Incorrectness Logic for Scalable Bug Detection

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State of the Art: ***Correctness***

- Lots of work on ***reasoning*** for proving ***correctness***
  - ➡ Prove the ***absence of bugs***
  - ➡ ***Over-approximate*** reasoning

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    in ***resources*** accessed ⇒ spatial locality

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  - ➡ ***Over-approximate*** reasoning
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    in ***code*** ⇒ reasoning about ***incomplete components***

    in ***resources*** accessed ⇒ spatial locality
  - ➡ ***Scalability*** to large teams and codebases

Hoare Logic (HL)

Hoare triples $\{p\}\ C\ \{q\}$

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For all states s *in* p
if running C *on* s *terminates in* s', *then* s' *is in* q

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Hoare triples $\{p\}\ C\ \{q\}$ *iff* $post(C)p \subseteq q$

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q *over-approximates* post(C)p

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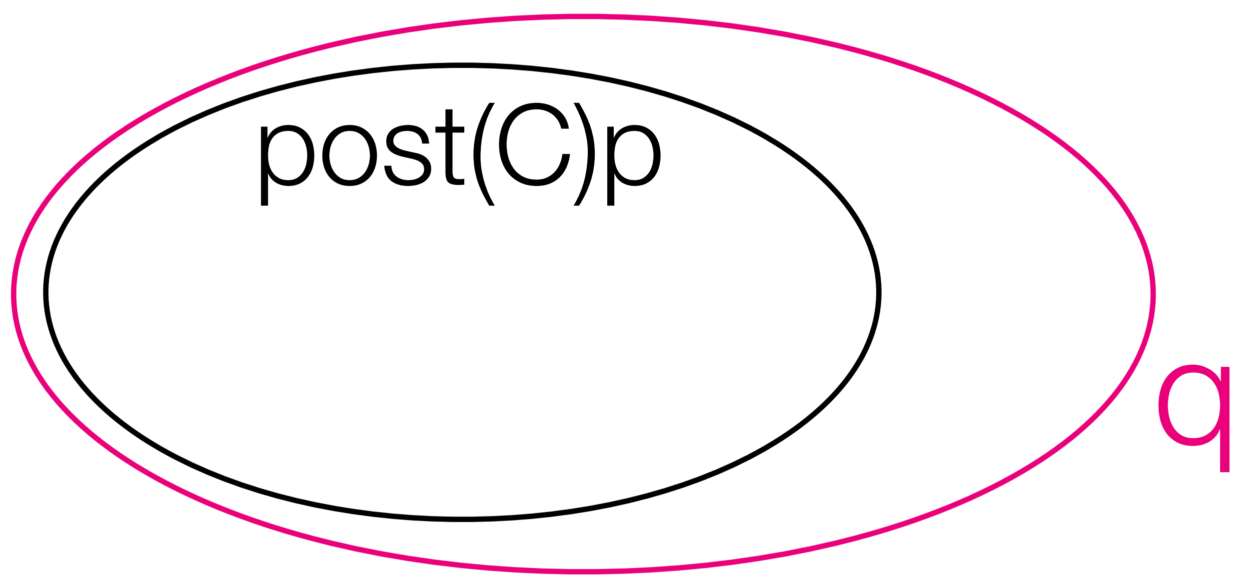

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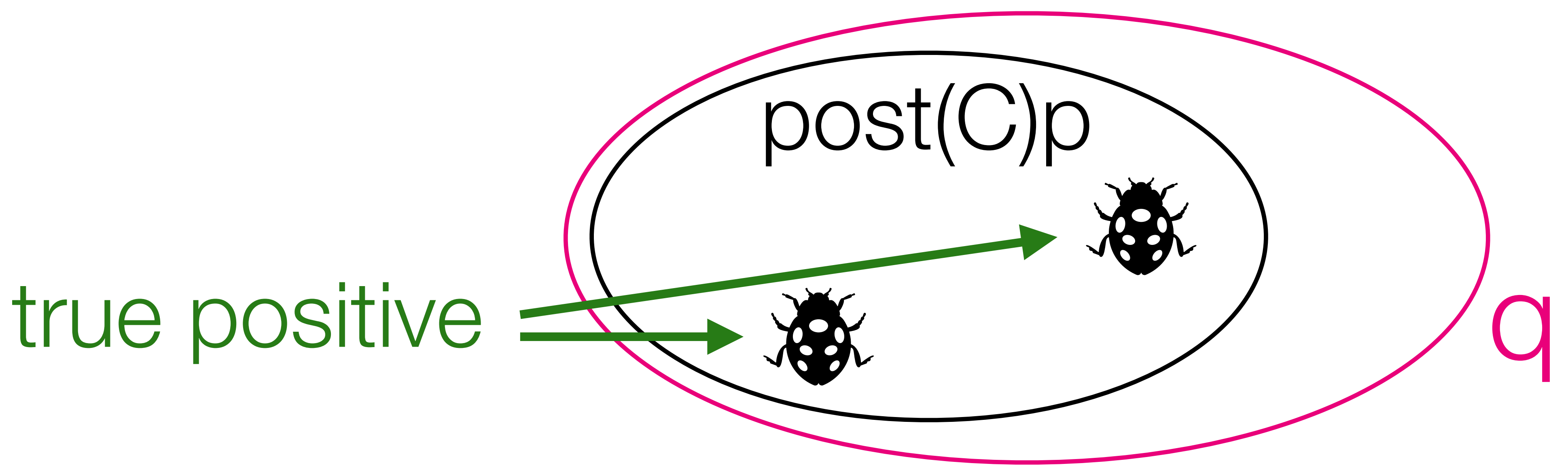

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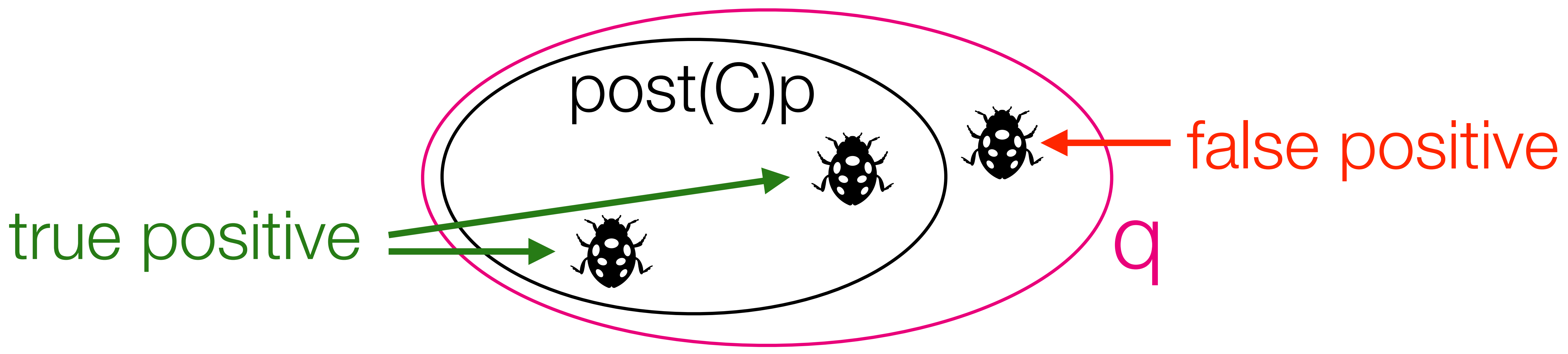

“Don’t spam the developers!”

Incorrectness Logic:

A Formal Foundation

for

Bug Catching

Part I.

Incorrectness Logic (IL)

&

Incorrectness Separation Logic (ISL)

Incorrectness Logic (IL)

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$post(C)p \supseteq q$

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Incorrectness triples $[p]\ C\ [q]$ *iff* $post(C)p \supseteq q$

For all states s in q
s *can be reached by running* C *on some* s' *in* p

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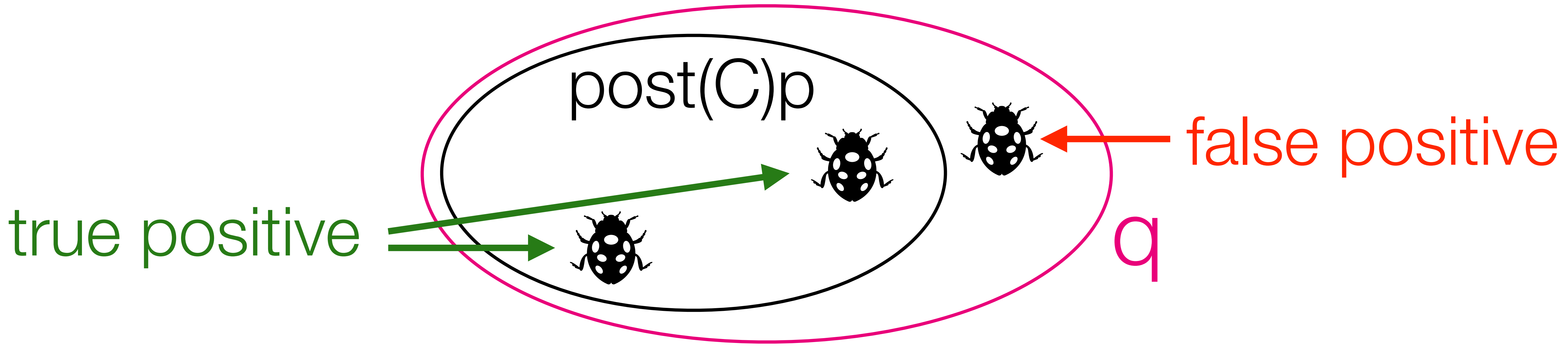
q *over-approximates* post(C)p



Incorrectness triples $[p]\ C\ [q]$ *iff* $post(C)p \supseteq q$

q *under-approximates* post(C)p

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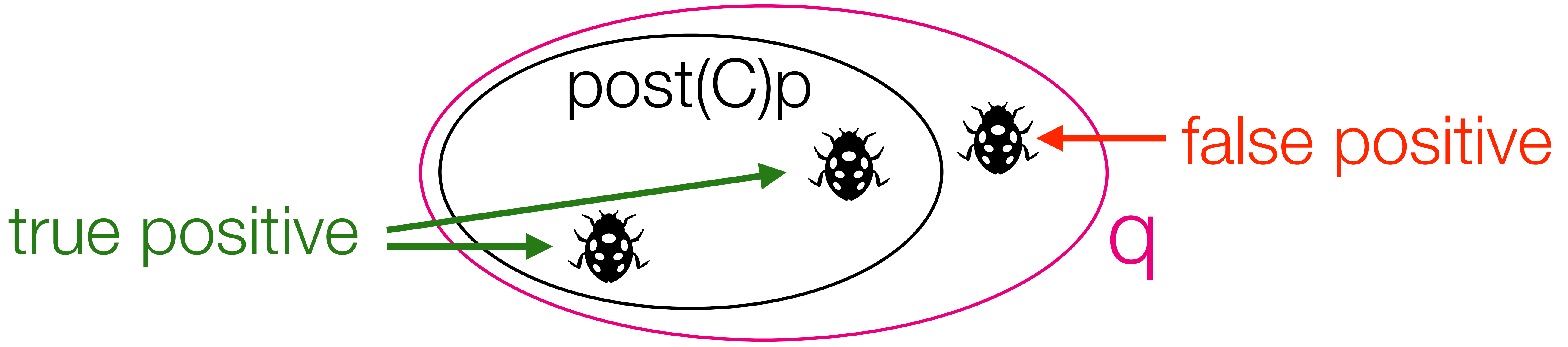

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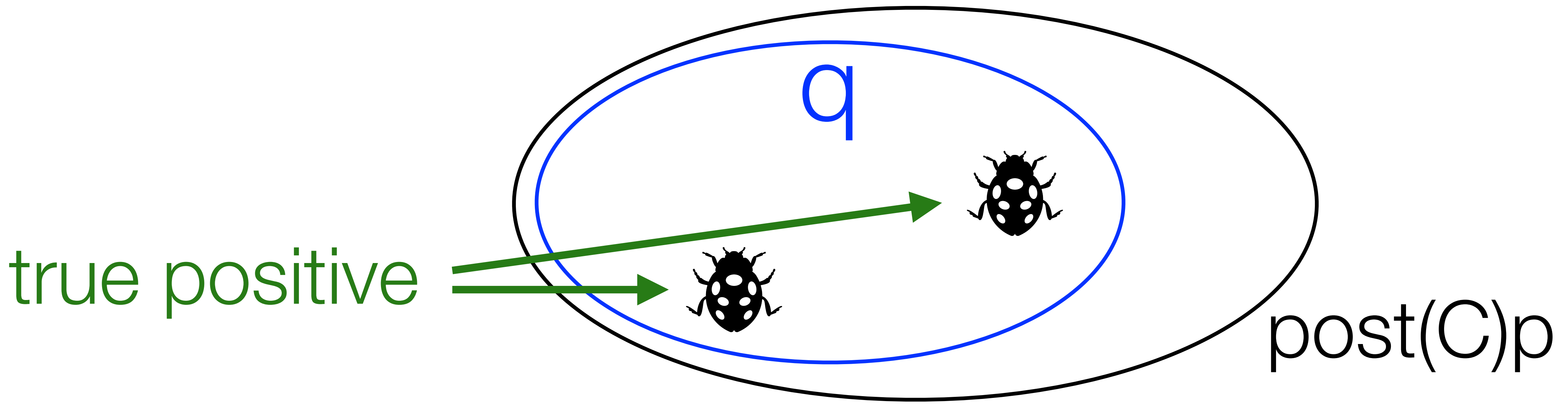

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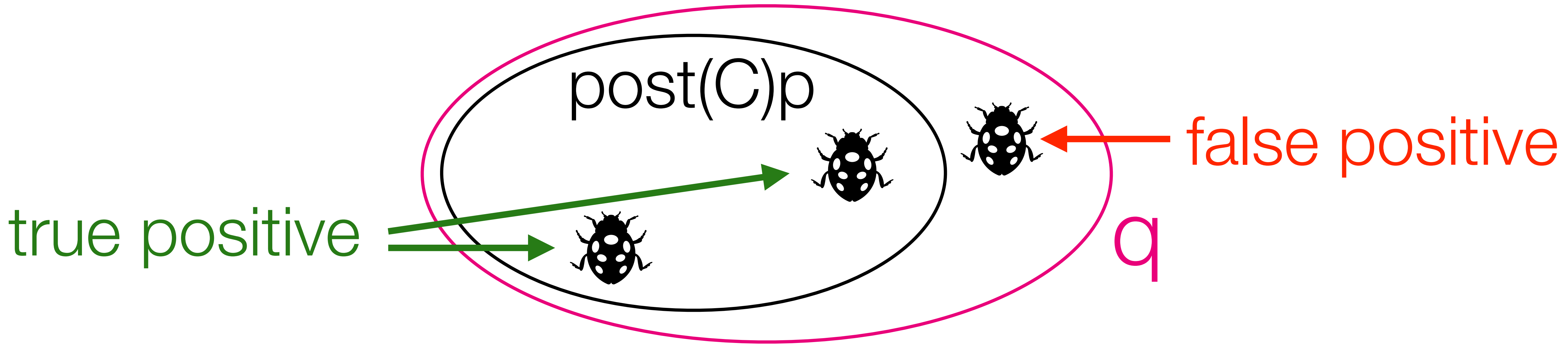

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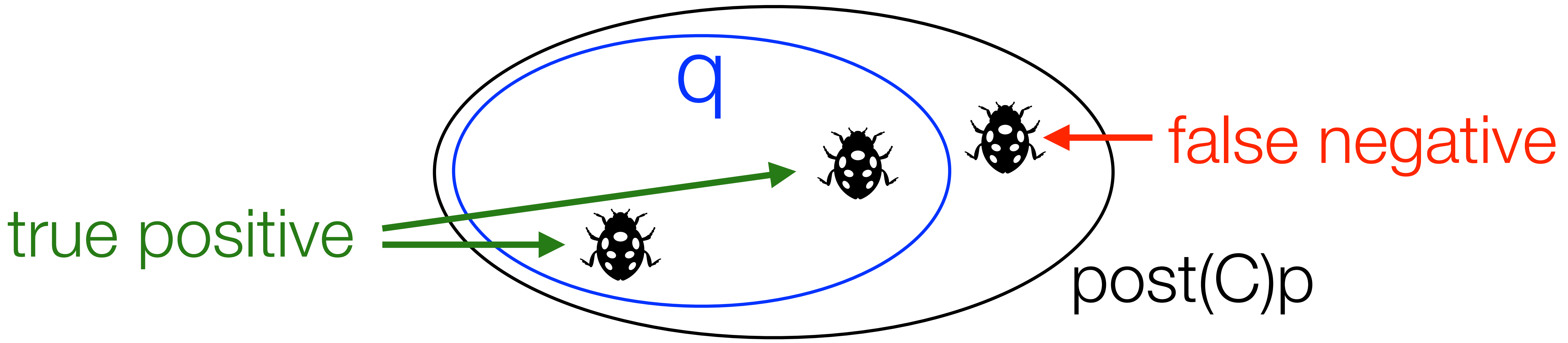

Incorrectness Logic (IL)

$[p]\ C\ [\varepsilon: q]$

ε: exit condition

ok: normal execution

er : erroneous execution

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ε: exit condition

ok: normal execution

er : erroneous execution

[y=v] x:=y [ok: x=y=v]

Incorrectness Logic (IL)

$[p]\ C\ [\varepsilon\!: q]$

ε: exit condition

ok: normal execution

er : erroneous execution

$[y{=}v]\ x{:=}y\ [ok\!: x{=}y{=}v]$

$[p]\ \mathrm{error}(\,)\ [er\!: p]$

Incorrectness Logic (IL)

$[p]\ C\ [\varepsilon : q]$ *iff* $\mathrm{post}(C, \varepsilon)p \supseteq q$

Equivalent Definition (reachability)

$[p]\ C\ [\varepsilon : q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s', s) \in [C]\varepsilon$

Incorrectness Logic: Summary

+ ***Under-approximate*** analogue of Hoare Logic

+ Formal foundation for ***bug catching***

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+ ***Under-approximate*** analogue of Hoare Logic

+ Formal foundation for ***bug catching***

– Global reasoning: ***non-compositional*** (as in original Hoare Logic)

– Cannot target ***memory safety bugs*** (e.g. use-after-free)

Incorrectness Logic: Summary

+ ***Under-approximate*** analogue of Hoare Logic

+ Formal foundation for ***bug catching***

– Global reasonin

– Cannot target *n*

<u>***Our Solution***</u>

Incorrectness Separation Logic

What Is Separation Logic (SL)?

SL : ***Local*** & ***compositional*** reasoning via ***ownership*** & ***separation***

☛ ideal for heap-manipulating programs with ***aliasing***

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☛ ideal for heap-manipulating programs with ***aliasing***

```
[x]:= 1;
[y]:= 2;
[z]:= 3;
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post: $\{x = 1 \wedge y = 2 \wedge z = 3\}$

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pre: $\{x \neq y \land x \neq z \land y \neq z\}$

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pre: $\{ x_1 \neq x_2 \wedge x_1 \neq x_3 \wedge \ldots \}$

```
[x1]:= 1;
[x2]:= 2;
…
[xn]:= n;
```

post: $\{ x_1 = 1 \wedge \ldots \wedge x_n = n \}$

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SL : ***Local*** & ***compositional*** reasoning via ***ownership*** & ***separation***

☛ ideal for heap-manipulating programs with ***aliasing***

pre: $\{\boxed{x_1 \neq x_2 \wedge x_1 \neq x_3 \wedge \ldots}\}$

```
[x₁]:= 1;
[x₂]:= 2;
…
[xₙ]:= n;
```

post: $\{ x_1 = 1 \wedge \ldots \wedge x_n = n \}$

n!/2 conjuncts !

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SL : ***Local*** & ***compositional*** reasoning via ***ownership*** & ***separation***

☛ ideal for heap-manipulating programs with ***aliasing***

pre: $\{ x \mapsto - * y \mapsto - * z \mapsto - \}$

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pre: $\{\boxed{x \mapsto -} * y \mapsto - * z \mapsto -\}$

ownership
of heap cell at x

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'and ***separately***'

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'and ***separately***'

post: $\{ x \mapsto 1 \ast y \mapsto 2 \ast z \mapsto 3 \}$

$$\forall x,v,v'.\ x \mapsto v \ast x \mapsto v' \Rightarrow \text{false}$$

The Essence of Separation Logic (SL)

Frame Rule

$$\frac{\{p\}\ C\ \{q\}}{\{p \ast r\}\ C\ \{q \ast r\}}$$

$x \mapsto v \ast x \mapsto v' \Leftrightarrow \text{false}$

$p \ast \text{emp} \Leftrightarrow p$

The Essence of Separation Logic (SL)

Frame Rule

$$\frac{\{p\}\ C\ \{q\}}{\{p * r\}\ C\ \{q * r\}}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$ $\qquad$ $p \ * \ \text{emp} \Leftrightarrow p$

Local Axioms

WRITE $\quad \{x \mapsto -\}\ [x] := v\ \{x \mapsto v\}$

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WRITE $\{x \mapsto -\}\ [x] := v\ \{x \mapsto v\}$

READ $\{x \mapsto v\}\ y := [x]\ \{x \mapsto v \wedge y = v\}$

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Local Axioms

WRITE	$\{x \mapsto -\}\ [x] := v\ \{x \mapsto v\}$
READ	$\{x \mapsto v\}\ y := [x]\ \{x \mapsto v \land y = v\}$
ALLOC	$\{\text{emp}\}\ x := \text{alloc}()\ \{\exists l.\ l \mapsto - \land x = l\}$

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READ $\{x \mapsto v\}\ y := [x]\ \{x \mapsto v \land y = v\}$

ALLOC $\{\text{emp}\}\ x := \text{alloc}()\ \{\exists l.\ l \mapsto - \land x = l\}$

FREE $\{x \mapsto -\}\ \text{free}(x)\ \{\ \text{emp}\ \}$

Incorrectness Separation Logic (ISL)

IL

$[p]\ C\ [\varepsilon: q]$

SL

$$\frac{\{p\}\ C\ \{q\}}{\{p * r\}\ C\ \{q * r\}}$$

$x \mapsto - \ * \ x \mapsto - \Leftrightarrow \text{false}$

$x \mapsto v \ * \ \text{emp} \Leftrightarrow x \mapsto v$

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IL

$$[p]\ C\ [\varepsilon\!: q]$$

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$$\frac{\{p\}\ C\ \{q\}}{\{p * r\}\ C\ \{q * r\}}$$

$$x \mapsto - \ * \ x \mapsto - \Leftrightarrow \text{false}$$

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ISL

$$\frac{[p]\ C\ [\varepsilon\!: q]}{[p * r]\ C\ [\varepsilon\!: q * r]}$$

$$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$$

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ISL: Local Axioms (First Attempt)

WRITE

[x ↦ v'] [x]:= v [ok: x ↦ v]

ISL: Local Axioms (First Attempt)

WRITE

[x ↦ v'] [x]:= v [ok: x ↦ v]

[x=null] [x]:= v [er: x=null]

ISL: Local Axioms (First Attempt)

WRITE

$[x \mapsto v'] \; [x] := v \; [ok: x \mapsto v]$

$\boxed{[x = \text{null}] \; [x] := v \; [er: x = \text{null}]}$

null-pointer dereference error

ISL: Local Axioms (First Attempt)

WRITE

$[x \mapsto v'] \ [x] := v \ [ok: x \mapsto v]$ $\qquad$ $\boxed{[x{=}null] \ [x] := v \ [er: x{=}null]}$

null-pointer dereference error

READ

$[x \mapsto v] \ y := [x] \ [ok: x \mapsto v \land y{=}v]$ $\qquad$ $[x{=}null] \ y := [x] \ [er: x{=}null]$

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$[x \mapsto v'] \; [x] := v \; [ok: x \mapsto v]$

$[x = null] \; [x] := v \; [er: x = null]$

null-pointer dereference error

READ

$[x \mapsto v] \; y := [x] \; [ok: x \mapsto v \land y = v]$

$[x = null] \; y := [x] \; [er: x = null]$

ALLOC

$[emp] \; x := alloc() \; [ok: \exists l.\; l \mapsto v \land x = l]$

ISL: Local Axioms (First Attempt)

WRITE

$[x \mapsto v'] \; [x] := v \; [ok: x \mapsto v]$ $\qquad$ $\boxed{[x{=}null] \; [x] := v \; [er: x{=}null]}$

null-pointer dereference error

READ

$[x \mapsto v] \; y := [x] \; [ok: x \mapsto v \wedge y{=}v]$ $\qquad$ $[x{=}null] \; y := [x] \; [er: x{=}null]$

ALLOC

$[emp] \; x := alloc() \; [ok: \exists l.\ l \mapsto v \wedge x{=}l]$

FREE

$[x \mapsto v] \; free(x) \; [ok: emp]$ $\qquad$ $[x{=}null] \; free(x) \; [er: x{=}null]$

ISL: Local Axioms (First Attempt)

WRITE

$[x \mapsto v']\ [x] := v\ [ok: x \mapsto v]$ $\qquad$ $\boxed{[x = null]\ [x] := v\ [er: x = null]}$

null-pointer dereference error

READ

$[x \mapsto v]\ y := [x]\ [ok: x \mapsto v \land y = v]$ $\qquad$ $[x = null]\ y := [x]\ [er: x = null]$

ALLOC

$[emp]\ x := alloc()\ [ok: \exists l.\ l \mapsto v \land x = l]$

FREE

$[x \mapsto v]\ free(x)\ [ok: emp]$ $\qquad$ $\ldots ll]\ free(x)\ [er: x = null]$

ISL: Local Axioms (First Attempt)

ISL

$$\frac{[p]\ C\ [\varepsilon\!:\ q]}{[p * r]\ C\ [\varepsilon\!:\ q * r]}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$

$\text{emp} \ * \ p \Leftrightarrow p$

$[x \mapsto v]$ free(x) $[ok\!:\ \text{emp}]$

$[p]\ C\ [\varepsilon\!:\ q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s', s) \in [C]\varepsilon$

ISL: Local Axioms (First Attempt)

ISL

$$\frac{[p]\ C\ [\varepsilon{:}\ q]}{[p * r]\ C\ [\varepsilon{:}\ q * r]}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$

$\text{emp} \ * \ p \Leftrightarrow p$

$$\frac{[x \mapsto v]\ \text{free}(x)\ [ok{:}\ \text{emp}]}{[x \mapsto v * x \mapsto v]\ \text{free}(x)\ [ok{:}\ \text{emp} * x \mapsto v]}\ (\text{Frame})$$

$[p]\ C\ [\varepsilon{:}\ q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s', s) \in [C]\varepsilon$

ISL: Local Axioms (First Attempt)

ISL

$$\frac{[p]\ C\ [\varepsilon: q]}{[p * r]\ C\ [\varepsilon: q * r]}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$

$\text{emp} \ * \ p \Leftrightarrow p$

$$\dfrac{\dfrac{[x \mapsto v]\ \text{free}(x)\ [ok: \text{emp}]}{[x \mapsto v * x \mapsto v]\ \text{free}(x)\ [ok: \text{emp} * x \mapsto v]}\ (\text{Frame})}{[\text{false}]\ \text{free}(x)\ [ok: x \mapsto v]}\ (\text{Cons})$$

$[p]\ C\ [\varepsilon: q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s',s) \in [C]\varepsilon$

ISL: Local Axioms (First Attempt)

ISL

$$\frac{[p]\ C\ [\varepsilon\!: q]}{[p * r]\ C\ [\varepsilon\!: q * r]}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$

$\text{emp} \ * \ p \Leftrightarrow p$

$$\dfrac{\dfrac{[x \mapsto v]\ \text{free}(x)\ [\text{ok: emp}]}{[x \mapsto v * x \mapsto v]\ \text{free}(x)\ [\text{ok: emp} * x \mapsto v]}\ \text{(Frame)}}{[\text{false}]\ \text{free}(x)\ [\text{ok: } x \mapsto v]}\ \text{(Cons)}$$

$[p]\ C\ [\varepsilon\!: q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s', s) \in [C]\varepsilon$

$[\text{false}]\ C\ [\varepsilon\!: q]$ ✗ (unless $q \Rightarrow \text{false}$)

ISL: Local Axioms (First Attempt)

ISL

$$\frac{[p]\ C\ [\varepsilon: q]}{[p * r]\ C\ [\varepsilon: q * r]}$$

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow \text{false}$

$\text{emp} \ * \ p \Leftrightarrow p$

(Frame)

[x ↦ v ... ↦ v]

(Cons)

Solution:

Track Deallocated Locations!

$[p]\ C\ [\varepsilon: q]$ *iff* $\forall s \in q.\ \exists s' \in p.\ (s', s) \in [C]\varepsilon$

$[\text{false}]\ C\ [\varepsilon: q]$ ✗ (unless $q \Rightarrow \text{false}$)

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$[x \mapsto v]$ free(x) $[ok: \ emp]$

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x is ***deallocated***

Solution: Track Deallocated Locations!

$[x \mapsto v]$ free(x) $[ok: \boxed{x \not\mapsto}]$

x is ***deallocated***

$x \mapsto v \ * \ x \mapsto v' \Leftrightarrow$ false

$p \ * \ emp \Leftrightarrow p$

Solution: Track Deallocated Locations!

$[x \mapsto v]$ free(x) $[ok: \boxed{x \not\mapsto}]$

x is ***deallocated***

$$x \mapsto v \ast x \mapsto v' \Leftrightarrow \text{false}$$
$$p \ast \text{emp} \Leftrightarrow p$$
$$x \mapsto v \ast x \not\mapsto \Leftrightarrow \text{false}$$
$$x \not\mapsto \ast x \not\mapsto \Leftrightarrow \text{false}$$

Solution: Track Deallocated Locations!

$[x \mapsto v]$ free(x) $[ok: x \not\mapsto]$

Solution: Track Deallocated Locations!

$$\frac{[x \mapsto v]\ \text{free}(x)\ [ok\colon x \not\mapsto\ ]}{[x \mapsto v * x \mapsto v]\ \text{free}(x)\ [ok\colon x \not\mapsto * x \mapsto v]}$$

Solution: Track Deallocated Locations!

$$\dfrac{\dfrac{[x \mapsto v]\ \mathrm{free}(x)\ [ok: x \not\mapsto\ ]}{[x \mapsto v * x \mapsto v]\ \mathrm{free}(x)\ [ok: x \not\mapsto * x \mapsto v]}}{[\mathrm{false}]\ \mathrm{free}(x)\ [ok: \mathrm{false}]} \quad ✔$$

$[p]\ C\ [\varepsilon: q]$ *iff* $\forall\, s \in q.\ \exists\, s' \in p.\ (s', s) \in [C]\varepsilon$

$[p]\ C\ [\varepsilon: \mathrm{false}]$ ✔ (vacuous)

ISL: Local Axioms

$[x \mapsto v]$ free(x) $[ok: x \not\mapsto]$

$[x=null]$ free(x) $[er: x=null]$

FREE

ISL: Local Axioms

$[x \mapsto v]$ free(x) $[ok: x \not\mapsto]$

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FREE

$[x \not\mapsto]$ free(x) $[er: x \not\mapsto]$

ISL: Local Axioms

$[x \mapsto v]$ free(x) $[ok: x \not\mapsto]$

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FREE

$\boxed{[x \not\mapsto]\ \text{free(x)}\ [er: x \not\mapsto]}$

use-after-free error

ISL: Local Axioms

$[x \mapsto v]$ free(x) $[ok: x \not\mapsto]$

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FREE

use-after-free error

$[x \mapsto v']$ [x]:= v $[ok: x \mapsto v]$

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$[x \not\mapsto]$ [x]:= v $[er: x \not\mapsto]$

WRITE

ISL: Local Axioms

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use-after-free error

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$[x{=}null]$ [x]:= v $[er: x{=}null]$

$[x \not\mapsto]$ [x]:= v $[er: x \not\mapsto]$

WRITE

$[x \mapsto v]$ y:= [x] $[ok: x \mapsto v \land y{=}v]$

$[x{=}null]$ y:= [x] $[er: x{=}null]$

$[x \not\mapsto]$ y:= [x] $[er: x \not\mapsto]$

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FREE

use-after-free error

$[x \mapsto v']$ [x]:= v $[ok: x \mapsto v]$

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WRITE

$[x \mapsto v]$ y:= [x] $[ok: x \mapsto v \wedge y = v]$

$[x = null]$ y:= [x] $[er: x = null]$

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READ

$[emp]$ x:= alloc() $[ok: \exists l.\ l \mapsto v \wedge x = l]$

ALLOC

ISL: Local Axioms

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$[x{=}null]$ free(x) $[er: x{=}null]$

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ISL Summary

- Incorrectness ***Separation*** Logic (ISL)
  - ➡ IL + SL for ***compositional bug catching***
  - ➡ ***Under-approximate*** analogue of SL
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- Fix: a ***monotonic model*** for frame preservation
- Recovering the ***footprint property*** for completeness
- ISL-based ***analysis***
  - ➡ ***No-false-positives theorem:***

    All bugs found are true bugs

Part II.

Pulse-X: ISL for Scalable Bug Detection

Pulse-X at a Glance

- **Automated** program analysis for **memory safety errors** (NPEs, UAFs) and **leaks**
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- **Compositional** (begin-anywhere analysis) — important for CI
- Deployed at Meta
- **Performance**: comparable to Infer, though merely an academic tool!
- **Fix rate**: comparable or better than Infer!
- Three dimensional scalability
  - code size (large codebases)
  - people (large teams, CI)
  - speed (high frequency of code changes)

Compositional, Begin-Anywhere Analysis

- Analysis result of a program = analysis results of its parts

  +

  a method of combining them

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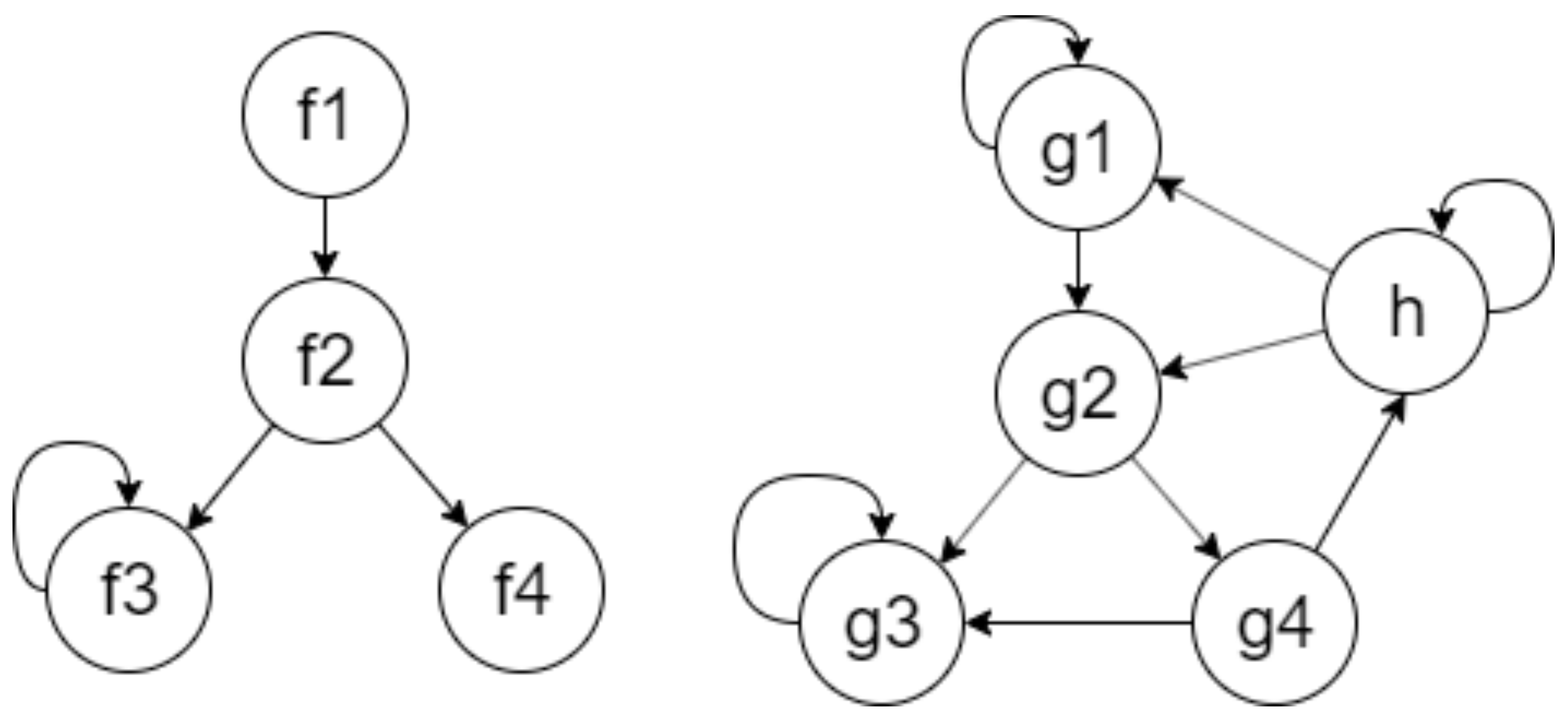

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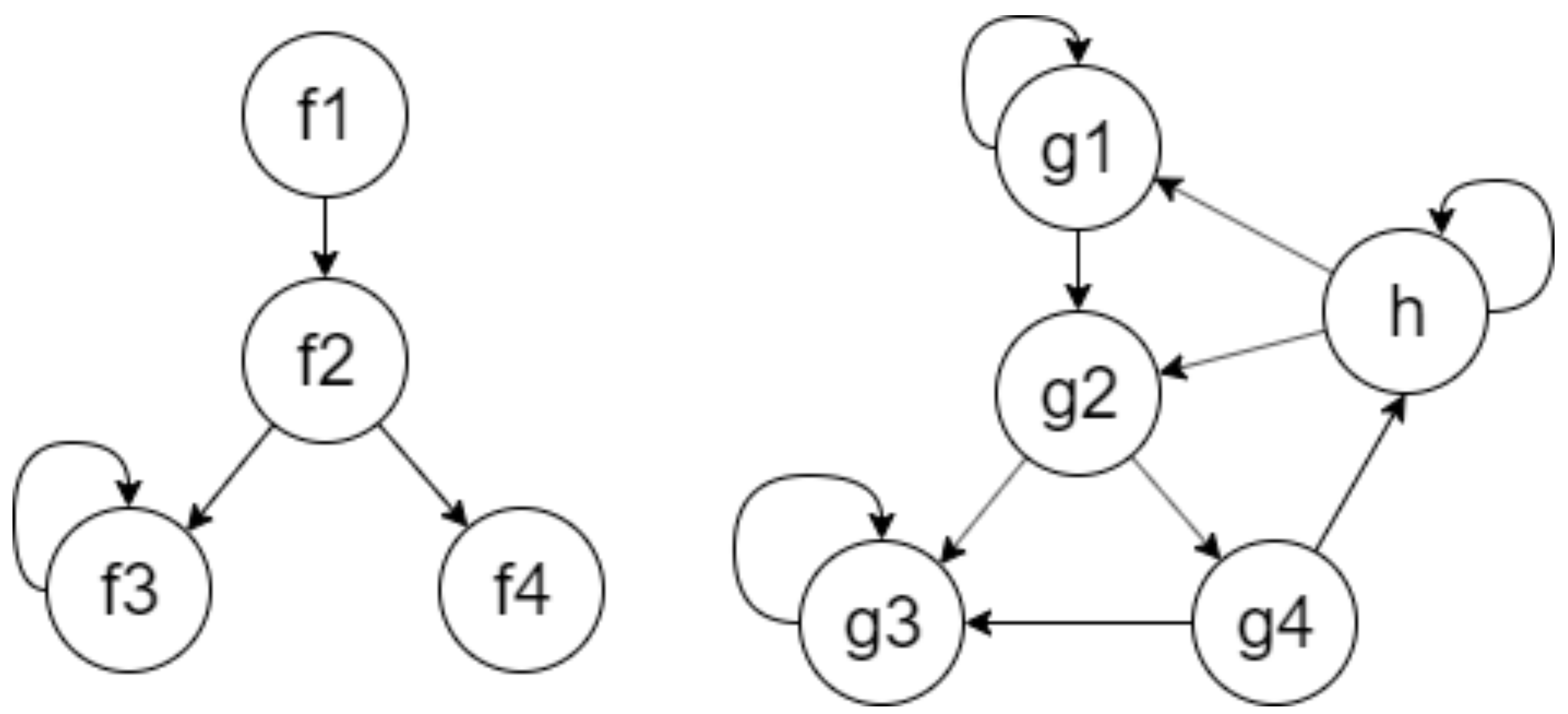

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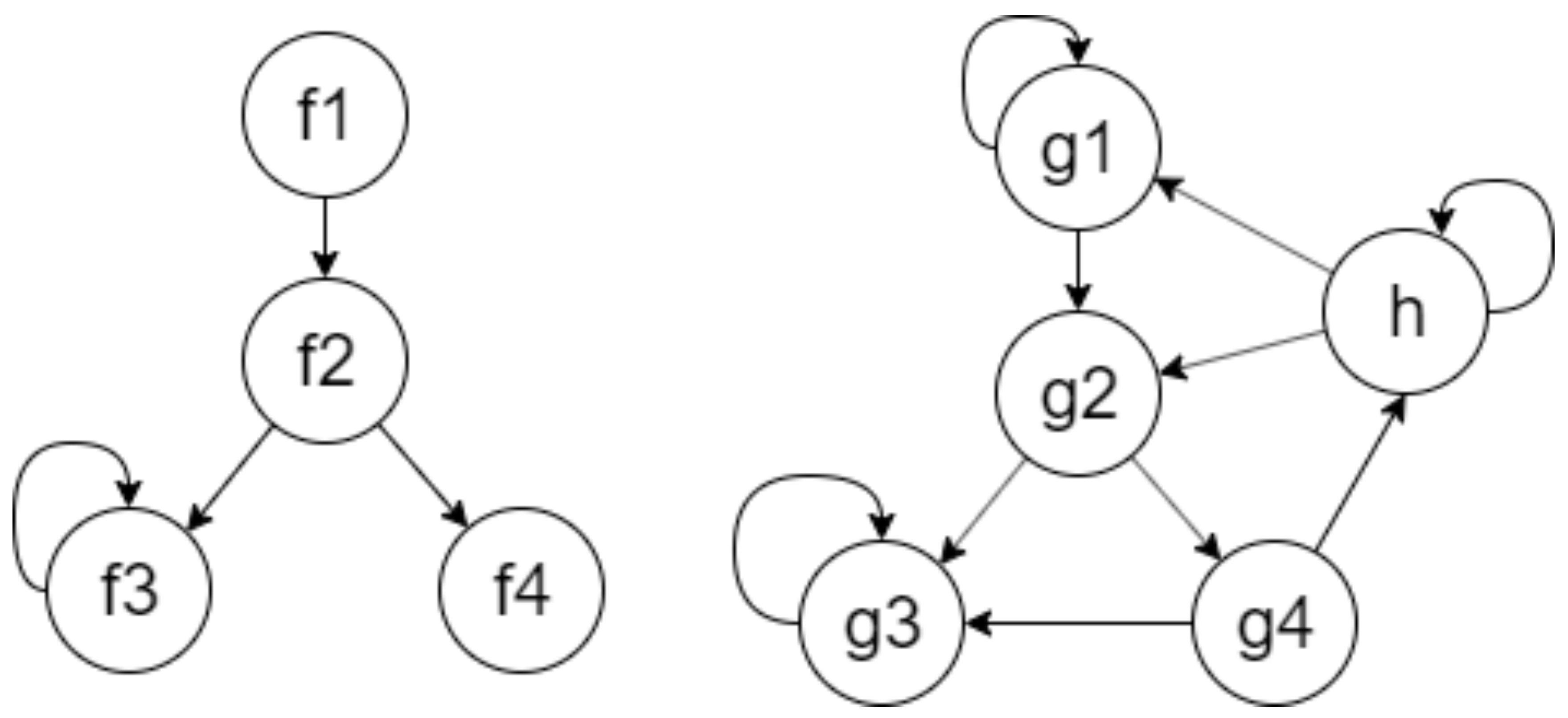

  - ➡ Method: under-approximate bi-abduction

  - ➡ Analysis result: incorrectness triples (under-approximate specs)

Pulse-X Algorithm: Proof Search in ISL

- Analyse each procedure f in isolation, find its **summary** (collection of ISL triples)
  - ➡ A **summary table** T, initially populated only with local (pre-defined) axioms
  - ➡ Use bi-abduction and T to find the summary of f
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- Similar bi-abductive mechanism to Infer, but:
  - ➡ Can **soundly** drop execution paths/branches
  - ➡ Can **soundly** bound loop unrolling

Pulse-X: Null Pointer Dereference in OpenSSL

```
int ssl_excert_prepend(...){
    SSL_EXCERT *exc= app_malloc(sizeof(*exc), "prepend cert”);
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`apps/lib/s_cb.c` Outdated — Hide resolved

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paulidale 13 days ago Contributor

False positive, `app_malloc()` doesn't return if the allocation fails.

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Our tool recognizes app_malloc() in test/testutil/apps_mem.c rather than the one in apps/lib/apps.c. While the former doesn't return if the allocation fails, the latter does. How do we know which one is actually called?

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It would need to look at the link lines or build dependencies to figure out which sources were used.

We should fix the one in `test/testutil/apps_mem.c`.

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We should fix the one in `test/testutil/apps_mem.c` .

Created pull request #15836 to commit the fix.

Pulse-X: Bug Reporting

No False Positives: Report ***All*** Bugs Found?

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Not quite…

Pulse-X: Bug Reporting

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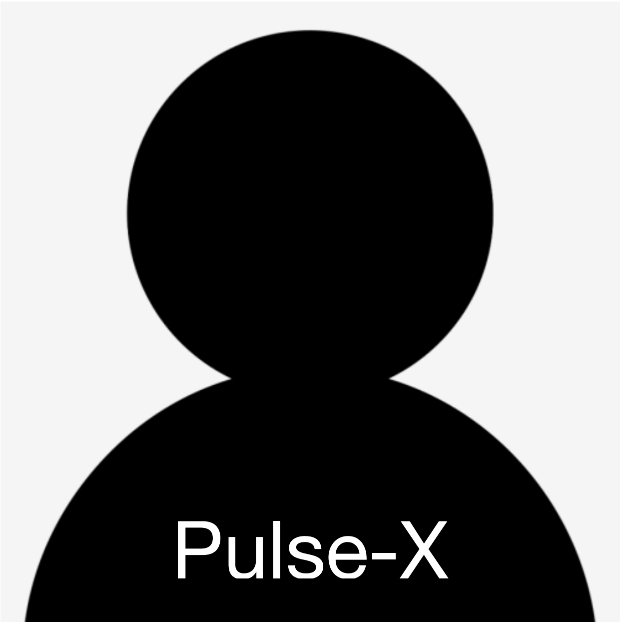

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Pulse-X

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Manifest Errors

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Pulse-X

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  - ➡ for all $\vec{v}$: $\text{sat}\ (\vec{v} / \text{flv}(q) \cup \vec{X}\ )$

Pulse-X: ***Manifest*** Errors

- Intuitively: the error occurs for **all input states**
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Theorem 3.5 (Manifest errors). *An error triple* $\models [p]\ \mathsf{C}\ [er: q]$ *with* $q \triangleq \exists \overrightarrow{X_q}.\ \kappa_q \wedge \pi_q$ *denotes a* manifest error *if:*

(1) $p \equiv \mathsf{emp} \wedge \mathsf{true}$*;*
(2) $\mathsf{sat}(q)$ *holds;*
(3) $\mathsf{locs}(\kappa_q) \subseteq \overrightarrow{X_q}$*, where* $\mathsf{locs}(.)$ *is as defined below; and*
(4) for all $\overrightarrow{v}$, $\mathsf{sat}(\pi_q[\overrightarrow{v} / \overrightarrow{Y} \cup \mathsf{locs}(\kappa_q)])$ *holds, where* $\overrightarrow{Y} = \mathsf{flv}(q)$*.*

$\mathsf{locs}(\mathsf{emp}) \triangleq \emptyset \quad \mathsf{locs}(x \mapsto X) \triangleq \{x\} \quad \mathsf{locs}(X \mapsto V) = \mathsf{locs}(X \not\mapsto) \triangleq \{X\} \quad \mathsf{locs}(\kappa_1 * \kappa_2) \triangleq \mathsf{locs}(\kappa_1) \cup \mathsf{locs}(\kappa_2)$

Pulse-X: Null Pointer Dereference in OpenSSL

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1.int ssl_excert_prepend(...){
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CRYPTO_malloc may return null!

[emp] `ssl_excert_prepend(…)` [er: exc = null]

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[emp] `ssl_excert_prepend(…)` [er: exc = null]

Manifest Error (all calls to `ssl_excert_prepend` can trigger the error)!

Pulse-X: ***Latent*** Errors

An error triple [p] C [er: q] is <u>latent</u> iff it is not manifest

Pulse-X: Latent Error

```
int chopup_args(ARGS *args,…){
    …
    if (args->count == 0 ) {
      args->count=20;
      args->data= (char**)ssl_excert_prepend(…);
    }
    for (i=0; i<args->count; i++) {
      args->data[i]=NULL;
      …
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```

null pointer dereference

Latent Error:

only calls with `args->count==0` can trigger the error

Pulse-X: Memory Leak in OpenSSL

```
static int www_body(…){
  ...
  io = BIO_new(BIO_f_buffer());
  ssl_bio BIO_new(BIO_f_ssl());
  ...
  BIO_push(io, ssl_bio);
  ...
  BIO_free_all(io);
  ...
  return ret;
}
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426 lines of complex code:
`io` manipulated by several procedures and multiple loops

Pulse-X performs under-approximation with bounded loop unrolling

No-False Positives: Caveat

- Unknown procedures (e.g. where the code is unavailable) are treated as `skip`

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Speed (fast but simplistic)	vs	Precision (slow but accurate)

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Speed
(fast but simplistic)

vs

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(slow but accurate)

"Scientists seek perfection and are idealists. … An engineer's task is to not be idealistic. You need to be realistic as you have to compromise between conflicting interests."

Part III.

Concurrent Incorrectness Separation Logic (CISL)

&

Concurrent Adversarial Separation Logic (CASL)

Extension 1: Concurrent Incorrectness Separation Logic (CISL)

ISL

$$\frac{[p]\ C\ [\varepsilon\!:\ q]}{[p * r]\ C\ [\varepsilon\!:\ q * r]}$$

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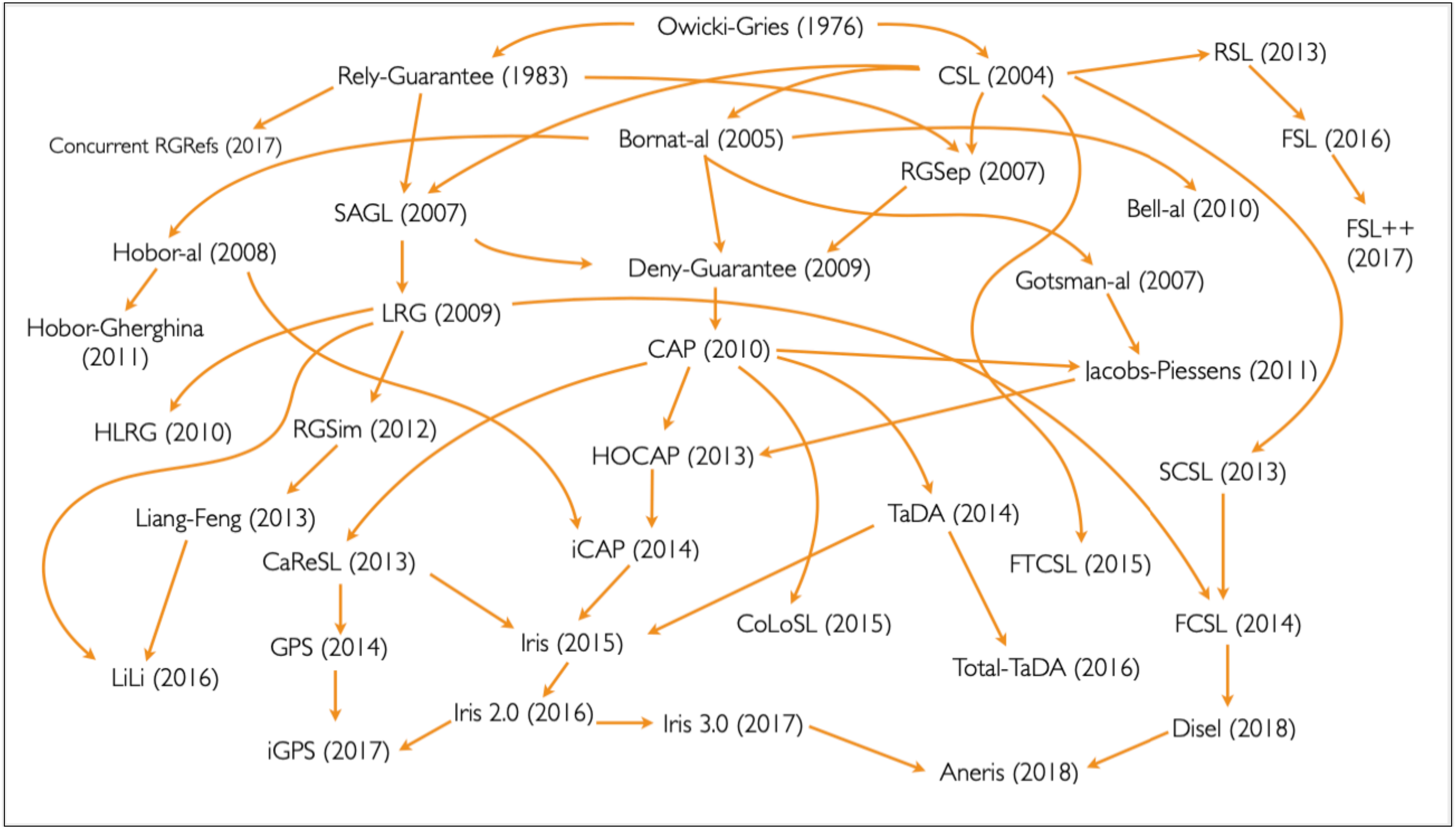
Which CISL?

CSL (Correctness) Family Tree…



Graph courtesy of Ilya Sergey

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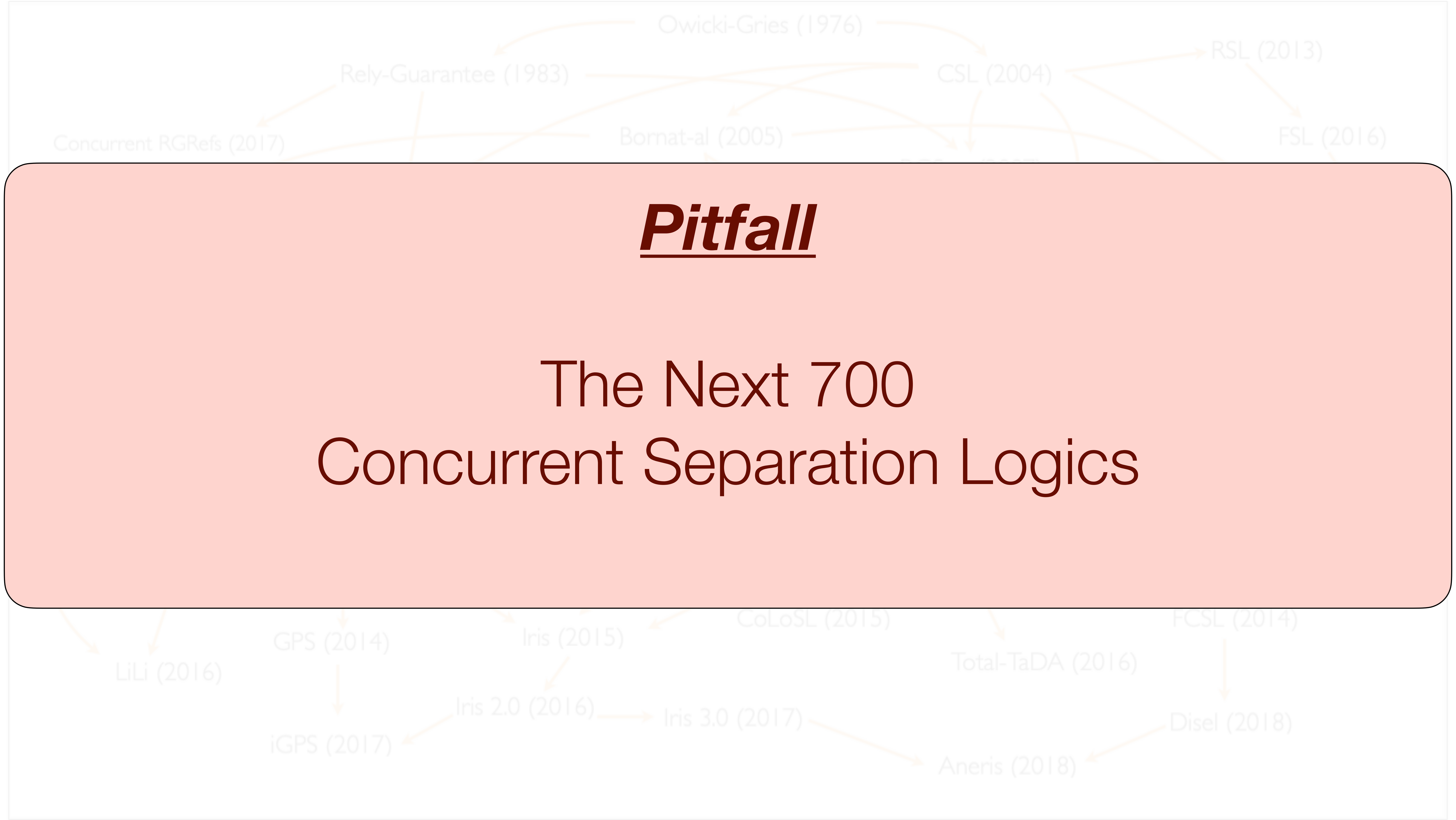

Pitfall

The Next 700
Concurrent Separation Logics

Graph courtesy of Ilya Sergey

Which CISL?

CSL (Correctness) Family Tree…

Pitfall

The Next 700
Concurrent ***Incorrectness*** Separation Logics

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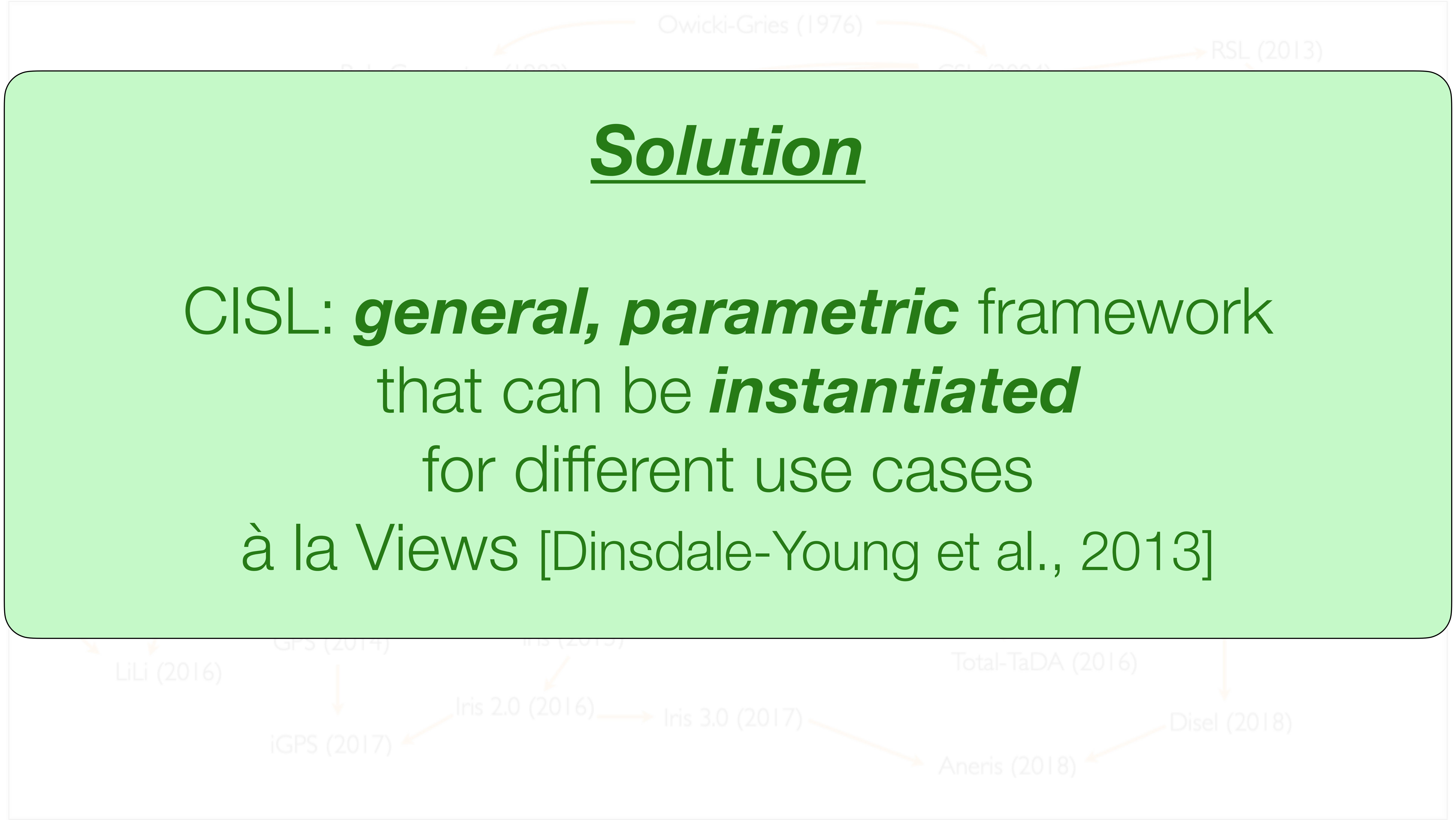
Which CISL?

CSL (Correctness) Family Tree…



Solution

CISL: ***general, parametric*** framework
that can be ***instantiated***
for different use cases
à la Views [Dinsdale-Young et al., 2013]

Graph courtesy of Ilya Sergey

CISL Framework

- ***First*** unifying framework for ***concurrent under-approximate*** reasoning
- ***General*** framework for multiple bug catching analyses
  - ➡ Memory safety errors (e.g. null-pointer exception, use-after-free errors): CISL_{SV}
  - ➡ Races: CISL_{RD}
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- Caveat: cannot detect bugs where there are control flow dependencies between threads

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- Future work:
  - ➡ Automated exploit detection tools
  - ➡ Automatic exploit generation techniques

Conclusions

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  - Automated program analysis for detecting memory safety errors and leaks
  - Manifest errors (underpinned by ISL): no false positives*
  - compositional, scalable, begin-anywhere

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Thank You for Listening!

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