LeanFlow

Workflow-Driven Lean Autoformalization

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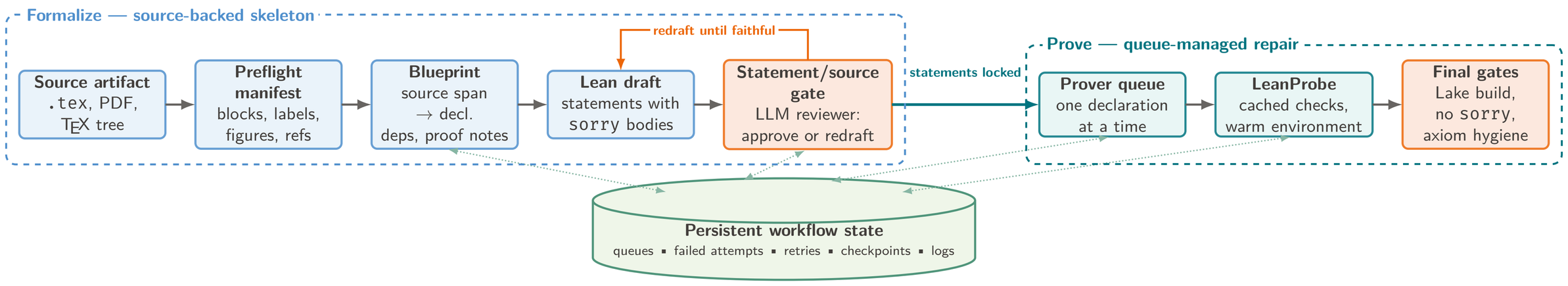
From informal mathematical document to sorry-free Lean 4 project: structured, source-gated statement translation and queue-based theorem proving.

From Document to Verified Lean Project



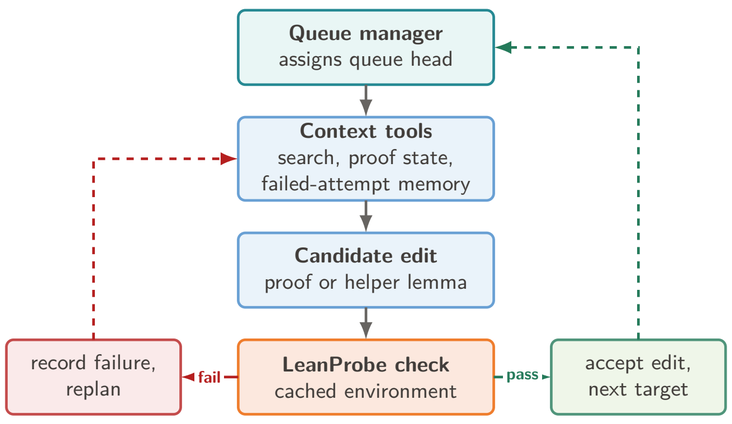
The formalizer drafts source-backed declarations and an autonomous reviewer gates statement faithfulness *before* proof search; the prover repairs one declaration at a time. All run state persists **outside the model context**, keeping runs resumable and auditable.

Why Naive Runs Break

- **Compiling ≠ faithful.** A well-typed theorem can formalize the *wrong* source claim — weakened conclusion, changed quantifiers, shifted domains. **LeanFlow's answer:** independent external reviews, in fresh contexts, gate each statement against its source — redrafting until faithful — before any proof search.
- **Transcripts forget.** Long runs lose failed-attempt memory after context compaction and repeat broken proof shapes.
- **Free agents wander.** Without routing, calls go to the wrong file, unstable dependencies, or already-failed paths.

Design rule. Separate statement faithfulness from proof completion: first approve *what each declaration means*, then let automated repair finish the proof under verifier control.

Inside the Prover Loop



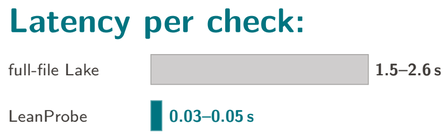
The manager exposes **one active declaration** at a time, stores theorem-local failures and retry budgets, and advances only after external Lean verification accepts the edit. Statements stay frozen: repair may add helpers, never weaken the target. Checkpoints keep every run resumable and auditable.

Cached Lean Feedback

Cached same-file verifier (CLI ▪ Python ▪ MCP server): prepare the target's Lean environment once, then check each candidate in milliseconds. Failed candidates come back as annotated Lean:

```
theorem my_add_comm (x y :  Nat) :
   x + y = y + x := by
 -- proof state:  x y :  Nat
 --          ⊢ x + y = y + x
  rfl
 -- error:  tactic 'rfl' failed
```

Latency per check:



Sequential file verification:

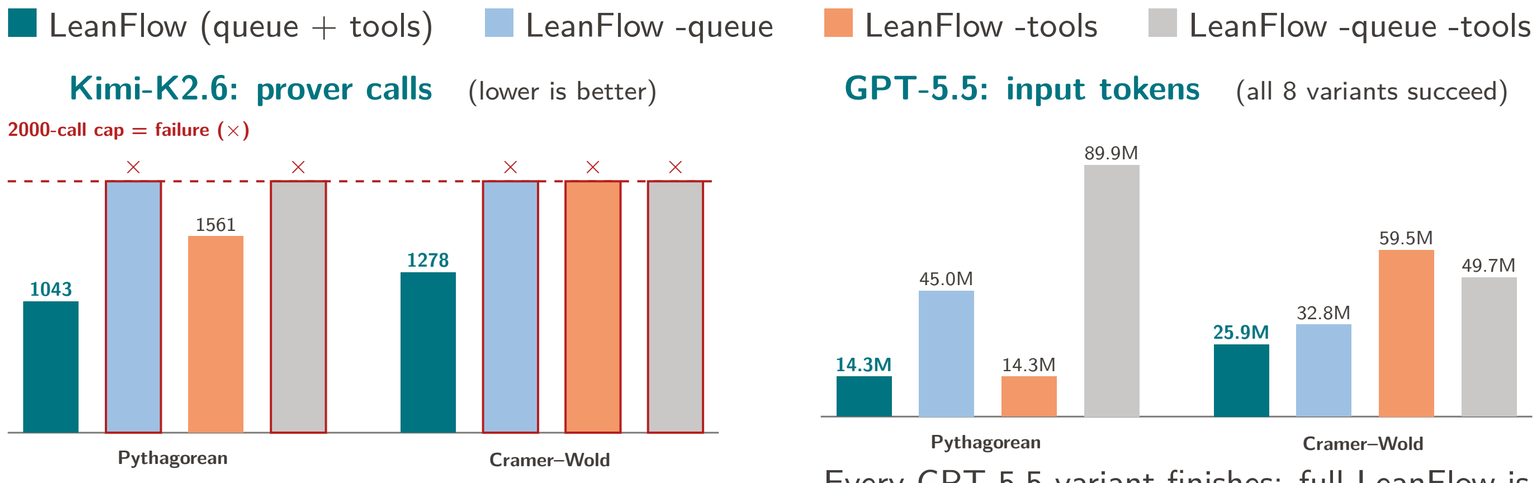
9–14× faster than growing-prefix Lake checks.

epfl-lara/LeanProbe

Plugs into the repair loop of any Lean agent; final acceptance stays with Lean/Lake.

Do Workflows Matter? Ablations on Real Papers

Two papers — **Frisch–Vaserstein** (Pythagorean triples) and **Lyons–Zumbrun** (Cramer–Wold) — proved from the same reviewed skeleton under a 2000-call budget. Full LeanFlow uses both queue manager and tool surface; ablations remove queue and/or tools (+tools = context/proof-state tools + LeanProbe).



Queue control is **decisive**: every no-queue Kimi-K2.6 run fails at the budget cap.

Every GPT-5.5 variant finishes: full LeanFlow is cheapest or tied on input tokens.

Calibration (GPT-5.5): RLM25-PFR: **81.2%** verified proofs, BEq+ **75.7%** vs. 72.9% terminal-only, 13% fewer calls, 14% fewer input tokens ▪ LeanProbe in 37% of steps.

2nd place, ICML AI for Math Challenge 2026 Track 2: 6 / 7 topics solved.

Code & Artifacts

Each run ships as an **inspectable Lean project with a replayable workflow trace** — blueprints, logs, checkpoints, failed attempts — not just final answers. **Pythagorean:** 83 declarations incl. 34 theorems/lemmas ▪ **Cramer–Wold:** 114 declarations incl. 101 theorems/lemmas — sorry-free, no unapproved axioms.

Both generated Lean projects:
github.com/epfl-lara/AutoformalizedProjects

github.com/epfl-lara/LeanFlow

runtime ▪ workflow logs ▪ benchmarks

ICML 2026 AI for Math Workshop
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github.com/epfl-lara ▪ LeanFlow ▪ LeanProbe ▪ AutoformalizedProjects

Laboratory for Automated Reasoning and Analysis