Motivation: Von Verifikation über Analyse zur Transformation – Optimierung am Beispiel "code motion"-basierter Transformationen (Teil 2)

Analyse und Verifikation (WS 2005/2006) / 6. Teil (28.11.2005)

Jens Knoop

Technische Universität Wien

TU WIEN
TECHNISCHE UNIVERSITÄT WIEN
VIENNA UNIVERSITY OF TECHNOLOGY

Optimality Results are quite sensitive!

Three examples to give evidence...

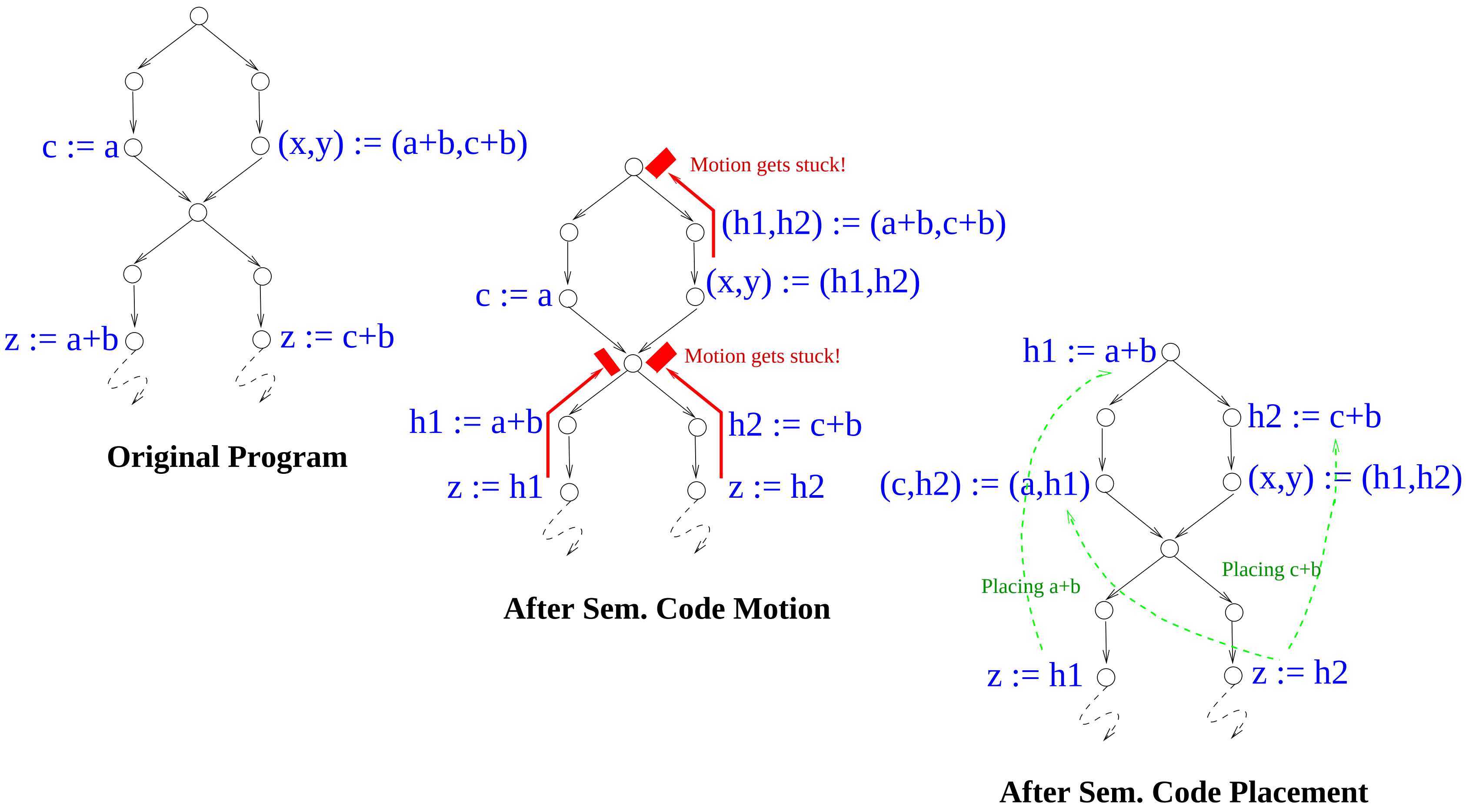
(I) Code motion vs. code placement

(II) Interdependencies of (elementary) transformations

(III) Paradigm dependencies

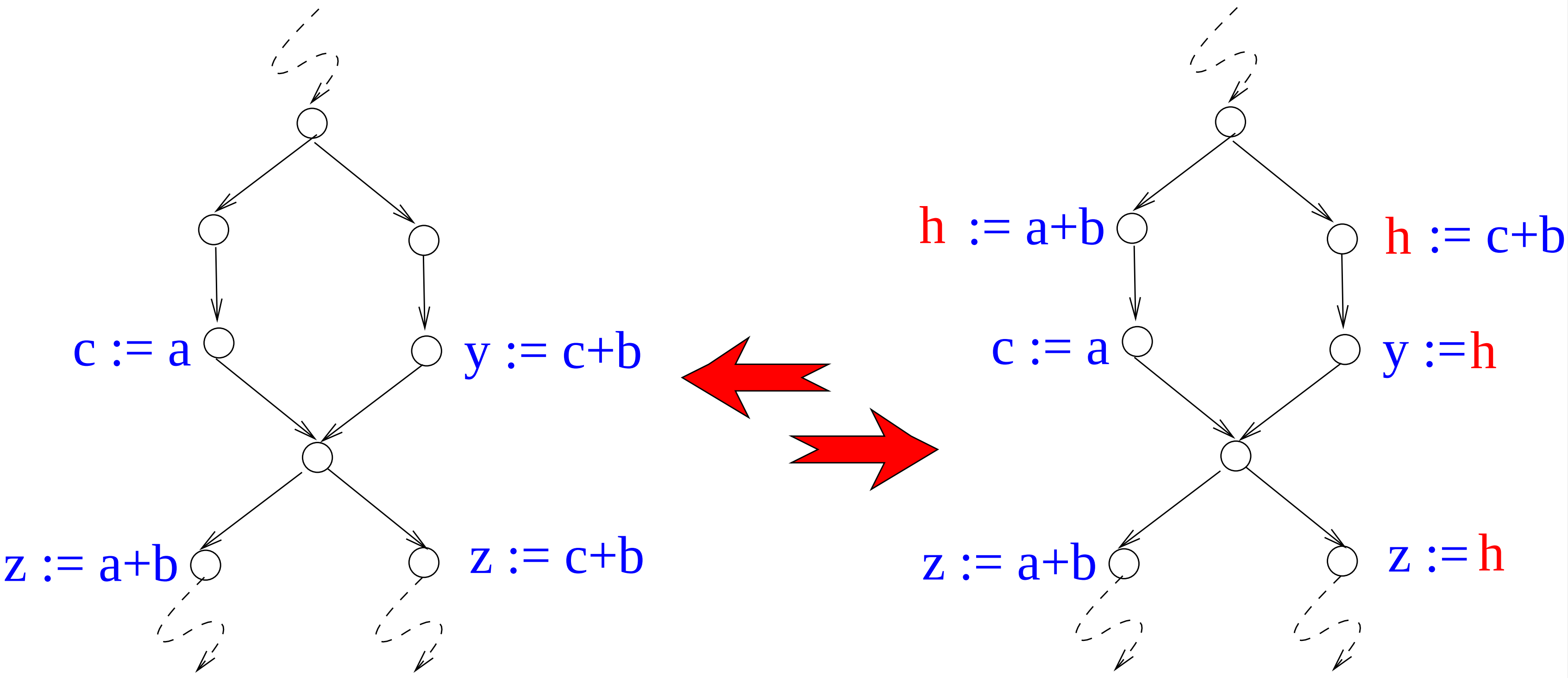
(I) Code Motion vs. Code Placement

...not just synonyms!



Even worse...

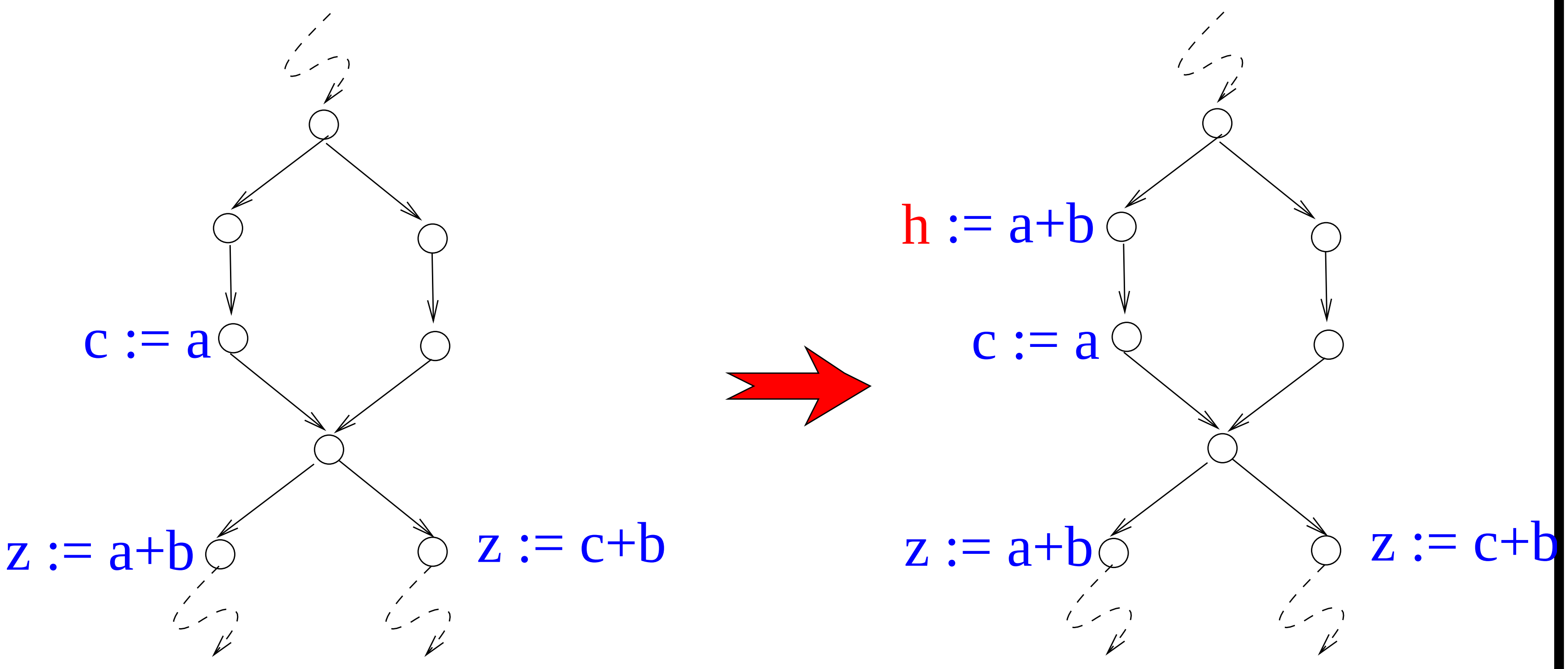
Optimality is lost!



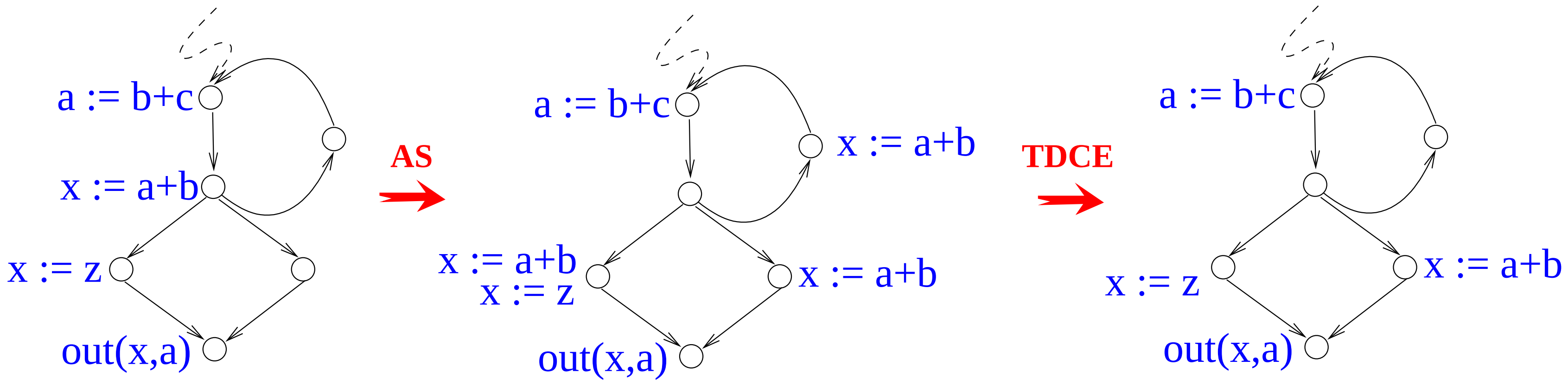
Incomparable!

Even more worse...

Performance may be lost, when naively applied!



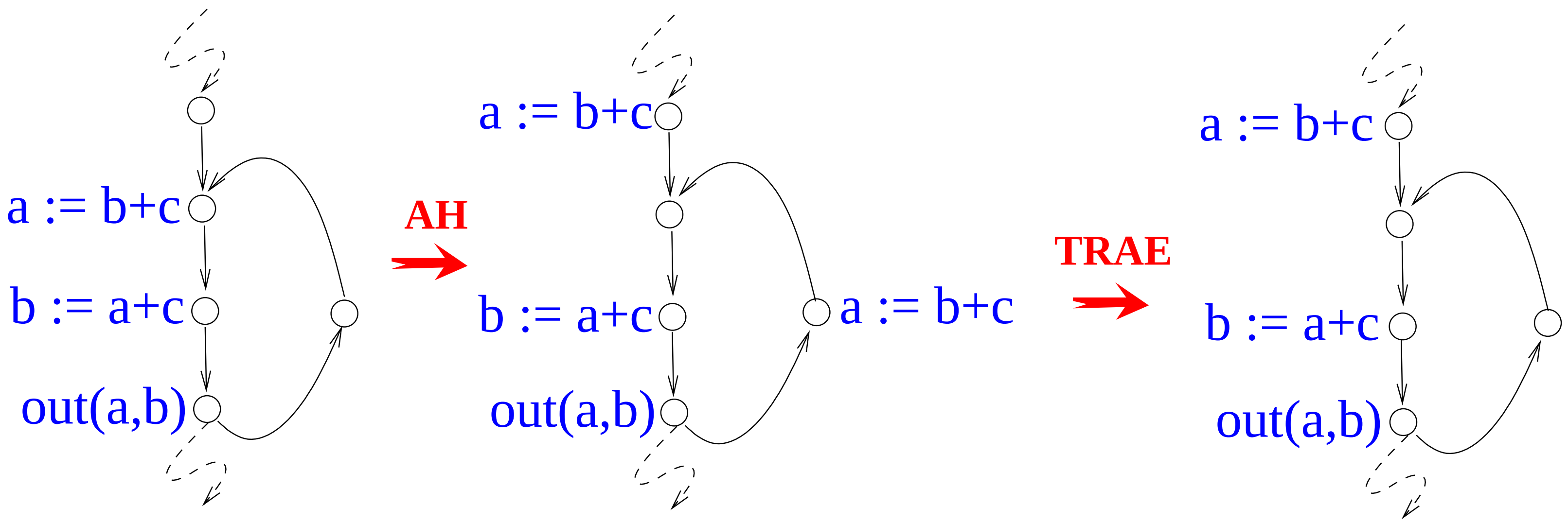
(II) Interdependencies of Transformations



...2nd Order Effects!

$\leadsto$ ...Partial Dead-Code Elimination (PDCE)

Interdependencies of Transformations



...2nd Order Effects!

$\leadsto$ ...Partially Redundant Assignment Elimination (PRAE)

Conceptually

...we can think of PREE, PRAE and PDCE in terms of

- PREE = AH ; TREE
- PRAE = $(\text{AH} + \text{TRAE})^*$
- PDCE = $(\text{AS} + \text{TDCE})^*$

PRAE/PDCE – Optimality Results

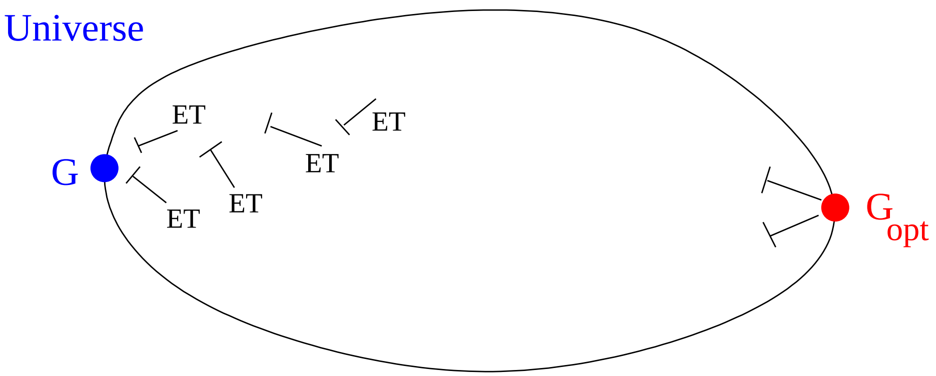
Derivation relation $\vdash$...

- PRAE... $G \vdash_{AH,TRAE} G'$ (ET=$\{$AH,TRAE$\}$)
- PDCE... $G \vdash_{AS,TDCE} G'$ (ET=$\{$AS,TDCE$\}$)

We can prove...

Optimality Theorem

For both PRAE and PDCE, $\vdash_{ET}$ is confluent and terminating



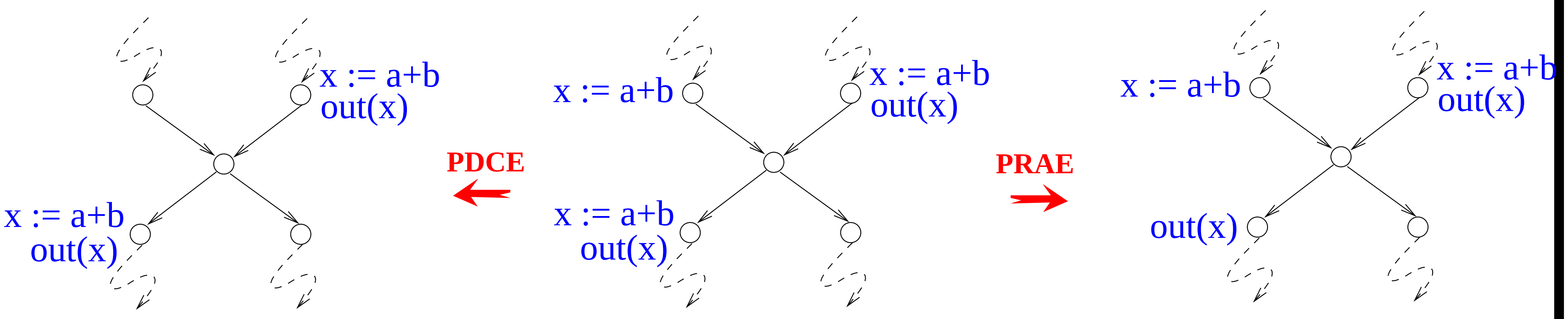
Consider now...

- Assignment Placement AP

$$AP = (AH + TRAE + AS + TDCE)^*$$

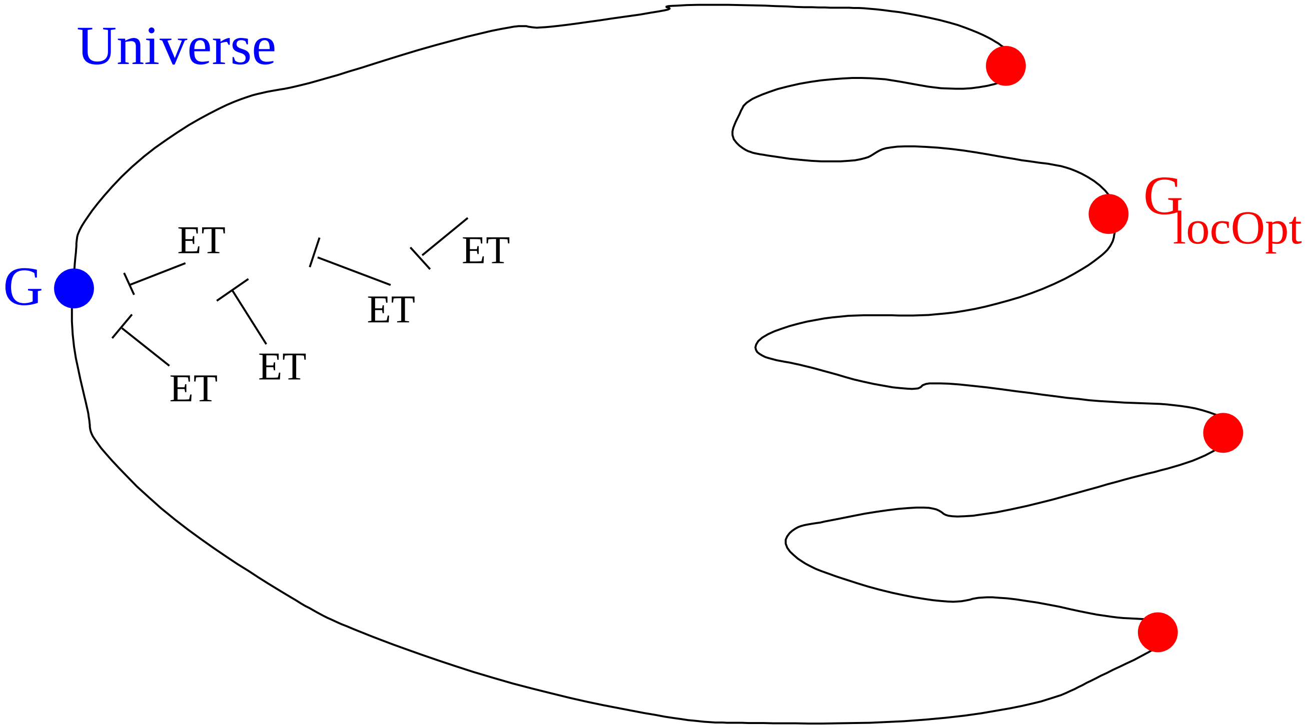
...should be even more powerful!

Indeed, but...



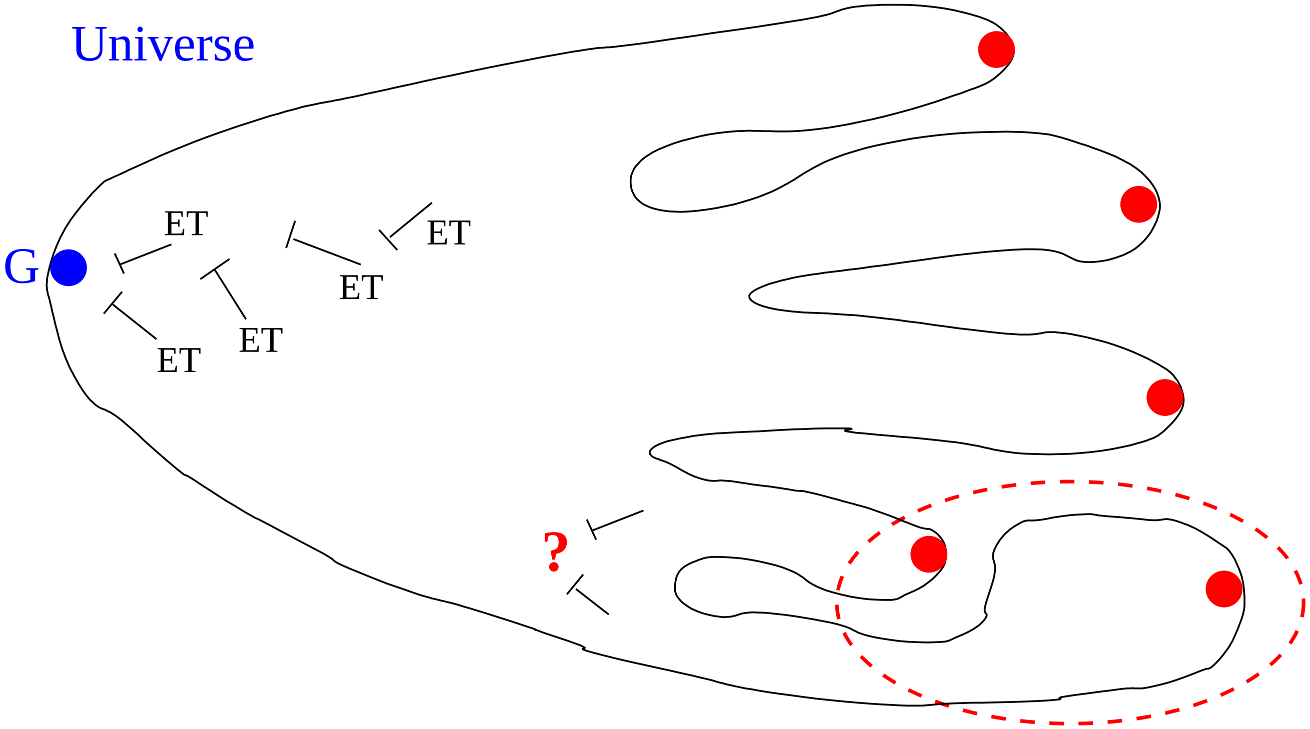
Confluence...

...and hence (global) optimality are lost!

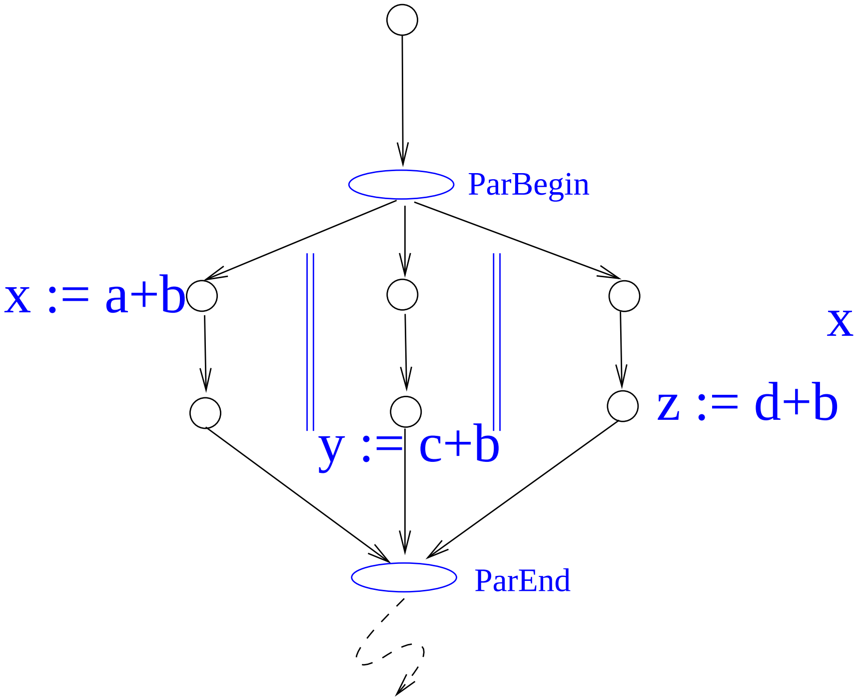


Even worse...

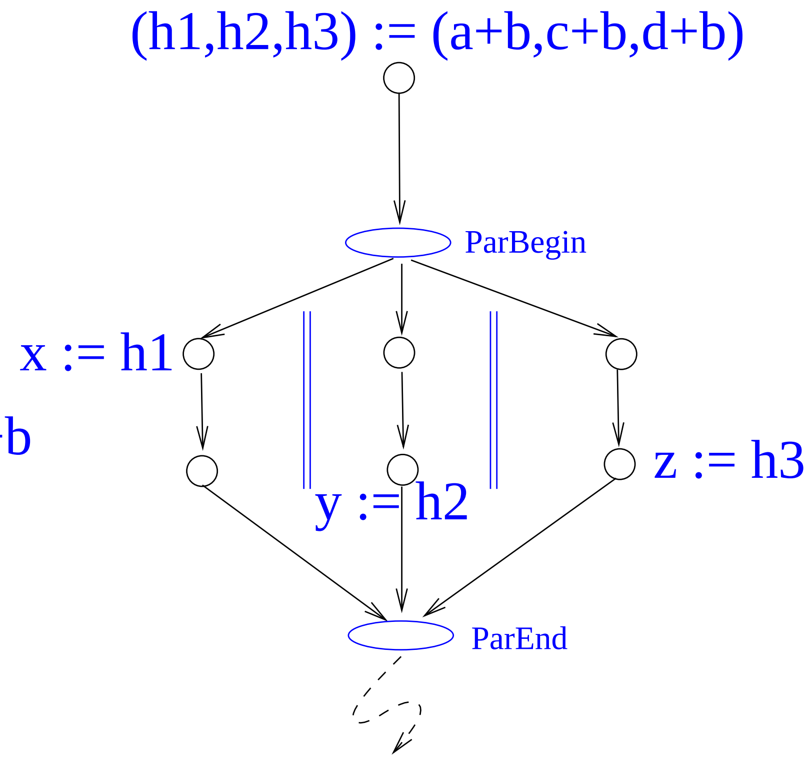
...there are scenarios, where we can end up with universes like



(III) Paradigm Dependencies



Original Program



After Earliestness Transformation

...a naive transfer of the transformation strategy results here in essentially a sequential program!

Back to PR(E)E

Recall: Code-size sensitive PRE at a glance...

Preprocess

- **Optional:** Perform LCM (3 GEN/KILL-DFAs)
- Compute Predicates of BCM for G resp. LCM (G) (2 GEN/KILL-DFAs)

Main Process

Reduction Phase

- Construct Bipartite Graph
- Compute Maximum Matching

Optimization Phase

- Compute Largest/Smallest Tight Set
- Determine Insertion Points

The Preprocess in more Detail

This means to consider the transformations of

- Busy Code Motion (BCM)
- Lazy Code Motion (LCM)

in more detail!

Fundamental are...

...the principles of

- Earliestness and
- Latestness

...for placing computations.

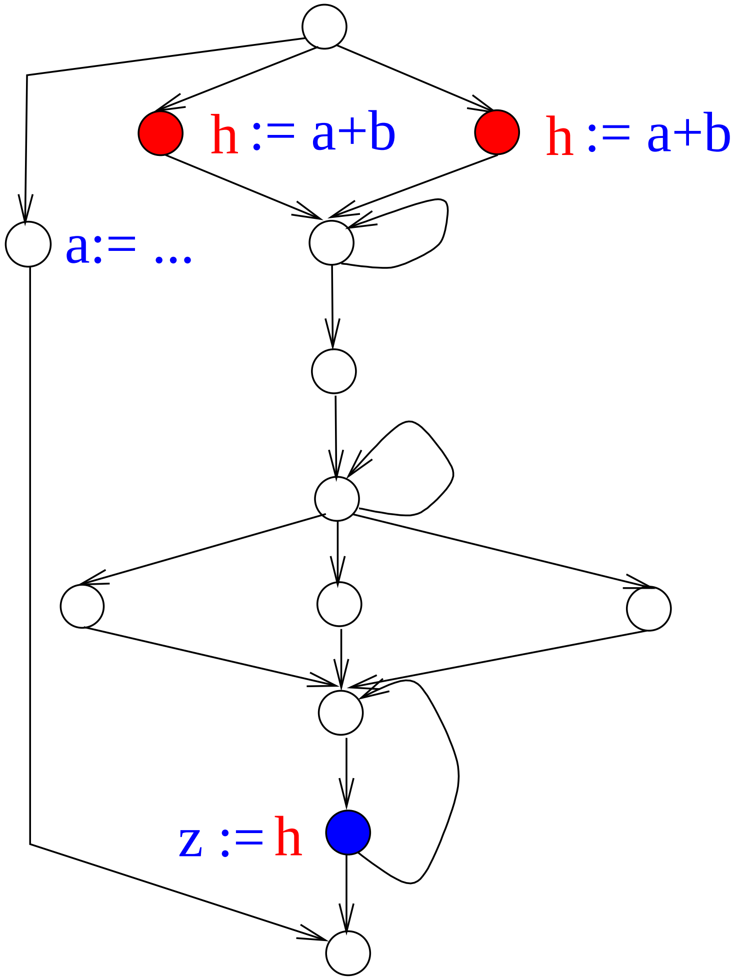
Busy Code Motion (PLDI'92)

- **Computationally optimal** results can be obtained by
  - ... placing computations **as early as possible,**
    while maintaining **admissibility**
    (i.e., semantics & performance)

$\boxed{\textbf{Earliestness Principle}}$

Earliestness Principle

...yields computationally optimal programs.



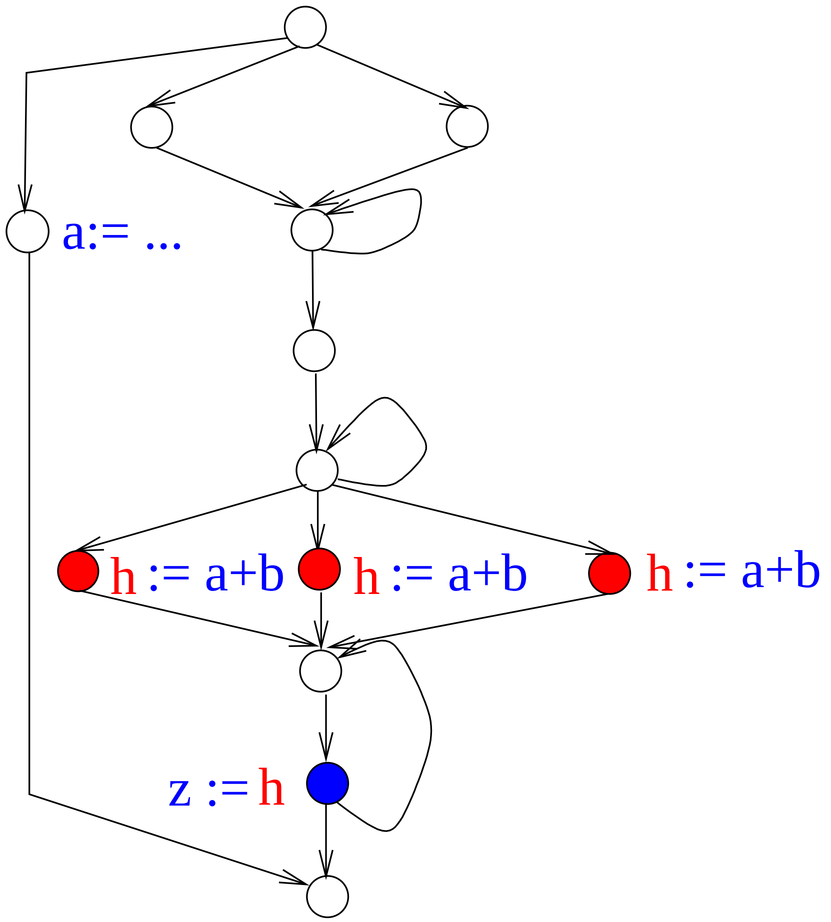
Lazy Code Motion (PLDI'92)

- **Computationally & lifetime optimal** results can be obtained by
  - ... placing computations **as late as possible,** while maintaining **computational optimality**

$$\boxed{\textbf{Latestness Principle}}$$

Latestness Principle

...yields computationally & lifetime optimal programs



BCM and LCM Algorithmically

- **BCM** relies on only two GEN/KILL-Analyses
  - UpSafety (also known as Availability)
  - DownSafety (also known as Very Busyness)

- **LCM** relies on the two analyses of **BCM** plus one additional GEN/KILL-Analysis
  - Delayability

How to automatically compute...

...properties such as

- UpSafety, DownSafety, and Delayability?

This will be (one of) the topics of the forthcoming lecture(s).