

# CS 472 – Provably Correct Programming

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## Questions

Nobody has responded yet.

Hang tight! Responses are coming in.

# Practical Hoare Logic: Iris



- Tool #2: Iris, a verification framework inside Coq/Rocq
  - Based on *separation logic*, a program logic with support for memory and shared resources
  - Default language is a simple functional language with memory
  - Proofs combine *symbolic execution* of programs with tactics for using/proving facts about resources
- Iris has lots of extensions, applications, and target languages. We'll look at a few!

# Separation Logic

- Logic for programs with *memory* (pointers, references, etc.)

- Two special kinds of assertions:

$p \mapsto v$  means “ $p$  is a pointer that points to  $v$ ”

$P * Q$  means “ $P$  and  $Q$  are true *on separate parts of memory*”

$$\{ p \mapsto 2 \wedge q \mapsto 2 \} * p = 4 \{ p \mapsto 4 \wedge q \mapsto 2 \}$$

Not true if  $p = q$ !

$$\{ p \mapsto 2 * q \mapsto 2 \} * p = 4 \{ p \mapsto 4 * q \mapsto 2 \}$$

# Separation Logic: Loads and Stores

- Logic for programs with *memory* (pointers, references, etc.)
- Two special kinds of assertions:
  - $p \mapsto v$  means “ $p$  is a pointer that points to  $v$ ”
  - $P * Q$  means “ $P$  and  $Q$  are true *on separate parts of memory*”

$$\{ p \mapsto v \} x = *p \{ p \mapsto v \wedge x = v \}$$

$$\{ p \mapsto v \} *p = a \{ p \mapsto a \}$$

# Separation Logic: Resources

$H : P$

---

$P \wedge P$

split.

$H : P$

---

$P$

$H : P$

---

$P$

# Separation Logic: Resources

$H : x \mapsto v$

---

$x \mapsto v * x \mapsto v$

Shouldn't be provable!

If we could split:

$H : x \mapsto v$

---

$x \mapsto v$

---

$x \mapsto v$

# Separation Logic: Resources

$H : x \mapsto v$

---

$\text{exists } p1 \ p2 \ v1 \ v2, \ p1 \mapsto v1 \ * \ p2 \mapsto v2$

Shouldn't be provable!

“two different pointers exist in memory”

We have to “use up” a points-to assertion in order to prove something with it: it's more like a *resource* than a logical fact

# Separation Logic: Resources

- Logical facts like  $x = 2$ ,  $x < 5$ , etc. stay true when they're true: we don't have to "use them up" to prove things about  $x$
- But points-to assertions *do* get used up!
  - $p \mapsto v$  does *not* imply  $p \mapsto v * p \mapsto v$
  - only one function/thread/program at a time can own a piece of memory
- $p \mapsto v$  is more like a *resource* than a logical statement: we can pass it around between functions, but once we use it to prove something, it's gone
- We'll need special tactics to manage resources in a program!

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# Setting Up Iris (version 4.2.0)

- If you installed the [Coq Platform](#), you probably have it already
- If you installed Coq via OPAM, you can use OPAM to install Iris too (see instructions at <https://gitlab.mpi-sws.org/iris/iris/-/tree/iris-4.2.0>)
- Otherwise, you may need to build it from source: clone the repo at <https://gitlab.mpi-sws.org/iris/iris/-/tree/iris-4.2.0>, and run `make && make install` in that folder
- If it's working, you should be able to run this line in your IDE:  
`Require Import iris.heap_lang.proofmode.`

# Setting Up Iris – Special Characters

- There's a lot of fancy notation and special characters in Iris!
- My preferred font is [DejaVu Sans Mono](#)
- You can find instructions for setting up your editor at <https://gitlab.mpi-sws.org/iris/iris/-/blob/master/docs/editor.md>
- You can also do `Require Import iris.bi.ascii.` to enable ASCII notations (full list at <https://gitlab.mpi-sws.org/iris/iris/-/blob/master/iris/bi/ascii.v>)

# Iris Resources

- We will be working from the Iris Tutorial (<https://github.com/logsem/iris-tutorial>)
- A really good overview of the whole system from the ground up is available at <https://arxiv.org/pdf/2105.12077.pdf>
- There are links to more tutorials and lecture notes at <https://iris-project.org/#learning>
- A list of tactics is at [https://gitlab.mpi-sws.org/iris/iris/-/blob/master/docs/proof\\_mode.md](https://gitlab.mpi-sws.org/iris/iris/-/blob/master/docs/proof_mode.md)

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