Agentic Programming: Planning & Execution

Week 2, Session 2

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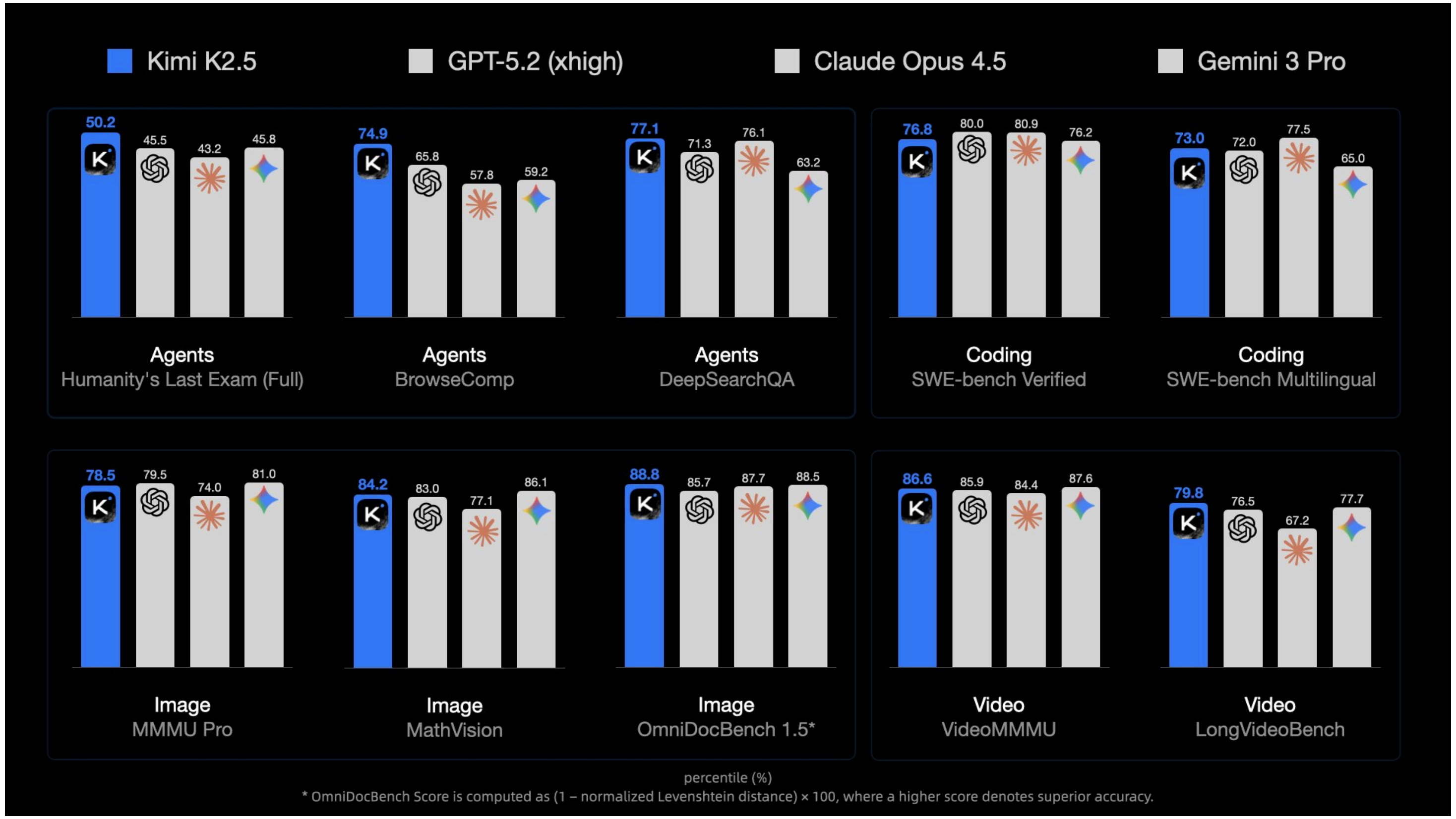
Sponsorship

I went to moonshot.ai for gift credits for this class.

Each of you can have $50 API usage for the experiments in the follow 6 months.

Try Kimi Code here - a great coding assistant CLI built on their SOTA mdoel Kimi K-2.5



Recap from w2d1

- **SDD** — Spec/Standard-Driven Development
- **DDD** — Document-Driven Development
- **TDD** — Test-Driven Development

The standard: **Docs first, Tests second, Code last**

Today: How to **plan** and **execute** using this workflow

Today's Topics

1. **Planning** — Using Plan Mode with few-shot learning
2. **Execution** — How to execute a plan iteratively
3. **Hands-on** — Building a Rust Lexer in C++

Part 1: Plan Mode

What is Plan Mode?

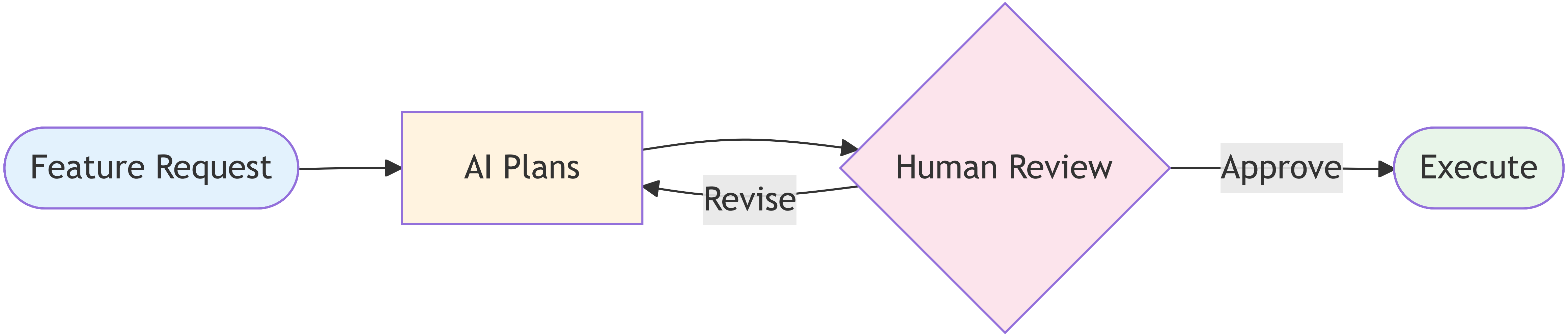
Claude Code/Cursor has a built-in **Plan Mode**:

```
claude
<Shift-Tab> twice to enter Plan Mode
```

Or trigger it with `/plan` in interactive mode.

Plan Mode = AI generates the plan, you review it

Plan Mode Workflow



You don't write the plan — you **review** the plan.

Two Checkpoints to Rollback

Like database transactions, Plan Mode gives you **two rollback points**:

```
Feature Request
     ↓
  ┌──────────────┐
  │  Plan Review │   ← Checkpoint 1: Reject bad plans early
  └──────────────┘
         │
         ↓
  Execute on Branch
         ↓
  ┌──────────────┐
  │  PR Review   │   ← Checkpoint 2: Reject bad code before merge
  └──────────────┘
         │
         ↓
  Merge to Main
```

Two chances to say "no" before anything hits main.

Why We Need Plan Mode

Complex features can take **hours or days** to implement.

Without a plan:

- We **lose ourselves** in the lengthy process
- We accumulate **tons of uncommitted changes**
- We forget what we were trying to do
- The whole progress becomes **a mess**

A plan keeps us on track:

- Clear milestones to check off
- Smaller, reviewable commits
- Easy to pause and resume

The Problem: AI Lacks the Mindset

Without guidance, AI jumps straight to **implementation**:

```
User: Add string literal support to the lexer

AI: Sure! Let me implement that...
    1. Modify lexer.cc to handle strings
    2. Done!
```

What's missing?

- **No documentation** — DDD ignored
- **No tests** — TDD ignored
- **No spec check** — SDD ignored

AI doesn't naturally think: **Docs → Tests → Code**

The Solution: Few-Shot Learning

Teach the AI **how to plan** by giving examples.

Few-shot learning = show the AI examples of good output

Where to put these examples?

- `CLAUDE.md` — always loaded
- `.claude/commands/plan.md` — triggered by `/plan`
- `.claude/skills/planning/SKILL.md` — auto-triggered

What Makes a Good Plan?

A good plan answers **three questions**:

1. **What files to READ?** — Understand current state
2. **What files to CHANGE?** — Know the scope
3. **How to TRANSLATE?** — From current → desired state

Question 1: What to Read?

AI needs an **entry point** to understand the codebase.

In `CLAUDE.md`, tell AI where to start:

```
## Project Architecture
See docs/architecture.md for the overall design.
Each module has its own README in docs/<module>.md
```

Then in `docs/architecture.md`:

```
# Architecture
- src/lexer/  → Tokenization (see docs/lexer.md)
- src/parser/ → AST building (see docs/parser.md)
- src/codegen/ → Code generation (see docs/codegen.md)
```

Give AI a map, not a maze.

Question 2: What to Change?

Write a **specific** feature request. Focus on **one thing at a time**.

Bad:

```
Build me a compiler
```

Good:

```
Create the lexer that tokenizes Rust source code.
Support: keywords, identifiers, numbers, strings, operators.
```

Also good:

```
Add string literal support to the lexer.
Handle escape sequences: \n, \t, \\, \"
```

One feature → One plan → One PR

Question 3: How to Translate?

You define the destination. AI finds the path.

You provide:

- Entry point → `docs/architecture.md`
- Specific feature request → "Add string literals"

AI figures out:

- What files to read (from architecture)
- What files to change (from feature scope)
- How to translate current → desired

```
Human: Here's the map. Here's what I want.
AI:    Let me read, understand, and plan the changes.
```

Example: AI-Generated Plan

With proper setup (architecture docs + few-shot examples), AI generates:

```
## Plan: Add string literal support

### 1. Files Verified:
- docs/architecture.md — project structure
- docs/lexer.md — current token types
- src/lexer.cc — existing implementation

### 2. Files to be Changed:
- docs/lexer.md, src/token.h, tests/lexer_test.cc, src/lexer.cc

### 3. Steps of Implementation:
1. Update docs/lexer.md — document STRING token (DDD)
2. Add tests for string literals (TDD)
3. Add STRING to TokenType enum
4. Implement readString() in lexer.cc
```

AI follows DDD → TDD → Code because we taught it to.

Plan Mode: The Review Step

This is where human intervention is encouraged.

Review carefully:

- Does the plan make sense?
- Does it follow DDD → TDD → Code?
- Are all files covered?

Take your time here. Ask questions. Request changes.

After Approval: Fully Hands Off

Once you approve the plan:

DO NOT intervene during execution.

- Don't correct the AI mid-way
- Don't change requirements
- Don't nitpick variable names

Let AI **finish the plan** before any intervention.

```
Review ──> Approve ──> AI Executes ──> Done ──> Review Again
  ↑                      (NO TOUCH)                 ↓
  └─────────────────────────────────────────────────┘
```

Catching mistakes at planning is cheaper than at execution.

Planning Summary

1. **Entry point** — `docs/architecture.md` as the map
2. **Specific request** — one feature at a time
3. **AI plans** — files verified, files to change, steps
4. **Review carefully** — this is your intervention point
5. **Then hands off** — let AI execute without interruption

Part 2: Executing a Plan

Stick to the Plan

Once approved, the goal is simple:

Execute until all success criteria are met.

```
while (!success_criteria) {
    state = look_at_current_state();
    success_criteria = execute_the_plan(plan, state);
}
```

No human intervention to interupt the loop.

Tool: Ralph Loop

There's an official plugin for this execution pattern:

```
https://github.com/anthropics/claude-plugins-official
  └── plugins/ralph-loop
```

How it works:

1. Feed the plan as prompt
2. AI executes one iteration
3. Check success criteria
4. If not done: feed the plan + previous output back
5. Repeat until done

Ralph Loop: The Idea

```
┌─────────────────────────────────────────┐
│ Iteration 1:                            │
│ Input:  Plan                            │
│ Output: Partial implementation          │
├─────────────────────────────────────────┤
│ Iteration 2:                            │
│ Input:  Plan + Output from Iteration 1  │
│ Output: More progress                   │
├─────────────────────────────────────────┤
│ Iteration N:                            │
│ Input:  Plan + All previous outputs     │
│ Output: Done! All tests pass.           │
└─────────────────────────────────────────┘
```

The plan stays constant. Context accumulates.

Ralph Loop: The Problem

It wastes tokens.

Each iteration re-sends:

- The full plan
- All previous outputs
- Growing context window

```
Iteration 1:  1,000 tokens
Iteration 2:  3,000 tokens
Iteration 3:  6,000 tokens
Iteration 4: 10,000 tokens
...
```

For complex features, this gets expensive fast.

Why No Human Intervention?

1. We already reviewed the plan carefully.
2. You can concurrently work on other tasks.

Trust the process. Let the models coordinate.

Human comes back when: **all tests pass** or **agent gives up**.

- What should we do when giving up?
- Incoperate the feedback into a new plan.

Part 3: Hands-on Tutorial

Building a Rust Lexer in C++

What We're Building

A **lexer** (tokenizer) for a subset of Rust:

- Written in **C++**
- Tokenizes **Rust source code**
- Produces a stream of tokens

```rust
fn main() {
    let x = 42;
}
```

↓

```
[FN] [IDENT:main] [LPAREN] [RPAREN] [LBRACE]
[LET] [IDENT:x] [ASSIGN] [NUMBER:42] [SEMICOLON]
[RBRACE]
```

Why C++ for a Rust Compiler?

1. **Learning exercise** — understand compiler internals
2. **No bootstrap problem** — don't need Rust to compile Rust
3. **Ecosystem** — C++ is standard for compiler dev
    - We have LLVM fully implemented in C++

Real-world Rust compiler (rustc) is written in Rust, but we start simple.

Project Structure (DDD)

Following our DDD principles, we set up:

```
rust-compiler/
├── docs/
│   ├── architecture.md       ← Project overview
│   └── lexer.md              ← Lexer design doc
├── src/
│   ├── token.h               ← Token types
│   ├── lexer.h               ← Lexer interface
│   └── lexer.cc              ← Lexer implementation
├── tests/
│   └── lexer_test.cc         ← Lexer tests
├── CMakeLists.txt
└── CLAUDE.md
```

First: Understand What We're Parsing

Before building a lexer, understand the **Rust syntax** we'll handle.

```rust
fn main() {
    let x = 42;
    let msg = "hello";
    if x > 0 {
        println!("{}", msg);
    }
}
```

What tokens do we see here?

Rust Basics: Keywords

Keywords are reserved words with special meaning:

```
fn       // function declaration
let      // variable binding
mut      // mutable variable
if       // conditional
else     // alternative branch
while    // loop
return   // return from function
struct   // struct definition
```

These cannot be used as variable names.

Some language allows keywords as identifiers, but Rust does not.

E.g. in Python, `sum = 0` to override built-in `sum()`.

Rust Basics: Identifiers & Literals

Identifiers — names for variables, functions, types:

```
main, x, msg, println, my_var, FooBar, _unused
```

Pattern: `[a-zA-Z_][a-zA-Z0-9_]*`

A combination of letters, digits, underscores; **cannot start with digit**.

Number literals:

```
42, 0, 1234, 3_141_592  // underscores allowed
```

String literals:

```
"hello", "world\n", "escaped \"quote\""
```

Rust Basics: Operators & Punctuation

Operators:

```
+  -  *  /            // arithmetic
=                     // assignment
==  !=  <  >  <=  >=  // comparison
->                    // return type arrow
```

Punctuation:

```
(  )    // function calls, grouping
{  }    // blocks
[  ]    // arrays
;       // statement terminator
:       // type annotation
,       // separator
```

Step 2: Design the Interface

Keep it minimal. Three things:

```cpp
class Lexer {
public:
    Lexer(std::istream& input);  // file descriptor
    bool hasNext();              // more tokens?
    Token nextToken();           // get next token
};
```

That's it. **Let AI figure out the rest.**

- Token struct? AI decides.
- TokenType enum? AI decides.
- Internal helpers? AI decides.

You define **what**, AI implements **how**.

What is a Lexer?

A **lexer** (tokenizer) converts source code into tokens.

```
Source:  "let x = 42;"

Lexer:   [LET] [IDENT:x] [ASSIGN] [NUMBER:42] [SEMICOLON]
```

Each token has:

- **Type** — what kind of token (keyword, number, operator)
- **Value** — the actual text ("x", "42")
- **Position** — line and column (for error messages)

Understanding Regex for Lexers

Tokens are defined by **patterns**. Regex helps express them:

<table>
<tr><th>Token Type</th><th>Pattern</th><th>Examples</th></tr>
<tr><td>Identifier</td><td><code>[a-zA-Z_][a-zA-Z0-9_]*</code></td><td><code>foo</code>, <code>_bar</code>, <code>x1</code></td></tr>
<tr><td>Number</td><td><code>[0-9]+</code></td><td><code>42</code>, <code>0</code>, <code>123</code></td></tr>
<tr><td>String</td><td><code>"[^"]*"</code></td><td><code>"hello"</code>, <code>""</code></td></tr>
<tr><td>Keyword</td><td><code>fn|let|if|...</code></td><td><code>fn</code>, <code>let</code></td></tr>
</table>

The lexer tries patterns in order until one matches.

Regex Basics

```
[a-z]     Match any lowercase letter
[A-Z]     Match any uppercase letter
[0-9]     Match any digit
[a-zA-Z]  Match any letter
_         Match underscore literally

+         One or more of the preceding
*         Zero or more of the preceding
?         Zero or one of the preceding

^         Start of string (or negation in [^...])
$         End of string
```

Example: `[a-zA-Z_][a-zA-Z0-9_]*` = identifier

CMake Basics

CMake generates build files for your C++ project.

```
# CMakeLists.txt
cmake_minimum_required(VERSION 3.10)
project(rust_compiler)

set(CMAKE_CXX_STANDARD 17)

# Build the compiler executable
add_executable(rustc
    src/main.cc
    src/lexer.cc
)
```

Build: `cmake -B build && cmake --build build`

CMake: What We Deliver

Two things you can deliver to users:

1. **Executables** — standalone programs

```
add_executable(rustc src/main.cc src/lexer.cc)
```

2. **Libraries + Headers** — for other projects to use

```
add_library(lexer STATIC src/lexer.cc)
target_include_directories(lexer PUBLIC include/)
```

For this class: we build an **executable** compiler.

CMake: Adding Tests

```
# Enable testing
enable_testing()

# Build test executable
add_executable(test_lexer tests/test_lexer.cc src/lexer.cc)

# Register with CTest
add_test(NAME lexer_tests COMMAND test_lexer)
```

Run tests: `cd build && ctest`

Preview: Recursive Descent Parser

After the lexer, we build a **parser**.

Recursive descent = each grammar rule becomes a function.

```
Grammar:
  expr   → term (('+' | '-') term)*
  term   → factor (('*' | '/') factor)*
  factor → NUMBER | '(' expr ')'
```

```
Expr* parseExpr() { ... calls parseTerm() ... }
Expr* parseTerm() { ... calls parseFactor() ... }
Expr* parseFactor() { ... }
```

Each function returns an **AST node**.

Parser: More Complex Than Lexer

Lexer is simple — describe in a few sentences.

Parser is complex — break into sub-tasks:

1. Parse **literals** (numbers, strings)
2. Parse **expressions** (binary ops, unary ops)
3. Parse **statements** (let, return, if)
4. Parse **functions** (fn declaration)
5. Connect everything into a **program**

Bottom-up approach: start simple, add complexity.

Bottom-Up Parsing Strategy

```
Week 1: Literals only
        42, "hello", true

Week 2: Add binary expressions
        1 + 2, x * y

Week 3: Add statements
        let x = 1 + 2;

Week 4: Add functions
        fn foo() { return 42; }

Week 5: Full program
        fn main() { ... }
```

Each week builds on the previous. Tests grow incrementally.

Assignment 1

Assignment 1: Lexer

Goal: Implement a lexer for basic Rust syntax.

Input: Rust source file

Output: Stream of tokens

Must handle:

- Keywords: `fn`, `let`, `mut`, `if`, `else`, `while`, `return`
- Identifiers: `foo`, `_bar`, `x1`
- Numbers: `42`, `0`
- Strings: `"hello"`
- Operators: `+`, `-`, `*`, `/`, `=`, `==`, `!=`, `<`, `>`, `<=`, `>=`
- Punctuation: `(`, `)`, `{`, `}`, `;`, `:`, `,`

Assignment 1: Deliverables

1. **Working lexer** — passes all provided tests
2. **CMakeLists.txt** — builds with `cmake`
3. **Your own tests** — at least 5 additional test cases

```
# Build
cmake -B build && cmake --build build

# Run tests
cd build && ctest

# Run on a file
./build/rustc input.rs
```

Assignment 1: Tips

1. **Use Plan Mode** — let AI generate the implementation plan
2. **Start with keywords** — easiest to implement
3. **Add one token type at a time** — test as you go
4. **Handle edge cases**:
    - `fn_name` is IDENT, not FN
    - `==` is EQ, not two ASSIGNs
    - Whitespace and comments should be skipped

Due: Next week

Questions?