Arrows in Commercial Web Applications

Eric Fritz Jose Antony Tian Zhao

University of Wisconsin - Milwaukee

Research History

Directing JavaScript with Arrows
Khoo Yit Phang, Michael Hicks, Jeffrey S. Foster, and Vibha Sazawal.
5th Symposium on Dynamic Languages, 2009.

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HotWeb, 2016.

Example Application - Inventory Search

bookcase

Prev · Displaying 21-24 of 24 · Next

ID	Name	Category	Subcategry	Price / Unit	Margin
223	Rush Hierlooms Collection 1" Thick Stackable Bookcases	Furniture	Bookcases	170.98	0.66
224	Rush Hierlooms Collection Rich Wood Bookcases	Furniture	Bookcases	160.98	0.72
230	Safco Value Mate Steel Bookcase, Baked Enamel Finish on Steel, Black	Furniture	Bookcases	70.98	0
231	Sauder Camden County Barrister Bookcase, Planked Cherry Finish	Furniture	Bookcases	120.98	0.71

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Filter displayed results by name and category

Paginate results when filtered set is $>$ 50 items

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Requirements:

Filter displayed results by name and category

Paginate results when filtered set is $>$ 50 items

Performance Optimizations:

Cache server results for same query/page

Attempt to pre-fetch the next page of results

Don't make a remote request while the user is typing

Sequencing Filtering + Paging (Using Callbacks)

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function call(query, page, handler) {
    $.ajax({ 'url': makeURL(query, page), 'success': handler });
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function showPage(resp) {
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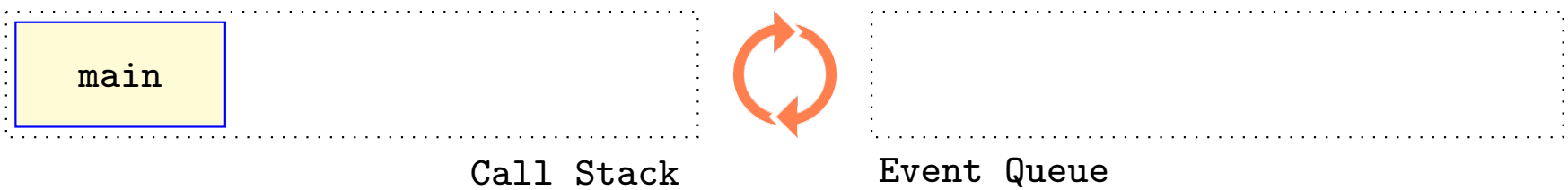

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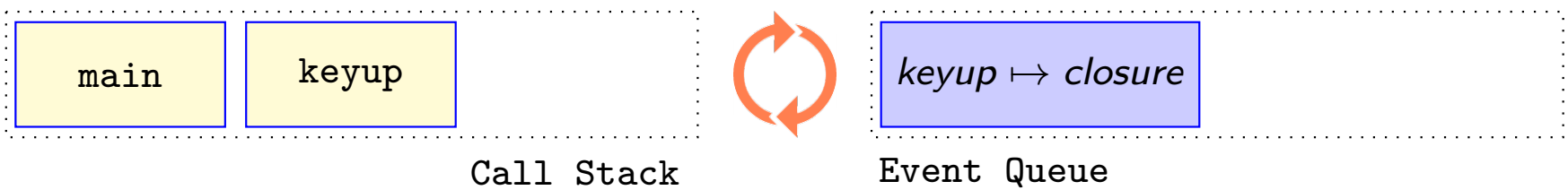

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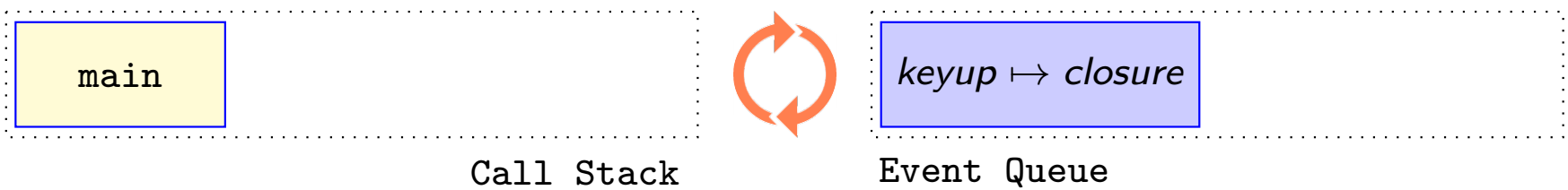

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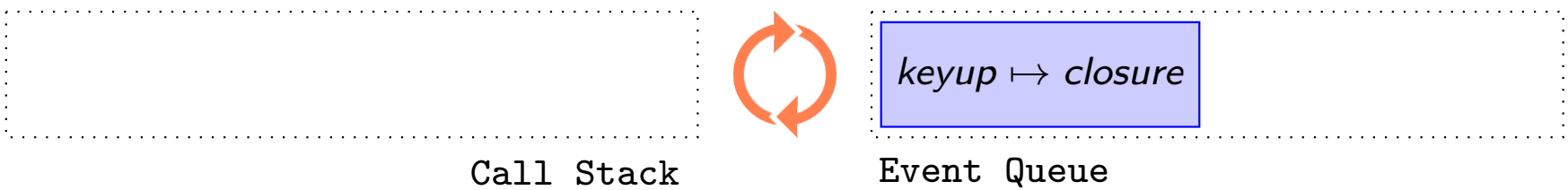

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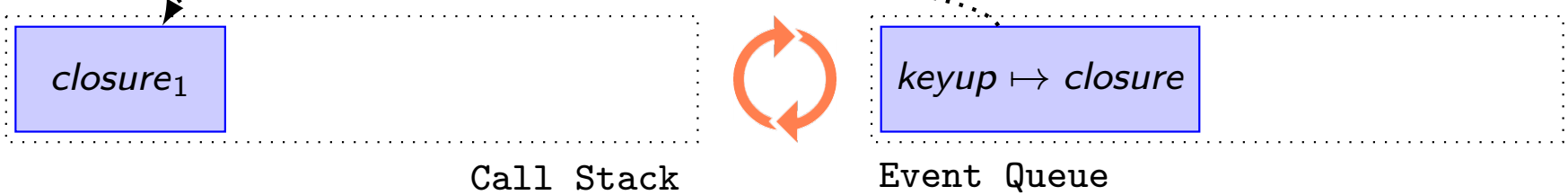

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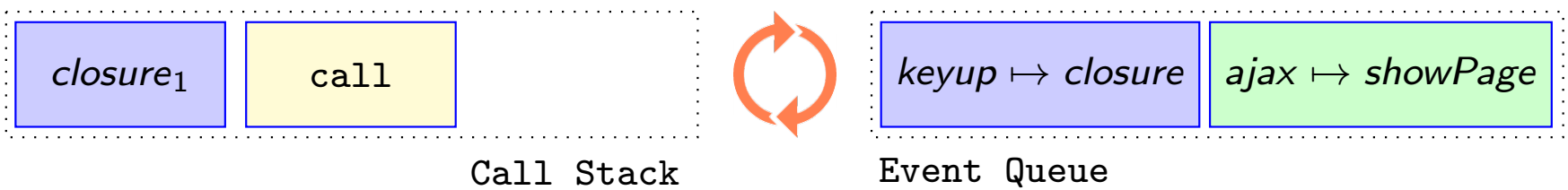

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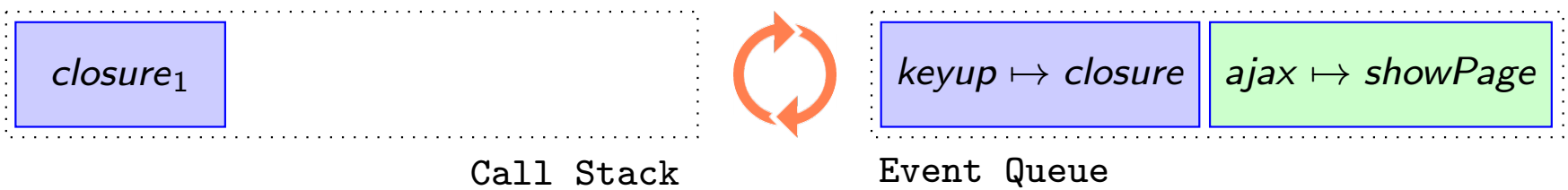

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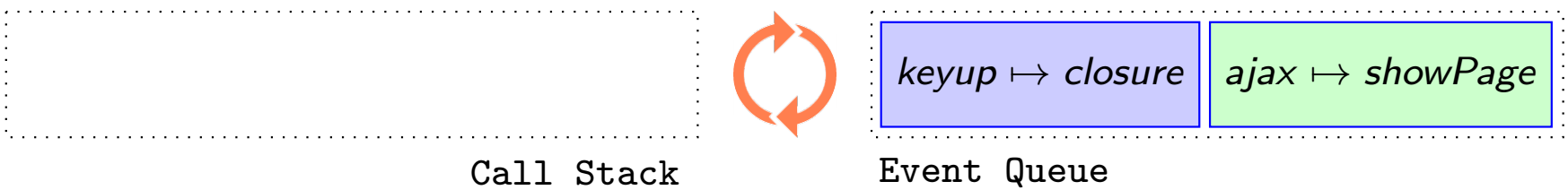

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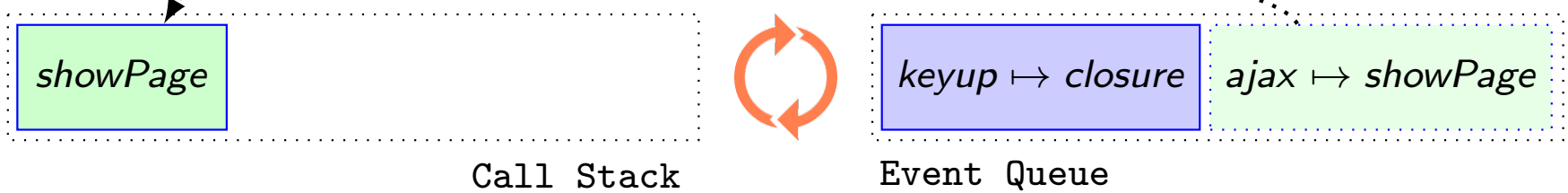

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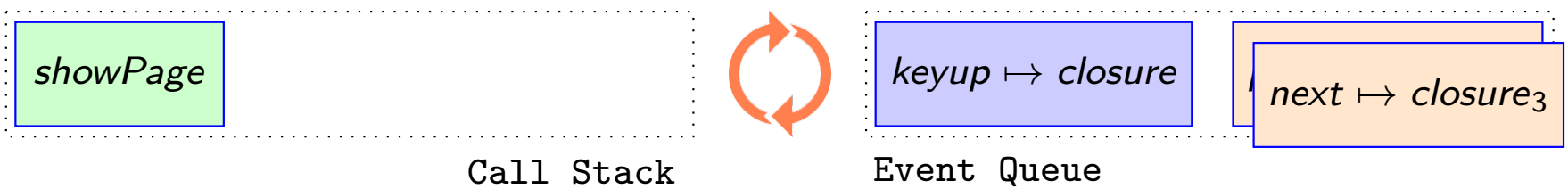

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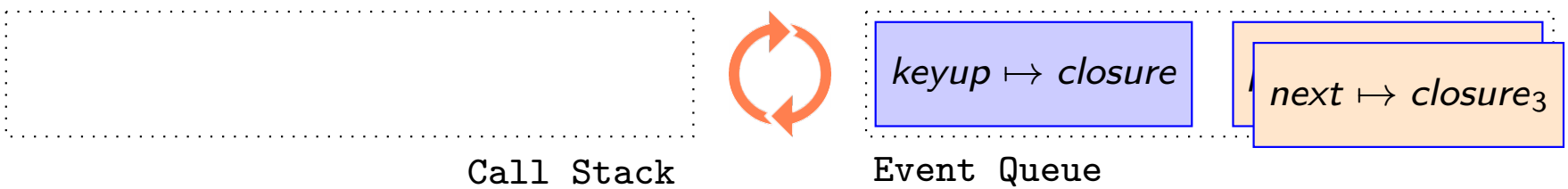

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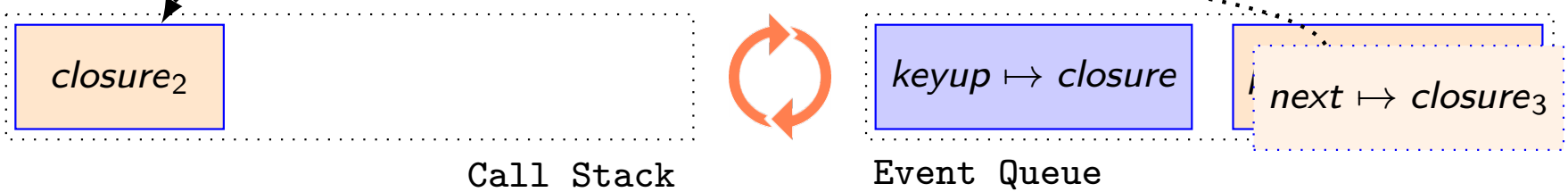

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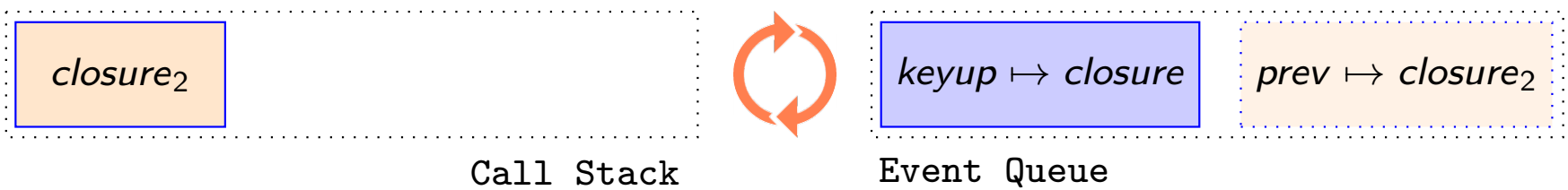

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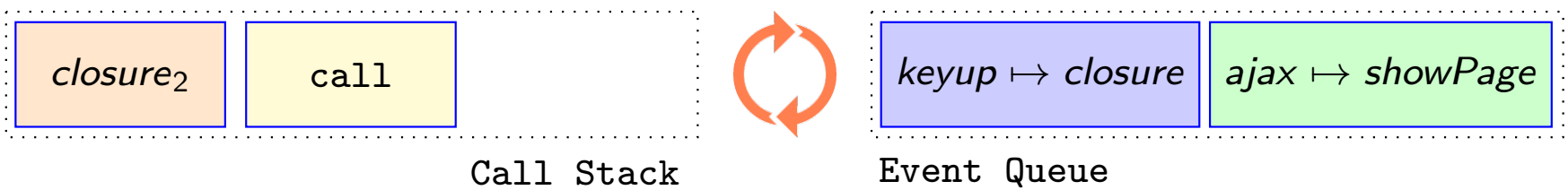

Callbacks - The Problems

Lose flow of (synchronous) code

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Event registration/de-registration is ad-hoc

Lose imperative exception semantics

```
try {
    User.findOne({name: 'Eric'}, (err, obj) => {
        if      (err != null) { throw err;                    }
        else if (obj == null) { throw new Error('Not Found'); }
        else                  { /*            ...           */ }
    });
} catch (err) {
    /* ... */
}
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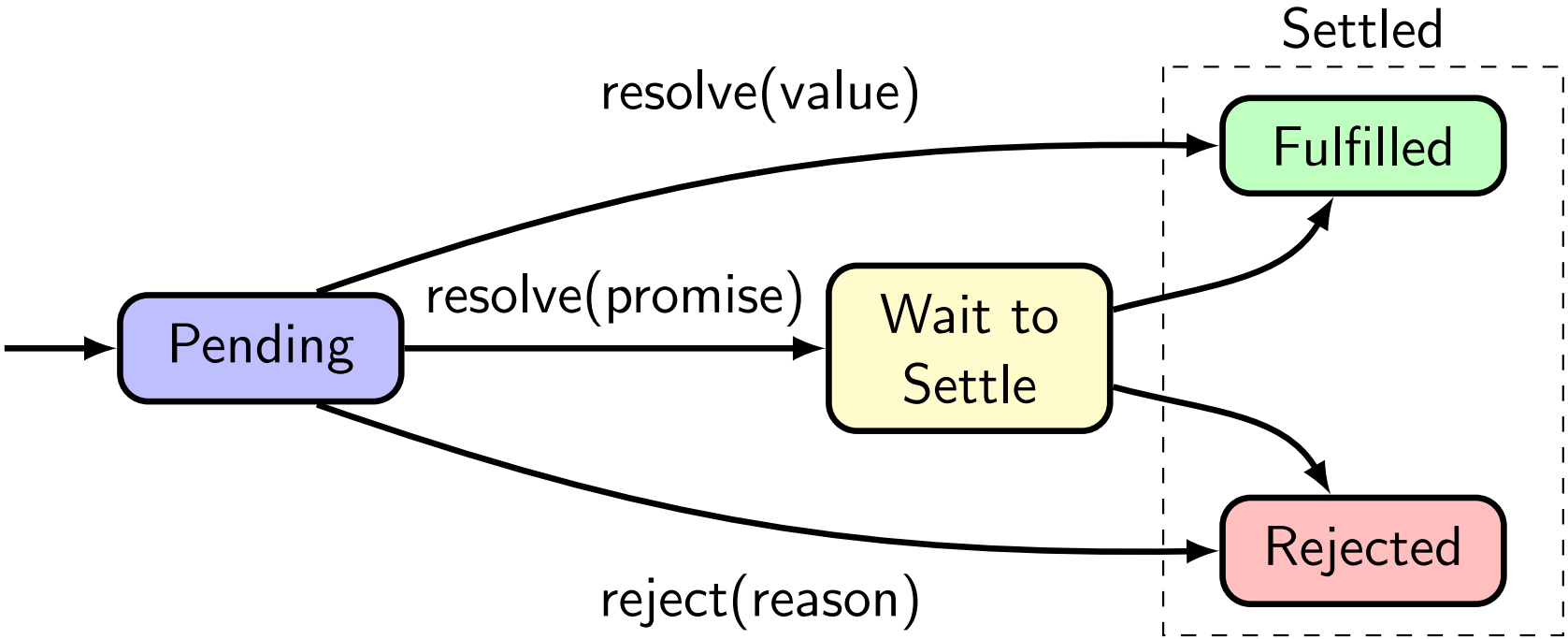
20% of function calls provide a callback
72% of callbacks are asynchronous
48% of callbacks are anonymous

Promises – A Better Abstraction



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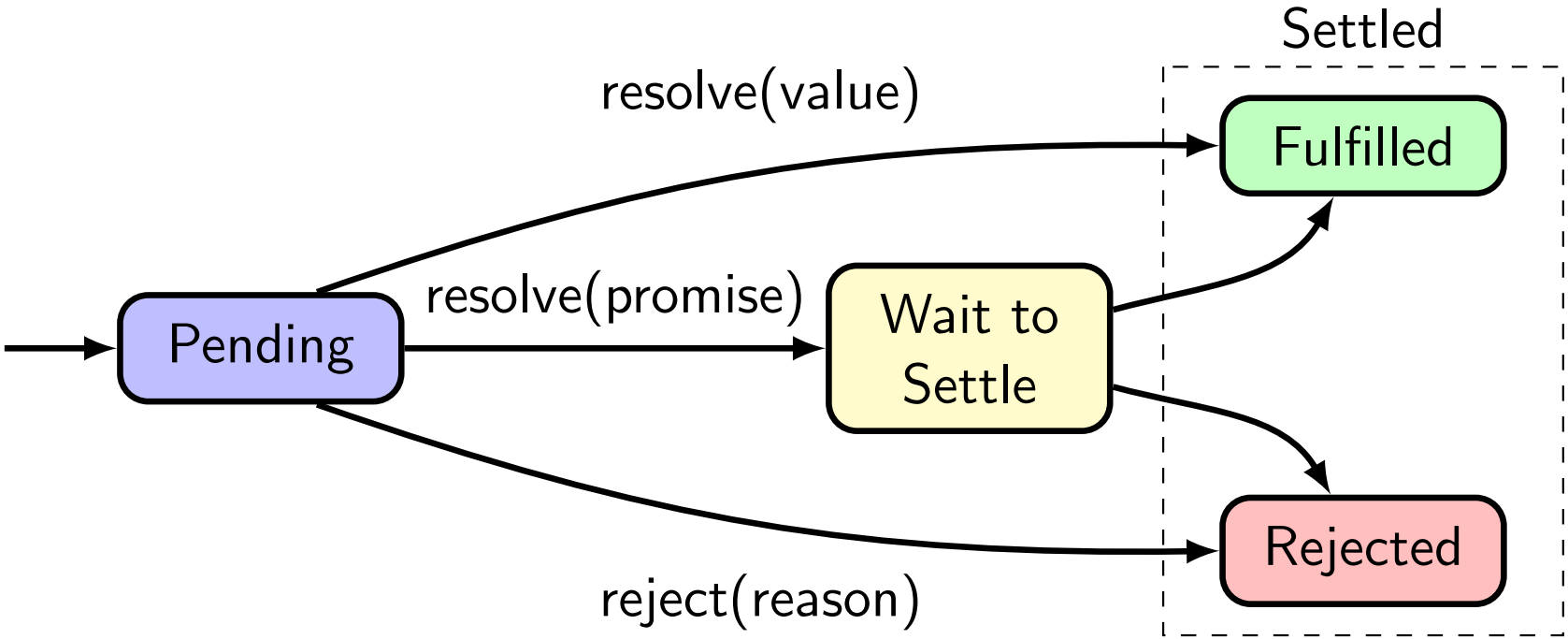


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var promise = new Promise((resolve, reject) => {
    conn.query('SELECT * from items', (err, row) => {
        if (!!err) resolve(row);
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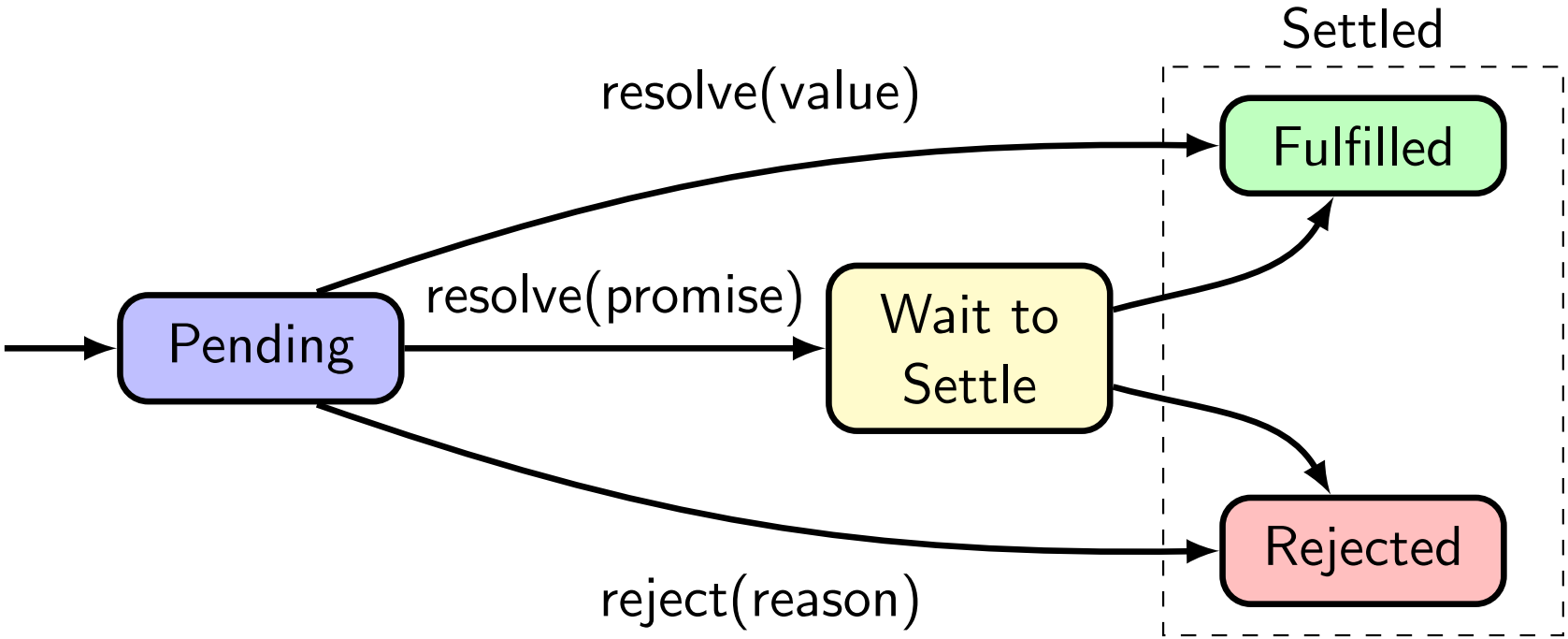


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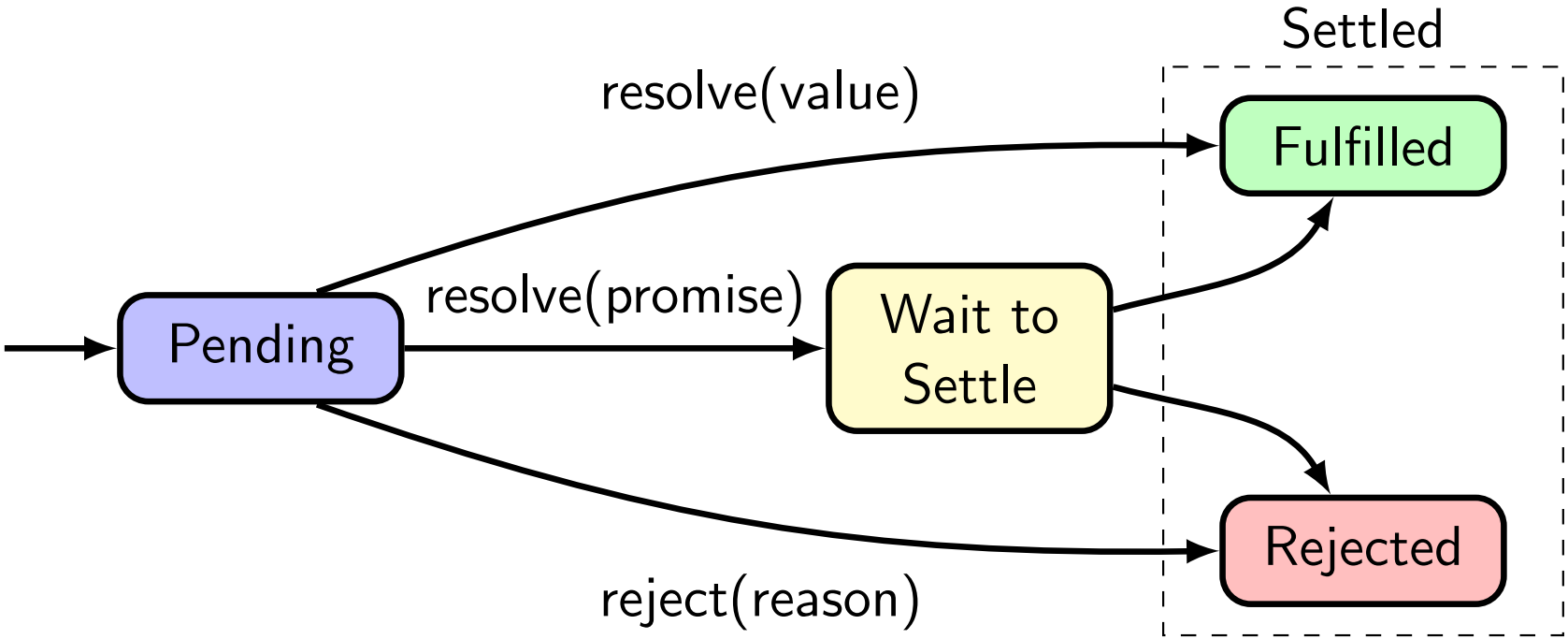


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```
promise.then(onSuccess);
promise.then(onSuccess, onError);
promise.then(onSuccess).catch(onError);
```

Arrows – Attacking the Abstraction Differently

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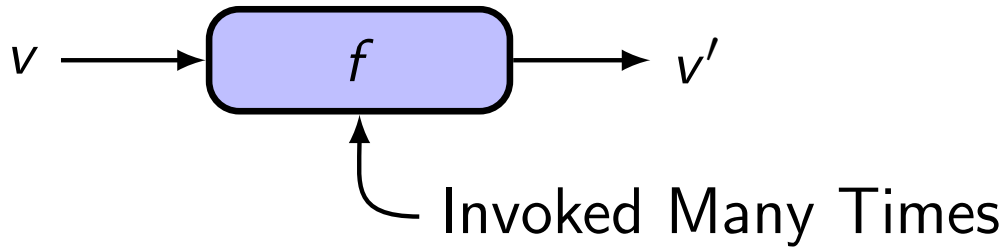

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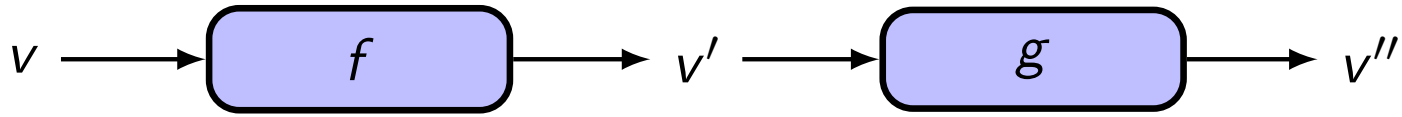

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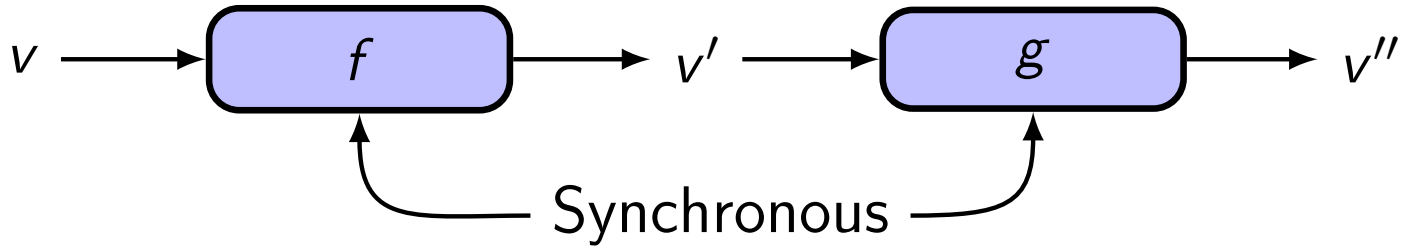
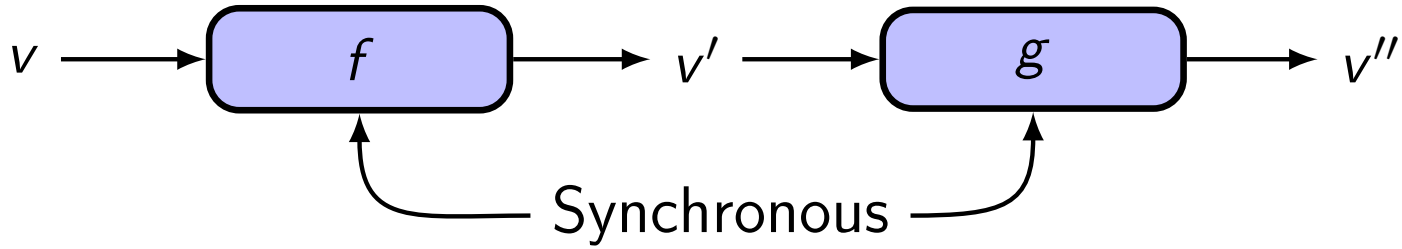
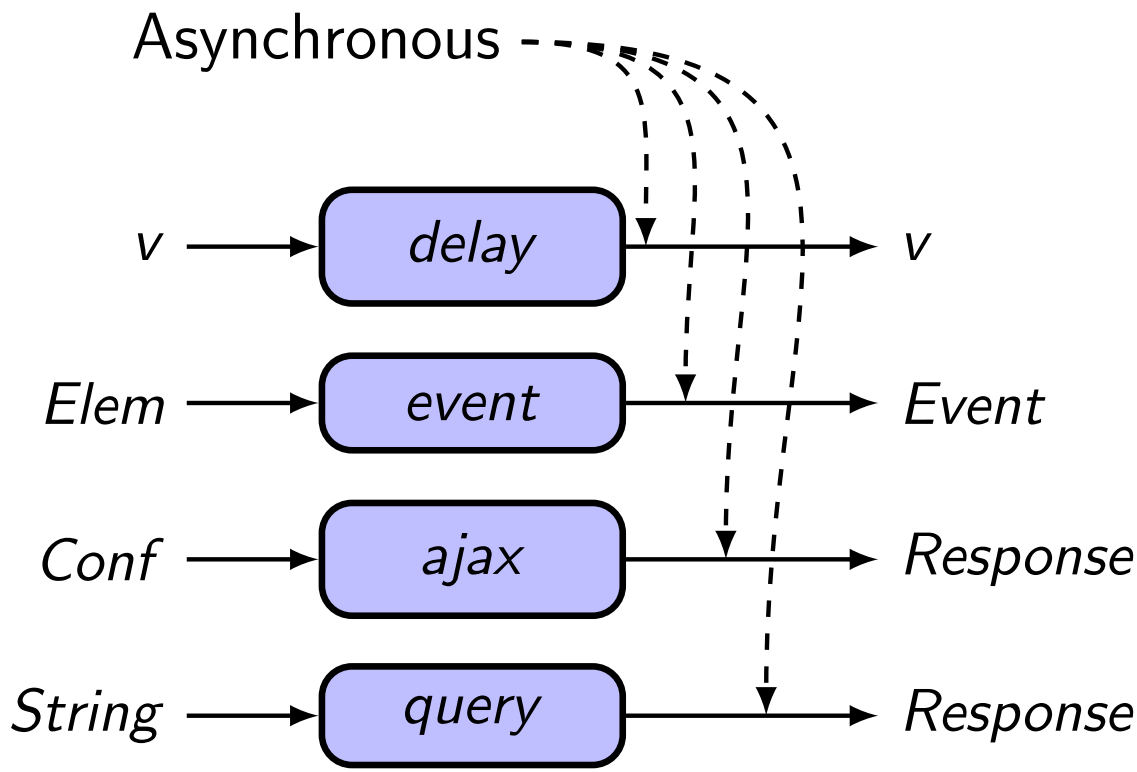


Arrows – Attacking the Abstraction Differently





Arrows - Async Machine Composition

Composition Time

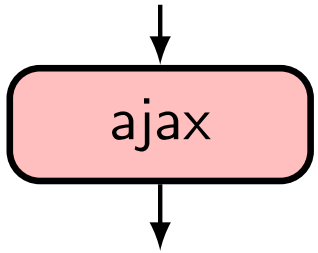
Execution Time

```
let page = Arrow.fix(a => Arrow.seq([
  ajax,
  explode,
  Arrow.seq([
    new NthArrow(3),
    handle
  ]).remember(),
  Arrow.any([
    new NthArrow(1).onclick('#prev'),
    new NthArrow(2).onclick('#next'),
  ]),
  a,
]));

let filter = Arrow.fix(a => Arrow.any([
  Arrow.seq([
    getQueryAndPage,
    page
  ]).noemit(),
  a
]).onkeyup('#filter'));

filter.run();
```

Arrows - Async Machine Composition

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  Arrow.seq([
    new NthArrow(3),
    handle
  ]).remember(),
  Arrow.any([
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    new NthArrow(2).onclick('#next'),
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    getQueryAndPage,
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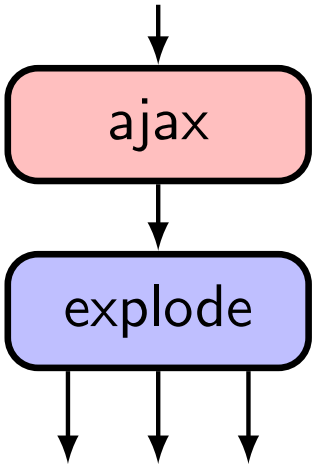
Arrows - Async Machine Composition

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  Arrow.seq([
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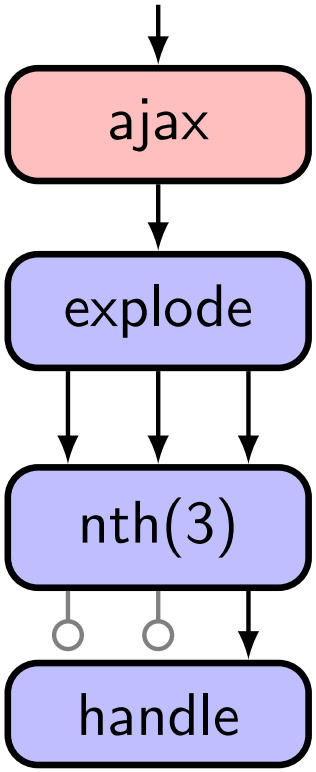
Arrows - Async Machine Composition

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  Arrow.seq([
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  Arrow.any([
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]).onkeyup('#filter'));

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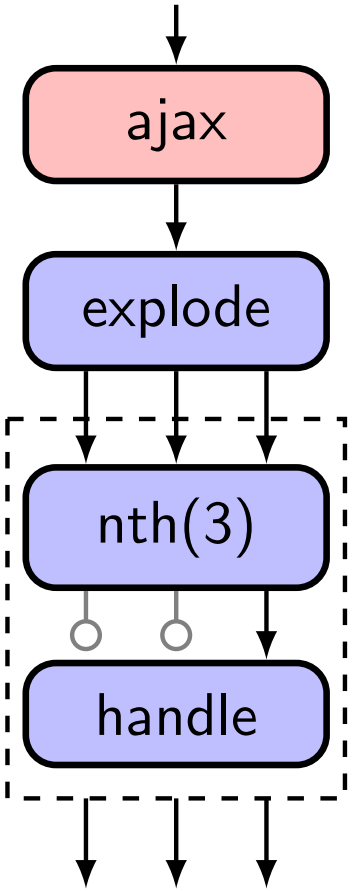
Arrows - Async Machine Composition

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  ajax,
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  Arrow.seq([
    new NthArrow(3),
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  ]).remember(),
  Arrow.any([
    new NthArrow(1).onclick('#prev'),
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  a,
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    getQueryAndPage,
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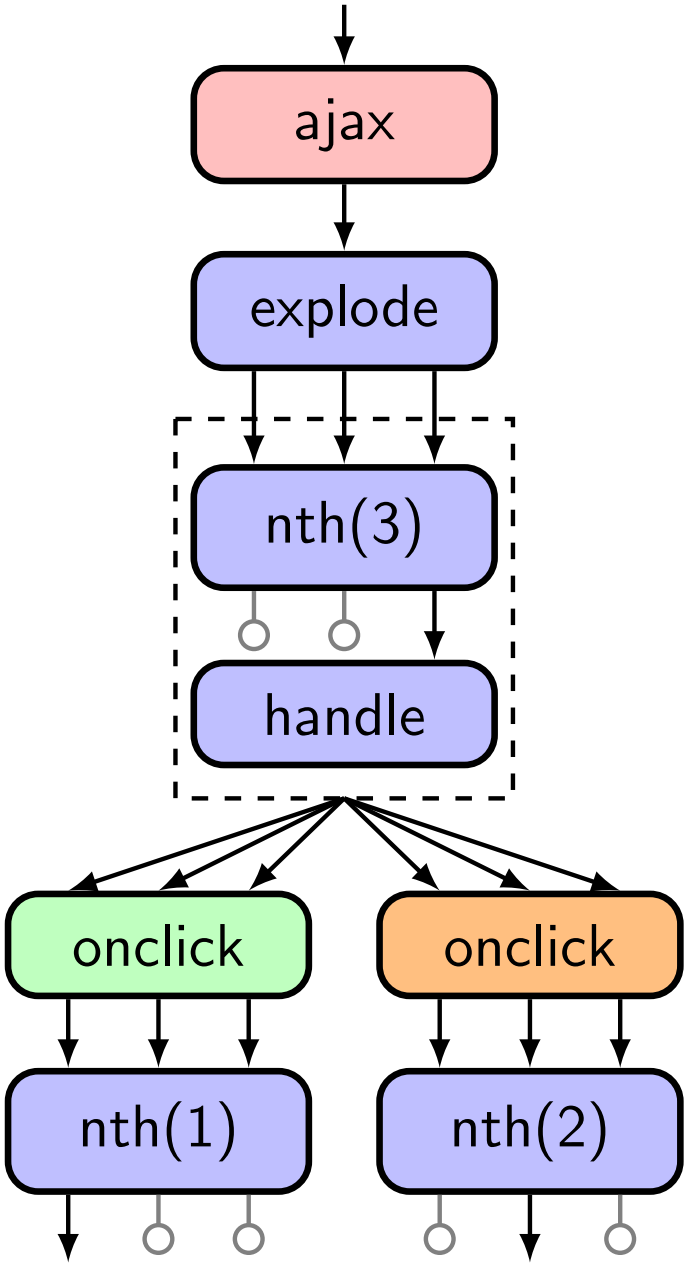
Arrows - Async Machine Composition

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  Arrow.seq([
    new NthArrow(3),
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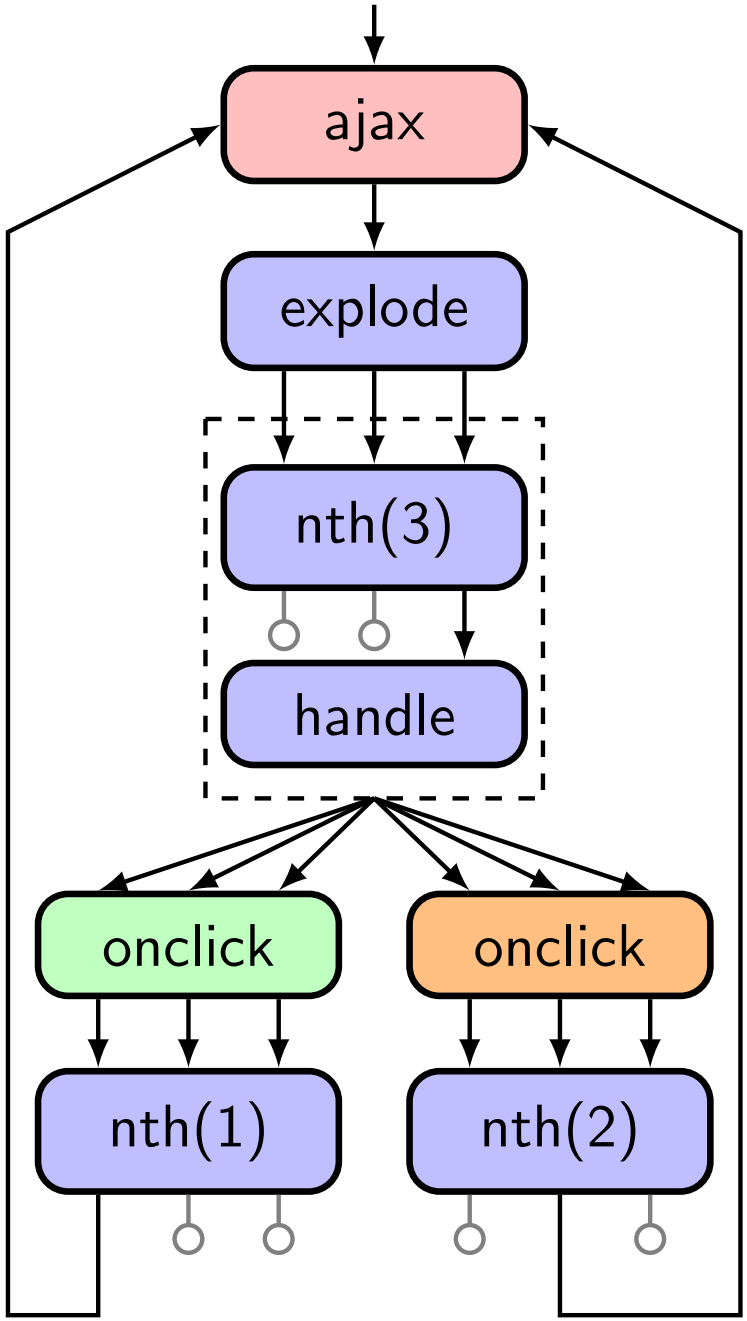
Arrows - Async Machine Composition




```
let page = Arrow.fix(a => Arrow.seq([
  ajax,
  explode,
  Arrow.seq([
    new NthArrow(3),
    handle
  ]).remember(),
  Arrow.any([
    new NthArrow(1).onclick('#prev'),
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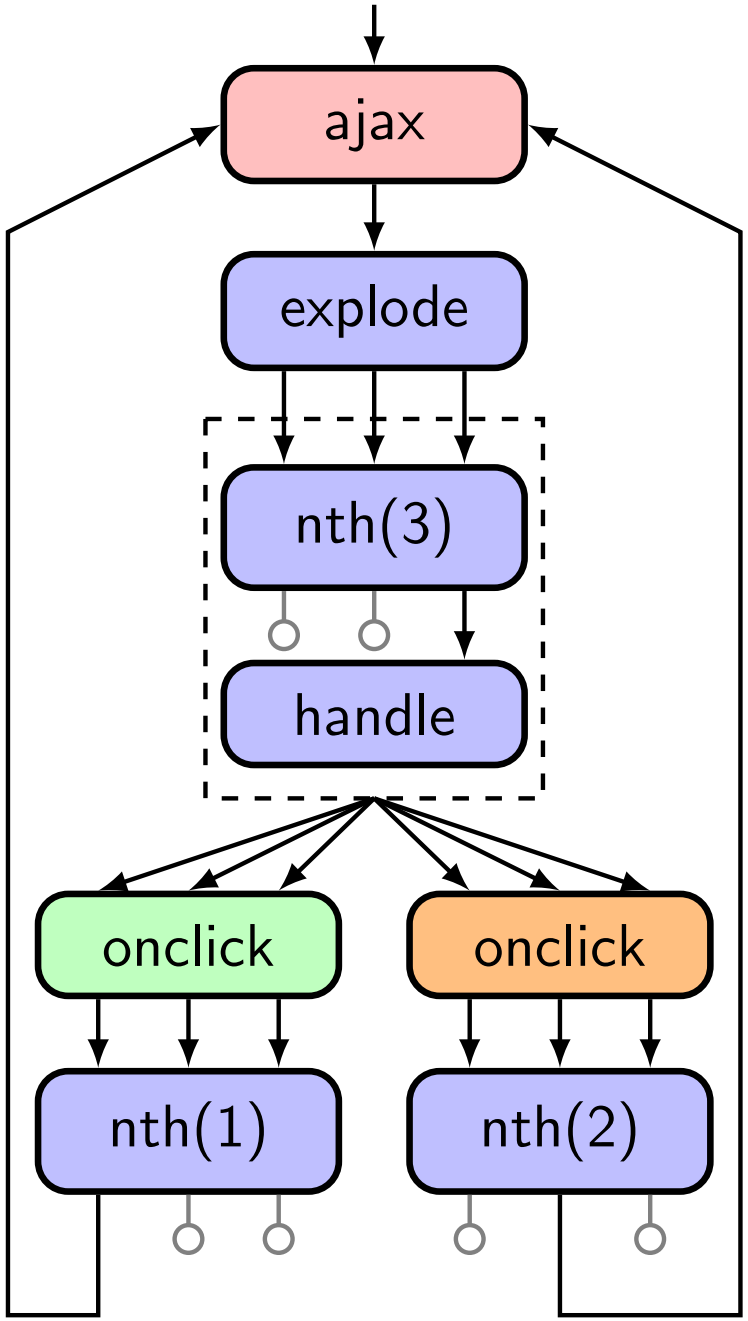
let filter = Arrow.fix(a => Arrow.any([
  Arrow.seq([
    getQueryAndPage,
    page
  ]).noemit(),
  a
]).onkeyup('#filter'));

filter.run();
```

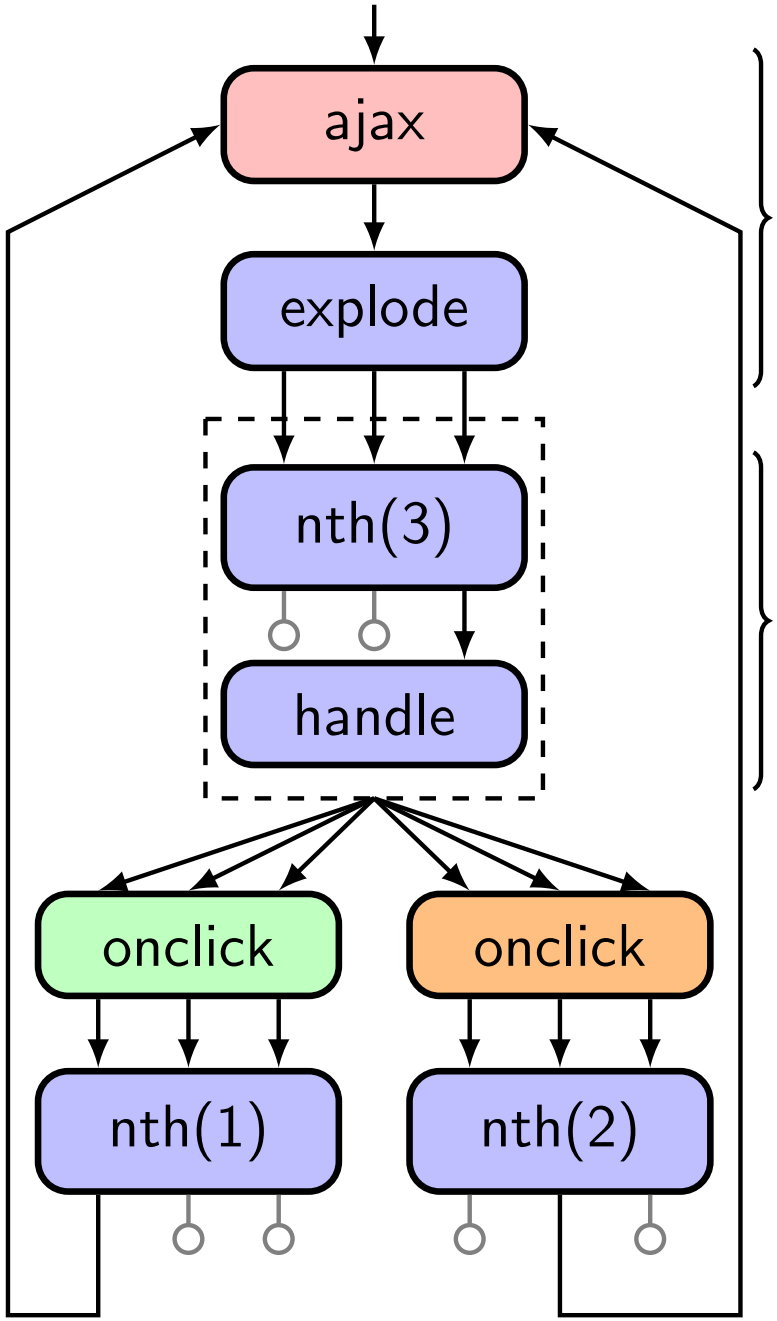
Composition-Time Inference



$(Str, Num) \rightsquigarrow$
$((Str, Num),\ (Str, Num),\ [Item])$

$[Item] \rightsquigarrow \top$

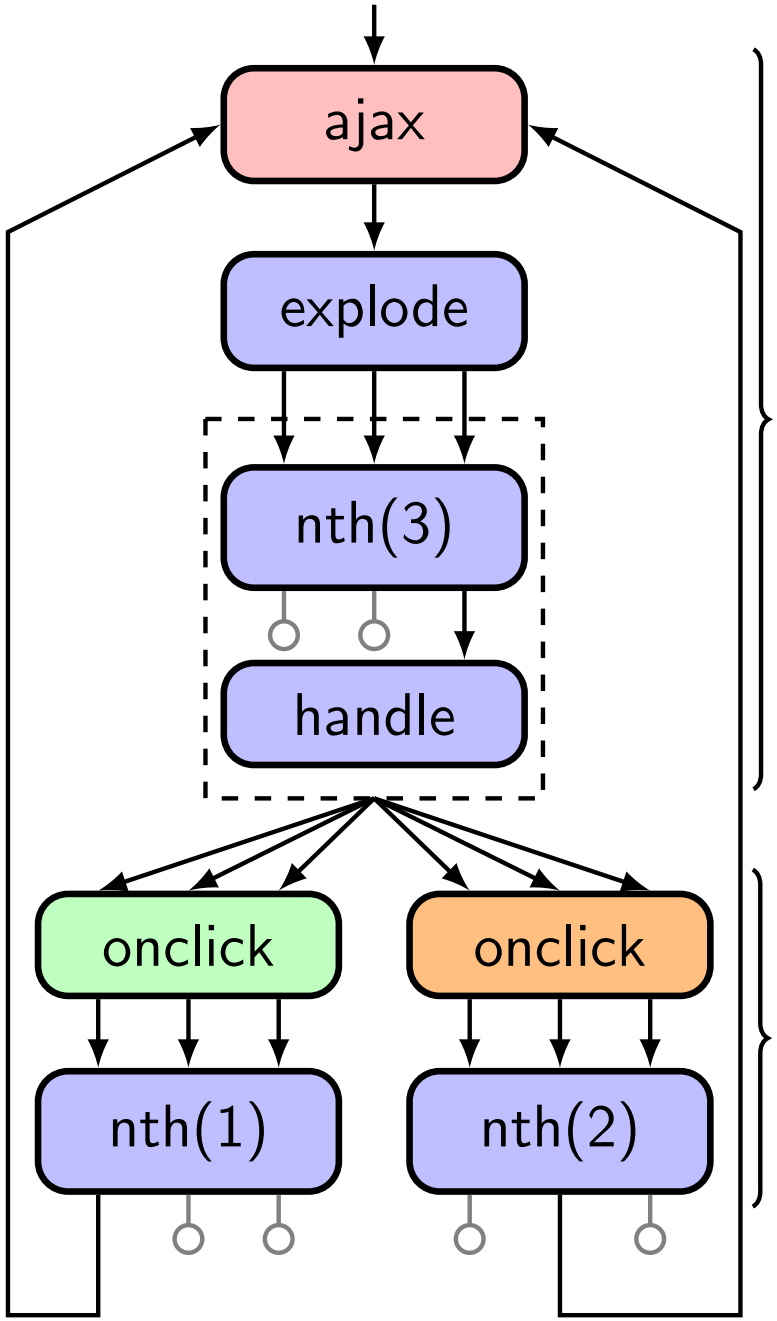
Composition-Time Inference



$(Str, Num) \rightsquigarrow$
$((Str, Num),\ (Str, Num),\ [Item])$

$(\alpha,\ \beta,\ [Item]) \rightsquigarrow (\alpha,\ \beta,\ [Item])$

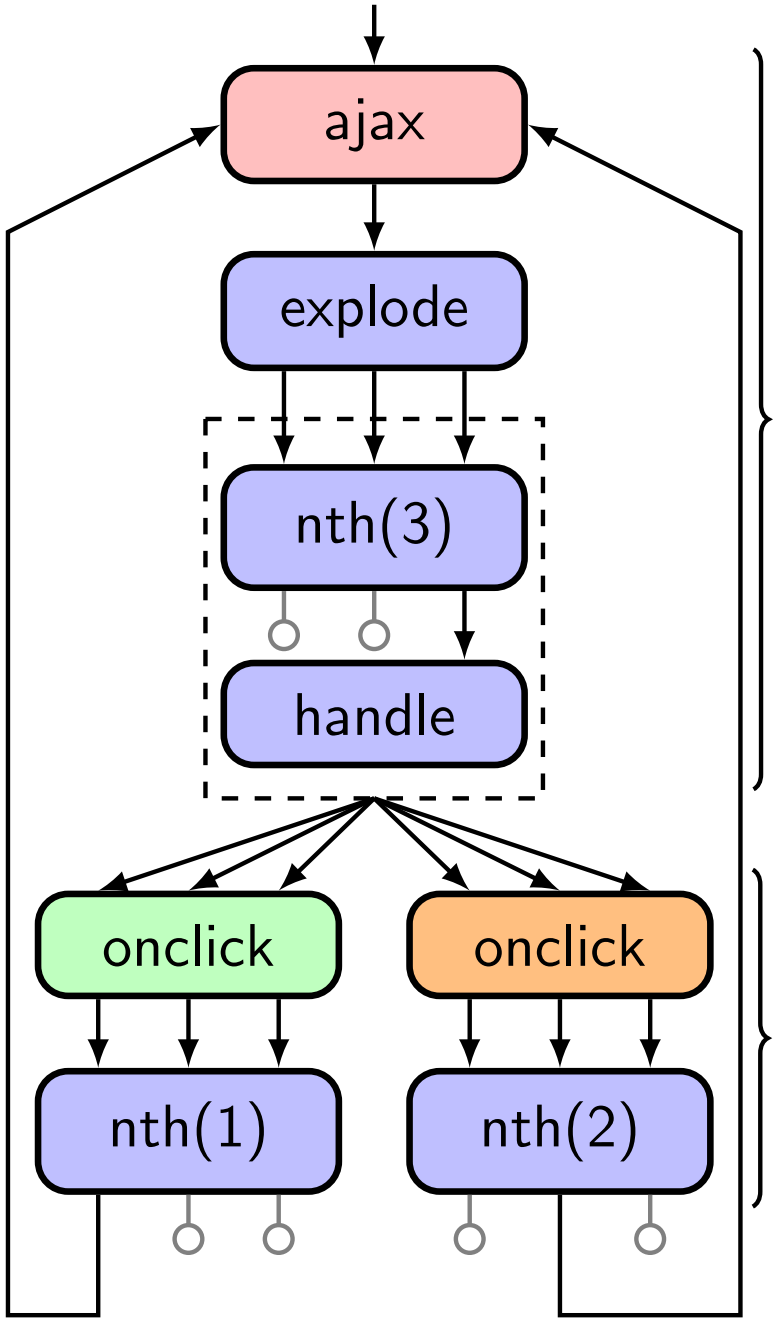
Composition-Time Inference



$(Str, Num) \rightsquigarrow$
$((Str, Num),\ (Str, Num),\ [Item])$

$(\mu,\ \nu,\ \theta) \rightsquigarrow \mu \setminus \{\mu \leq (Str, Num)\}$ and
$(\mu,\ \nu,\ \theta) \rightsquigarrow \nu \setminus \{\nu \leq (Str, Num)\}$

Composition-Time Inference

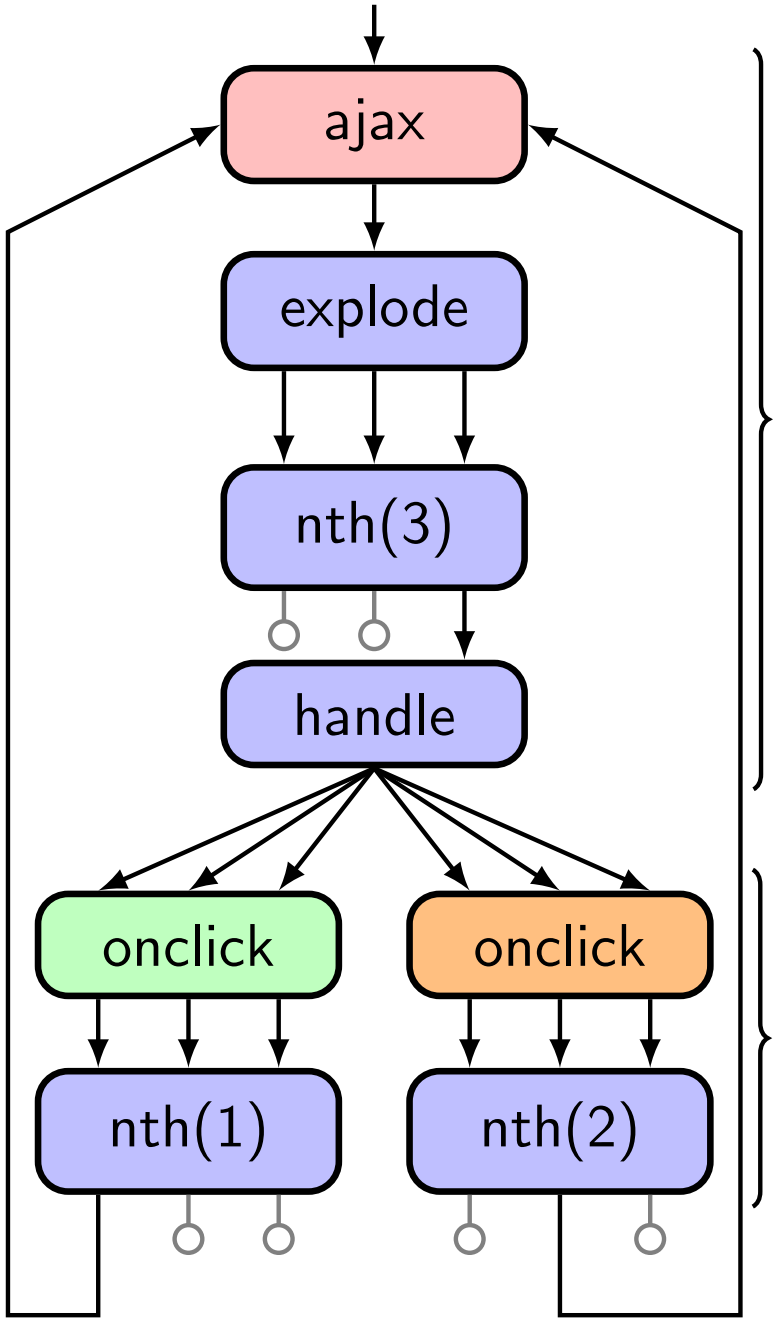


$(Str, Num) \rightsquigarrow$
$((Str, Num),\ (Str, Num),\ [Item])$

$(Str, Num) \leq \nu \leq (Str, Num)$
$(Str, Num) \leq \mu \leq (Str, Num)$

$(\mu,\ \nu,\ \theta) \rightsquigarrow \mu \setminus \{\mu \leq (Str, Num)\}$ and
$(\mu,\ \nu,\ \theta) \rightsquigarrow \nu \setminus \{\nu \leq (Str, Num)\}$

Type Clash Detection



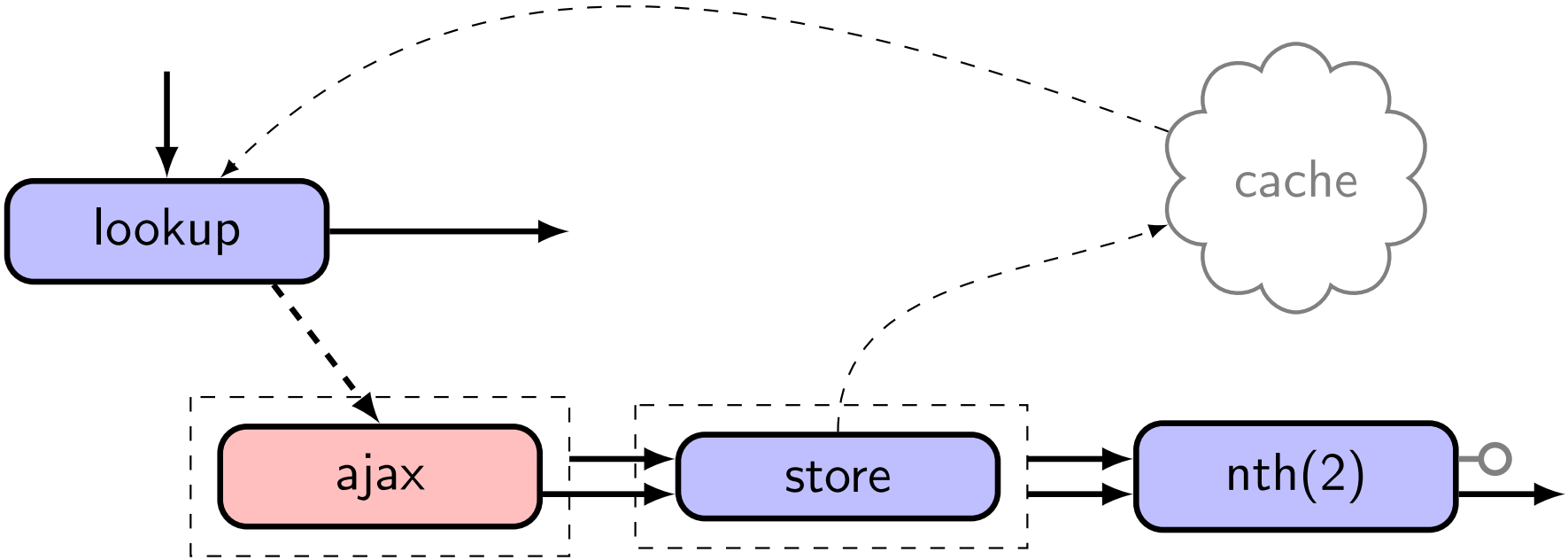
$(Str, Num) \rightsquigarrow \top$

$\top \not\leq (\mu,\ \nu,\ \theta)$

$(\mu,\ \nu,\ \theta) \rightsquigarrow \mu \setminus \{\mu \leq (Str, Num)\}$ and
$(\mu,\ \nu,\ \theta) \rightsquigarrow \nu \setminus \{\nu \leq (Str, Num)\}$

Adding Optimizations

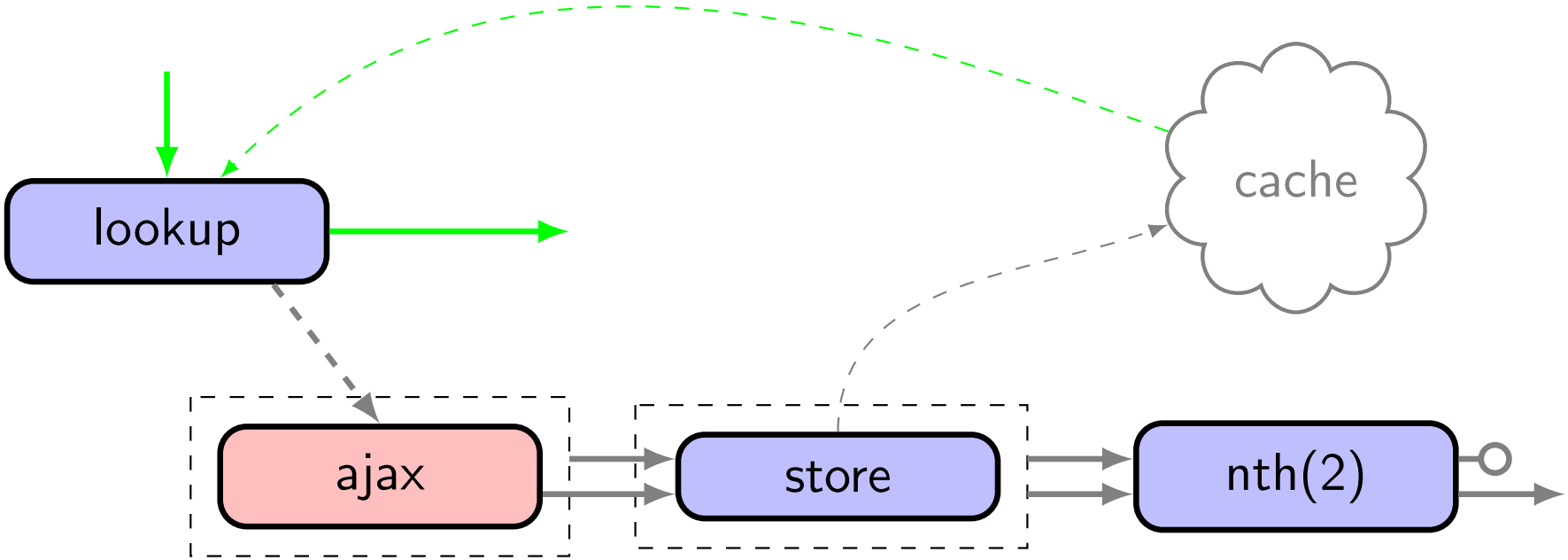
Cached Ajax Responses




```
const cachedAjax = Arrow.catch(lookup, Arrow.seq([
    ajax.carry(),
    store.remember(),
    new NthArrow(2)
]));
```

```
function lookup(key) {
    if (key in cache) return cache[key];
    else              throw key;
}
```

Cached Ajax Responses

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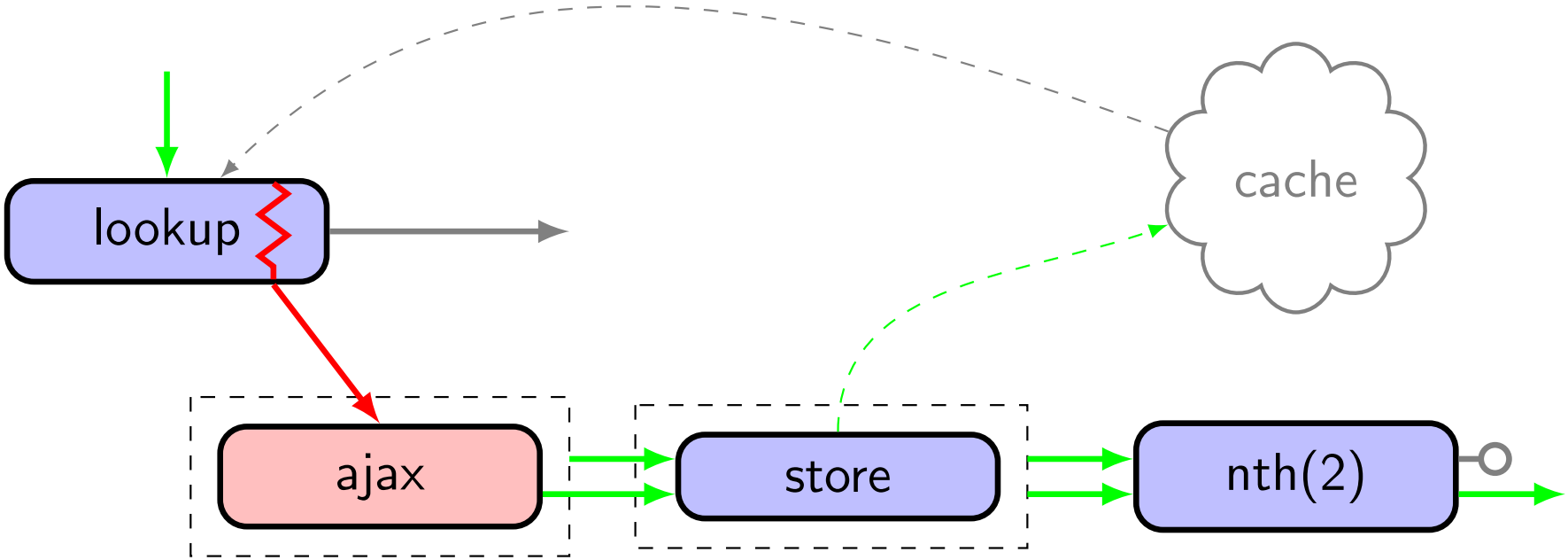


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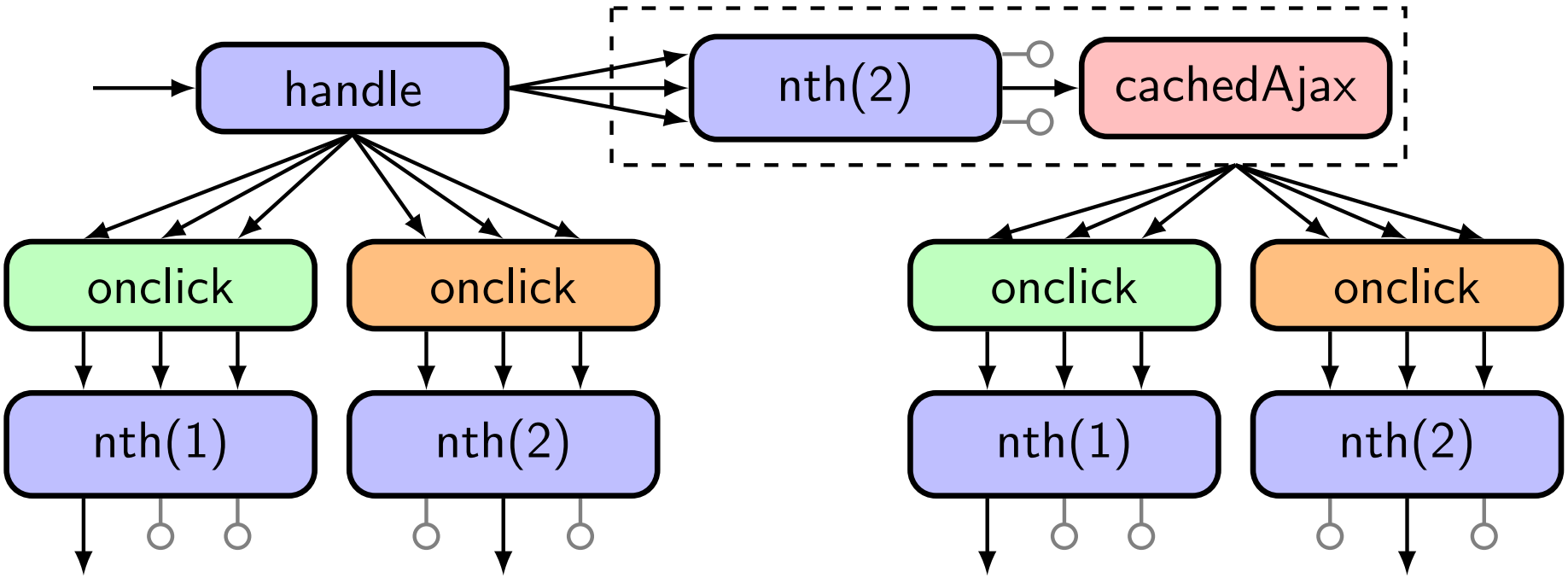
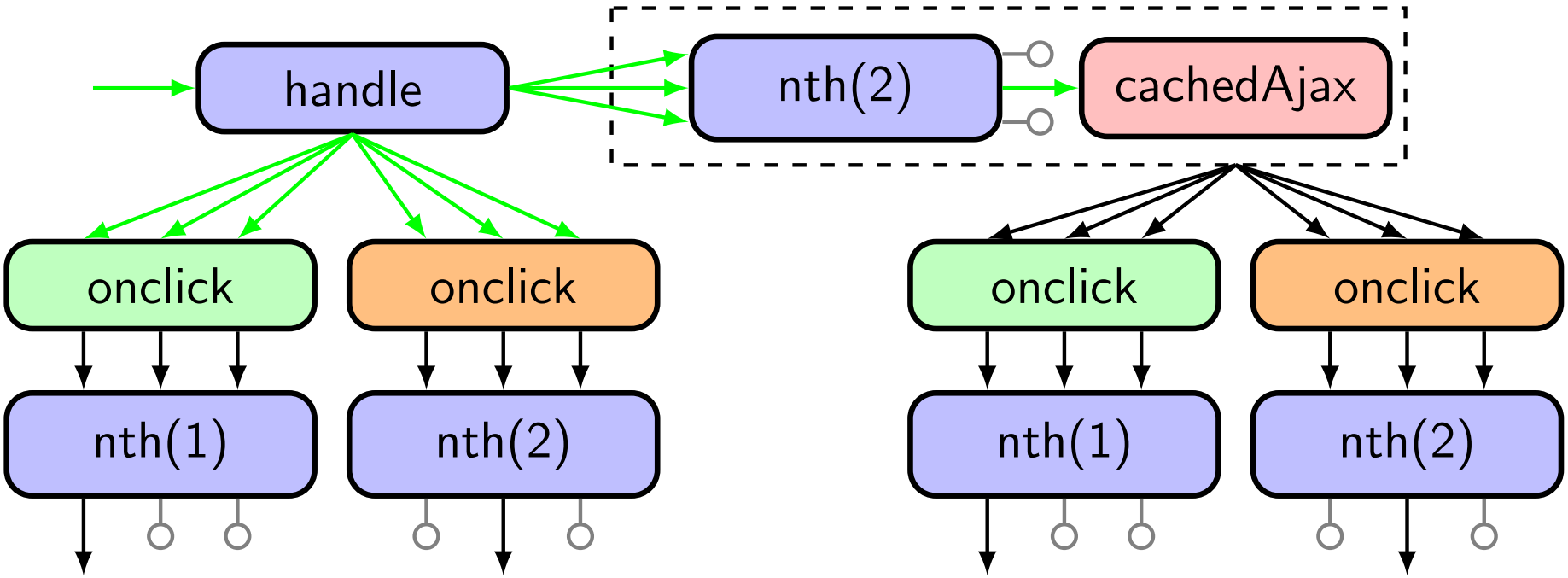
Pre-Fetching Next Page




```
const progress = Arrows.any([
    new NthArrow(1).onclick('#prev'),
    new NthArrow(1).onclick('#next')
]);

Arrow.any([progress, Arrow.seq([
    Arrow.seq([new NthArrow(2), cachedAjax]).remember(),
    progress
])]);
```

Pre-Fetching Next Page

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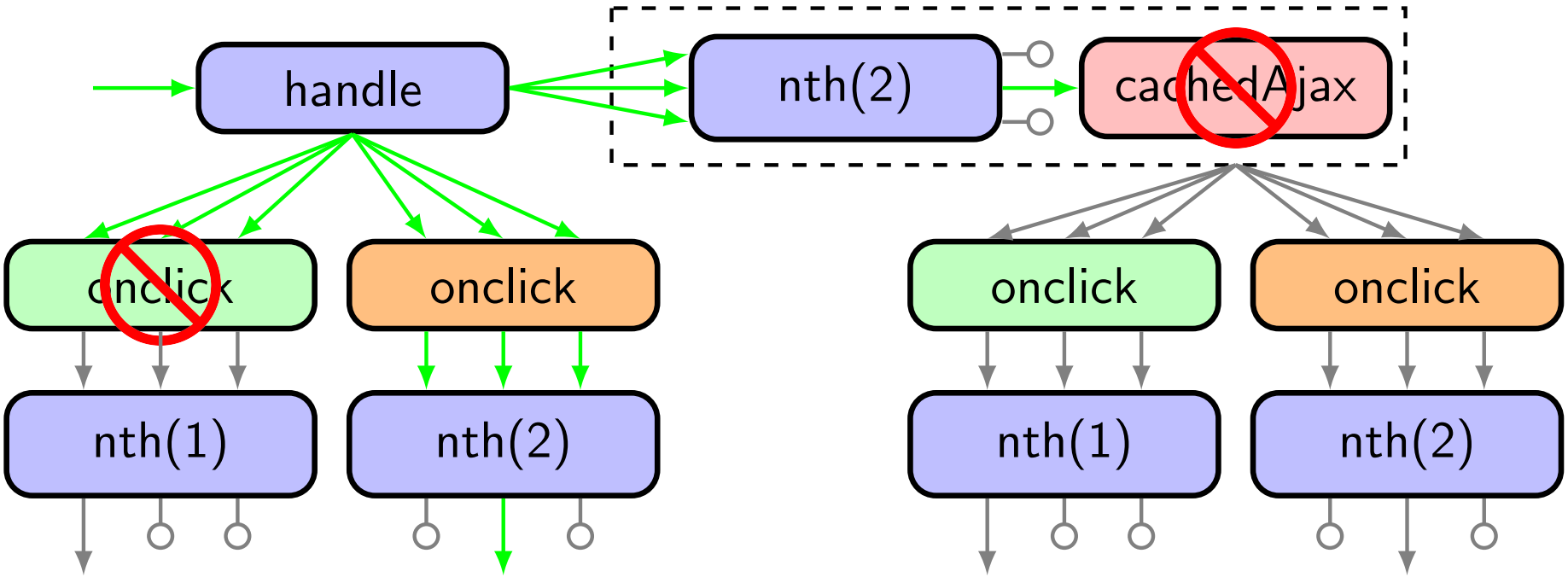
Pre-Fetching Next Page

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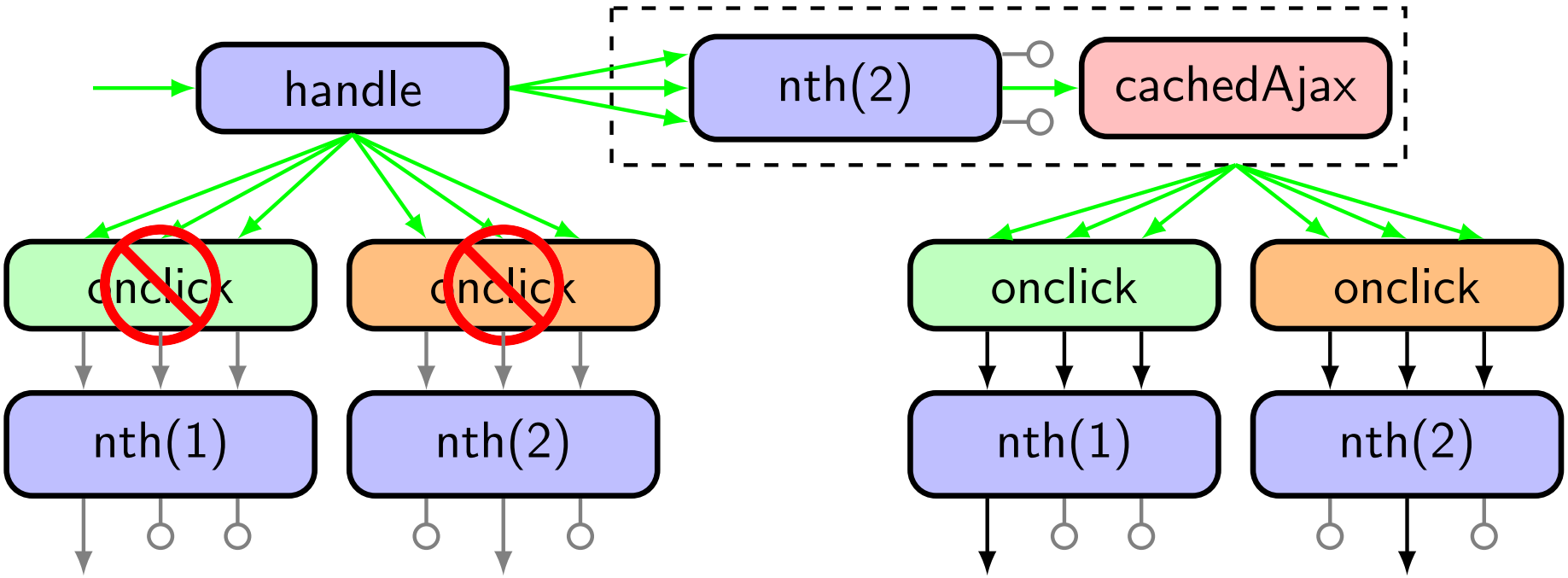


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```
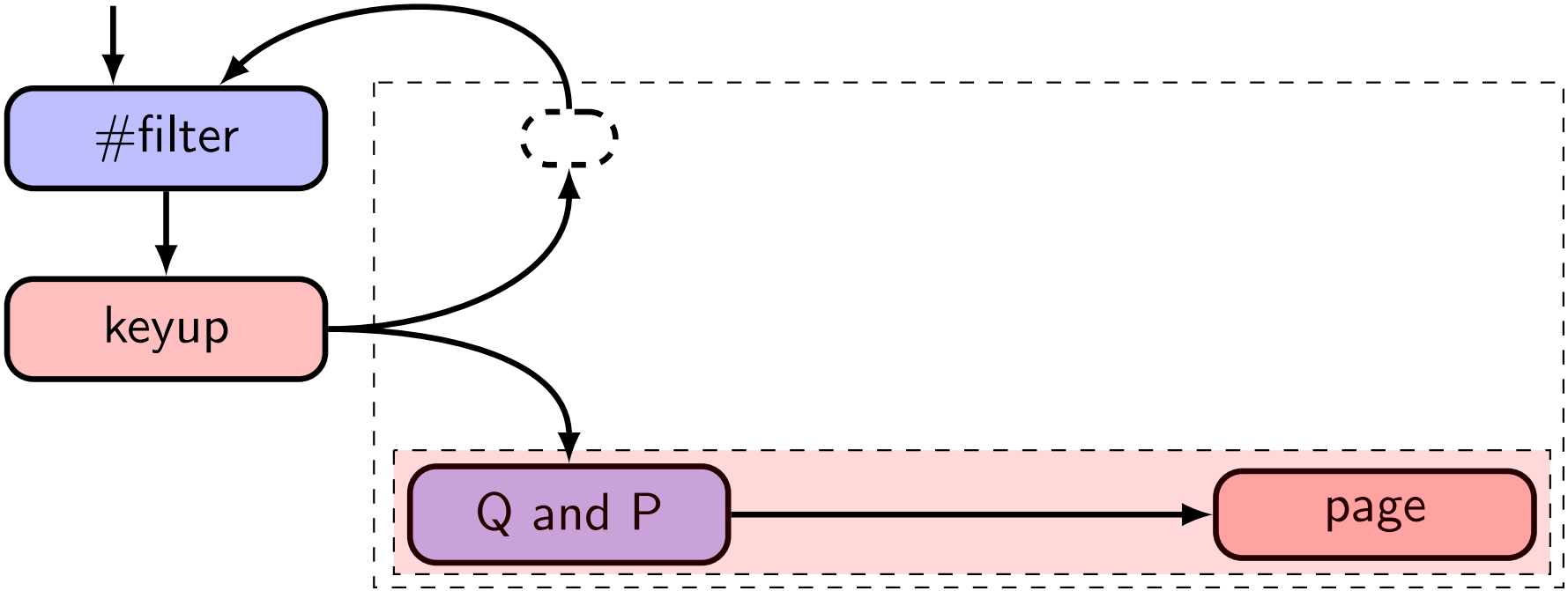
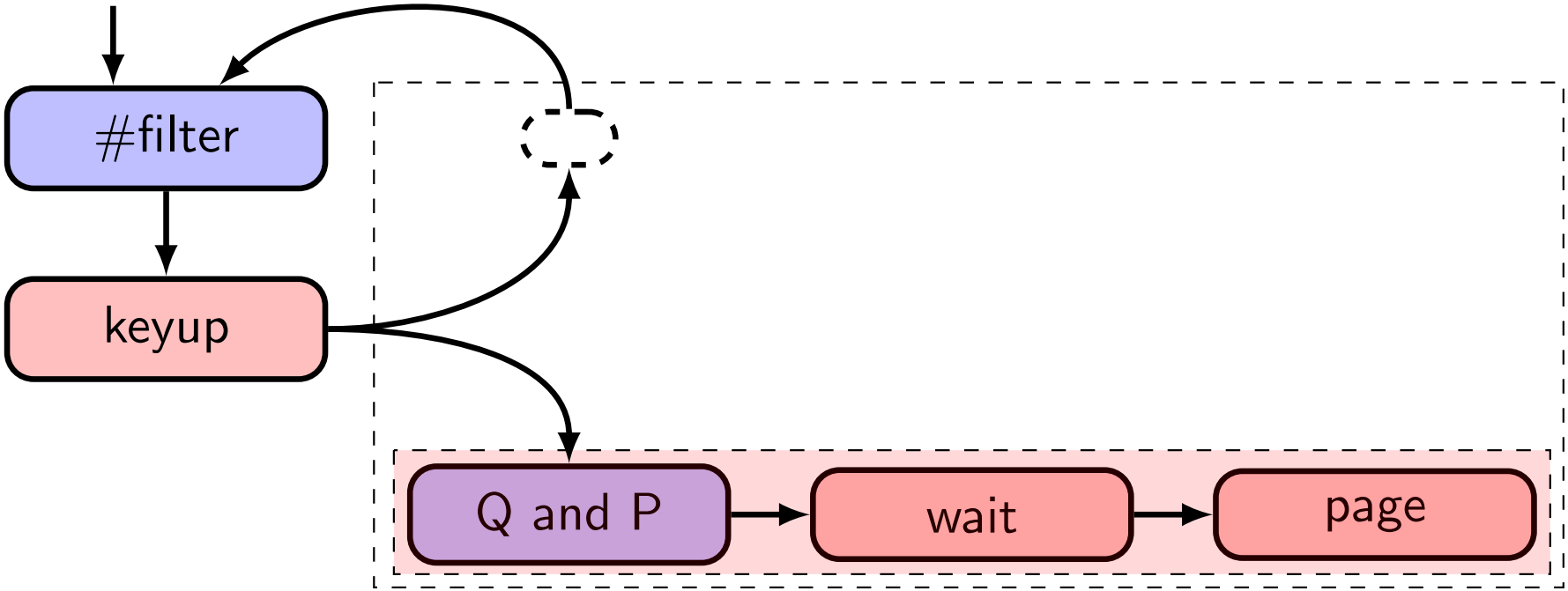

No In-Flight Requests as User Types




```
let filter = Arrow.fix(a => Arrow.any([
  a,
  Arrow.seq([
    getQueryAndPage,
    new DelayArrow(400),
    page
  ]).noemit(),
]).onkeyup('#filter'));
```

No In-Flight Requests as User Types

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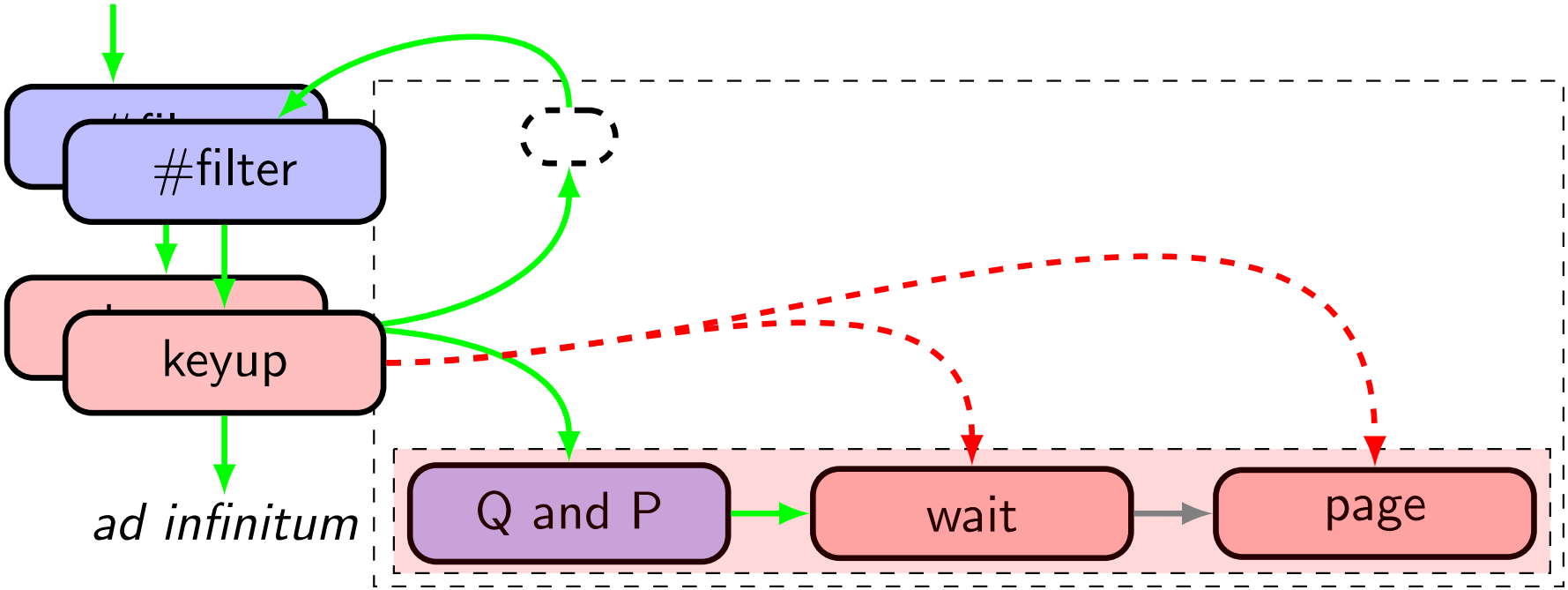


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  Arrow.seq([
    getQueryAndPage,
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Conclusion

Composing an *interaction machine* is a powerful shift in abstraction
Opens up opportunity for ‘static’ benefits

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Questions?