutation groups

- Verification by proof search instead of hard-wired scripts
- Use of critical methods and introduction of annotated constants
- 1600 proofs [CADE02]

$\sqrt{2}$ is irrational

- Tactic proof, Island proof planning and automated proof planning strategy in MULTI
- Generalization to any $\sqrt[j]{l} \notin \mathbb{Q}$ problem [AutoMath-Book-03,LPAR-02]

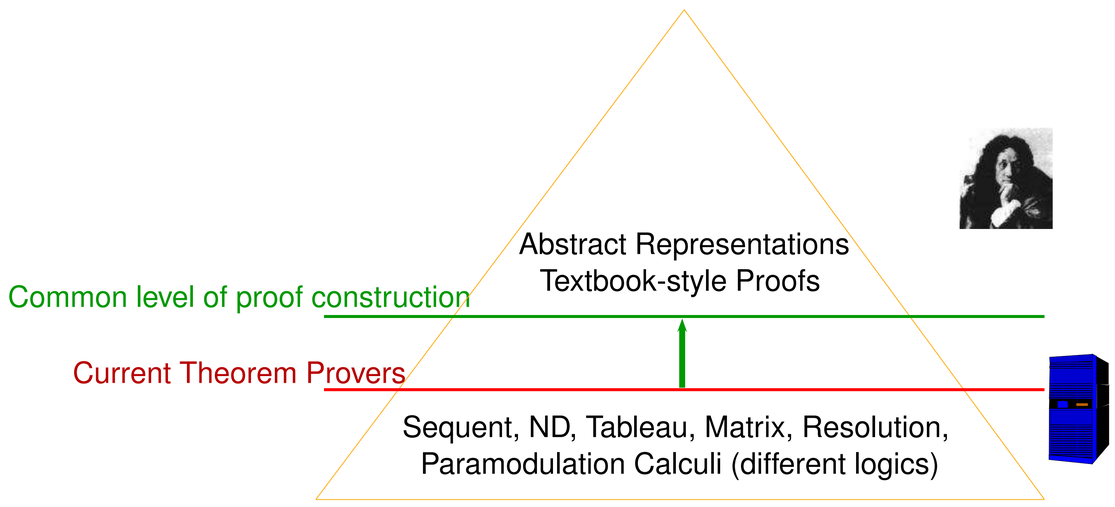
Evaluation of LEARNΩMATIC [J-IGPL-03,ECAI-02,CADE-02a]

Experiments with agent-based reasoning, set theory in CORE [MSc-Huebner-03,ENTCS-04a]

## CORE-Calculus

- Contextual Reasoning calculus supporting proof construction at the level of assertions (definitions, theorems, lemmata)
- Uniform notion of context within formula subparts
- Determination of contextually available rules
- Formal basis: Uniform matrix calculus for modal and higher-order logics with extensionality, proof-theoretic information provided by uniform notation
- Uniform calculus for variety of logics which enables direct assertion-level proof construction and human-oriented ("no calculus") interaction

[PHD-Autexier-2003]

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