🔧 Agent Loop & Tool Calling

Technical Deep Dive

Guest Finder Agent Internals

Understanding the Claude Agentic Loop

Agenda

1. **Agent Loop Architecture** - Multi-turn conversation flow
2. **Tool Calling Mechanism** - How tools are defined and executed
3. **Memory & Learning** - How the agent learns from history

Part 1: Agent Loop Architecture

What is an Agent Loop?

Definition:

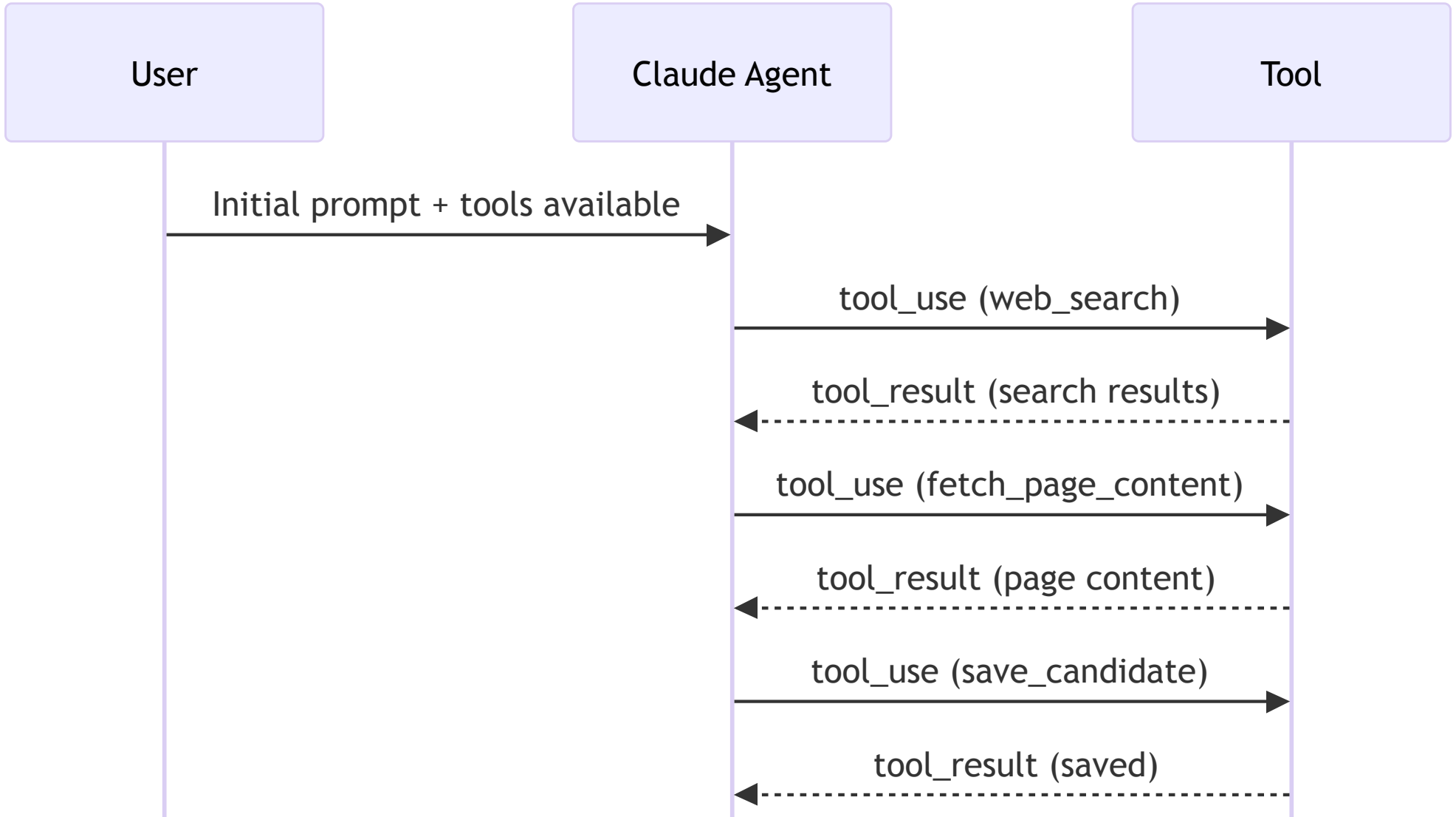
An agent loop is a conversation cycle where Claude:

1. Receives a message with tools available
2. Decides to use tools or respond with text
3. Receives tool results
4. Continues or stops

Key Insight:

The agent autonomously decides when to use tools and when it's done

Multi-Turn Conversation Flow



Stop Reasons: How Loops End

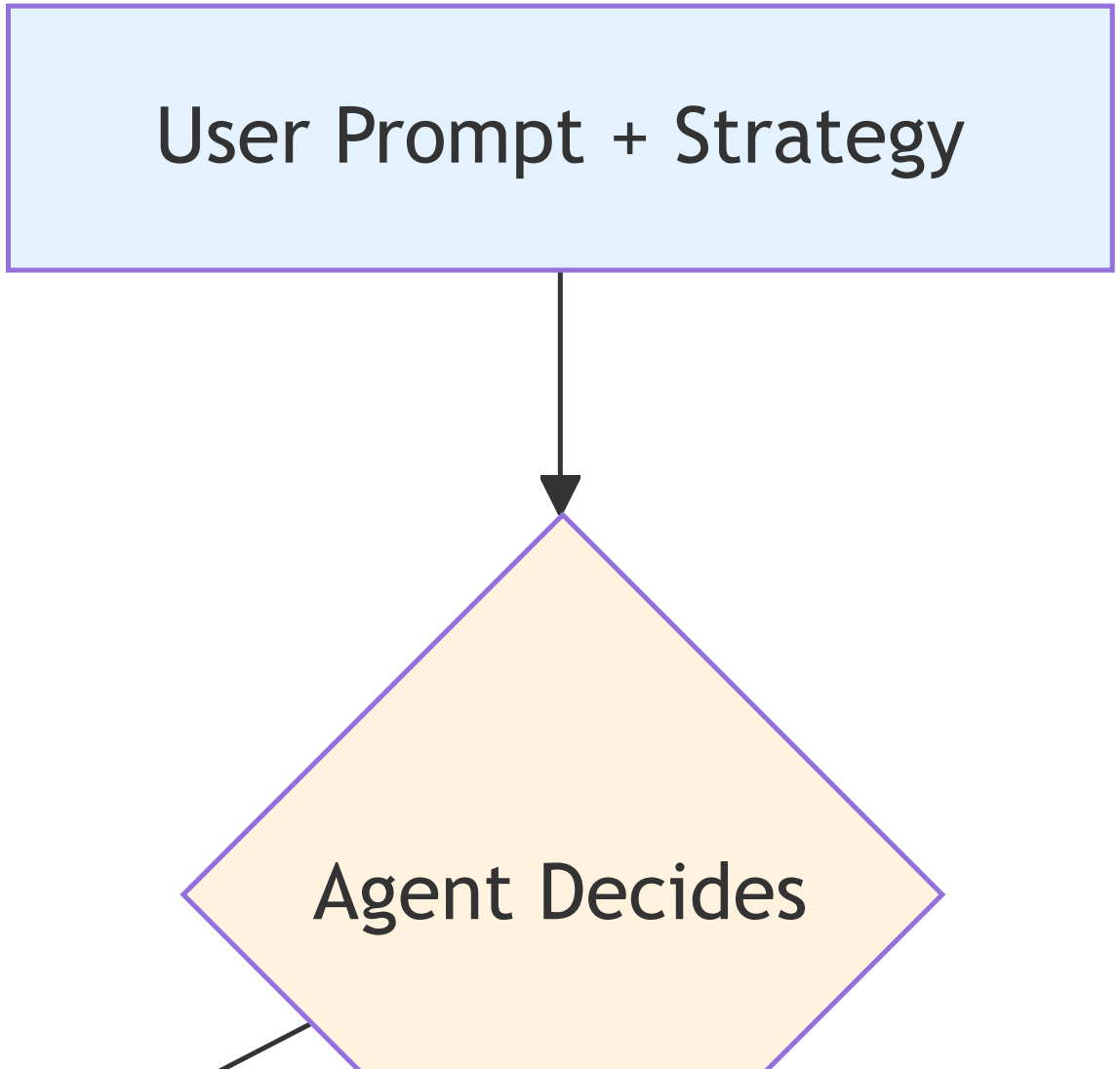
```
# Inside run_search_phase() - Turn-based loop
while turn_count < max_turns:
    turn_count += 1

    response = self.client.messages.create(
        model=Config.MODEL,
        max_tokens=Config.SEARCH_MAX_TOKENS,
        tools=cast(list[ToolParam], self.tools),
        messages=conversation,
    )

    # Check stop reason
    has_tool_use = False
    for block in response.content:
        if block.type == "tool_use":
            has_tool_use = True
            # Execute tool and add result to conversation

    # Loop ends when agent doesn't use tools
    if not has_tool_use:
        break  # Agent is done!
```

Conversation Structure

Messages Array:

```
conversation = [
    {
        "role": "user",
        "content": "Search for AI experts in healthcare"
    },
    {
        "role": "assistant",
        "content": [
            {"type": "text", "text": "I'll search for that"},
            {"type": "tool_use", "id": "tool_1", "name": "web_search",
             "input": {"query": "AI healthcare experts Nederland"}}
        ]
    },
    {
        "role": "user",
        "content": [
            {"type": "tool_result", "tool_use_id": "tool_1",
             "content": "{\"results\": [...]}"}
        ]
    },
    #    more turns
```

Guest Finder Agent Loop



Real Example: Search Phase Loop

Turn 1:

- User: "Execute query: AI healthcare startups Nederland"
- Agent: `tool_use(web_search, query="AI healthcare startups Nederland")`
- User: `tool_result([10 search results])`

Turn 2:

- Agent: `tool_use(fetch_page_content, url="https://example.com/startup")`
- User: `tool_result({content: "...", potential_persons: [...]})`

Turn 3:

- Agent: `tool_use(check_previous_guests, name="Dr. Sarah Veldman")`
- User: `tool_result({already_recommended: false})`

Turn 4:

Prompt Caching in Agent Loop

Problem: Same ~1500 token instructions repeated 8-12 times

Solution: Split prompt into cacheable + dynamic parts

```
if Config.ENABLE_PROMPT_CACHING:
    conversation.append({
        "role": "user",
        "content": [
            {
                "type": "text",
                "text": SEARCH_EXECUTION_PROMPT_CACHEABLE,  # 1500 tokens
                "cache_control": {"type": "ephemeral"}  # Cache this!
            },
            {
                "type": "text",
                "text": dynamic_prompt  # 200 tokens (status update)
            }
        ]
    })
```

Part 2: Tool Calling Mechanism

Tool Definition Structure

```
def get_tools():
    return [
        {
            "name": "web_search",
            "description": """Zoek op het web naar recente informatie...

            Gebruik voor:
            - Nederlandse AI-experts zoeken
            - Recente persberichten

            Tips voor effectief zoeken:
            - Voeg "Nederland" toe aan queries
            - Gebruik quotes voor exacte zinnen
            """,
            "input_schema": {
                "type": "object",
                "properties": {
                    "query": {
                        "type": "string",
                        "description": "De zoekopdracht"
                    }
                },
                "required": ["query"]
            }
        }
    ]
```

Tool Description Best Practices

❌ Bad Description:

```
"description": "Search the web"
```

✅ Good Description:

```
"description": """Zoek op het web naar recente informatie over AI-experts.

Gebruik voor:
- Nederlandse AI-experts zoeken
- Recente persberichten van universiteiten
- Vakmedia artikelen

Tips voor effectief zoeken:
- Voeg "Nederland" of "Dutch" toe aan queries
- Gebruik quotes voor exacte zinnen: "AI Act implementatie"
- Combineer naam + organisatie voor verificatie
"""
```

All 4 Tools in Guest Finder

Search Tools:

1. **web_search**
    - Multi-provider fallback
    - Returns snippets + URLs
    - Caching enabled
2. **fetch_page_content**
    - Full HTML fetch
    - Auto name extraction
    - Returns persons + context

Data Tools:

3. **check_previous_guests**

- 8-week deduplication
- Returns recommendation date
- Prevents duplicates

Tool Execution Flow

```python
def _handle_tool_call(self, tool_name: str, tool_input: dict, silent: bool = False):
    """Execute a tool and return result"""

    if tool_name == "web_search":
        query = tool_input["query"]
        search_result = self.smart_search.search(query, num_results=10)

        if search_result.get("results"):
            return {
                "results": [
                    {
                        "title": r.get("title", ""),
                        "snippet": r.get("snippet", ""),
                        "url": r.get("link", "")
                    }
                    for r in search_result["results"]
                ],
                "provider": search_result.get("provider", "unknown")
            }

    elif tool_name == "save_candidate":
        # Validate and save candidate
        self.candidates.append({
            "name": tool_input["name"],
            "role": tool_input["role"],
            # ... more fields
            "date": datetime.now().isoformat()
        })
        return f"✓ Candidate '{tool_input['name']}' saved"

    # ... other tools
```

Tool Result Format

Simple String:

```
return "✓ Candidate 'Dr. Sarah Veldman' saved"
```

Structured Data:

```
return {
    "url": "https://example.com",
    "content": "Full page text...",
    "potential_persons": [
        {"name": "Dr. Sarah Veldman", "context": "..."}
    ],
    "persons_found": 3,
    "status": "success"
}
```

Error Handling:

fetch_page_content: Advanced Tool

Smart Name Extraction:

```
# Pattern 1: Titles (Prof., Dr., Drs., Ir.)
title_patterns = [
    r"(Prof\.?\s+(?:dr\.?\s+)?([A-Z][a-z]+(?:\s+[A-Z][a-z]+)+))",
    r"(Dr\.?\s+([A-Z][a-z]+(?:\s+[A-Z][a-z]+)+))",
]

# Pattern 2: Roles
role_patterns = [
    r"([A-Z][a-z]+(?:\s+[A-Z][a-z]+)+),?\s+(hoogleraar|CEO|directeur)",
    r"volgens\s+([A-Z][a-z]+(?:\s+[A-Z][a-z]+)+)",
    r"zegt\s+([A-Z][a-z]+(?:\s+[A-Z][a-z]+)+)",
]

# Extract with context (150 chars)
for match in matches:
    name = match.group(2)
    start = max(0, match.start() - 50)
    end = min(len(text), match.end() + 100)
    context = text[start:end]

    potential_persons.append({
        "name": name,
        "context": context,
        "title_match": match.group(1),  # Optional
```

Multi-Provider Search Tool

```
class SmartSearchTool:
    def search(self, query: str, num_results: int = 10):
        # Try providers in order
        for provider in self.providers:
            if provider in self.rate_limited_providers:
                continue  # Skip rate-limited

            try:
                result = self._search_with_provider(provider, query)
                return result
            except RateLimitError:
                self.rate_limited_providers.add(provider)
                continue
            except Exception as e:
                continue

        raise Exception("All providers failed")
```

Features:

Part 3: Memory & Learning

Learning System Overview

What the agent remembers:

1. **Search History** - All queries with performance metrics
2. **Previous Guests** - 8-week deduplication database
3. **Successful Strategies** - What worked in past sessions

Storage:

- `data/search_history.json` - Query performance
- `data/previous_guests.json` - Guest tracking
- `data/candidates_latest.json` - Latest results

Search History Structure

```
{
  "sessions": [
    {
      "date": "2025-10-15T14:30:00",
      "week_focus": "AI Act implementatie en HR impact",
      "sectors_to_prioritize": ["overheid", "zorg", "HR"],
      "candidates_found": 8,
      "queries": [
        {
          "query": "AI Act implementatie Nederland 2025",
          "rationale": "Focus op praktische implementatie",
          "priority": "high",
          "candidates_found": 3,
          "successful_sources": [
            "https://aic4nl.nl/evenement/...",
            "https://www.werf-en.nl/event/..."
          ],
          "timestamp": "2025-10-15T14:32:15"
        }
      ]
    }
  ]
}
```

Learning Insights Generation

```python
def _get_learning_insights(self, weeks: int = 4):
    """Analyze last 4 weeks of search history"""

    recent_sessions = [s for s in self.search_history["sessions"]
                       if date_within_weeks(s["date"], weeks)]

    if not recent_sessions:
        return None

    # Collect all queries
    all_queries = []
    for session in recent_sessions:
        all_queries.extend(session.get("queries", []))

    # Find top performers
    successful_queries = [q for q in all_queries
                          if q.get("candidates_found", 0) > 0]
    successful_queries.sort(
        key=lambda x: x.get("candidates_found", 0),
        reverse=True
    )

    # Analyze sources
    source_stats = {}
    for query in successful_queries:
        for source in query.get("successful_sources", []):
            domain = extract_domain(source)
            source_stats[domain] = source_stats.get(domain, 0) + 1

    top_sources = sorted(source_stats.items(),
                         key=lambda x: x[1], reverse=True)

    return {
        "top_performing_queries": successful_queries[:5],
        "top_sources": [s[0] for s in top_sources[:5]],
        "avg_candidates_per_query": avg(...)
    }
```

Learning in Planning Phase

```
def run_planning_phase(self):
    # Get learning insights from last 4 weeks
    learning_insights = self._get_learning_insights(weeks=4)

    if learning_insights:
        learning_section = """
## 🎓 Leergeschiedenis

**Succesvol gebleken queries** (vonden meeste kandidaten):
1. "AI Act implementatie experts Nederland" → 3 kandidaten
2. "Nederlandse AI healthcare startups 2025" → 2 kandidaten

**Meest productieve bronnen:**
- aic4nl.nl
- werf-en.nl
- computable.nl

**Gemiddeld**: 1.2 kandidaten per query

⚠️ **Recent gebruikte bronnen** (laatste week):
Deze bronnen zijn recent gebruikt. Personen hiervan vallen
mogelijk binnen de 8-weken exclusie.

**Zoek bij voorkeur naar NIEUWE bronnen** om duplicaten te voorkomen.
"""

    # Add to planning prompt
    prompt = PLANNING_PROMPT.format(
        learning_section=learning_section
    )
```

Session Recording

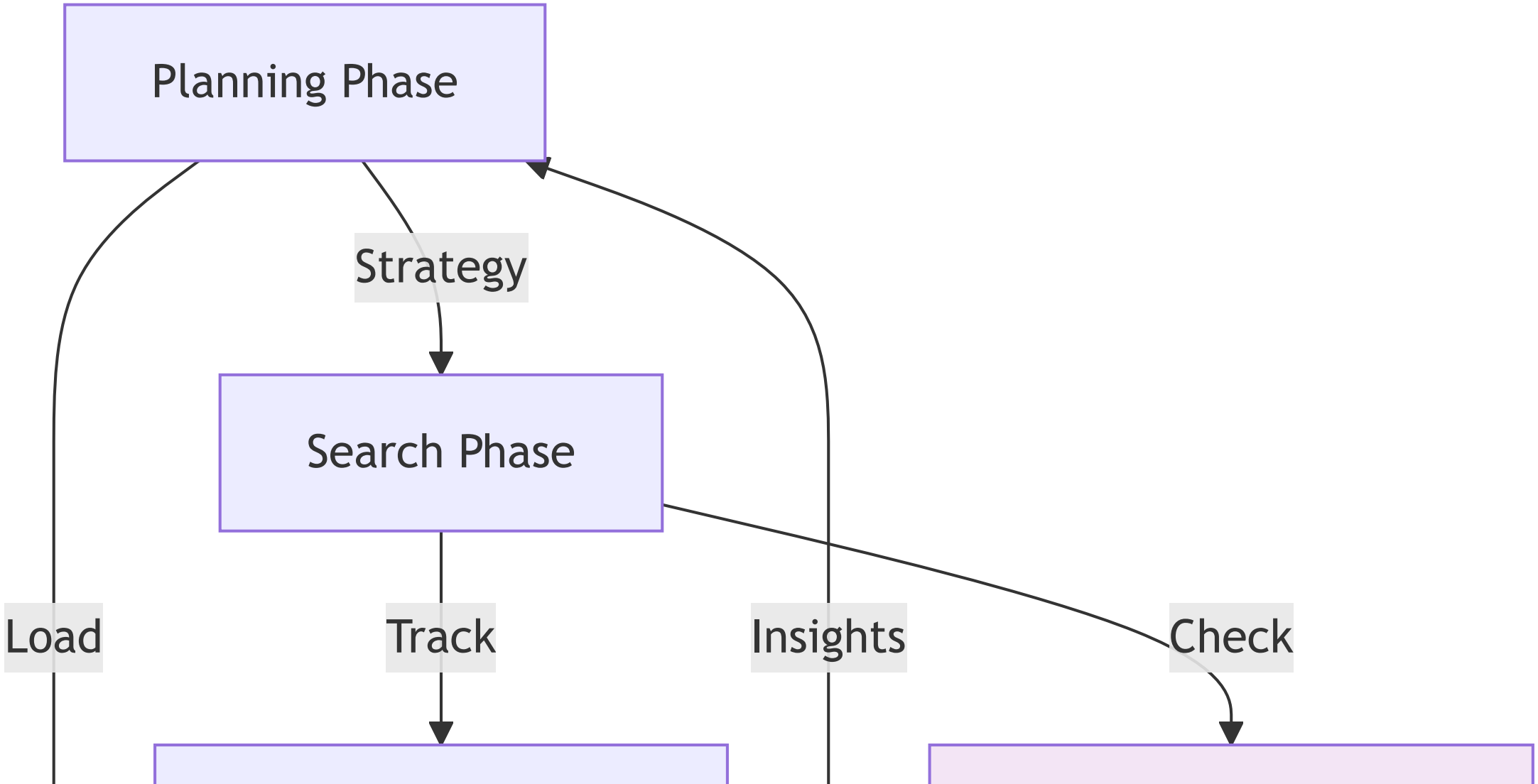
```
def run_full_cycle(self):
    # ... planning phase
    strategy = self.run_planning_phase()

    # Save strategy for this session
    self.current_session_strategy = {
        "week_focus": strategy.get("week_focus", ""),
        "sectors_to_prioritize": strategy.get("sectors_to_prioritize", []),
        "total_queries_planned": len(strategy.get("search_queries", []))
    }

    # ... search phase
    self.run_search_phase(strategy)

    # After search: Record session
    session_record = {
        "date": datetime.now().isoformat(),
        **self.current_session_strategy,
        "candidates_found": len(self.candidates),
        "queries": self.current_session_queries  # Tracked during search
    }

    self.search_history["sessions"].append(session_record)
    self._save_search_history()
```

Previous Guests Deduplication

```
def _handle_tool_call(self, tool_name, tool_input):
    if tool_name == "check_previous_guests":
        name = tool_input["name"]
        cutoff_date = datetime.now() - timedelta(weeks=8)

        for guest in self.previous_guests:
            if guest["name"].lower() == name.lower():
                guest_date = datetime.fromisoformat(guest["date"])

                if guest_date >= cutoff_date:
                    return {
                        "already_recommended": True,
                        "date": guest["date"],
                        "weeks_ago": calculate_weeks(guest_date)
                    }

        return {"already_recommended": False}
```

Agent Decision:

Memory Flow Diagram



Learning Reflection

Low Performance Detection:

```
if learning_insights["avg_candidates_per_query"] < 1.0:
    learning_section += """
⚠️ **KRITISCH**: Gemiddeld <1 kandidaat per query.
Vorige strategieën werkten niet. Overweeg:

- Andere query types (niet alleen site:)
- Bredere bronnen (niet alleen vakmedia)
- Andere zoektermen (meer Nederlands, minder technisch)
"""
```

Agent sees this warning and adjusts strategy!

Previous Strategies:

```
for strat in learning_insights["previous_strategies"][:3]:
    focus = strat.get("week_focus", "")
    candidates = strat.get("candidates_found", 0)
```

Learning Impact: Real Example

Week 1 (No History):

```
Planning output:
- "AI experts Nederland" → Generic search
- "AI bedrijven Amsterdam" → Location-based
```

Result: 3 candidates found

Week 2 (With History):

```
Learning insights show:
- Top query: "AI Act implementatie congres" → 5 candidates
- Top source: aic4nl.nl (congres programma's)

Planning output:
- "AI governance conferenties Nederland november 2025"
- "Nederlandse AI ethics symposium sprekers"
```

Result: 8 candidates found 🎯

Memory Persistence

File Operations:

```
def _load_search_history(self):
    try:
        with open("data/search_history.json", encoding="utf-8") as f:
            return json.load(f)
    except FileNotFoundError:
        return {"sessions": []}

def _save_search_history(self):
    os.makedirs("data", exist_ok=True)
    with open("data/search_history.json", "w", encoding="utf-8") as f:
        json.dump(self.search_history, f, indent=2, ensure_ascii=False)
```

Called:

- Load: At agent initialization
- Save: After each full cycle completes

Key Takeaways

Agent Loop:

- Multi-turn conversations enable autonomous tool chaining
- Stop reasons determine when loops end
- Prompt caching reduces costs by 82%

Tool Calling:

- Rich descriptions guide agent behavior
- Structured input schemas validate calls
- Tool results can be simple or complex

Memory & Learning:

- Search history tracks query performance
- Previous guests enable 8-week deduplication

Advanced Patterns

Pattern 1: Tool Chaining

```
web_search → fetch_page_content → check_previous_guests → save_candidate
```

Agent autonomously chains 4 tools per candidate

Pattern 2: Parallel Tool Use

```
# Agent can request multiple tools in one turn:
[
    {"type": "tool_use", "name": "fetch_page_content", "input": {"url": "..."}},
    {"type": "tool_use", "name": "fetch_page_content", "input": {"url": "..."}}
]
```

Pattern 3: Conditional Tool Use

```
if check_previous_guests.already_recommended == false:
    save_candidate(...)
```

Debugging Tools

Environment Variable:

```
export DEBUG_TOOLS=1
python guest_search.py
```

Debug Output:

```
Turn 1, Stop: end_turn
🔧 Tool: web_search
   → Results: 10

Turn 2, Stop: end_turn
🔧 Tool: fetch_page_content
   → Status: success, Persons: 3

Turn 3, Stop: end_turn
🔧 Tool: save_candidate
   → Saved: Dr. Sarah Veldman
```

Performance Metrics

Typical Search Phase:

- **Queries executed:** 8-12
- **Tool calls per query:** 5-8
- **Total turns:** 40-96
- **Candidates found:** 5-10
- **Duration:** 2-4 minutes

Cost Breakdown:

- Without caching: ~18,000 tokens = $0.054
- With caching: ~3,000 tokens = $0.006
- **Savings: 82%** ✅

Token Usage:

Code Locations

Agent Loop:

- agent.py:639-749 - `run_search_phase()` multi-turn loop

Tool Calling:

- tools.py:4-114 - Tool definitions
- agent.py:187-375 - `_handle_tool_call()`

Memory & Learning:

- agent.py:89-103 - Load/save search history
- agent.py:123-180 - `_get_learning_insights()`
- agent.py:389-449 - Learning section in planning

Further Reading

Documentation:

- 📘 architecture.md - Arc42 documentation
- 📗 LEARNING_SYSTEM.md - Learning details
- 📙 RATE_LIMIT_HANDLING.md - SmartSearch

Anthropic Docs:

- Tool Use Guide
- Prompt Caching

Code:

- src/guest_search/agent.py - Full agent implementation
- src/guest_search/tools.py - Tool definitions

Questions? 💬

Repository: https://github.com/Joopsnijder/guest_search

Key Files:

- `src/guest_search/agent.py` - Agent loop implementation
- `src/guest_search/tools.py` - Tool definitions
- `data/search_history.json` - Learning database

Built with: Claude Code by Anthropic

Thank You! 🎉

Happy Hacking! 🔧🤖