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Algebraic Effects, Evidently

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Microsoft Research

Introduction

algebraic effects → evidence passing → polymorphic lambda calculus

a theoretical basis for languages such as Haskell and ML

Algebraic Effects

Composable and modular computational effects

Algebraic effects

define a family of operations

operation — effect

```
effect reader {
  ask : () -> int
}
```

Effect handlers

give semantics to operations

effect handler — implementation

```
handler {
  ask -> \x.\k. k 1
} (\_.
  perform ask () + perform ask () //2
)
```

raise an effect

Drawbacks

Runtime Support

Difficult to integrate into existing languages

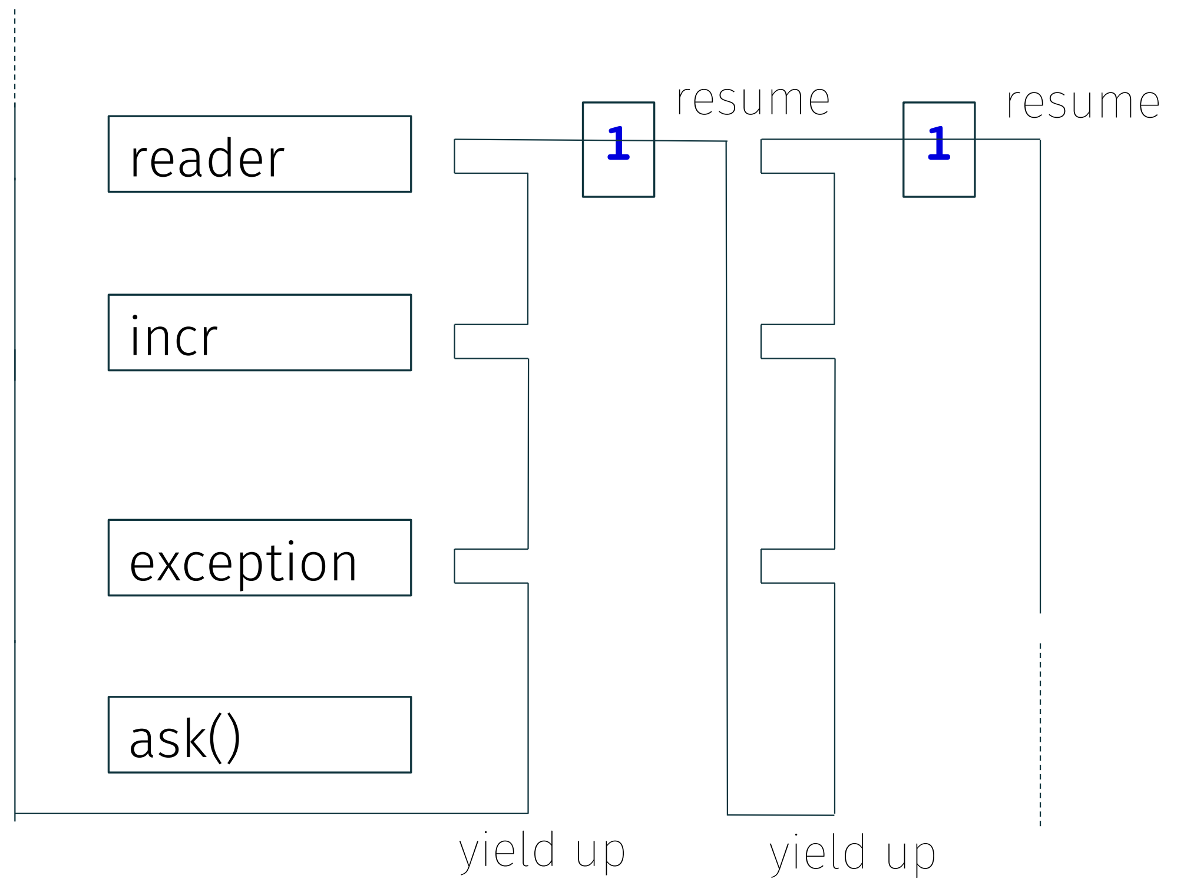
Inefficiency

Dynamically yield up to search for the handler

Evaluation Under Traditional Semantics

```
handler {
  ask -> \x.\k. k 1
} (\_.
handler {
  incr -> \x.\k. 1 + k ()
} (\_.
handler {
  fail -> \x.\k. 3
} (\_.
  perform ask () + perform ask () // 2
)))
```

tail-resumptive
(\x.\k. k e with k∉ fv(e))



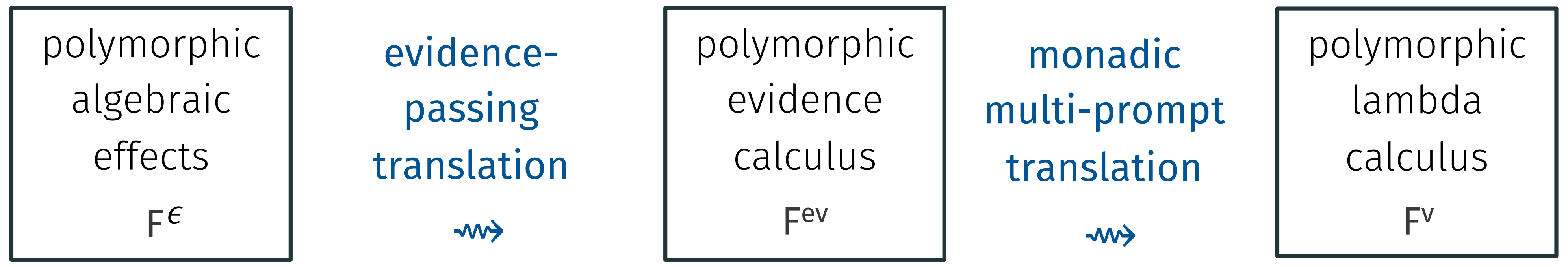
Evaluation Under Evidence Semantics

Q.E.D

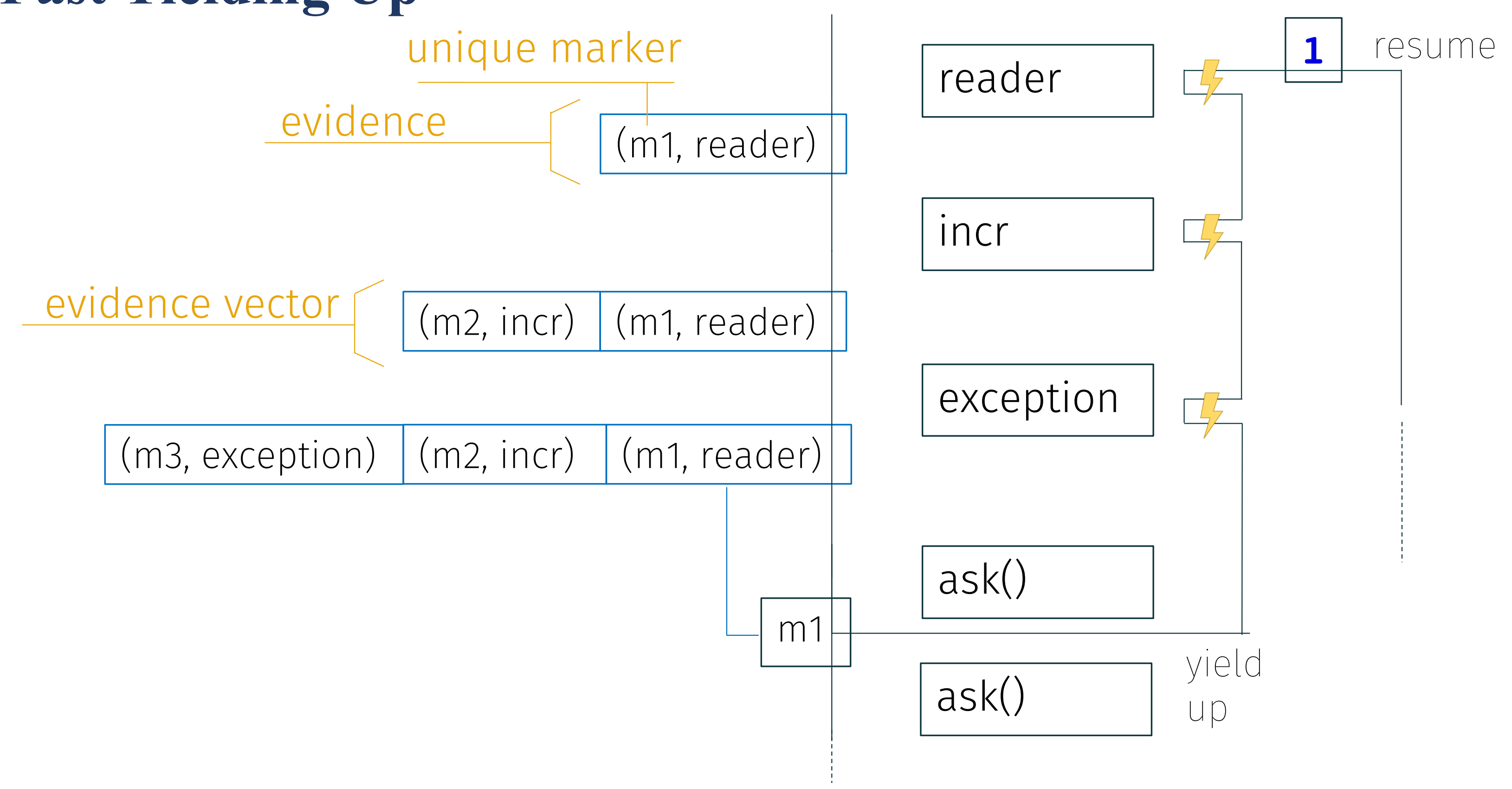
composable, modular, efficient, and easy-to-implement computational effects

Key Idea

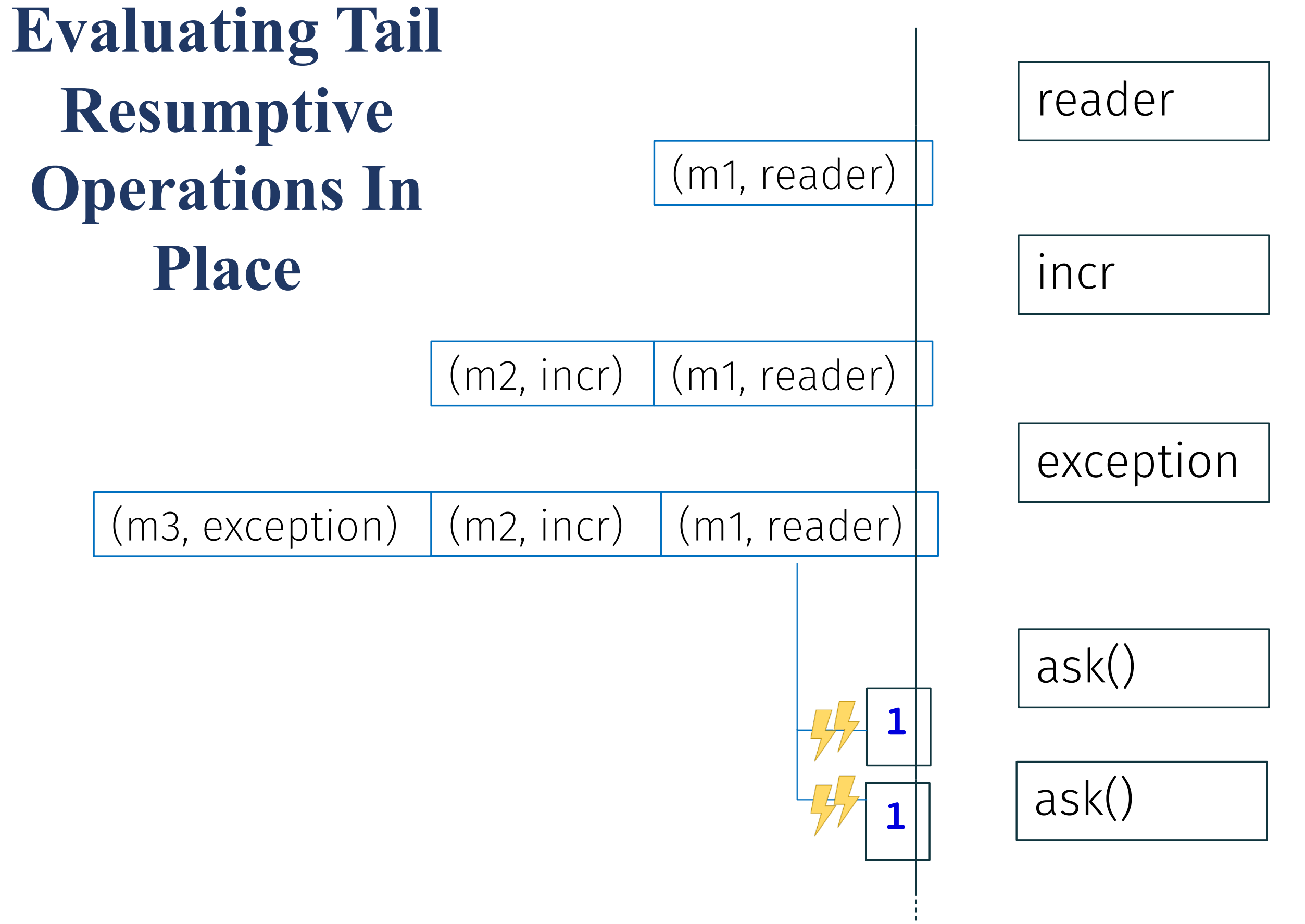
A vector of handlers is passed down as an implicit parameter to all operation invocations


polymorphic algebraic effects
F^{ϵ}
evidence-passing translation
⇝
polymorphic evidence calculus
F^{ev}
monadic multi-prompt translation
⇝
polymorphic lambda calculus
F^{v}

Fast Yielding Up



Evaluating Tail Resumptive Operations In Place



Challenge

(1) A well-typed source program translates to a well-typed target program; and

(2) their evaluation semantics coincides

Solution

Restriction: Scoped Resumption

Resumptions can only be applied in the very scope of their original handler context

Expressiveness All important effect handlers in practice

✓ No special runtime support needed

✓ Advanced compilation strategies can be used (e.g., reference counting)

Implementation

https://github.com/koka-lang/koka

Koka is a strongly typed, strict functional language which tracks the (side) *effects* of every function in its type.

Benchmarks

	runtime	evidence	direct
counter	1.00×	1.94×	2.14×
count-mod5	1.00×	1.28×	0.83×
layered	1.00×	2.23×	2.34×
nqueens	1.00×	46.09×	76.20×

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