Vorhersagbare Migration in Echtzeitsystemen

Fachgruppentreffen Betriebssysteme, 11.03.2021

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technische universität dortmund

DFG

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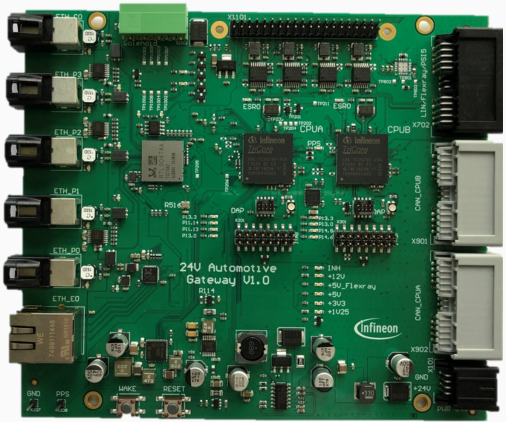
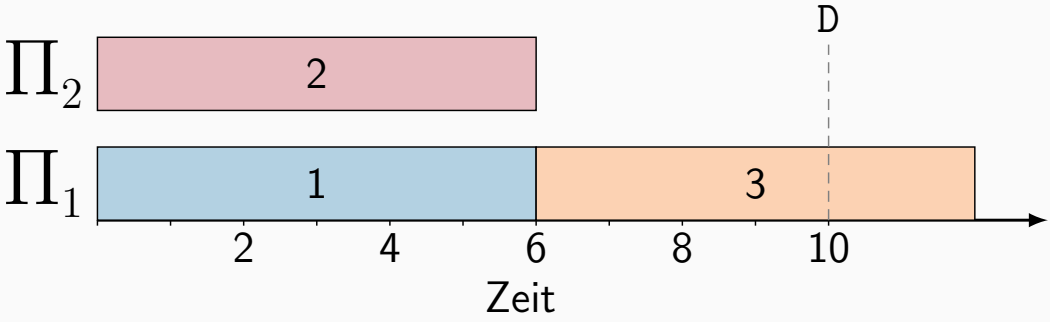
Komplexe, eingebettete Systeme



Quelle: Infineon

https://www.infineon.com/cms/en/product/evaluation-boards/kit_a2g_tc397_24v_gtw

Migration als Notwendigkeit



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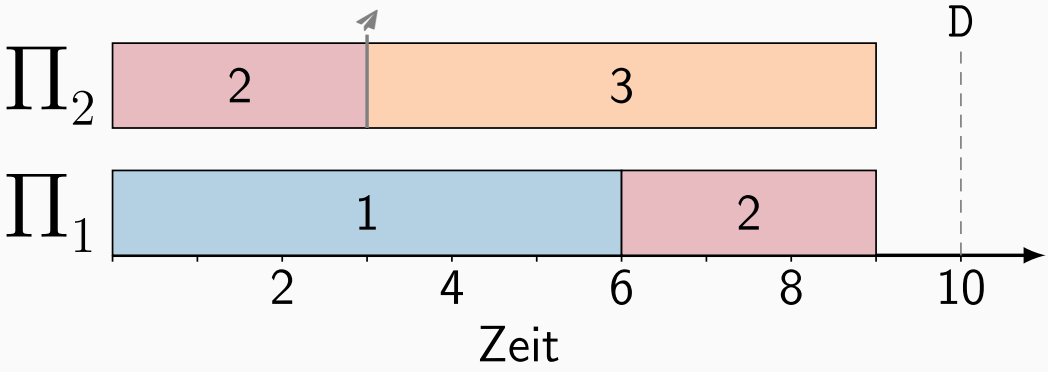

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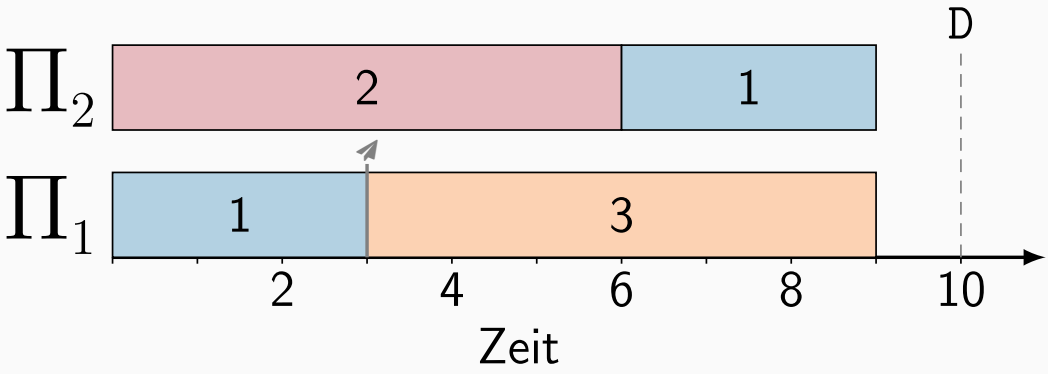

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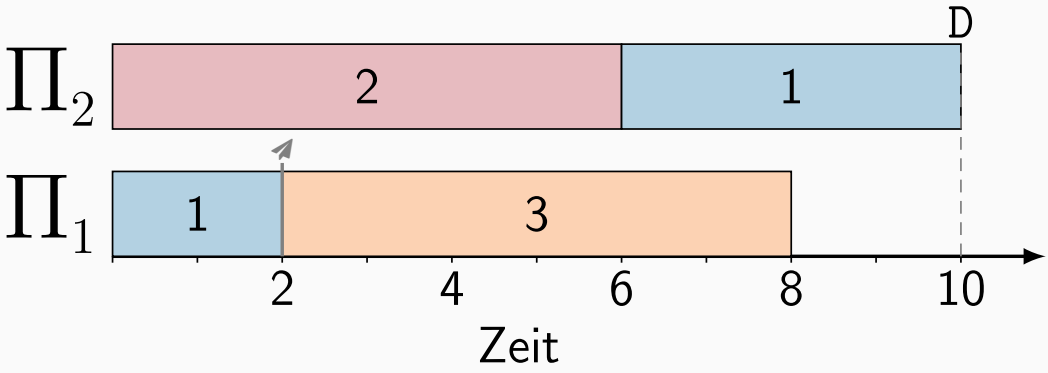

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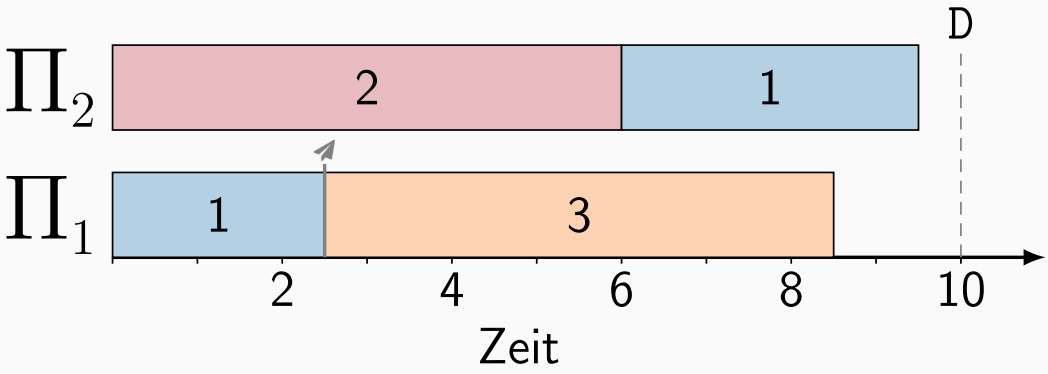

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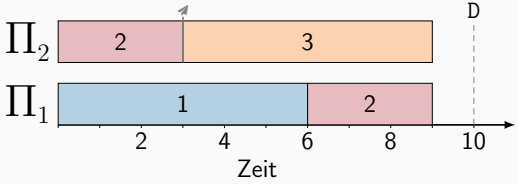

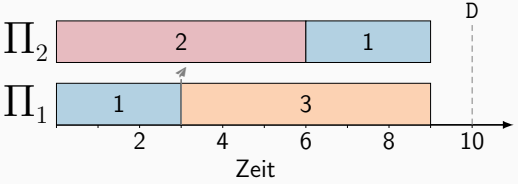

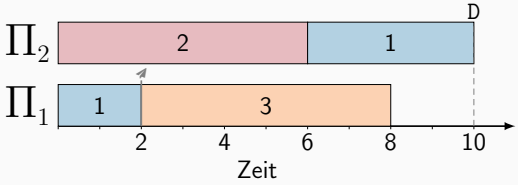

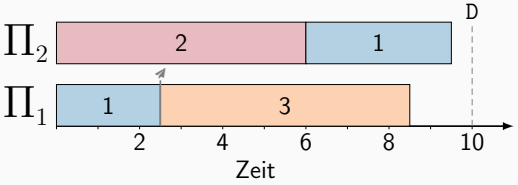

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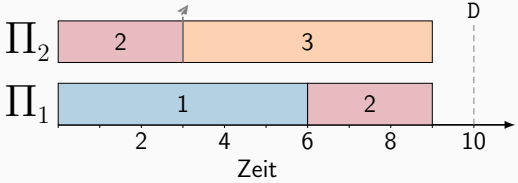
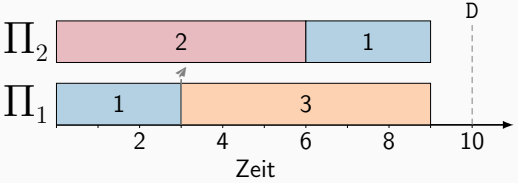
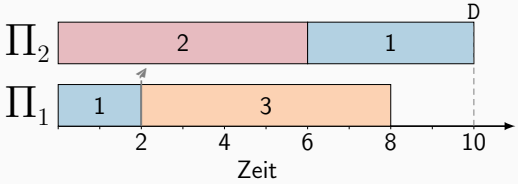
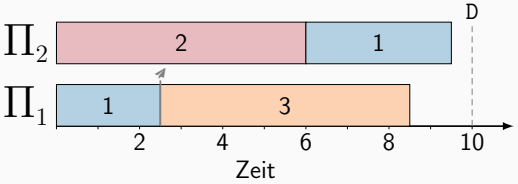




Migration = Migration?





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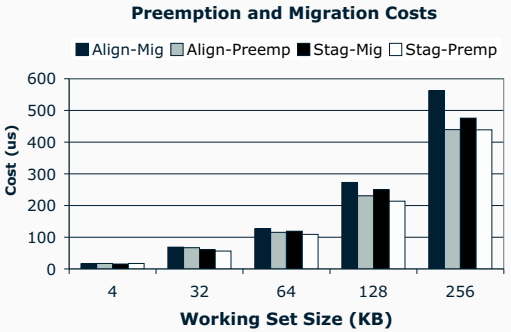
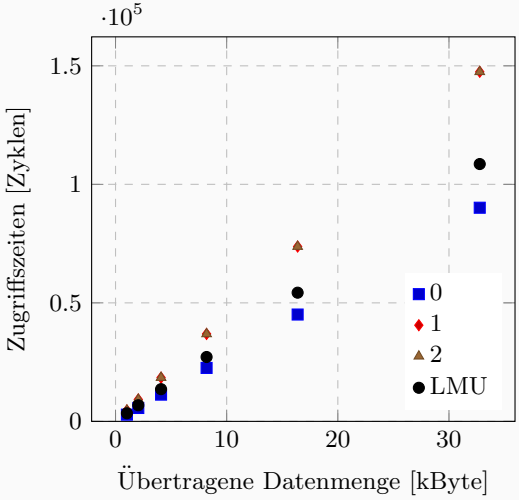
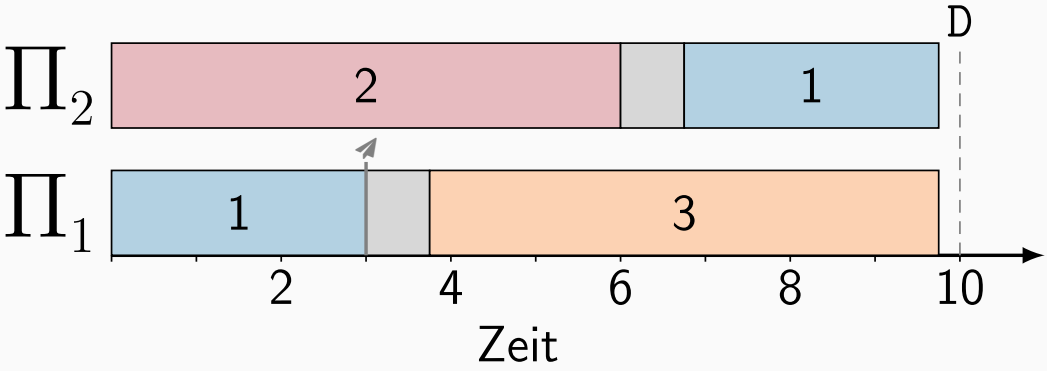


Abbildung aus: Calandrino, J, et al. LITMUSRT: A Testbed for Empirically Comparing Real-Time Multiprocessor Schedulers, RTSS'06



Verwaltungsgemeinkosten



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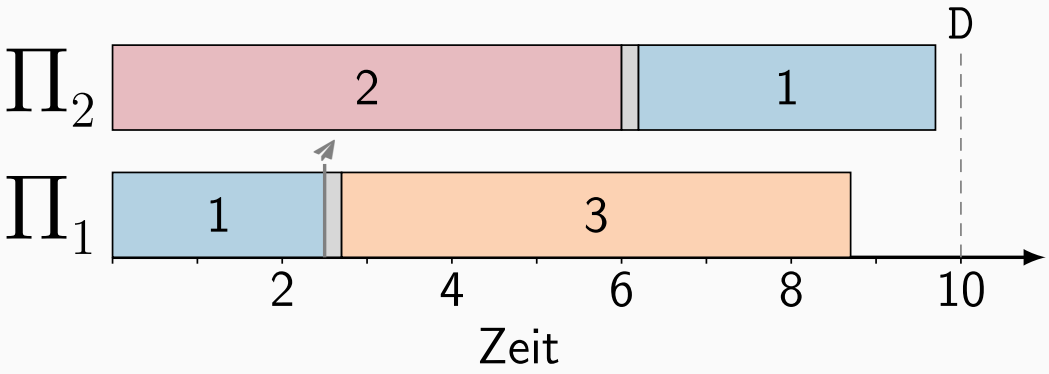

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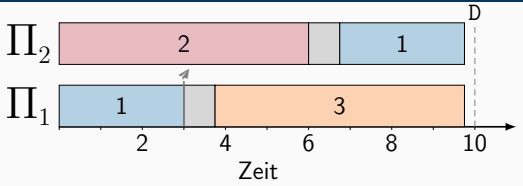

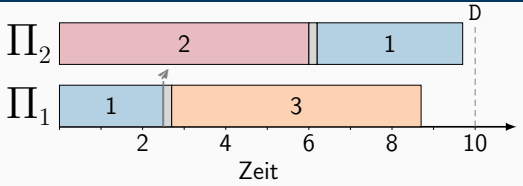

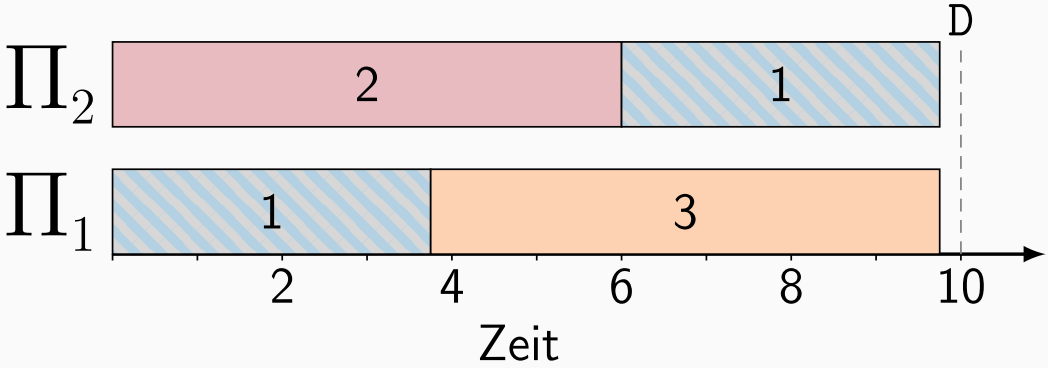

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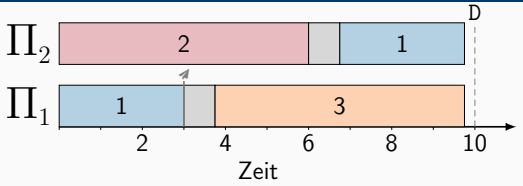
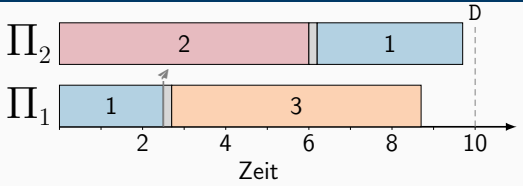
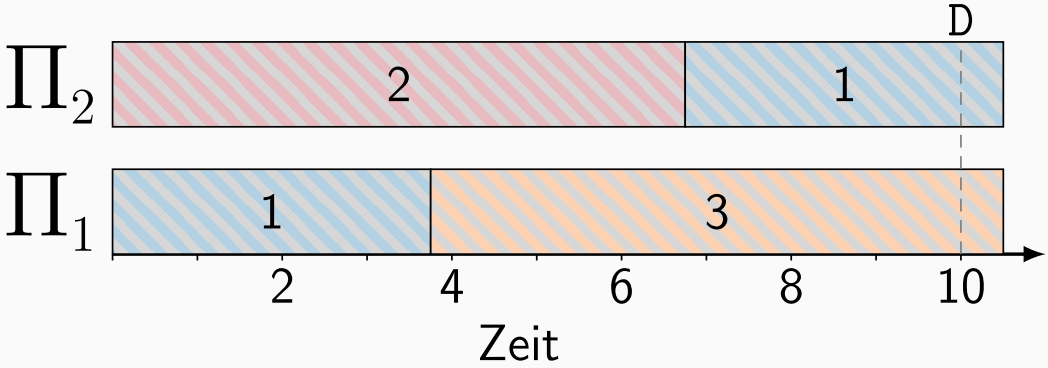
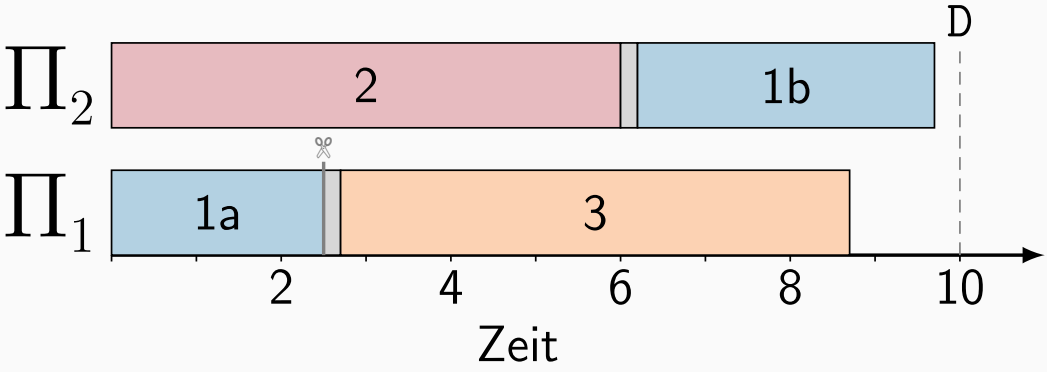






Statisch gebilligte Migration



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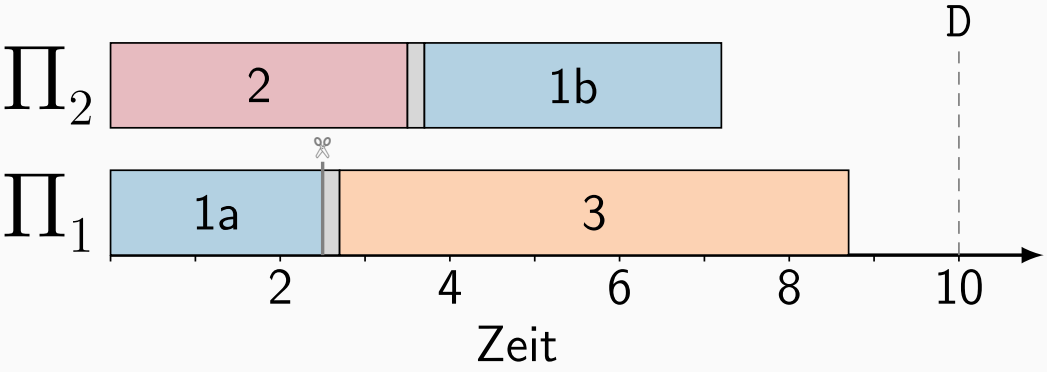

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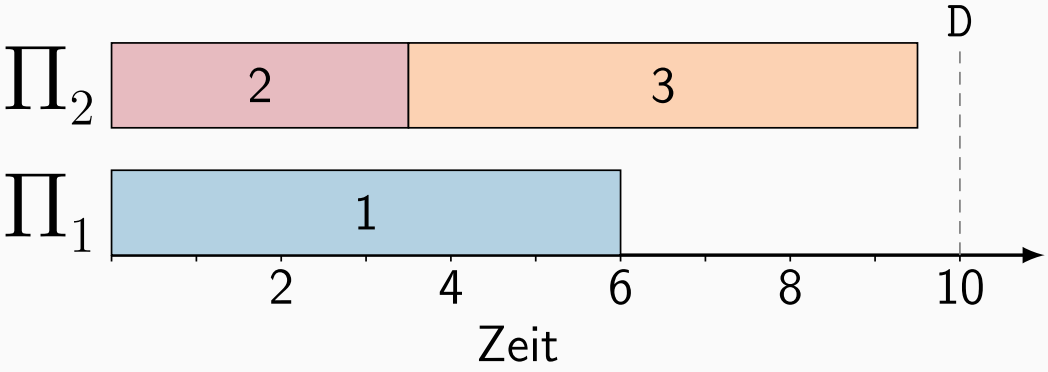


Ziele

- Vorhersagbarkeit: Finden günstiger Migrationspunkte
- Flexibilität: Vermeidung unnötiger Migration
- Laufzeiteffizienz

Agenda

Migration in Echtzeitsystemen

Vorhersagbarkeit

Betriebssystemmechanismen

Migrationsbasierte Synchronisation

Fazit

Statische Festlegung

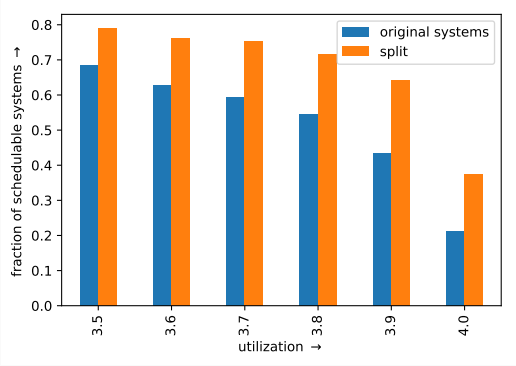
Bekannte Ansätze

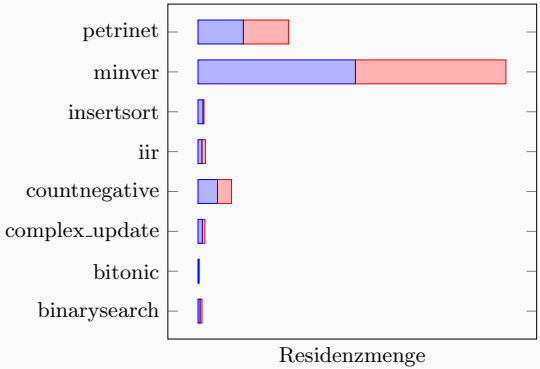
- automatisiertes Checkpointing
- implizit kooperatives Scheduling
- Platzierung von Migrationspunkten

Unser Ansatz

- multikriteriell: WCET und Migrationskosten
- gezielte Suche vs. gleichmäßiges Streuen
- Maßschneiderung

Erste Ergebnisse

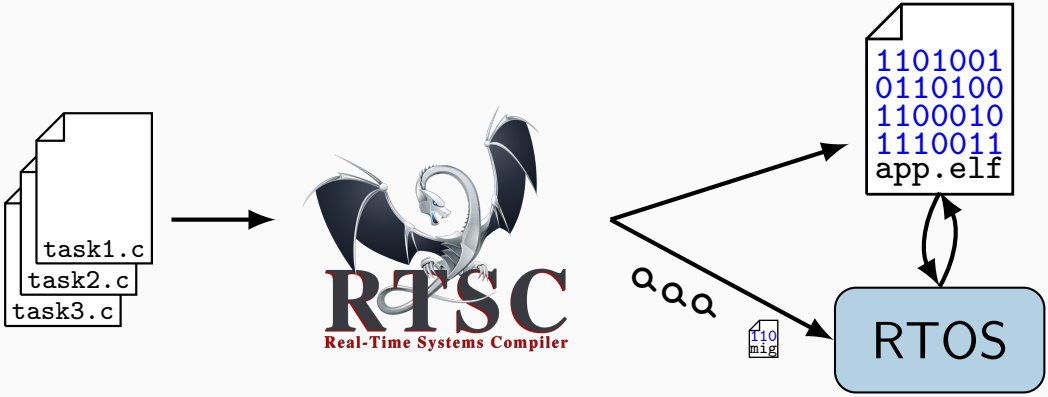




Klaus, T; Ulbrich, P; Raffeck, P; Frank, B; Wernet, L; Ritter von Onciul, M; Schröder-Preikschat, W. Boosting Job-Level Migration by Static Analysis, OSPERT'19

Betriebssystemmechanismen

Betriebssystemschnittstelle



Migrationsmechanismen

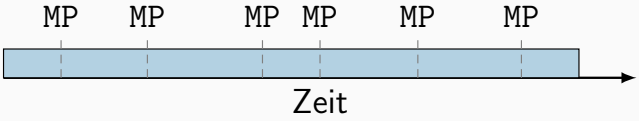
Vorbereitung

- Auslösen durch Anwendung
  - Systemaufruf
  - maßgeschneiderte Funktion
- eingewoben durch den Compiler
- sichere Kooperation

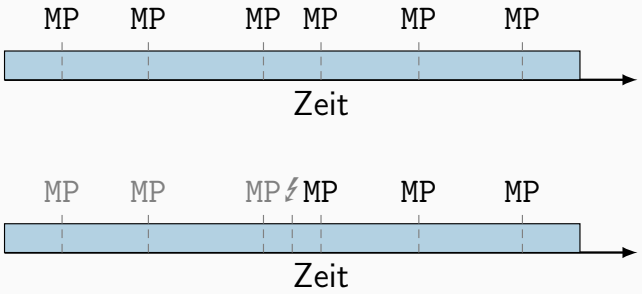
Zur Laufzeit

- Entscheidung nach Schlupf
- Überprüfung an Migrationspunkt
- Überprüfung nach Zeitspanne
- Überspringen unnötiger Punkte

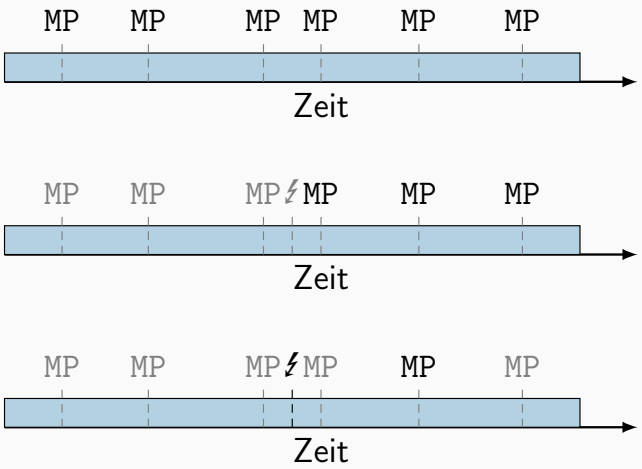
Mögliche Ablaufplanung zur Laufzeit



Mögliche Ablaufplanung zur Laufzeit



Mögliche Ablaufplanung zur Laufzeit



Wohin mit dem gesammelten Wissen?

1. Migration statt Verzögerung wartender Tasks
2. Erweiterung des Entscheidungsspielraums um Kritikalität
3. Migration als primäre Koordinationsmaßnahme

Migrationsbasierte Synchronisation

Synchronisation Globaler Datenstrukturen

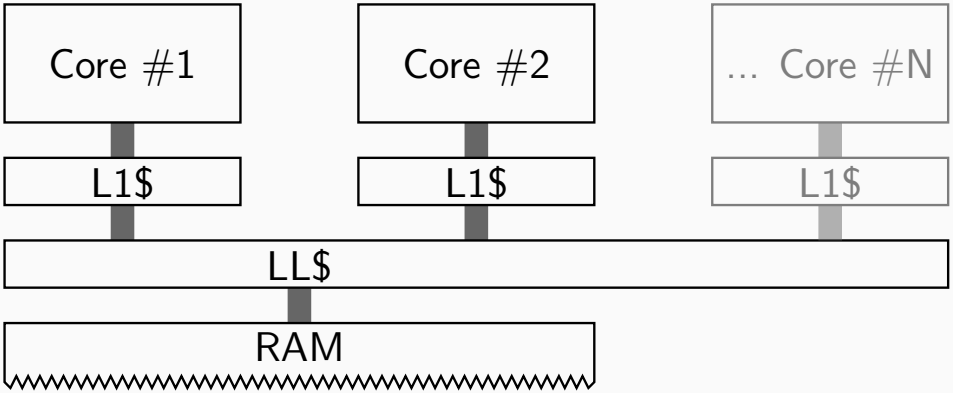
Lock-basierte Synchronisation

- schlechte Datenlokalität, häufige Cache-misses
- Blockadezeiten abhängig von WCET kritischer Abschnitte

Migrationsbasierte Synchronisation

- Kontrollfluss- statt Datenmigration
- dedizierte „Synchronisationskerne”
- geteilte Daten in garantiert warmen Caches
- Schnittstellenkompatibel zu Locks

Migrationsbasierte Synchronisation



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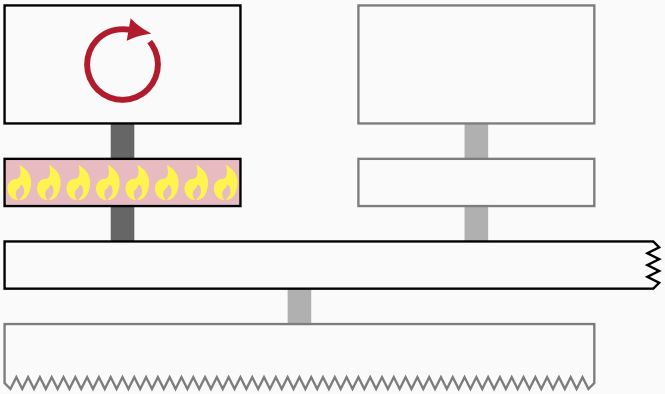

```
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```

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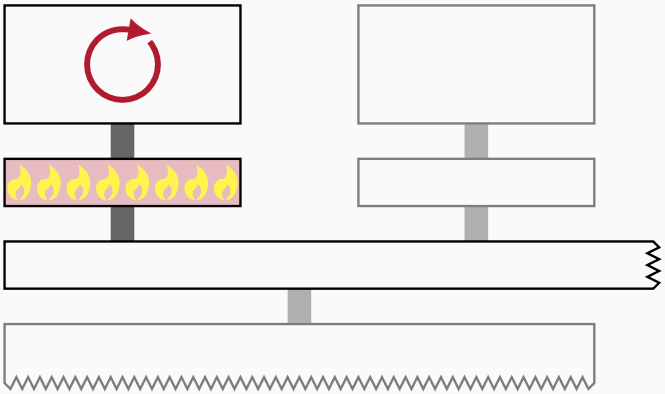

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foo();
lock();

use(data);
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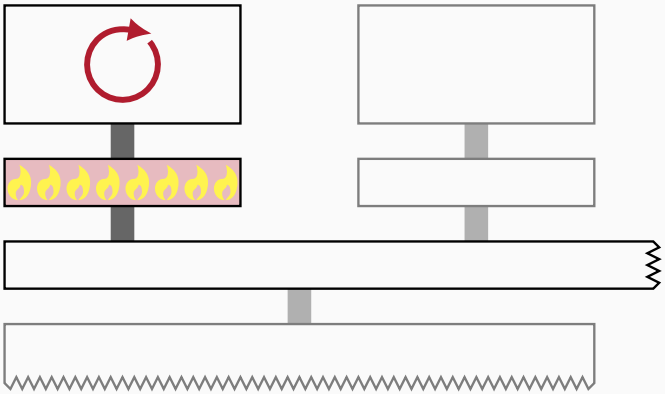
Migrationsbasierte Synchronisation



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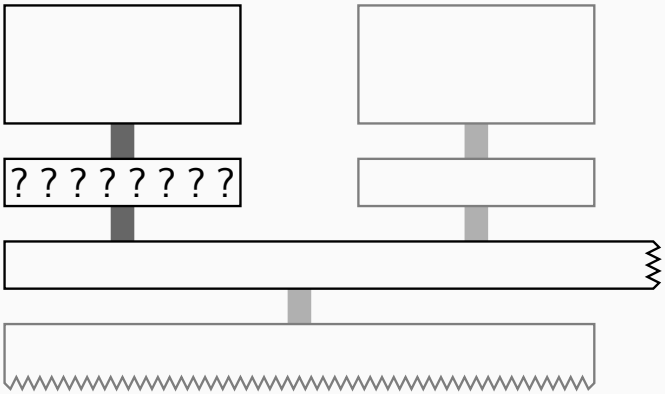


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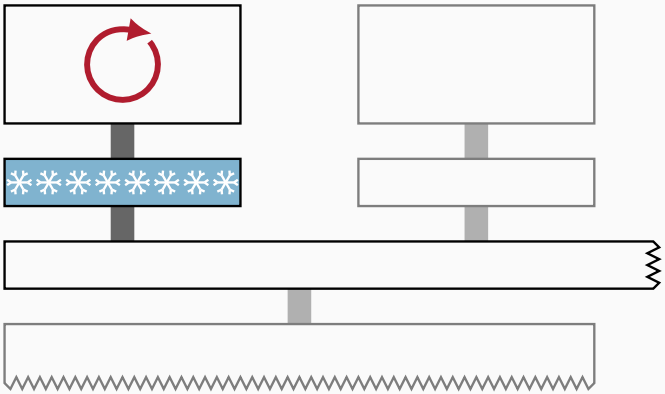

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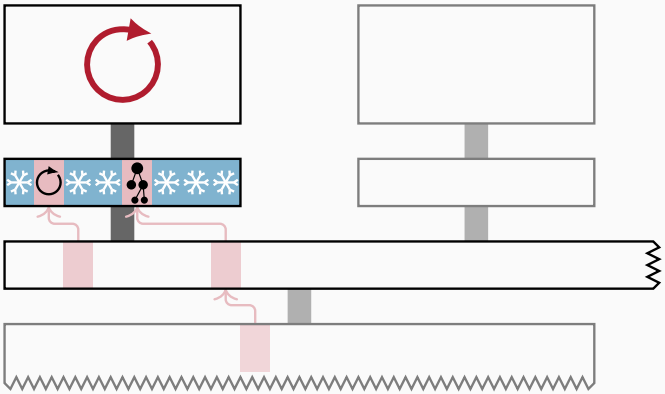

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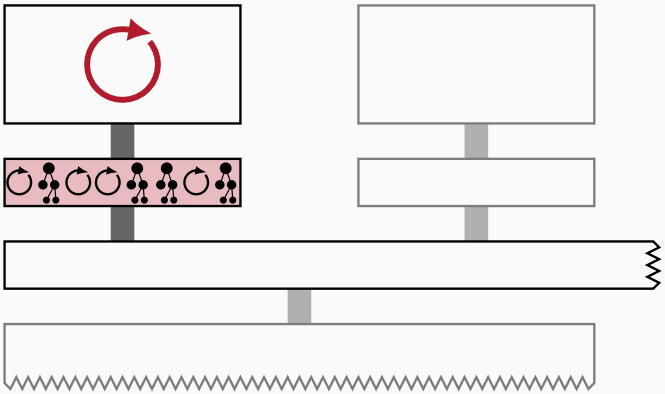

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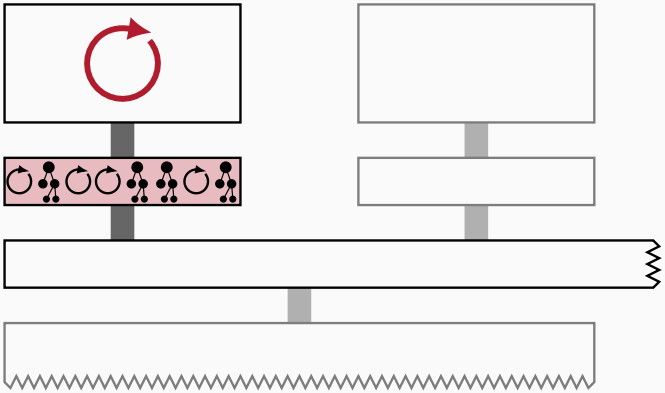

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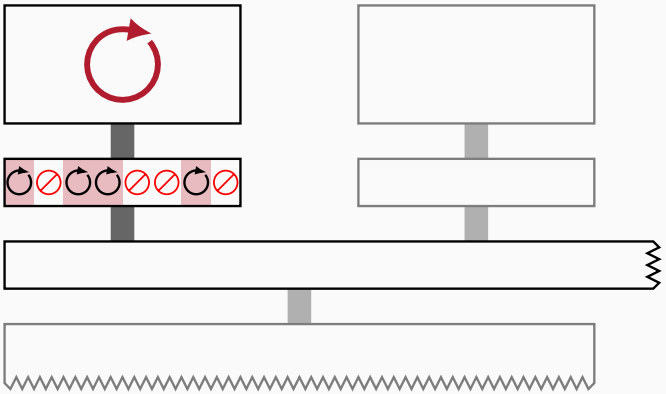

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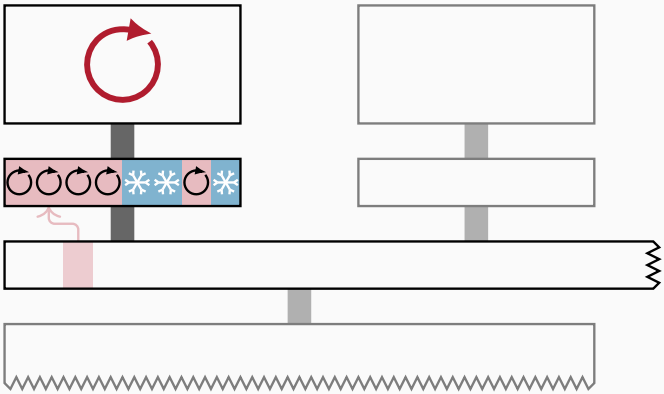

```
foo();
lock();
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use(data);
unlock();
bar();
```

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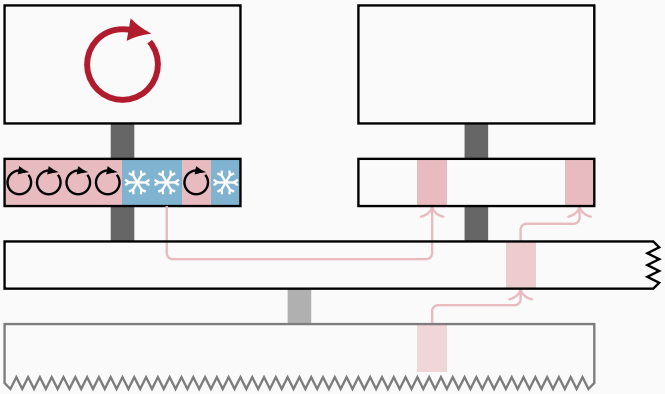

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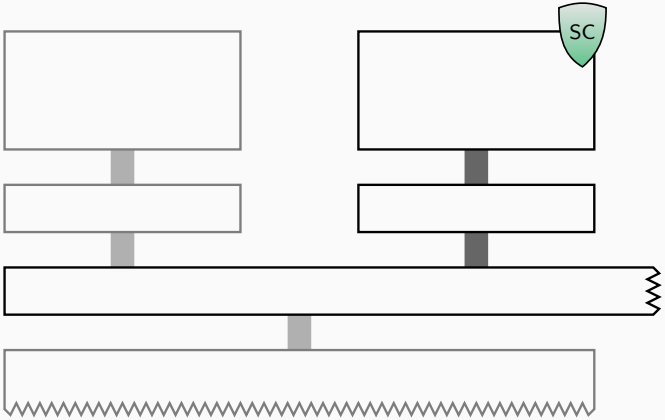

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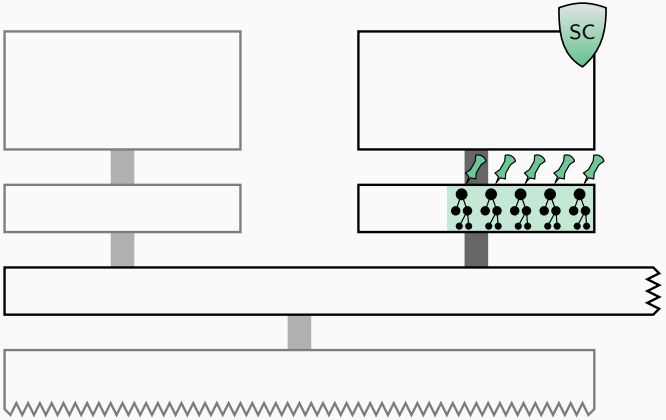

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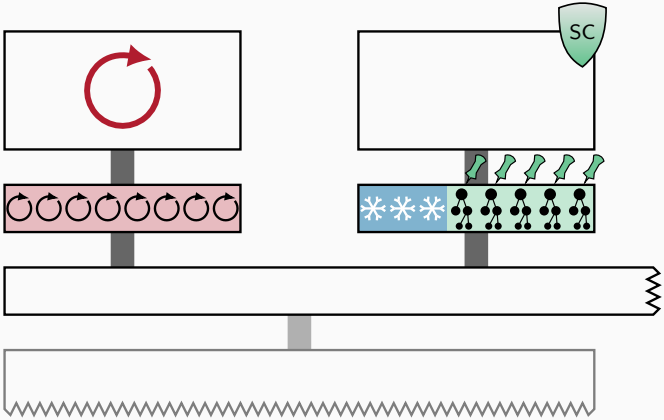

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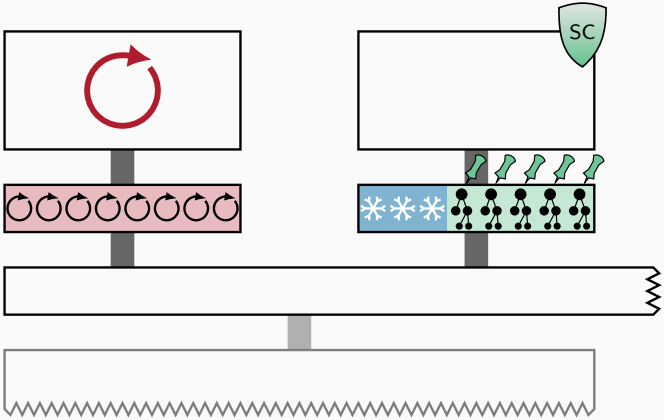


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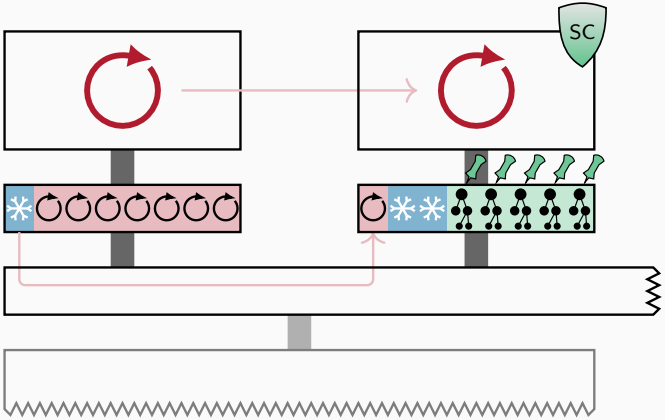


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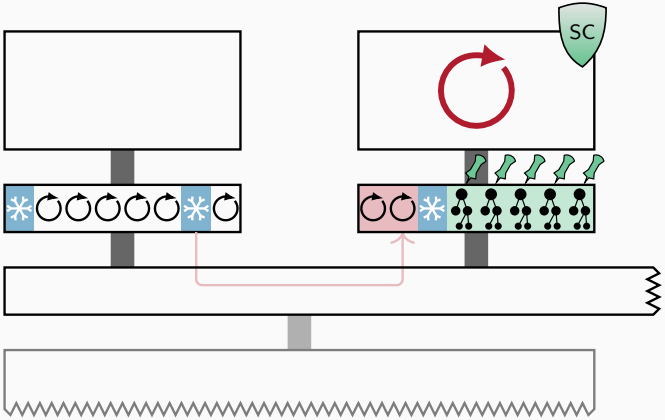
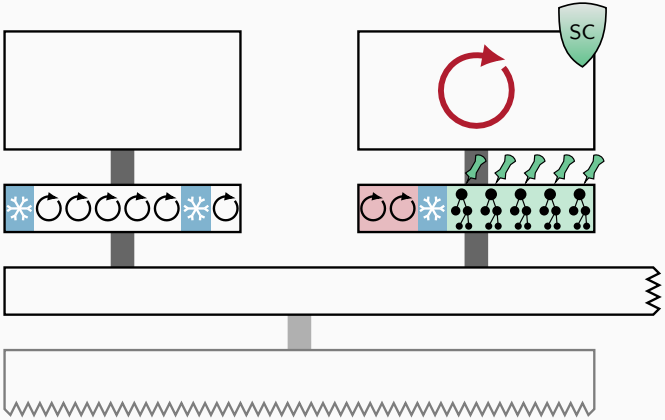
```

Migrationsbasierte Synchronisation



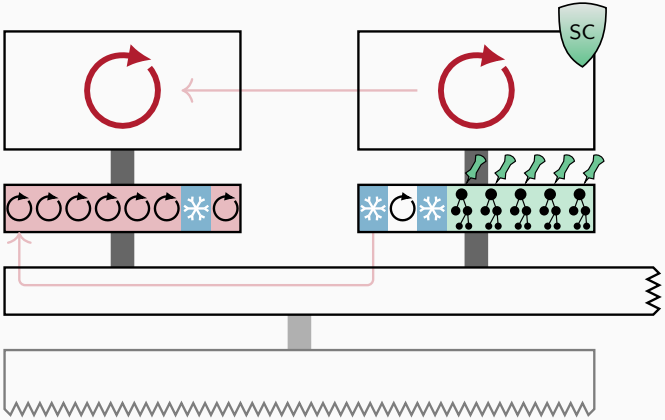

```
foo();
lock();
└▸migrate(sc);
use(data);
```

Migrationsbasierte Synchronisation



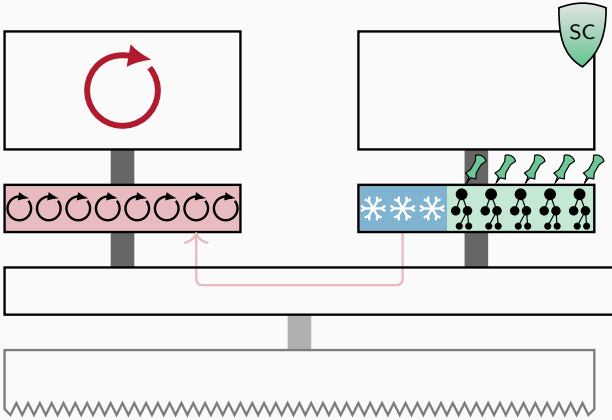

```
foo();
lock();
└►migrate(sc);
use(data);
unlock();
```

Migrationsbasierte Synchronisation



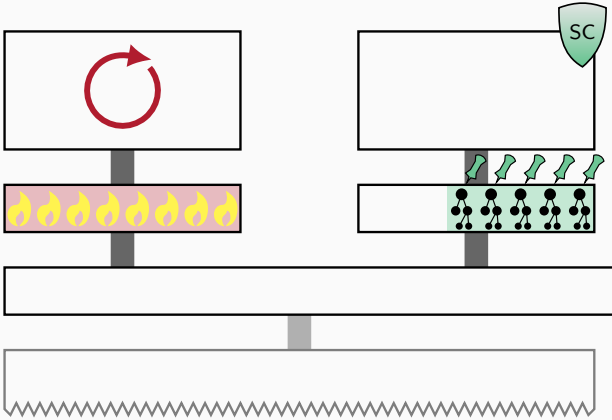

```
foo();
lock();
  └migrate(sc);
use(data);
unlock();
  └migrate(back);
```

Migrationsbasierte Synchronisation




```
foo();
lock();
└migrate(sc);
use(data);
unlock();
└migrate(back);
bar();
```

Migrationsbasierte Synchronisation




```
foo();
lock();
└migrate(sc);
use(data);
unlock();
└migrate(back);
bar();
```

Fazit

Fazit

- vorhersagbare Migration
- Laufzeitentscheidungen basierend auf Hinweisen
- Werkzeugunterstützung nötig
- geschickte Ausnutzung der Möglichkeiten
- effizientere, gut vorhersagbare Ausführung