# Operational View of CodeQL

## Thinking of CodeQL as Preprocessor, Compiler, and Runtime

Michael Hohn, hohn@github.com

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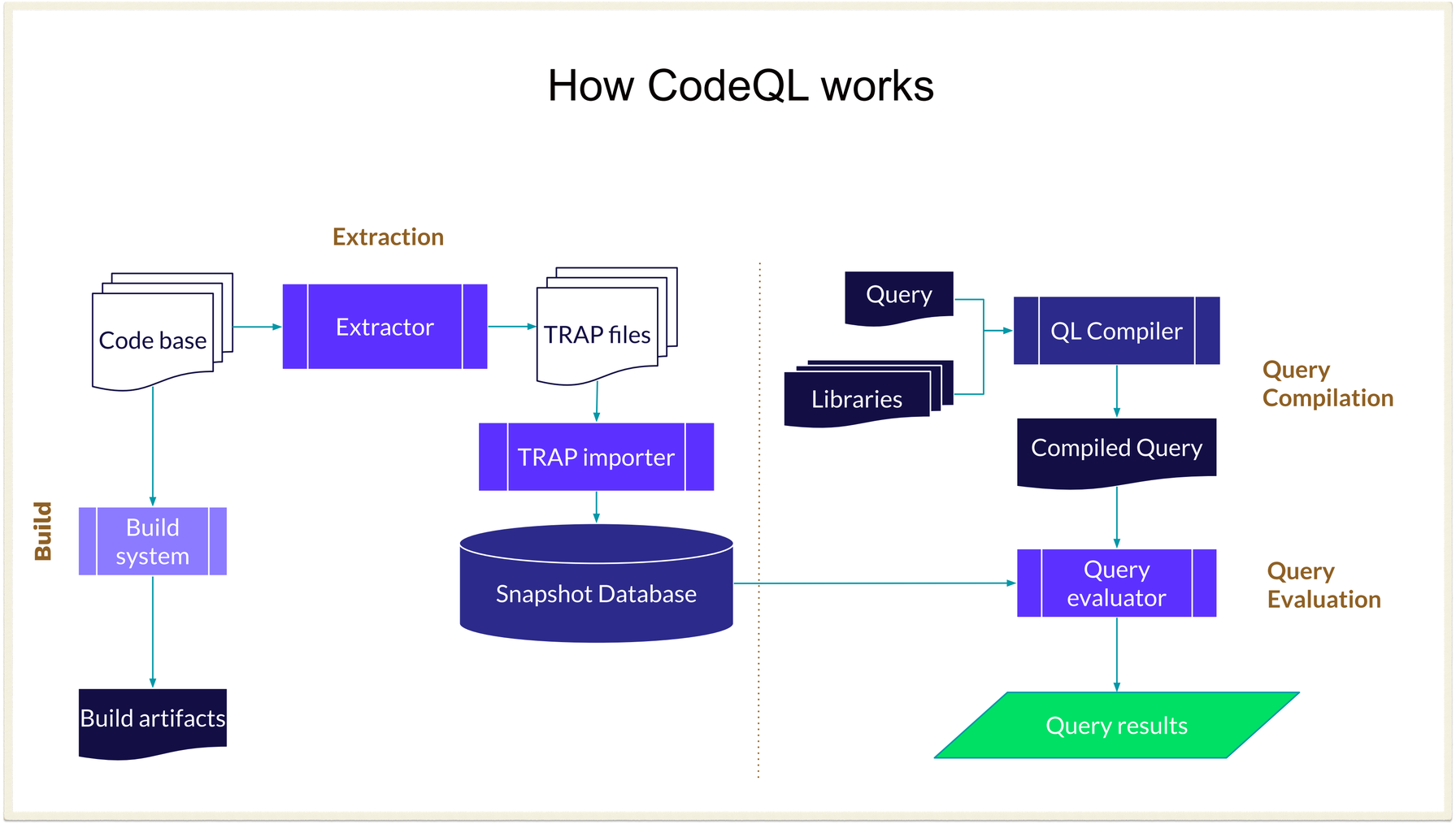
In the following, we use this analogy to get some best (codeql) practices for
- query re-use
- query structuring
- query customization
- tool use points (what tool when and where)
- larger system integration

# You may have seen this slide



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With that in mind, let's jump right in

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# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                          \
    codeql database create --language=cpp                              \
           -s . -j 8 -v                                                \
           $DB                                                         \
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# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze                          \
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Note: this is the sequence that is always run, whether in the CLI, github actions, or VS Code

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2. give us a Data Flow Graph

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Structural Answer: the C standard library is linked at runtime via the -L search path. CodeQL libraries also have a search path.

A: To find the supported APIs, search the ql/ library source tree. Practically, much of the standard C library is supported, typically from a conceptual level. Don't try to find 1-1 mappings between C headers and the ql/ library.

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Ex: For example, for a top-down search start with cpp.qll and notice the statement

```
import semmle.code.cpp.commons.Printf
```

Follow this to find the cpp.commons module and see what it models:

```
Alloc.qll       Dependency.qll   NullTermination.qll   StringAnalysis.qll
Assertions.qll  Environment.qll  PolymorphicClass.qll  StructLikeClass.qll
Buffer.qll      Exclusions.qll   Printf.qll            Synchronization.qll
CommonType.qll  File.qll         Scanf.qll             VoidContext.qll
DateTime.qll    NULL.qll         Strcat.qll            unix/
```

Think of preprocessor + compiler + libraries

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Q: Is library X supported?

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A: If it is, you'll find it in the `ql/` library source tree. A whole-tree search, `grep`-style, is easiest.

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E: For example, to check support for sqlite:
0:$ cd ~/local/vmsync/ql/cpp/ql/src
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```
/**
 * Extend this class to customize the security queries for
 * a particular code base. Provide no constructor in the
 * subclass, and override any methods that need customizing.
 */
class SecurityOptions extends string {
    predicate sqlArgument(string function, int arg) {
        // SQLite3 C API
        function = "sqlite3_exec" and arg = 1
    }
    /**
     * The argument of the given function is filled in from user input.
     */
    predicate userInputArgument(FunctionCall functionCall, int arg) {
        fname = "scanf" and arg >= 1
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}
```

Aside: this class and its documentation have been updated

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`semmle/code/cpp/security/Security.qll` is a library, so some sample uses would be nice. Another search via

```
    grep  -nH  -R SecurityOptions *
```

- finds (potential) documentation:

```
    docs/codeql/ql-training/cpp/global-data-flow-cpp.rst:59:The library
class ``SecurityOptions`` provides a (configurable) model of what counts as
user-controlled data:
```

- and an extension point:

```
    cpp/ql/src/semmle/code/cpp/security/SecurityOptions.qll:16:class
CustomSecurityOptions extends SecurityOptions
/**
 * This class overrides `SecurityOptions` and can be used to add project
 * specific customization.
 */
class CustomSecurityOptions extends SecurityOptions {...}
```

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Q: What do we have to help with?

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       --                                       \
       $DB                                      \
       $SRCDIR/SqlInjection.ql

# Examine results
# Plain text, look for
#     "results" : [ {
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# Or
jq --raw-output --join-output  -f sarif-summary.jq < cpp-sqli.sarif | less
# Or use vs code's sarif viewer
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```

Q: What do we have to help with?

A: What does your code use beyond the C/Python/Java standard library?

# Think of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                   \
    codeql database create --language=cpp                       \
           -s . -j 8 -v                                         \
           $DB                                                  \
           --command='clang -Wall add-user.c -lsqlite3 -o add-user'

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze                         \
       -v --ram=14000 -j12 --rerun              \
       --search-path ~/local/vmsync/ql          \
       --format=sarif-latest                    \
       --output=$RESULTS                        \
       --                                       \
       $DB                                      \
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#     "results" : [ {
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Q: What do we have to help with?

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- For this example, the `sqlite3` library.

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Think Compiler (CodeQL) with library:

```
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# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                   \
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Q: What else should we do?

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Q: What else should we do?

Write queries for known & patched vulnerabilities. This will uncover points in your code where CodeQL gets stuck (those you encode in your custom codeql library for other queries) and provide a regression test for the vulnerability

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Think of preprocessor + compiler + libraries

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Q: How should we go about modeling our libraries with CodeQL?

# Think of preprocessor + compiler + libraries

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DB=add-user.db
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cd $SRCDIR &&                                                   \
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```
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SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                   \
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# Edit your code
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Use separate query files (*.ql) and library files (*.qll)

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A: Structure the query set by size and complexity
Some examples are given in this gist; use the simplest one that fits your problem.

Think of preprocessor + compiler + libraries

# Think of preprocessor + compiler + libraries

Q: We don't want to reinvent the wheel.  How do we extend existing queries?

# Think of preprocessor + compiler + libraries

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A: For C/Python etc.
Common approaches to extending libraries are configurations, callbacks & other hooks.
When those fail, patching the source.

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Customizations can be injected when libraries use abstract base classes.  When those are extended before use by queries, the additions are part of the queries.

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Q: Say what?

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A: The steps to customize a query:

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Examine the query and libraries it uses

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Q: Say what?

A: The steps to customize a query:

Examine the query and libraries it uses

Subclass abstract base classes, if there are any (otherwise, see next answer)

# Think of preprocessor + compiler + libraries

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A: The steps to customize a query:

Examine the query and libraries it uses

Subclass abstract base classes, if there are any (otherwise, see next answer)

Add these to Customizations/Options.qll so they are included by all queries. The files by language are:

# Think of preprocessor + compiler + libraries

Q: We don't want to reinvent the wheel. How do we extend existing queries?

A: For C/Python etc.

Common approaches to extending libraries are configurations, callbacks & other hooks.
When those fail, patching the source.

A: For CodeQL

Customizations can be injected when libraries use abstract base classes. When those are extended before use by queries, the additions are part of the queries.

Q: Say what?

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ql/csharp/ql/src/Customizations.qll
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ql/javascript/ql/src/Customizations.qll
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ql/cpp/ql/src/Options.qll
```

# Think of preprocessor + compiler + libraries

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ql/cpp/ql/src/Options.qll
```

A: In some cases, you will need heavy modifications.
Clone the ql/ tree, patch it as needed, and use your customized version.

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                   \
    codeql database create --language=cpp                       \
           -s . -j 8 -v                                         \
           $DB                                                  \
           --command='clang -Wall add-user.c -lsqlite3 -o add-user'

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze                         \
       -v --ram=14000 -j12 --rerun              \
       --search-path ~/local/vmsync/ql          \
       --format=sarif-latest                    \
       --output=$RESULTS                        \
       --                                       \
       $DB                                      \
       $SRCDIR/SqlInjection.ql

# Examine results
# Plain text, look for
#     "results" : [ {
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edit $RESULTS
# Or
jq --raw-output --join-output  -f sarif-summary.jq < cpp-sqli.sarif | less
# Or use vs code's sarif viewer
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# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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The general sequence

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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The general sequence

1. set up the system

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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The general sequence

1. set up the system

2. prepare data

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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The general sequence

1. set up the system
2. prepare data
3. edit code

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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# Prepare System
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# Convert data if needed
SRCDIR=.
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           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
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The general sequence

1. set up the system
2. prepare data
3. edit code
4. compile & run

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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# Prepare System
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# Convert data if needed
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           $DB
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# Edit your code
edit SqlInjection.ql

# Compile & run your code
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The general sequence

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2. prepare data
3. edit code
4. compile & run
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# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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# Edit your code
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       -v --ram=14000 -j12 --rerun
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The general sequence

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3. edit code
4. compile & run
5. examine results

shell/scripts

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

The general sequence

shell/scripts

vs code

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# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
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3. edit code
4. compile & run
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# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
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The general sequence

1. set up the system
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3. edit code
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5. examine results

shell/scripts

vs code

emacs/vi/lsp editors

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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# Edit your code
edit SqlInjection.ql

# Compile & run your code
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       -v --ram=14000 -j12 --rerun
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| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
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# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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# Edit your code
edit SqlInjection.ql

# Compile & run your code
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       -v --ram=14000 -j12 --rerun
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| 5. examine results | | | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

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| 1. set up the system | ✓ | | |
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Use cases

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | | |
| 4. compile & run | ✓ | | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
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       --format=sarif-latest
       --output=$RESULTS
       --
       $DB
       $SRCDIR/SqlInjection.ql

# Examine results
# Plain text, look for
#     "results" : [ {
#     and
#     "codeFlows" : [ {
edit $RESULTS
# Or
jq --raw-output --join-output  -f sarif-summary.
# Or use vs code's sarif viewer
# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | |
| 4. compile & run | ✓ | | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
       --format=sarif-latest
       --output=$RESULTS
       --
       $DB
       $SRCDIR/SqlInjection.ql

# Examine results
# Plain text, look for
#     "results" : [ {
#     and
#     "codeFlows" : [ {
edit $RESULTS
# Or
jq --raw-output --join-output  -f sarif-summary.
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# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
       --format=sarif-latest
       --output=$RESULTS
       --
       $DB
       $SRCDIR/SqlInjection.ql

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# Plain text, look for
#     "results" : [ {
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edit $RESULTS
# Or
jq --raw-output --join-output  -f sarif-summary.
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```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | ✓ | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
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```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | ✓ | |
| Use cases | direct control, setup, debugging, automation, result transformation | CodeQL editing with jump-to-definition etc. and integrated result review on desktop | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
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```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | ✓ |
| 4. compile & run | ✓ | ✓ | |
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| Use cases | direct control, setup, debugging, automation, result transformation | CodeQL editing with jump-to-definition etc. and integrated result review on desktop | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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       -v --ram=14000 -j12 --rerun
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jq --raw-output --join-output  -f sarif-summary.
# Or use vs code's sarif viewer
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```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | ✓ |
| 4. compile & run | ✓ | ✓ | * |
| 5. examine results | * | ✓ | |
| Use cases | direct control, setup, debugging, automation, result transformation | CodeQL editing with jump-to-definition etc. and integrated result review on desktop | |

# Tool coverage: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

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# Edit your code
edit SqlInjection.ql

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RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
       --format=sarif-latest
       --output=$RESULTS
       --
       $DB
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# Plain text, look for
#     "results" : [ {
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# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | vs code | emacs/vi/lsp editors |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | ✓ | ✓ |
| 4. compile & run | ✓ | ✓ | * |
| 5. examine results | * | ✓ | |
| Use cases | direct control, setup, debugging, automation, result transformation | CodeQL editing with jump-to-definition etc. and integrated result review on desktop | CodeQL editing with jump-to-definition etc. |

# Integration: Keep Thinking of preprocessor + compiler + libraries

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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export PATH=$HOME/local/vmsync/codeql250:"$PATH"

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The general sequence

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2. prepare data
3. edit code
4. compile & run
5. examine results

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

The general sequence

shell/scripts

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The general sequence

1. set up the system
2. prepare data
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shell/scripts

github actions or any ci/cd

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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```

The general sequence

1. set up the system
2. prepare data
3. edit code
4. compile & run
5. examine results

shell/scripts

github actions or any ci/cd

github security alerts

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
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cd $SRCDIR &&
    codeql database create --language=cpp
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           $DB
           --command='clang -Wall add-user.c -ls

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       -v --ram=14000 -j12 --rerun
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# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | | |
| 2. prepare data | ✓ | | |
| 3. edit code | | | |
| 4. compile & run | ✓ | | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
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           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
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# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | | |
| 3. edit code | | | |
| 4. compile & run | ✓ | | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

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SRCDIR=.
DB=add-user.db
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```

| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | ✓ | |
| 3. edit code | | | |
| 4. compile & run | ✓ | | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
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       --output=$RESULTS
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#     "results" : [ {
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jq --raw-output --join-output  -f sarif-summary.
# Or use vs code's sarif viewer
# Or use the GHAS integration via actions
```

| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | ✓ | |
| 3. edit code | | | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
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# Or
jq --raw-output --join-output  -f sarif-summary.
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```

| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | ✓ | |
| 3. edit code | | | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | | |
| Use cases | direct control, setup, debugging, automation, result transformation | fully automated pipeline for the three indicated steps | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
       --format=sarif-latest
       --output=$RESULTS
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| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | ✓ | |
| 3. edit code | | | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | | ✓ |
| Use cases | direct control, setup, debugging, automation, result transformation | fully automated pipeline for the three indicated steps | |

# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&
    codeql database create --language=cpp
           -s . -j 8 -v
           $DB
           --command='clang -Wall add-user.c -ls

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze
       -v --ram=14000 -j12 --rerun
       --search-path ~/local/vmsync/ql
       --format=sarif-latest
       --output=$RESULTS
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       $DB
       $SRCDIR/SqlInjection.ql

# Examine results
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# Or
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| The general sequence | shell/scripts | github actions or any ci/cd | github security alerts |
|---|---|---|---|
| 1. set up the system | ✓ | ✓ | |
| 2. prepare data | ✓ | ✓ | |
| 3. edit code | | | |
| 4. compile & run | ✓ | ✓ | |
| 5. examine results | * | | ✓ |
| Use cases | direct control, setup, debugging, automation, result transformation | fully automated pipeline for the three indicated steps | developer review of alerts, linking github, query, and source code |

# Key takeaways

# Key takeaways

You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

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You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

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The general development sequence is

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You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

The general development sequence is

1. set up the system

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CodeQL is a preprocessor + compiler + libraries

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1. set up the system

2. prepare data

# Key takeaways

You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

The general development sequence is

1. set up the system

2. prepare data

3. edit code

# Key takeaways

You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

The general development sequence is

1. set up the system
2. prepare data
3. edit code
4. compile & run

# Key takeaways

You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

The general development sequence is

1. set up the system
2. prepare data
3. edit code
4. compile & run
5. examine results

# Key takeaways

You already use C/Python/Java etc. as a combination of preprocessor + compiler + libraries

CodeQL is a preprocessor + compiler + libraries

The general development sequence is

1. set up the system
2. prepare data
3. edit code
4. compile & run
5. examine results

Apply your existing best practices to CodeQL

The end… Questions?

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# On to the GHAS overview

Q: Should we use the most recent version of codeql at all times?
A: Follow the way you use your compiler. Do you use the most recent version of compiler at all times, or do you use a rolling release cycle?
To get your current version's info:

```
hohn@gh-hohn ~/local/vmsync/ql/cpp/ql/src
0:$ codeql --version
CodeQL command-line toolchain release 2.5.0.
Copyright (C) 2019-2021 GitHub, Inc.
Unpacked in: /Users/hohn/local/vmsync/codeql250
   Analysis results depend critically on separately distributed query
and
   extractor modules. To list modules that are visible to the
toolchain,
   use 'codeql resolve qlpacks' and 'codeql resolve languages'.
```

You should match the CodeQL cli version to the CodeQL library version; the library releases have `codeql-cli/<VERSION>` tags to allow matching with the binaries.
When using git for the library, you should check out the appropriate version via, e.g.,

```
cd $HOME/local/vmsync/ql && git checkout codeql-cli/v2.5.9
```

Think Compiler (CodeQL) with library:

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cd $HOME/local/vmsync/ql && git checkout codeql-cli/v2.5.9
```

## Think Compiler (CodeQL) with library:

```
# Prepare System
export PATH=$HOME/local/vmsync/codeql250:"$PATH"

# Convert data if needed
SRCDIR=.
DB=add-user.db
cd $SRCDIR &&                                                   \
    codeql database create --language=cpp                       \
           -s . -j 8 -v                                         \
           $DB                                                  \
           --command='clang -Wall add-user.c -lsqlite3 -o add-user'

# Edit your code
edit SqlInjection.ql

# Compile & run your code
RESULTS=cpp-sqli.sarif
codeql database analyze                         \
       -v --ram=14000 -j12 --rerun              \
       --search-path ~/local/vmsync/ql          \
       --format=sarif-latest                    \
       --output=$RESULTS                        \
       --                                       \
       $DB                                      \
       $SRCDIR/SqlInjection.ql

# Examine results
# Plain text, look for
#     "results" : [ {
#     and
#     "codeFlows" : [ {
edit $RESULTS
# Or
jq --raw-output --join-output  -f sarif-summary.jq < cpp-sqli.sarif | less
# Or use vs code's sarif viewer
# Or use the GHAS integration via actions
```

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# Integration: Keep Thinking of preprocessor + compiler + libraries

Think Compiler (CodeQL) with library:

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       --format=sarif-latest                    \
       --output=$RESULTS                        \
       --                                       \
       $DB                                      \
       $SRCDIR/SqlInjection.ql

# Examine results
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# Flow in `get_user_info`

```
char* get_user_info() {
#define BUFSIZE 1024
    char* buf = (char*) malloc(BUFSIZE * sizeof(char));
    int count;
    // Disable buffering to avoid need for fflush
    // after printf().
    setbuf( stdout, NULL );
    printf("*** Welcome to sql injection ***\n");
    printf("Please enter name: ");
    count = read(STDIN_FILENO, buf, BUFSIZE);
    if (count <= 0) abort();
    /* strip trailing whitespace */
    while (count && isspace(buf[count-1])) {
        buf[count-1] = 0; --count;
    }
    return buf;
}
```

Agent Smith

```
    count = read(STDIN_FILENO, buf, BUFSIZE);

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char* get_user_info() {
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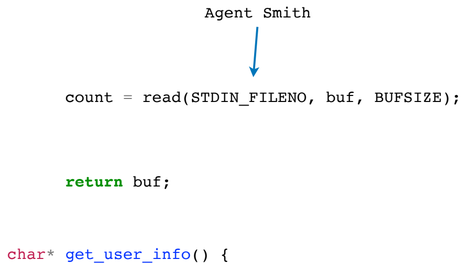
```



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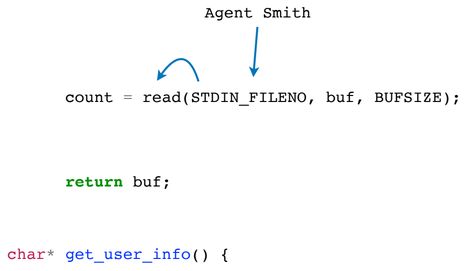

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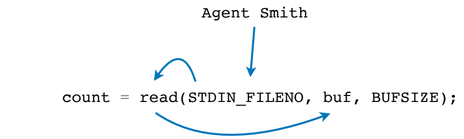


```
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char* get_user_info() {
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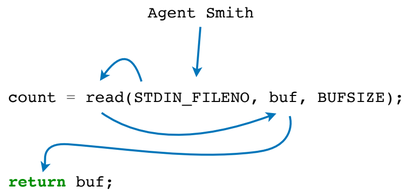


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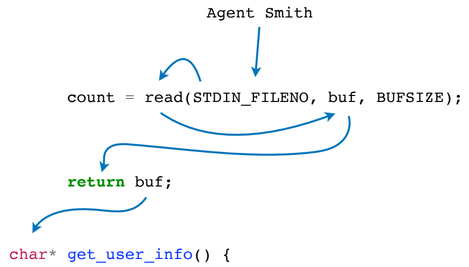

# Flow in `write_info`

```c
void write_info(int id, char* info) {
    sqlite3 *db;
    int rc;
    int bufsize = 1024;
    char *zErrMsg = 0;
    char query[bufsize];

    /* open db */
    rc = sqlite3_open("users.sqlite", &db);
    abort_on_error(rc, db);

    /* Format query */
    snprintf(query, bufsize,
             "INSERT INTO users VALUES (%d, '%s')",
             id, info);
    write_log("query: %s\n", query);

    /* Write info */
    rc = sqlite3_exec(db, query, NULL, 0, &zErrMsg);
    abort_on_exec_error(rc, db, zErrMsg);

    sqlite3_close(db);
}
```

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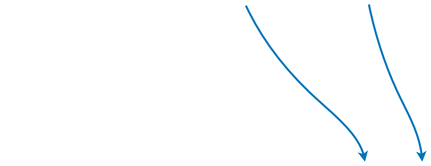

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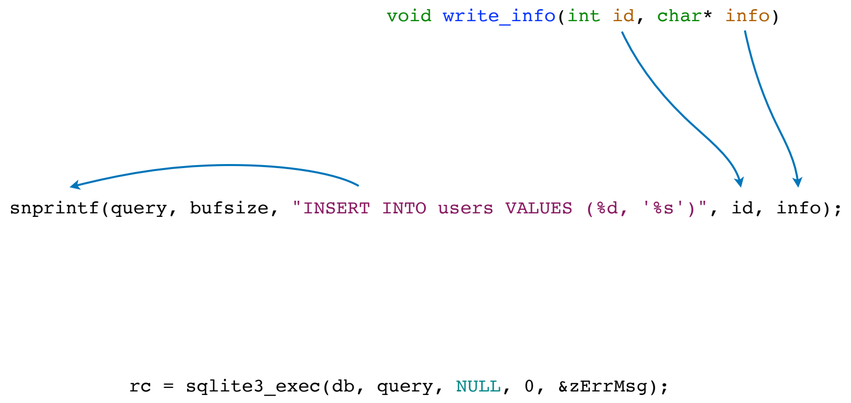

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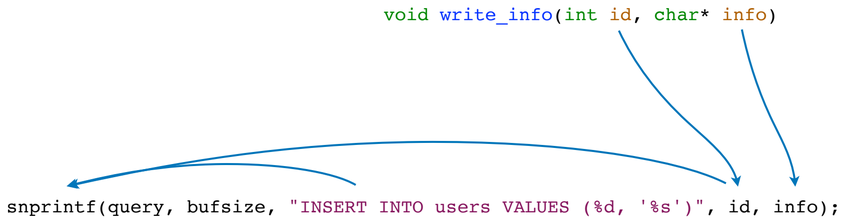


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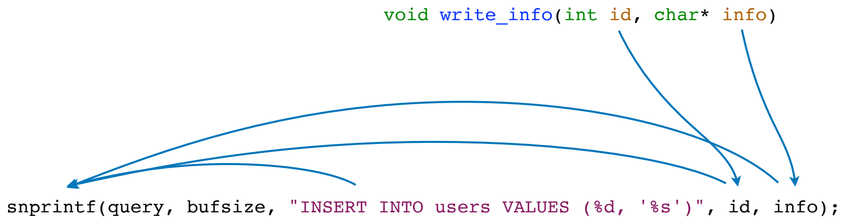


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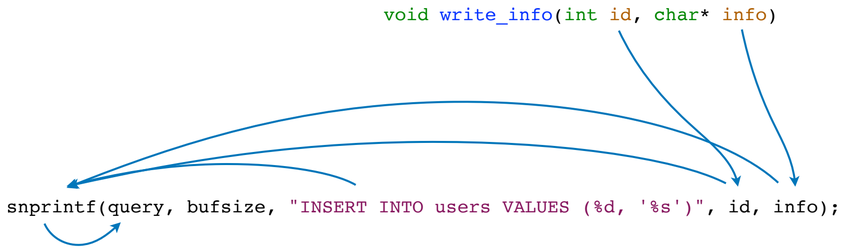


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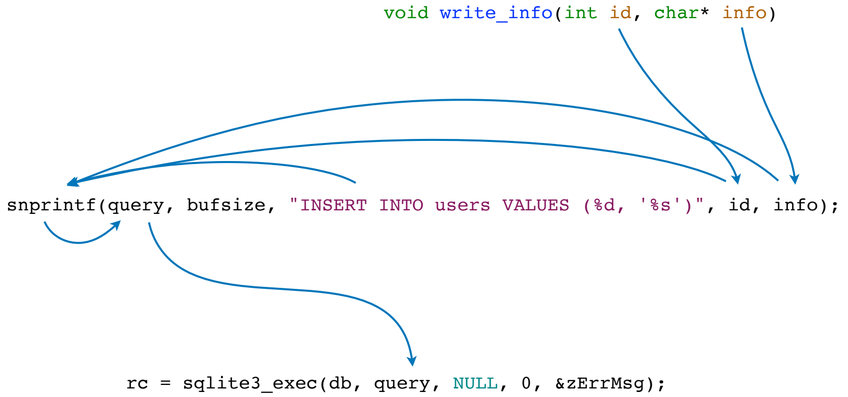

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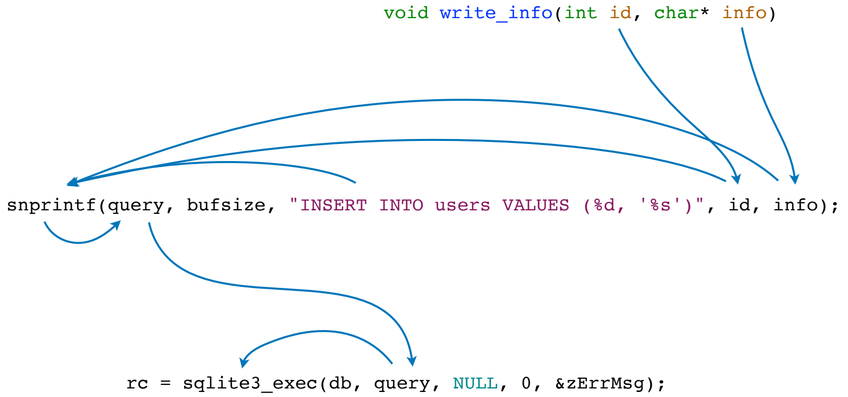

# Flow in `main`

```
int main(int argc, char* argv[]) {
    char* info;
    int id;
    info = get_user_info();
    id = get_new_id();
    write_info(id, info);
}
```

```
                                        info = get_user_info();
```

```
                    id = get_new_id();
```

```
                                write_info(id, info);
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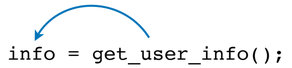


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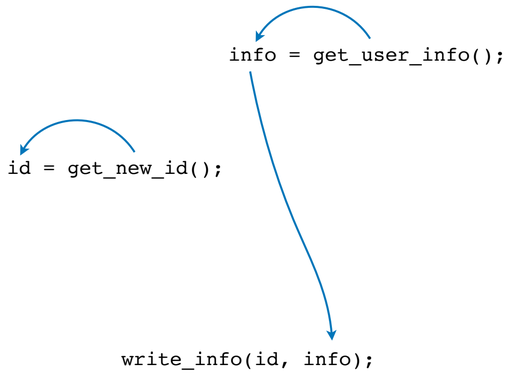

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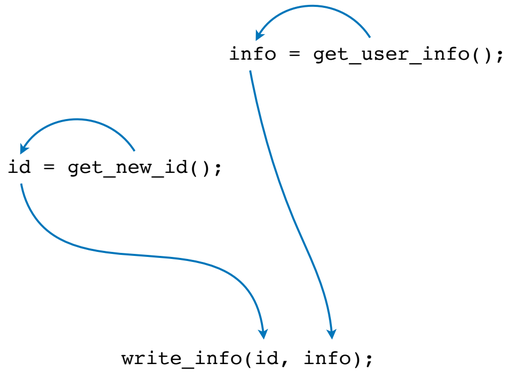

# Flow in `main`

```
int main(int argc, char* argv[]) {

    char* info;

    int id;

    info = get_user_info();

    id = get_new_id();

    write_info(id, info);

}
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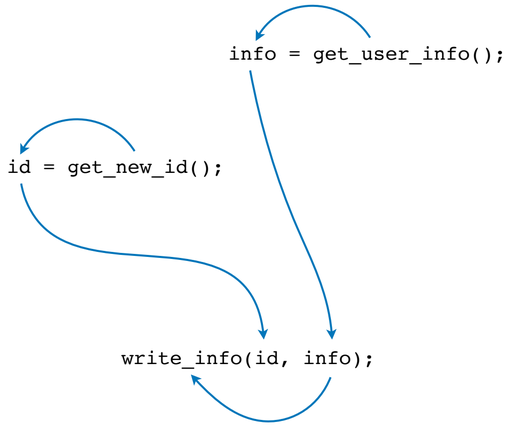

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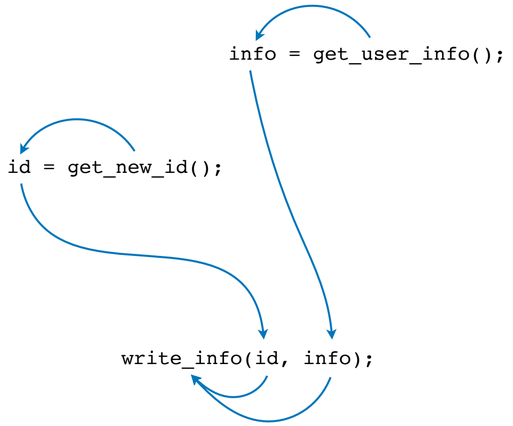
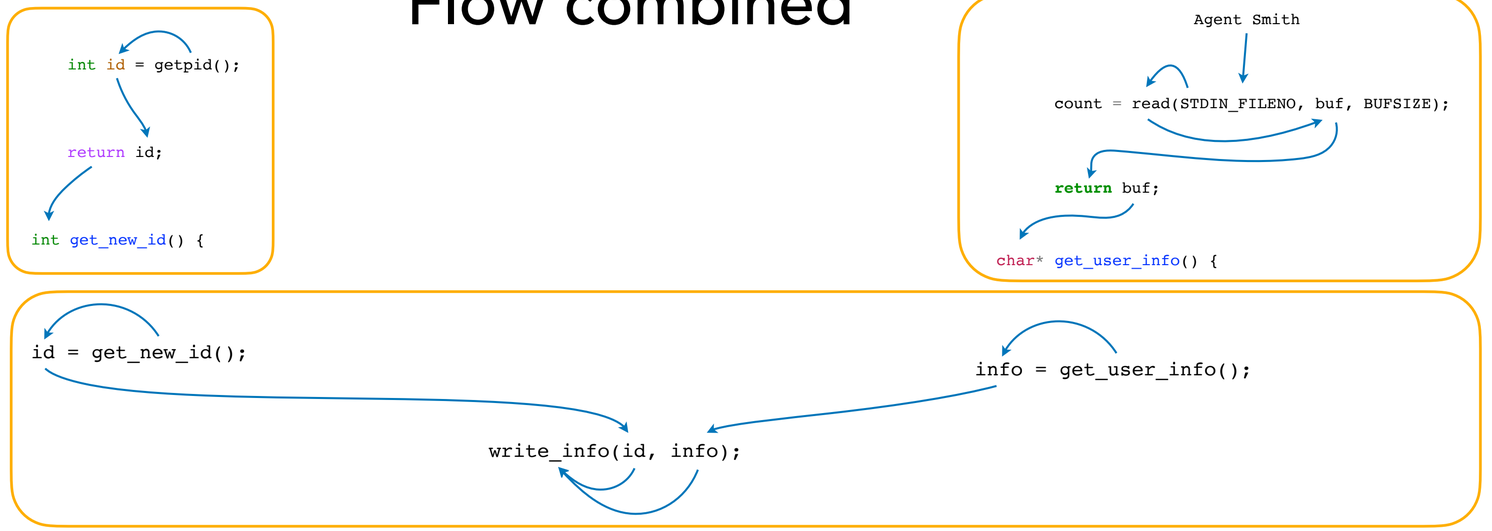


# Flow combined




- sink on bottom: second argument to `sqlite3_exec`
- propagation through `snprintf` needs taint flow
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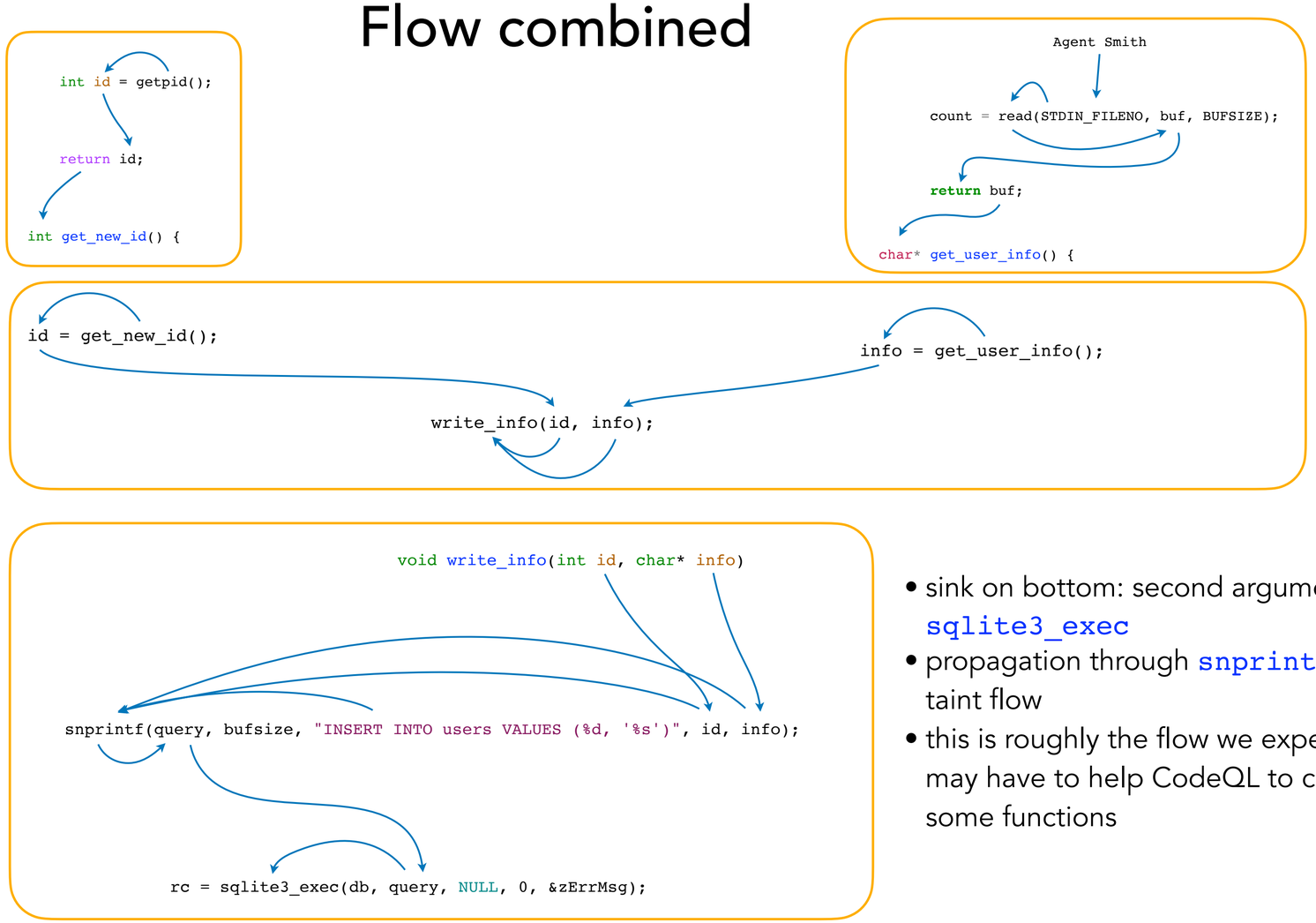
# Flow combined

- inter-procedural (global) data flow

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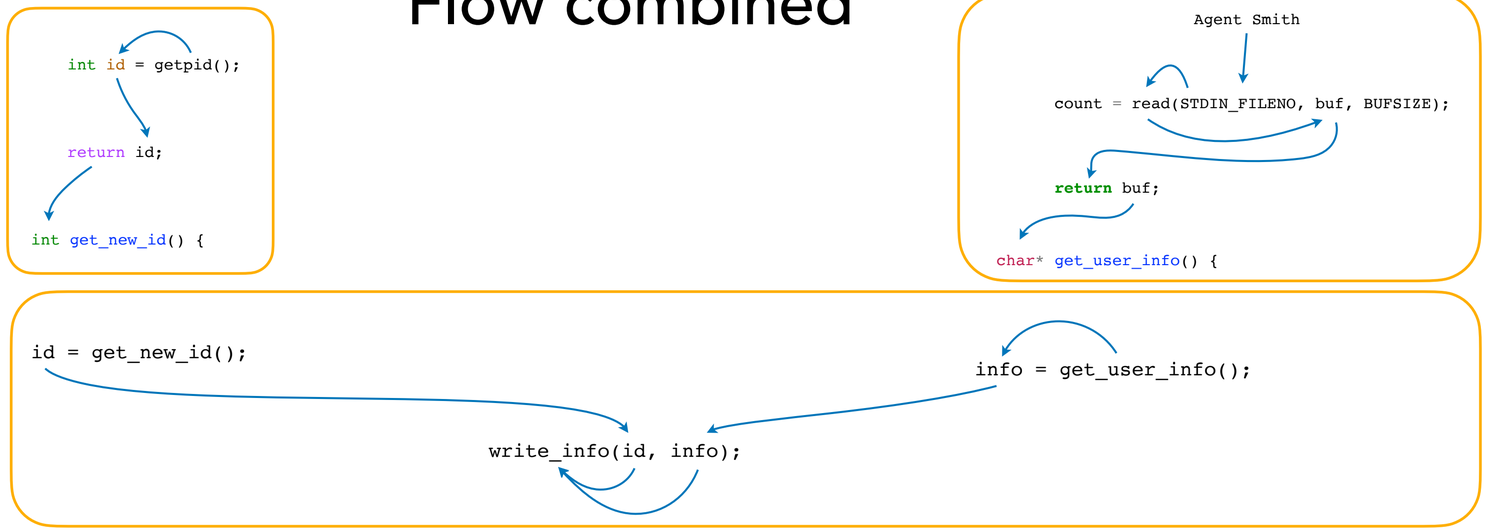


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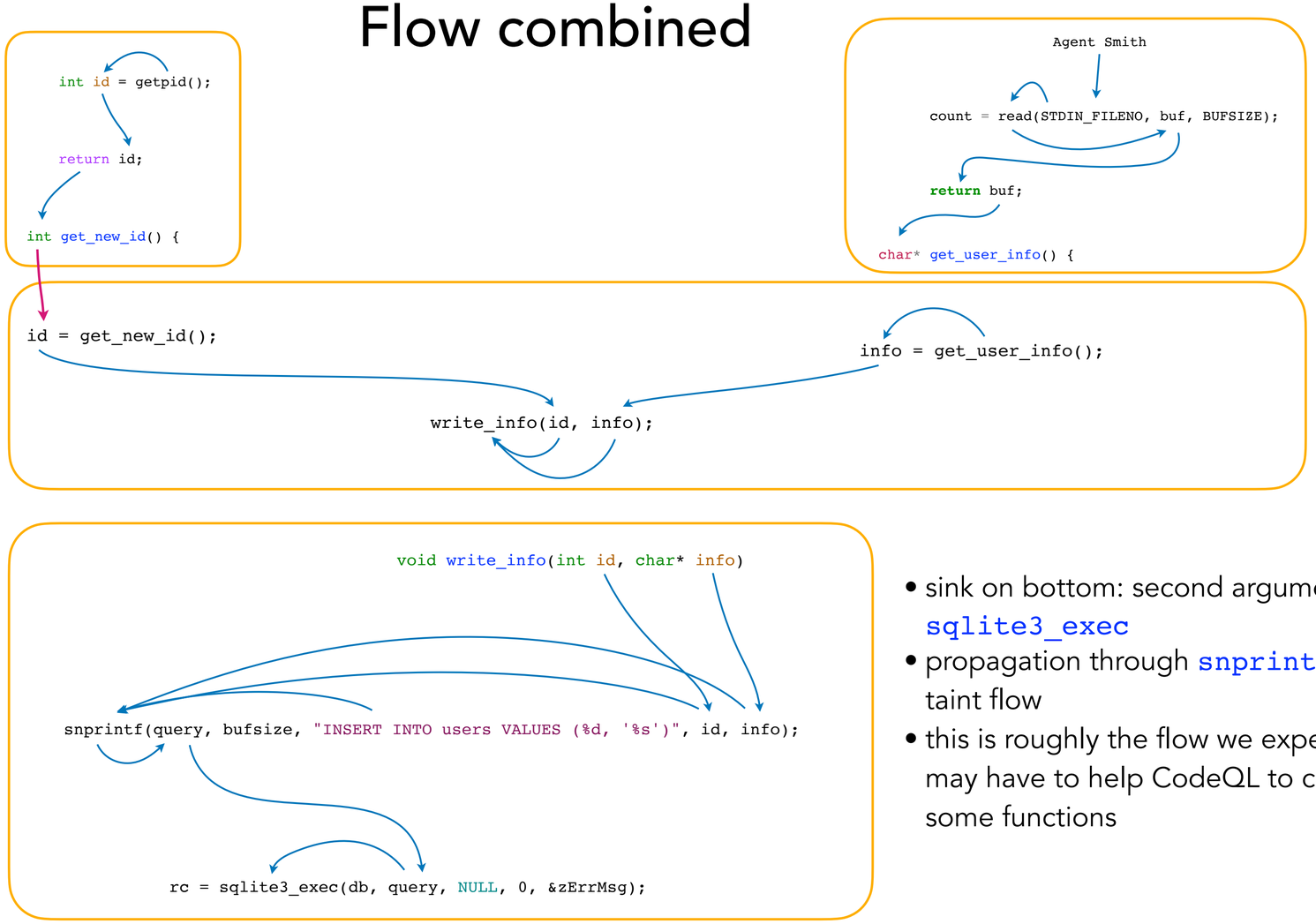


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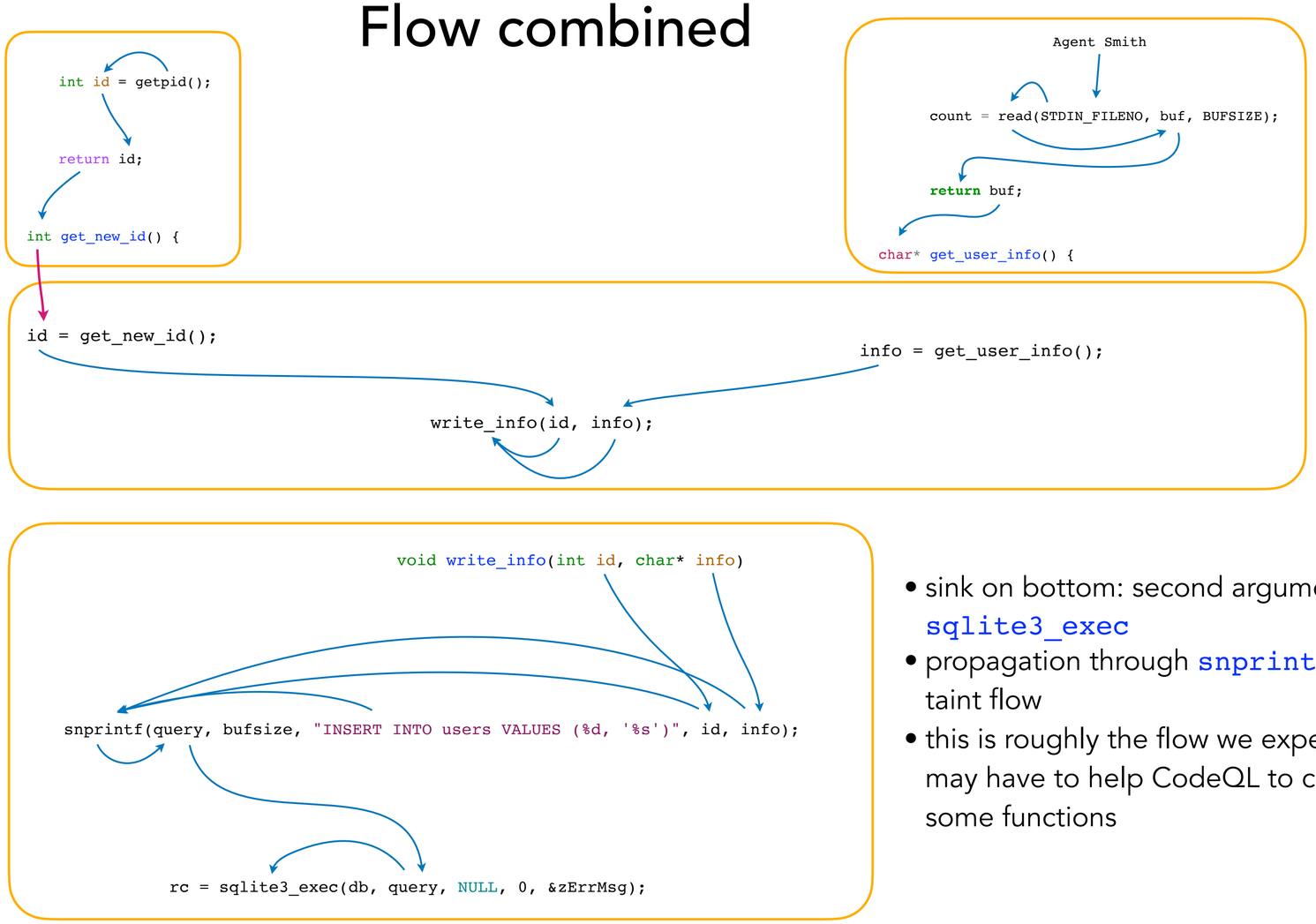


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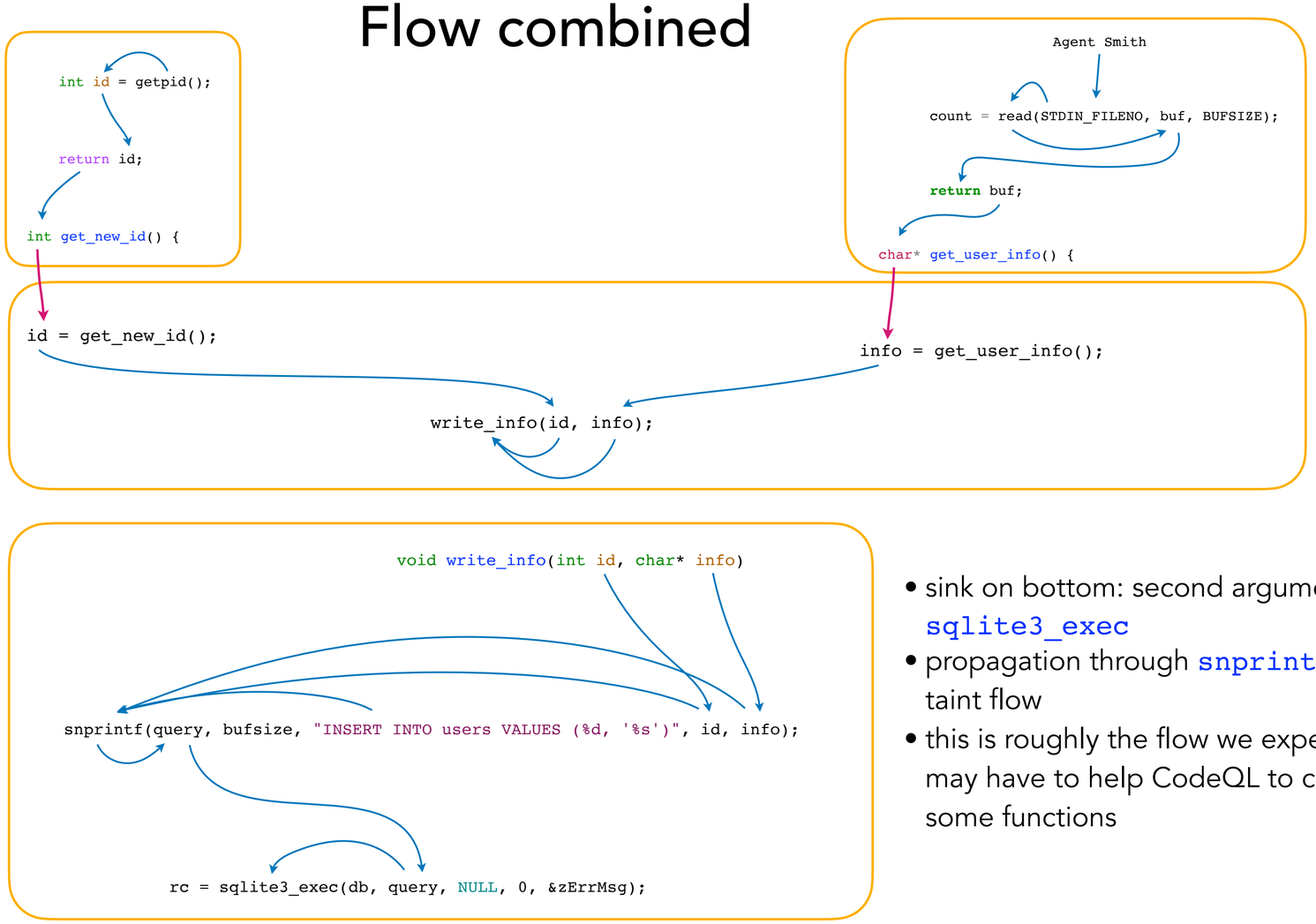


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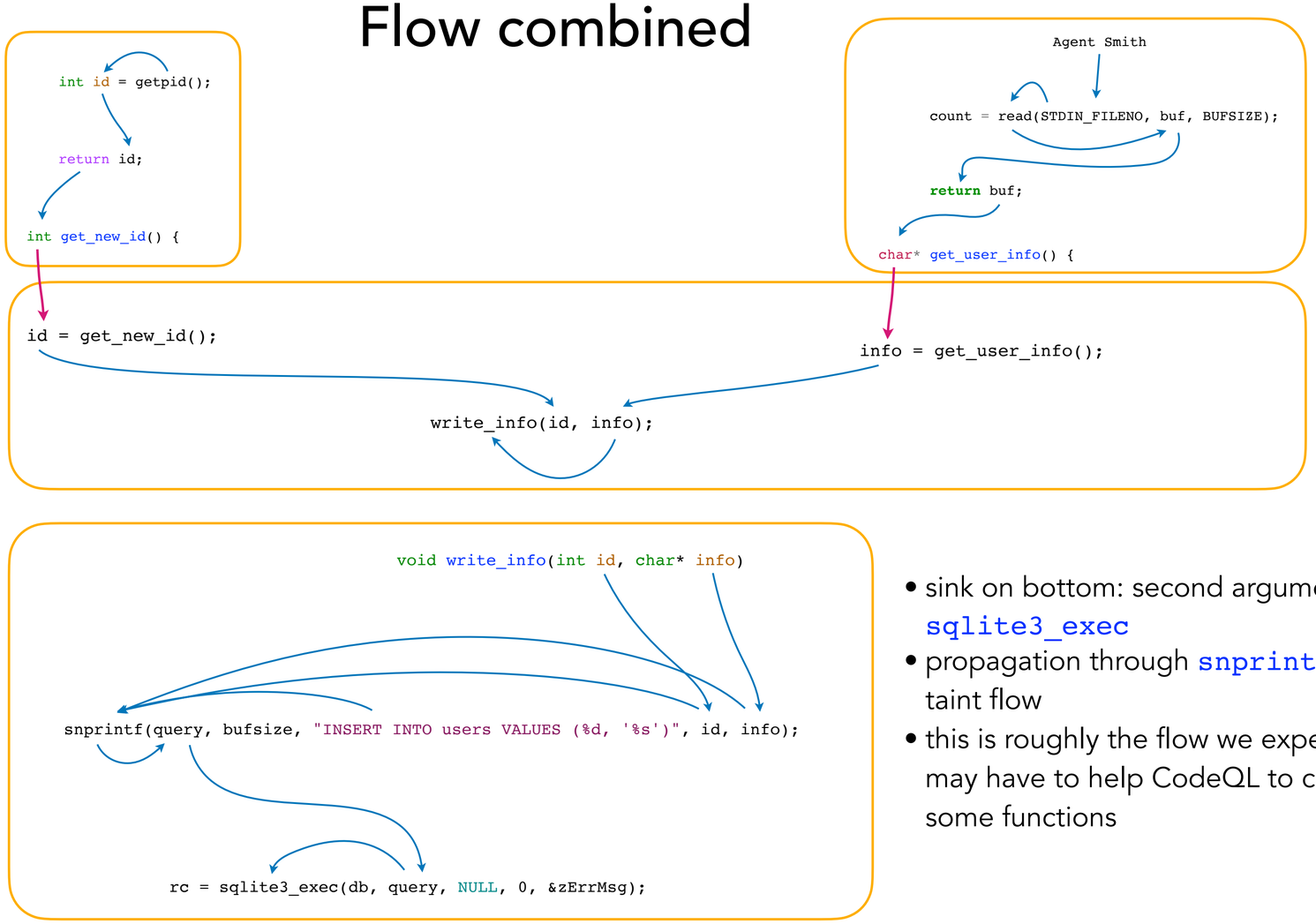


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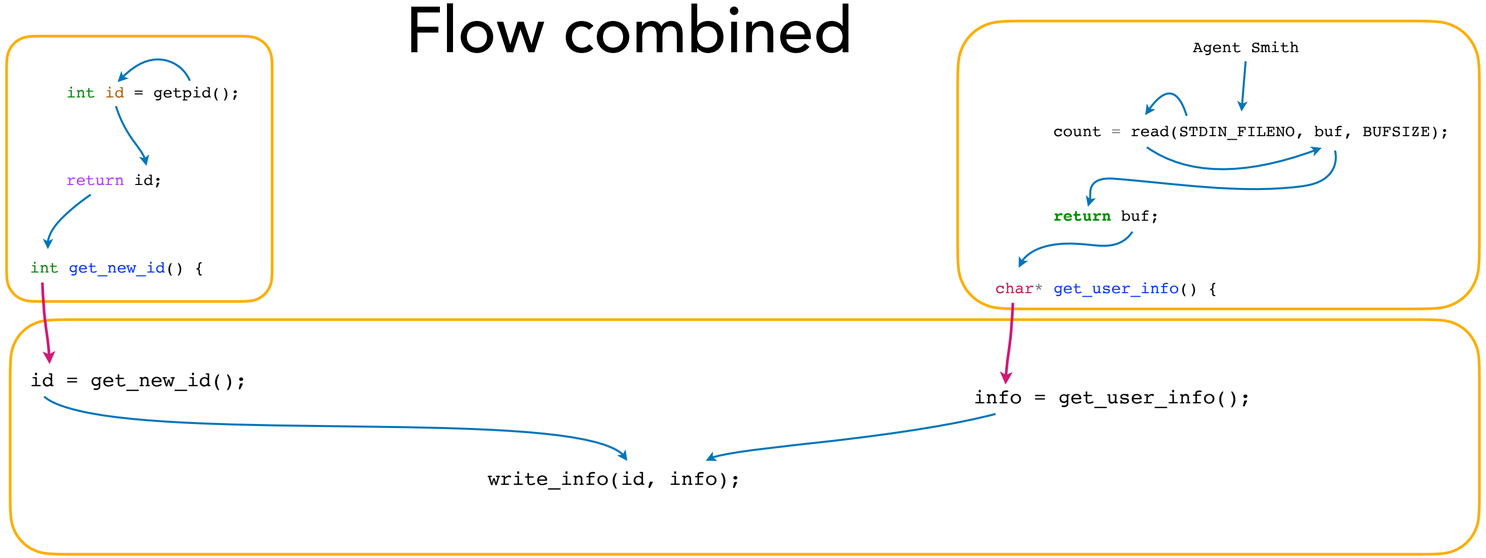


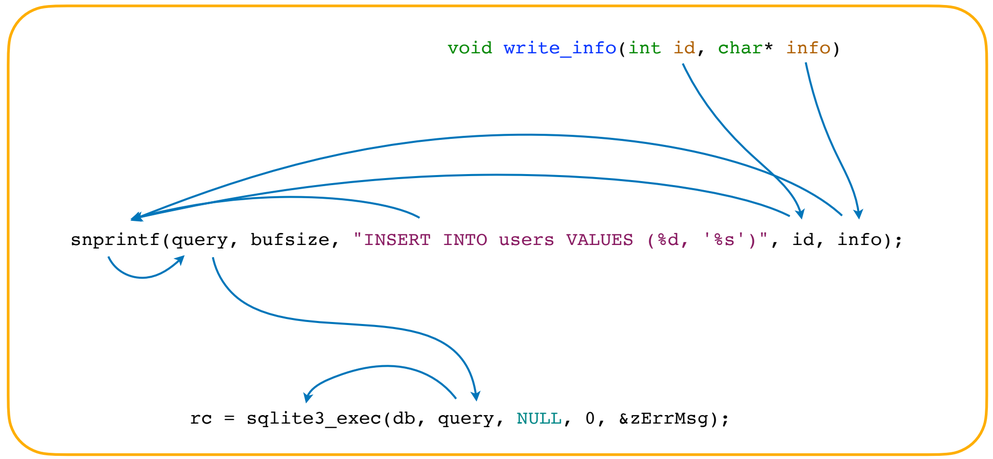


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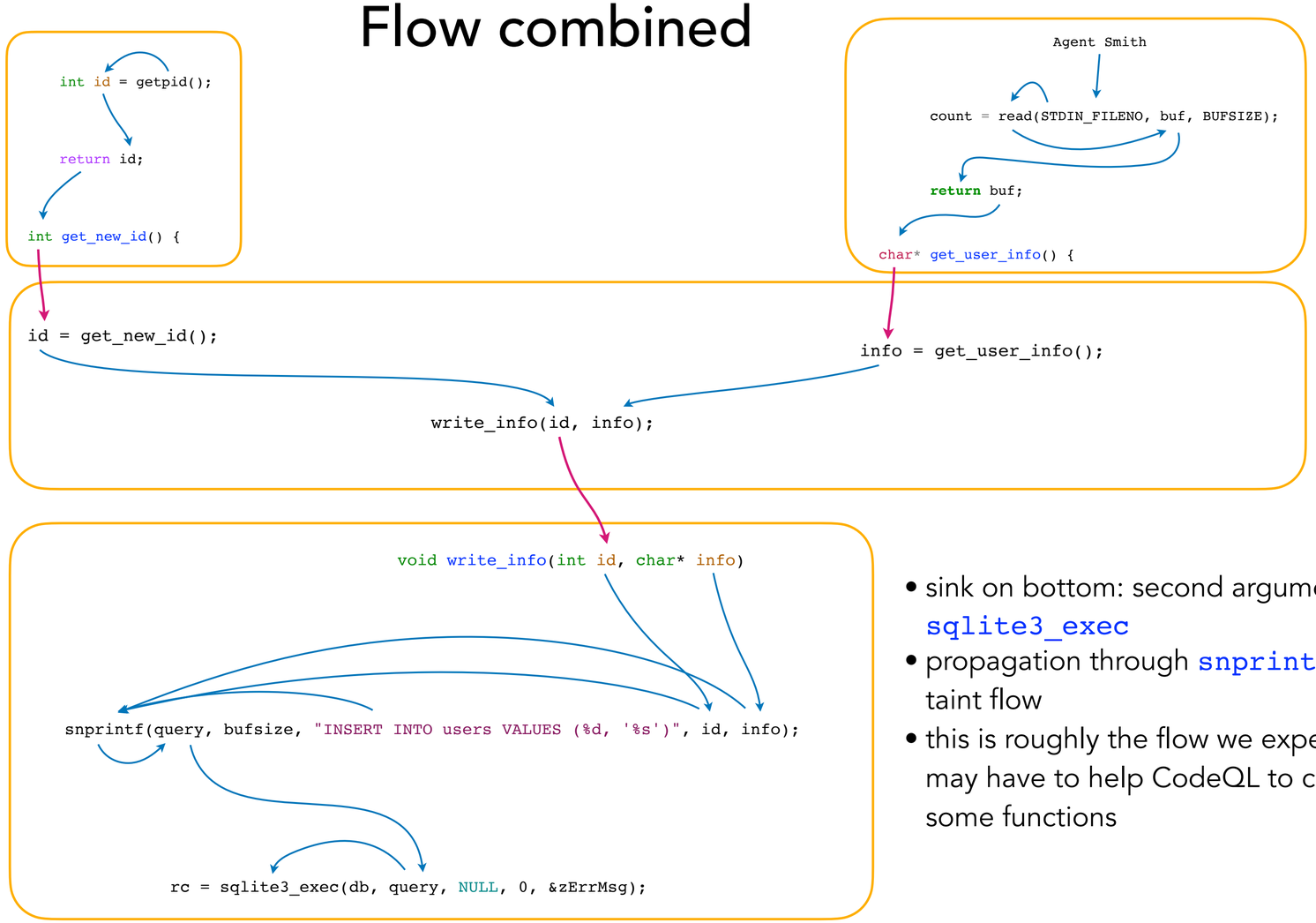


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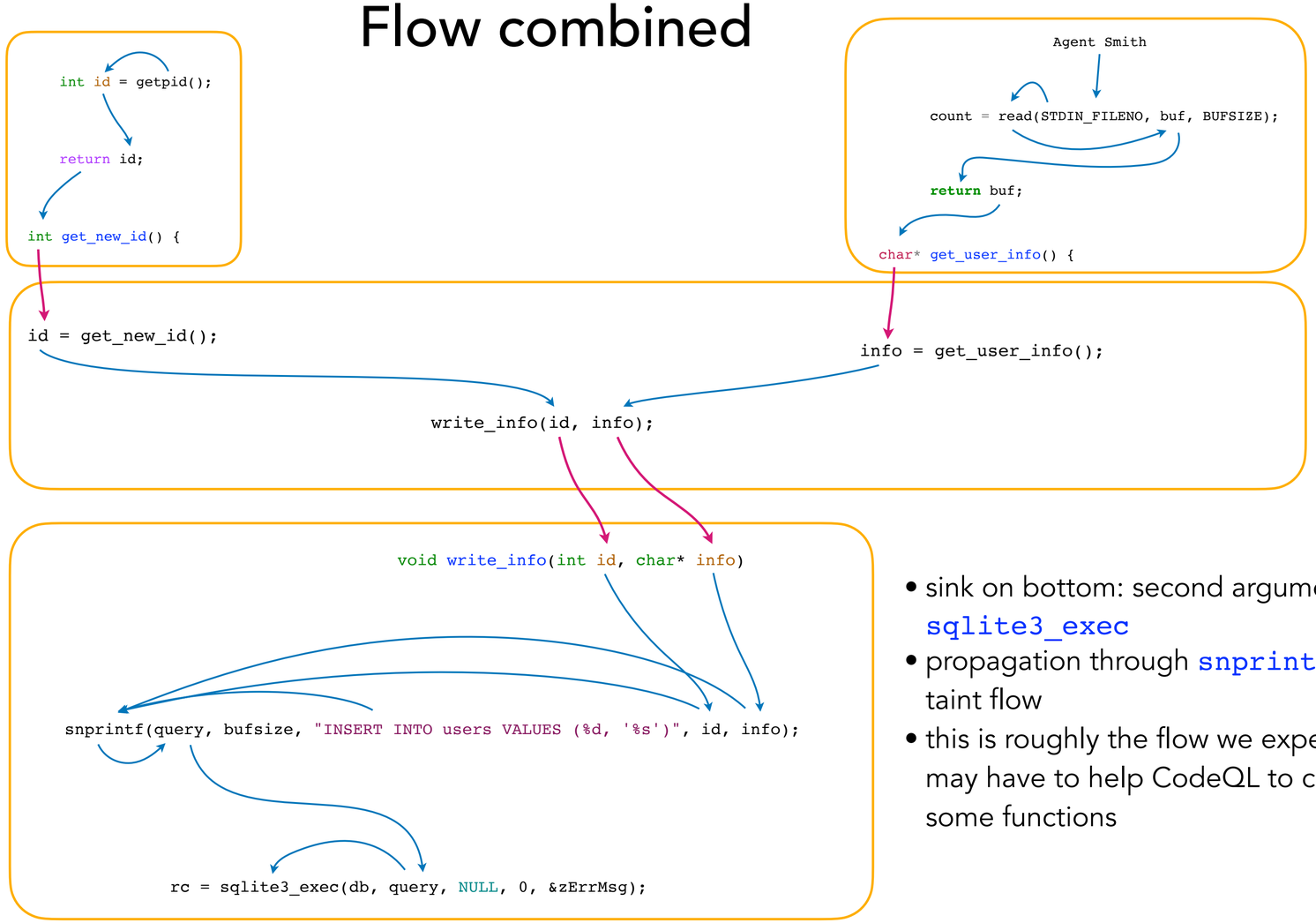


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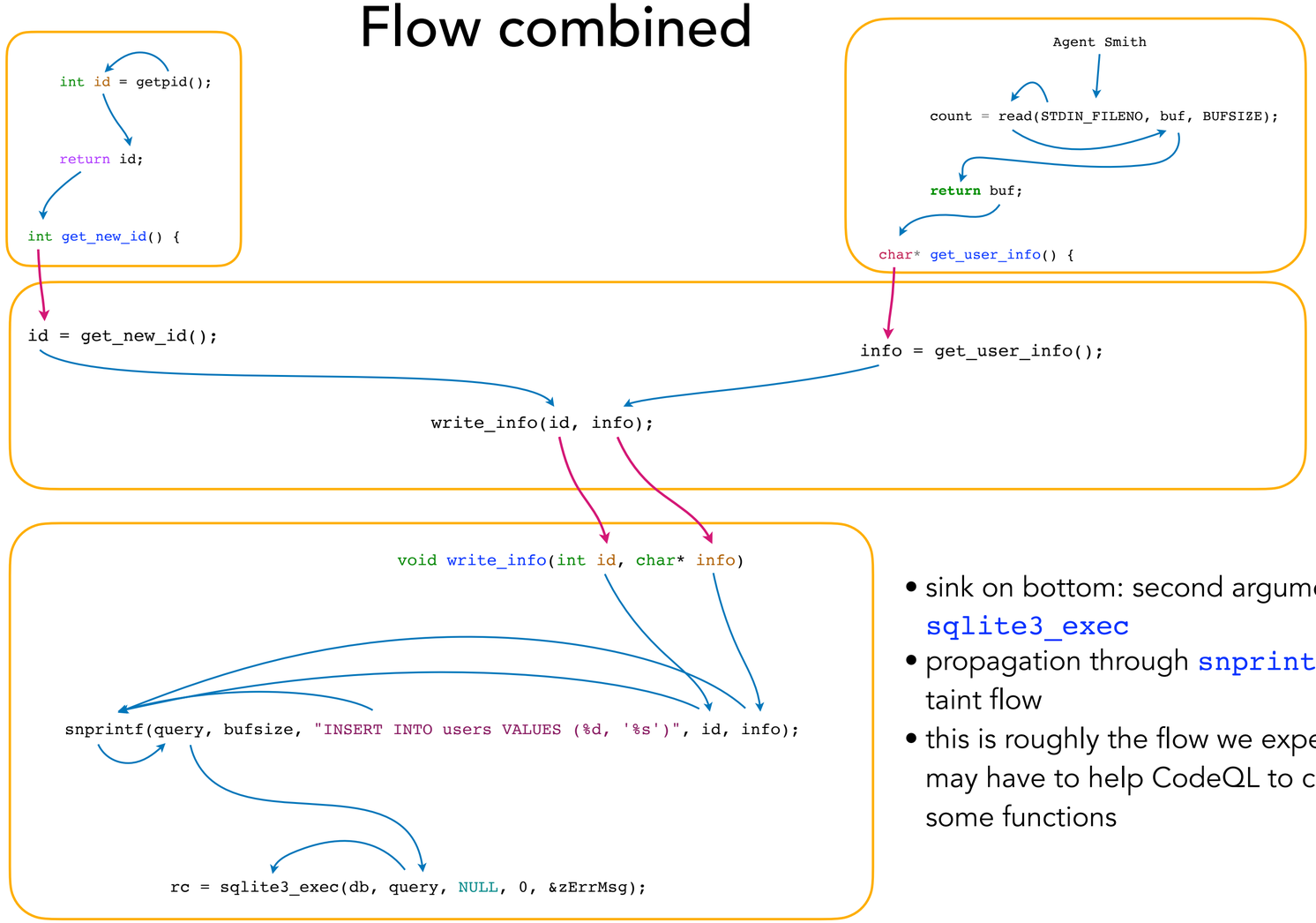


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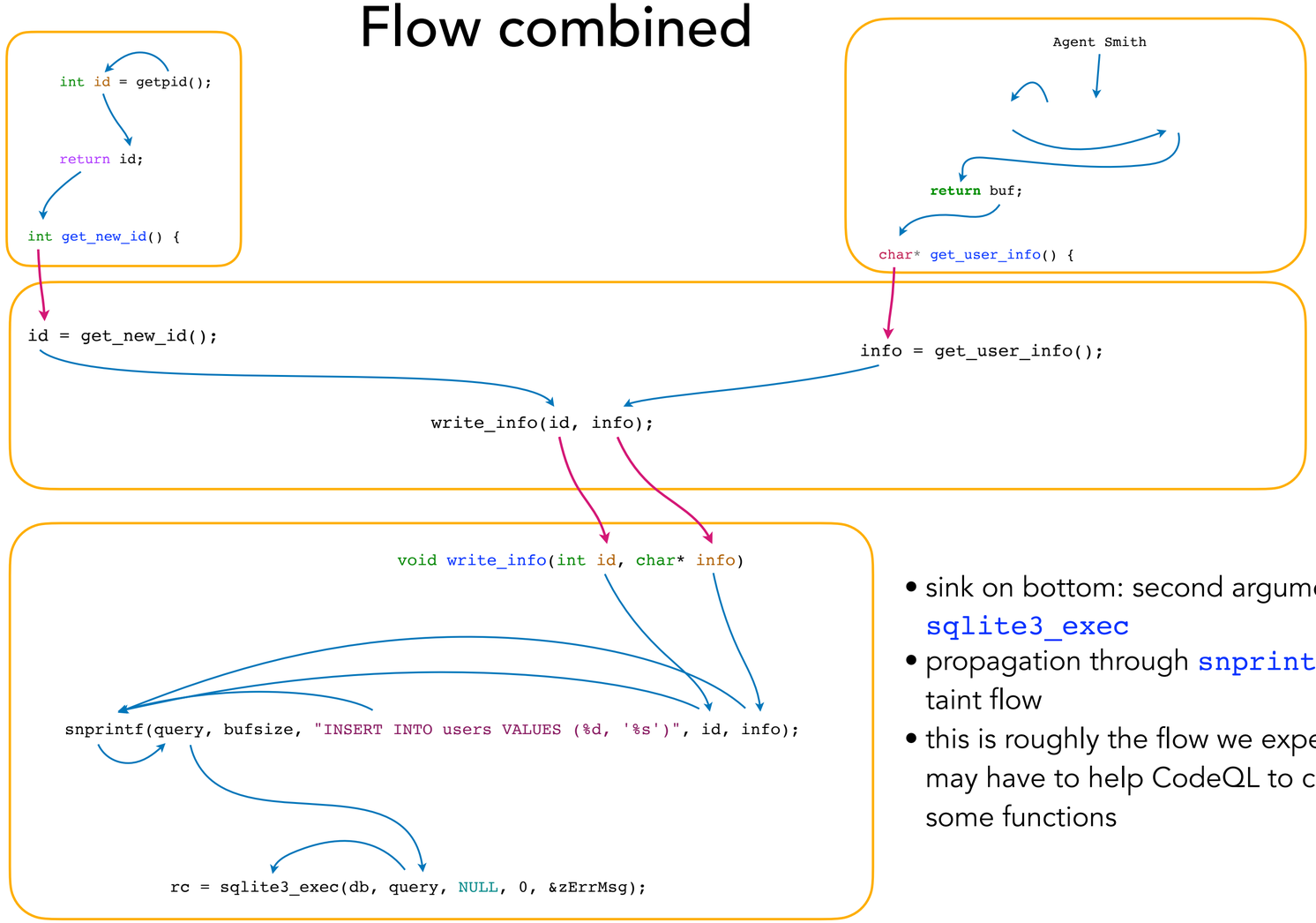


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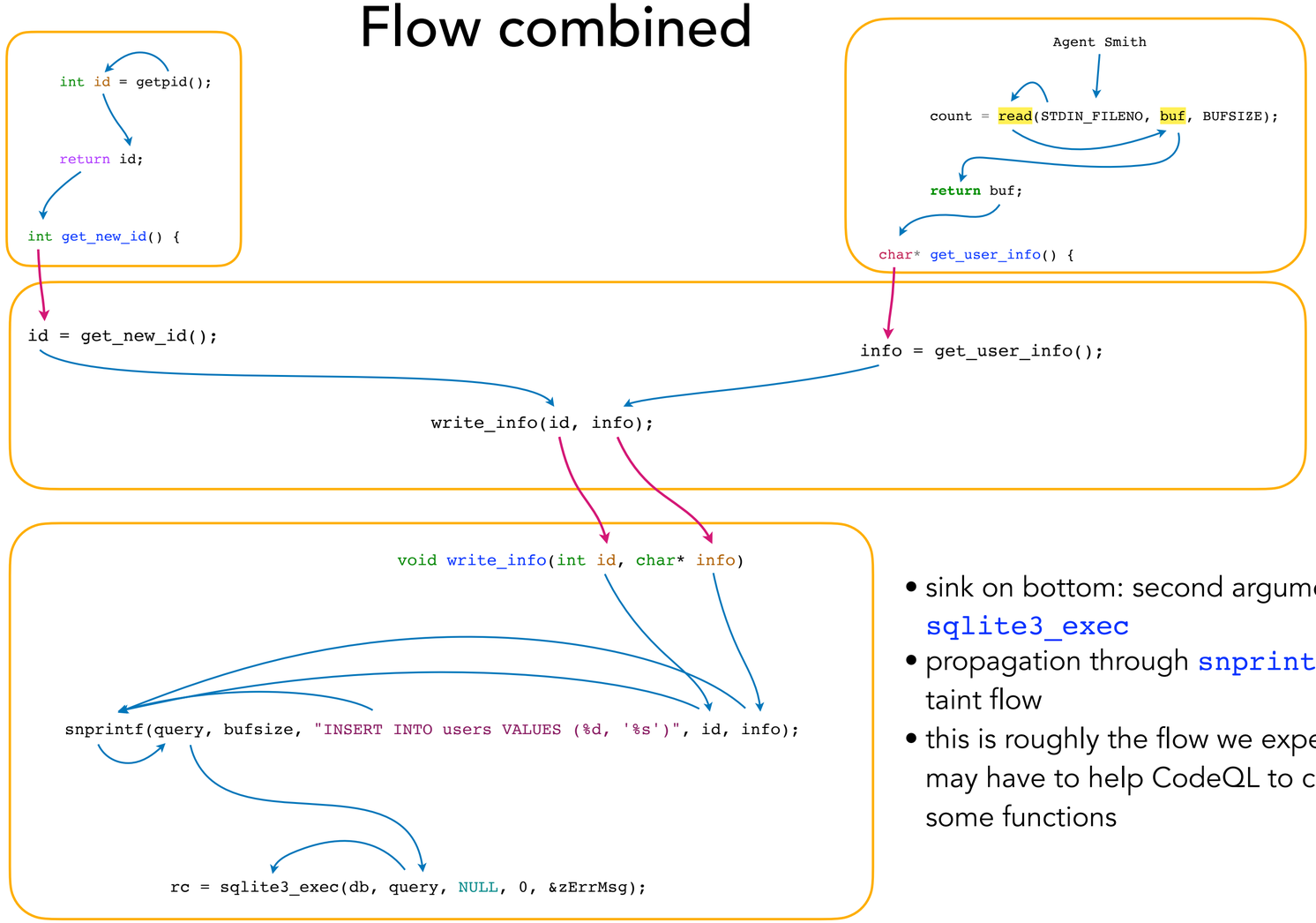


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