

Interoperability in Programming Languages

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What is interop?

- Interoperability: The ability for a system to use parts from another system.
- Often shortened to interop.
- In programming languages: The ability of a language to call on code from another language.

Why is interop important?

Developer time and effort

- Existing and working code is easier to use as-is.
- Legacy systems: extensive or little-understood code base.
- Third-party systems: source code is unavailable

Language Strength:

- Explicit memory access (C)
- Parallel or distributed systems (Clojure, Erlang)
- Statistics (R)

Outline

- 1 Common difficulties in interop
- 2 Concepts in interoperability
- 3 Tools used in achieving interoperability
- 4 Conclusions

Outline

1 Common difficulties in interop

- Type systems
- Data structures
- Data processing

2 Concepts in interoperability

3 Tools used in achieving interoperability

4 Conclusions

Differences in type systems

- Languages represent data in different ways
- Statically-typed languages assign types as soon as data is collected.
- Dynamically-typed languages only deal with types when evaluating data.
-

```
Class Person
  string name = "Cliff"
  date dateOfBirth = 4/16/1978
  int height = 74
  double weight = 212
end
```

```
Class Person
  var name = "Cliff"
  var dateOfBirth = 4/16/1978
  var height = 74
  var weight = 212
end
```

Mismatched structures

- Untyped lists can contain different types,
- Strongly typed lists can only contain the type given by the list.
- A data structure in one language may be absent in another
- Maps are common data structures, but absent in C.

```
[23, v, "hello", True]
```

An untyped list

```
{:name "Cliff", :age 32}
```

A map

```
[1, 53, 13, 100]
```

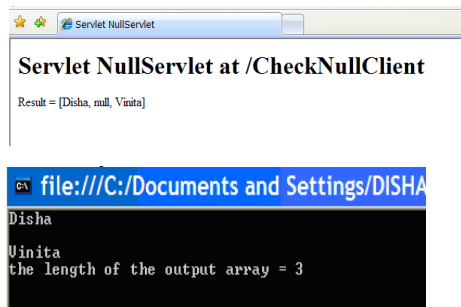
a typed list

```
Object[] = [?, ?, ?, ?]
```

A Java list of Objects

Handling data

- Languages act on data in different ways.
- Handling NULL or NIL objects.
- Decimal precision: Java returns 12.999999, .NET returns 13



images based on Shetty and Vadivel[1]

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- 1 Common difficulties in interop
- 2 Concepts in interoperability**
 - Metadata
 - Standards
- 3 Tools used in achieving interoperability
- 4 Conclusions

Metadata and type conversion

Metadata: Data about data

or: Information beyond what the data itself can convey

```
(def mylist [1, 2, 3, 4])  
(with-meta mylist {:length 4, :type Integer}))
```

In Clojure:

- lists are untyped; can contain entries of different types.
- metadata, added as above, is all user-controlled.

Metadata and type conversion

no metadata

Clojure: [1, 2, 3, 4]

(down arrow)

Java: [?, ?, ?, ?]

metadata: {:type Integer}

Clojure [1, 2, 3, 4]

(down arrow)

Java [1, 2, 3, 4]

Metadata and standards

Metadata: { :type number }
[1, 2, 3, 4]

->

Metadata: { :type Integer }
[?, ?, ?, ?]

Metadata: { :type Integer }
[1, 2, 3, 4]

->

Metadata: { :type Integer }
[1, 2, 3, 4]

The importance of standards

Standards are meant to ensure:

- Agreement on what metadata is being used, and how.
- All involved parties know how data will be represented.
- Future parties will know how data is represented.
- In general, that correct communication happens.

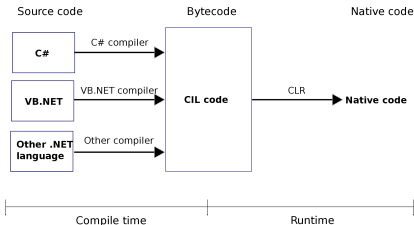
```
{  
  "name": "Person",  
  "properties": {  
    "name": {  
      "type": "string"  
    },  
    "birthdate": {  
      "type": "date"  
    },  
    "height": {  
      "type": "number"  
    },  
    "weight": {  
      "type": "number"  
    }  
  }  
}
```

Outline

- 1 Common difficulties in interop
- 2 Concepts in interoperability
- 3 Tools used in achieving interoperability**
 - Virtual Machines
 - Markup Languages
- 4 Conclusions

Virtual machines

- Virtual Machines (VMs) are a runtime environment for a program
- High-level languages compile to an intermediate language
- Intermediate language: Java bytecode or Common Intermediate Language



Wikipedia

https://en.wikipedia.org/wiki/Common_Intermediate_Language_Runtime

High-level vs Bytecode

```
public class Fib{  
    public int fibonacci(int n) {  
        if(n == 0){  
            return 0;  
        }else if(n == 1){  
            return 1;  
        }else{  
            return fibonacci(n - 1) + fibonacci(n - 2);  
        }  
    }  
}
```

```
public class Fib {  
    public Fib();  
        Code:  
        0: aload_0  
        1: invokespecial #1  
        4: return  
  
    public int fibonacci(int)  
        Code:  
        0: iload_1  
        1: ifne          6  
        4: iconst_0  
        5: ireturn  
        6: iload_1  
        7: iconst_1  
        8: if_icmpne     13  
       11: iconst_1  
       12: ireturn  
       13: aload_0  
       14: iload_1  
       15: iconst_1  
       16: isub  
       17: invokevirtual #2  
       20: aload_0  
       21: iload_1  
       22: iconst_2  
       23: isub  
       24: invokevirtual #2
```


Interoperability with virtual machines

- Usually some overhead associated with calling other languages.
- Overhead can be lessened when all languages are on one VM.
- High-level languages can have conventions to call other high-level languages on the same VM.
- Common language ensures common syntax and behavior.

A Java method of object cliff:

```
cliff.getAge();
```

Clojure calling Java:

```
(. getAge cliff)
```

JRuby calling Java:

```
require 'java'  
cliff.getAge()
```

Markup languages

- Markup languages are a way of modeling data.
- XML and JSON can model data like objects.
- Markup languages are independent of programming languages.

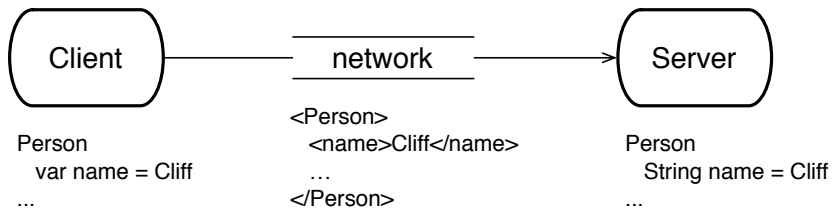
```
<Person>
  <name> Cliff </name>
  <birthdate> 4/16/1978 </birthdate>
  <height> 74 </height>
  <weight> 212 </weight>
</Person>
```

```
{
  "name": "Cliff",
  "birthdate": "4/16/1978",
  "height": "74",
  "weight": "212";
}
```

Interoperability with markup languages

- Act as Metadata.
- Can be used to communicate across networks or between VMs.
- Schema provide both standardization and additional metadata.

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema elementFormDefault="qualified"
  xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="Person">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="name" type="xs:string" />
        <xs:element name="birthdate" type="xs:date" />
        <xs:element name="height" type="xs:double" />
        <xs:element name="weight" type="xs:double" />
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```



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Conclusions

- Interop can make system design simpler by allowing programmers to use otherwise incompatible languages.
- Metadata and standards are core concepts that can make interop possible.
- Virtual machines and markup languages make use of these concepts to enable interop in ways.
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Thank you for listening!

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Questions?

References



D. S. V. Sujala D Shetty.

Interoperability issues seen in web services.

IJCSNS International Journal of Computer Science and Network Security, 9:160–169, August 2009.