

Many-to-many, Source-tosource, transpilation infrastructure

Francesco Bertolotti

Prellininaries

 δ -translatio

Example

situational

 δ -alternativ

Conclusions

Many-to-many, Source-to-source, transpilation infrastructure

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Joint work with Walter Cazzola





Disclaimer#1

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Disclaimer

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0-translati

Example

∂-translation

o-arternatives

Conclusions

This is a work in its very early stages.

So early that this is just an idea.

- If you have any suggestions please let us know.
- If you do not think this is a good idea please let us know.
- Or, if you know similar tools.





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Example

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Condusions

I am going to use a little Bit of notation from:

- BNF grammars, and
- denotational semantics

With a pinch of abuse.

However, I am no expert with these formalism.

Again, if you see any error let us know.





Library ecosystem

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Conclusions

A Library ecosystem represent the libraries available to developers for a specific language.

- Example: Numpy is part of the Python library ecosystem.
- Example: Apache commons is part of the Java library ecosystem.

Most of these libraries are tied to one or a few languages.





Library ecosystems are not interchangeable.

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Conclusions

A library from an ecosystem cannot be used in another one.

- Example: You cannot use Numpy in Java.
- Example: You cannot use Apache commons in Python.

At least, not without ad-hoc Bindings.





Library ecosystems are overlapping.

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Conclusions

Software from different ecosystems offer similar functionalities.

- Example: Java Random class is similar to Python random module.
- Example: Java Nd4j is similar to Python Numpy.

This means that there is a lot of replication.





Library ecosystems development take time.

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Condusions

A mature software ecosystems takes years of community development.

- Example: Numpy development lasted more than 15 years of community work.
- Example: Java still lacks a mature autodiff. library.

New programming languages need a mature ecosystem before becoming compelling.





Library ecosystems are different

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Condusions

Changing programming language means learning a new library ecosystem.

Which takes

- time, and
- practice.





Migratable library ecosystem

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Conclusions

With a transpiler, we can render libraries for an ecosystem available to another.

It can be done systematically.

However, we need to build transpilers between languages.

We need many of them.





Migratable library ecosystem

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Conclusions

We need an infrastructure that allows for:

- modular, and
- reusable development.





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Condusions

Languages are formed by stacking language features together.

A language feature is a piece of syntax with a piece of semantics.

A piece of syntax represents form. (add \leftarrow expr "+" expr).

A piece of semantics represents computation $(\llbracket a+b\rrbracket(\sigma))=\llbracket a\rrbracket(\sigma)+\llbracket b\rrbracket(\sigma)).$





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Example

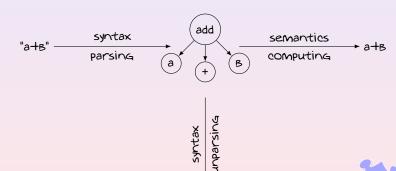
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Conclusions

The syntax tells how to parse text.

The semantics tells how to evaluate the parsed text.



"a+в"



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Conclusion

Abstract Syntax Tree (AST) represents Both:

- the sources, and
- the computation.





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Conclusions

There are infinite languages that could have generated a given AST.

If a language L can generate the AST T, then we say that T belongs $\ensuremath{\mathcal{L}}$

$$(T \in \mathcal{L})$$





Problem statement and proposed solution

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Conclusions

Problem: Library availability is language-dependent.

Objective: Translating libraries from any language to any language.





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δ-translation

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Example

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Conclusions

Build a transpilation infrastructure made of small translation functions.

Each function translate a small piece of the AST.

The functions are used by a system to find a transpilation from one language to the other.





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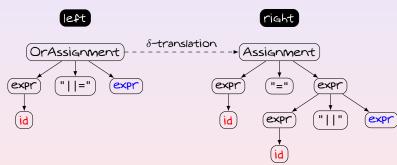
 δ -translation

Example

 δ -translation

Condusions

A δ -translation is represented as a directed connection between trees. E.g.:



A δ -translation δ on an AST T, $\delta(T)$:

- it pattern matches the left tree.
- it replace the match with the right tree.





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 δ -translation

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Conclusions

A δ -translation is:

- Modular. (one does not affect the other).
- Reusable. (it can be reused in other scenarios).
- Composable. (it can be chained).





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Condusions

A translation is computationally invariant iff:

 $\forall x \in id$,

 $\forall y \in expr$,

 $\forall \sigma \in \Sigma$:

 $[\![\delta(\mathit{OrAss}(x,y))]\!](\sigma) = [\![\mathit{OrAss}(x,y)]\!](\sigma)$

Computational invariance cannot be verified.

It is the developer responsibility to write and use computation invariant δs



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Conclusions

Applying a δ -translation can change AST language by changing: a language-feature, a μ -language, a sub-language or the entire language.

$$T \in \mathcal{L} \implies \delta(T) \in \mathcal{L}$$

(But it does not change the outcome of execution.)





if-while language

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Conducione

```
[x; y](\sigma) = [x]([y](\sigma))
stmt ←stmt ":" stmt
        ← assgn
        ← while
        ← if
                                                                                                \llbracket if(x)\{y\} \rrbracket(\sigma) = \llbracket y \rrbracket(\sigma) \text{ if } x \neq \mathbf{0} \text{ else } \sigma
    if ← "if" "(" expr ")" "{" stmt "}"
 while \leftarrow "while" "(" expr ")" "\{" stmt"\}" \qquad \llbracket while(x)\{y\} \rrbracket (\sigma) = \llbracket while(x)\{y\} \rrbracket (\llbracket y\rrbracket (\sigma)) \text{ if } x \neq \mathbf{0} \text{ else } \sigma 
                                                                                                                            [x = y](\sigma) = \sigma[x \leftarrow y]
assgn ←id "=" expr
                                                                                                                  [x + y](\sigma) = [x](\sigma) + [y](\sigma)
 expr ←expr "+" expr
        ←expr "-" expr
                                                                                                               [x - y](\sigma) = [x](\sigma) - [y](\sigma)
       ← expr "==" expr
                                                                                                          [x == y](\sigma) = 1 if x == y else 0
       ← id
        ← int
    id \leftarrow [a..za..z]+
                                                                                                                                         [x](\sigma) = lit(x)
   int ← [0..91+
                                                                                                                                         [x](\sigma) = int(x)
```



While language

stmt ←stmt ":" stmt

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Example

```
\llbracket x;y \rrbracket(\sigma) = \llbracket x \rrbracket(\llbracket y \rrbracket(\sigma))
        ← assgn
         ← while
while \leftarrow "while" "(" expr ")" "{" stmt"}" [while(x){y}](\sigma) = [while(x){y}]([[y]](\sigma)) if x \neq 0 else \sigma
```

assgn ←id "=" expr $[x = y](\sigma) = \sigma[x \leftarrow y]$ $[x + y](\sigma) = [x](\sigma) + [y](\sigma)$ expr ←expr "+" expr ←expr "-" expr $[x - y](\sigma) = [x](\sigma) - [y](\sigma)$ ← expr "==" expr $[x == y](\sigma) = 1$ if x == y else 0 ← id ← int $id \leftarrow [a..zA..Z]+$ $[x](\sigma) = lit(x)$ int ← [0..91+ $[x](\sigma) = int(x)$





if language

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Example

situational δ -translation

 δ -alternative

```
 \begin{bmatrix} [if(x)\{y\}]](\sigma) = \llbracket y \rrbracket(\sigma) \text{ if } x \neq \mathbf{0} \text{ else } \sigma \\ [if(x)\{y\}]](\sigma) = \llbracket y \rrbracket(\sigma) \text{ if } x \neq \mathbf{0} \text{ else } \sigma \\ \\ \llbracket x = y \rrbracket(\sigma) = \sigma \llbracket x + \varphi \rrbracket \\ \\ \llbracket x + y \rrbracket(\sigma) = \llbracket x \rrbracket(\sigma) + \llbracket y \rrbracket(\sigma) \\ \\ \llbracket x - y \rrbracket(\sigma) = \llbracket x \rrbracket(\sigma) - \llbracket y \rrbracket(\sigma) \\ \\ \llbracket x = y \rrbracket(\sigma) = \mathbf{1} \text{ if } x = y \text{ else } \mathbf{0} \end{bmatrix}
```

 $[x; y](\sigma) = [x]([y](\sigma))$

 $\llbracket x \rrbracket(\sigma) = lit(x)$



$(if \rightarrow while)$ -translation

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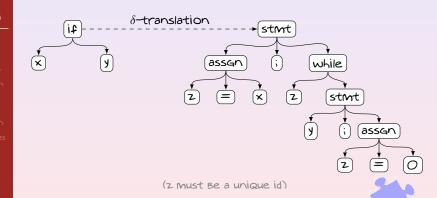
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Example

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 δ -alternative





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Example

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 δ -alternativ

Condusions

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```





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```

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Example

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Condusions

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    z = x == 1;
    while(z) {
       flag = 0;
       z = 0;
    }
}
```





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```

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Example

 δ -translatio

 δ -alternative

Conclusions

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    z = x == 1;
    while(z) {
        flag = 0;
        z = 0;
    }
}
```

while

if-while





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```

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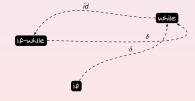
Example

situational

 δ -alternative

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    z = x == 1;
    while(z) {
        flag = 0;
        z = 0;
    }
}
```







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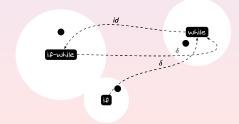
Example

 δ –translatio

 δ -alternative

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    z = x == 1;
    while(z) {
       flag = 0;
       z = 0;
    }
}
```







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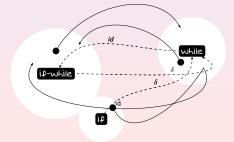
Example

 δ -translatio

 δ -alternativ

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    if (x == 1) {flag = 0};
}
```

```
flag = 1;
x = 10;
while(flag) {
    x = x - 1;
    z = x == 1;
    while(z) {
        flag = 0;
        z = 0;
    }
}
```







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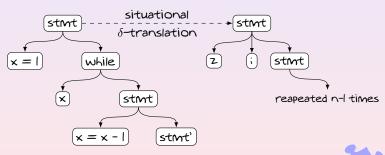
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situational δ -translation

o-translation

Condusions

Situational δ -translations are translations that are only aplicable under few circumstances. For example:



Provided that stmt' does not modify x



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Example

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Conclusions

Situational δ -translations are not reliable to translate one language into another.

Situational δ -translation may succeed into translating only in certain situations.





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Example

situational δ –translation

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Condusions

```
x = 3;
y = 0;
while(x) {
    x = x - 1;
    y = y + 2;
}
```





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```

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Motivation

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Example

situational δ -translation

o-arternati

```
x = 3;
y = 0;
while(x) {
    x = x - 1;
    y = y + 2;
}
```

```
y = 0;
y = y + 2;
y = y + 2;
y = y + 2;
```





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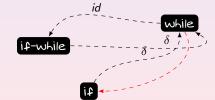
Example

situational δ –translation

 δ -alternative

```
x = 3;
y = 0;
while(x) {
    x = x - 1;
    y = y + 2;
}
```

```
y = 0;
y = y + 2;
y = y + 2;
y = y + 2;
```







δ -alternatives

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Example

0 4 5 5 5 6 6

 δ -alternatives

Conclusion

A δ -translation may have alternatives that are user dependent.

For example:

- The user may have a preference on the generation of the identifier z.
- Or, it may want to use a different translation pattern.





Transpilation Product Lines

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Example

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 δ -alternatives

Conclusions

We need to model the δ -variability that can occur.

Different δ -translation lead to different products.

Feature models seems a good model for this kind of variability.





Conclusion

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Conclusions

 δ s can be used to translate any language to any other language.

 δ s are reusable, modular but have alternatives.

 δ s can be chained to build new transpilers.

The target language can be expressed declaratively.

 δ s Product lines can be used to model alternatives.





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Conclusions

Thank you for your attention.

