Algorithmic Nominal Game Semantics

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Automata for programs with integer references

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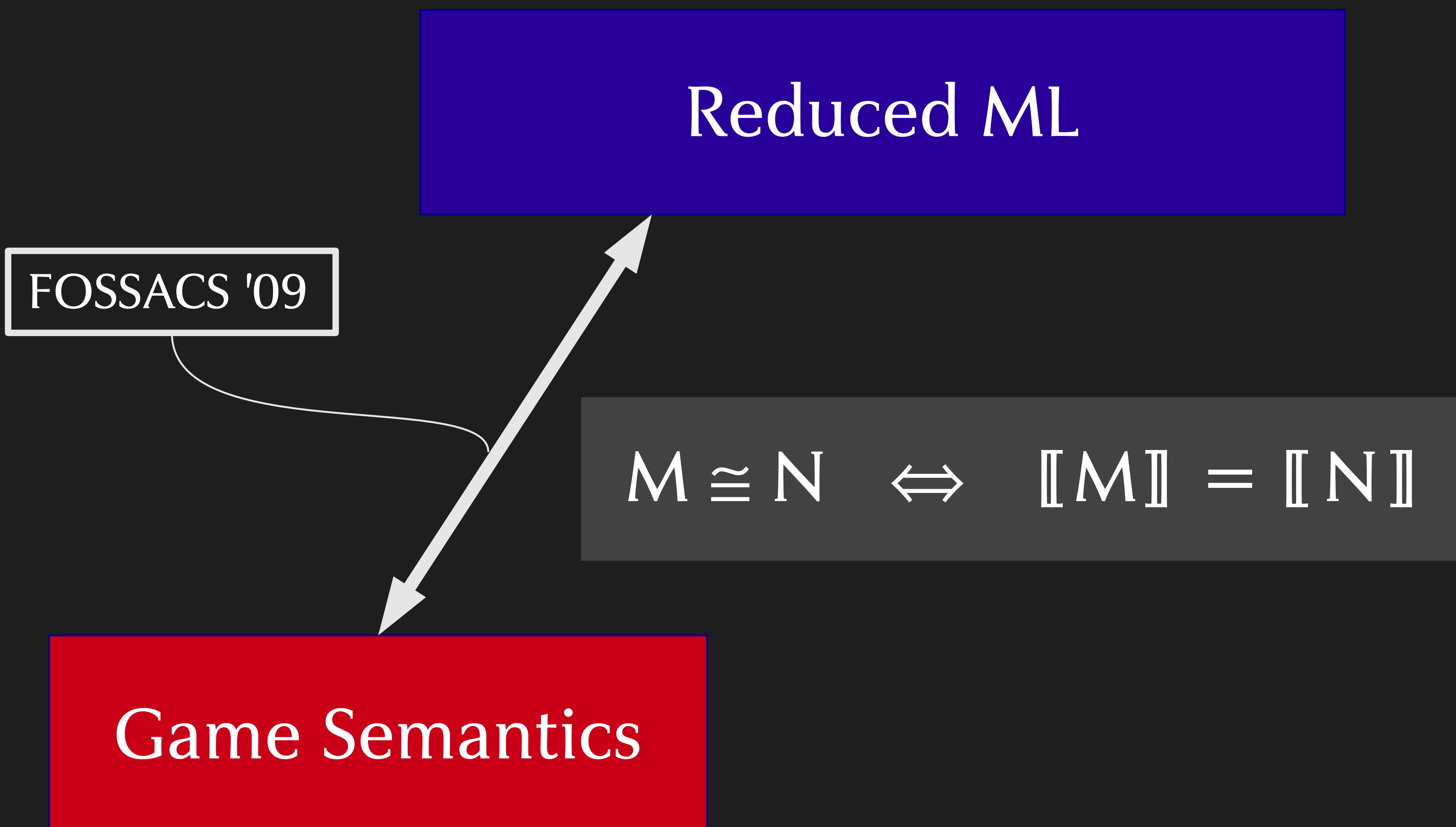
Method



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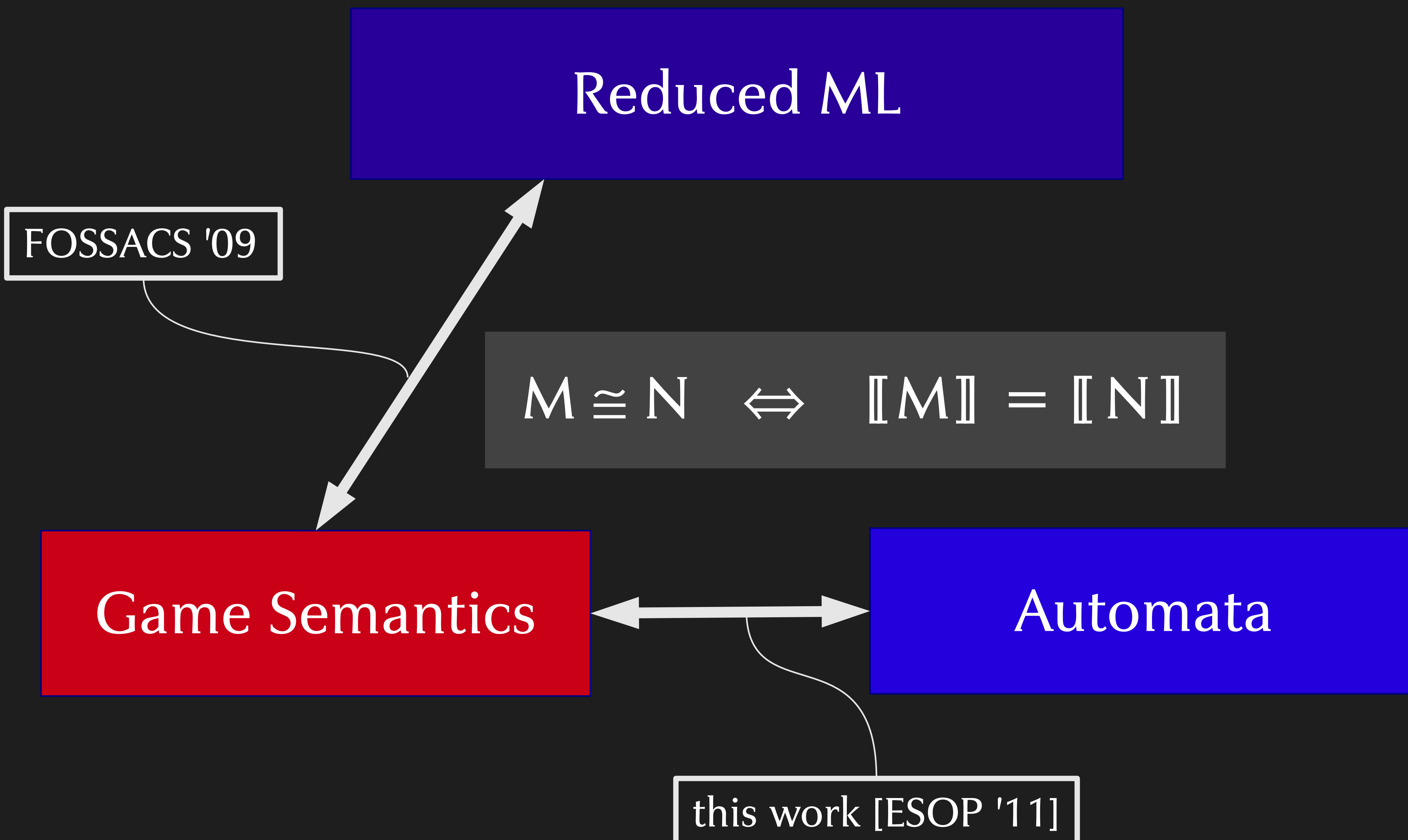
Reduced ML
FOSSACS '09
M ≅ N ⇔ ⟦M⟧ = ⟦N⟧
Game Semantics
Automata
this work [ESOP '11]

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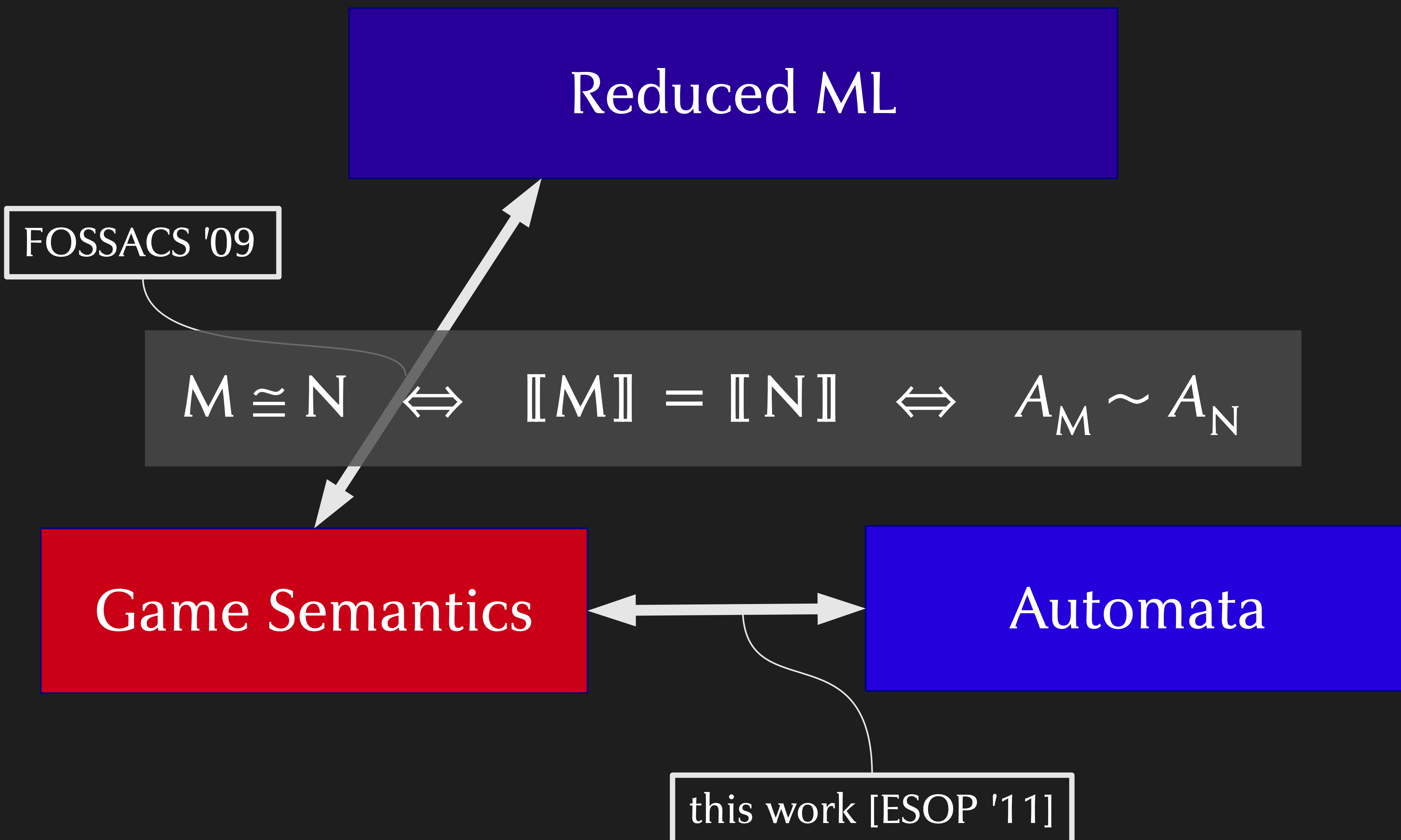
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$M \cong N \iff [\![M]\!] = [\![N]\!] \iff A_M \sim A_N$
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A language with ground references

Reduced ML = simply-typed lambda-calculus
+ integer references

Stark '95

$$x : \mathsf{int\,ref} \vdash x := 0; x := 1 \quad \cong \quad x := 1 : \mathsf{unit}$$

$$\mathsf{let}\, x = \mathsf{ref}(0)\, \mathsf{in}\ \lambda y.\, (x == y) \quad \cong \quad \lambda y.\, 0 : \mathsf{int\,ref} \to \mathsf{int}$$

$$\lambda y.\, \mathsf{let}\, x = \mathsf{ref}(0)\, \mathsf{in}\, x \quad \not\cong \quad \mathsf{let}\, x = \mathsf{ref}(0)\, \mathsf{in}\, (\lambda y.\, x) : \mathsf{unit} \to \mathsf{int\,ref}$$

$$f : \mathsf{int\,ref} \to \mathsf{int} \ \vdash\ \lambda y.\, \mathsf{let}\, x = \mathsf{ref}(0)\, \mathsf{in}\, f(x)$$

$$\cong \quad \mathsf{let}\, x = \mathsf{ref}(0)\, \mathsf{in}\, \lambda y.\, x := 0; f(x) : \mathsf{unit} \to \mathsf{int}$$

Games

$\vdash$ `λx.ref(0)` : `unit` $\to$ `intref`

$$1 \longrightarrow 1 \to Ref$$

O

P

O

P

O

P

Games

$\vdash$ `λx.ref(0)` : `unit` $\rightarrow$ `intref`

$$1 \longrightarrow 1 \rightarrow Ref$$

$*$ O

P

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Games

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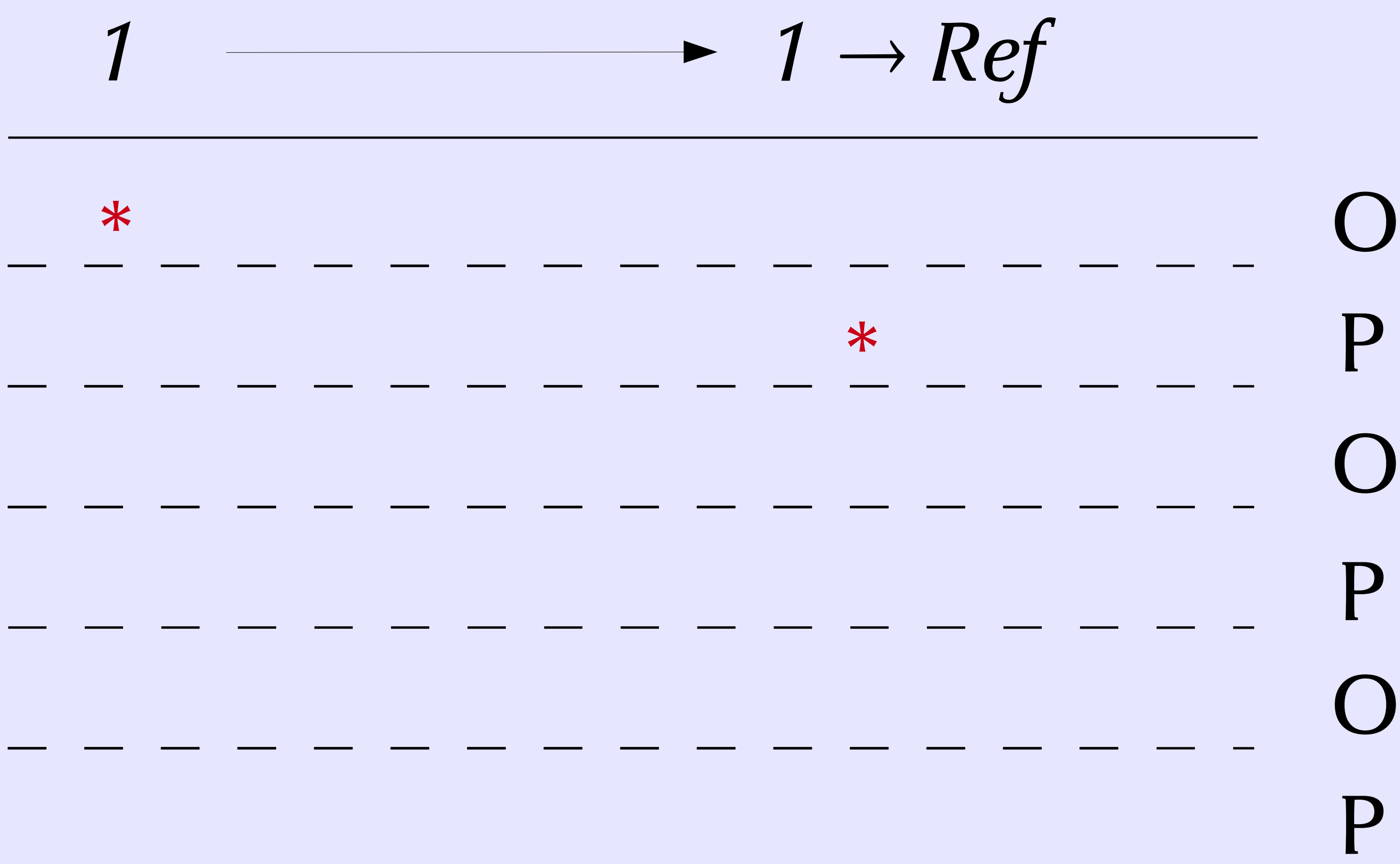

Games

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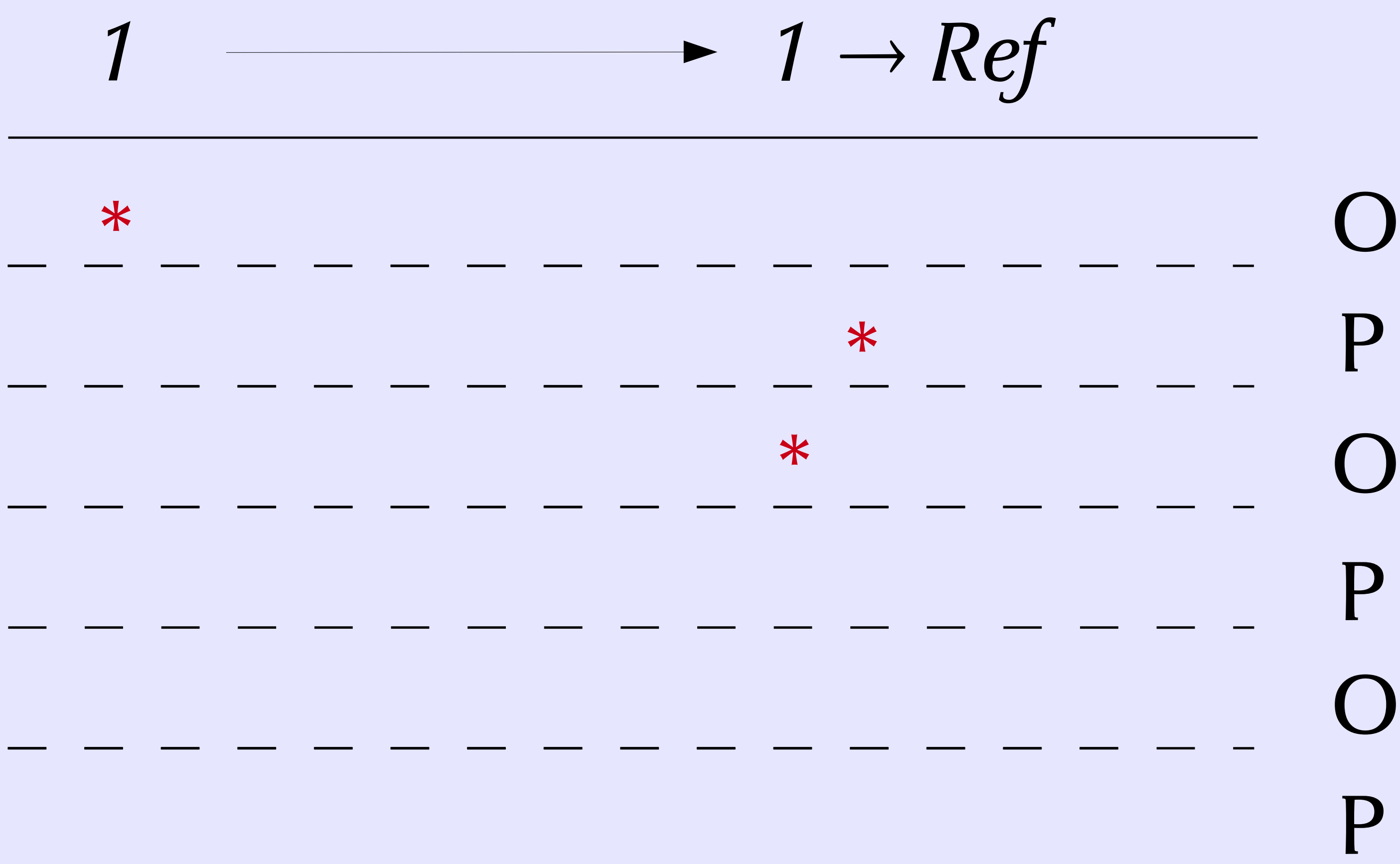
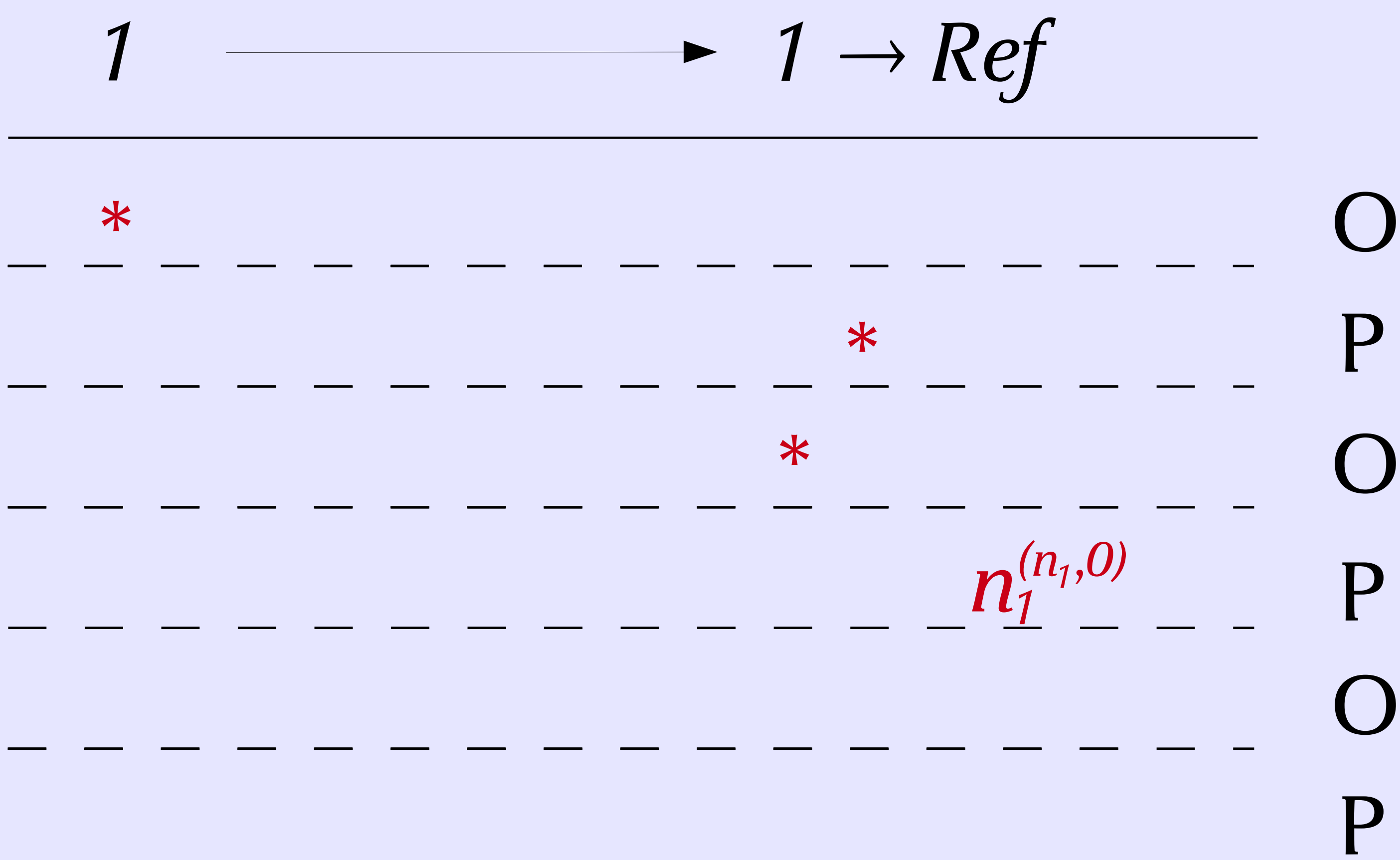


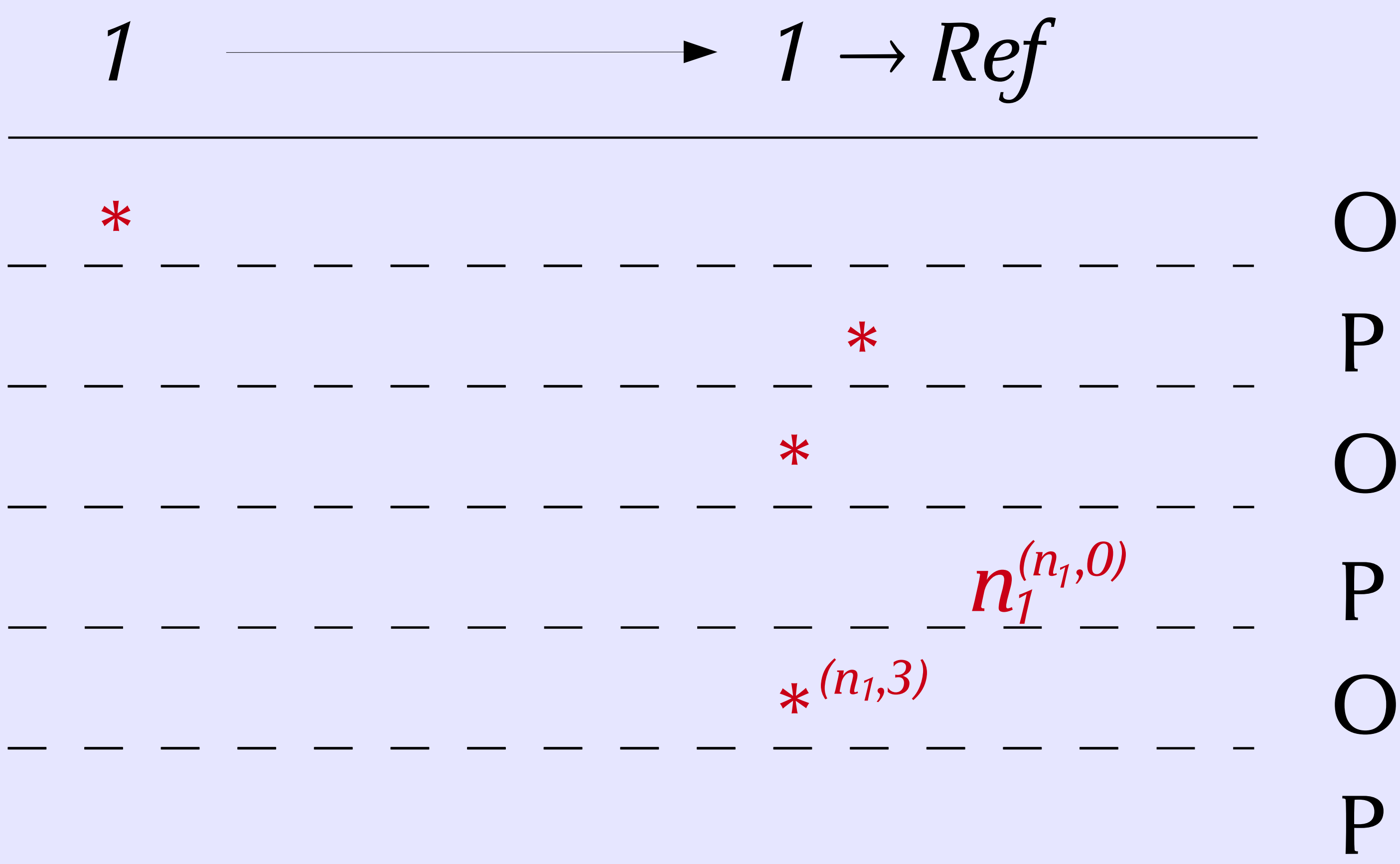
Games

$\vdash$ `λx.ref(0) : unit` $\rightarrow$ `intref`



Games

$\vdash$ `λx.ref(0)` : `unit` $\rightarrow$ `intref`



Games

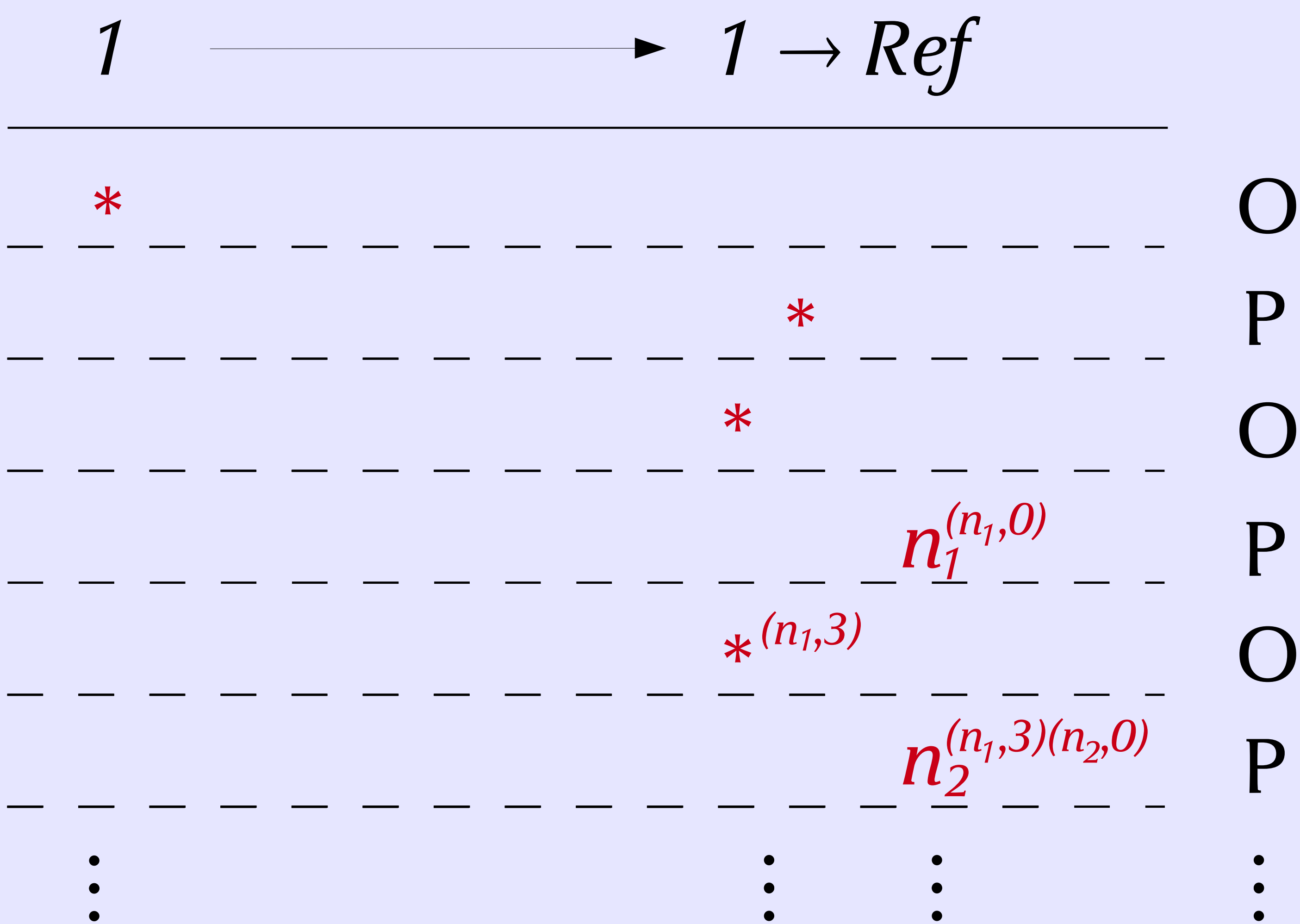
$\vdash$ `λx.ref(0)` : `unit` $\rightarrow$ `intref`

$$1 \longrightarrow 1 \rightarrow Ref$$

1	$1 \rightarrow Ref$	
$*$		O
	$*$	P
	$*$	O
	$n_1^{(n_1,0)}$	P
	$*^{(n_1,3)}$	O
	$n_2^{(n_1,3)(n_2,0)}$	P

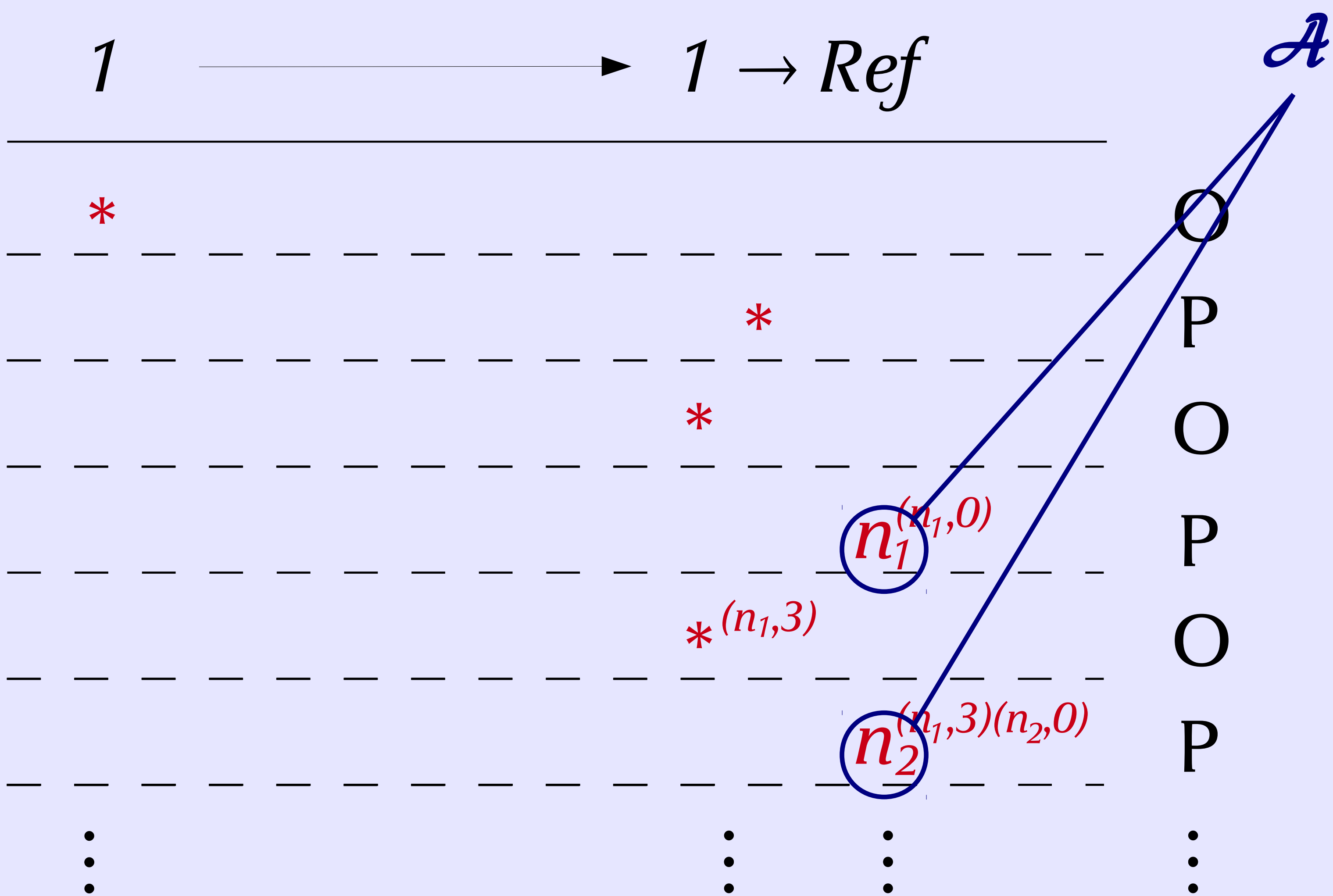
Games

$\vdash$ `λx.ref(0) : unit` $\to$ `intref`



Games

$\vdash$ `λx.ref(0) : unit → intref`



Algorithmics

Basic infiniteness

- Bound int-type: $0, \ldots, max$
- Restrict types: $\theta ::= \beta \mid \beta \rightarrow \beta$

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Infinite alphabet (*names*)

- Automata with *n* registers
- Oracle for freshness

} Fresh-Register Automata [POPL '11]

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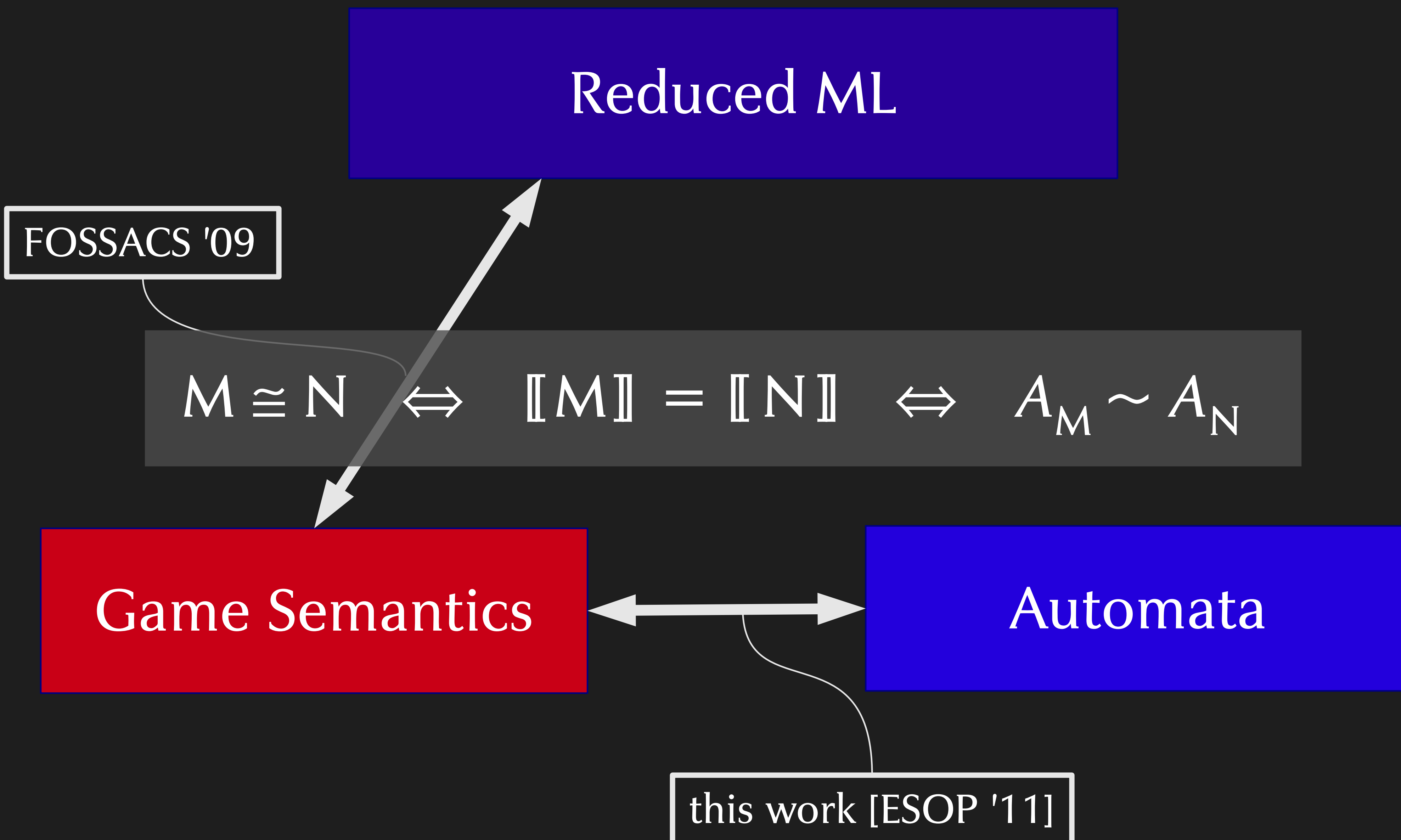
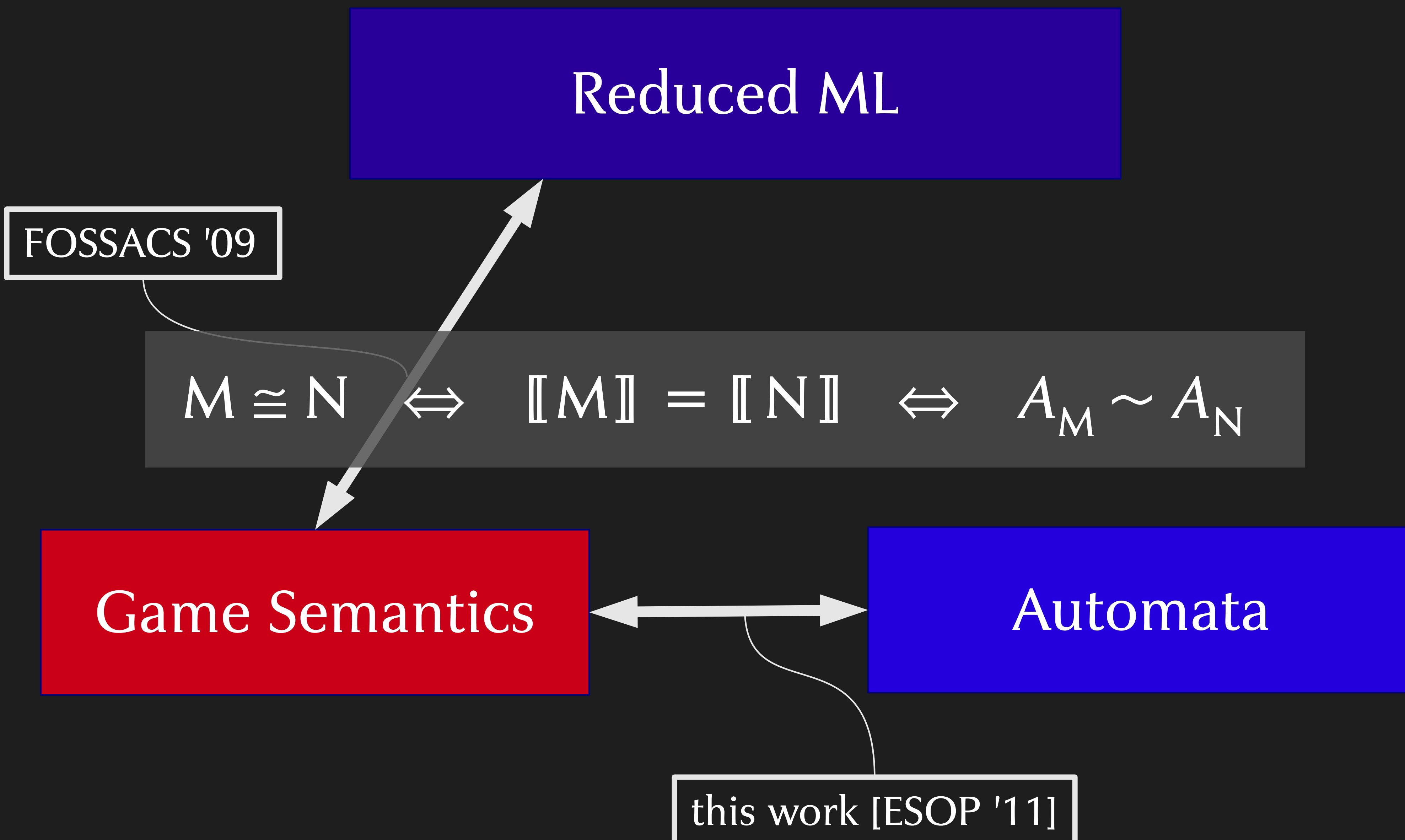
Stores

- Store representations
- Focus on bisimulations

Algorithmic nominal game semantics



thank you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Further on

- Higher types
- Complexity
- More expressiveness
- Program verification