# Meta: Enabling Programming Languages to Learn from the Crowd

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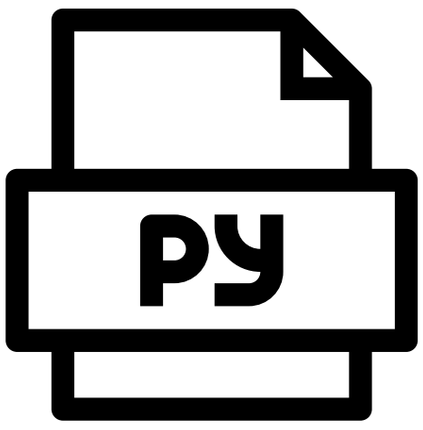
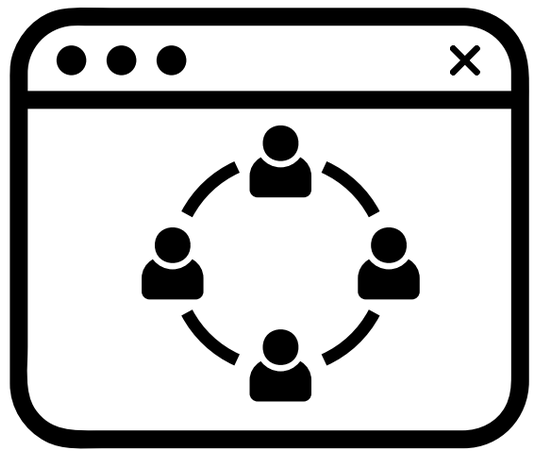
Stanford HCI

# What can programming languages learn from how users write programs?

PROGRAMS




COMMUNITY



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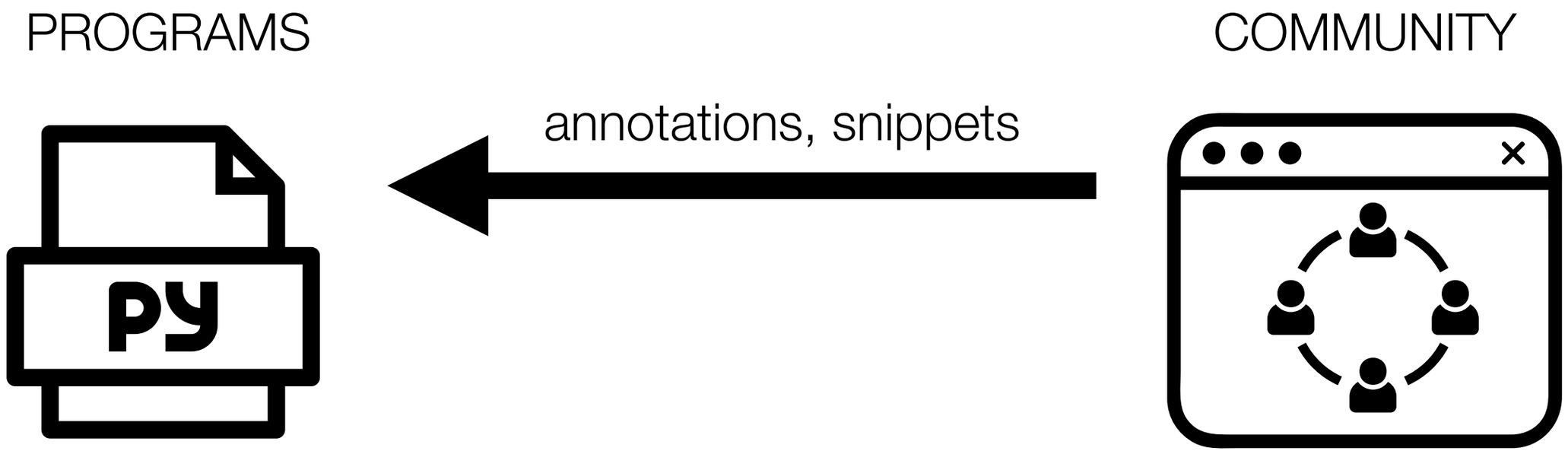


Codex (Fast et al., CHI 2014)
Blueprint (Brandt et al., CHI 2011)

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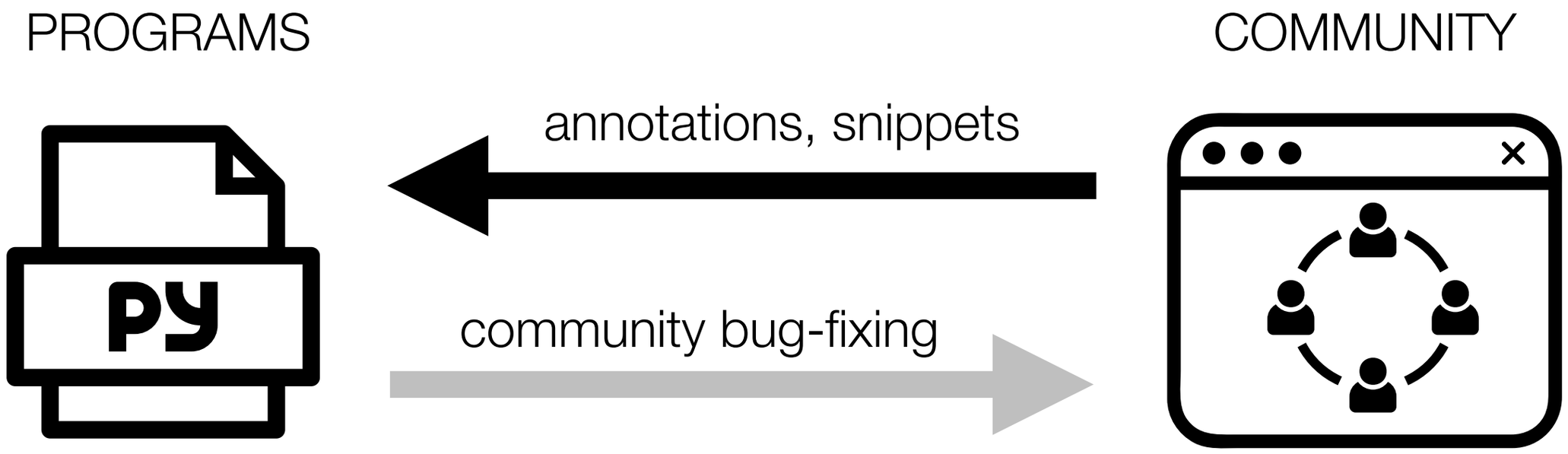


Codex (Fast et al., CHI 2014)
Blueprint (Brandt et al., CHI 2010)
HelpMeOut (Hartmann et al., CHI 2010)

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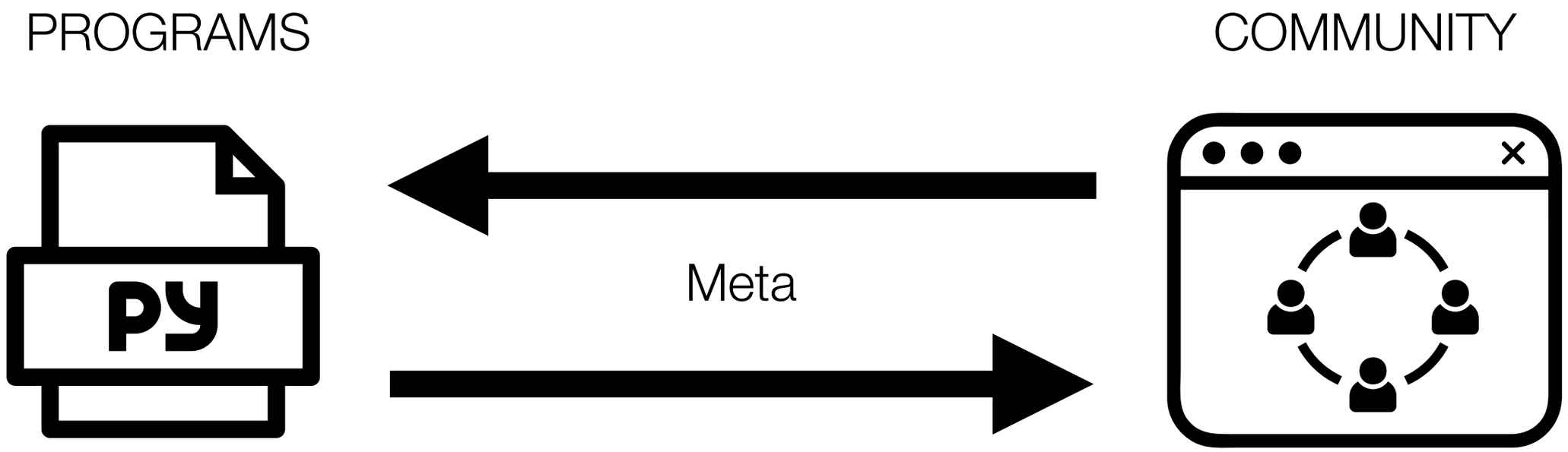


Meta is a language extension for Python that allows users to share functions and records their behavior

```
Meta.search(…)
```

```
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MetaFunction.optimize()
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MetaFunction.bugs()
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# DEMO

Documentation (types and examples)

Search (leverage types and examples)

Optimization (make code faster)

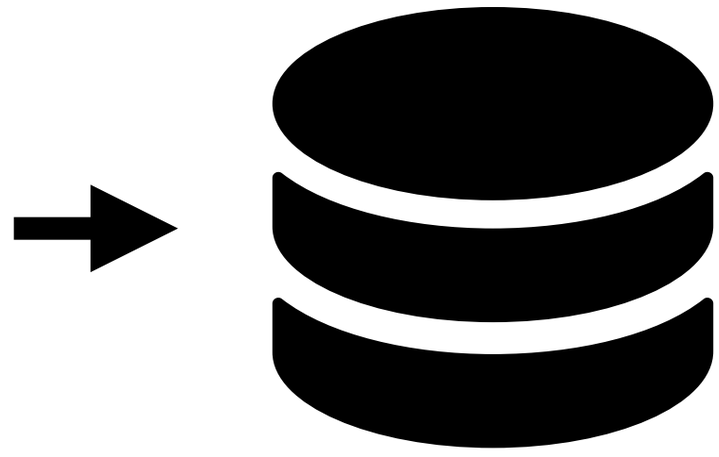
Patching (recover from run-time bugs)

# System Architecture

## CREATING AND LOADING META FUNCTIONS

`@meta(...)`

function name
source code
imported libraries



COMMUNITY DB

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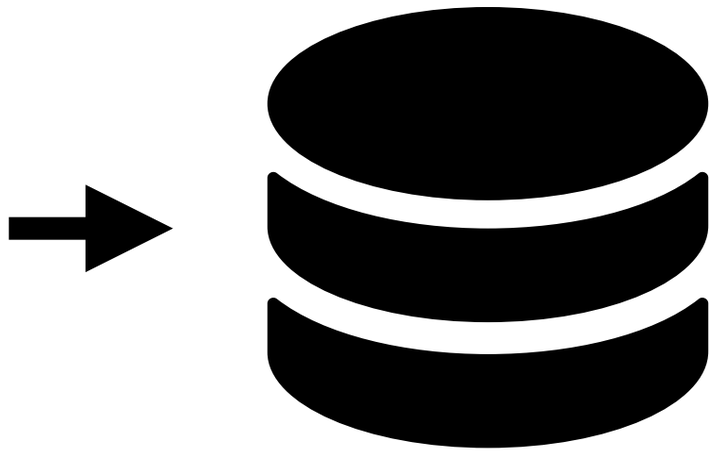

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`meta.load(...)`

load libraries
execute source

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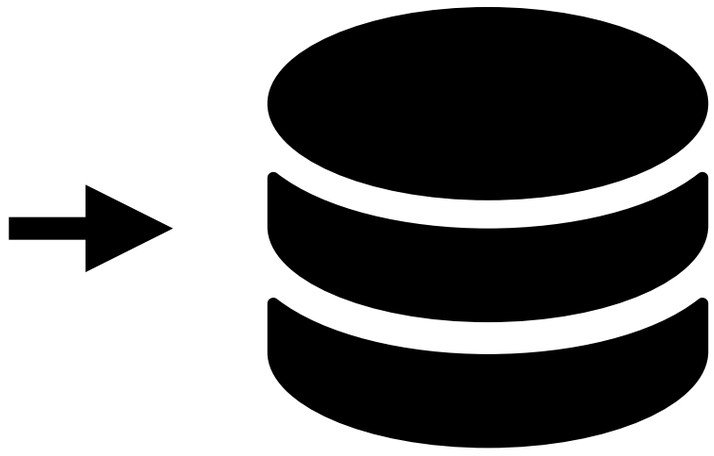

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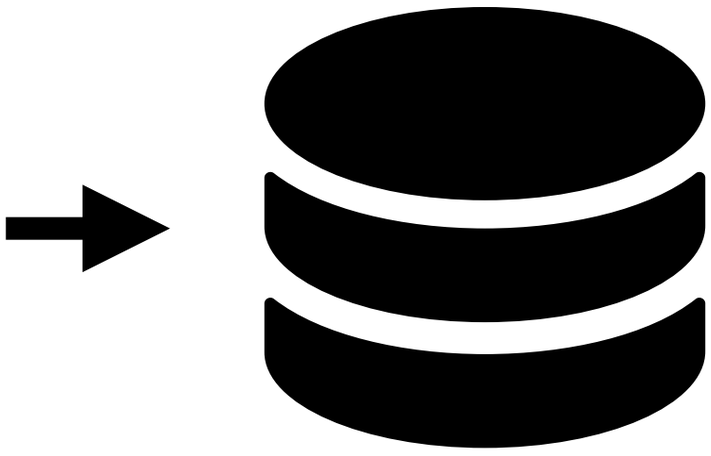

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`meta.load(...)`

load libraries
execute source

Detect IO by instrumenting core system libraries, no global state

Cache loaded functions locally to speed things up and work outside network

# System Architecture

## LEVERAGING COMMUNITY RUN-TIME DATA

`metafunc(...)`

arguments
return value
types of data
execution time
run-time exceptions



COMMUNITY DB

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APIs

```
get_type()
examples()
optimize()
bugs()
auto_patch()
...
```

Sample arguments with P(x) = 1/n for better performance

# Evaluation

## STUDY OF PROFESSIONAL PROGRAMMERS

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**7** programmers, machine learning task

**746** lines of code, **26**% Meta functions

Created **17** Meta functions, loaded **6** unique, executed **15,000** times

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**Design concerns**: security, privacy, community

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**47**ms to load Meta function

**133**ms to create Meta function

**0.31**ms of overhead to run Meta function

For comparison, sorting a list of 5000 words takes **27**ms

Note: creating and loading Meta functions are fixed costs

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Median optimized function was **1.45** times faster

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```
is_capitalized('abc') #=> False
str_is_number('abc') #=> False

# with only this datapoint, can conclude functions are equal
is_capitalized('abc') == str_is_number('abc')
```

# Future Work

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What other features can we design when programming languages learn from how people code?

Is it possible to extend a system like Meta to work beyond pure functions, handling global variables and other kinds of complex state?

# Conclusion

Meta envisions a world where an enormous amount of data about how people program is available for analysis, enabling a new class of intelligent programming environments

Check out www.meta-lang.org/tutorial