Type-Based Capability for Java

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Sydney November 2017

Under the ARC Linkage Project with Oracle Labs, Australia

Outline

- An Overview of Capabilities for Java
- Motivation
- Ongoing Work
- Summary and Future Direction

Java Security Issues

- doPrivileged blocks
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  - access to a privileged object escapes to unauthorized domains
- Caller-sensitive methods
  - depend on the privileges of the class loader of the caller

How to provide a more secure access to resources for Java, with the aim of preventing security flaws

Philosophy behind Capabilities in Java

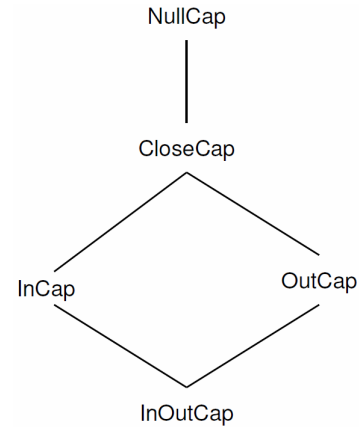
- All access to resources given by explicit "capabilities"
- An object with a restricted interface
  - a set of operations that can be invoked
  - encapsulate what one can do with a resource
- Permission checking done when a capability created
  - access the resource via methods of the capability
  - no further permission checking is required

Reference

- Ian J. Hayes, Xi Wu and Larissa A. Meinicke.: Capabilities for Java: Secure Access to Resources. In: Proc. 15th Asian Symposium on Programming Languages and Systems, APLAS 2017. pp 67-84.

Running Example: File Input and Output Streams

```
capability CloseCap { // Implicitly extends NullCap
    void close();
}
capability InCap extends CloseCap {
    int read();
    int read(byte[] b);
    int read(byte[] b, int off, int len);
    long skip(long n);
}
capability OutCap extends CloseCap {
    void write(int b);
    void write(byte[] b);
    void write(byte[] b, int off, int len);
    void flush();
}
capability InOutCap extends InCap, OutCap {
    // Only the methods from InCap and OutCap.
    // Note that InCap and OutCap share method close.
}
```



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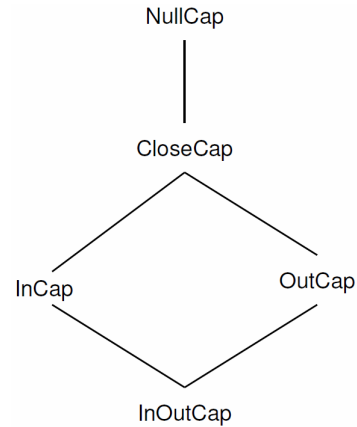

Inherit from the empty capability **NullCap**

- methods inherited from class object are disallowed unless explicitly included with restrictions

Generating Capabilities

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- Capability Manager

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```
capability FileAccessCap {
    InCap requestInCap(String name)
        throws FileNotFoundException, SecurityException;
    OutCap requestOutCap(String name)
        throws FileNotFoundException, SecurityException;
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```

```
class RandomAccessFileManager implements FileAccessCap {
    RandomAccessFileManager() { super(); }
    /* Factory method for InCap */
    public InCap requestInCap(String name)
        throws SecurityException, FileNotFoundException {
        SecurityManager sm = System.getSecurityManager();
        if( sm != null ) {
          sm.checkPermission(new FilePermission(name, "read"));
        }
        return capability (InCap) new RandomAccessFile(name);
    }
```

Capabilities Escape to Untrusted Code

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public class A {
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}

public class B {
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RandomAccess FileManager	All Permission
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  - regarding capabilities as types
  - proper use of capabilities by type checking
- Capabilities as permissions
  - grant to code by user-defined policy files
  - restrict capabilities to only authorised code

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$$\text{access}(\text{code}, \text{cap}) \Rightarrow \text{grant}(\text{code}, \text{cap})$$

- access(code, cap): code uses the capability cap
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- access(code, cap): code uses the capability cap
- grant(code, cap): code is granted the capability cap by user
  - Transitivity:

    $\text{grant(code, cap2)} \wedge \text{cap1} <: \text{cap2} \Rightarrow \text{grant(code, cap1)}$
  - cap1 $<:$ cap2: is satisfied if cap2 is more privileged than cap1
  - relation $<:$ is opposite of the standard Java subset relation
  - e.g., InCap $<:$ InOutCap and InCap $\not<:$ OutCap

Revisited Capabilities Escape

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public class A {
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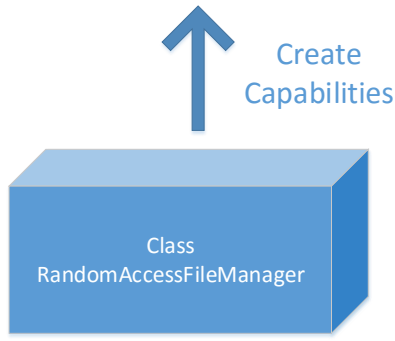

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Class	Capability
A	FileAccessCap InCap
B	NullCap

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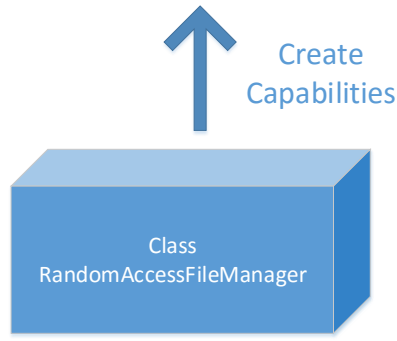

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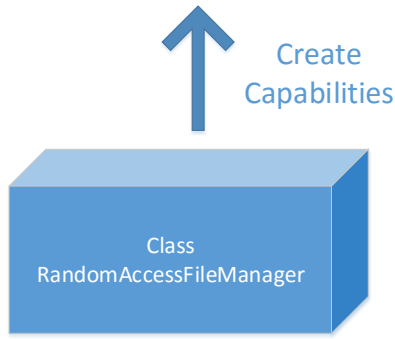

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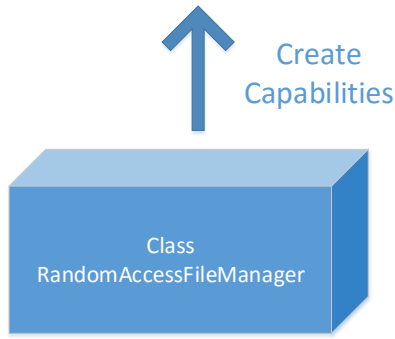

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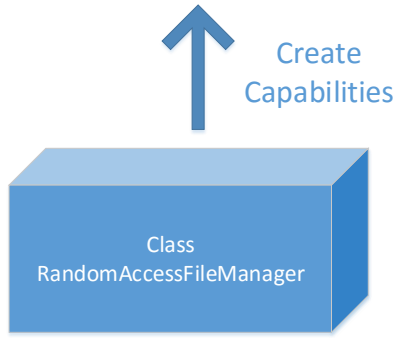

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@grant{InOutCap}
public class B {
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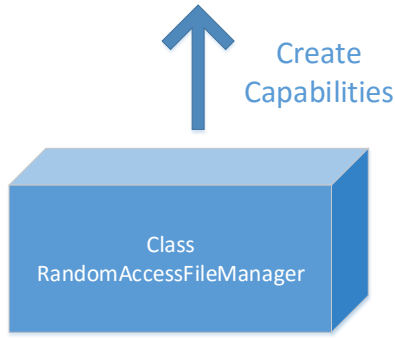

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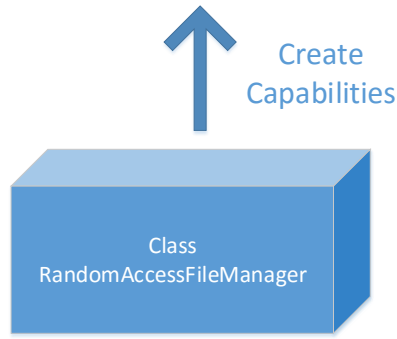

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    - applies capabilities on describing dependency in module system
  - Properties from Object-Capability and Design Patterns
    - describes object-capability properties and design patterns
  - Parameterization
    - specifies the specific file names that the code with capabilities can access

capability FileAccessCap (filename) {.....}

sm.checkPermission (new FilePermission (filename, “read”));

Thanks.

Questions?