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

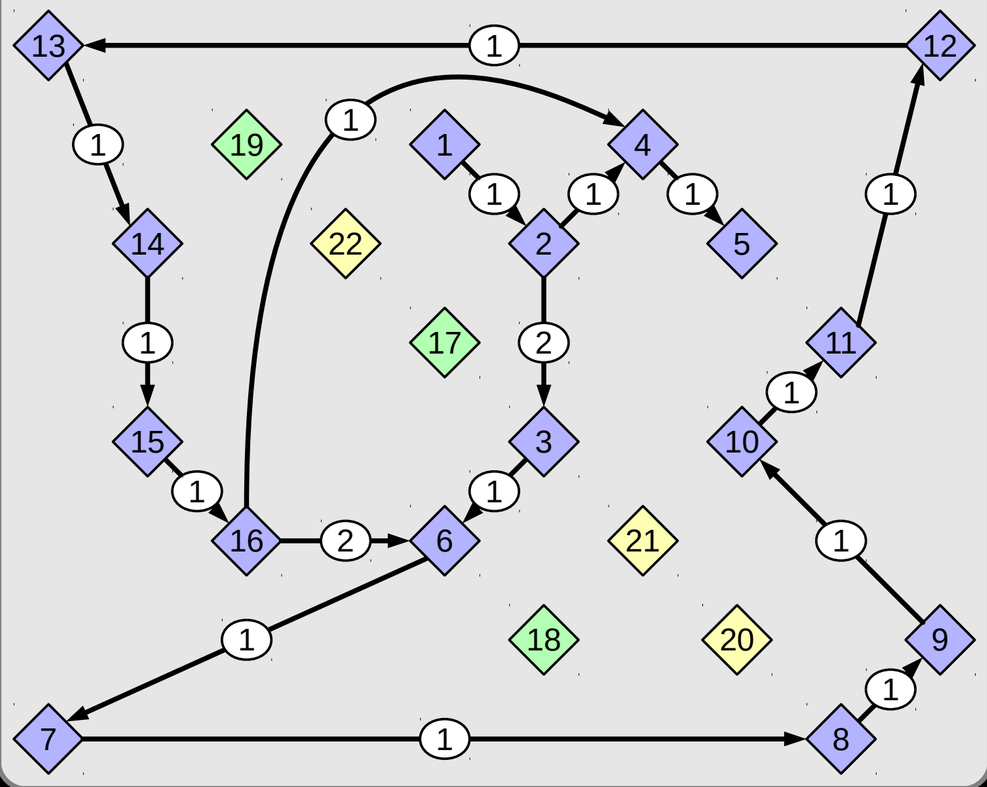
i64	17	0
double	18	0.0
i64	19	1

3 parameters

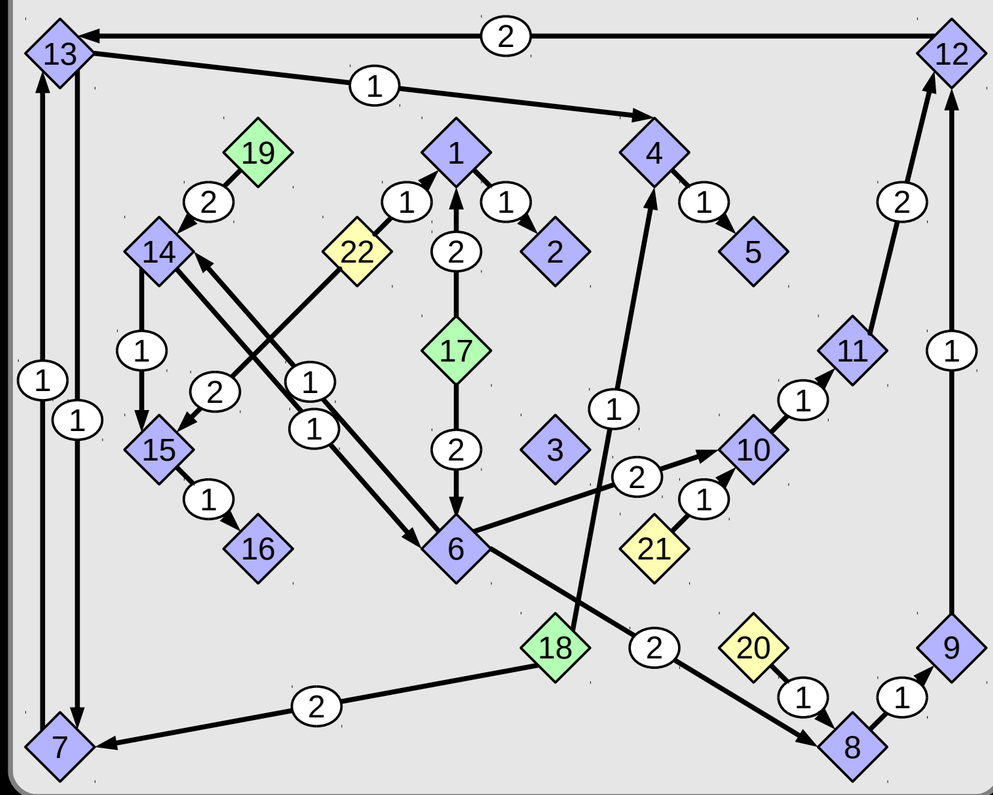
double*	17	
double*	18	
i64	19	

0 globals

Control Flow Graph



Data Flow Graph



Mathematical Representation

$$
\begin{aligned}
T_{\mathcal{F}} &= \{(1, i1), (4, double), (6, i64), \dots\} \\
&\subset \mathbb{N} \times Types_{\text{LLVM}} \\
I_{\mathcal{F}} &= \{(1, icmp\ eq), (2, cond\ br), \dots\} \\
&\subset \mathbb{N} \times Opcodes_{\text{LLVM}} \\
C_{\mathcal{F}} &= \{(17, 0), (18, 0), (19, 1)\} \\
&\subset \mathbb{N} \times \mathbb{R} \\
P_{\mathcal{F}} &= \{17, 18, 19\} \subset \mathbb{N} \\
G_{\mathcal{F}} &= \{\} \subset \mathbb{N}
\end{aligned}
$$

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

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

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