# Textual Representations

## FORTRAN

```
SUBROUTINE DOT(A,N,RES)

  INTEGER N
  REAL X,A(:)
  X=0.0
  DO I = 1, N, 1
    X = X + A(i)*B(i)
  END DO
  RES=X
  RETURN

END
```

## C

```
double dot(double* a, double* b, uint64_t n)
{
  double d = 0.0;
  for(int i = 0; i < n; i++)
    d += a[i]*b[i];
  return d;
}
```

## C++

```
double dot(vector<double> vec_a,
           vector<double> vec_b)
{
  double x = 0.0;
  for(int i = 0; i < vec_a.size(); i++)
    x += vec_a[i]*vec_b[i];
  return x;
}
```

## LLVM Intermediate

```
define double @dot(double*, double*, i64) {
  %4 = icmp eq i64 %2, 0
  br i1 %4, label %6, label %5

; <label>:5:
  br label %8

; <label>:6:
  %7 = phi double [ 0.0, %3 ], [ %16, %8 ]
  ret double %7

; <label>:8:
  %9 = phi i64 [ %17, %8 ], [ 0, %5 ]
  %10 = phi double [ %16, %8 ], [ 0.0, %5 ]
  %11 = getelementptr double, double* %0, i64 %9
  %12 = load double, double* %11
  %13 = getelementptr double, double* %1, i64 %9
  %14 = load double, double* %13
  %15 = fmul double %12, %14
  %16 = fadd double %10, %15
  %17 = add i64 %9, 1
  %18 = icmp eq i64 %17, %2
  br i1 %18, label %6, label %8
}
```

# Data Structure Representation

## Properties

| | | |
|---|---|---|
| i1 | 1 | icmp eq |
| | 2 | cond br |
| | 3 | br |
| double | 4 | phi |
| | 5 | ret |
| i64 | 6 | phi |
| double | 7 | phi |
| double* | 8 | gep |
| double | 9 | load |
| double* | 10 | gep |
| double | 11 | load |
| double | 12 | fmul |
| double | 13 | fadd |
| i64 | 14 | add |
| i1 | 15 | icmp eq |
| | 16 | cond br |

3 constants

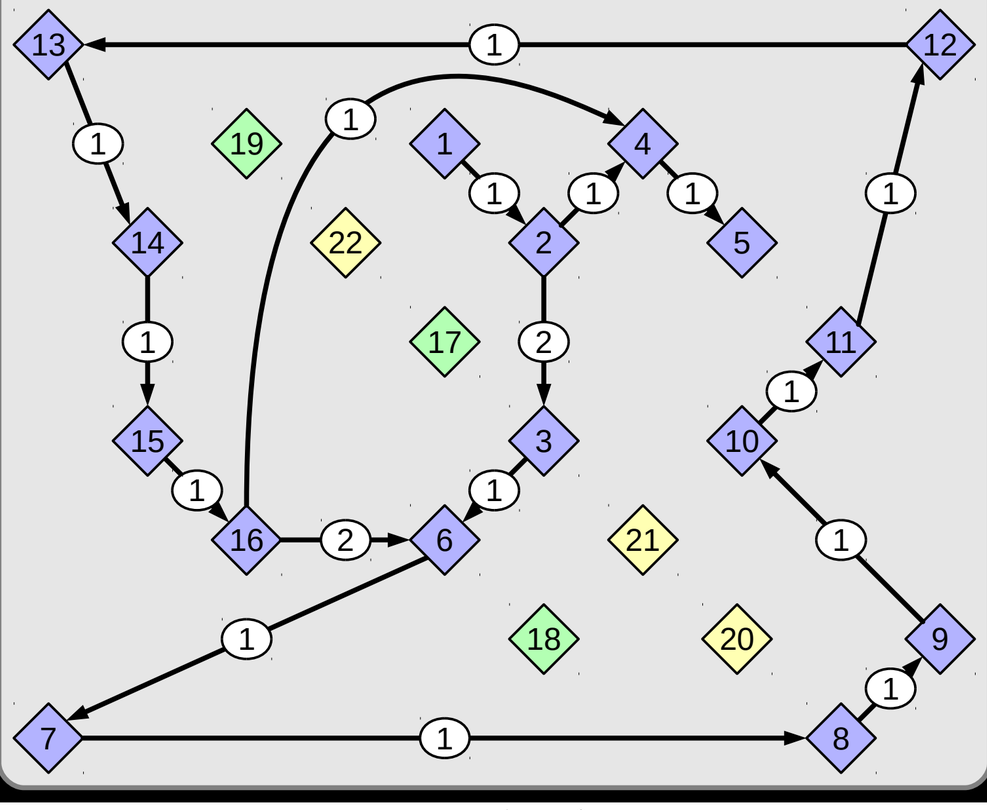
| | | |
|---|---|---|
| i64 | 17 | 0 |
| double | 18 | 0.0 |
| i64 | 19 | 1 |

3 parameters

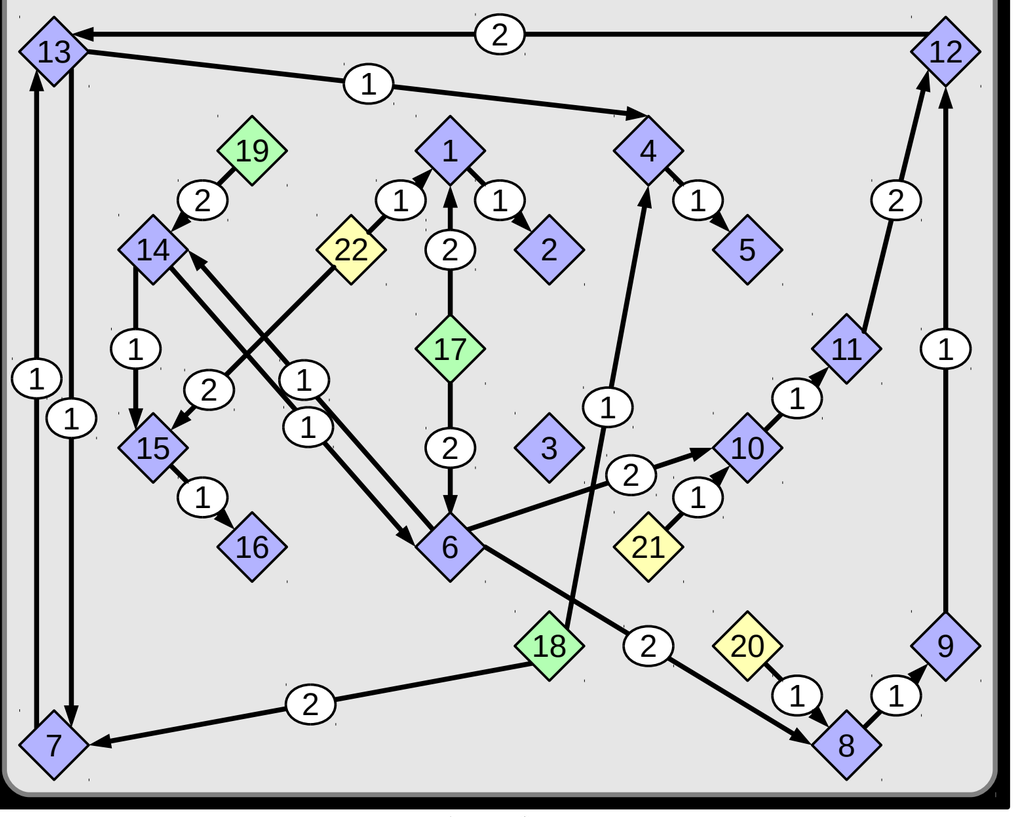
| | |
|---|---|
| double* | 17 |
| double* | 18 |
| i64 | 19 |

0 globals

## Control Flow Graph




## Data Flow Graph




# Mathematical Representation

$$T_{\mathcal{F}} = \{(1, i1), (4, double), (6, i64), \dots\} \subset \mathbb{N} \times Types_{\text{LLVM}}$$

$$I_{\mathcal{F}} = \{(1, icmp\ eq), (2, cond\ br), \dots\} \subset \mathbb{N} \times Opcodes_{\text{LLVM}}$$

$$C_{\mathcal{F}} = \{(17, 0), (18, 0), (19, 1)\} \subset \mathbb{N} \times \mathbb{R}$$

$$P_{\mathcal{F}} = \{17, 18, 19\} \subset \mathbb{N}$$

$$G_{\mathcal{F}} = \{\} \subset \mathbb{N}$$

$$CFG_{\mathcal{F}} = \{(1,2,1), (2,4,1), (2,3,2), (3,6,1), (4,5,1), (6,7,1), (7,8,1), (8,9,1), (9,10,1), (10,11,1), (11,12,1), (12,13,1), (13,14,1), (14,15,1), (15,16,1), (16,4,1), (16,6,2)\} \subset \mathbb{N}^3$$

$$DFG_{\mathcal{F}} = \{(1,2,1), (4,5,1), (6,8,2), (6,10,2), (6,14,1), (7,13,1), (8,9,1), (9,12,1), (10,11,1), (11,12,2), (12,13,2), (13,4,1), (13,7,1), (14,6,1), (14,15,1), (15,16,1), (17,1,1), (17,6,1), (18,4,1), (18,7,2), (19,14,2), (20,8,1), (21,10,1), (22,1,1), (22,15,2)\} \subset \mathbb{N}^3$$

$$\mathcal{F} = (T_{\mathcal{F}}, I_{\mathcal{F}}, C_{\mathcal{F}}, P_{\mathcal{F}}, G_{\mathcal{F}}, CFG_{\mathcal{F}}, DFG_{\mathcal{F}})$$