On Contracts, Sandboxes, and Proxies for JavaScript

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TreatJS

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- Language embedded contract system for JavaScript
- Enforced by run-time monitoring

- Standard abstractions for higher-order-contracts (base, function, and dependent contracts) [Findler,Felleisen'02]

- Systematic blame calculation
- Contract constructors generalize dependent contracts
- **Internal noninterference**

Base Contract [Findler,Felleisen'02]

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- *Base Contracts* are built from predicates
- Specified by a plain JavaScript function

Base Contract

```
function isNumber (arg) {
  return (typeof arg) === 'number';
};
var _Number_ = Contract.Base(isNumber);

assert(1, _Number_); ✓
assert('a', _Number_); ✗ blame the subject
```

Function Contract [Findler,Felleisen'02]

```
// Number × Number → Number
function plus (x, y) {
  return (x + y);
}
```

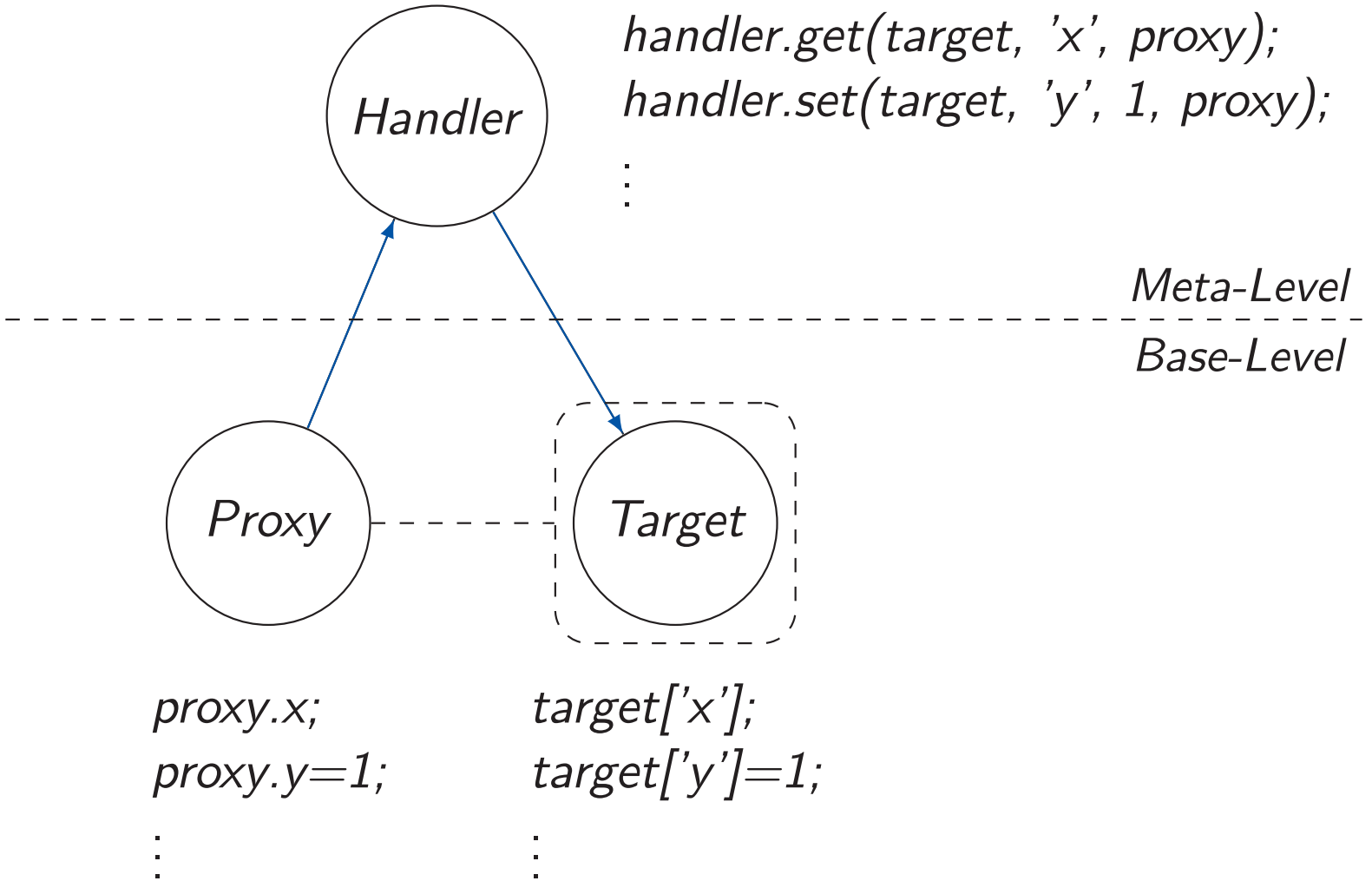
Function Contract

```
var _Plus_ = Contract.Function([_Number_, _Number_],
    _Number_);

var plusNumber = assert(plus, _Plus_);

plusNumber(1, 1); ✓
plusNumber('a', 'a'); ✗ blame the context
```

JavaScript Proxies



Noninterference

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Noninterference

The contract system should not interfere with the execution of application code.

- *External Noninterference* arises from the interaction of the contract system with the host program
  1. Exceptions
  2. Object equality
- *Internal Noninterference* arises from executing unrestricted code in predicates

Internal Noninterference

- No syntactic restrictions on predicates
- Predicates may try to write to data that is visible to the application
- *Solution:* Predicate evaluation takes place in a sandbox

Faulty Predicate

```
function isNumber (arg) {
  typetype = (typeof arg); ✗ access forbidden
  return type === 'number';
};
```

TreatJS Sandbox

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- All contracts guarantee noninterference
- Read-only access is safe

Predicate with Read-Access

```
function isArray (arg) {
  return (arg instanceof Array); ✓
}
```

TreatJS Sandbox

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- Predicate execution may violate contracts
- *Solution:* Sandbox redefines the responsibility

Predicate with Read-Access

```
function addOne (arg) {
  return plusNumber(arg, '1'); ✗ blame the ?
        blame the contract
}
```

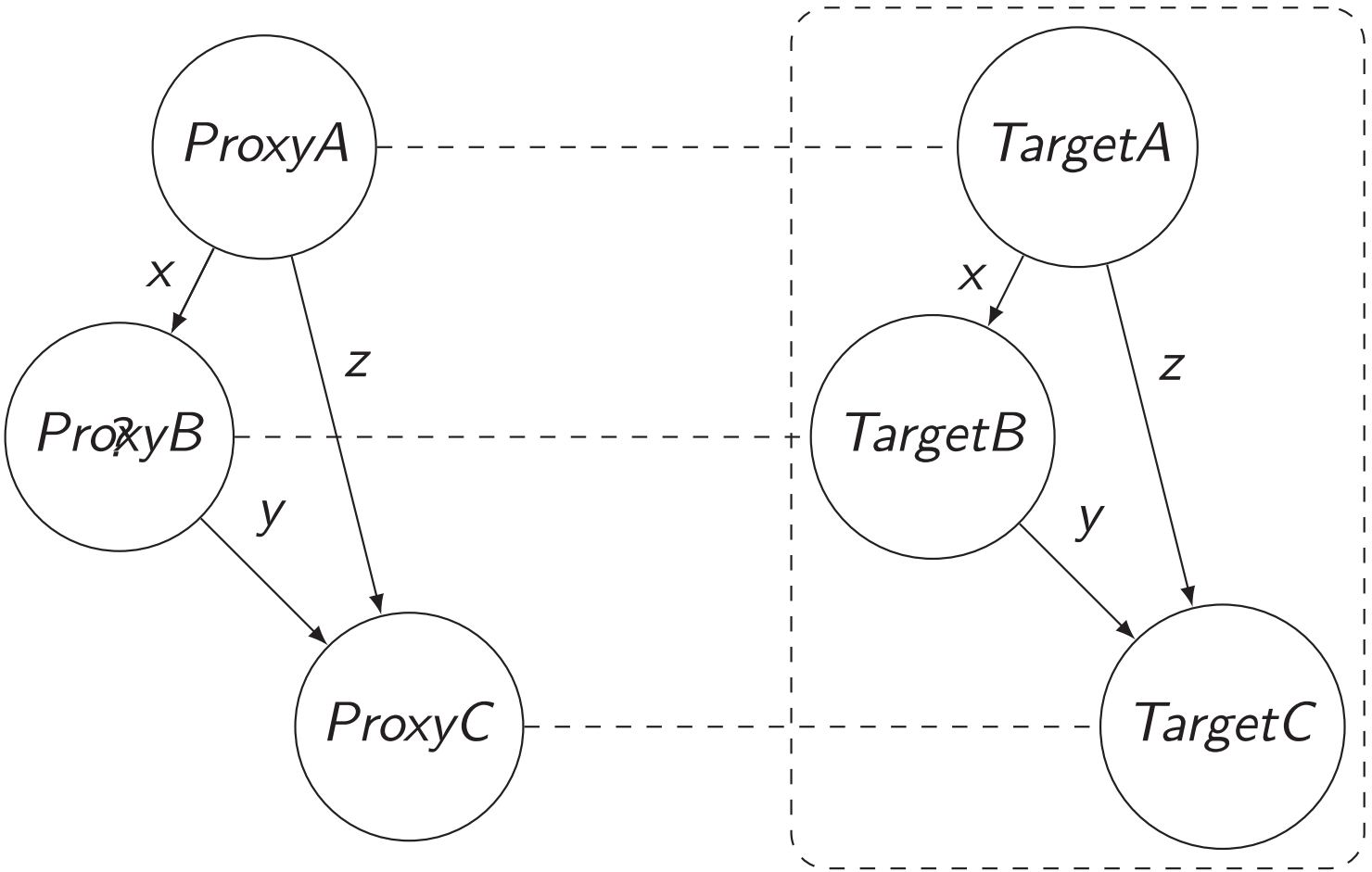
Sandbox Encapsulation

Faulty Predicate

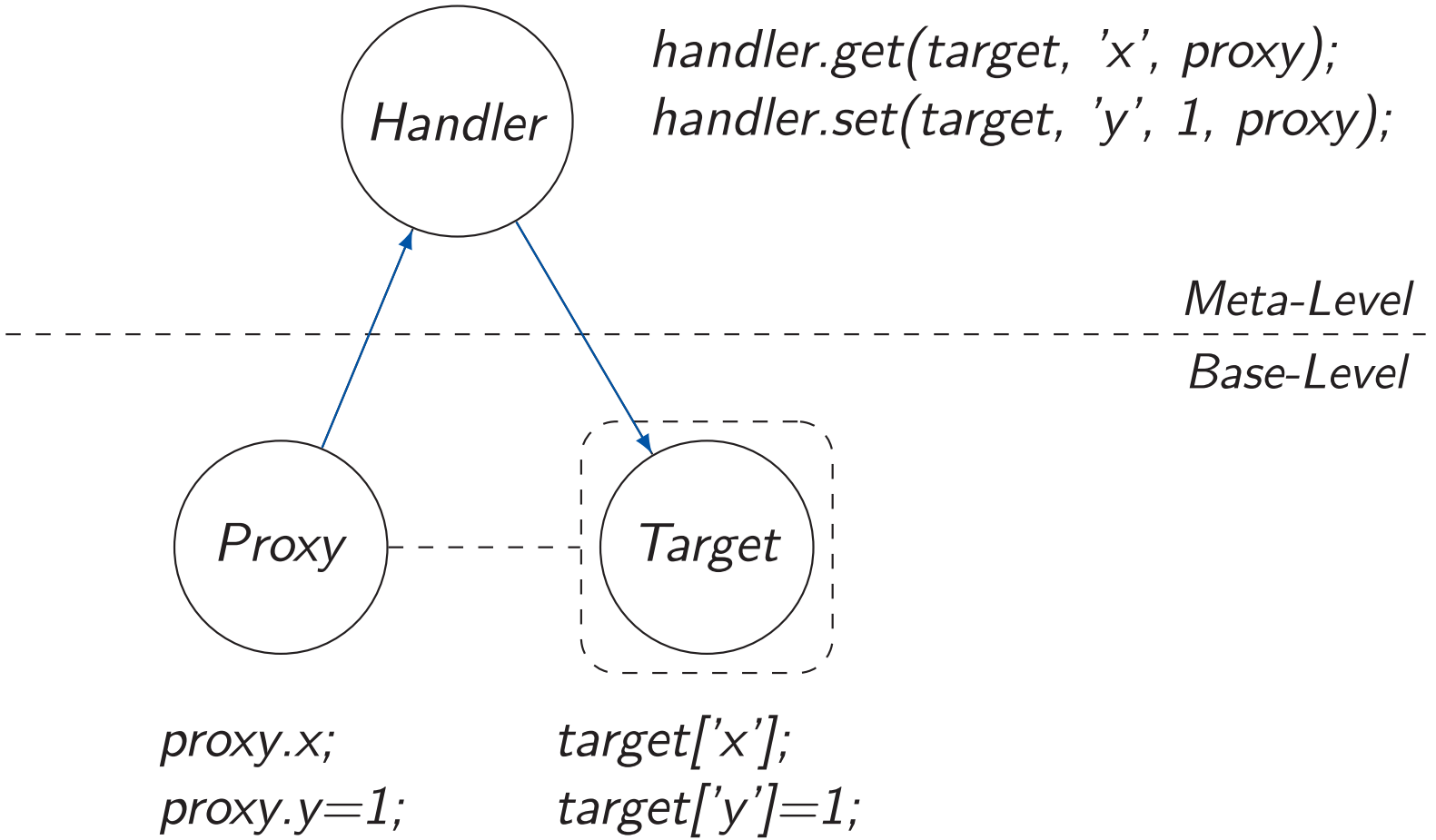
```
function isNumber (arg) {
  type = (typeof arg);
  return type === 'number';
};
```

1. Place a write protection on objects (e.g. *this*, *arg*)
2. Remove external bindings of functions (e.g. *type*)

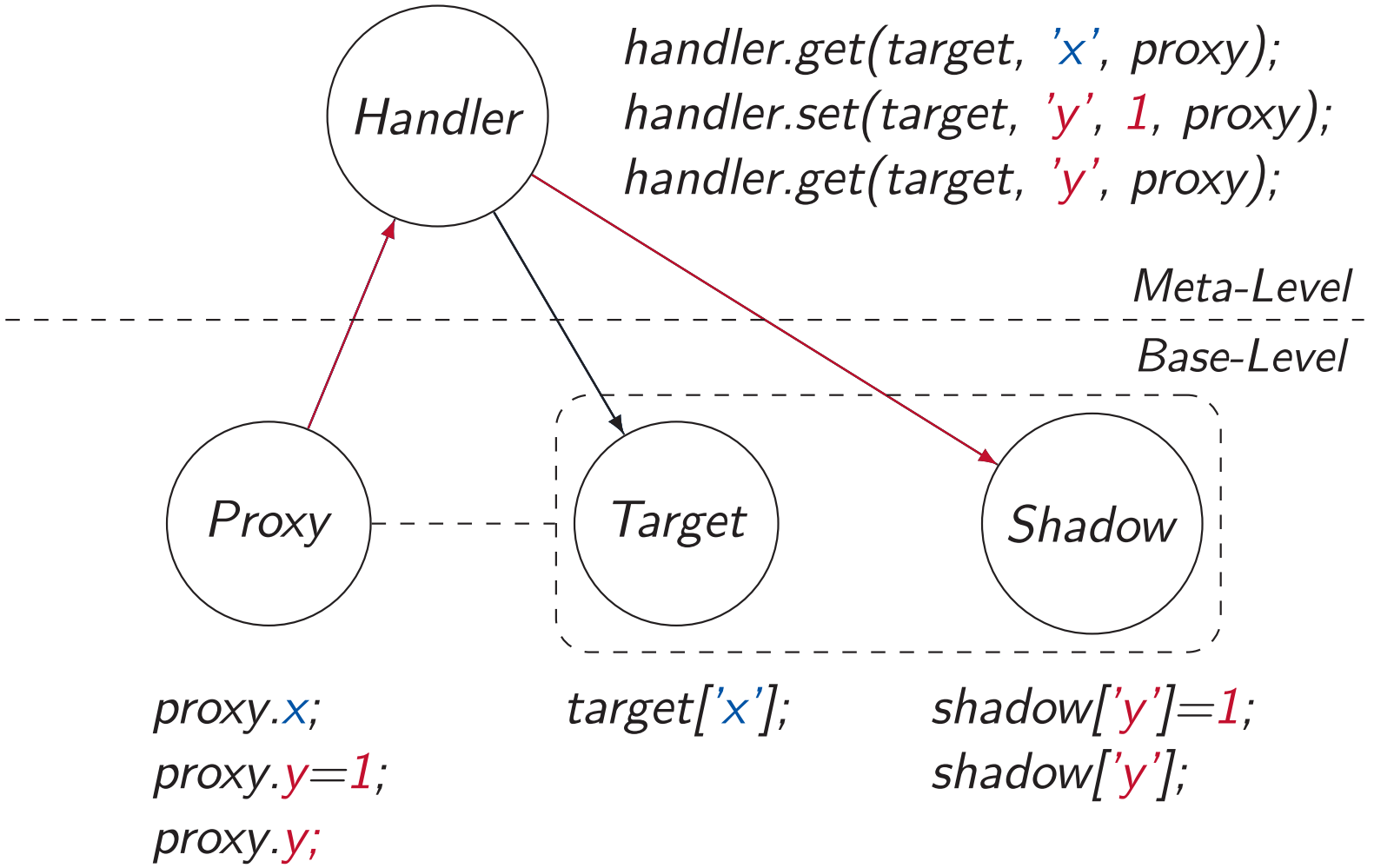
Identity Preserving Membrane



Shadow Objects



Shadow Objects



Function Recompilation

```
var x = 1;

  function f (){

    function g (y) {
      var z = 1;
      return x+y+z;
    }

  }
```

Function Recompilation

```
var x = 1;

  function f (){

    " function g (y) {
        var z = 1;
        return x+y+z;
      }"

  }
```

Function Recompilation

```
var x = 1;

  with(sbxglobal){

    eval(" function g (y) {
      var z = 1;
      return x+y+z;
    }");

  }
```

Function Recompilation

```
var x = 1;

  with(sbxglobal){

    function g (y) {
      var z = 1;
      return x+y+z;
    }

  }
```

Conclusion

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TreatJS:

- Language embedded, dynamic, higher-order contract system for full JavaScript
- Guarantees noninterference

Sandbox:

- Language embedded sandbox for full JavaScript
- Runs JavaScript code in isolation isolation