European Collaboration on Automated Reasoning

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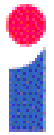
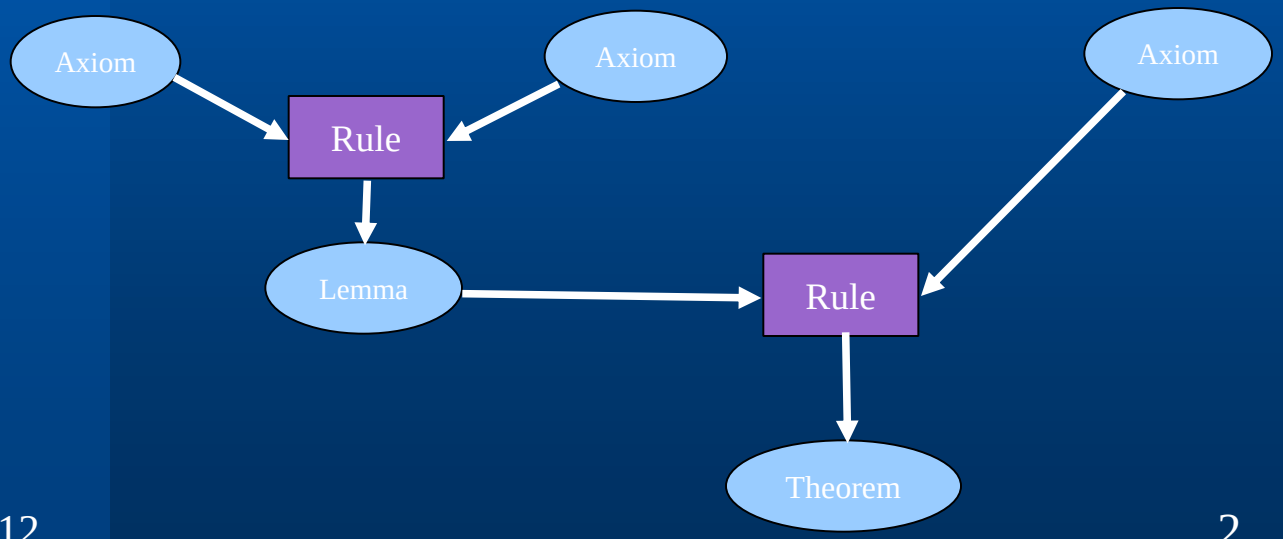
ECAI 2012 "Turing and Anniversary Session"



A Bluffer's Guide to Automated Reasoning

- **Logical theory: formal language, axioms and rules of inference.**
- **Automated reasoning derives new theorems from old.**



A Bluffer's Guide to Inductive Proof

- **Mathematical induction:**

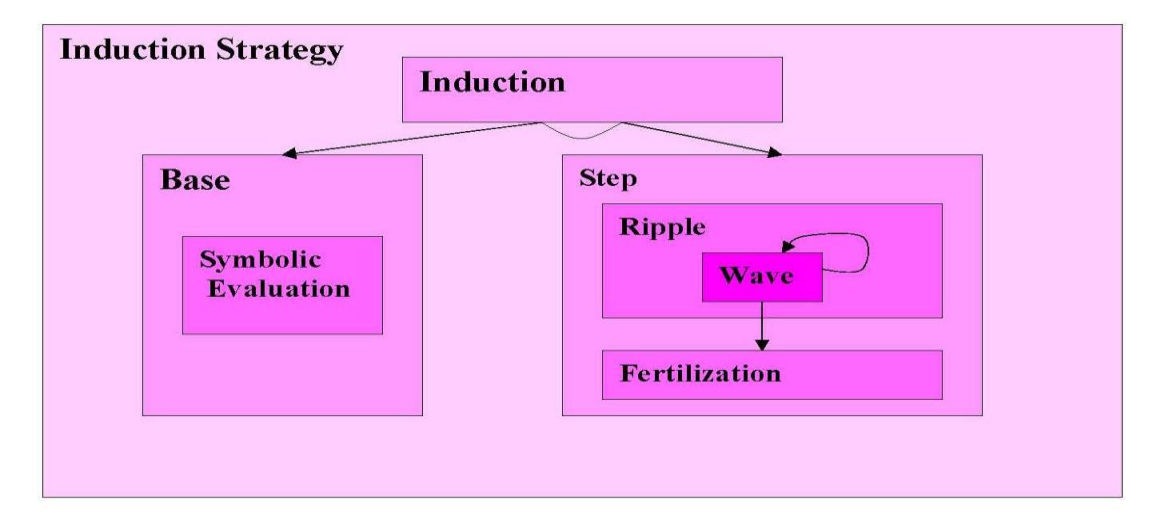
$$\frac{P(0),\ \forall n\ P(n) \rightarrow P(n+1)}{\forall n\ P(n)}$$

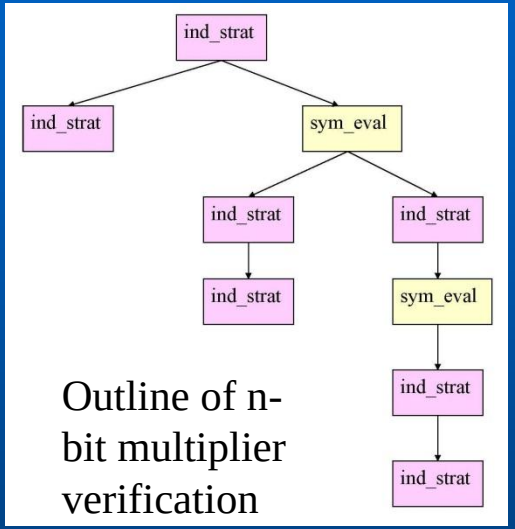
- **Need for intermediate lemmas:**

$$\frac{P, L \vdash Q, \qquad P \vdash L}{P \vdash Q}$$ Cut rule

- **Rippling:** $P(n) \vdash P(n+1^{\uparrow}) \ \ldots \ P(n) \vdash Q(P(n))^{\uparrow}$
  - Ripple failures suggest lemmas
  - e.g., *rev(rev(l)=l* suggests *rev(app(x,y))=app(rev(y),rev(x))*

A Bluffer's Guide to Proof Planning





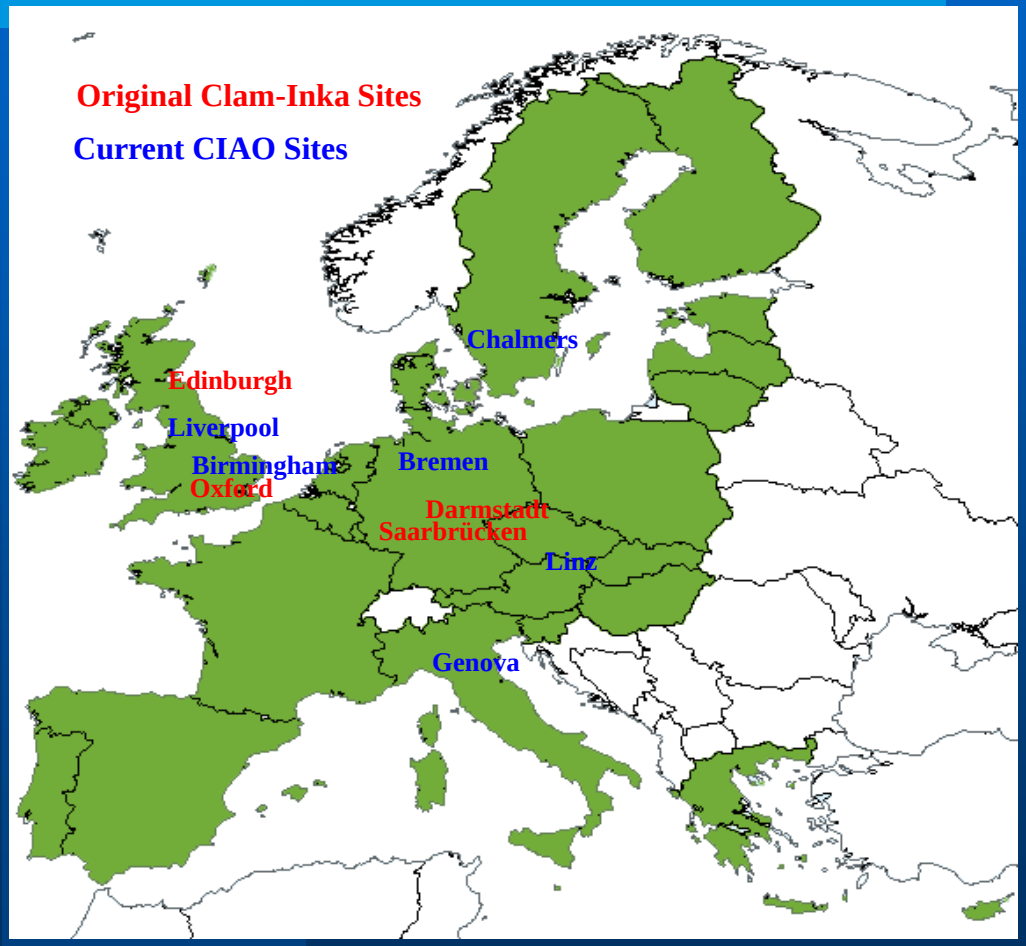
Outline of n-bit multiplier verification

- Boxes are proof methods; arrows are (sub)goals.
- Nesting indicates chunking of proof.
- Effects of earlier methods set up preconditions of later ones.
- Plan guides proof; critics patch failed proofs.
- Applications outside maths, e.g., bridge, configuration.

Birth of a Collaboration

- **Development of *Proof Planning***
  - **Inductive theorem proving and *rippling***
- **Edinburgh/Saarbrücken dialogue**
- **INKA: Karlsruhe Induction Theorem Proving System.**
  - **Moved to Saarbrücken and Darmstadt.**
- **Joint development of rippling.**

The CIAO Workshops



- Originally, collaboration in inductive proof & proof planning.
- 1992-date: Series of bilateral visits and workshops.
- Funded by British Council, DAAD, CRUI ‘lab twinning’ scheme.
- Growth in collaborators and research areas.
- Informal, invitation-only workshops facilitate rapid interaction.

Attendees at the 1993 CLAM-INKA Workshop

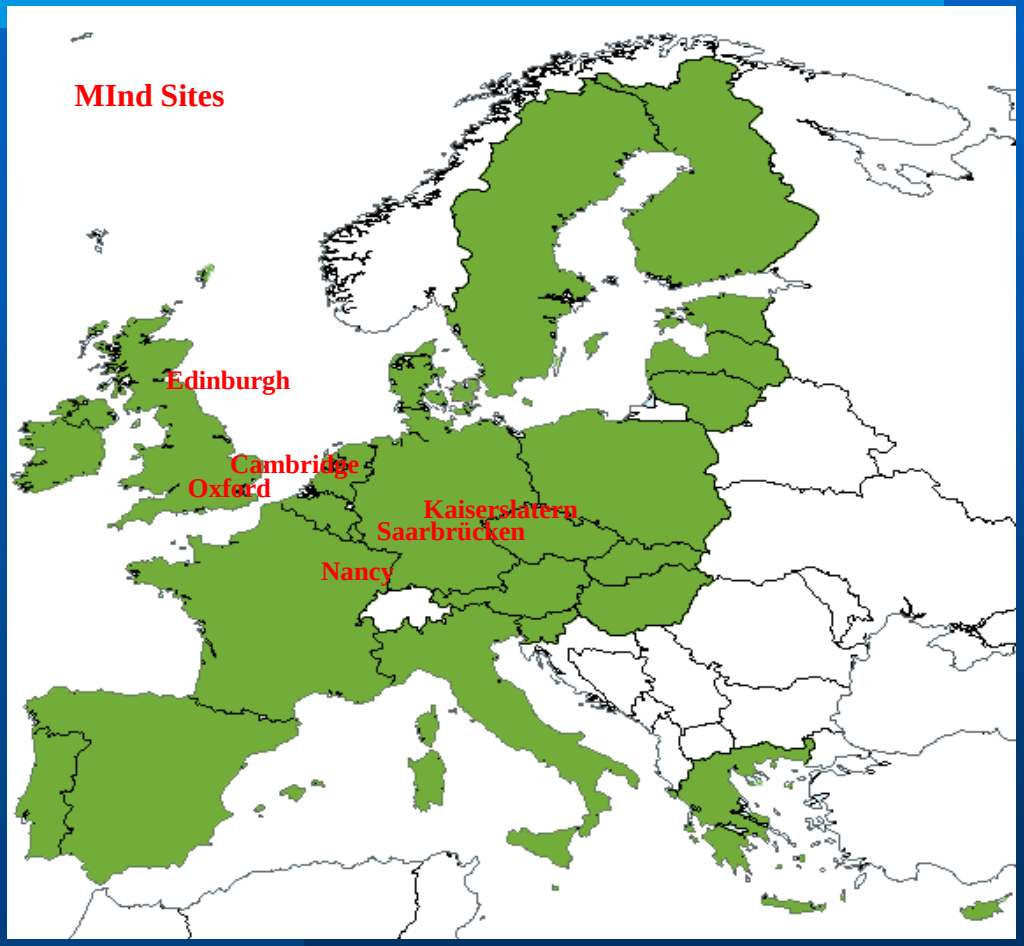
New Directions 1

- **Continuing interest in proof planning and induction.**
- **Combining reasoners and theories:**
  - **Provers + computer algebra + decision procedures + constraint solvers + ….**
  - **Spawned FroCoS: International Symposia on Frontiers of Combining Systems**
  - **Use of Category Theory to inter-relate theories.**

New Directions 2

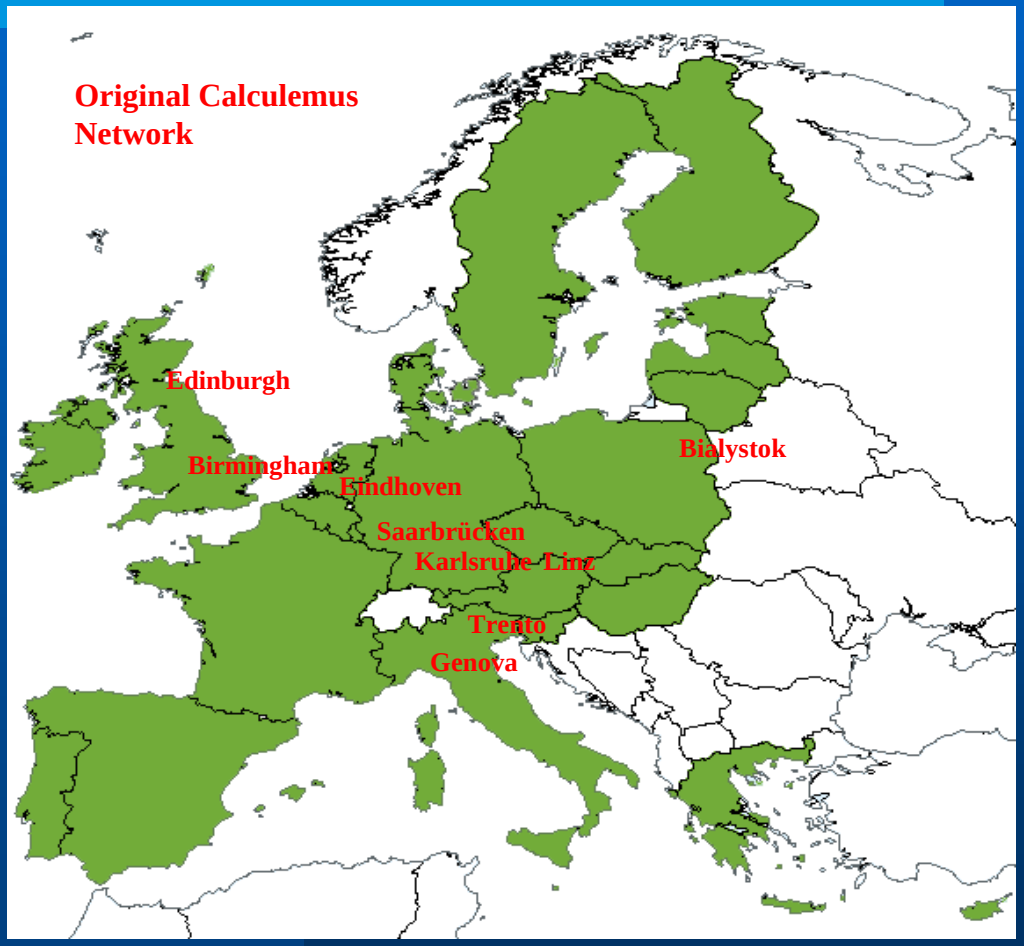
- **Termination of recursive functions.**
  - **Practical results despite Turing's negative result in general case.**
- **Verification of computer systems.**
- **Theory exploration: new conjectures + concepts.**
- **Diagrammatic and graphical reasoning.**
- **Proof presentation.**

The MInd Consortium



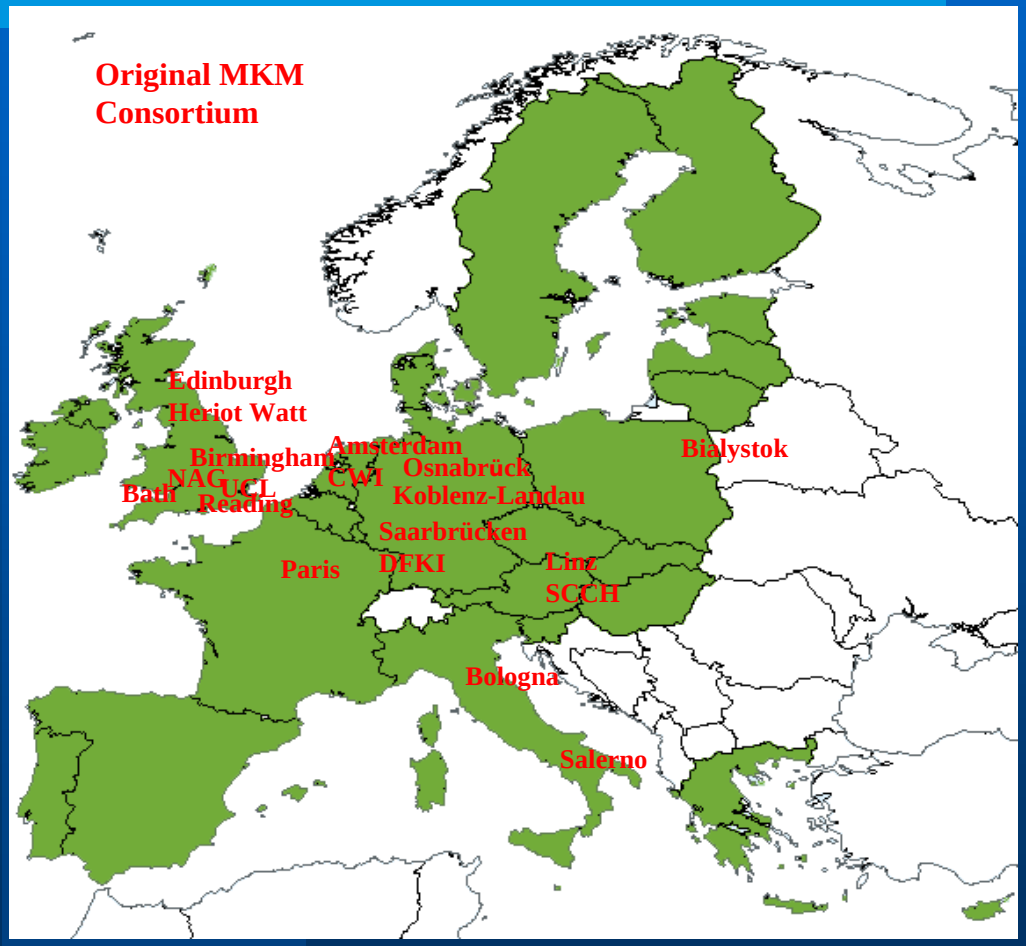
- European (MInd) and US (Indus) consortia.
- 1992-5: Supported by ESPRIT Working Group grant.
- Workshops at major conferences: AAAI-93, CADE-94, Dagstuhl 95.
- Explicit vs implicit induction.

The Calculemus Project



- Collaboration between automated reasoning and computer algebra.
- 1996-date: Series of conferences, young researchers, bilateral visits, autumn school, etc.
- 2000-2004: Supported by EU IHP Research Training Network.
- Applications to verification, mathematics and intelligent teaching systems.

Mathematical Knowledge Management



- Online organisation and application of all of mathematical knowledge.
- Automated reasoning, computer algebra and mathematics.
- 2003-date: MKM conference series.
- Concern with presentation standards: MathML, OpenMath, OMDoc.

Applications

- **Verification: proof that systems meet their specifications:**
  - **Passport protocols, smart cards, robots, etc.**
- **Teaching Maths: instruction linked to automated proof.**
- **Mathematical Aids: increasing interest from mathematicians,**
  - **e.g., Flyspeck Project.**

Where are we now?

- **Large increase in collaborating labs.**
- **Diversification into new research areas.**
- **Practical applications, e.g., to verification, mathematical aids, math education, etc.**
- **Several new, international conferences and workshop series.**
  - **+ Young researchers, bilateral visits, autumn school, large projects, special issues, etc.**
- **Main leadership role from Europe.**

Where are we going?

- **Key role for automated reasoning in Semantic Web, multi-agent systems, etc.**
- **Further uptake by mathematicians: both research and teaching.**
- **Further uptake by industry, especially in formal methods.**
- **Increased interest in evolution of representation: both beliefs and language.**