

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

Analyse und Verifikation (WS 2006/2007) / 8. Teil (12.12.2006)

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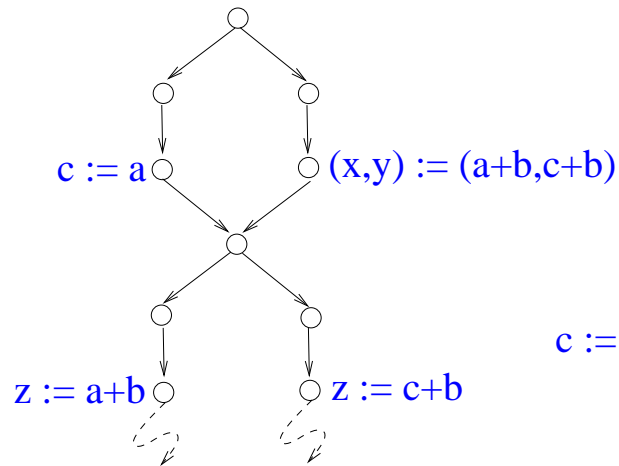
Optimality Results are quite sensitive!

Three examples to give evidence...

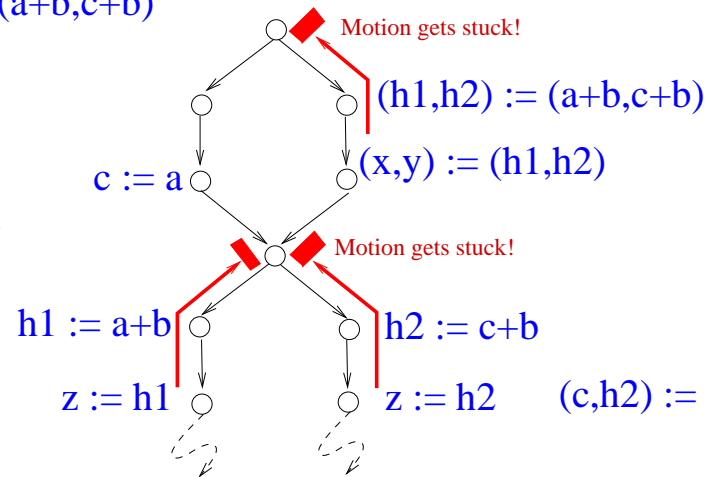
- (I) Code motion vs. code placement
- (II) Interdependencies of (elementary) transformations
- (III) Paradigm dependencies

(I) Code Motion vs. Code Placement

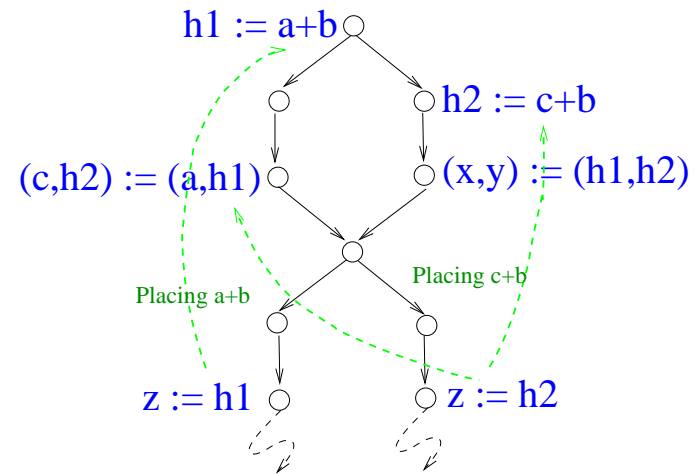
...not just synonyms!



Original Program



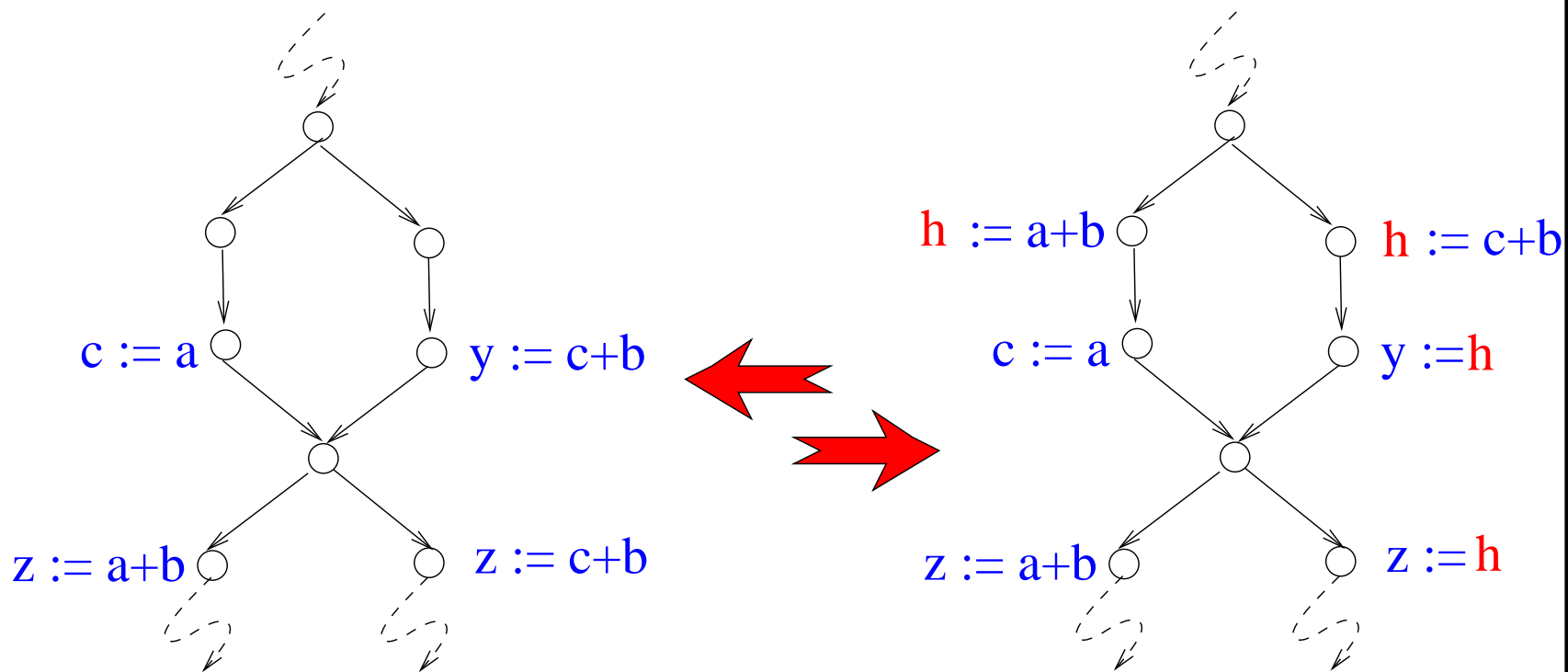
After Sem. Code Motion



After Sem. Code Placement

Even worse...

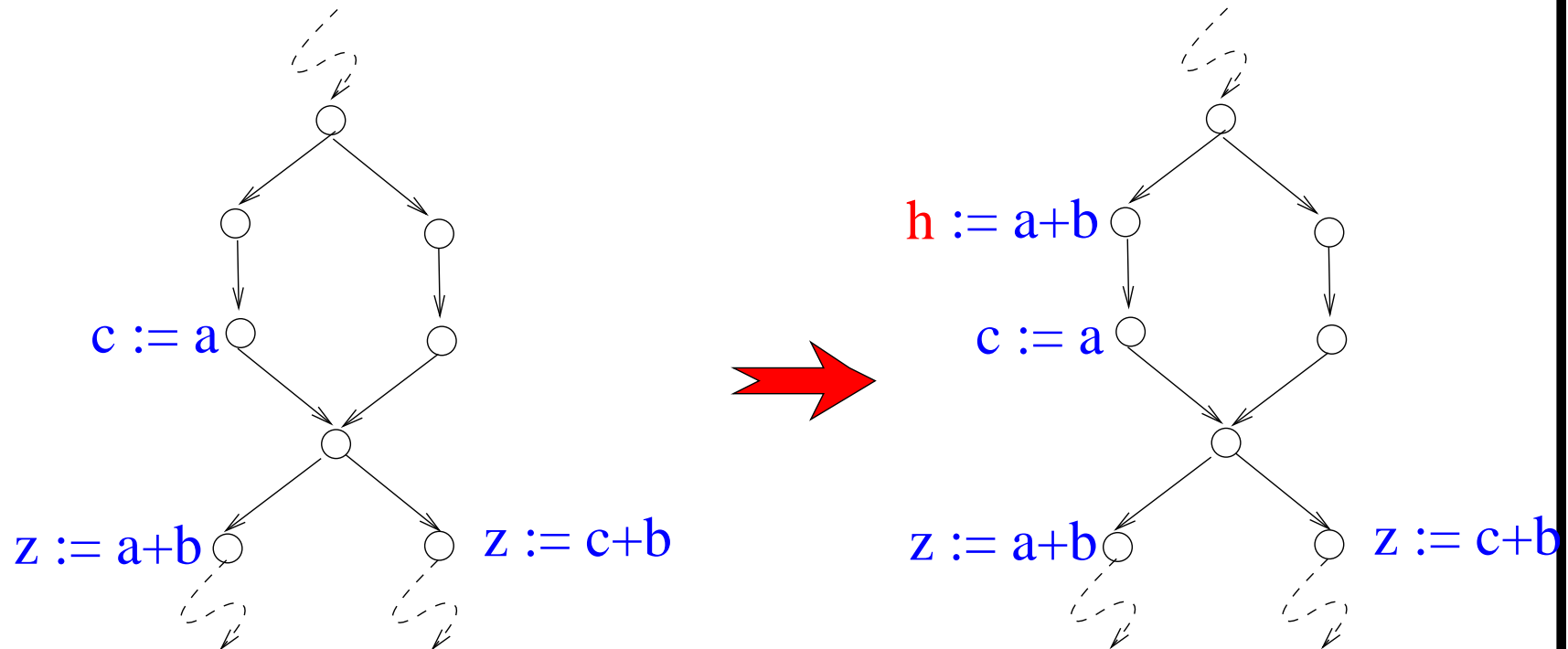
Optimality is lost!



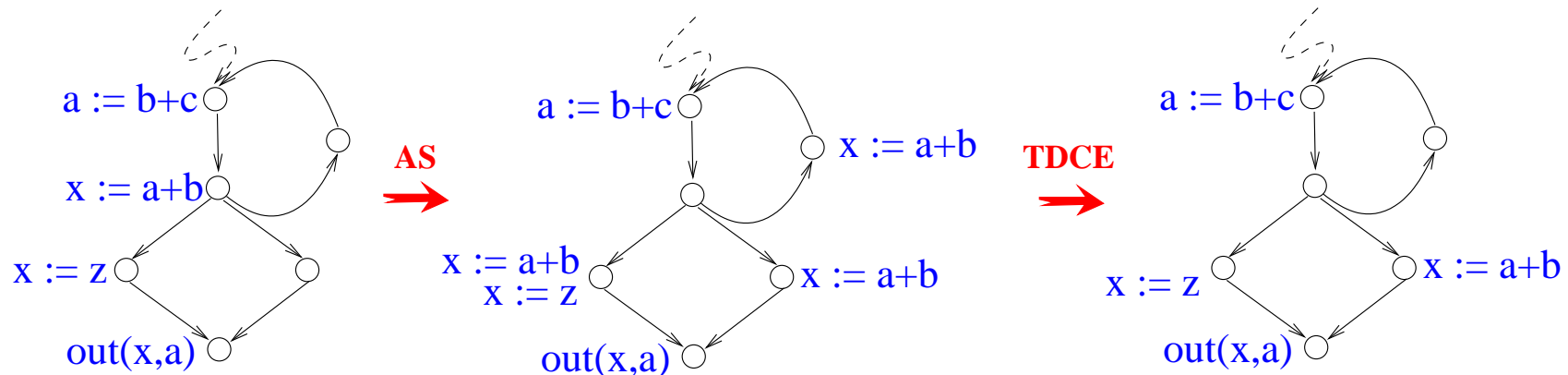
Incomparable!

Even more worse...

Performance may be lost, when naively applied!



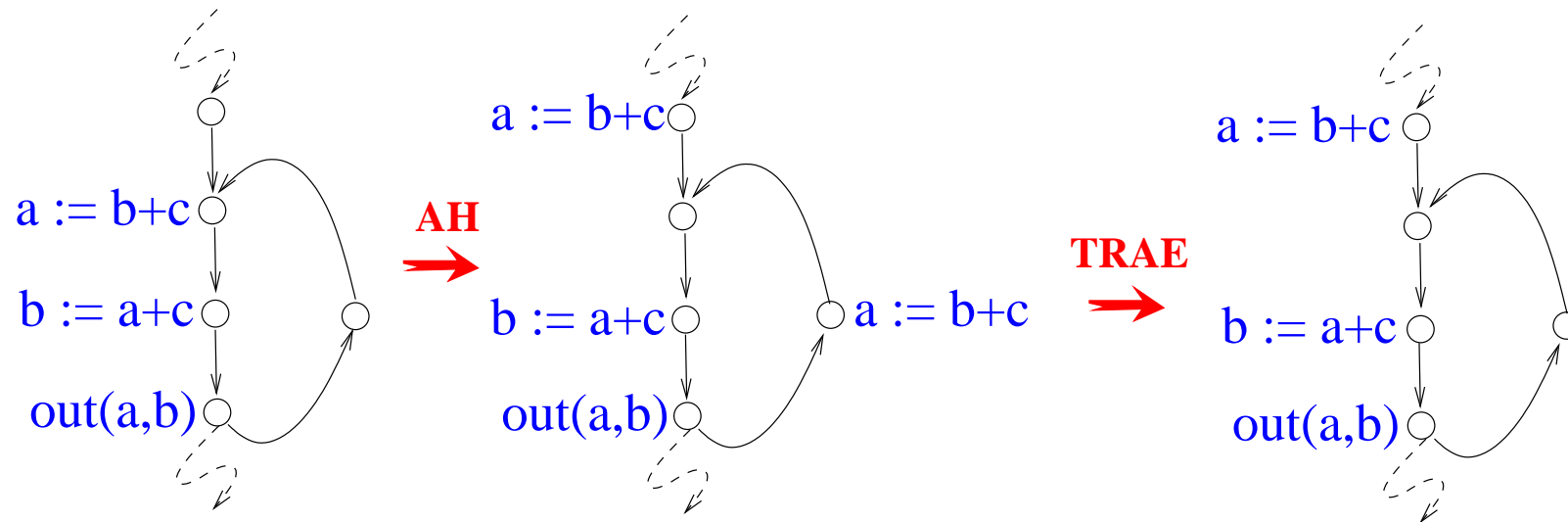
(II) Interdependencies of Transformations



...2nd Order Effects!

~> ...Partial Dead-Code Elimination (PDCE)

Interdependencies of Transformations



...2nd Order Effects!

~> ...Partially Redundant Assignment Elimination (PRAE)

Conceptually

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

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

PRAE/PDCE – Optimality Results

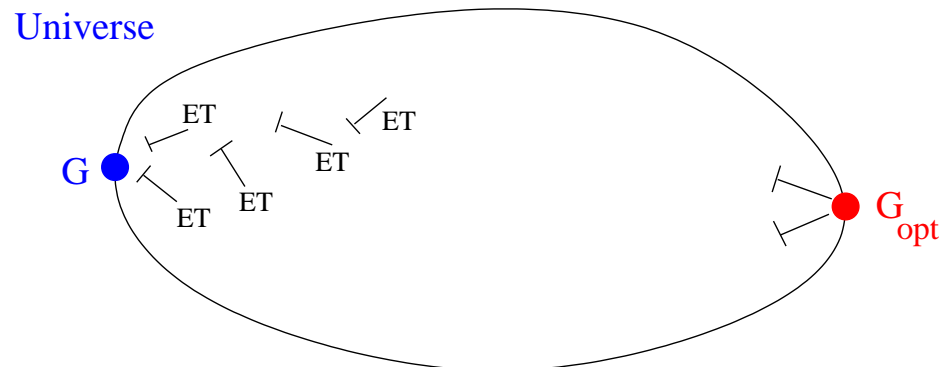
Derivation relation $\vdash \dots$

- 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



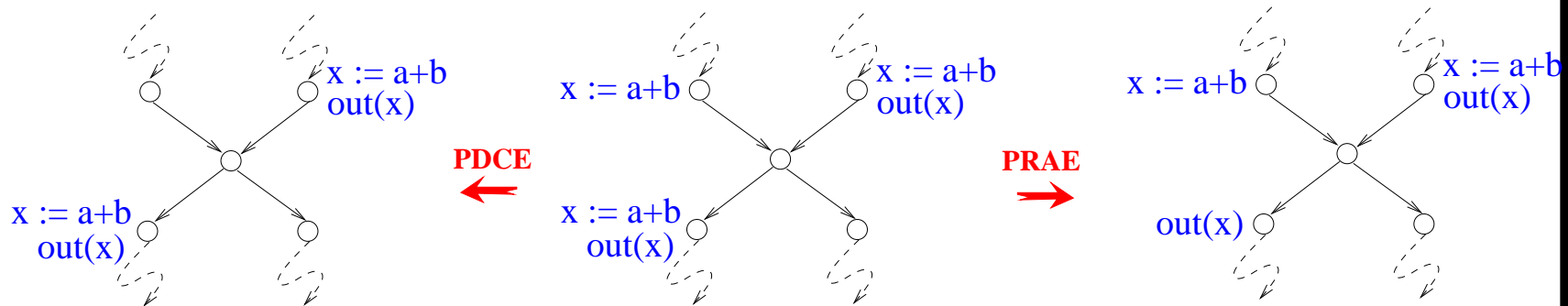
Consider now...

- Assignment Placement AP

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

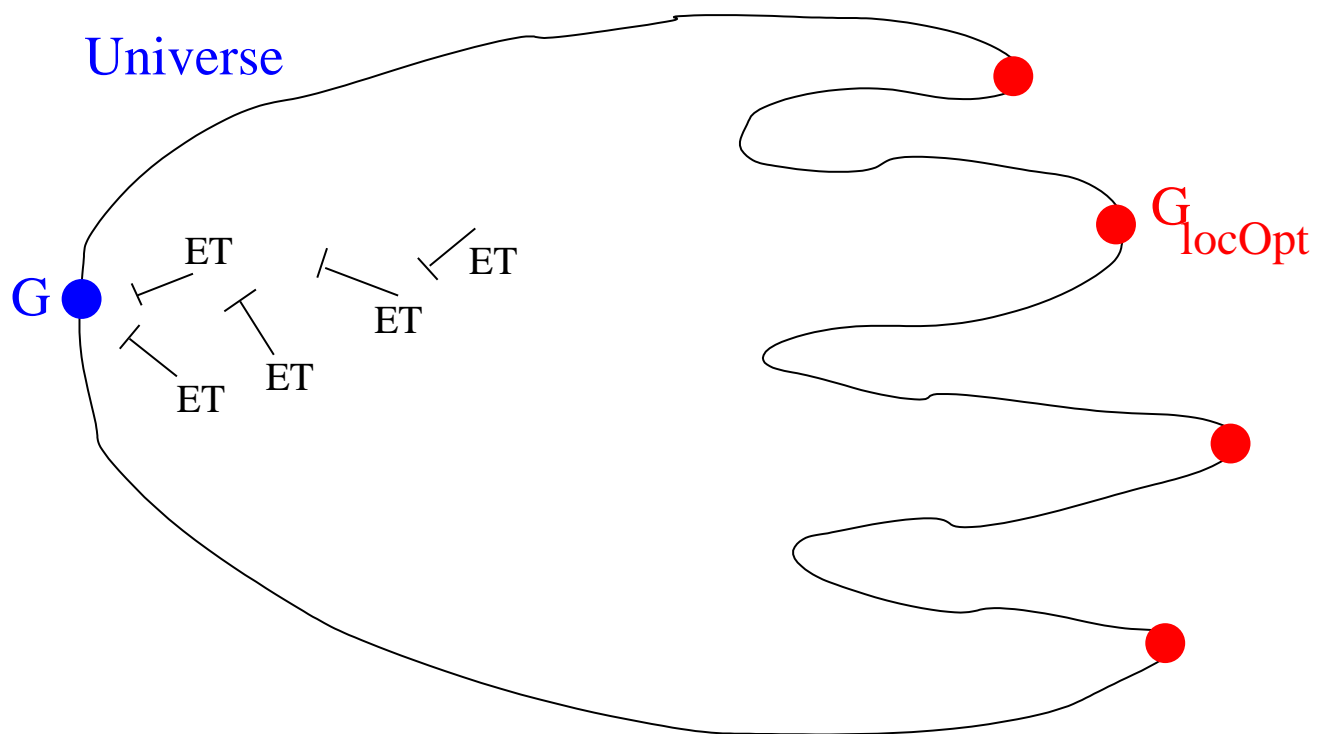
...should be even more powerful!

Indeed, but...



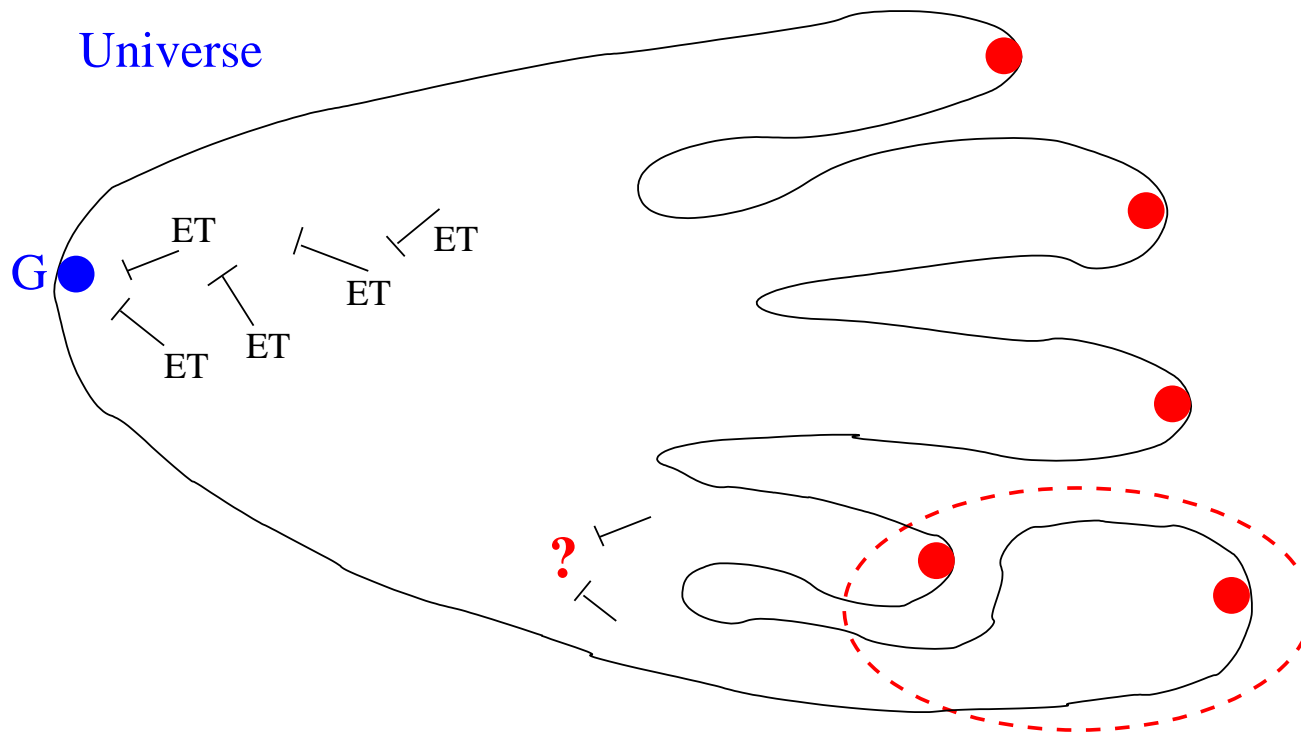
Confluence...

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

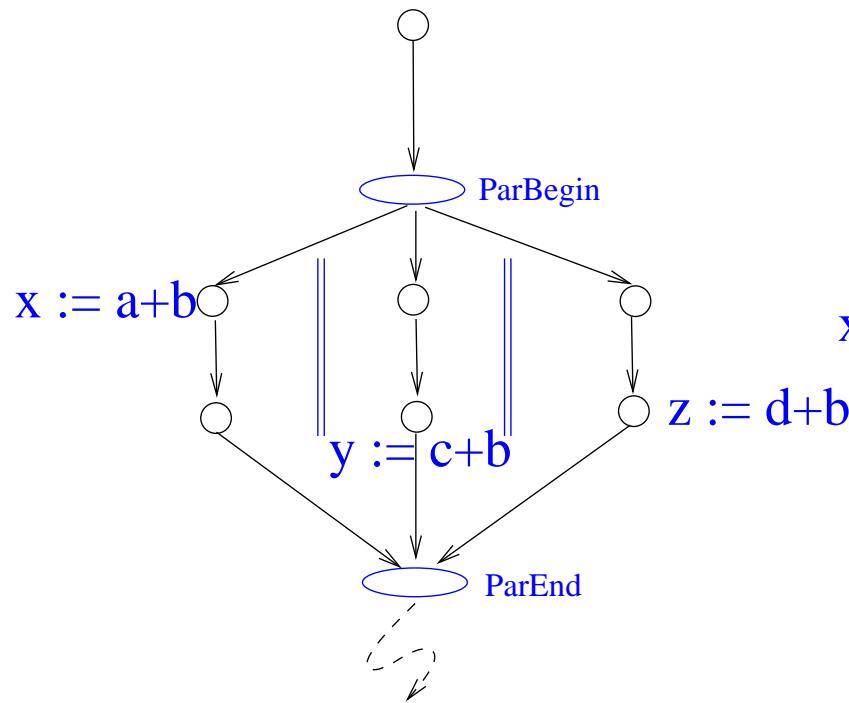


Even worse...

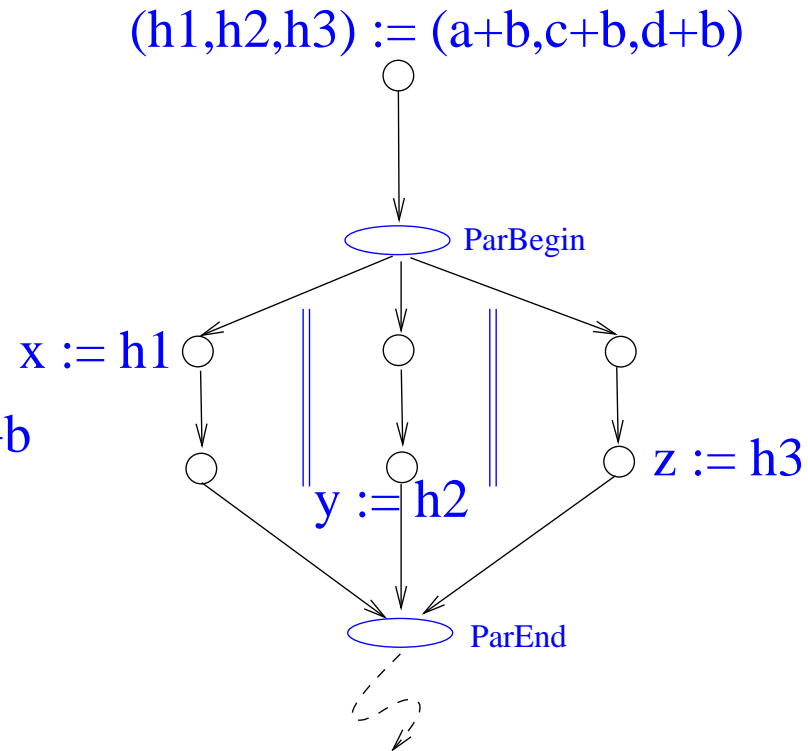
...there are scenarios, where we can end up with universes like



(III) Paradigm Dependencies



Original Program

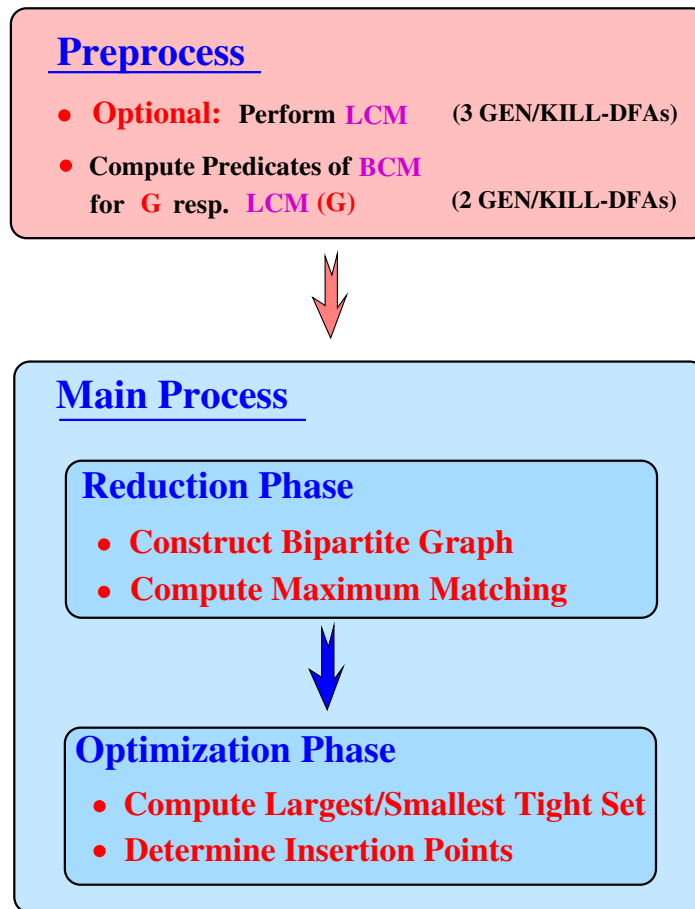


After Earliestness Transformation

...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...



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.

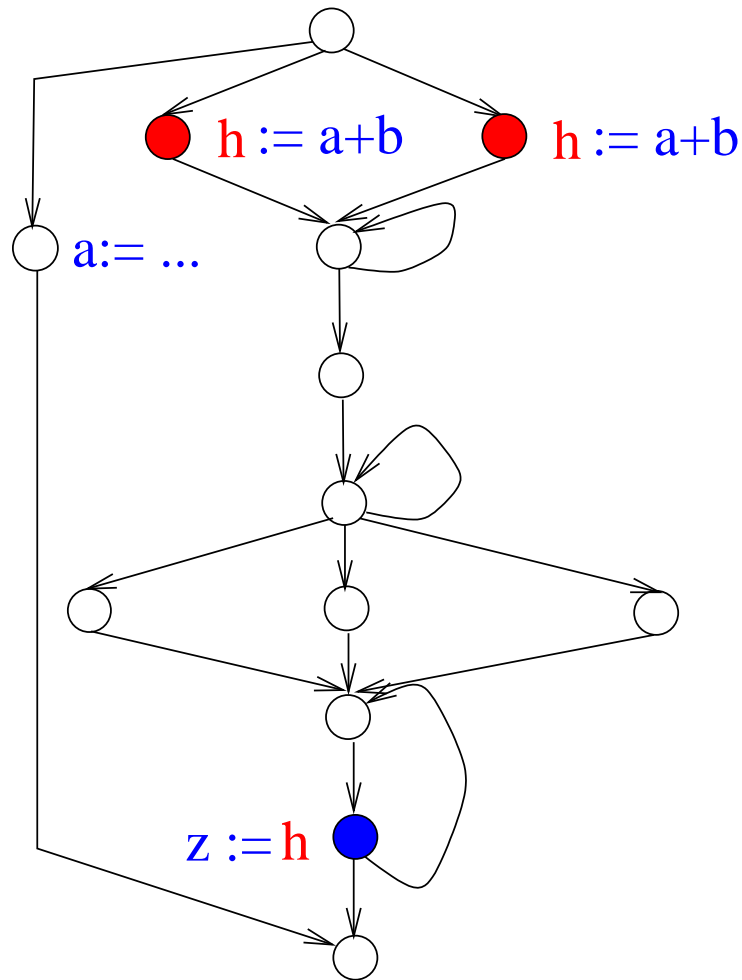
Busy Code Motion (PLDI'92)

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

Earliestness Principle

Earliestness Principle

...yields **computationally optimal** programs.



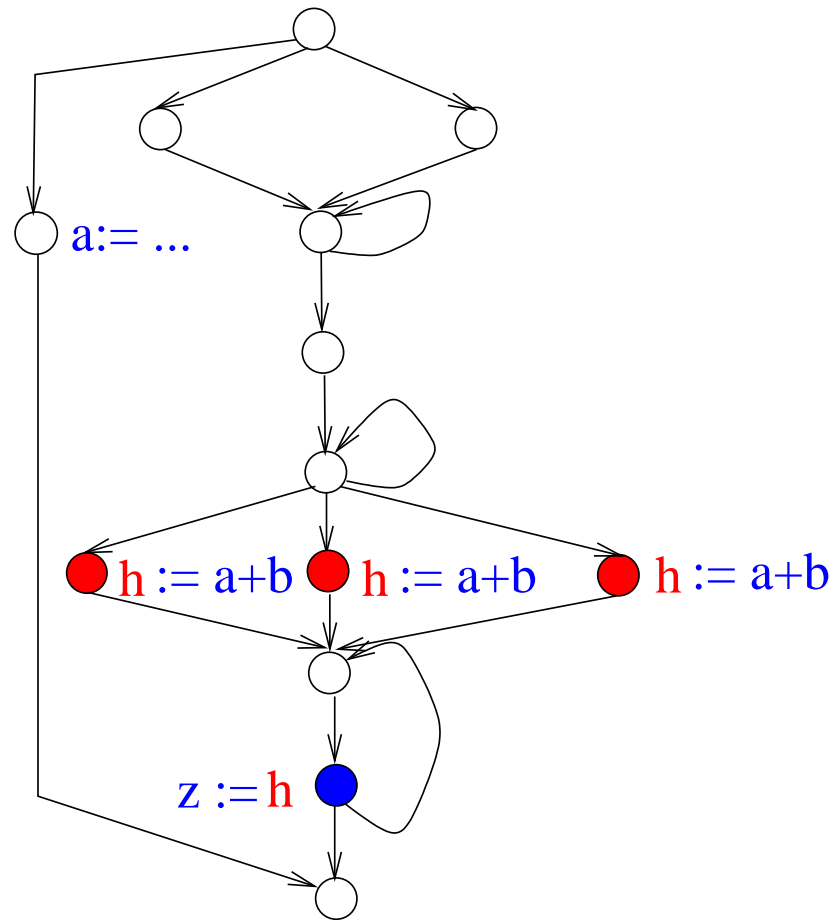
Lazy Code Motion (PLDI'92)

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

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).