System Description

The OMEGA Group

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SFB 378
Ressourcenadaptive
Kognitive Prozesse

Research in the OMEGA project

Aim: assistant for the working mathematician

Means: development and integration of heterogenous tools

- reasoning — proof planning (PP), agent-based reasoning, ATP
- computation — computer algebra
- interaction — tactical TP, mixed initiative PP
- proof maintenance — proof object, diff. levels of detail
- user interface — graphical UI, natural language
- knowledge management — mathematical database
- infrastructure — network of service systems

OMEGA project :=

collection of integrated heterogeneous research projects linked

via the core OMEGA-system

Proof Planning

Knowledge-based Proof Planning [MELISSIEKMANN99],[MELISMEIER00]

- Proof method: domain specific, mathematically motivated, may encapsulate and employ external systems
- Control knowledge: heuristic information on how to guide plan search, may employ external systems
- Strategy := (set-of-proof-methods, control-knowledge)

Proof Planning with MULTI: [MELISMEIER00]

- Supports interleaving of different strategies

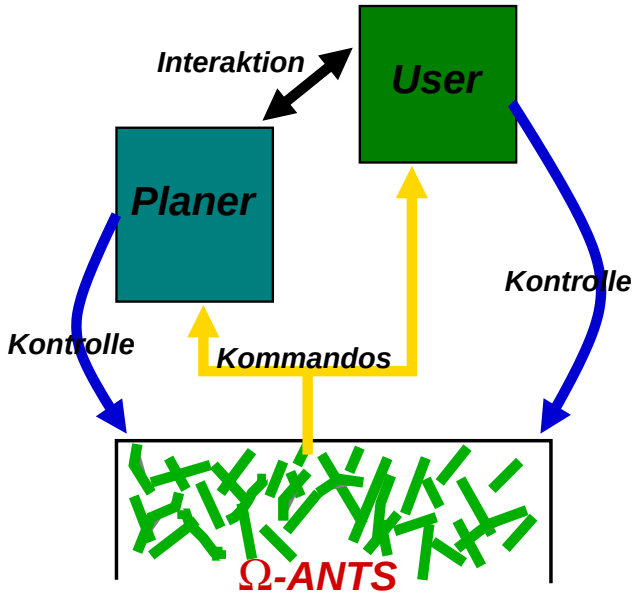
Agent-based Reasoning

Agent-based Reasoning . . . [BenzmüllerSorge99][BenzmüllerEtAl-00]

- Idea: model methods, tactics, external systems as pro-active entities

Interactive Theorem Proving

- Suggestion mechanism with anytime character
- Mixed-initiative proof planning



External Systems

External Systems . . . [BENZMÜLLERETAL99],[MELISETAL00],[SORGE00]

- as subsystems in proof methods or control rules
- as own tactics $\frac{P_1 \quad \ldots \quad P_n}{C}\ Otter \qquad \frac{P}{C}\ SimplifyWithMaple$
- Soundness: Transformation in proof plan, Expansion, Checking
- Tool Support for Transformation:
  - TRAMP: FO refutation proofs [MEIER00]
  - SAPPER: CAS computations [SORGE00]

Proof Objects

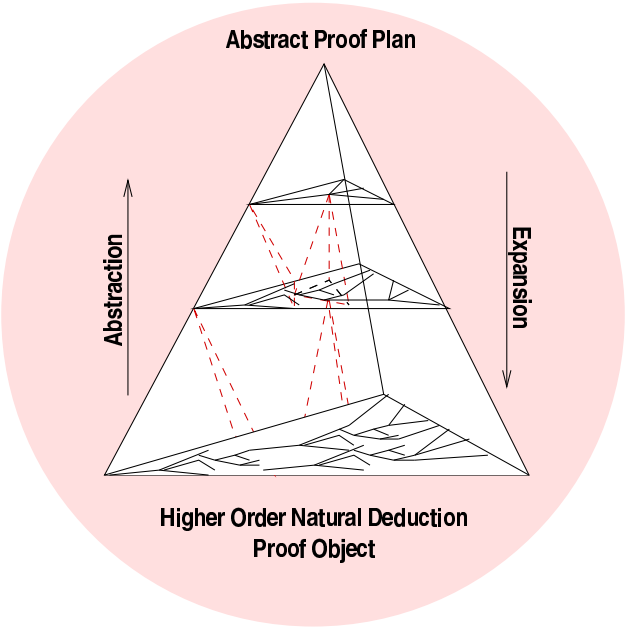
Multi-Strategy Proof Planning | Agent-based Reasoning | Interactive Theorem Proving | External Support Systems

OMEGA proof data structure (PDS)

[CHEIKHR.SORGE00]

Logic & Calculi

- maintains proof plans at different levels of detail simultaneously
- base layer: higher order ND variant for simply typed λ-calculus
- abstract level proof plans not necessarily sound: verification by expansion to more detailed layer



Case Studies

Graphical User Interface | Natural Language Proof Presentation | Mathematical Knowledge Base | Mathematical Software Bus

User Interface

Multi-Strategy Proof Planning

Agent-based Reasoning

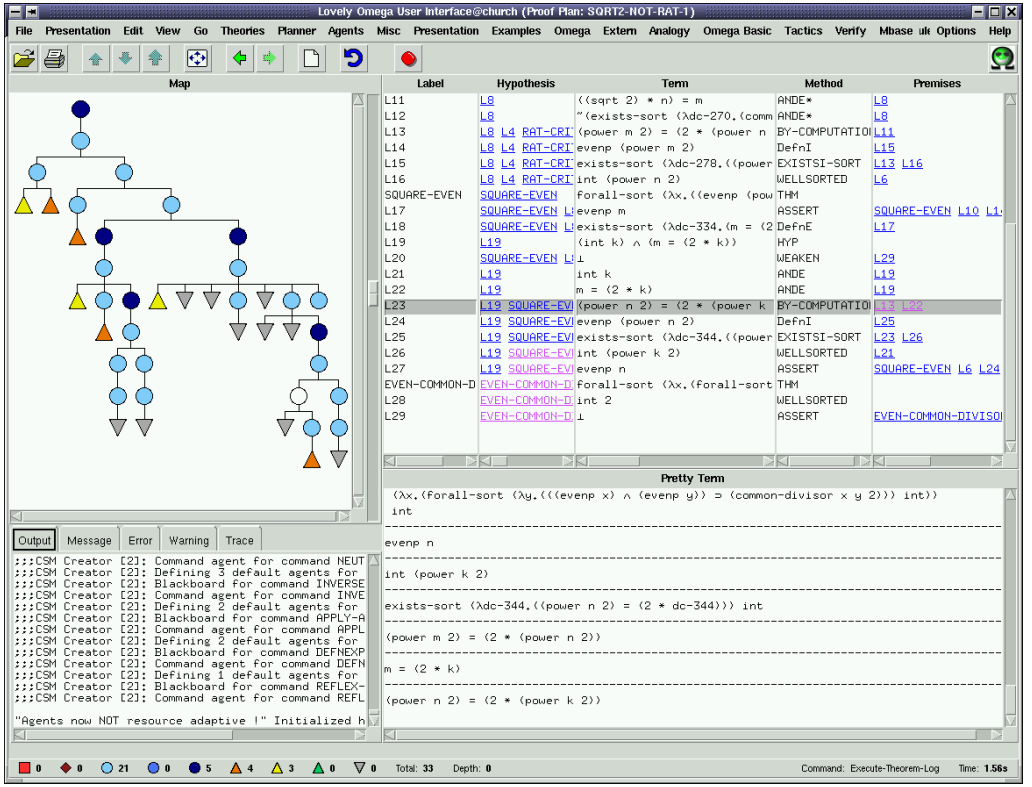
Interactive Theorem Proving

External Support Systems

Logic & Calculi

Graphical user interface $\mathcal{LOUI}$ [SIEKMANNETAL99]

- multi-modal: proof tree, linearized proof, term browser
- hypertext mechanism
- natural language proof presentation



Case Studies

Graphical User Interface

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Mathematical Knowledge Base

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User Interface

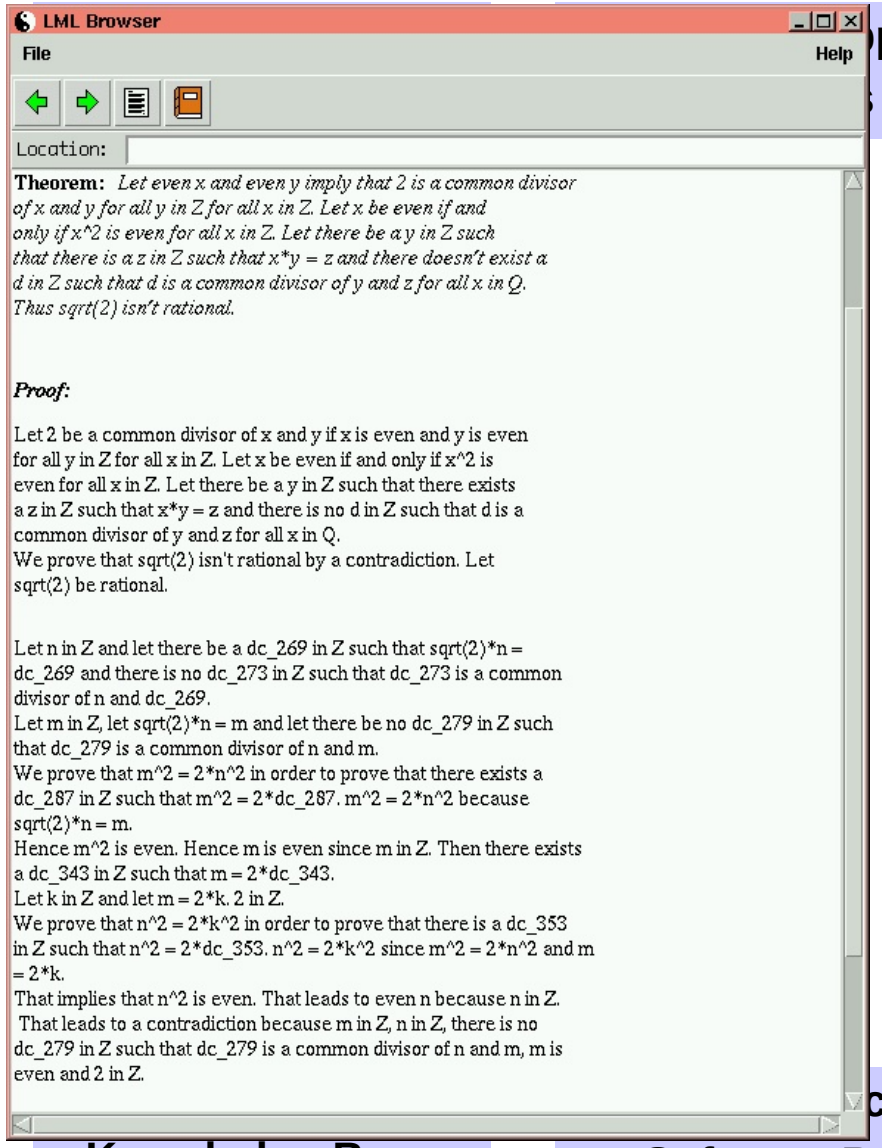
Multi-Strategy Proof Planning

Agent-based Reasoning

…port

Natural language proof presentation with *P.rex* [FIEDLER01]

- interactive and adaptive
- supports different levels of detail



Logic & Calculi

Case Studies

Graphical User Interface

Natural Language Proof Presentation

Knowledge Base

…cal Software Bus

Knowledge Management & Infrastructure

Multi-Strategy Proof Planning | **Agent-based Reasoning** | **Interactive Theorem Proving** | **External Support Systems**

Logic & Calculi

MBASE [FRANKEKOHLHASE00]

- currrently: migration from old knowledge base to MBASE
- ideally: MBASE maintains **all** domain specific knowledge

MATHWEB [ZIMMERKOHLHASE02]

- OMEGA environment

=

bunch of MATHWEB tools orchestrated by the OMEGA core system

Case Studies

Graphical User Interface | **Natural Language Proof Presentation** | **Mathematical Knowledge Base** | **Mathematical Software Bus**

Case Studies

$\epsilon - \delta$ proofs [MELISSIEKMANN99]

- Maple for manipulation of arithmetic expressions
- constraint solver $\mathcal{CoSIE}$ for instantiation of meta-variables

Classification of residue class structures, e.g. $(\mathbb{Z}_5, \bar{*})$ [MEIERETAL00]

- which algebr. structure (semi-goup, monoid, etc.)?, isomorphic?
- more than 10.000 structures analyzed
- 3 essentially different kinds of proofs

Recently: Irrationality of $\sqrt{2}$; interactive and automated with PP

Conclusion

Multi-Strategy Proof Planning | Agent-based Reasoning | Interactive Theorem Proving | External Support Systems

Is OMEGA already a tool for the working mathematician?

- No . . . but the perspective is there

What is needed?

- Better integration of tools
- Improvement (research!) of all tools
- Software engineers to turn research products in solid system

Logic & Calculi

Case Studies

Graphical User Interface | Natural Language Proof Presentation | Mathematical Knowledge Base | Mathematical Software Bus