Adversarial Validation & Null Hypothesis Testing Mindset

Proof by Contradiction | Red Team | Exploratory Testing

Fong

Contents

PHILOSOPHY (Core Mindset)

> **ZERO TRUST! "Assume it's WRONG, prove it. If you can't, it's likely RIGHT."**

READING INSTRUCTIONS

File is long (667 lines). Use sliding window read: `sed -n "N,M+33p" file` (5% chunks) or `grep -A 20 "## Section"` or `awk '/^## Start/,/^## End/'`.

LANGUAGE REQUIREMENT

Precise Vietnamese Response. Don't response in English.

All reports, analysis, and communications using this methodology MUST be in Vietnamese unless explicitly requested otherwise by the user.

Adversarial Validation & Null Hypothesis Testing Mindset

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Methodology Overview

Core Principle: **Assume the Null Hypothesis** (H : "This is WRONG") and systematically attempt to prove it.

Outcome:
- **Proof successful** (found violations) → Report detailed errors with citations
- **Proof failed** (no violations found) → Accept as correct, simple report

Use Cases:
- Code validation (DRY, SOLID, naming conventions)
- Content validation (SSoT, accuracy, completeness)
- Architecture validation (design patterns, best practices)
- Security validation (red team thinking)

Core Mindset: Adversarial Thinking

The Devil's Advocate Approach

> "The great tragedy of Science—the slaying of a beautiful hypothesis by an ugly fact."
> — Thomas Huxley

Three Fundamental Questions:

1. **What could be WRONG?**
   - List all possible violations (DRY, SSoT, SOLID, naming, security, etc.)
   - Example: "This file violates DRY by duplicating section X"
2. **Can I PROVE it's wrong?**
   - Search for evidence using 3 strategies (see below)
   - Evidence sources: Model knowledge, Perplexity AI, RAG systems
3. **If I can't prove it's wrong, is it RIGHT?**
   - Absence of evidence evidence of absence (but strong indicator)
   - Document what was checked and why no violations were found

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Formal Names & Related Approaches

Methodology	Domain	Description	When to Use
Proof by Contradiction (Reductio ad Absurdum)	Mathematics/Logic	Assume opposite of what you want to prove; derive contradiction	Logical code validation
Null Hypothesis Testing	Scientific Research	Assume H (no effect/no violation); seek evidence to reject it	Statistical validation
Adversarial Validation	Software/ML	Design inputs/tests to expose failures	Code quality, ML models

Methodology	Domain	Description	When to Use
Red Team Thinking	Security/QA	Adopt attacker's mindset to challenge robustness	Security audits
Exploratory Testing	Software QA	Assume system has bugs; explore systematically	Manual testing

Sources:
- Debug It! Find, Repair, and Prevent Bugs in Your Code (Paul Butcher, 2009) - Scientific method in debugging
- Machine Learning for High-Risk Applications (Hall et al., 2023) - Adversarial validation
- Machine Learning Systems (2025) - Adversarial testing methodologies

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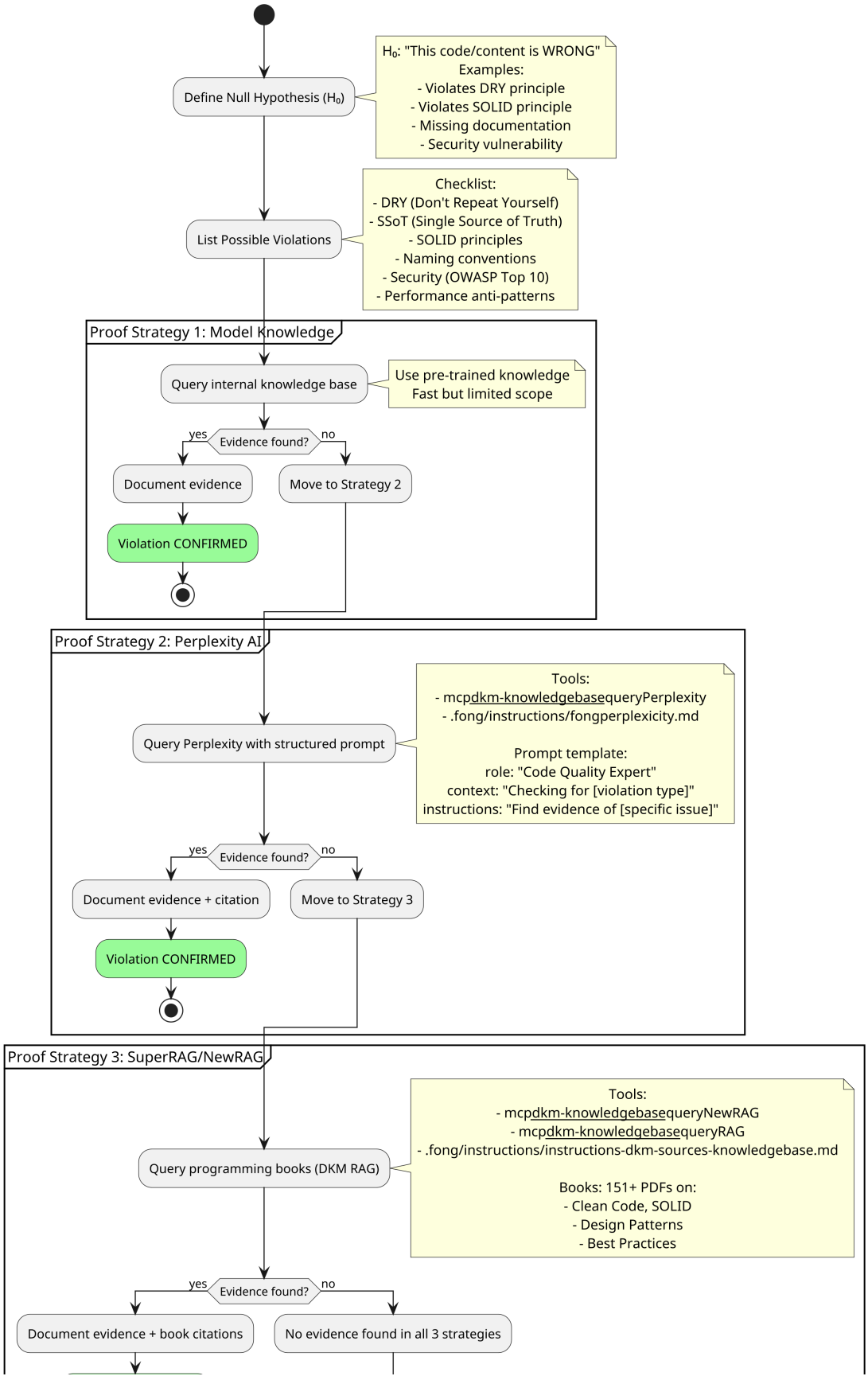
Workflow


Define Null Hypothesis (H_0)
H_0: "This code/content is WRONG"
Examples:
- Violates DRY principle
- Violates SOLID principle
- Missing documentation
- Security vulnerability
List Possible Violations
Checklist:
- DRY (Don't Repeat Yourself)
- SSoT (Single Source of Truth)
- SOLID principles
- Naming conventions
- Security (OWASP Top 10)
- Performance anti-patterns
Proof Strategy 1: Model Knowledge
Query internal knowledge base
Use pre-trained knowledge
Fast but limited scope
Evidence found?
yes
no
Document evidence
Move to Strategy 2
Violation CONFIRMED
Proof Strategy 2: Perplexity AI
Query Perplexity with structured prompt
Tools:
- mcpdkm-knowledgebasequeryPerplexity
- .fong/instructions/fongperplexicity.md
Prompt template:
role: "Code Quality Expert"
context: "Checking for [violation type]"
instructions: "Find evidence of [specific issue]"
Evidence found?
yes
no
Document evidence + citation
Move to Strategy 3
Violation CONFIRMED
Proof Strategy 3: SuperRAG/NewRAG
Query programming books (DKM RAG)
Tools:
- mcpdkm-knowledgebasequeryNewRAG
- mcpdkm-knowledgebasequeryRAG
- .fong/instructions/instructions-dkm-sources-knowledgebase.md
Books: 151+ PDFs on:
- Clean Code, SOLID
- Design Patterns
- Best Practices
Evidence found?
yes
no
Document evidence + book citations
No evidence found in all 3 strategies

Proof Strategies (3 Levels)

Strategy 1: Model Knowledge (Fast)

Use when: Quick validation needed, common patterns

How:

```
# Internal reasoning based on training data
# No tool calls needed
# Example: "This violates DRY because section X appears twice"
```

Limitations:
- Knowledge cutoff date
- May miss domain-specific rules
- No citations

When to use: Initial quick check before deeper validation

Strategy 2: Perplexity AI (Latest Practices)

Use when: Need latest best practices, internet research

Tools:
- `mcp__dkm-knowledgebase__queryPerplexity` (MCP)
- `.fong/instructions/fongperplexicity.md` (fallback)

Structured Prompt Template:

```
{
  "role": "Software Quality Assurance Expert",
  "context": "Validating [file/code] for [violation type: DRY, SOLID, etc.]",
  "instructions": [
    "1. Check if [specific pattern] violates [principle]",
    "2. Find authoritative sources (books, papers, standards)",
    "3. Provide specific examples of violations",
    "4. Cite sources with author, year, page numbers"
  ],
  "output_format": "Structured report with: Violation found (yes/no), Evidence,
  ↪  Citation",
  "cautions": [
    "Focus on practical violations, not theoretical edge cases",
    "Prioritize authoritative sources (peer-reviewed, industry standards)"
  ],
  "question": "Does [this code/pattern] violate [principle]? Provide evidence."
}
```

Example Usage:

```
# Check DRY violation
mcp__dkm-knowledgebase__queryPerplexity \
  --role "Clean Code Expert" \
  --context "File has duplicate Pre-workflow sections at lines 424 and 426" \
  --instructions '["Check if this violates DRY principle", "Provide citation from
   ↪  Clean Code book"]' \
  --output_format "Yes/No + Evidence + Citation" \
  --question "Is duplicate section a DRY violation?"
```

Strategy 3: SuperRAG/NewRAG (Authoritative Books)

Use when: Need citations from programming books, deep technical validation

Tools:
- `mcp__dkm-knowledgebase__queryNewRAG` (hash-filtered, 151 books)
- `mcp__dkm-knowledgebase__queryRAG` (general RAG)
- `.fong/instructions/instructions-dkm-sources-knowledgebase.md` (guide)

NewRAG Workflow:

```
# Step 1: List available books
/home/fong/Projects/mini-rag/multi-query/run-multiquery.sh --list-pdfs

# Step 2: Select relevant books (5-9 max)
# Example: Clean Code, SOLID, Design Patterns books


# Step 3: Query with multiple keywords
mcp__dkm-knowledgebase__queryNewRAG \
  --queries '["DRY principle violation", "duplicate code smell"]' \
  --source_hashes "hash1,hash2,hash3"  # From step 1
```

QueryRAG (Quick Alternative):

```
# Query across all collections (faster, broader)
mcp__dkm-knowledgebase__queryRAG \
  --question "DRY principle duplicate sections" \
  --top_k 5
```

Book Categories (151+ PDFs):
- Clean Code: Robert C. Martin, Martin Fowler
- SOLID Principles: Agile Software Development
- Design Patterns: Gang of Four, Head First Design Patterns
- Refactoring: Martin Fowler
- Code Smells: Refactoring, Clean Code

Report Templates

Template 1: Violation FOUND (Detailed Report)

```
# Adversarial Validation Report


**Date**: YYYY-MM-DD
**File/Code**: [filename or code snippet]
**Hypothesis**: H : "This is WRONG" (assumed violation of [principle])
**Result**:  **VIOLATION CONFIRMED**

---

## 1. What is WRONG?


**Violation Type**: [DRY / SOLID / SSoT / Security / etc.]

**Specific Issue**:
- **Location**: Line X-Y, Section Z
- **Problem**: Duplicate content / Missing abstraction / etc.
- **Impact**: Maintenance burden, confusion, technical debt

**Evidence**:
```

[Exact code/content excerpt showing violation]

```
---

## 2. Why is it WRONG?


**Principle Violated**: [e.g., DRY - Don't Repeat Yourself]

**Authoritative Definition**:
> "Every piece of knowledge must have a single, unambiguous, authoritative representation wi
> - The Pragmatic Programmer (Hunt & Thomas, 1999)

**Explanation**:
- [Why this specific pattern violates the principle]
- [Consequences of this violation]

**Proof Strategy Used**: [Model Knowledge / Perplexity / RAG]

**Citations**:
1. [Author, Year] - [Book/Paper Title], Page X
2. [Source 2]
3. [Source 3]
```

```
---

## 3. What is the CORRECT approach?


**Solution**:
- **Before** (WRONG):

[Current problematic code/content]
“‘
```

- **After** (CORRECT):

```
[Refactored code/content]
```

Why this is better:
- Single source of truth
- Easier maintenance
- Reduced duplication

Reference Implementation:
- [Link to example or pattern]
- [Citation from authoritative source]

---

4. How to MEASURE correctness?

Verification Checklist:
- [ ] No duplicate content (grep, diff)
- [ ] Single source of truth (all references point to one location)
- [ ] DRY score: [metric, e.g., 0 duplicate lines]

Automated Checks:

```
# Command to verify fix
grep -n "duplicate pattern" file.md | wc -l  # Should be 1 (not 2+)
```

Manual Review:
- Code review: Check for other instances
- Documentation: Update related docs

---

5. How to FIX it?

Step-by-step Fix:

1. **Identify all duplicate instances**:

```
grep -rn "duplicate content" .
```

2. **Choose canonical location** (SSoT):

- Keep: [Location A - reason why]

- Remove: [Location B, C, D]

3. **Refactor**:

```
# Edit commands
vim file.md +424  # Remove duplicate at line 426
```

4. **Verify fix**:

```
git diff file.md  # Show changes
grep "duplicate" file.md | wc -l  # Verify only 1 instance
```

5. **Commit with descriptive message**:

```
git commit -m "fix(DRY): Remove duplicate Pre-workflow section

- Violation: Duplicate section at lines 424 & 426
- Fix: Removed line 426, kept line 424 as SSoT
- Citation: Clean Code (Martin, 2008), Chapter 17: Code Smells"
```

---

6. Citations & References

Primary Sources:
1. **Clean Code** (Robert C. Martin, 2008) - Chapter 17: Smells and Heuristics
- "G5: Duplication" - Page 289
2. **The Pragmatic Programmer** (Hunt & Thomas, 1999) - DRY Principle
- "Orthogonality and the DRY Principle" - Page 27
3. **Refactoring** (Martin Fowler, 1999) - Code Smells
- "Duplicated Code" - Page 76

Proof Strategy:
- Strategy 2: Perplexity AI query
- Strategy 3: RAG query (Clean Code book, hash: abc123...)

Validation Date: YYYY-MM-DD HH:MM:SS
Validator: [Your name or system name]

Template 2: No Violation FOUND (Simple Report)

````
```markdown
# Adversarial Validation Report

**Date**: YYYY-MM-DD
**File/Code**: [filename or code snippet]
**Hypothesis**: H : "This is WRONG" (assumed violation of [principle])
**Result**:  **NO VIOLATION FOUND** (Null hypothesis REJECTED)
````
````

```
---

## Validation Summary


**Checked for**:
- [x] DRY violations (duplicate content)
- [x] SOLID violations (SRP, OCP, LSP, ISP, DIP)
- [x] SSoT violations (multiple authoritative sources)
- [x] Naming convention violations
- [x] Security issues (OWASP Top 10)

**Proof Strategies Applied**:
1.  Model Knowledge - No violations detected
2.  Perplexity AI - No authoritative sources cite this as violation
3.  RAG Query (151 books) - No code smell patterns matched

**Conclusion**:
Code/content follows best practices. No refactoring needed.

**Validation Date**: YYYY-MM-DD HH:MM:SS
**Validator**: [Your name or system name]
```

Citation Patterns

For Proof by Contradiction

> "The validation employed **proof by contradiction** (reductio ad absurdum), assuming the system was incorrect and deriving a logical inconsistency to demonstrate correctness."
> — Source: Mathematical proofs methodology

For Null Hypothesis Testing

> "We applied **null hypothesis testing**, assuming no significant violation (H), and sought evidence to reject this assumption through systematic exploration."
> — Source: Scientific method, statistical validation

For Adversarial Validation

> "**Adversarial validation** was conducted by assuming the code violated [principle] and systematically generating test cases to trigger failures, following established red team practices."
> — Source: Security testing, ML adversarial examples

For Book Citations (RAG Results)

Format: `[Author, Year] - [Book Title], [Publisher], Page [X]`

Examples:
1. "Martin, R. C. (2008). *Clean Code: A Handbook of Agile Software Craftsmanship*. Prentice Hall. Page 289."
2. "Fowler, M. (1999). *Refactoring: Improving the Design of Existing Code*. Addison-Wesley. Page 76."
3. "Gamma, E. et al. (1994). *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison-Wesley. Page 151."

Best Practices

1. Explicit Assumption of Fault

DO:
- Start with clear H : "This code violates DRY"
- List all possible violations upfront
- Document what you're checking

DON'T:
- Assume code is correct until proven wrong
- Skip systematic checks
- Rely only on gut feeling

2. Systematic Exploration (All 3 Strategies)

DO:
- Use all 3 proof strategies in order
- Start fast (Model Knowledge) $\rightarrow$ escalate to deeper (RAG)
- Document which strategy found evidence

DON'T:
- Stop at first strategy (may miss violations)
- Skip citation gathering
- Use only one knowledge source

3. Citation-Driven Evidence

DO:
- Cite authoritative sources (books, papers, standards)
- Include page numbers and exact quotes
- Link to original source when possible

DON'T:
- Use vague claims ("everyone knows this is bad")
- Cite outdated or non-authoritative sources
- Skip attribution

4. Measurable Correctness

DO:
- Define clear metrics (e.g., "0 duplicate lines")

- Provide automated verification commands
- Include manual review checklist

DON'T:
- Use subjective measures ("looks good")
- Skip verification step
- Rely only on visual inspection

5. Actionable Fixes

DO:
- Provide step-by-step fix instructions
- Include before/after code examples
- Explain WHY fix is better (not just WHAT changed)

DON'T:
- Report problems without solutions
- Provide vague guidance ("refactor this")
- Skip explanation of benefits

6. Avoid Confirmation Bias

DO:
- Actively try to DISPROVE correctness
- Check edge cases and uncommon patterns
- Question your assumptions

DON'T:
- Design checks to confirm what you believe
- Ignore contradictory evidence
- Stop when you find what you expect

7. Document Negative Results

DO:
- Report when NO violations found
- List what was checked
- Explain why certain patterns are acceptable

DON'T:
- Only report violations
- Skip documentation when everything is correct
- Leave uncertainty unresolved

References

Books Cited

1.**Debug It! Find, Repair, and Prevent Bugs in Your Code**
Paul Butcher, Pragmatic Bookshelf, 2009

- Chapter: "Stand Back—I'm Going to Try Science"
- Scientific method in debugging

2. **Machine Learning for High-Risk Applications**
Hall, Curtis, Pandey, 2023
- Chapter 3: Model Debugging
- Adversarial validation techniques

3. **Clean Code: A Handbook of Agile Software Craftsmanship**
Robert C. Martin, Prentice Hall, 2008
- Chapter 17: Smells and Heuristics
- DRY principle violations

4. **The Pragmatic Programmer**
Hunt & Thomas, Addison-Wesley, 1999
- DRY principle definition
- Orthogonality and SSoT

5. **Refactoring: Improving the Design of Existing Code**
Martin Fowler, Addison-Wesley, 1999
- Code smells catalog
- Duplicated code patterns

MCP Tools

- **DKM Knowledge Base MCP**: `mcp__dkm-knowledgebase__*`
  - `queryPerplexity` - Latest best practices
  - `queryNewRAG` - Multi-query with book filtering
  - `queryRAG` - General RAG across all collections

Instruction Files

- `.fong/instructions/fongperplexicity.md` - Perplexity AI usage
- `.fong/instructions/instructions-dkm-sources-knowledgebase.md` - Knowledge sources map
- `.fong/instructions/instructions-mem0.md` - Memory alignment

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