Fortran Standards Toolkit (FST)

Frank Duffy
SIParCS
Dan Nagle, Davide Del Vento

Bridgewater State University
Bridgewater MA
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What is FST?

- An ongoing project
- Mission: provide automated source-to-source translation tools for Fortran
  - Identify and transform non-standard, obsolescent and deleted syntactic constructs to follow recent standards
- Developed using the Rose compiler infrastructure
  - an open source compiler infrastructure to build source-to-source program transformation and analysis tools
  - for large-scale C (C89 and C98), C++ (C++98 and C++11), UPC, Fortran (77, 95, 2003), OpenMP, Java, Python, PHP, and Binary applications.

The Issue with Archaic Constructs

- Often compiler specific
  - Introduces portability issue
- Not guaranteed to behave as intended
  - Especially concerning for scientific programs
  - Reproducibility is at risk

Examples of Archaic Constructs

1. The "*n" notation in type declarations
2. Hollerith data
3. DO with CONTINUE as terminal label
4. f66-style array(1) declarations
5. Livermore/Cray/VAX pointers
6. common blocks
7. equivalence
8. PAUSE
9. BUUFER IN/BUFFER OUT/UNIT
10. ENCODE/DECODE
11. direct access record numbers following a quote
12. The list goes on …

Why the Rose Compiler?

- Provides high level interfaces for AST manipulation
  - SageBuilder
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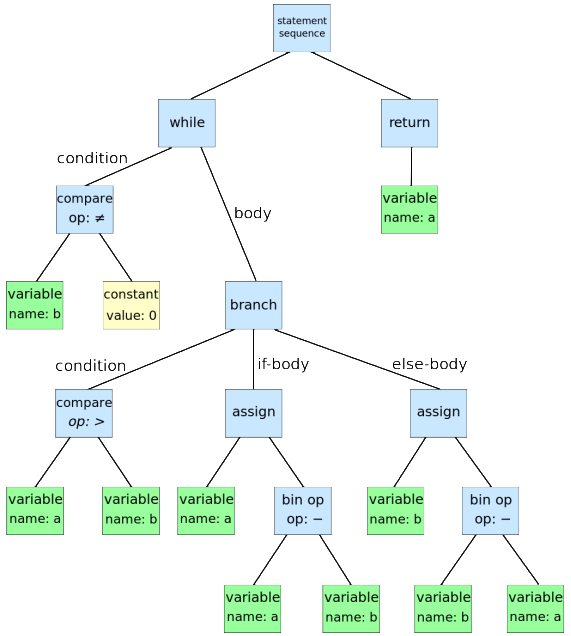
```
while b ≠ 0
      if a > b
            a := a − b
      else
            b := b − a
return a
```

Represents



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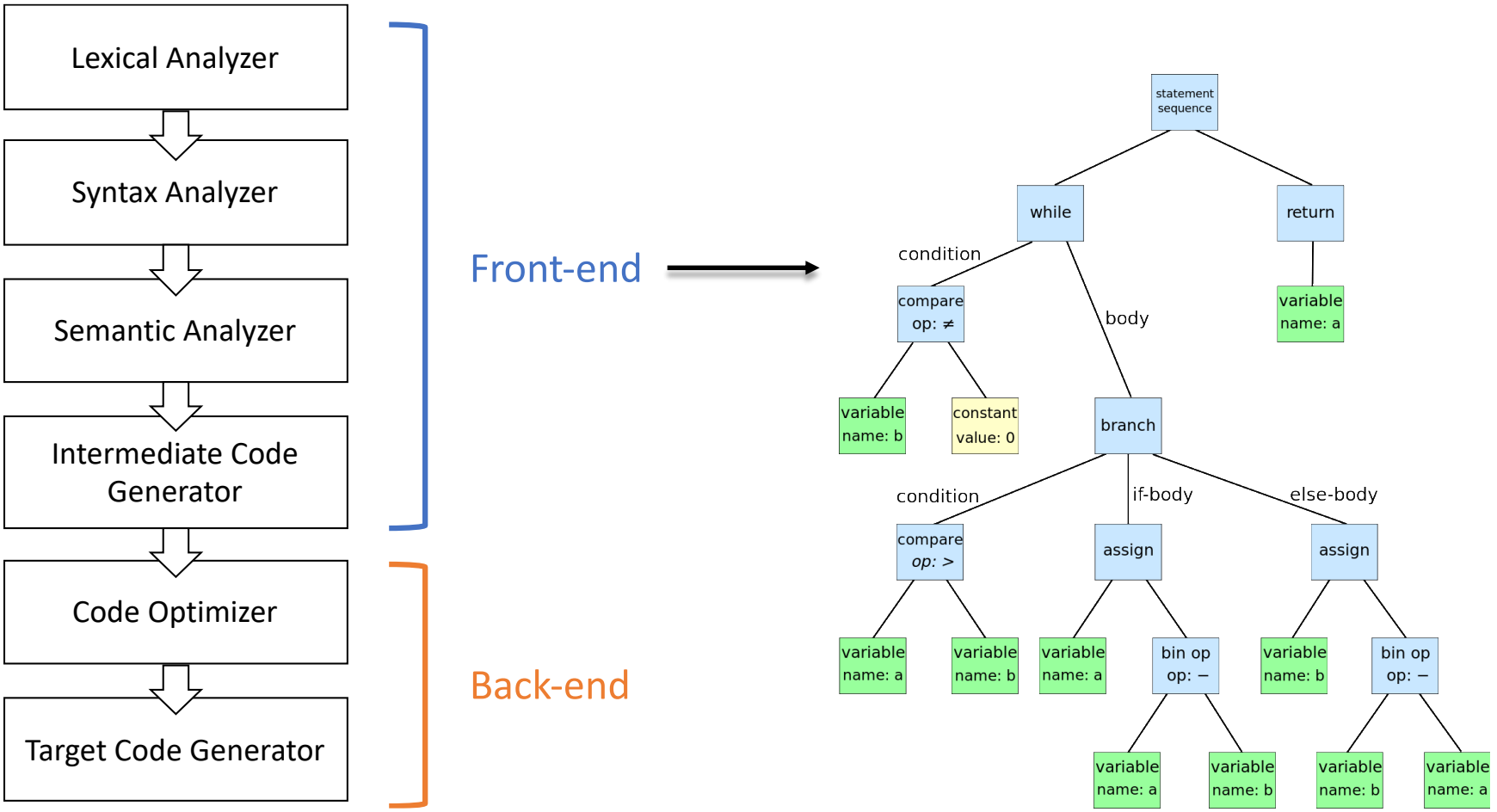

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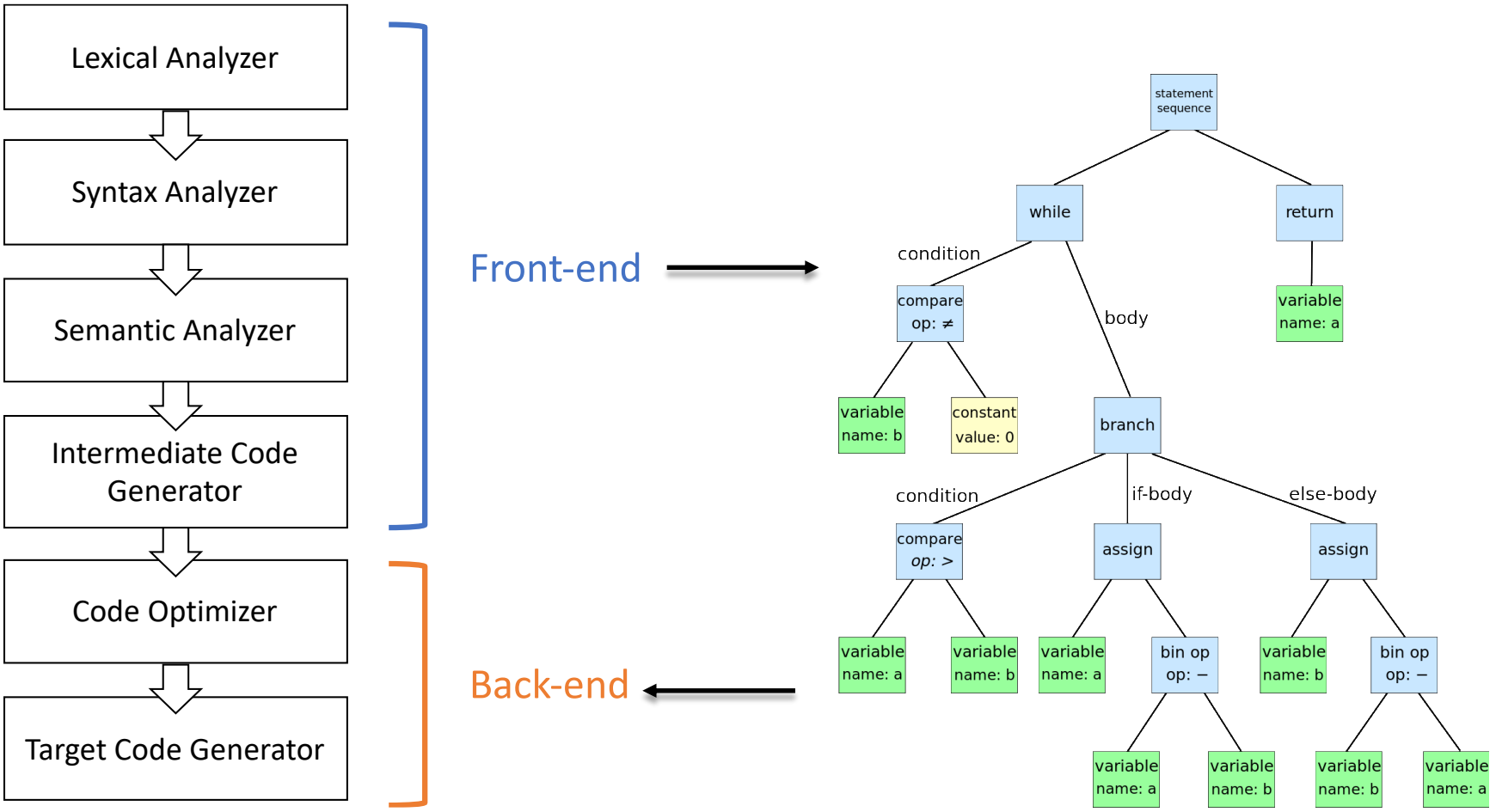

Tools Built Using Rose

- Follow a visitor pattern
  - Method of operating on a structure

```
#include "rose.h"
#include "helperFunctions.h"
#include <iostream>
#include <regex>

using namespace std;
using namespace Rose;
using namespace SageInterface;
using namespace SageBuilder;

 class visitorPrinter : public AstSimpleProcessing {
  public:
    int printDebug;
  protected:
    helperFunctions h;
    void virtual visit(SgNode* astNode);
};

void visitorPrinter::visit(SgNode* node) {
  h.printClass(node);

  if((node->variantT() != V_SgSourceFile) && (node->variantT() != V_SgGlobal) &&
                (node->variantT() != V_SgFunctionParameterList)){

    h.printSource(node);
    if(node->variantT() == V_SgFunctionRefExp){
      SgFunctionType* type = isSgFunctionType(isSgFunctionRefExp(node)->get_type());
      h.printClass(type);
      SgFunctionParameterTypeList* list = type->get_argument_list();
      h.printSource(list);
//      cout << list->front() << endl;
    }
  }
}

}
```

```
int main(int argc, char* argv[]){

  //Initialize and check compatibility
  ROSE_INITIALIZE;

  //commandline processing of flags
  Rose_STL_Container<string> l =
        CommandlineProcessing::
                generateArgListFromArgcArgv (argc, argv);

  //Build traversal object
  visitorPrinter v;


  //build AST
  SgProject* project = frontend(l);

  //Start traversal
  v.traverseInputFiles(project, preorder);

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Tools Included in FST

- Nonblocked do-loop translator
  - DO with CONTINUE as terminal label
  - Goto's by necessity
- Arithmetic-if translator
- Type-star translator
  - The "*n" notation in type declarations

Nonblocked Do-Loop Translator

- Nonblocked do-loop – a loop whose terminal statement is not ‘end do’

Nonblocked Do-Loop Translator

- Nonblocked do-loop – a loop whose terminal statement is not ‘end do’

nonblocked

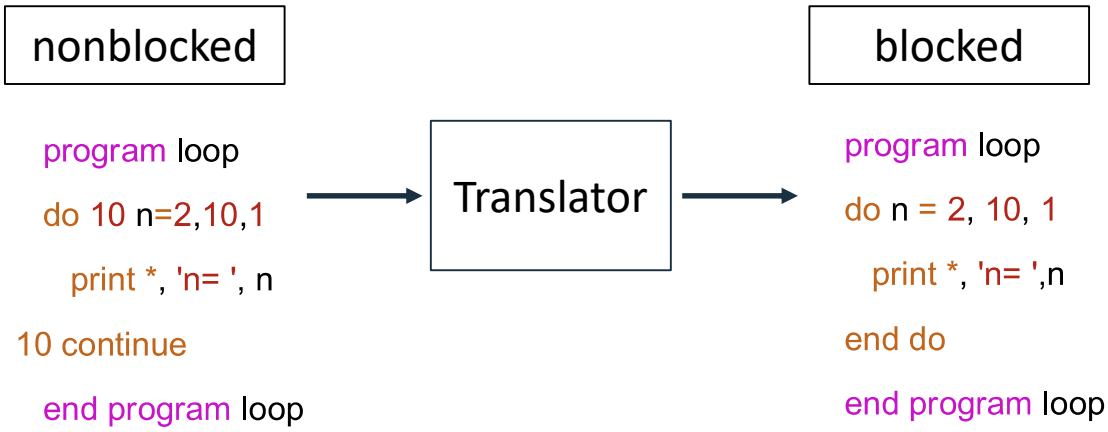
```
program loop
do 10 n=2,10,1
   print *, 'n= ', n
10 continue
end program loop
```

blocked

```
program loop
do n = 2, 10, 1
   print *, 'n= ',n
end do
end program loop
```

Nonblocked Do-Loop Translator

- Nonblocked do-loop – loop's terminal statement is a labeled continue statement



Nonblocked Do-Loop Translator

```
      program loop
      do 10 n=2,10,1
         print *, 'n= ', n
   10 continue

      goto 20
   20 continue

      do 30 n=2,10,1
         if (n .GT. 5) goto 30
   30 continue

      do 40 n=2,10,1
         if (n .GT. 5) goto 50
   40 continue
   50 continue

      do 60 n=2,10,1
         if (n .GT. 5) goto 70
   60 continue
      print *, 'n= ', n
   70 continue

      do 80 n=2,10,1
         do 90 k=2,10,1
            if (k .eq. 5) goto 100
   90 continue
   80 continue
  100 continue

      do 110 n=2,10,1
         do 120 k=2,10,1
            if (k .eq. 5) goto 110
  120 continue
  110 continue

      do 130 n=2,10,1
         do 140 k=2,10,1
            if (k .eq. 5) goto 140
  140 continue
  130 continue

      do 150 n=2,10,1
         do 150 k=2,10,1
            print *, 'n= ', n
  150 continue
      end program loop
```


```
      program loop
      do n = 2, 10, 1
         print *, 'n= ',n
      end do

      goto 20
   20 continue

      do n = 2, 10, 1
         if (n > 5) cycle
      end do

      do n = 2, 10, 1
         if (n > 5) exit
      end do

      do n = 2, 10, 1
         if (n > 5) goto 70
      end do
      print *, 'n= ',n
   70 continue

      do n = 2, 10, 1
         do k = 2, 10, 1
            if (k .eq. 5) goto 100
         end do
      end do
  100 continue

      do n = 2, 10, 1
         do k = 2, 10, 1
            if (k .eq. 5) exit
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      do n = 2, 10, 1
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            print *, 'n= ',n
         end do
      end do
      end program loop
```

Nonblocked Do-Loop Translator

Un-translated

```
program l
do 10 n=2
   print
10 continue
```

```
do 10 n=2,10,1
        print *, 'n= ', n
  10 continue
```

Basic non-blocked do-loop

```
do n = 2, 10, 1
   print *, 'n= ',n
end do
```

Translated

```
gram loop
n = 2, 10, 1
print *, 'n= ',n
 do
```

```
   goto 20
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   do 30 n=2,10,1
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   do 80 n=2,10,1
      do 90 k=2,10,1
         if (k .eq. 5) goto 100
90 continue
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100 continue

   do 110 n=2,10,1
      do 120 k=2,10,1
         if (k .eq. 5) goto 110
120 continue
110 continue

   do 130 n=2,10,1
      do 140 k=2,10,1
         if (k .eq. 5) goto 140
140 continue
130 continue

   do 150 n=2,10,1
      do 150 k=2,10,1
         print *, 'n= ', n
150 continue
   end program loop
```

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   end do
   end program loop
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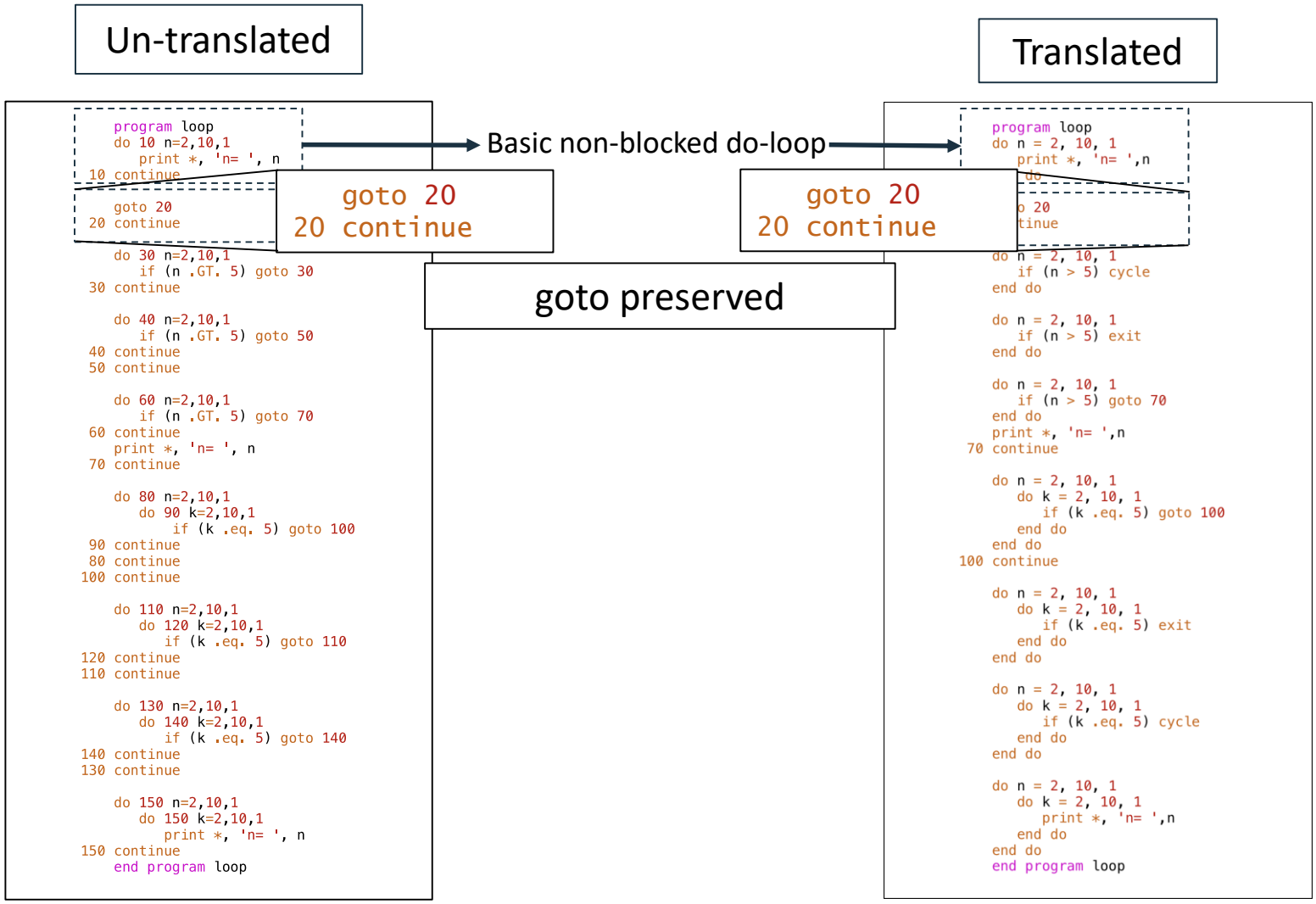

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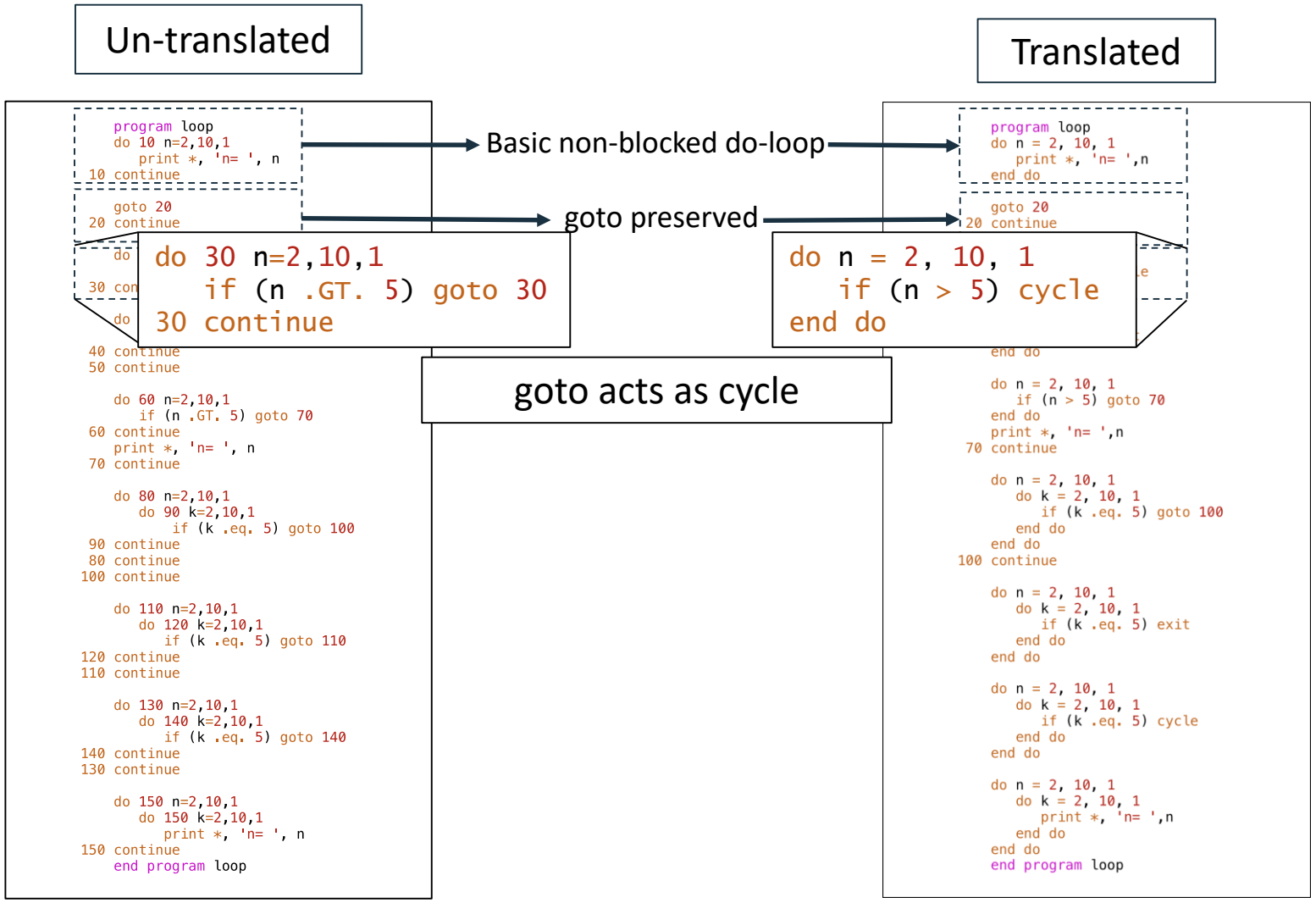


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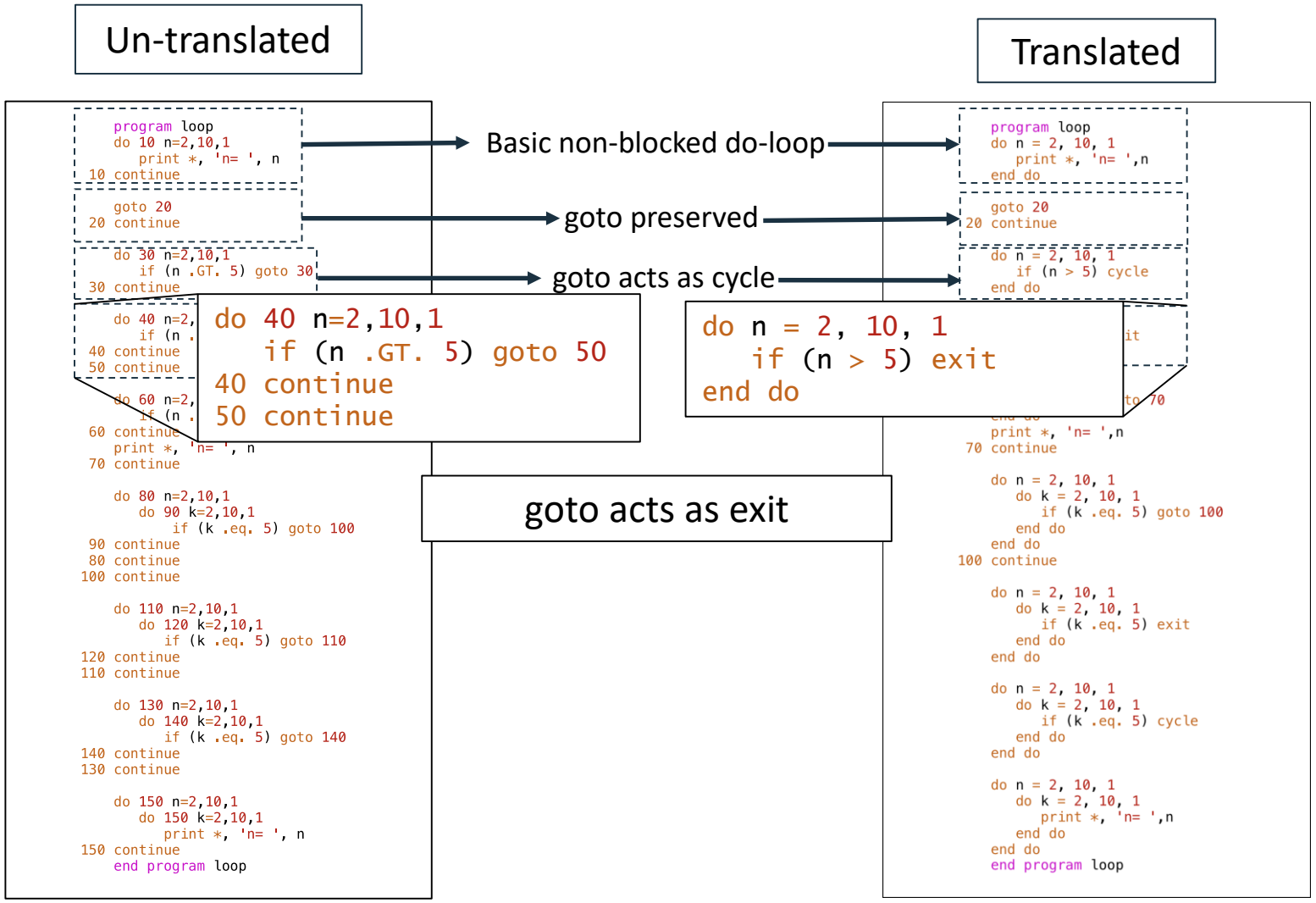

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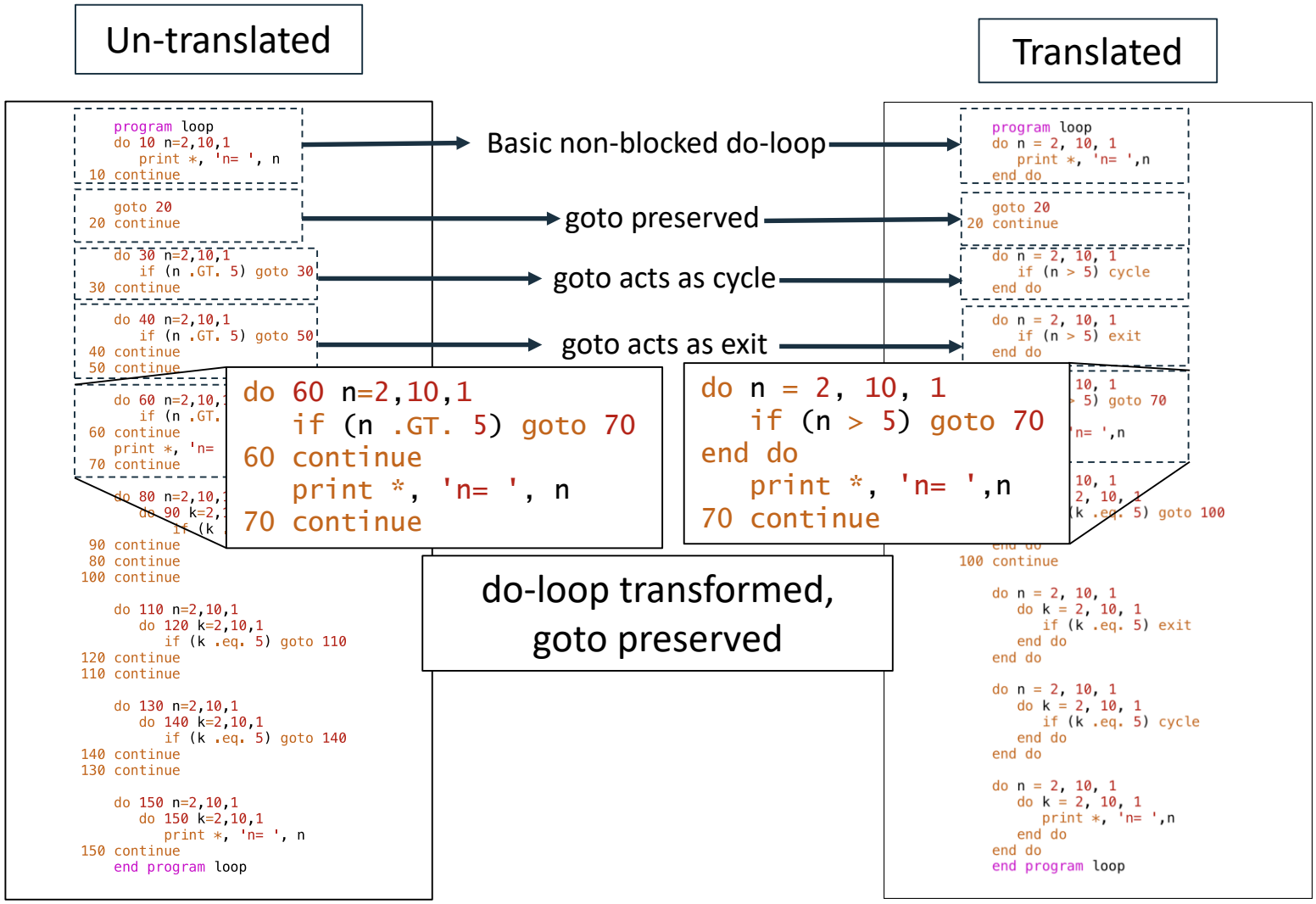

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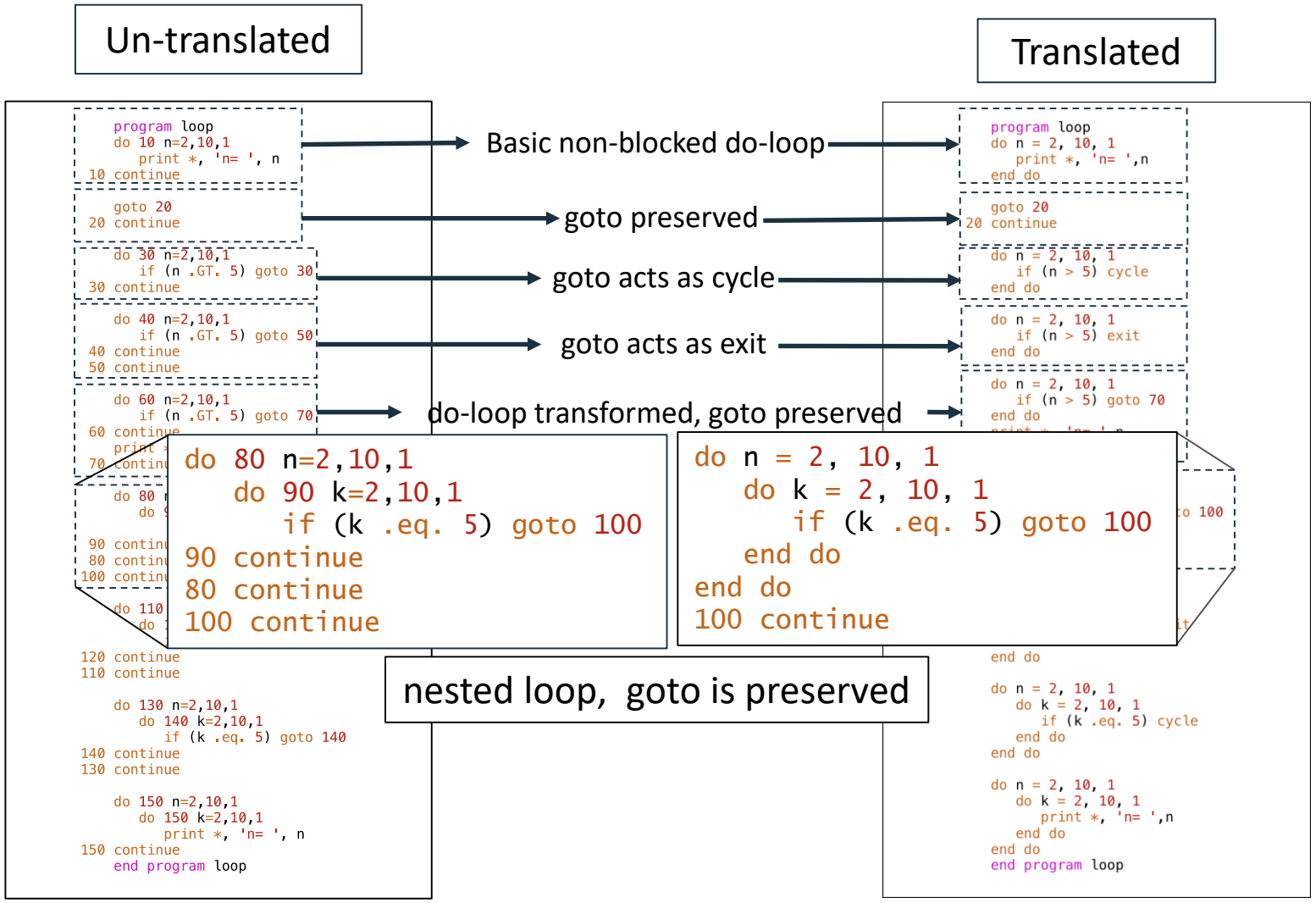

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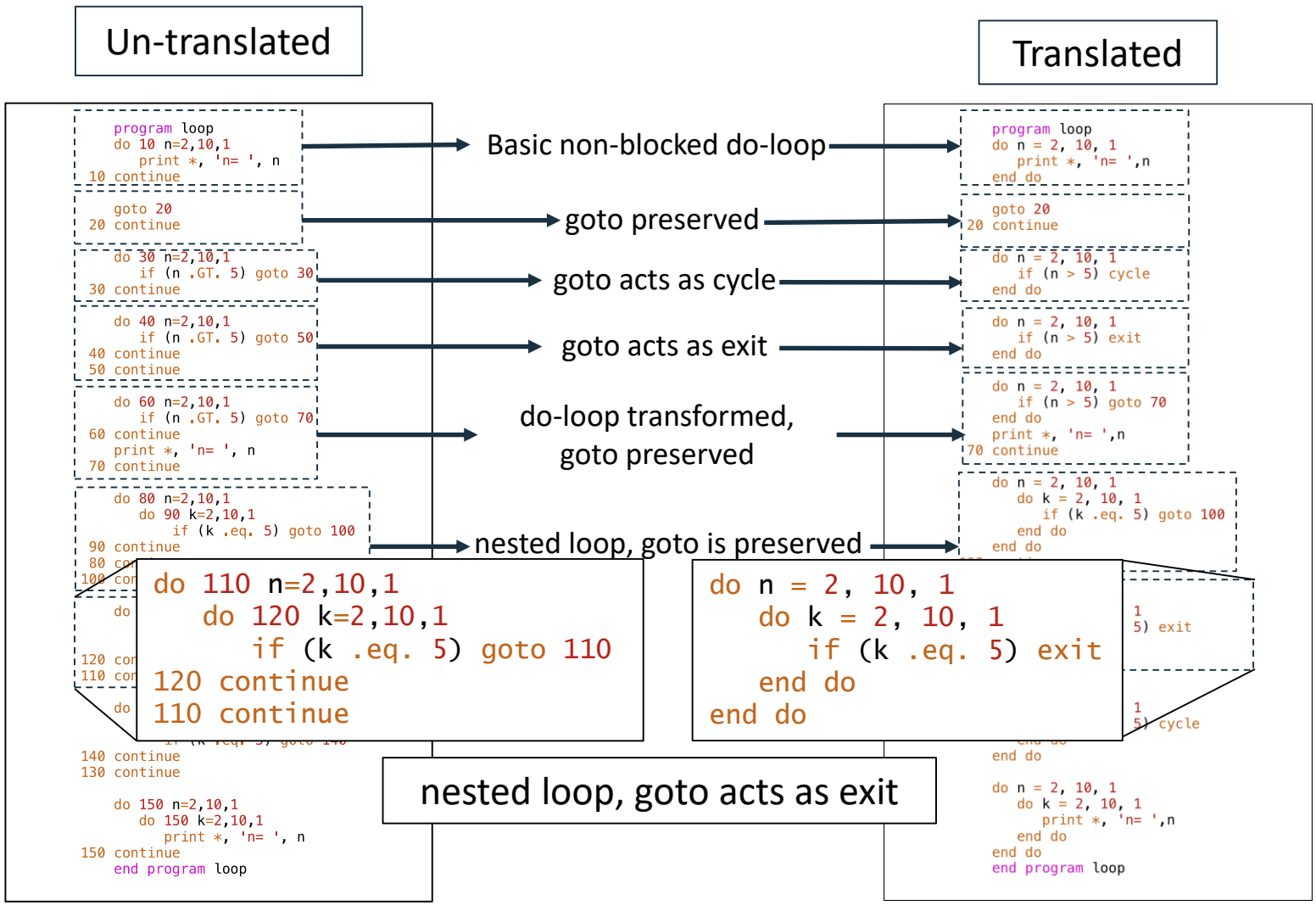
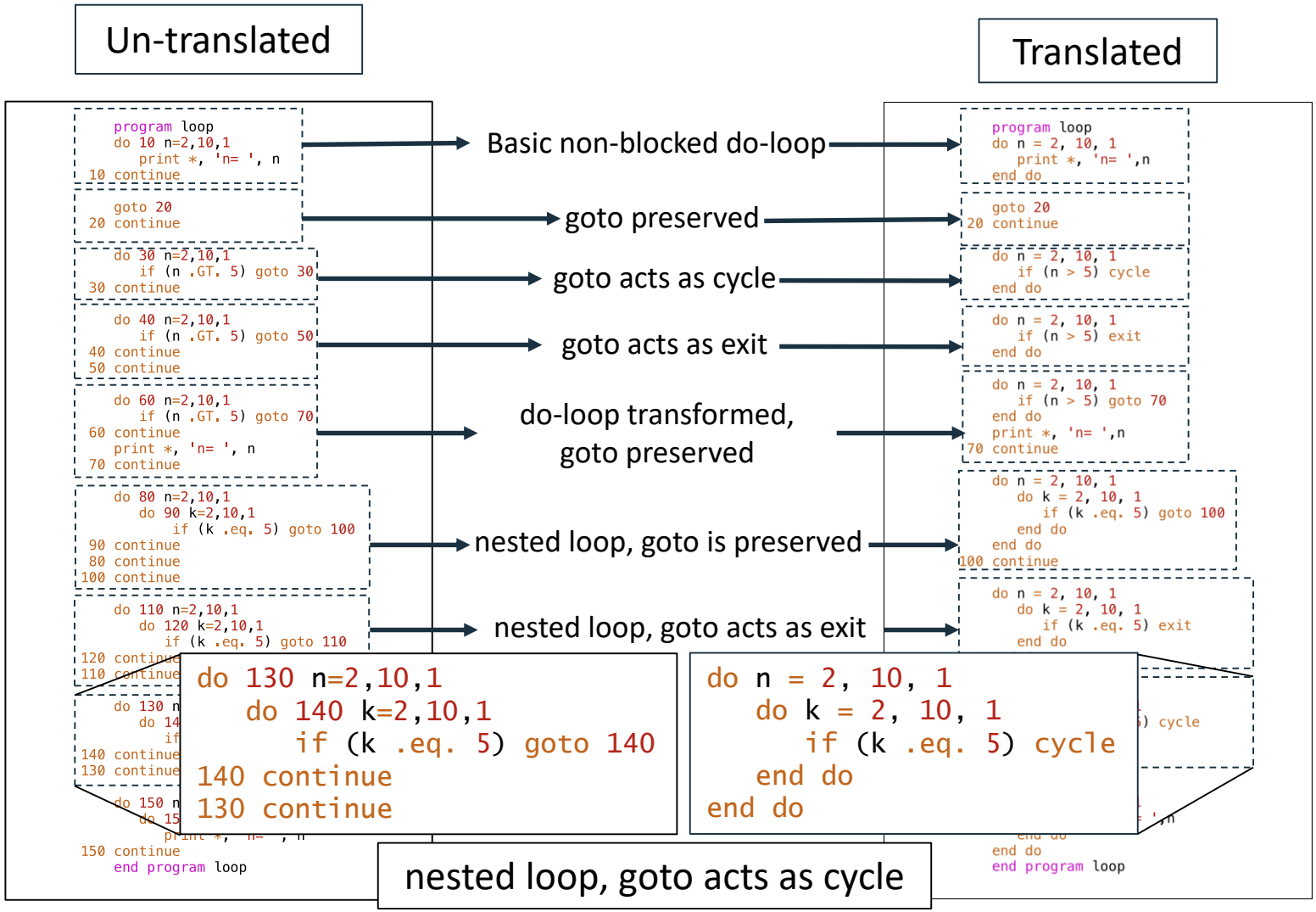
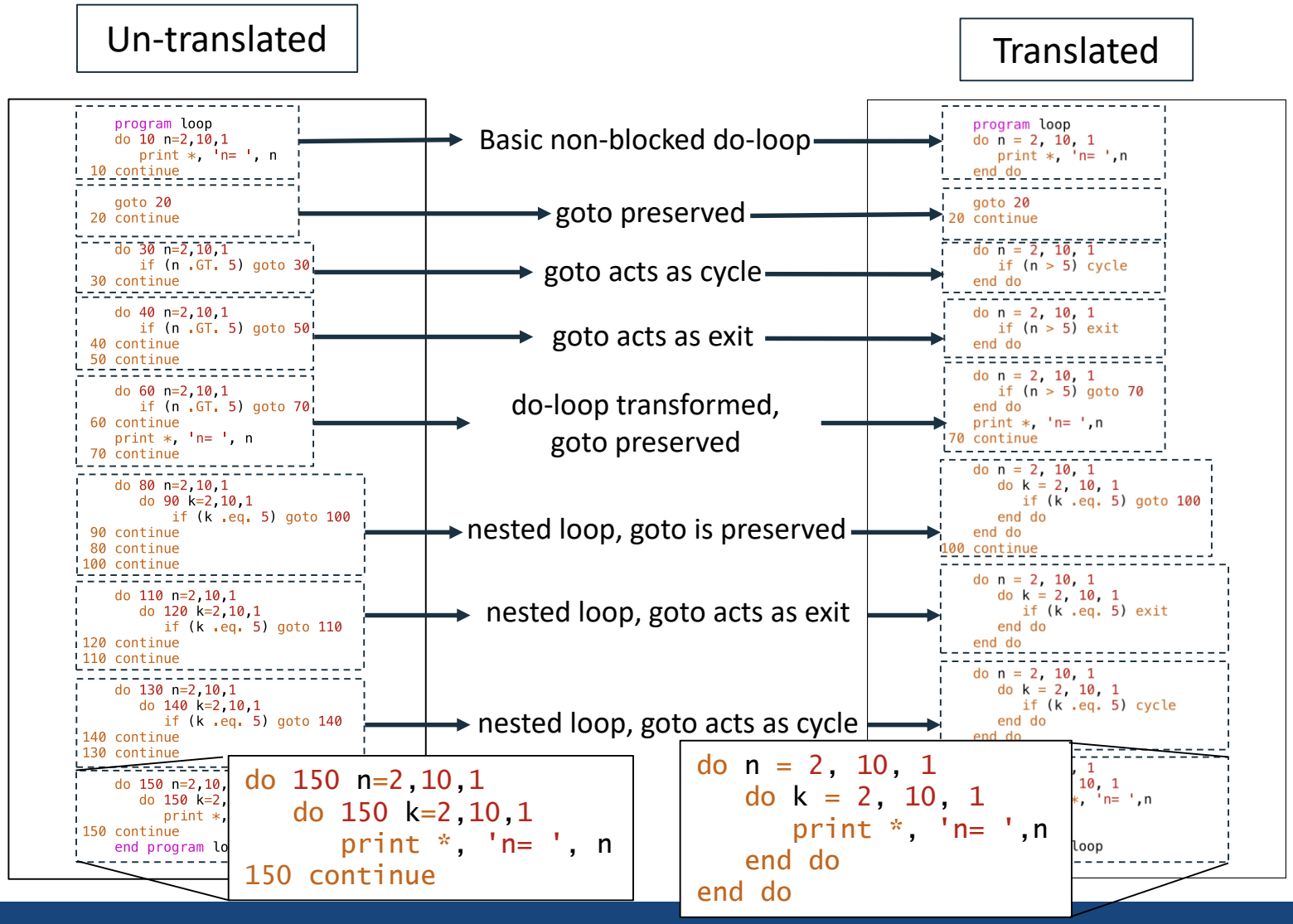


Nonblocked Do-Loop Translator



Nonblocked Do-Loop Translator



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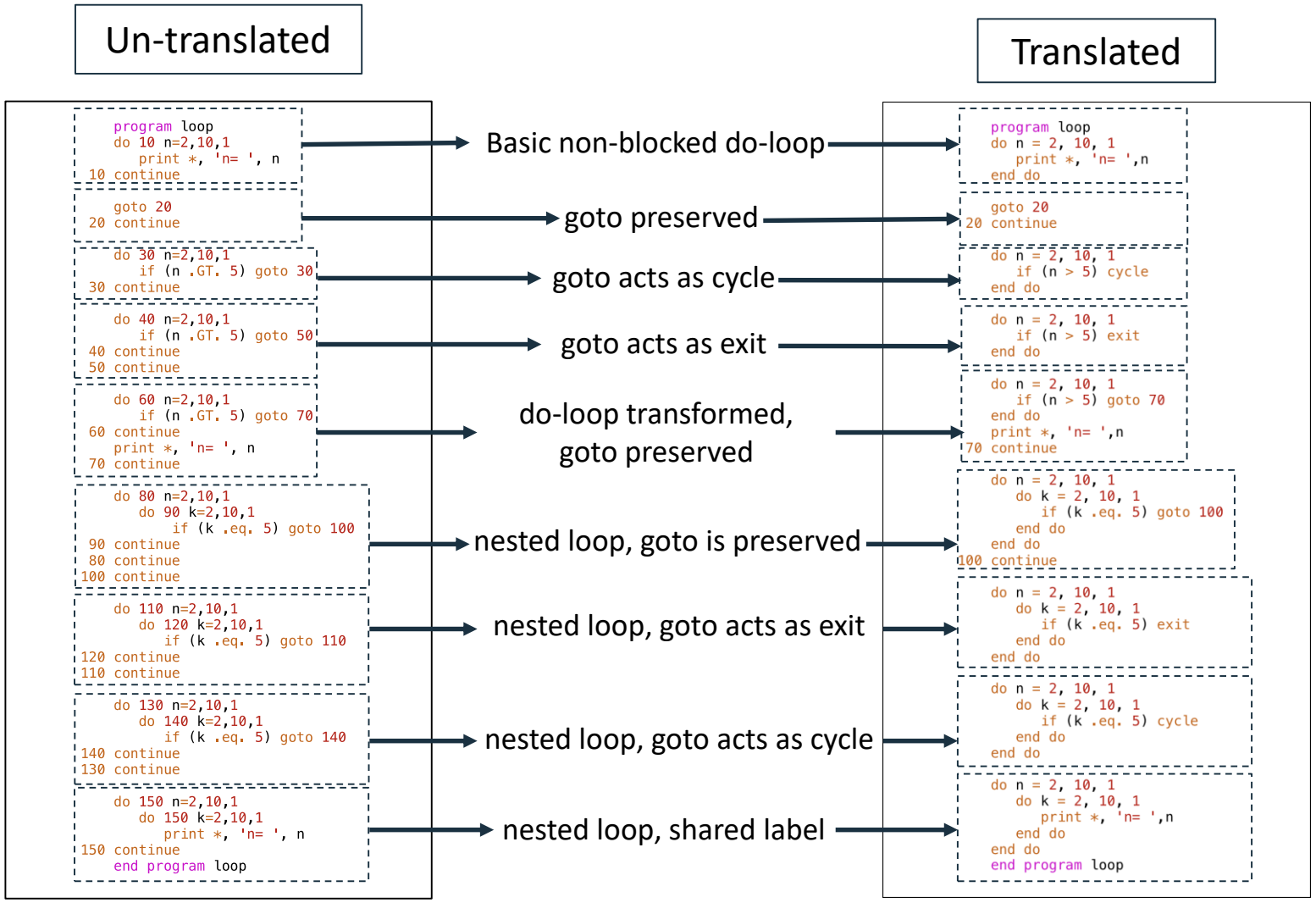

Arithmetic-If Translator

- Translates arithmetic if's to standard if constructs

Arithmetic-If Translator

- Translates arithmetic if's to standard if constructs

```
   program arithmeticif
   n = 5
   if(n) 10,20,30
10 continue
20 continue
30 continue
   end program arithmeticif
```


```
   program arithmeticif
   n = 5
   if (n > 0) then
      goto 30
   else
      if (n < 0) then
         goto 10
      else
         goto 20
      end if
   end if
10 continue
20 continue
30 continue
   end program arithmetif
```

Type-star Translator

- Handles "*n" notation in type declarations

Type-star Translator

- Handles "*n" notation in type declarations

```
program test
real*4 x1
real*8 x2
real*16 x3
complex*8 y2
complex*16 y3
integer*2 z1
integer*4 z2
integer*8 z3
integer*16 z4
character*2 c1
character*4 c2
character*8 c3
character*16 c4
end program test
```


```
program test
real(kind=real32) :: x1
real(kind=real64) :: x2
real(kind=real128) :: x3
complex(kind=real64) :: y2
complex(kind=real128) :: y3
integer(kind=int16) :: z1
integer(kind=int32) :: z2
integer(kind=int64) :: z3
integer(kind=int128) :: z4
character(len=2) :: c1
character(len=4) :: c2
character(len=8) :: c3
character(len=16) :: c4
end program test
```

fst Interface

fst Interface

```
fduffy@cheyenne1:~/fst2018> ./fst -help

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                      Fortran Standards Toolkit v1.0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
usage: fst [tool_sequence] [options] [source]

[tool_sequence]    must be a set of one or more integers delimited
                   by comma ',' with no spaces

[options]          may be any number of options supported by the Rose
                   compiler and/or FST tools.

[source]           may be any source file. The output will be put in the
                   directory of the source file given as input.

Disregard clobber warning. FST operates on a copy of your input source.

Available tools
1. Arithmetic-if Translator
2. Nonblocked-do Translator
3. Type-star Translator


fduffy@cheyenne1:~/fst2018> fst 1,2,3 -v source.f90
```

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fduffy@cheyenne1:~/fst2018> fst 1,2,3 -v source.f90
```

Current Status

- Works well on free form Fortran
- Often encounters problems with fixed form and older
  - Other archaic constructs not handled by the kit keep compilation from succeeding.

Future Work

- Handle more constructs
  - F77 style comments
  - Common blocks to modules
- F77 –> f90

Thanks to...

- Dan Nagle and Davide del Vento for their mentorship and support with the project.
- AJ Lauer and Jenna Preston for supporting all the interns during our stay in Boulder.
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