Remarks on flowcharts

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by

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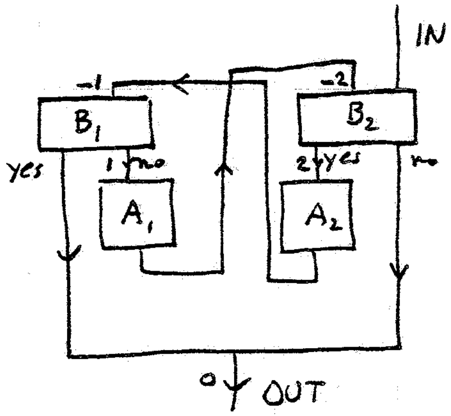
1. Every flowchart can be written as a do-loop.

A flowchart can be described as a set of program fragments $A_1, \ldots, A_m$ each one of which has just a single exit, and a set $B_1, \ldots, B_n$, each one of which has two exits (yes and no). An A_j is followed by goto $P(j)$, and B_j at the exit "yes" by goto $Q(j)$, at the exit "no" to goto $R(j)$. The labels $P(j)$, $Q(j)$, $R(j)$ belong to $\{-n, \ldots, m\}$. Here $+j$ is the label we have at the entrance of A_j $(1 \leq j \leq m)$ and $-i$ is the label of the entrance of B_i $(1 \leq i \leq n)$. The label 0 refers to the program exit; the entry label is a.

Example :



Here we have $P(1) = -2$, $P(2) = -1$, $Q(1) = 0$, $Q(2) = 2$, $R(1) = 1$, $R(2) = 0$.

Starting with the declaration of an integer i we write the program like this:

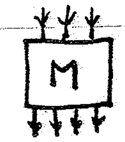
```
 i = -2;
do   i = 1  →   A1  ;   i := -2
   ▯ i = 2  →   A2  ;   i := -1
   ▯ i = -1 ∧  B1   →   i := 0
   ▯ i = -1 ∧ ¬B1   →   i := 1
   ▯ i = -2 ∧  B2   →   i := 2
   ▯ i = -2 ∧ ¬B2   →   i := 0
od
```

Sometimes one can describe the set of A_i's as a single program A[i] with parameter i, and the B_i's as B[i]. In general, the program now becomes

```
i: = a;
do   i > 0   →  A[i]; i := P[i]
     i > 0   ∧  B[-i]  →  i := Q[-i]
     i < 0   ∧¬B[-i]  →  i := R[-i]
od
```

2. A class of structured programs.

We shall now remove the distinction between A's and B's. We consider programs with entries $\{1,\dots,m\}$ and exits $\{1,\dots,n\}$.



If the index i indicates one of the entries, the assignment x: = exit (M,i) is intended to say that M has to be executed with entry i, and that after the execution the value of the exit (i.e. one of the numbers 1,...n) is assigned to x.

We have an index set B; for every $b \in B$ we have a program M(b) with P(b) as a set of entries and Q(b) as a set of exits. B is partitioned like this: $B = B_0 \cup B_1 \cup B_2 \cup \dots$.

If $b \in B_0$ we consider M(b) as a given black box. If $n > 0$ and $b \in B_n$ then M(b) will be defined by means of the M(c)'s with $c \in B_0 \cup \dots \cup B_{n-1}$.

If $b \in B_k$ with $k > 0$ than there is a "label set" L(b) with subsets P(b) and Q(b) ("entries" and "exits", respectively; P(b) and Q(b) are not necessarily disjoint).

If $b \in B_k$ with $k > 0$ and $j \in L(b)\backslash Q(b)$ than $\varphi(b,j)$ is given as an element of $B_0 \cup \dots \cup B_{k-1}$, and $\psi(b,j)$ as element of $P(\varphi(b,j))$.

If $b \in B_k$ with $k > 0$, and $i \in P(b)$, then the program

x := exit(M(b),i)

is defined as

```
x := i;
do  x ∈ L(b)\Q(b)  →  x := exit(M(φ(b,x)), ψ(b,x))
od
```

In order to get to programs with more than one exit one can assume that B_0 contains "question blocks", i.e. programs with a single entry 1 and two exits ("yes" and "no"). If $b \in B_0$ then x := exit(M,1) will not modify the state space but just indicate one of the two exits. We might even go so far that we get rid of the state space entirely, e.g. by taking the state space as a part of L(b), like taking it as a cartesian factor of L(b). Then we can consider the M's as procedures, and selecting the actual values of the procedure parameter can be interpreted as selecting the entrance.

It seems, however, that the pursuit of this kind of abstractions conflicts with the tendencies in program languages; it may lead back to something like machine code.

One can get non-deterministic programs by starting from primitive programs of a kind where the selection of exit(M,i) is left to the "free will" of a computer.

Remark: Most of the contents in this note can be found in some form in "On Folk Theorems" by David Harel, Communications ACM. Vol. 20 (7) 379-389.