Opacity

Concurrent Algorithms 2011

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

What is TM?

What is TM?

What does TM guarantee?

Serializability

Serializability

```
int a = acc_a;
acc_a = a - 20;
int b = acc_b;
acc_b = b + 20;
```

Serializability

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atomic { // t1
   int a = acc_a;
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atomic { // t1
1: int a = acc_a;
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atomic { // t2
5: int a = acc_a;
6: acc_a = a + 10;
}
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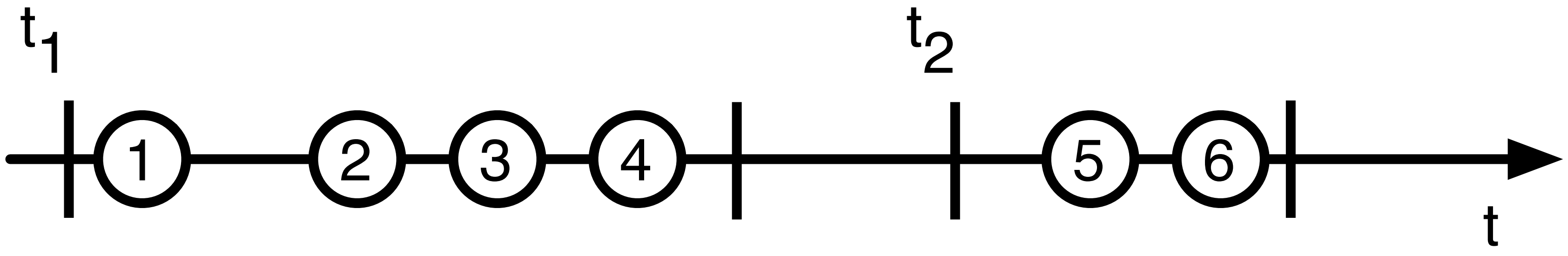

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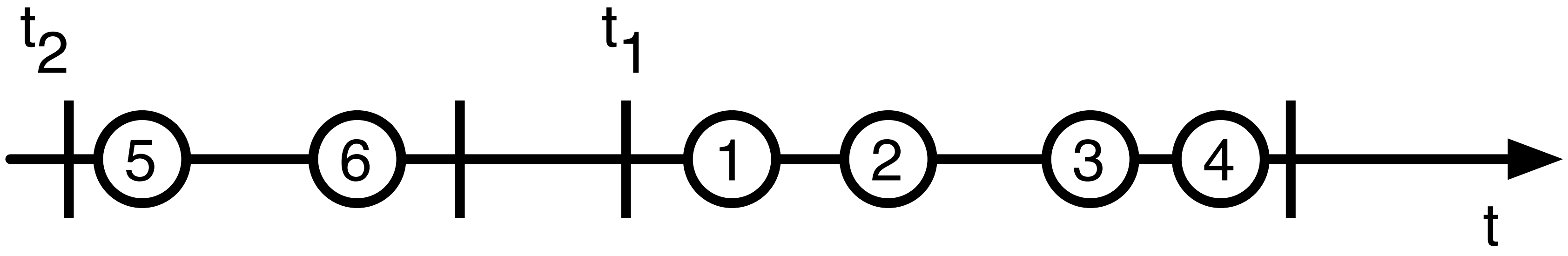

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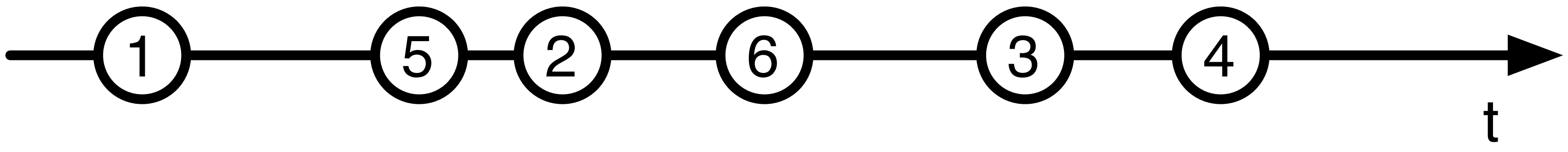

client ☺

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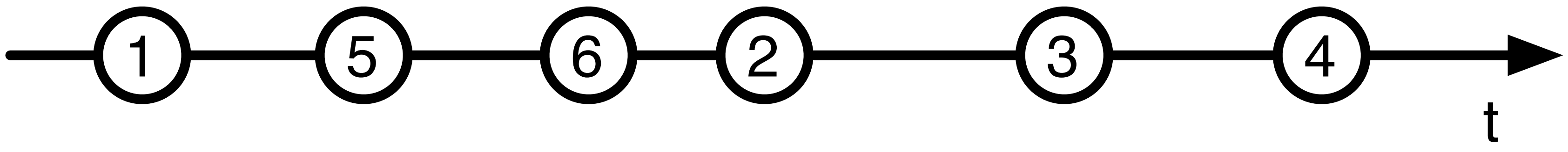
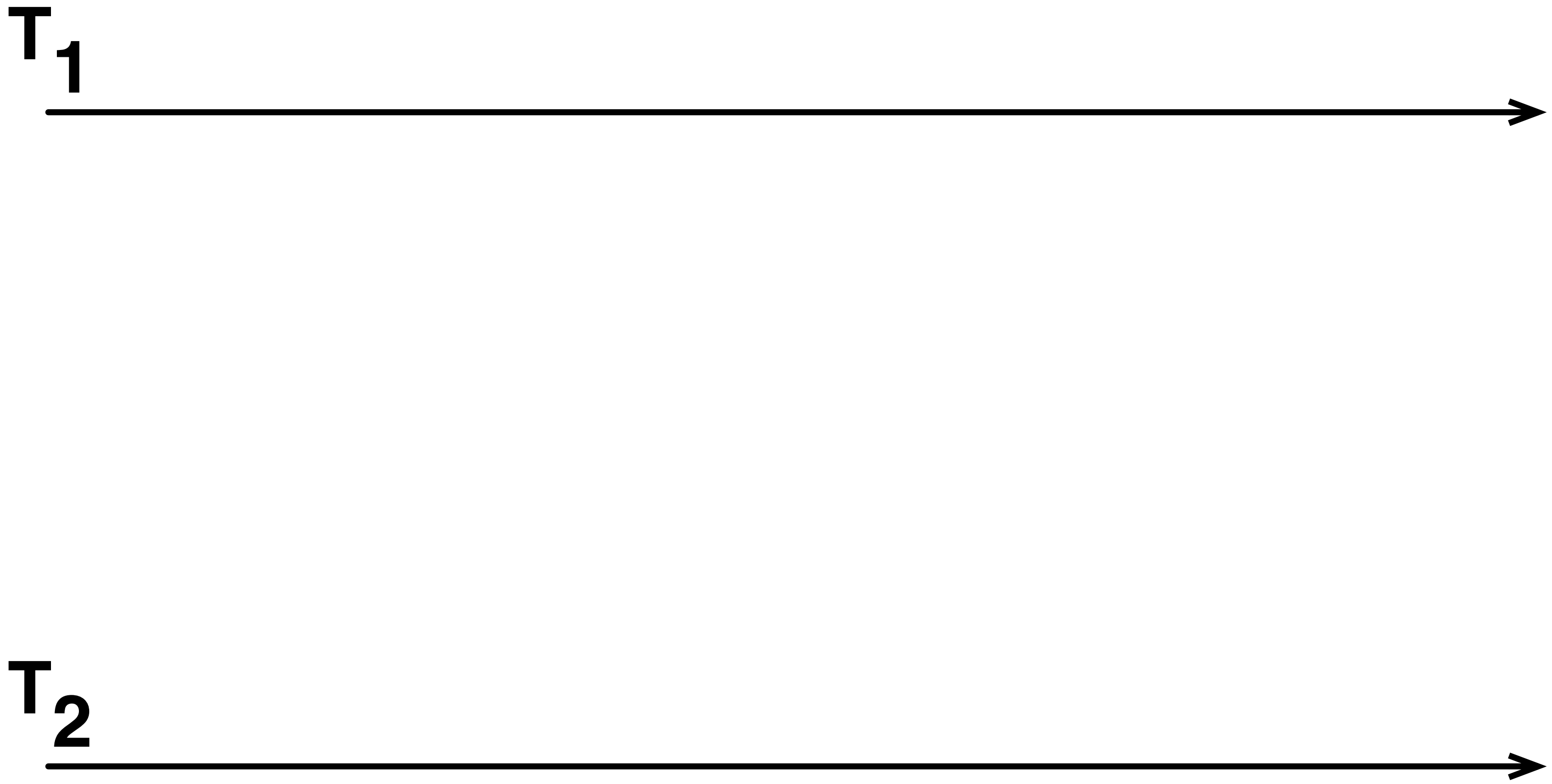


bank ☺

How is this achieved?



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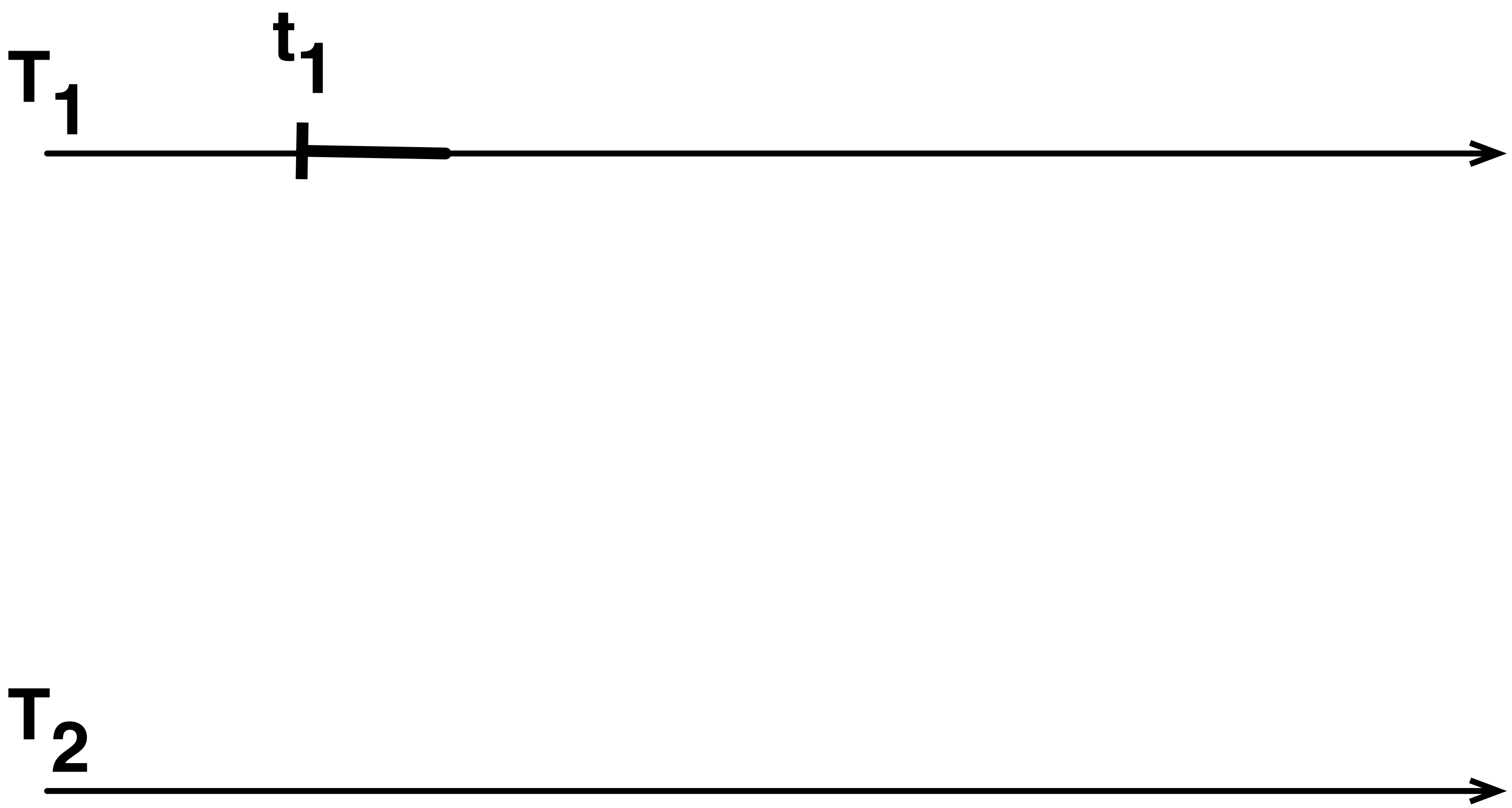

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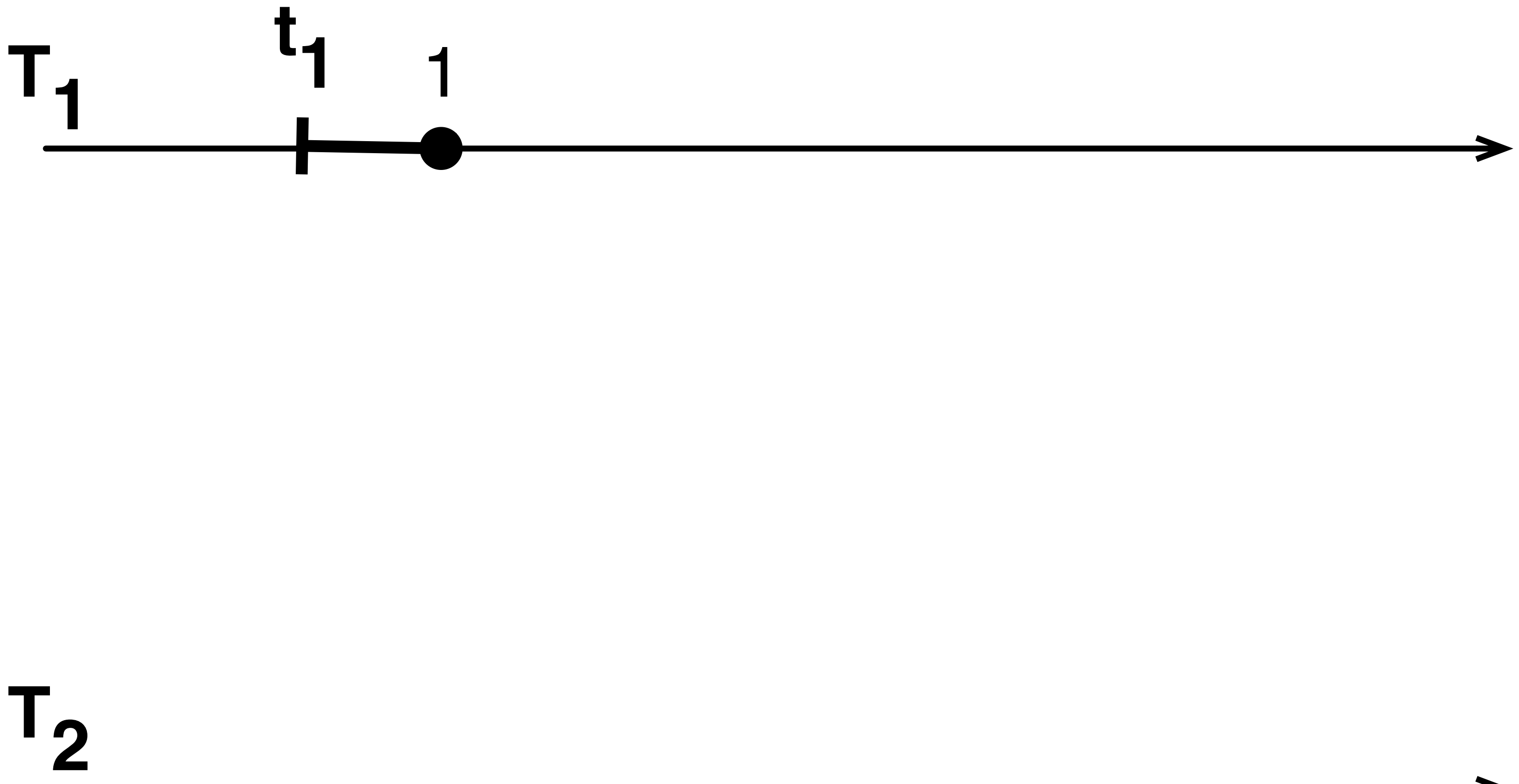

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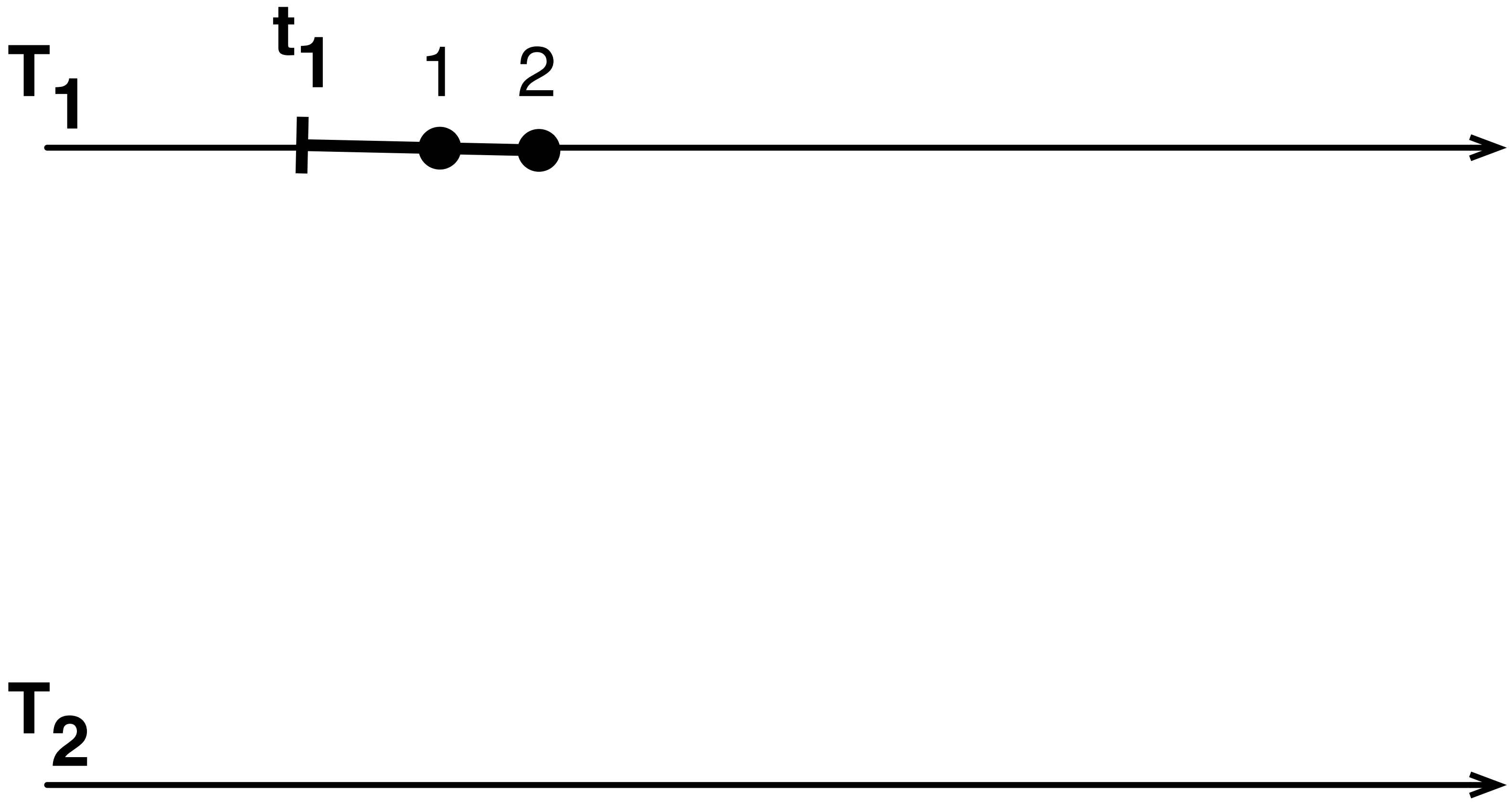

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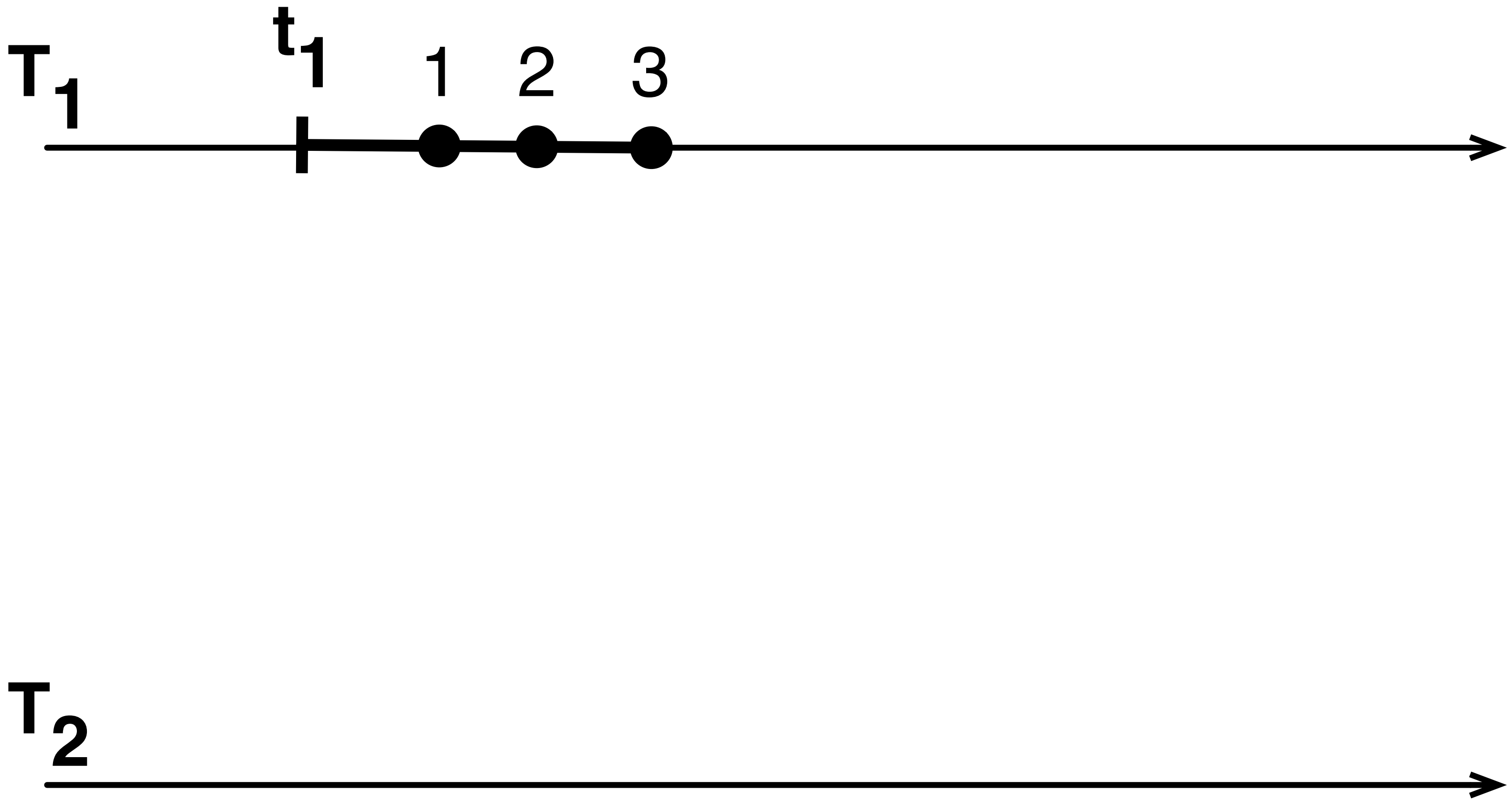

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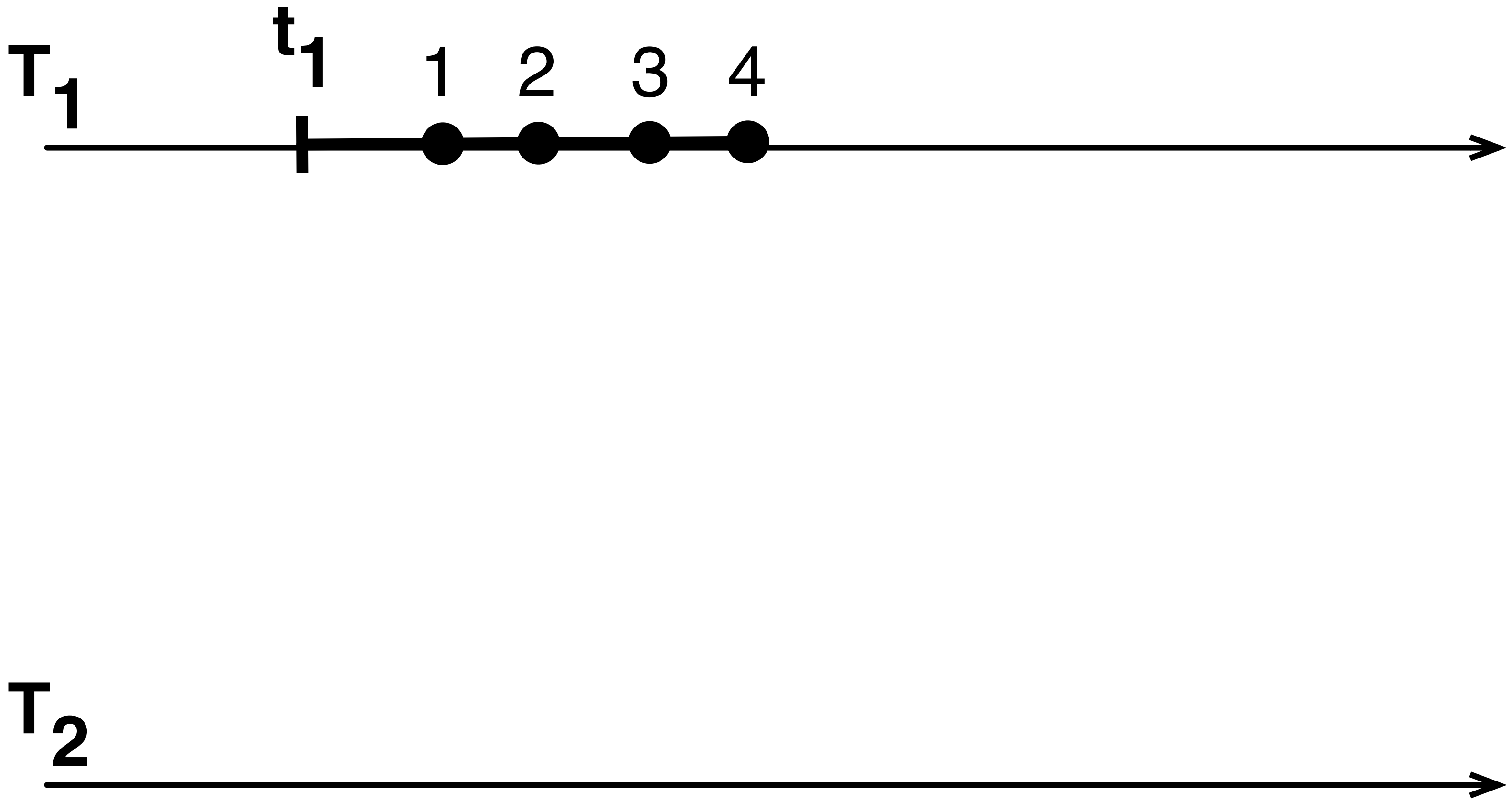

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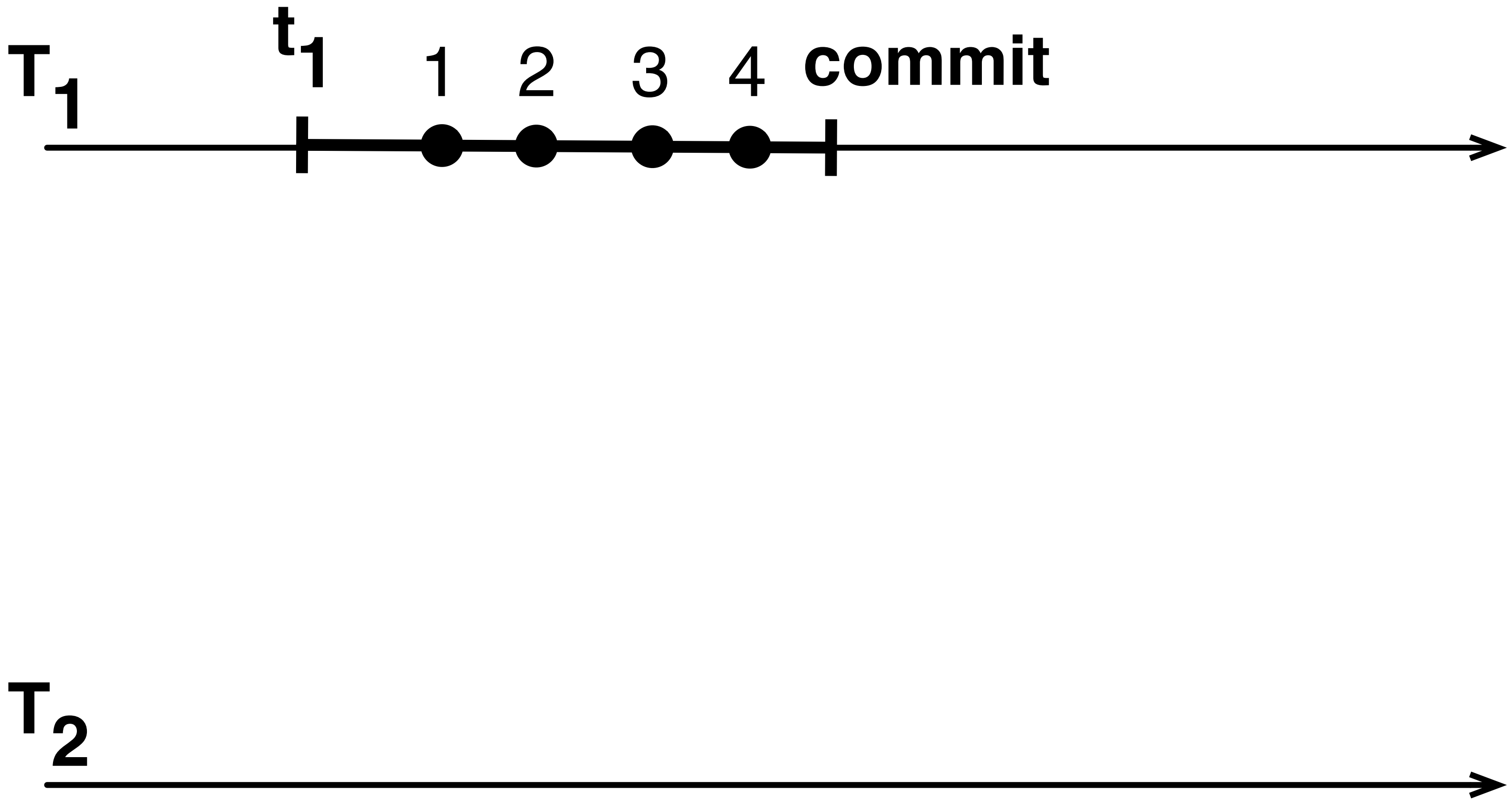

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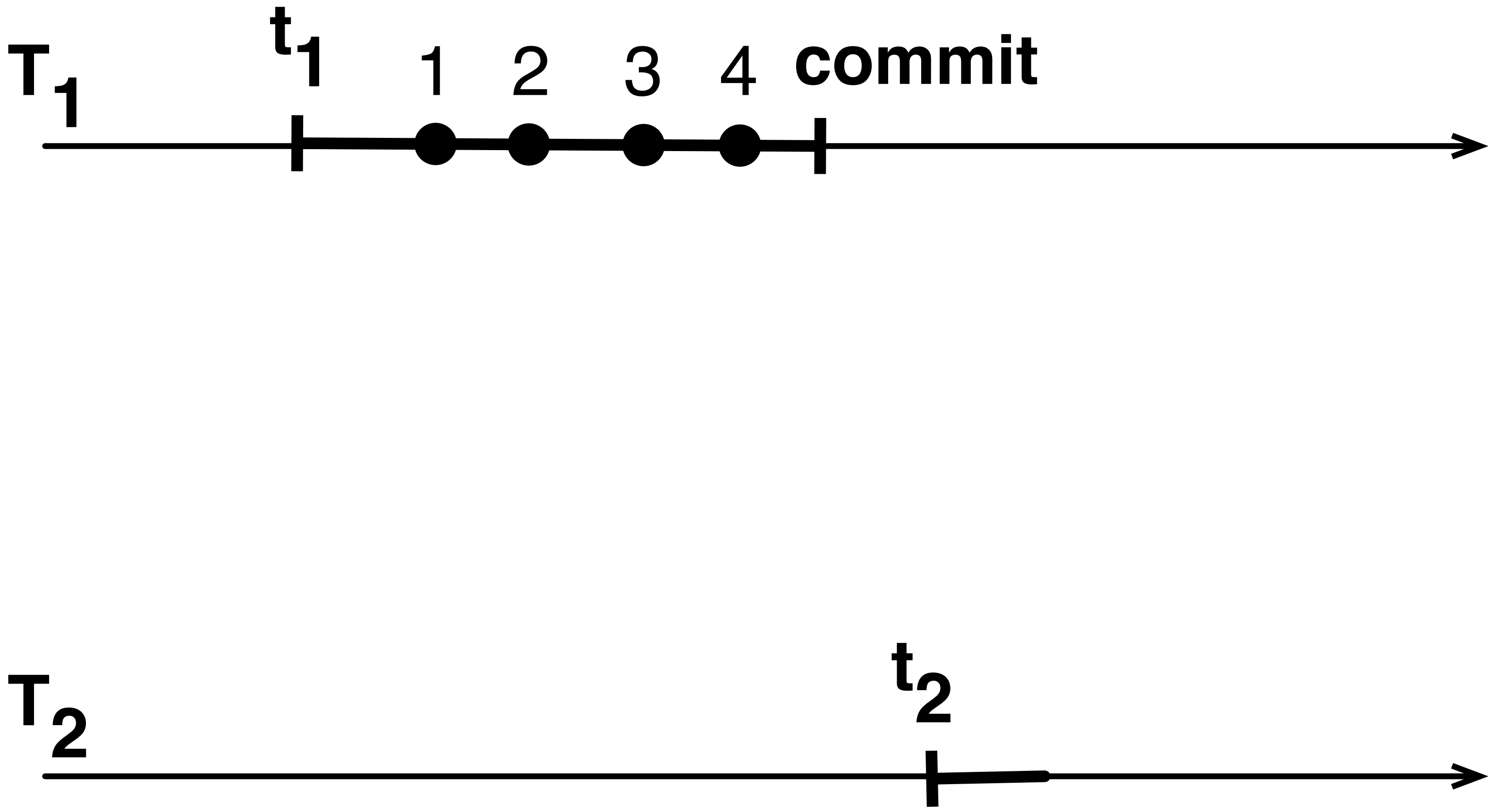

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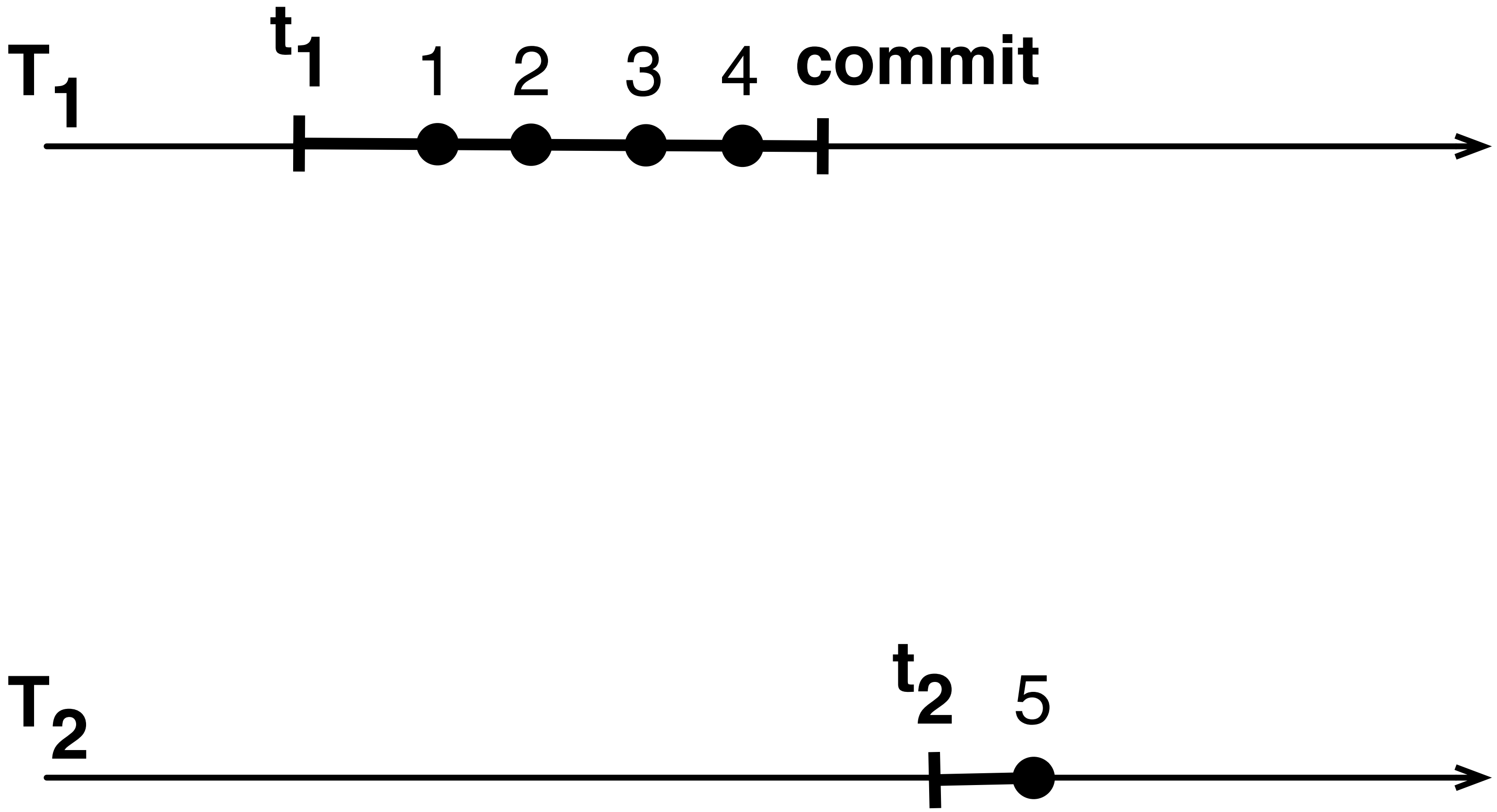

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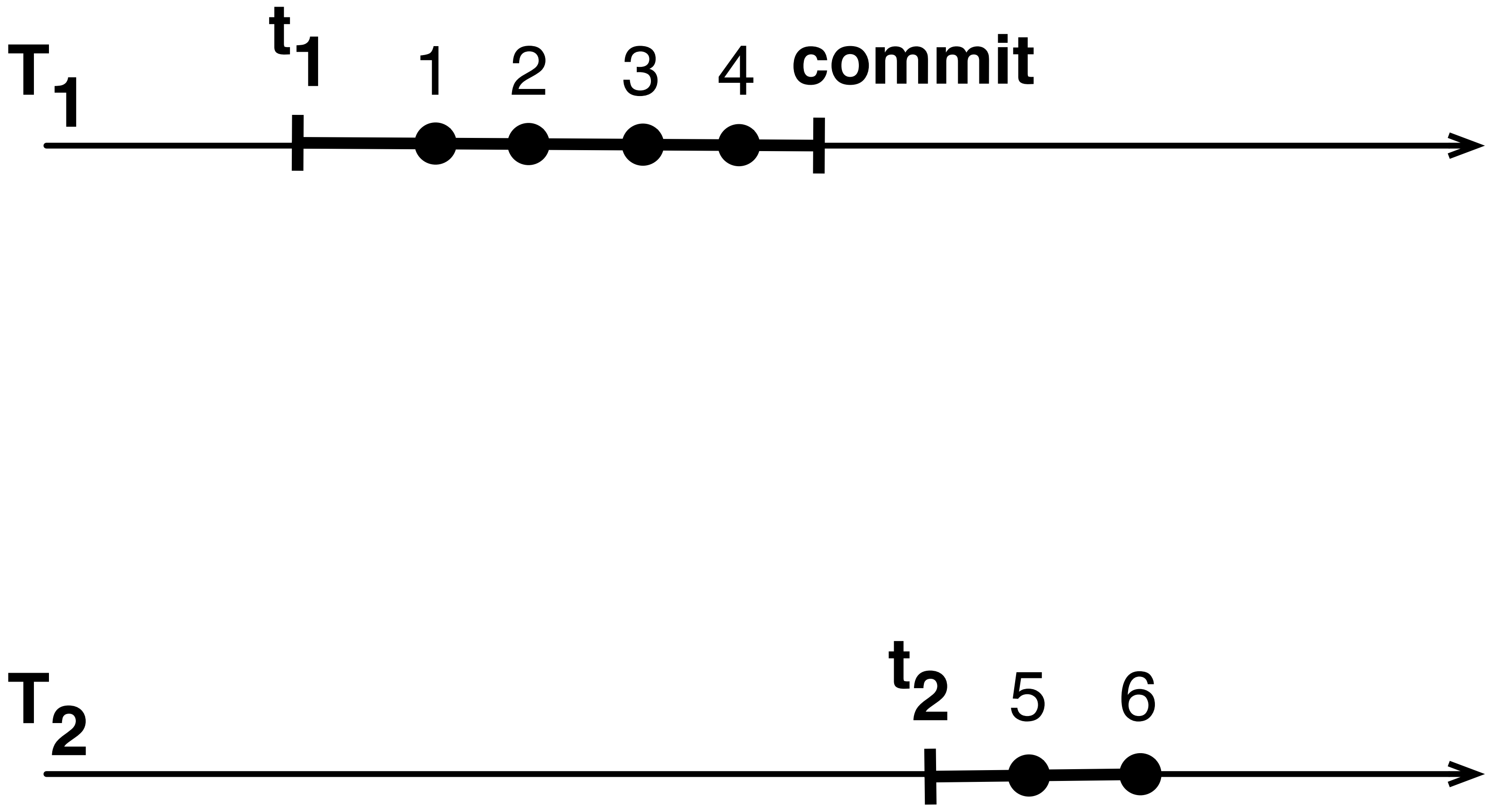

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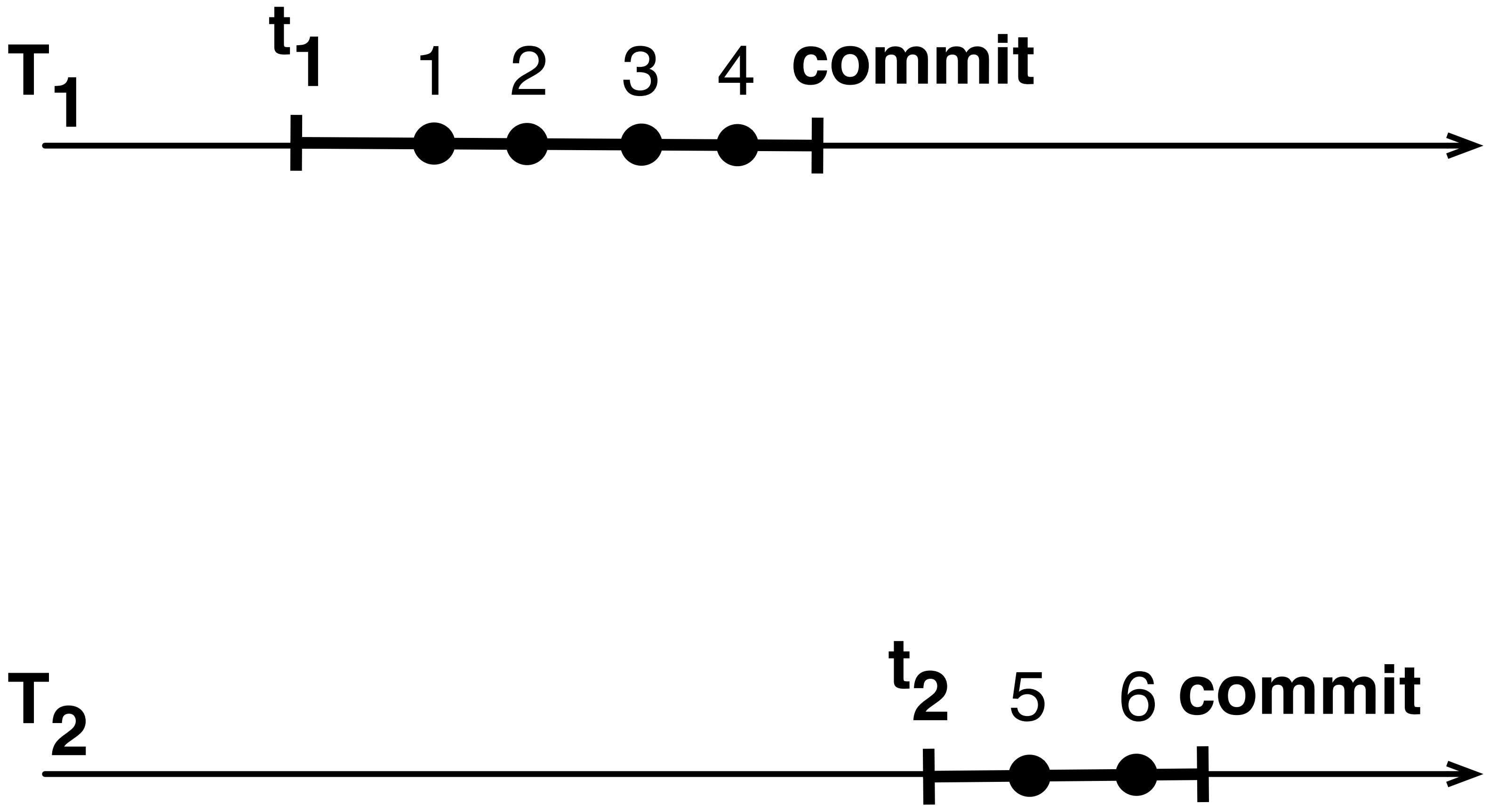

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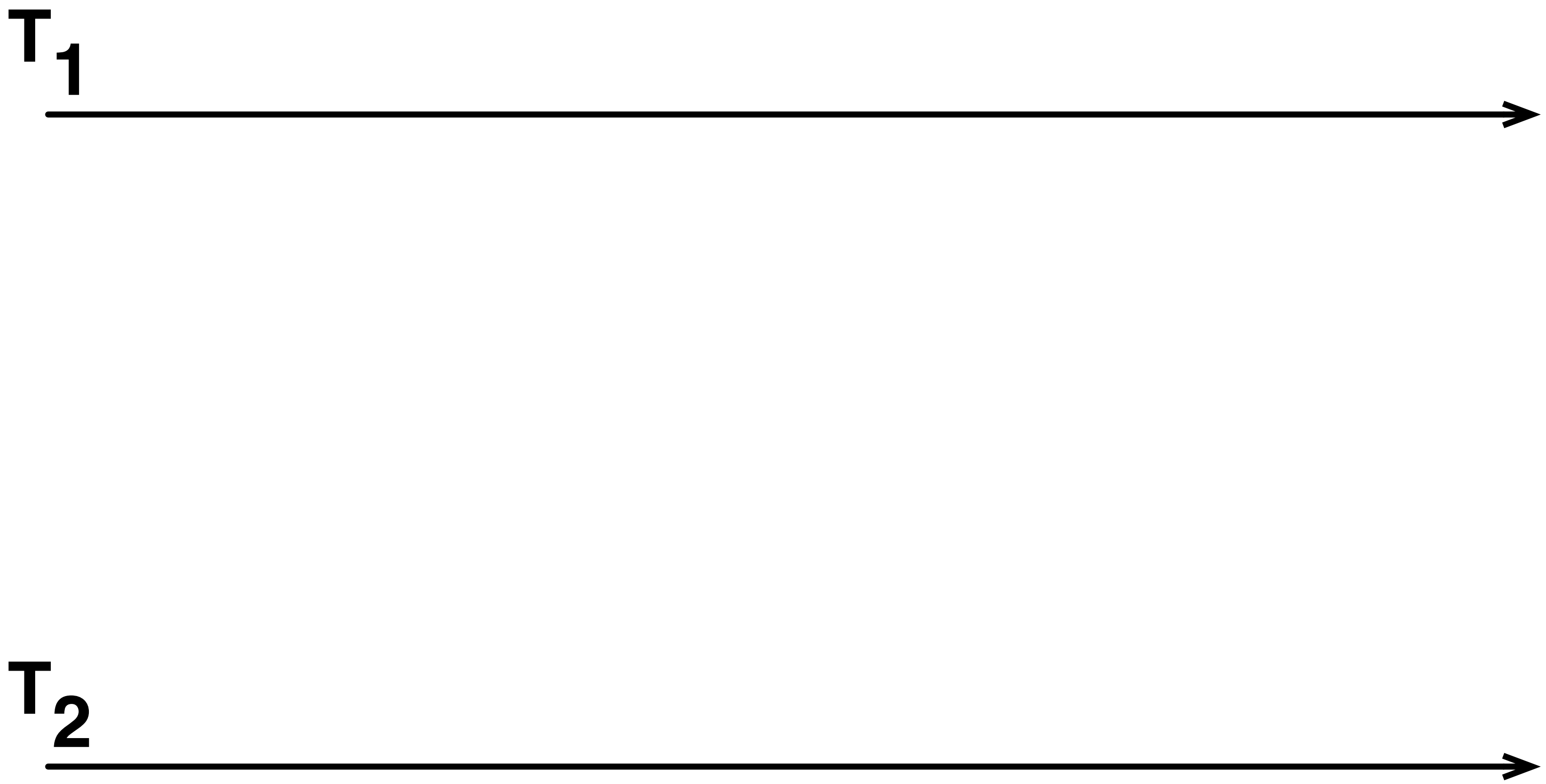

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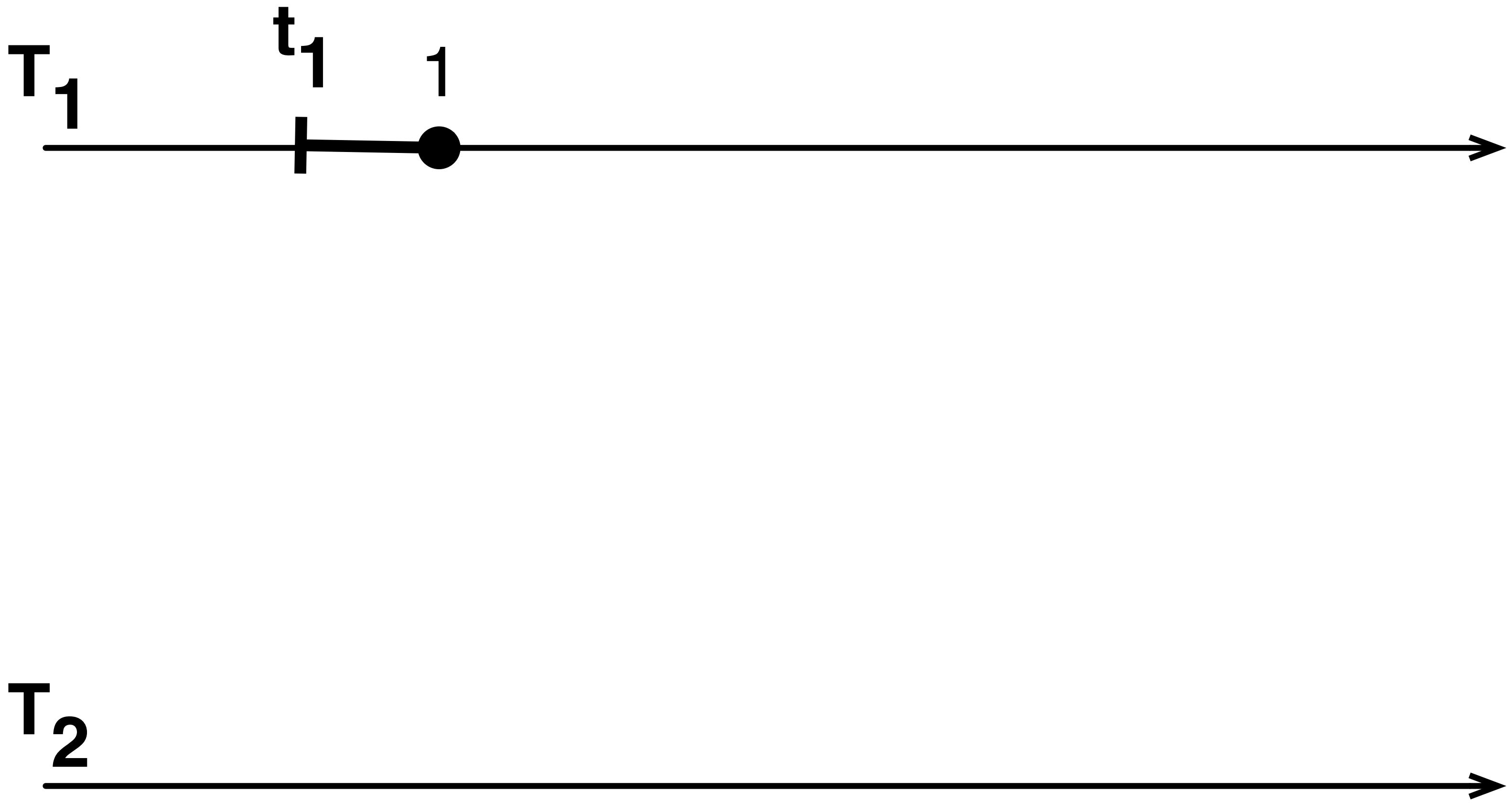

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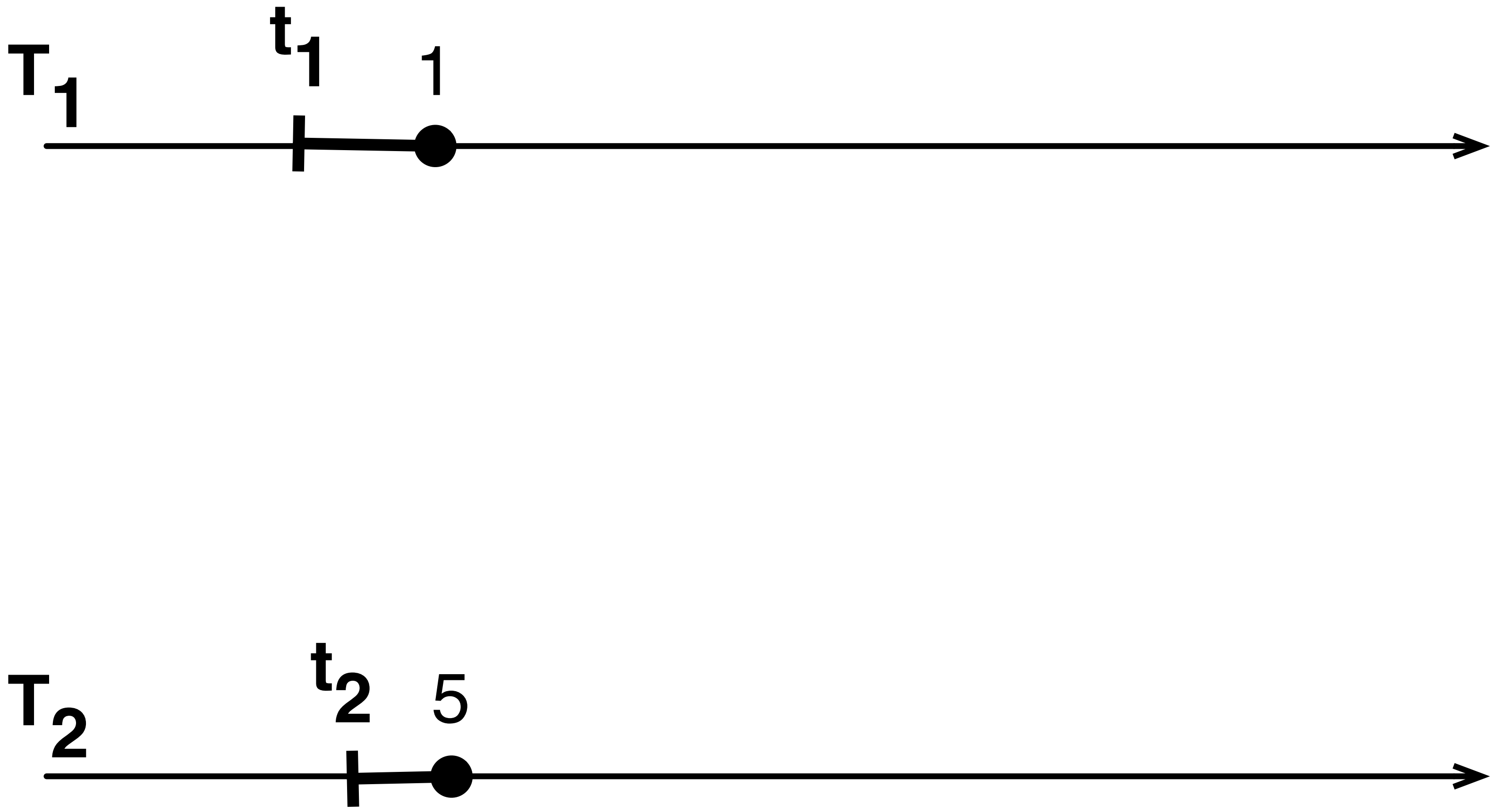

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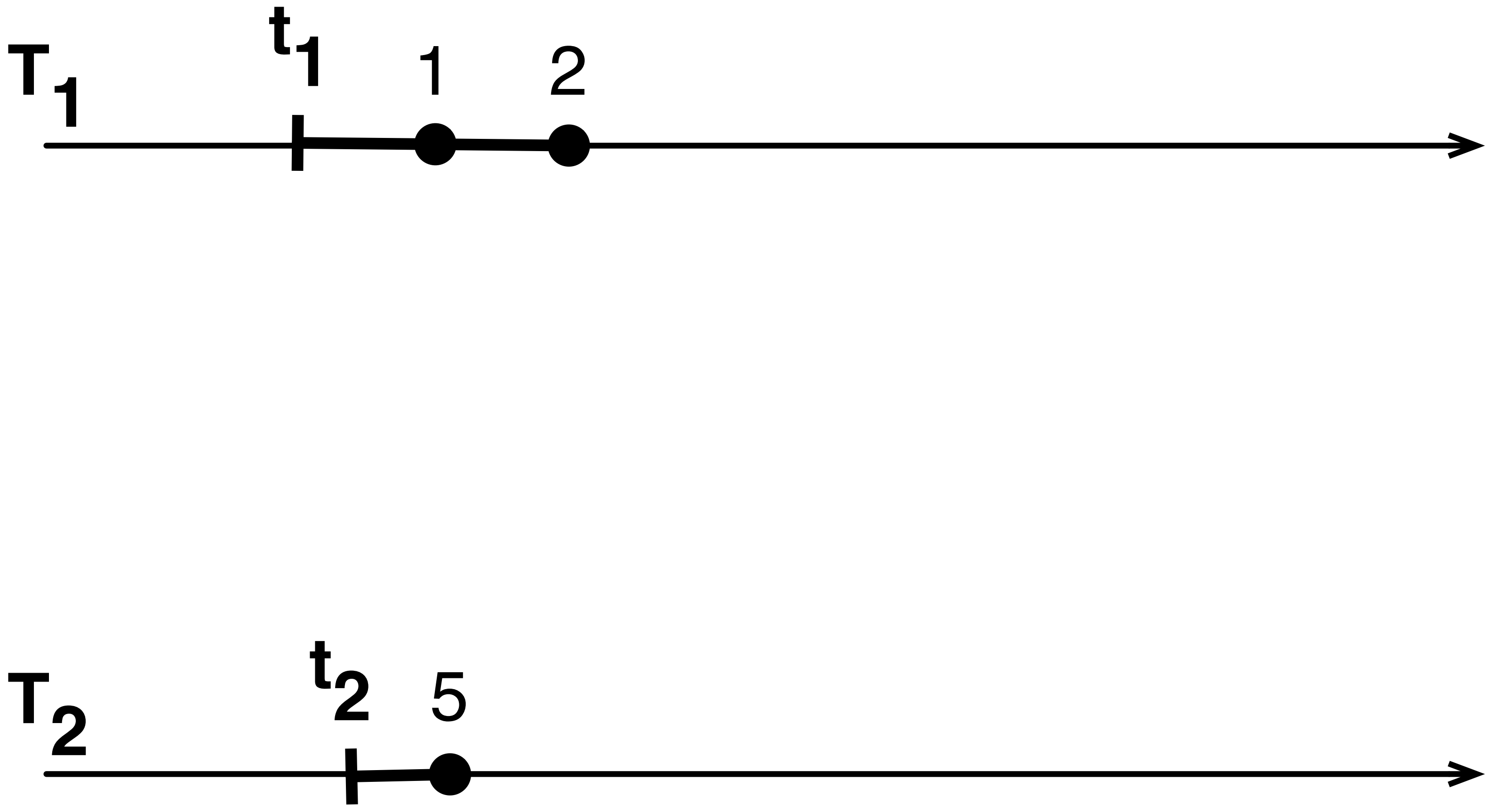

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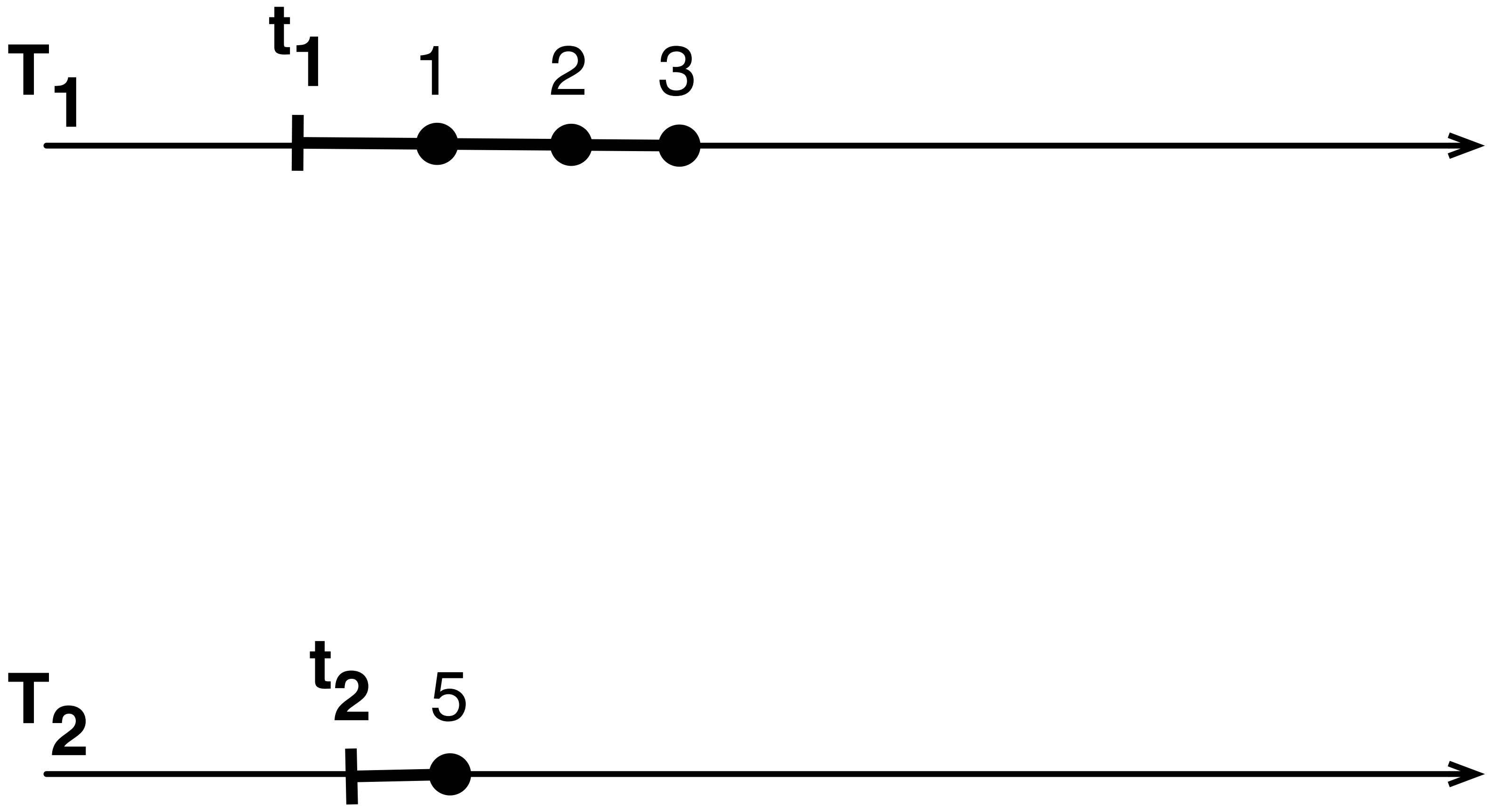

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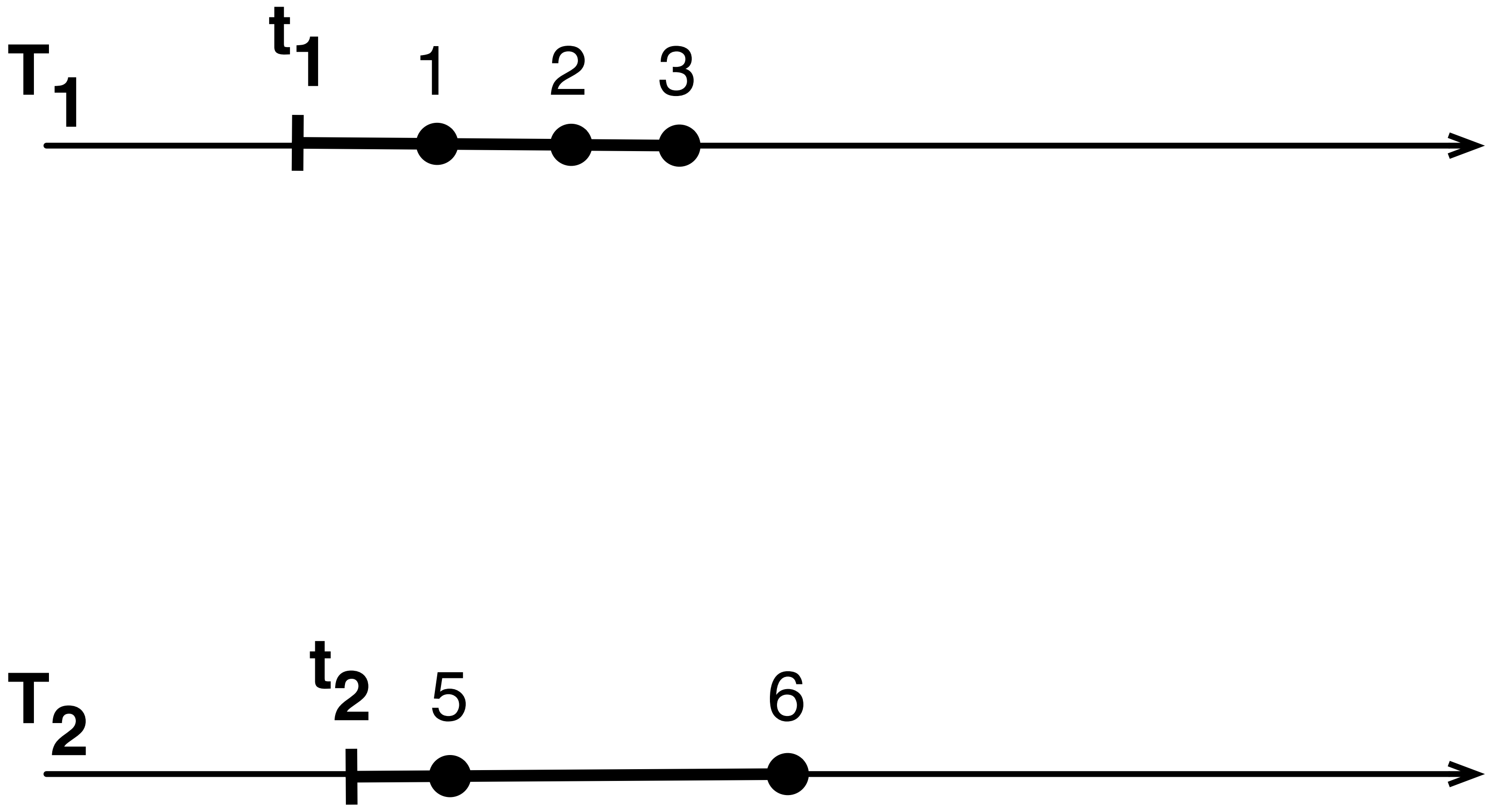

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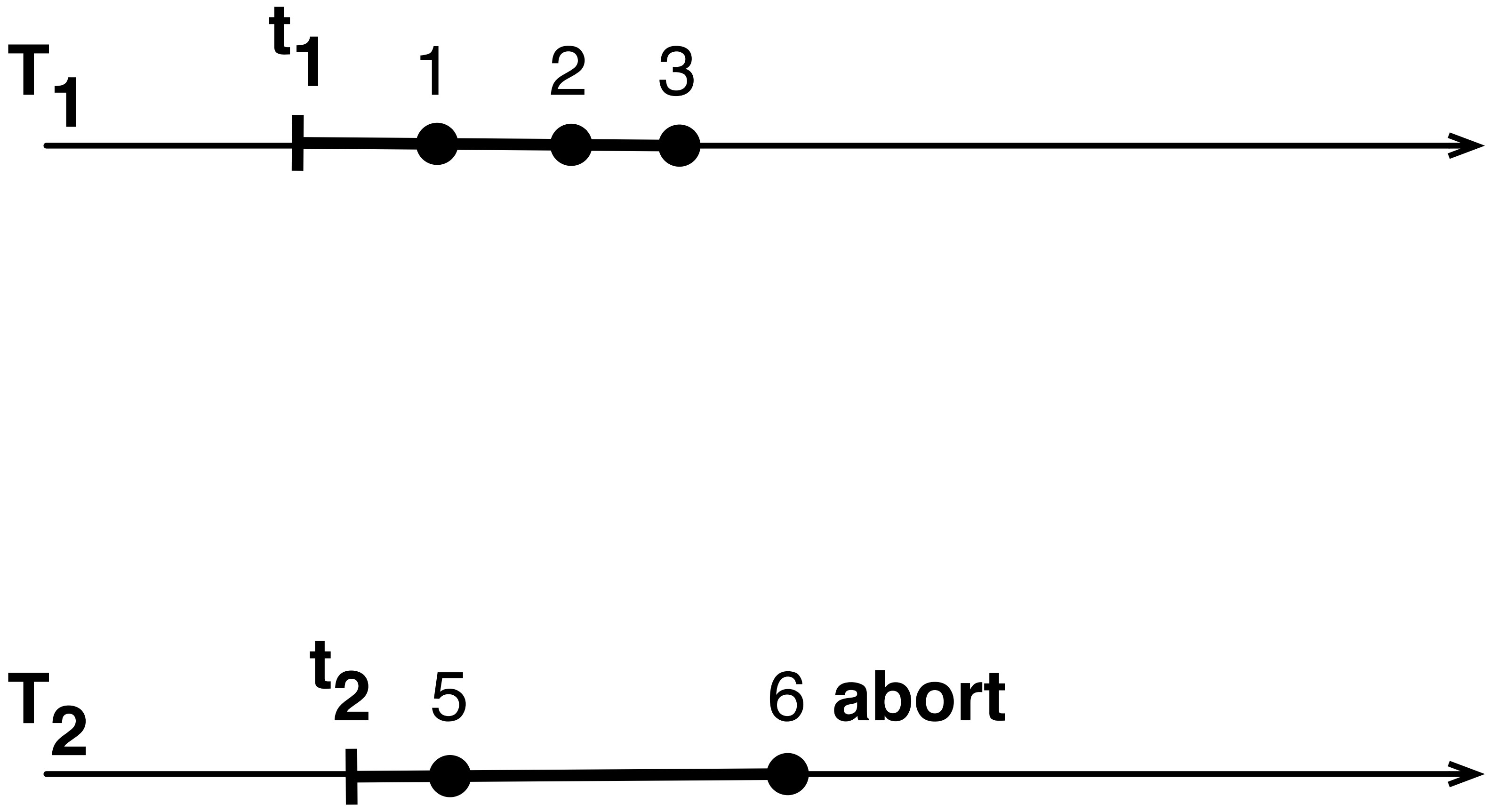

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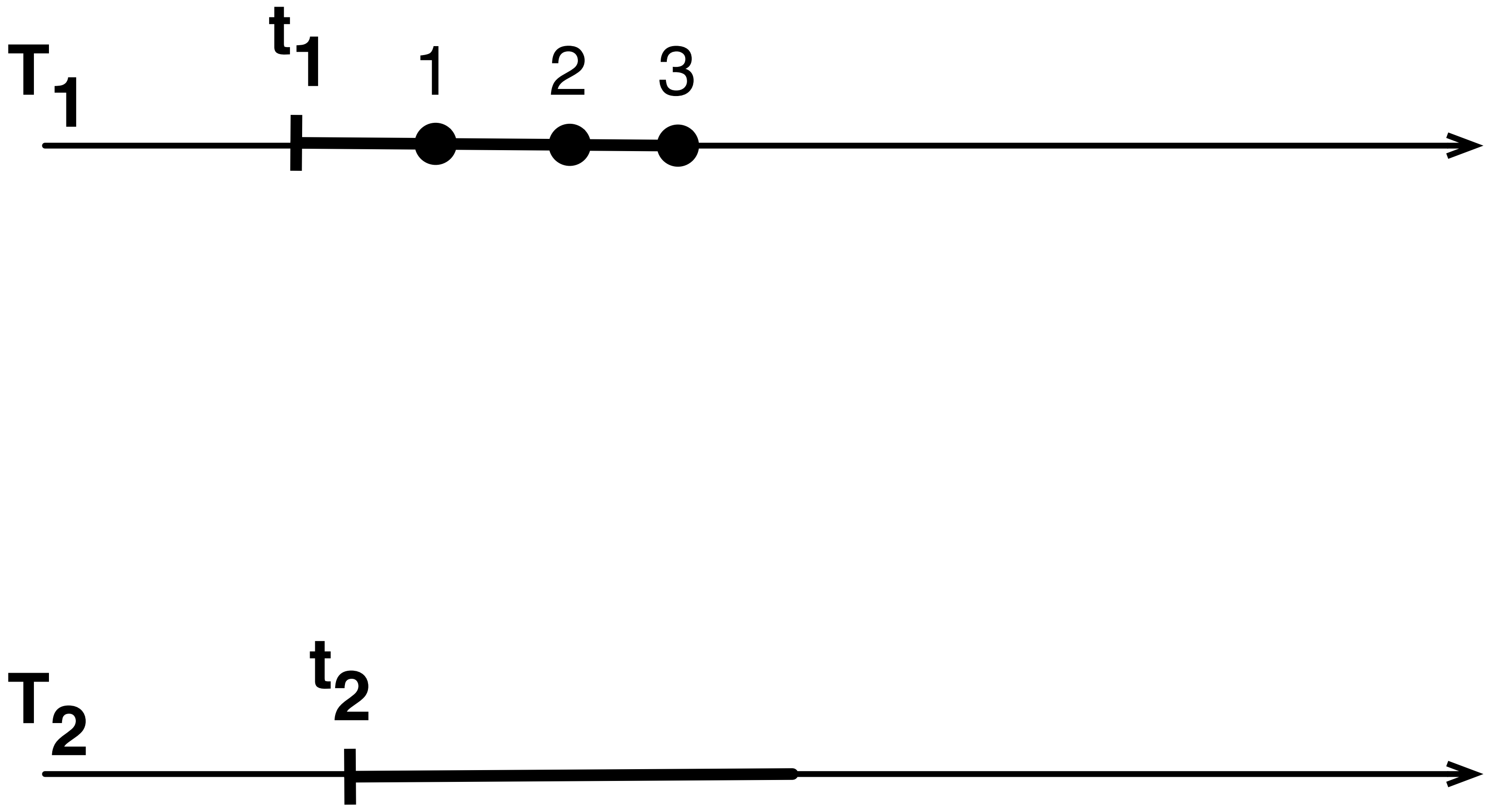

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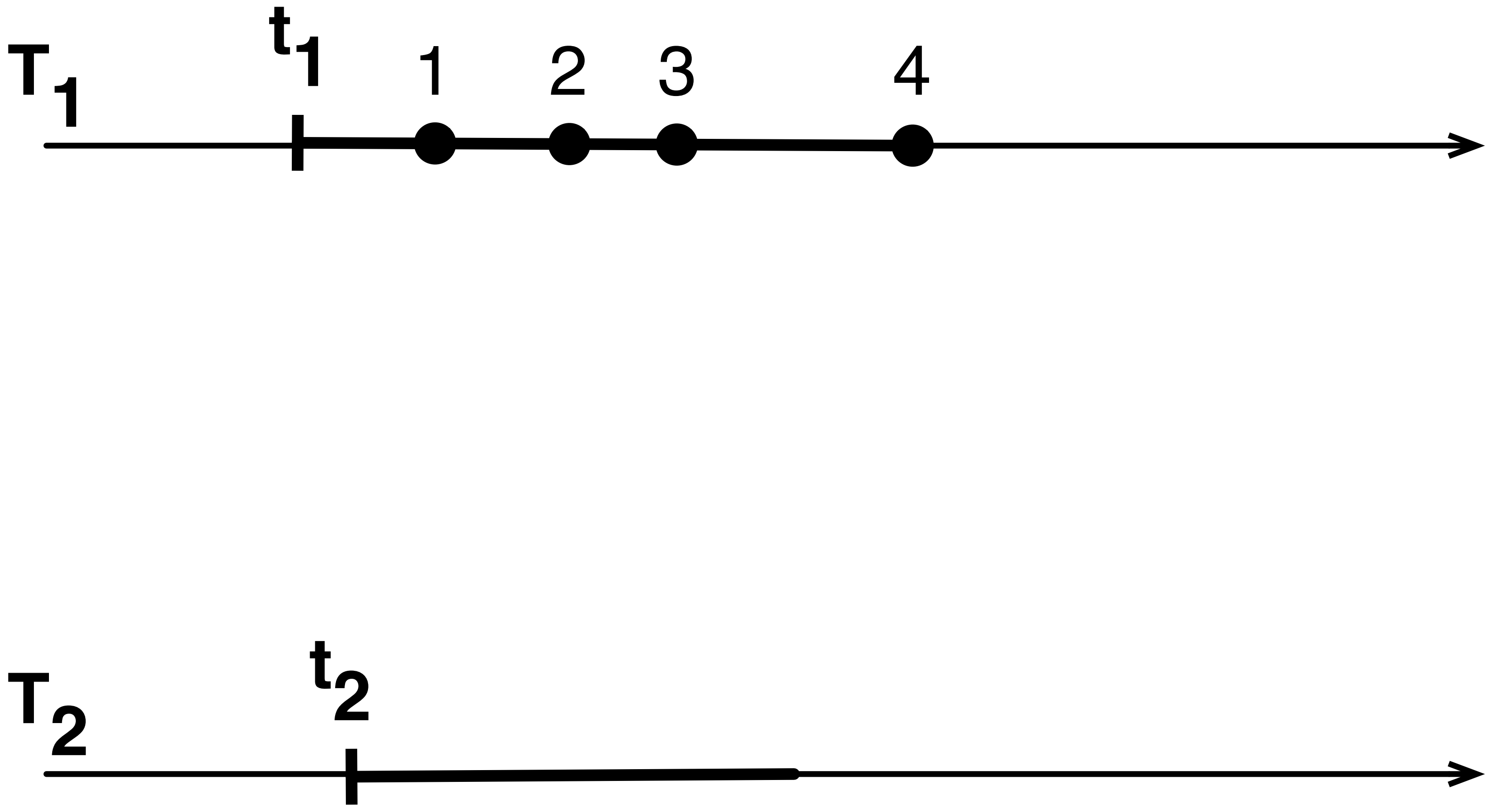

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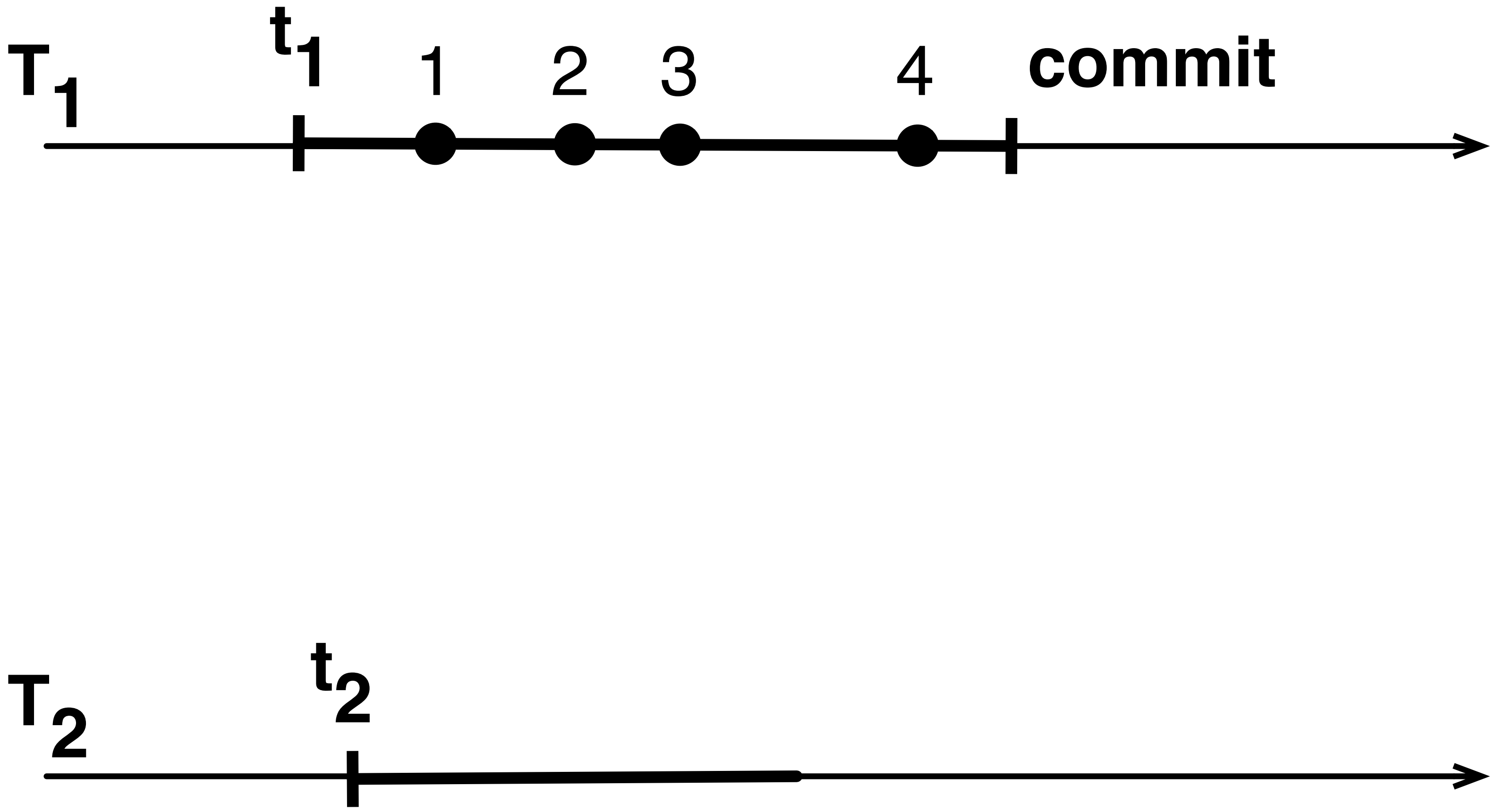

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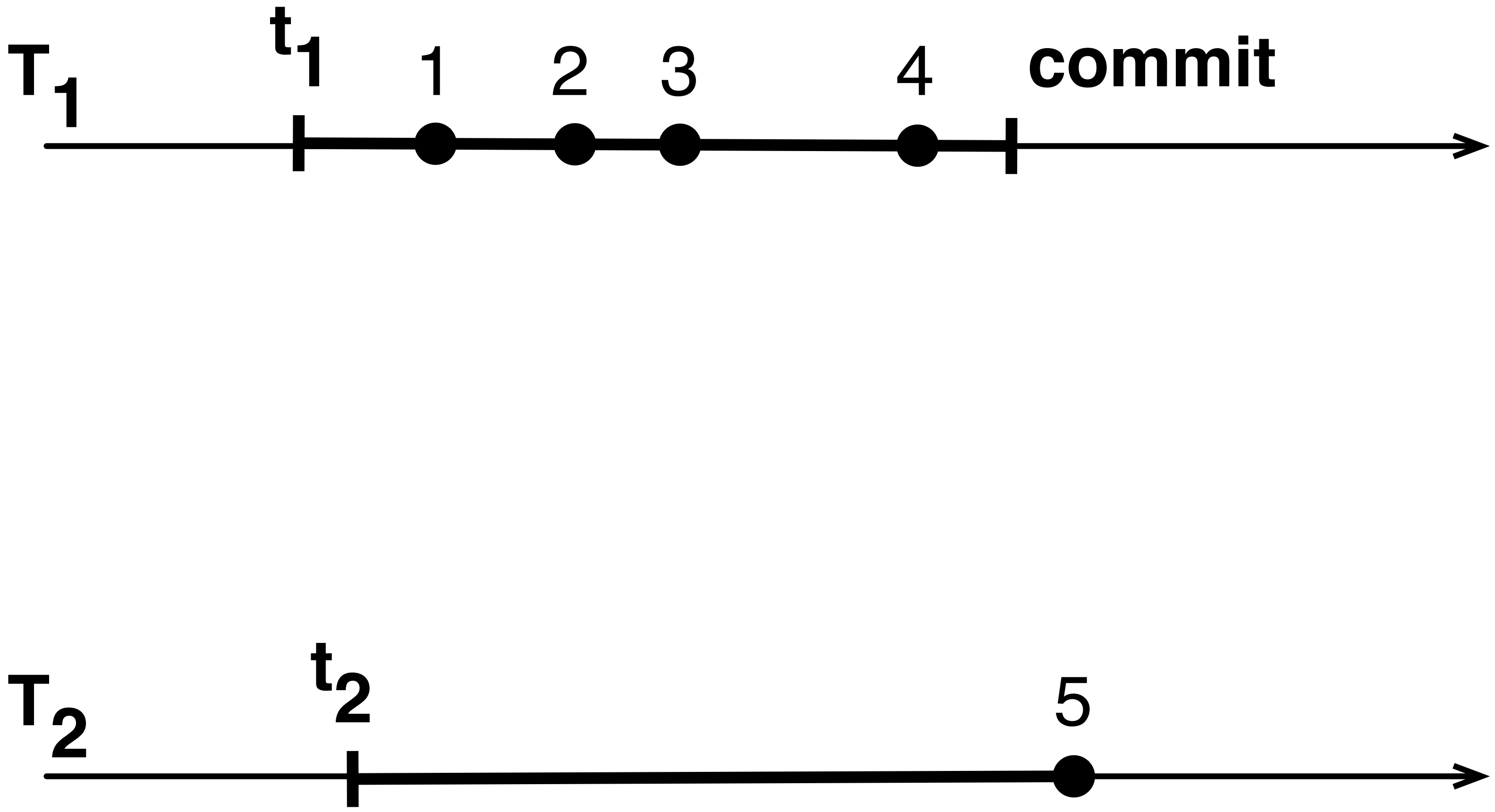

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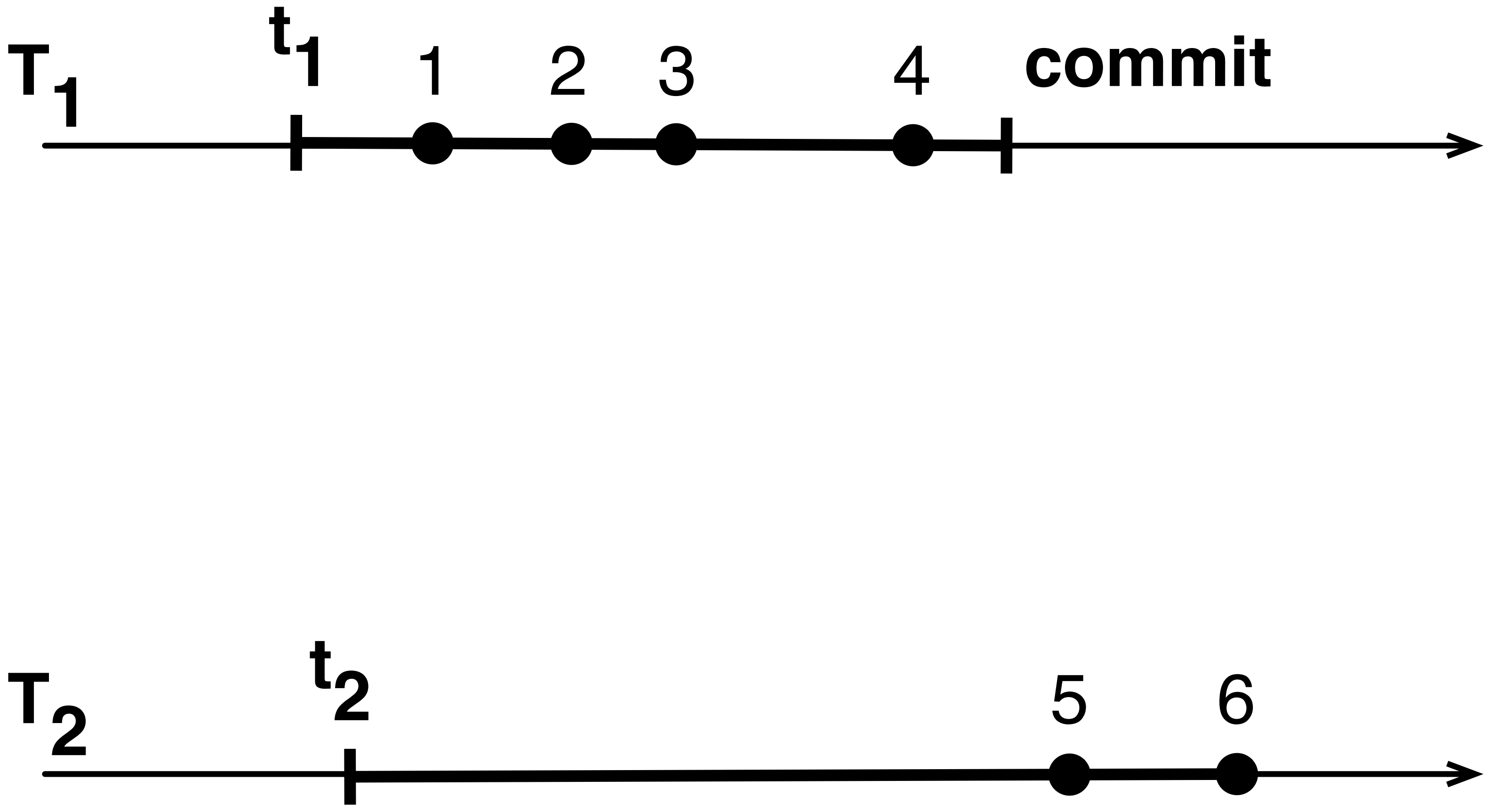

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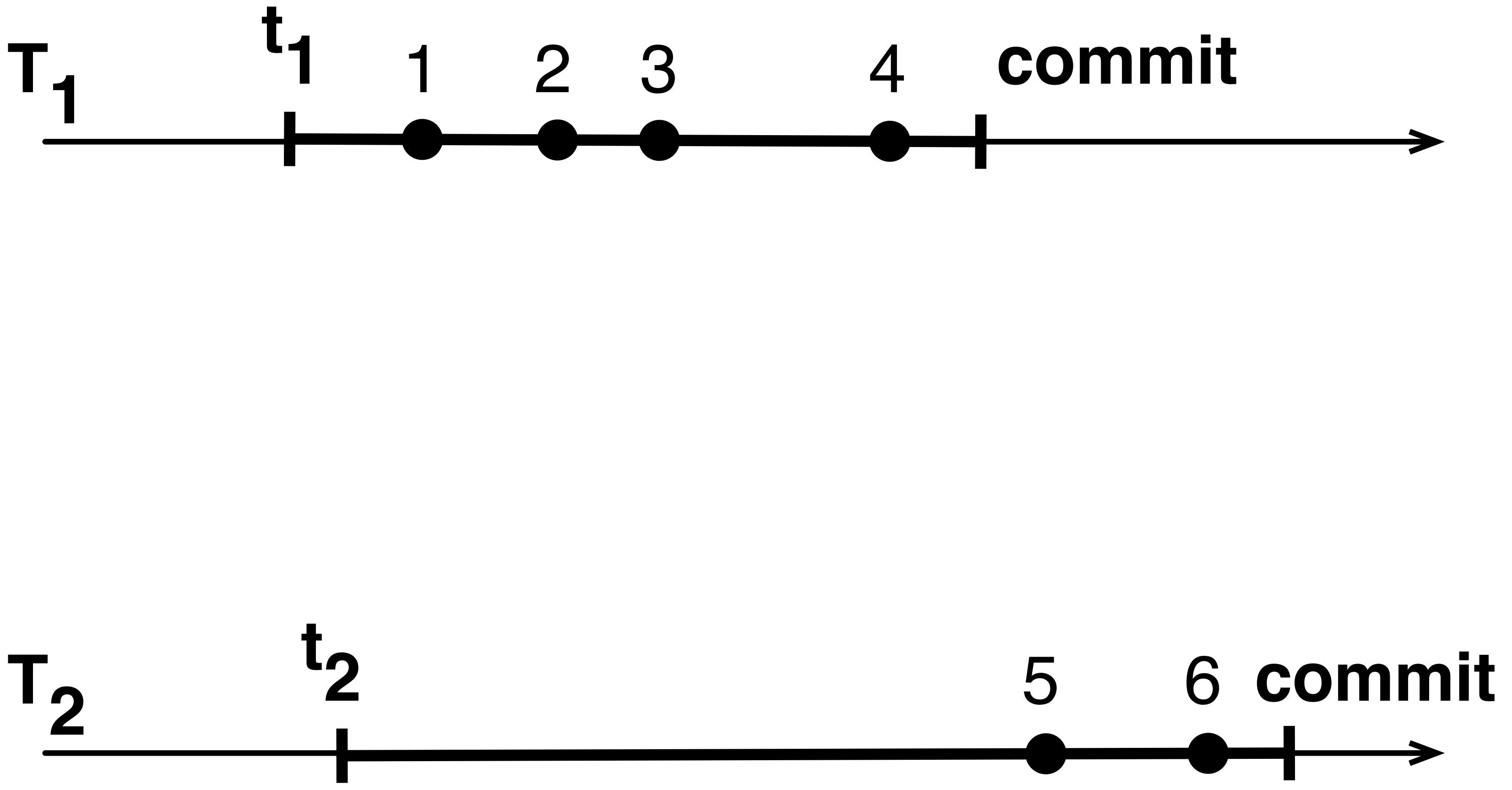

How is this achieved?

- TM monitors accesses to objects
- When it detects *conflicting* access
  - one transaction is *aborted*
  - its actions are *rolled back*
  - it is *restarted*
- When all actions are not conflicting
  - transaction *commits*

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```
Variables:
    int x=0, y=1;
Invariant:
    x < y
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```
atomic {
   int xl = x;
   int yl = y;
   x = yl;
   y = yl * 2;
}
```

Is serializability enough?

```
Variables:
    int x=0, y=1;
Invariant:
    x < y
```

```
atomic {
int xl = x;
int yl = y;
x = yl;
y = yl * 2;
}
```

```
atomic {
int xl = x;
int yl = y;
int zl = 1/(yl-xl);
z = zl;
}
```

Consistent view

- All transactions must observe consistent views of memory at all times
  - even the aborted ones

Opacity

- Serializability
  - there exists an equivalent serial (one thread) execution
- Consistent memory view
  - no transaction can e.g. divide by zero because of non-consistent reads

TM semantics

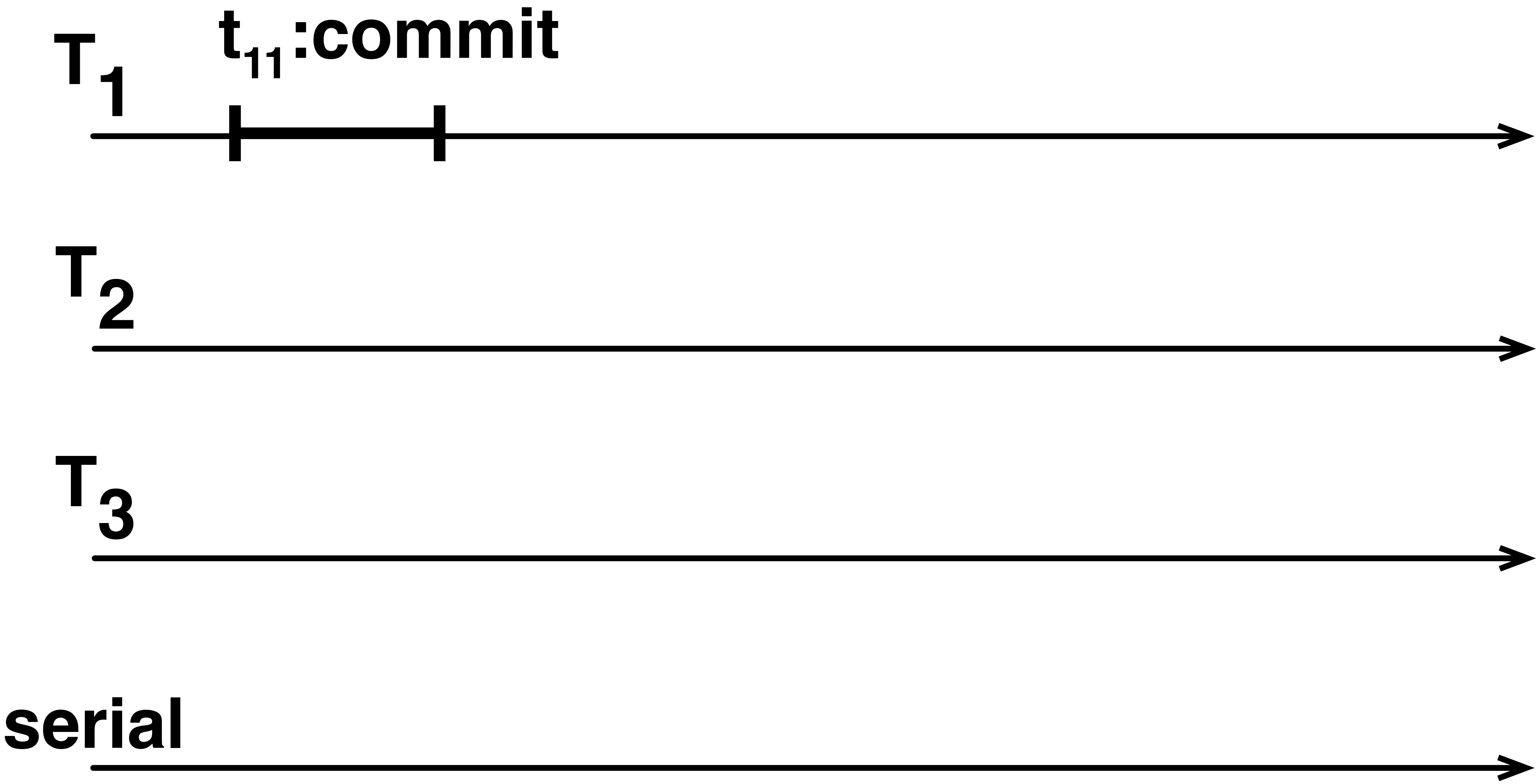
- Committed: instantaneous
- Aborted: never visible
- All: observe consistent state

TM semantics

TM semantics

T_1
T_2
T_3
serial

TM semantics



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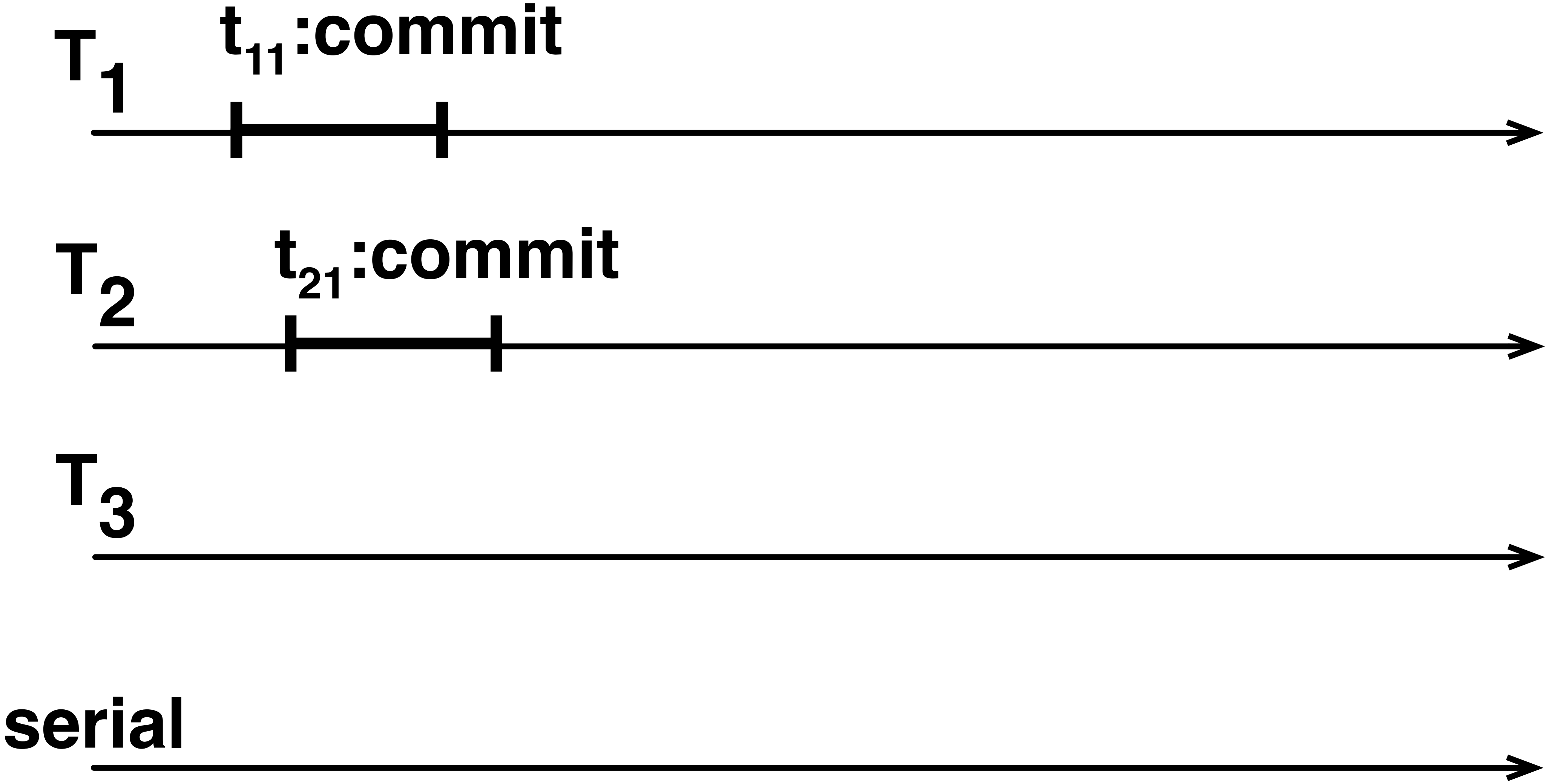

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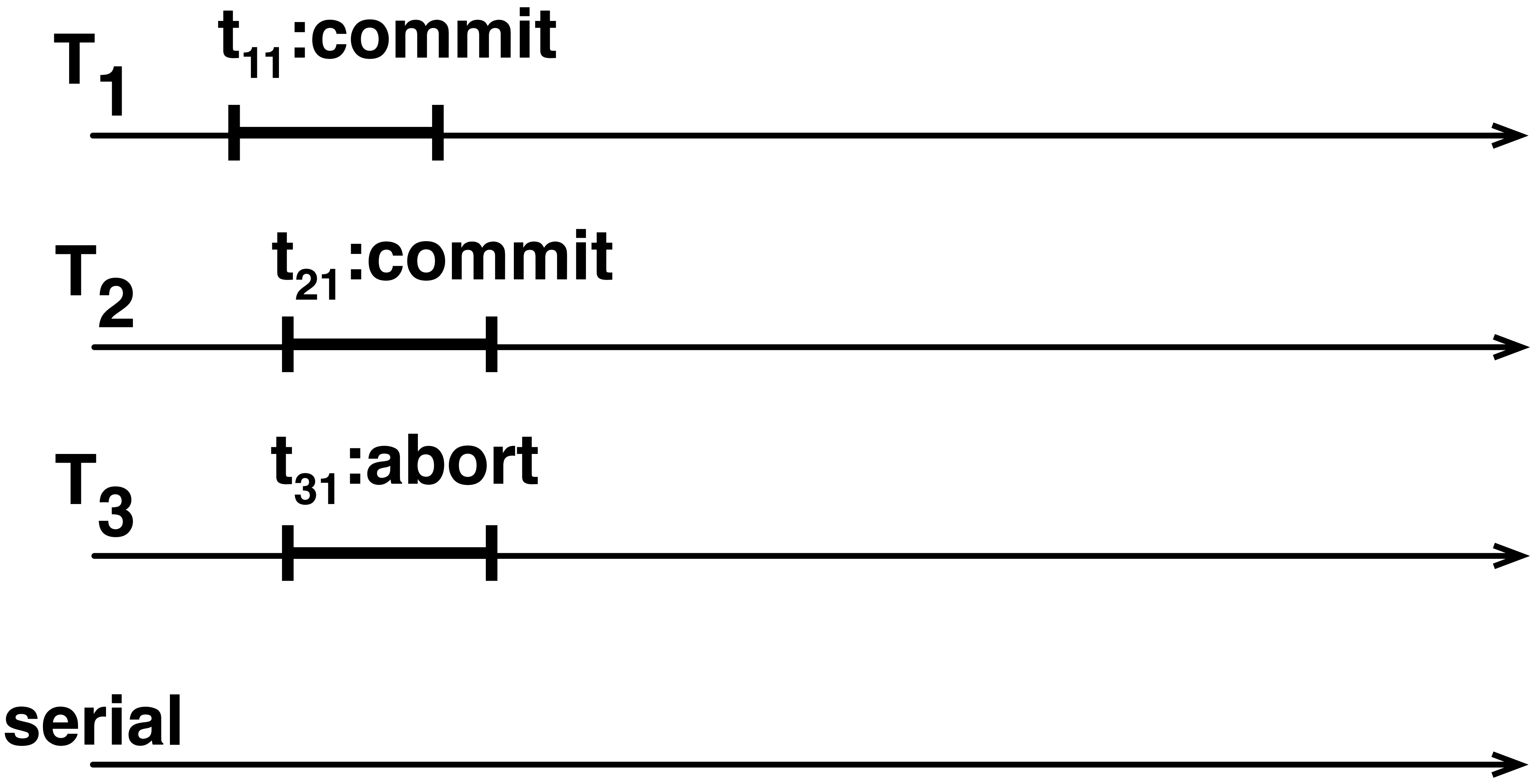

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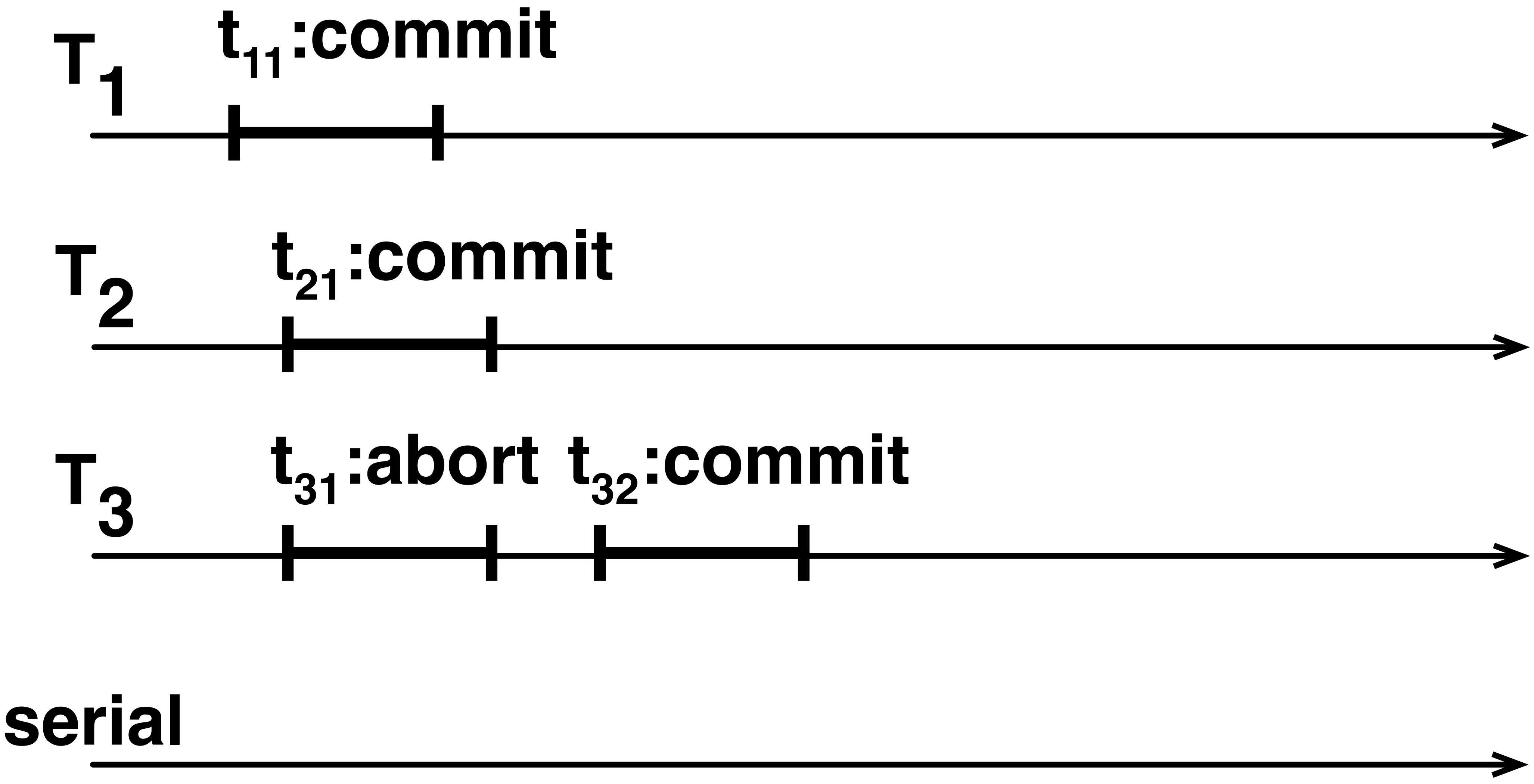

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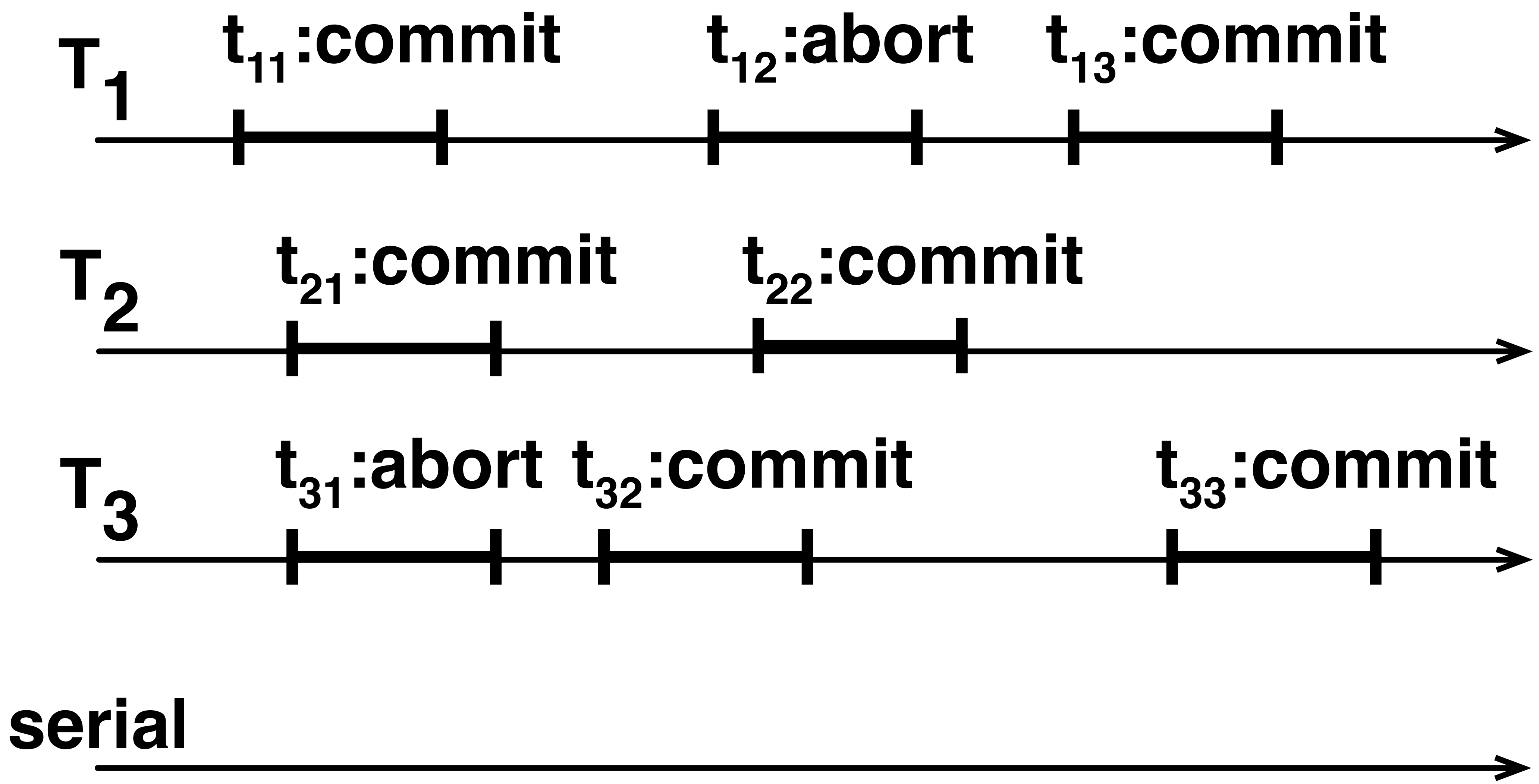


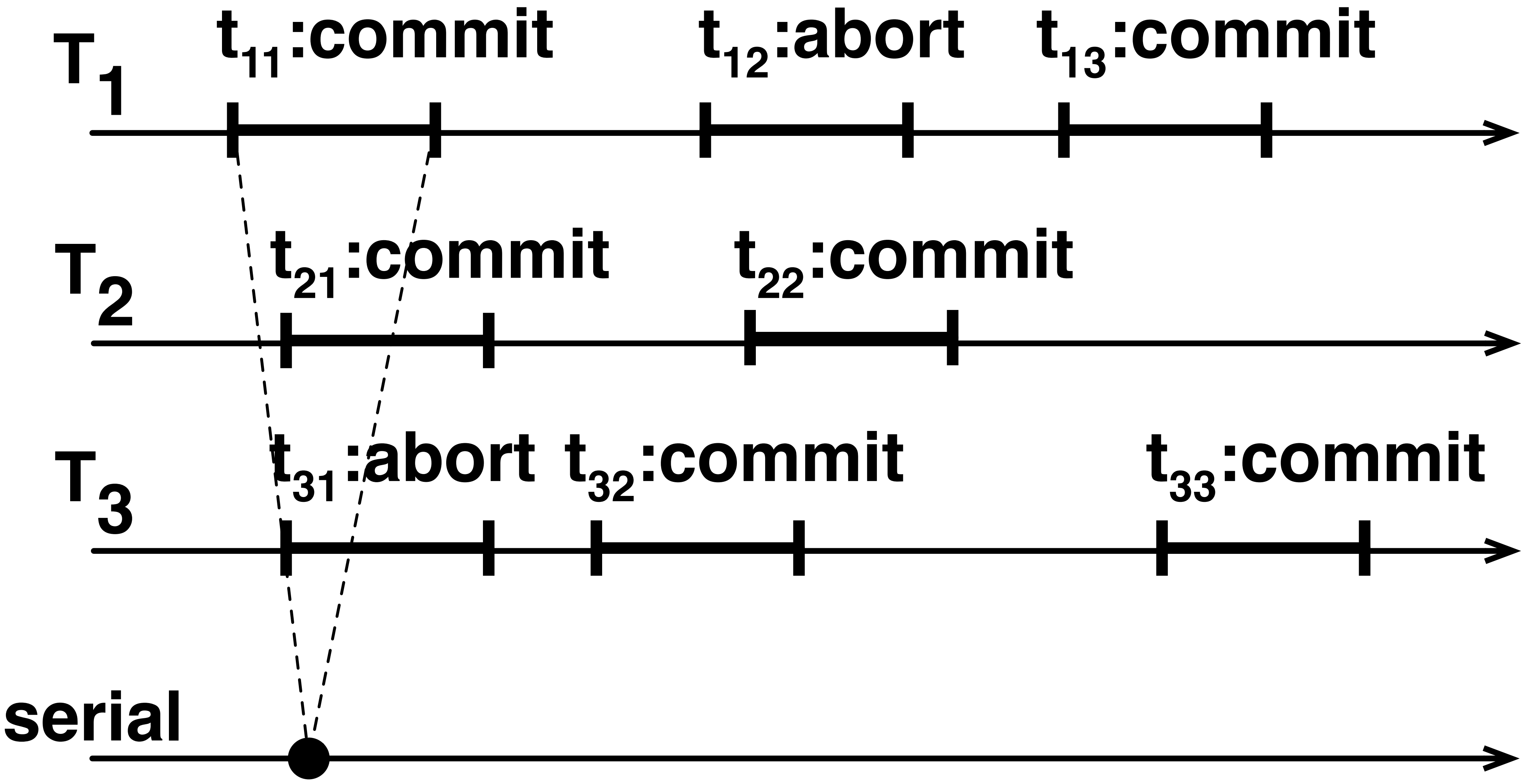
T_1 t_{11}:commit t_{12}:abort t_{13}:commit

T_2 t_{21}:commit t_{22}:commit

T_3 t_{31}:abort t_{32}:commit t_{33}:commit

serial

TM semantics



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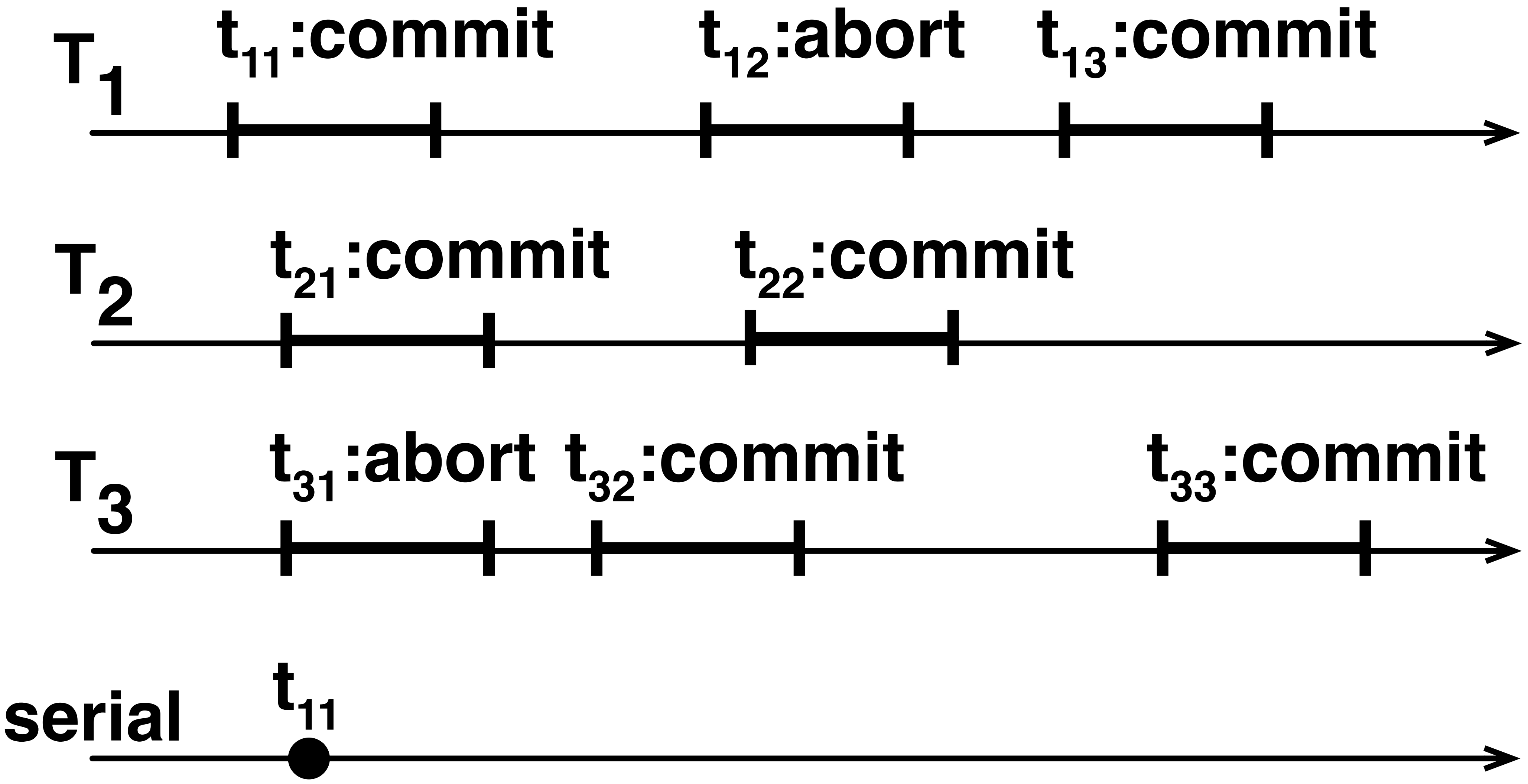

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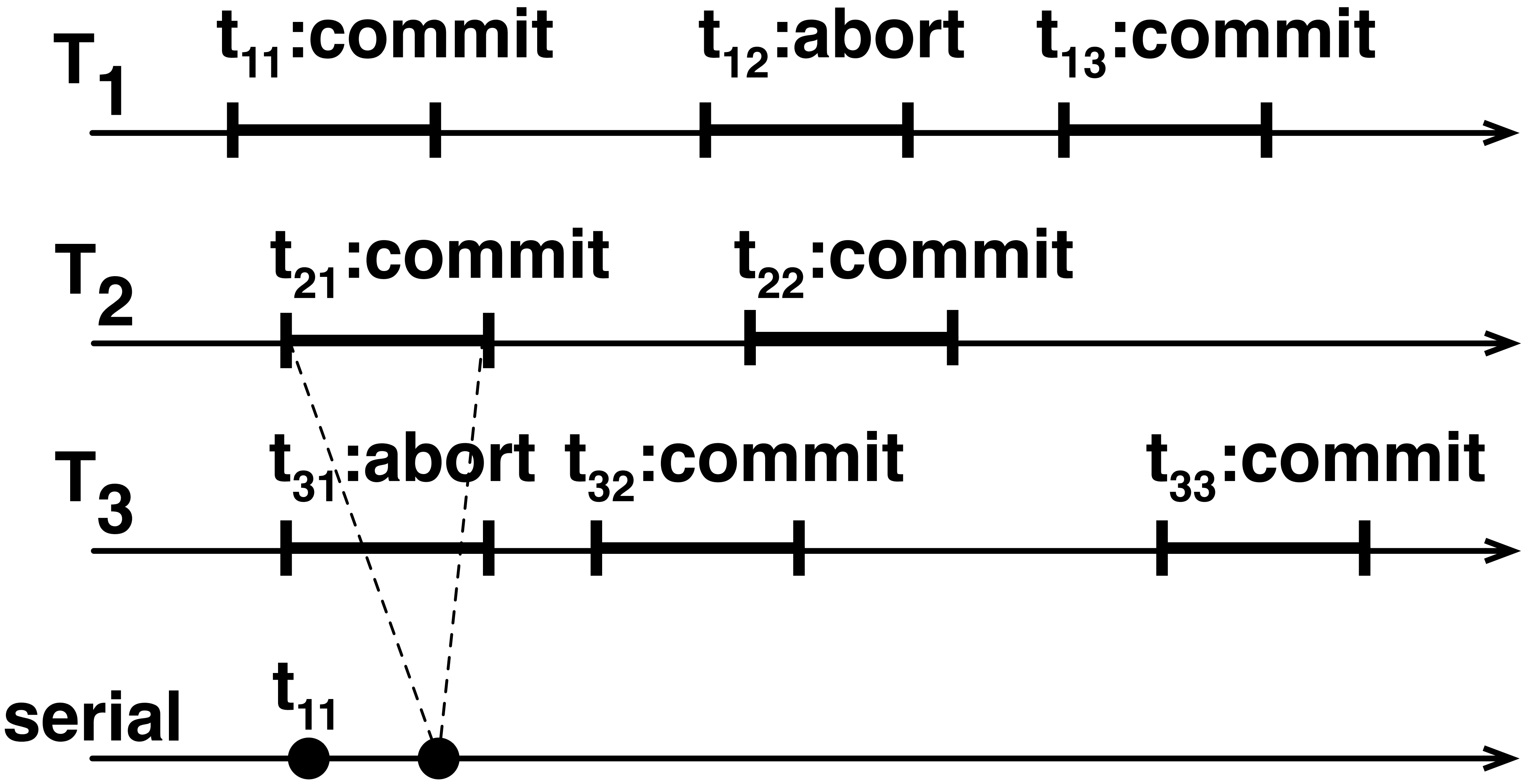

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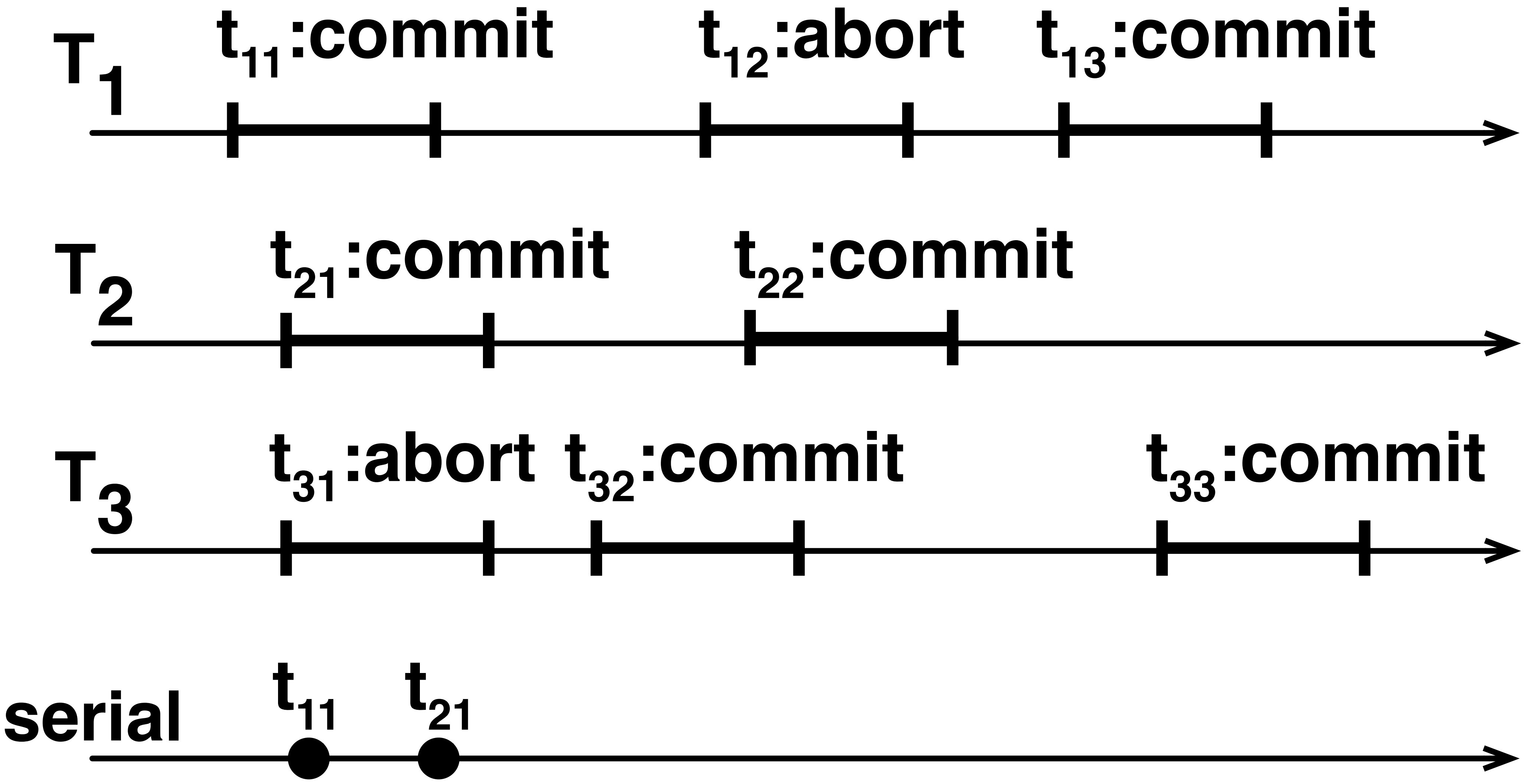

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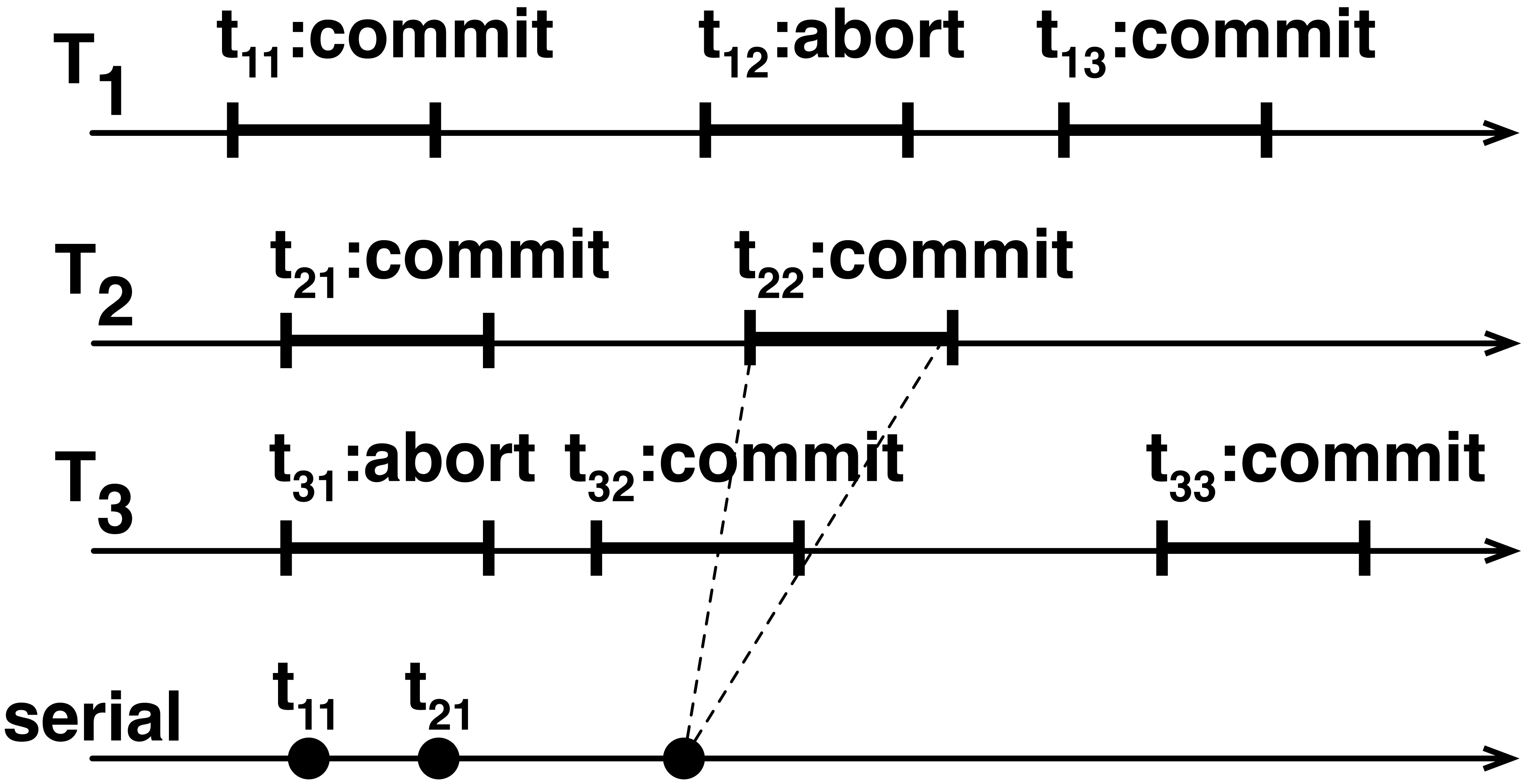

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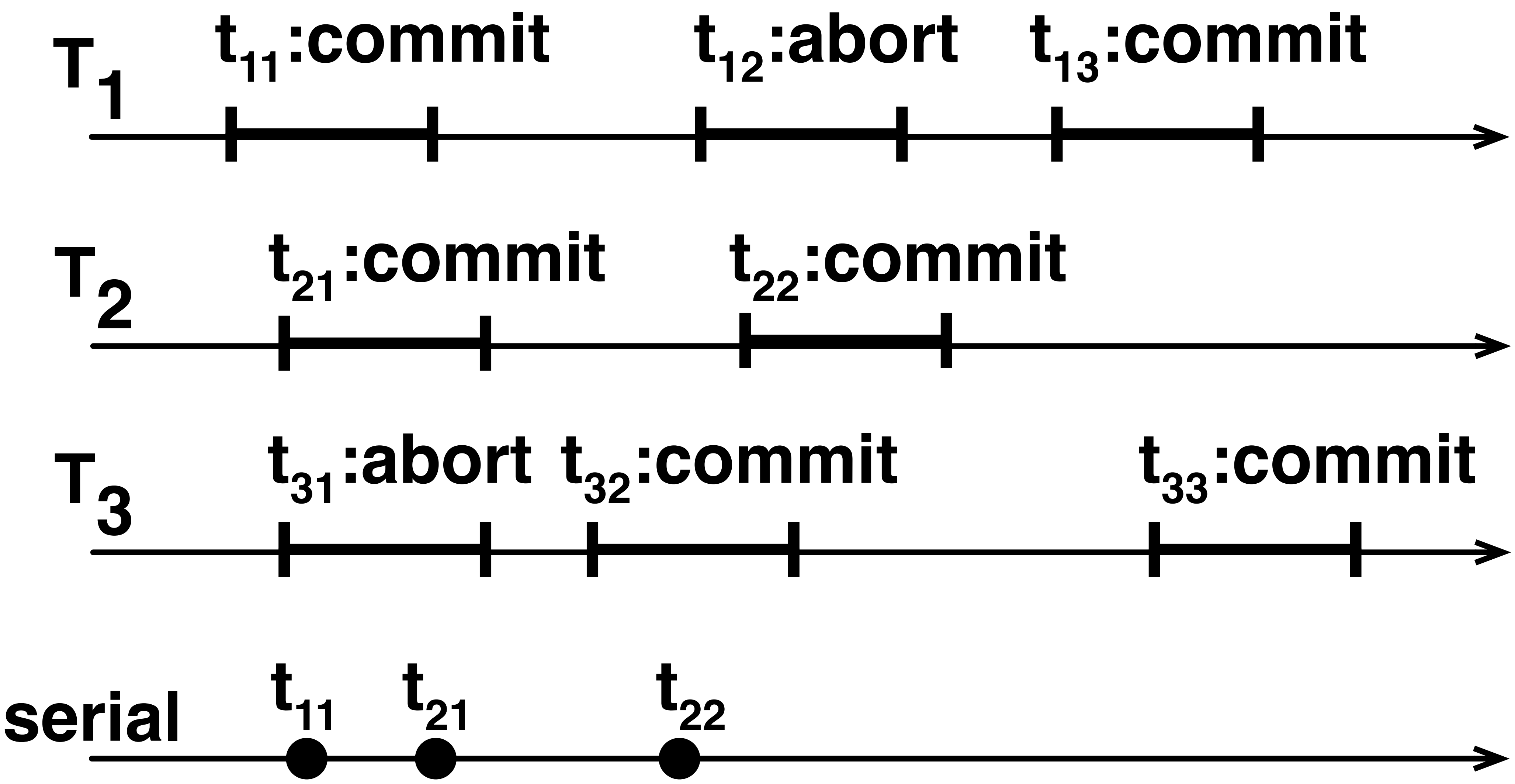

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serial t_{11} t_{21} t_{22}

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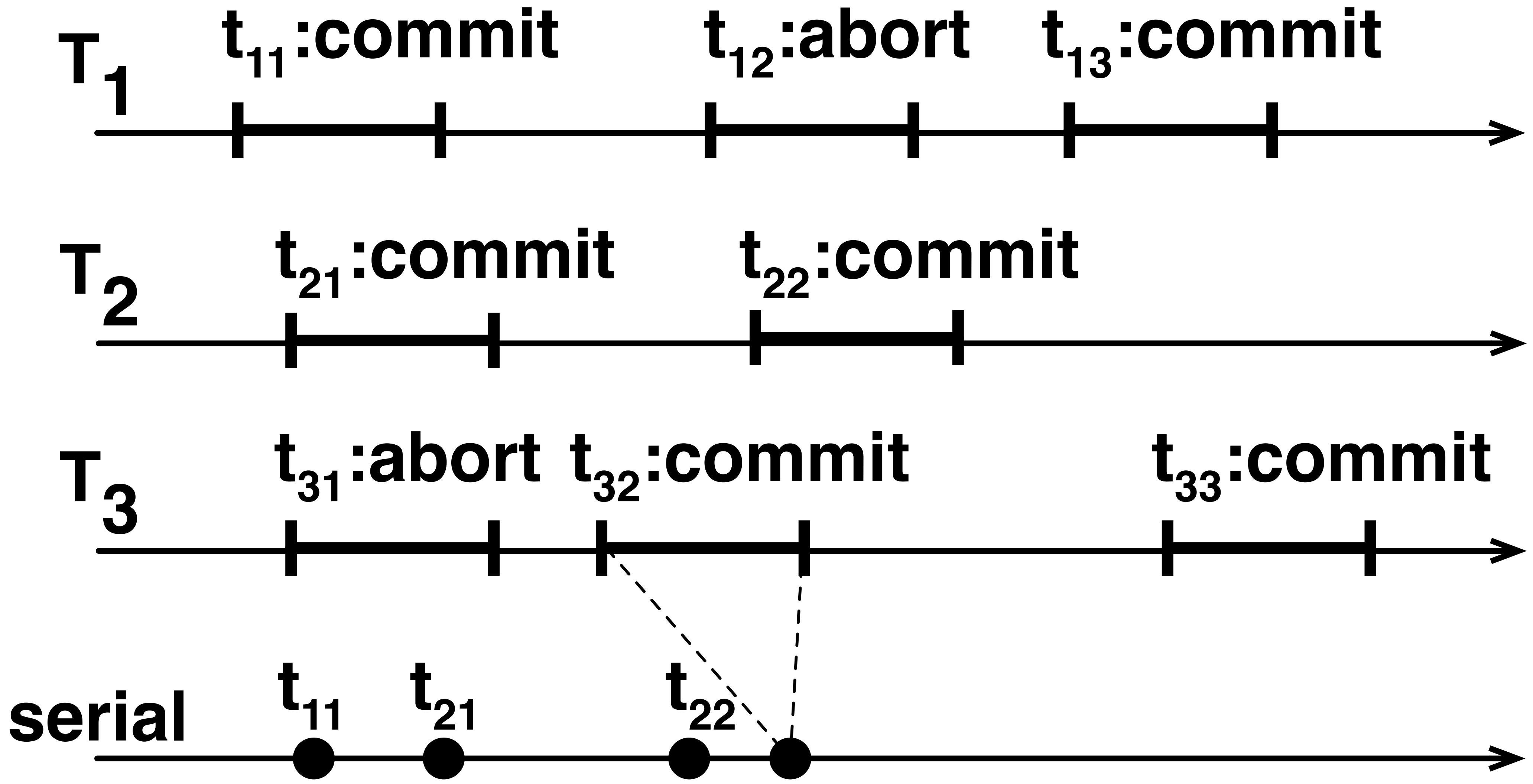

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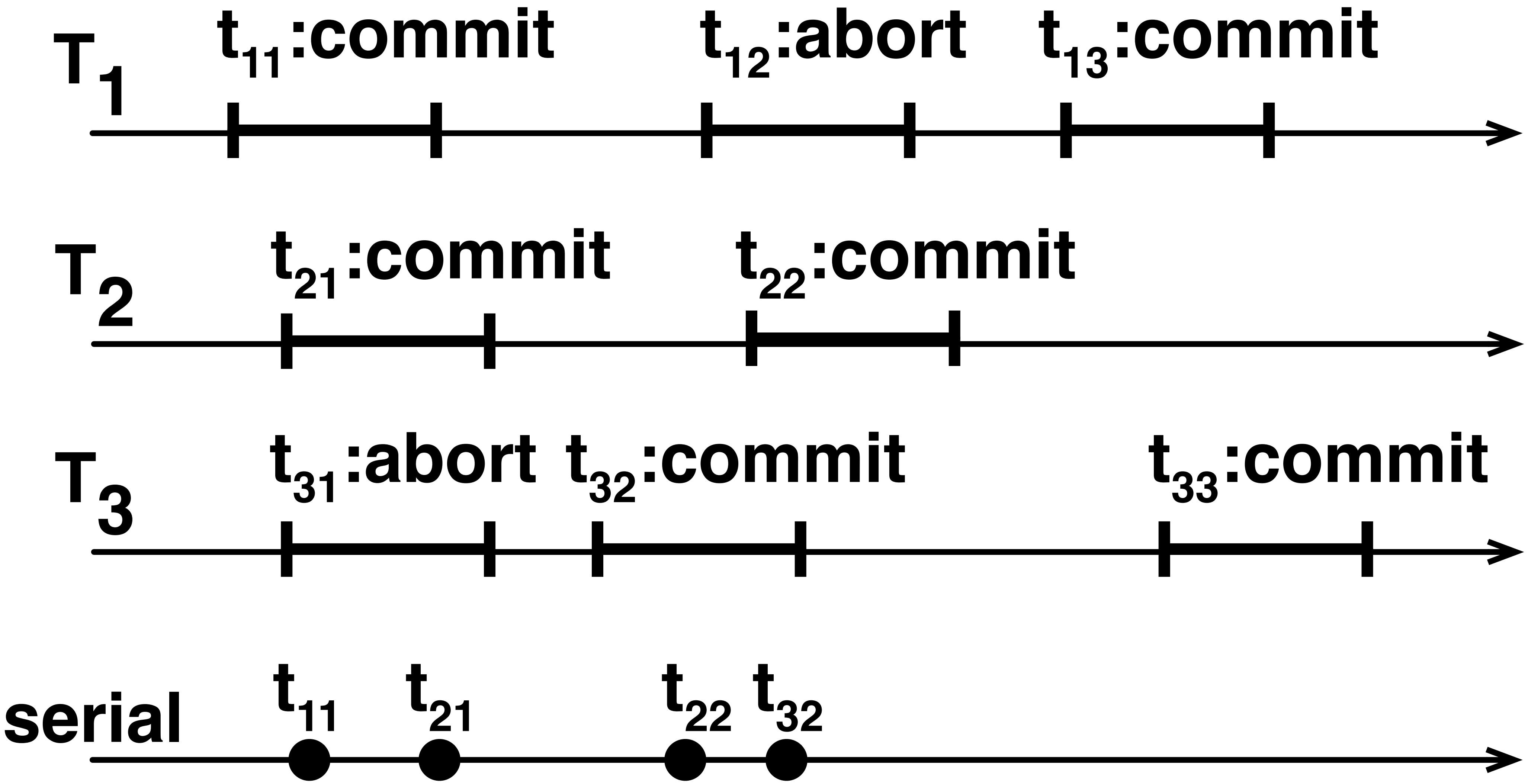

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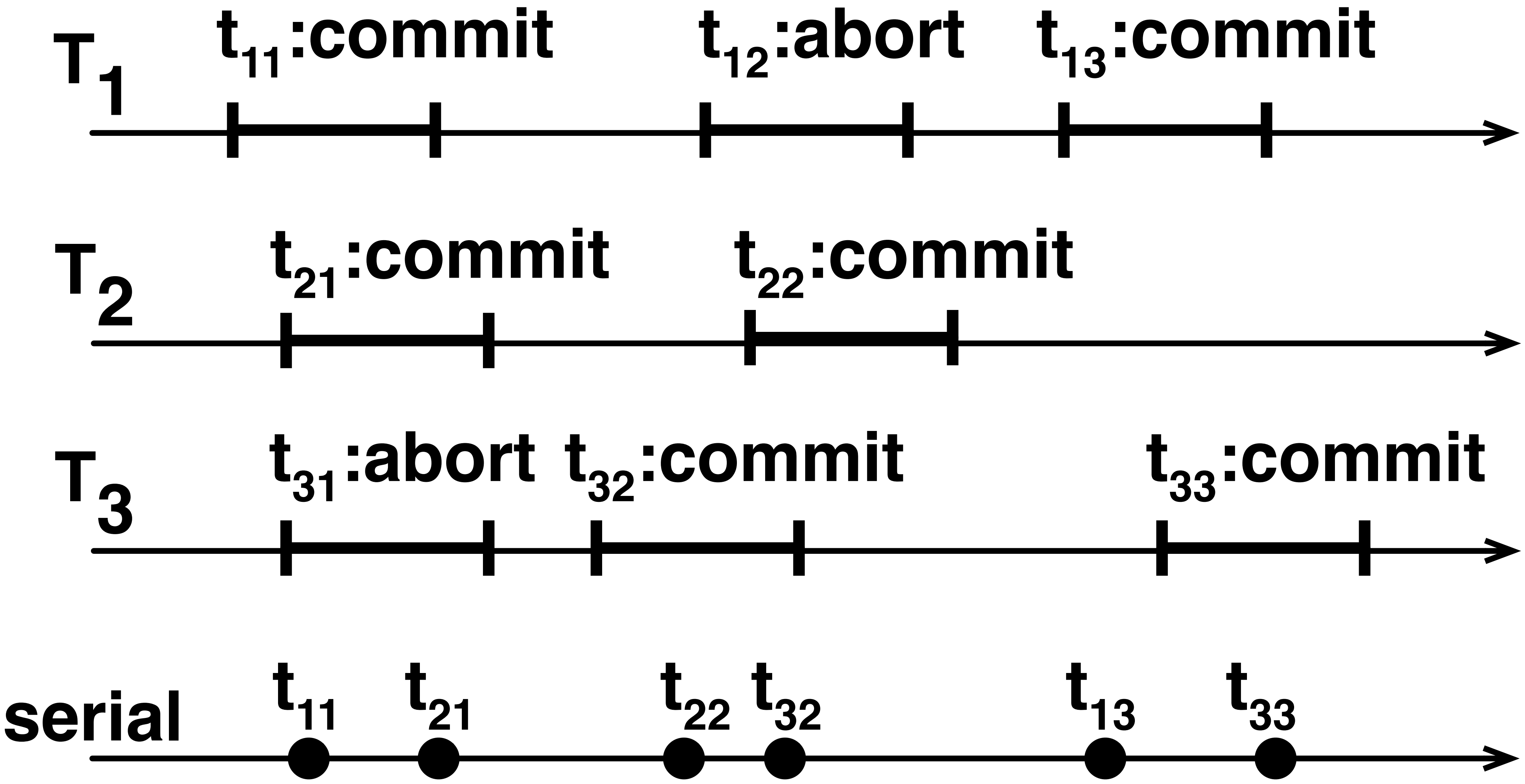
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