Université de la Réunion – Faculté des Sciences et Technologies Avril 2014

**Master M1 informatique**

# Vérification – contrôle continu

**Durée : 85 minutes – sans document ni moyen électronique**

*Répondre dans les cadres prévus à cet effet en gérant l'espace*

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| Nom : | Signature : |
| Prénom(s) : | |

**Exercice 1** (4 •) Quels étaient les deux thèmes de recherche abordés lors de la présentation du LIM à la FST ?

Quels étaient les deux principaux concepts développés par Gilles Dowek lors de son exposé au LIM ?

## Liveness Analysis

- A variable is *live* at a program point if its current value may be read in the remaining execution
- This is clearly undecidable, but the property can be conservatively approximated
- The answer "*dead*" must be the true one
  - dead variables may be ignored

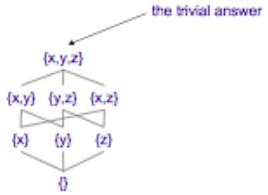



## A Lattice for Liveness

- A subset lattice of program variables

```
var x,y,z;
x = input;
while (x>1) {
  y = x/2;
  if (y>3) x = x-y;
  z = x-4;
  if (z>0) x = x/2;
  z = z-1;
}
output x;
```

$L = (2^{\{x,y,z\}}, \subseteq)$

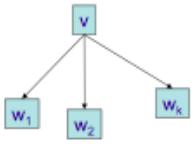





## Setting Up

- For every CFG node, v, we have a variable [[v]]:
  - the subset of program variables that are live at the program point *before* v
- Since the analysis is conservative, the computed sets may be *too large*
- Auxiliary definition:

$$JOIN(v) = \bigcup_{w \in succ(v)} [[w]]$$






## Liveness Constraints

- For the exit node:
  $[[exit]] = \{\}$
- For conditions and `output`:
  $[[v]] = JOIN(v) \cup vars(E)$
- For assignments:
  $[[v]] = JOIN(v) \setminus \{id\} \cup vars(E)$
- For variable declarations:
  $[[v]] = JOIN(v) \setminus \{id_1, ..., id_n\}$
- For all other nodes:
  $[[v]] = JOIN(v)$

$vars(E)$ = variables occurring in $E$

right-hand sides are monotone since *JOIN* is monotone



## Classifying Analyses

| | forwards | backwards |
|---|---|---|
| may | reaching definitions<br>[[v]] describes state *after* v<br>$JOIN(v) = \bigsqcup_{w \in pred(v)} [[w]] = \bigcup_{w \in pred(v)} [[w]]$ | liveness<br>[[v]] describes state *before* v<br>$JOIN(v) = \bigsqcup_{w \in succ(v)} [[w]] = \bigcup_{w \in succ(v)} [[w]]$ |
| must | available expressions<br>[[v]] describes state *after* v<br>$JOIN(v) = \bigsqcup_{w \in pred(v)} [[w]] = \bigcap_{w \in pred(v)} [[w]]$ | very busy expressions<br>[[v]] describes state *before* v<br>$JOIN(v) = \bigsqcup_{w \in succ(v)} [[w]] = \bigcap_{w \in succ(v)} [[w]]$ |



## Initialized Variables Analysis

- Compute for each program point those variables that have *definitely* been initialized in the *past*
- $\Rightarrow$ *forwards must analysis*
- Reverse subset lattice of all variables
- $JOIN(v) = \bigcap_{w \in pred(v)} [[w]]$
- $[[entry]] = \{\}$
- For assignments: $[[v]] = JOIN(v) \cup \{id\}$
- For all others: $[[v]] = JOIN(v)$

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**Exercice 2** (8 •) **Vivacité.** Pour le programme ci-dessous, déterminez le CFG, le système de contraintes de vivacité, calculez le plus petit point fixe et reportez les résultats sur le CFG.

```
var x,y,z;
x = 27; y = input; z =2*x+z;
if (0 > x) {y=z-3;} else {y=12;}
```

**Exercice 3** (8 •) **Variables initialisées.** Pour le programme ci-dessous, déterminez le CFG, le système de contraintes pour l'analyse des variables initialisées, calculez le plus petit point fixe et reportez les résultats sur le CFG. Que pouvez-vous déduire de cette analyse ?

```
var r,s,t,u,v;
r = 0;  s = 1;  t = input;
while (t > s*s) {  u = s;  s = s+1;  }
output u;
```