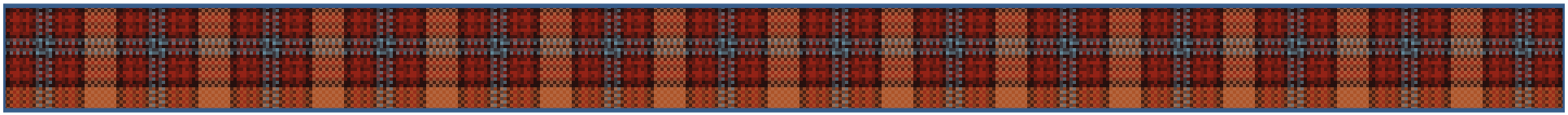
Permission-Based Programming Languages



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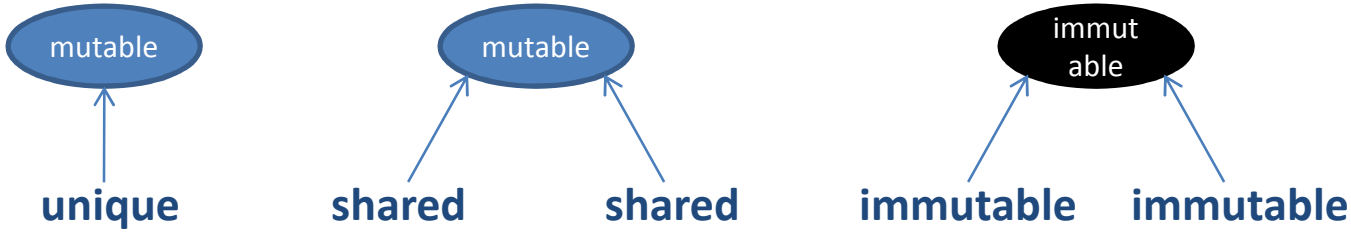
ICSE New Ideas and Emerging Results
May 25, 2011

Background: Permissions

- Permission systems associate every reference with both a type and a permission that restricts aliasing and mutability

```
var unique InputStream stream = new FileInputStream(…);
```

- Some permissions and their intuitive semantics [Boyland][Noble][…]



- Type system checks permission consistency
  - **unique**: no other references to the object
  - **immutable**: no-one can modify the object

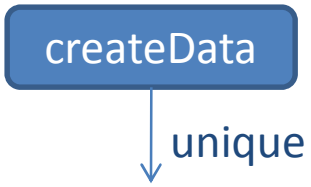
Permission-Based Language

- A language whose type system, object model, and run-time are co-designed with permissions in mind
  - Contrast: prior permission systems layered static permission checking onto existing languages

- Potential benefits
  - Design and encapsulation enforcement
  - Parallel execution
  - Explicit state change in the object model
  - Compile-time and run-time checking

Automatic Parallelization

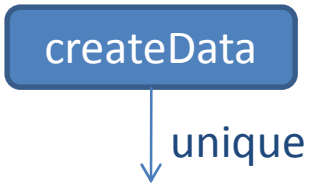
method unique Data createData();




```
val d = createData();
print(d);
val s = getStats(d);
manipulate(d, s);
```

Automatic Parallelization

method unique Data createData();



val d = createData();
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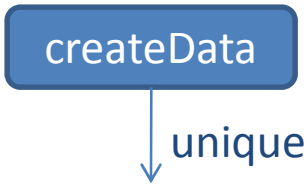
manipulate(d, s);

Automatic Parallelization

```
method unique Data createData();
method void print(immutable Data d);
method unique Stats getStats(immutable Data d);
```

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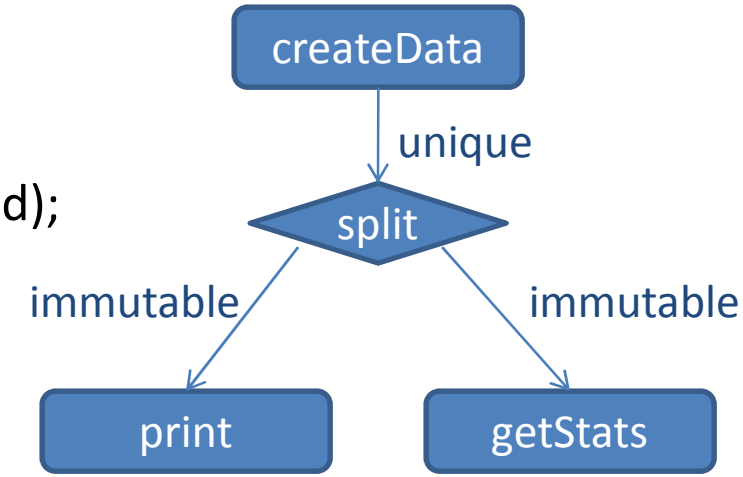


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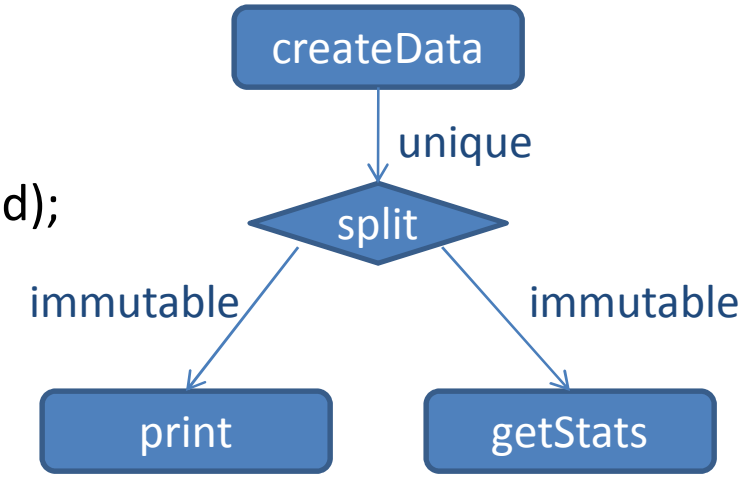


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method unique Stats getStats(immutable Data d);
method void manipulate(unique Data d,
                       immutable Stats s);

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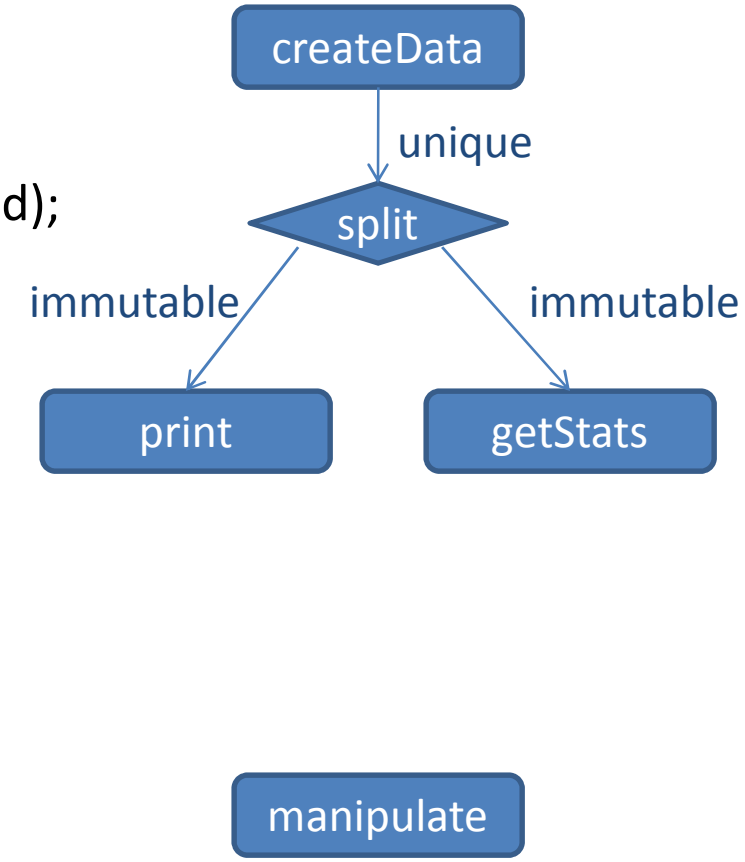
val s = getStats(d);
manipulate(d, s);
```



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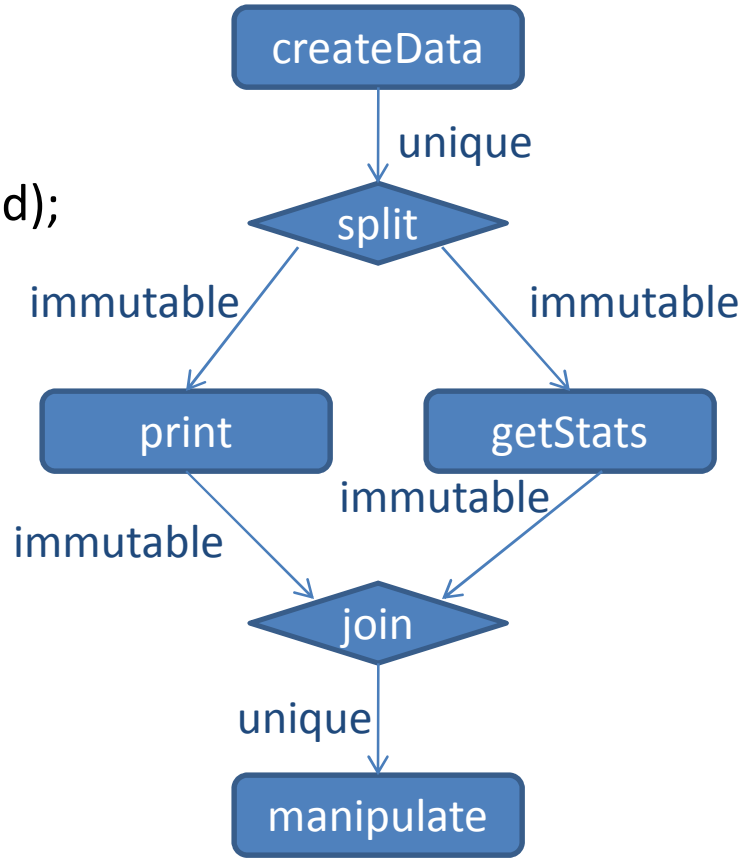

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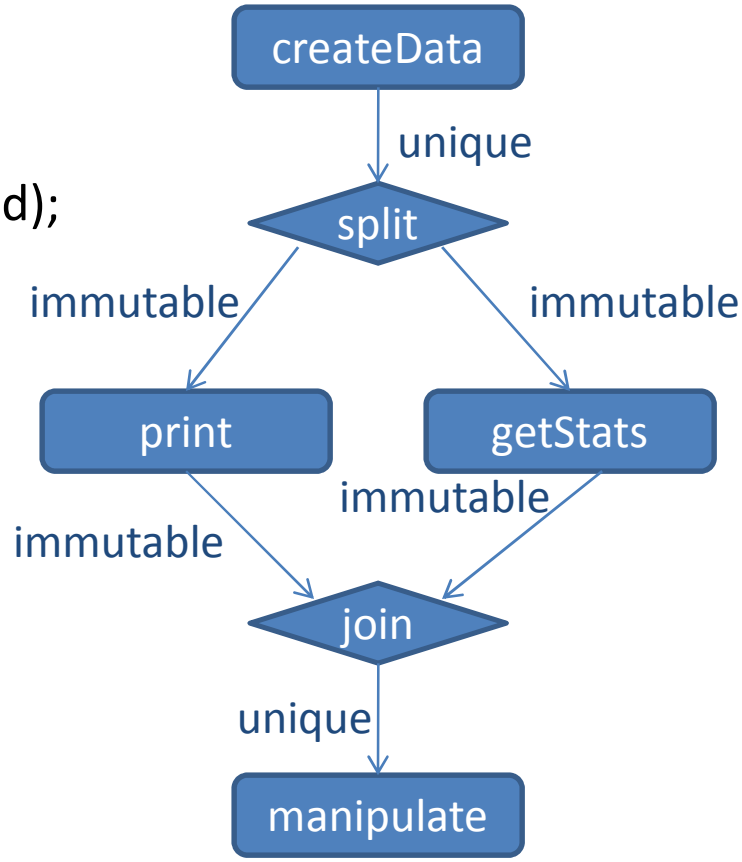
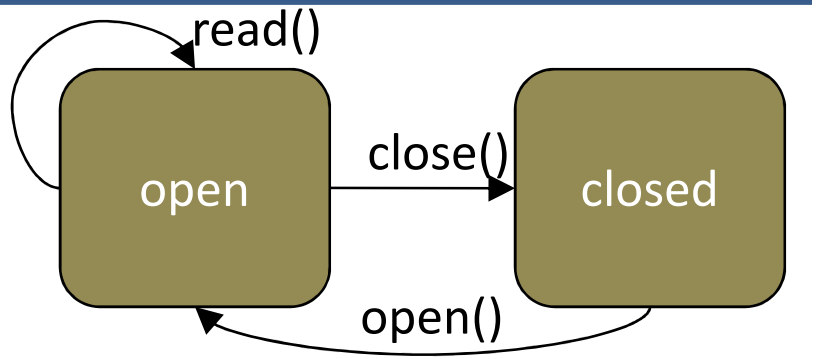


Casts can also be used to recover unique
The runtime checks the cast using reference counts

Explicit State Change

```
state File {
    val String filename;
}
```

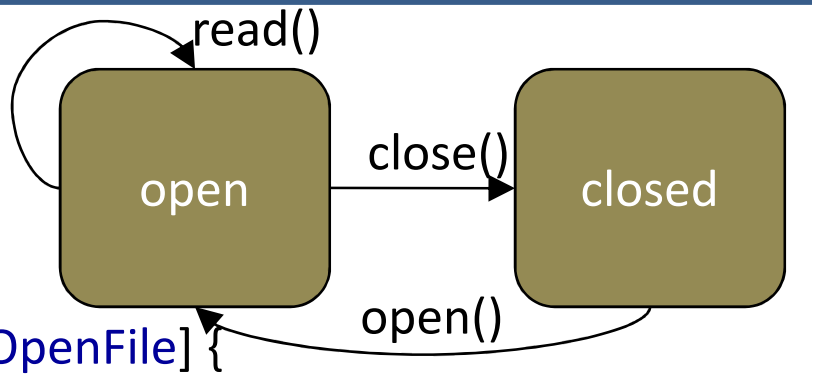


Explicit State Change

```
state File {
    val String filename;
}
state ClosedFile = File with {
    method void open() [unique ClosedFile>>OpenFile] {



    }
}
```



Explicit State Change

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state File {
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```
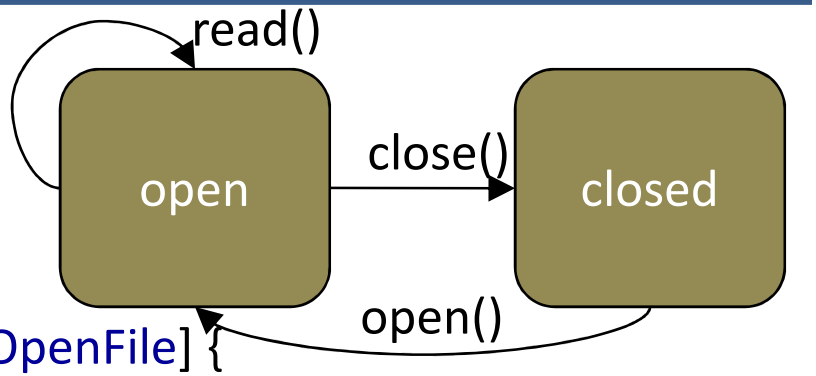

State transition

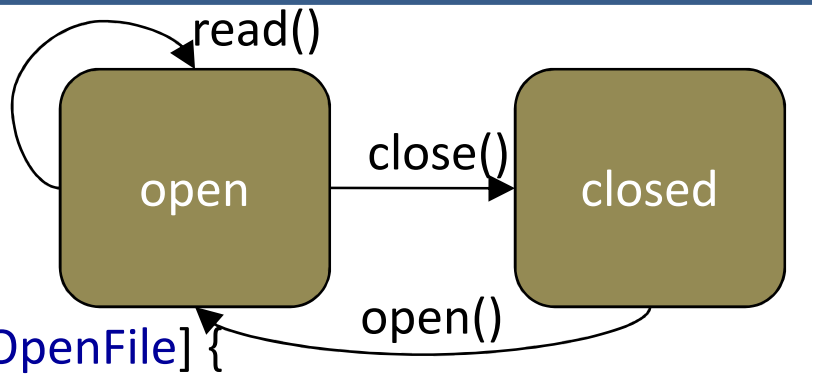
Permission / aliasing info.



Explicit State Change

```
state File {
    val String filename;
}
state ClosedFile = File with {
    method void open() [unique ClosedFile>>OpenFile] {

    }
}
state OpenFile = File with {
    private val CFile fileResource;

    method int read();
    method void close() [OpenFile>>ClosedFile];
}
```

State transition



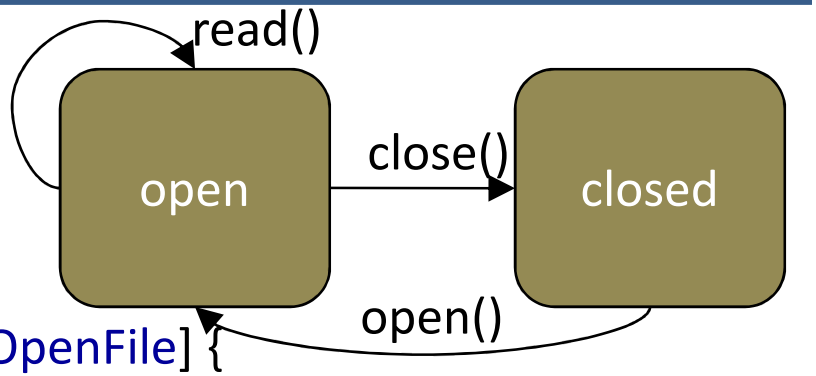
Permission / aliasing info.

New methods, Different representation

Explicit State Change

```
state File {
    val String filename;
}
state ClosedFile = File with {
    method void open() [unique ClosedFile>>OpenFile] {
        this <- OpenFile {
            fileResource = fopen(filename);
        }
    }
}
state OpenFile = File with {
    private val CFile fileResource;

    method int read();
    method void close() [OpenFile>>ClosedFile];
}
```

State transition



Permission / aliasing info.

State change primitive

New methods, Different representation

Plaid: A Permission-Based Language

- Currently exploring these ideas with Plaid
  - First-class abstractions for changing state
  - Naturally safe concurrent execution
  - Practical mix of static & dynamic checking
- Other research directions possible
  - Systems languages: permissions support memory management
  - Security: permissions help control access, information flow
- Status: compiler implemented, typechecker underway
  - Web-based interface available

http://www.plaid-lang.org/