Effects: to be or not to be?

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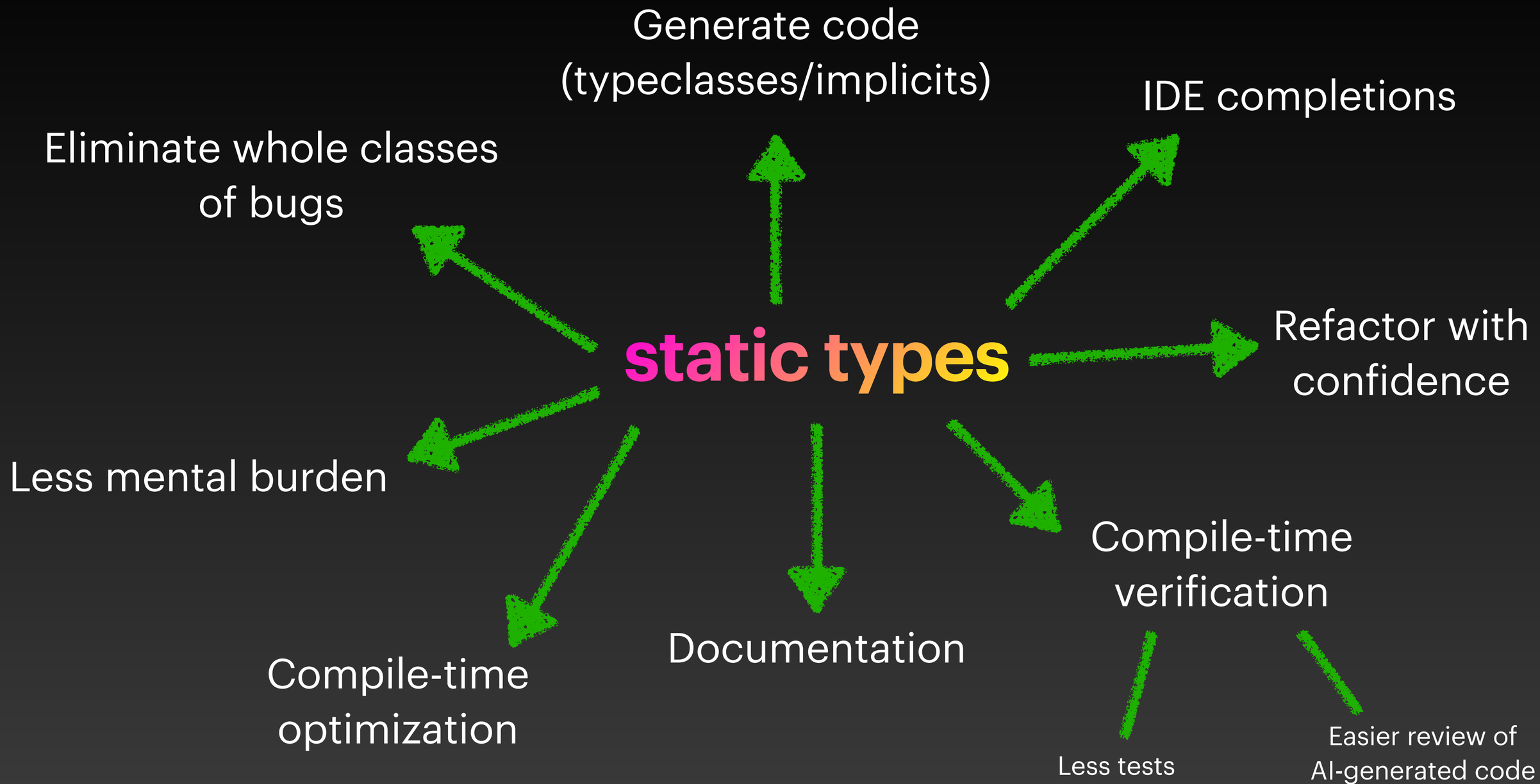
What's the problem?

```
function prepareLaunch(passengers, heading)
```

```
def prepareLaunch(
  passengers: List[Passenger],
  heading: Double): LaunchParameters
```


Generate code
(typeclasses/implicits)
IDE completions
Eliminate whole classes
of bugs
static types
Refactor with
confidence
Less mental burden
Compile-time
verification
Compile-time
optimization
Documentation
Less tests
Easier review of
AI-generated code

What's the problem?

- Can we extend the same to effects?
- Again: adding some more structure
- Will the benefits still outweigh the costs?

A function has a side effect if

(...) it has an observable effect other than returning a value to the caller

https://en.wikipedia.org/wiki/Side_effect_(computer_science)

A function has a side effect if

apart from returning a value, changes observable behaviour of the system

side effect

Unwanted

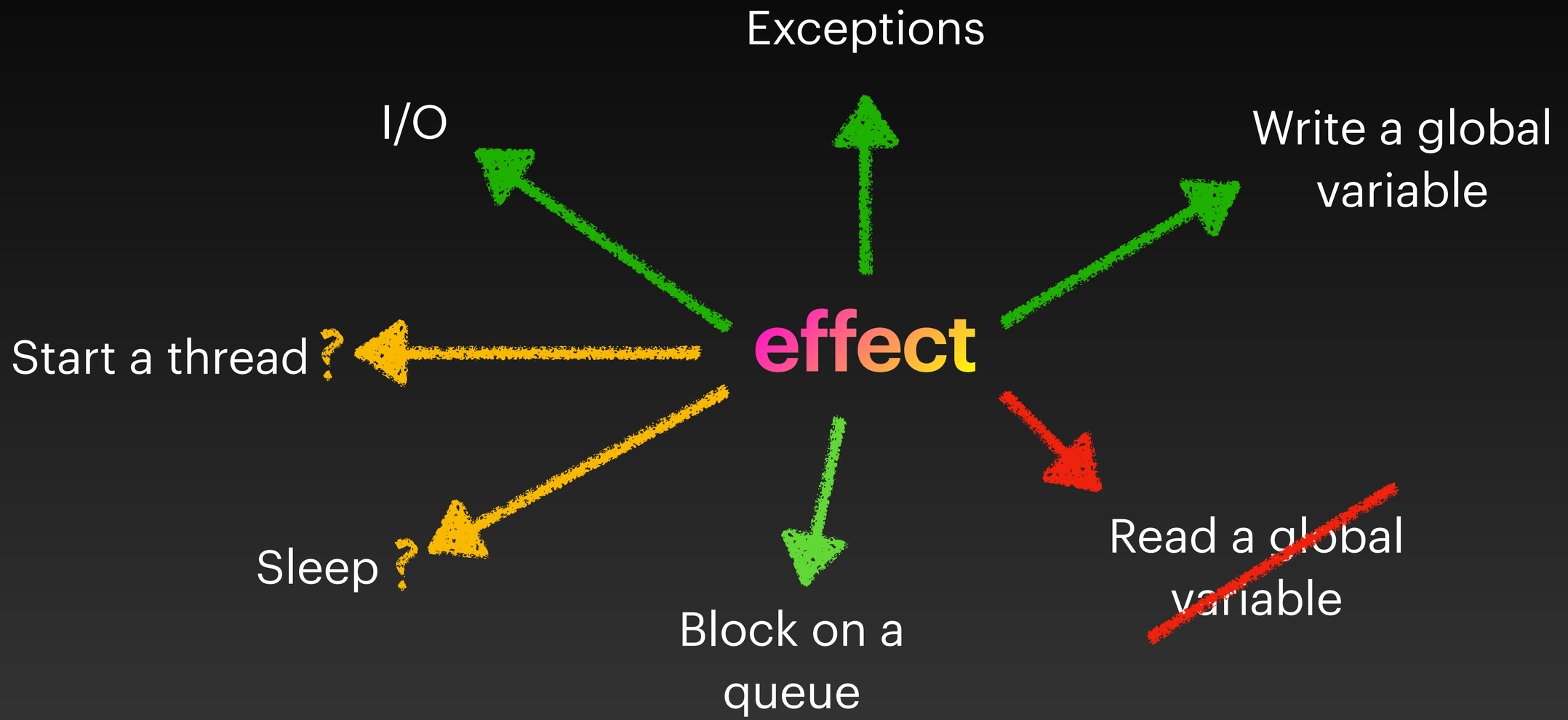
Undesirable

vs

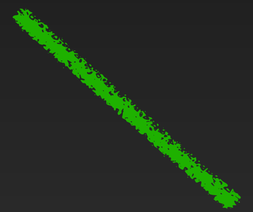
effect

Wanted

The purpose of calling a method


Exceptions
I/O
Write a global variable
Start a thread ?
effect
Sleep ?
Read a global variable
Block on a queue

effect-free != pure



Mathematical function

An effect system: the what?

Formal system that describes effects of programs

Guard rails for expressing program's logic involving effects

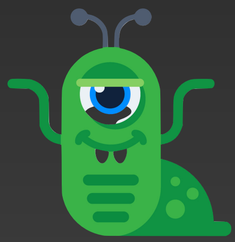
Wikipedia, Unison docs

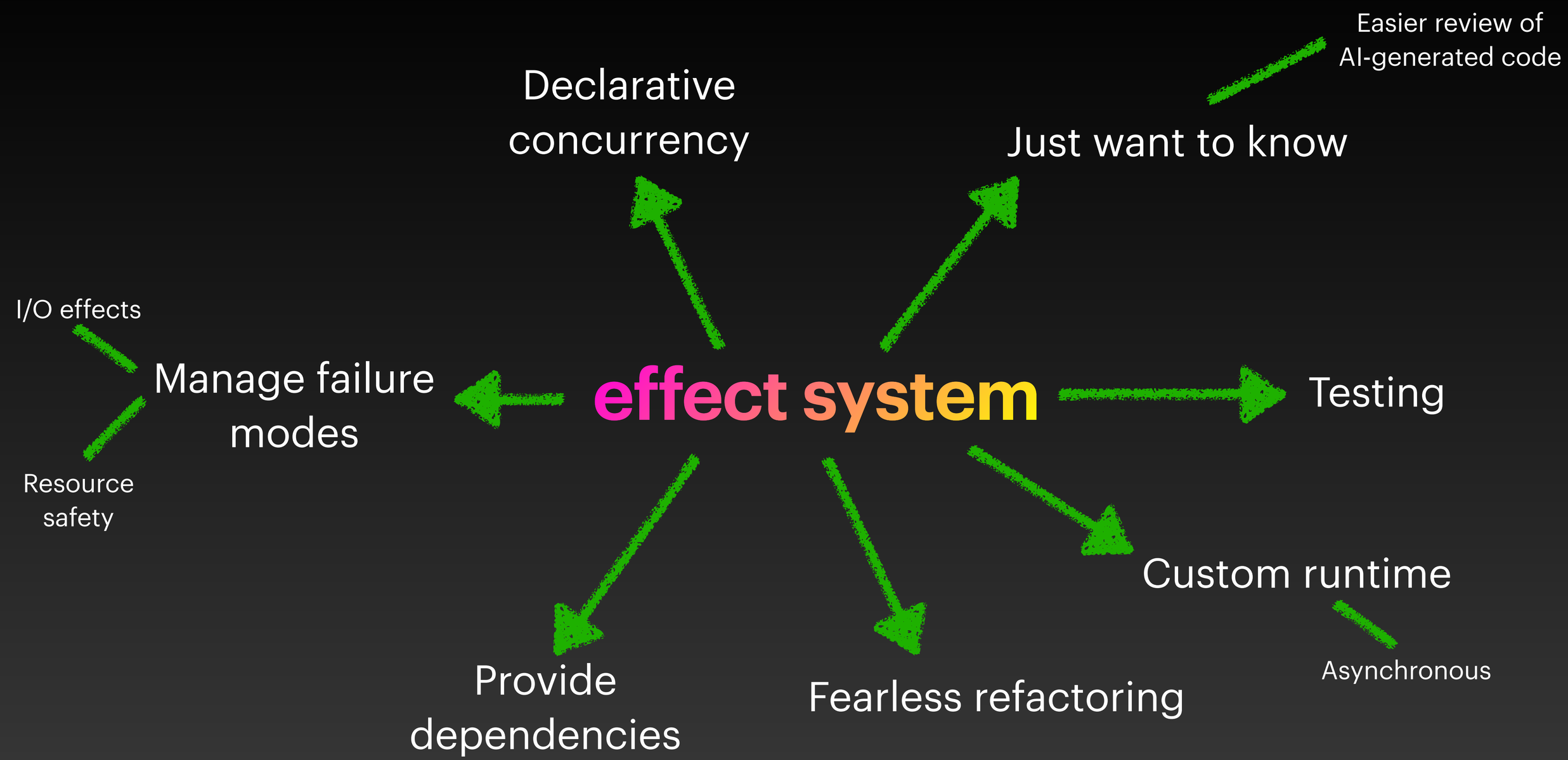
An effect system: the why?

RPC fallacy

- Make RPC calls look & behave the same as local calls
- But: latency
- But: different failure modes
  - intermittent failures
  - timeouts
  - partial failures

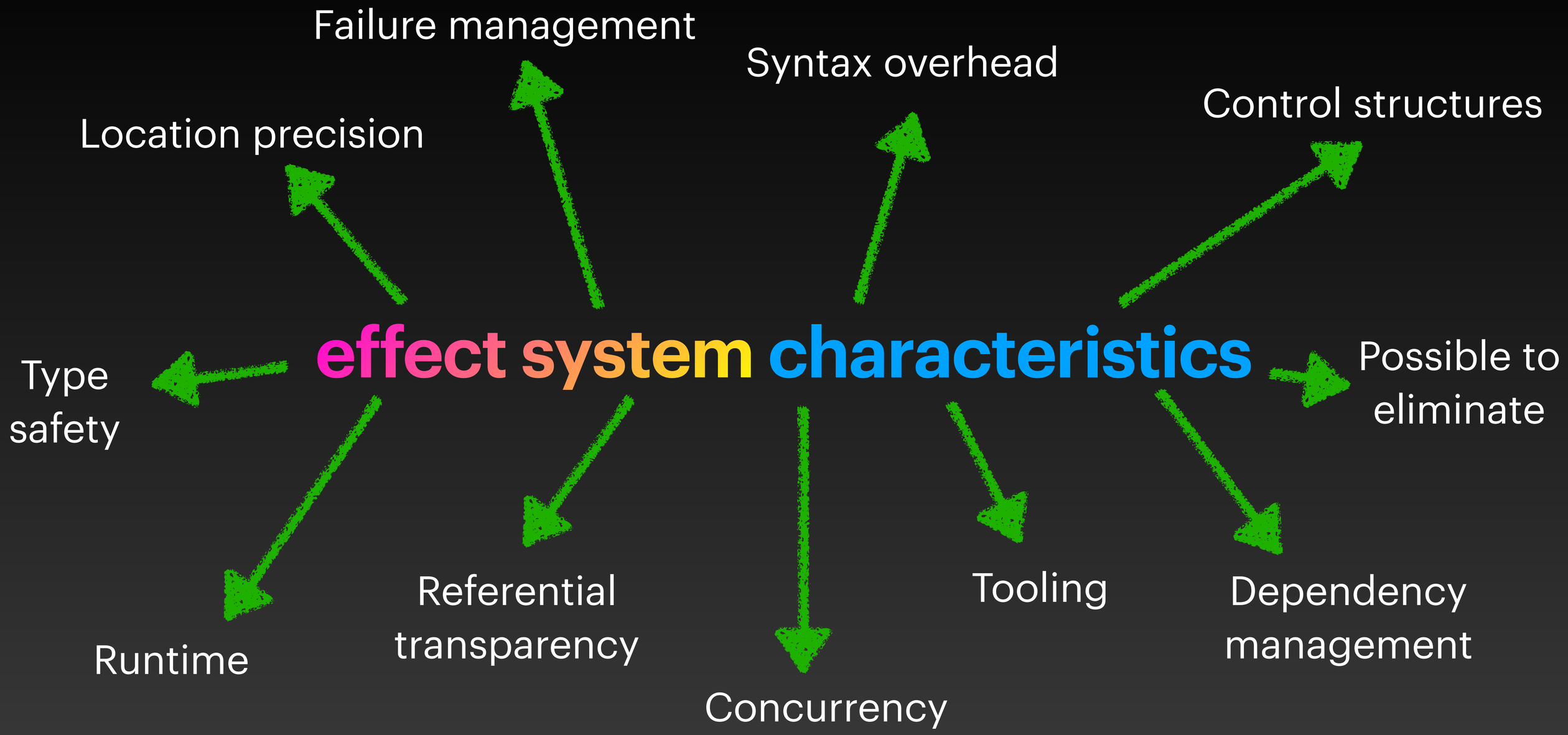
See also: distributed systems fallacy #1, *"the network is reliable"*




Easier review of
AI-generated code
Declarative
concurrency
Just want to know
I/O effects
Manage failure
modes
effect system
Testing
Resource
safety
Custom runtime
Provide
dependencies
Fearless refactoring
Asynchronous

An effect system: the how?

Extend the type system


Failure management
Location precision
Syntax overhead
Control structures
effect system characteristics
Type safety
Possible to eliminate
Runtime
Referential transparency
Concurrency
Tooling
Dependency management

Checked exceptions

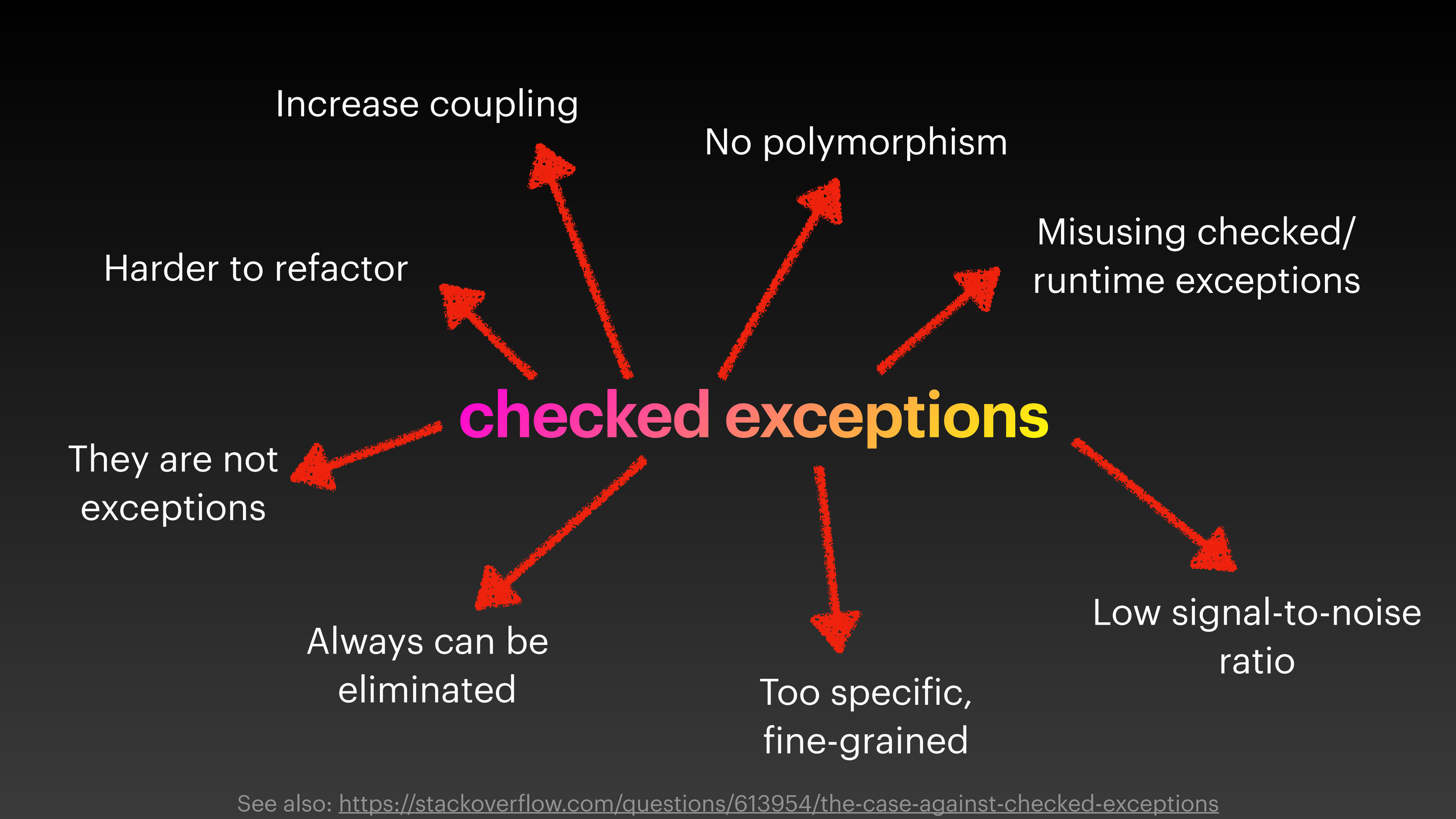
```
def goHome(): Unit throws IOException,
    WrongFuelException = {

  val passengers = fetchPassengers()

  val params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway) {
    attachBoosterRockets()
  }

  params
   .rocketStages
   .forEach { stage => fuelUp(stage) }

  pressBigRedButton()
}
```

```
def fetchPassengers: List[Passenger]
  throws IOException

def prepareLaunch(
  passangers: List[Passenger],
  heading: Double): LaunchParams

def attachBoosterRockets(): Unit
  throws IOException

def fuelUp(stage: Stage): Unit
  throws WrongFuelException

def pressBigRedButton(): Unit
  throws IOException
```

Checked exceptions

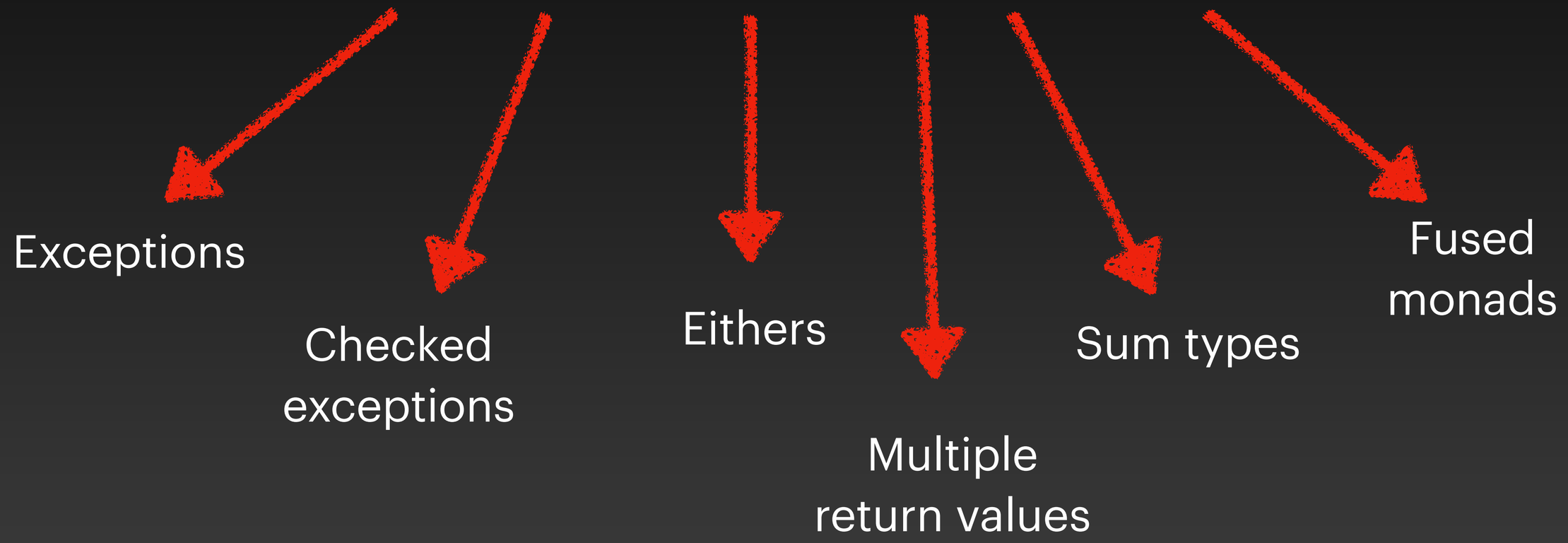
```
def goHome(): Unit throws IOException,
    WrongFuelException = {

  val passengers = fetchPassengers()

  val params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway) {
    attachBoosterRockets()
  }

  params
   .rocketStages
   .map { stage => fuelUp(stage) }

  pressBigRedButton()
}
```

Location precision	Low
Syntax overhead	Low
Type safety	Yes
Referential transparency	No
Concurrency	No
Control structures	Built-in
Failure management	Some
Resource safety	Some
Runtime	Built-in
Eliminatable	Yes
Dependency management	No



See also: https://stackoverflow.com/questions/613954/the-case-against-checked-exceptions

error handling
+
statically-typed languages



Future

```
def goHome(): Future[Unit] =
  fetchPassengers
    .flatMap { passengers =>
      val params = prepareLaunch(
        passengers, Headings.Home)

      def attach = if (params.farAway) {
        attachBoosterRockets
      } else Future.unit

      def fuel = Future.sequence(
        params.rocketStages.map(fuelUp))

      attach
        .flatMap(_ => fuel)
        .flatMap(_ => pressBigRedButton)
    }
```

```
def fetchPassengers
  : Future[List[Passenger]]

def prepareLaunch(
  passangers: List[Passenger],
  heading: Double): LaunchParams

def attachBoosterRockets(): Future[Unit]

def fuelUp(stage: Stage): Future[Unit]

def pressBigRedButton(): Future[Unit]
```

Future

```
def goHome(): Future[Unit] =
  fetchPassengers
    .flatMap { passengers =>
      val params = prepareLaunch(
        passengers, Headings.Home)

      def attach = if (params.farAway) {
        attachBoosterRockets
      } else Future.unit

      def fuel = Future.sequence(
        params.rocketStages.map(fuelUp))

      attach
        .flatMap(_ => fuel)
        .flatMap(_ => pressBigRedButton)
    }
```

Location precision	High
Syntax overhead	High
Type safety	Yes
Referential transparency	No
Concurrency	Some
Control structures	Custom
Failure management	Some
Resource safety	Some
Runtime	Custom
Eliminatable	Preferably not
Dependency management	No

ZIO

```
def goHome(): ZIO[Exception, Unit] =
  fetchPassengers
    .flatMap { passengers =>
      val params = prepareLaunch(
        passengers, Headings.Home)

      val attach = if (params.farAway) {
        attachBoosterRockets
      } else ZIO.unit

      val fuel = ZIO.foreachPar(
        params.rocketStages)(fuelUp)

      attach
        .flatMap(_ => fuel)
        .flatMap(_ => pressBigRedButton)
    }
```

```
def fetchPassengers
  : ZIO[IOException, List[Passenger]]

def prepareLaunch(
  passangers: List[Passenger],
  heading: Double): LaunchParams

def attachBoosterRockets()
  : ZIO[IOException, Unit]

def fuelUp(stage: Stage)
  : ZIO[WrongFuelException , Unit]

def pressBigRedButton()
  : ZIO[IOException, Unit]
```

ZIO

```
def goHome(): ZIO[Exception, Unit] =
  fetchPassengers
    .flatMap { passengers =>
      val params = prepareLaunch(
        passengers, Headings.Home)

      val attach = if (params.farAway) {
        attachBoosterRockets
      } else ZIO.unit

      val fuel = ZIO.foreachPar(
        params.rocketStages)(fuelUp)

      attach
        .flatMap(_ => fuel)
        .flatMap(_ => pressBigRedButton)
    }
```

Location precision	High
Syntax overhead	High
Type safety	Yes
Referential transparency	Yes
Concurrency	Yes
Control structures	Custom
Failure management	Yes
Resource safety	Yes
Runtime	Custom
Eliminatable	Preferably not
Dependency management	Yes

ZIO + ZIO-direct

```
def goHome(): ZIO[Any, Exception, Unit] =
  defer {
    val passengers = fetchPassengers.run
    val params = prepareLaunch(
      passengers, Headings.Home)

    if (params.farAway) {
      attachBoosterRockets.run
    }

    ZIO.foreachPar(
      params.rocketStages)(fuelUp)
      .run

    pressBigRedButton.run
  }
```

```
def fetchPassengers
  : ZIO[IOException, List[Passenger]]

def prepareLaunch(
  passangers: List[Passenger],
  heading: Double): LaunchParams

def attachBoosterRockets()
  : ZIO[IOException, Unit]

def fuelUp(stage: Stage)
  : ZIO[WrongFuelException , Unit]

def pressBigRedButton()
  : ZIO[IOException, Unit]
```

ZIO + ZIO-direct

```
def goHome(): ZIO[Any, Exception, Unit] =
  defer {
    val passengers = fetchPassengers.run
    val params = prepareLaunch(
      passengers, Headings.Home)

    if (params.farAway) {
      attachBoosterRockets.run
    }

    ZIO.foreachPar(
      params.rocketStages)(fuelUp)
      .run

    pressBigRedButton.run
  }
```

Location precision	High
Syntax overhead	Medium
Type safety	Yes
Referential transparency	Mixed
Concurrency	Yes
Control structures	Mostly custom
Failure management	Yes
Resource safety	Yes
Runtime	Custom
Eliminatable	Preferably not
Dependency management	No

Abilities (Unison)

```
goHome : '{IO} Unit
goHome =
  passengers = !fetchPassengers
  params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway)
    then !attachBoosterRockets
    else ()

  map (stage -> !fuelUp(stage))
    params.rocketStages

  !pressBigRedButton
```

```
fetchPassengers : '{IO} List Passenger
-- sugar for: () {IO}-> List Passenger

prepareLaunch : List Passenger ->
  Double -> LaunchParams

attachBoosterRockets : '{IO} Unit

fuelUp(stage: Stage) : '{IO} Unit

pressBigRedButton() : '{IO} Unit
```

Abilities (Unison)

```
goHome : '{IO} Unit
goHome =
  passengers = !fetchPassengers
  params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway)
    then !attachBoosterRockets
    else ()

  map (stage -> !fuelUp(stage))
    params.rocketStages

  !pressBigRedButton
```

Location precision	High
Syntax overhead	Medium
Type safety	Yes
Referential transparency	Mixed
Concurrency	Yes
Control structures	Built-in
Failure management	Some
Resource safety	No
Runtime	Built-in
Eliminatable	`IO` - No, other - Yes
Dependency management	Yes

Loom-based library + capabilities

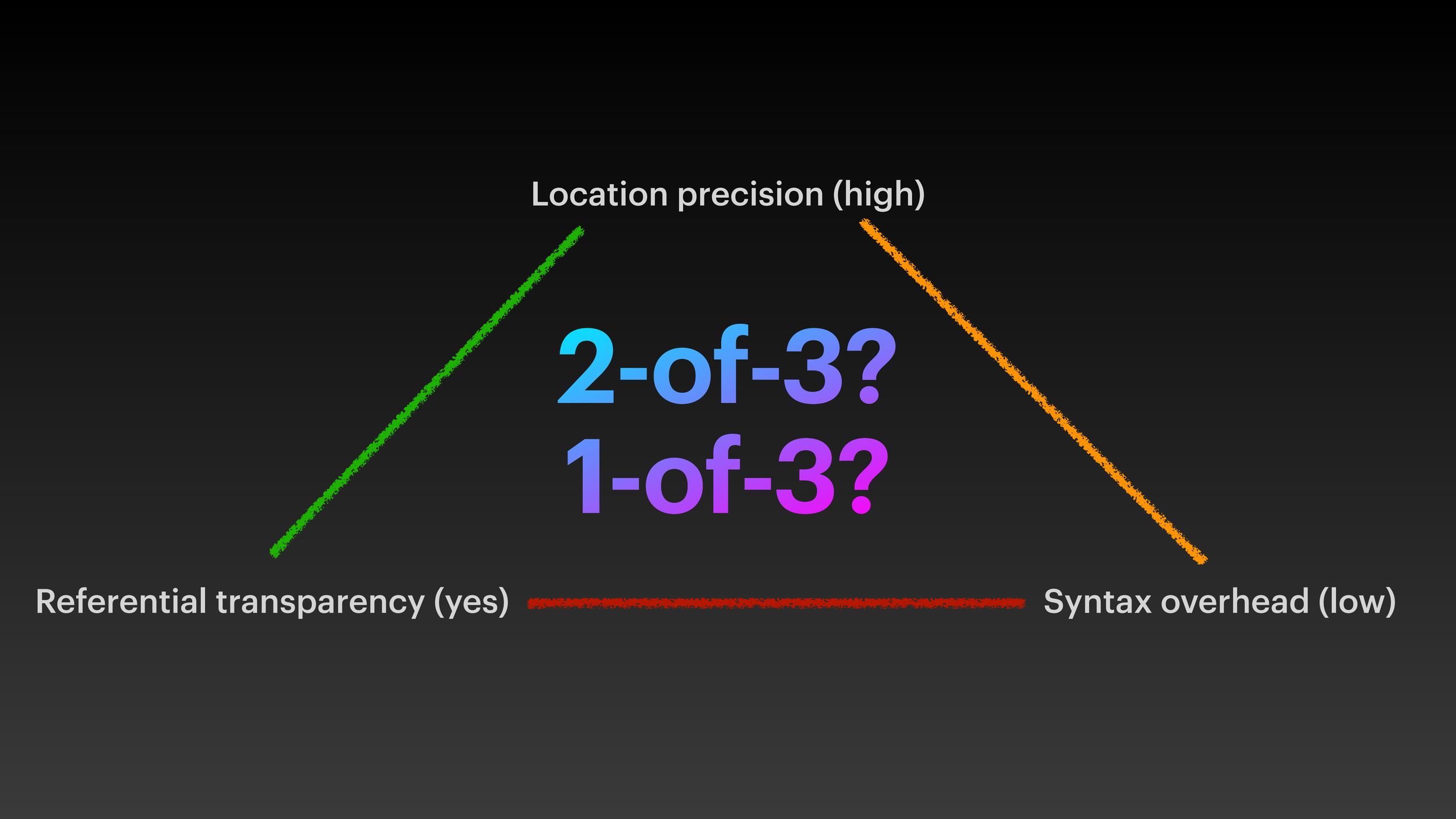
```
def goHome(): IO[Unit] = {
  val passengers = fetchPassengers()

  val params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway) {
    attachBoosterRockets()
  }

  params
   .rocketStages
   .map { stage => fuelUp(stage) }

  pressBigRedButton()
}
```

```
def fetchPassengers: IO[List[Passenger]]
// def fetchPassengers(
//   using IO): List[Passenger]

def prepareLaunch(
  passangers: List[Passenger],
  heading: Double): LaunchParams

def attachBoosterRockets(): IO[Unit]

def fuelUp(stage: Stage): IO[Unit]

def pressBigRedButton(): IO[Unit]
```

Loom-based library + capabilities

```
def goHome(): IO[Unit] = {
  val passengers = fetchPassengers()

  val params = prepareLaunch(
    passengers, Headings.Home)

  if (params.farAway) {
    attachBoosterRockets()
  }

  params
   .rocketStages
   .map { stage => fuelUp(stage) }

  pressBigRedButton()
}
```

Location precision	Low
Syntax overhead	Low
Type safety	Yes
Referential transparency	No
Concurrency	Yes
Control structures	Built-in
Failure management	Some
Resource safety	?
Runtime	Built-in
Eliminatable	`IO` - Preferably not, other - Yes
Dependency management	No


Location precision (high)
2-of-3?
1-of-3?
Referential transparency (yes)
Syntax overhead (low)

Decisions, decisions …

- How important is the lack syntax overhead for you?
- What can we learn from checked exceptions?
- How representing computations as values fits your programming style?
- Is the JVM runtime a good fit, or do you need more control / performance?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IRTUSLAB

IO.pure("Thank you!")

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