Systemgewahre statische Laufzeitanalyse von Universalbetriebssystemen

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Betreuer:
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Wolfgang Schröder-Preikschat

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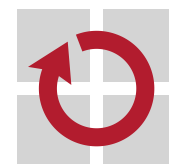
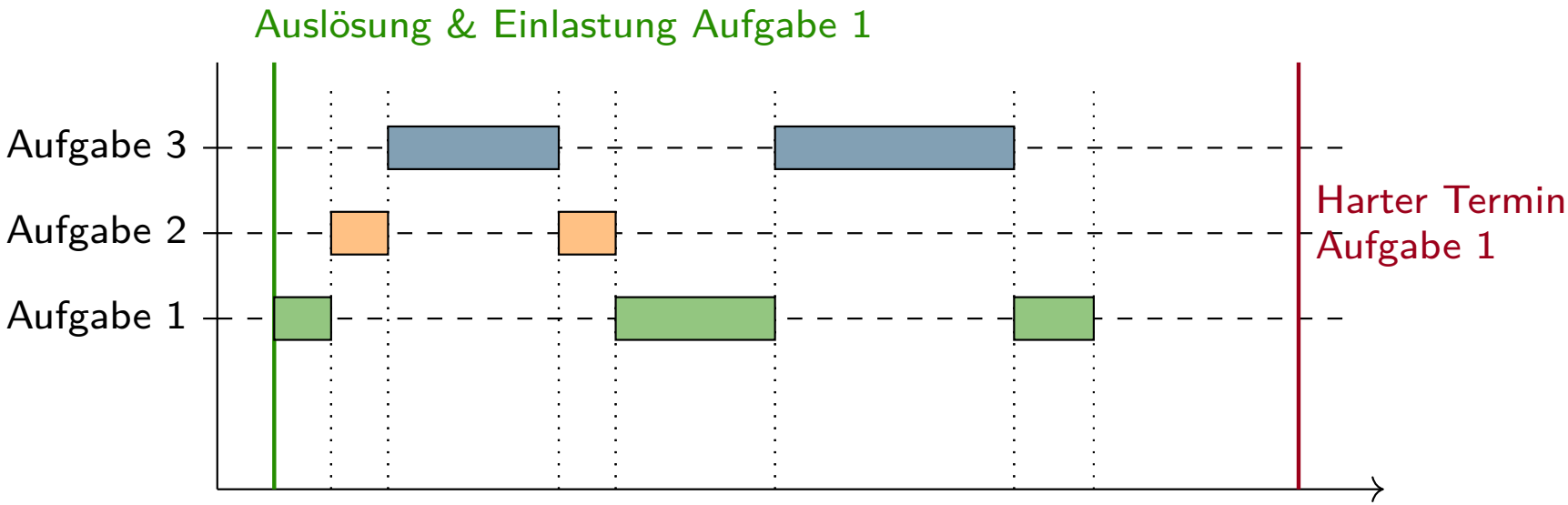
Lehrstuhl für Informatik 4
Verteilte Systeme und Betriebssysteme
Friedrich-Alexander-Universität
Erlangen-Nürnberg



Betriebssystemvorgänge und Termintreue



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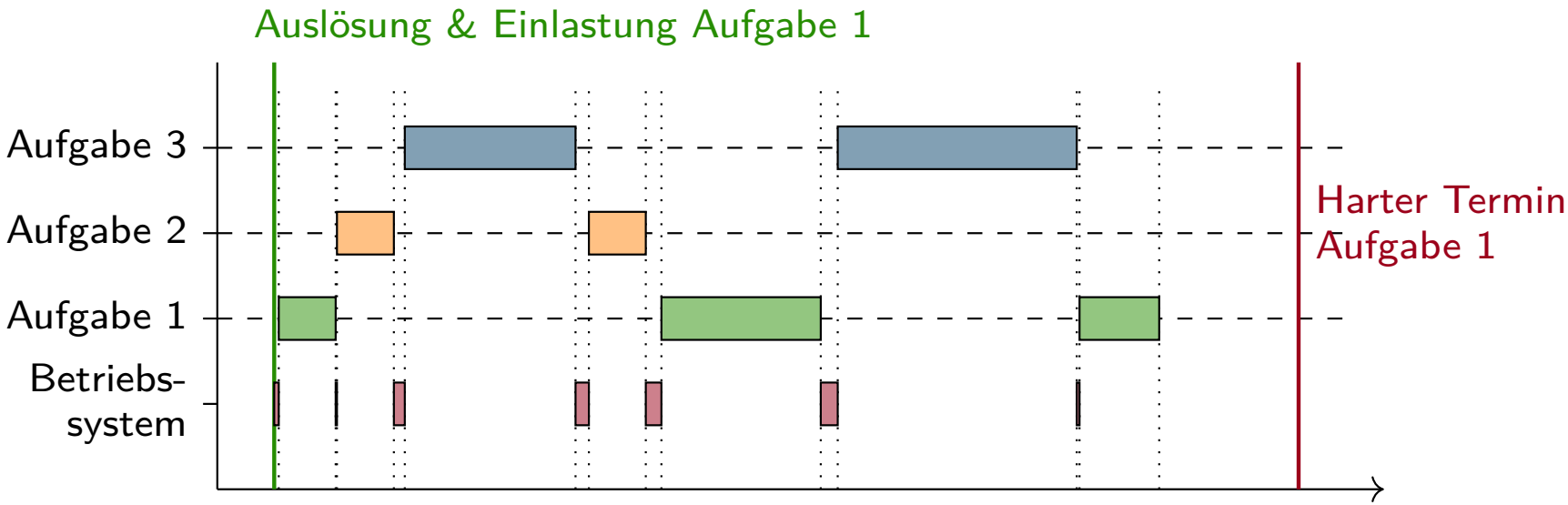

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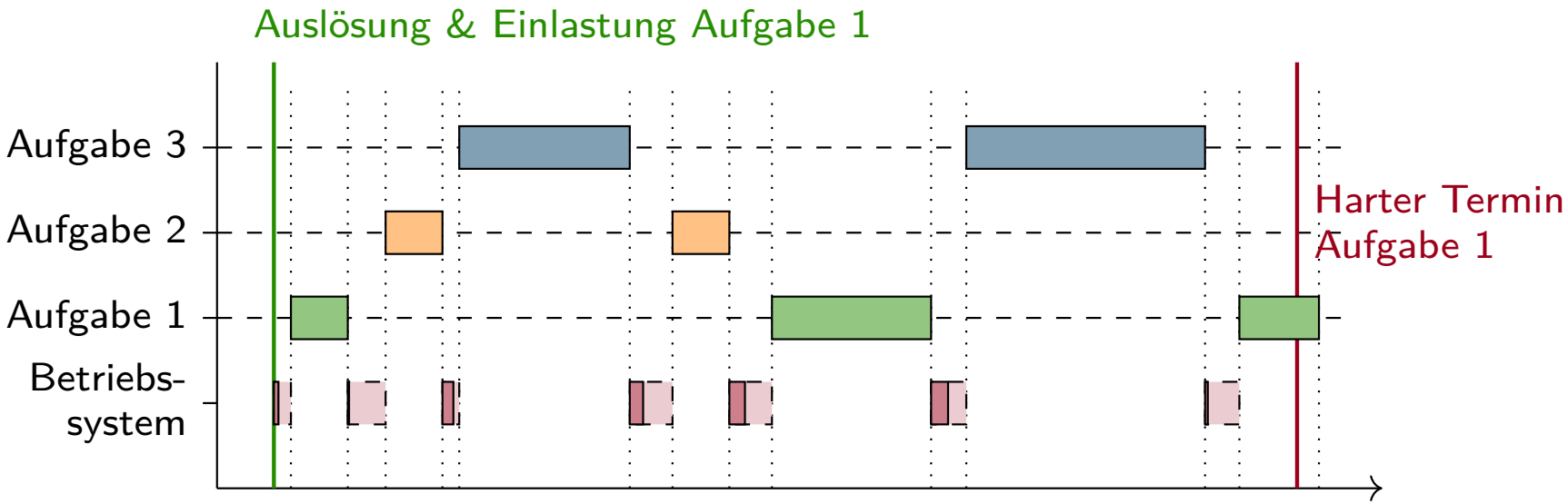

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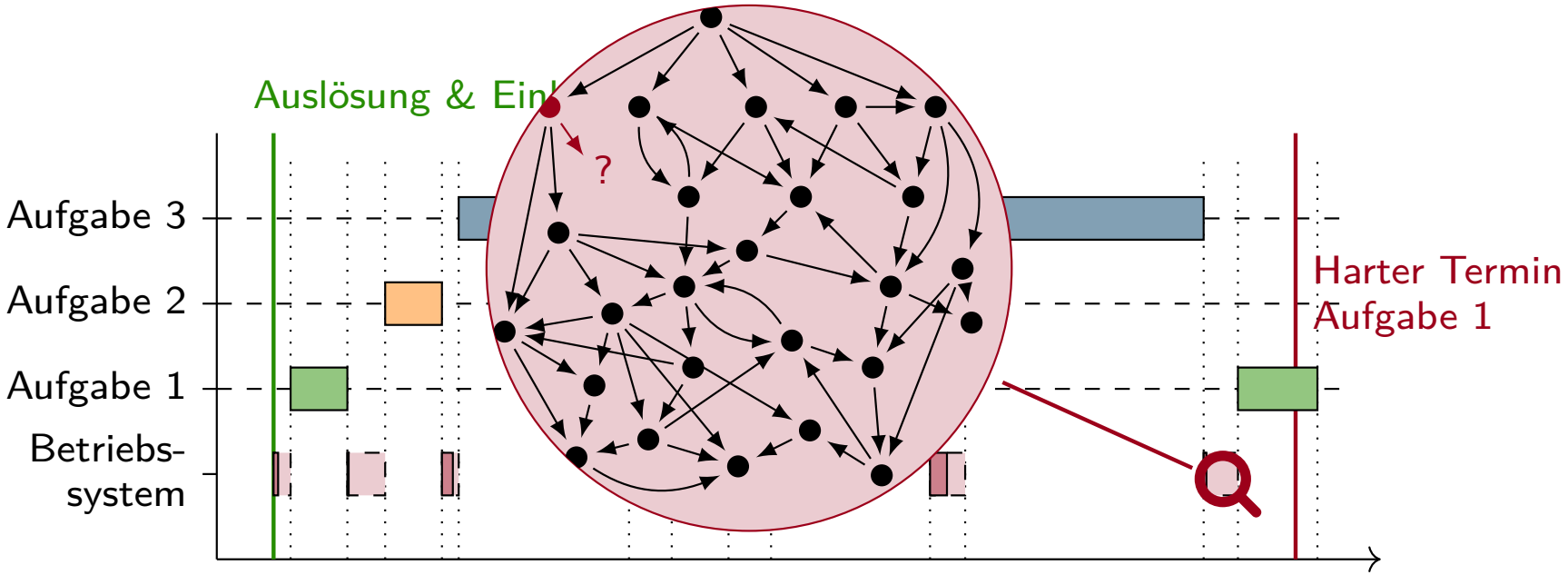
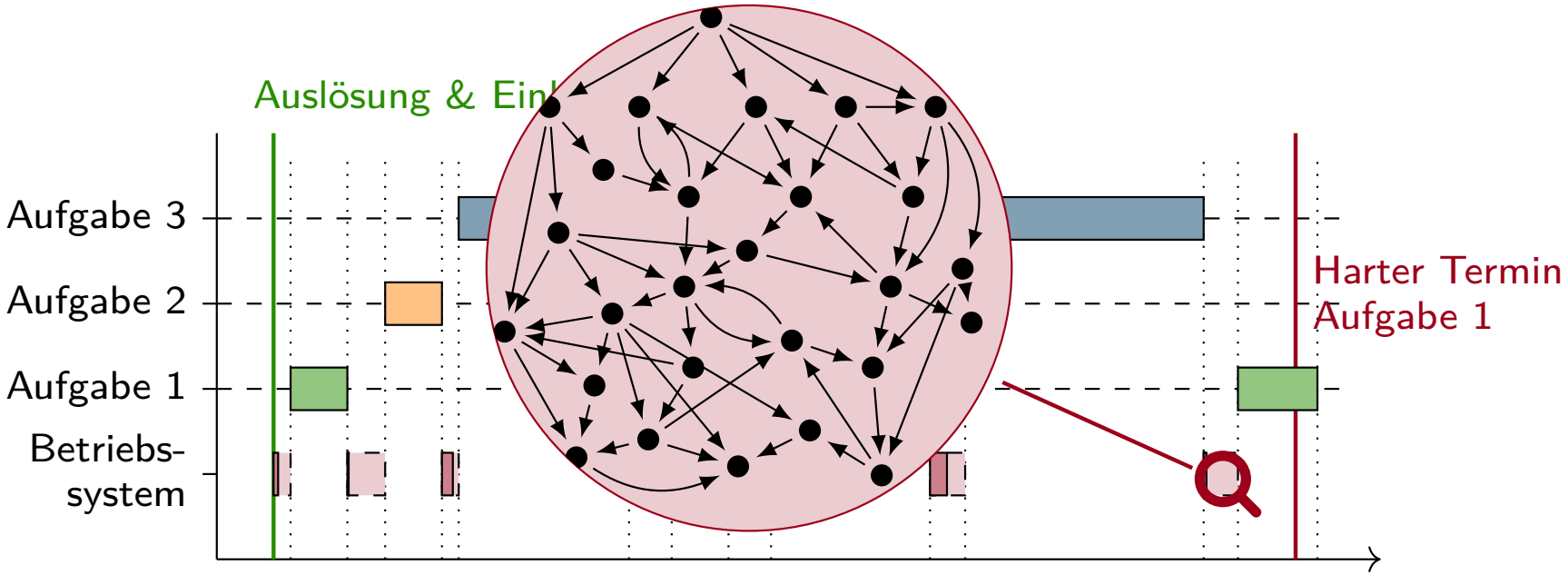


✗ **Fehlschlagende Kontrollflussrekonstruktion** durch Funktionszeiger

Betriebssystemvorgänge und Termintreue



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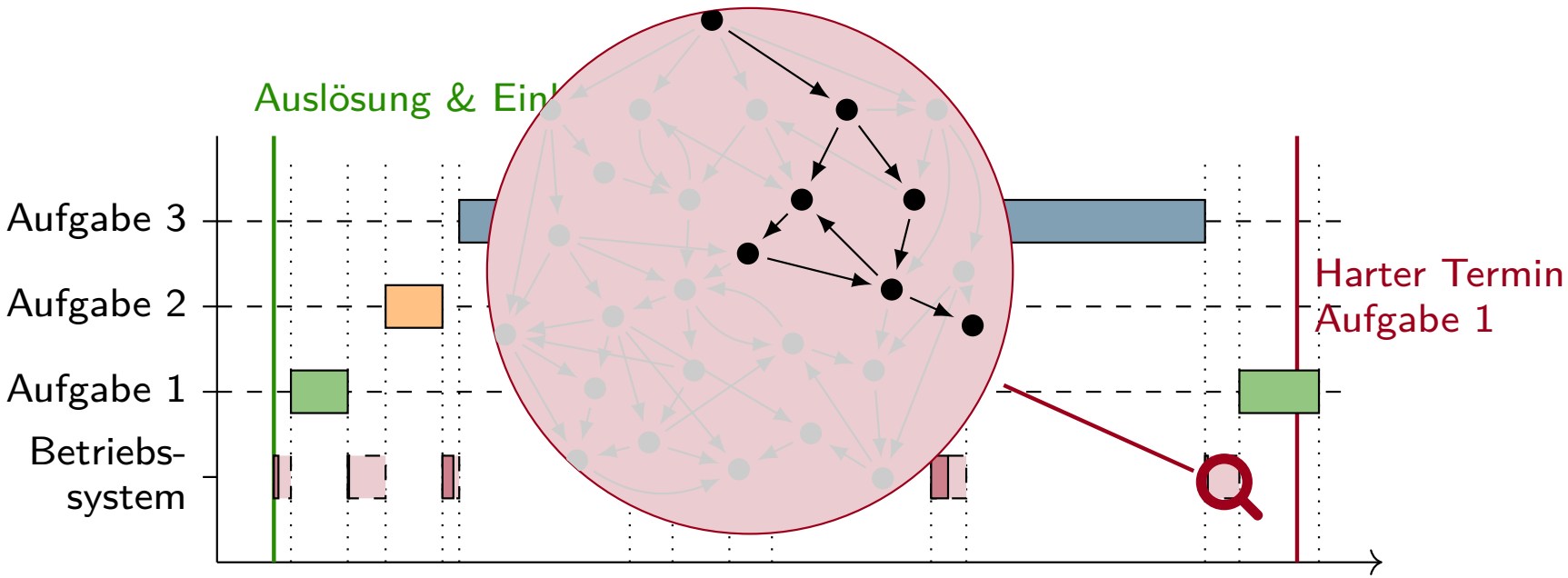

- ✗ **Fehlschlagende Kontrollflussrekonstruktion** durch Funktionszeiger
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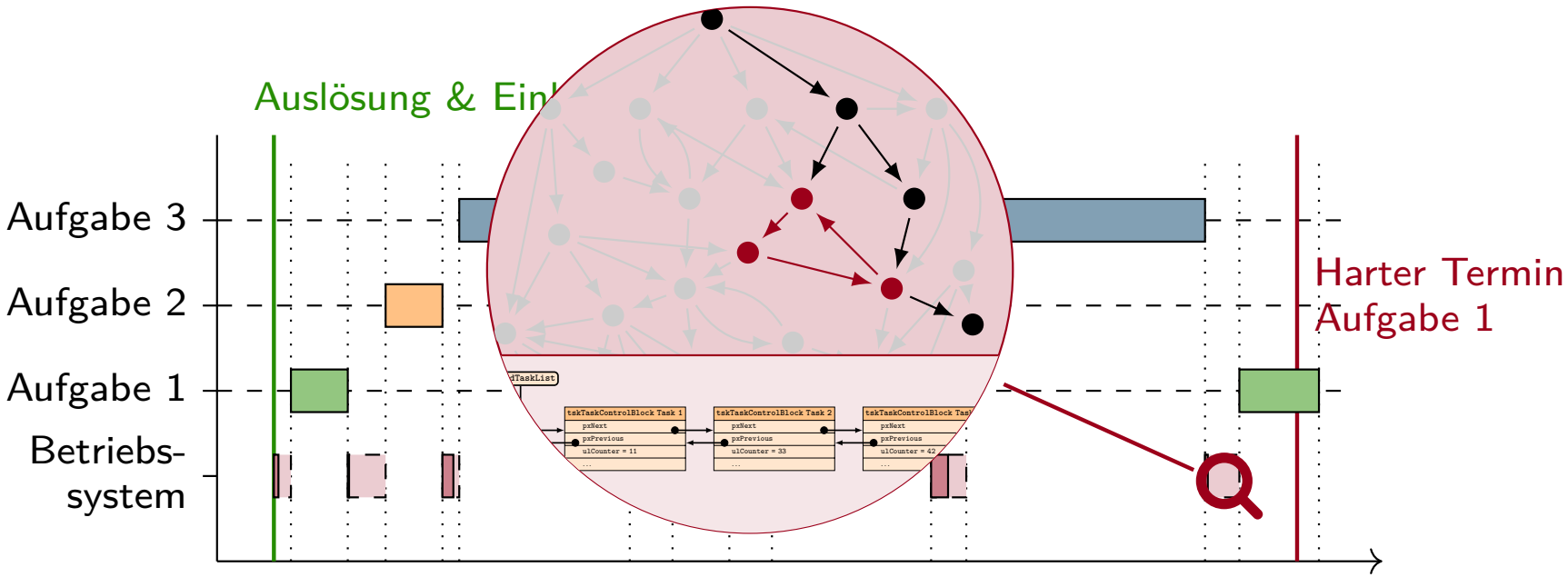
Betriebssystemvorgänge und Termintreue



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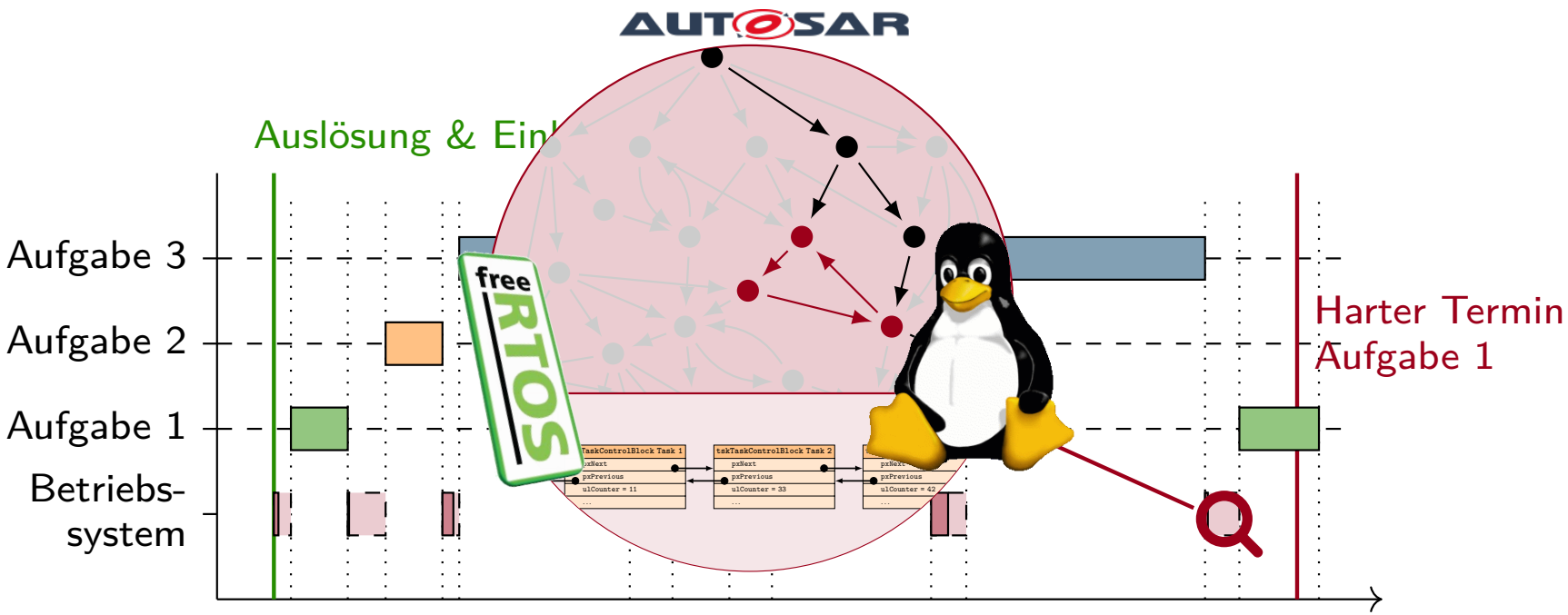
- ✗ **Unbeschränkte WCET** aufgrund anwendungsabhängiger Datenstrukturen

Betriebssystemvorgänge und Termintreue



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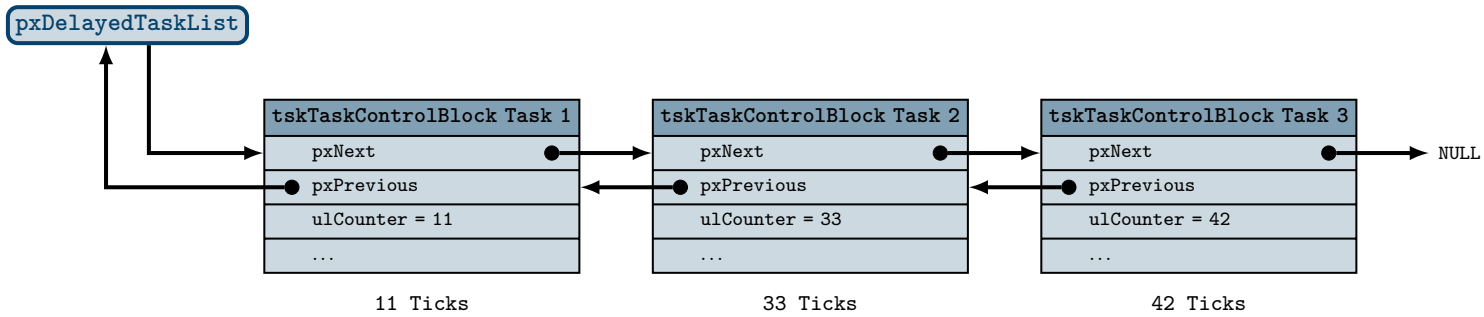
Anatomie von Betriebssystemaufrufen



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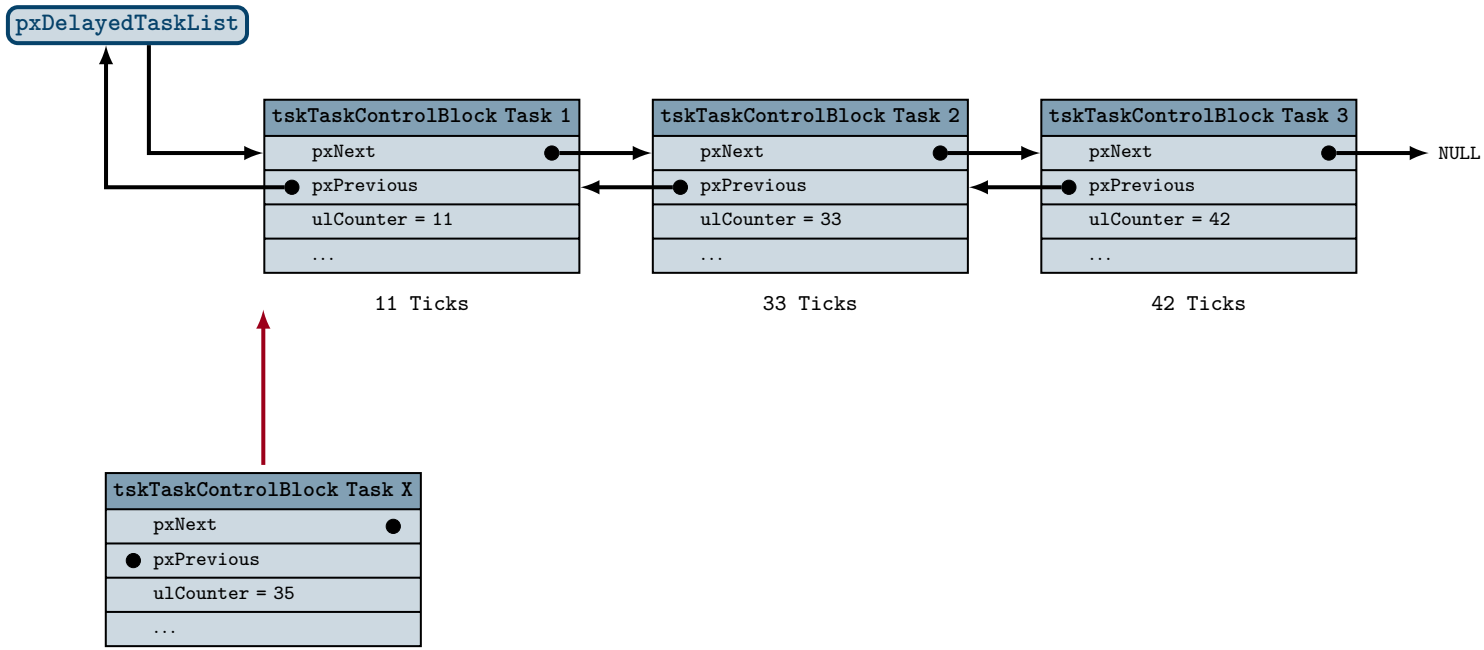

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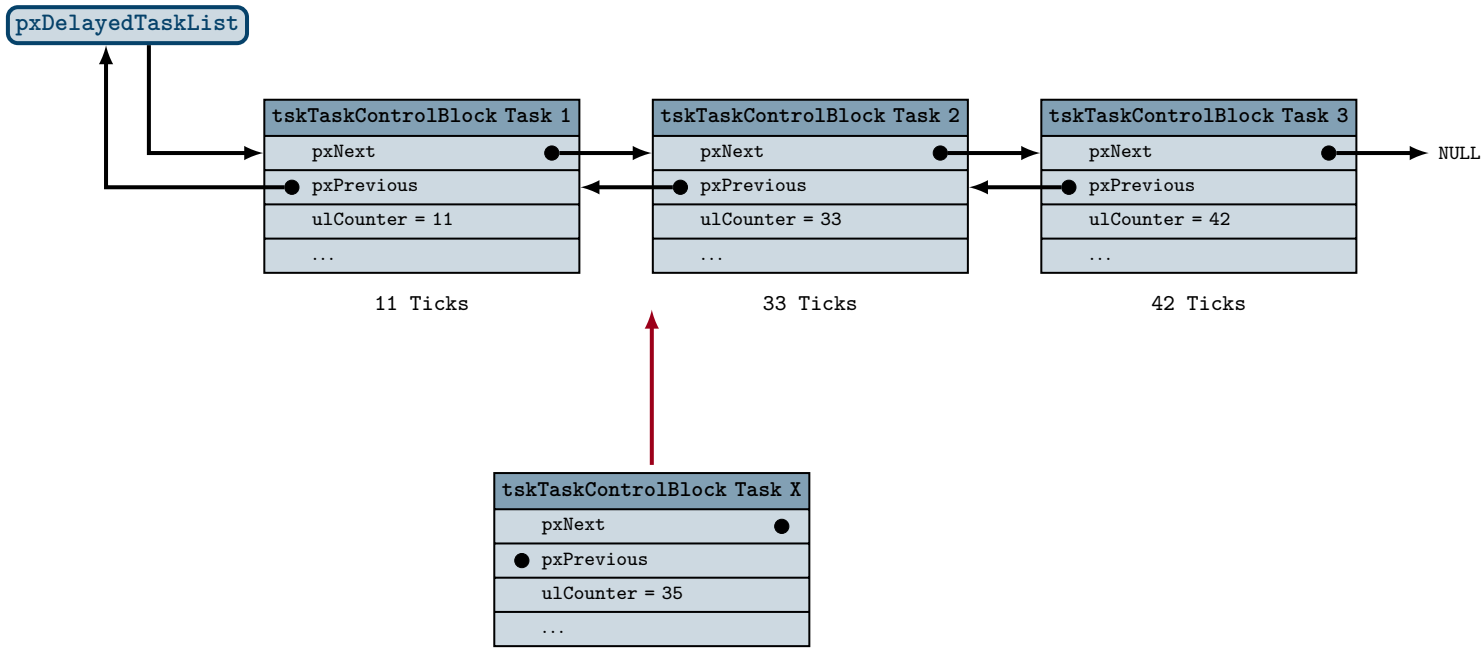
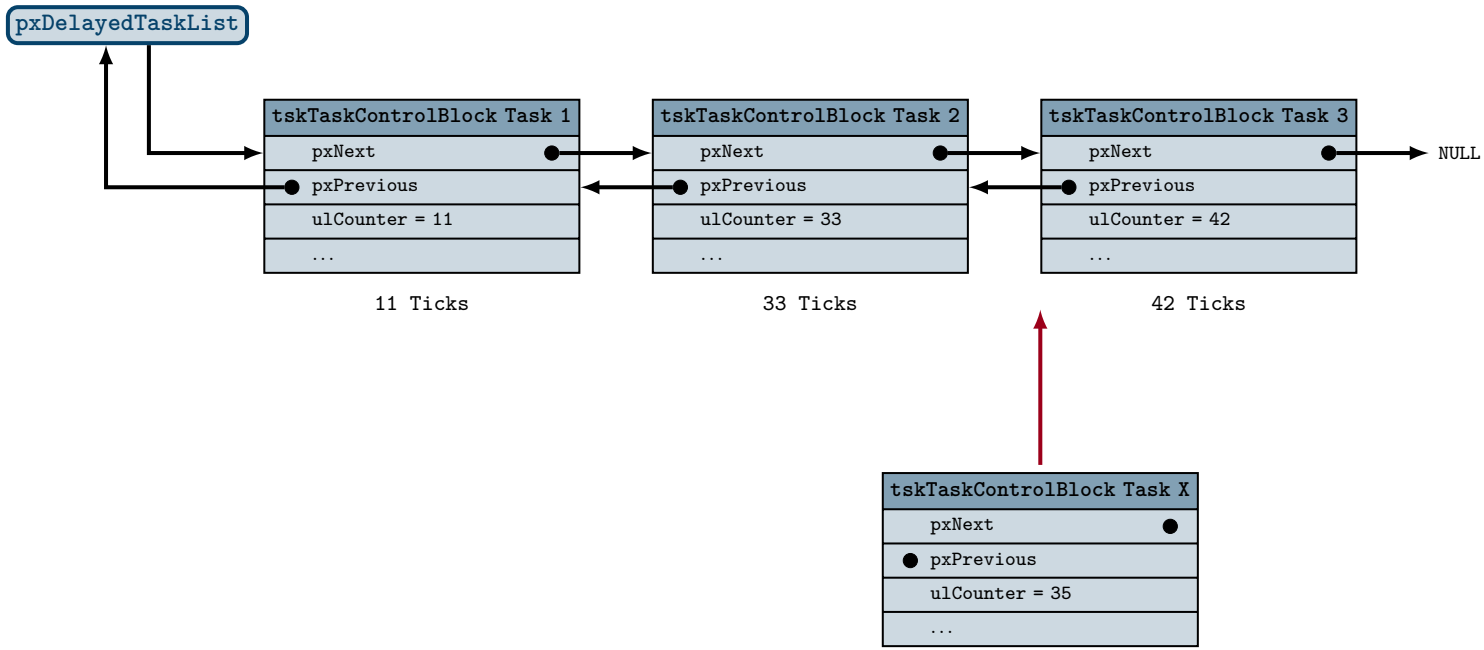


Anatomie von Betriebssystemaufrufen



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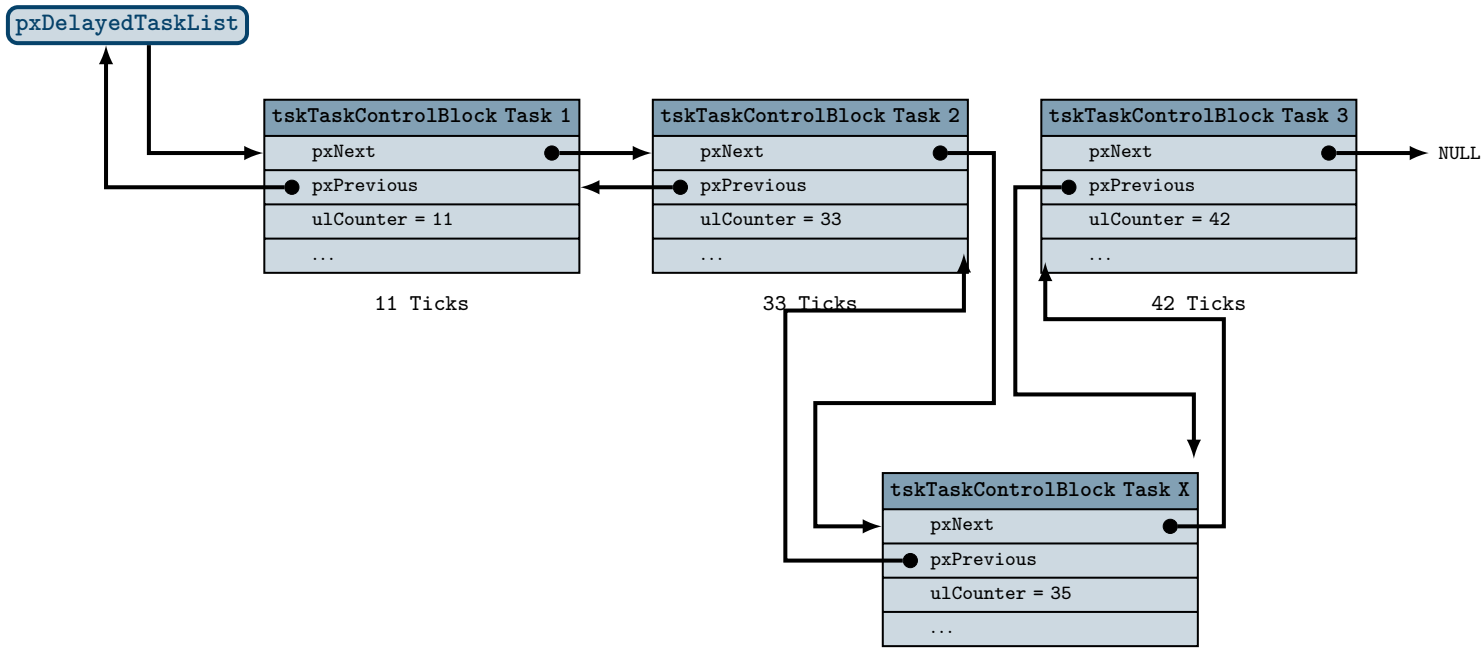

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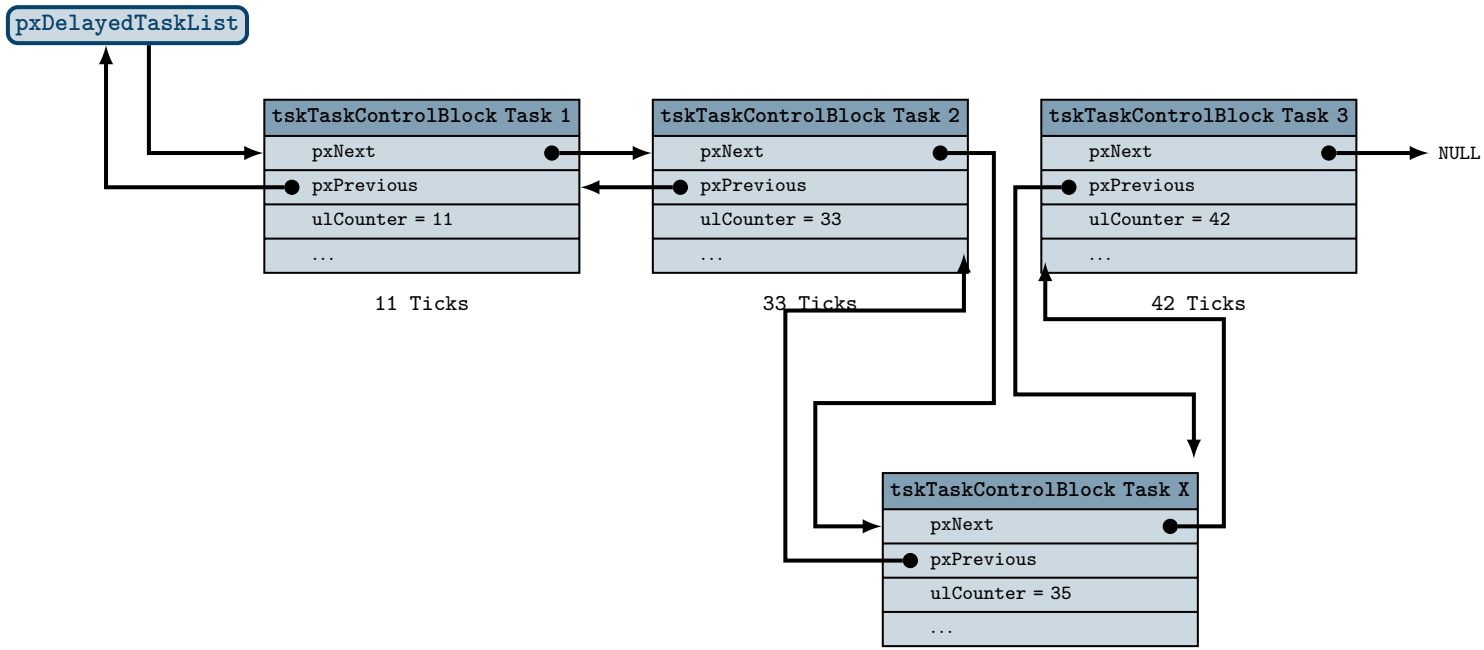

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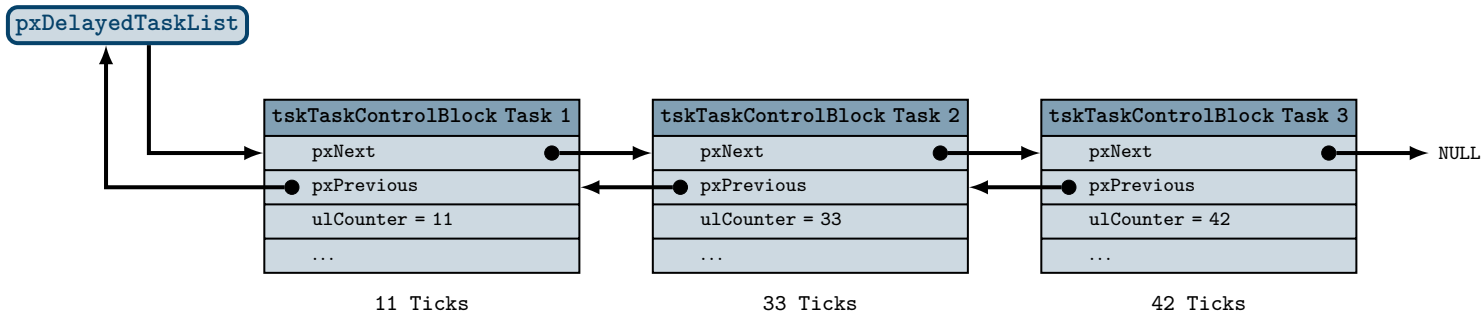
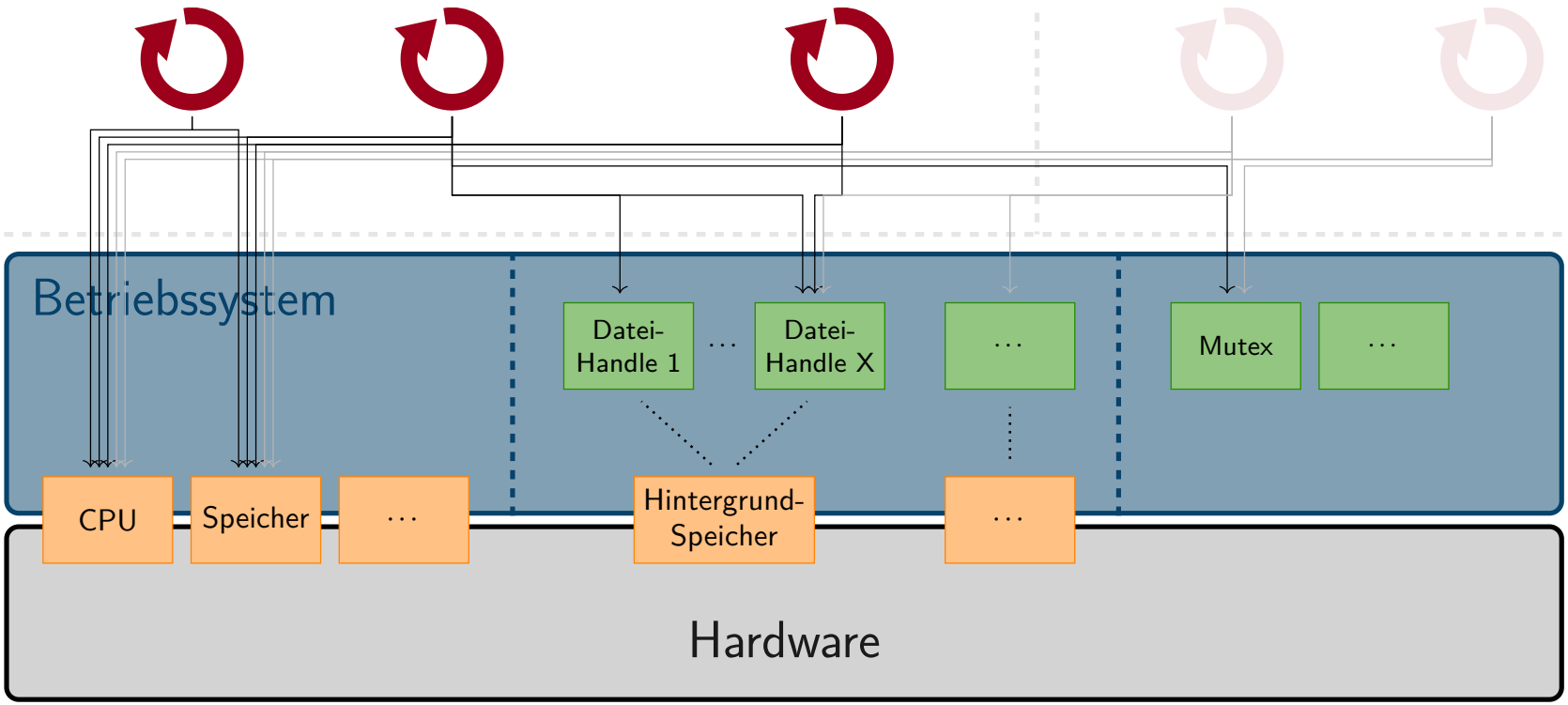
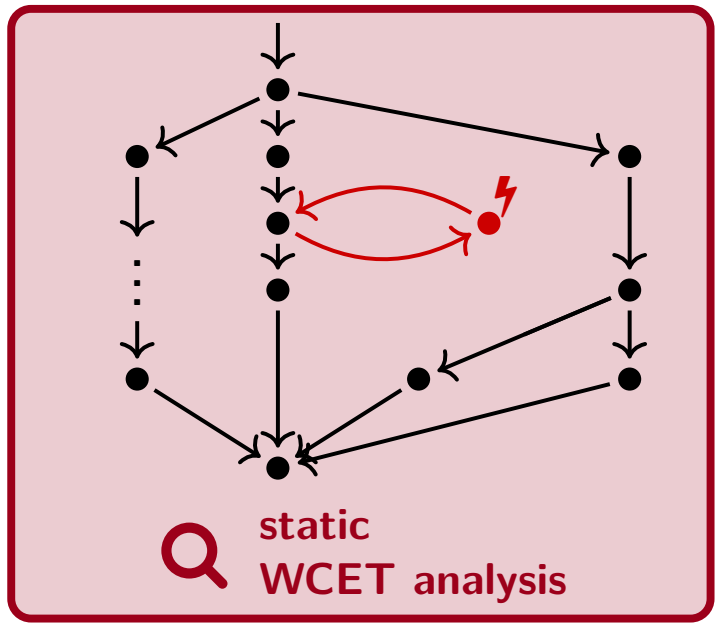




Statische Laufzeitanlyse von Betriebssystemaufrufen



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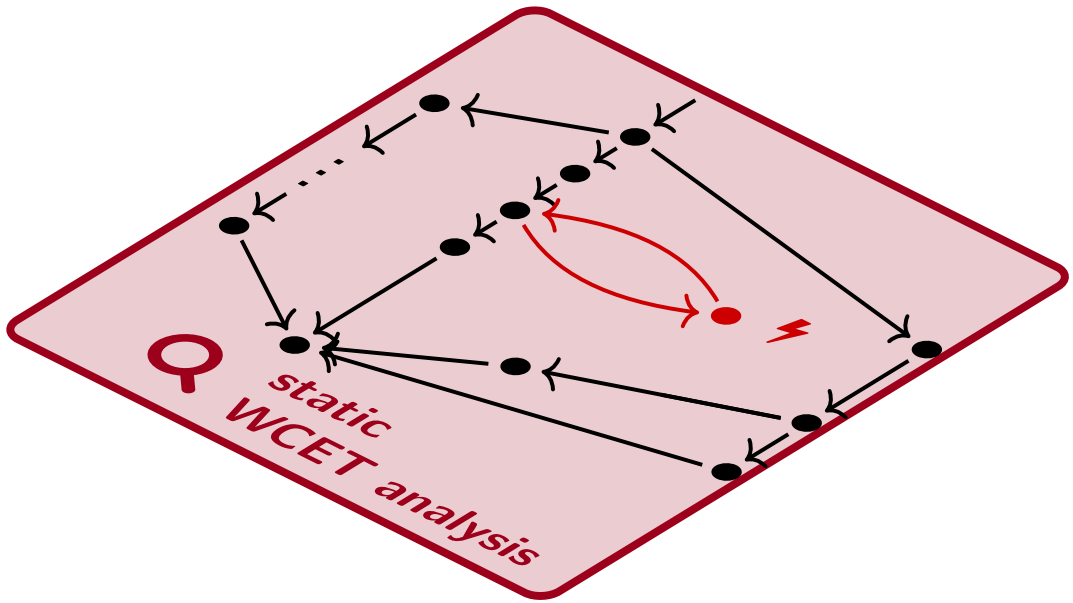

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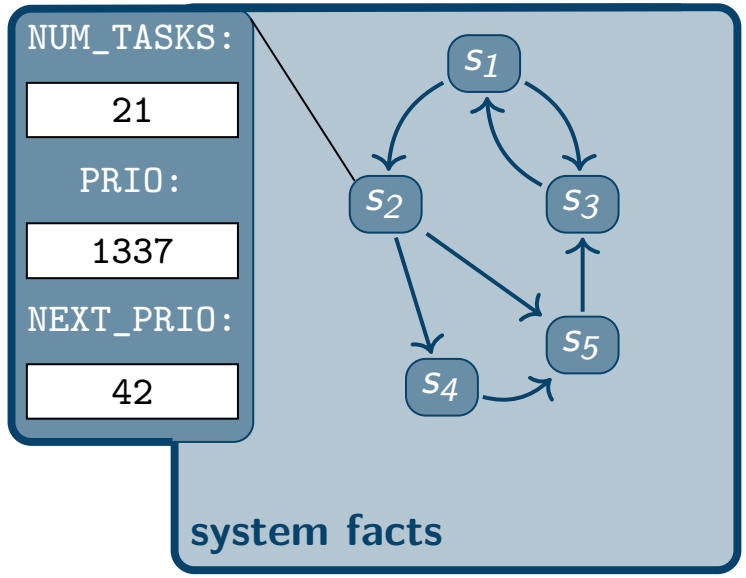

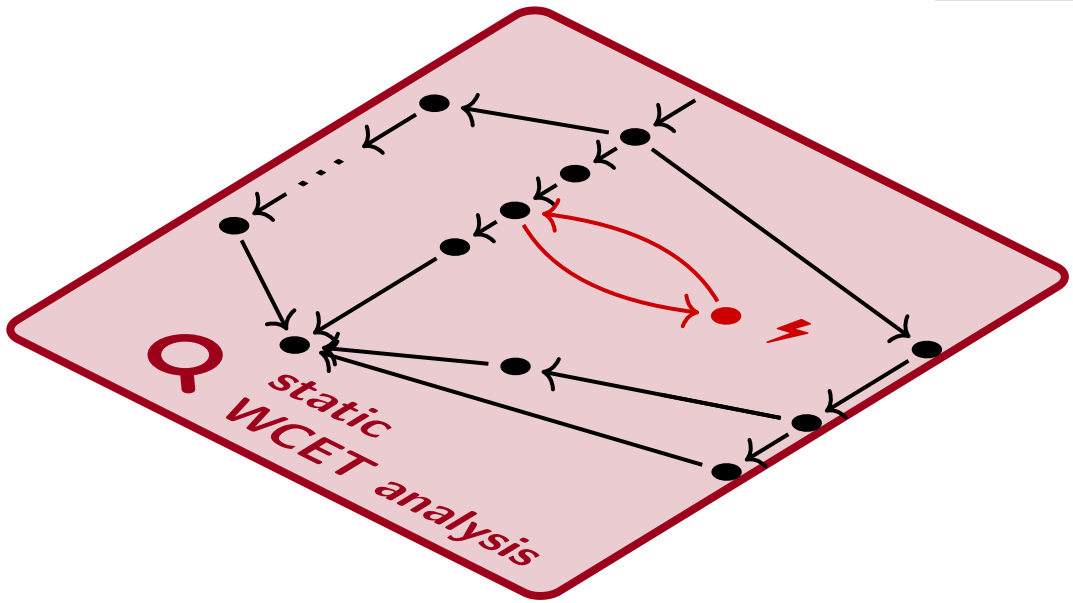

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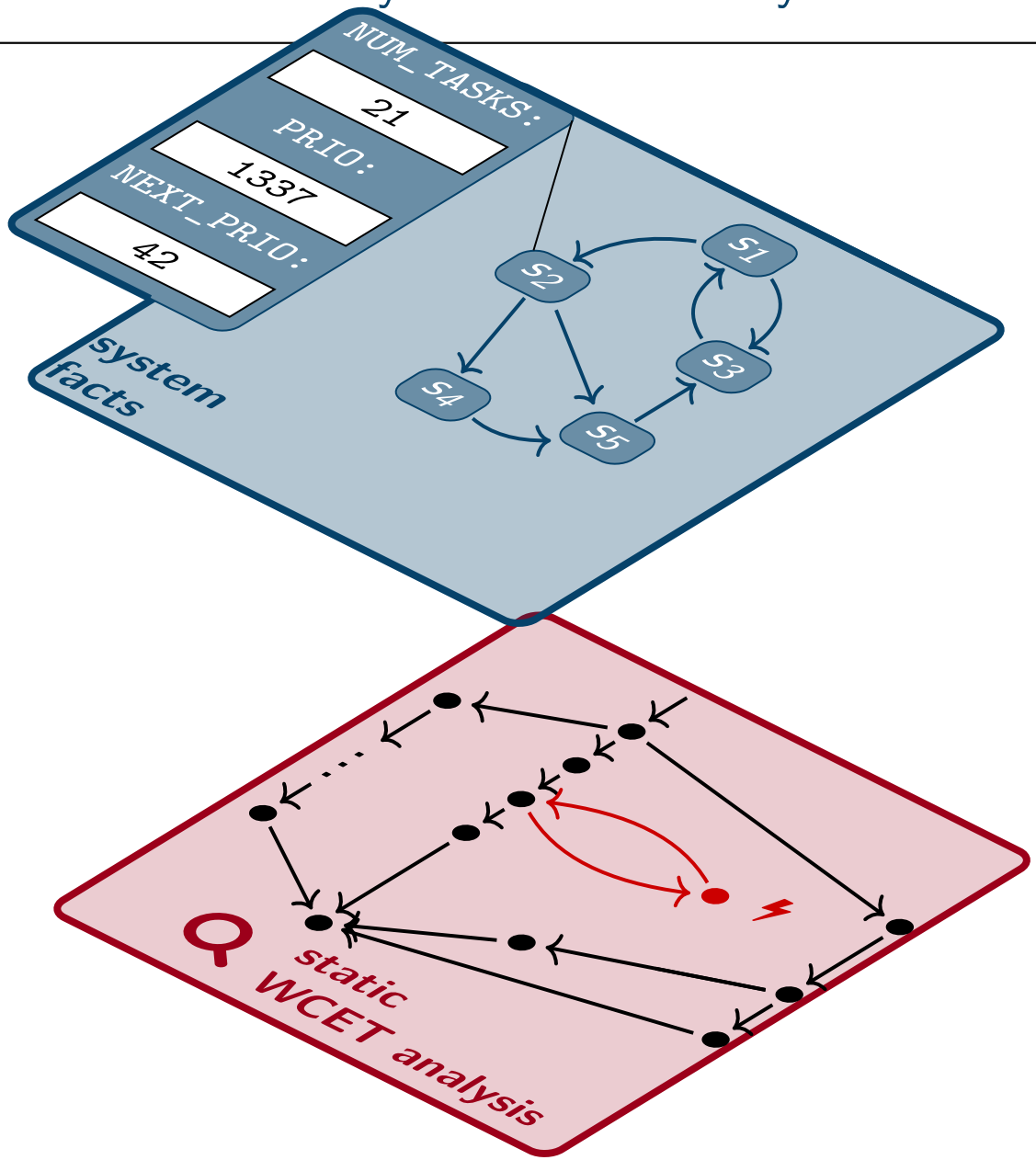
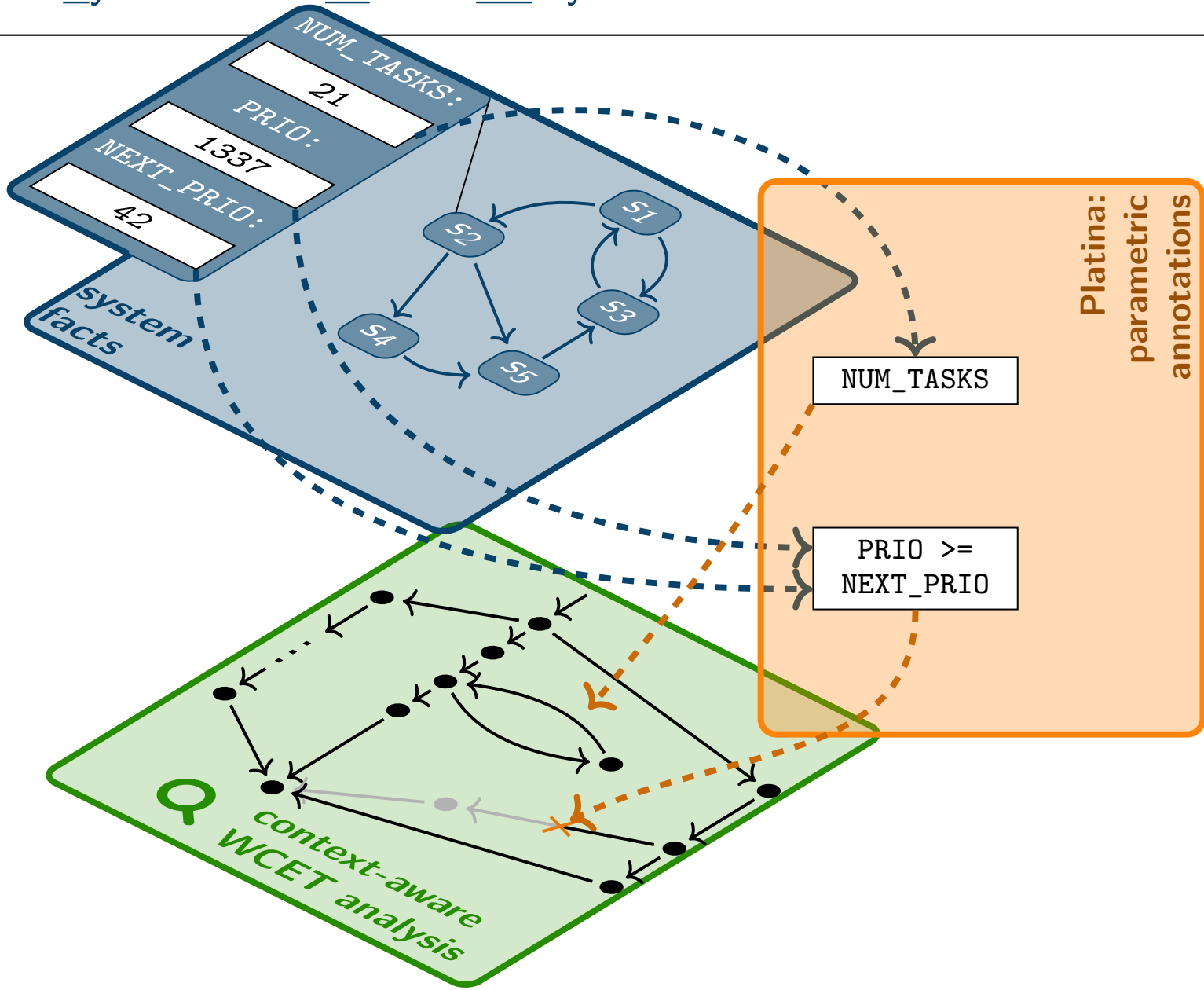


SWAN: System-wide WCET Analyzer



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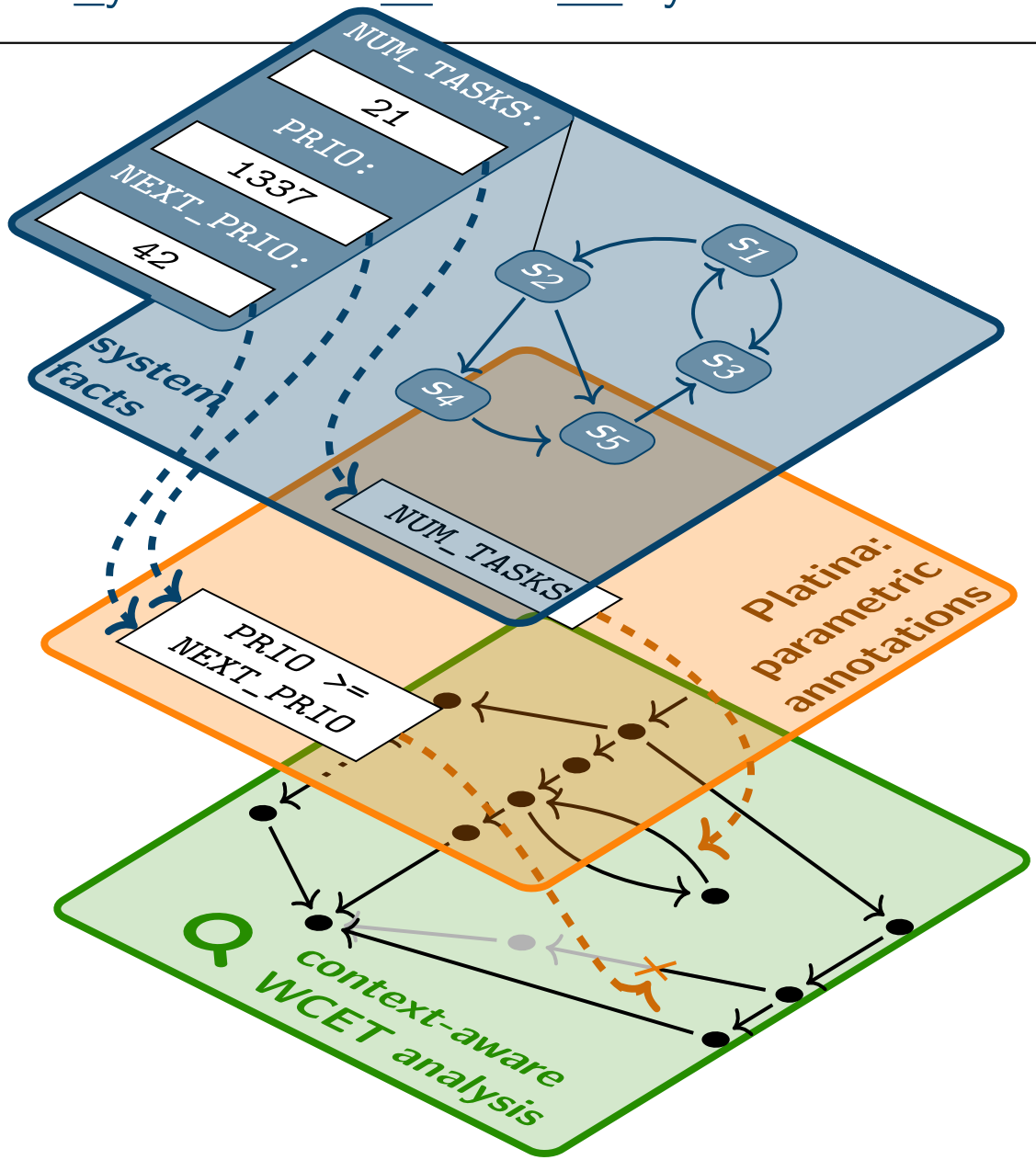

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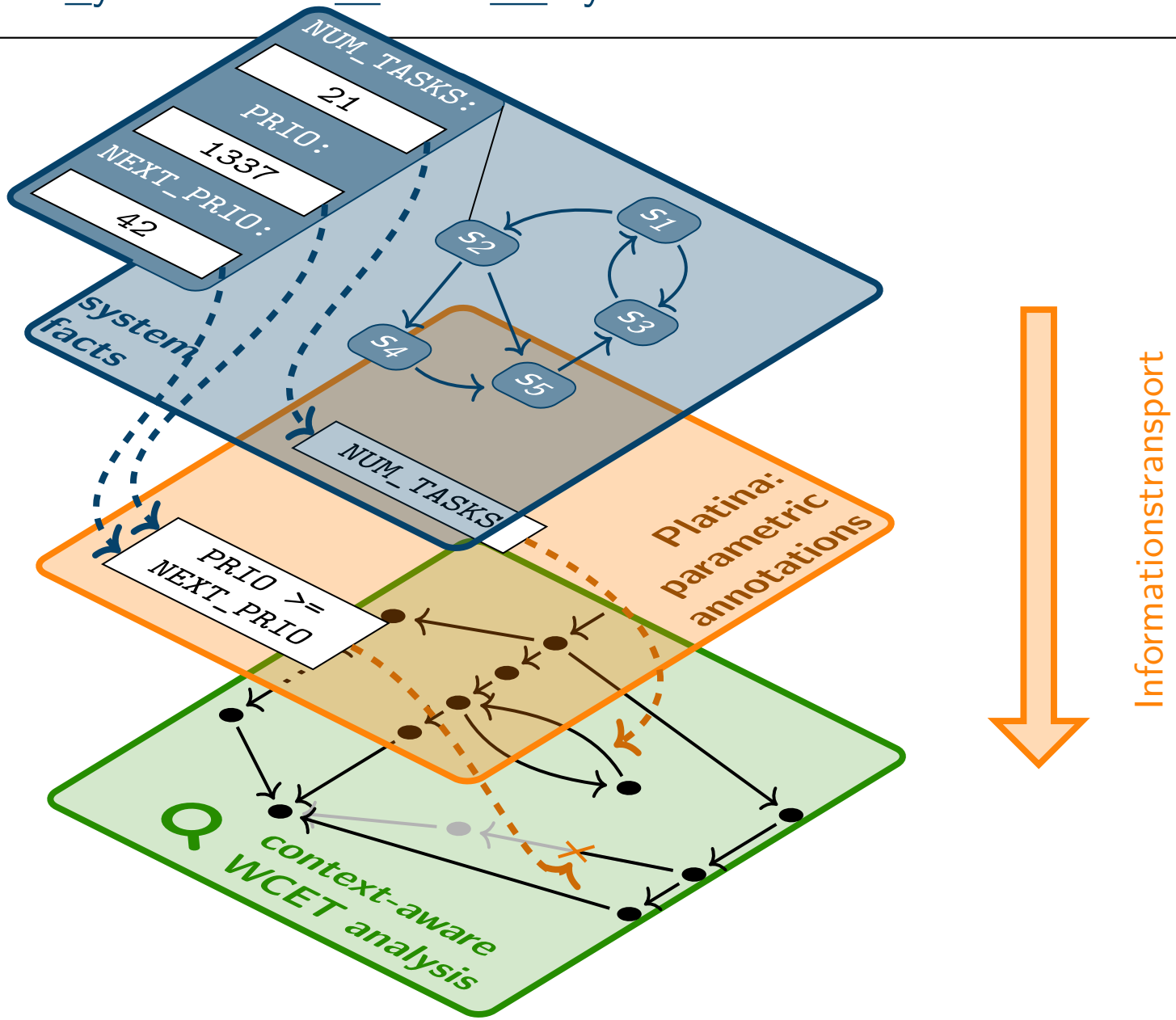
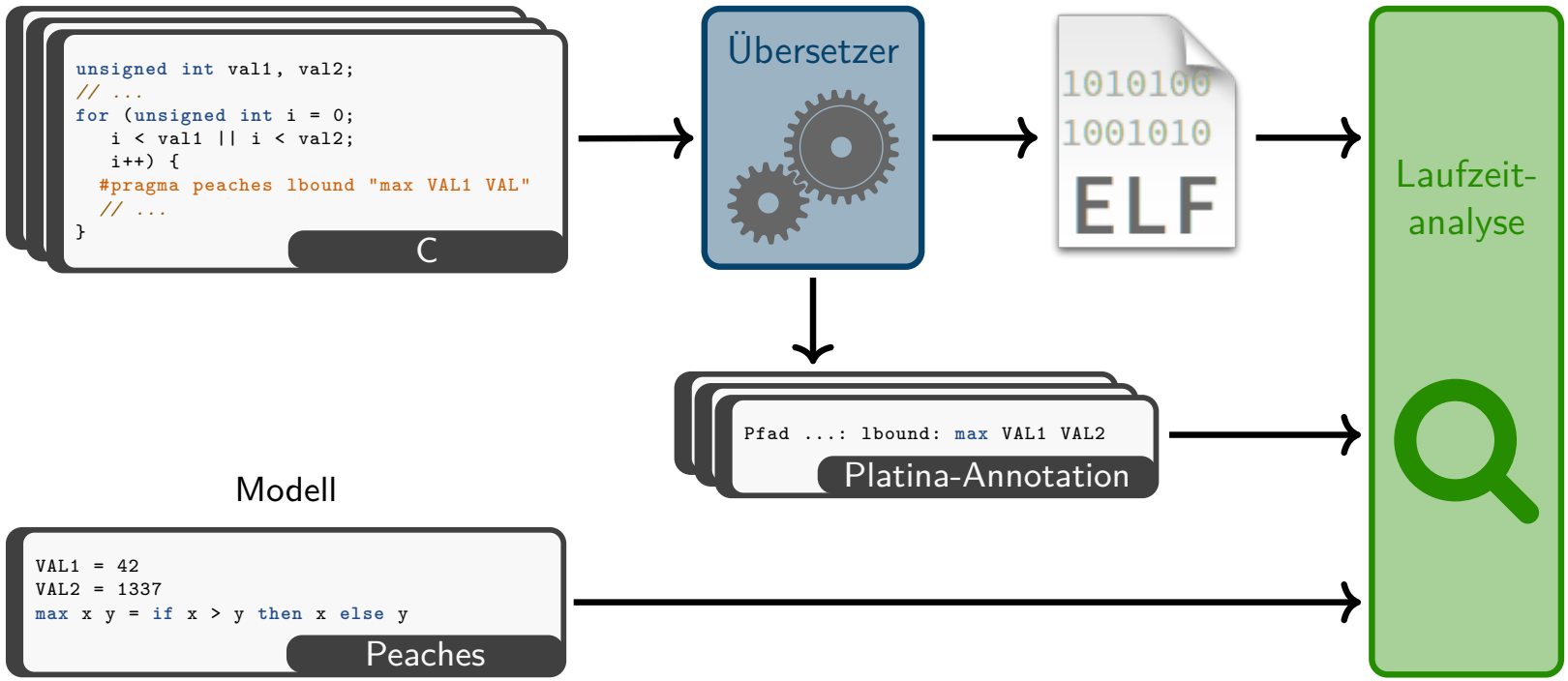


Architektur



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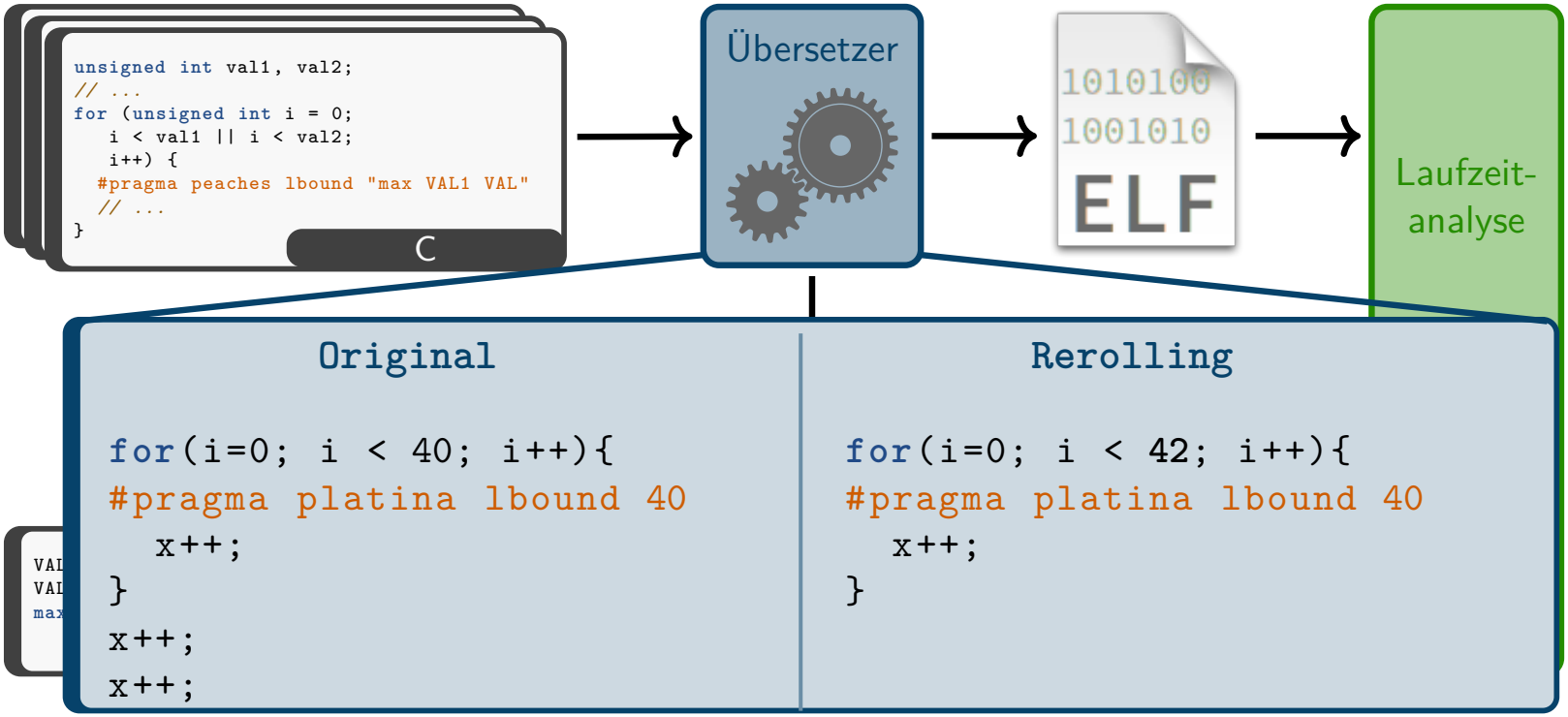

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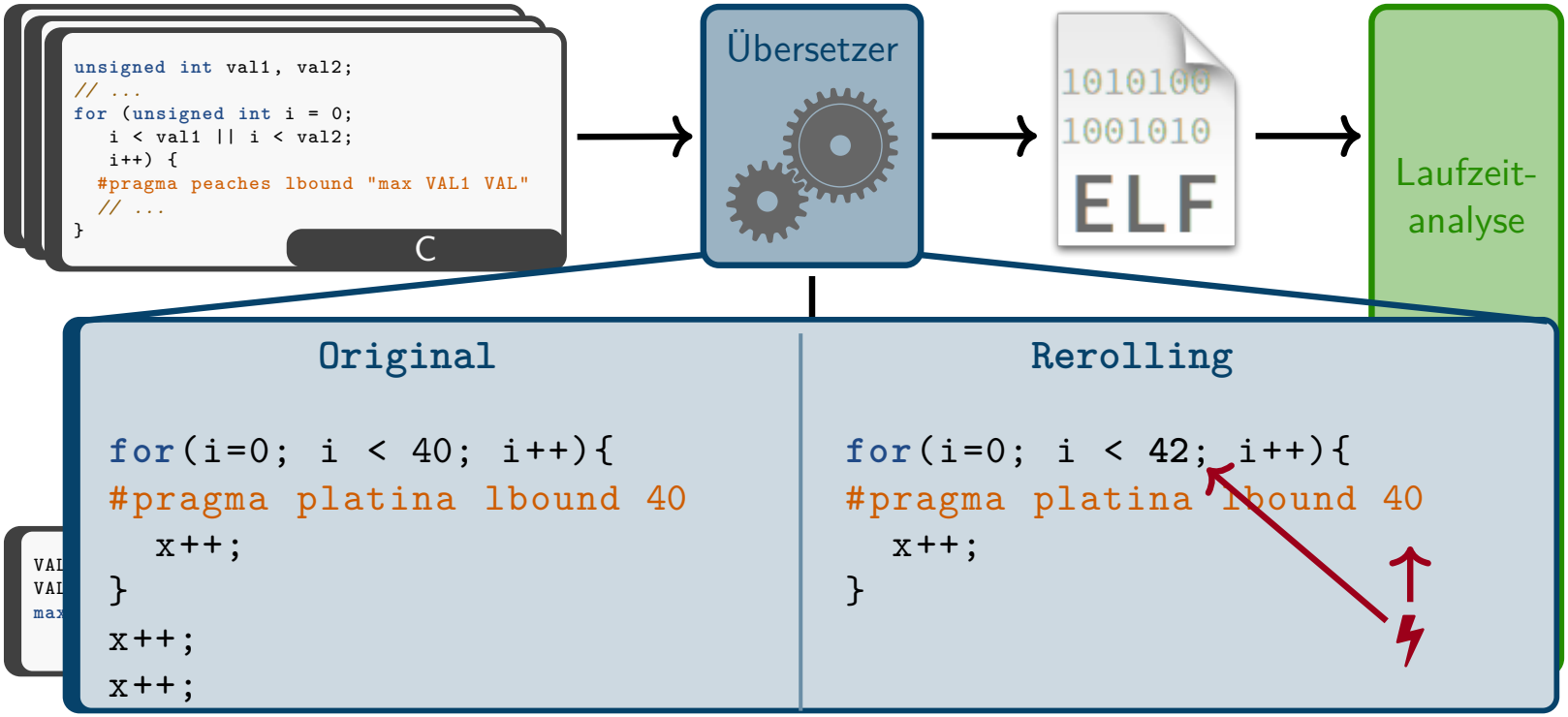

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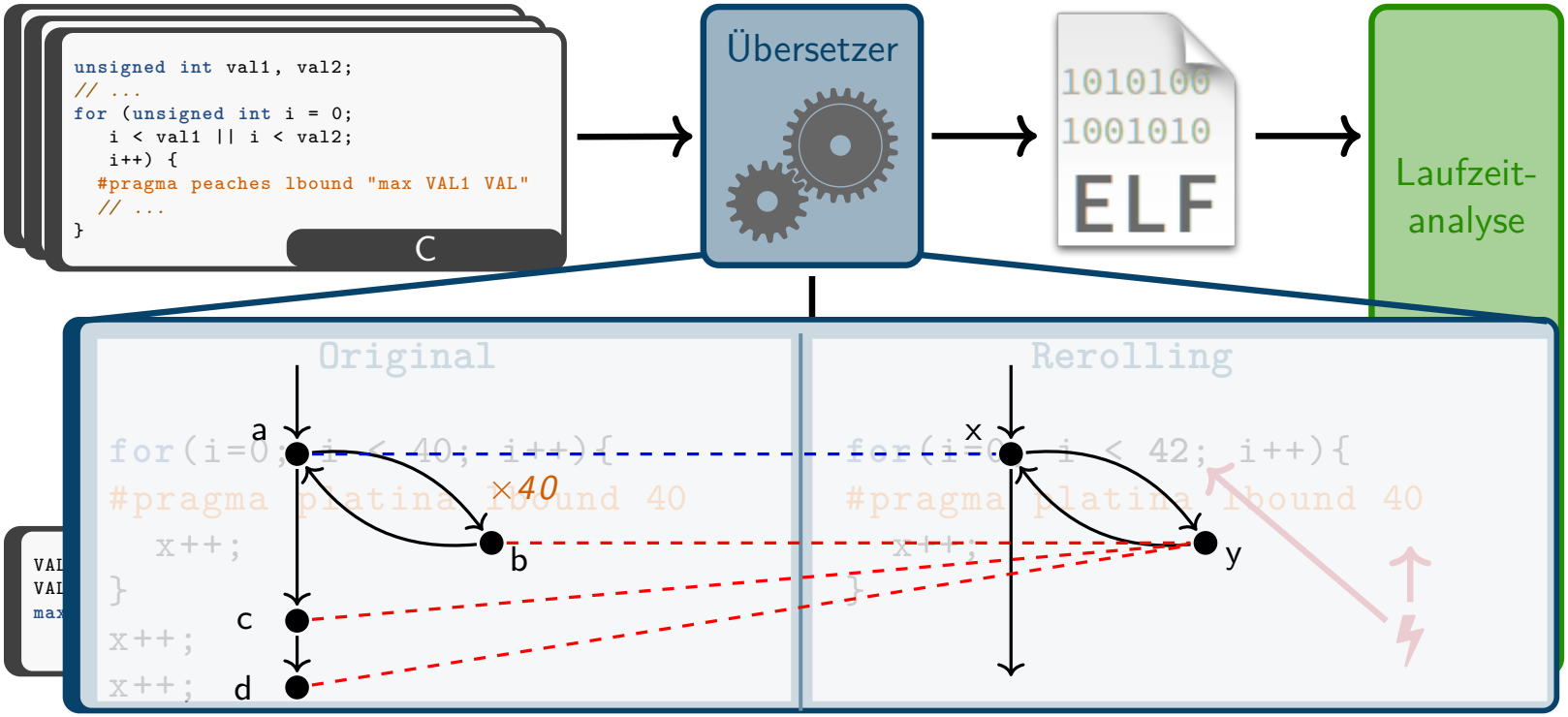

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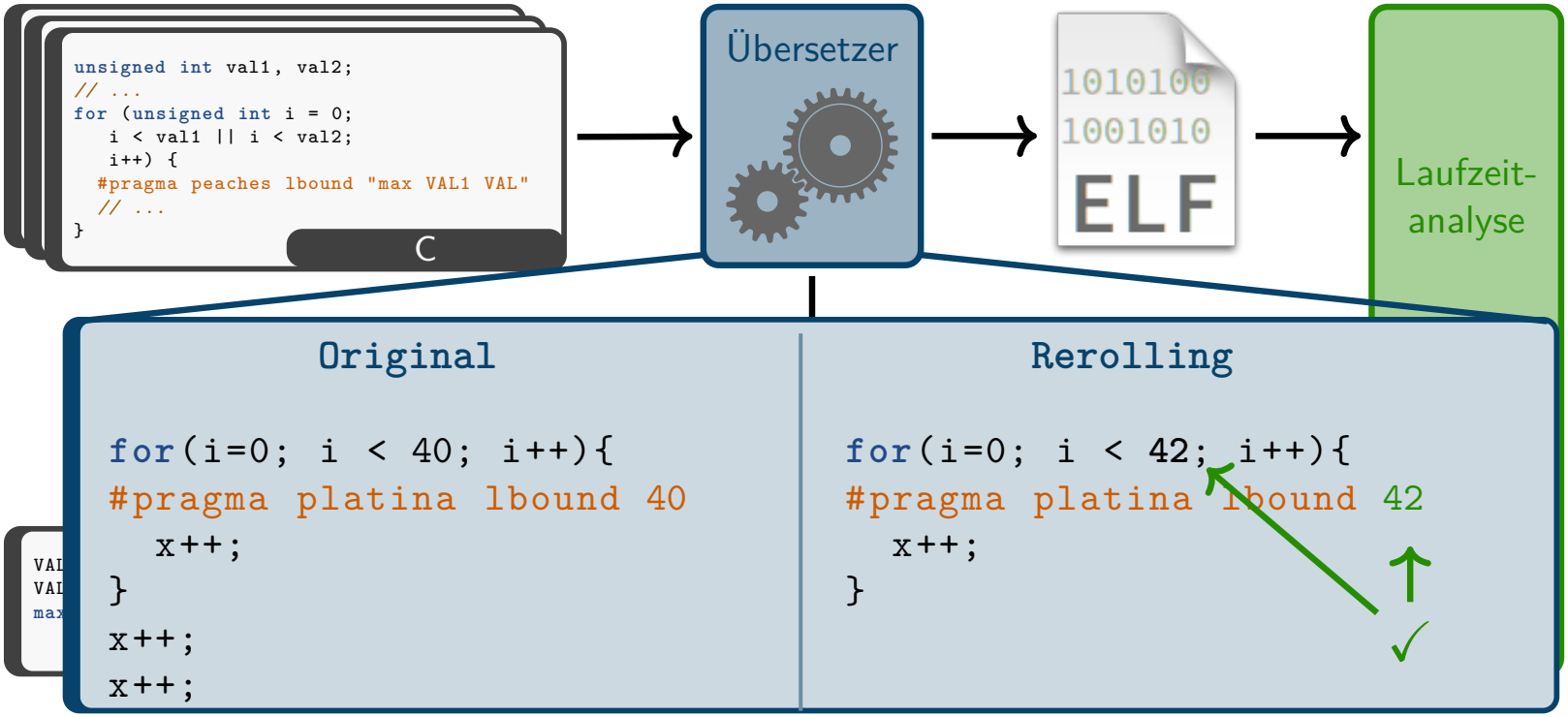

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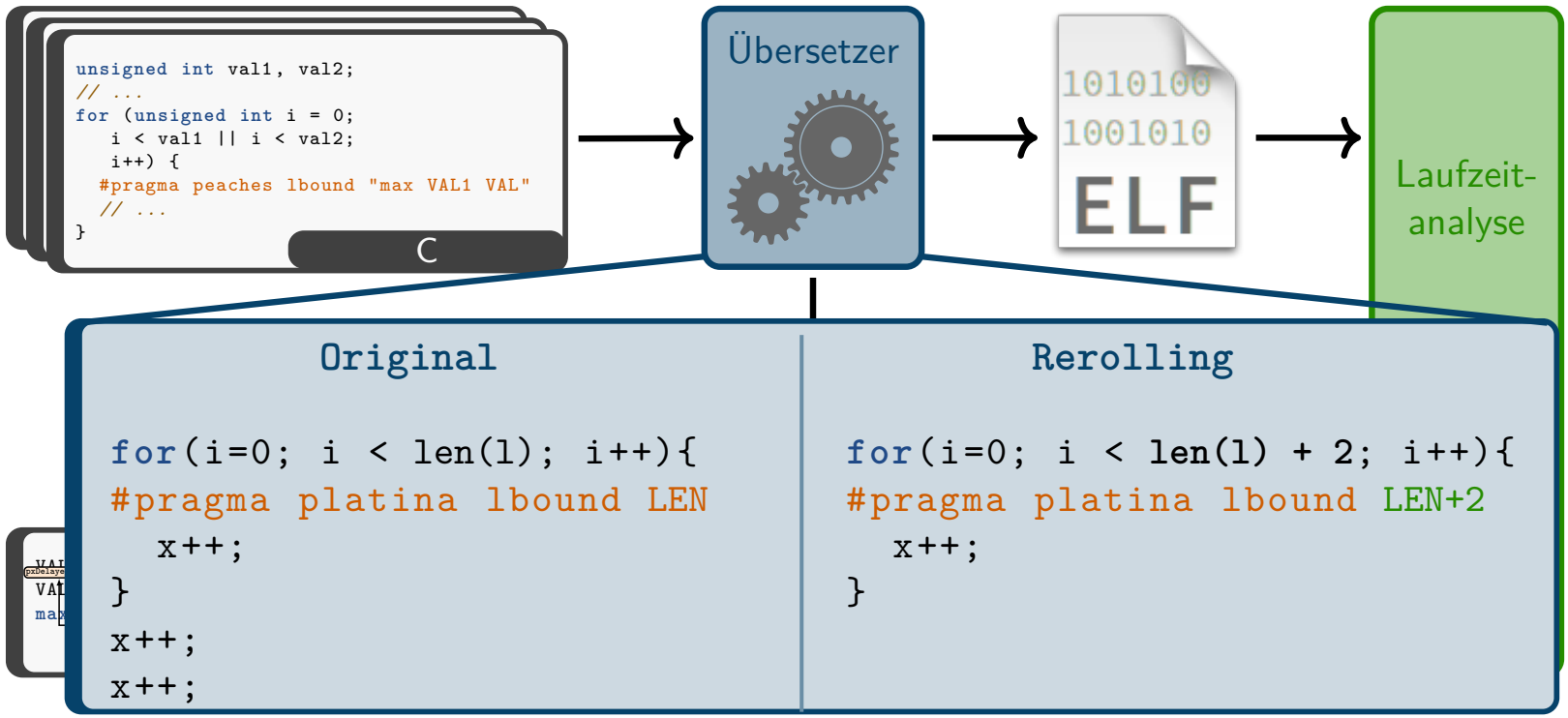

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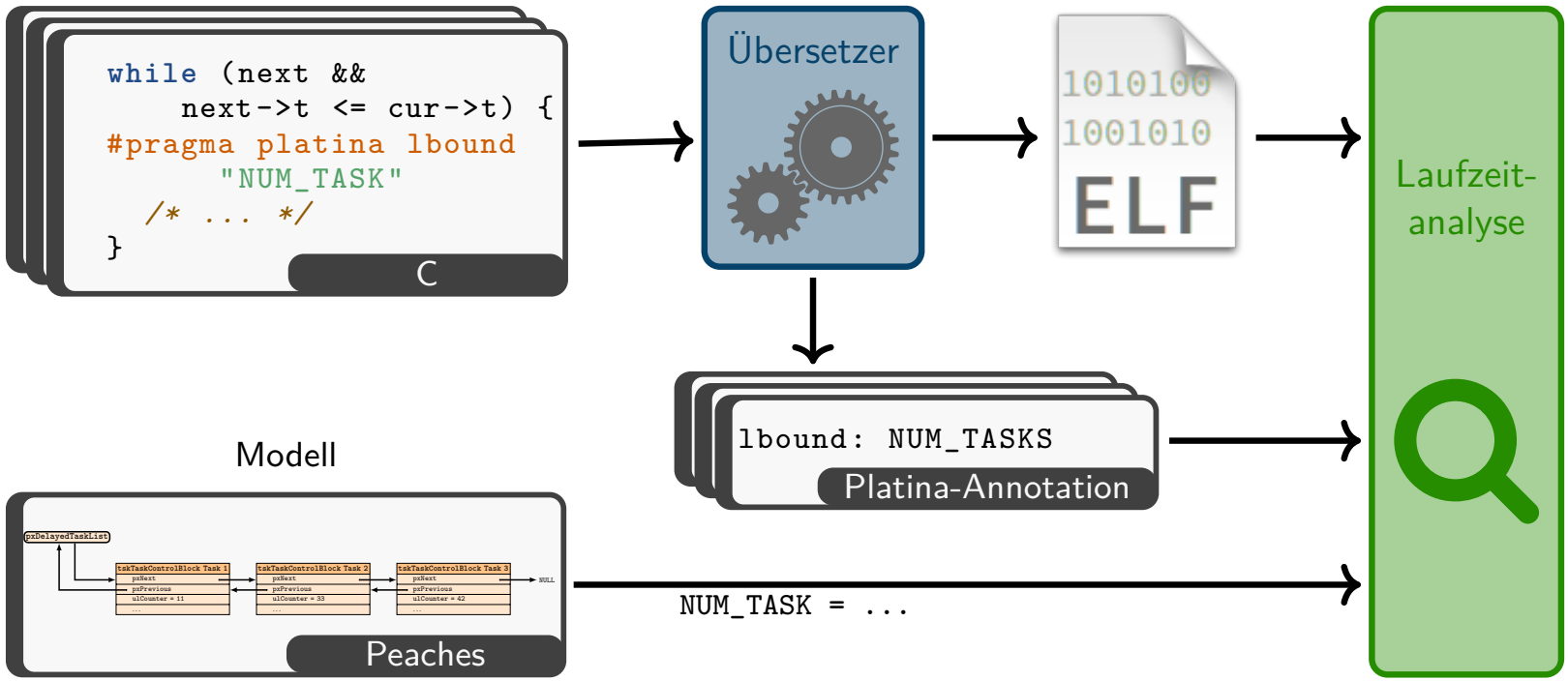

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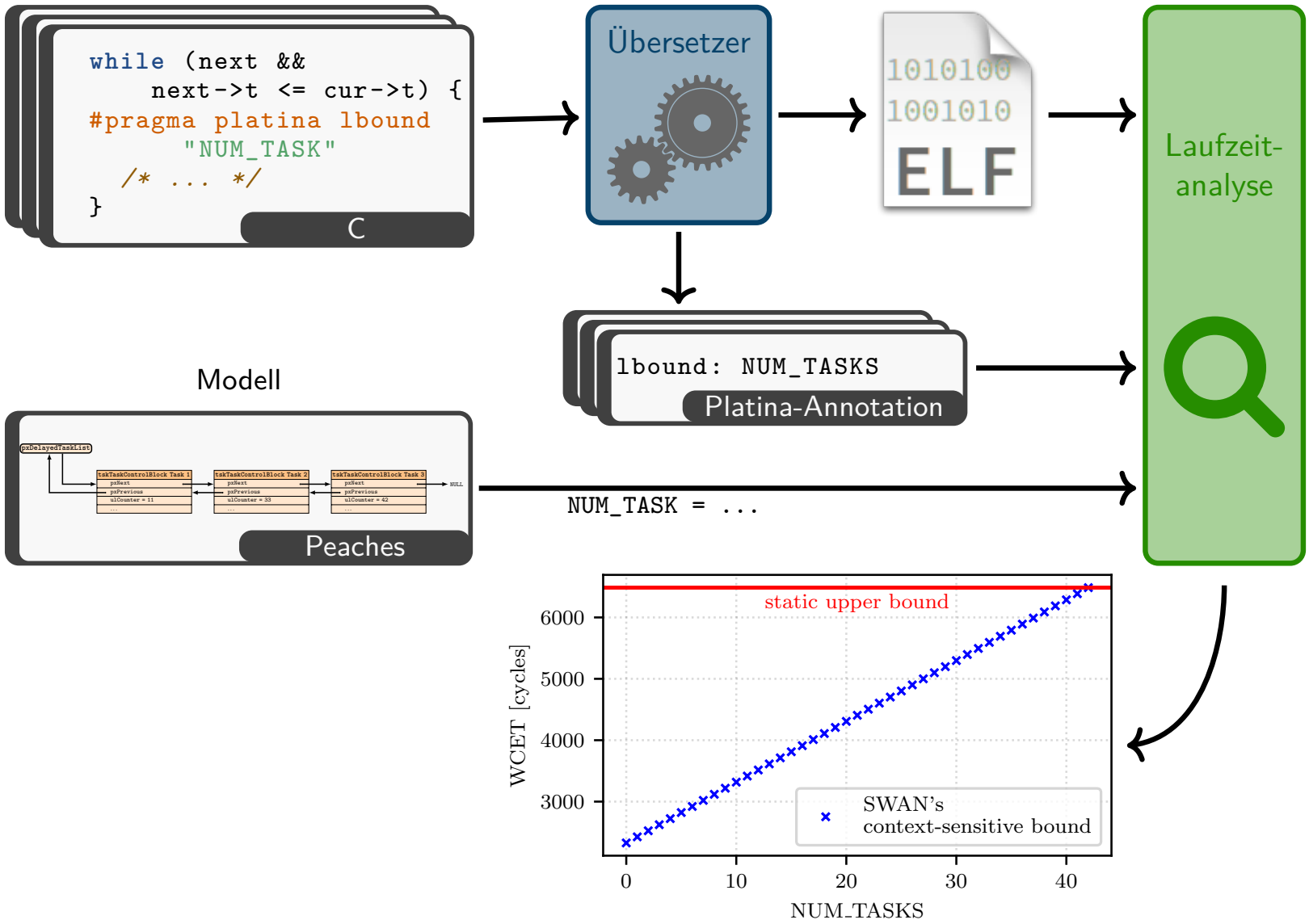
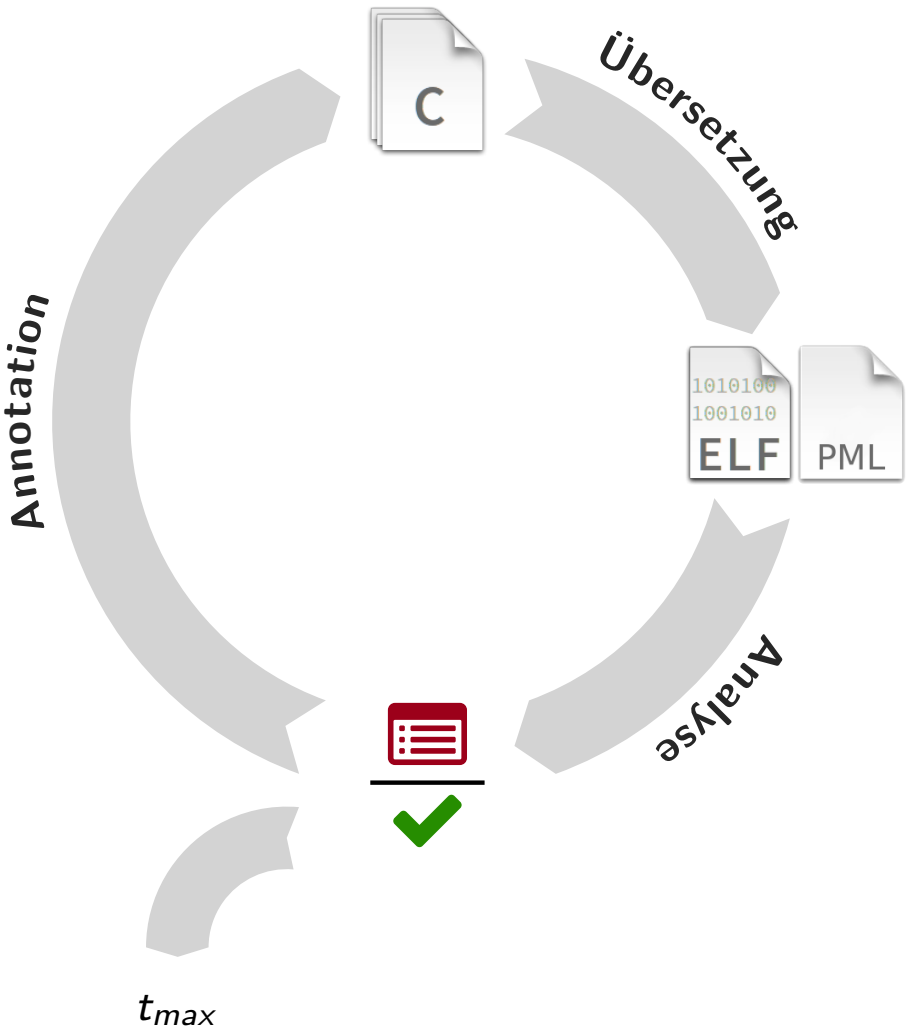


Arbeitsablauf



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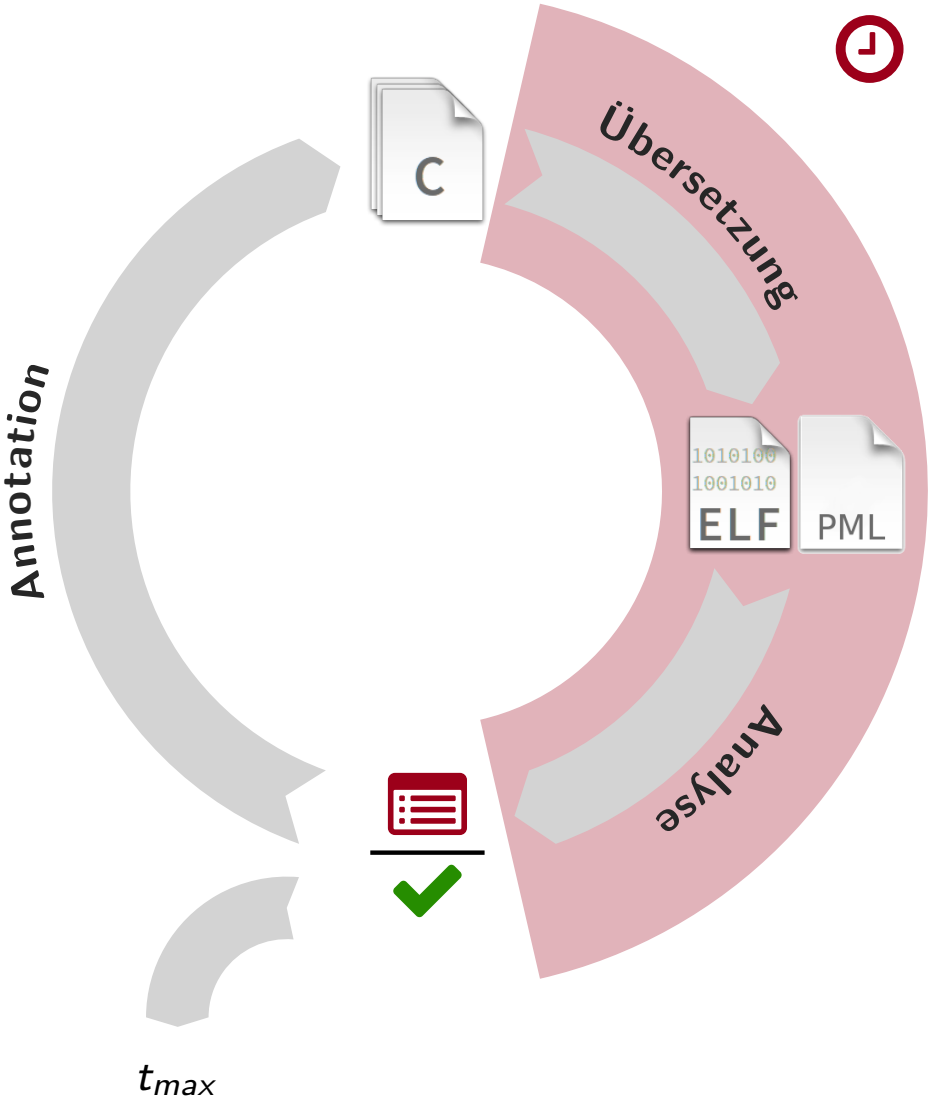

Linuxkern: über 15 min
40 Kerne @ 2.20 GHz
(Xeon E5-4640)
128GB RAM

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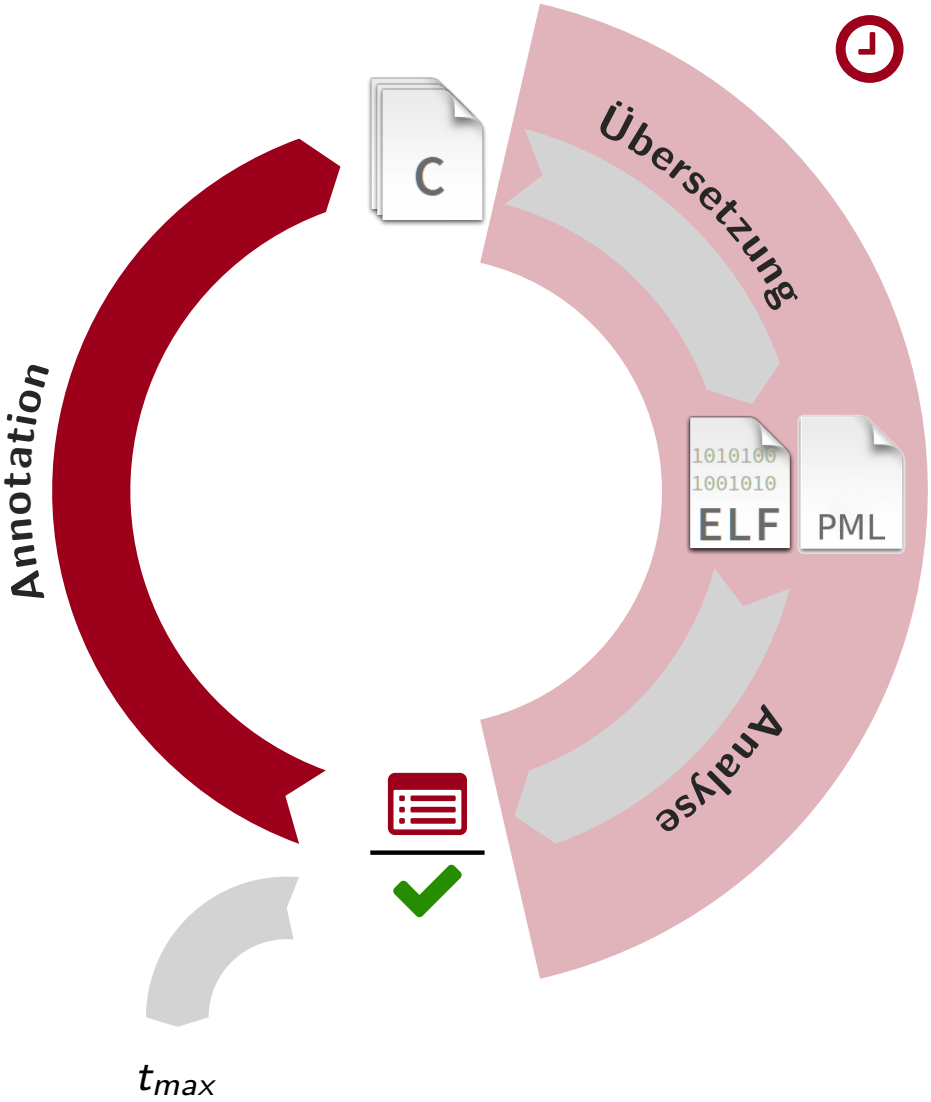

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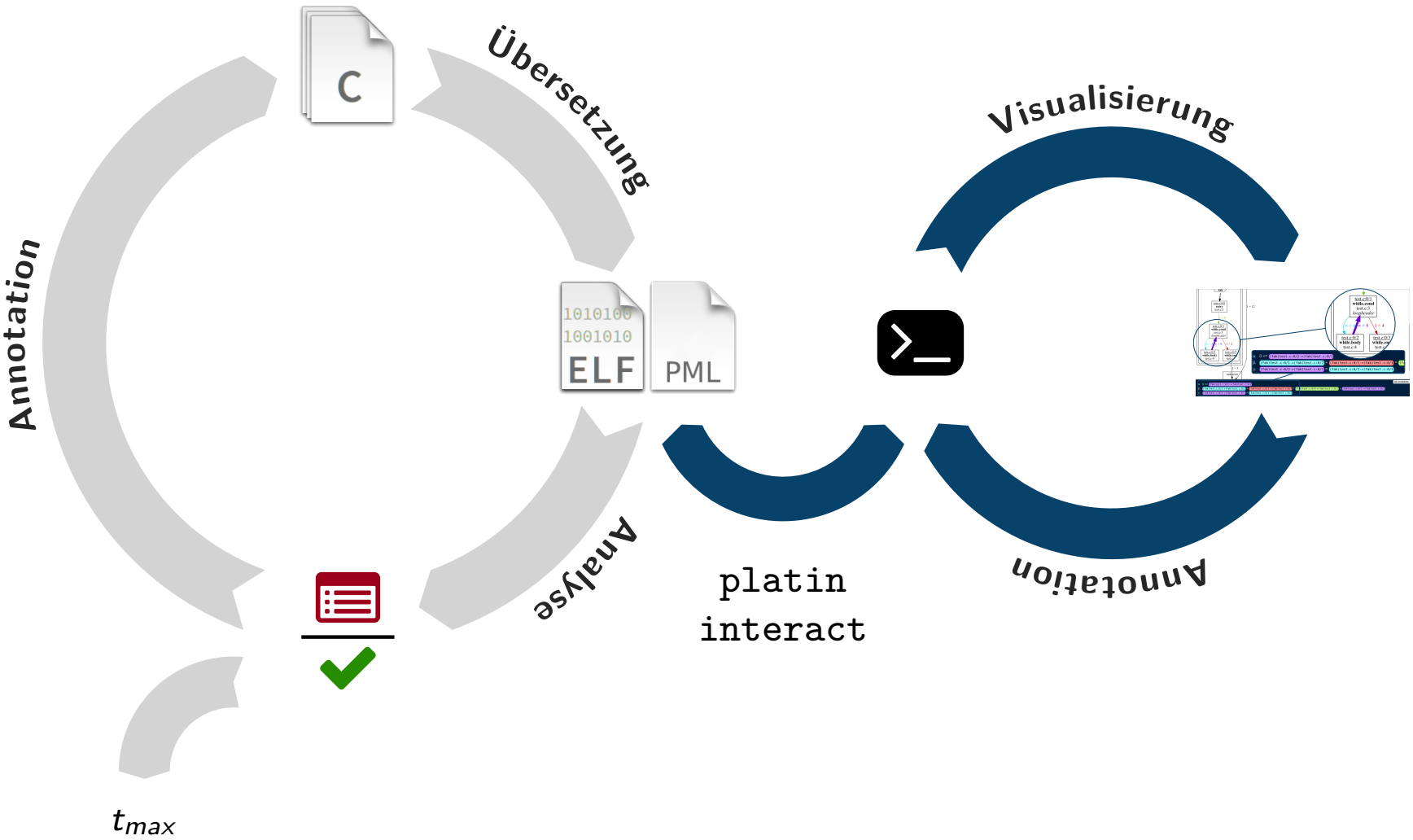


Interaktive Annotation

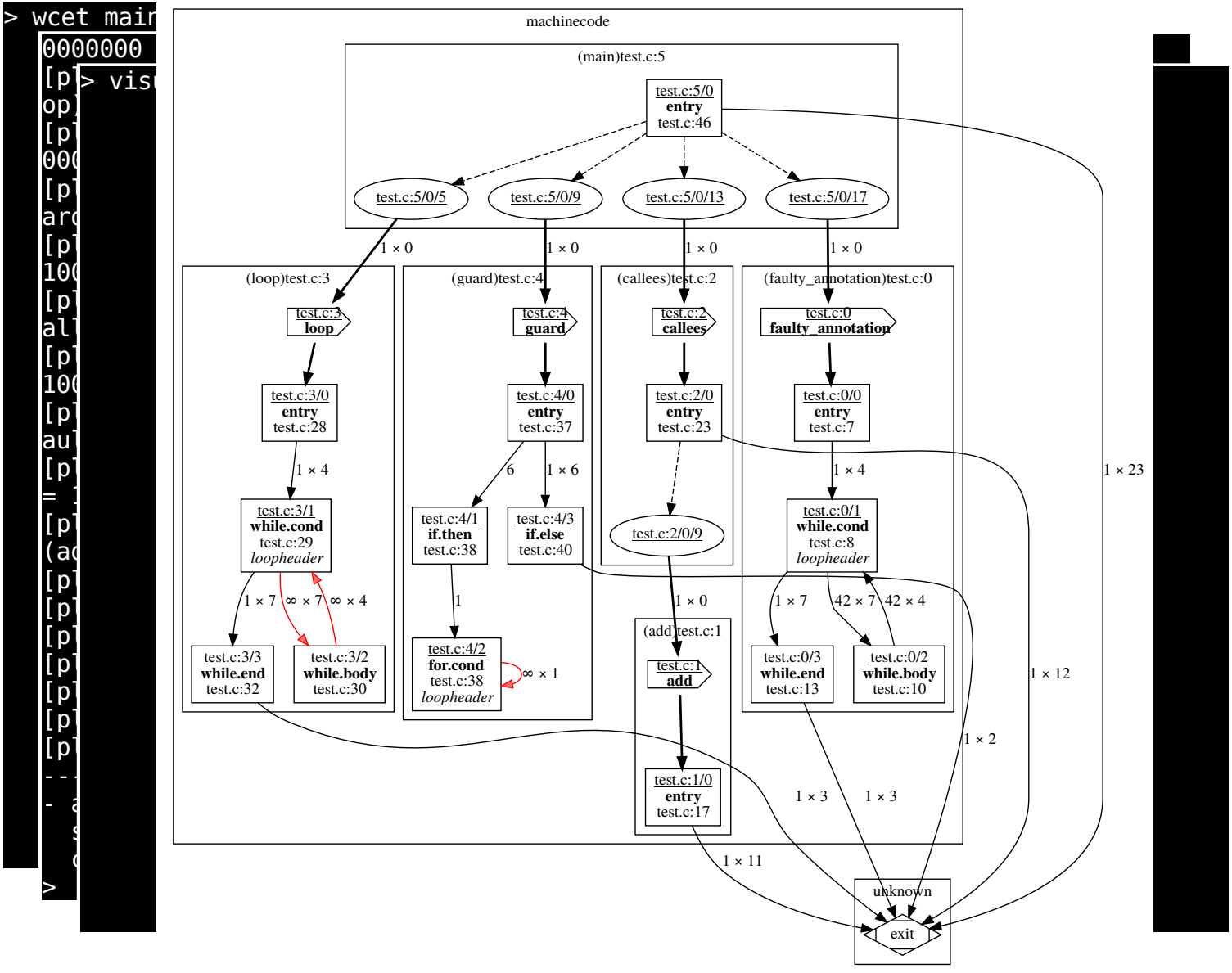
```
> wcet main
```

Interaktive Annotation

```
> wcet main
0000000
[platin] DEBUG:  74: constraint __debug_upper_bound_v20: (main)test.c:5/0/5->(lo
op)test.c:3 <= 10000000
[platin] DEBUG:  75: constraint __debug_upper_bound_v21: (main)test.c:5/0/9 <= 1
0000000
[platin] DEBUG:  76: constraint __debug_upper_bound_v22: (main)test.c:5/0/9->(gu
ard)test.c:4 <= 10000000
[platin] DEBUG:  77: constraint __debug_upper_bound_v23: (main)test.c:5/0/13 <=
10000000
[platin] DEBUG:  78: constraint __debug_upper_bound_v24: (main)test.c:5/0/13->(c
allees)test.c:2 <= 10000000
[platin] DEBUG:  79: constraint __debug_upper_bound_v25: (main)test.c:5/0/17 <=
10000000
[platin] DEBUG:  80: constraint __debug_upper_bound_v26: (main)test.c:5/0/17->(f
aulty_annotation)test.c:0 <= 10000000
[platin] DEBUG:  81: constraint __debug_upper_bound_v27: (callees)test.c:2/0/9 <
= 10000000
[platin] DEBUG:  82: constraint __debug_upper_bound_v28: (callees)test.c:2/0/9->
(add)test.c:1 <= 10000000
[platin] DEBUG: #<Set:0x00000002733168>
[platin] WARNING: ILP: Unbounded loops: (guard)test.c:4/2, (loop)test.c:3/1
[platin] WARNING: Unbounded hint [(guard)test.c:4/2]: test.c:38
[platin] WARNING: Unbounded hint [(loop)test.c:3/1]: test.c:29
[platin] WARNING: WCA: ILP failed: LPSolver Error: UNBOUNDED (E3)
[platin] INFO: Finished run WCET analysis (platin)          in 19 ms
[platin] INFO: best WCET bound: -1 cycles
---
- analysis-entry: main
  source: platin
  cycles: -1
>
```

Interaktive Annotation

Interaktive Annotation



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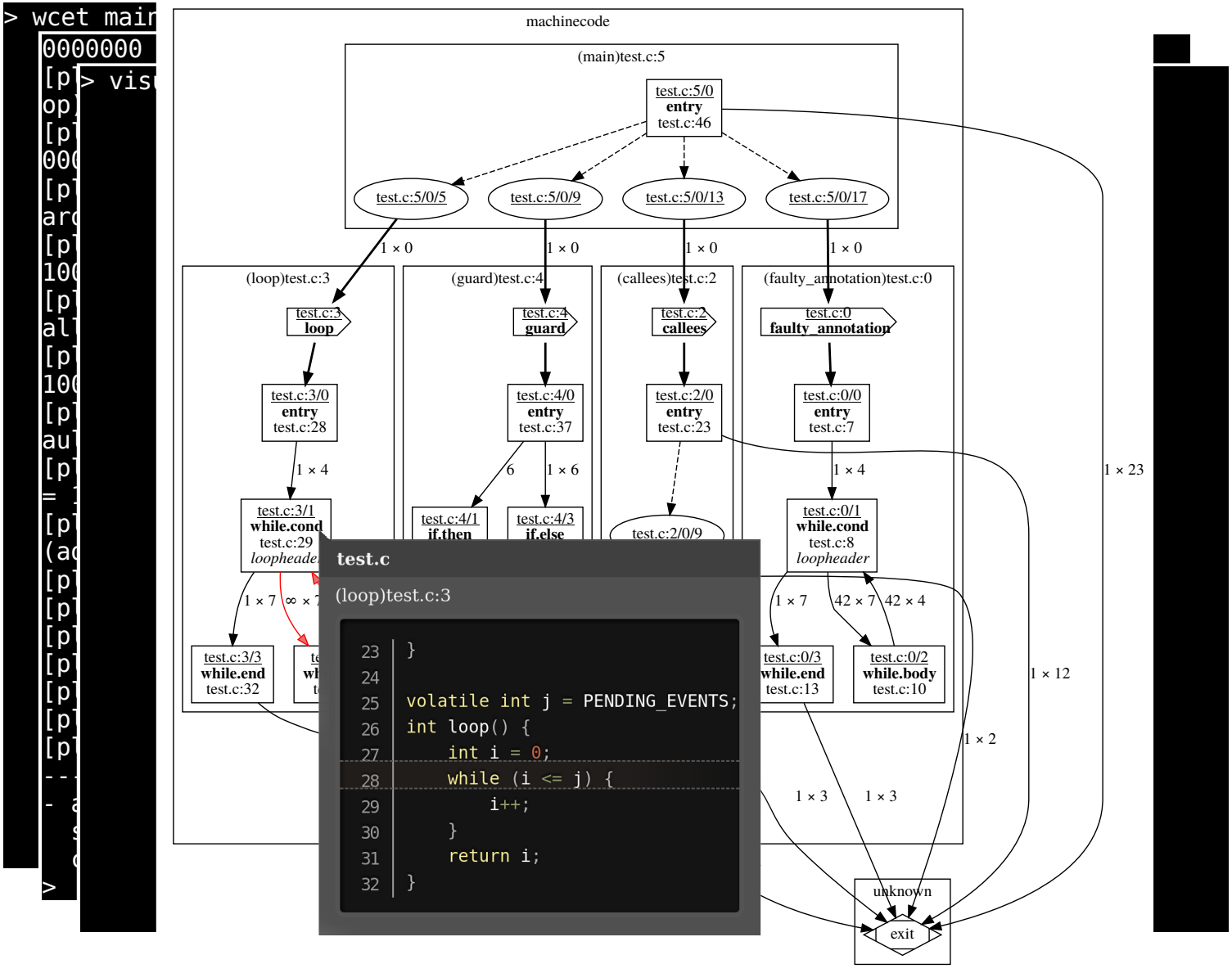

Interaktive Annotation

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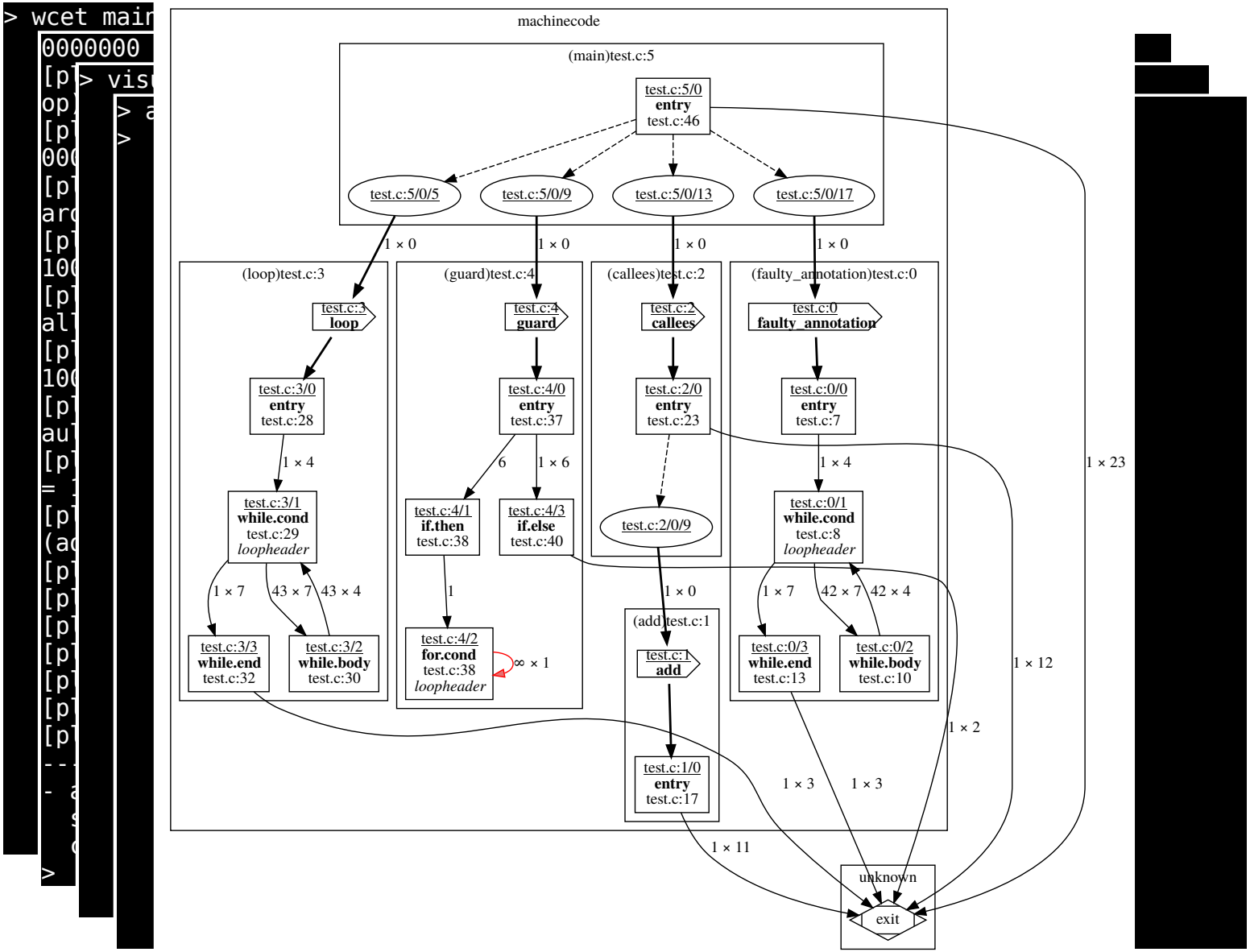

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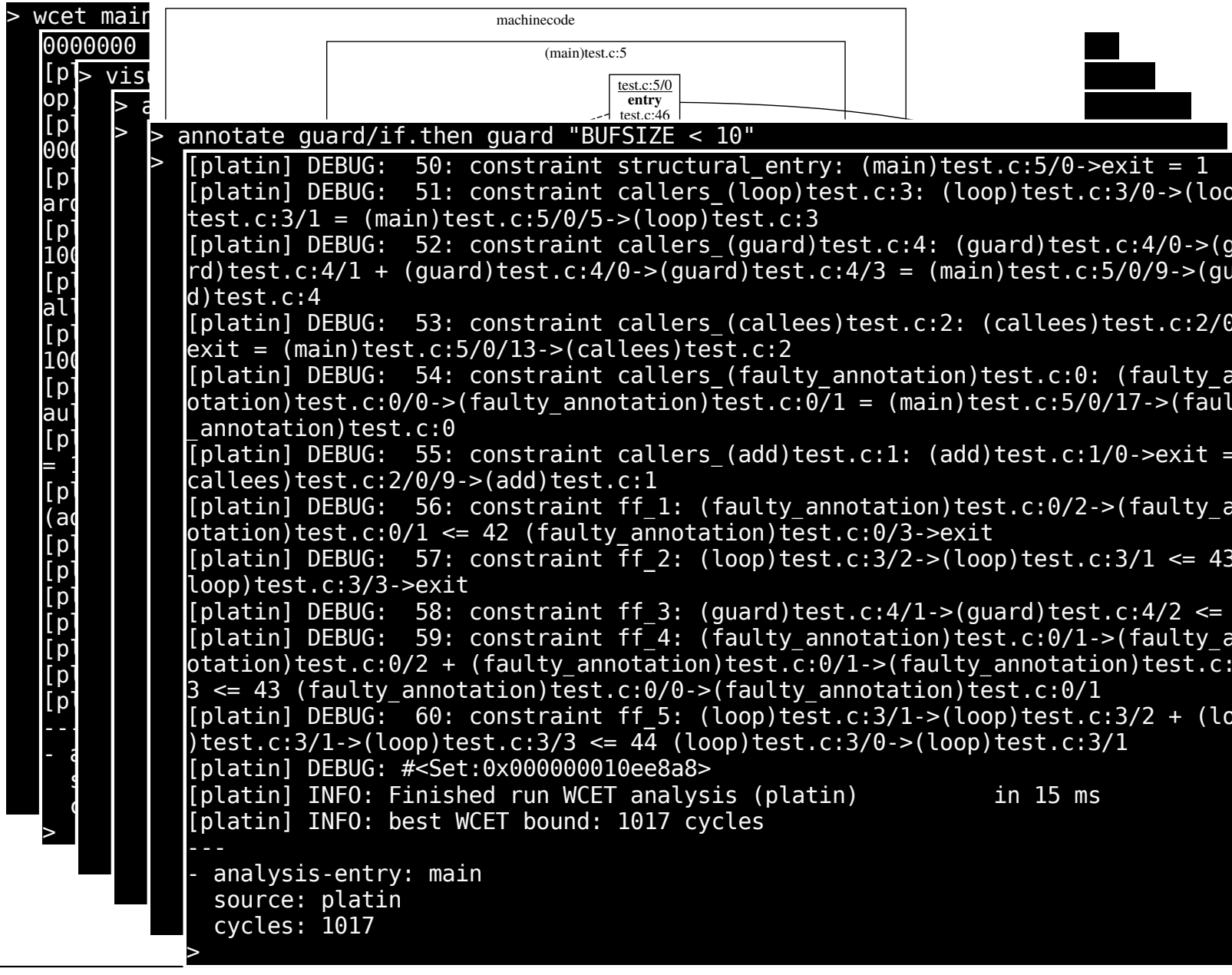

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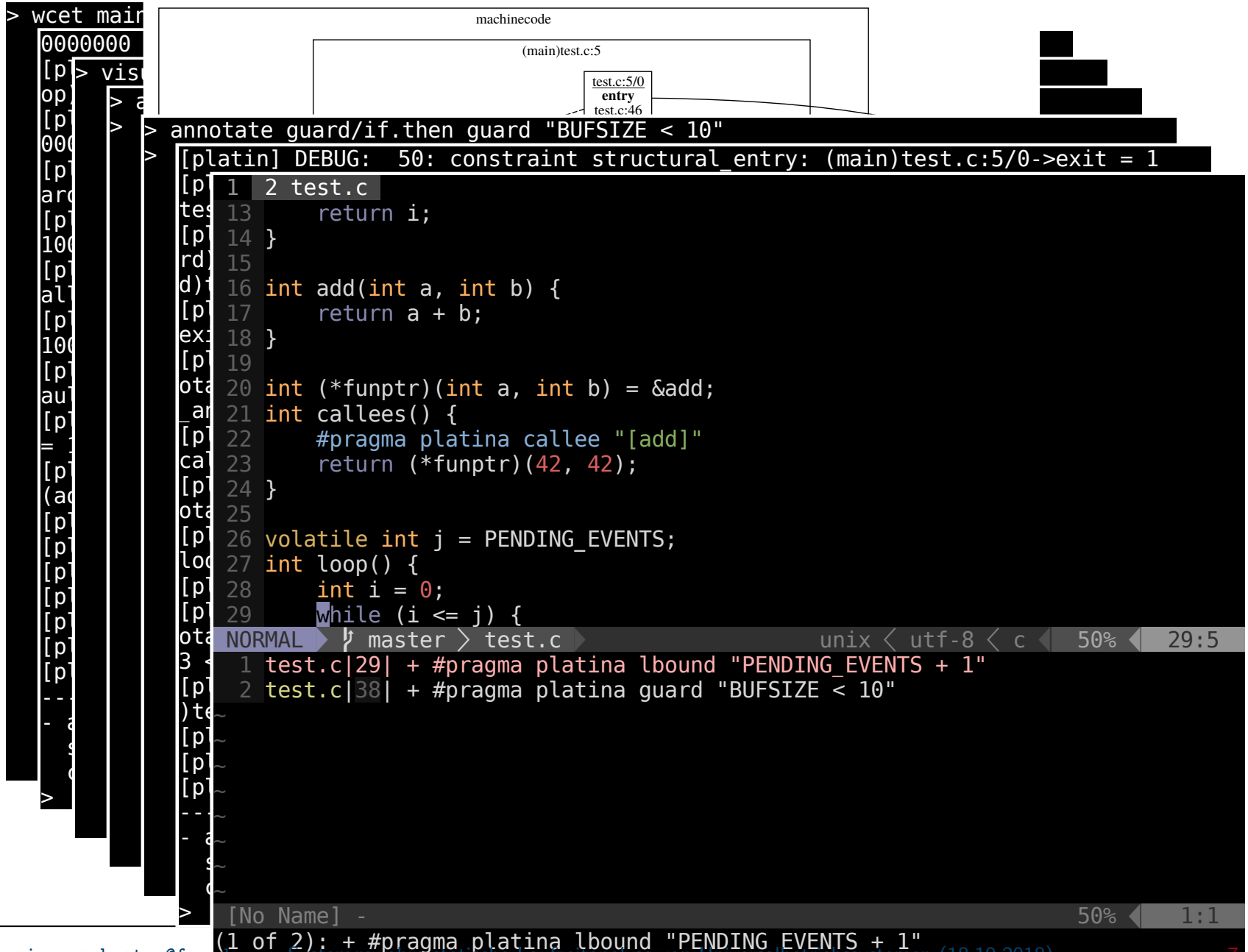

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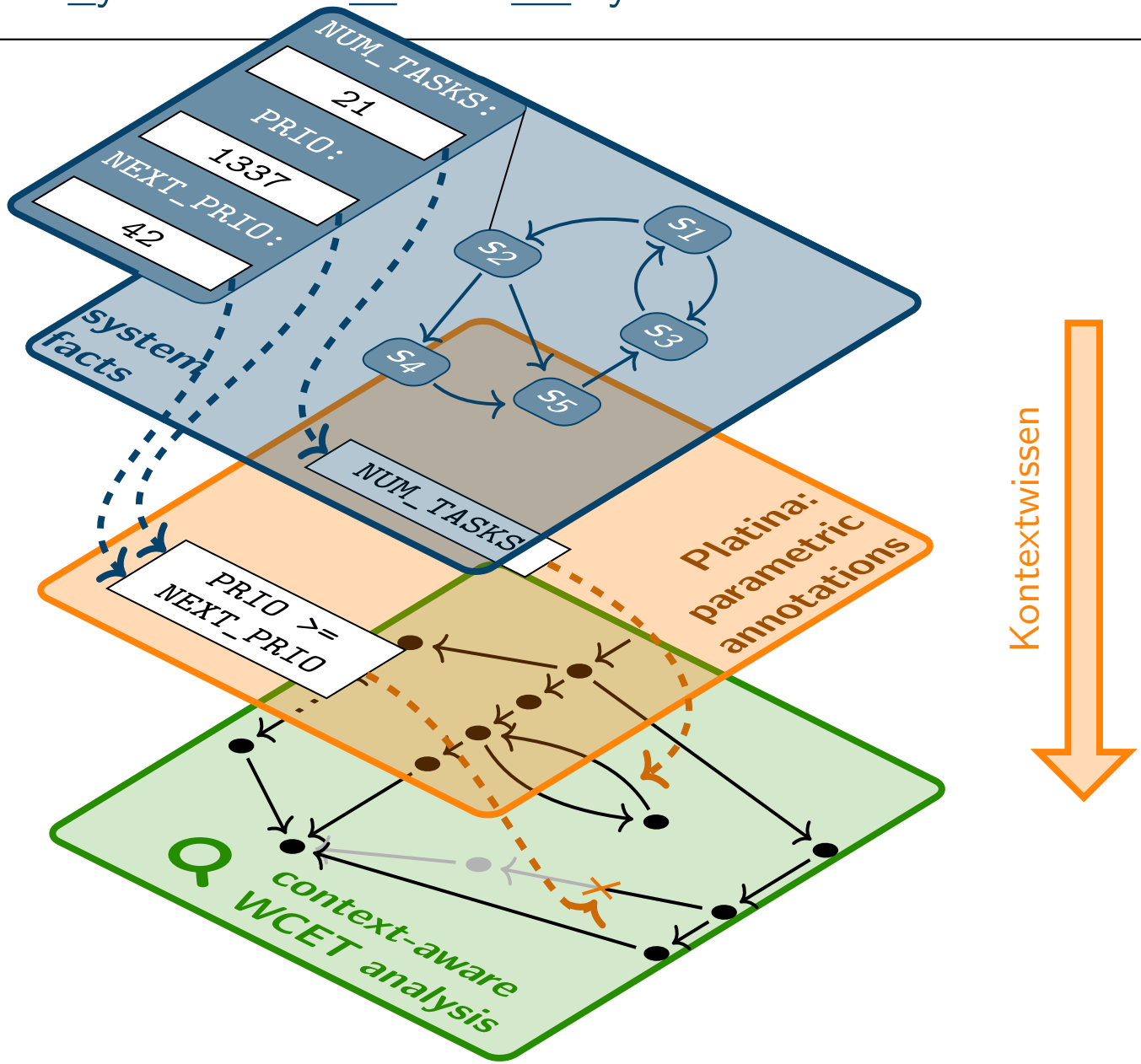

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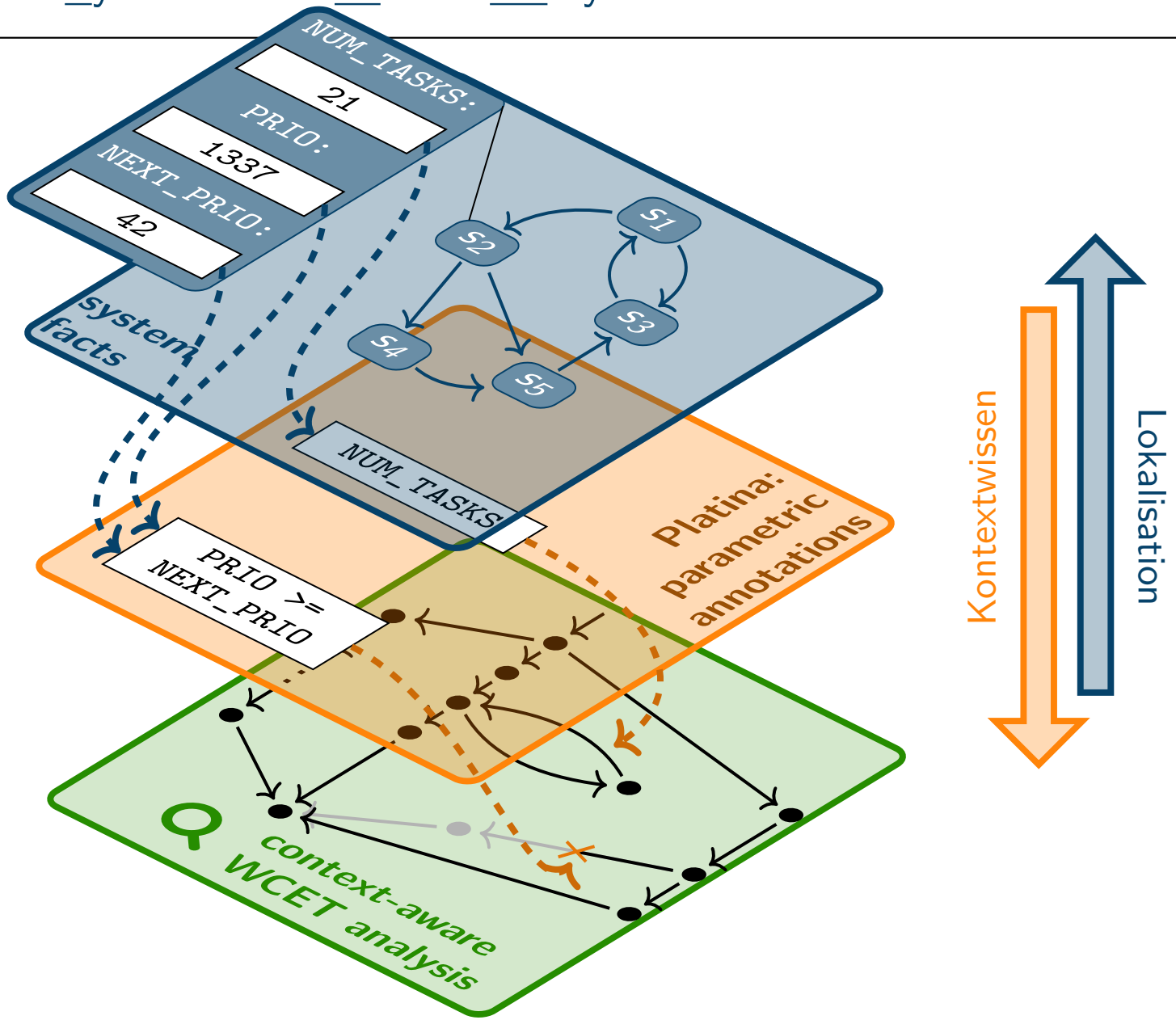
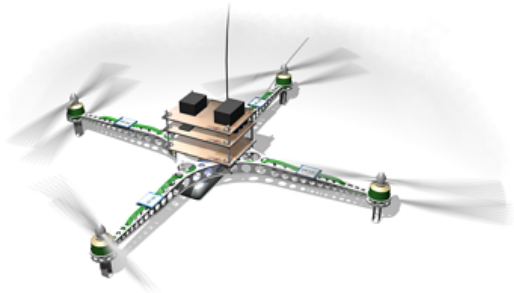
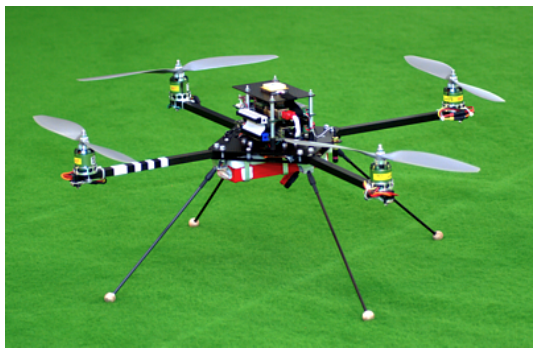
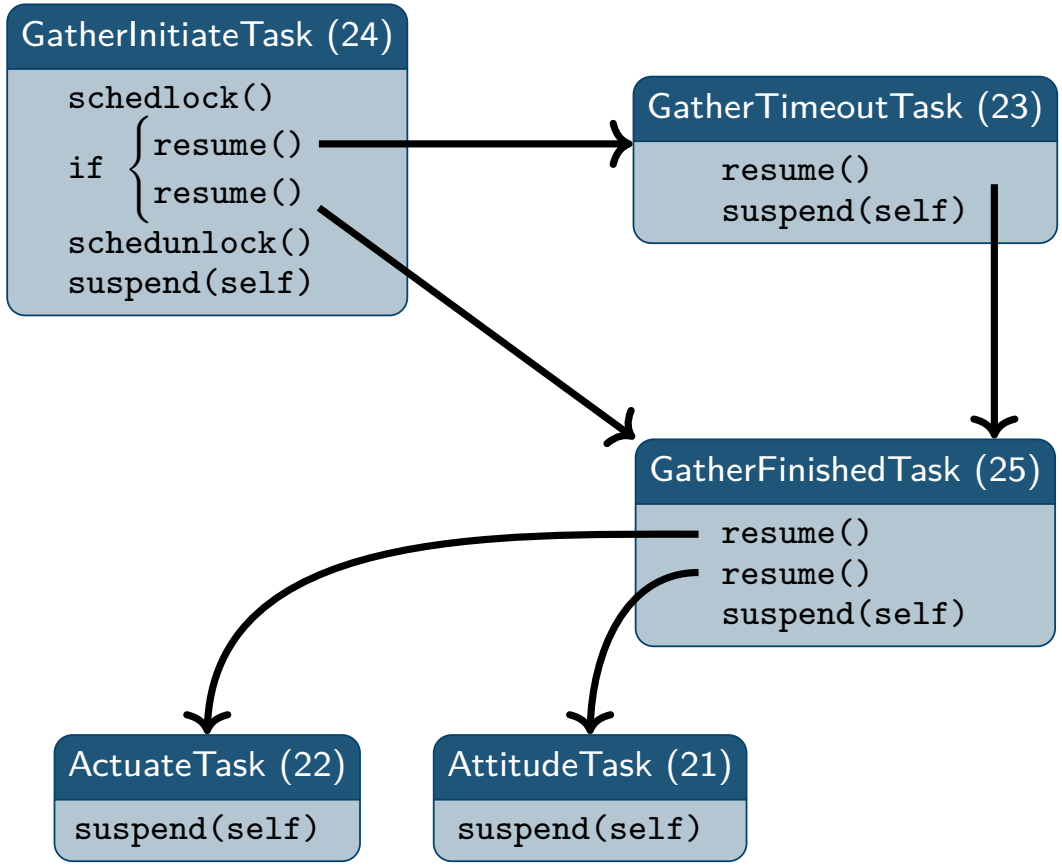


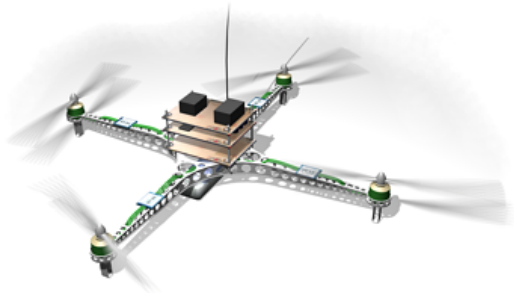
Fallstudie I4Copter (I)

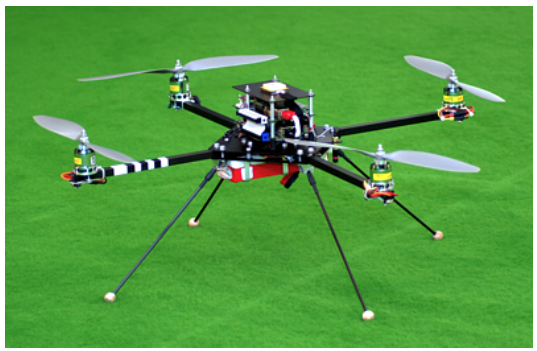


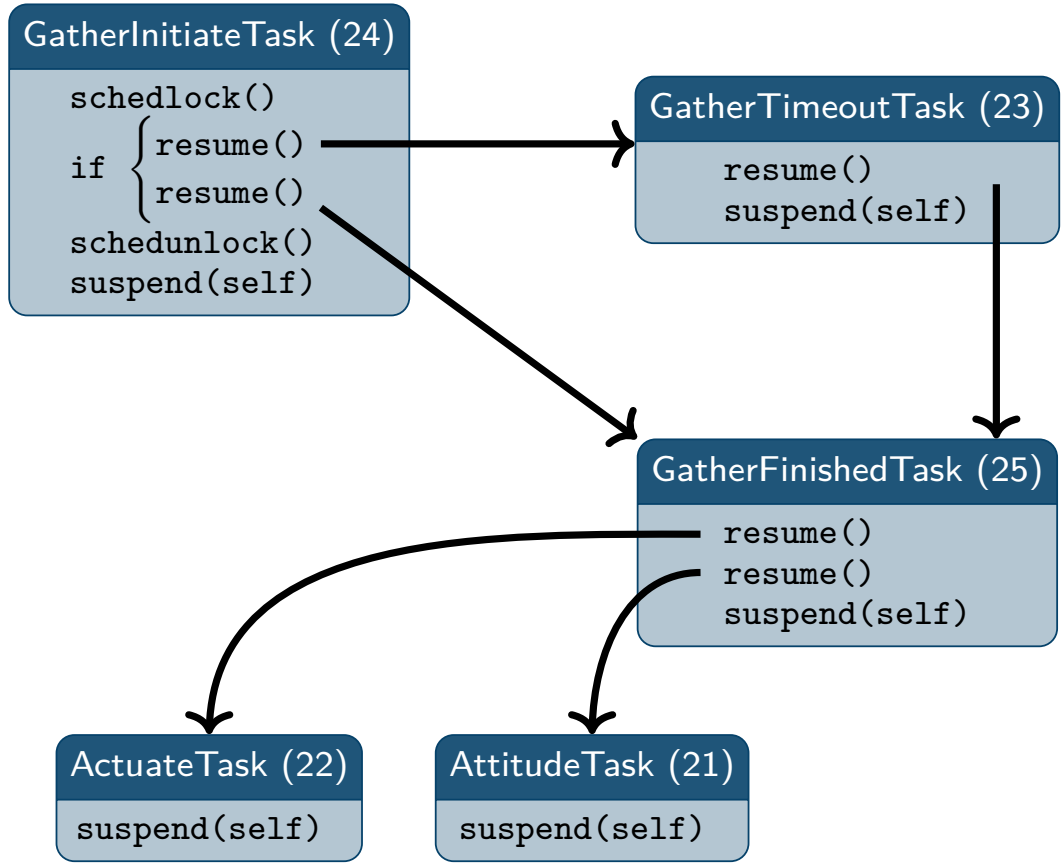




Fallstudie I4Copter (I)

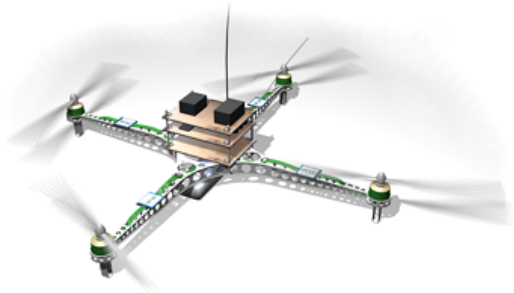


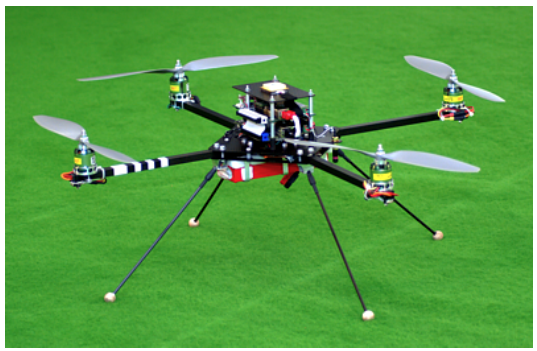


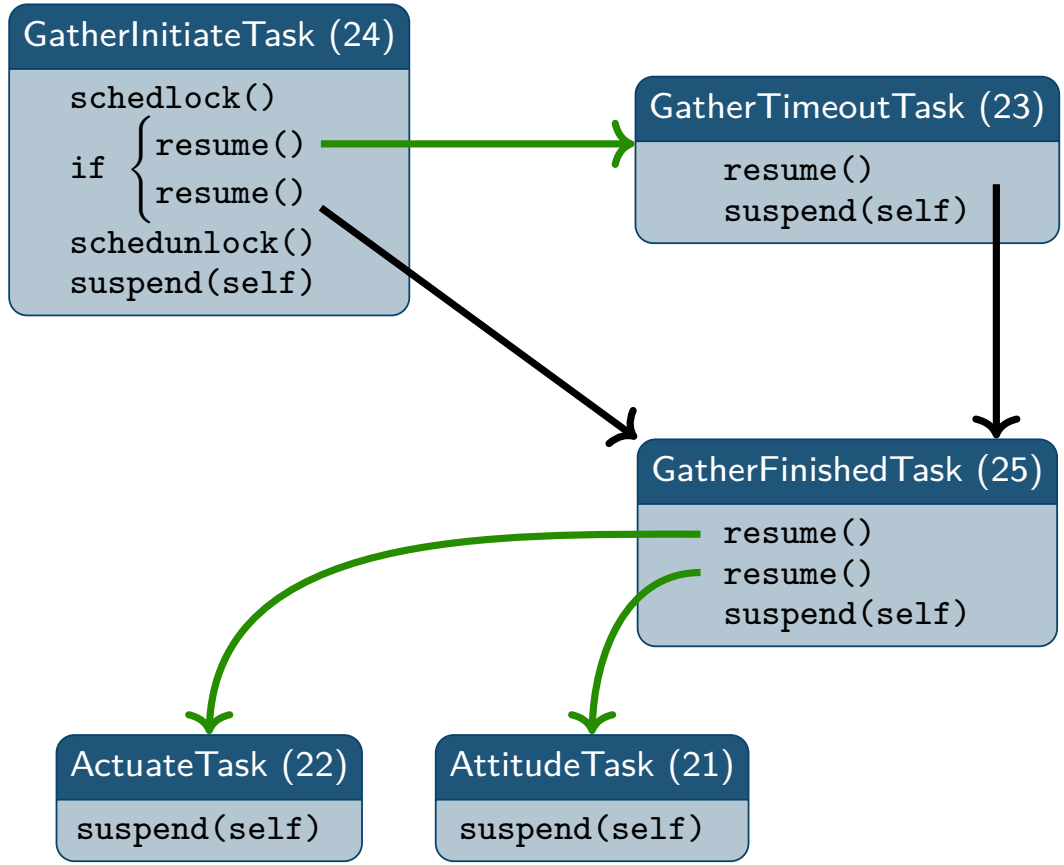



```
void ResumeTask(struct tcb* next) {
  // ...
  if (next->prio > cur->prio) {
  #pragma platina guard "NEXT_PRIO > CUR_PRIO"
    reschedule(); // expensive
  } // ...
}
```

Fallstudie I4Copter (I)

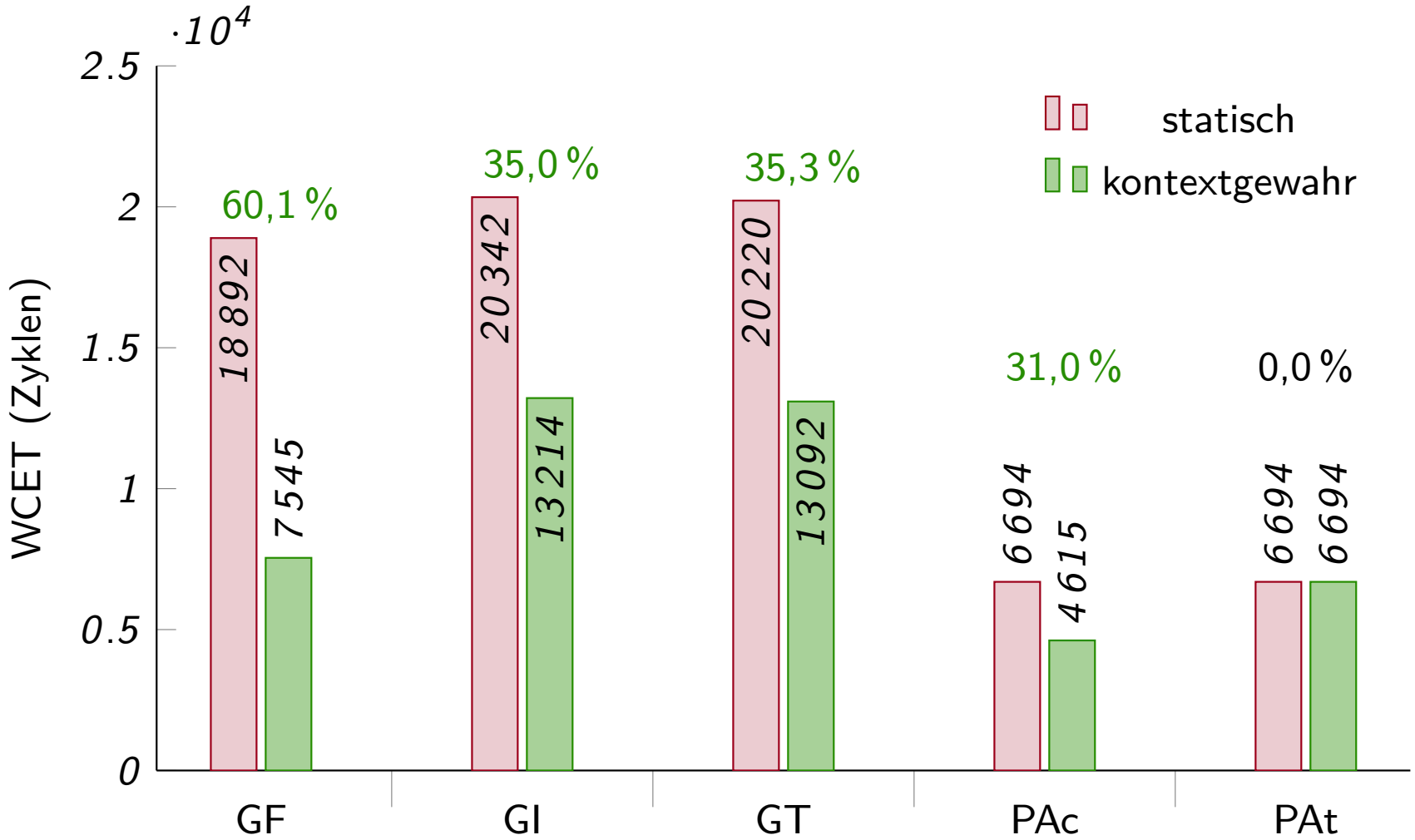




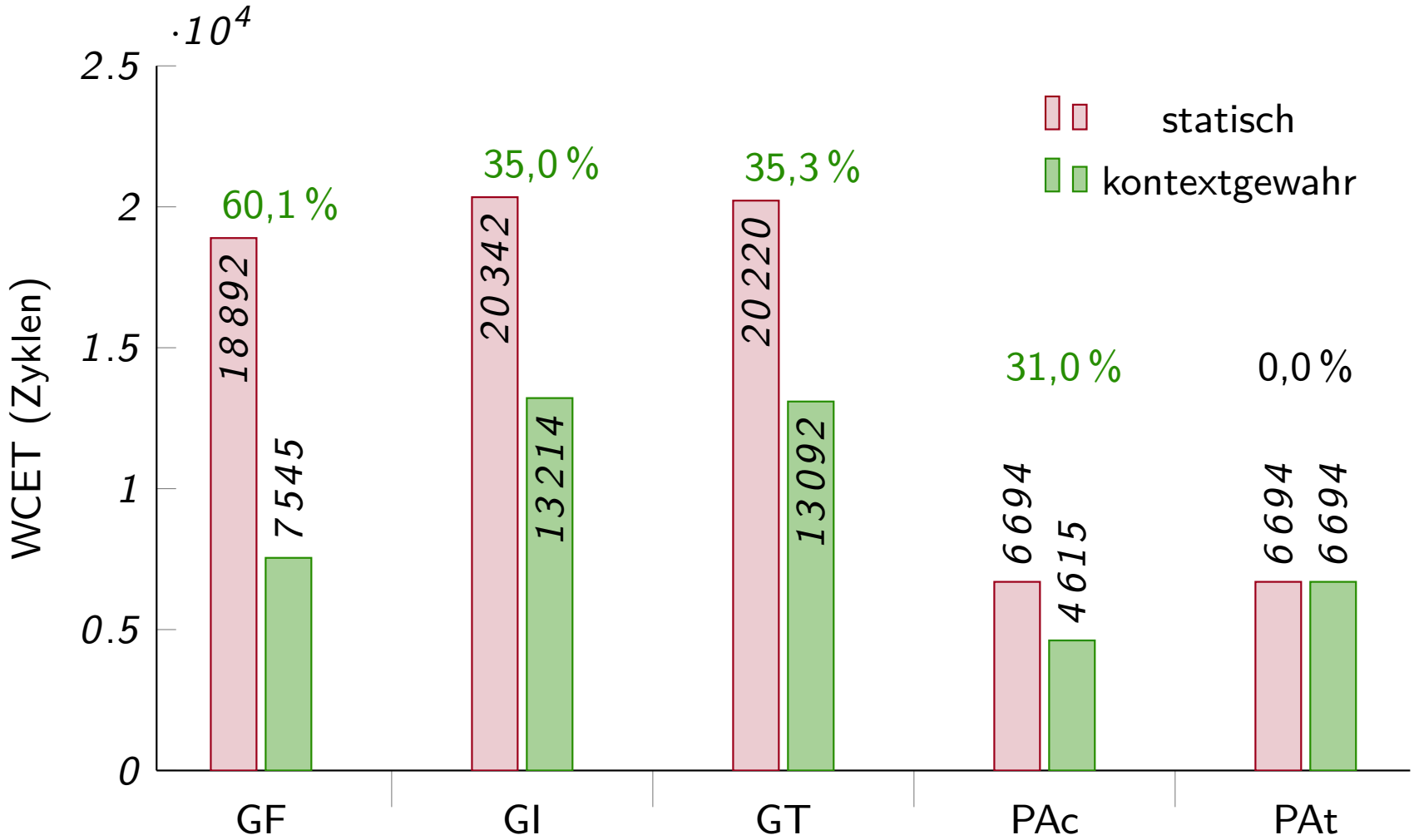



```
void ResumeTask(struct tcb* next) {
  // ...
  if (next->prio > cur->prio) {
  #pragma platina guard "NEXT_PRIO > CUR_PRIO"
    reschedule(); // expensive
  } // ...
}
```

Fallstudie I4Copter (II)



Fallstudie I4Copter (II)



⇒ Schlimmstmögliche Antwortzeit des Aufgabensystems um **40,7 %** geringer

Zusammenfassung

- statische Laufzeitanalyse von Universalbetriebssystemen problematisch
  - Pfadidentifikation
  - Abhängigkeit vom dynamischen Laufzeitkontext

⇒ Lösungsansatz: modellbasierte, parametrierbare statische Laufzeitanalyse

✓ Annotationssprache auf Hochsprachenebene
✓ Optimierungsgewahre Integration in Übersetzer und Laufzeitanalyse
✓ Effiziente Annotation durch interaktive, integrierte Annotationsumgebung

- Ermöglicht statische Laufzeitanalyse kompletter Betriebssysteme

⇒ Kontextgewahre Analyse ermöglicht über 40 % bessere Schranken

`https://gitlab.cs.fau.de/SWAN/`