Example of Subprogram Execution

In order to get a better understanding of the roles of the internal registers and runtime stack when executing subprograms, let's examine in detail the call of and return from a simple function. Consider the following CPRL program.

```
declare
  var x : Integer;
  function abs(n : Integer) return Integer is
  begin
    if n >= 0 then
       return n;
    else
       return -n;
    end if;
  end abs;

begin
  x := -5;
  writeln abs(x);
end.
```

Compiling this program yields the following assembly code:

```
PROGRAM 4
                                                   LOADW
   BR L5
                                                   NEG
L0:
                                                   STOREW
   PROC 0
                                                   RET 4
   LDLADDR -4
                                                L4:
   LOADW
                                                L5:
   LDCINT 0
                                                   LDGADDR 0
   CMP
                                                   LDCINT 5
   BL L3
                                                   NEG
                                                   STOREW
   LDLADDR -8
   LDLADDR -4
                                                   ALLOC 4
   LOADW
                                                   LDGADDR 0
   STOREW
                                                   LOADW
                                                   CALL L0
   RET 4
   BR L4
                                                   PUTINT
                                                   PUTEOL
L3:
   LDLADDR -8
                                                   HALT
   LDLADDR -4
```

After optimization and assembly, a disassembled version of the code would look as follows:

0:	PROGRAM 4	59:	LDLADDR -4
5:	BR 67	64:	LOADW
10:	PROC 0	65:	NEG
15:	LDLADDR -4	66:	STOREW
20:	LOADW	67:	RET 4
21:	LDCINT 0	72:	LDGADDR 0
26:	CMP	77:	LDCINT -5
27:	BL 27	82:	STOREW
32:	LDLADDR -8	83:	ALLOC 4
37:	LDLADDR -4	88:	LDGADDR 0
42:	LOADW	93:	LOADW
43:	STOREW	94:	CALL -84
44:	RET 4	99:	PUTINT
49:	BR 23	100:	PUTEOL
54:	LDLADDR -8	101:	HALT

Note that before execution of the first instruction, PC has the value 0, BP has the value 102, SB also has the value 102, and SP has the value 101. We visualize this state as follows:

```
PC ->
       0: PROGRAM 4
                                                  64:
                                                     LOADW
       5: BR 67
                                                  65: NEG
      10: PROC 0
                                                  66: STOREW
      15: LDLADDR -4
                                                  67: RET 4
      20: LOADW
                                                  72: LDGADDR 0
      21: LDCINT 0
                                                  77: LDCINT -5
      26: CMP
                                                  82: STOREW
           BL 27
                                                  83: ALLOC 4
      27:
                                                  88: LDGADDR 0
      32: LDLADDR -8
      37: LDLADDR -4
                                                  93: LOADW
                                                  94: CALL -84
      42: LOADW
      43: STOREW
                                                  99: PUTINT
      44: RET 4
                                                 100: PUTEOL
      49: BR 23
                                           SP -> 101: HALT
      54: LDLADDR -8
                                           SB -> 102: ?
                                                                <- BP
      59: LDLADDR -4
```

The first instruction, PROGRAM 4, allocates four bytes on the runtime stack, which now gives us the following:

```
PROGRAM 4
                                                  65:
       0:
                                                      NEG
PC ->
      5: BR 67
                                                  66: STOREW
      10: PROC 0
                                                  67: RET 4
      15: LDLADDR -4
                                                  72: LDGADDR 0
      20: LOADW
                                                  77: LDCINT -5
      21: LDCINT 0
                                                  82: STOREW
      26: CMP
                                                  83: ALLOC 4
      27: BL 27
                                                  88: LDGADDR 0
      32: LDLADDR -8
                                                  93: LOADW
      37: LDLADDR -4
                                                  94: CALL -84
      42: LOADW
                                                  99: PUTINT
      43: STOREW
                                                 100: PUTEOL
      44: RET 4
                                                 101: HALT
      49: BR 23
                                           SB -> 102: 0
                                                                 <- BP
      54: LDLADDR -8
                                                 103: 0
      59: LDLADDR -4
                                                 104: 0
                                           SP -> 105: 0
      64: LOADW
```

Below is a complete step-by-step execution trace of this code that shows memory contents, memory locations referenced by the registers, the runtime stack, etc.

```
0: PROGRAM 4
                                           65: NEG
5: BR 67
                                           66: STOREW
10:
    PROC 0
                                           67: RET 4
                                    PC -> 72: LDGADDR 0
15: LDLADDR -4
20: LOADW
                                           77: LDCINT -5
21: LDCINT 0
                                           82: STOREW
26: CMP
                                           83: ALLOC 4
27: BL 27
                                           88: LDGADDR 0
                                           93: LOADW
32: LDLADDR -8
37: LDLADDR -4
                                           94: CALL -84
                                           99: PUTINT
42: LOADW
43: STOREW
                                          100: PUTEOL
44: RET 4
                                          101: HALT
                                    SB -> 102: 0
49: BR 23
                                                          <- BP
                                          103: 0
54: LDLADDR -8
59: LDLADDR -4
                                          104: 0
                                    SP -> 105: 0
64: LOADW
```

```
0: PROGRAM 4
                                         67: RET 4
5: BR 67
                                         72: LDGADDR 0
                                   PC -> 77: LDCINT -5
10: PROC 0
15: LDLADDR -4
                                         82: STOREW
20: LOADW
                                         83: ALLOC 4
                                         88: LDGADDR 0
21: LDCINT 0
                                         93: LOADW
26: CMP
27: BL 27
                                         94: CALL -84
                                        99: PUTINT
32: LDLADDR -8
37: LDLADDR -4
                                        100: PUTEOL
                                        101: HALT
42: LOADW
43: STOREW
                                   SB -> 102: 0 <- BP
44: RET 4
                                        103: 0
                                        104: 0
49: BR 23
54: LDLADDR -8
                                        105: 0
59: LDLADDR -4
                                        106: 0
64: LOADW
                                        107: 0
65: NEG
                                        108: 0
66: STOREW
                                   SP -> 109: 102
0: PROGRAM 4
                                         77: LDCINT -5
                                   PC -> 82: STOREW
5: BR 67
10: PROC 0
                                         83: ALLOC 4
                                         88: LDGADDR 0
15: LDLADDR -4
                                         93: LOADW
20: LOADW
21: LDCINT 0
                                         94: CALL -84
                                         99: PUTINT
26: CMP
27: BL 27
                                        100: PUTEOL
                                        101: HALT
32: LDLADDR -8
37: LDLADDR -4
                                   SB -> 102: 0
                                                     <- BP
42: LOADW
                                        103: 0
43: STOREW
                                        104: 0
44: RET 4
                                        105: 0
49: BR 23
                                        106: 0
                                        107: 0
54: LDLADDR -8
59: LDLADDR -4
                                        108: 0
64: LOADW
                                        109: 102
65: NEG
                                        110: -1
66: STOREW
                                        111: -1
67: RET 4
                                        112: -1
                                   SP -> 113: -5
```

72: LDGADDR 0

```
0: PROGRAM 4
                                          65: NEG
5: BR 67
                                          66: STOREW
10: PROC 0
                                          67: RET 4
15: LDLADDR -4
                                          72: LDGADDR 0
20: LOADW
                                          77: LDCINT -5
                                          82: STOREW
21: LDCINT 0
                                   PC -> 83: ALLOC 4
26: CMP
                                          88: LDGADDR 0
27: BL 27
                                          93: LOADW
32: LDLADDR -8
37: LDLADDR -4
                                          94: CALL -84
                                          99: PUTINT
42: LOADW
43: STOREW
                                         100: PUTEOL
44: RET 4
                                         101: HALT
49: BR 23
                                   SB -> 102: -1
                                                      <- BP
54: LDLADDR -8
                                         103: -1
59: LDLADDR -4
                                         104: -1
                                   SP -> 105: -5
64: LOADW
0: PROGRAM 4
                                          67: RET 4
5: BR 67
                                          72: LDGADDR 0
10: PROC 0
                                          77: LDCINT -5
                                          82: STOREW
15: LDLADDR -4
                                          83: ALLOC 4
20: LOADW
21: LDCINT 0
                                    PC -> 88: LDGADDR 0
                                          93: LOADW
26: CMP
27: BL 27
                                          94: CALL -84
                                          99: PUTINT
32: LDLADDR -8
37: LDLADDR -4
                                         100: PUTEOL
42: LOADW
                                         101: HALT
43: STOREW
                                   SB -> 102: -1
                                                       <- BP
44: RET 4
                                         103: -1
                                         104: -1
49: BR 23
54: LDLADDR -8
                                         105: -5
59: LDLADDR -4
                                         106: 0
64: LOADW
                                         107: 0
65: NEG
                                         108: 0
66: STOREW
                                   SP -> 109: 102
```

```
77: LDCINT -5
0: PROGRAM 4
5: BR 67
                                         82: STOREW
                                         83: ALLOC 4
10: PROC 0
15: LDLADDR -4
                                         88: LDGADDR 0
20: LOADW
                                   PC -> 93: LOADW
                                         94: CALL -84
21: LDCINT 0
                                         99: PUTINT
26: CMP
27: BL 27
                                        100: PUTEOL
                                        101: HALT
32: LDLADDR -8
                                   SB -> 102: -1
37: LDLADDR -4
                                                     <- BP
                                        103: -1
42: LOADW
43: STOREW
                                        104: -1
44: RET 4
                                        105: -5
49: BR 23
                                        106: 0
                                        107: 0
54: LDLADDR -8
59: LDLADDR -4
                                        108: 0
64: LOADW
                                        109: 102
65: NEG
                                        110: 0
66: STOREW
                                        111: 0
67: RET 4
                                        112: 0
72: LDGADDR 0
                                   SP -> 113: 102
0: PROGRAM 4
                                         82: STOREW
5: BR 67
                                         83: ALLOC 4
                                         88: LDGADDR 0
10: PROC 0
15: LDLADDR -4
                                         93: LOADW
                                   PC -> 94: CALL -84
20: LOADW
26: CMP
                                        99: PUTINT
27: BL 27
                                        100: PUTEOL
32: LDLADDR -8
                                        101: HALT
37: LDLADDR -4
                                   SB -> 102: -1
                                                     <- BP
                                        103: -1
42: LOADW
43: STOREW
                                        104: -1
44: RET 4
                                        105: -5
                                        106: 0
49: BR 23
54: LDLADDR -8
                                        107: 0
59: LDLADDR -4
                                        108: 0
64: LOADW
                                        109: 102
65: NEG
                                        110: -1
                                        111: -1
66: STOREW
67: RET 4
                                        112: -1
72: LDGADDR 0
                                  SP -> 113: -5
77: LDCINT -5
```

	0:	PROGRAM 4		93:	LOADW
	5:	BR 67		94:	CALL -84
PC ->		PROC Ø		99:	PUTINT
	15:	LDLADDR -4		100:	PUTEOL
	20:	LOADW			HALT
	21:	LDCINT 0	SB ->	102:	-1
	26:	CMP		103:	
	27:	BL 27			-1
	32:	LDLADDR -8			- -5
	37:	LDLADDR -4		106:	0
	42:	LOADW		107:	0
	43:	STOREW		108:	0
	44:	RET 4		109:	102
	49:	BR 23		110:	-1
	54:	LDLADDR -8		111:	-1
	59:	LDLADDR -4		112:	-1
	64:	LOADW		113:	-5
	65:	NEG	BP ->		0
	66:	STOREW	DF -/	115:	0
	67:	RET 4		116:	0
	72:	LDGADDR Ø		117:	102
	72. 77:	LDCINT -5		117:	0
					_
	82:	STOREW		119:	0
	83:	ALLOC 4	CD .	120:	0
	88:	LDGADDR 0	SP ->	121:	99

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	0:	PROGRAM 4		93:	LOADW
	5:	BR 67		94:	CALL -84
	10:	PROC 0		99:	PUTINT
PC ->	15:	LDLADDR -4		100:	PUTEOL
	20:	LOADW		101:	HALT
	21:	LDCINT 0	SB ->	102:	-1
	26:	CMP		103:	-1
	27:	BL 27		104:	-1
	32:	LDLADDR -8		105:	-5
	37:	LDLADDR -4		106:	0
	42:	LOADW		107:	0
	43:	STOREW		108:	0
	44:	RET 4		109:	102
	49:	BR 23		110:	-1
	54:	LDLADDR -8		111:	-1
	59:	LDLADDR -4		112:	-1
	64:	LOADW		113:	-5
	65:	NEG	BP ->	114:	0
	66:	STOREW		115:	0
	67:	RET 4		116:	0
	72:	LDGADDR 0		117:	102
	77:	LDCINT -5		118:	0
	82:	STOREW		119:	0
	83:	• · • · · = · ·		120:	0
			CD s		_
	88:	LDGADDR 0	SP ->	121:	99

	0:	PROGRAM 4			99:	PUTINT
	5:	BR 67			100:	PUTEOL
	10:	PROC 0			101:	HALT
	15:	LDLADDR -4	SB	->	102:	-1
PC ->	20:	LOADW			103:	-1
	21:	LDCINT 0			104:	-1
	26:	CMP			105:	-5
	27:	BL 27			106:	0
	32:	LDLADDR -8			107:	0
	37:	LDLADDR -4			108:	0
	42:	LOADW			109:	102
	43:	STOREW			110:	-1
	44:	RET 4			111:	-1
	49:	BR 23			112:	-1
	54:	LDLADDR -8			113:	-5
	59:	LDLADDR -4	BP	->	114:	0
	64:	LOADW			115:	0
	65:	NEG			116:	0
	66:	STOREW			117:	102
	67:	RET 4			118:	0
	72:	LDGADDR 0			119:	0
	77:	LDCINT -5			120:	0
	82:	STOREW			121:	99
	83:	ALLOC 4			122:	0
	88:	LDGADDR 0			123:	0
	93:	LOADW			124:	0
	94:	CALL -84	SP	->	125:	110

	0:	PROGRAM 4		99:	PUTINT
	5:	BR 67		100:	PUTEOL
	10:	PROC 0		101:	HALT
	15:	LDLADDR -4	SB ->	102:	-1
	20:	LOADW		103:	-1
PC ->	21:	LDCINT 0		104:	-1
	26:	CMP		105:	-5
	27:	BL 27		106:	0
	32:	LDLADDR -8		107:	0
	37:	LDLADDR -4		108:	0
	42:	LOADW		109:	102
	43:	STOREW		110:	-1
	44:	RET 4		111:	-1
	49:	BR 23		112:	-1
	54:	LDLADDR -8		113:	-5
	59:	LDLADDR -4	BP ->	114:	0
	64:	LOADW		115:	0
	65:	NEG		116:	0
	66:	STOREW		117:	102
	67:	RET 4		118:	0
	72:	LDGADDR 0		119:	0
	77:	LDCINT -5		120:	0
	82:	STOREW		121:	99
	83:	ALLOC 4		122:	-1
	88:	LDGADDR 0		123:	-1
	93:	LOADW		124:	-1
	94:	CALL -84	SP ->	125:	-5

	_					
	0:	PROGRAM 4			101:	HALT
	5:	BR 67	SB	->	102:	-1
	10:	PROC 0			103:	-1
	15:	LDLADDR -4			104:	-1
	20:	LOADW			105:	-5
	21:	LDCINT 0			106:	0
PC ->	26:	CMP			107:	0
	27:	BL 27			108:	0
	32:	LDLADDR -8			109:	102
	37:	LDLADDR -4			110:	-1
	42:	LOADW			111:	-1
	43:	STOREW			112:	-1
	44:	RET 4			113:	-5
	49:	BR 23	ВP	->	114:	0
	54:	LDLADDR -8			115:	0
	59:	LDLADDR -4			116:	0
	64:	LOADW			117:	102
	65:	NEG			118:	0
	66:	STOREW			119:	0
	67:	RET 4			120:	0
	72:	LDGADDR 0			121:	99
	77:	LDCINT -5			122:	-1
	82:	STOREW			123:	-1
	83:	ALLOC 4			124:	-1
	88:	LDGADDR 0			125:	-5
	93:	LOADW			126:	0
	94:	CALL -84			127:	0
	99:	PUTINT			128:	0
	100:	PUTEOL	SP	->	129:	0

```
0: PROGRAM 4
                                                    94: CALL -84
        5: BR 67
                                                    99: PUTINT
       10:
           PROC 0
                                                   100: PUTEOL
       15: LDLADDR -4
                                                   101: HALT
       20:
           LOADW
                                             SB -> 102:
                                                   103:
       21: LDCINT 0
                                                        -1
                                                   104:
                                                        -1
       26:
           CMP
PC -> 27:
           BL 27
                                                   105:
                                                        -5
                                                   106:
       32: LDLADDR -8
                                                        0
       37:
           LDLADDR -4
                                                   107:
       42:
           LOADW
                                                   108:
                                                        0
       43:
           STOREW
                                                   109:
                                                        102
       44: RET 4
                                                   110:
                                                        -1
       49: BR 23
                                                   111: -1
       54:
           LDLADDR -8
                                                   112:
                                                        -1
       59: LDLADDR -4
                                                   113:
                                                        -5
       64: LOADW
                                             BP -> 114:
                                                        0
       65: NEG
                                                   115:
                                                        0
       66: STOREW
                                                   116:
                                                        0
       67: RET 4
                                                   117:
                                                        102
       72: LDGADDR 0
                                                   118: 0
       77: LDCINT -5
                                                   119:
                                                        0
       82: STOREW
                                                   120:
                                                        0
       83: ALLOC 4
                                                   121:
                                                        99
       88: LDGADDR 0
                                             SP -> 122:
                                                        -1
       93: LOADW
       0: PROGRAM 4
                                                    93: LOADW
        5:
           BR 67
                                                    94: CALL -84
       10: PROC 0
                                                    99: PUTINT
       15: LDLADDR -4
                                                   100: PUTEOL
       20: LOADW
                                                   101: HALT
                                             SB -> 102:
       21: LDCINT 0
                                                        -1
       26: CMP
                                                   103:
                                                        -1
       27: BL 27
                                                   104:
                                                        -1
       32: LDLADDR -8
                                                   105:
                                                        -5
       37: LDLADDR -4
                                                   106:
                                                        0
                                                   107:
       42: LOADW
                                                        0
       43:
           STOREW
                                                   108:
                                                         0
       44: RET 4
                                                   109: 102
       49:
           BR 23
                                                   110:
                                                        -1
PC -> 54: LDLADDR -8
                                                   111:
                                                        -1
       59: LDLADDR -4
                                                   112:
                                                        -1
       64:
           LOADW
                                                   113:
                                                        -5
       65: NEG
                                             BP -> 114:
       66: STOREW
                                                   115:
                                                        0
       67:
                                                   116: 0
           RET 4
       72: LDGADDR 0
                                                   117:
                                                        102
       77:
           LDCINT -5
                                                   118:
       82: STOREW
                                                   119:
       83: ALLOC 4
                                                   120:
                                             SP -> 121: 99
       88: LDGADDR 0
```

	•	DDOCDAM A			00.	DUTTNT
	0:	PROGRAM 4			99:	PUTINT
	5:	BR 67			100:	PUTEOL
	10:	PROC 0			101:	HALT
	15:	LDLADDR -4	SB	->		-1
	20:	LOADW			103:	-1
	21:	LDCINT 0			104:	-1
	26:	CMP			105:	-5
	27:	BL 27			106:	0
	32:	LDLADDR -8			107:	0
	37:	LDLADDR -4			108:	0
	42:	LOADW			109:	102
	43:	STOREW			110:	-1
	44:	RET 4			111:	-1
	49:	BR 23			112:	-1
	54:	LDLADDR -8			113:	-5
PC ->	59:	LDLADDR -4	ВР	->	114:	0
	64:	LOADW			115:	0
	65:	NEG			116:	0
	66:	STOREW			117:	102
	67:	RET 4			118:	0
	72:	LDGADDR 0			119:	0
	77:	LDCINT -5			120:	0
	82:	STOREW			121:	99
	83:	ALLOC 4			122:	0
	88:	LDGADDR 0			123:	0
	93:	LOADW			124:	0
	94:	CALL -84	SP	->	125:	106
	-		-			

	0:	PROGRAM 4		101:	HALT
	5:	BR 67	SB ->	102:	-1
	10:	PROC 0		103:	-1
	15:	LDLADDR -4		104:	-1
	20:	LOADW		105:	-5
	21:	LDCINT 0		106:	0
	26:	CMP		107:	0
	27:	BL 27		108:	0
	32:	LDLADDR -8		109:	102
	37:	LDLADDR -4		110:	-1
	42:	LOADW		111:	-1
	43:	STOREW		112:	-1
	44:	RET 4		113:	-5
	49:	BR 23	BP -:	114:	0
	54:	LDLADDR -8		115:	0
	59:	LDLADDR -4		116:	0
PC ->	64:	LOADW		117:	102
	65:	NEG		118:	0
	66:	STOREW		119:	0
	67:	RET 4		120:	0
	72:	LDGADDR 0		121:	99
	77:	LDCINT -5		122:	0
	82:	STOREW		123:	0
	83:	ALLOC 4		124:	0
	88:	LDGADDR 0		125:	106
	93:	LOADW		126:	0
	94:	CALL -84		127:	0
	99:	PUTINT		128:	0
	100:	PUTEOL	SP -:	129:	110

	0:	PROGRAM 4		101:	HALT
	5:	BR 67	SB ->	102:	-1
	10:	PROC 0		103:	-1
	15:	LDLADDR -4		104:	-1
	20:	LOADW		105:	-5
	21:	LDCINT 0		106:	0
	26:	CMP		107:	0
	27:	BL 27		108:	0
	32:	LDLADDR -8		109:	102
	37:	LDLADDR -4		110:	-1
	42:	LOADW		111:	-1
	43:	STOREW		112:	-1
	44:	RET 4		113:	-5
	49:	BR 23	BP ->	114:	0
	54:	LDLADDR -8		115:	0
	59:	LDLADDR -4		116:	0
	64:	LOADW		117:	102
PC ->	65:	NEG		118:	0
	66:	STOREW		119:	0
	67:	RET 4		120:	0
	72:	LDGADDR 0		121:	99
	77:	LDCINT -5		122:	0
	82:	STOREW		123:	0
	83:	ALLOC 4		124:	0
	88:	LDGADDR 0		125:	106
	93:	LOADW		126:	-1
	94:	CALL -84		127:	-1
	99:	PUTINT		128:	-1
	100:	PUTEOL	SP ->	129:	-5

	0:	PROGRAM 4		101:	HALT
	5:	BR 67	SB ->	102:	-1
	10:	PROC 0		103:	-1
	15:	LDLADDR -4		104:	-1
	20:	LOADW		105:	-5
	21:	LDCINT 0		106:	0
	26:	CMP		107:	0
	27:	BL 27		108:	0
	32:	LDLADDR -8		109:	102
	37:	LDLADDR -4		110:	-1
	42:	LOADW		111:	-1
	43:	STOREW		112:	-1
	44:	RET 4		113:	-5
	49:	BR 23	BP ->	114:	0
	54:	LDLADDR -8		115:	0
	59:	LDLADDR -4		116:	0
	64:	LOADW		117:	102
	65:	NEG		118:	0
PC ->	66:	STOREW		119:	0
	67:	RET 4		120:	0
	72:	LDGADDR 0		121:	99
	77:	LDCINT -5		122:	0
	82:	STOREW		123:	0
	83:	ALLOC 4		124:	0
	88:	LDGADDR 0		125:	106
	93:	LOADW		126:	0
	94:	CALL -84		127:	0
	99:	PUTINT		128:	0
	100:	PUTEOL	SP ->	129:	5

```
0: PROGRAM 4
                                                 93: LOADW
       5: BR 67
                                                 94: CALL -84
      10: PROC 0
                                                 99: PUTINT
      15: LDLADDR -4
                                                100: PUTEOL
      20: LOADW
                                                101: HALT
                                          SB -> 102: -1
      21: LDCINT 0
      26: CMP
                                                103: -1
      27: BL 27
                                                104: -1
                                                105: -5
      32: LDLADDR -8
      37: LDLADDR -4
                                                106: 0
      42: LOADW
                                                107: 0
      43: STOREW
                                                108: 0
      44: RET 4
                                                109: 5
      49: BR 23
                                                110: -1
      54: LDLADDR -8
                                                111: -1
      59: LDLADDR -4
                                                112: -1
      64: LOADW
                                                113: -5
      65: NEG
                                          BP -> 114: 0
                                                115: 0
      66: STOREW
PC -> 67: RET 4
                                                116: 0
      72: LDGADDR 0
                                                117: 102
      77: LDCINT -5
                                                118: 0
      82: STOREW
                                                119: 0
      83: ALLOC 4
                                                120: 0
      88: LDGADDR 0
                                          SP -> 121: 99
                                                 67: RET 4
       0: PROGRAM 4
       5: BR 67
                                                 72: LDGADDR 0
                                                 77: LDCINT -5
      10: PROC 0
      15: LDLADDR -4
                                                 82: STOREW
      20: LOADW
                                                 83: ALLOC 4
                                                 88: LDGADDR 0
      21: LDCINT 0
      26: CMP
                                                 93: LOADW
      27: BL 27
                                                 94: CALL -84
                                          PC -> 99: PUTINT
      32: LDLADDR -8
      37: LDLADDR -4
                                                100: PUTEOL
      42: LOADW
                                                101: HALT
                                          SB -> 102: -1
      43: STOREW
                                                              <- BP
      44: RET 4
                                                103: -1
      49: BR 23
                                                104: -1
      54: LDLADDR -8
                                                105: -5
      59: LDLADDR -4
                                                106: 0
      64: LOADW
                                                107: 0
      65: NEG
                                                108: 0
      66: STOREW
                                          SP -> 109: 5
```

```
0: PROGRAM 4
                                          65: NEG
5: BR 67
                                          66: STOREW
                                          67: RET 4
10: PROC 0
15: LDLADDR -4
                                         72: LDGADDR 0
20: LOADW
                                         77: LDCINT -5
                                          82: STOREW
21: LDCINT 0
                                          83: ALLOC 4
26: CMP
                                          88: LDGADDR 0
27: BL 27
                                          93: LOADW
32: LDLADDR -8
37: LDLADDR -4
                                         94: CALL -84
                                         99: PUTINT
42: LOADW
43: STOREW
                                   PC -> 100: PUTEOL
44: RET 4
                                         101: HALT
                                   SB -> 102: -1 <- BP
49: BR 23
                                         103: -1
54: LDLADDR -8
59: LDLADDR -4
                                         104: -1
                                   SP -> 105: -5
64: LOADW
0: PROGRAM 4
                                          65: NEG
5: BR 67
                                          66: STOREW
10: PROC 0
                                          67: RET 4
                                          72: LDGADDR 0
15: LDLADDR -4
                                         77: LDCINT -5
20: LOADW
                                         82: STOREW
21: LDCINT 0
26: CMP
                                         83: ALLOC 4
                                         88: LDGADDR 0
27: BL 27
                                         93: LOADW
32: LDLADDR -8
37: LDLADDR -4
                                         94: CALL -84
42: LOADW
                                         99: PUTINT
43: STOREW
                                         100: PUTEOL
44: RET 4
                                   PC -> 101: HALT
                                   SB -> 102: -1
49: BR 23
                                                     <- BP
54: LDLADDR -8
                                        103: -1
59: LDLADDR -4
                                         104: -1
64: LOADW
                                   SP -> 105: -5
```