Support for "Trusted" Extension in ACL2

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August, 2010

A Computational **L**ogic for
Applicative **C**ommon **L**isp = **ACL2**

- a functional programming language
- a first-order mathematical theory
- a mechanized theorem prover
- implemented primarily in ACL2

Primary Concerns

- soundness
- industrial-scale usability

Our primary "customers" are AMD, Rockwell-Collins, Centaur Technology, IBM, and various government agencies

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because efficient execution of ACL2 models is a major (driving?) concern

Soundness is based on the care Kaufmann and Moore have taken in the implementation

ACL2 is not "foundational" – we strive for good design and elegance in our coding, but we are willing to add logically "redundant" features as necessary

"Blessed" extension mechanisms are primarily based on proof of appropriate properties

Our "trust story" is that if users stick with certain features, they preserve as much soundness as we had in the first place

Users can always go "under the hood" and do anything in Lisp

Keys to ACL2's extensibility include

- expressions "are" objects
- user can access the state of the system
- system is coded in ACL2 so system functions are available in many contexts

Two Senses of "Extension"

- Logical – changing the logical theory
- Behaviorial – changing the behavior of the prover

Logical Extension Facilities

- Ground-zero theory (starting point)
- Theory Extension Events
  - Simple axiomatic events
    - `DEFUN` - *intro new rec fns; conservative*
    - `DEFCHOOSE` (basis for `DEFUN-SK`) - *witness fns; conservative*
    - `DEFAXIOM` - *risky; rarely used*
  - Non-axiomatic events: `DEFTHM` - *prove a theorem*
  - Compound
    - `PROGN` - *grouping*
    - `LOCAL` - *scoping*
    - `INCLUDE-BOOK` - *import pre-certified events*
    - `ENCAPSULATE` - *intro constrained un-interp fns*
- `Syntax extensions`
  - `DEFCONST` - *abbrev constants*
  - `DEFMACRO` - *computed trans of new syntax*

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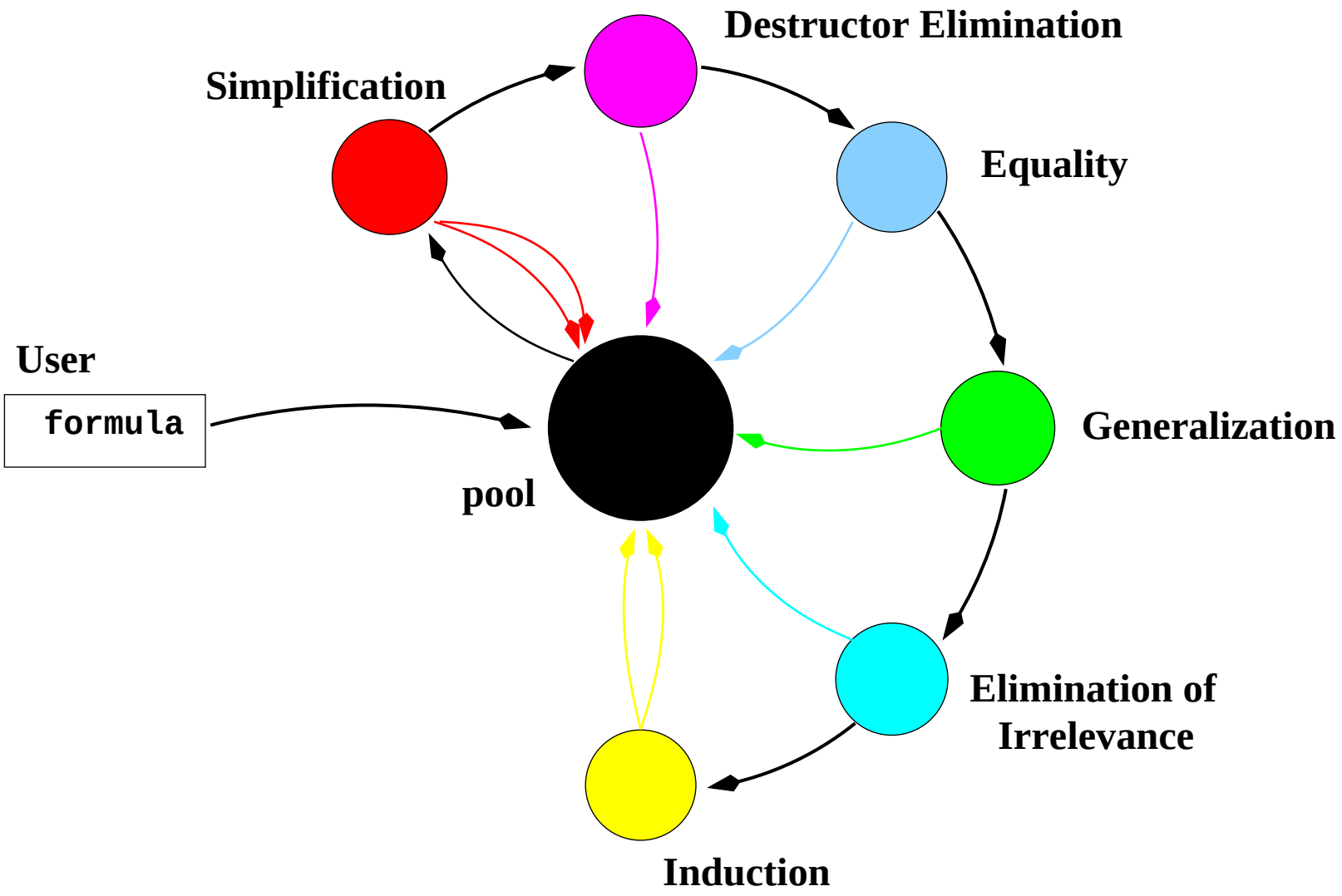
Destructor Elimination
Simplification
Equality
User
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Generalization
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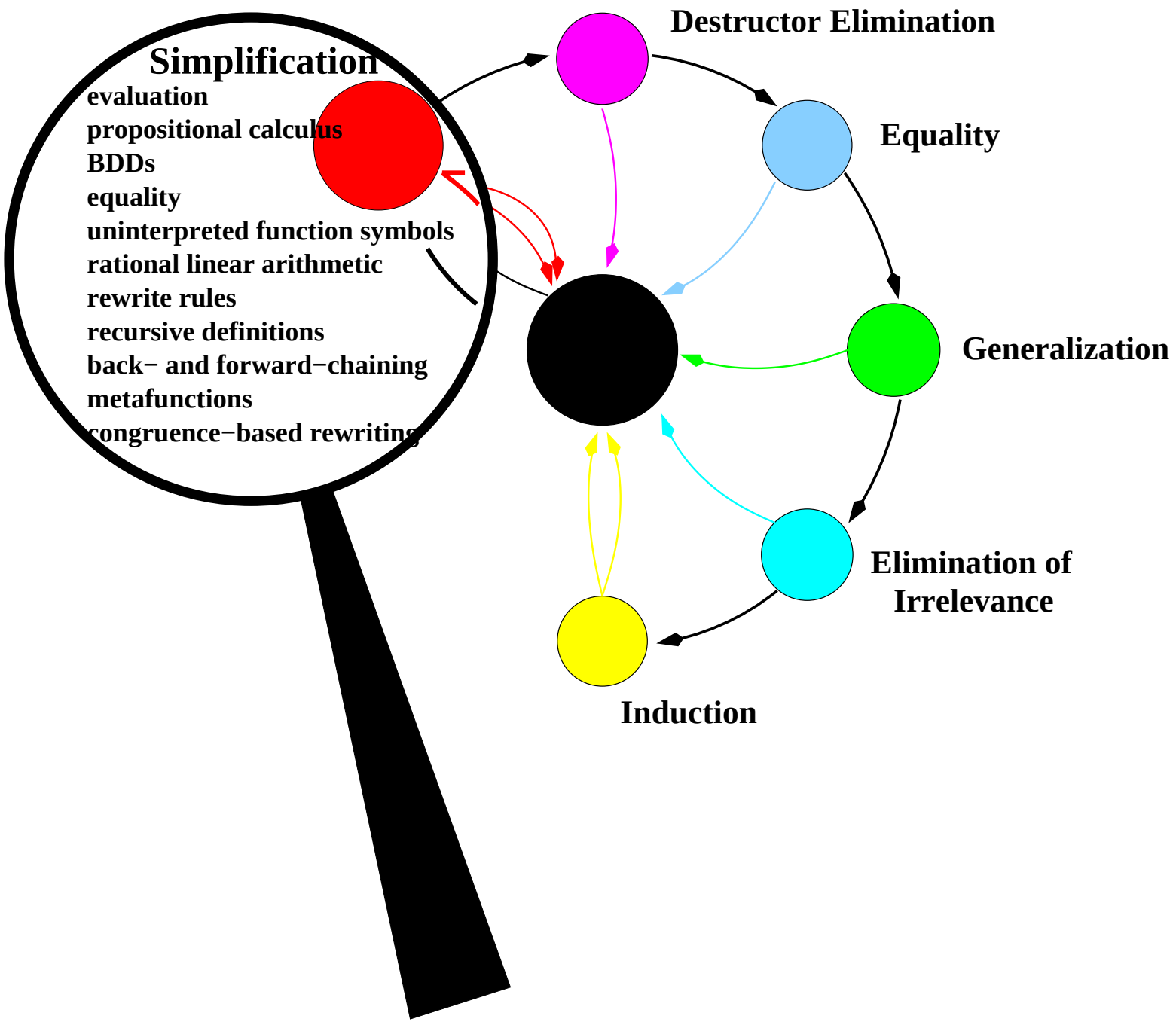
Simplification
evaluation
propositional calculus
BDDs
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uninterpreted function symbols
rational linear arithmetic
rewrite rules
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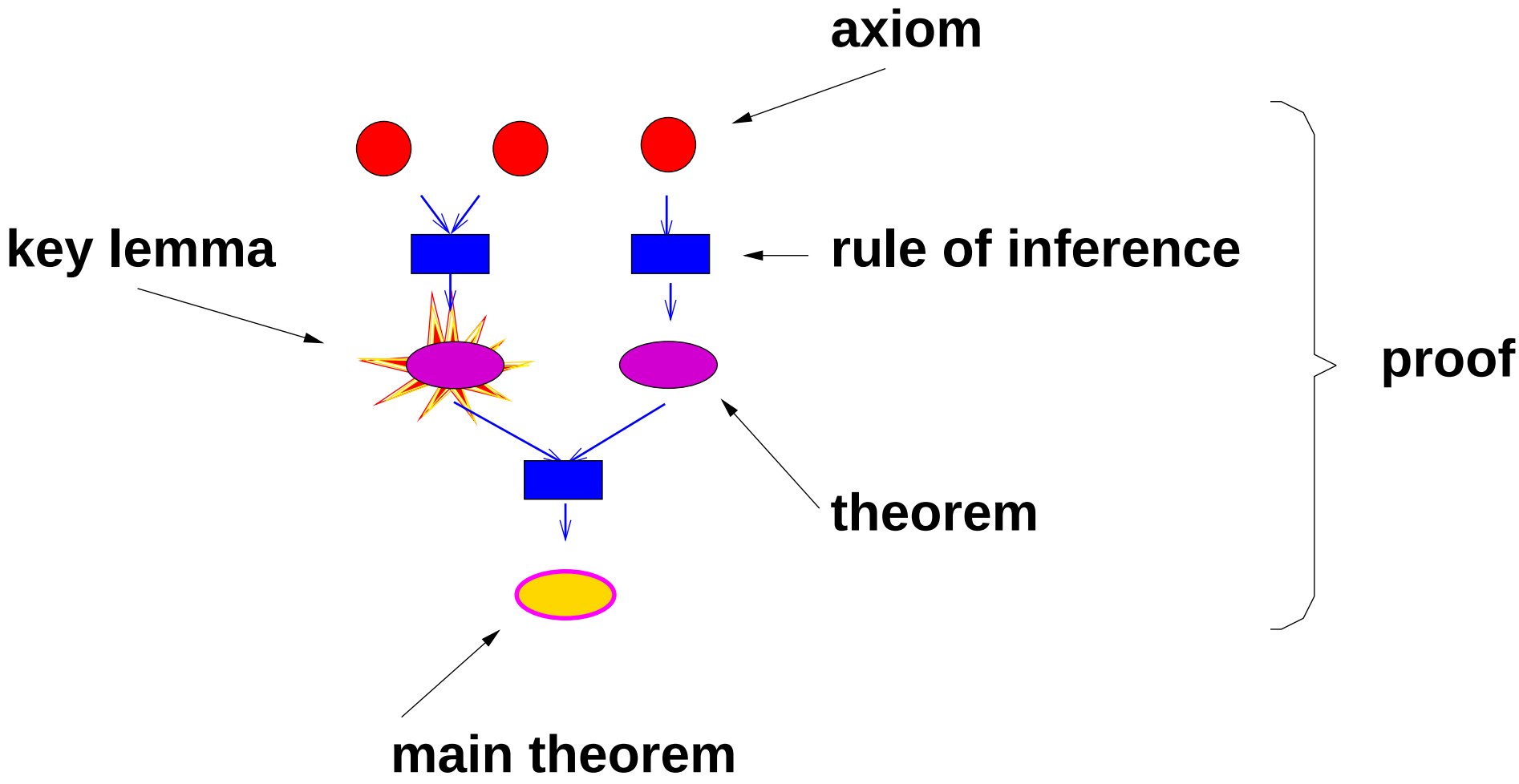
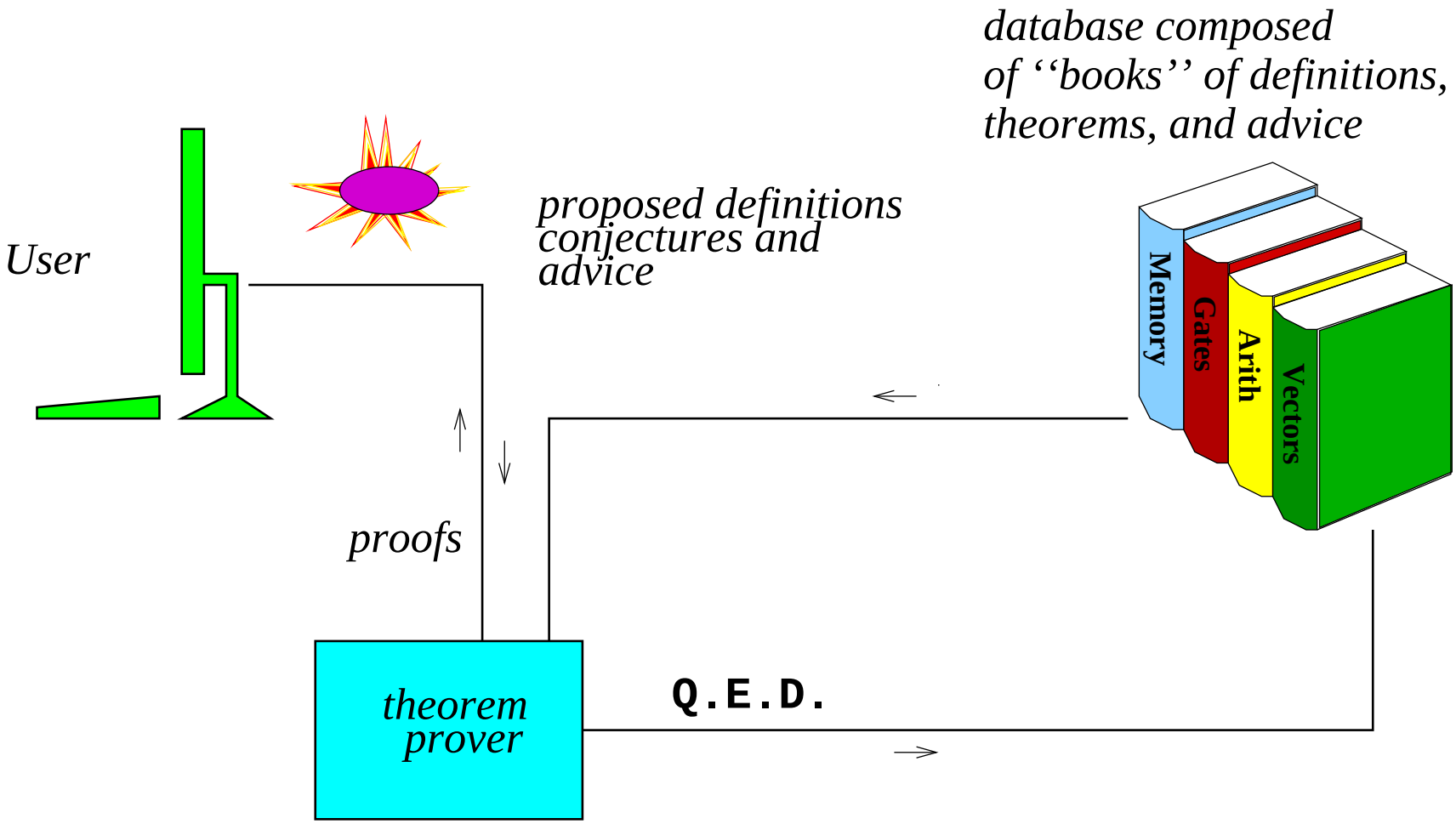

axiom
key lemma
rule of inference
proof
theorem
main theorem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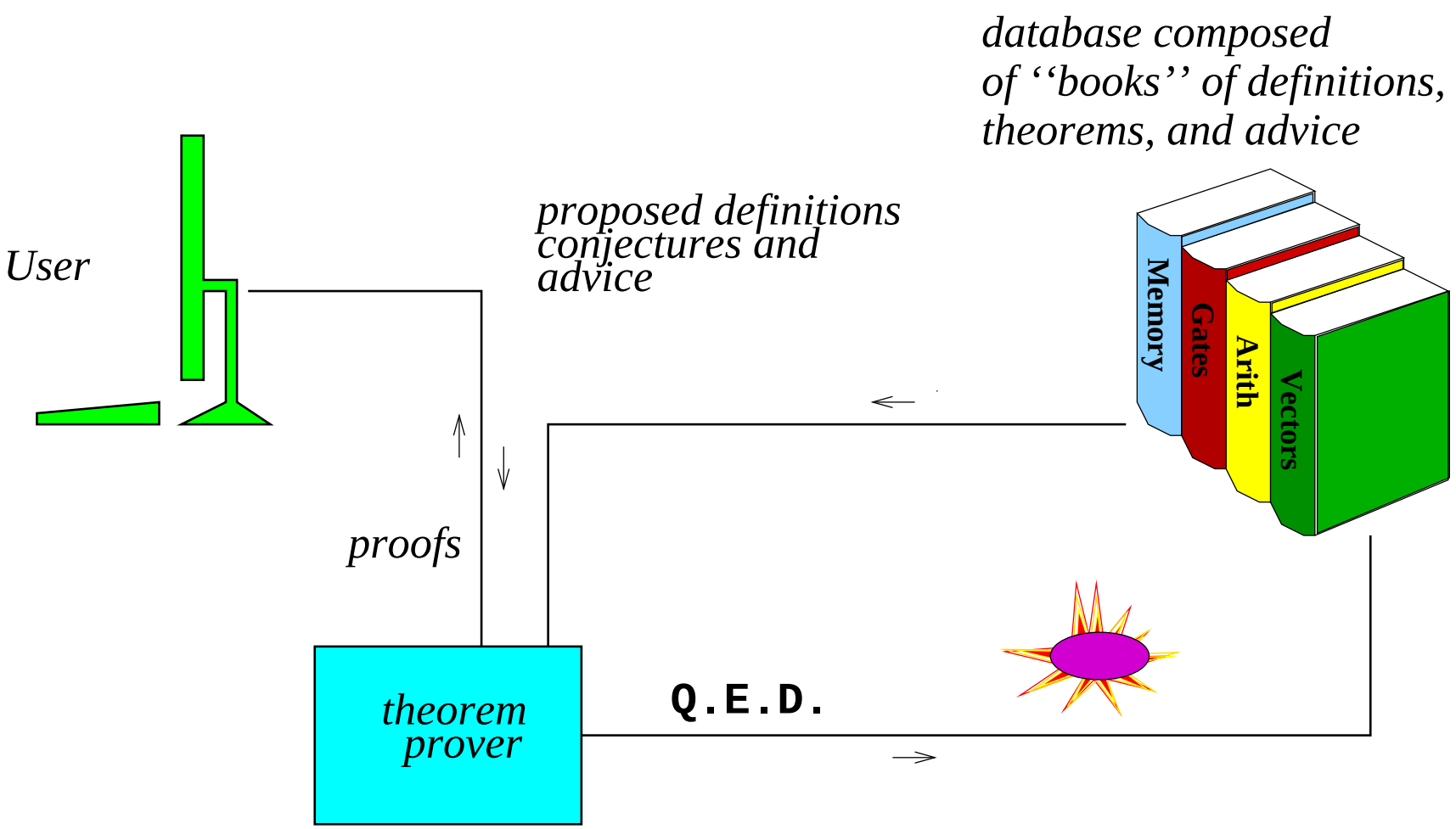
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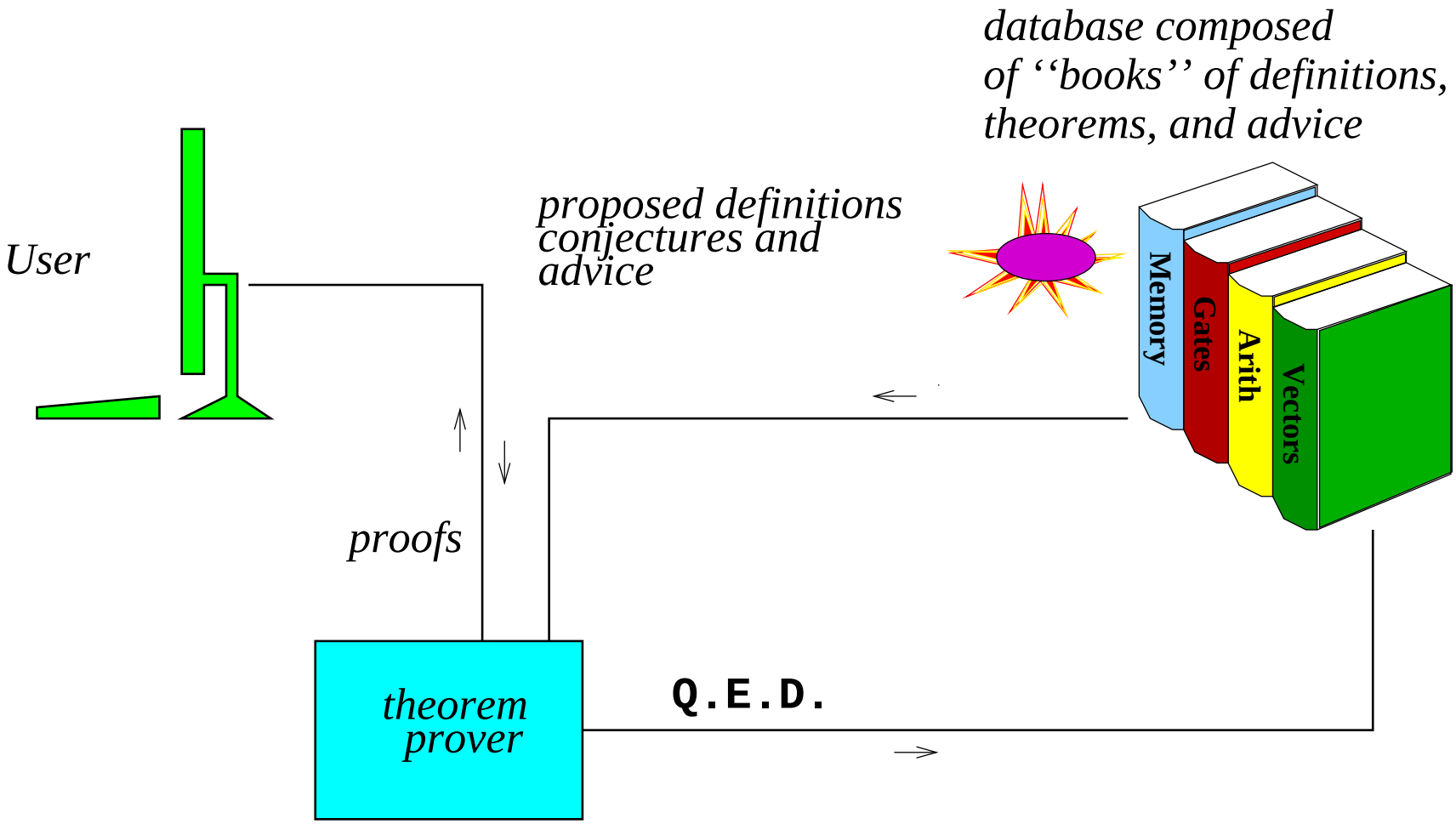
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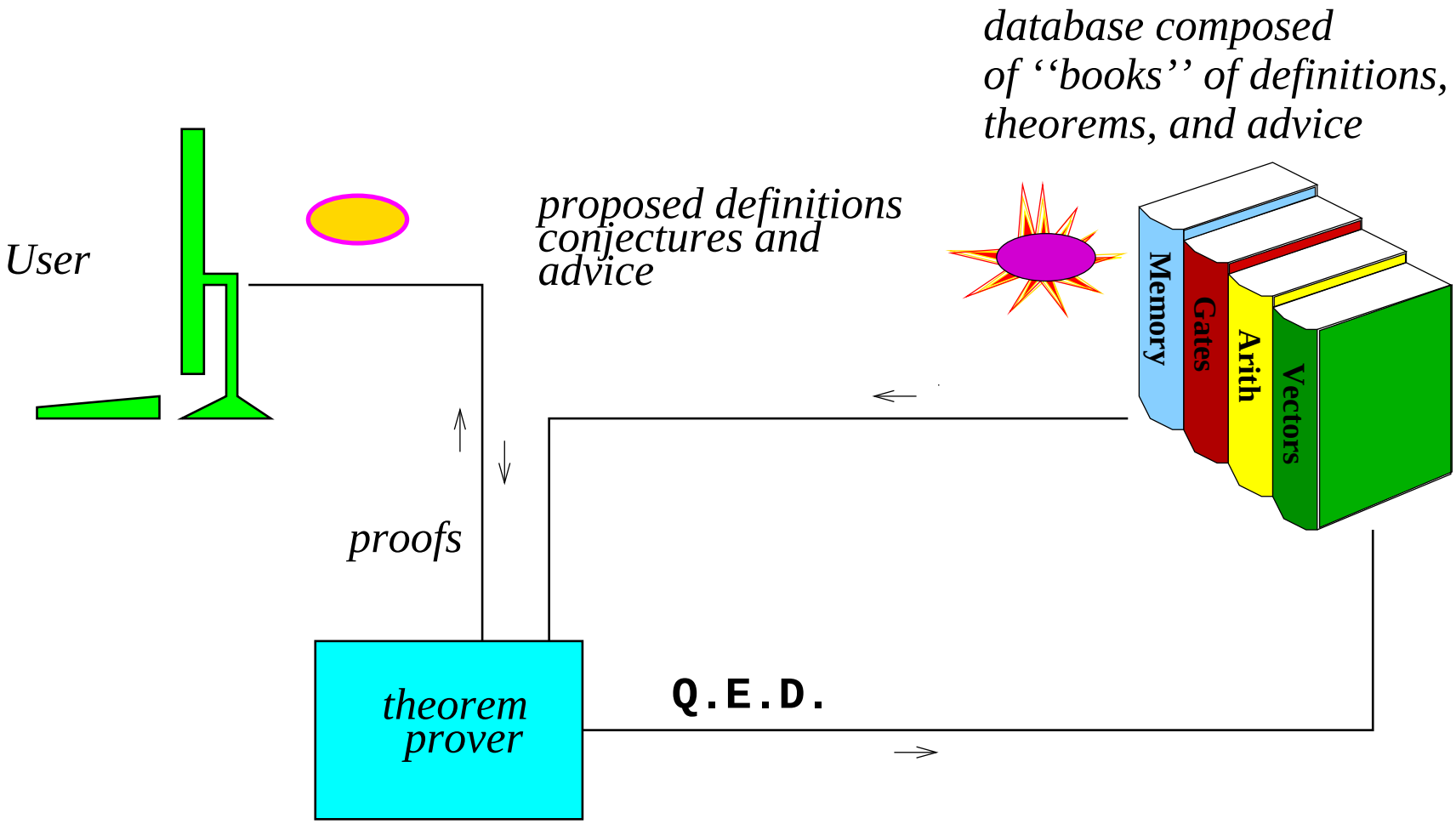
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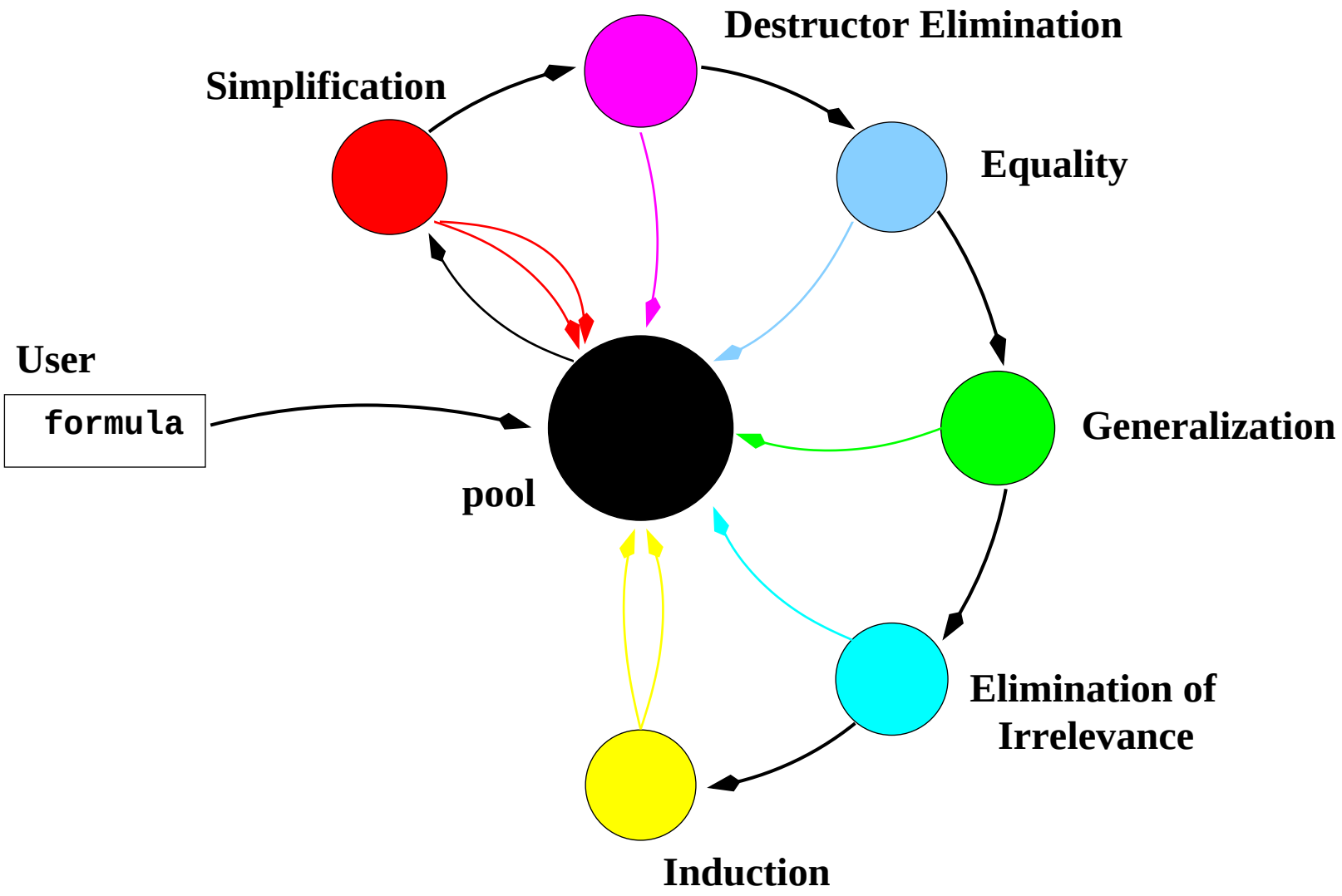
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Behavorial Extension Facilities

- Customization of Built-in Features
  - Extending automation through rule-classes
    - Rewriting (conditional, contextual, congruence-based)
    - Metafunctions and Verified Clause-Processors
    - Pragmas -- `syntaxp`, `bind-free`, `force`, `case-split`, `double-rewr`
  - Static (Goal Specific) Hints
- Programmatic (analogous to tactics)
  - Computed Hints
  - Make-event
- Extending evaluation capabilities:
  - Prototype without proof -- e.g., `program` mode, `skip-proofs`
  - Optimizing Evaluation -- `guard`, `mbe`
- Unverified (but useful) extensions

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- Verified extensions

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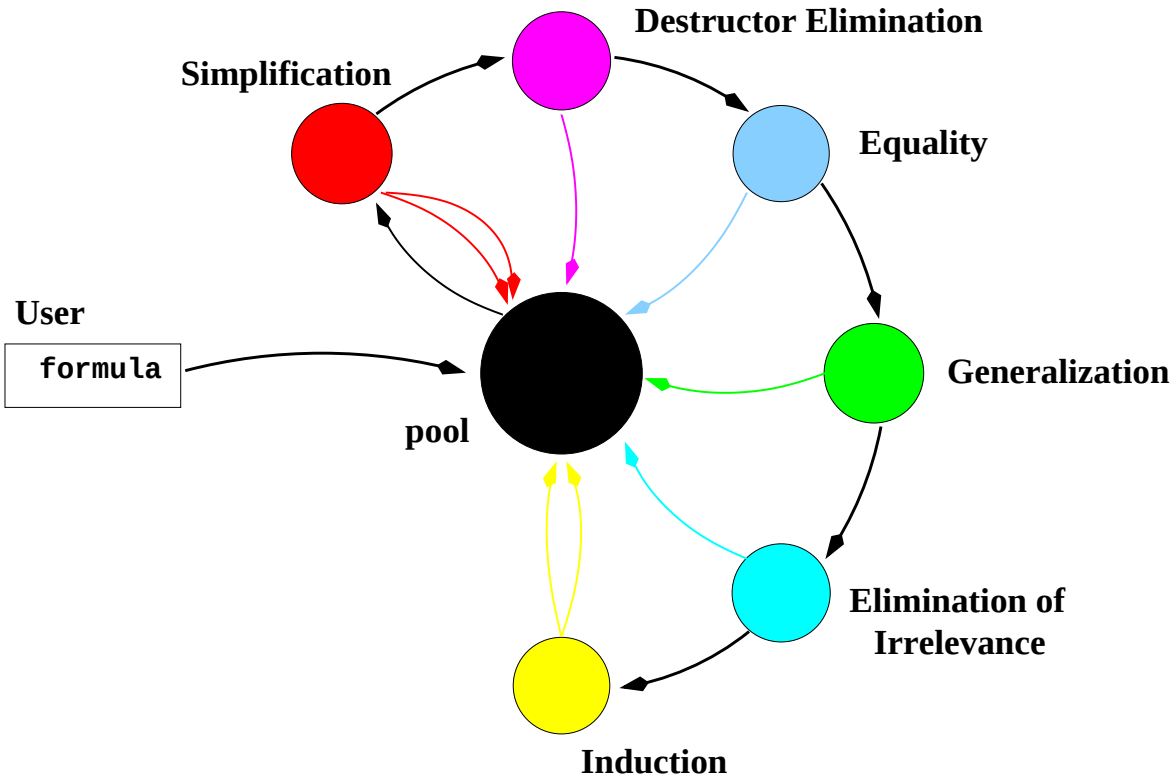
Clause Processors



Verified clause processors are like metafunctions except operate at the goal level rather than the subterm level

Unverified clause processors are external tools (like SAT-solvers, IBM's SixthSense, etc.)

It is possible to introduce partially constrained functions whose execution is carried out by calls to external tools.

Matt Kaufmann, J S. Moore, Sandip Ray, and Erik Reeber. Integrating External Deduction Tools with ACL2. *Journal of Applied Logic* (Special Issue: Empirically Successful Computerized Reasoning), Volume 7, Issue 1, March 2009, pp. 3–25. Also published online (DOI 10.1016/j.jal.2007.07.002).

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```
(defp run (s)
  (if (haltedp s)
      s
      (run (step s))))
```

`defp` ("define partial function") book: establishes that generic (uninterpreted) tail-recursive equation is satisfiable by an admissible function and then *functionally instantiates* that result for the user's fns

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  - Trust tags (used at Centaur and in ACL2s)
  - Feature-based
    - Hash-cons, memoization, applicative hash tables
    - ACL2(r)
    - Parallel ACL2
- Verified extensions

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  - Defattach (also for testing) -- contributed talk
  - Untranslate and untranslate-preprocess
  - Verified clause-processors

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Questions?