Сутки профиля

На одной странице

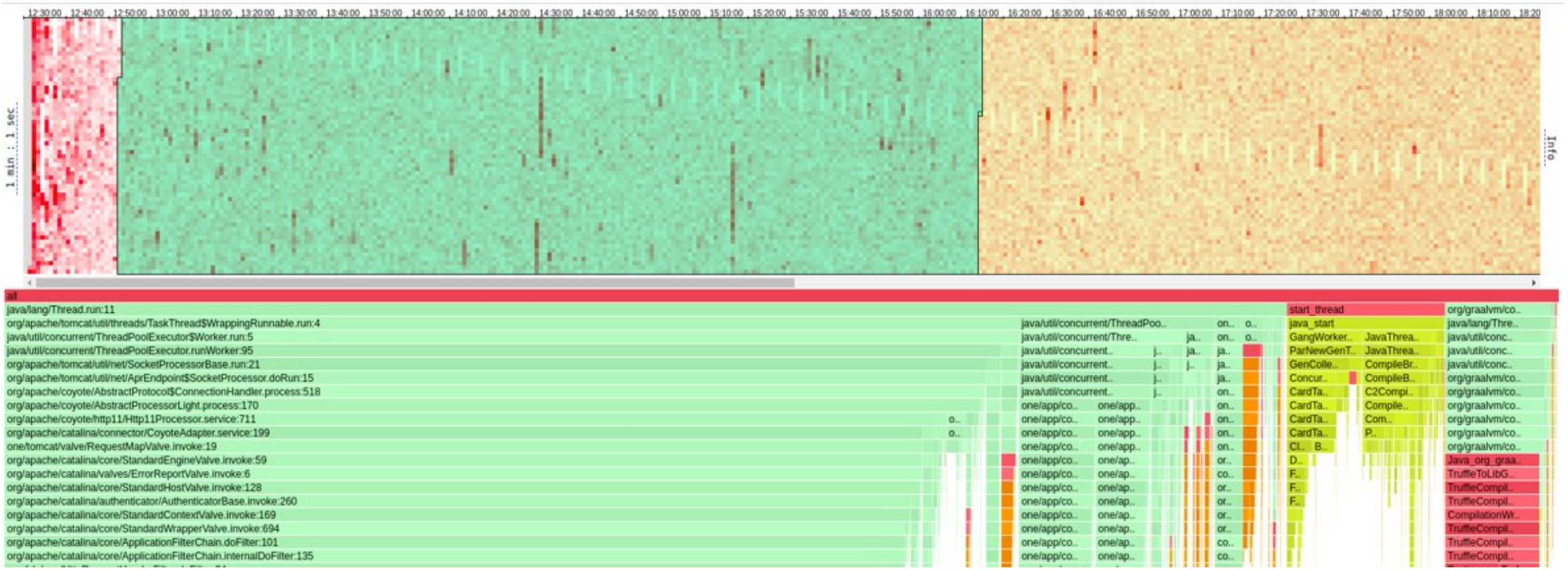
Артём Дроздов

Одноклассники

- 12K серверов в 7 ЦОД
- 50K контейнеров в one-cloud*
- >1 EB данных
- 4 Tbps исходящего трафика
- до 100K rps на контейнер

* https://www.youtube.com/watch?v=eJShMFzDV6g
One-cloud: ОС уровня дата-центра в Одноклассниках

Профилируем 24/7



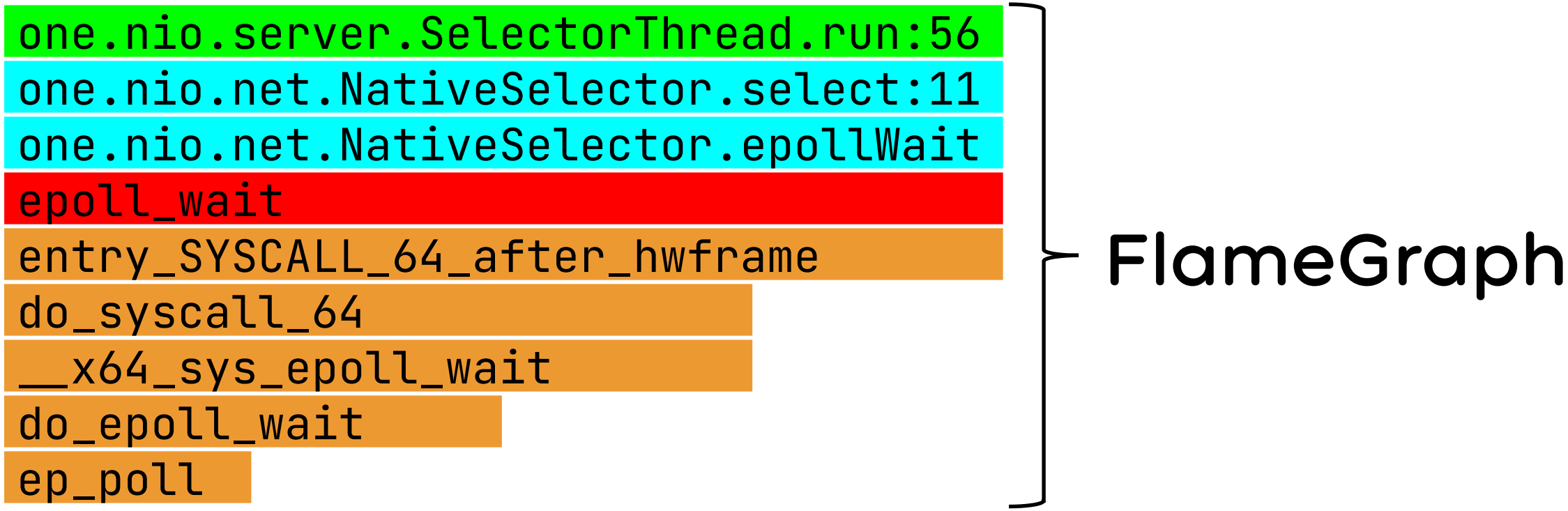
* https://www.youtube.com/watch?v=EcmR2BOeVZE

Непрерывное профилирование в облаке с помощью eBPF

Что ты такое?

Введение

Введение


one.nio.server.SelectorThread.run:56
one.nio.net.NativeSelector.select:11
one.nio.net.NativeSelector.epollWait
epoll_wait
entry_SYSCALL_64_after_hwframe
do_syscall_64
__x64_sys_epoll_wait
do_epoll_wait
ep_poll
FlameGraph

Введение

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epoll_wait
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do_syscall_64
__x64_sys_epoll_wait
do_epoll_wait
ep_poll
```

Frame

Class: ...SelectorThread
Method: run
Line: 56
Type: JIT-compiled

M1

Введение

```
one.nio.server.SelectorThread.run:56
one.nio.net.NativeSelector.select:11
one.nio.net.NativeSelector.epollWait
epoll_wait
entry_SYSCALL_64_after_hwframe
do_syscall_64
__x64_sys_epoll_wait
do_epoll_wait
ep_poll
```

Frame

Class: ...NativeSelector
Method: select
Line: 11
Type: Inlined

M2

Введение

```
one.nio.server.SelectorThread.run:56
one.nio.net.NativeSelector.select:11
one.nio.net.NativeSelector.epollWait
epoll_wait
entry_SYSCALL_64_after_hwframe
do_syscall_64
__x64_sys_epoll_wait
do_epoll_wait
ep_poll
```

Class: ...NativeSelector
Method: epollWait
~~Line: ???~~
Type: Inlined

M3

Введение

```
one.nio.server.SelectorThread.run:56
one.nio.net.NativeSelector.select:11
one.nio.net.NativeSelector.epollWait
epoll_wait
entry_SYSCALL_64_after_hwframe
do_syscall_64
__x64_sys_epoll_wait
do_epoll_wait
ep_poll
```

~~Class: ???~~
Method: epoll_wait
~~Line: ???~~
Type: Native

M4

Введение

```
one.nio.server.SelectorThread.run:56
one.nio.net.NativeSelector.select:11
one.nio.net.NativeSelector.epollWait
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entry_SYSCALL_64_after_hwframe
do_syscall_64
__x64_sys_epoll_wait
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ep_poll
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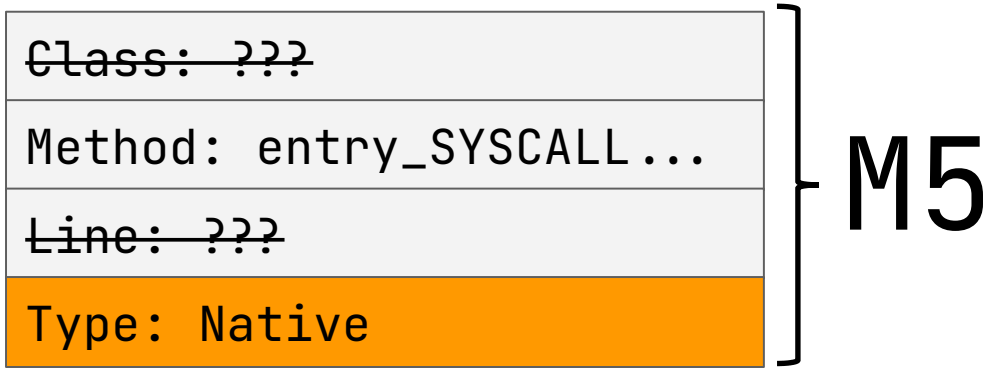

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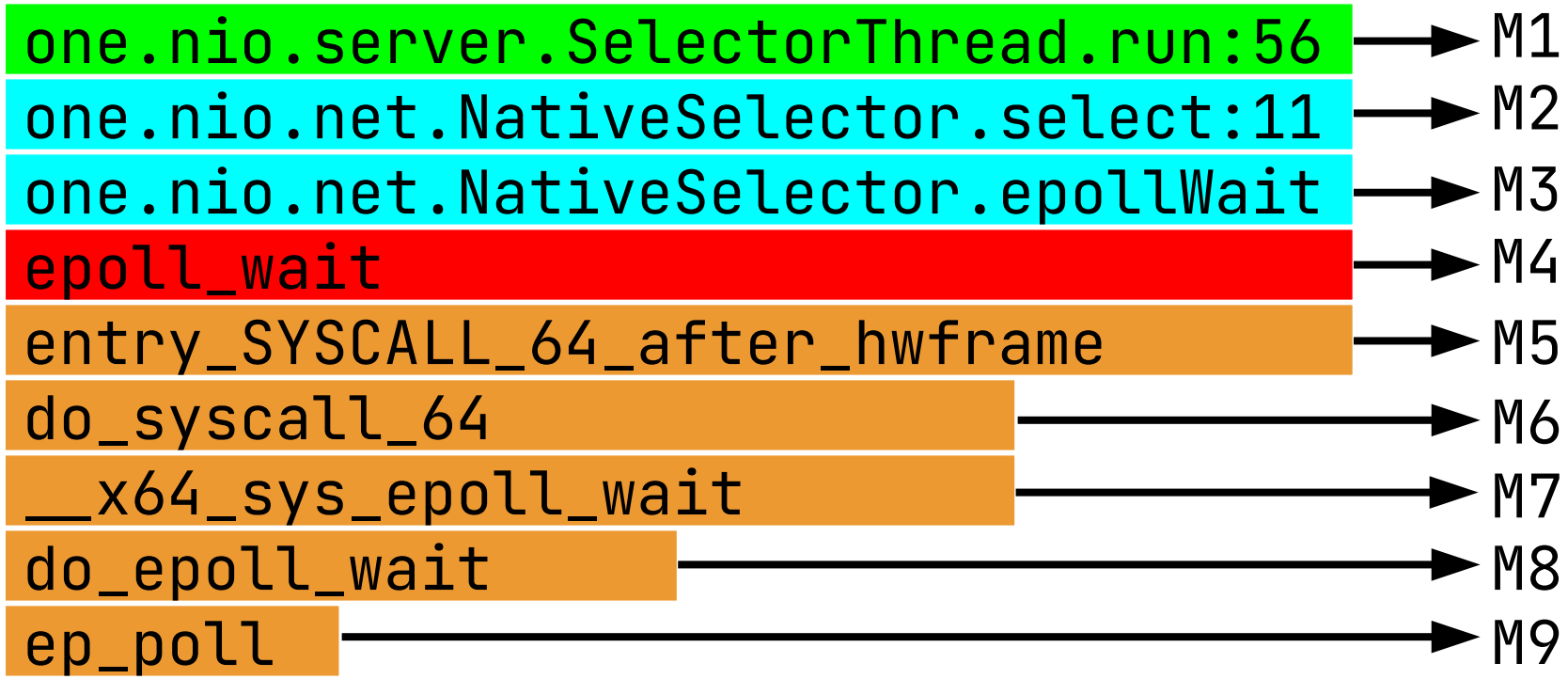
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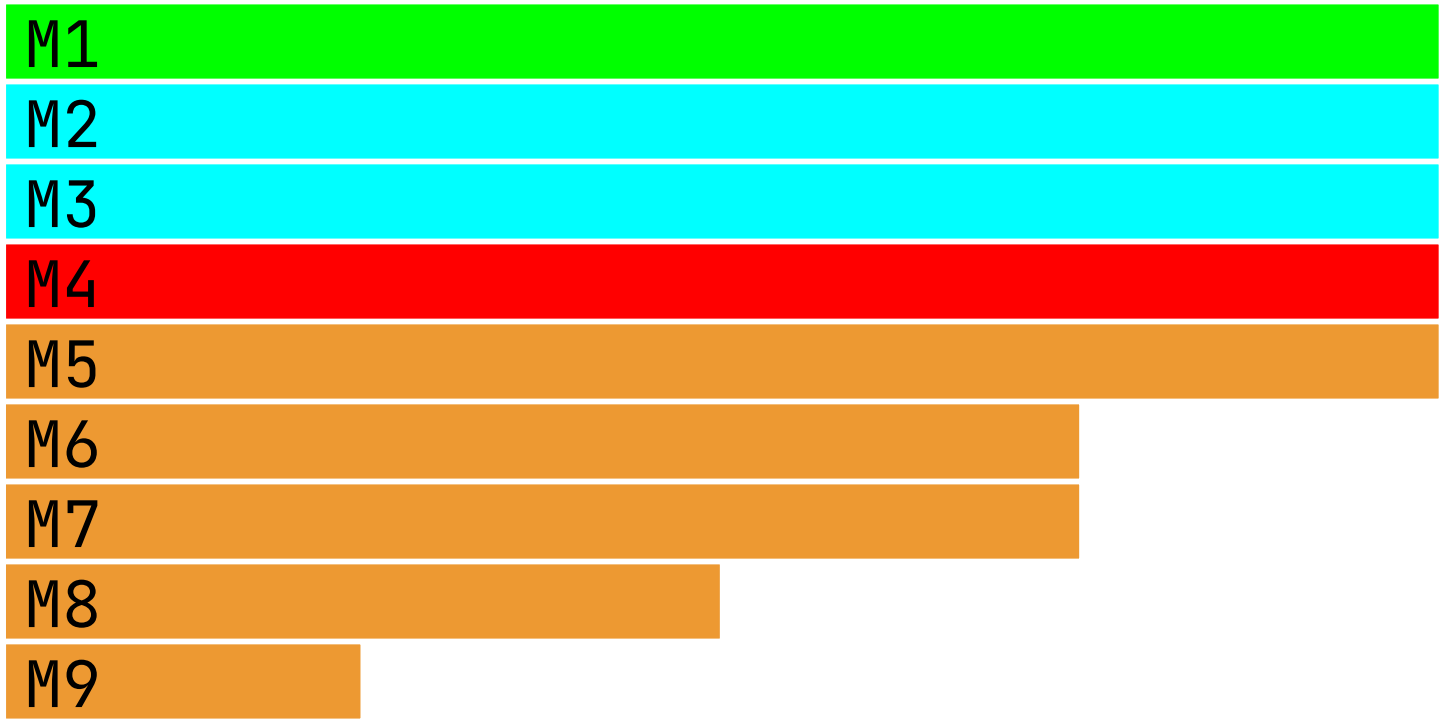

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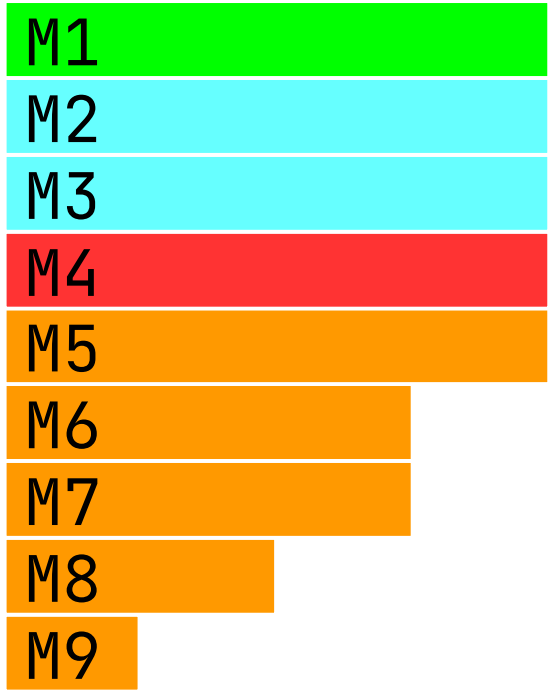

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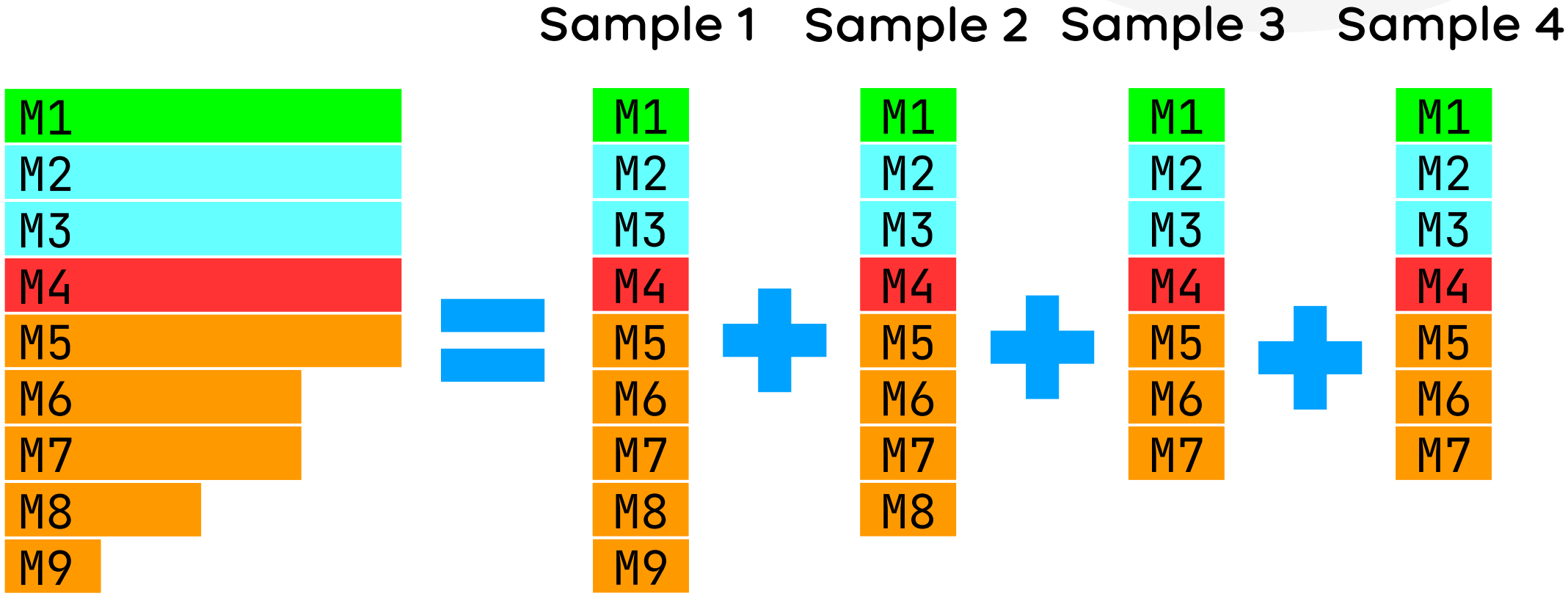
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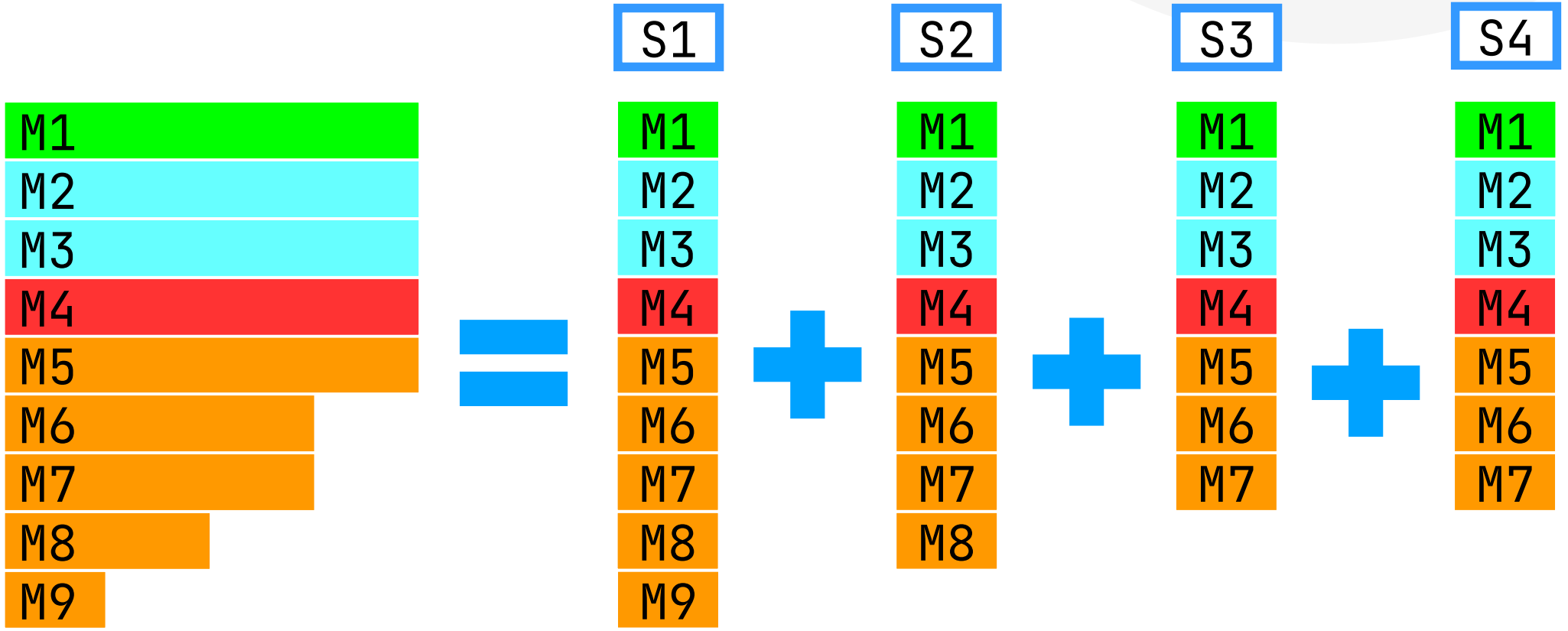
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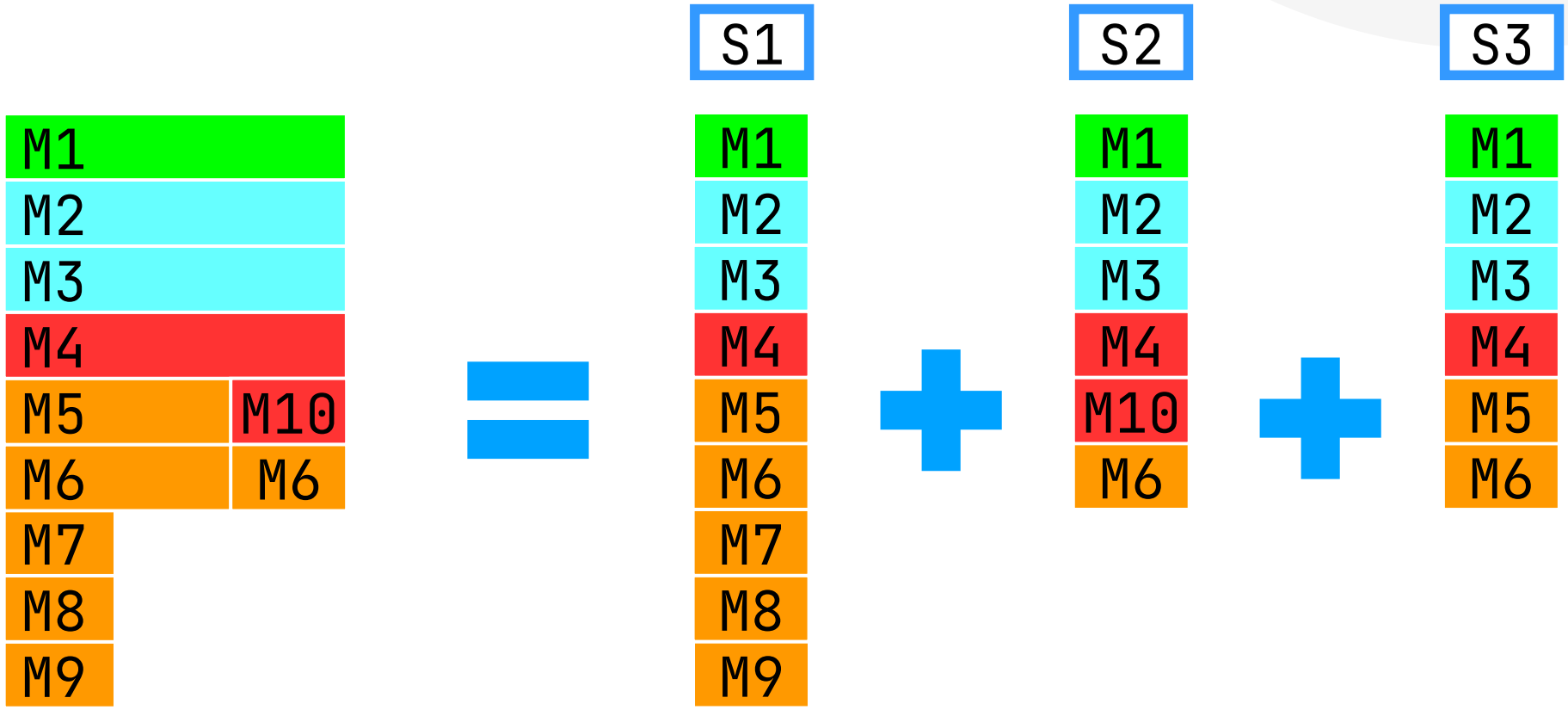
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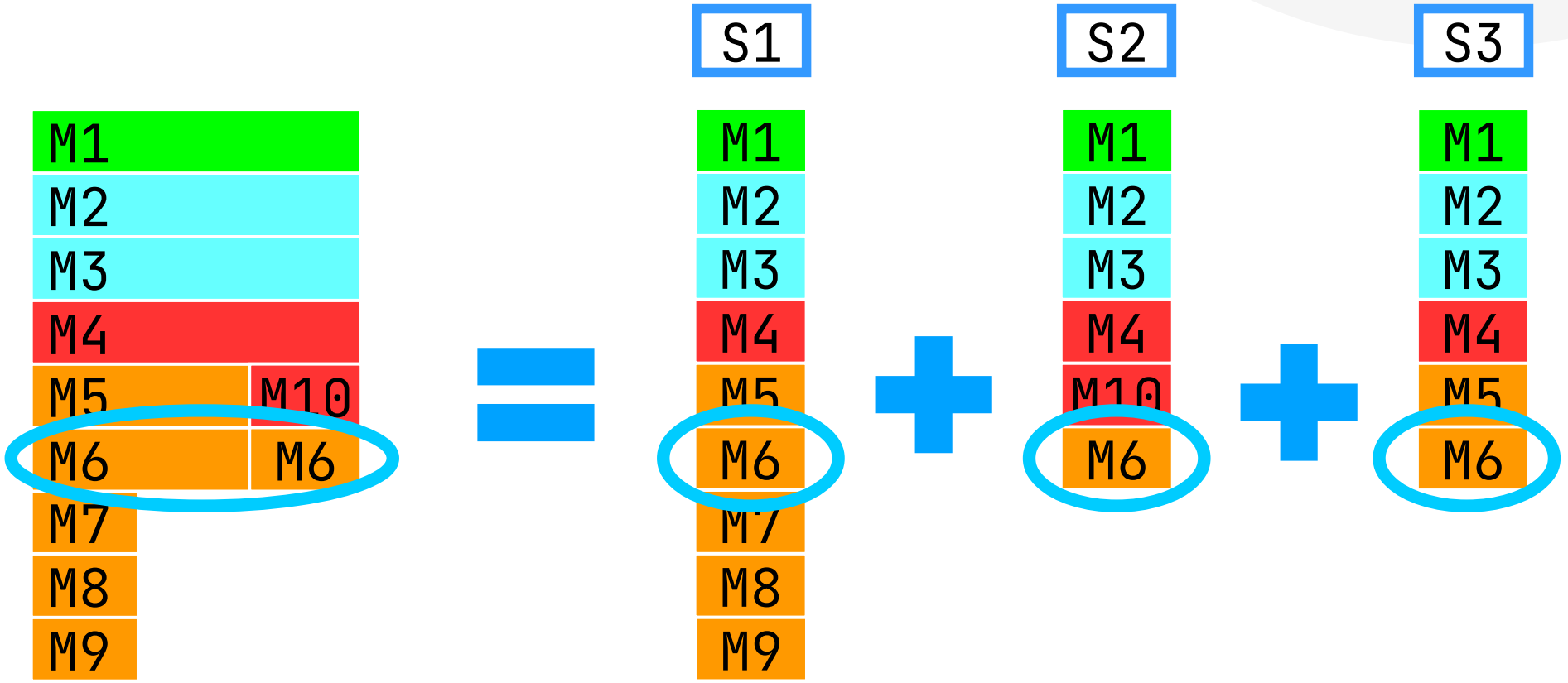
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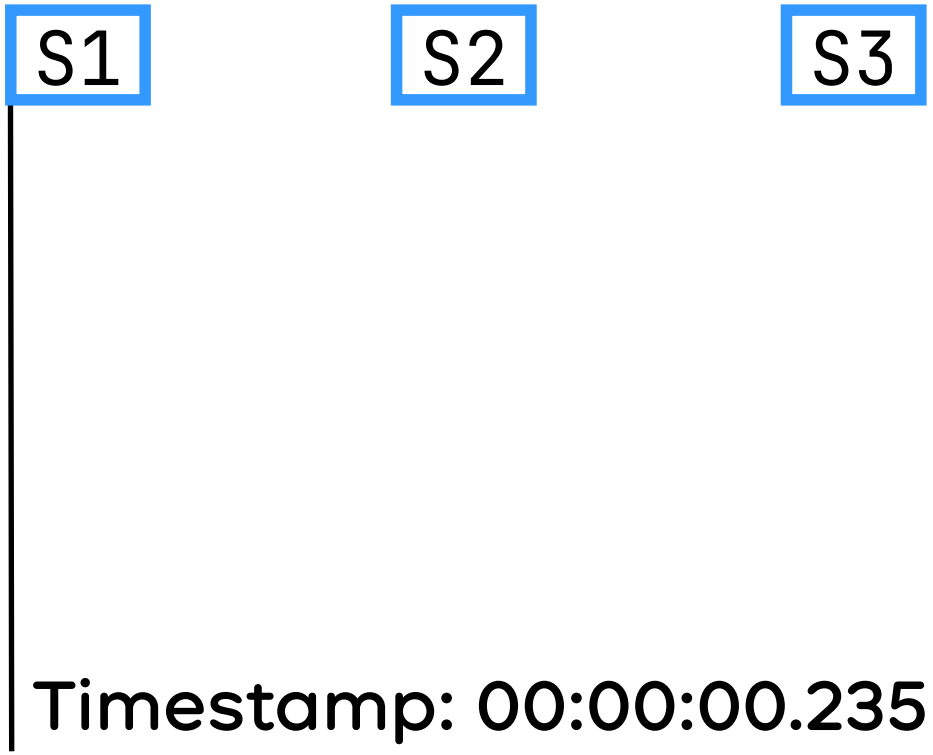

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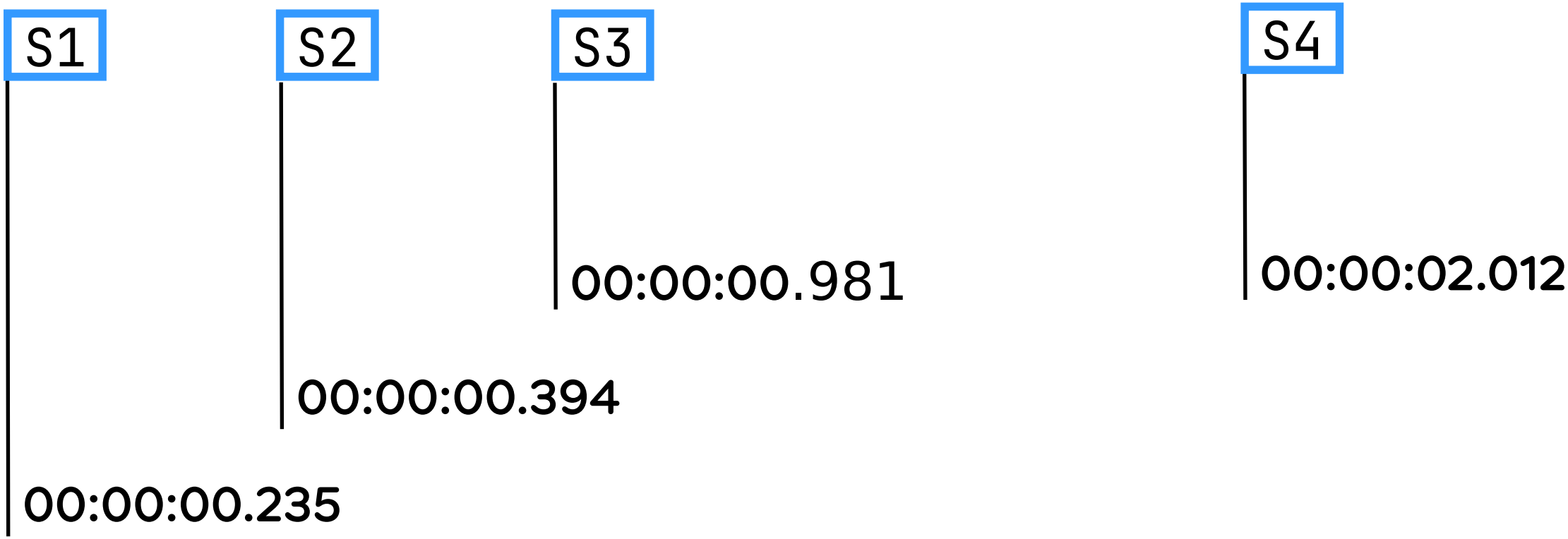

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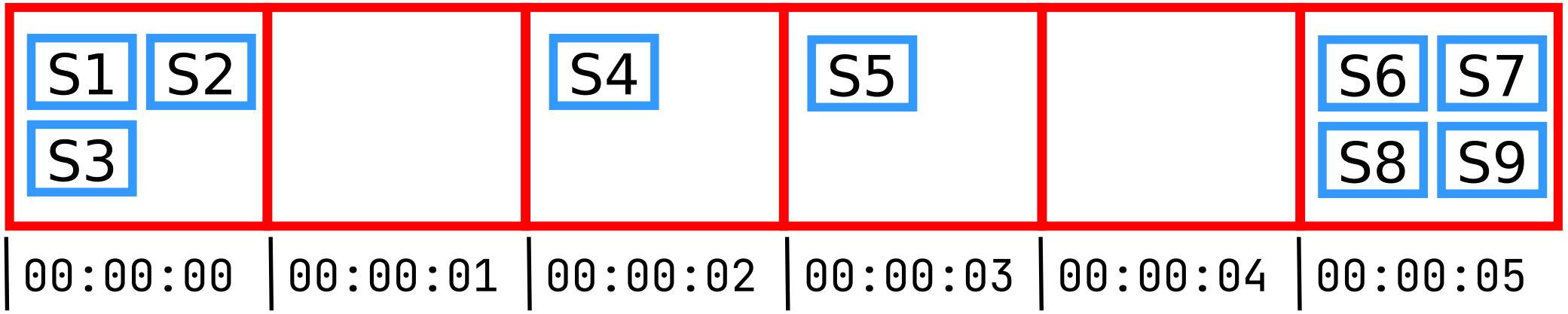
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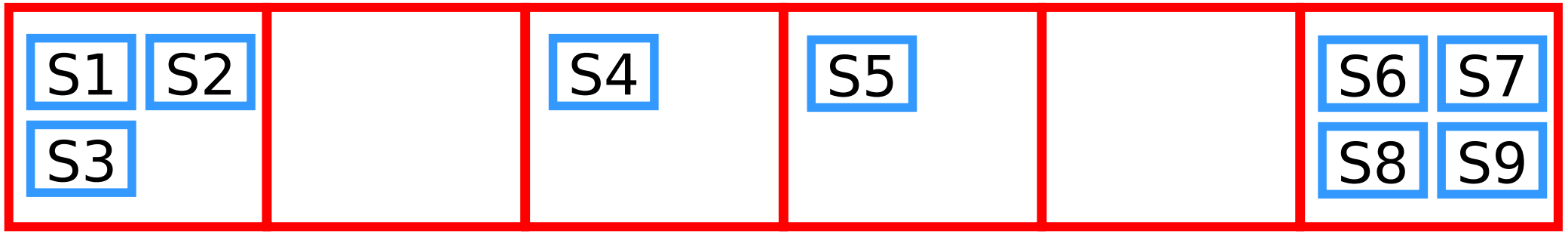

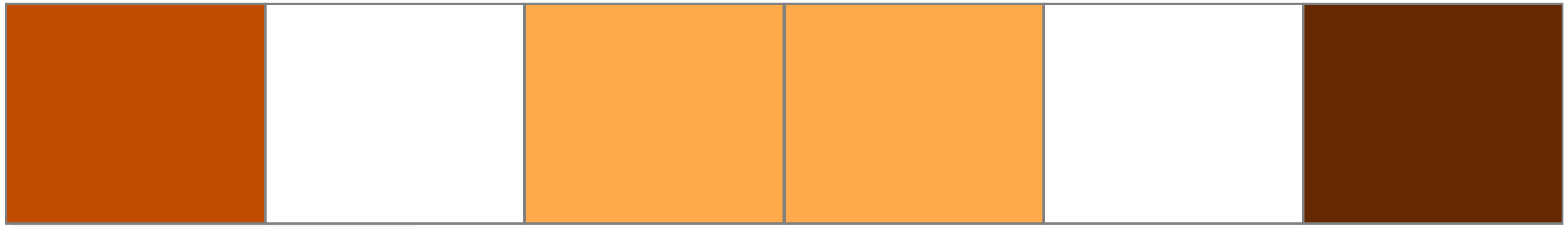

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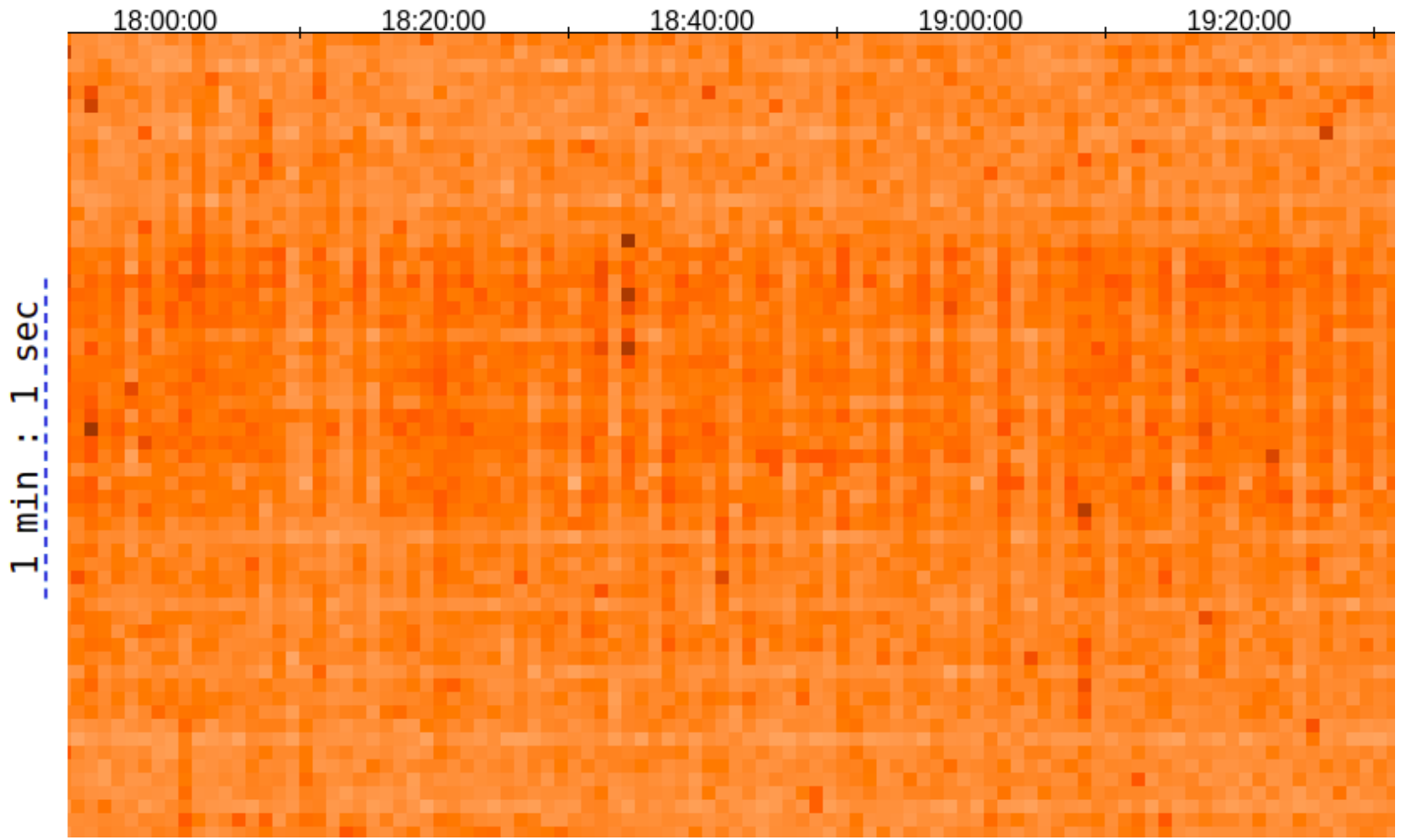

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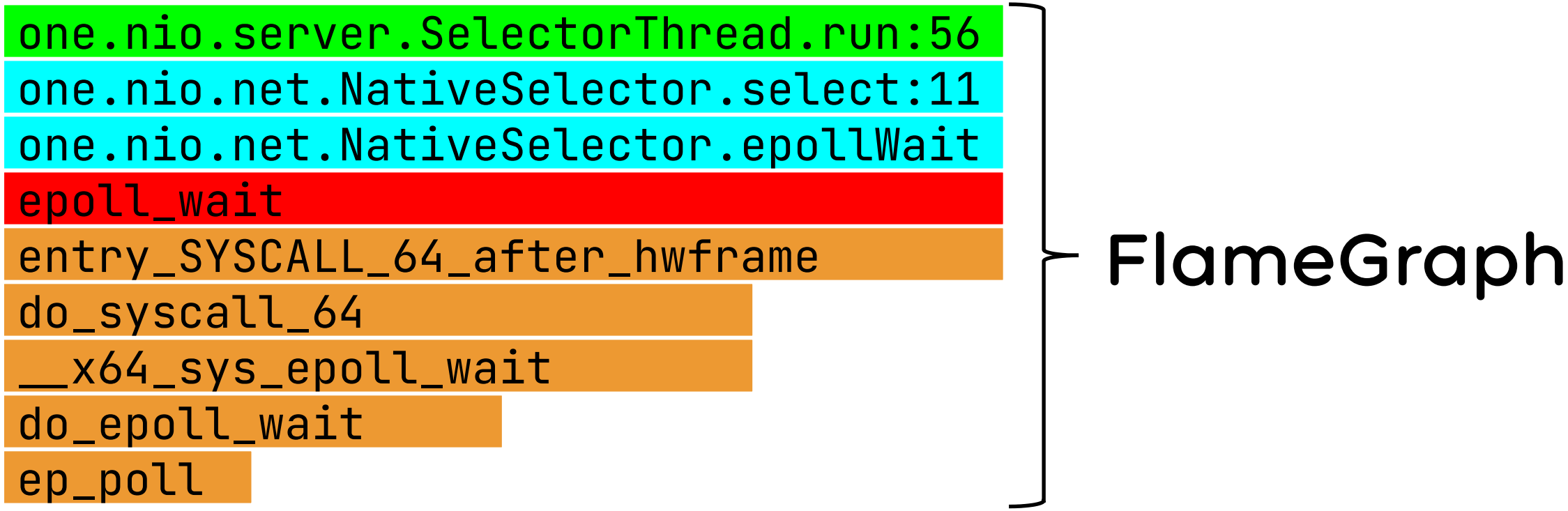
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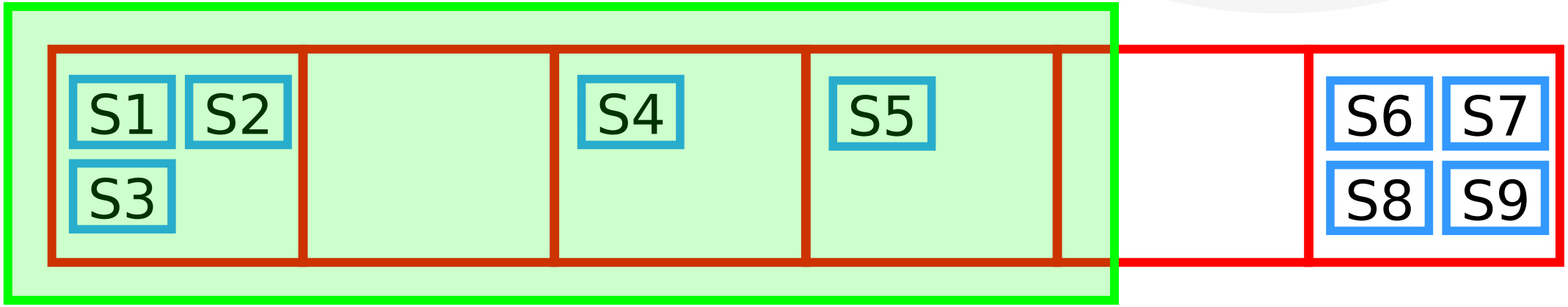

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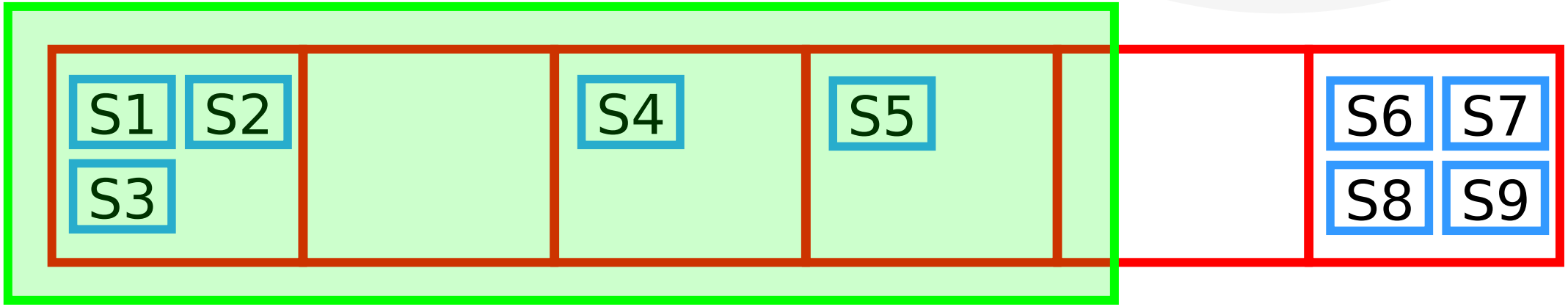

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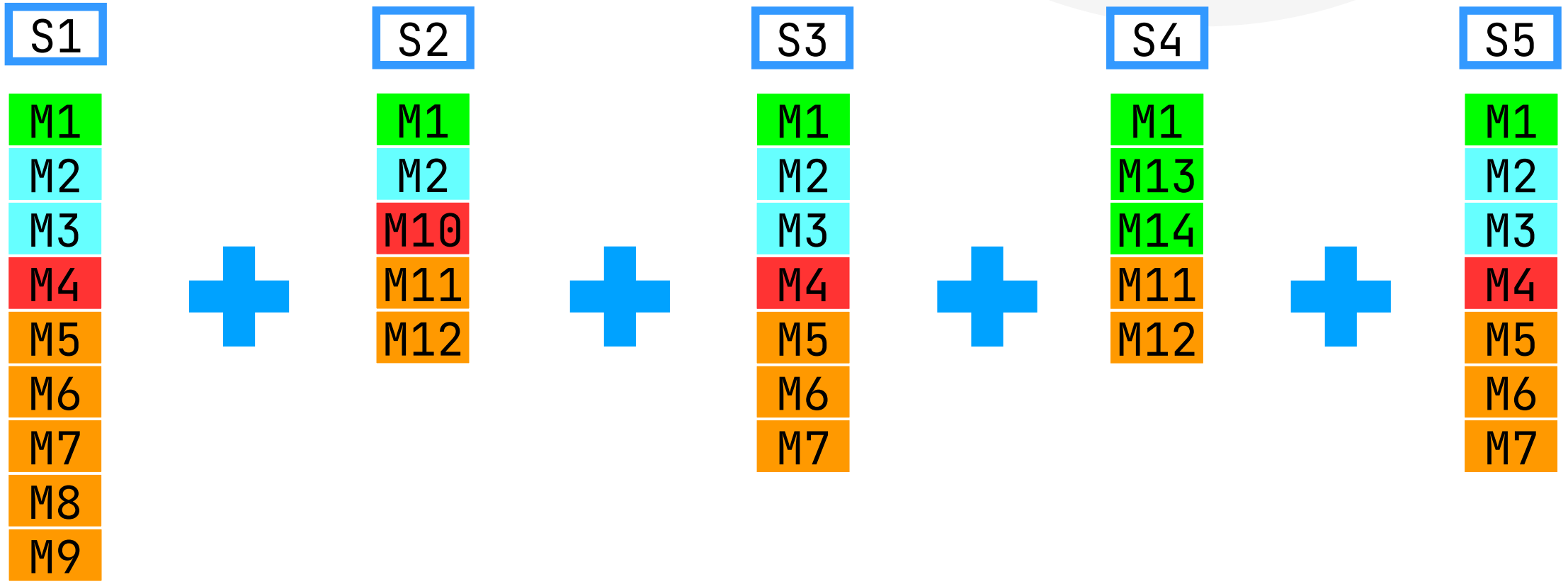
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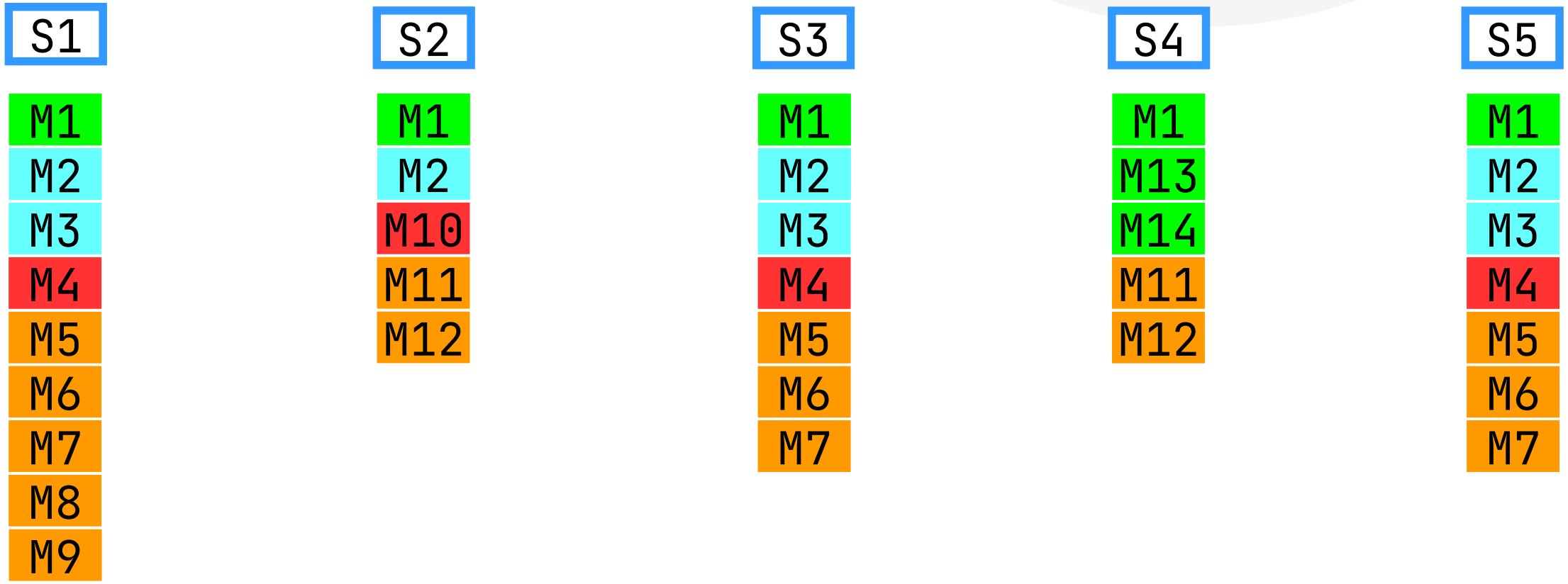
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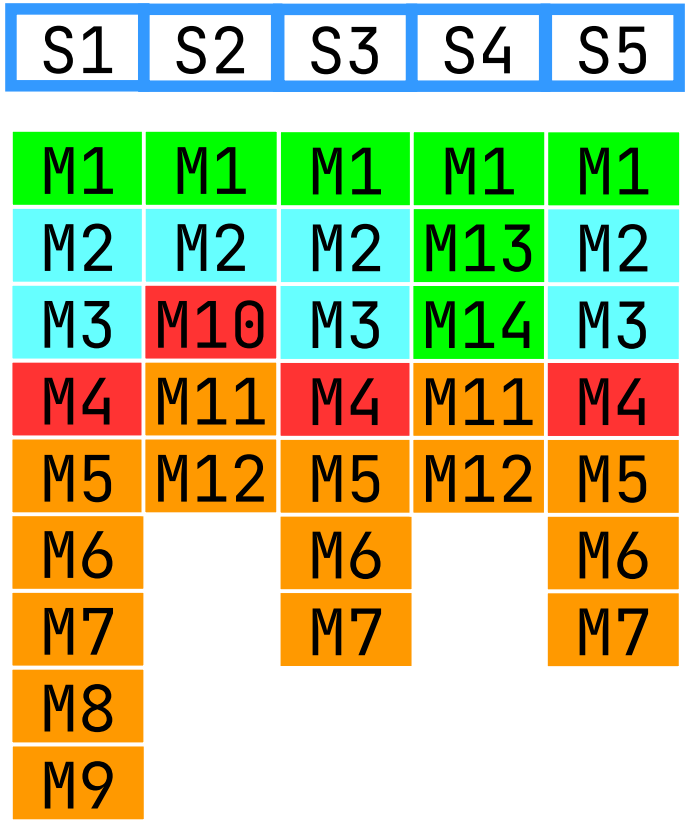
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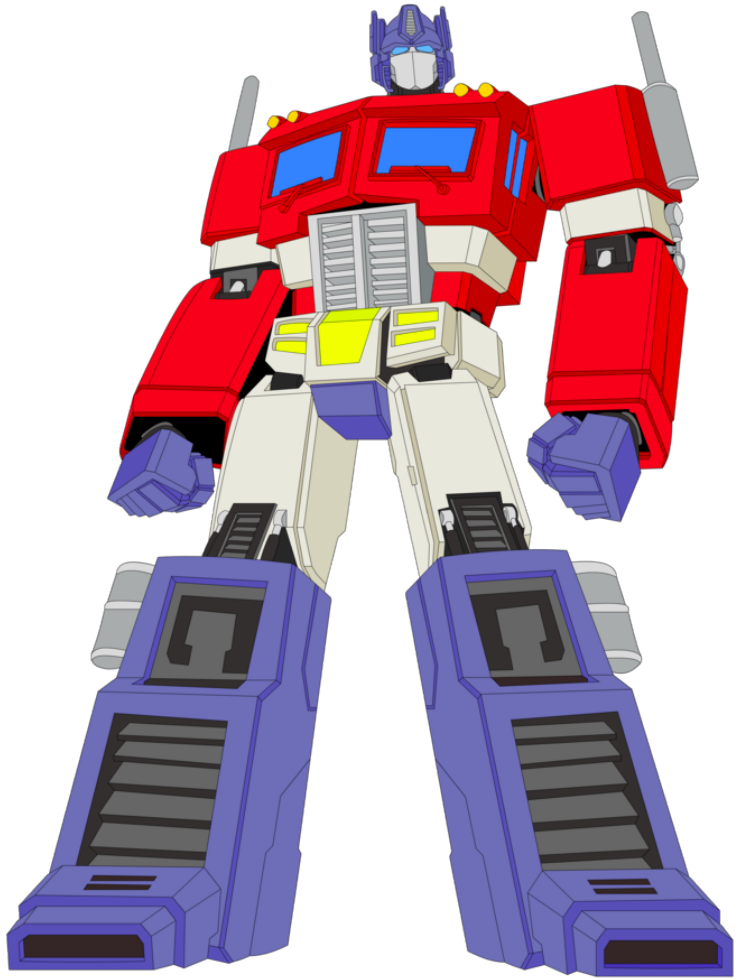

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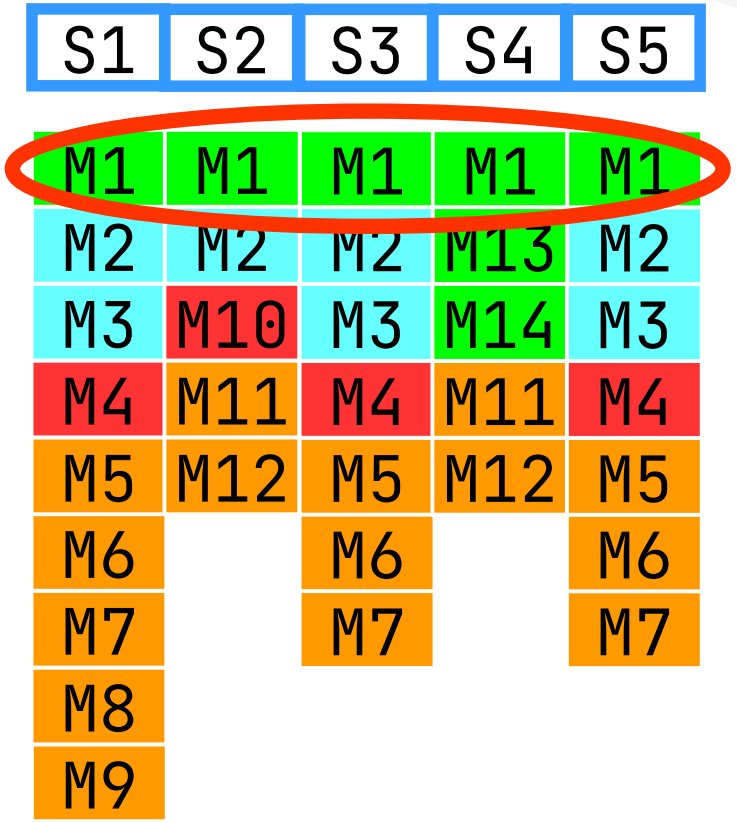
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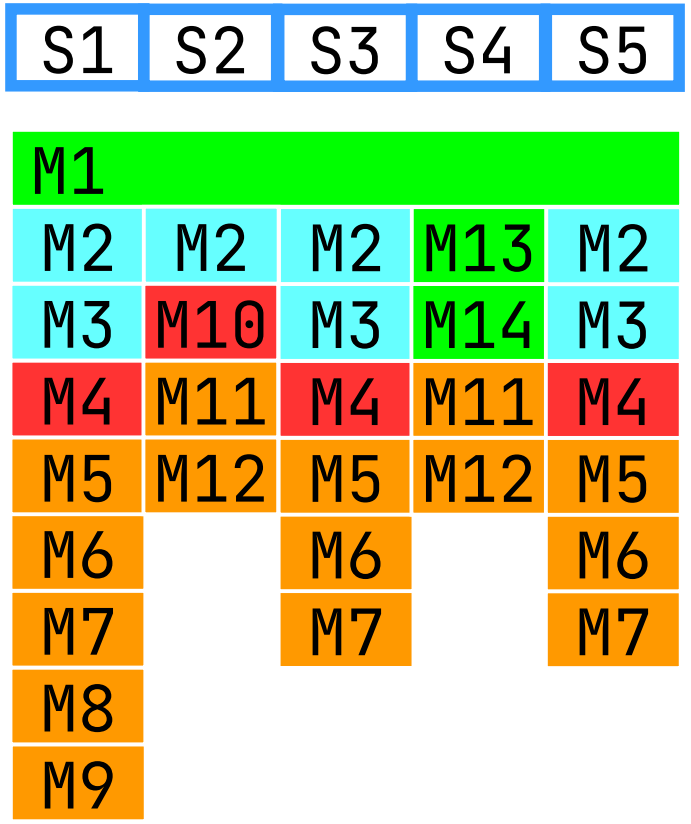
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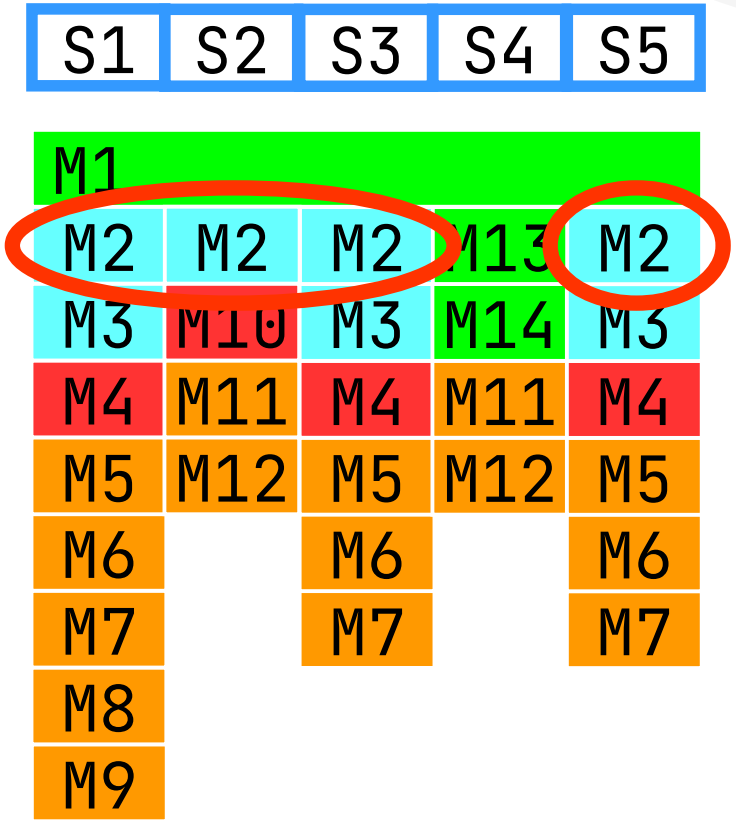
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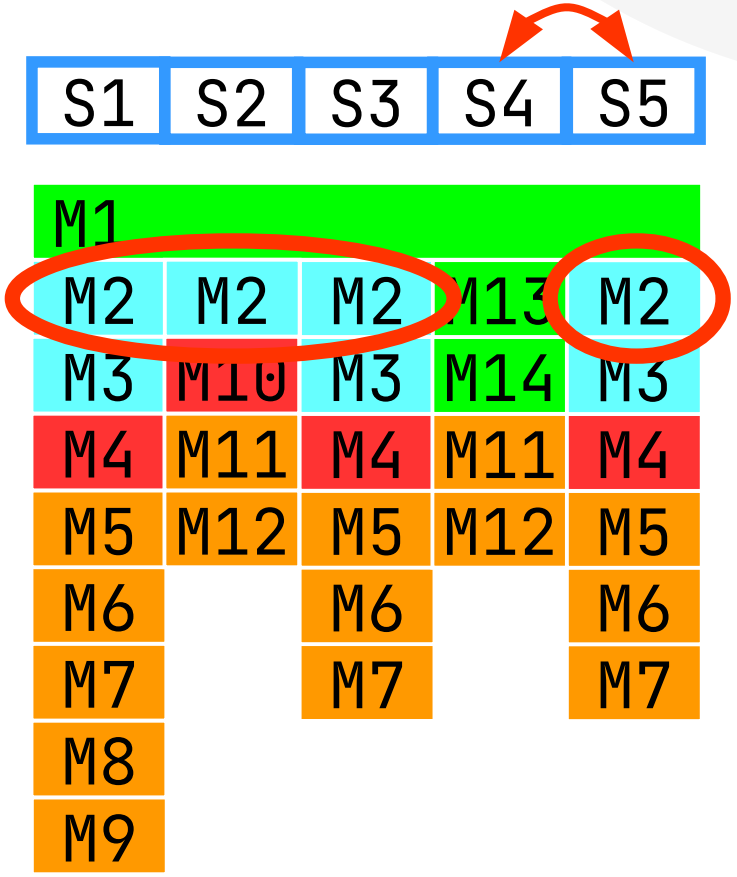
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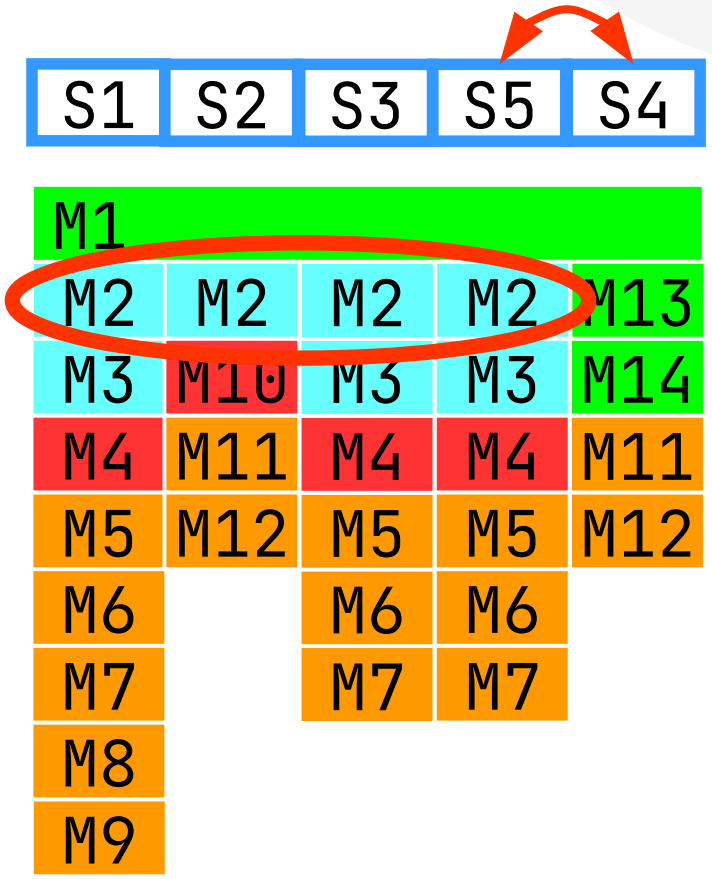
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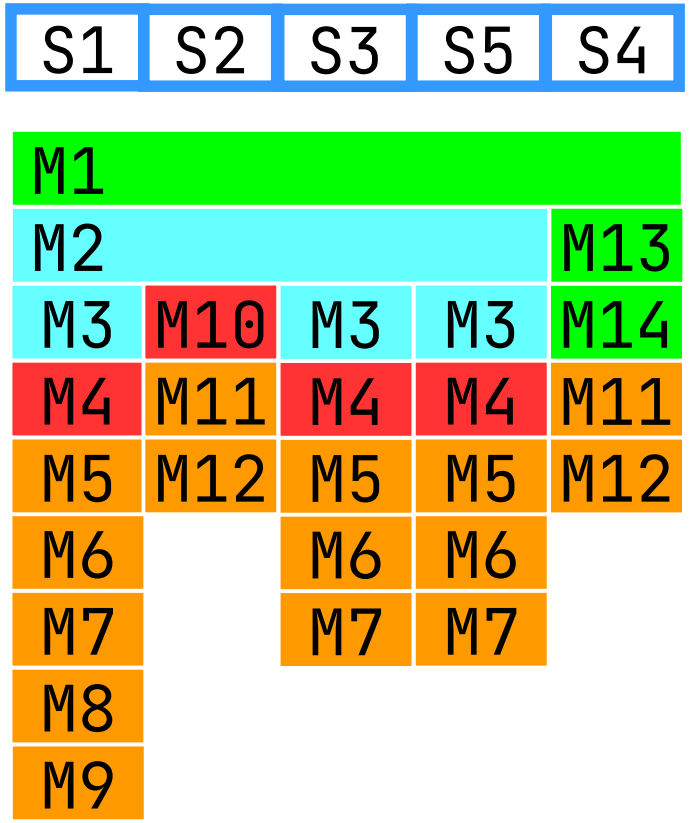
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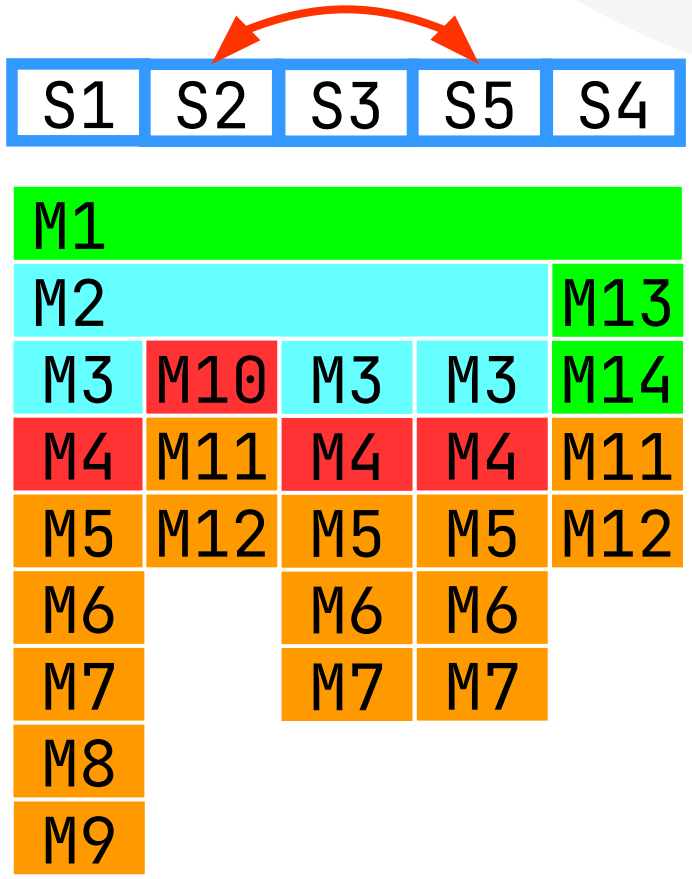
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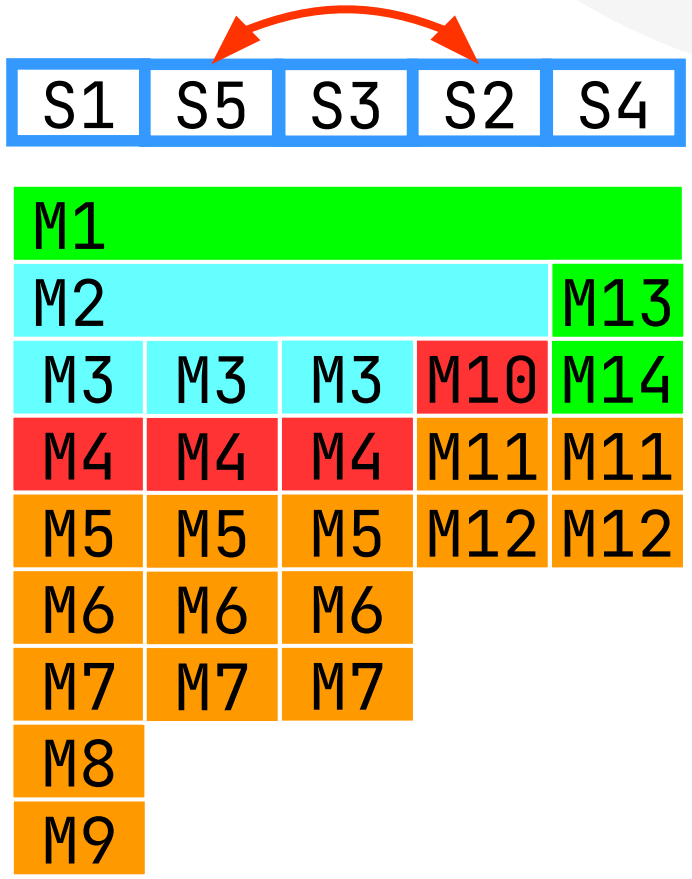
M7
M7
M7
M8
M9

Введение


S1
S5
S3
S2
S4
M1
M2
M13
M3
M3
M3
M10
M14
M4
M4
M4
M11
M11
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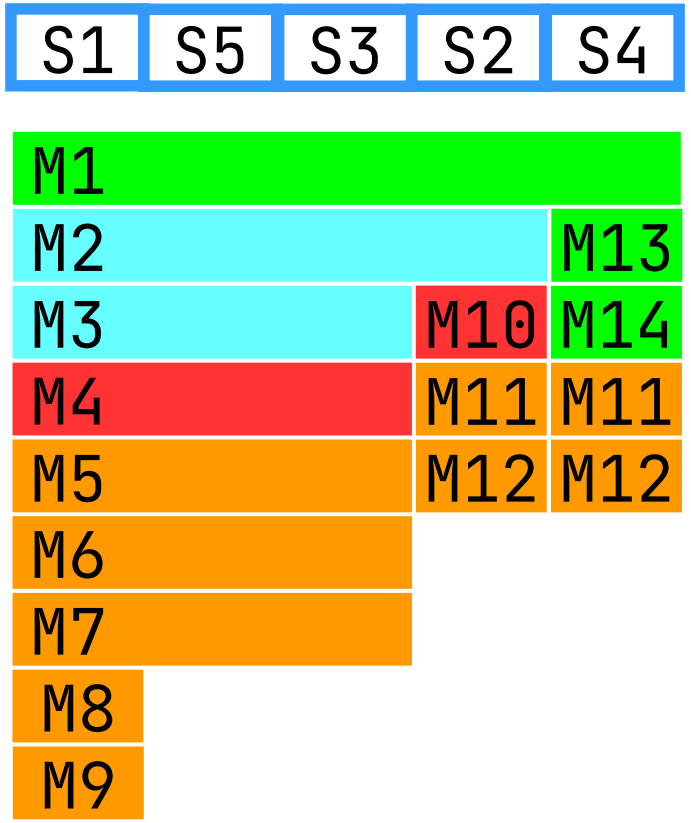
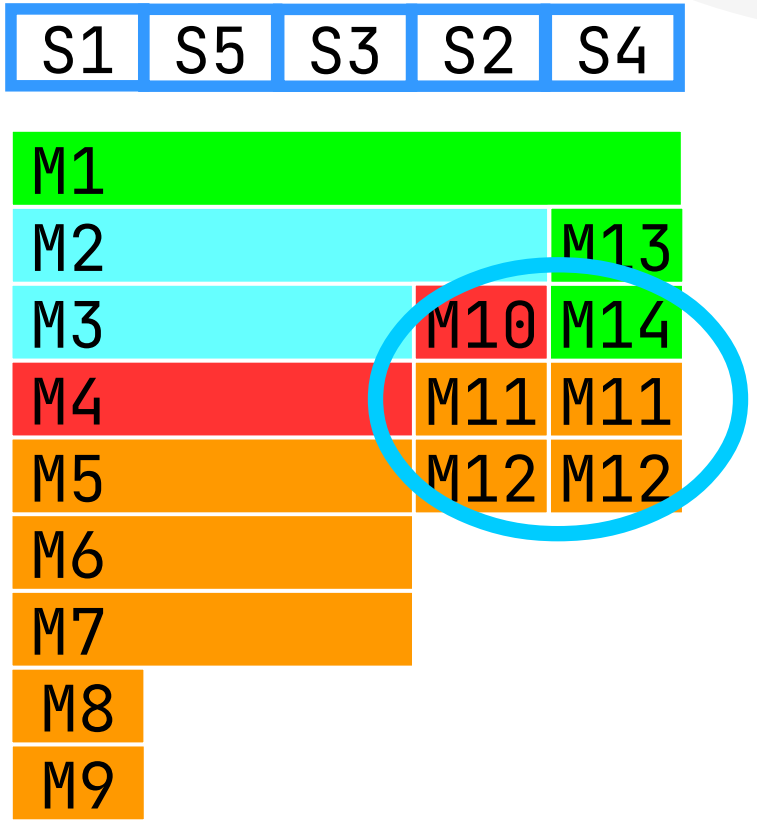
M8
M9

Введение



Введение

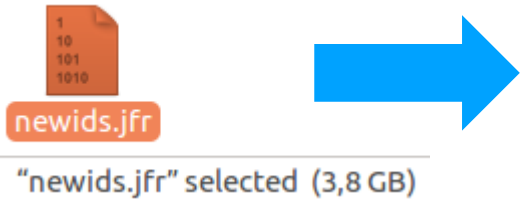


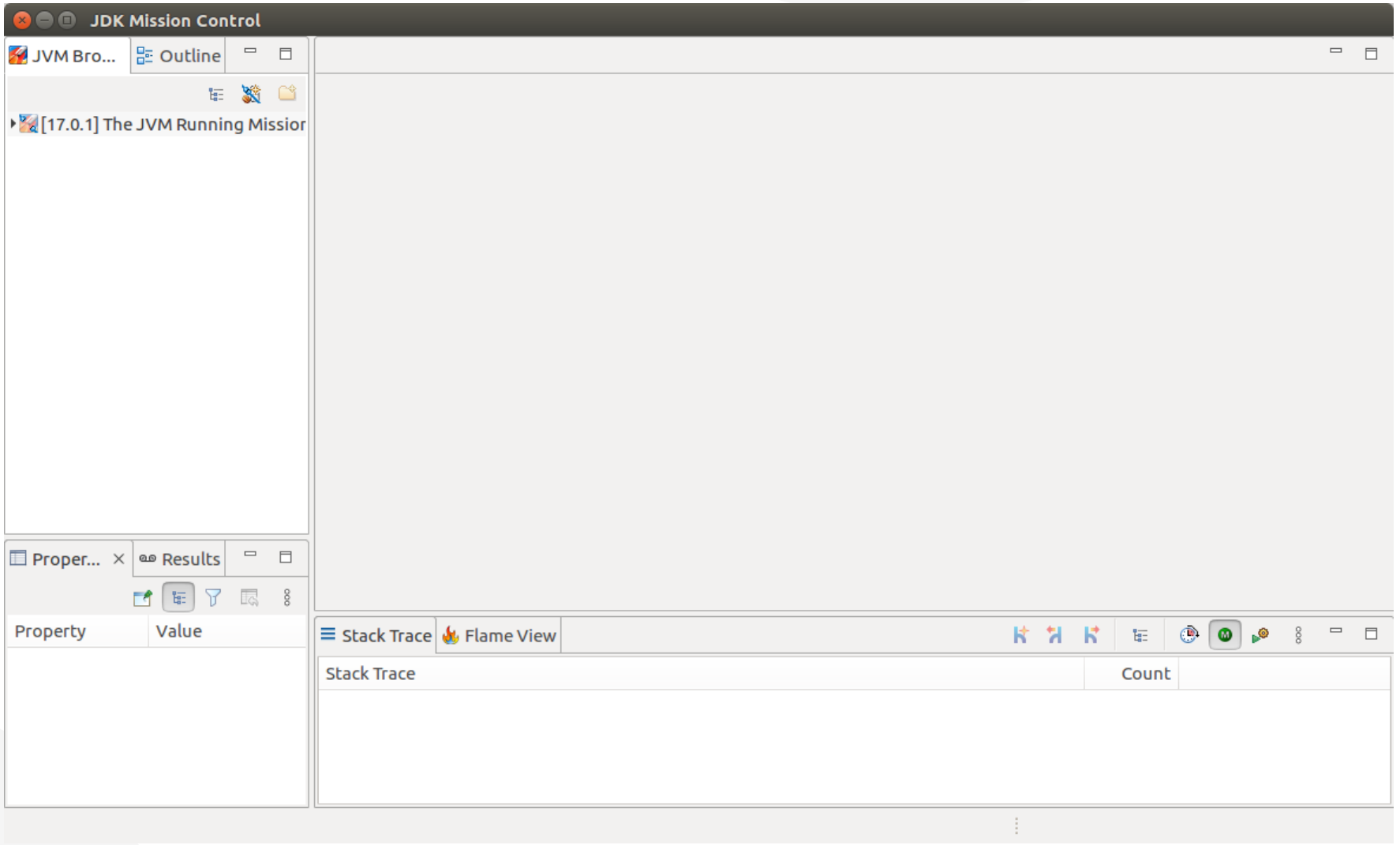
Сутки профиля

По версии JMC

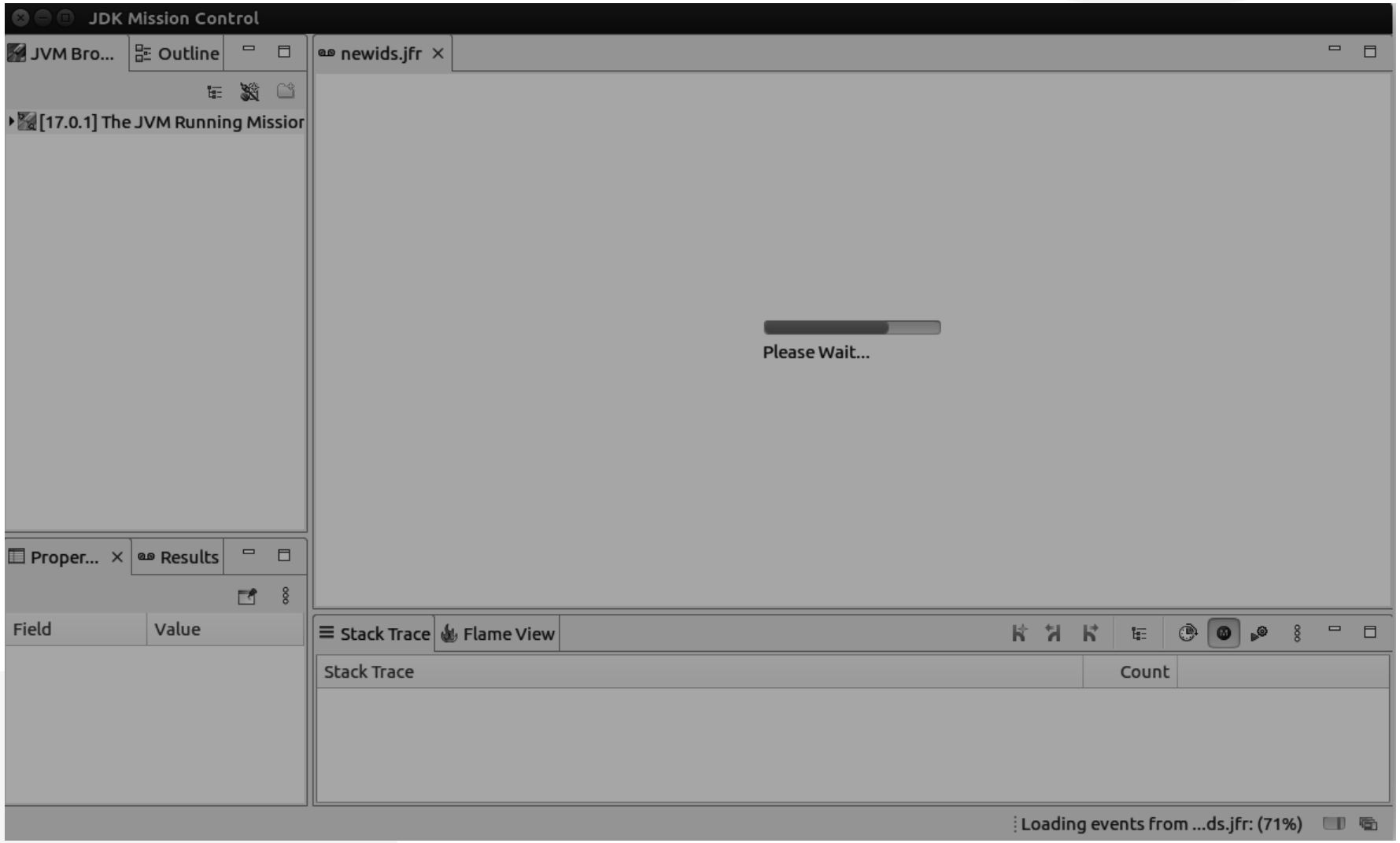
Mission Control

Mission Control

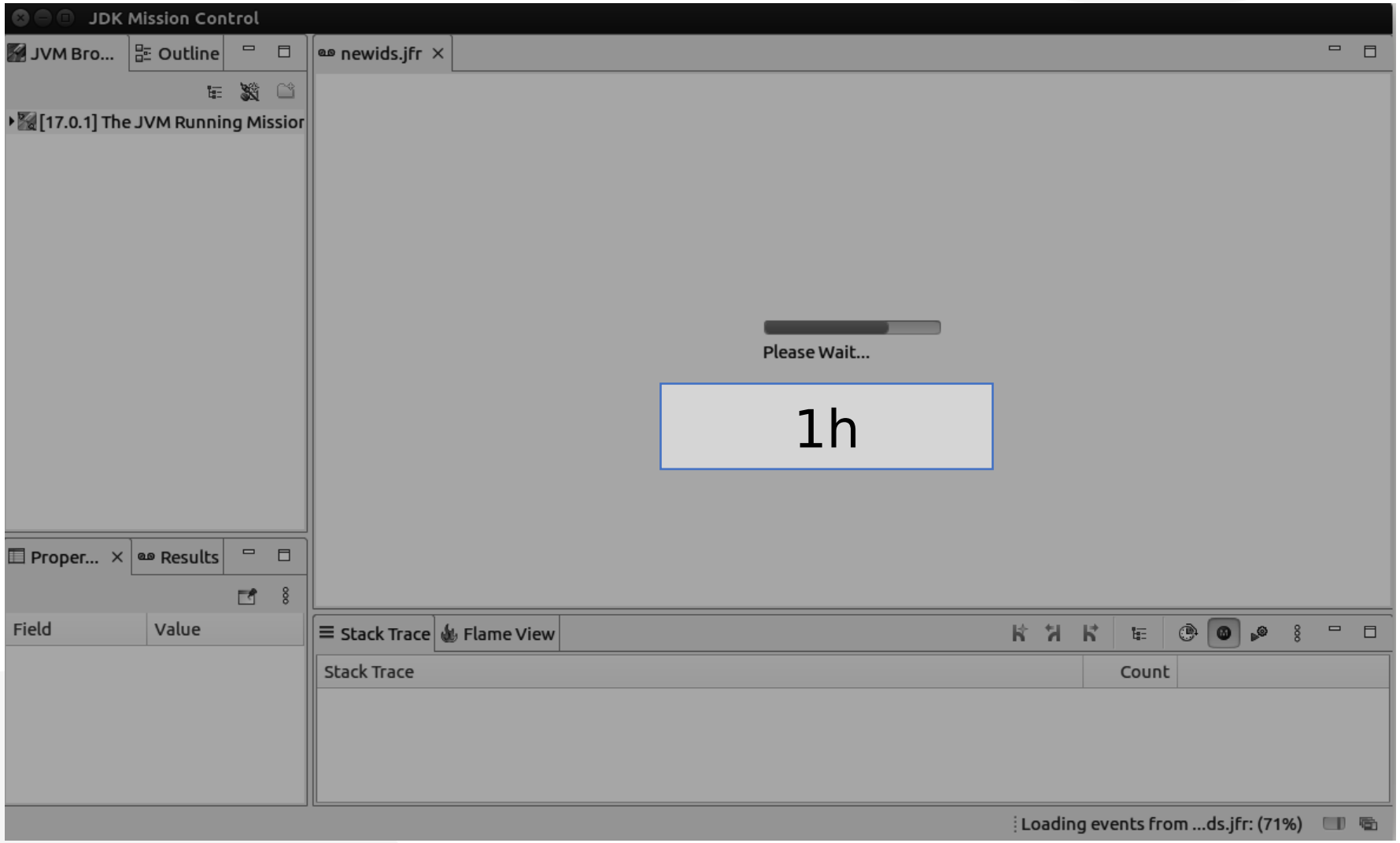




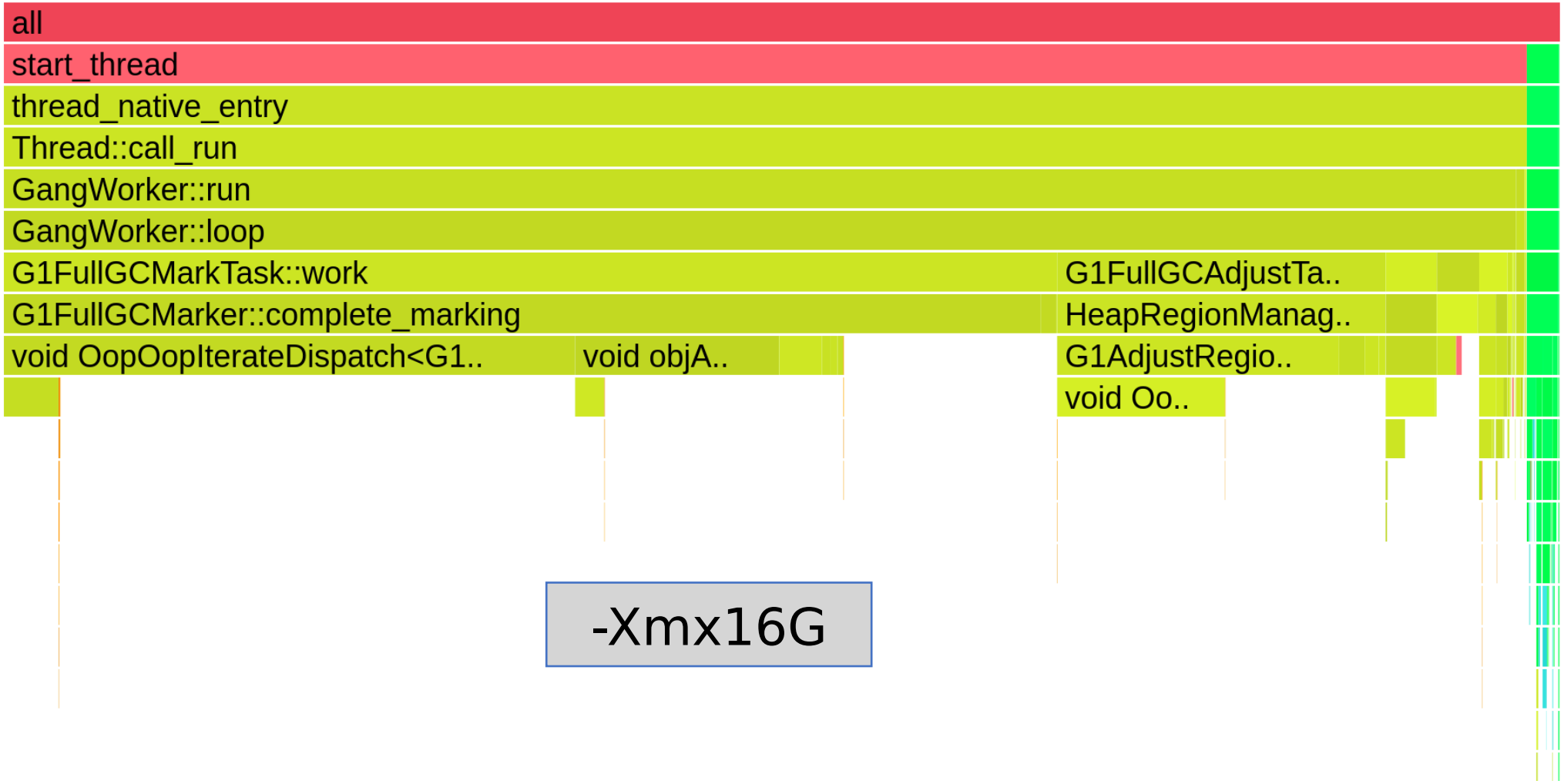
Mission Control



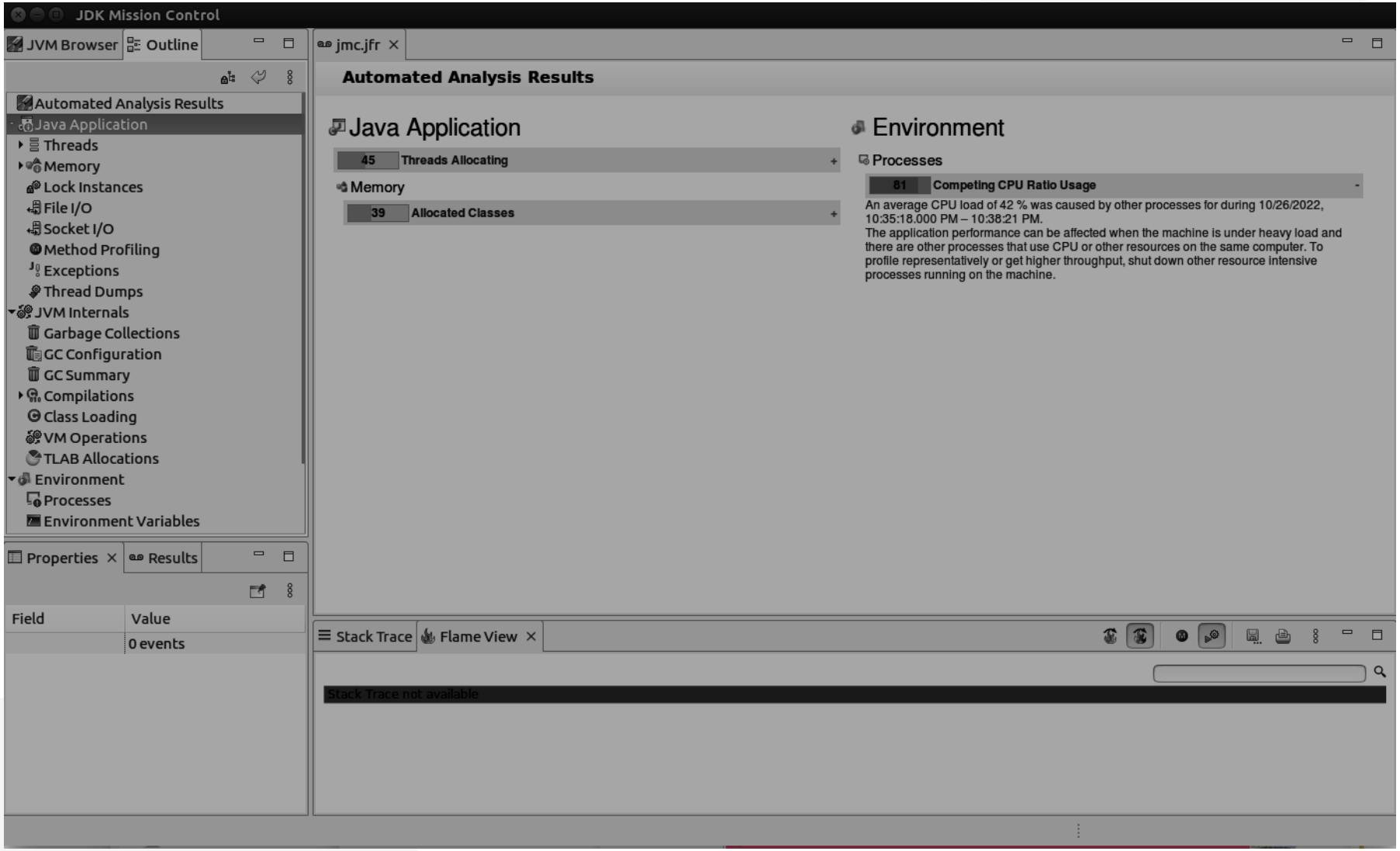
Mission Control



Mission Control



JMC смотрит сам себя



Что предстоит сделать?

- Загрузить

Что предстоит сделать?

- Загрузить
- Отобразить

Что предстоит сделать?

- Подготовить
- Загрузить
- Отобразить

Требования и ограничения

Требования и ограничения

- HeatMap за сутки

Требования и ограничения

- HeatMap за сутки
- FlameGraph за любой период

Требования и ограничения

- HeatMap за сутки
- FlameGraph за любой период
- Гранулярность 20 мс

Требования и ограничения

- HeatMap за сутки
- FlameGraph за любой период
- Гранулярность 20 мс
- Профили до 4 ГБ

Требования и ограничения

- HeatMap за сутки
- FlameGraph за любой период
- Гранулярность 20 мс
- Профили до 4 ГБ
- CPU: 6 млн сэмплов

Требования и ограничения

- HeatMap за сутки
- FlameGraph за любой период
- Гранулярность 20 мс
- Профили до 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов

Готовим данные

Зачем готовить данные?

Зачем готовить данные?

- JFR: 4 ГБ

Зачем готовить данные?

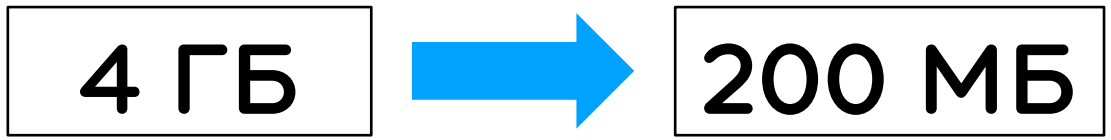
- JFR: 4 ГБ
- CPU: 6 млн сэмплов

Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов

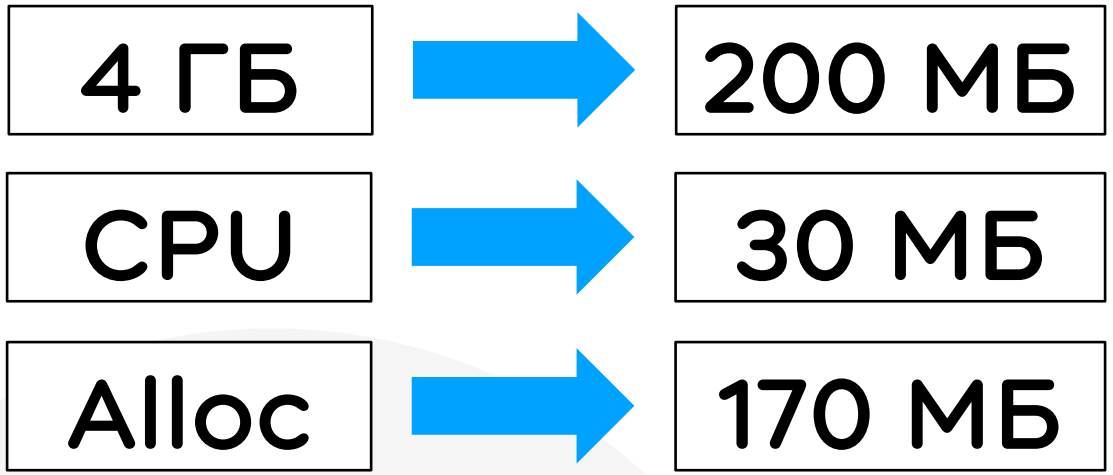
Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов



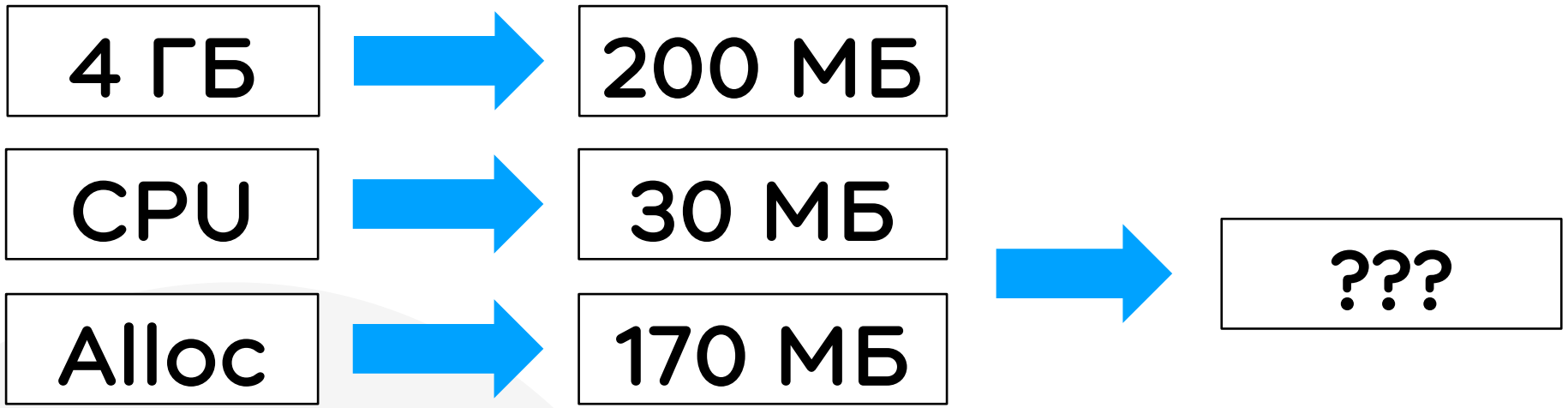
Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов



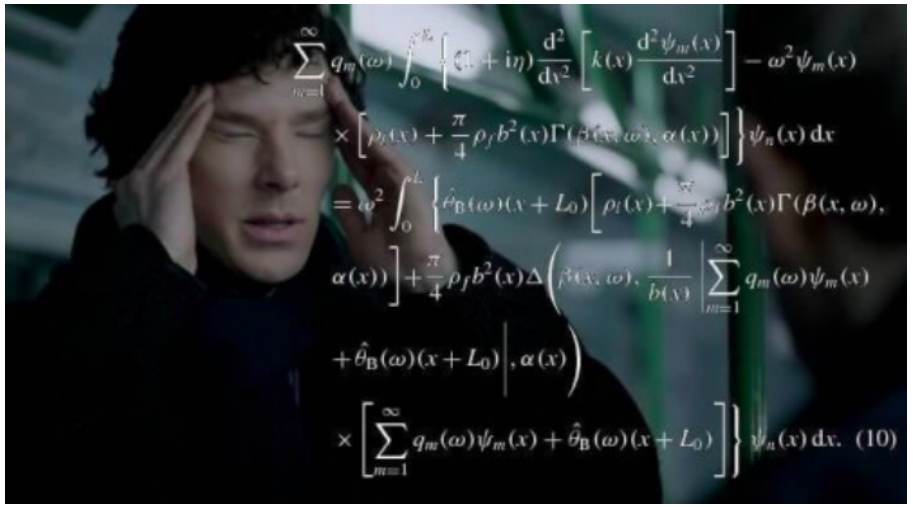
Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов



Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов

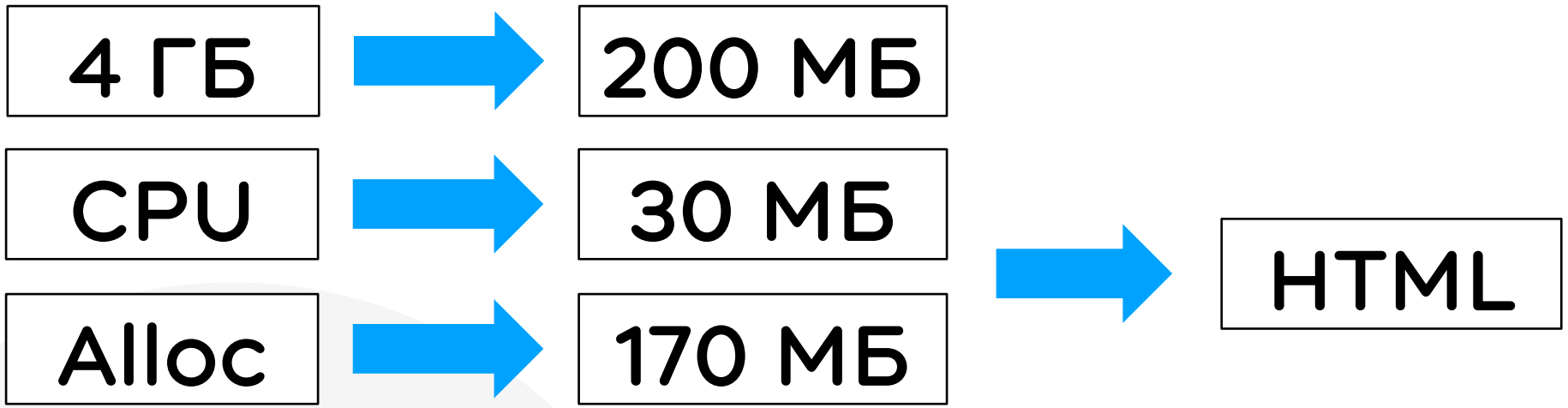


4 ГБ	→	200 МБ
CPU	→	30 МБ
Alloc	→	170 МБ

→ ???

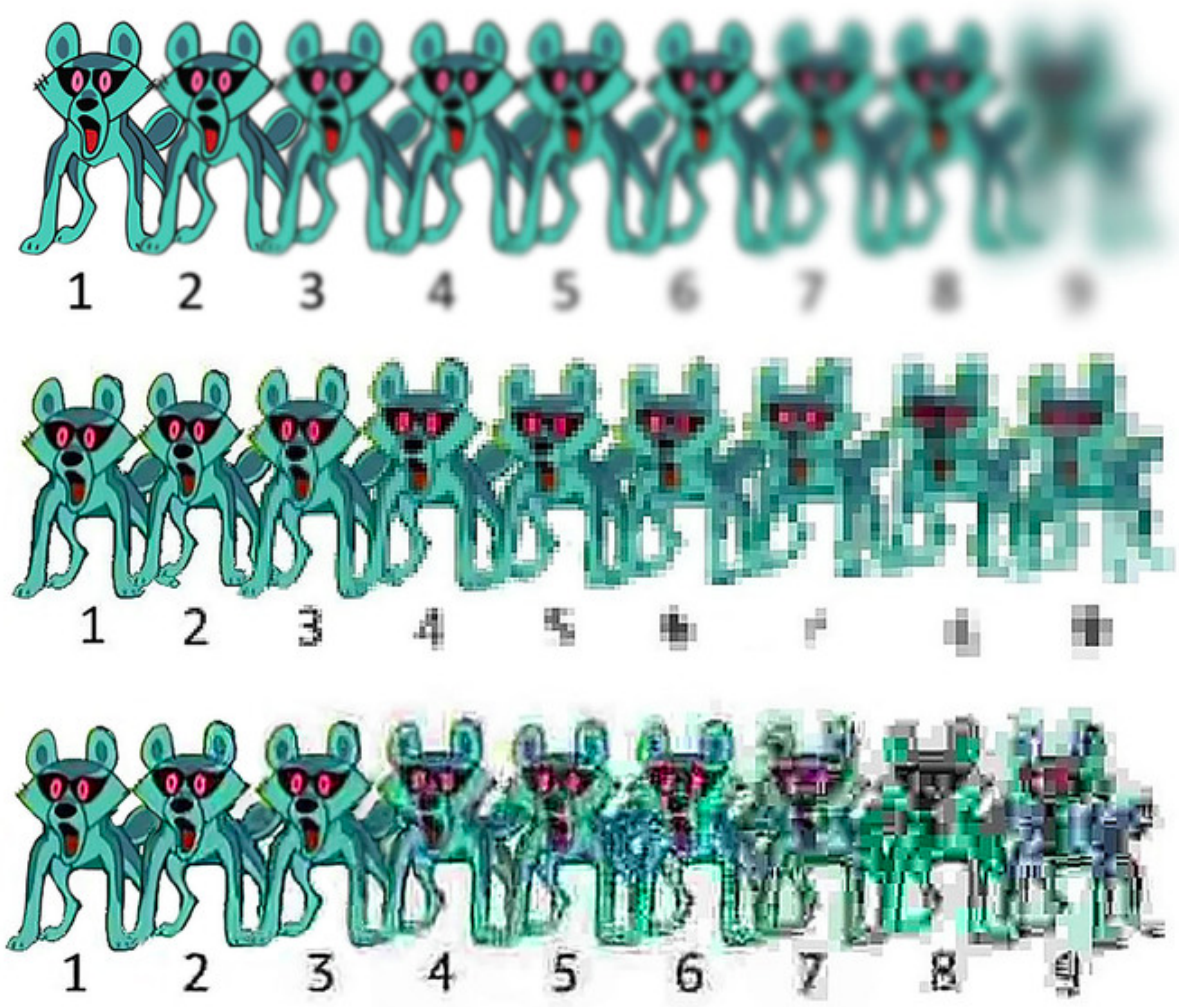
Зачем готовить данные?

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов

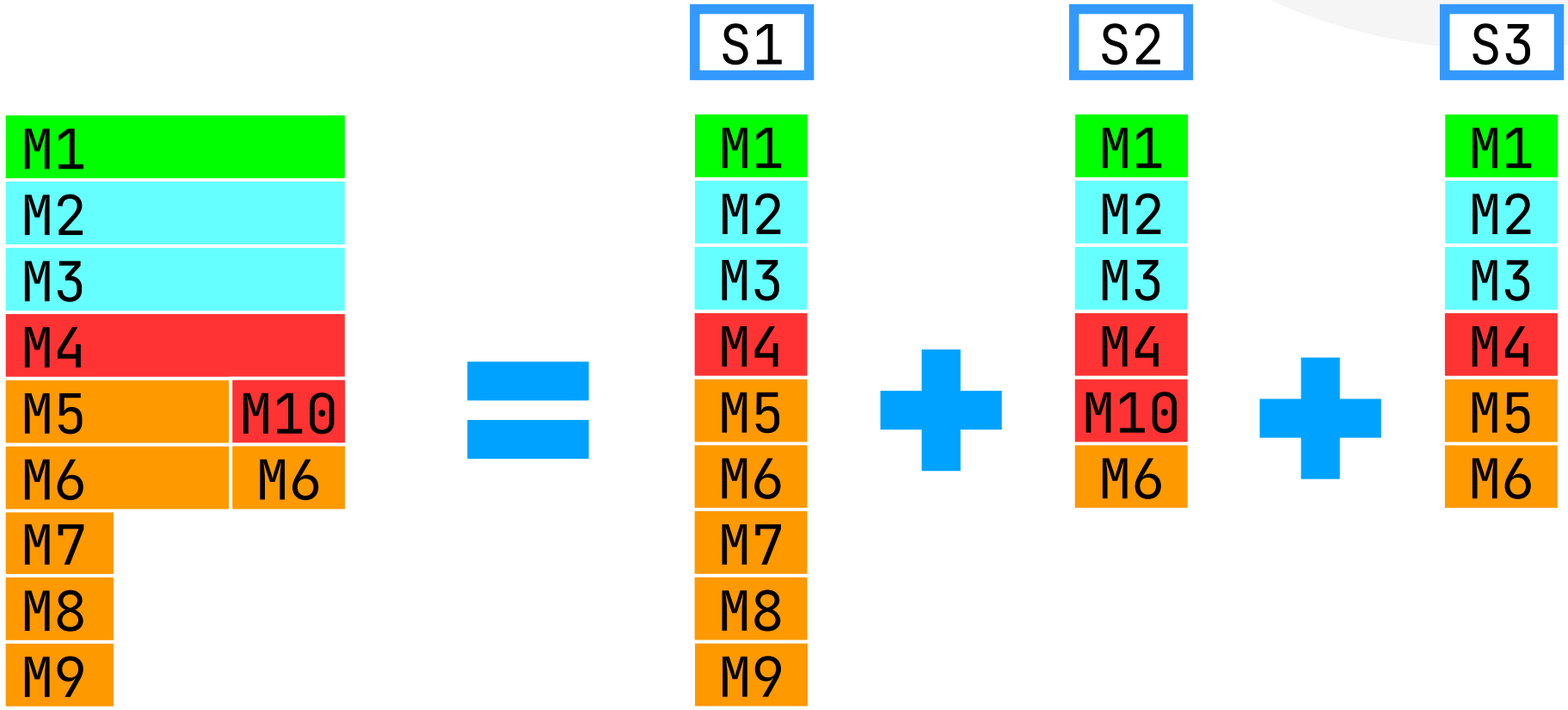


Готовим данные

Сжатие



Сжатие


M1
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S1
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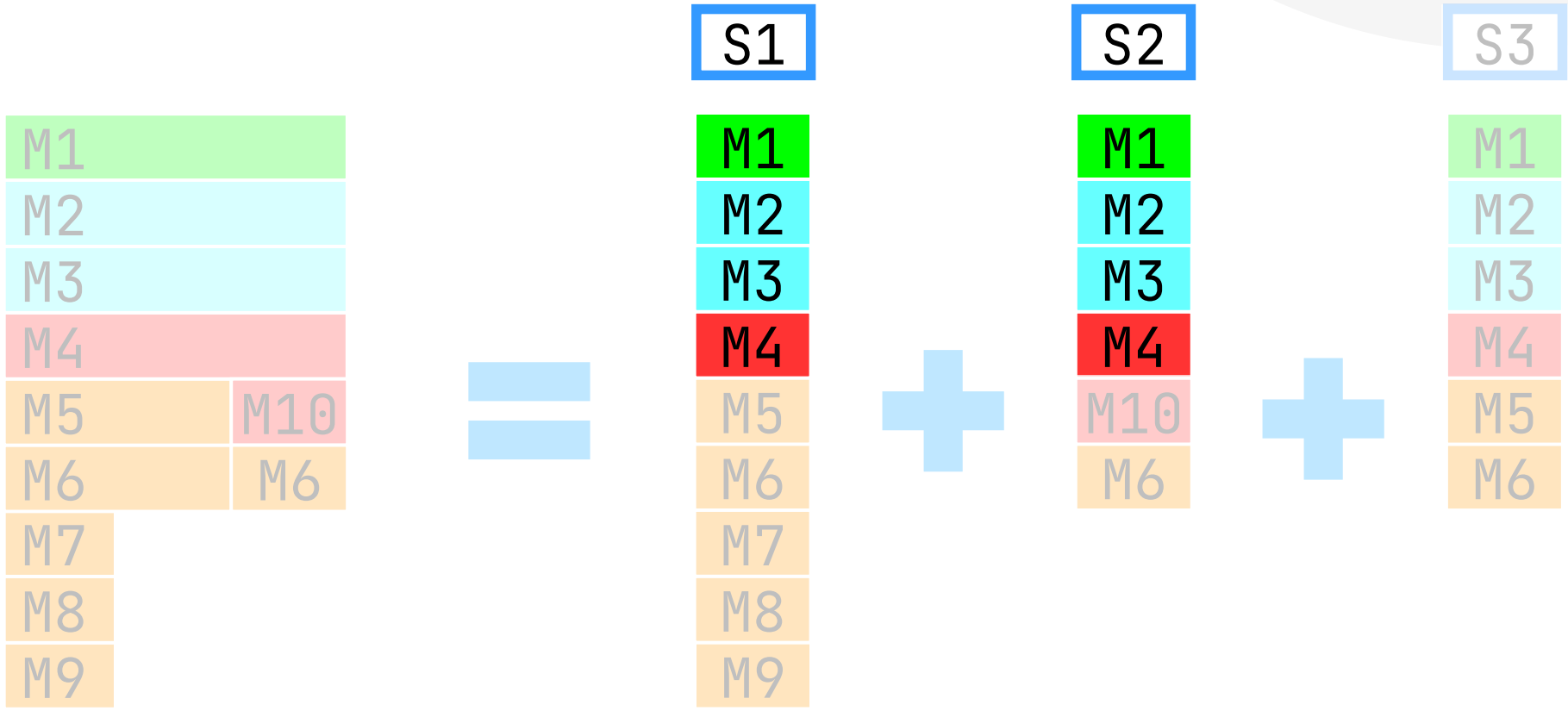
Сжатие


M1
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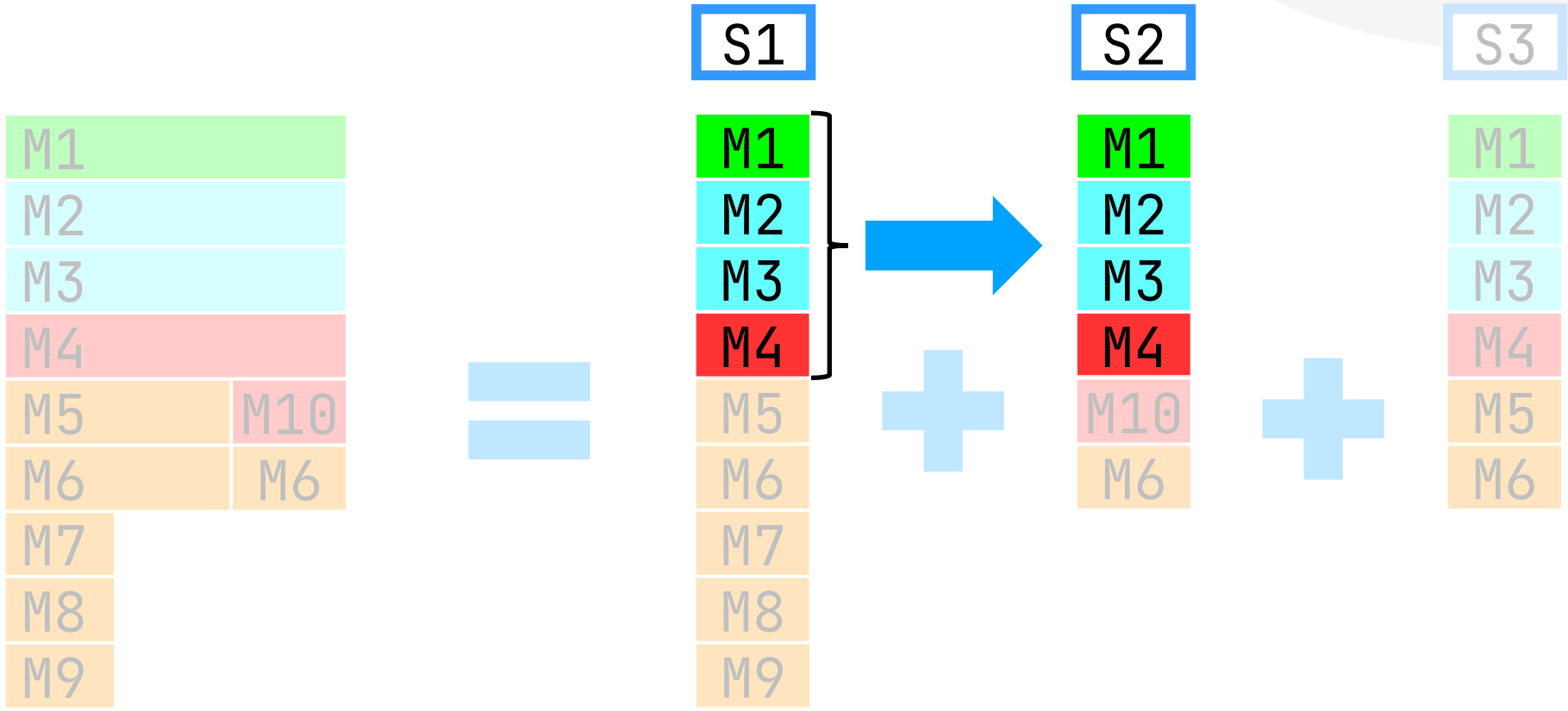
Сжатие


M1
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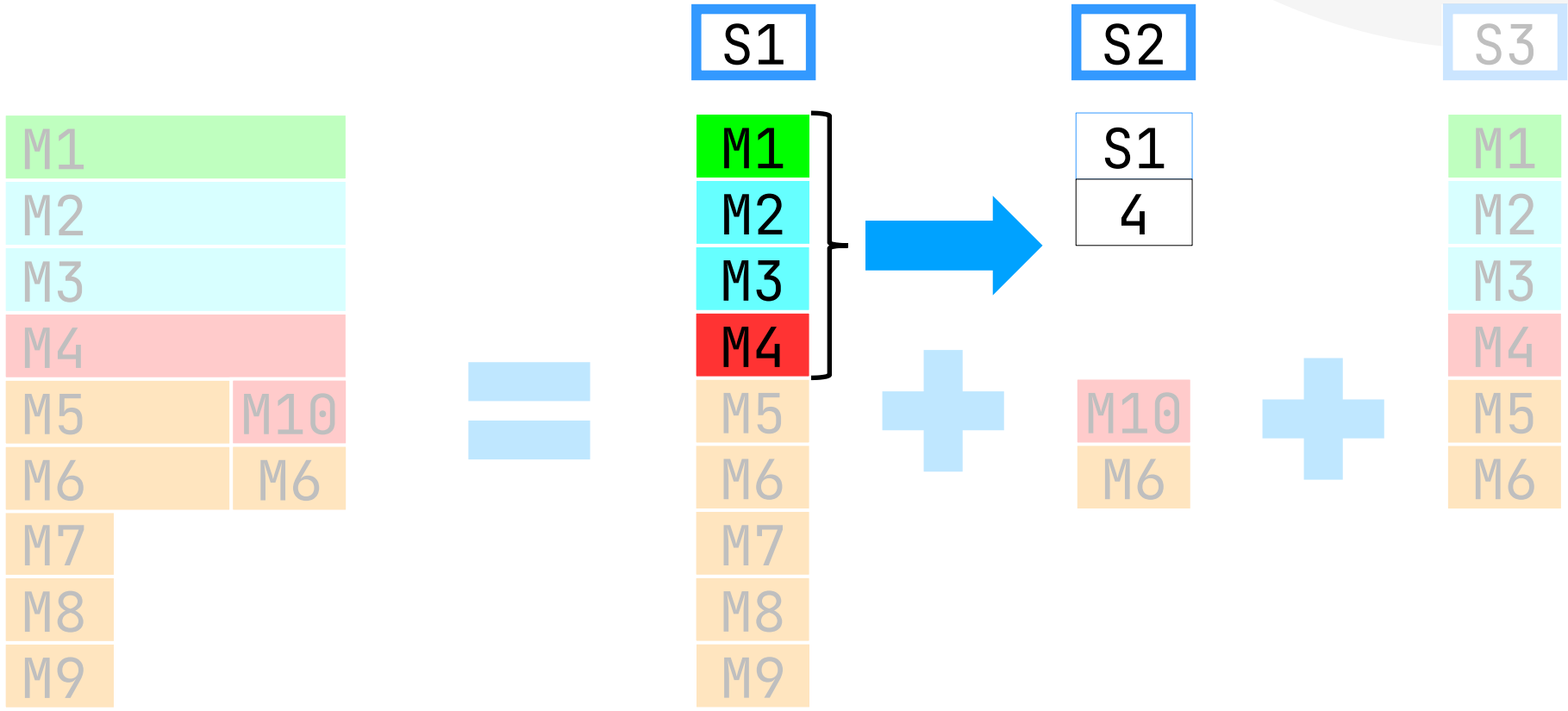
Сжатие


M1
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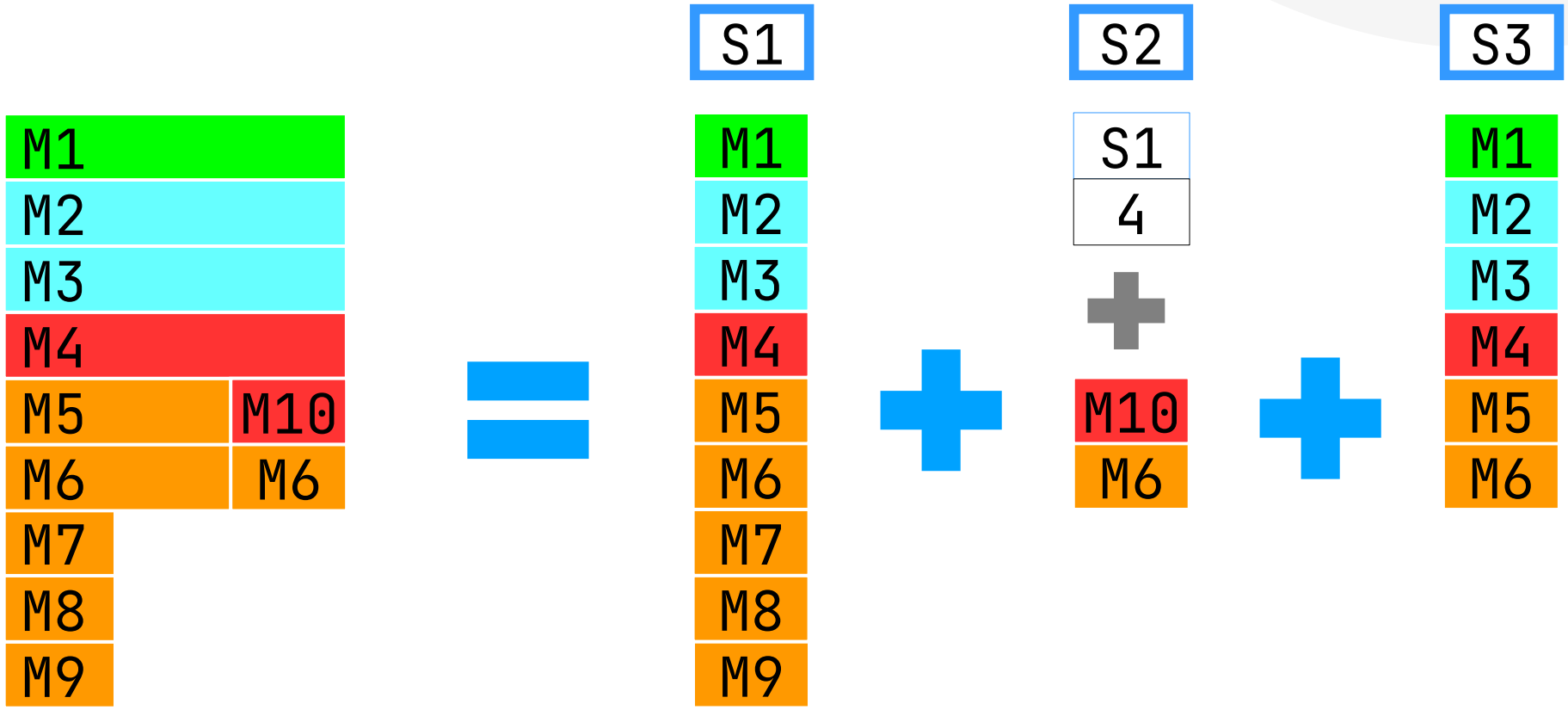
Сжатие


M1
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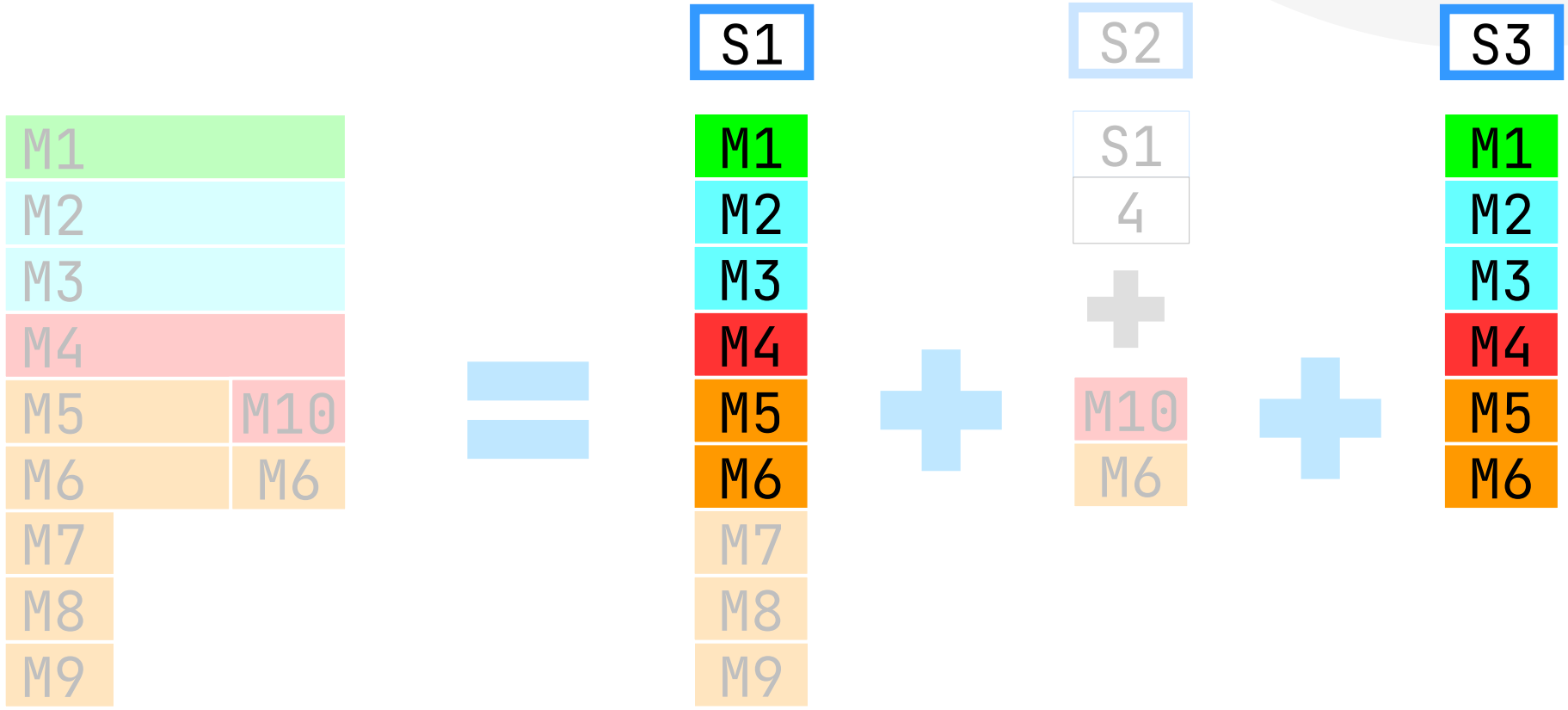
Сжатие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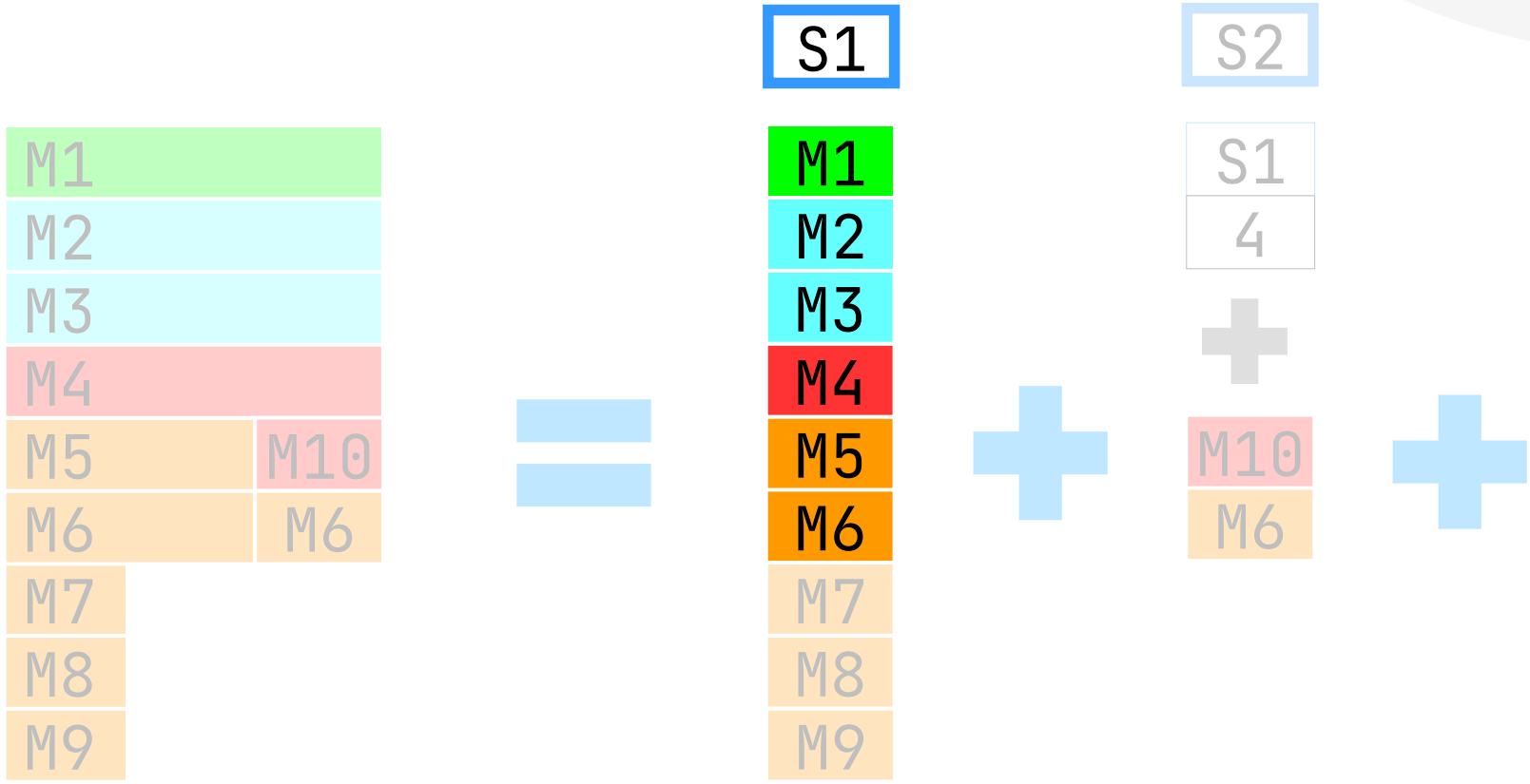
Сжатие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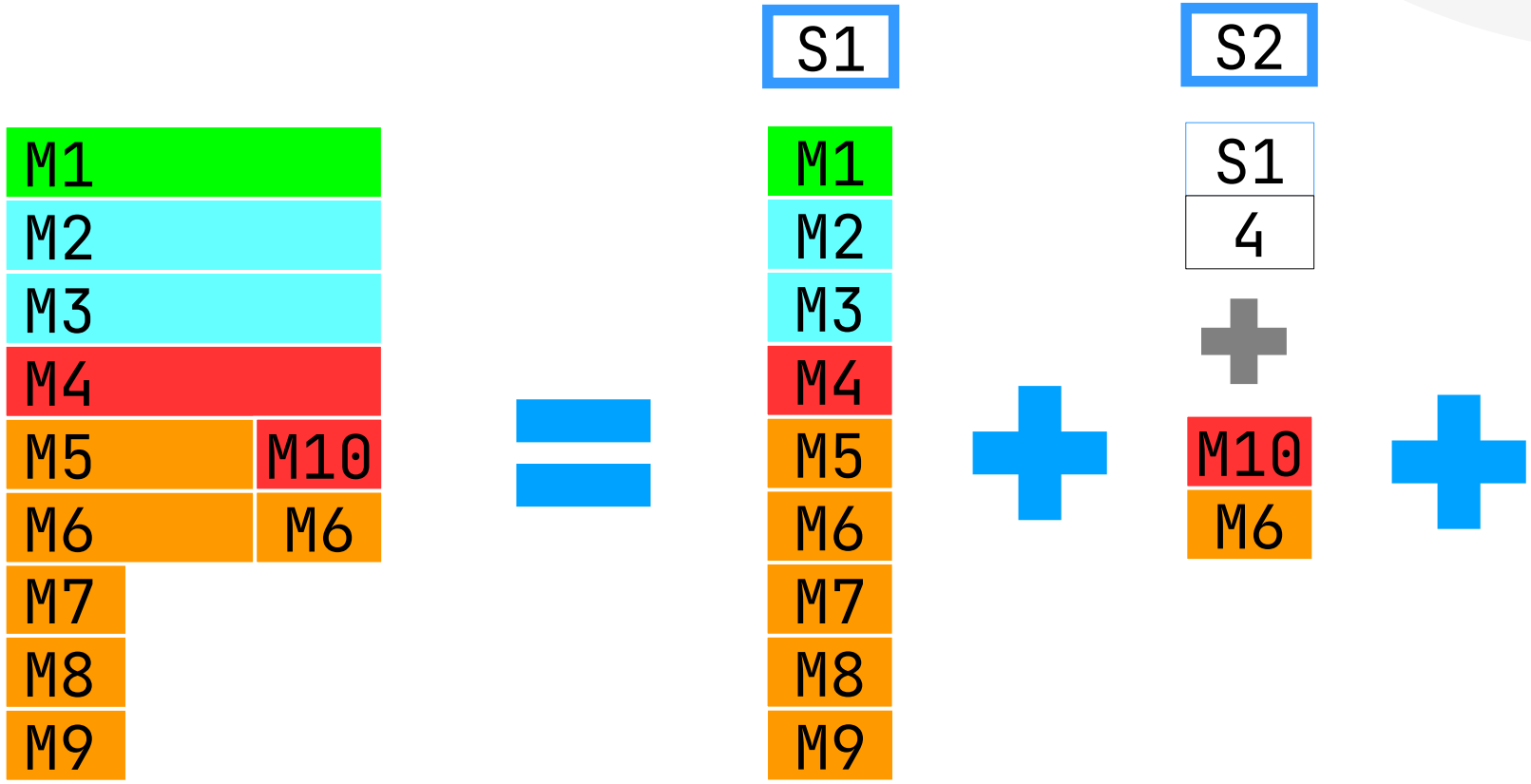
M6
+
S3
S1
6

Сжатие


M1
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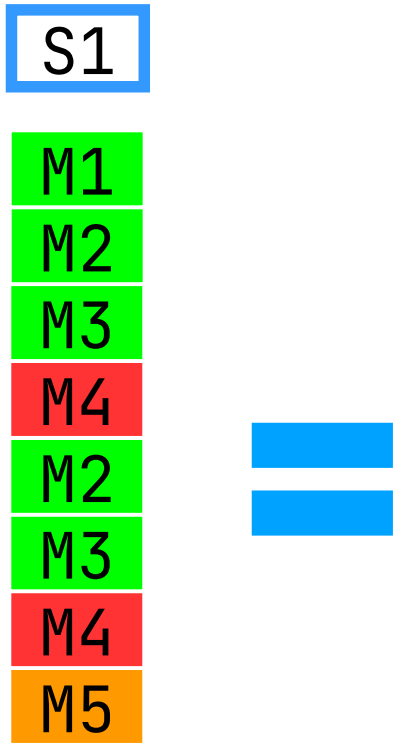
S1
6

Сжатие



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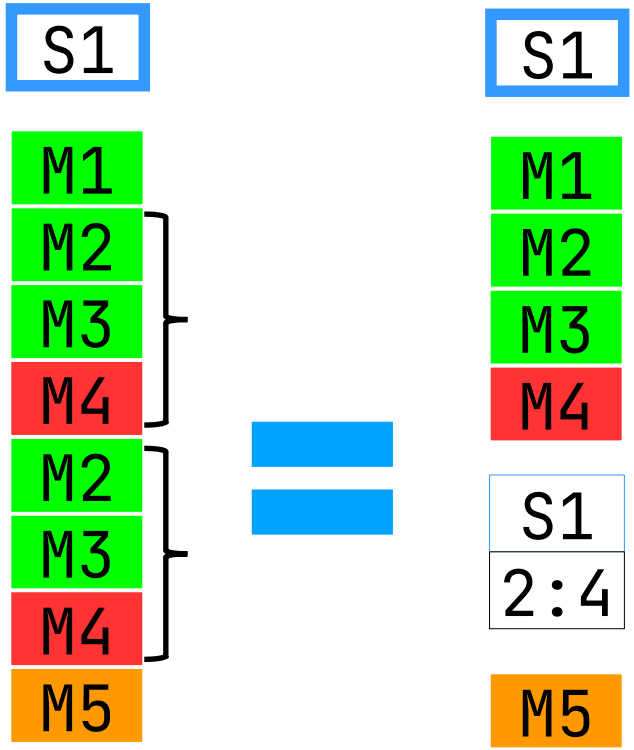

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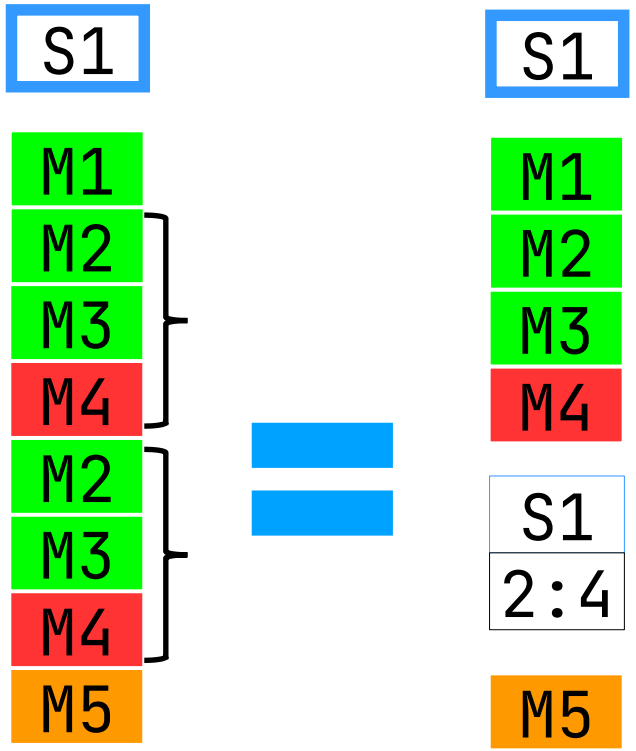
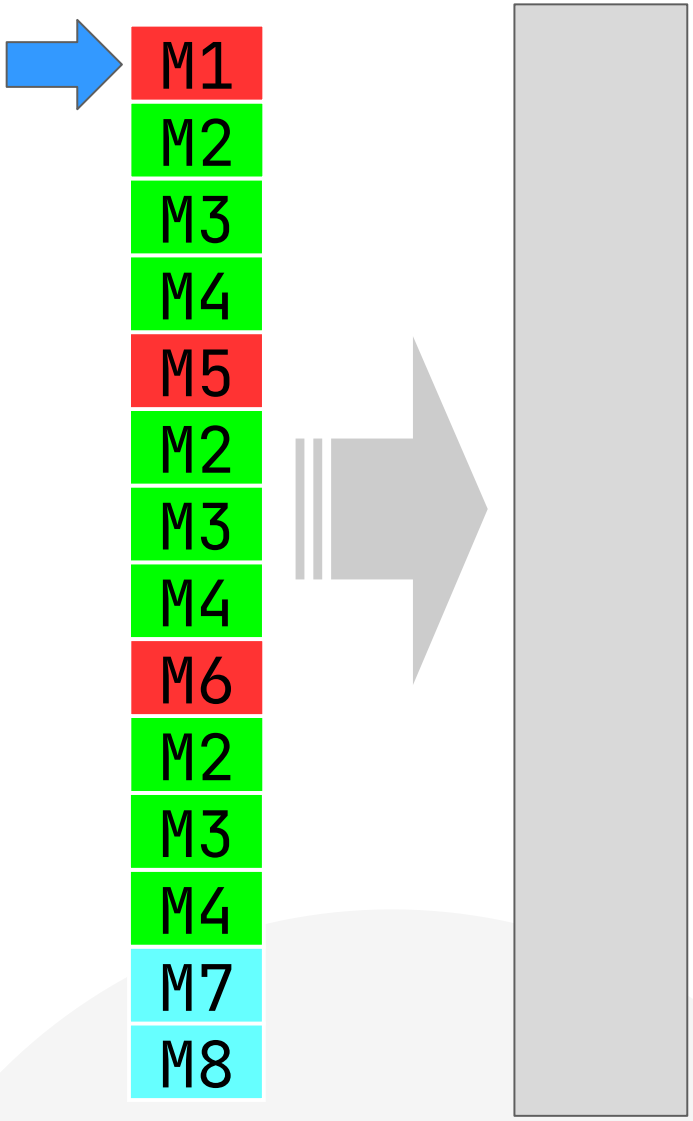


Что если

Помнить то что вижу часто?

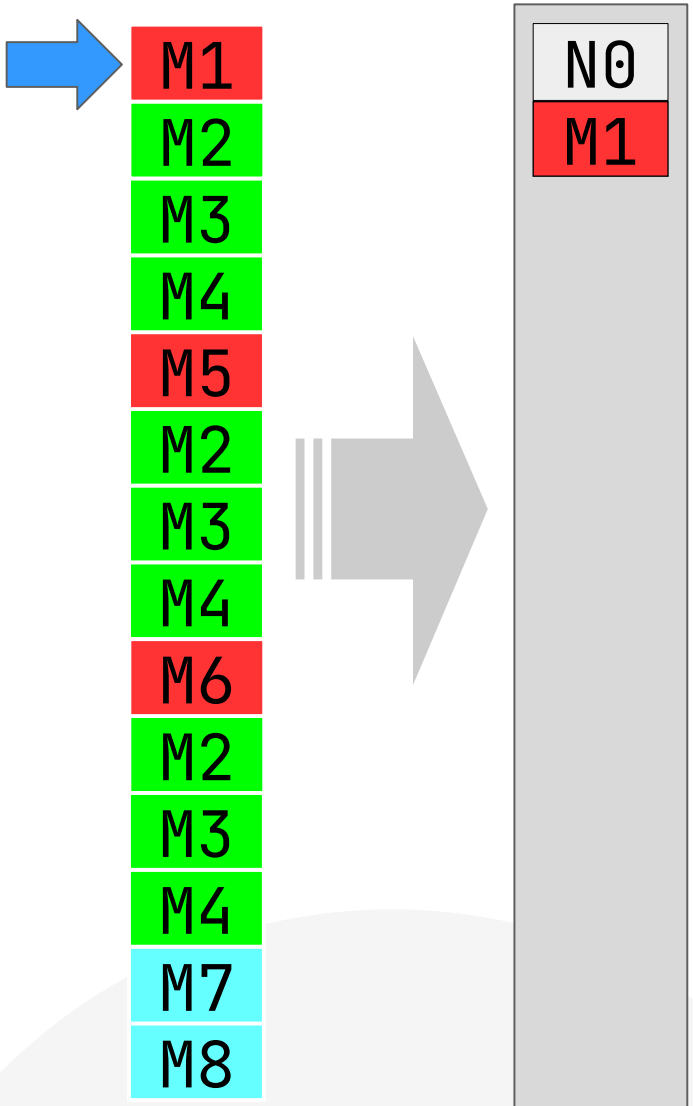
Сжимаем



Словарь

```
0: ""
```

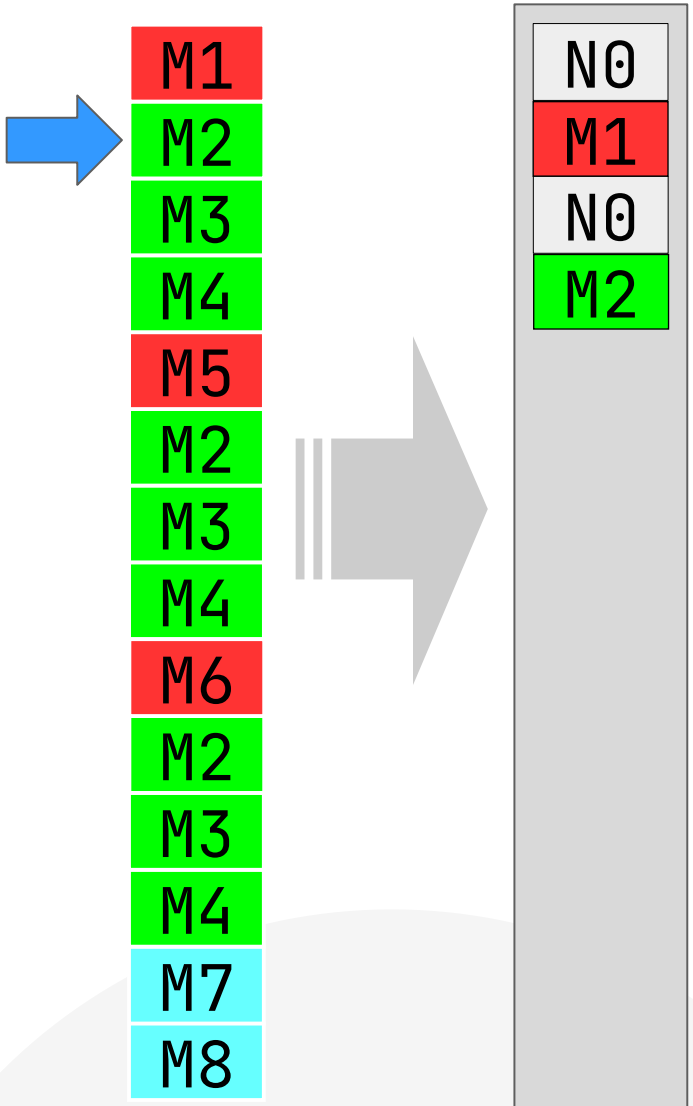
Сжимаем



Словарь

```
0: ""
1: "M1"
```

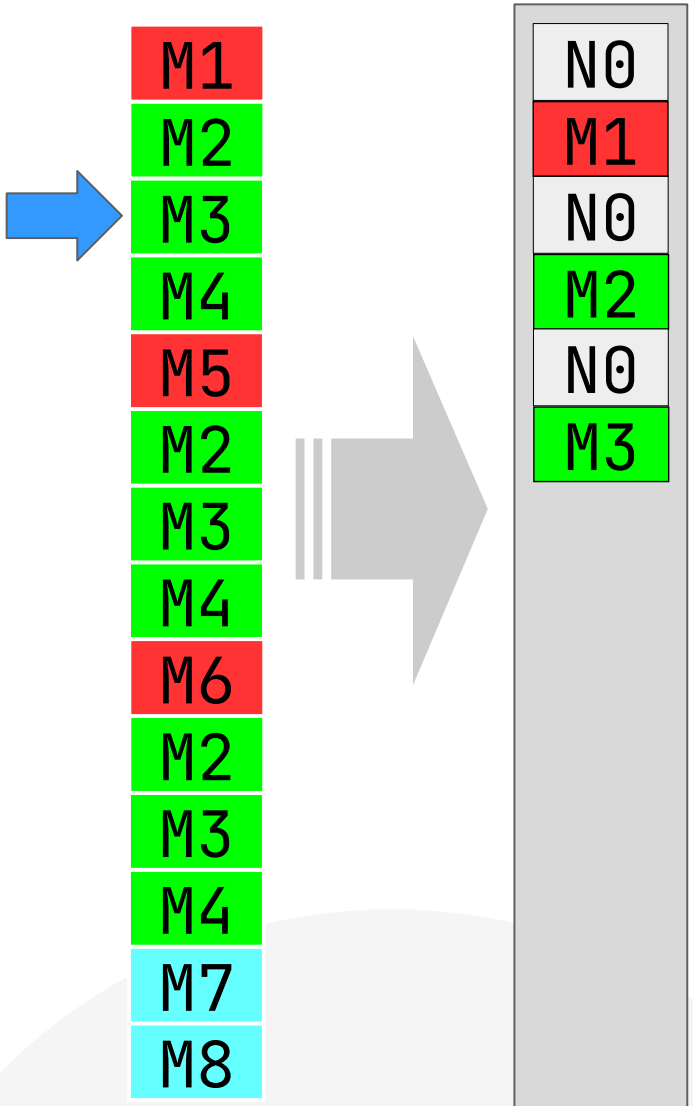
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
```

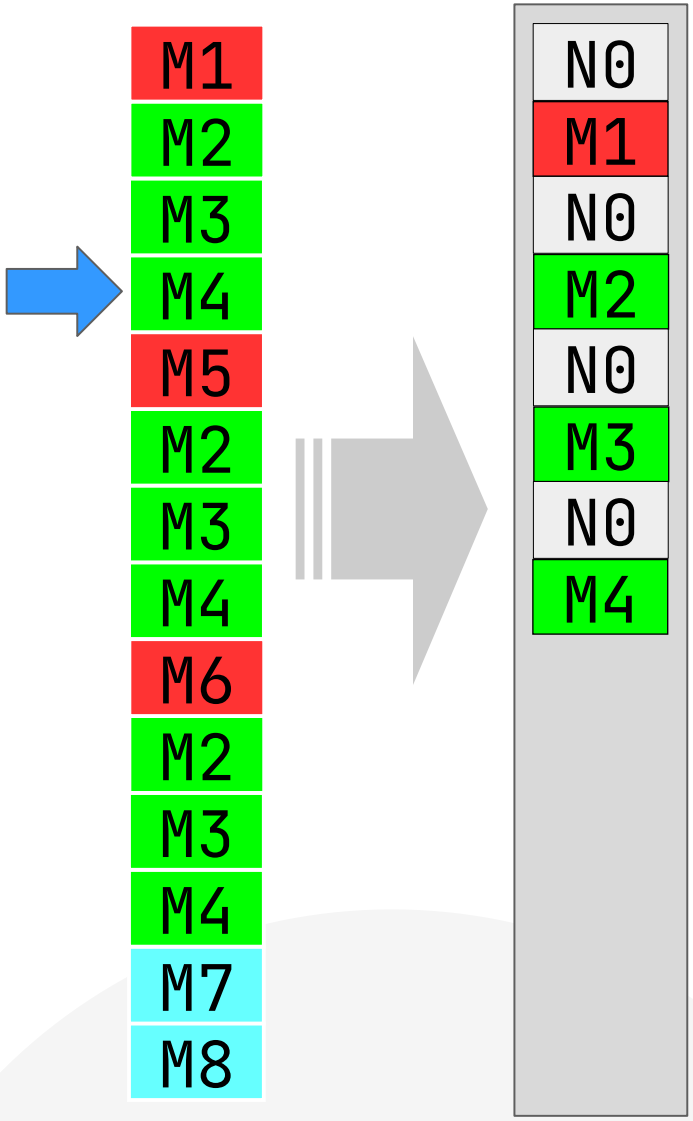
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
```

Сжимаем



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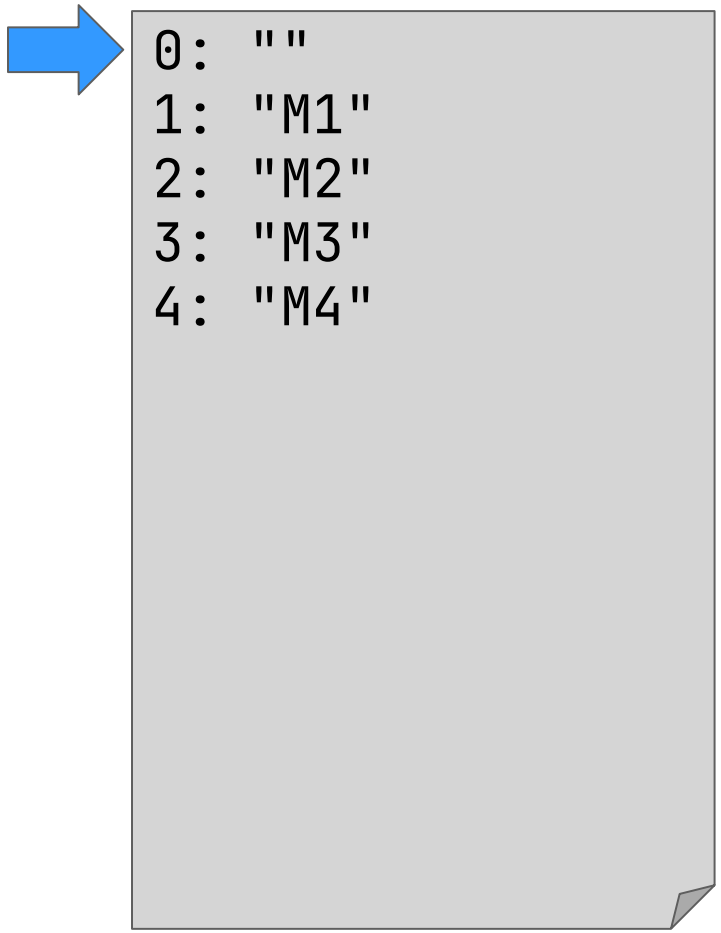
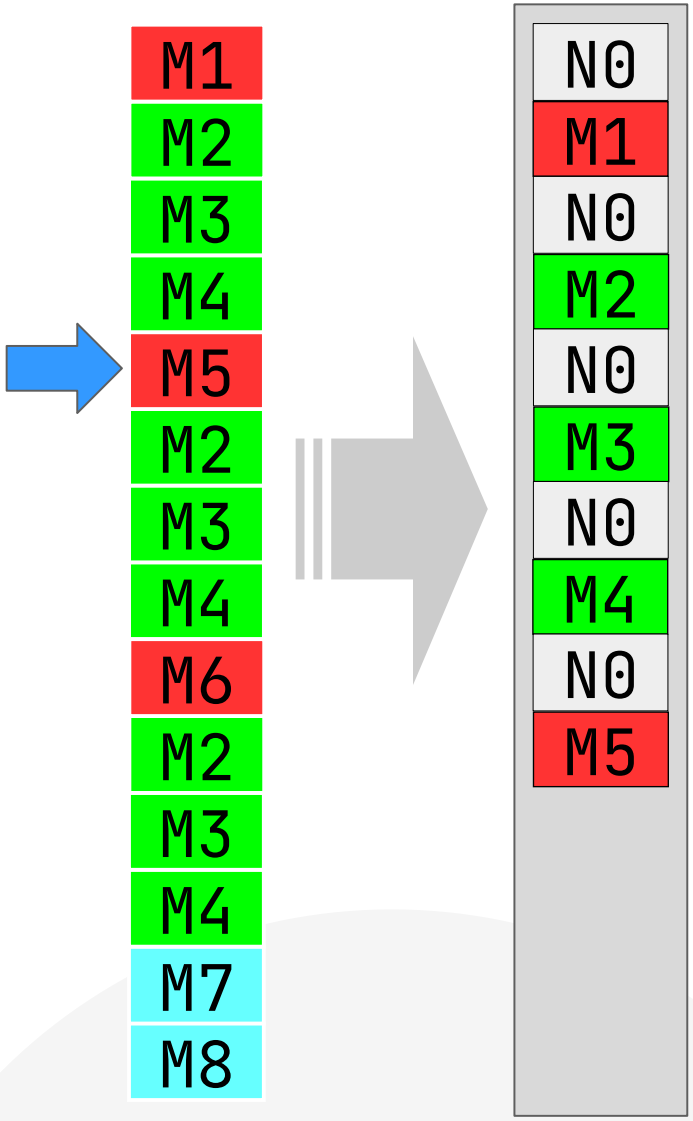


Сжимаем



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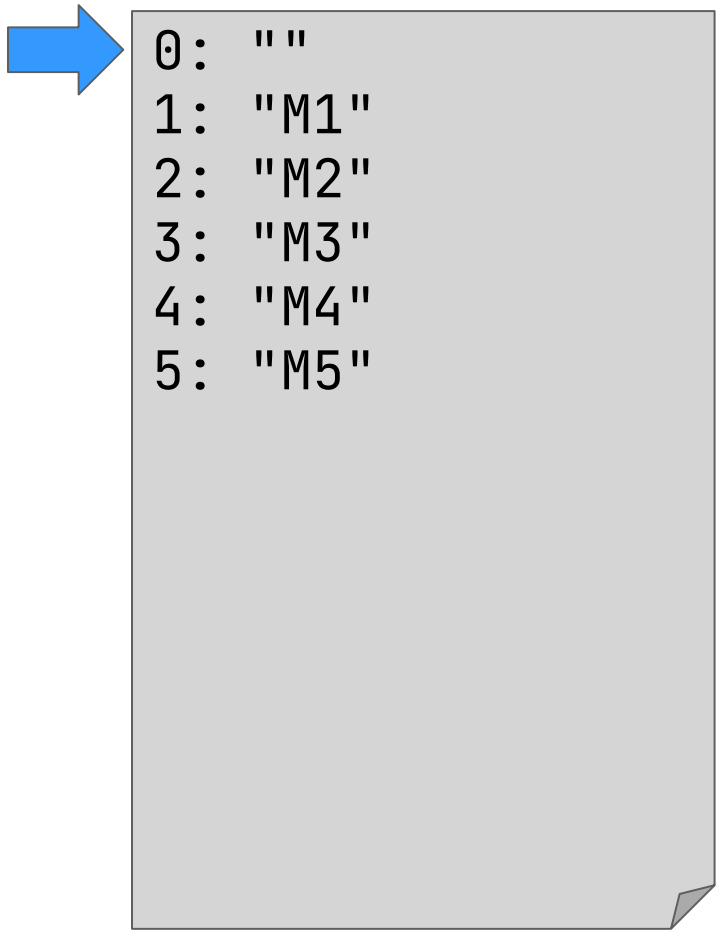

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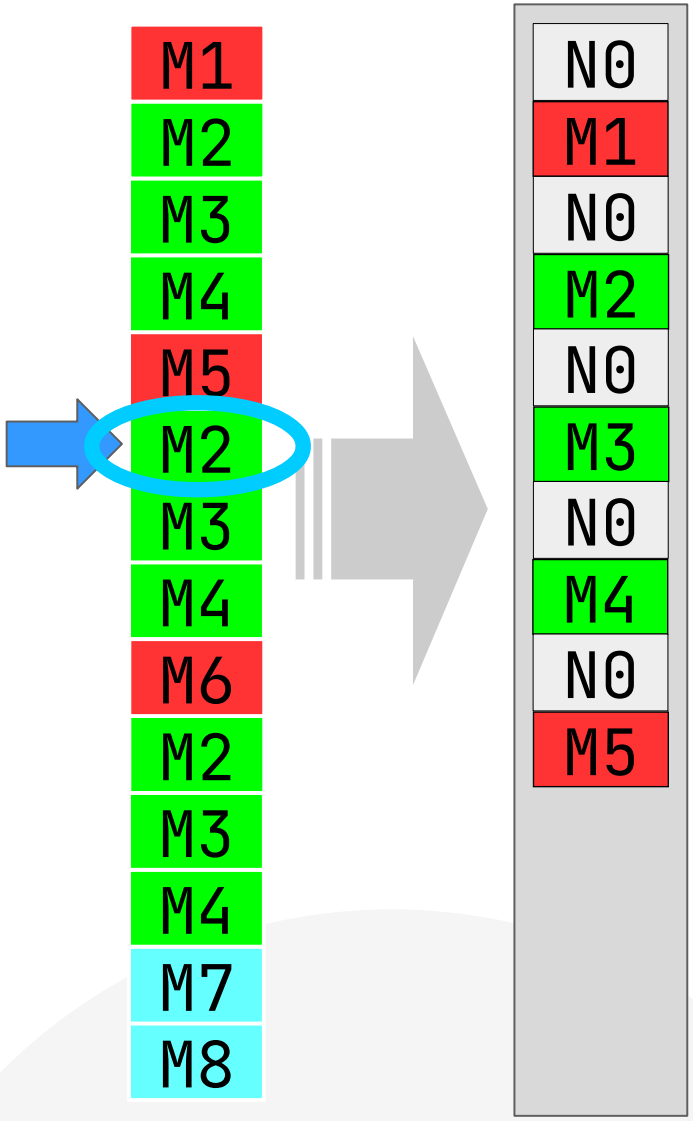
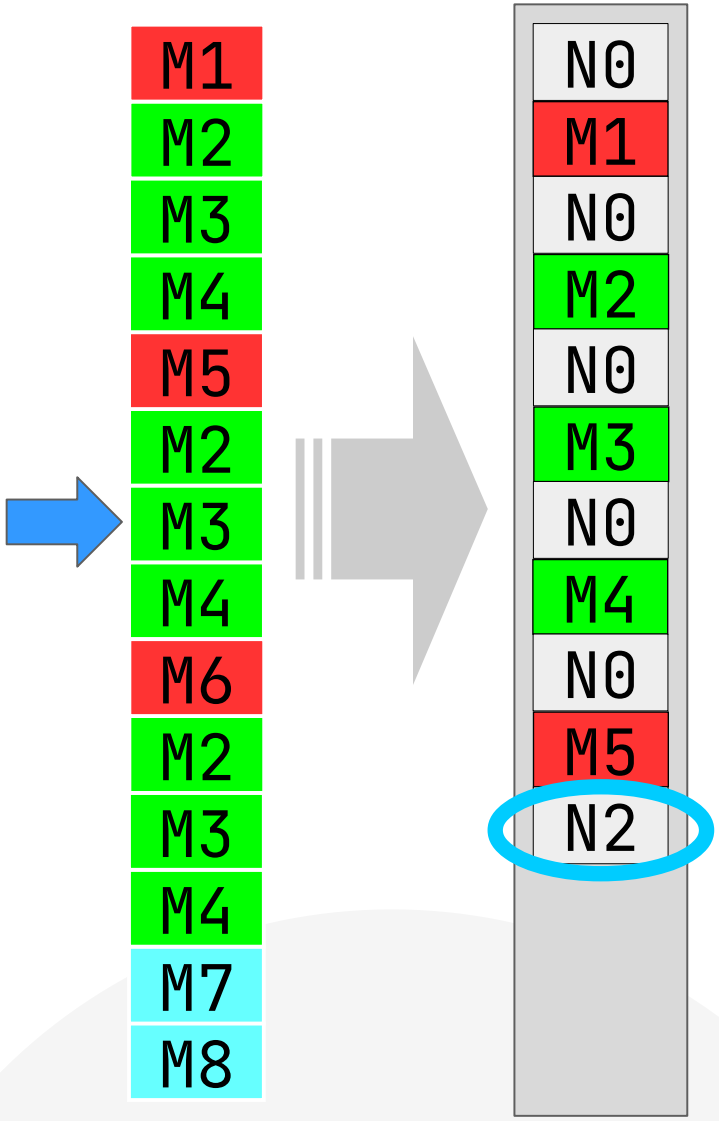


Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
```

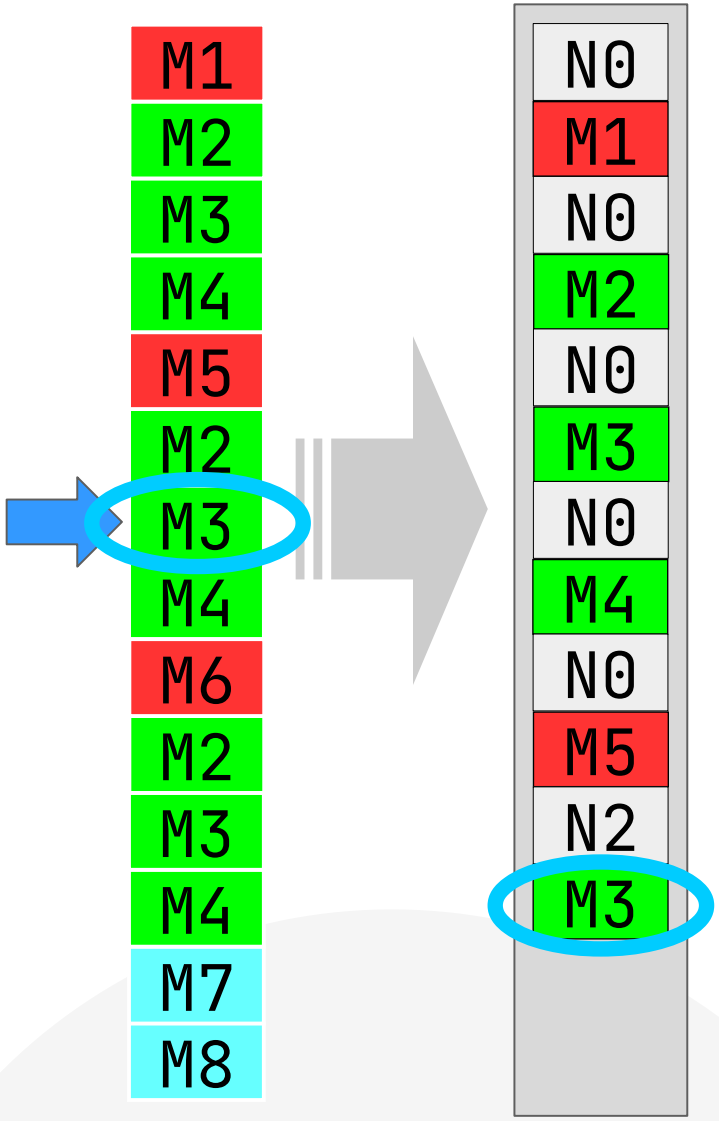
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
```

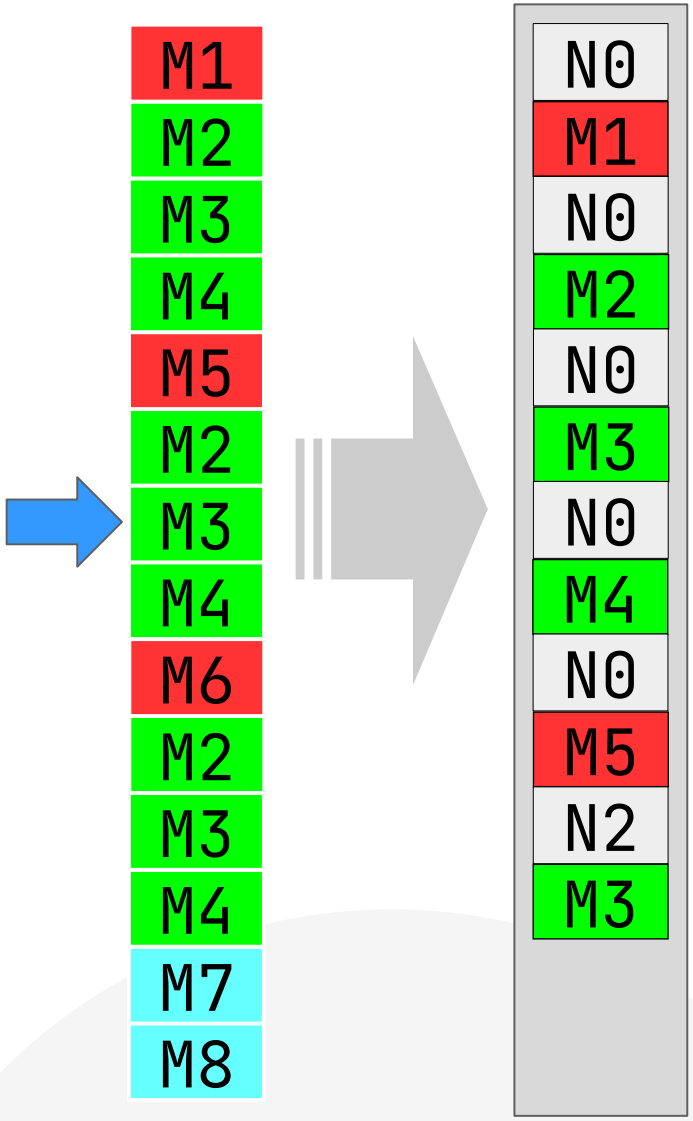
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
```

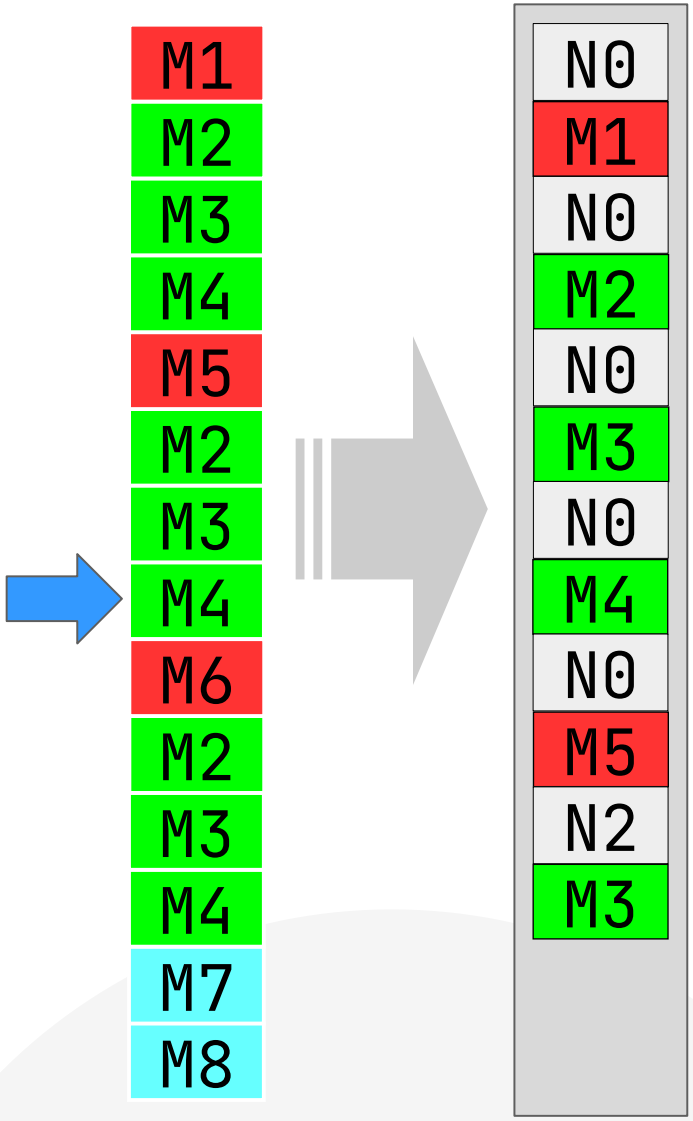
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
```

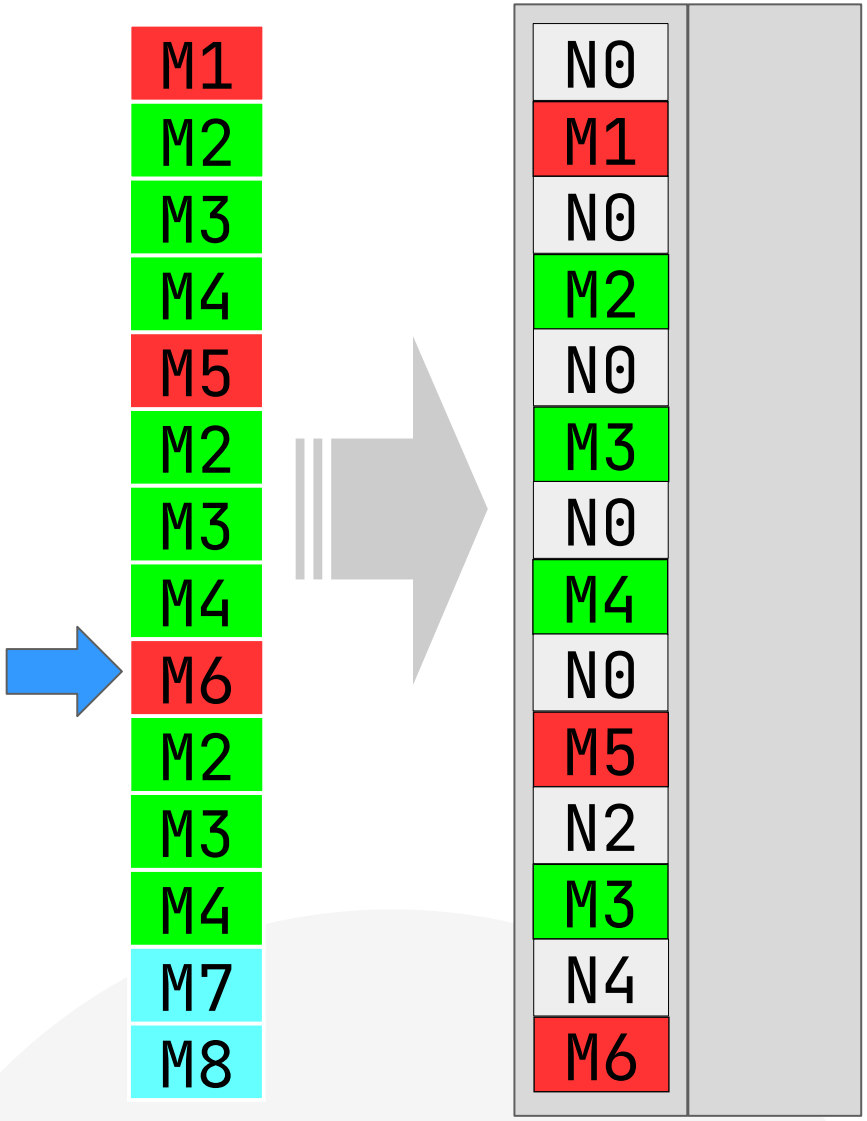
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
```

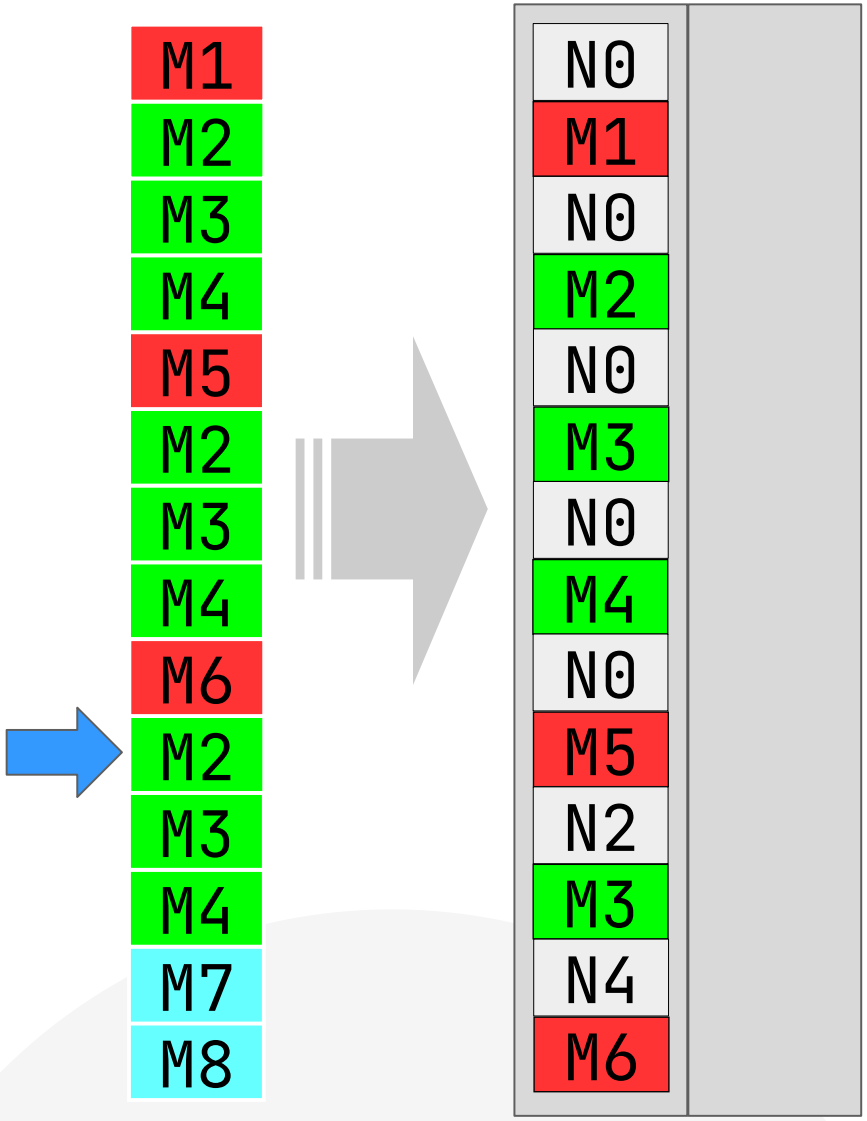
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
```

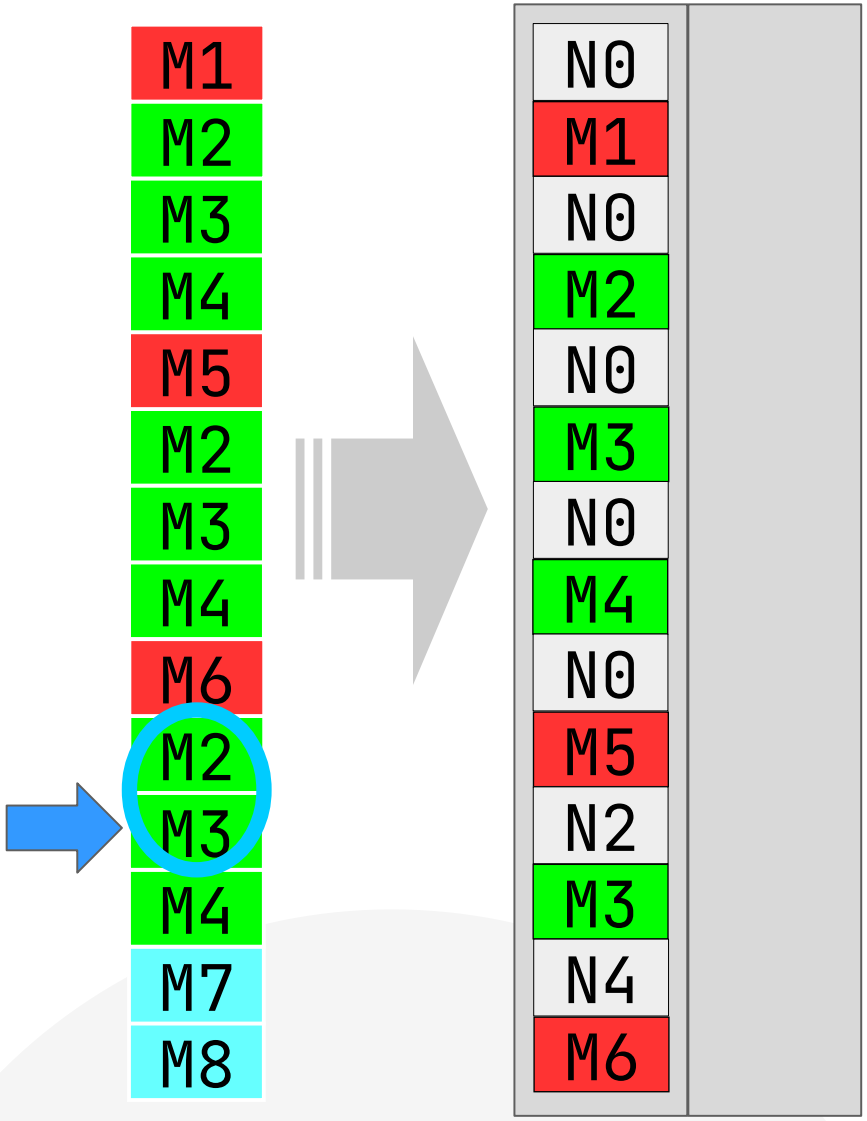
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
```

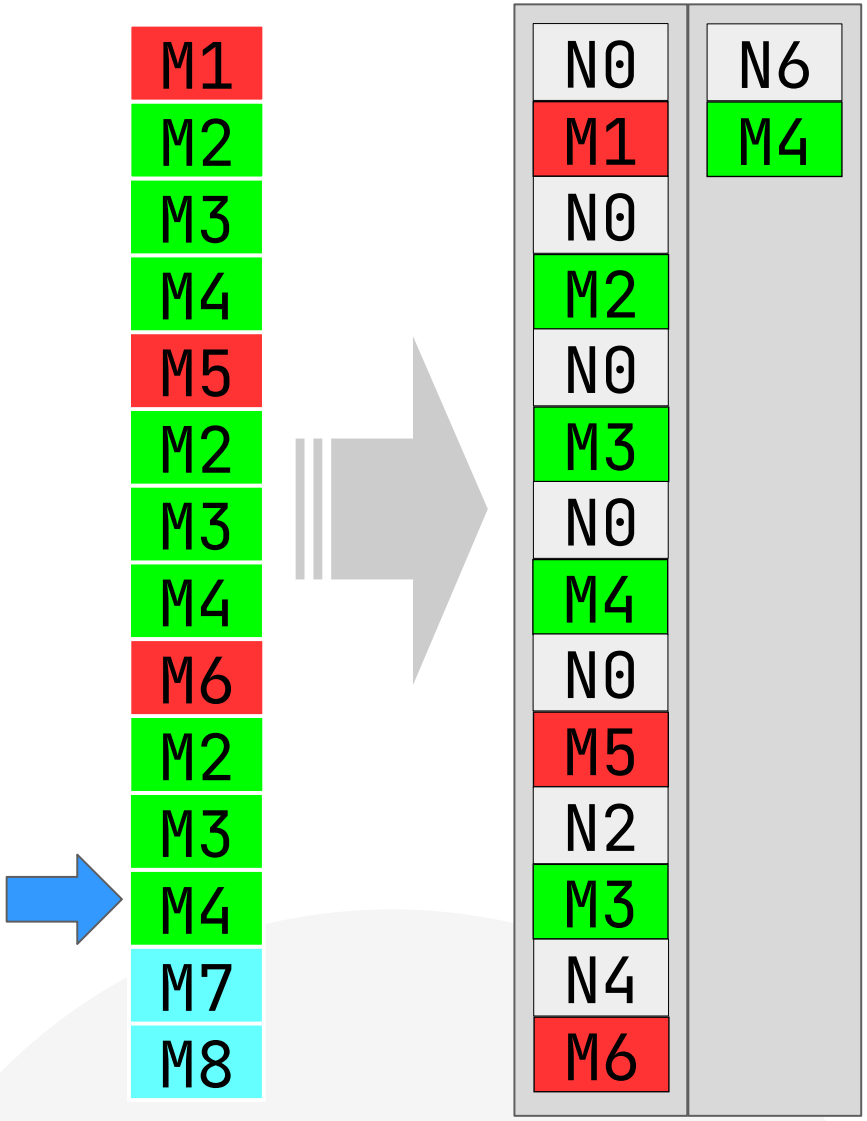
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
```

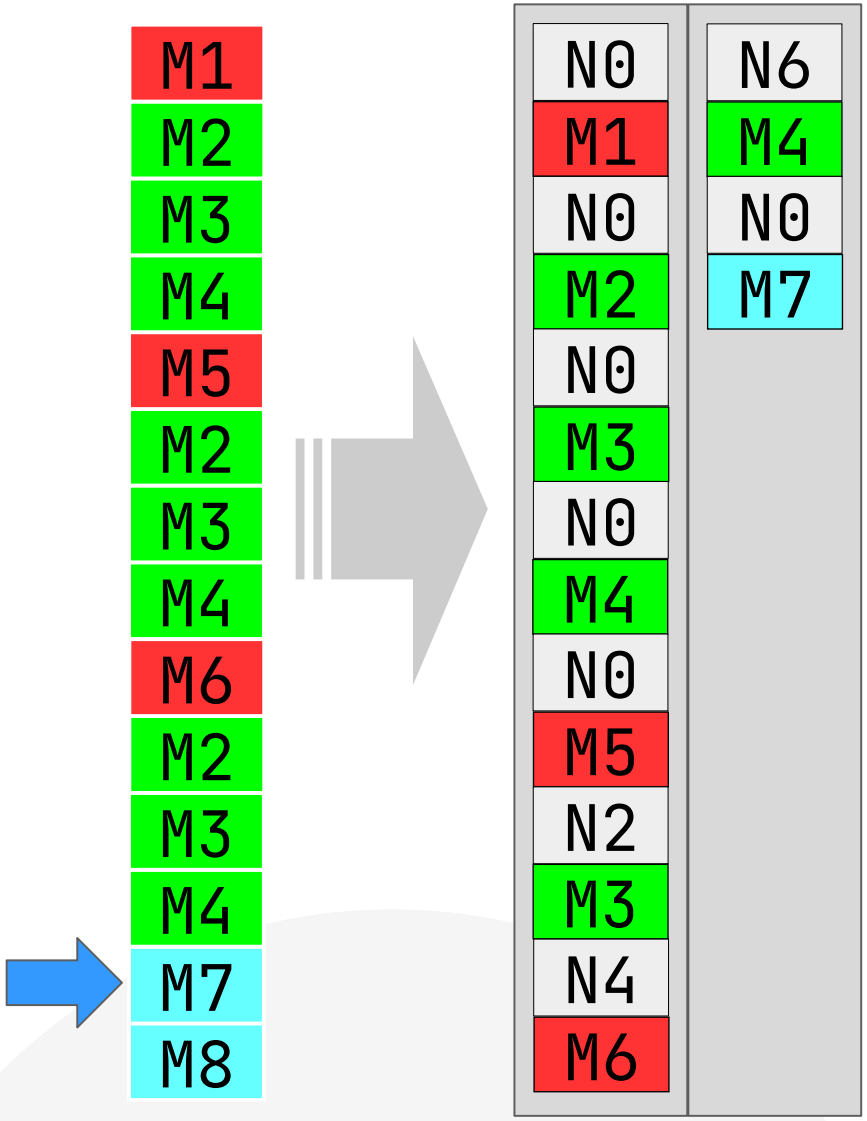
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
```

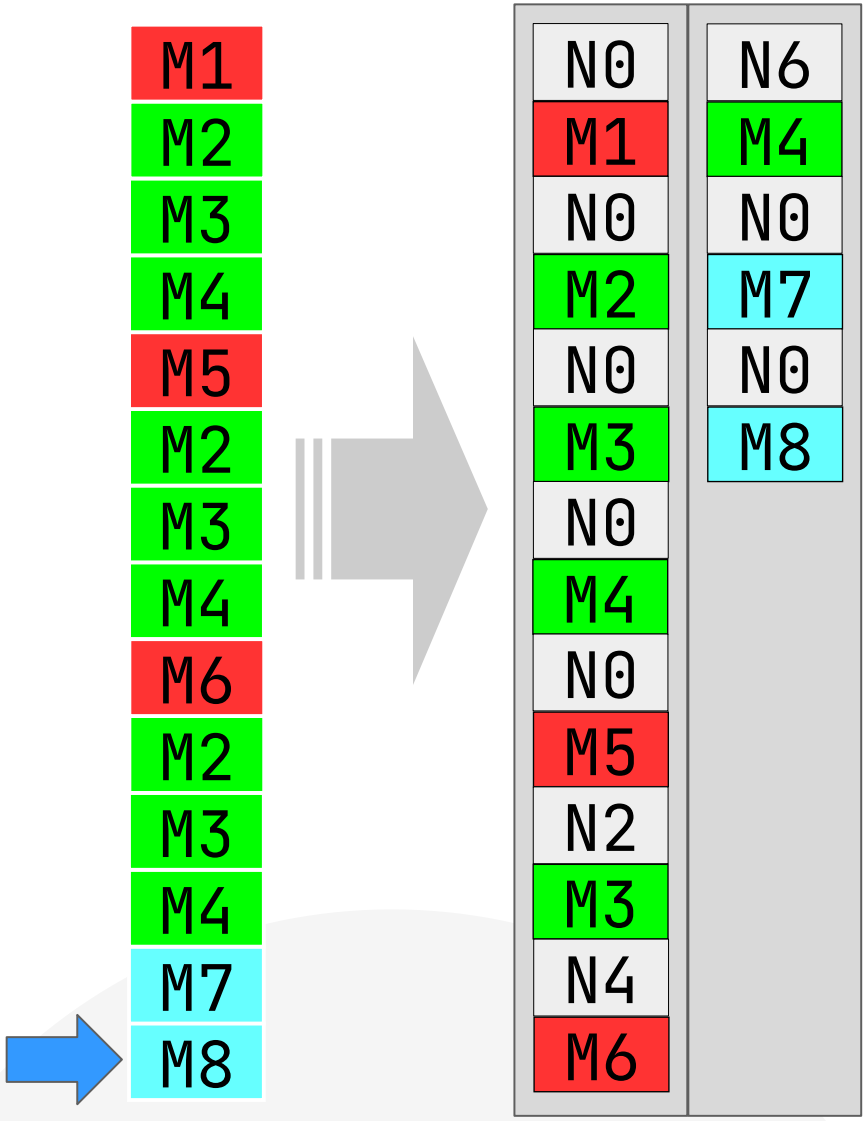
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
```

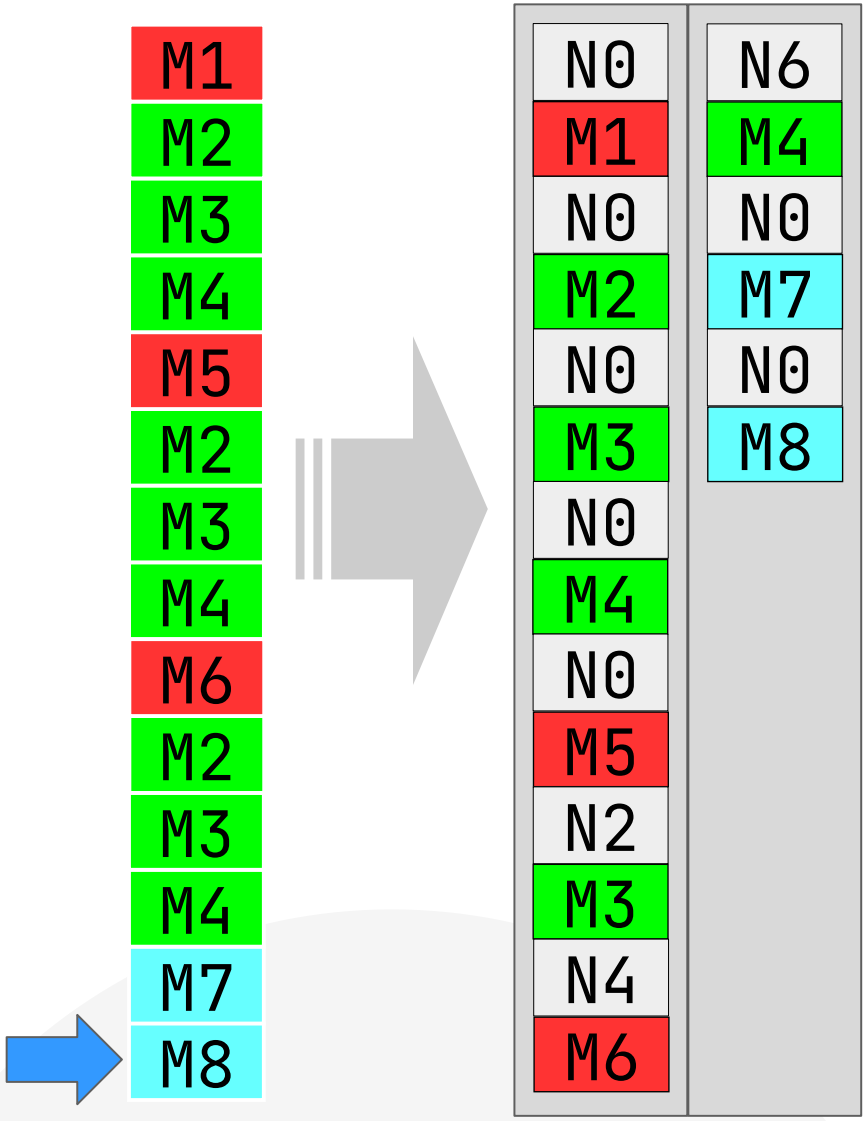
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
```

Сжимаем

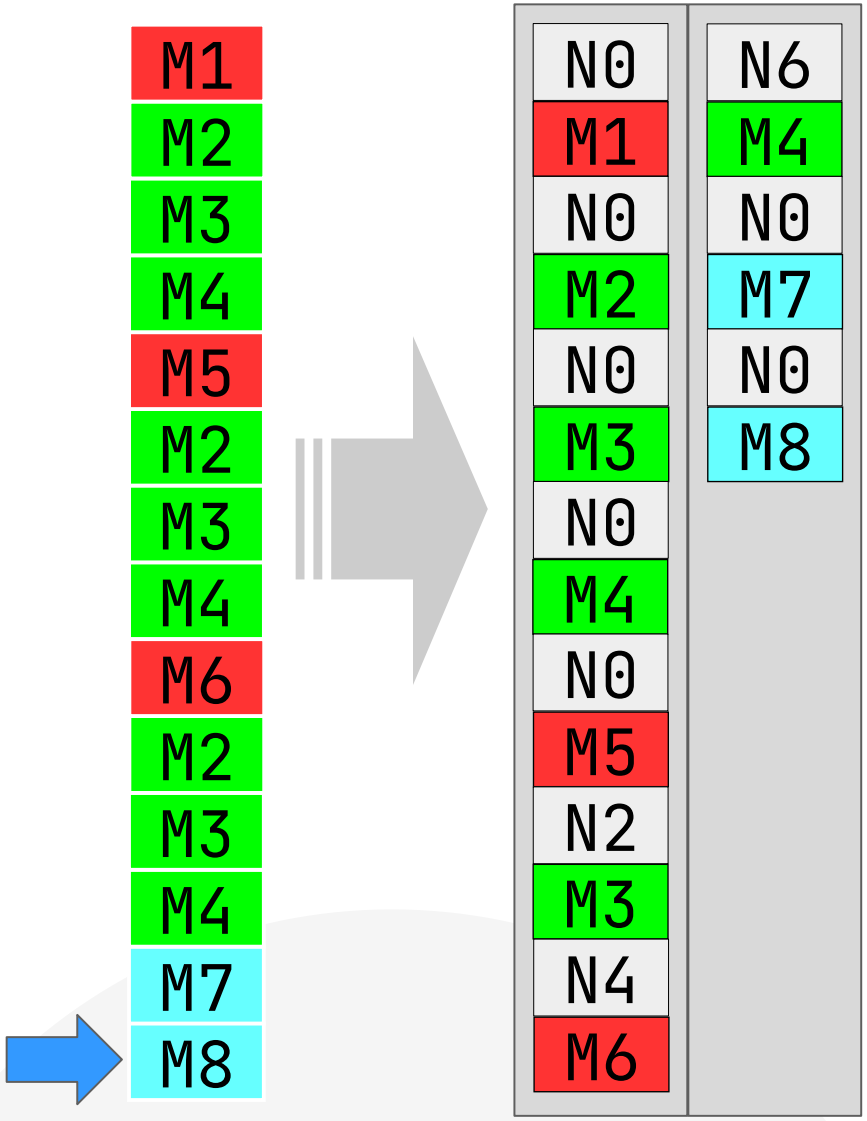


Сжал почти в полтора раза!

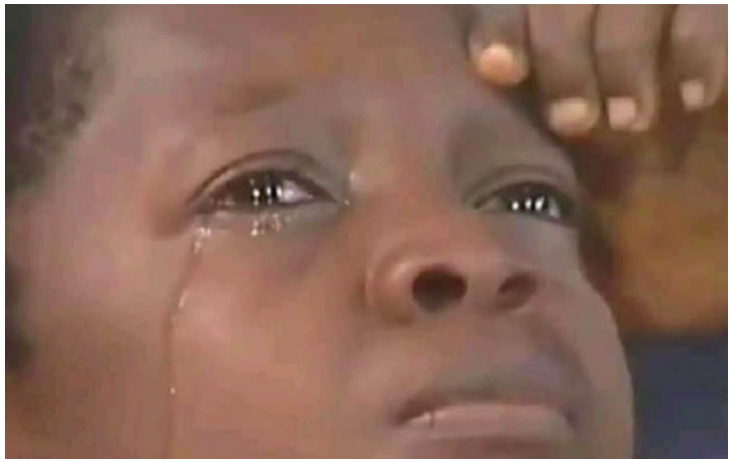
Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
```

Сжимаем



Сжал почти в полтора раза!

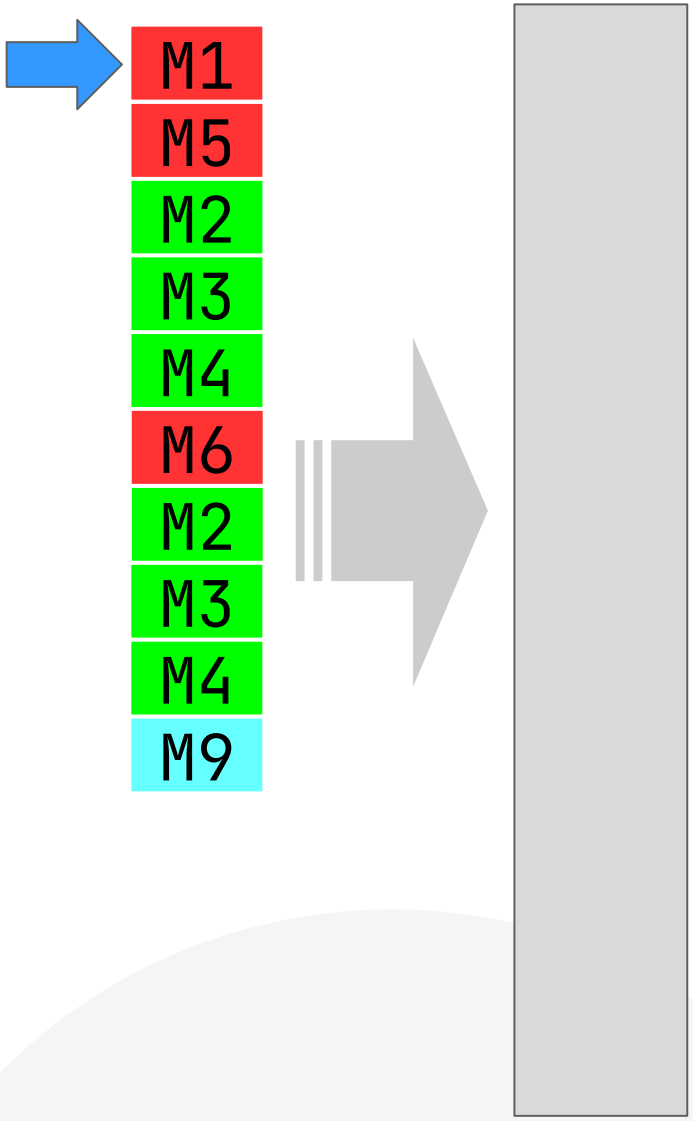


Но не в ту сторону...

Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
```

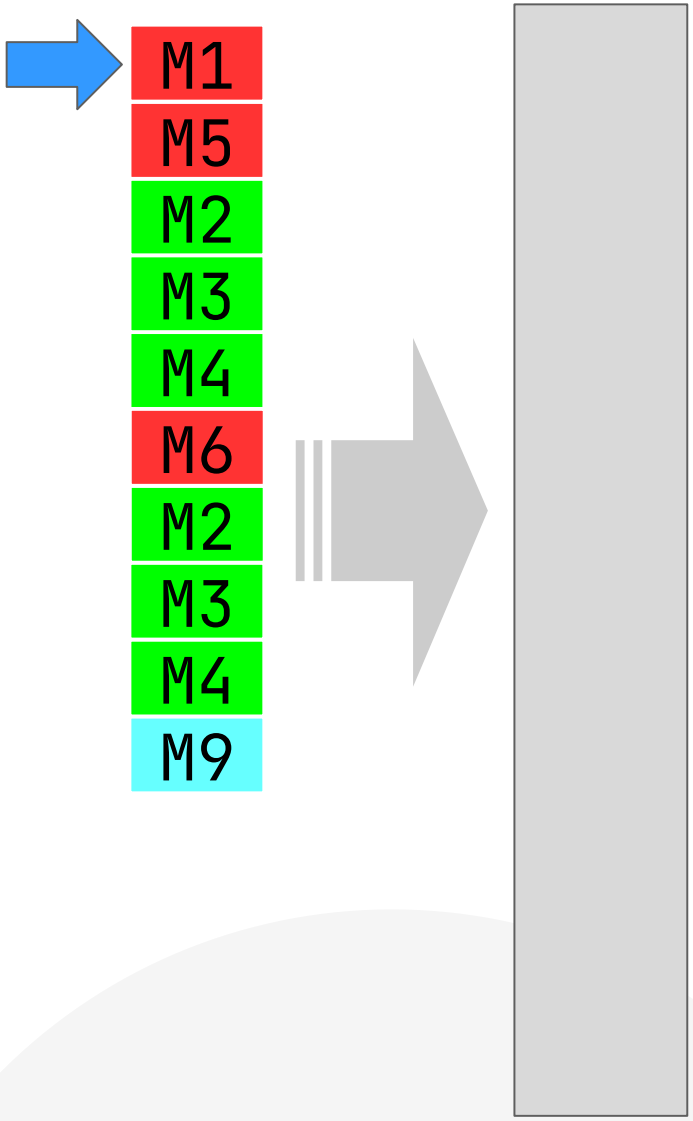
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
```

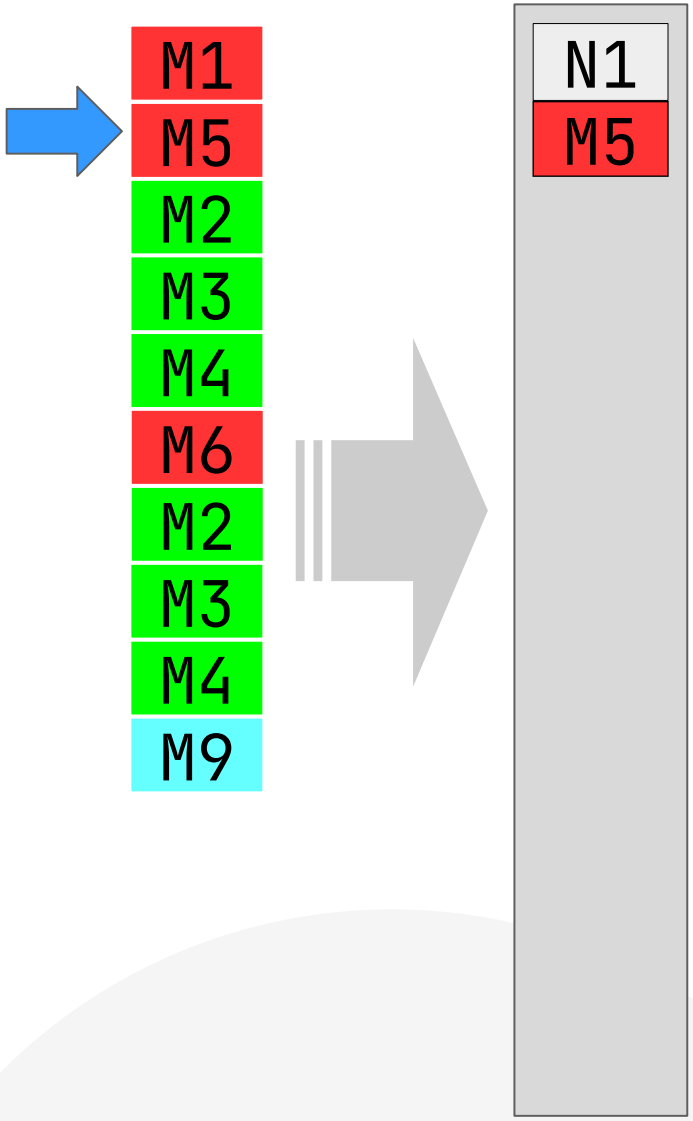
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
```

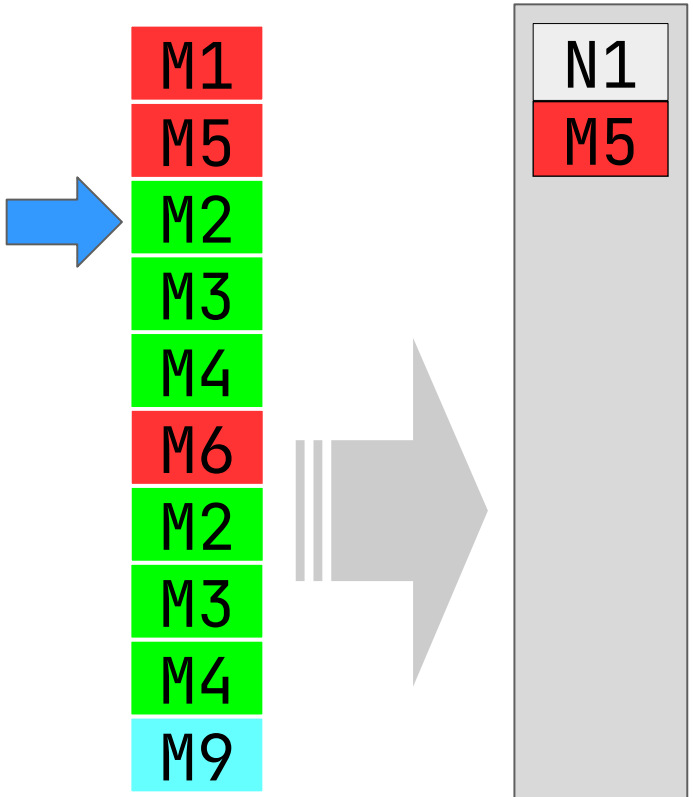
Сжимаем



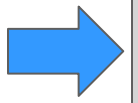
Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
```

Сжимаем

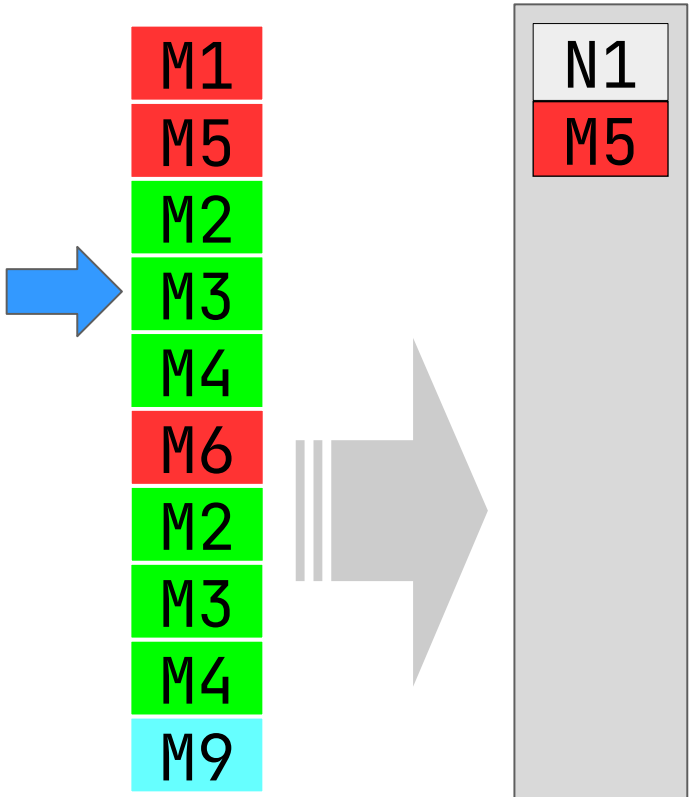


Словарь

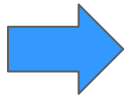


```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
```

Сжимаем

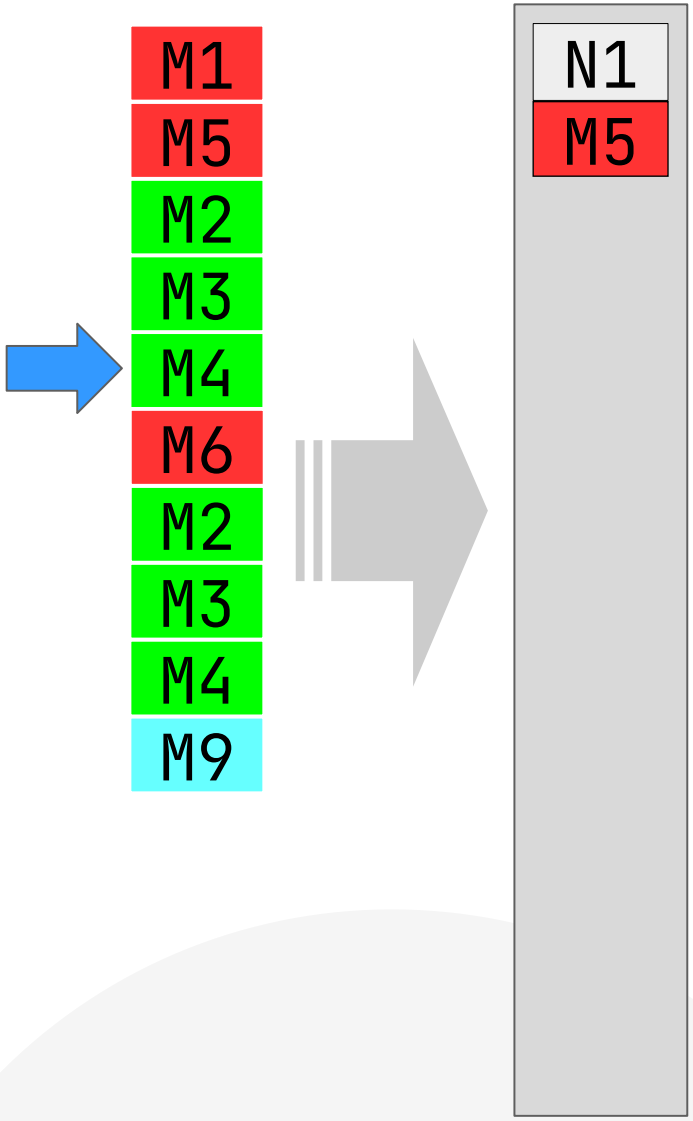


Словарь



```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
```

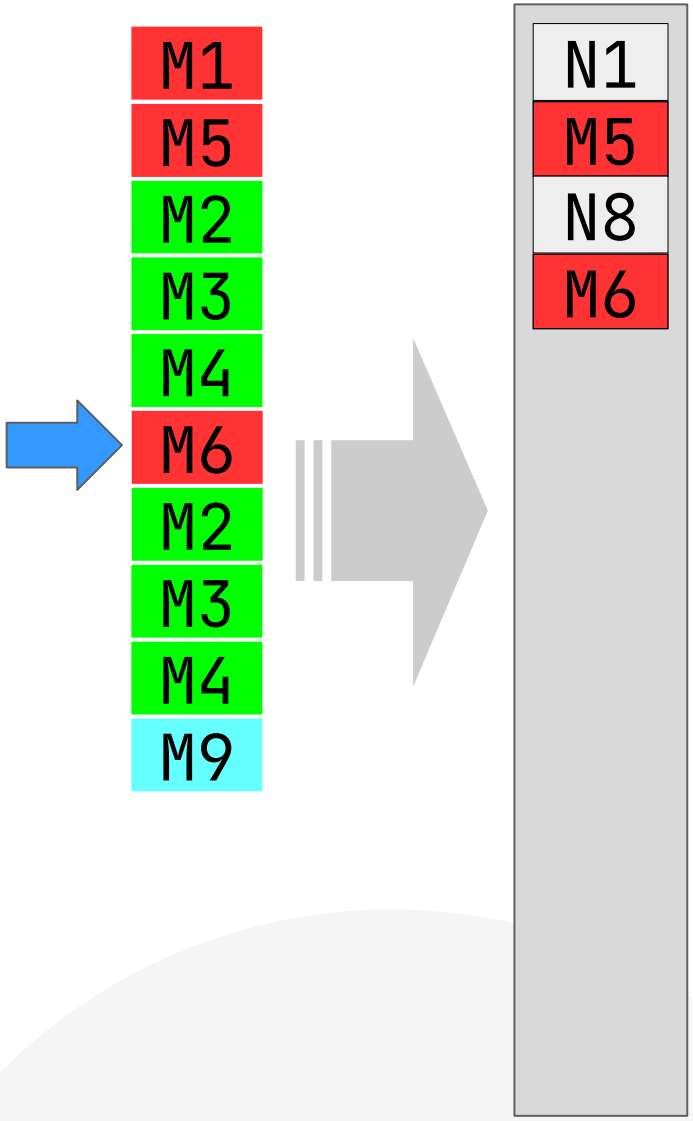
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
```

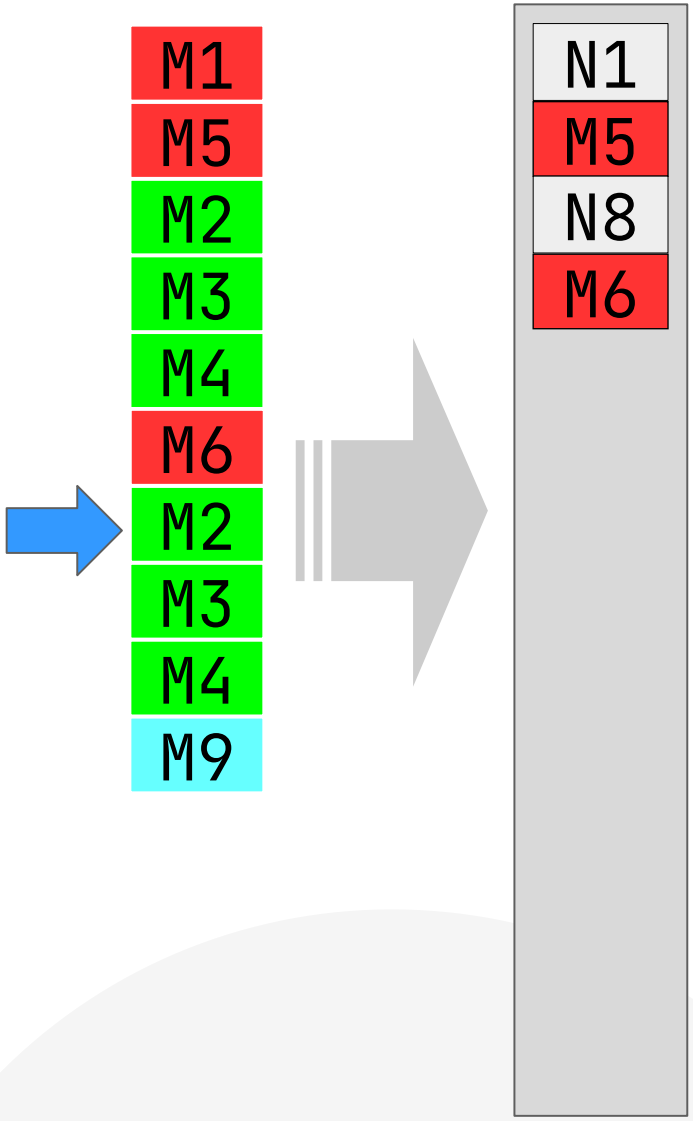
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
```

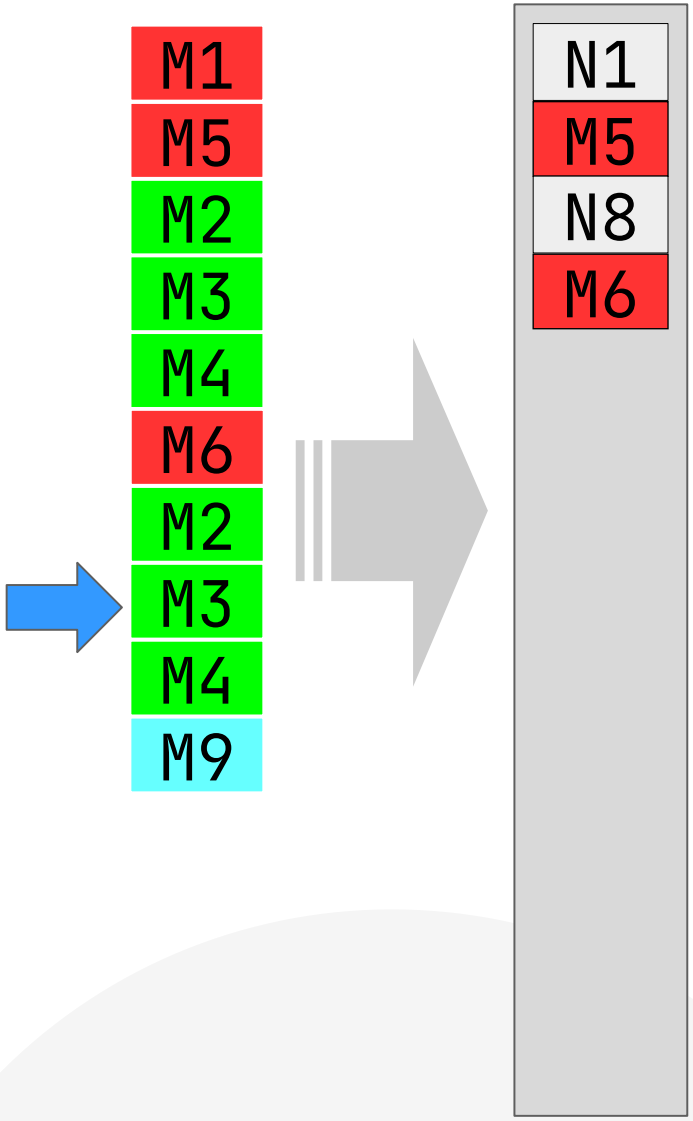
Сжимаем



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
```

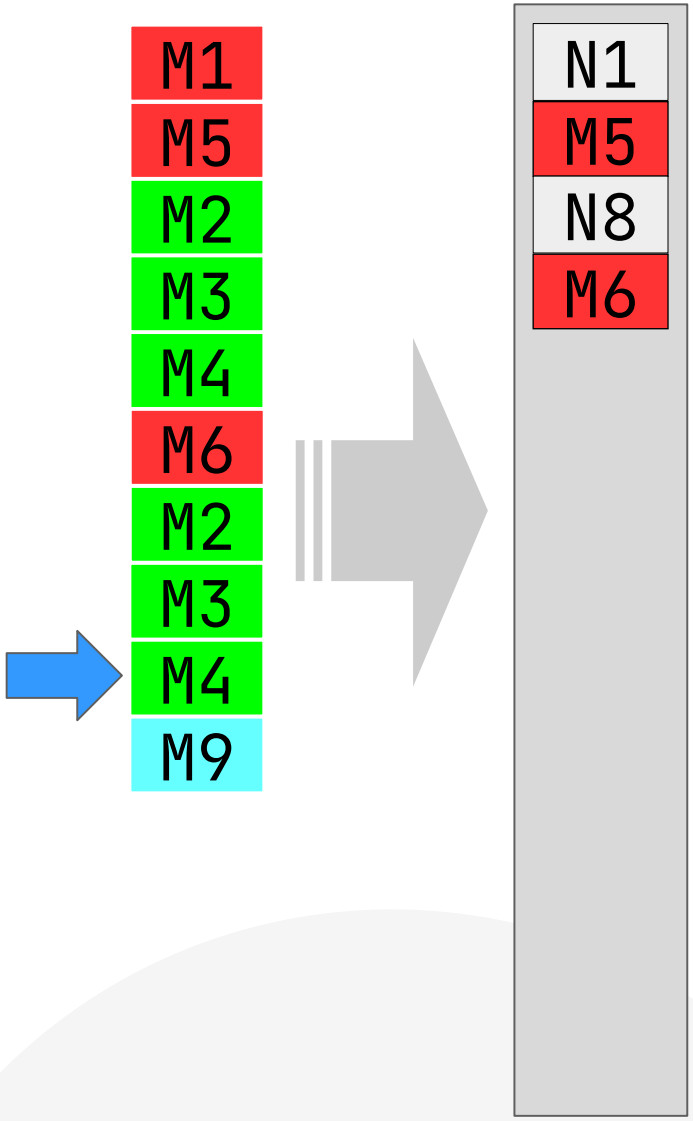
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
```

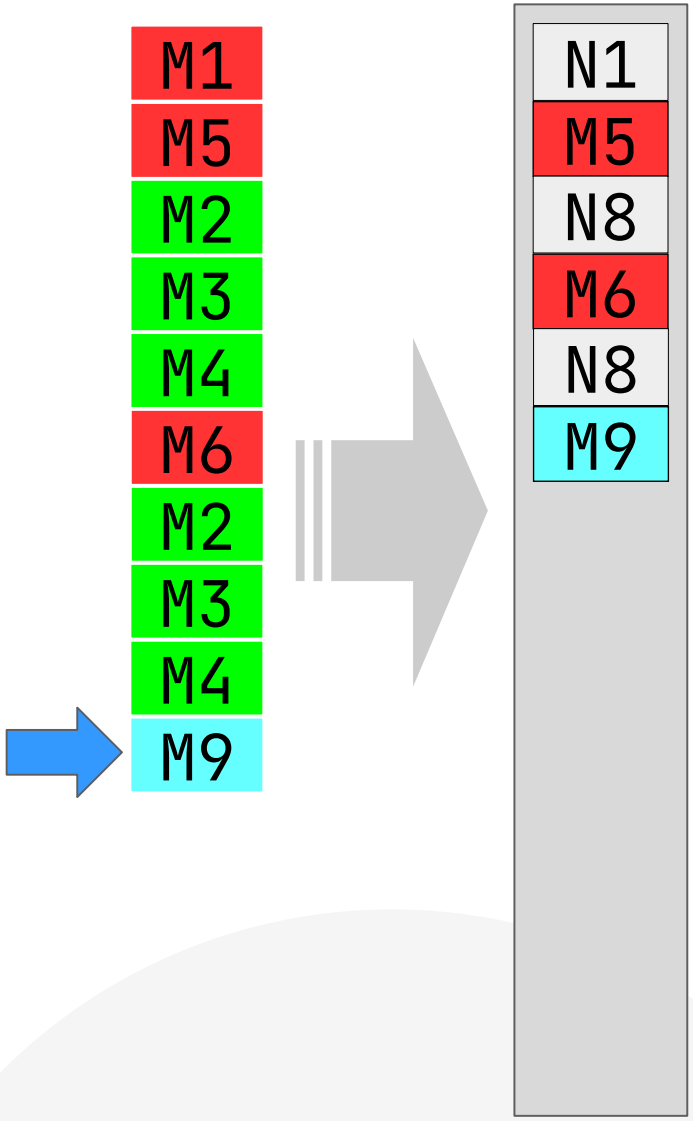
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
```

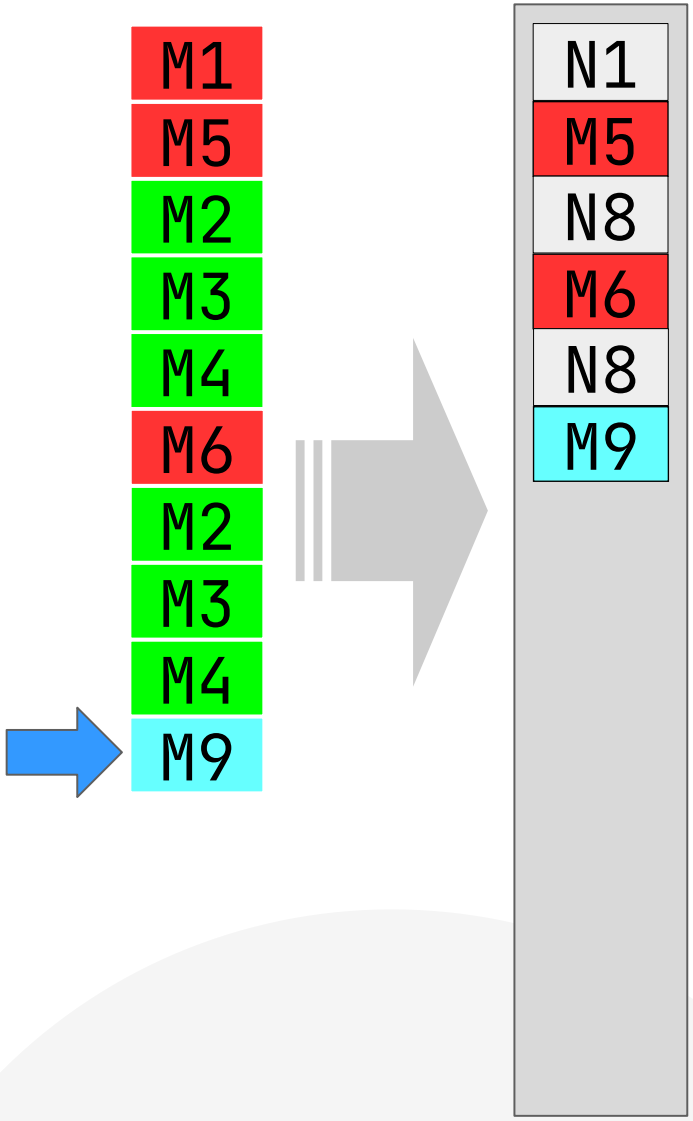
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

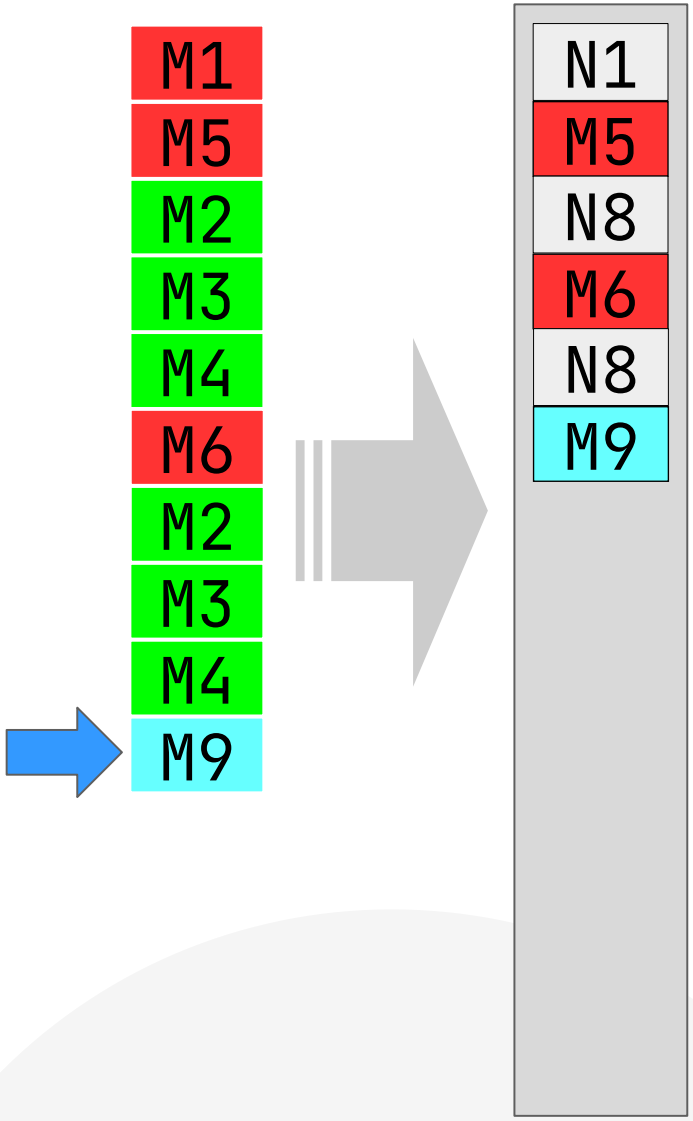
Сжимаем



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Сжимаем

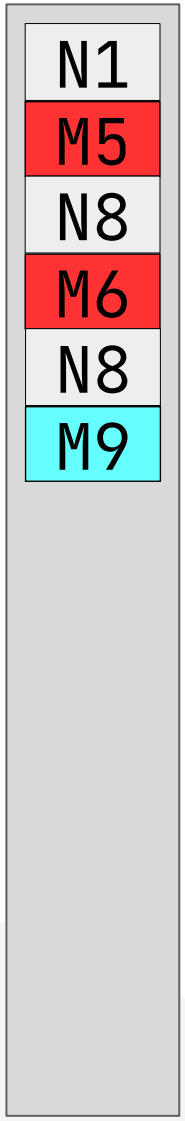


LZ78

Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

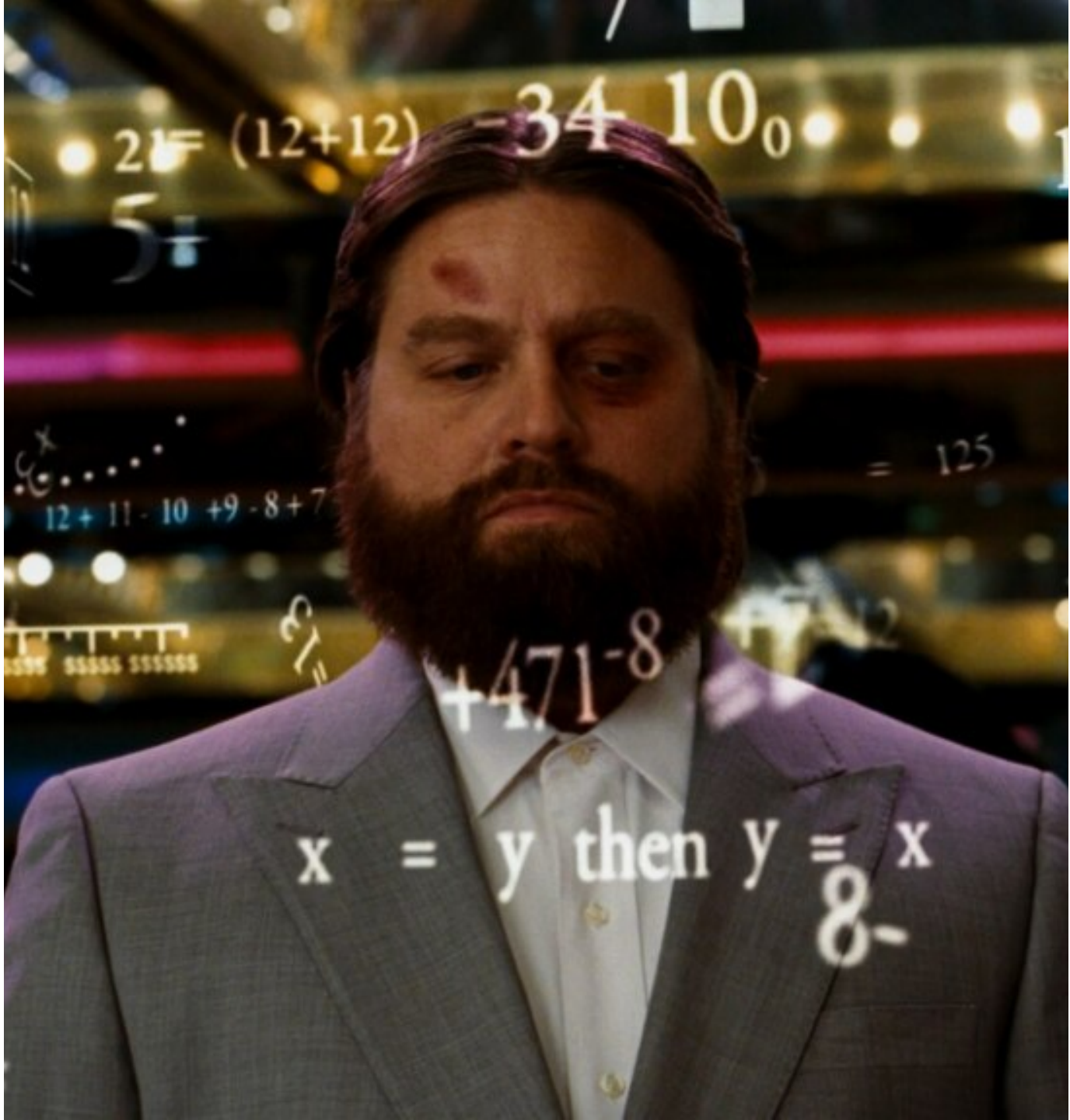
Сжимаем



HTML

Готовим данные

Кодируем числа



Кодируем числа

N102
M504
N898
M602
N835
M991

HTML

Кодируем числа

N102
M504
N898
M602
N835
M991


```
<pre>
102\n
504\n
898\n
602\n
835\n
991\n
</pre>
```

Кодируем числа

N102
M504
N898
M602
N835
M991


```
<pre>
102\n
504\n
898\n
602\n
835\n
991\n
</pre>
```

4 байта

Кодируем числа: HEX

N102
M504
N898
M602
N835
M991


```
<pre>
66\n
1F8\n
382\n
25A\n
343\n
3DF\n
</pre>
```

3 байта

4 байта

4 байта

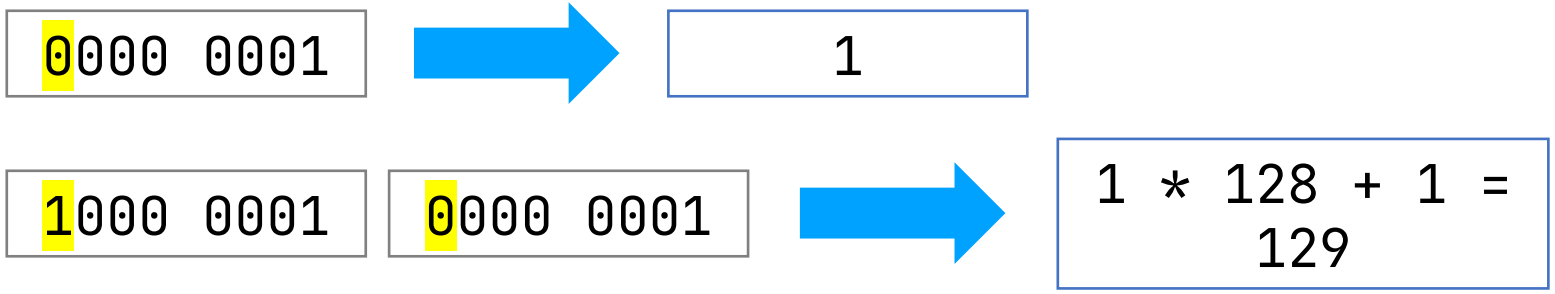
4 байта

4 байта

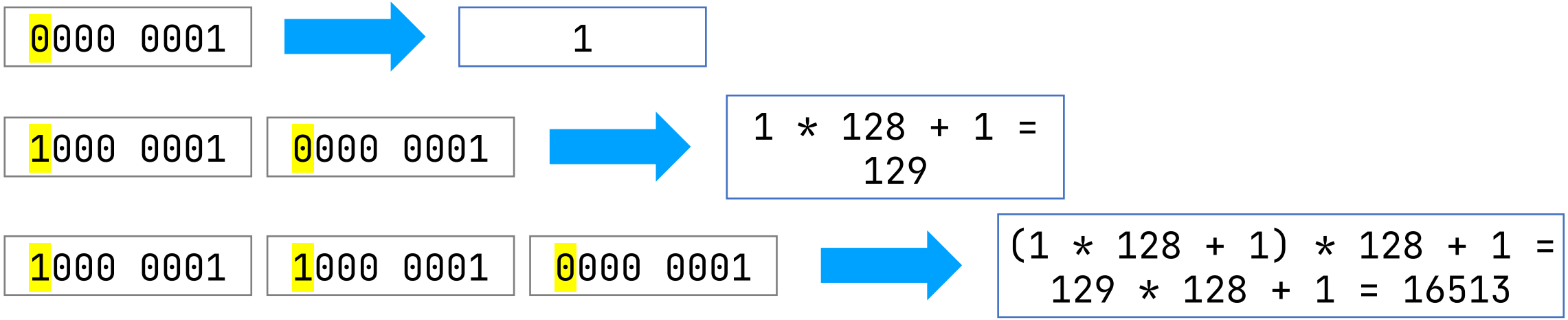
4 байта

23 байта

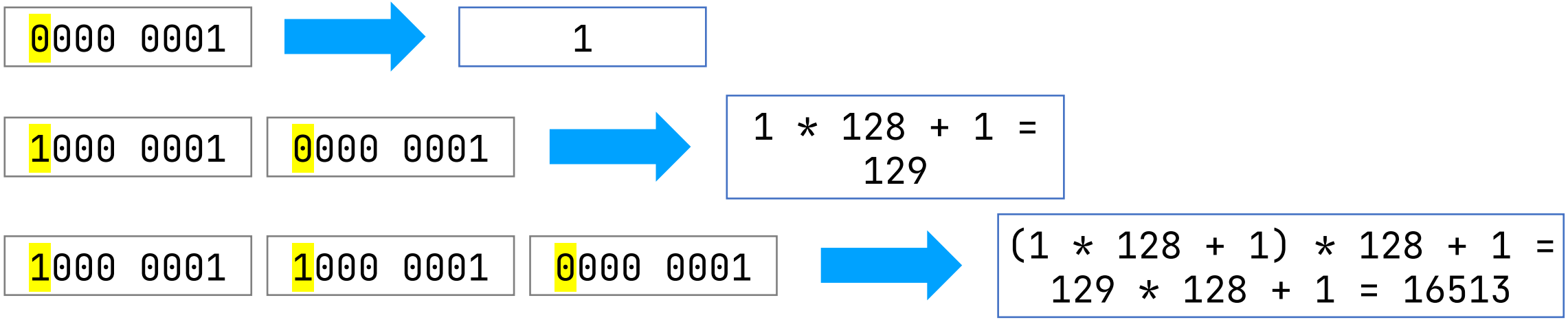
Кодируем числа: VarInt



Кодируем числа: VarInt

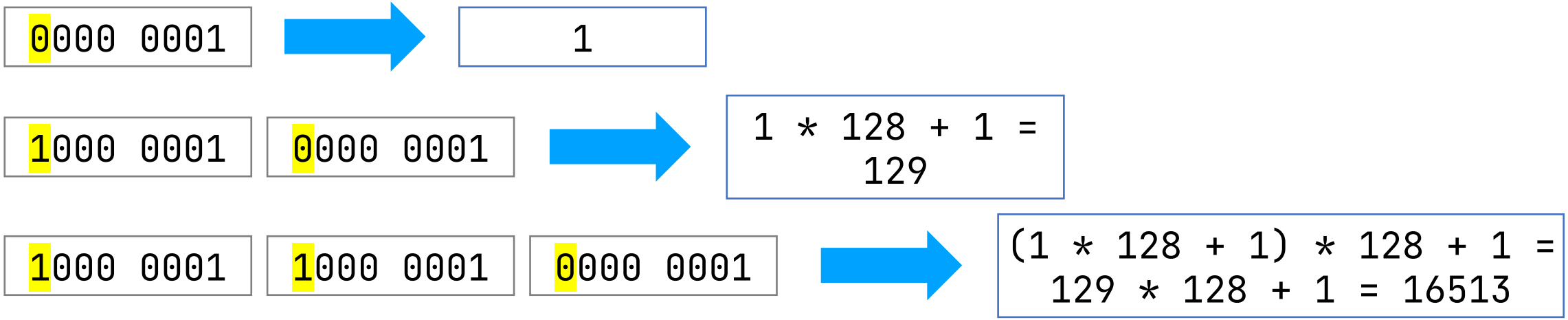


Кодируем числа: VarInt



Q: Где Хаффман?

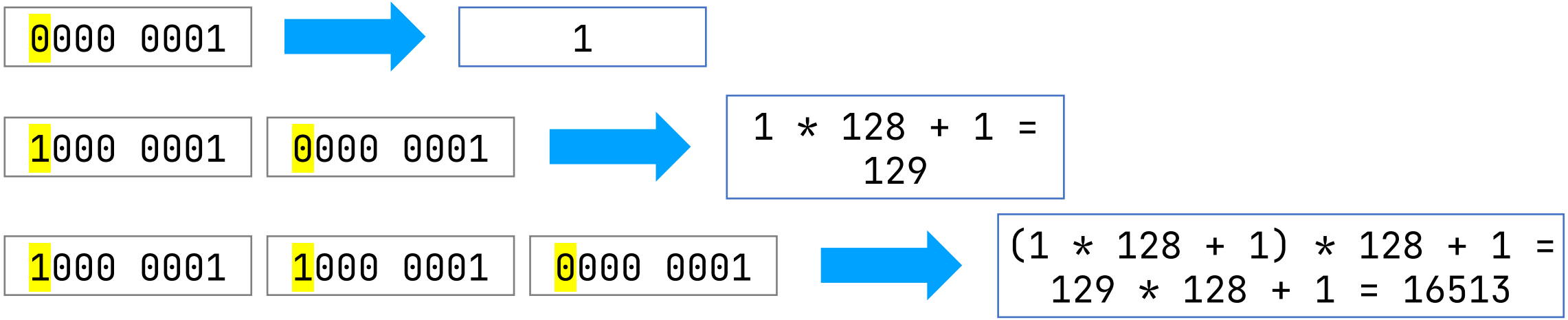
Кодируем числа: VarInt



Q: Где Хаффман?

Q: А арифметическое кодирование?

Кодируем числа: VarInt



Q: Где Хаффман?

Q: А арифметическое кодирование?

Q: Асимметрические системы счисления?

VarInt в дикой природе

```
public void writeVar(int v) {
    while (v ⩾ 128) {
        int b = 128 + v % 128;
        nextByte(b);
        v ⊨ 128;
    }
    nextByte(v);
}
```

VarInt в дикой природе

```
public void writeVar(int v) {
    while (v ⩾ 128) {
        int b = 128 + v % 128;
        nextByte(b);
        v ⊨ 128;
    }
    nextByte(v);
}
```

VarInt в HTML

```
<pre>0-127</pre>
```

1) \0
2) \r
3) &
4) <
5) >

Итого: 123 значения

VarInt в дикой природе

```
public void writeVar(int v) {
    while (v ⩾ 128) {
        int b = 128 + v % 128;
        nextByte(b);
        v ⊨ 128;
    }
    nextByte(v);
}
```

VarInt в HTML

```
public void writeVar(int v) {
    while (v >= 61) {
        int b = 61 + v % 61;
        nextByte(b);
        v /= 61;
    }
    nextByte(v);
}
```

VarInt в дикой природе

```
public void writeVar(int v) {
    while (v ⩾ 128) {
        int b = 128 + v % 128;
        nextByte(b);
        v ⫦ 128;
    }
    nextByte(v);
}
```

VarInt в HTML

```
public void writeVar(int v) {
    while (v >= 61) {
        int b = 61 + v % 61;
        nextByte(b);
        v /= 61;
    }
    nextByte(v);
}
```

VarInt

- Подходит, когда мало значащих бит

VarInt

- Подходит, когда мало значащих бит
- Гранулярность - 1 байт

VarInt

- Подходит, когда мало значащих бит
- Гранулярность - 1 байт
- Теряем 1 бит каждого байта

VarInt

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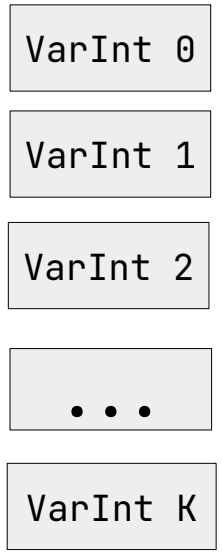
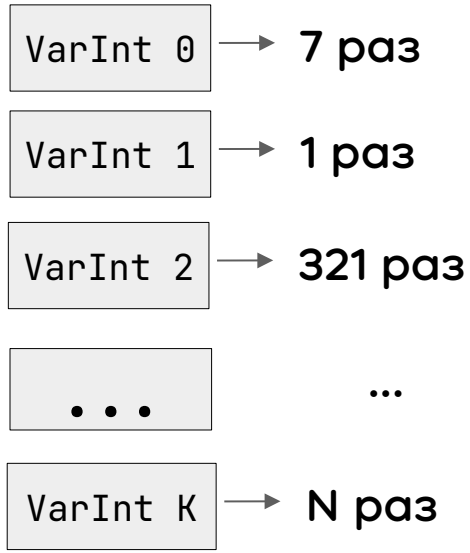
- Теряем 1 бит каждого байта

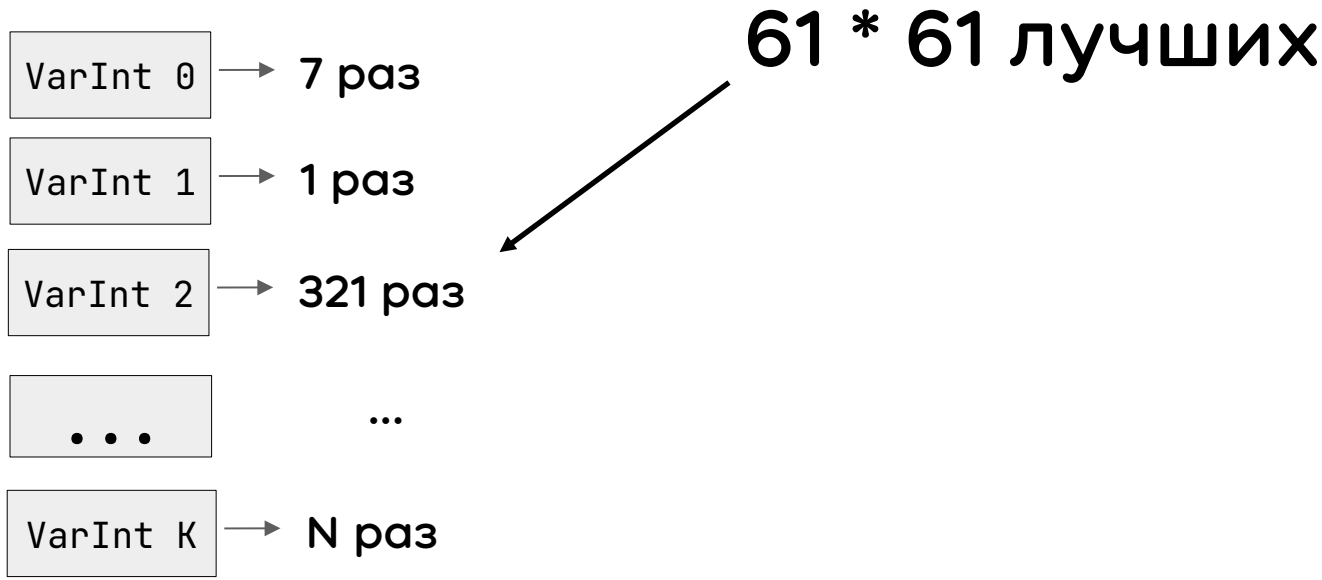
Словарь синонимов



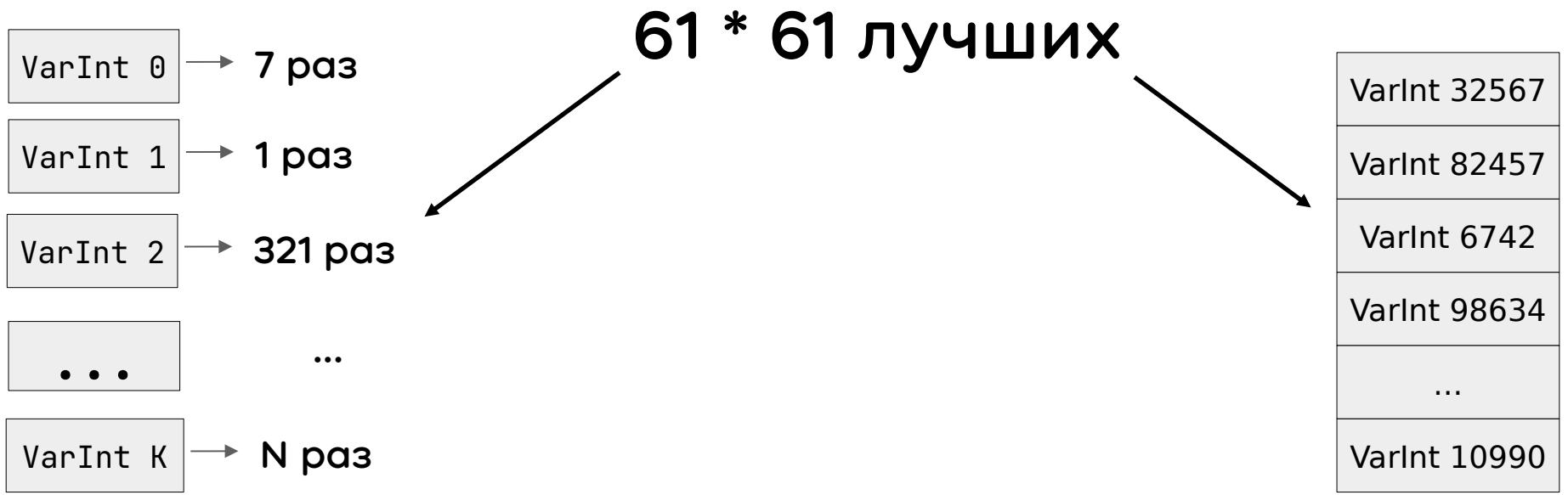
Словарь синонимов



Словарь синонимов



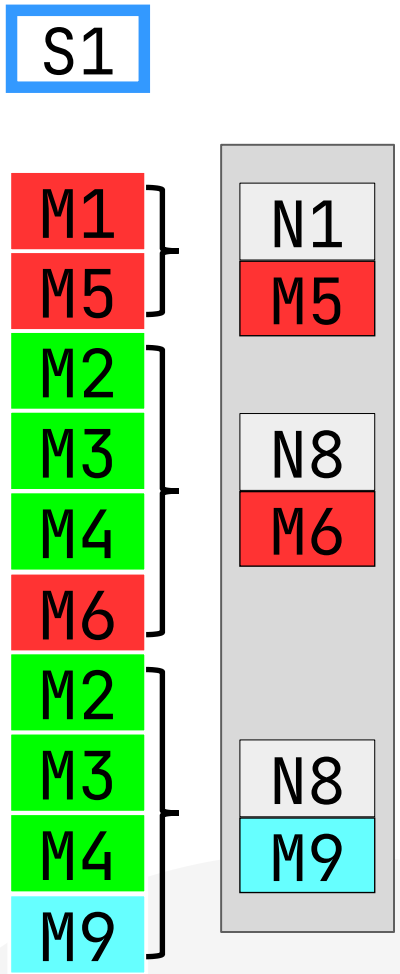
Словарь синонимов



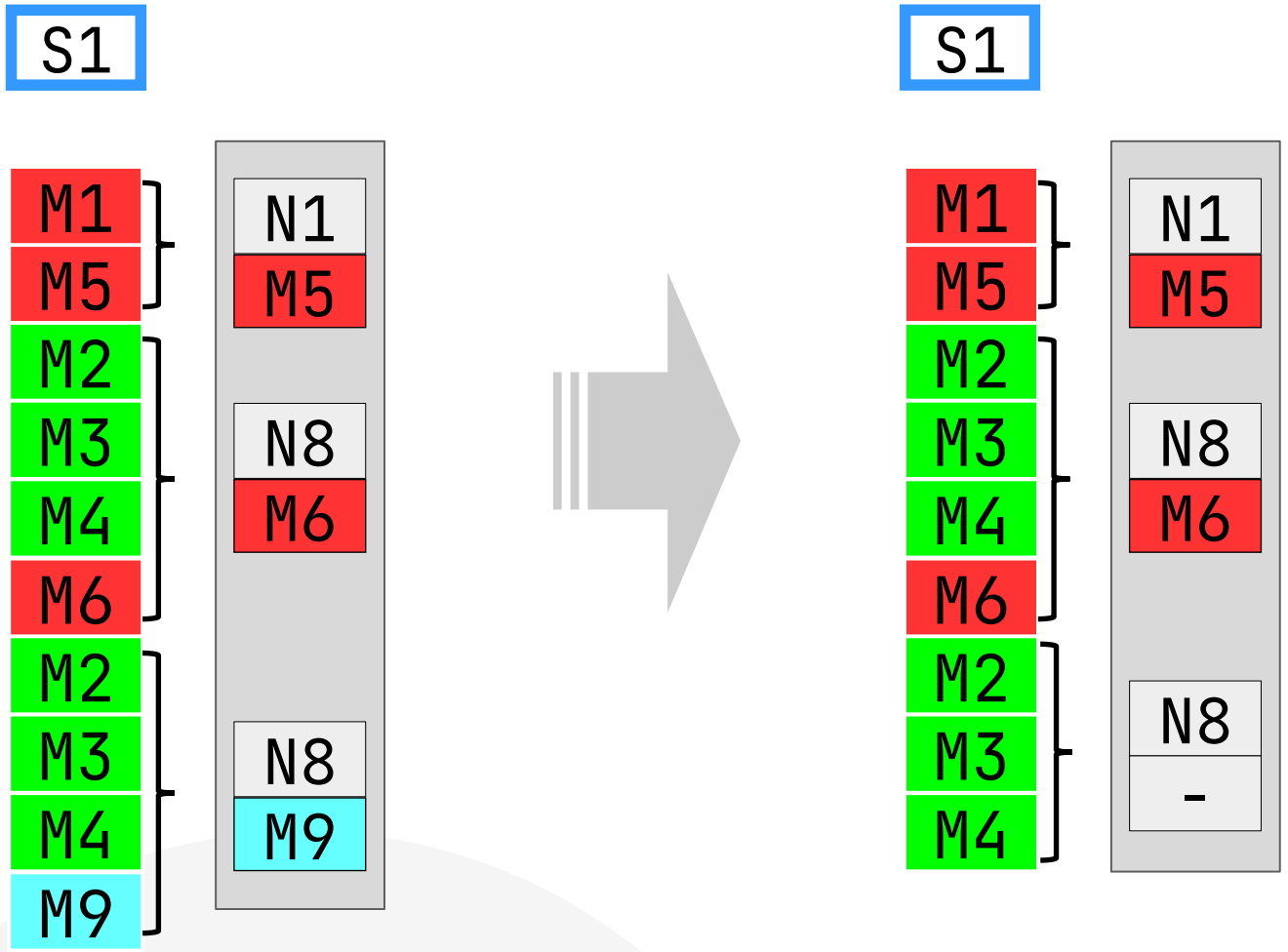
Готовим данные

Промежуточный итог

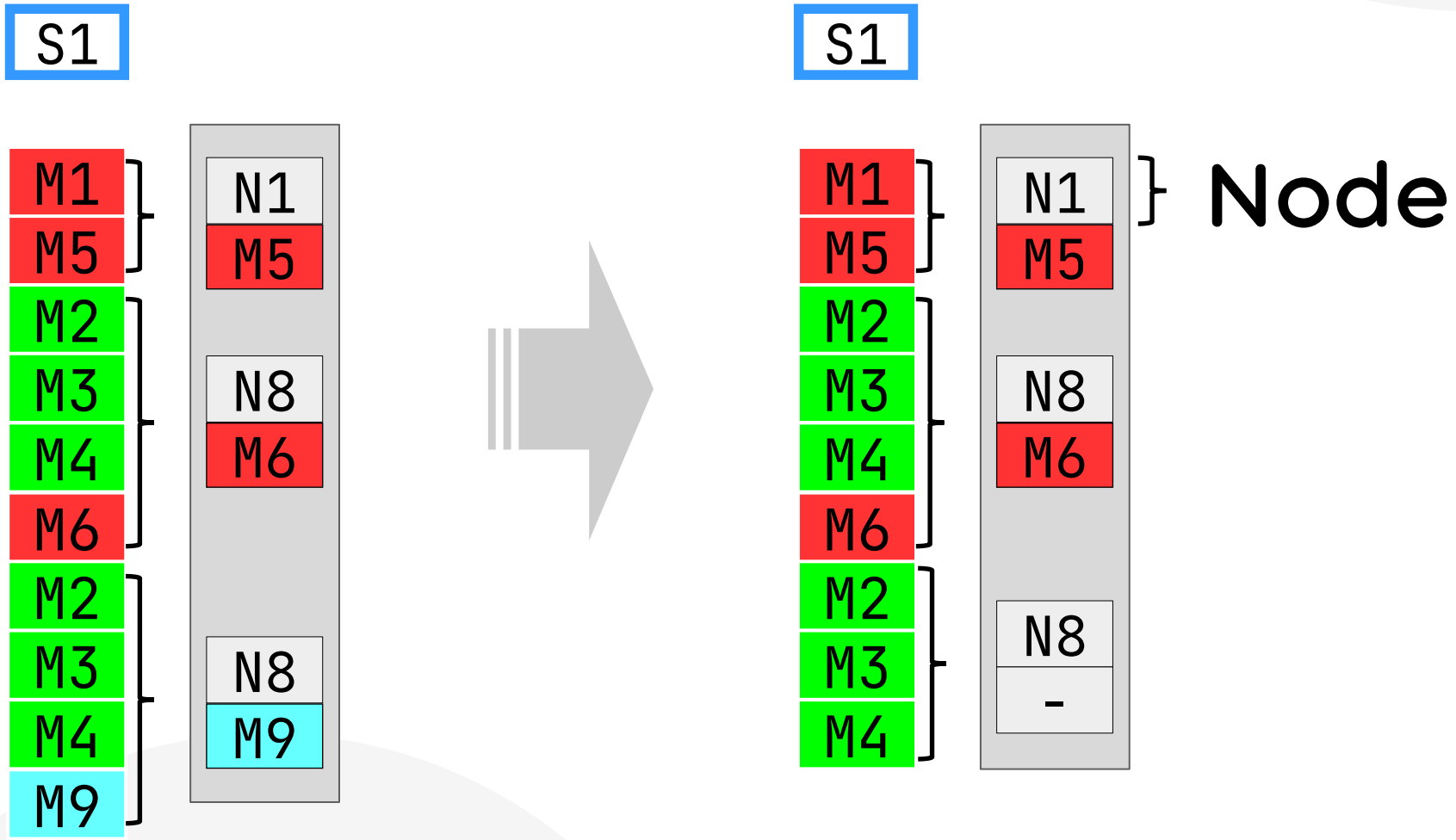
Промежуточный итог



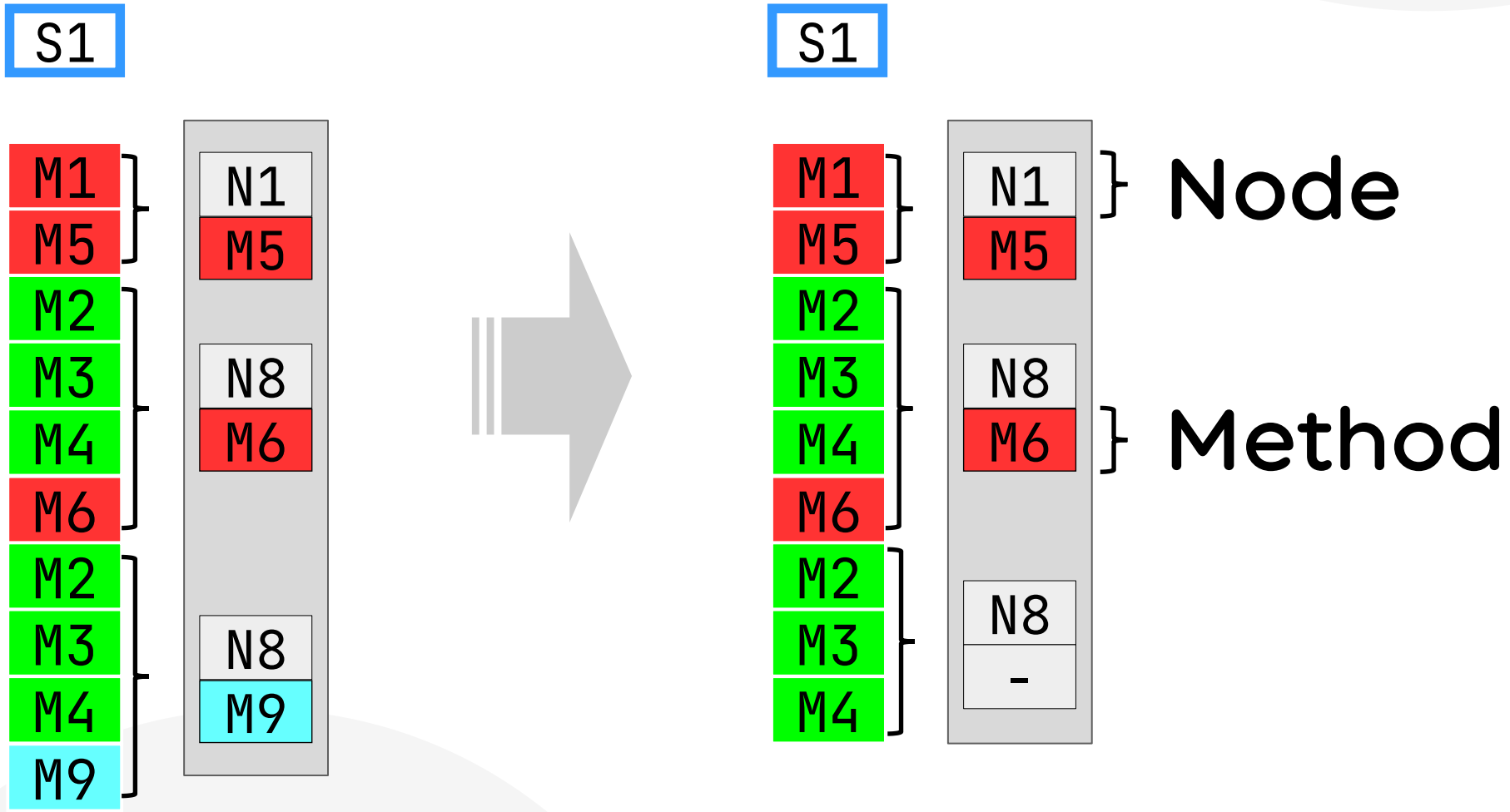
Промежуточный итог



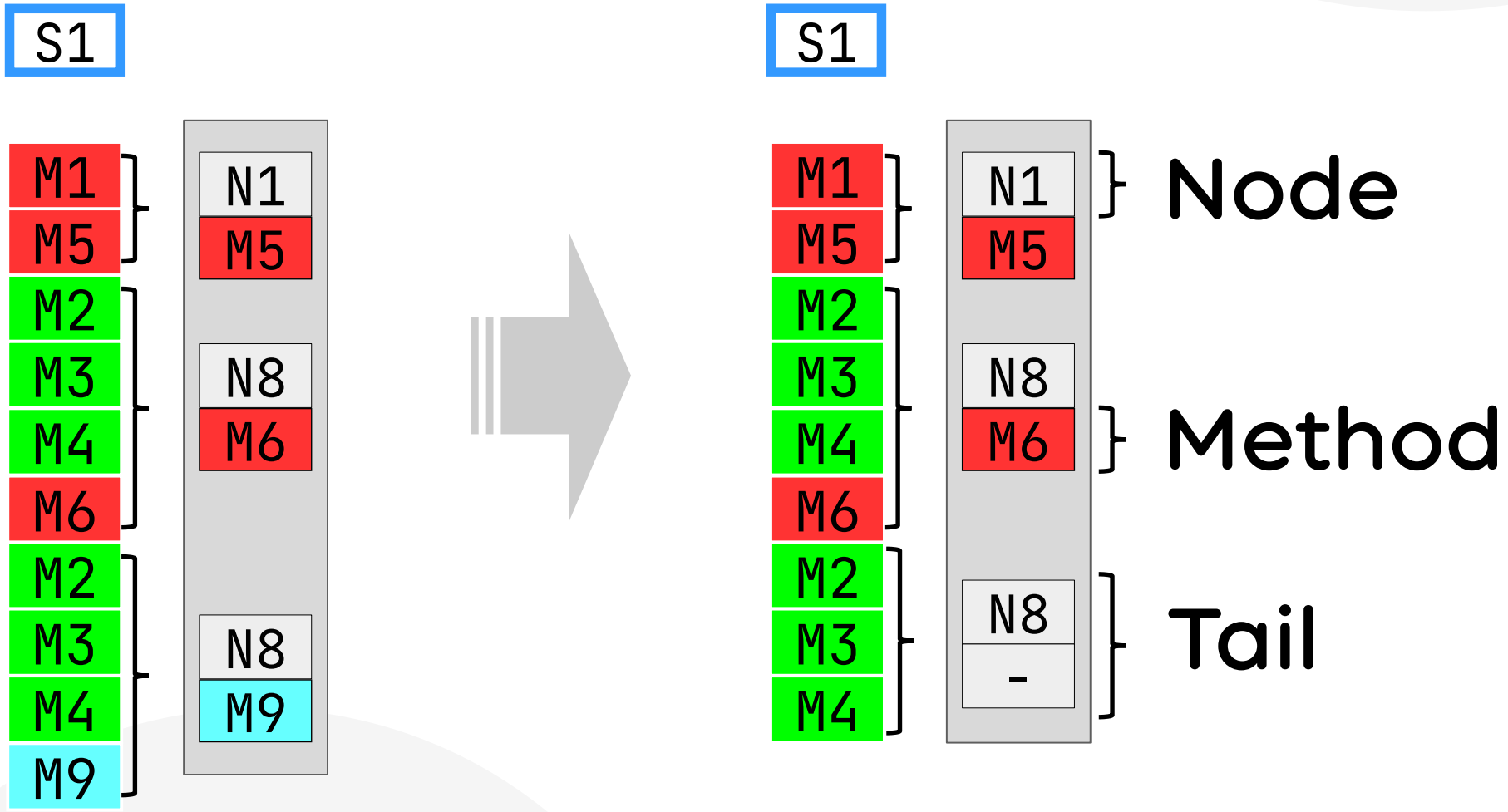
Промежуточный итог



Промежуточный итог



Промежуточный итог



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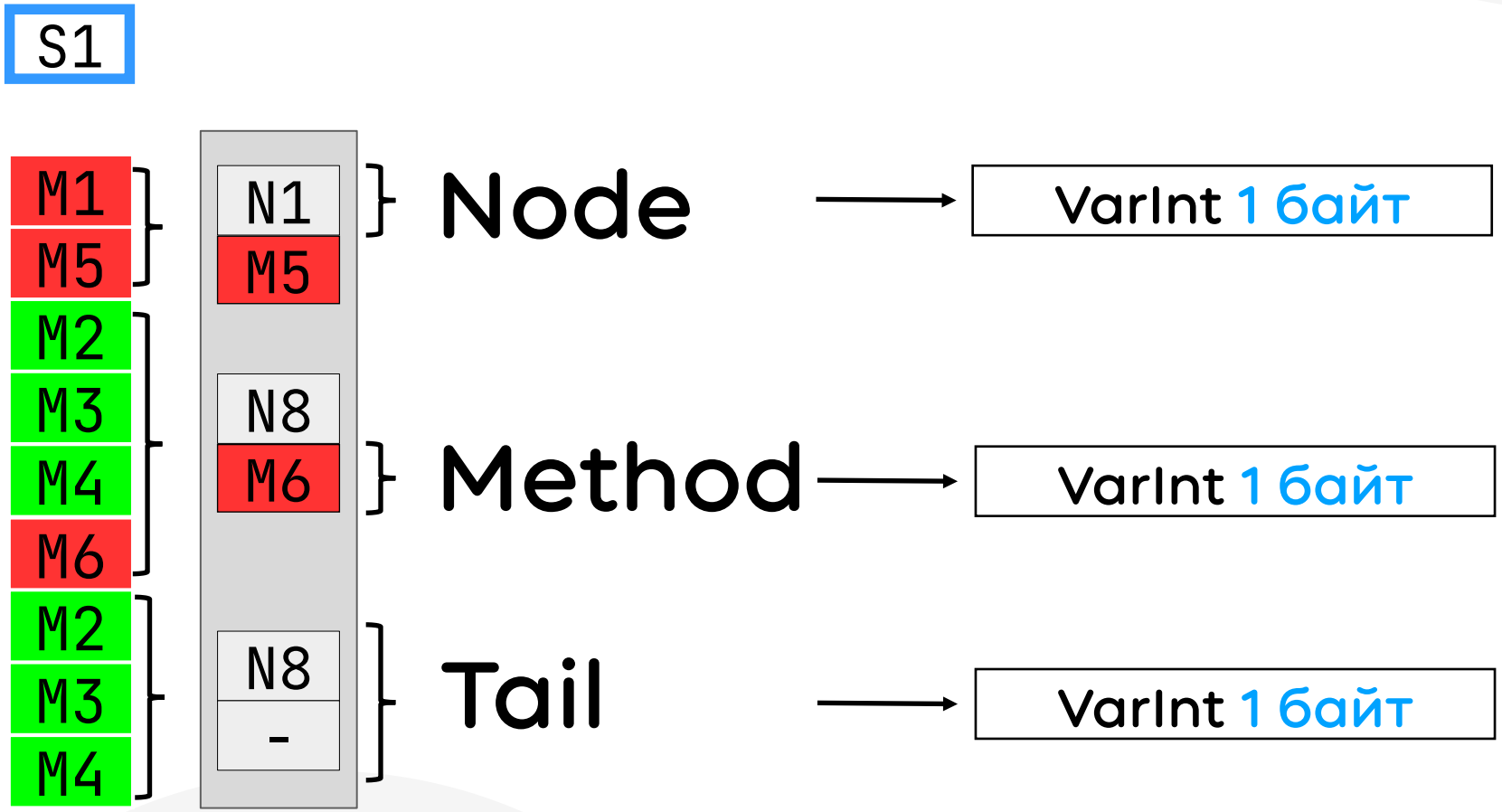

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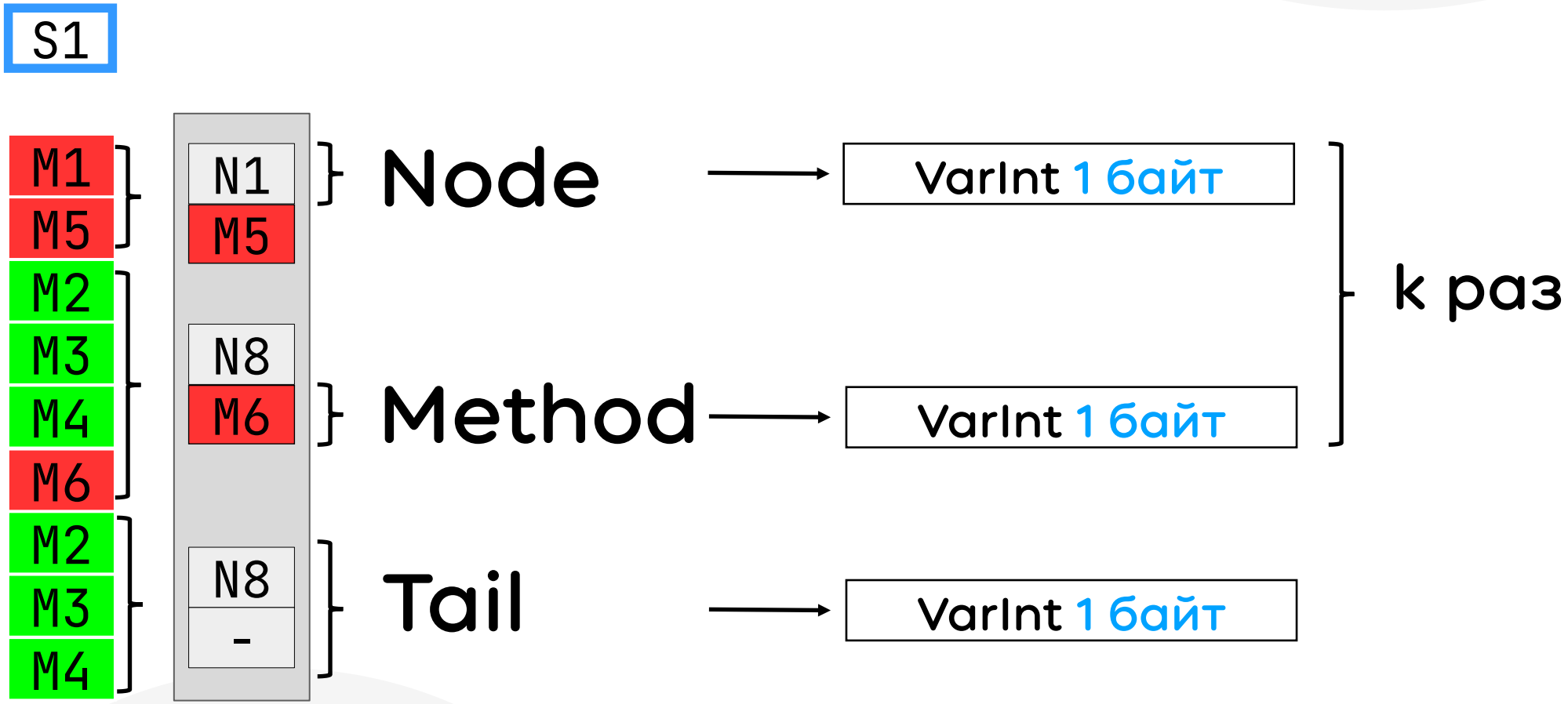

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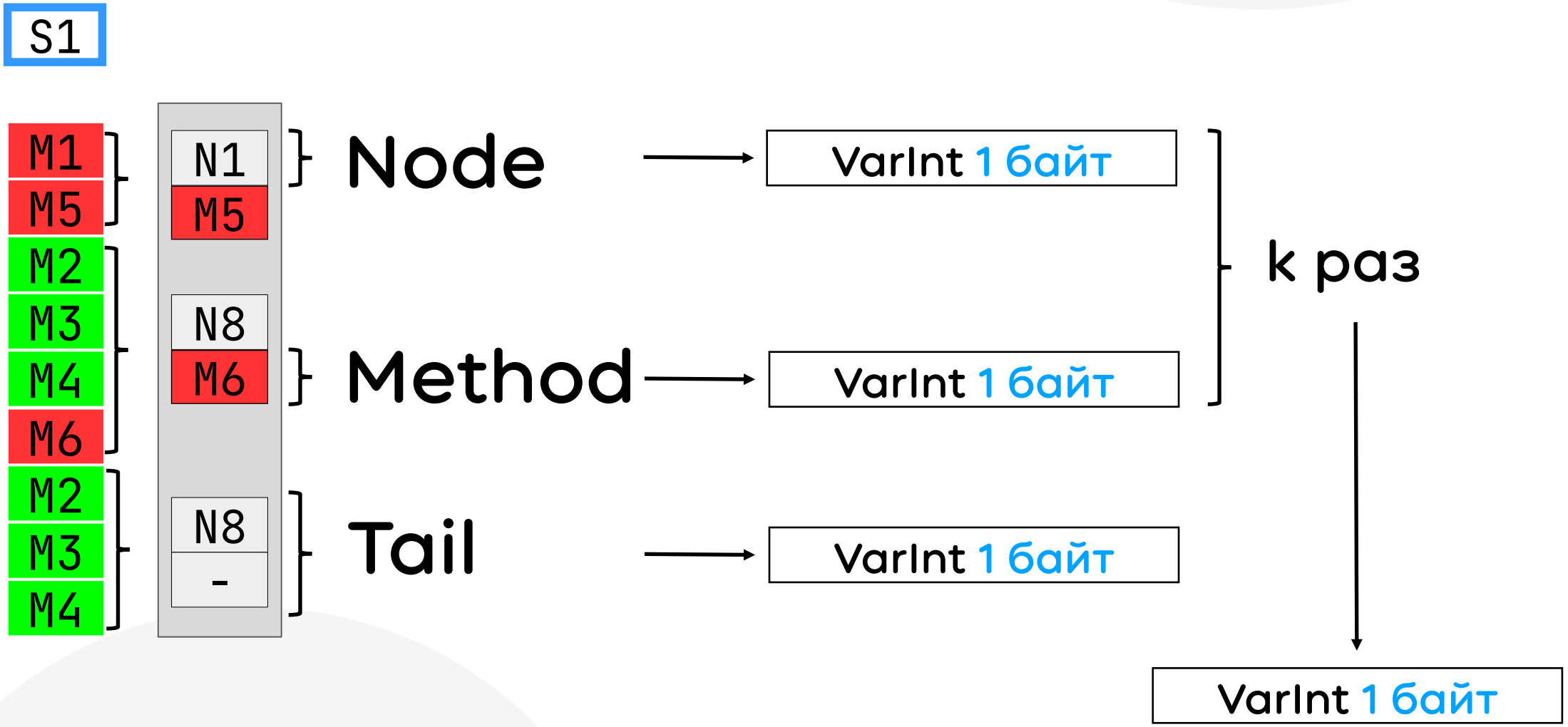

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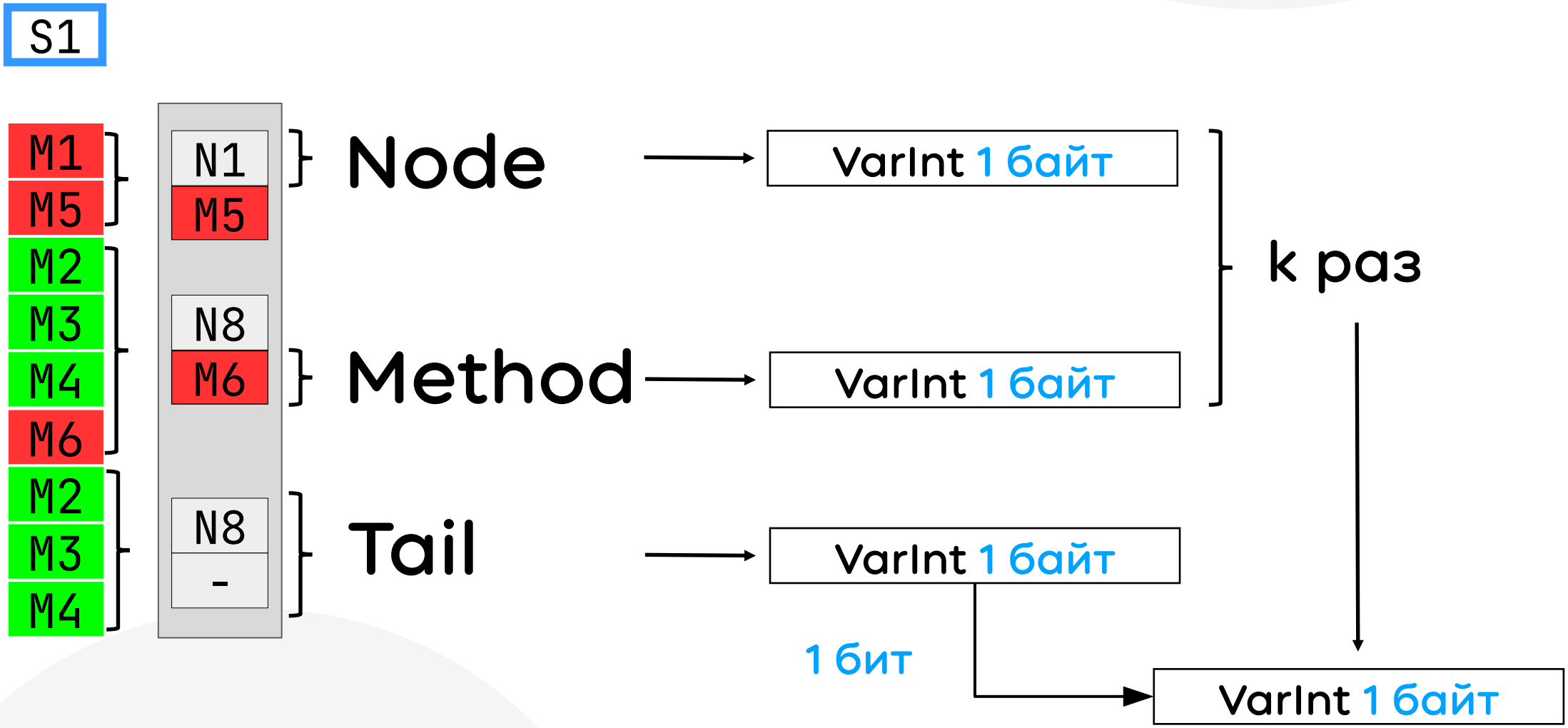

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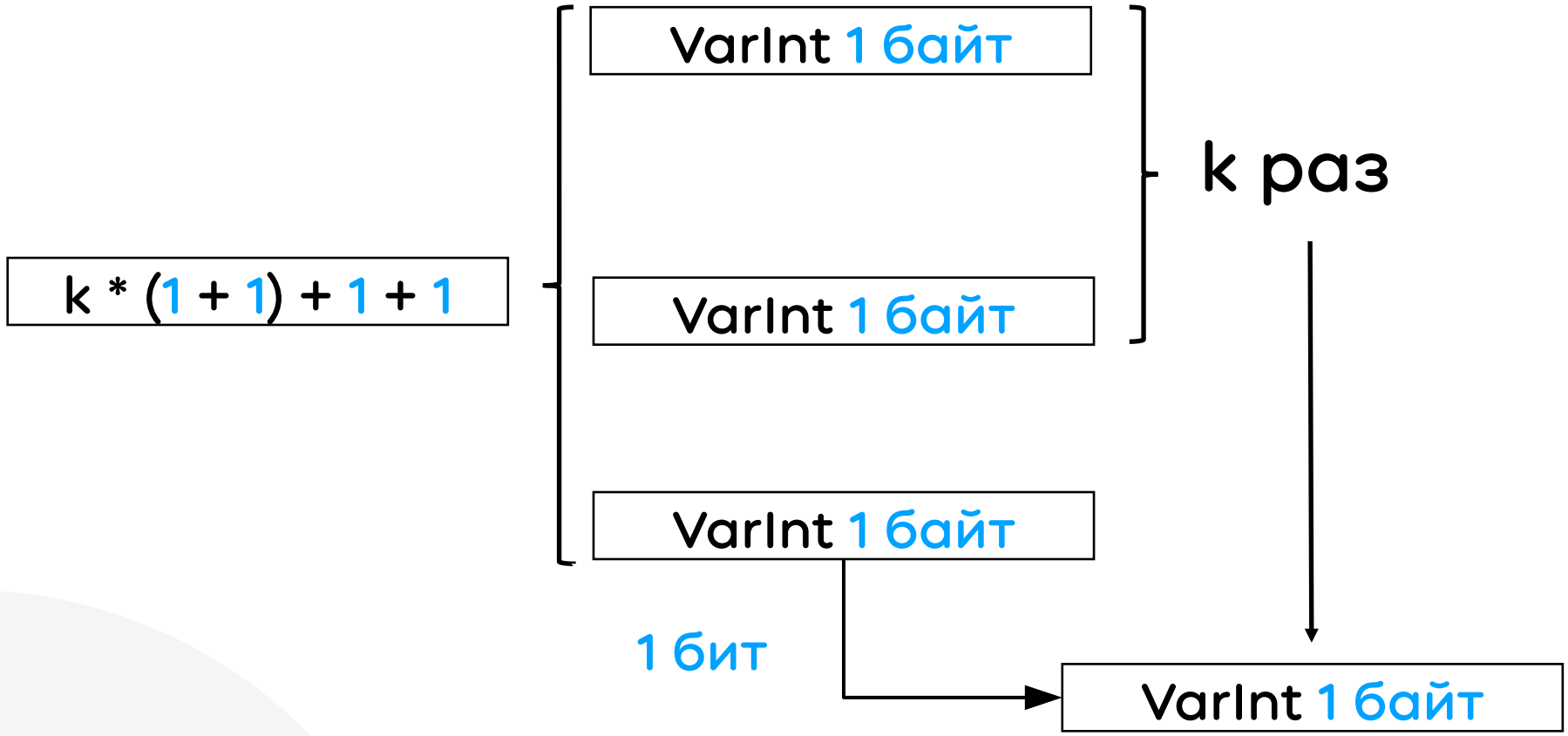
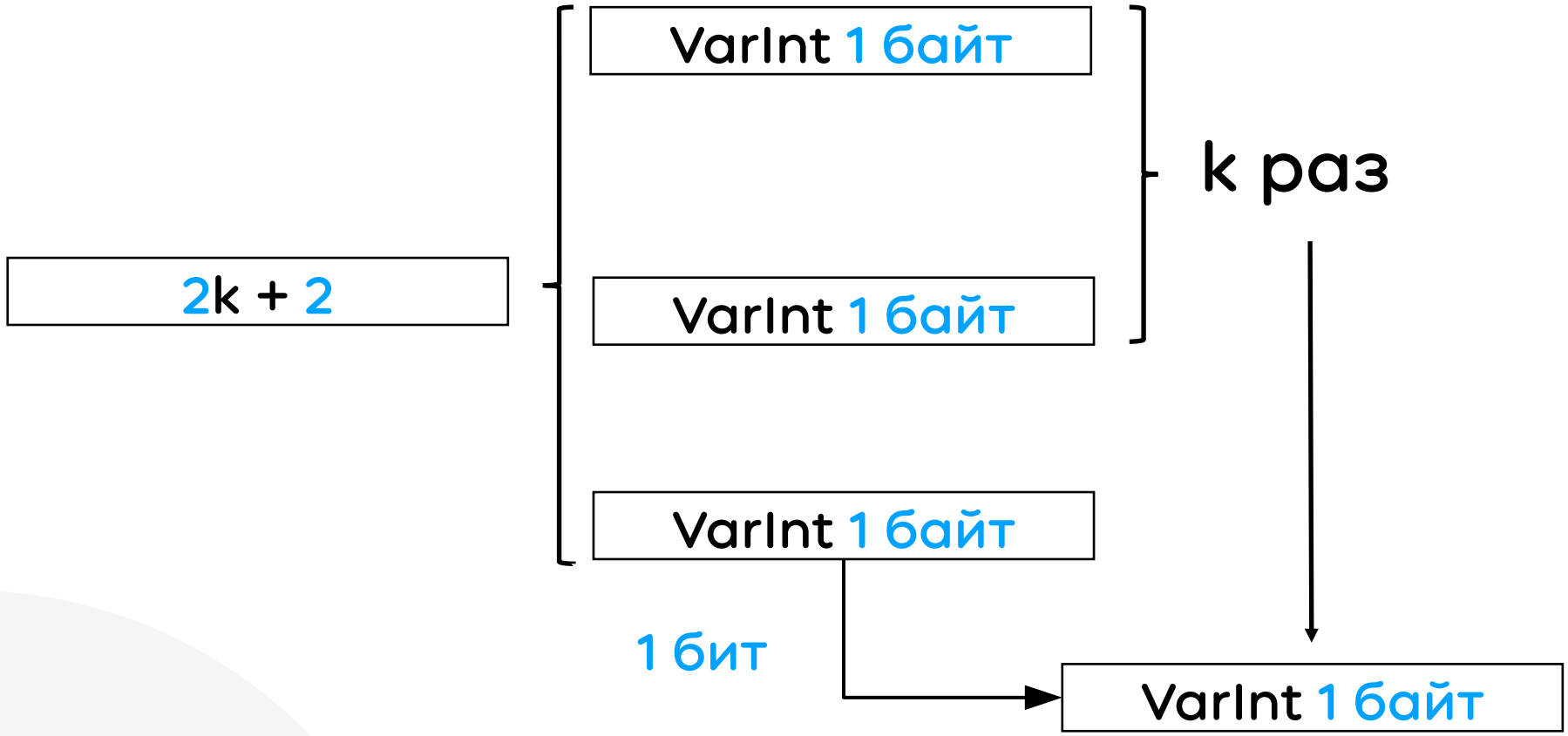


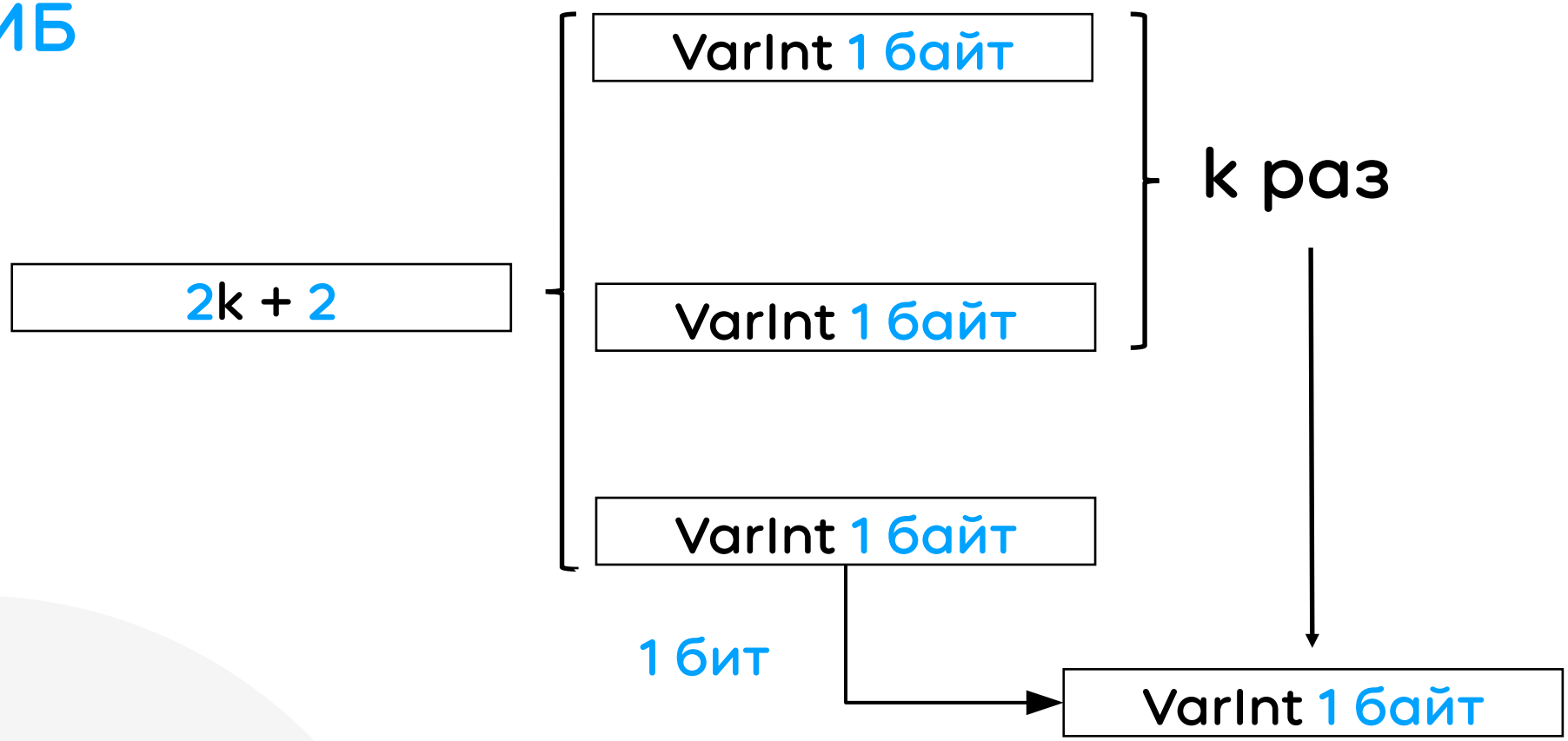
Промежуточный итог



Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ



Промежуточный итог

Alloc: 78 млн сэмплов

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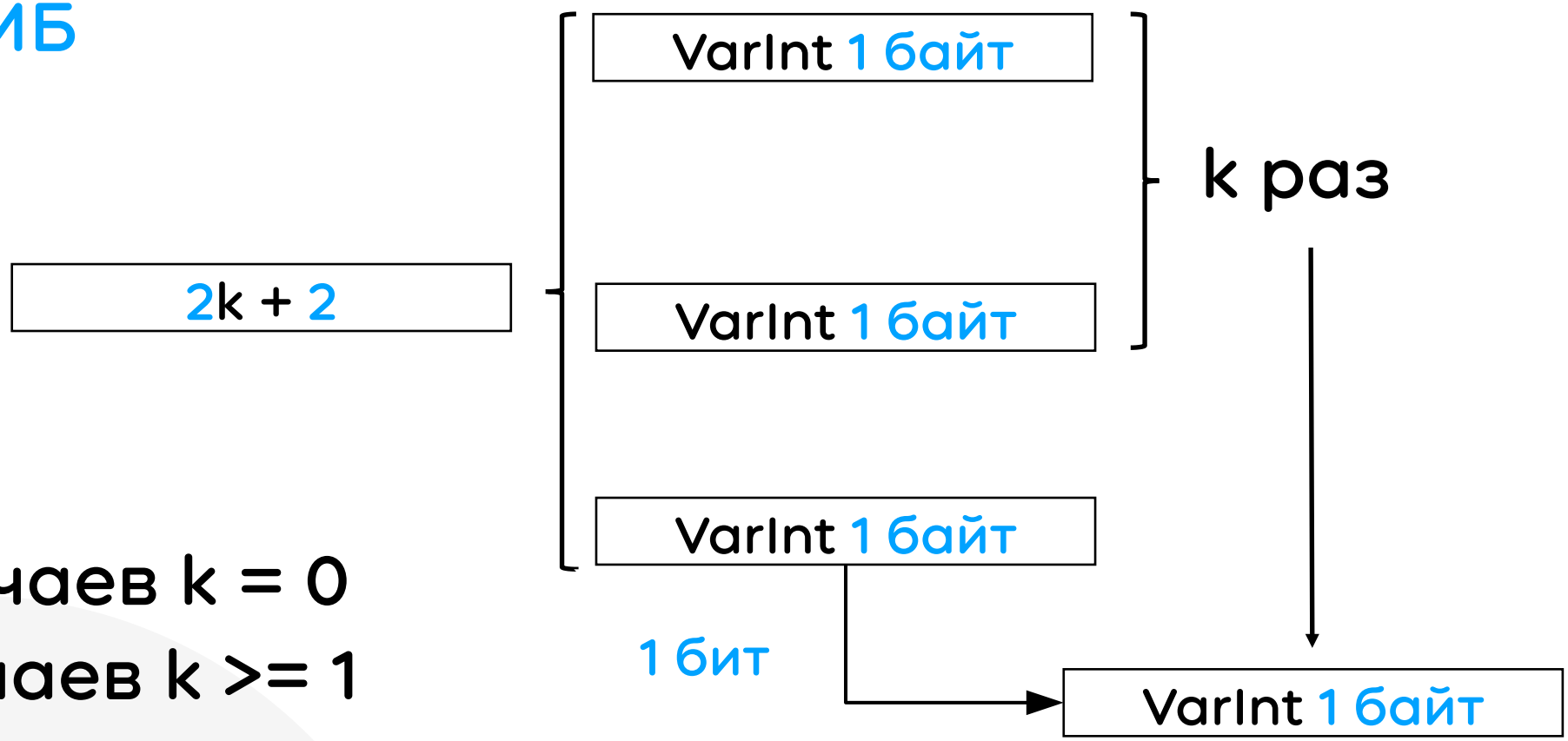


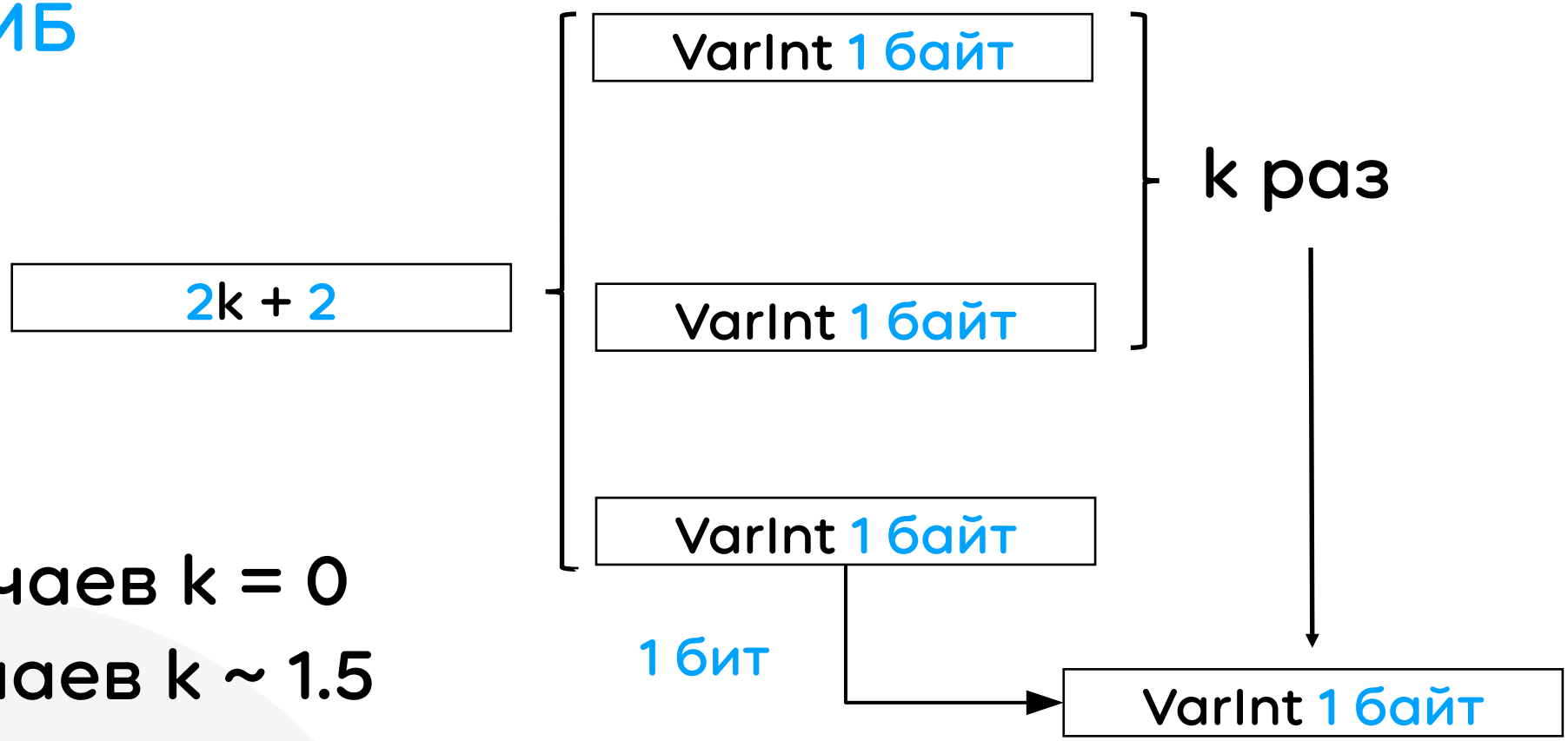
В 90% случаев k = 0

В 10% случаев k >= 1

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ



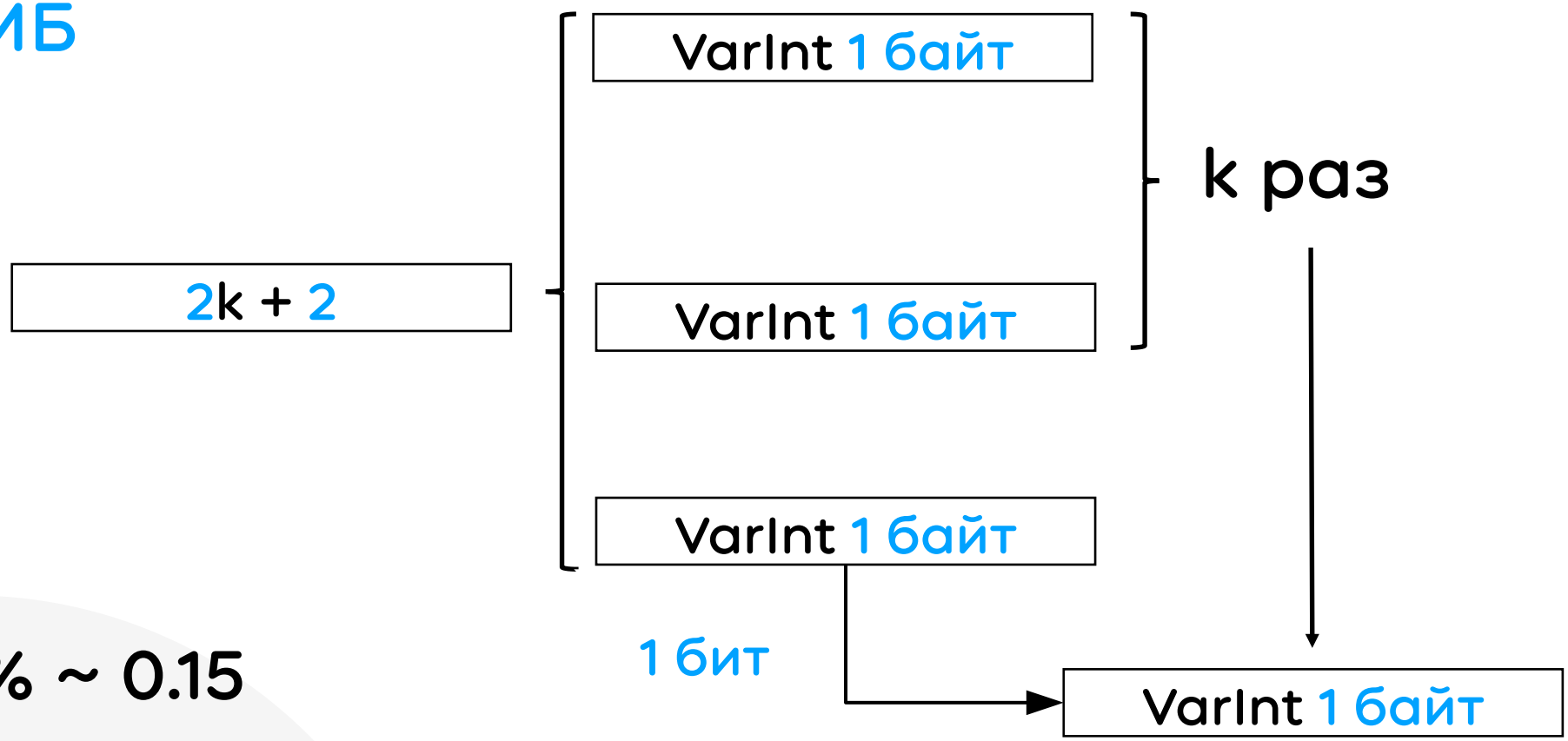
В 90% случаев k = 0

В 10% случаев k ~ 1.5

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ

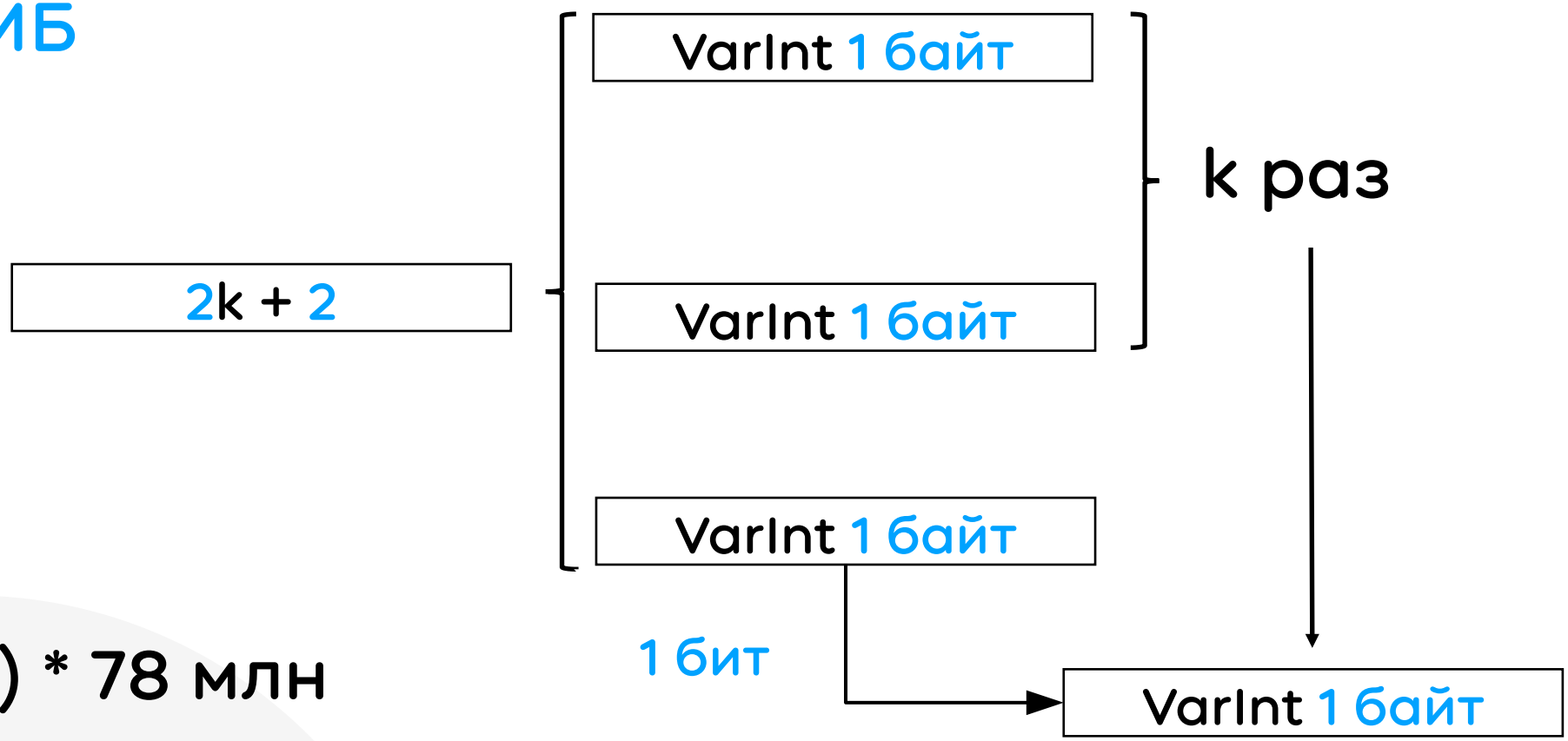


k ~ 1.5 * 10% ~ 0.15

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ

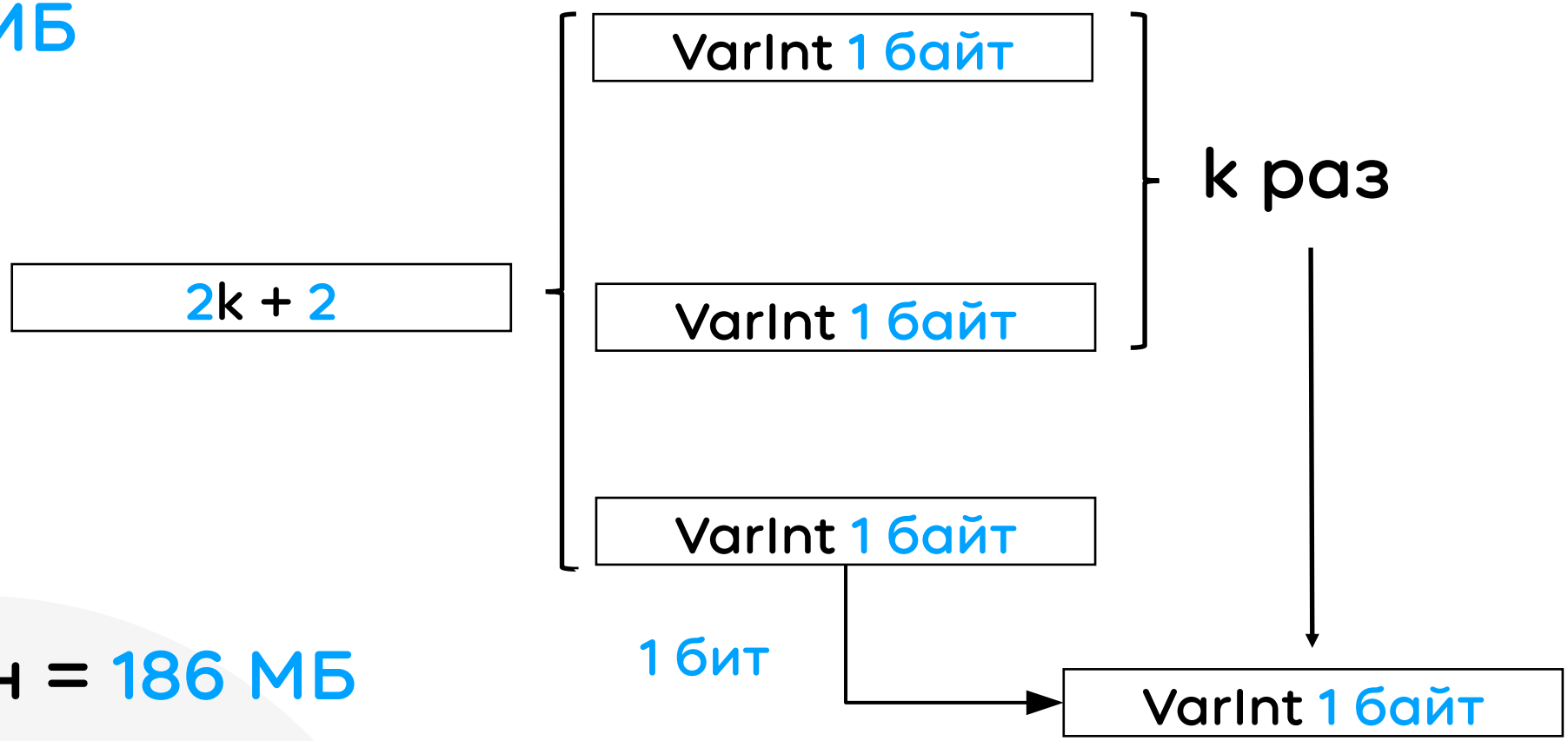


(2 * 0.15 + 2) * 78 млн

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ

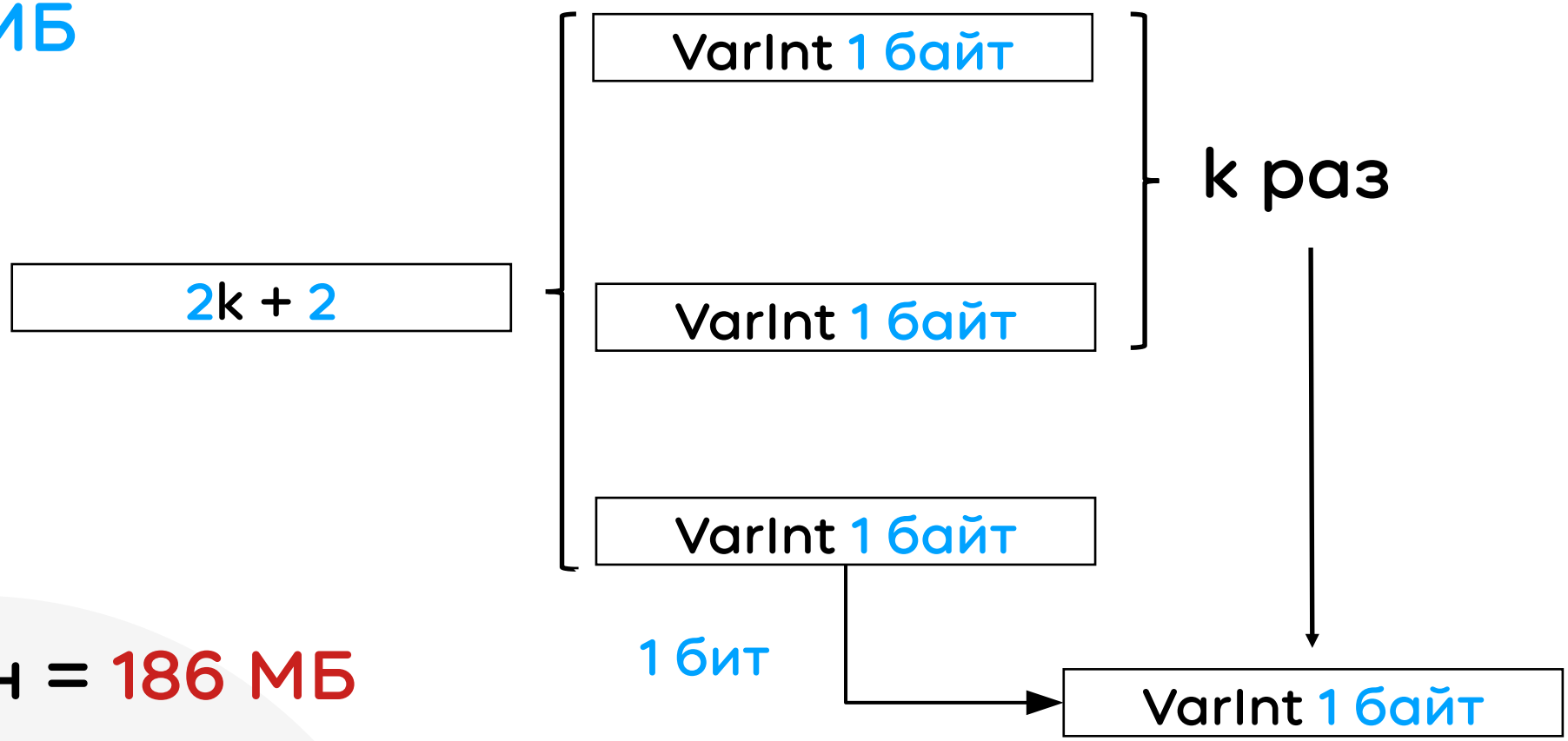


2.3 * 78 млн = 186 МБ

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ



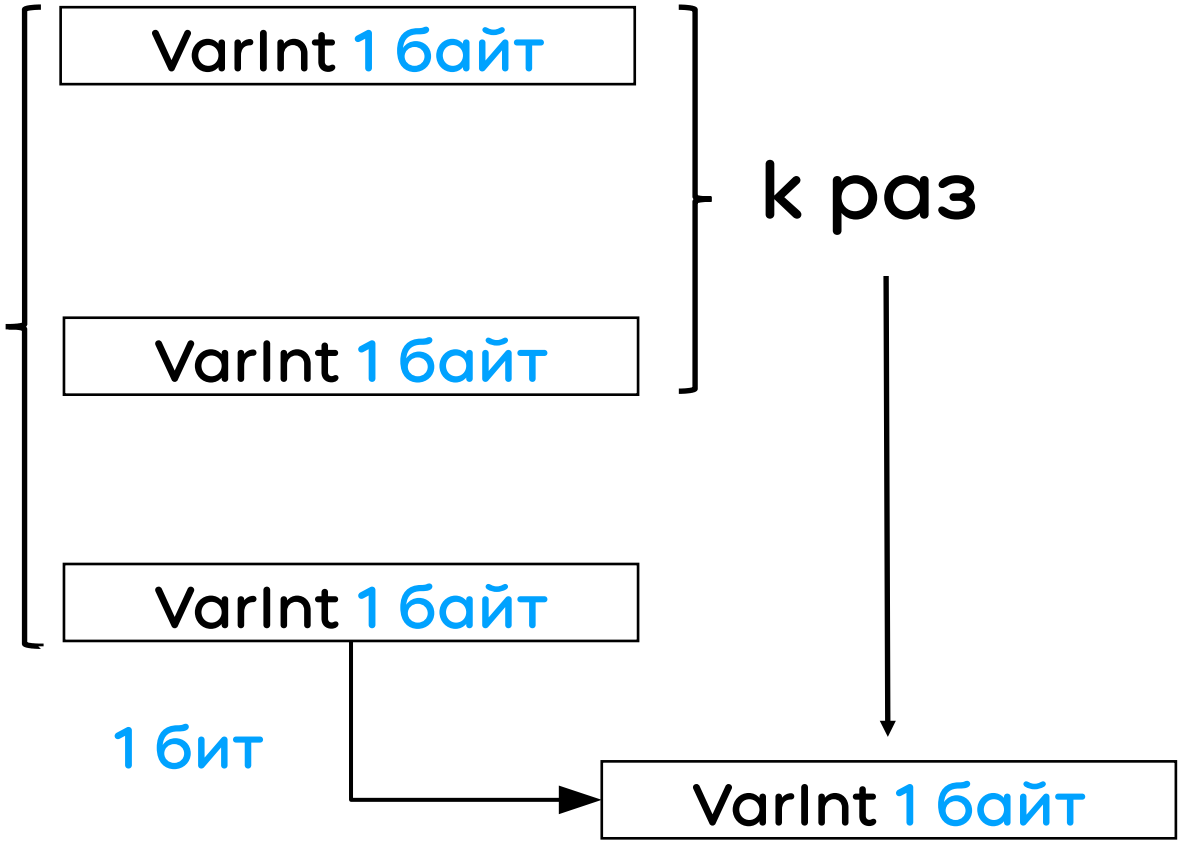
2.3 * 78 млн = 186 МБ

Промежуточный итог

Alloc: 78 млн сэмплов

Цель: 170 МБ

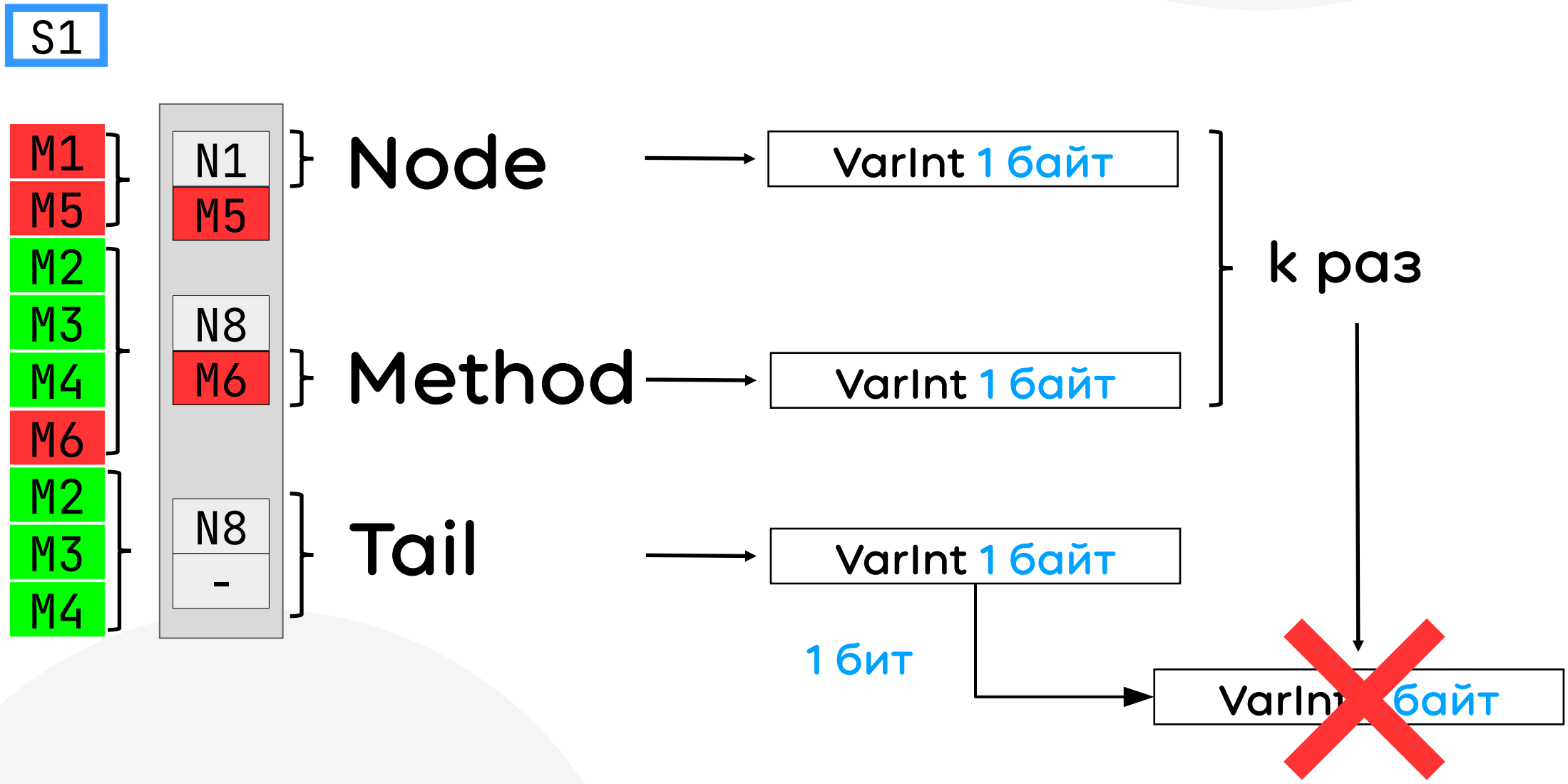
2.3 * 78 млн = 186 МБ



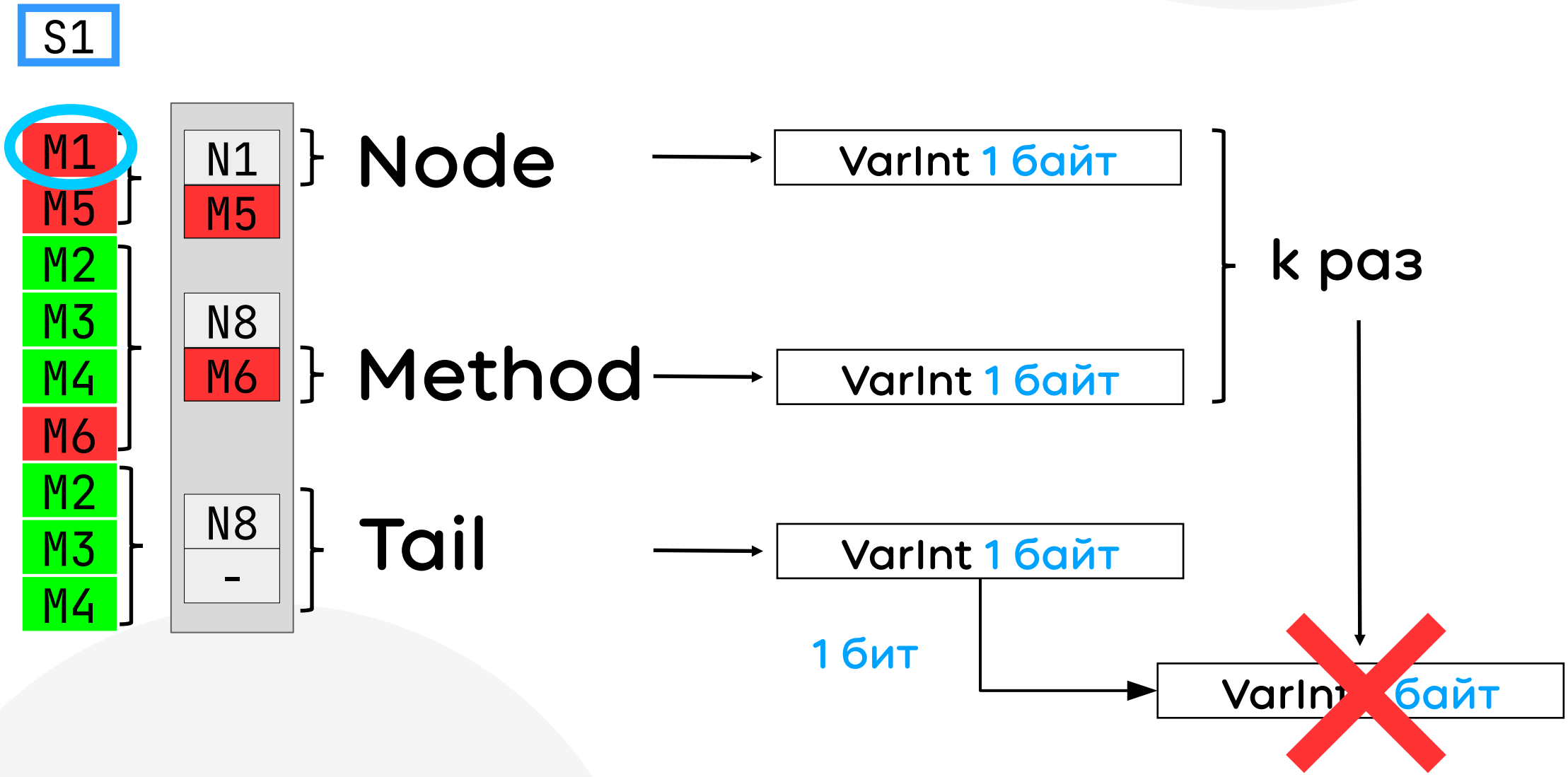
Сжимаем

Со всей силы

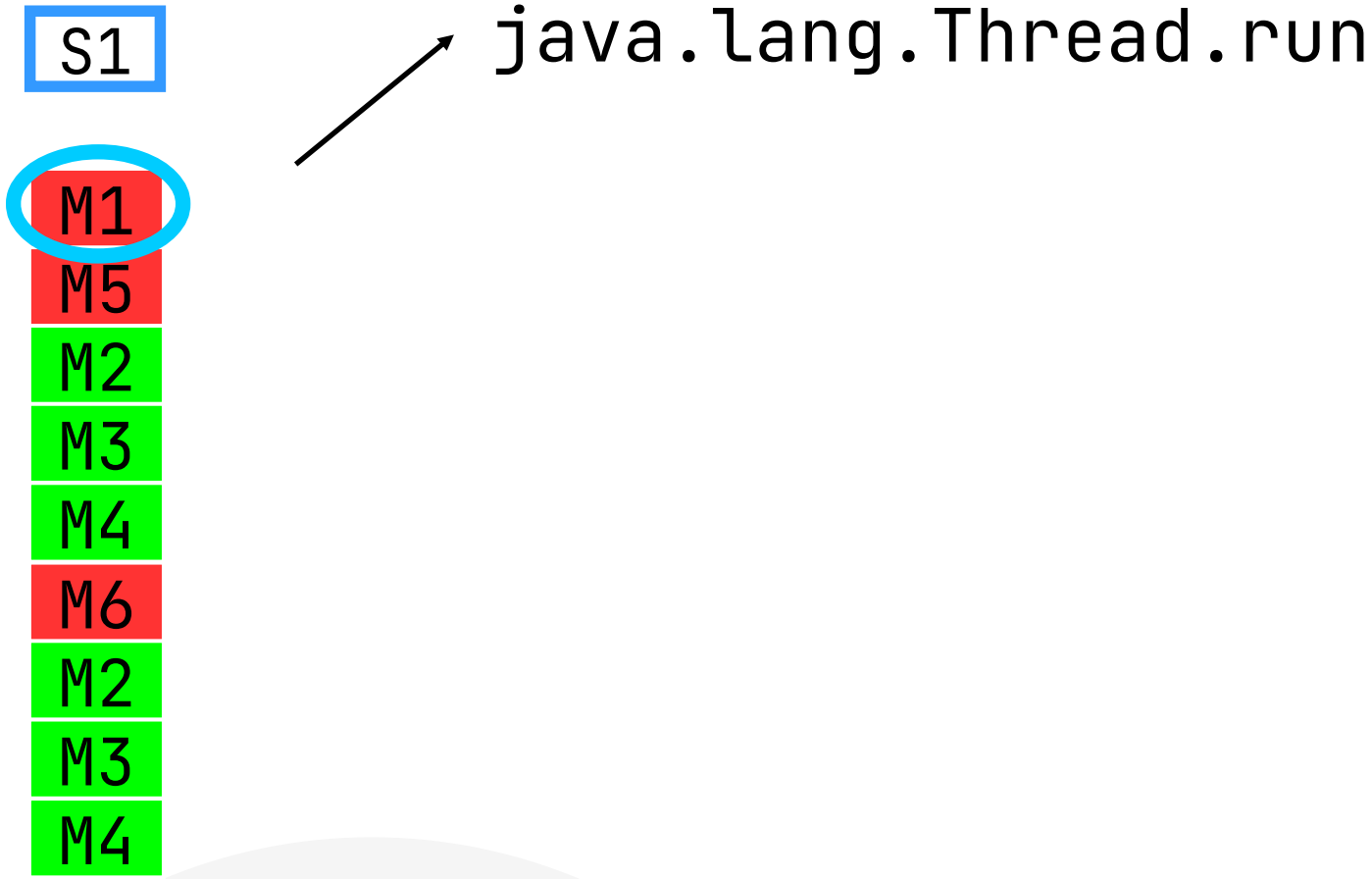
Сжимаем со всей силы



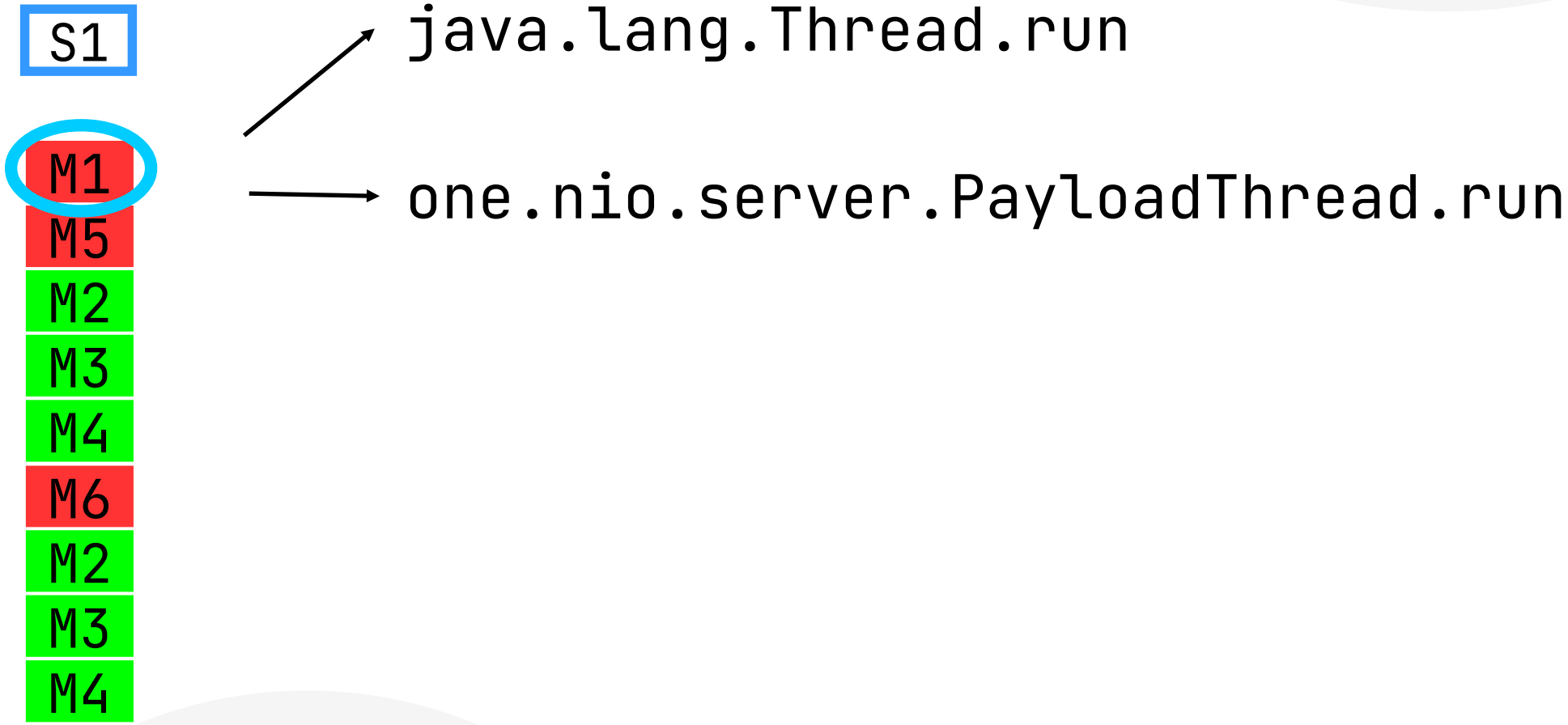
Сжимаем со всей силы



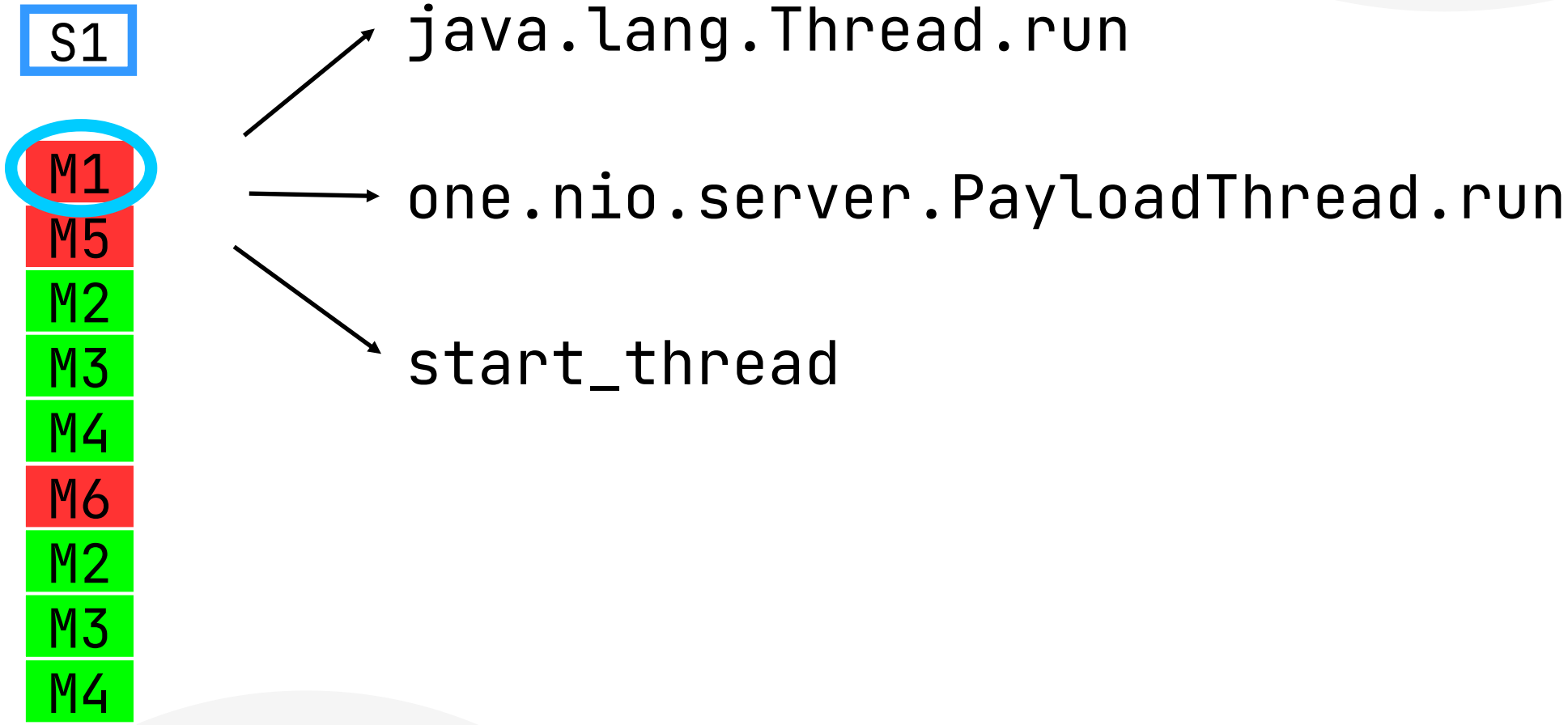
Сжимаем со всей силы



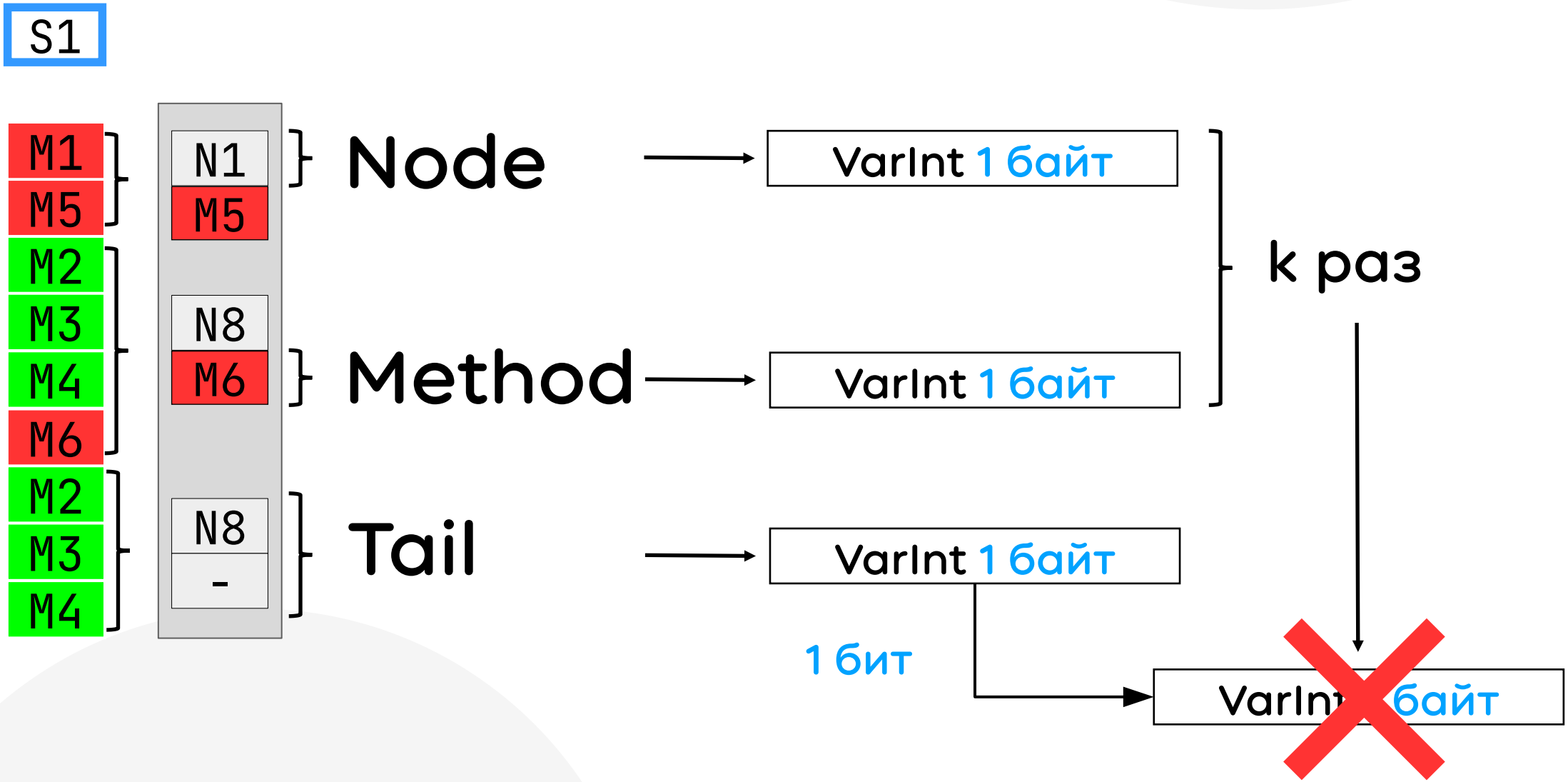
Сжимаем со всей силы



Сжимаем со всей силы



Сжимаем со всей силы



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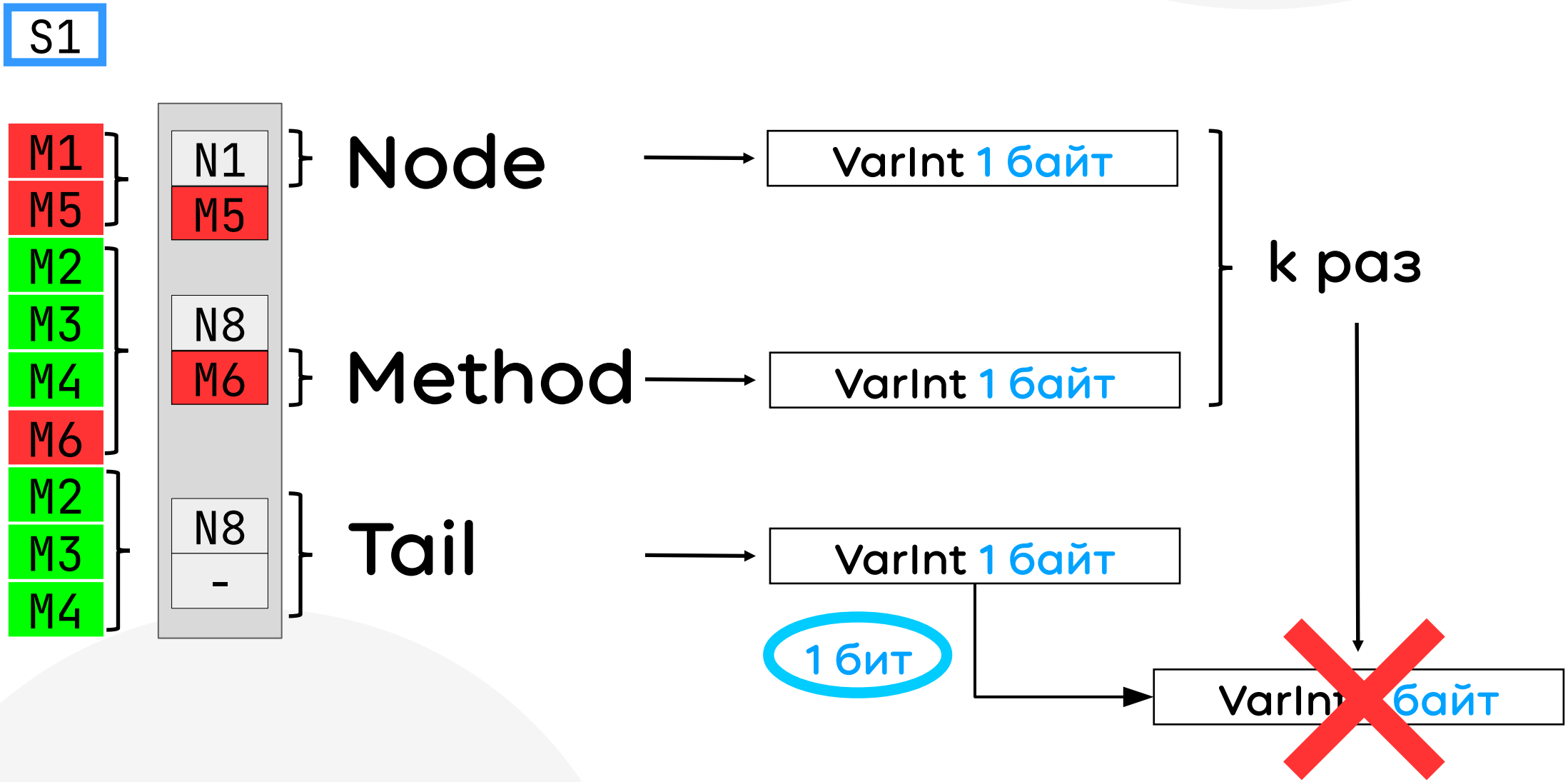

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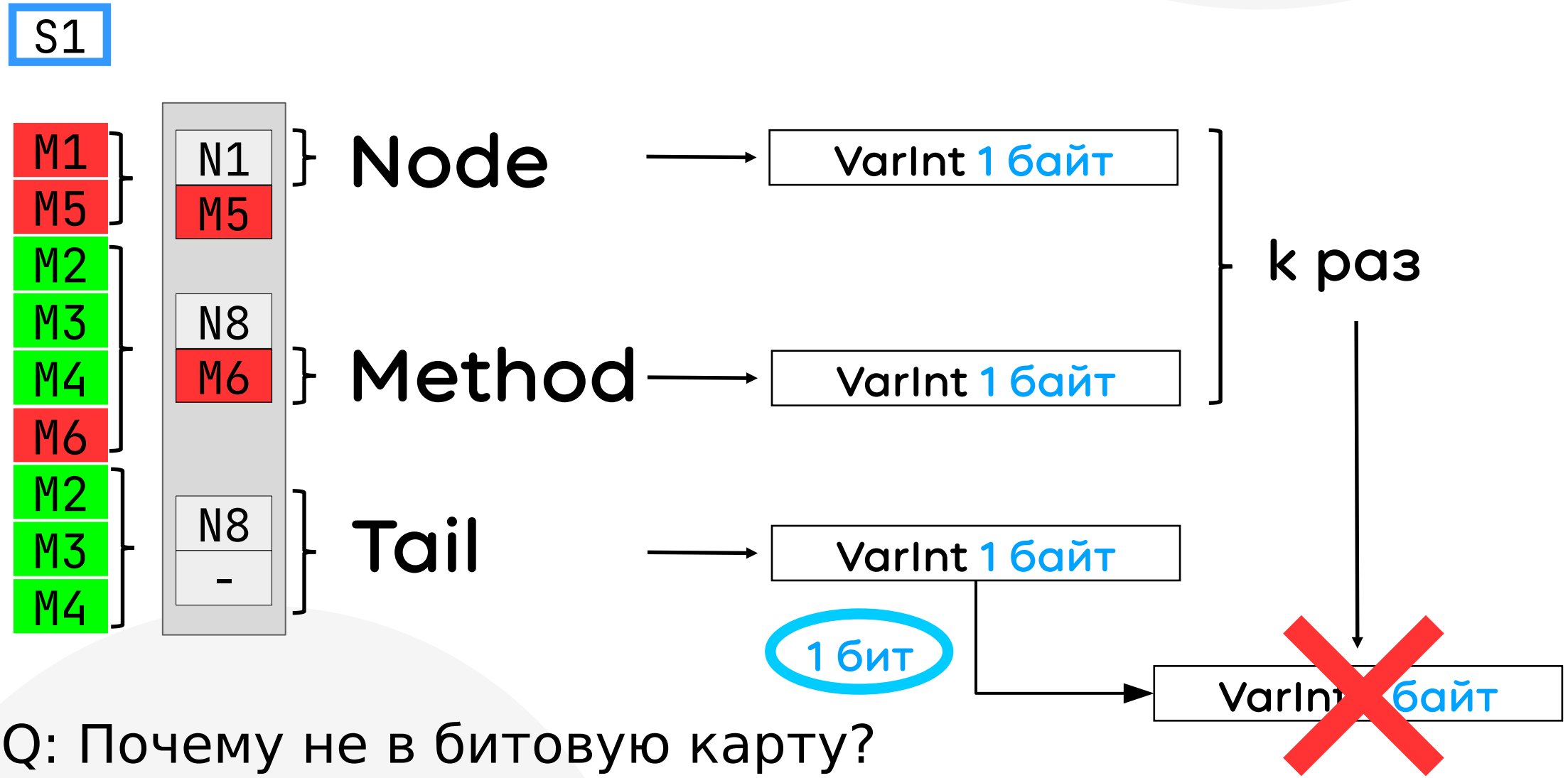
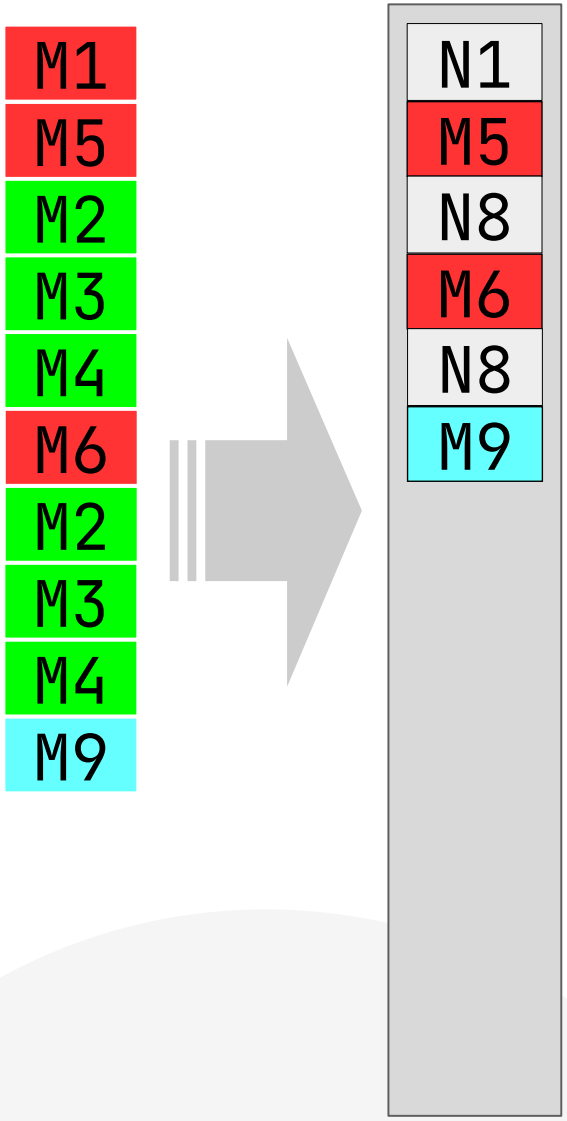


Q: Почему не в битовую карту?

Сжимаем со всей силы

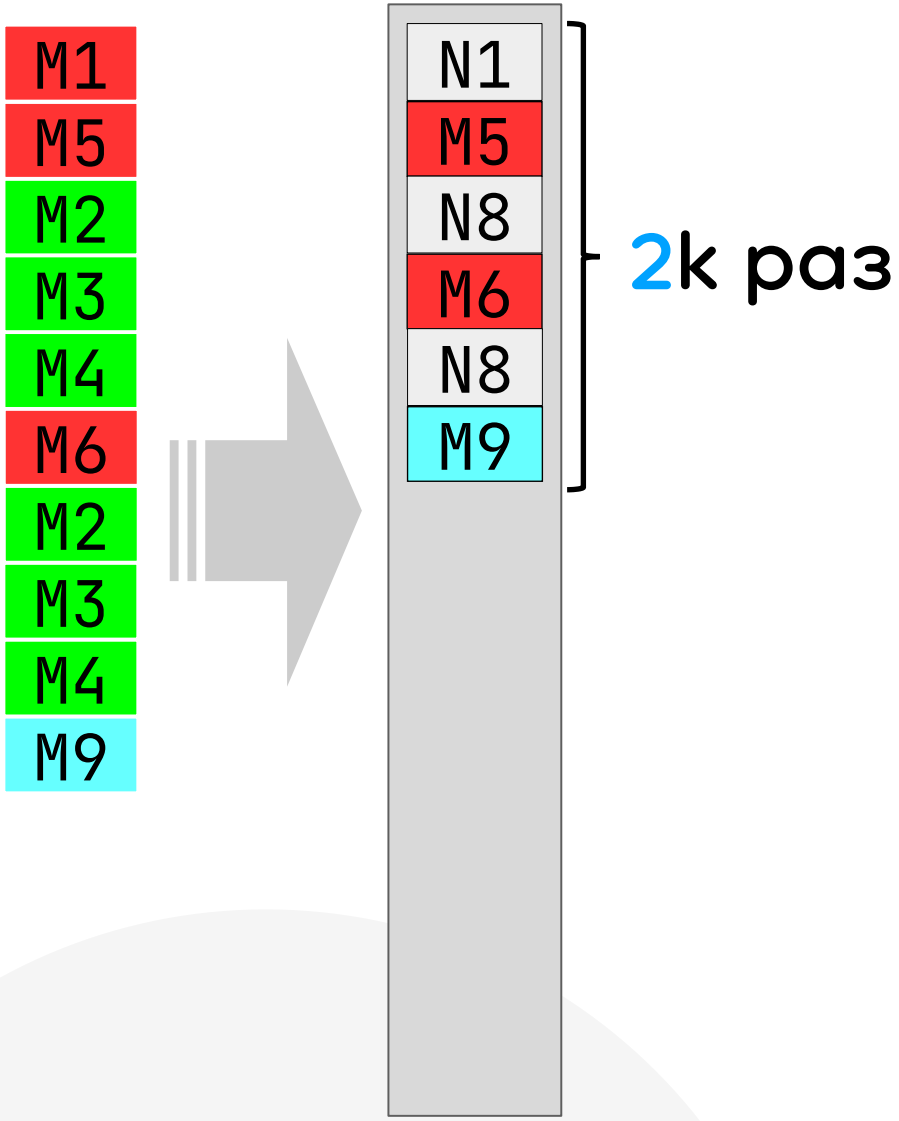


LZ78

Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

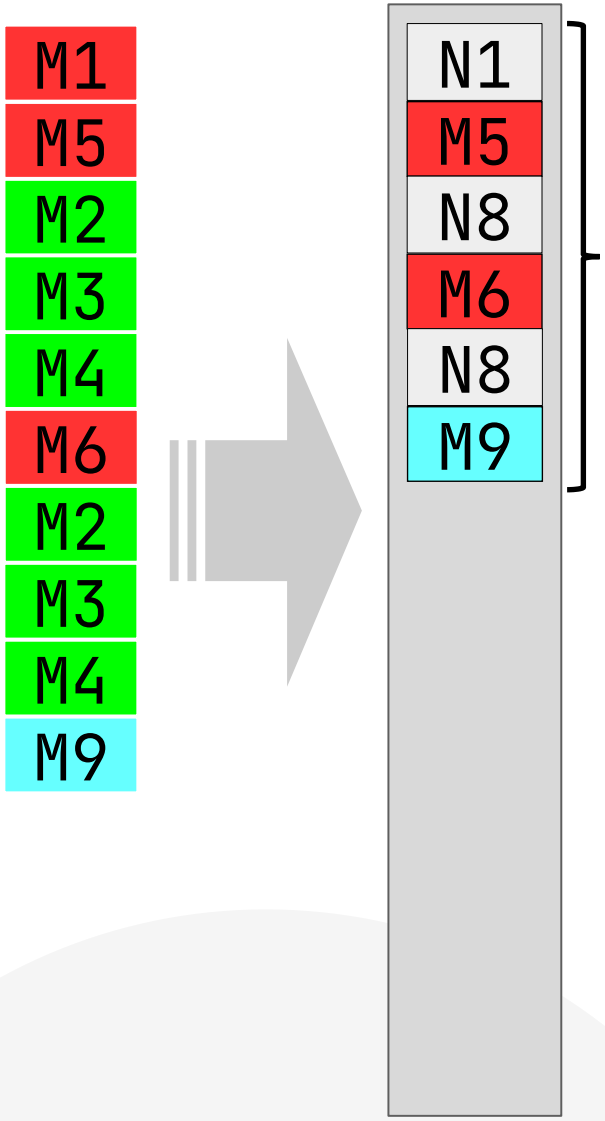
Сжимаем со всей силы



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

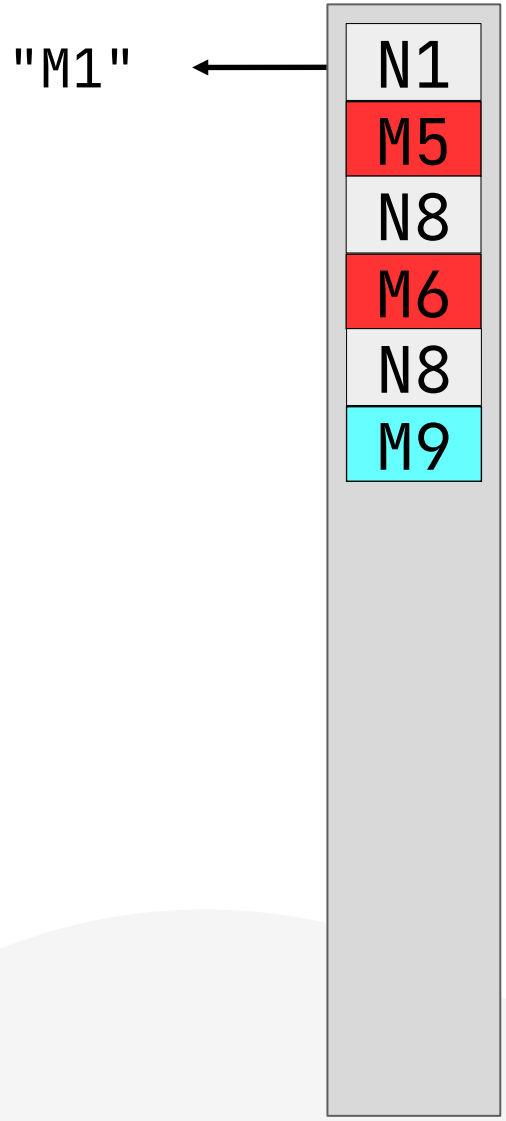
Сжимаем со всей силы



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

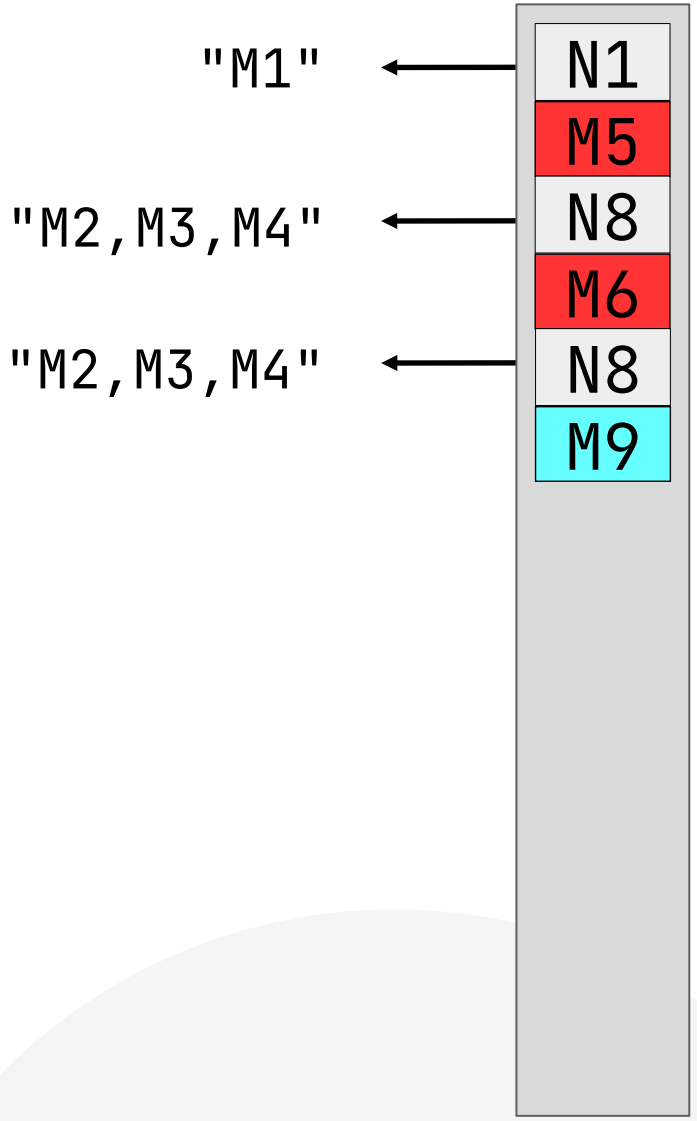
Сжимаем со всей силы



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

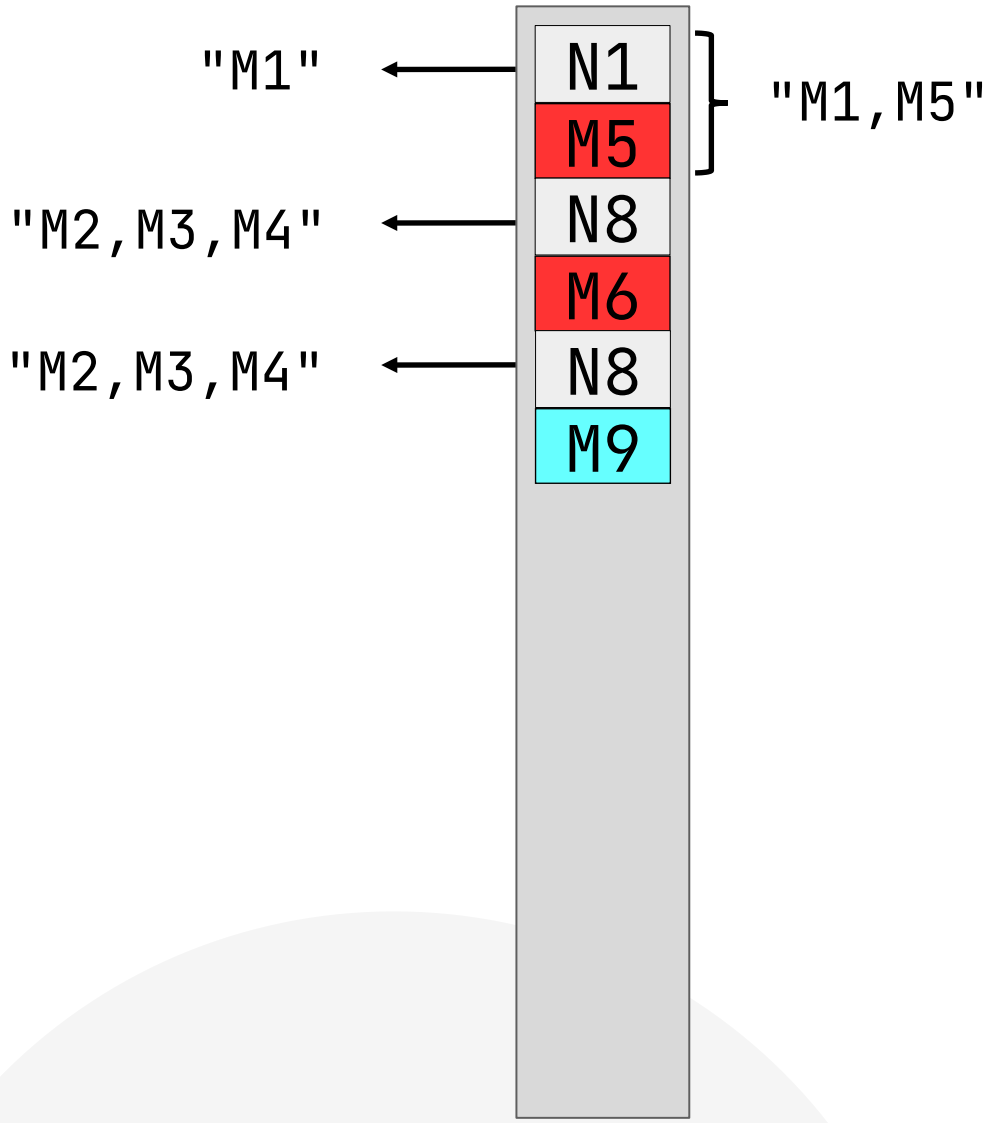
Сжимаем со всей силы



Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Сжимаем со всей силы



Словарь

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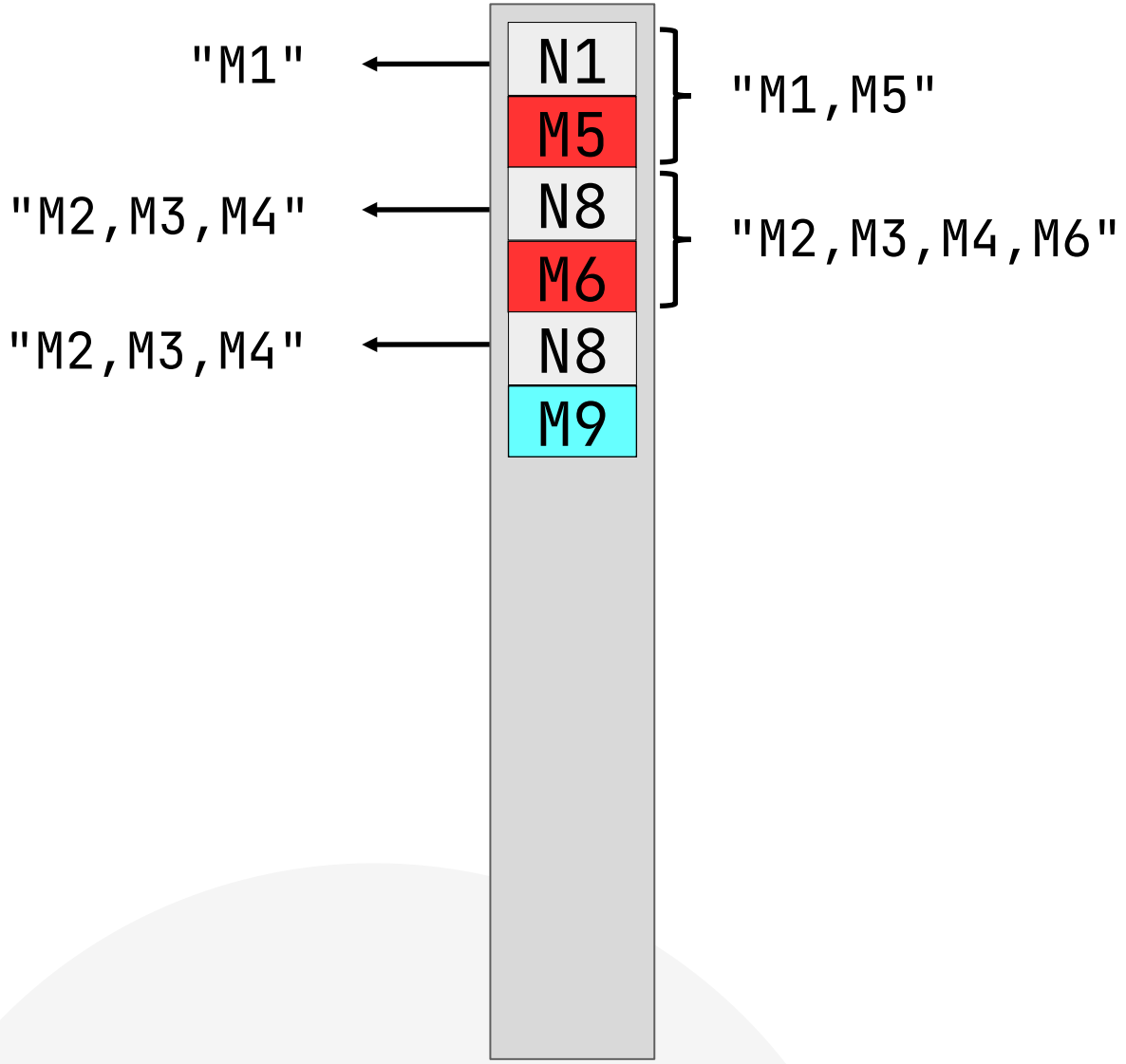

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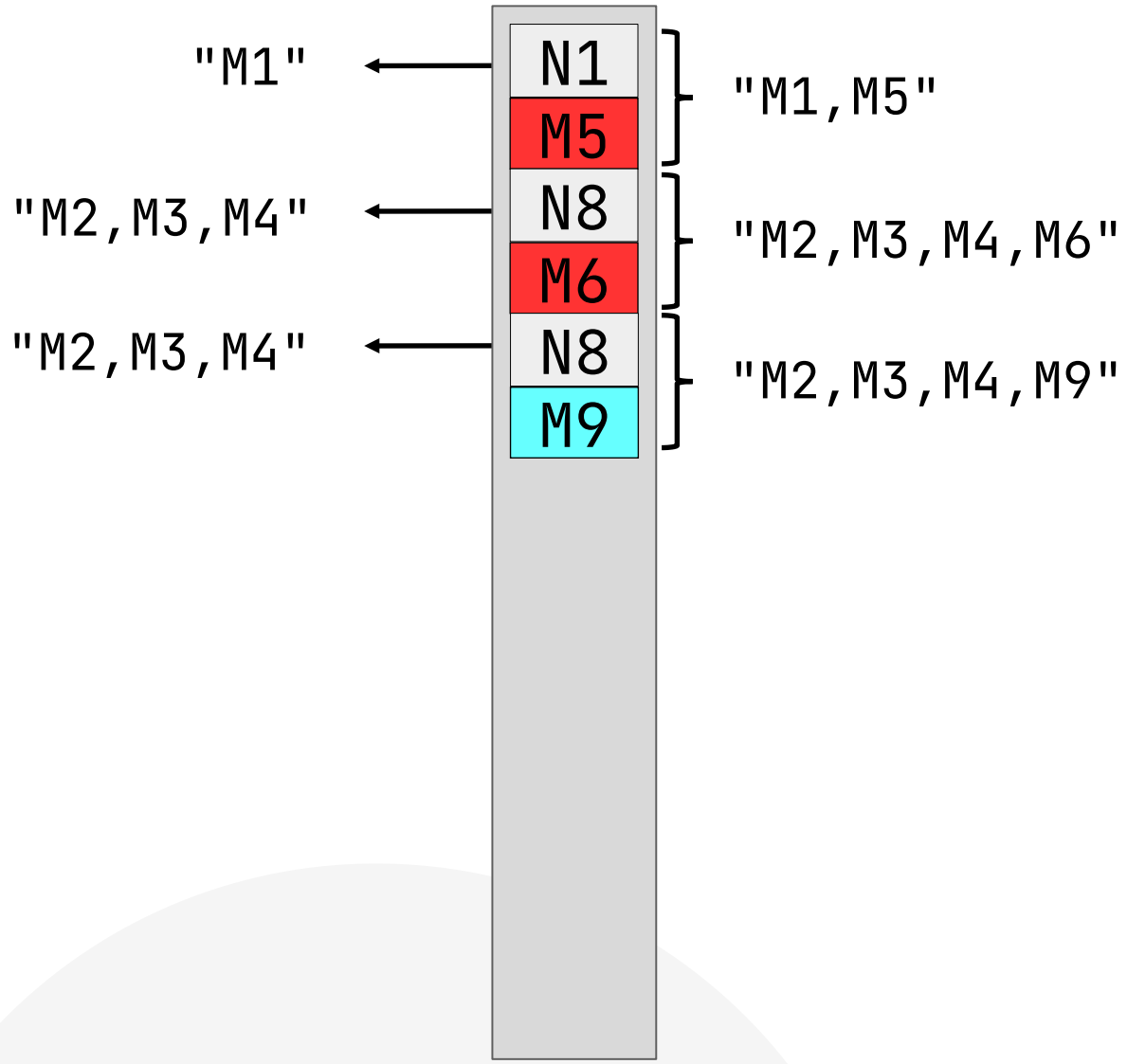

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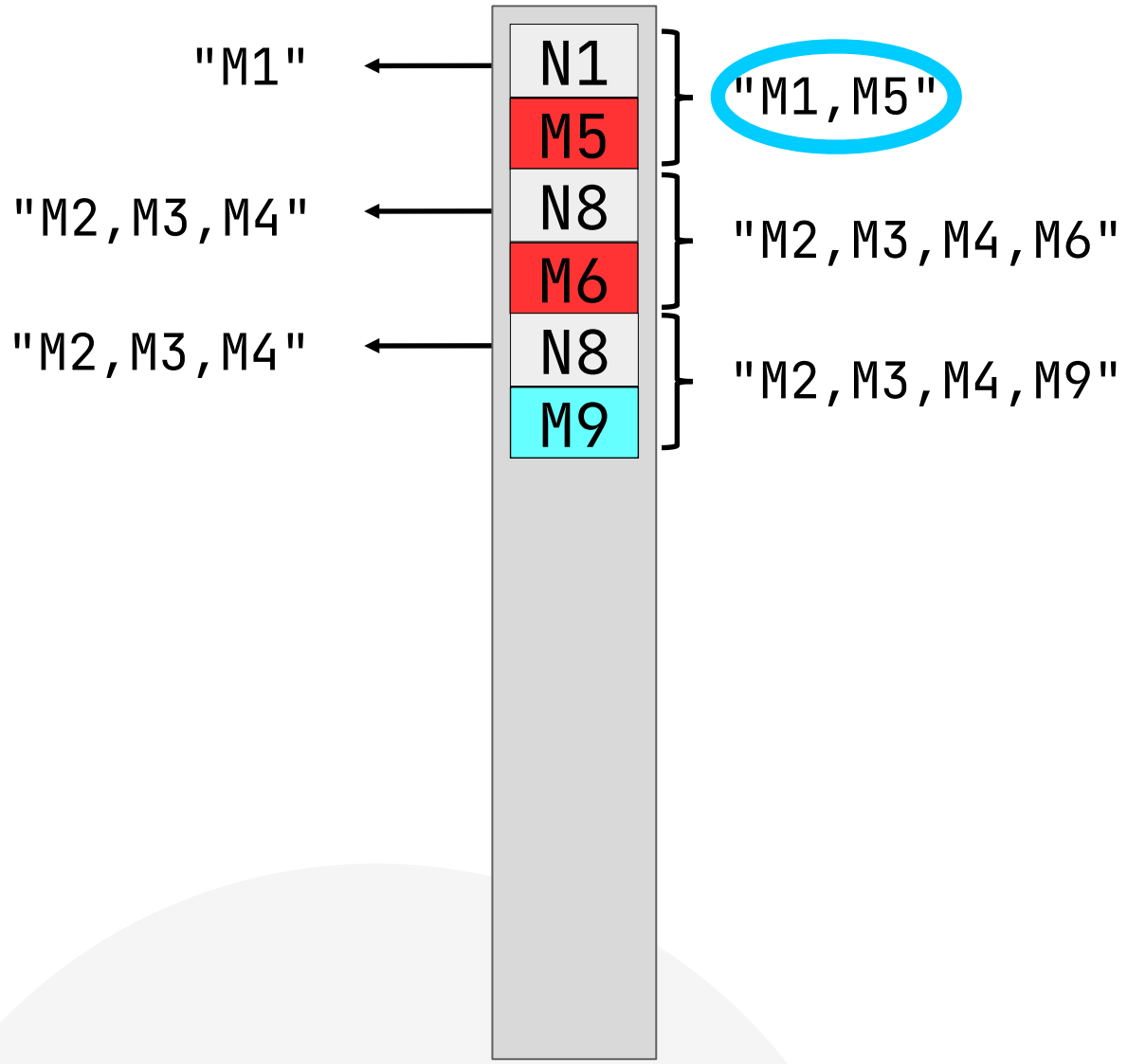

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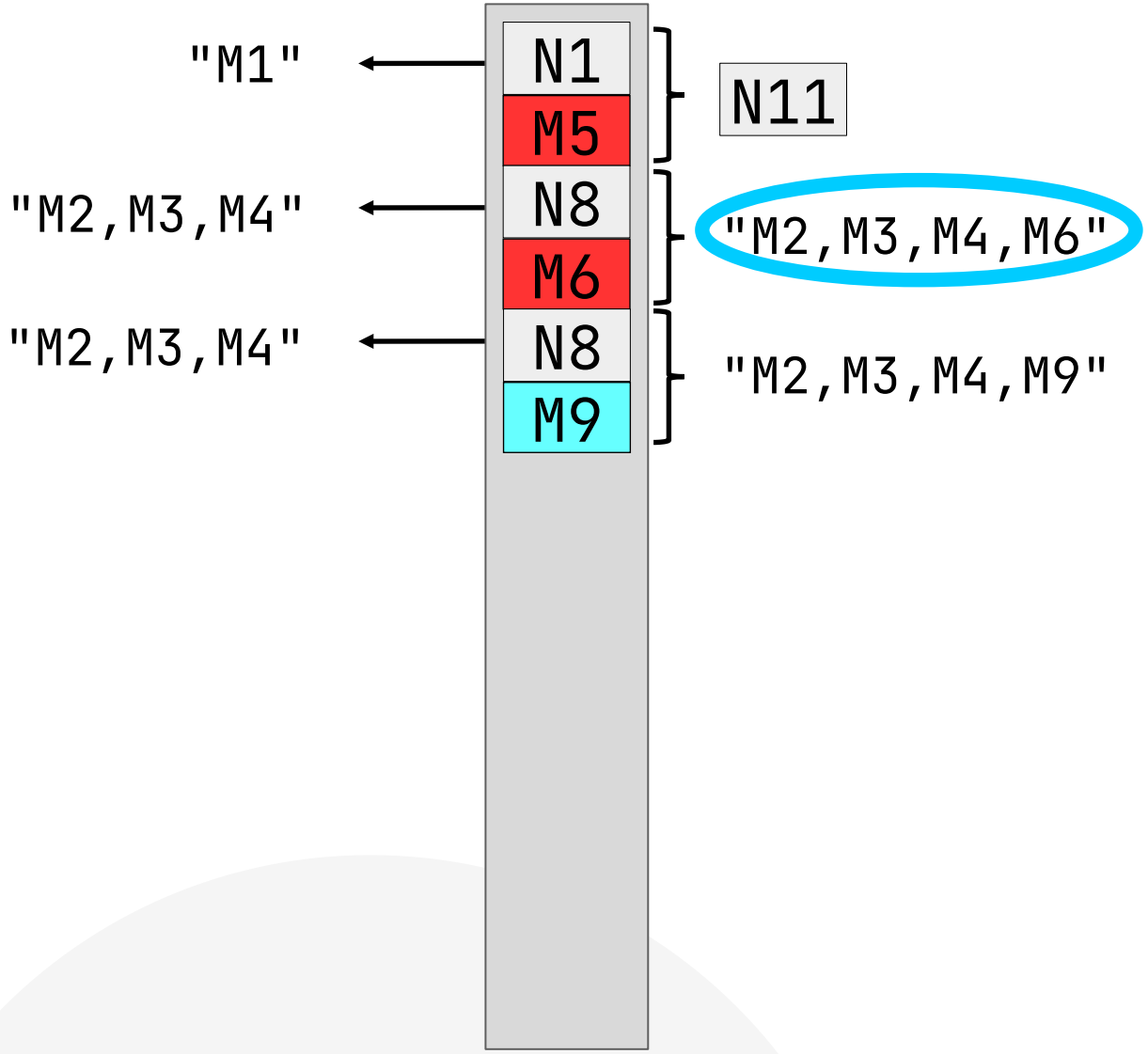

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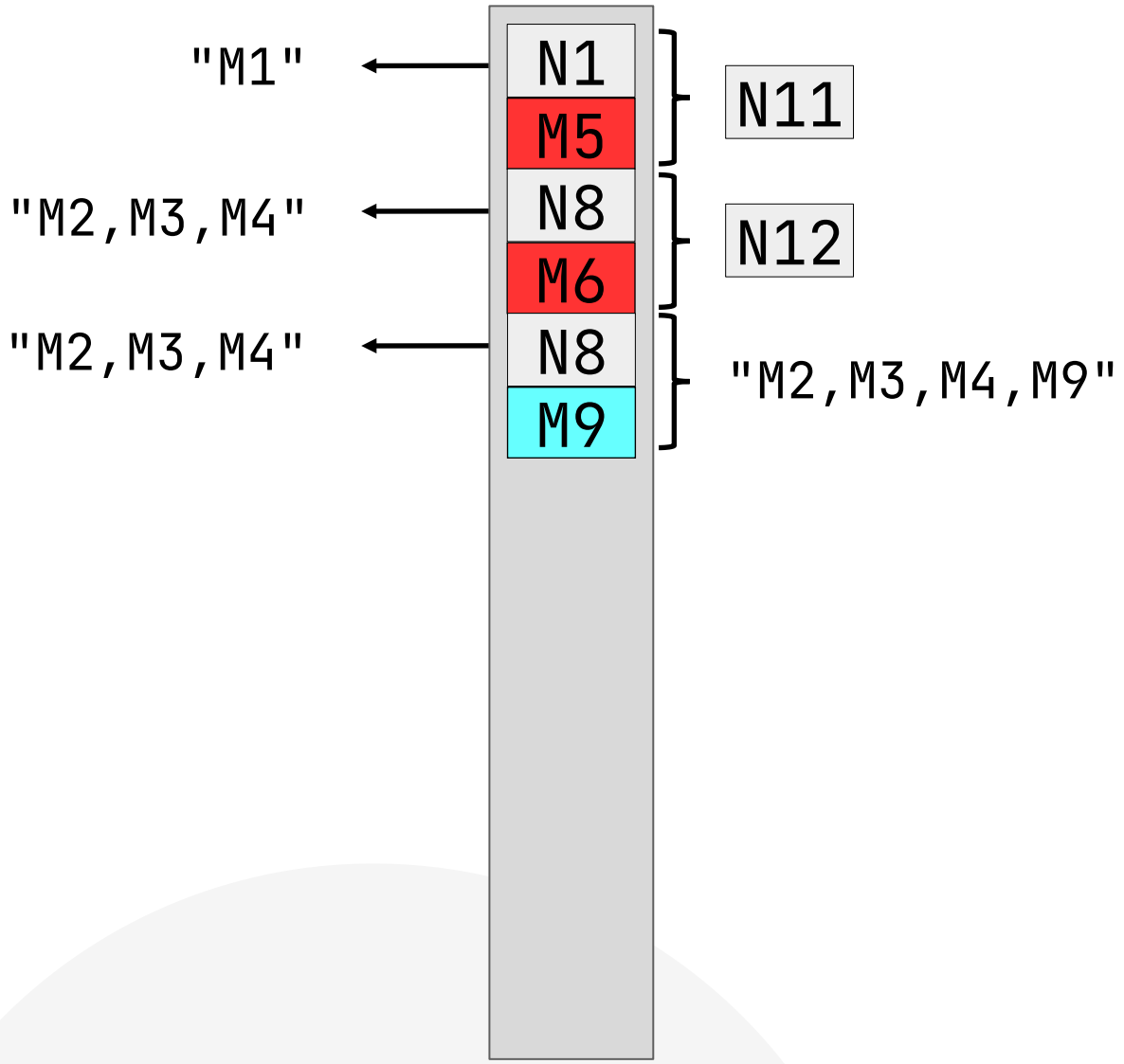
Сжимаем со всей силы



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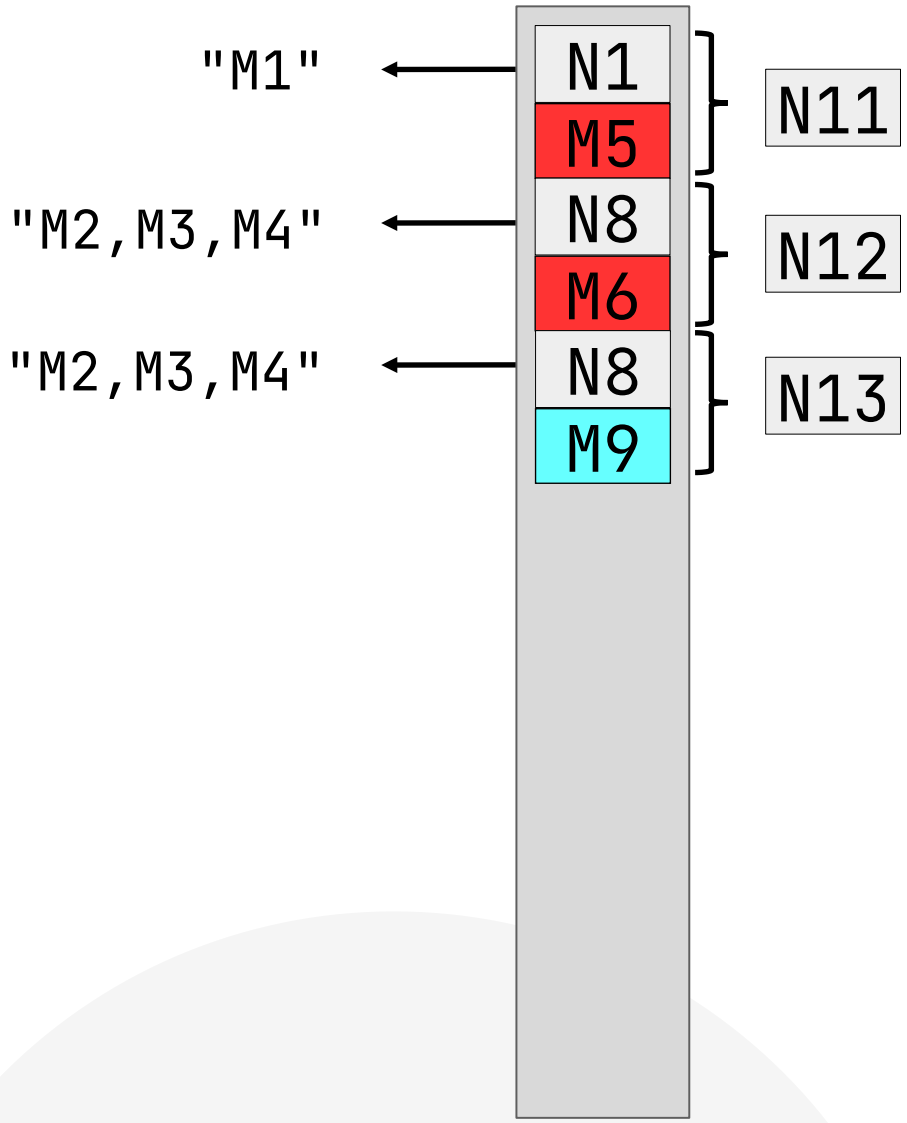

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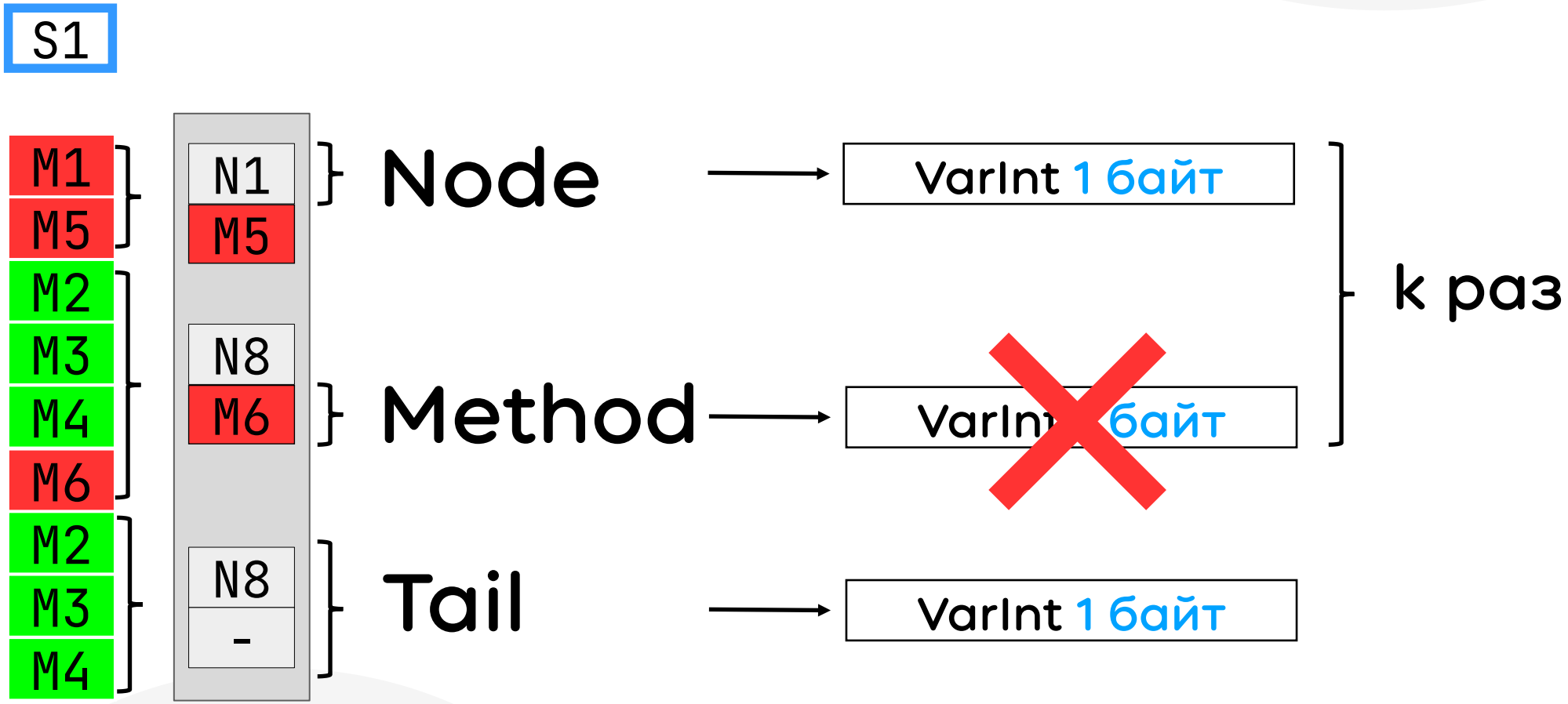
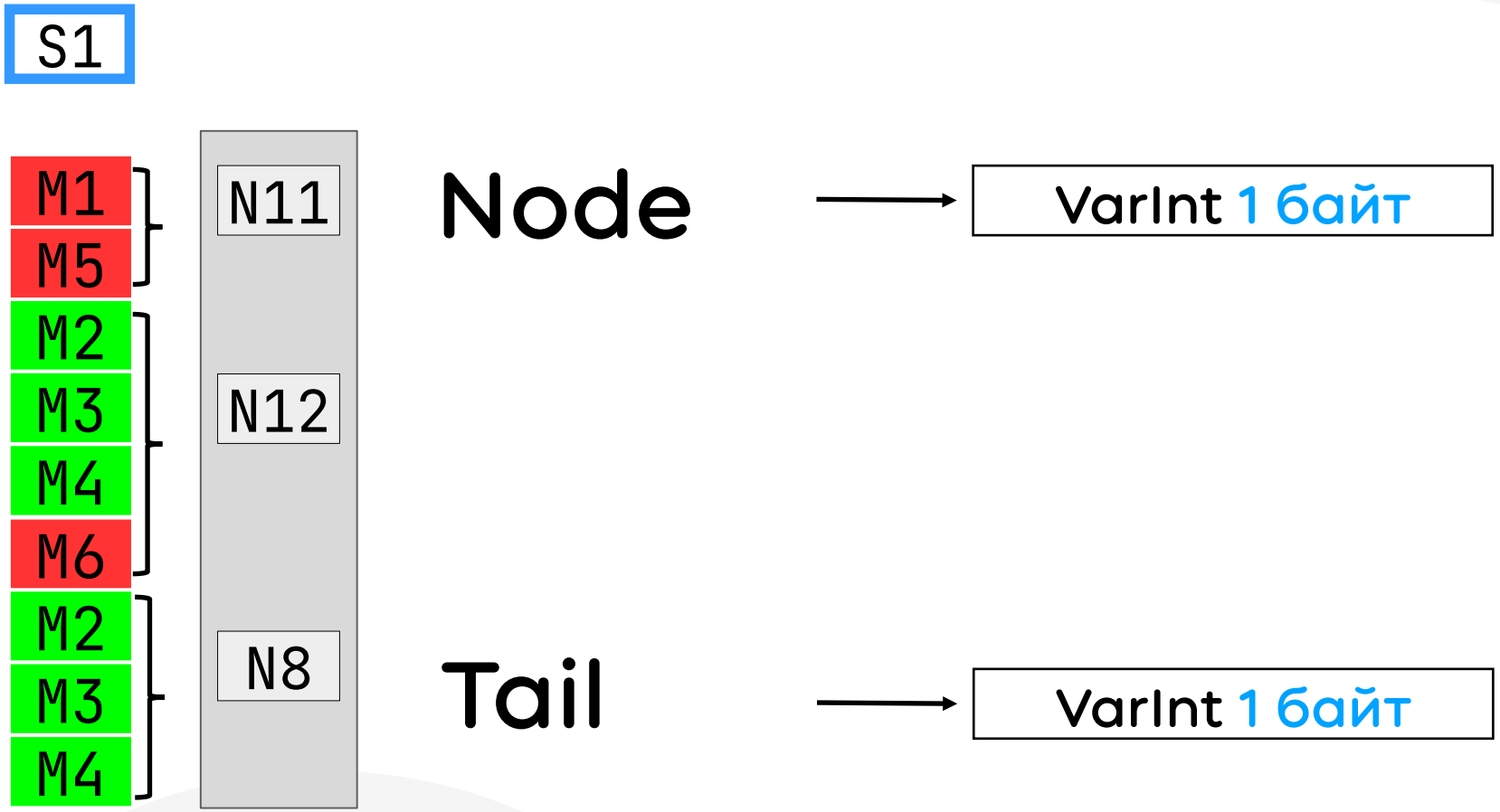
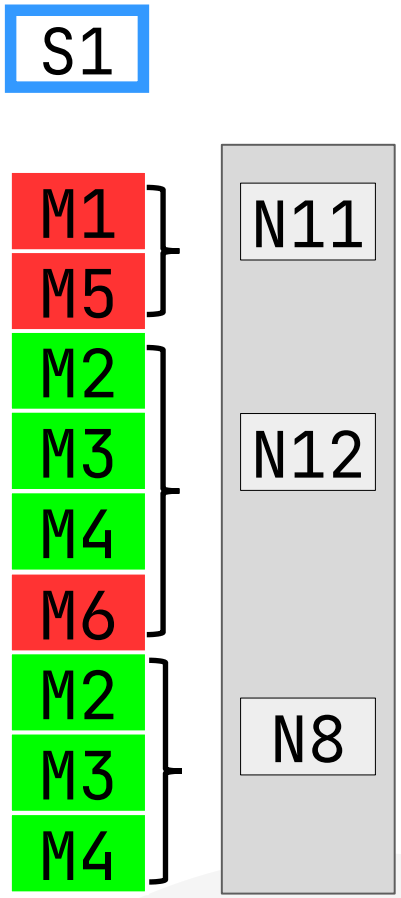


Сжимаем со всей силы



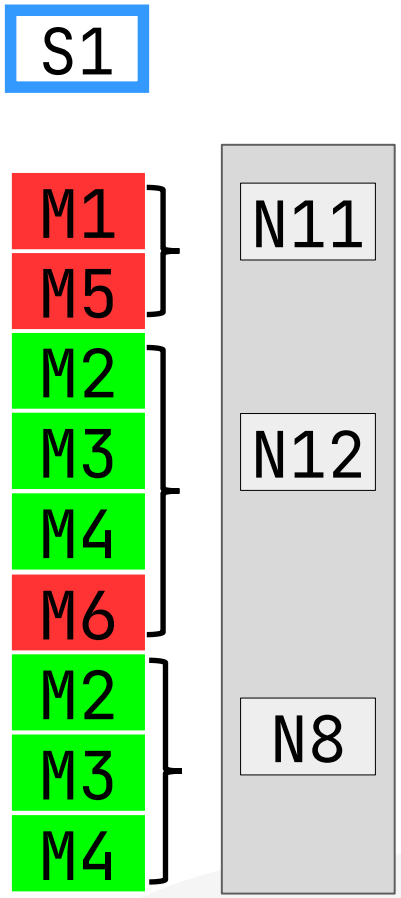
Сжимаем со всей силы



Node → VarInt 1 байт k раз

Tail → VarInt 1 байт

Сжимаем со всей силы

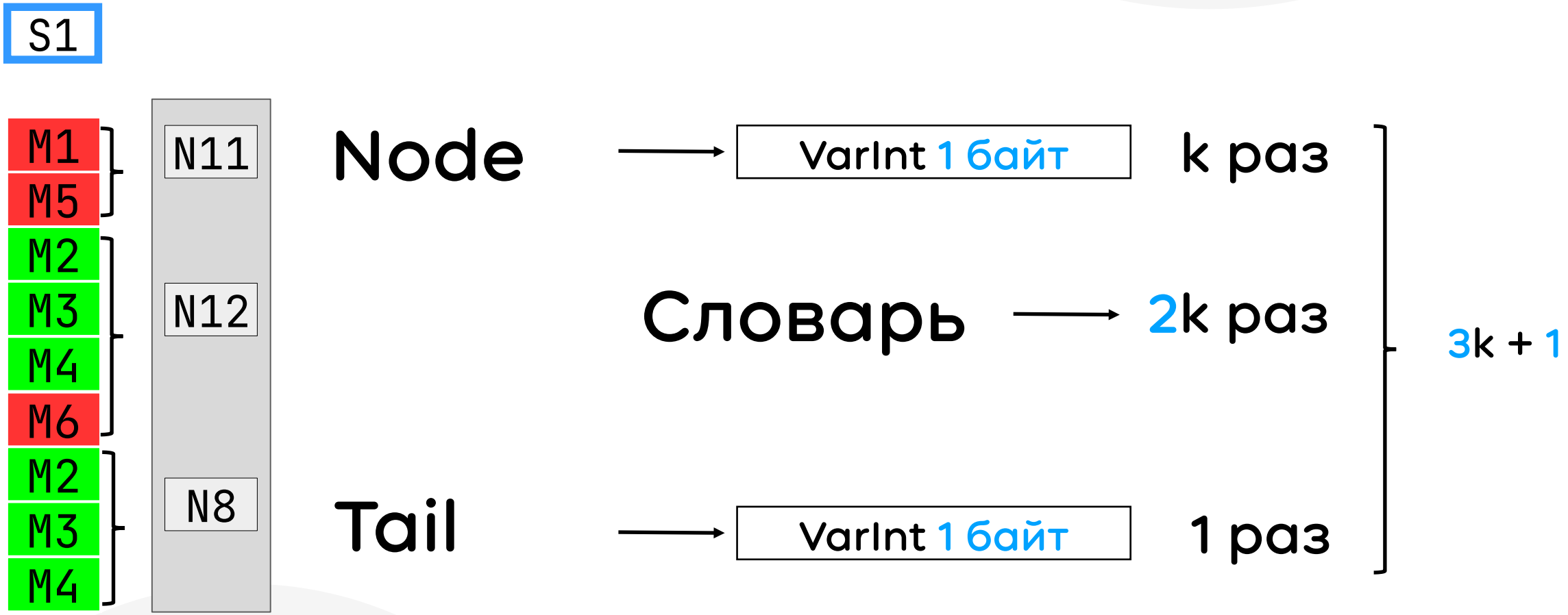


Node → VarInt 1 байт — k раз

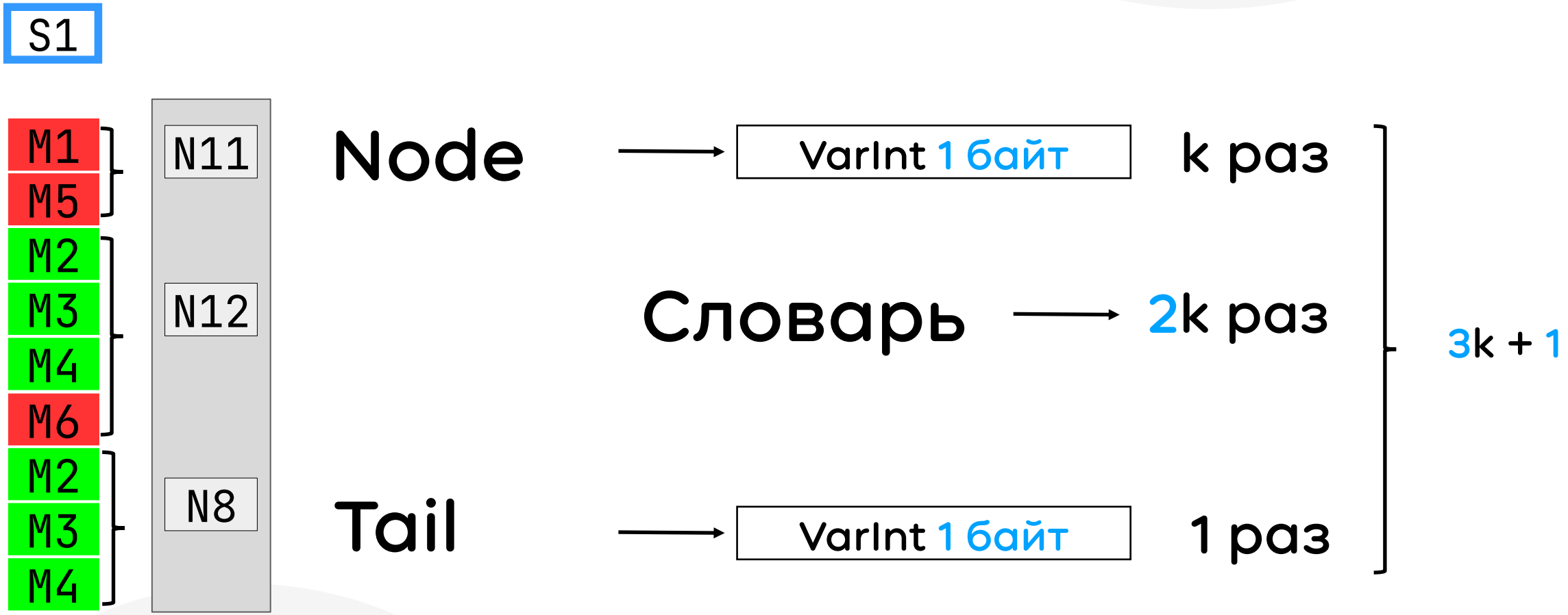
Словарь → 2k раз

Tail → VarInt 1 байт — 1 раз

Сжимаем со всей силы

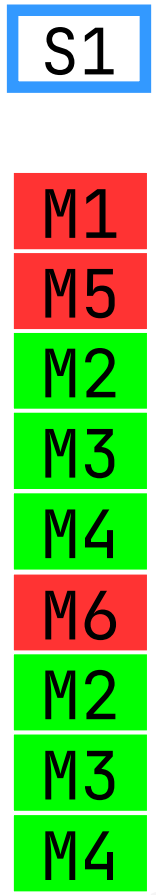


Сжимаем со всей силы



И всё ради одного бита!

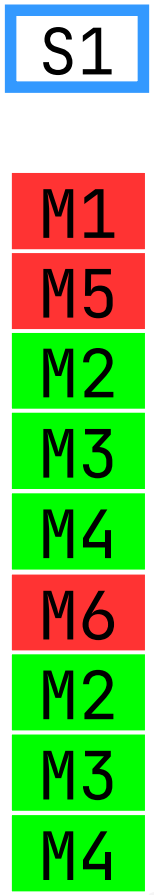
Сжимаем со всей силы



$3k + 1 \sim 1.45$

$k \sim 0.15$

Сжимаем со всей силы



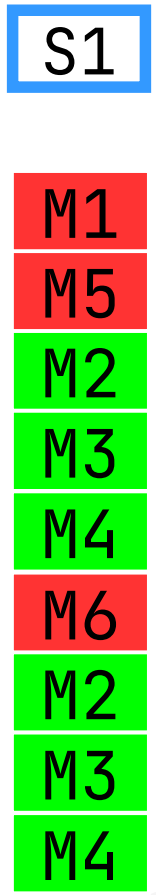
1.45 * 78 млн = 107 МБ

Цель: 170 МБ

3k + 1 ~ 1.45

k ~ 0.15

Сжимаем со всей силы

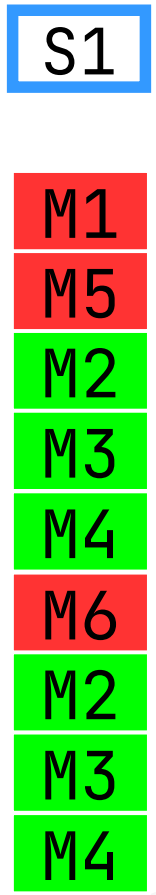


В теории: 107 МБ

Цель: 170 МБ (Alloc)

Реальный результат: 120 МБ (Alloc)

Сжимаем со всей силы



Цель: 170 МБ (Alloc)

Реальный результат: 120 МБ (Alloc)

Цель: 30 МБ (CPU)

Реальный результат: 20 МБ (CPU)

Сжимаем со всей силы

S1

M1
M5
M2
M3
M4
M6
M2
M3
M4

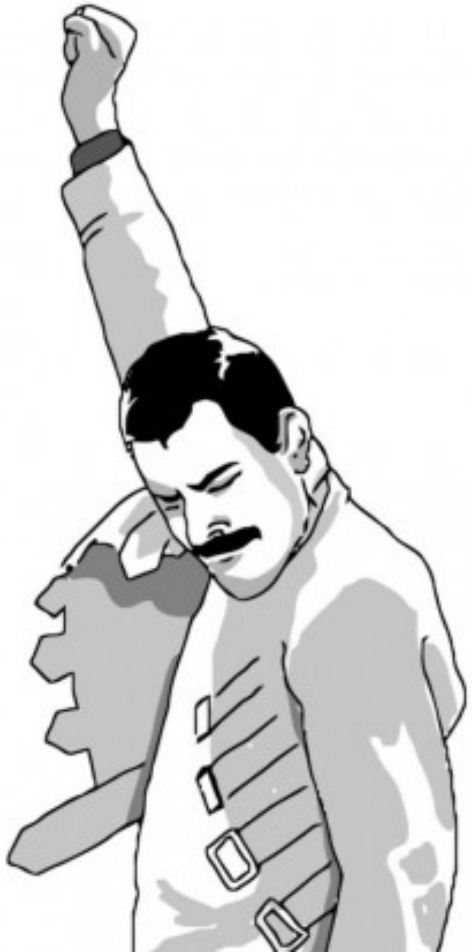
Цель: 170 МБ (Alloc)

Реальный результат: 120 МБ (Alloc)

Цель: 30 МБ (CPU)

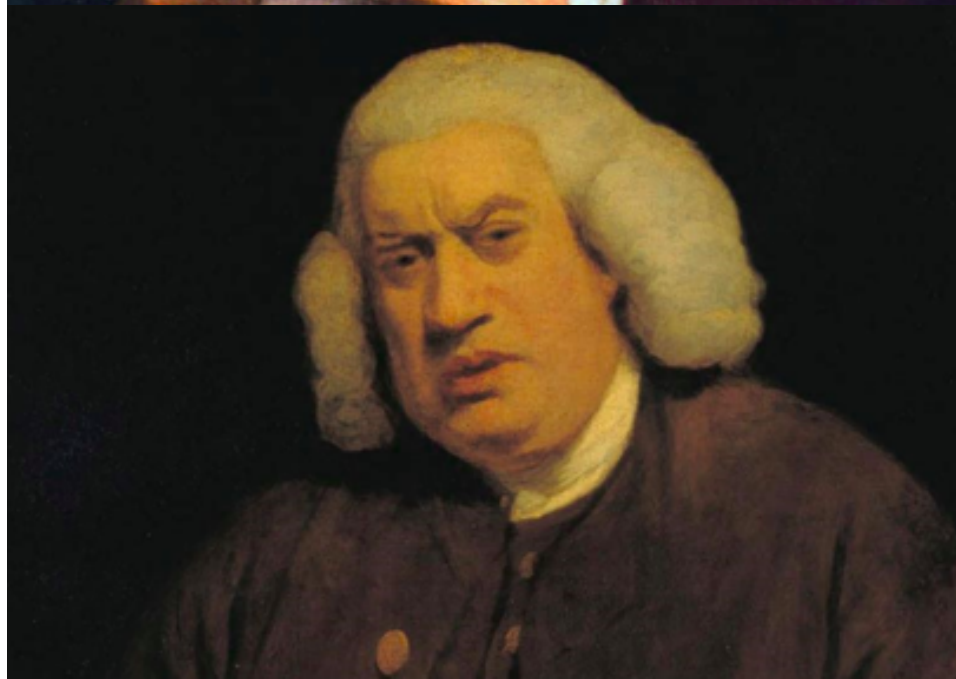
Реальный результат: 20 МБ (CPU)

Исходные данные: 4 ГБ



Данные готовы

Перерыв на вопросы



Распаковка

Распаковка

- JFR: 4 ГБ
- CPU: 6 млн сэмплов
- Alloc: 78 млн сэмплов

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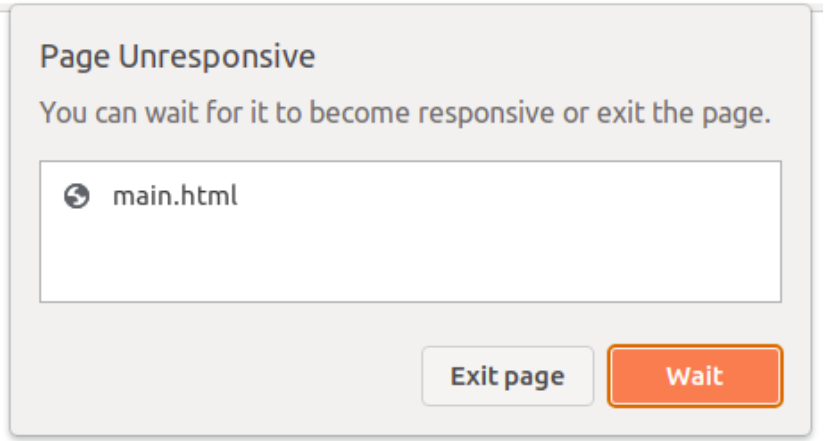

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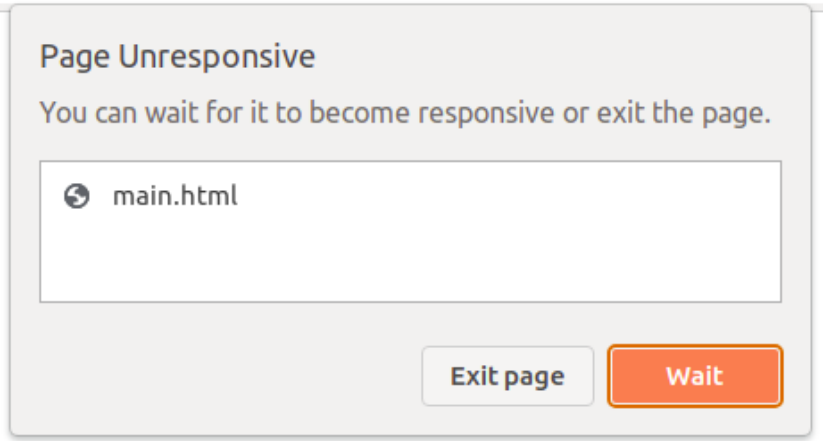

CPU → 10 сек

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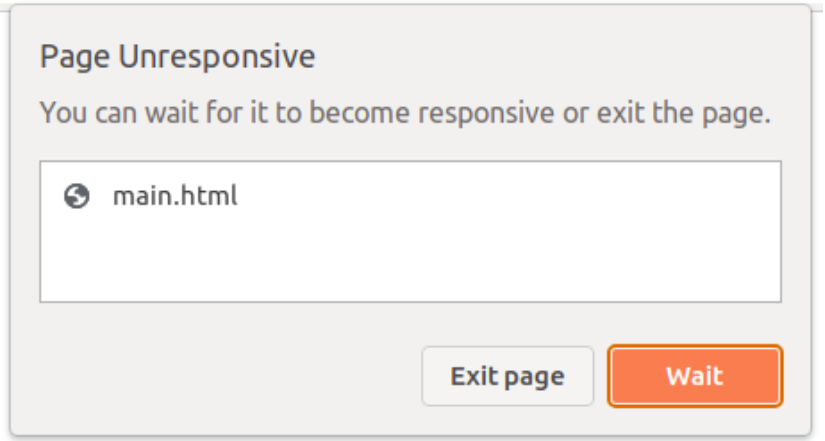

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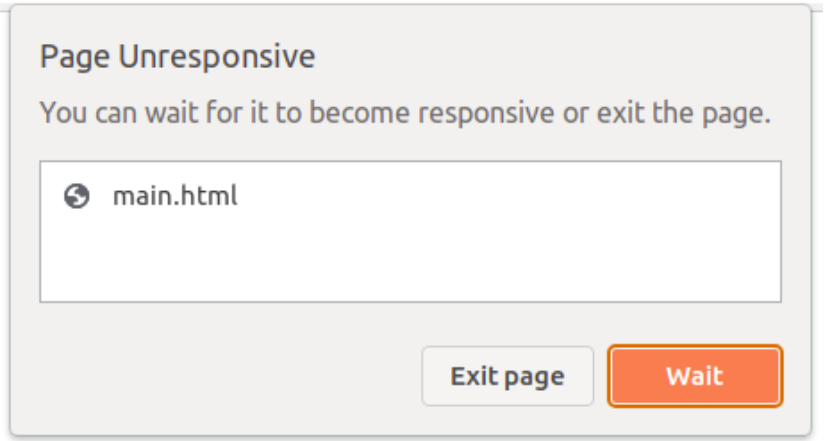

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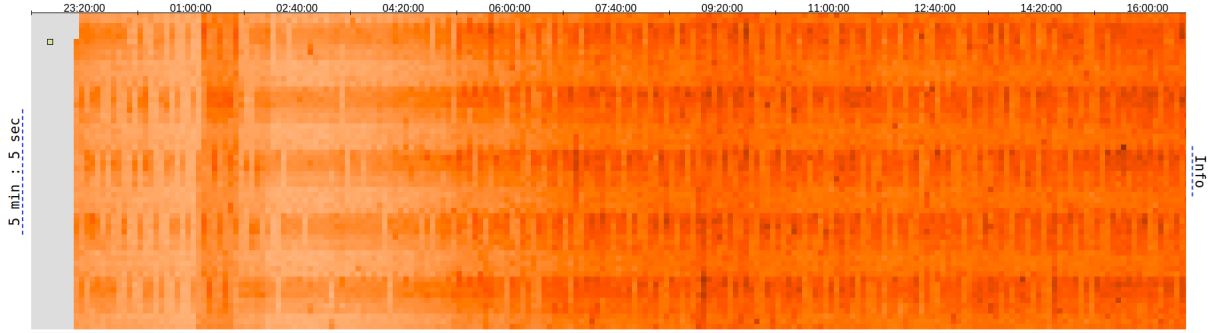
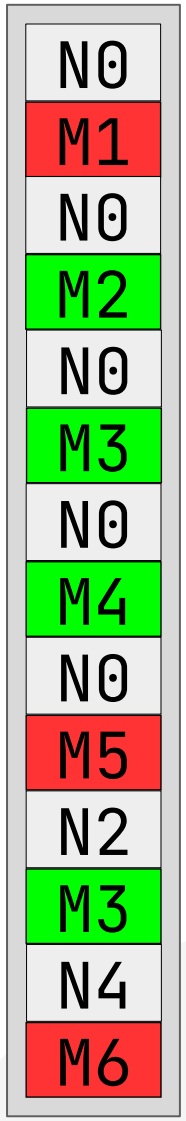


Распаковка словаря



N0

Словарь

```
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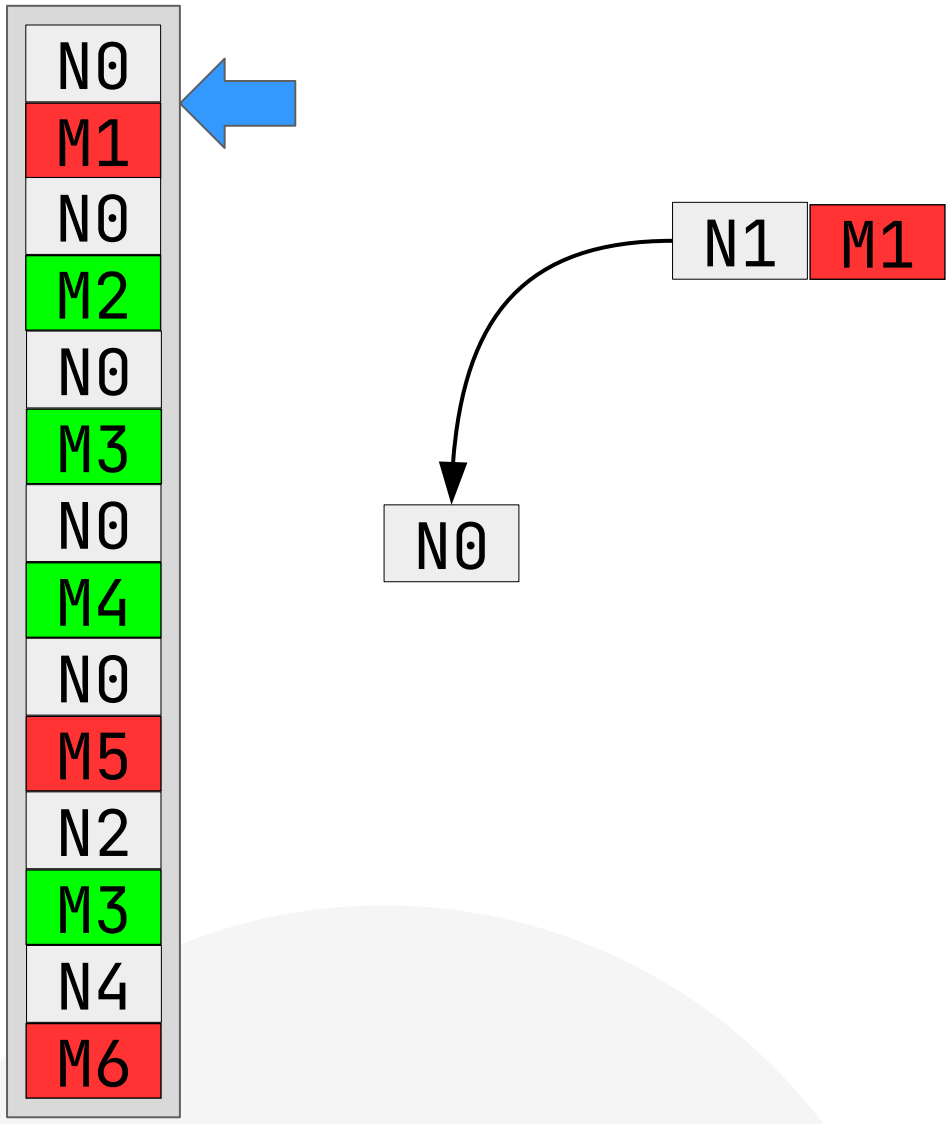
Распаковка словаря



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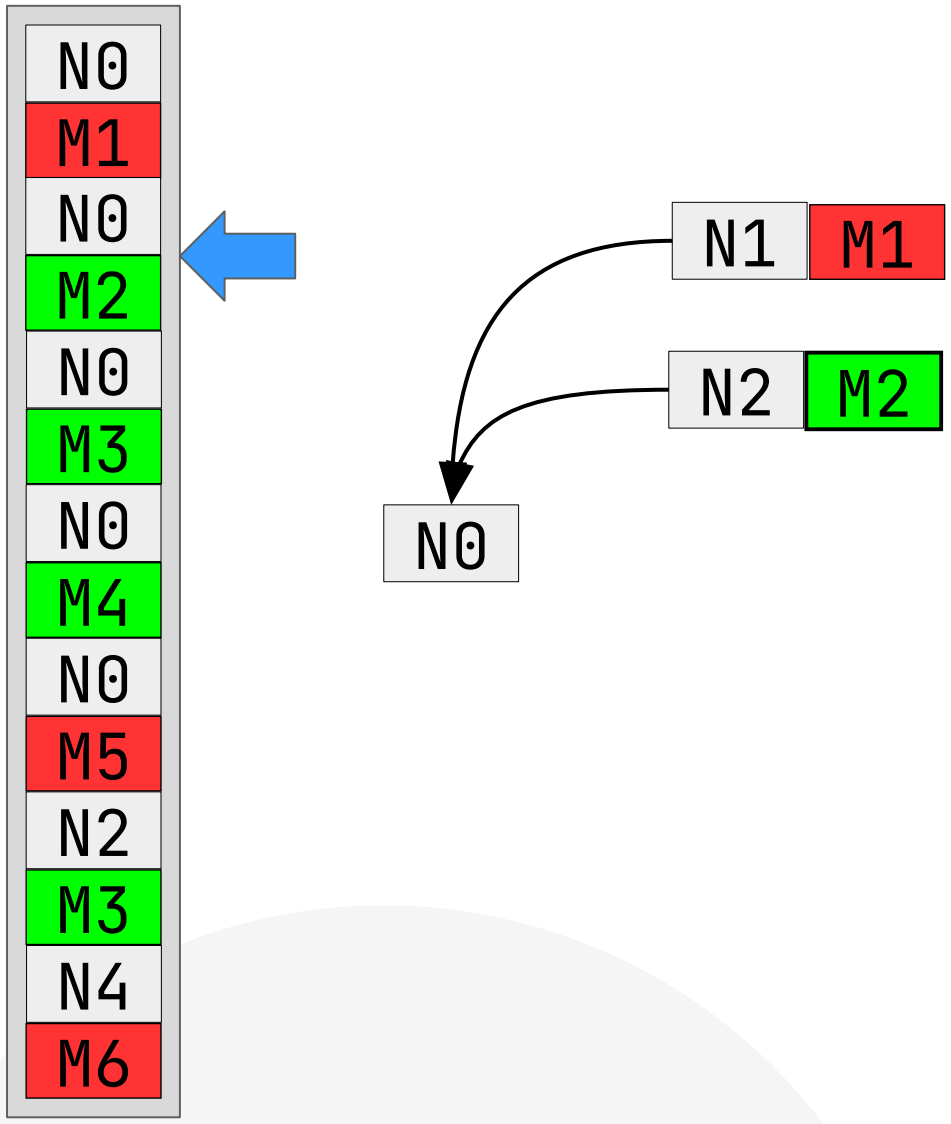

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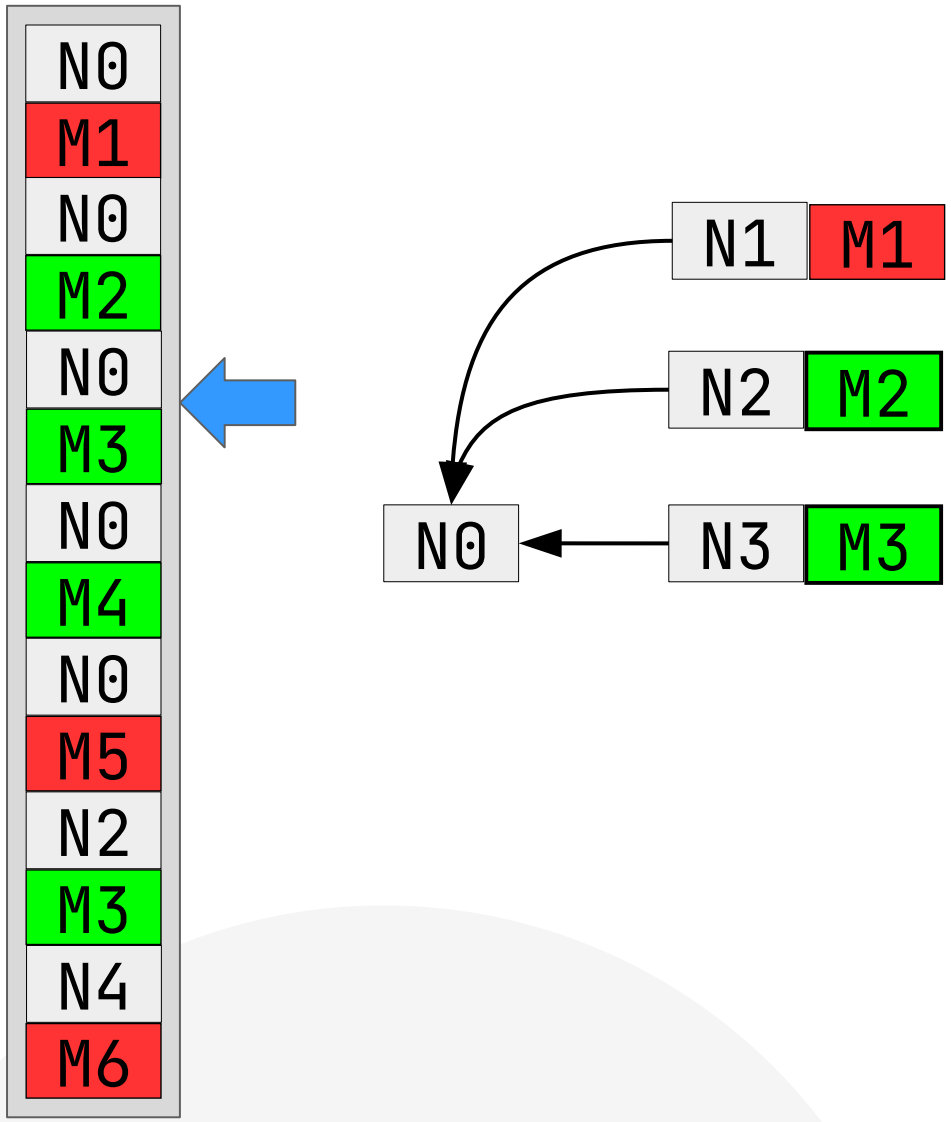

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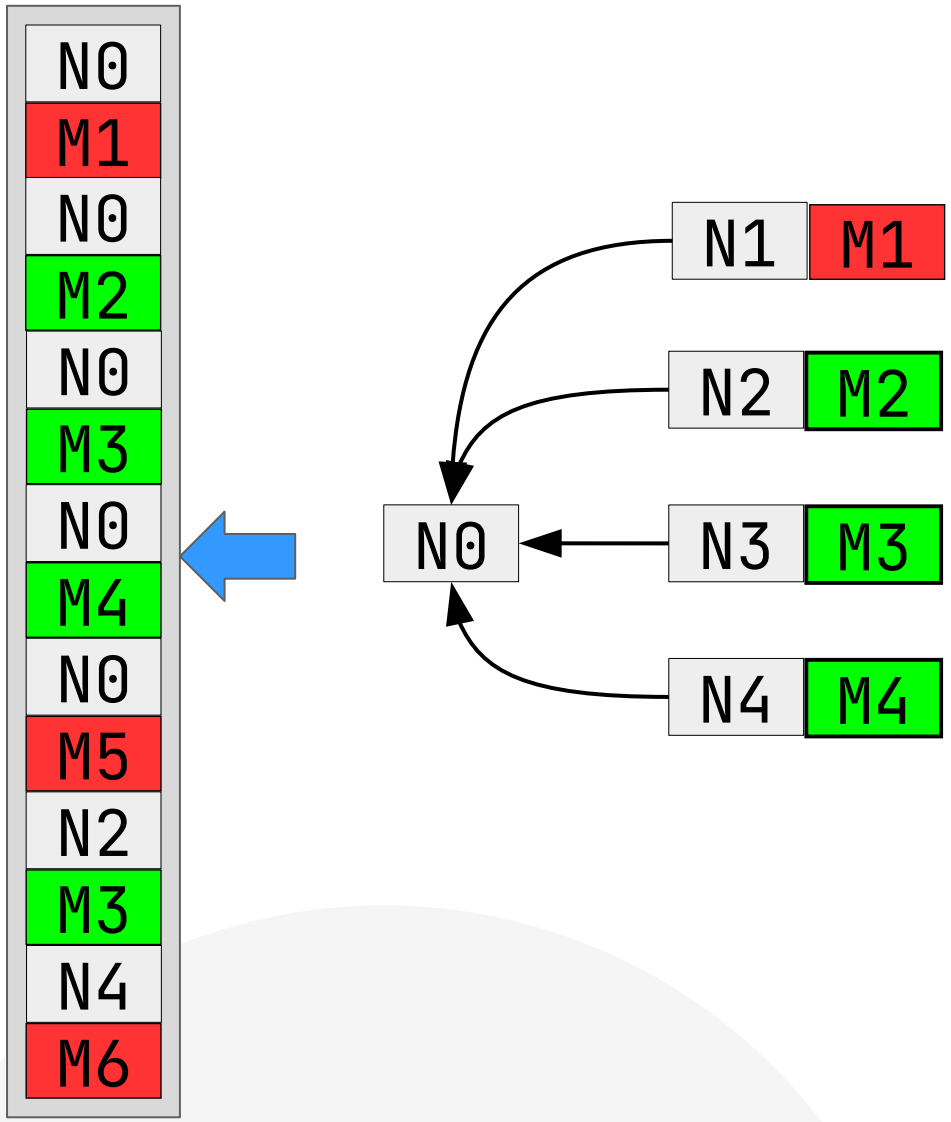

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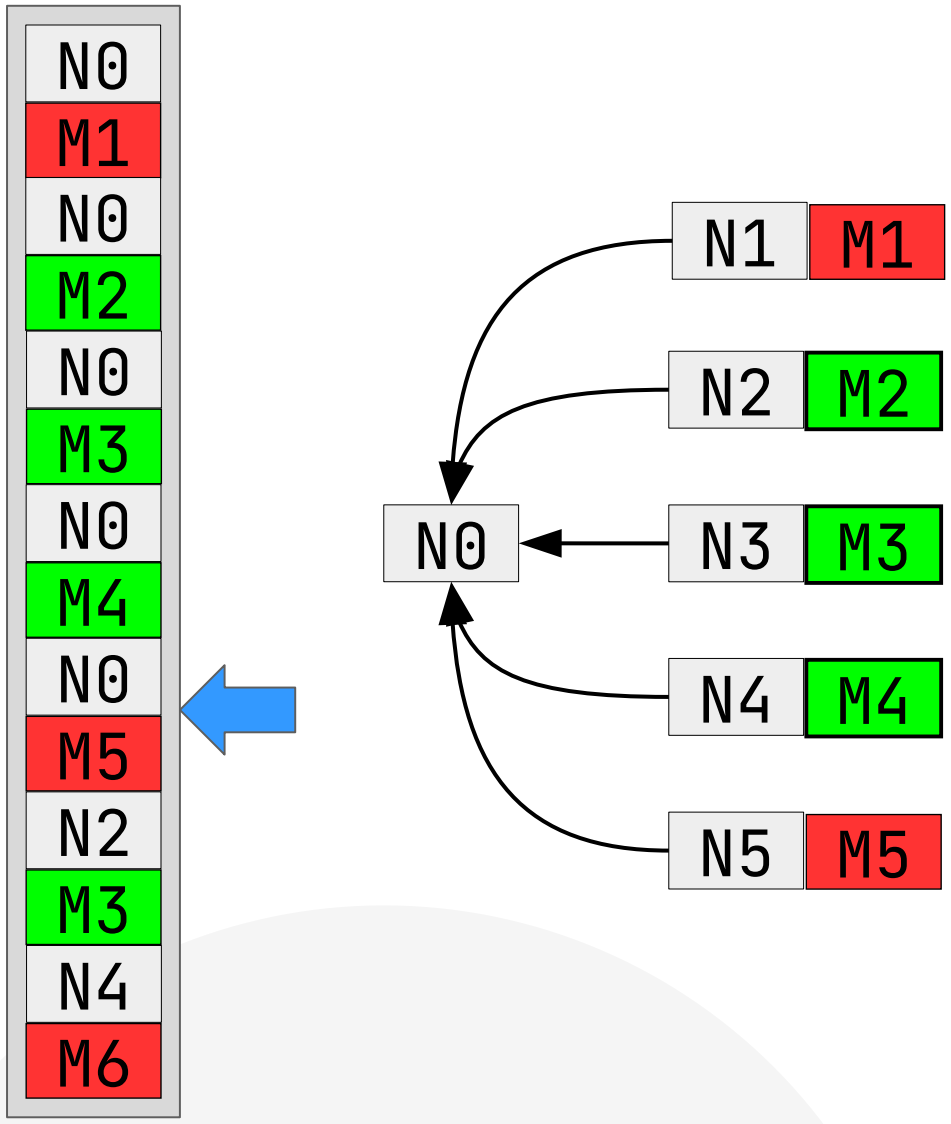

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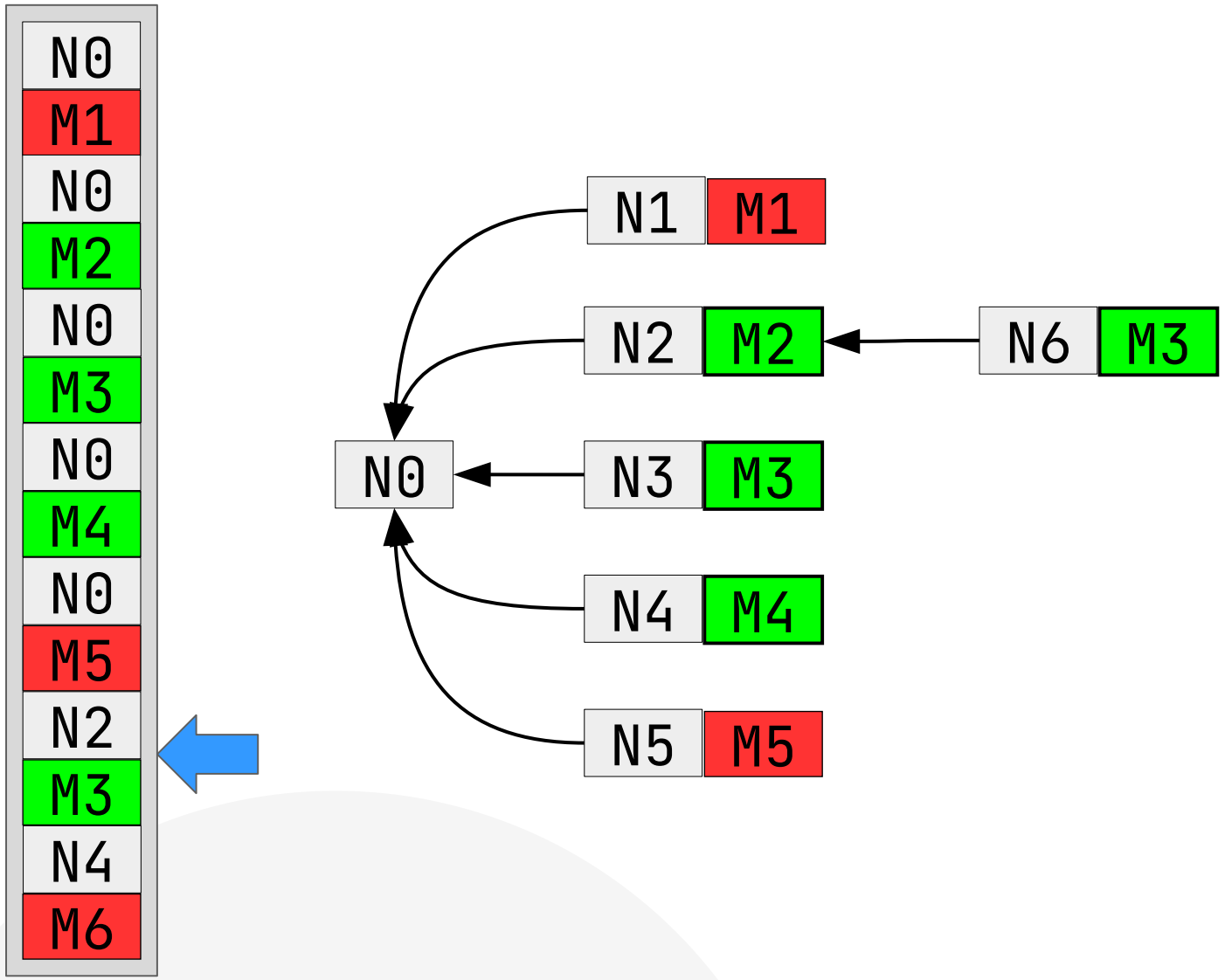

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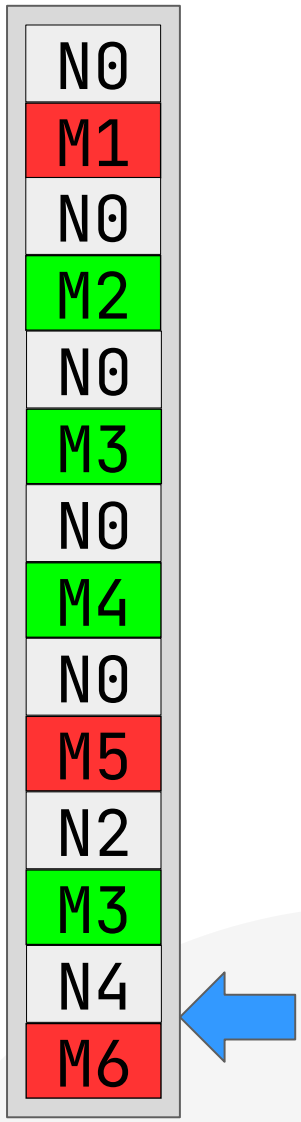

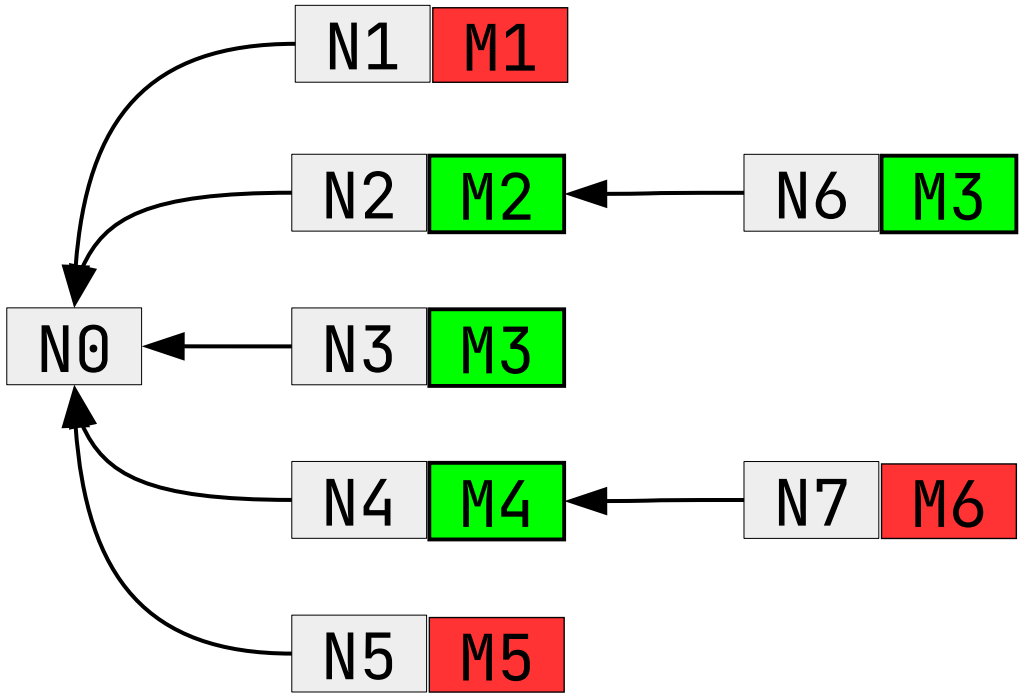

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```
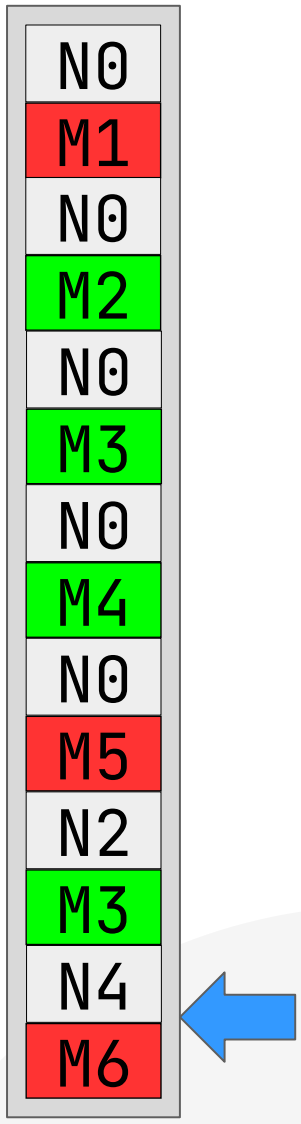
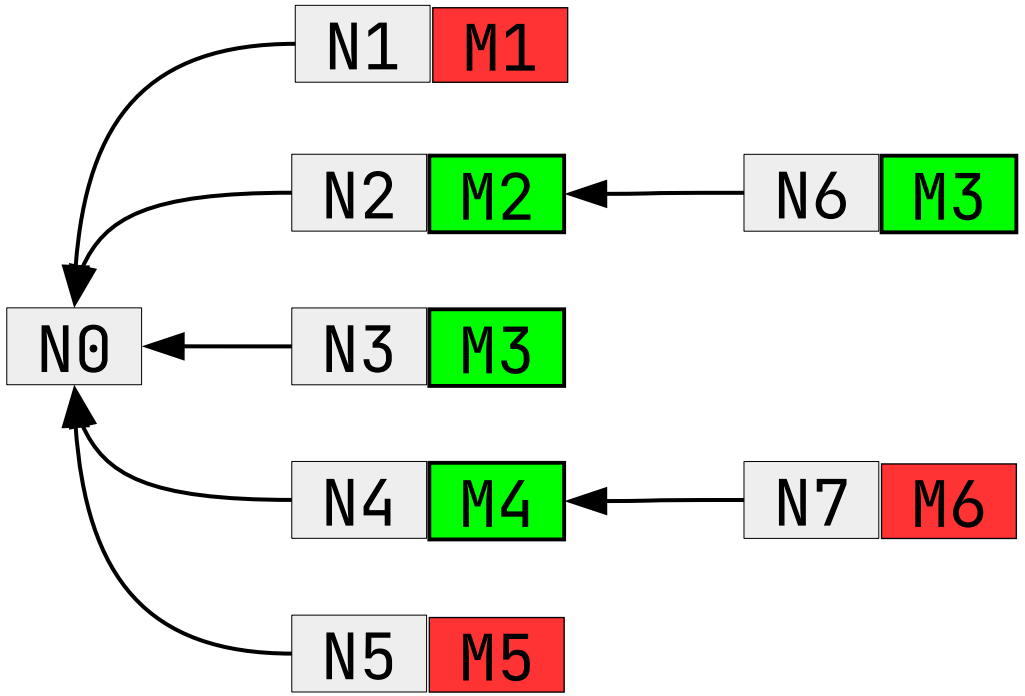

Распаковка словаря





Опасно для психического здоровья!

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O(N)?

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* при достаточном натяжении совы

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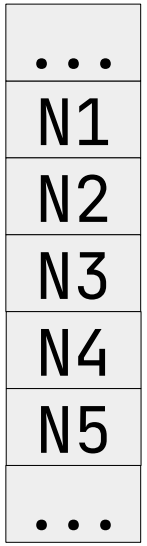

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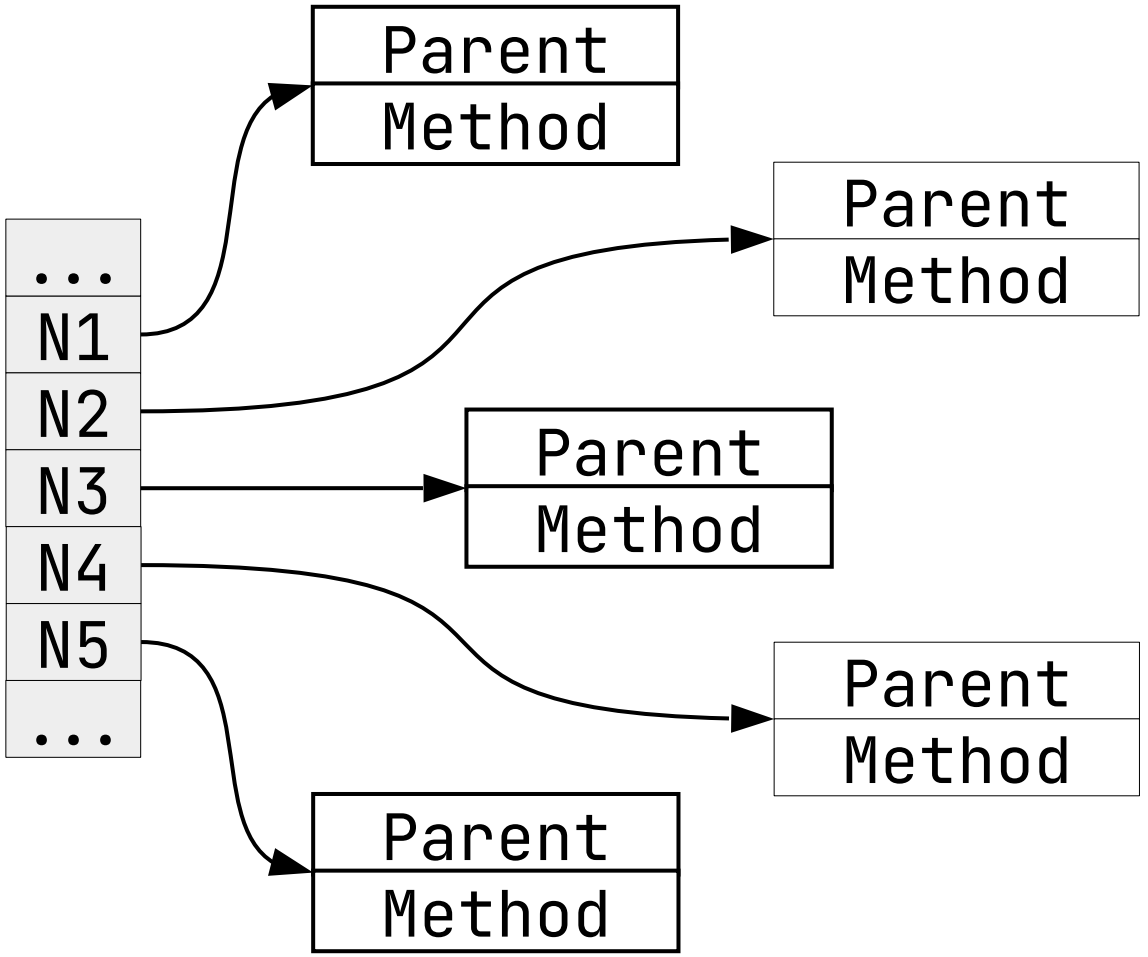

* https://deepu.tech/memory-management-in-v8/

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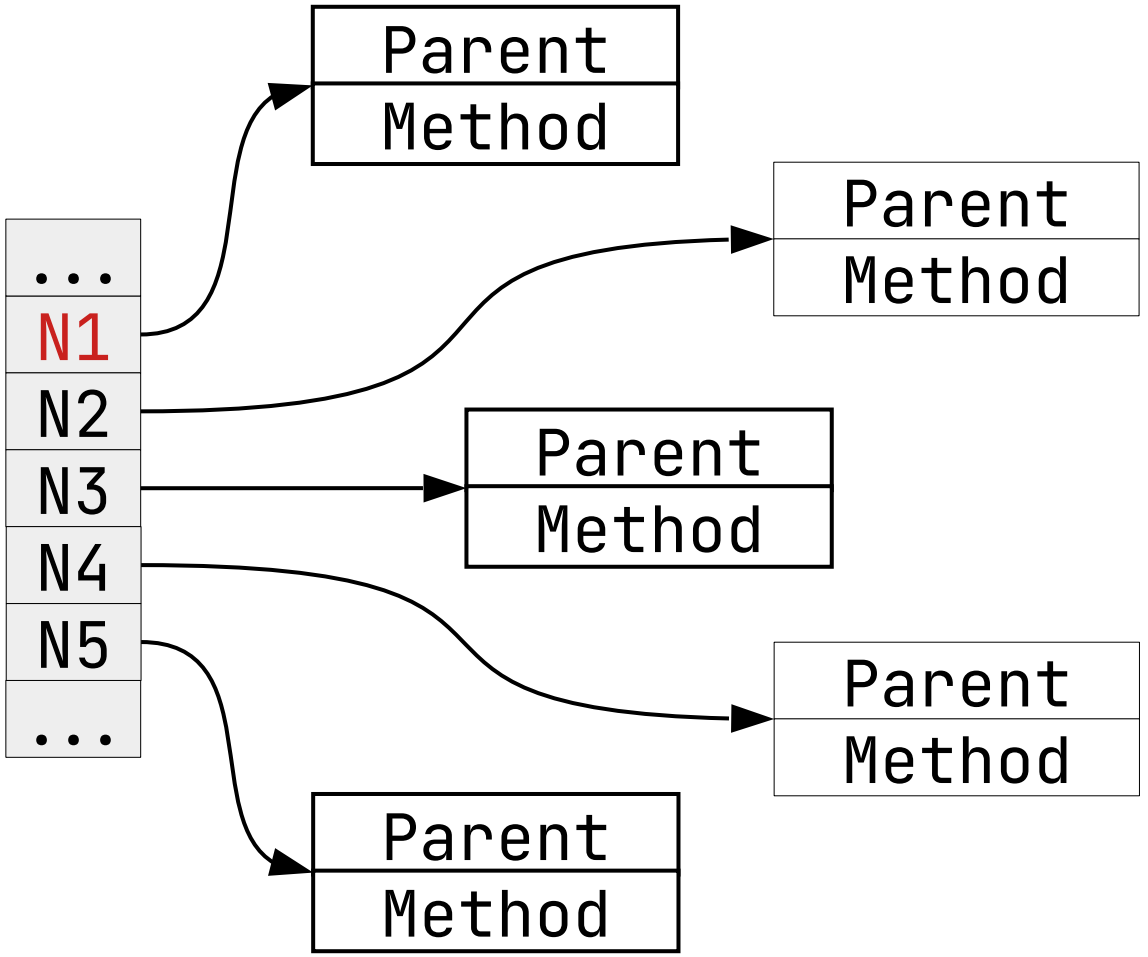

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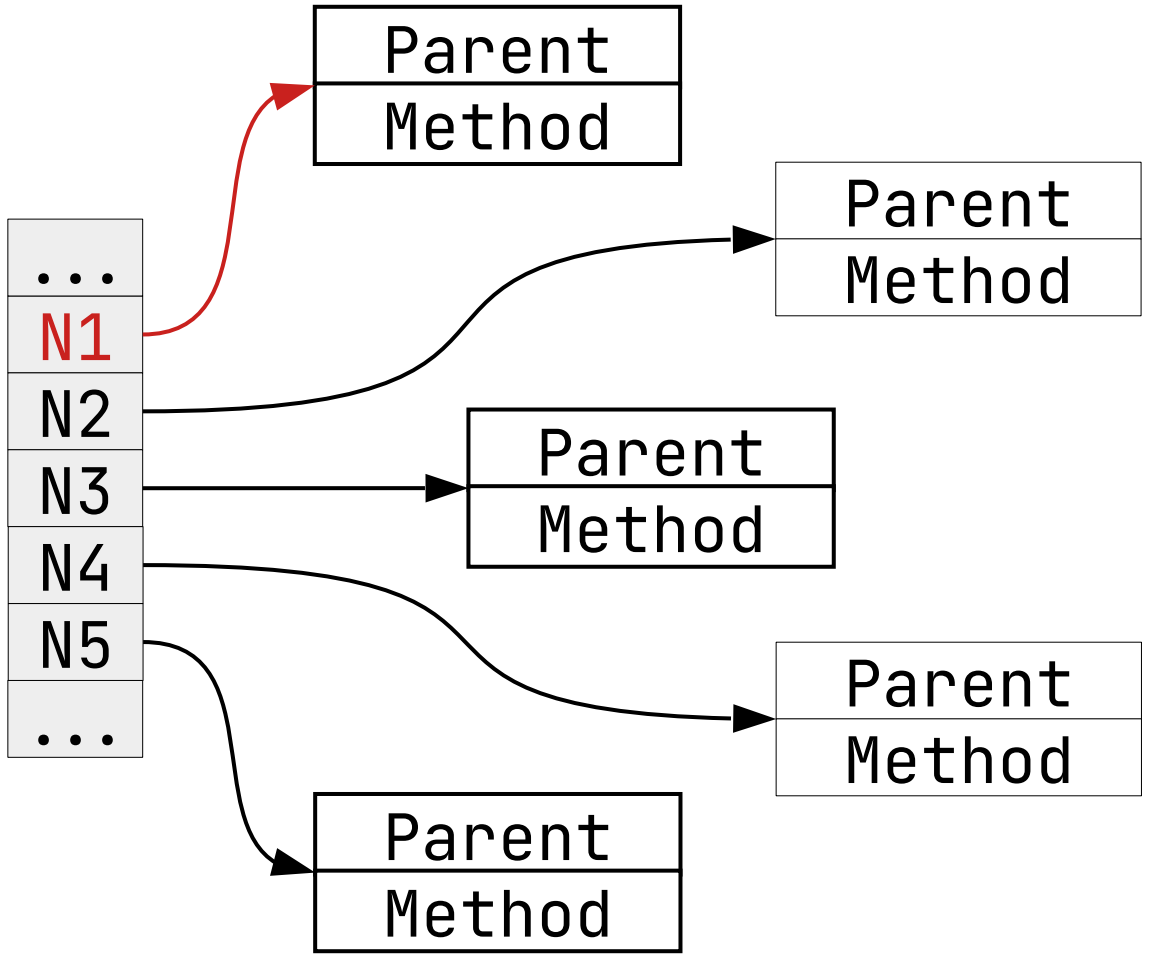

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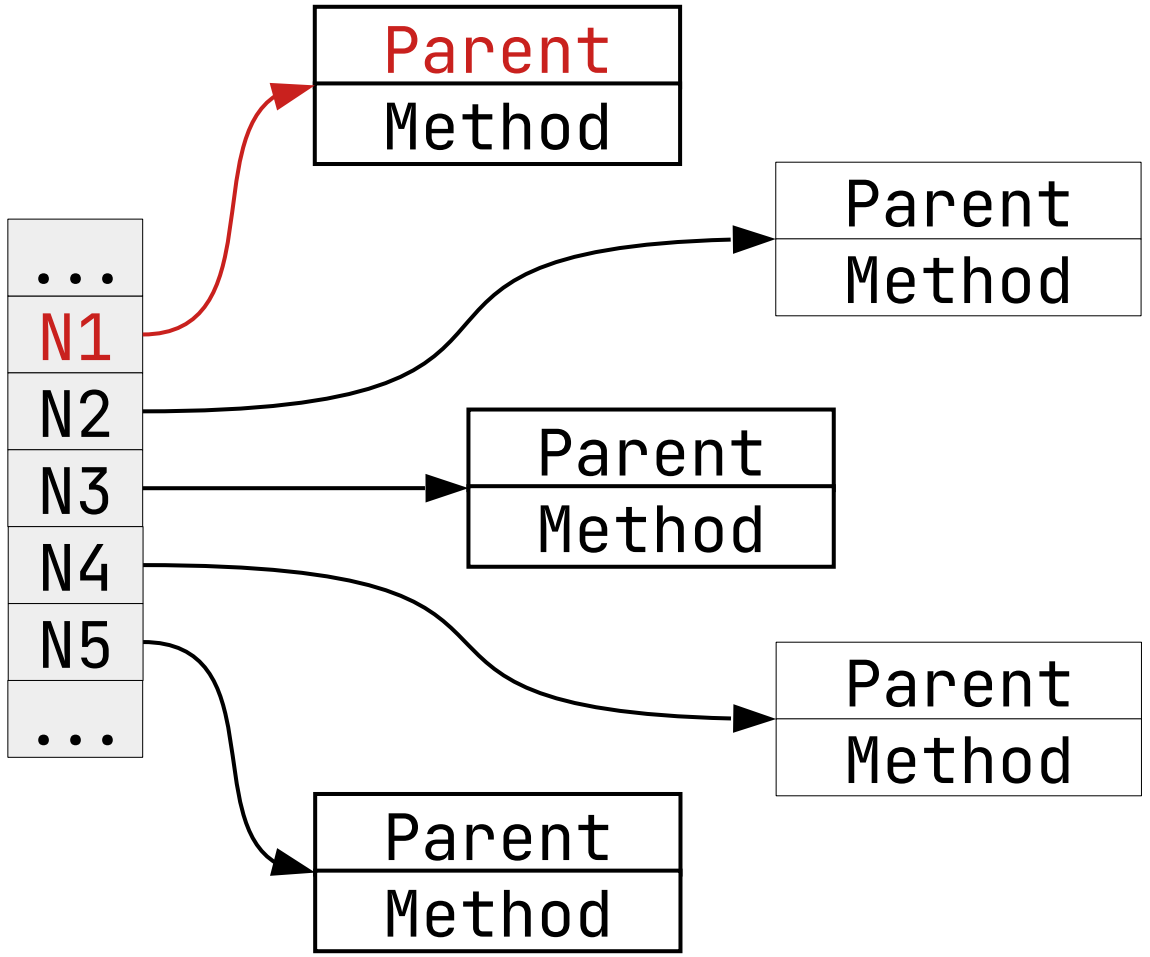

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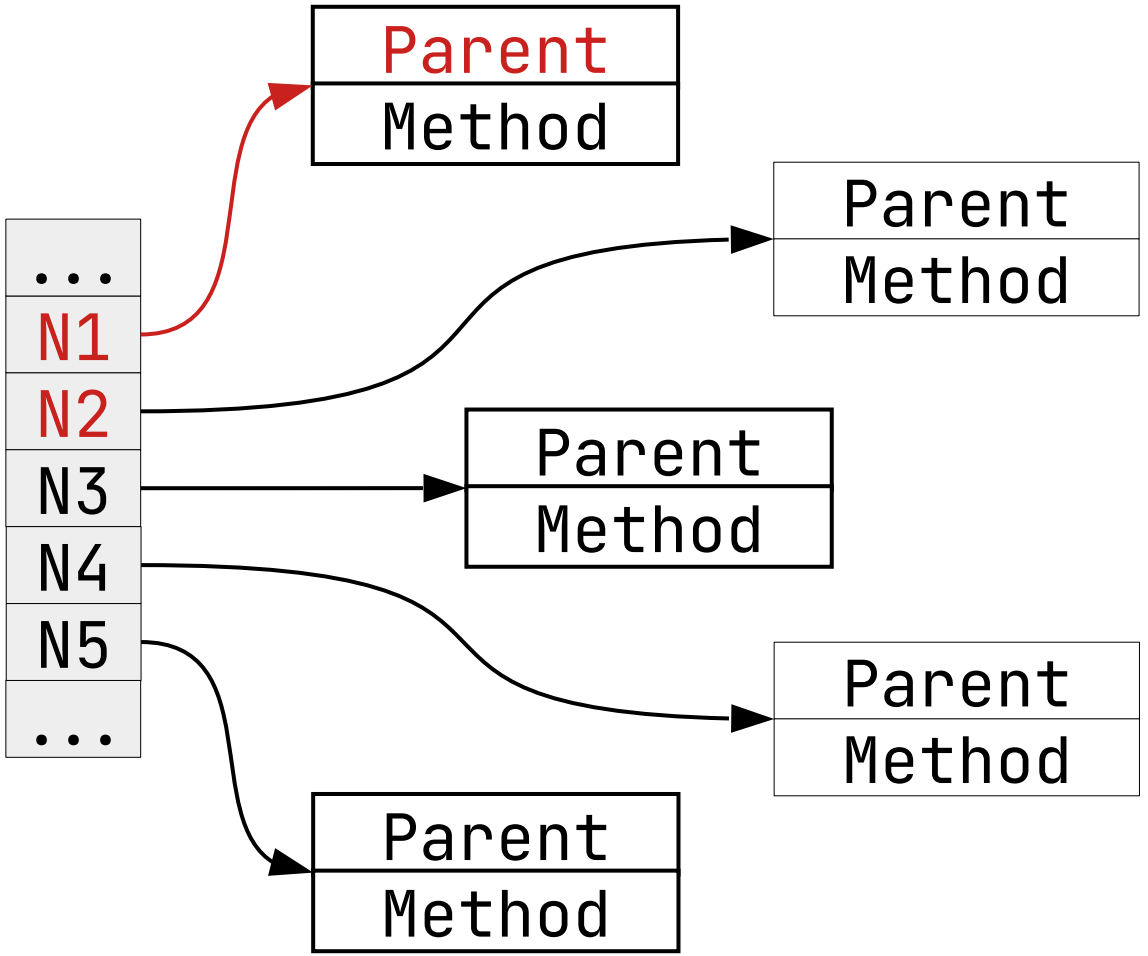

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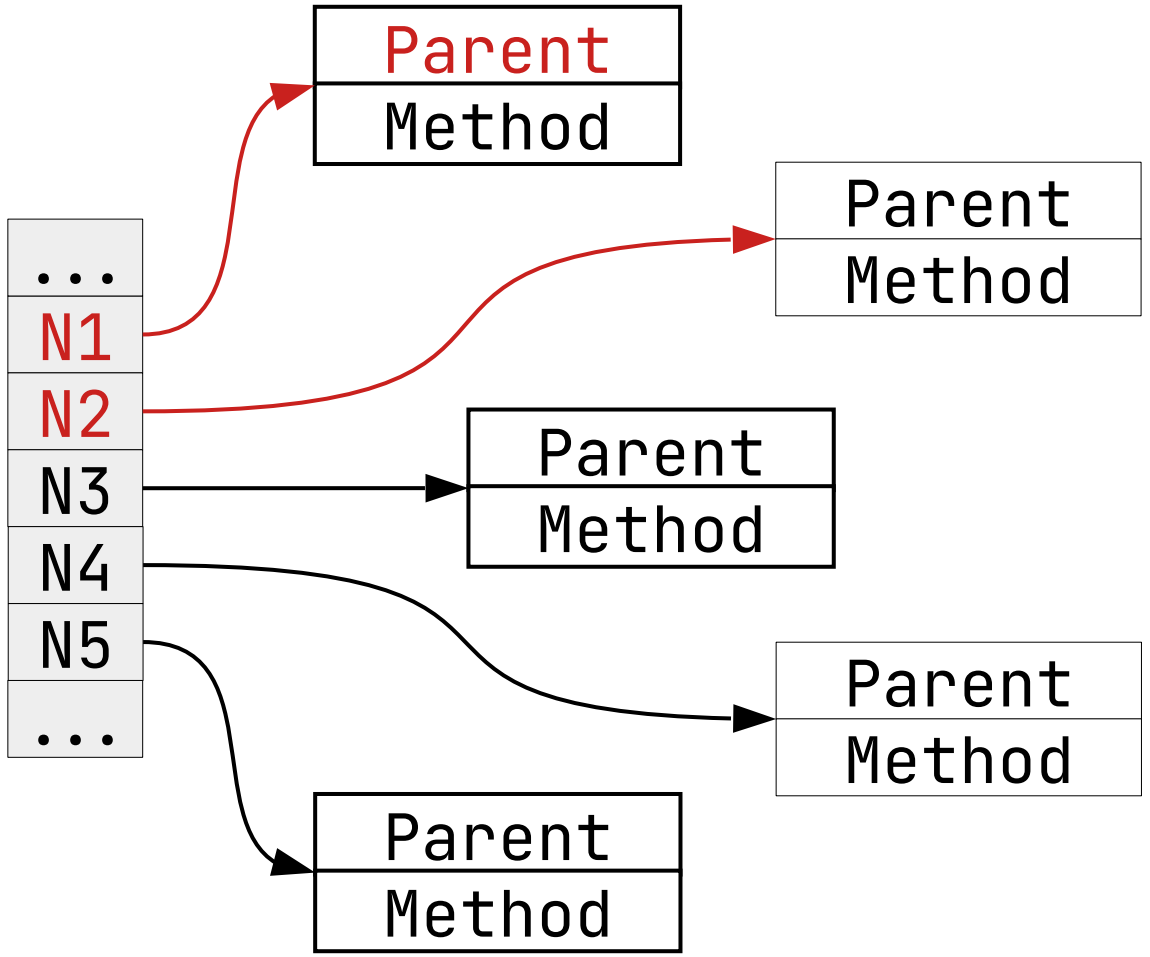

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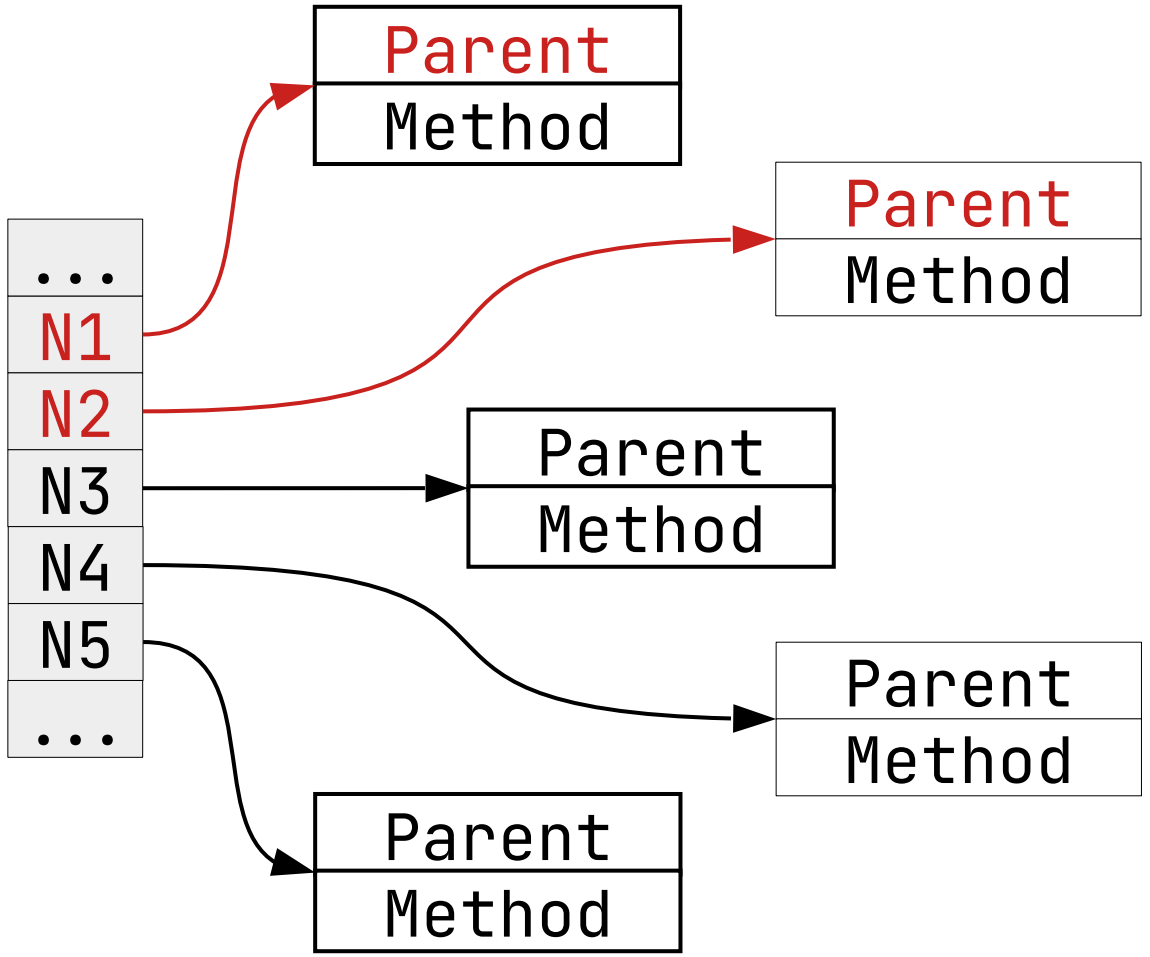

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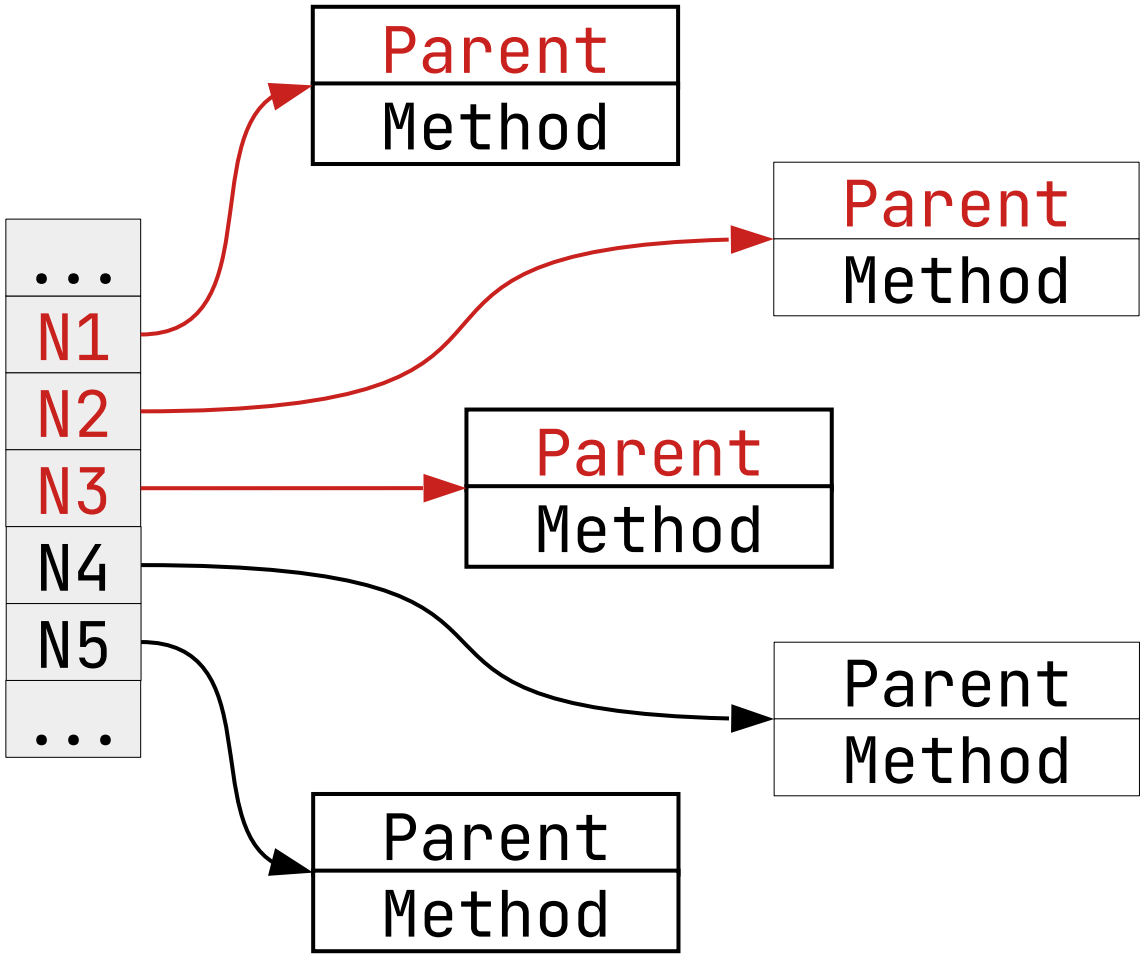

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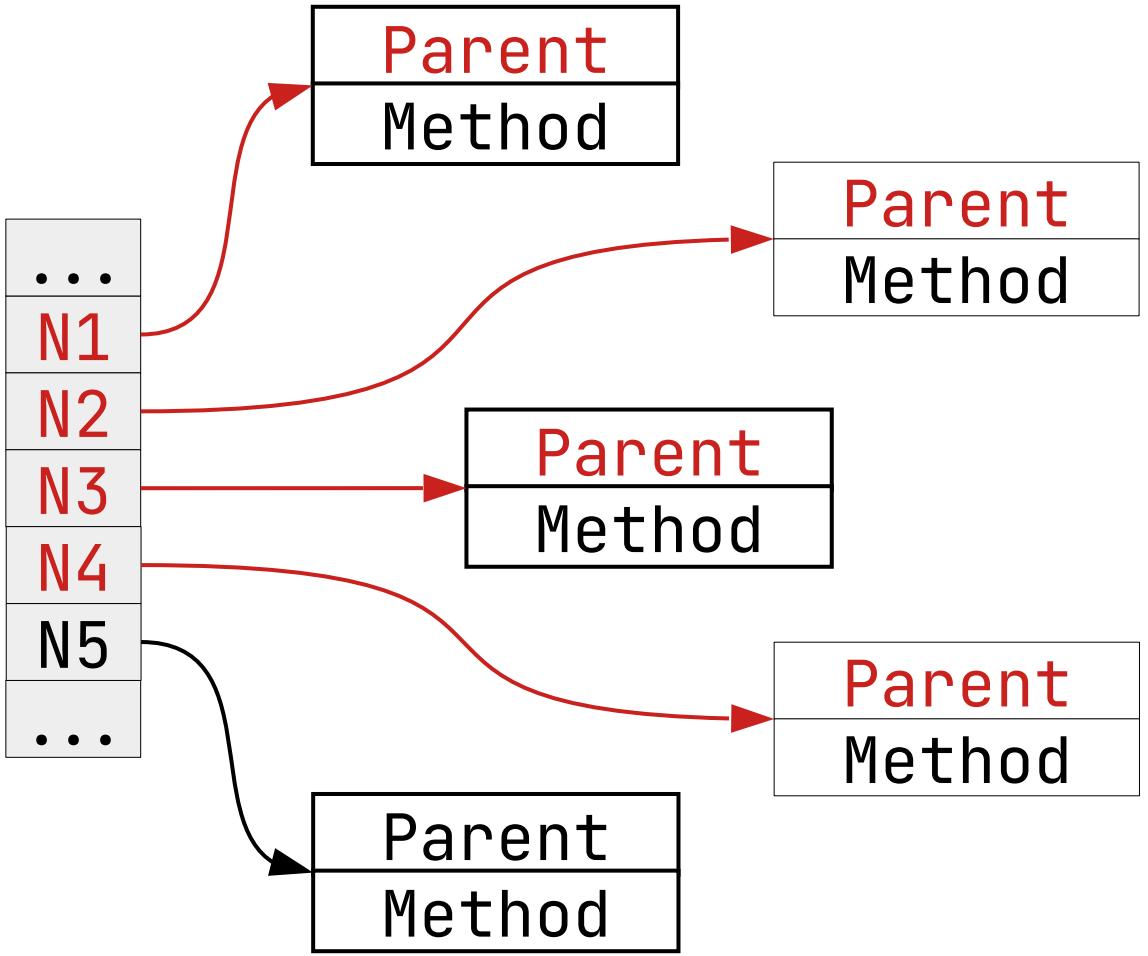

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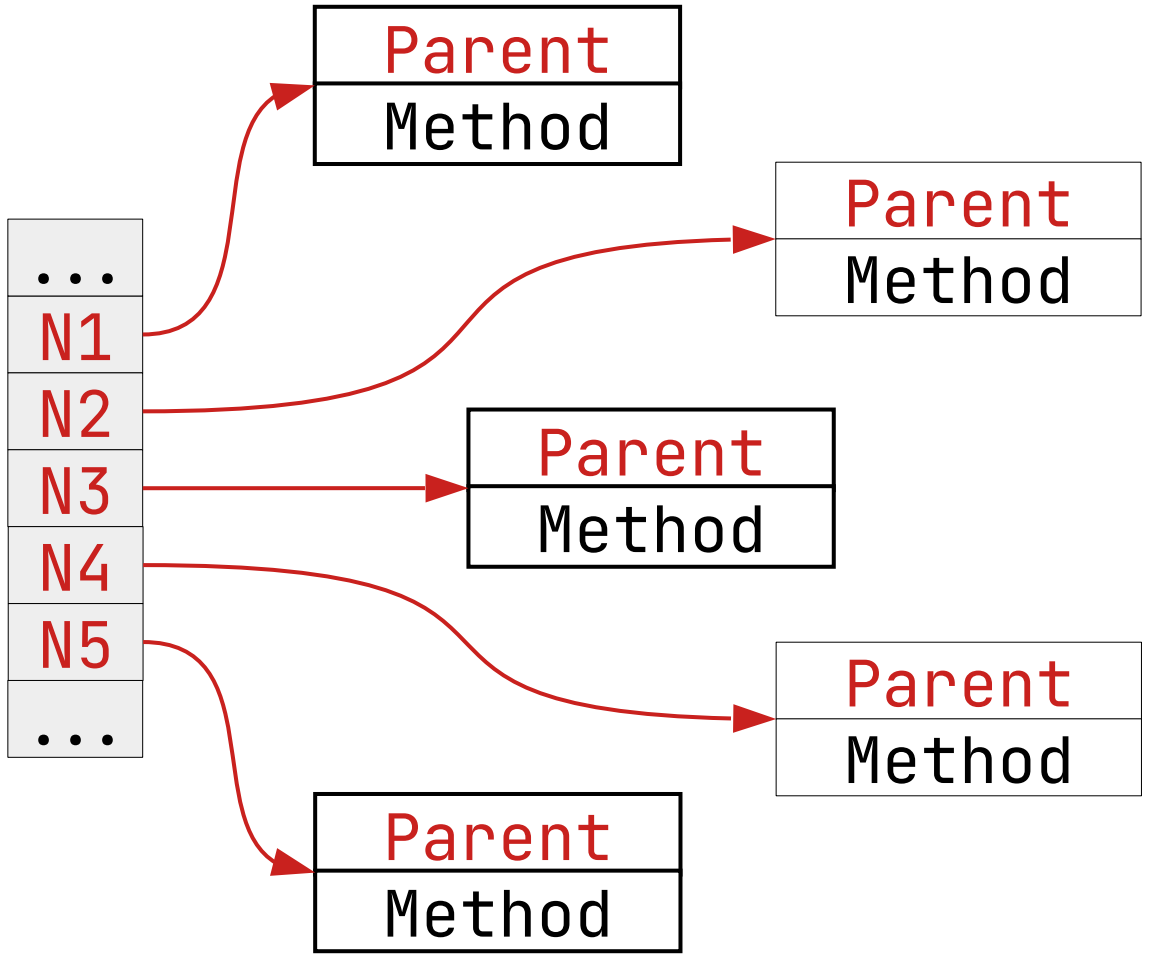

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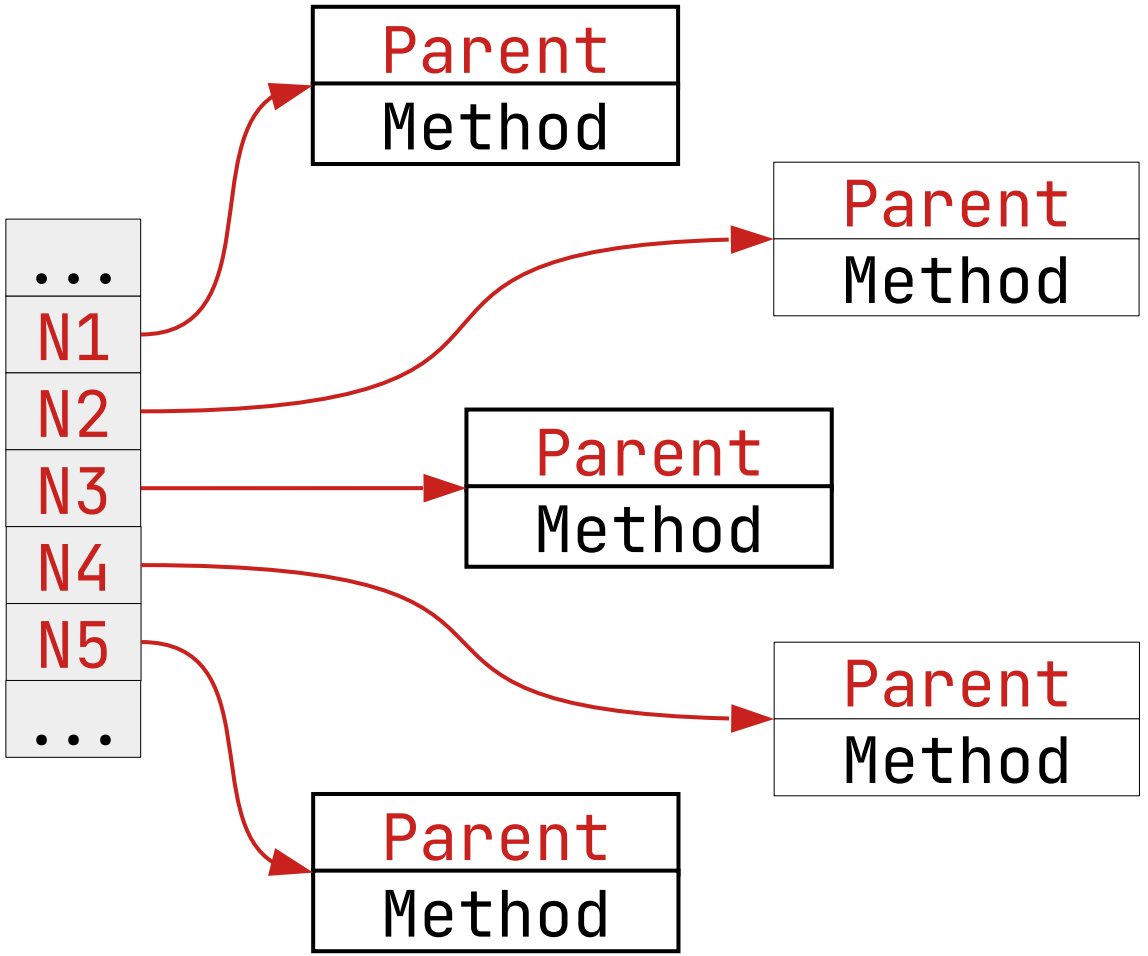
CPU → 10 сек



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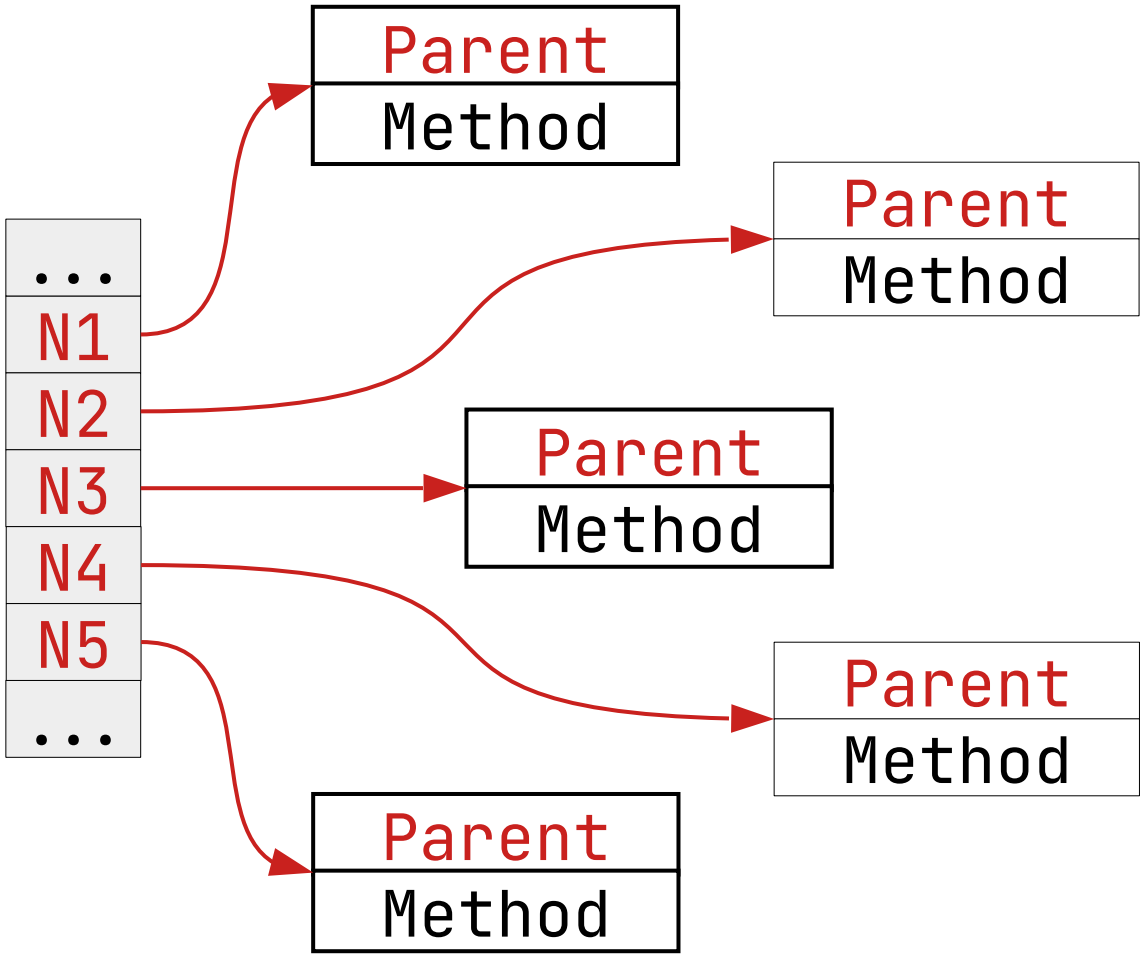
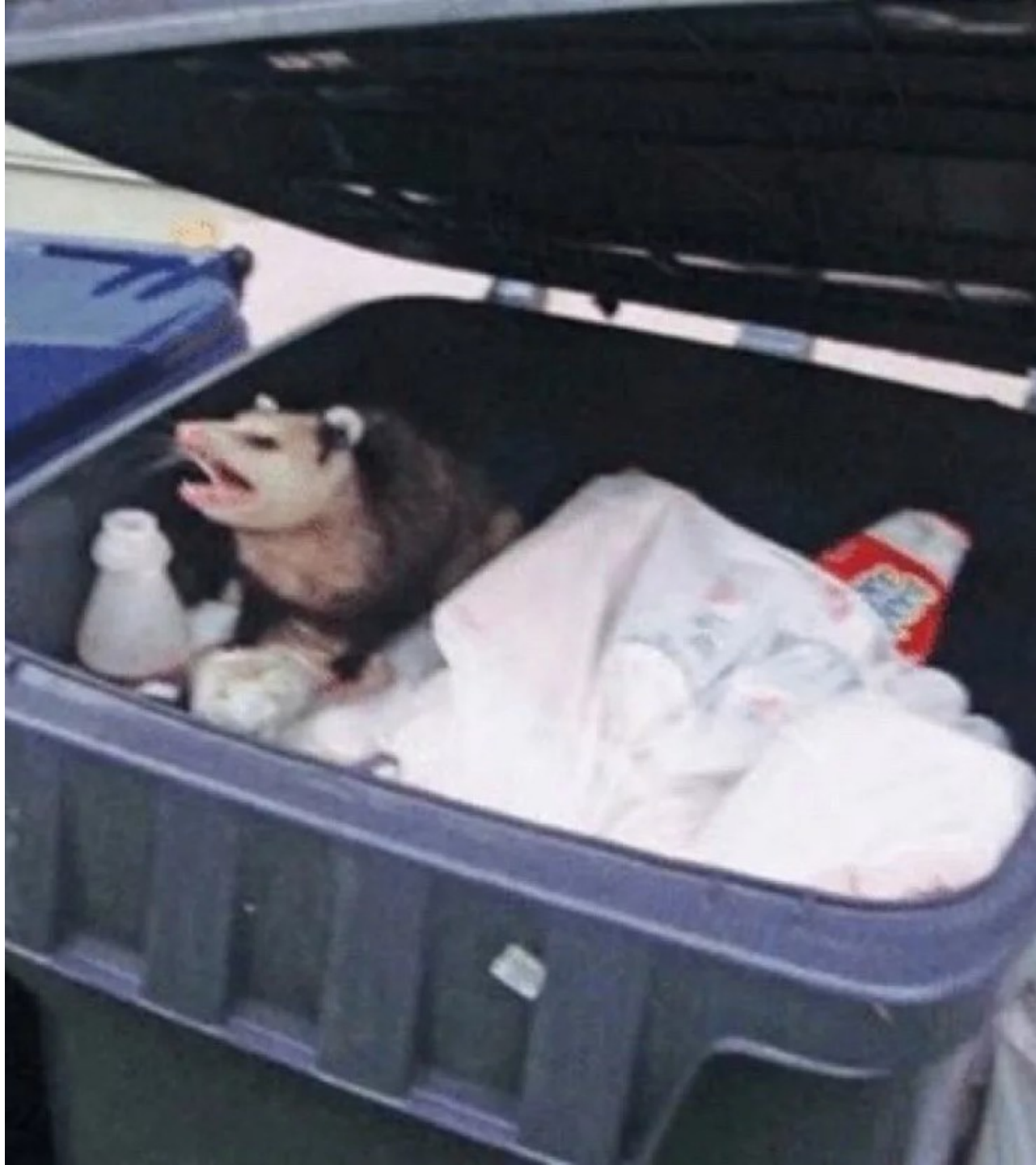
CPU → 15 сек



* https://deepu.tech/memory-management-in-v8/

Не трожь мой мусор!



GC страдает

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GC доволен

```
const lz78OwnMethods = new Uint32Array(...);
const lz78Parents = new Uint32Array(...);

for (let i = 1; i < lz78RecordsCount; i++) {
  const parentId = data.nextVarInt();
  const methodId = data.nextVarInt();


  lz78Parents[i] = parentId;
  lz78OwnMethods[i] = methodId;

}
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    lz78Parents[i] = parentId;
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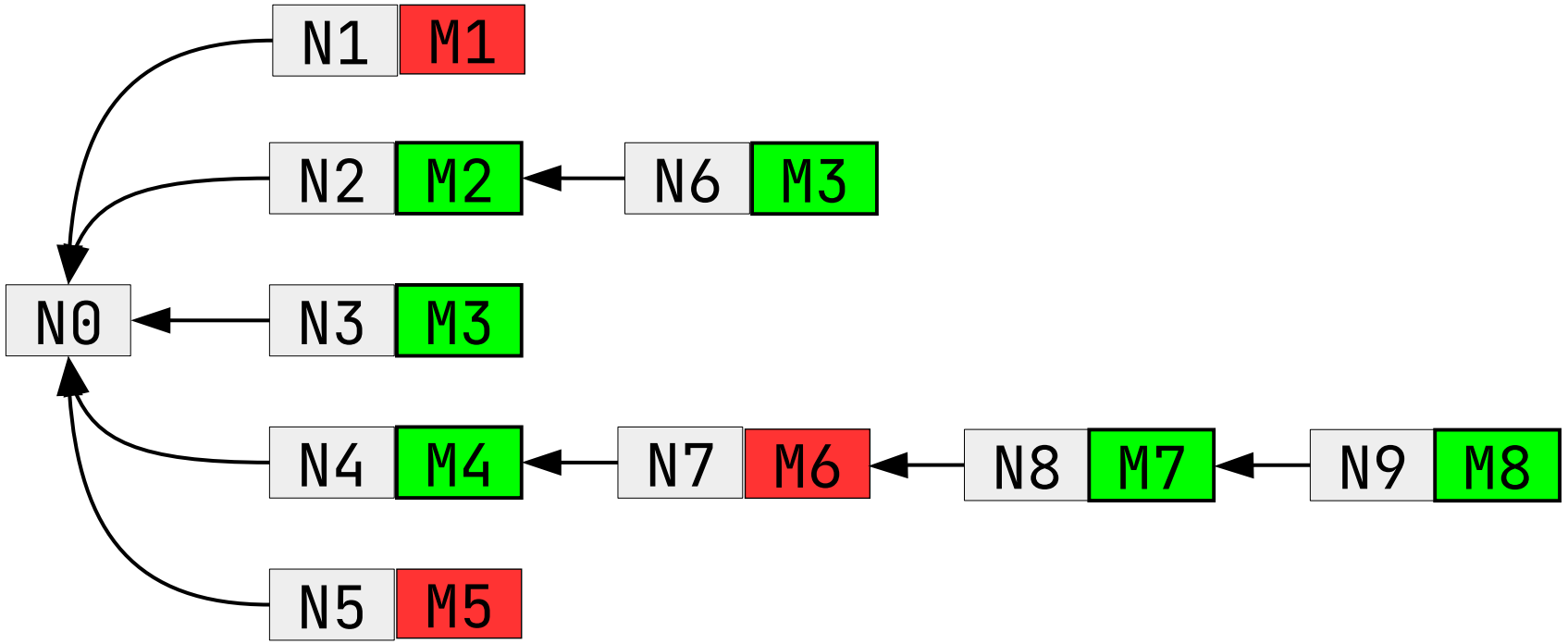
Распаковка словаря



Словарь

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6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
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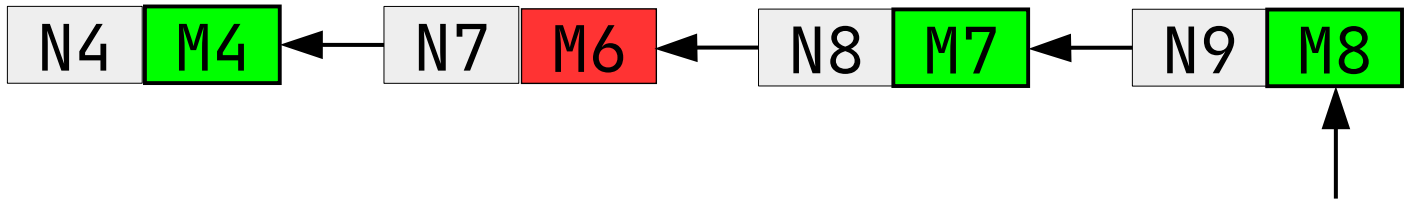
Распаковка словаря



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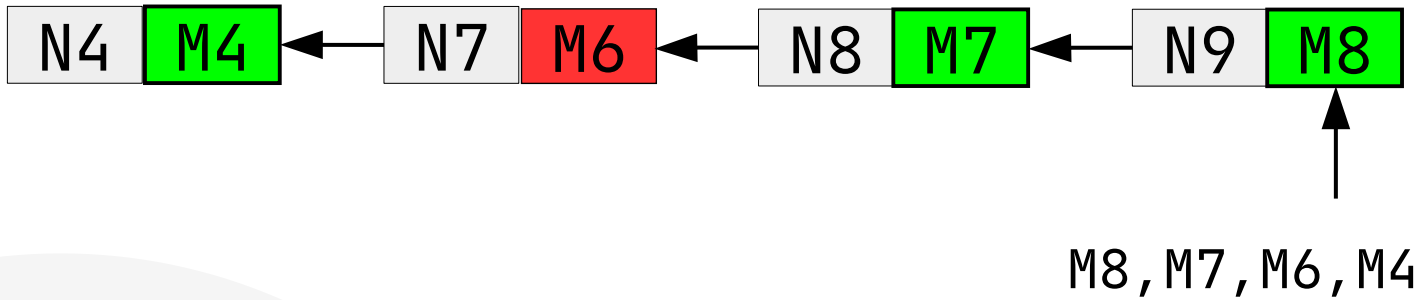

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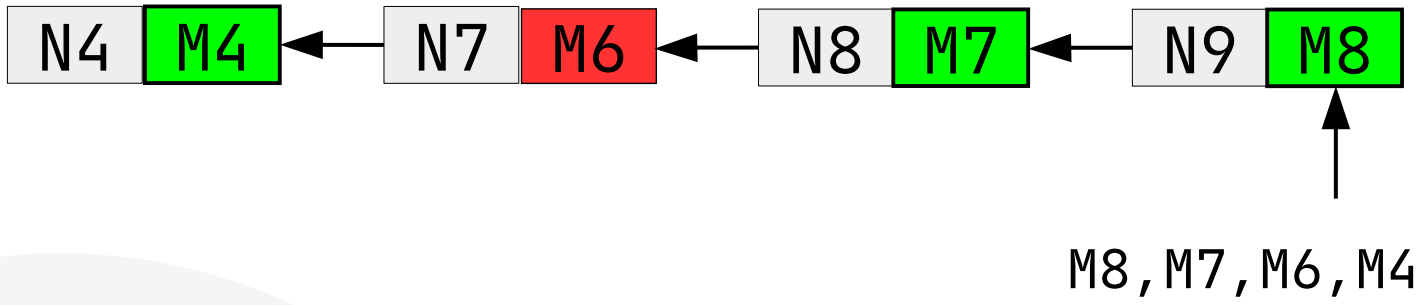

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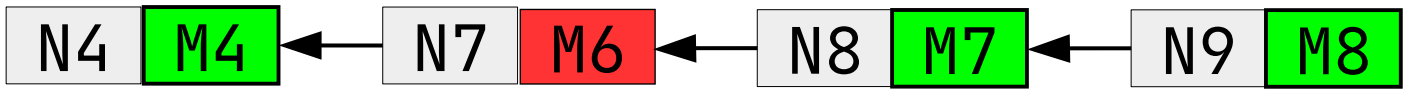

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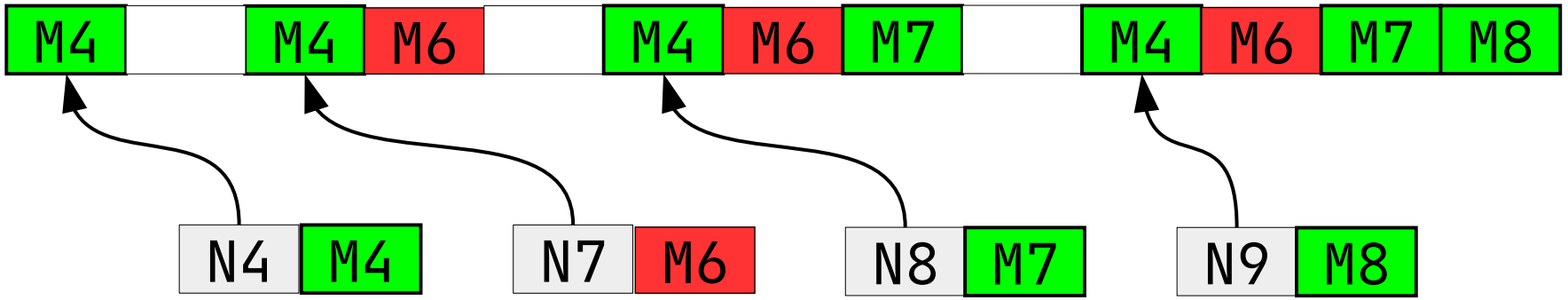

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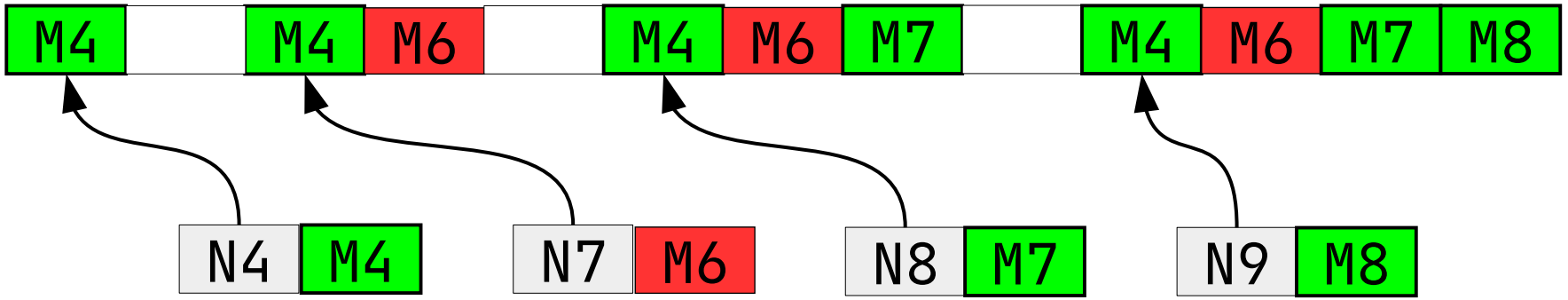
Распаковка словаря

Так это же почти JFR!



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Распаковка словаря

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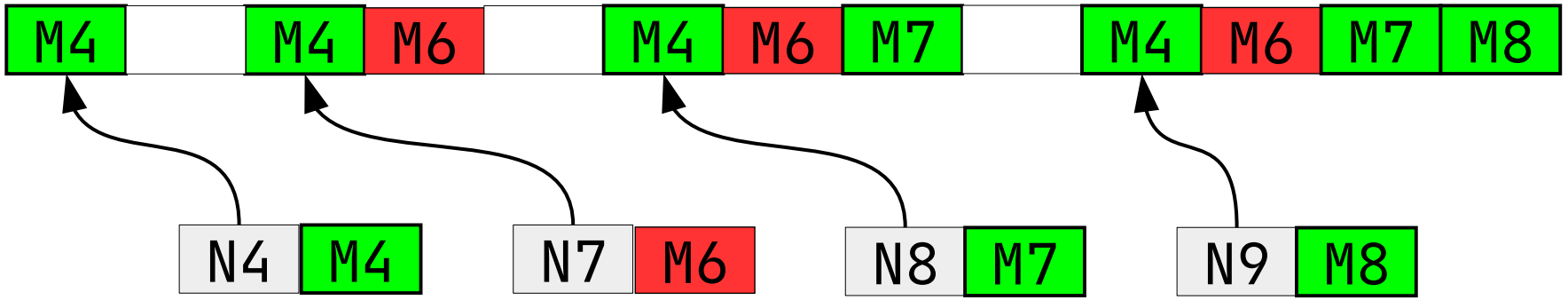
...4 GB...



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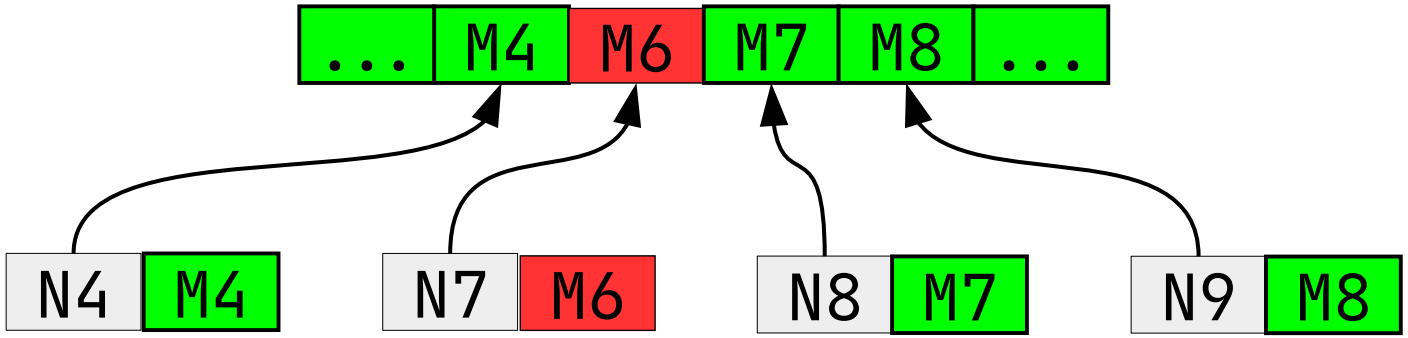

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```
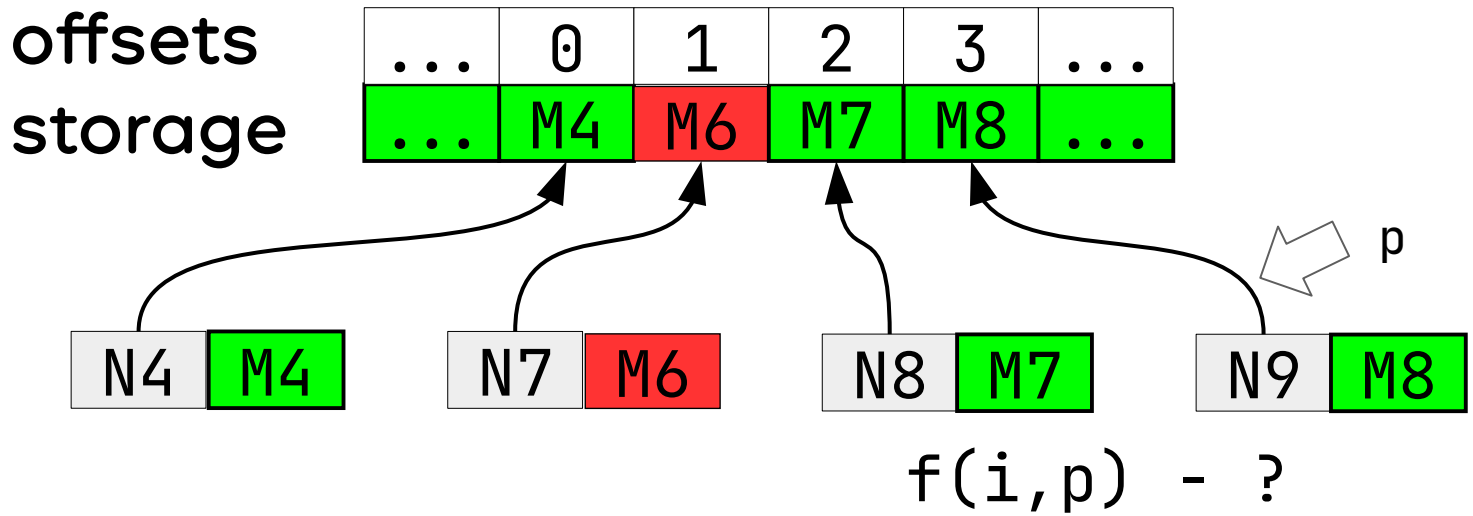

Распаковка словаря

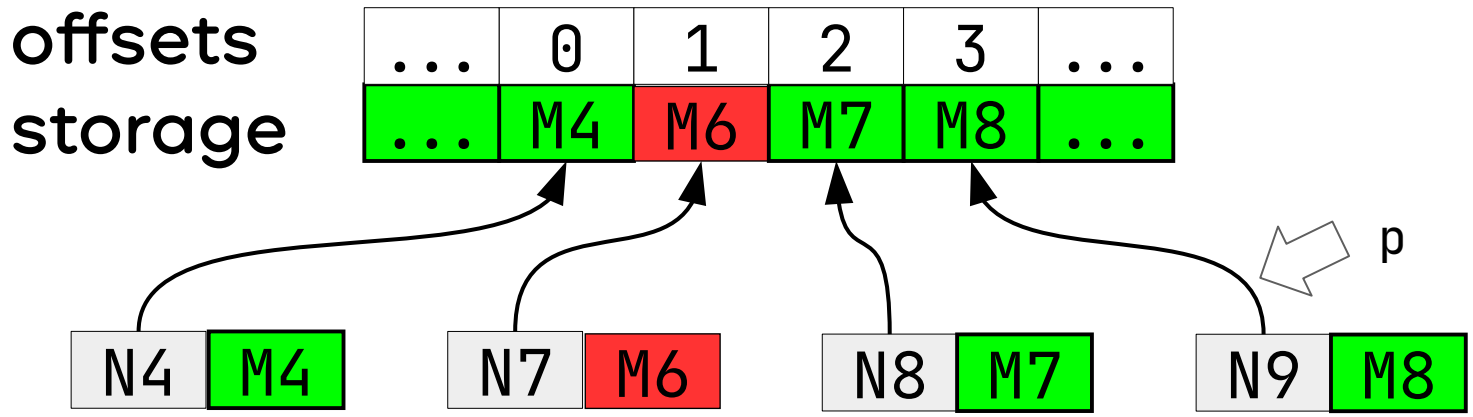


Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
9: "M4,M6,M7,M8"
     ↑ i
```

Распаковка словаря

```
f(i,p) = storage[p - offsets[p] + i]
```




```
f(0,p) = M4
f(1,p) = M6
f(2,p) = M7
f(3,p) = M8
```

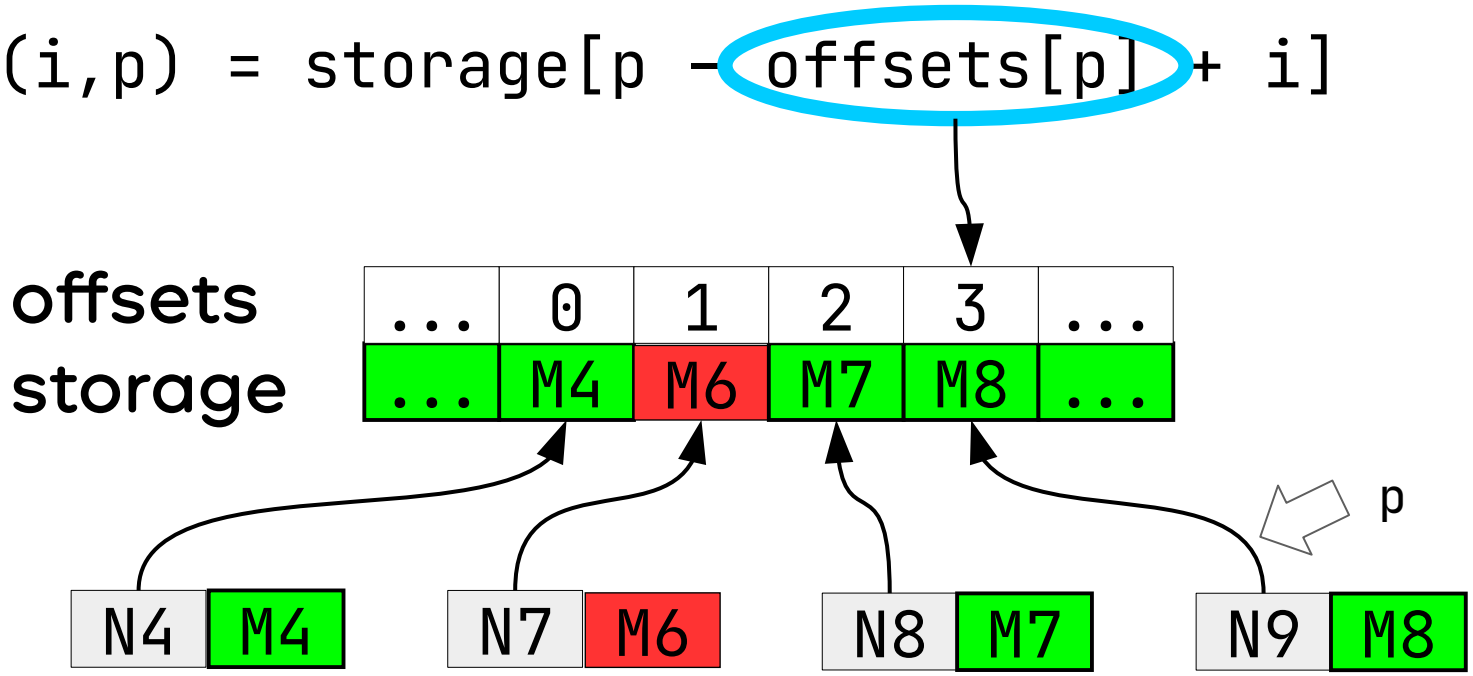
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
9: "M4,M6,M7,M8"
```

i

Распаковка словаря

```
f(i,p) = storage[p - offsets[p] + i]
```




```
f(0,p) = M4
f(1,p) = M6
f(2,p) = M7
f(3,p) = M8
```

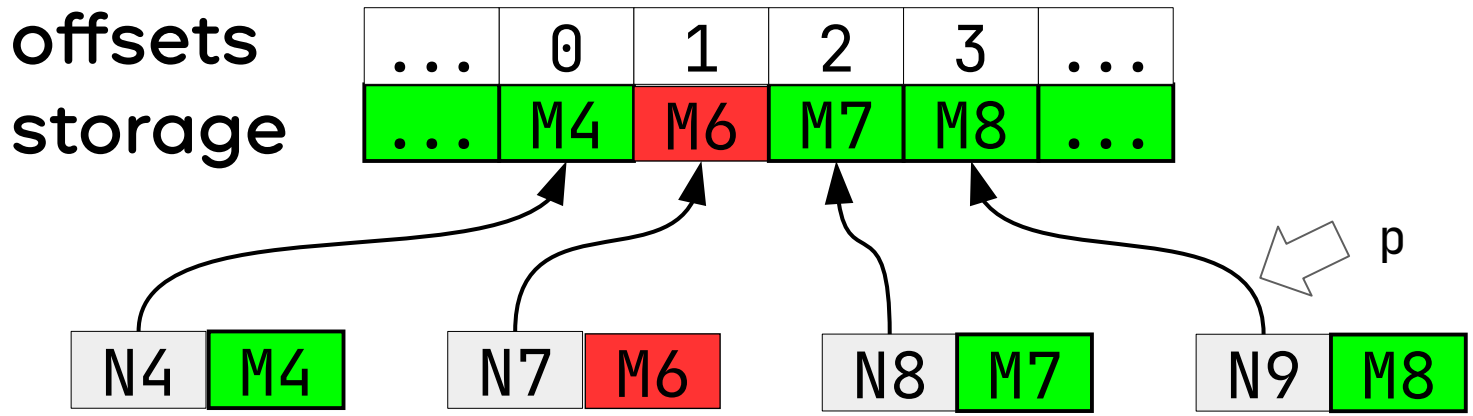
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
9: "M4,M6,M7,M8"
```

i

Распаковка словаря

```
f(i,p) = storage[p - 3 + i]
```




```
f(0,p) = storage[p - 3 + 0] = M4
f(1,p) = storage[p - 3 + 1] = M6
f(2,p) = storage[p - 3 + 2] = M7
f(3,p) = storage[p - 3 + 3] = M8
```

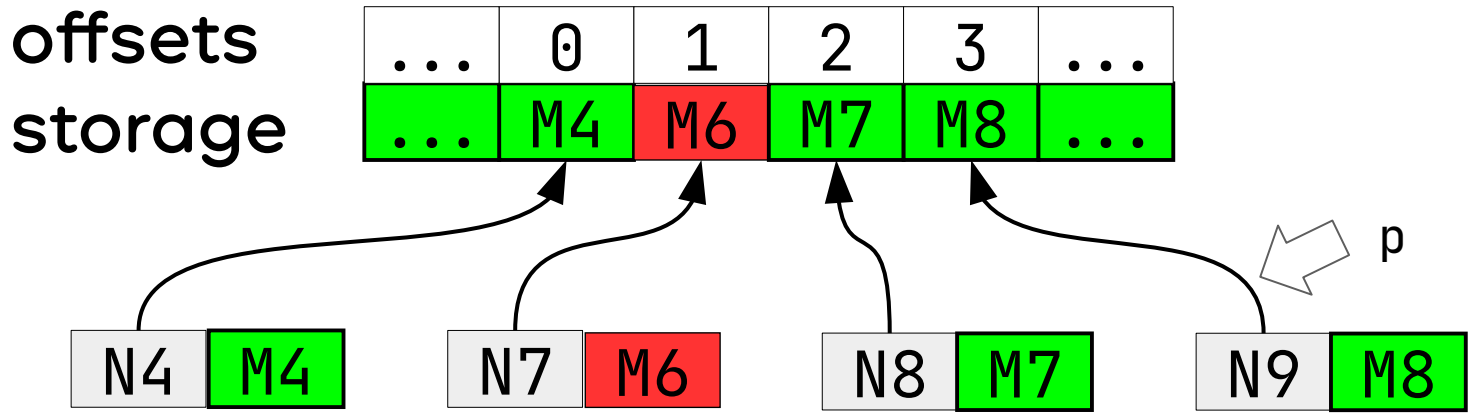
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
9: "M4,M6,M7,M8"
```

i

Распаковка словаря

80 МБ CPU
24 МБ Alloc




```
f(0,p) = storage[p - 3 + 0] = M4
f(1,p) = storage[p - 3 + 1] = M6
f(2,p) = storage[p - 3 + 2] = M7
f(3,p) = storage[p - 3 + 3] = M8
```

Словарь

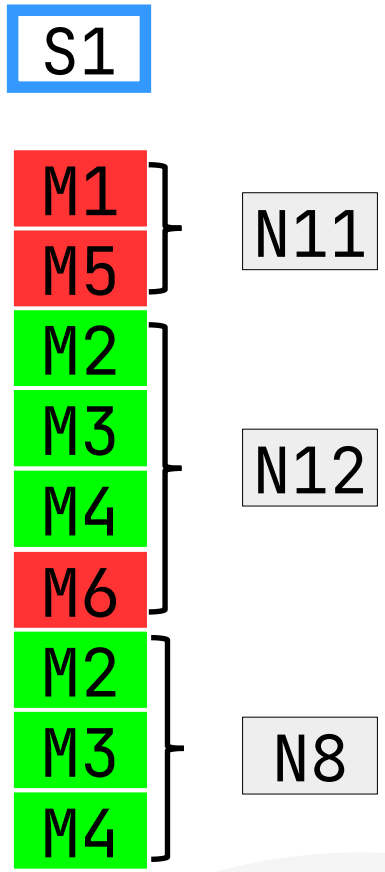
```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M4,M6,M7"
9: "M4,M6,M7,M8"
```

i

Распаковка

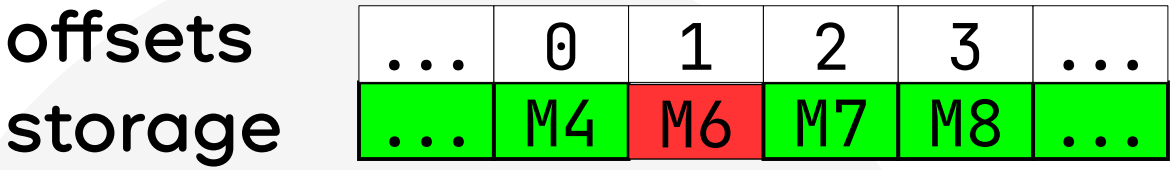
Сэмплов

Распаковка сэмплов



Словарь

```
0:  ""
1:  "M1"
2:  "M2"
3:  "M3"
4:  "M4"
5:  "M5"
6:  "M2,M3"
7:  "M4,M6"
8:  "M2,M3,M4"
9:  "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

N11

N12

N8

offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Словарь

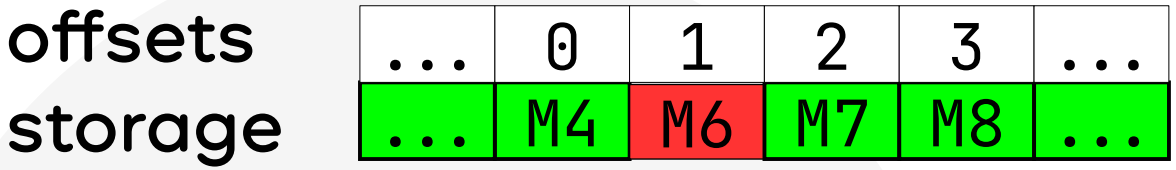
```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

N11 N12 N8

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

N11	N12	N8	N1	N6	N11	N13	...

Сэмплы

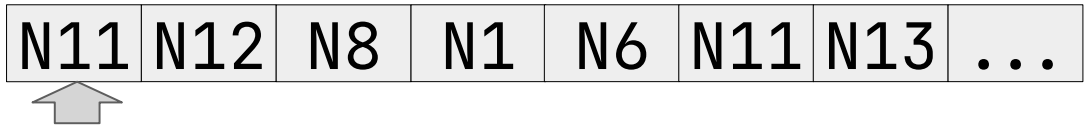
```
0:
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Распаковка сэмплов

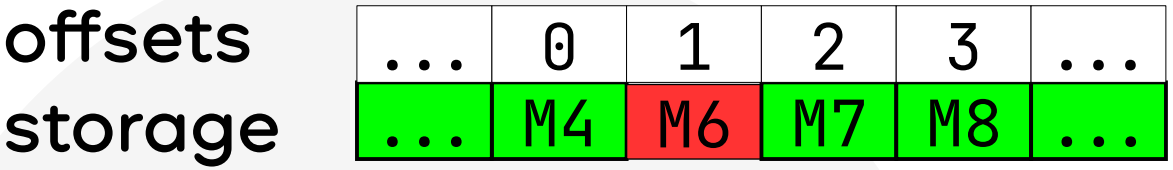


Сэмплы

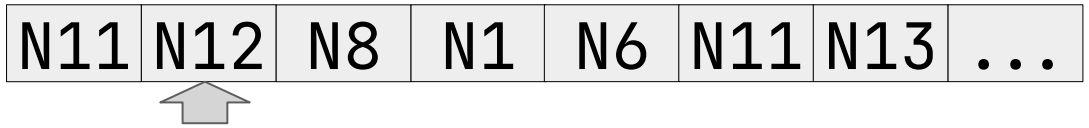
```
0: "N11"
```

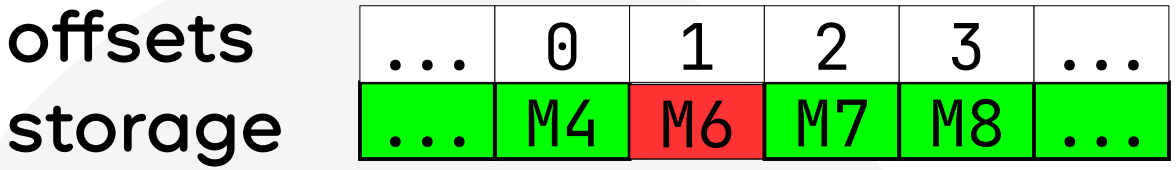
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов





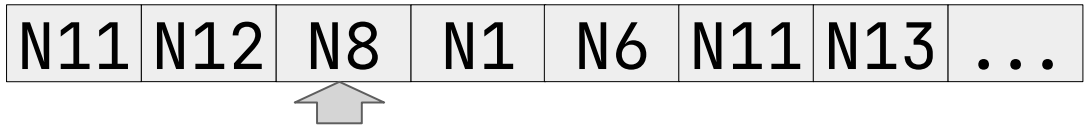
Сэмплы

```
0: "N11,N12"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

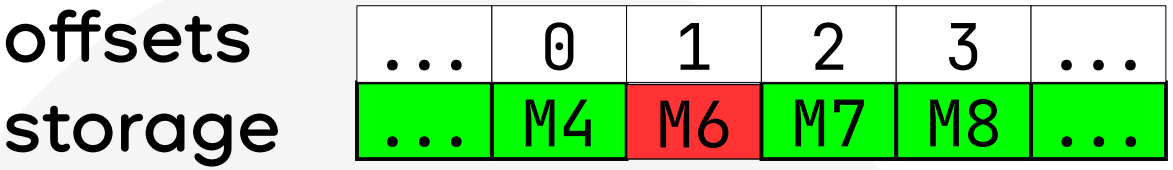


Сэмплы

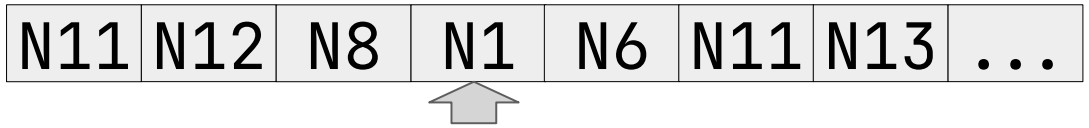
```
0: "N11,N12,N8"
```

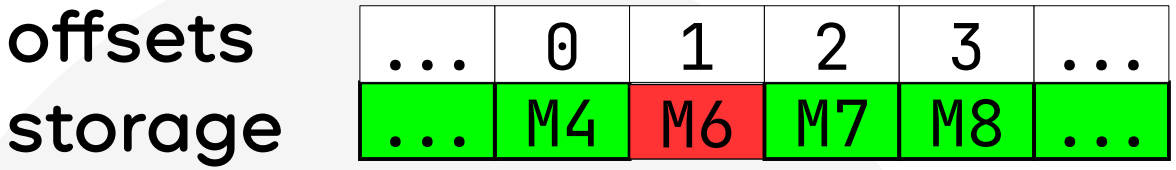
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов





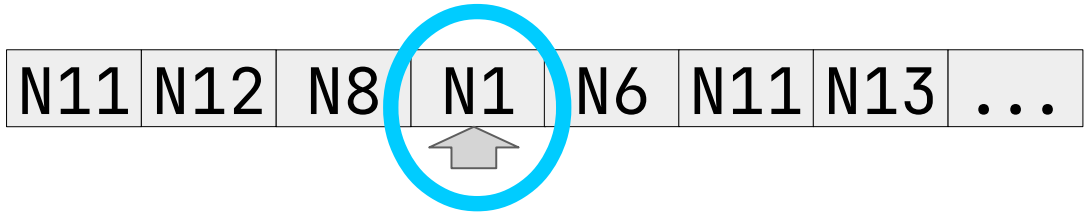
Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

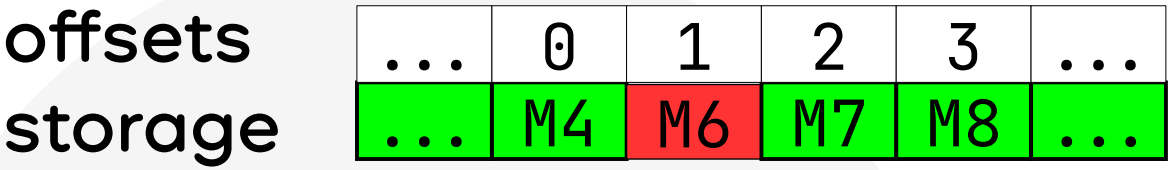


Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

N11	N12	N8	N1	N6	N11	N13	...

offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

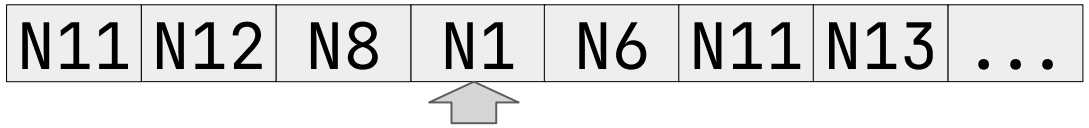
Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

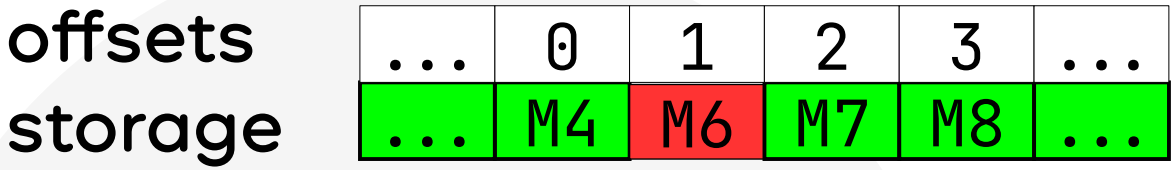
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов




```
java.lang.Thread.run
```



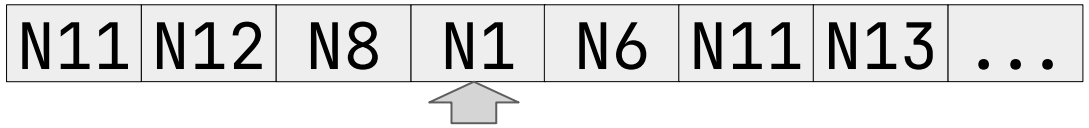
Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

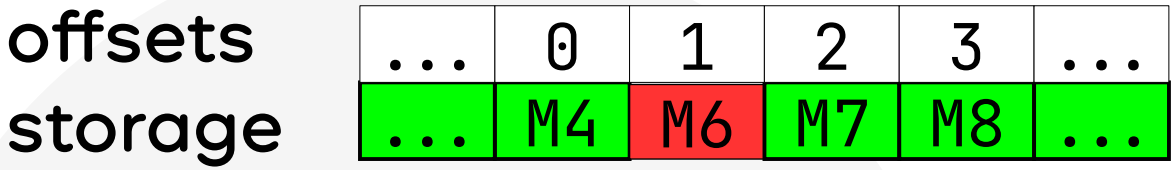
Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов




```
java.lang.Thread.run
```



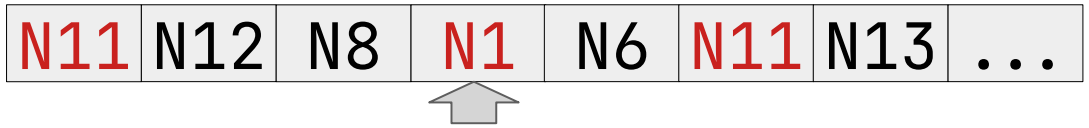
Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов



java.lang.Thread.run

offsets

...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

N11	N12	N8	N1	N6	N11	N13	...

offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

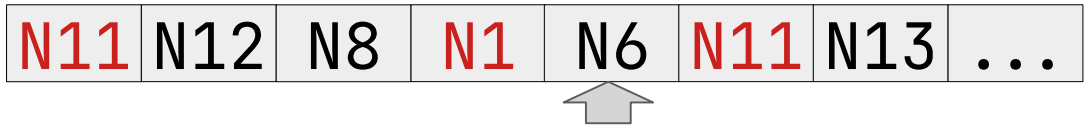
Сэмплы

```
0: "N11,N12,N8"
1: "N1"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

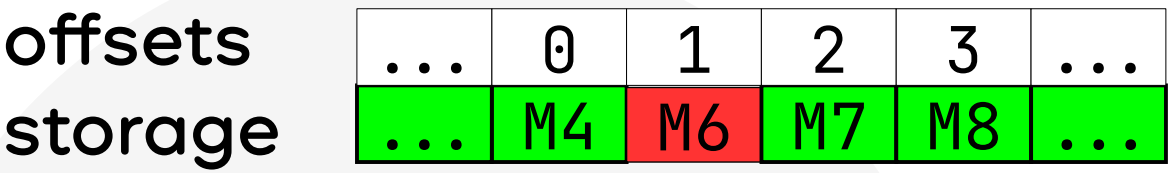


Сэмплы

```
0: "N11,N12,N8"
1: "N1,N6"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



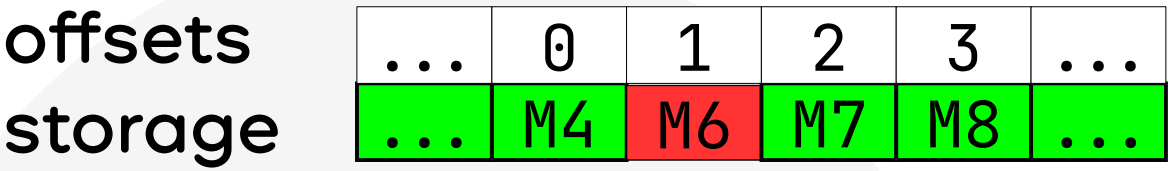
Распаковка сэмплов

Сэмплы

```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



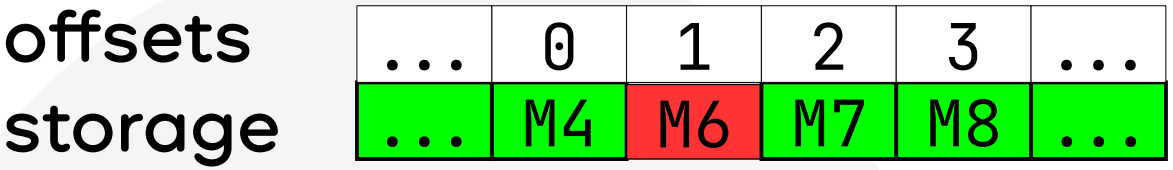
Распаковка сэмплов

Сэмплы

```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

N11	N12	N8	N1	N6	N11	N13	...

offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Сэмплы

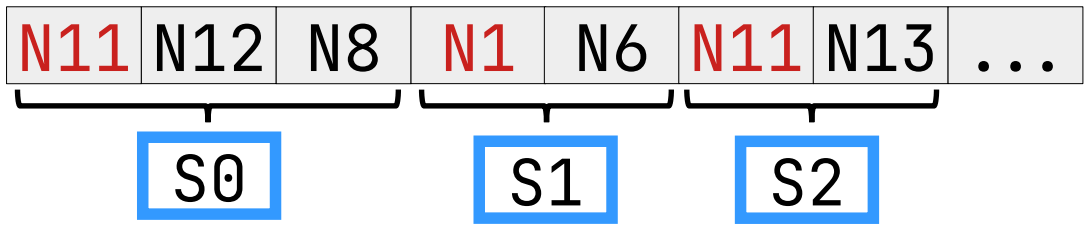
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Аллоцировать нельзя, Карл!

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

Распаковка сэмплов

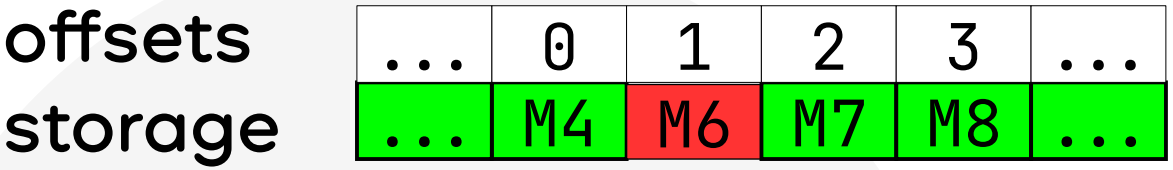


Сэмплы

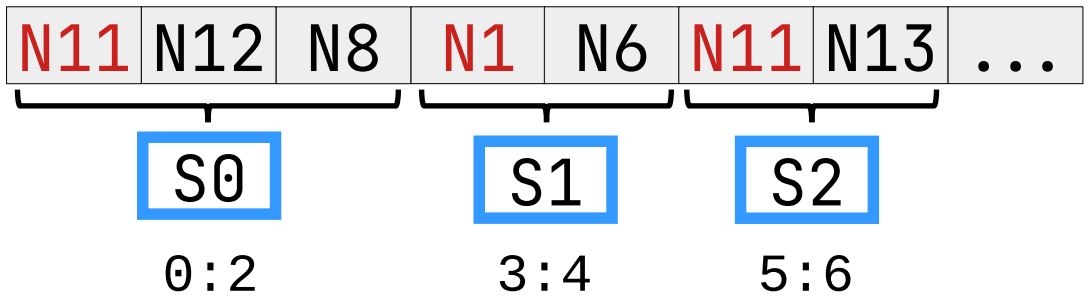
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

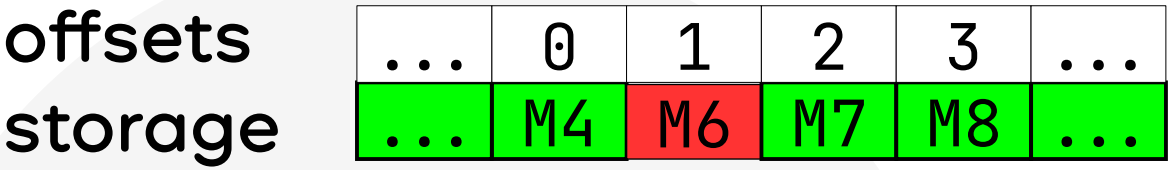


Сэмплы

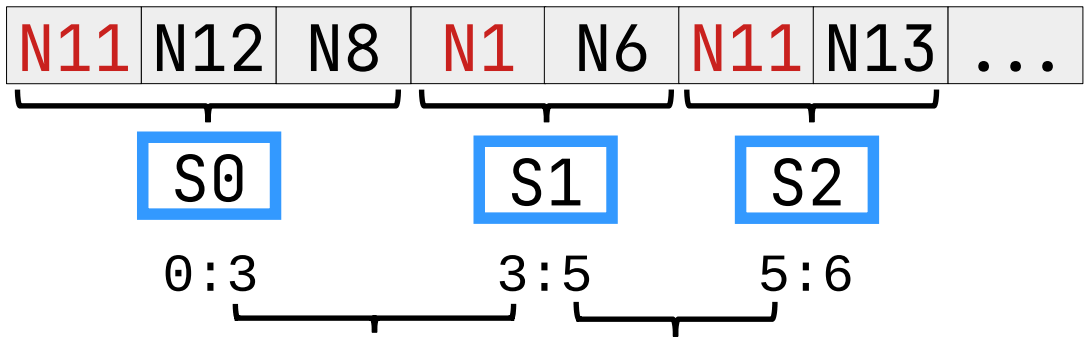
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

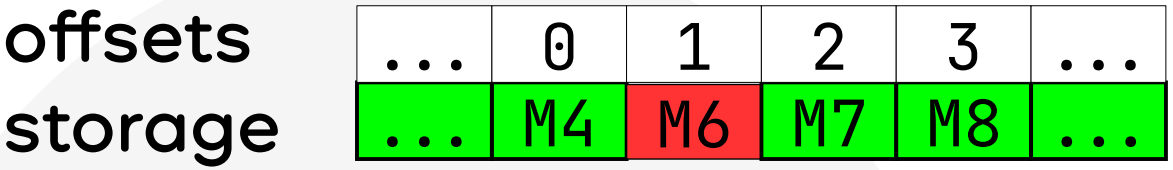


Сэмплы

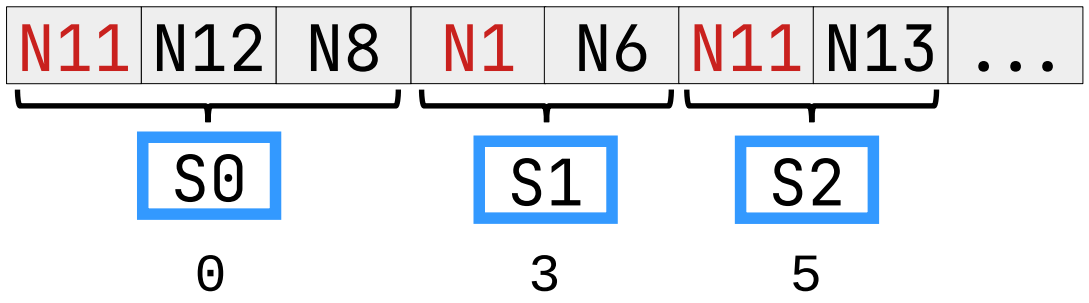
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

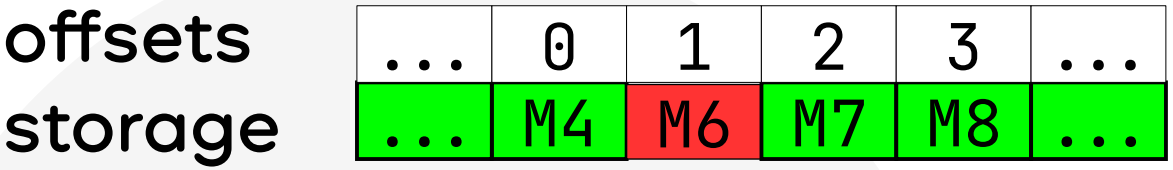


Сэмплы

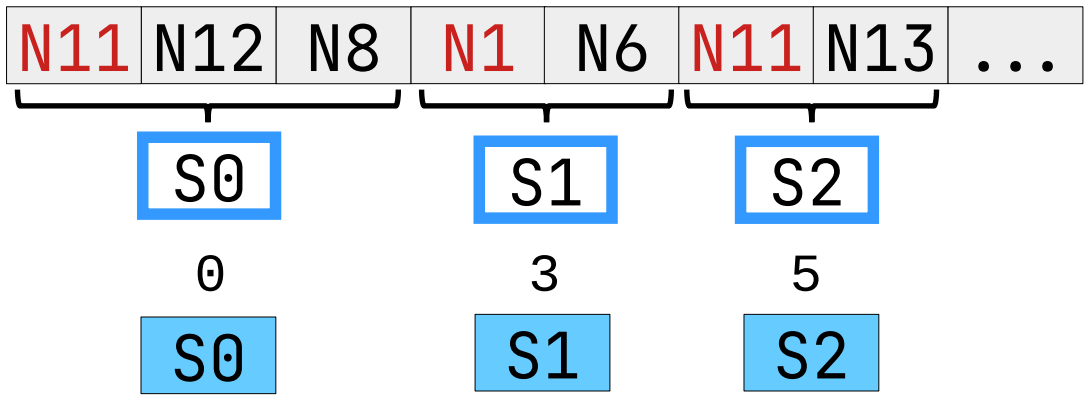
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```



Распаковка сэмплов

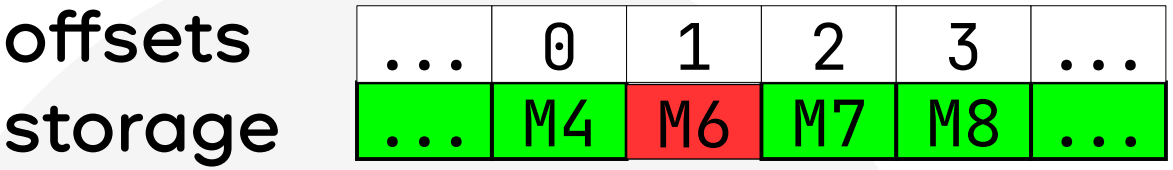


Сэмплы

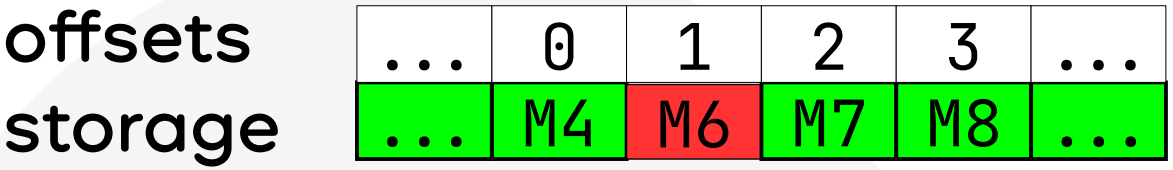
```
0: "N11,N12,N8"
1: "N1,N6"
2: "N11,N13"
```

Словарь

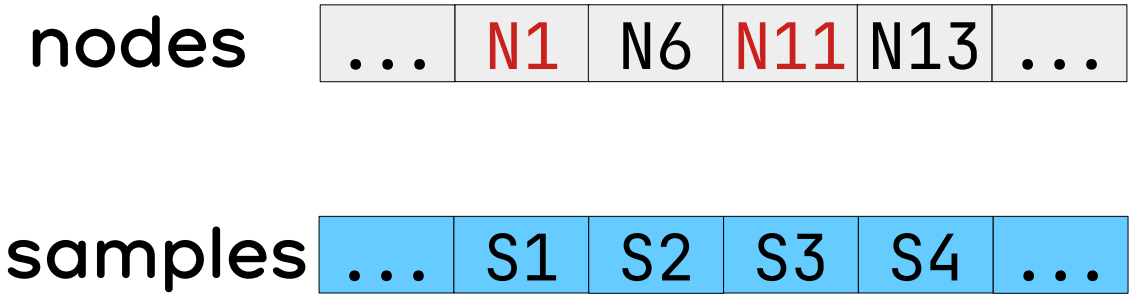
```
0: ""
1: "M1"
2: "M2"
3: "M3"
4: "M4"
5: "M5"
6: "M2,M3"
7: "M4,M6"
8: "M2,M3,M4"
9: "M7"
10:"M8"
11:"M1,M5"
12:"M2,M3,M4,M6"
13:"M2,M3,M4,M9"
```

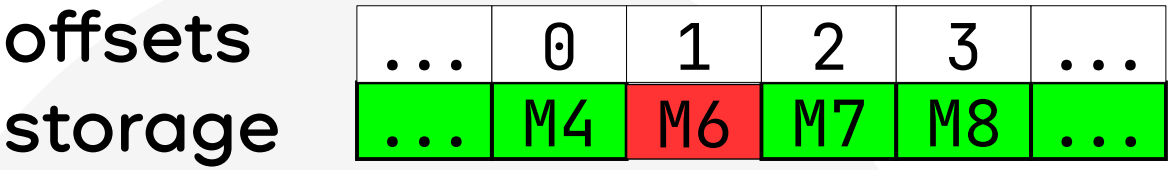


Распаковка сэмплов

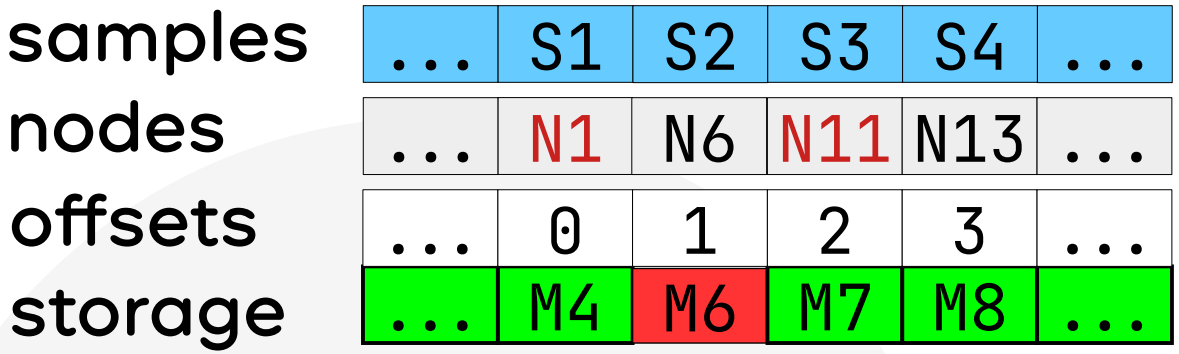


Распаковка сэмплов





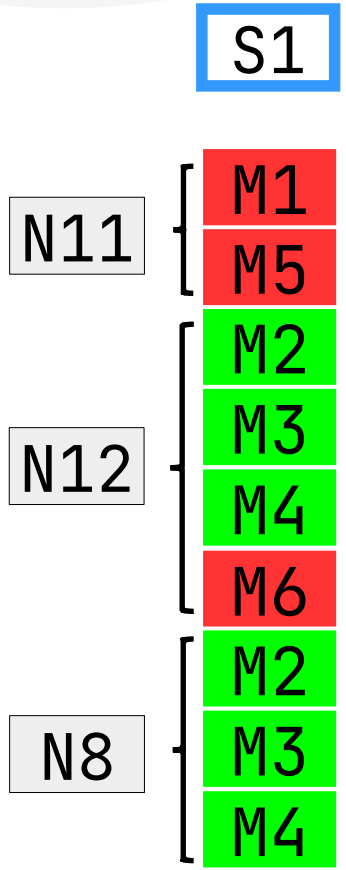
Распаковка сэмплов



Распаковка

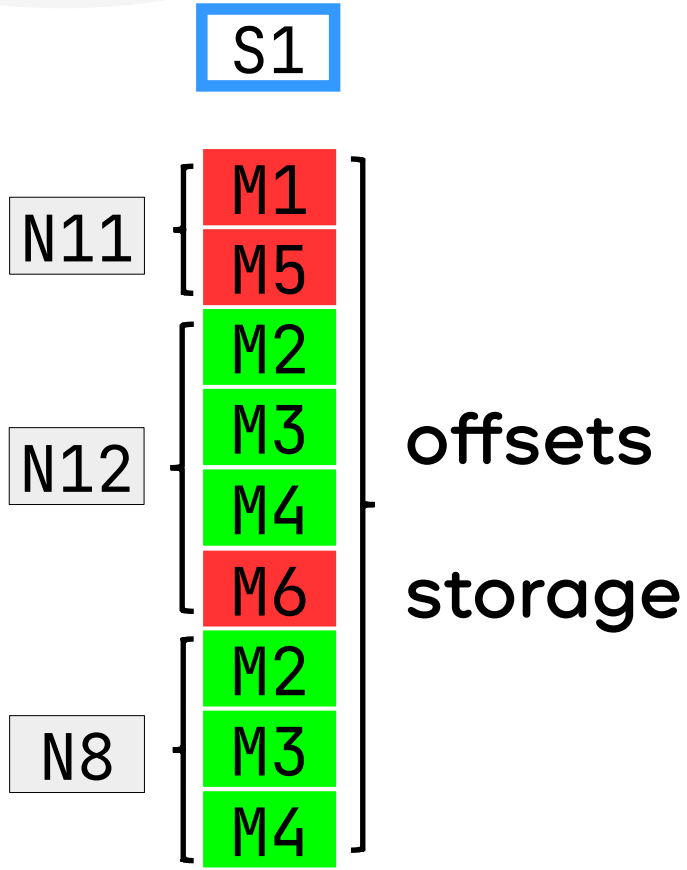
Закрепляем

Распаковка: закрепляем



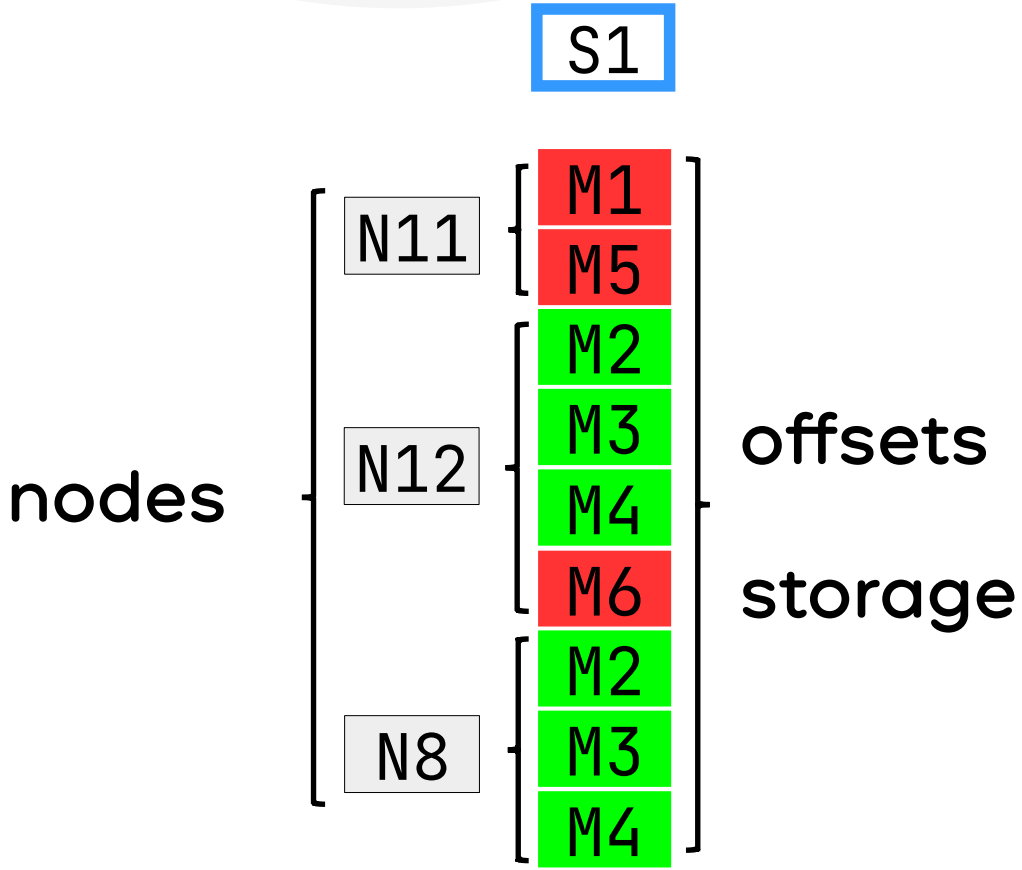
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Распаковка: закрепляем



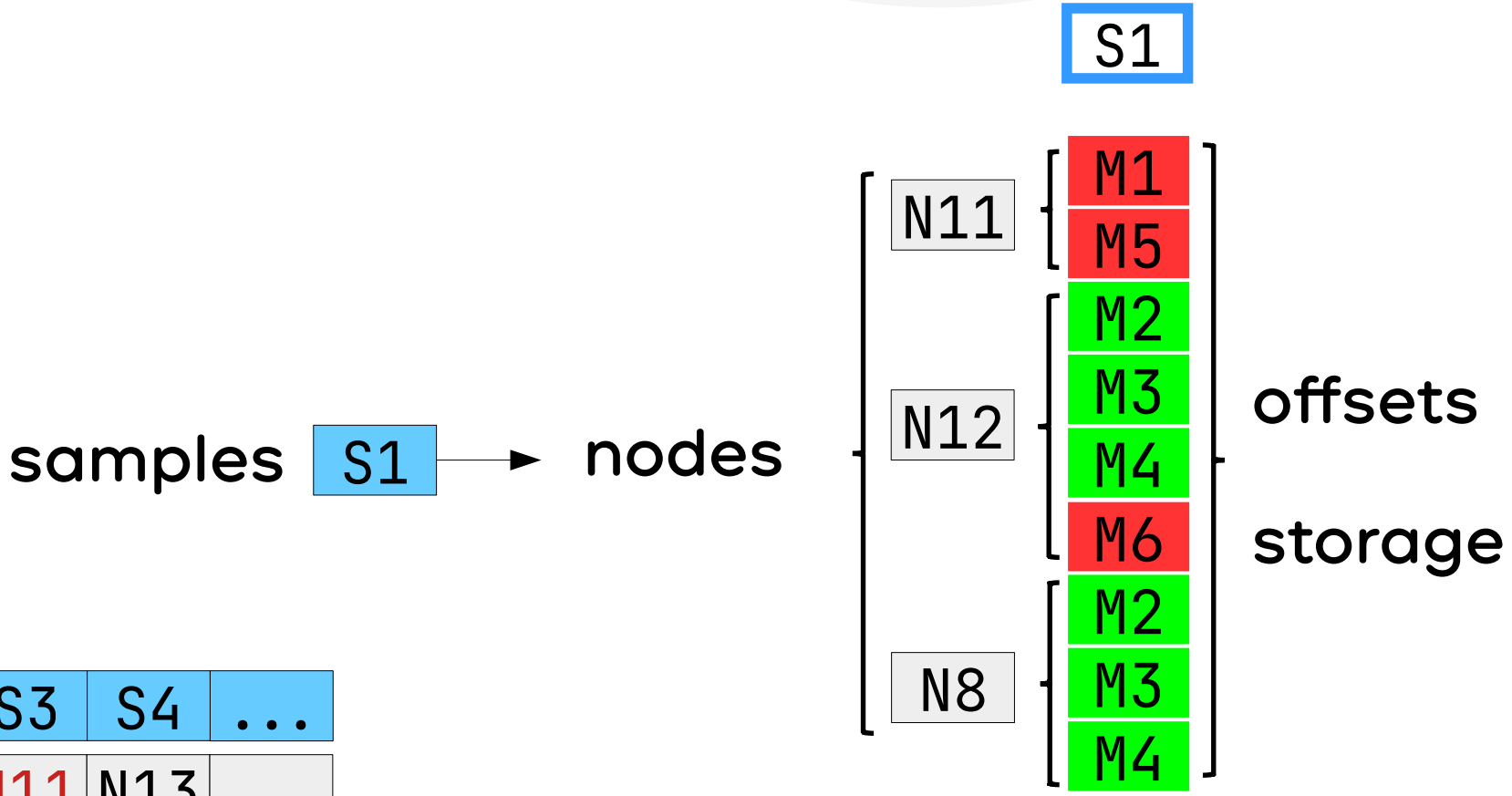
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Распаковка: закрепляем



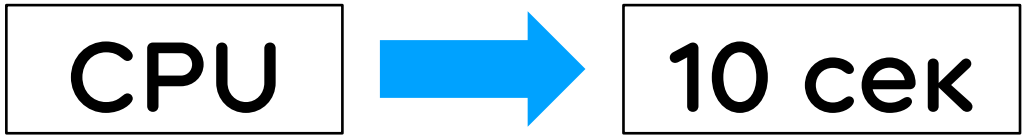
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

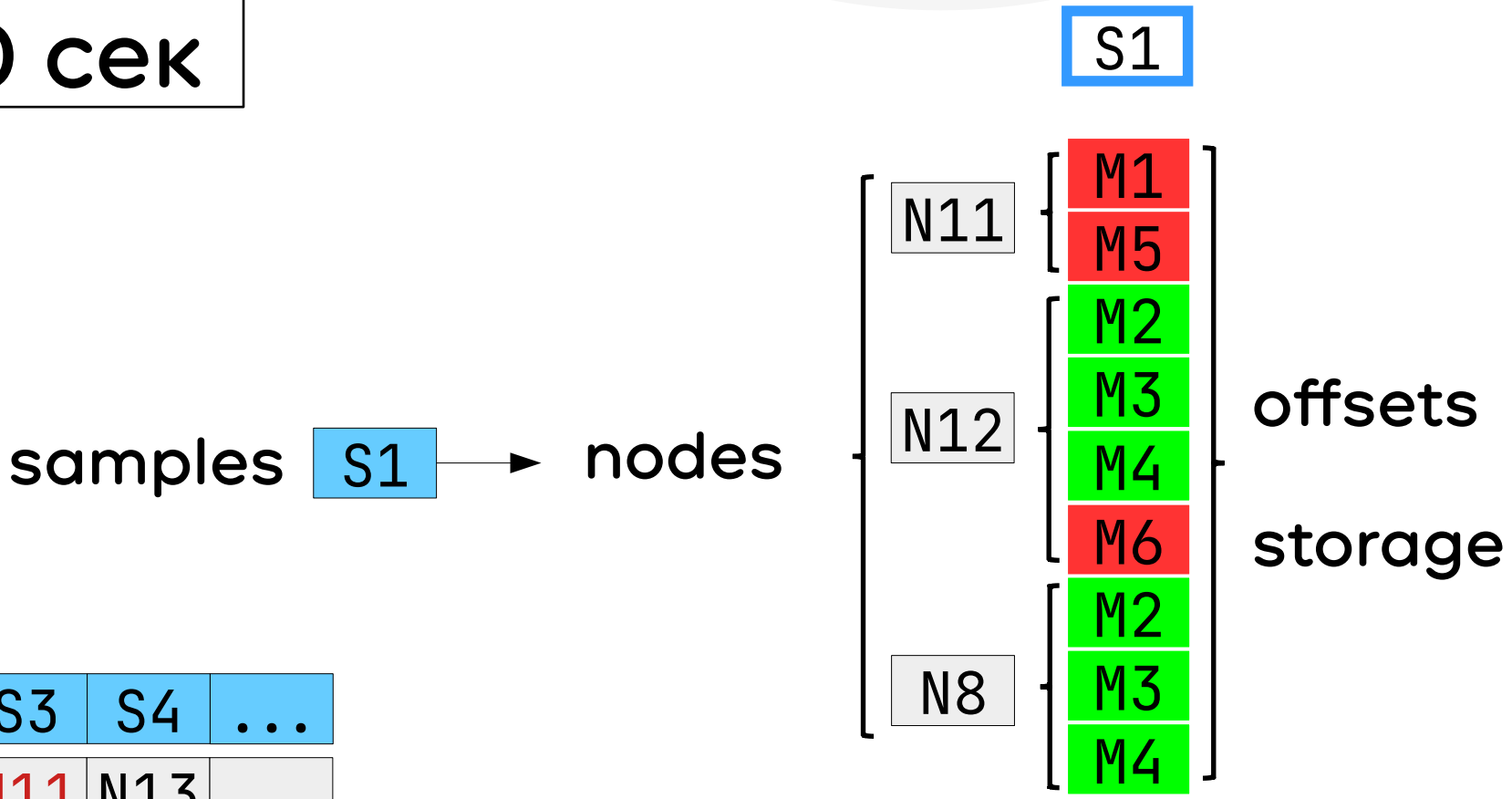
Распаковка: закрепляем



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

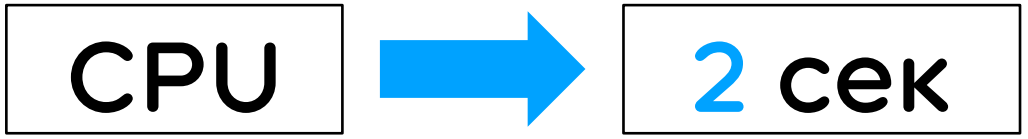
Распаковка: закрепляем

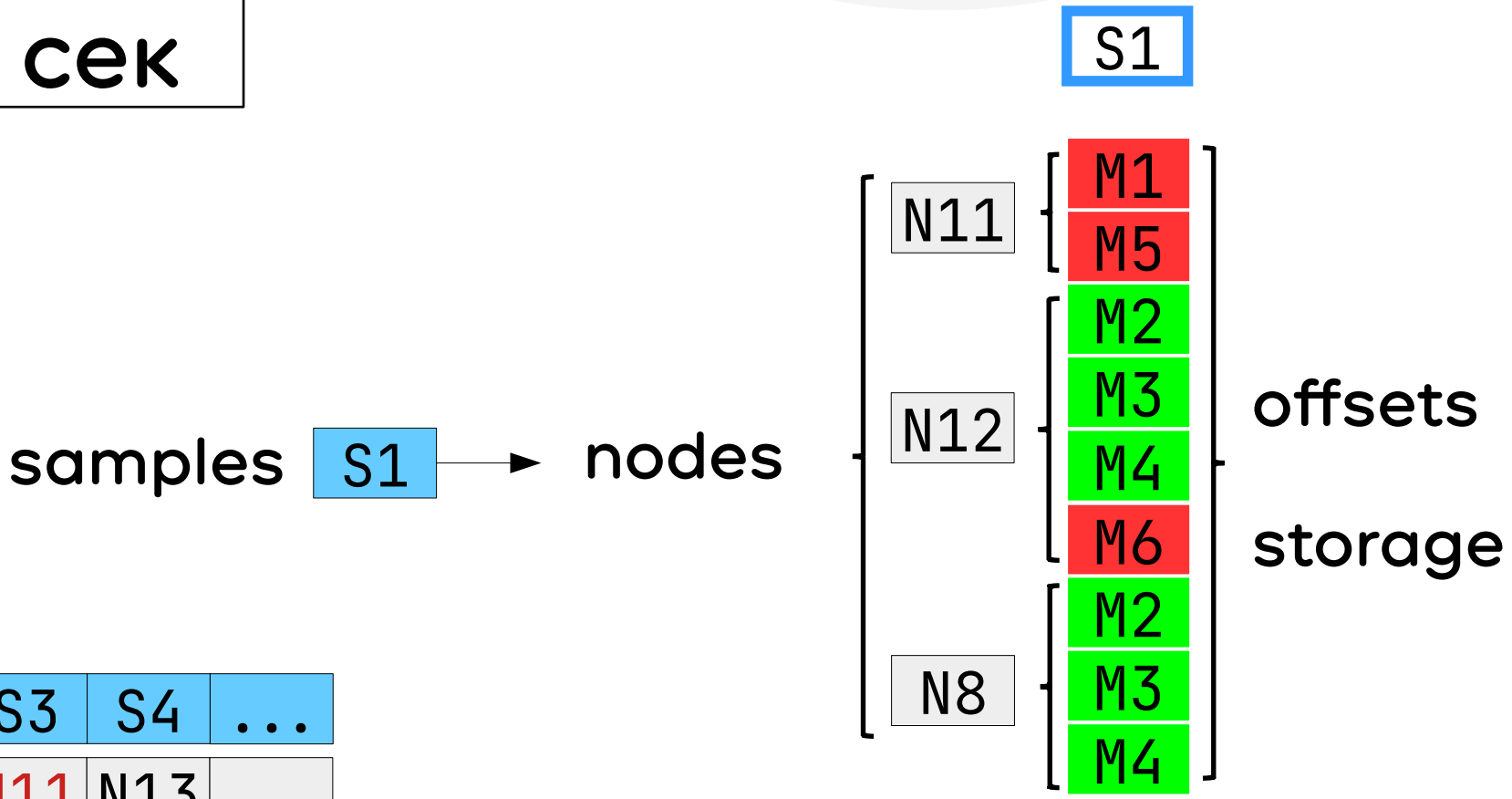




samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

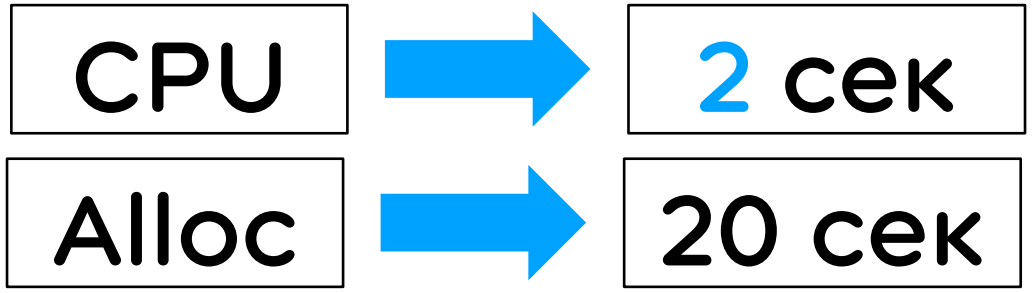
Распаковка: закрепляем

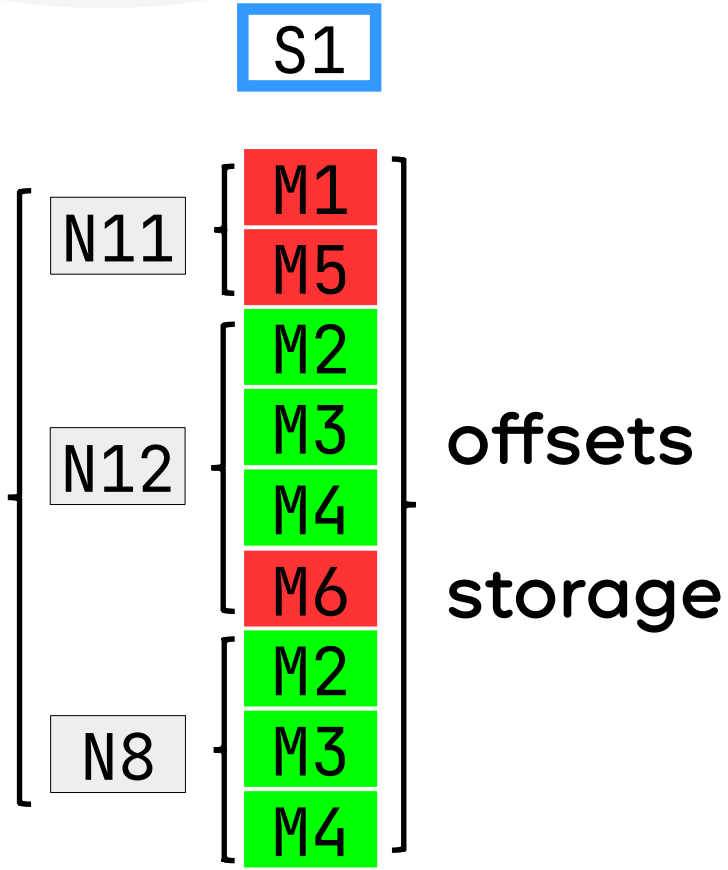




samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

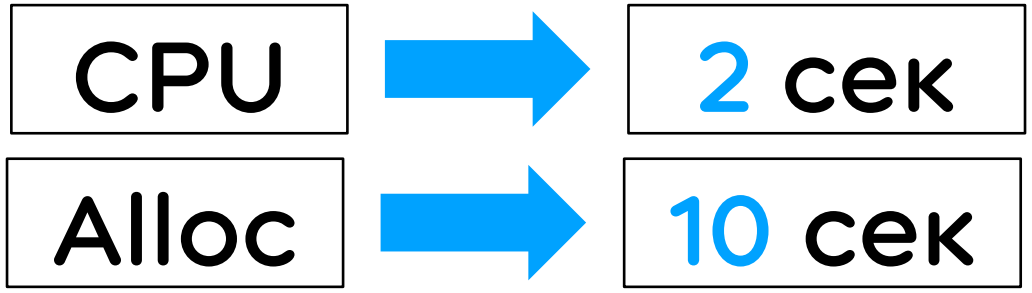
Распаковка: закрепляем

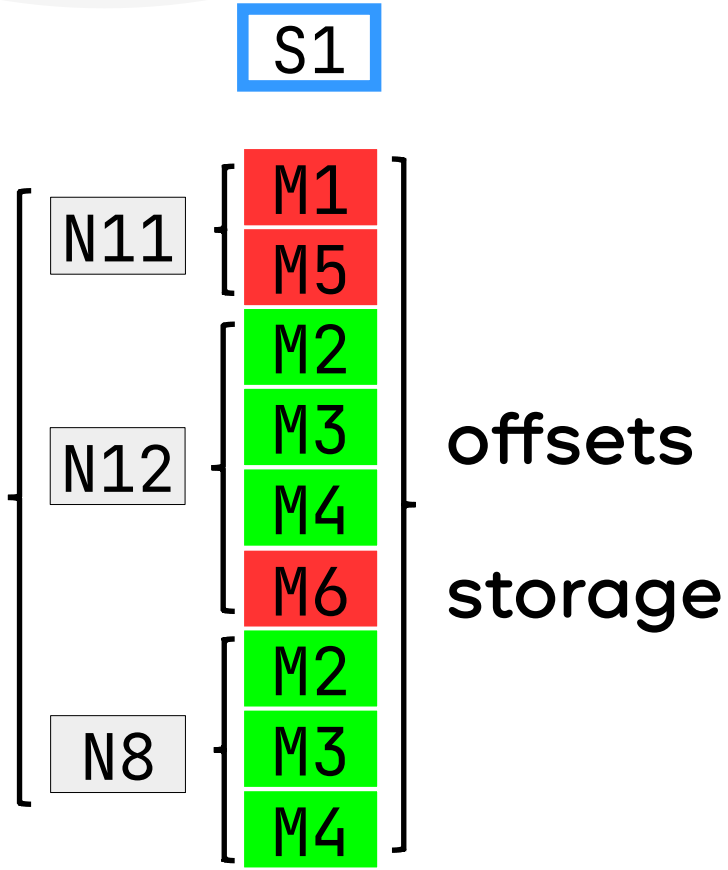




samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Распаковка: закрепляем



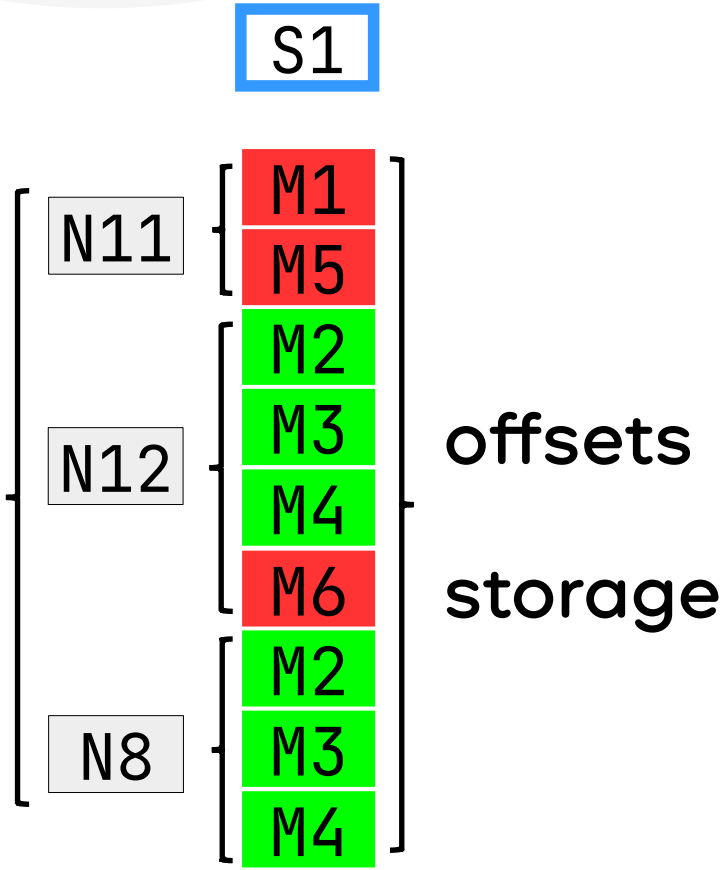


samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Распаковка: закрепляем

CPU	2 сек
Alloc	10 сек

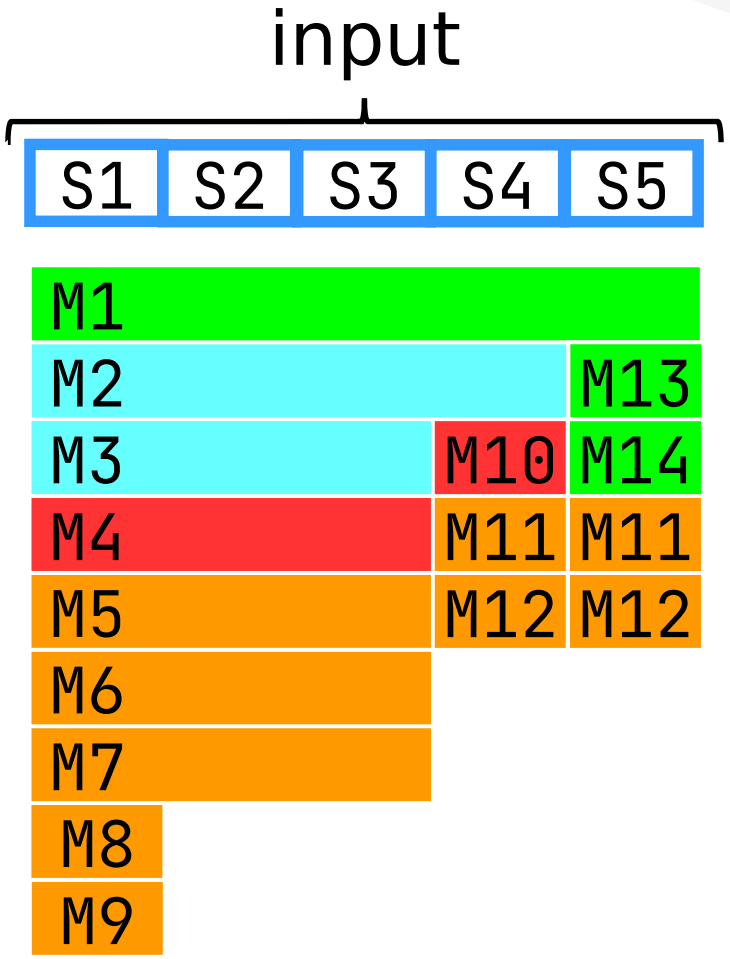
samples S1 → nodes



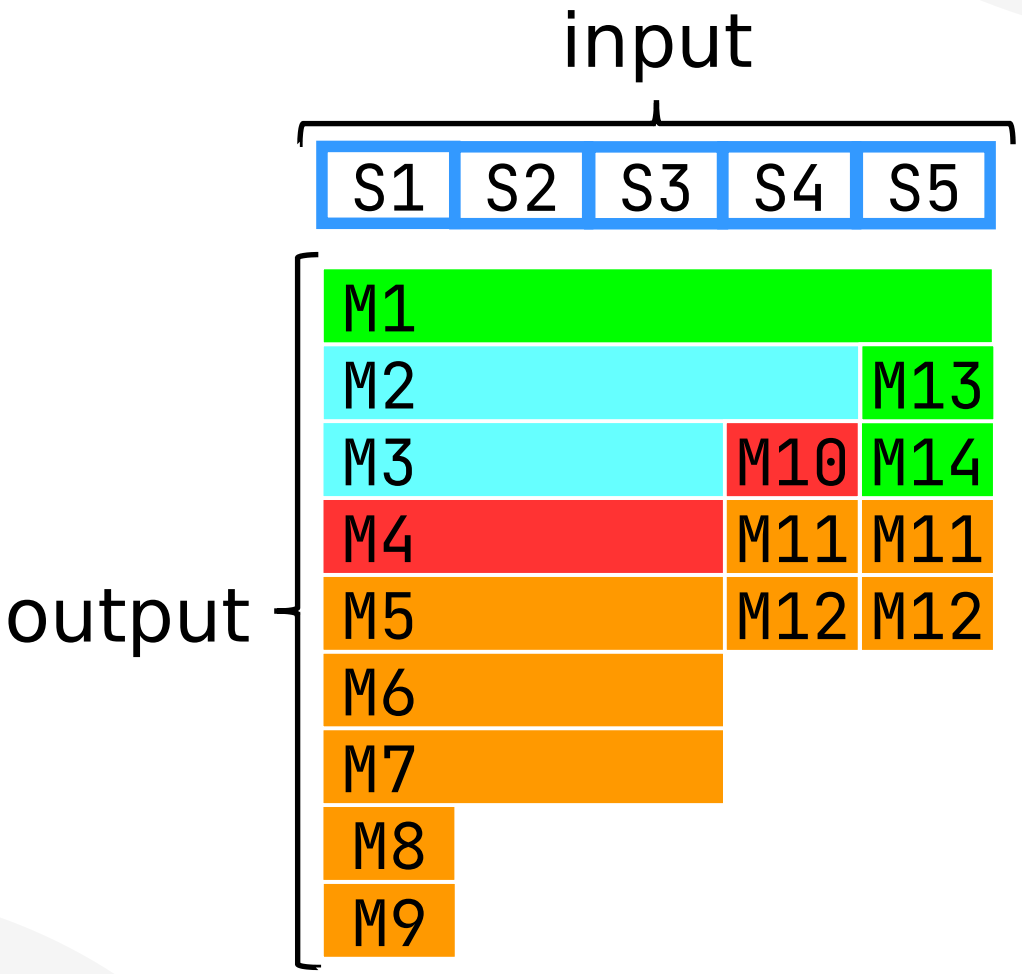
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

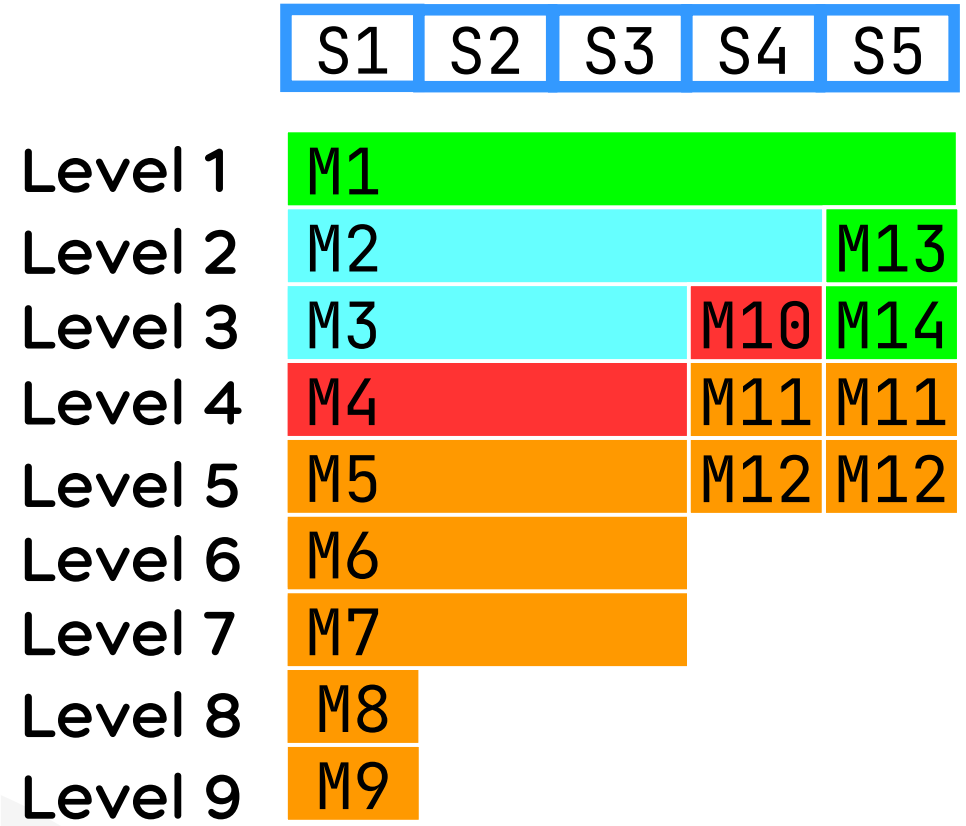
Что рисуем?


input
S1
S2
S3
S4
S5
M1
M2
M13
M3
M10
M14
M4
M11
M11
M5
M12
M12
M6
M7
M8
M9

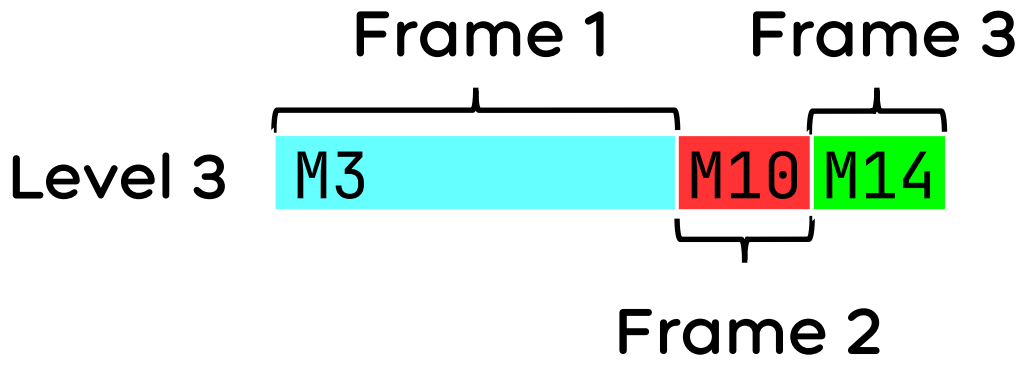
Что рисуем?


input
S1
S2
S3
S4
S5
output
M1
M2
M13
M3
M10
M14
M4
M11
M11
M5
M12
M12
M6
M7
M8
M9

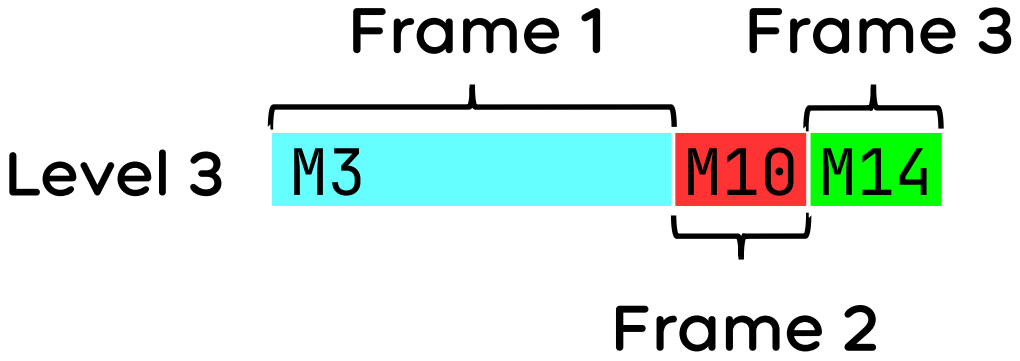
Что рисуем?


S1
S2
S3
S4
S5
Level 1
Level 2
Level 3
Level 4
Level 5
Level 6
Level 7
Level 8
Level 9
M1
M2
M13
M3
M10
M14
M4
M11
M11
M5
M12
M12
M6
M7
M8
M9

Что рисуем?



Что рисуем?

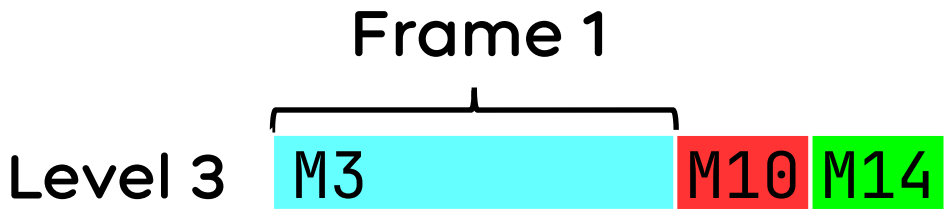


Что рисуем?

FlameGraph: `Level[]`

Level: `Frame[]`

Frame: `{x, width, text, color}`



Что рисуем?

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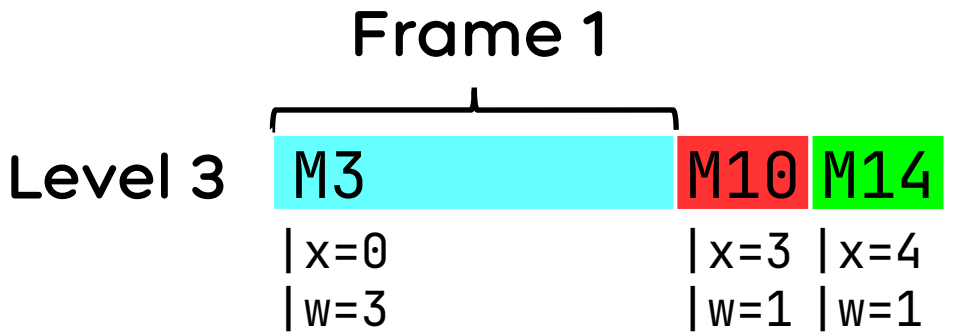

Что рисуем?

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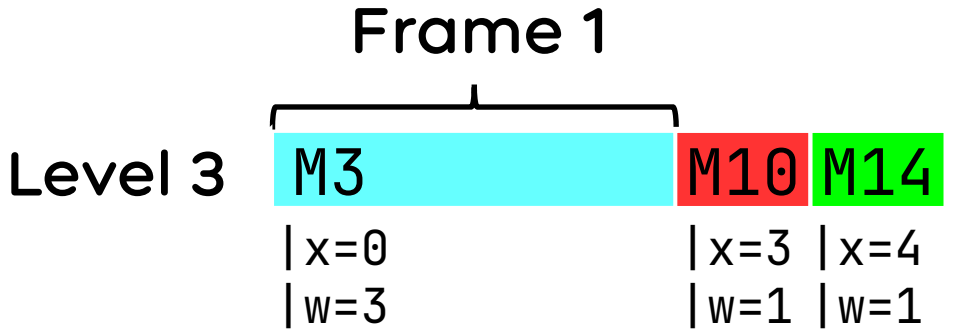
} Результат работы



Что рисуем?

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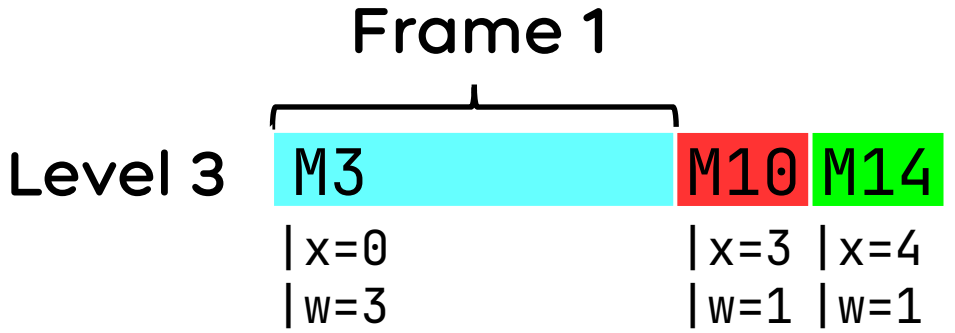
Результат работы



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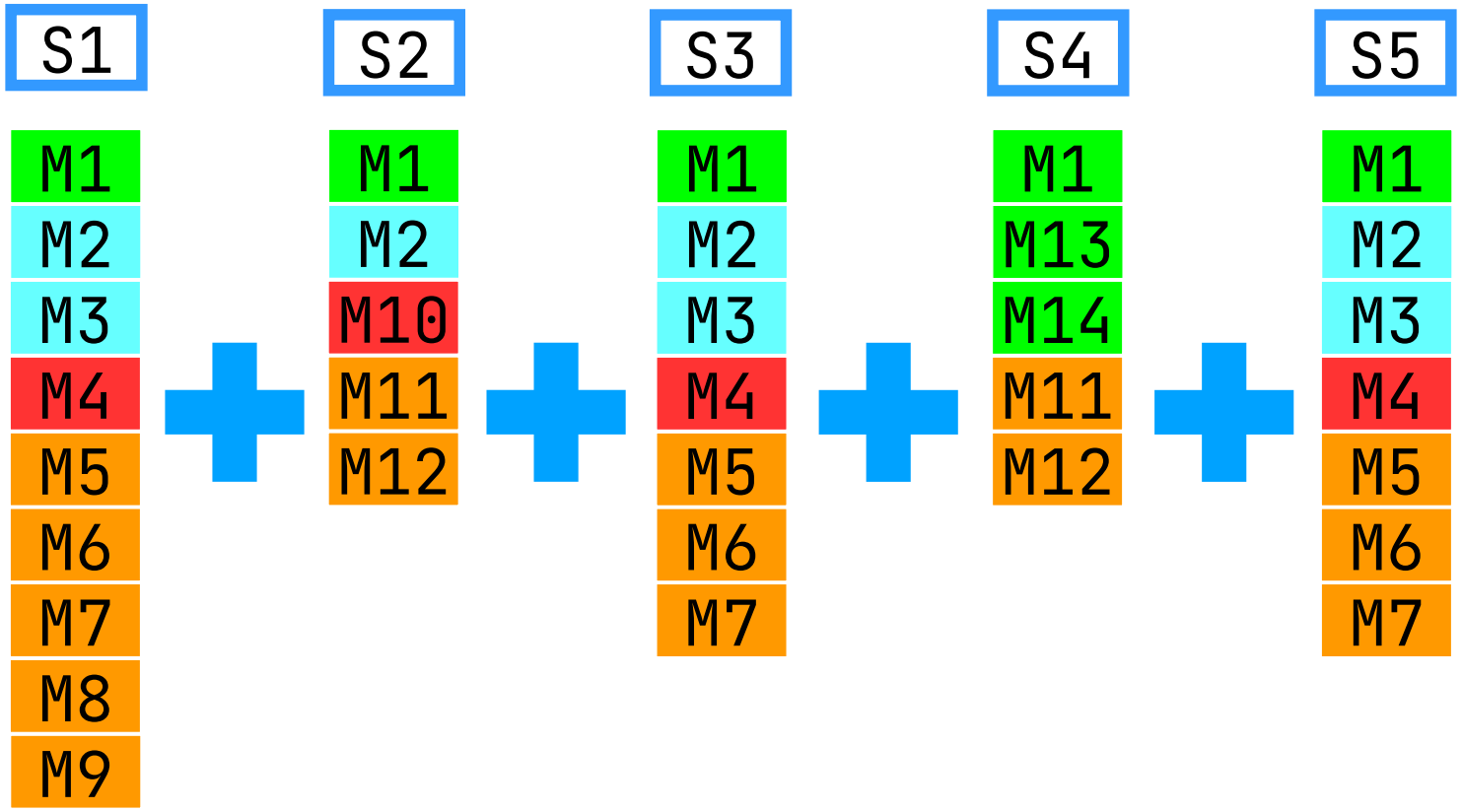
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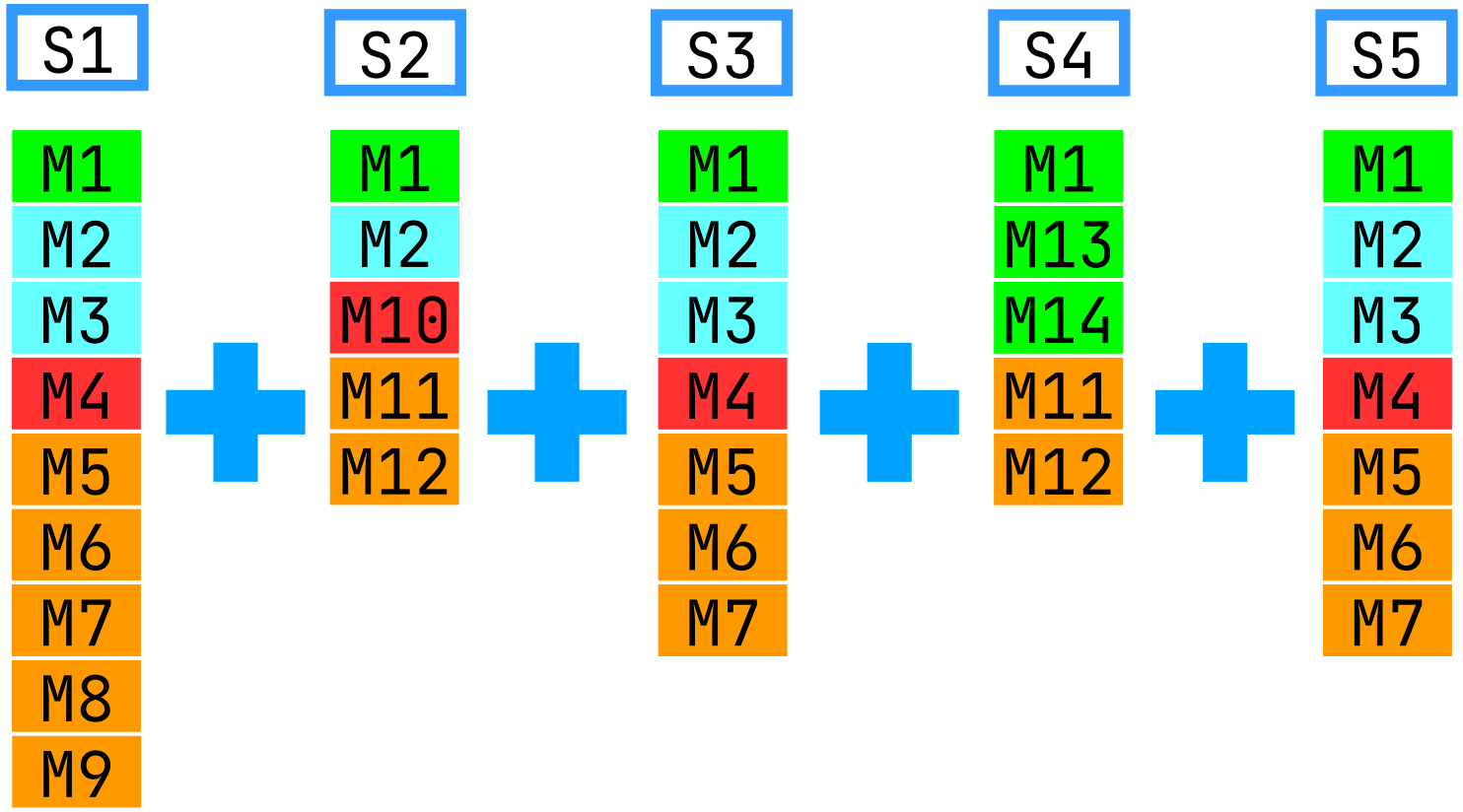
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Как рисуем?

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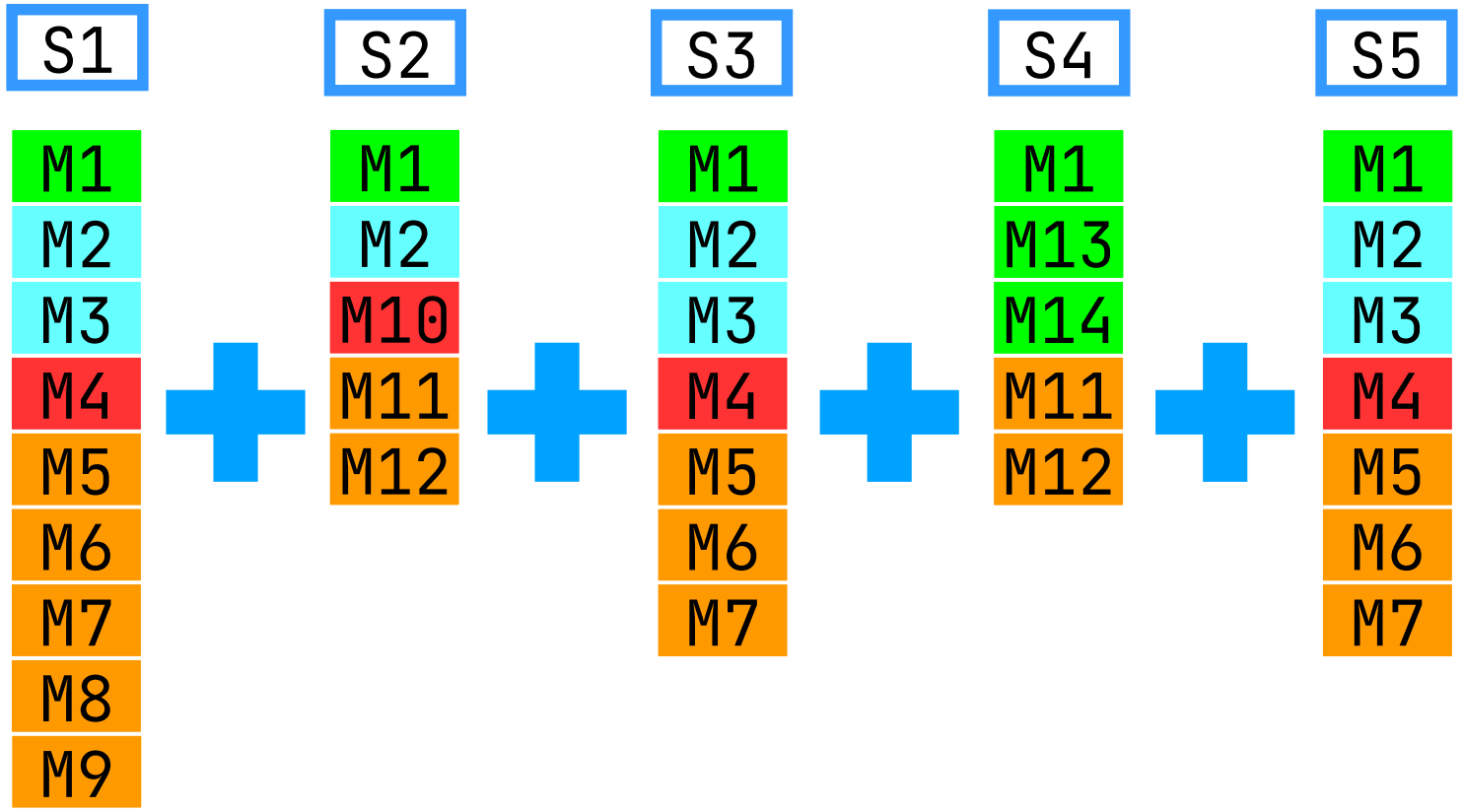
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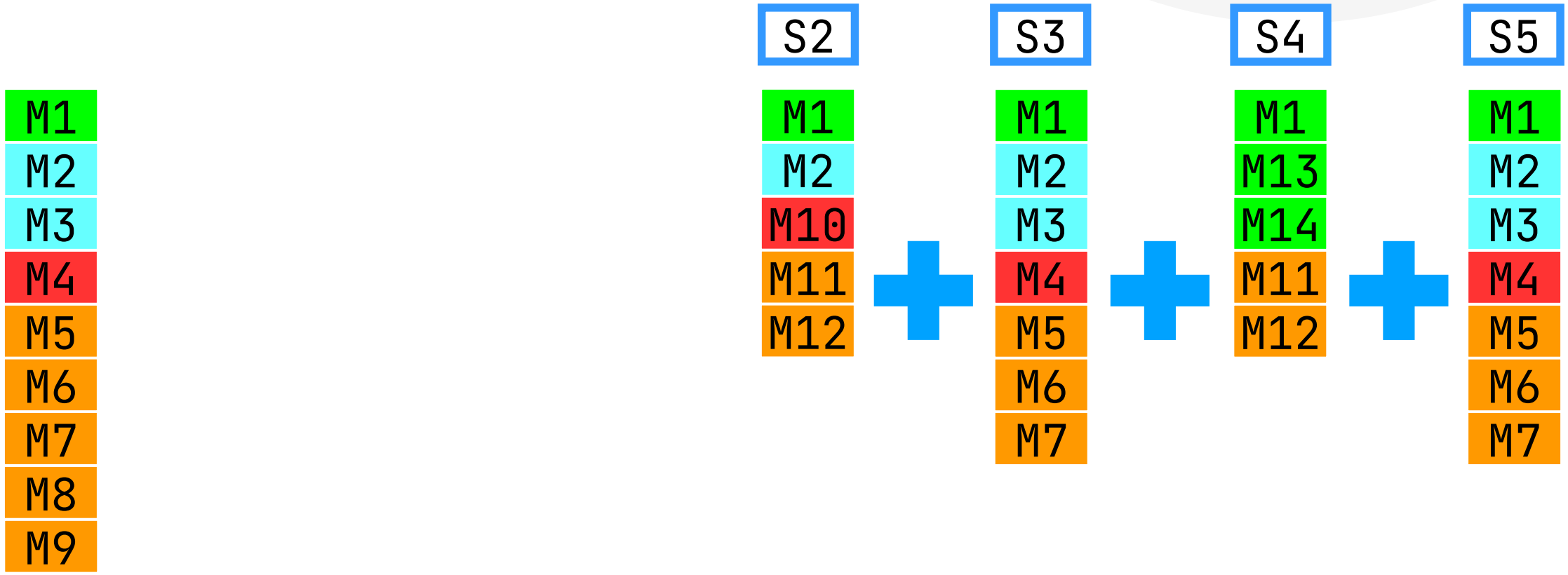
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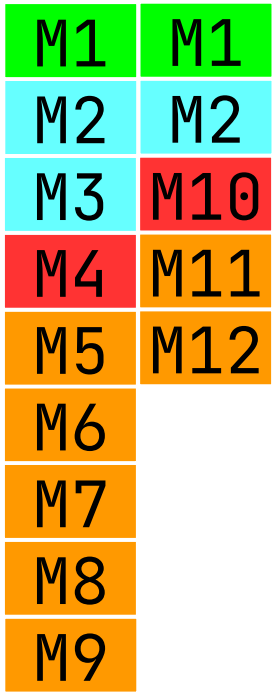
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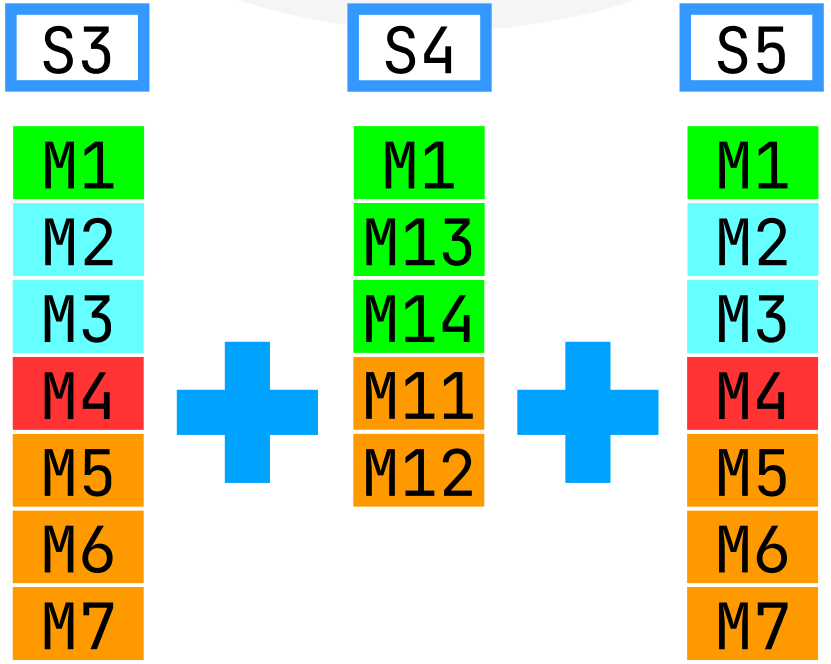
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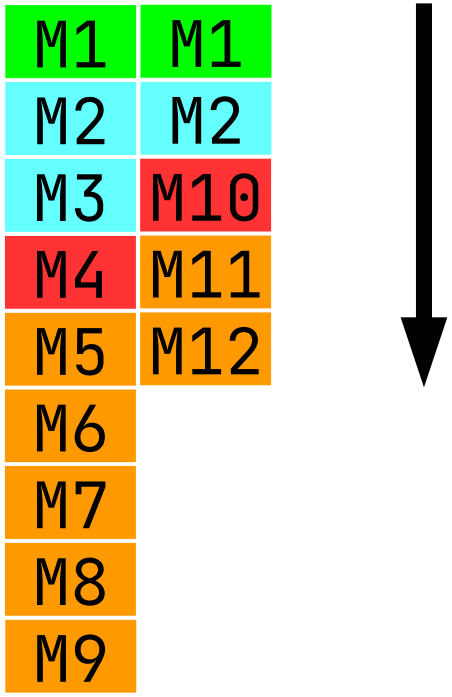
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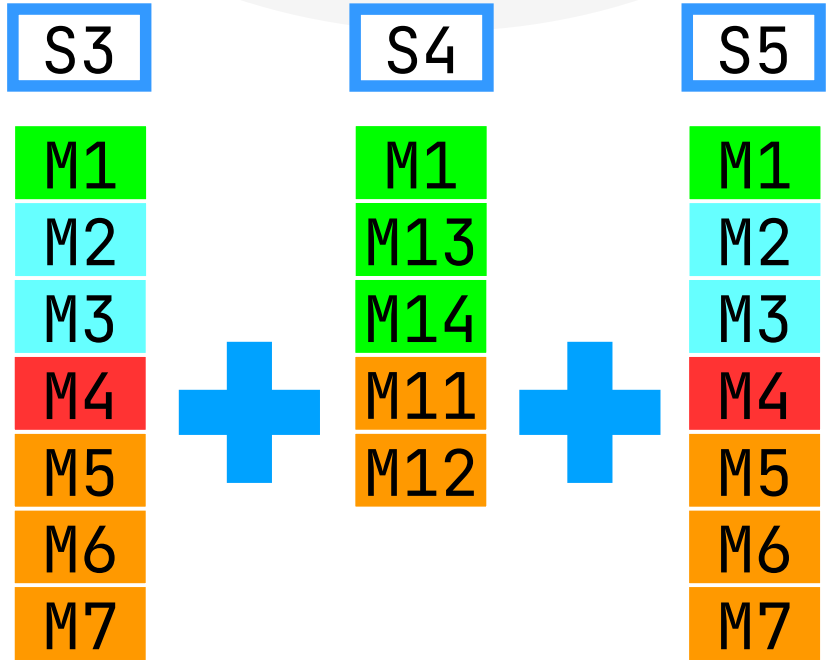
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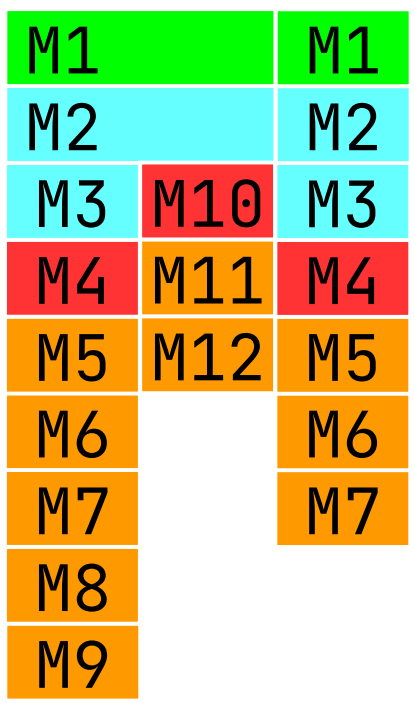
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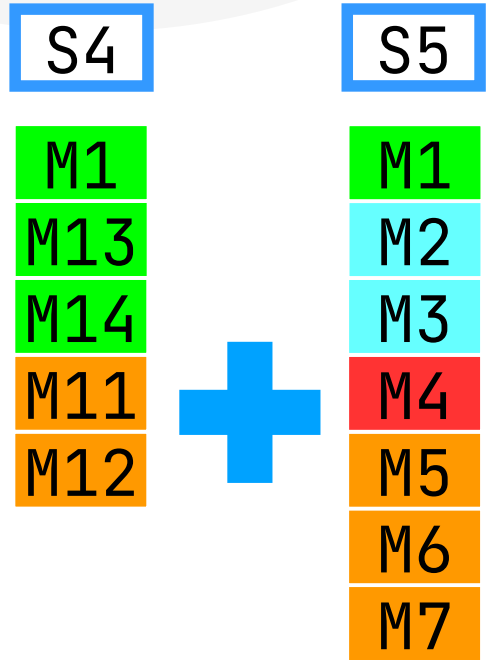
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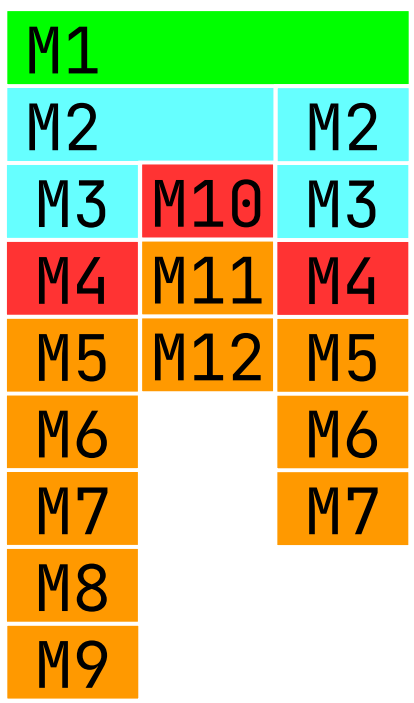
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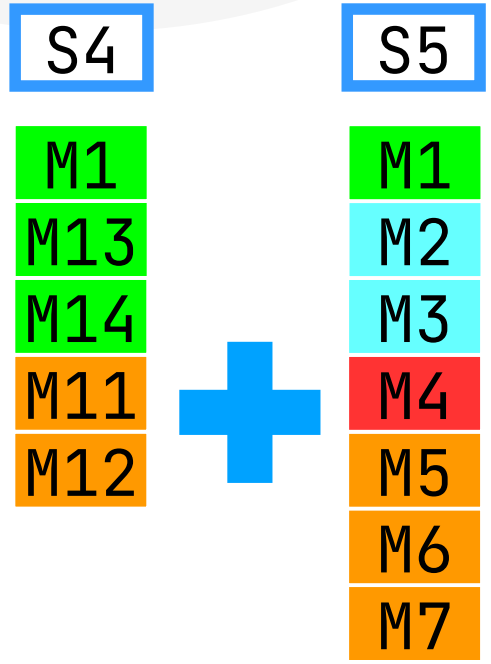
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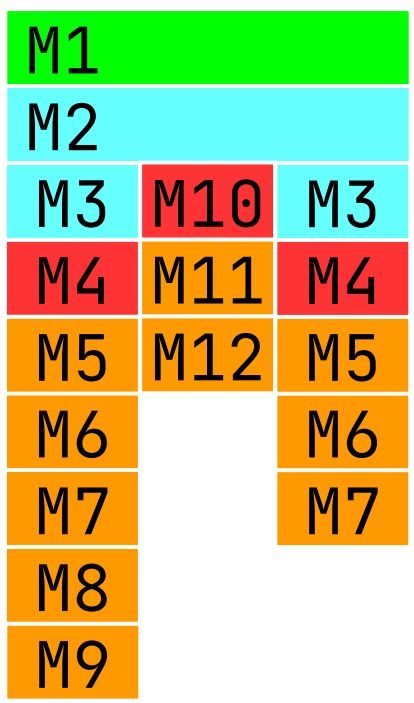
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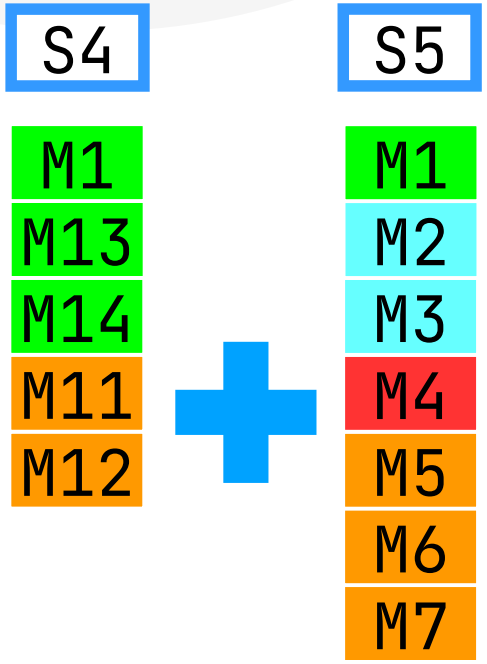
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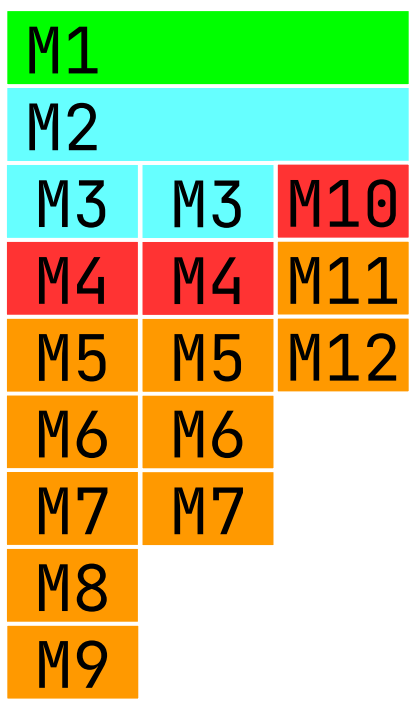
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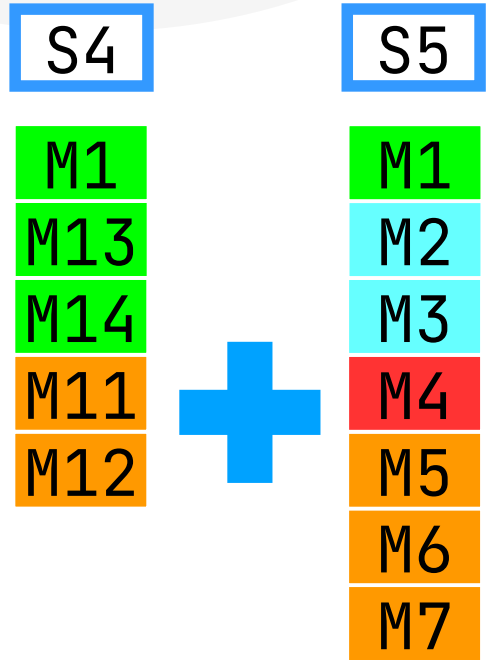
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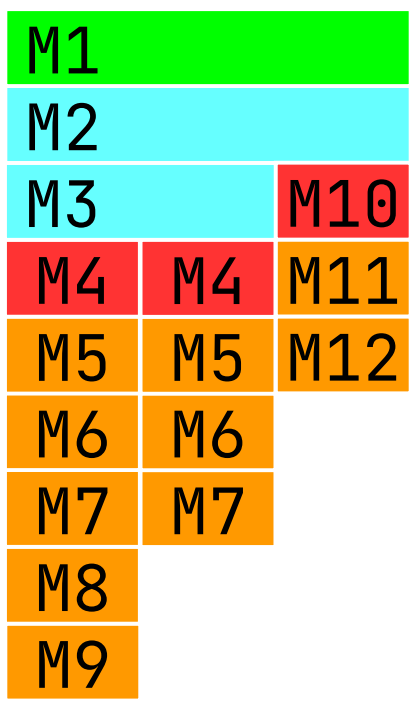
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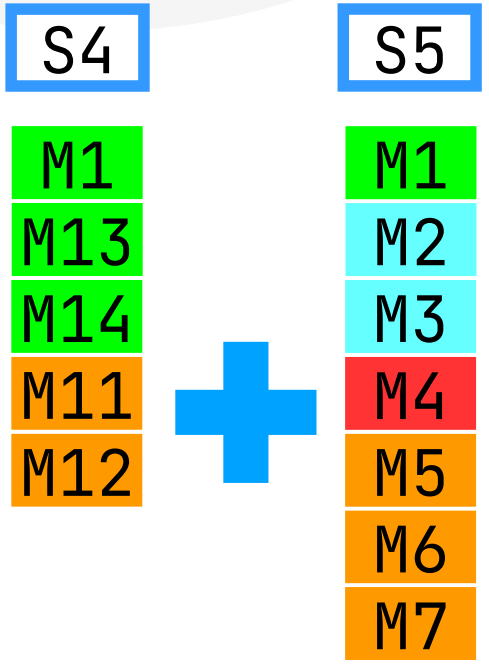
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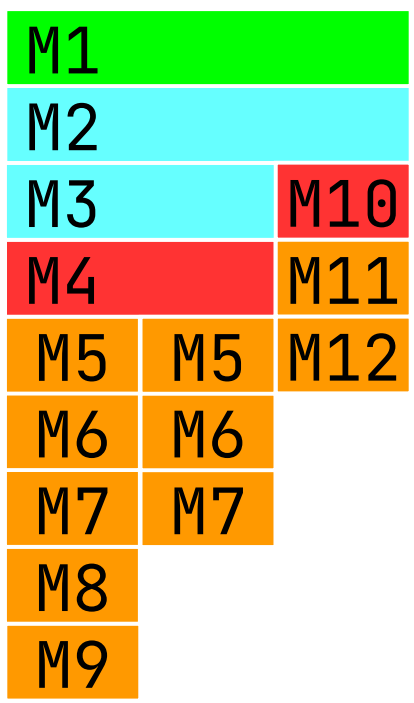
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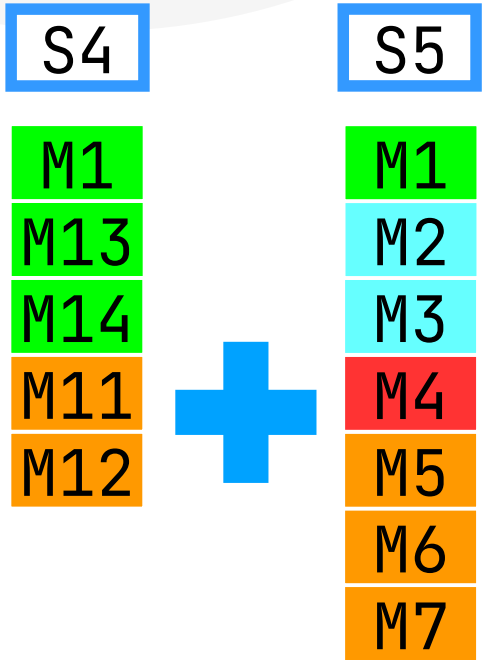
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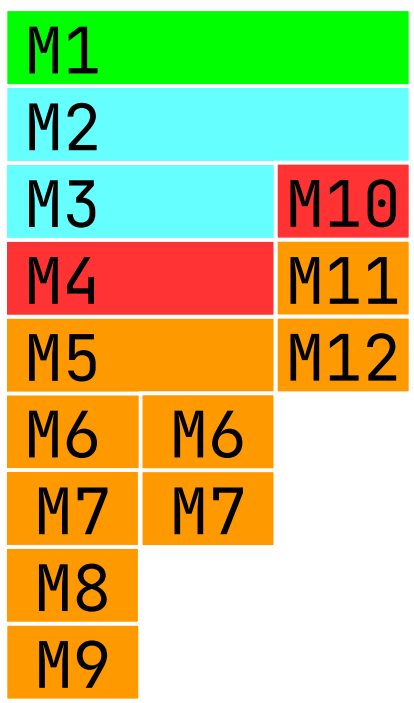
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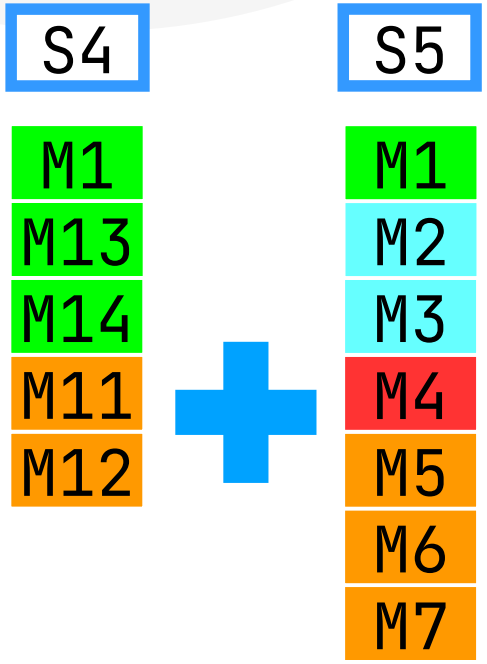
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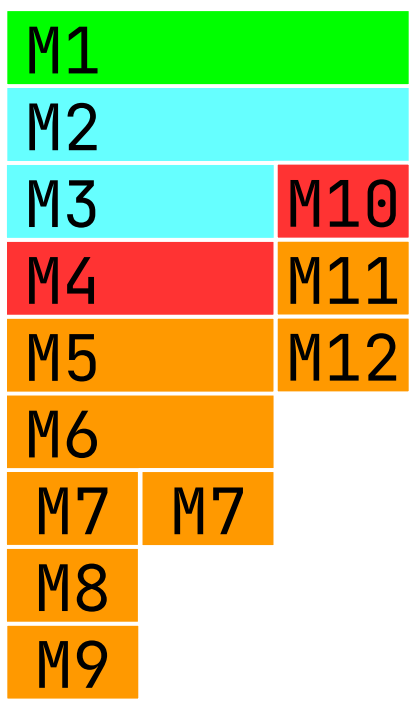
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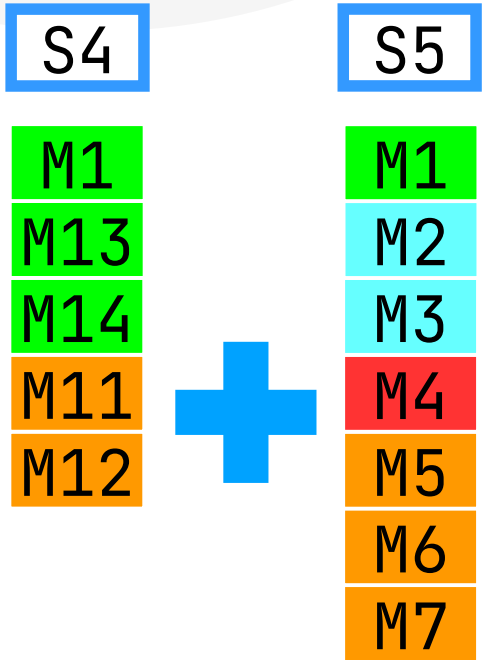
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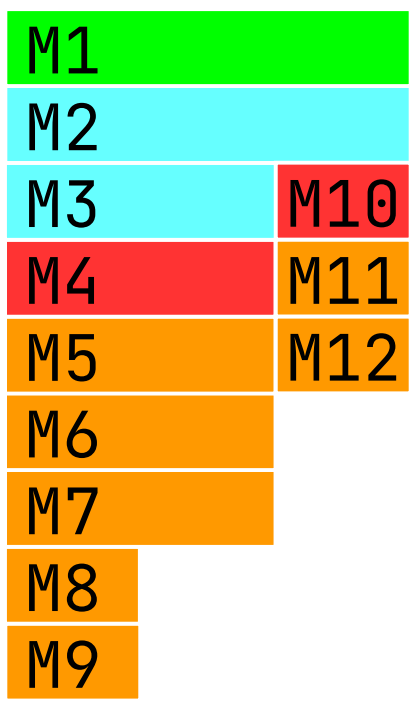
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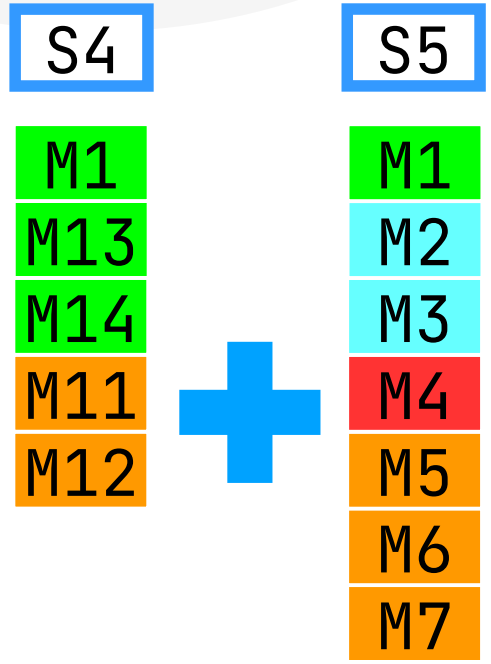
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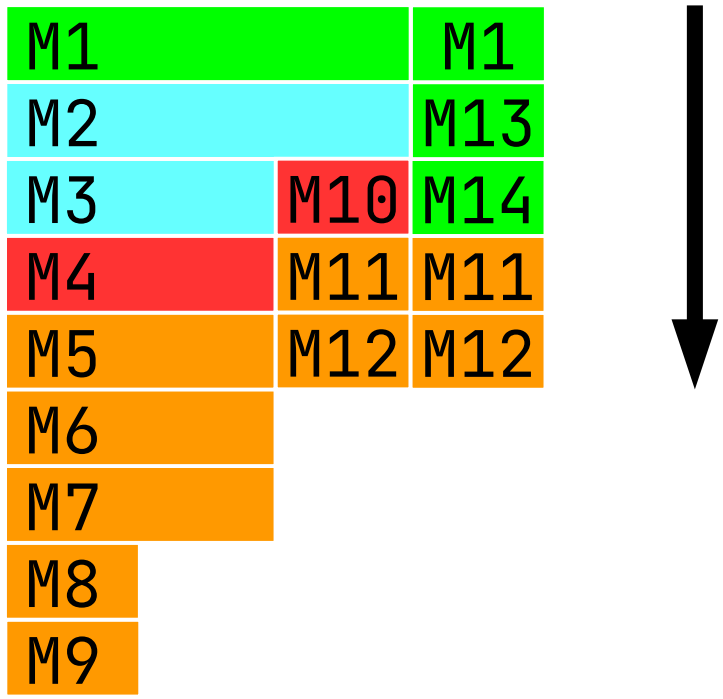
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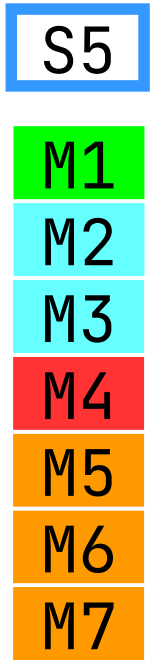
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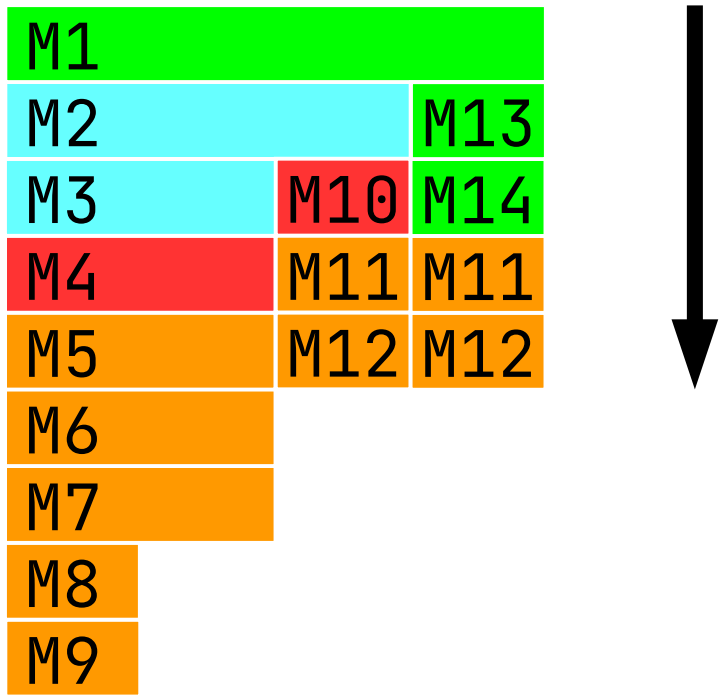
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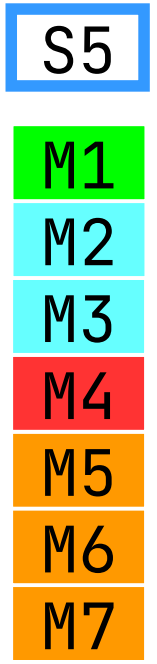
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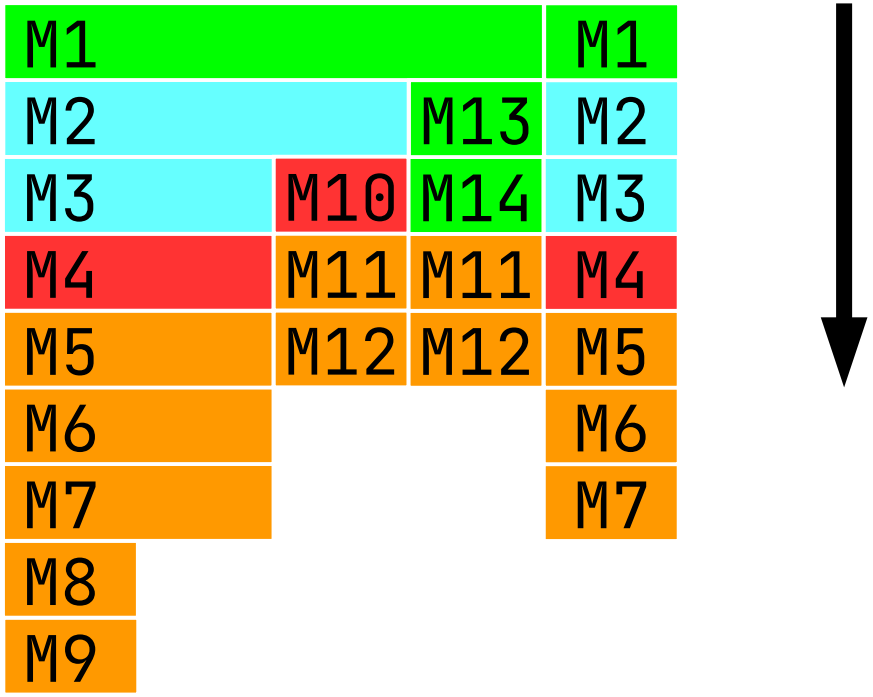
A. В глубину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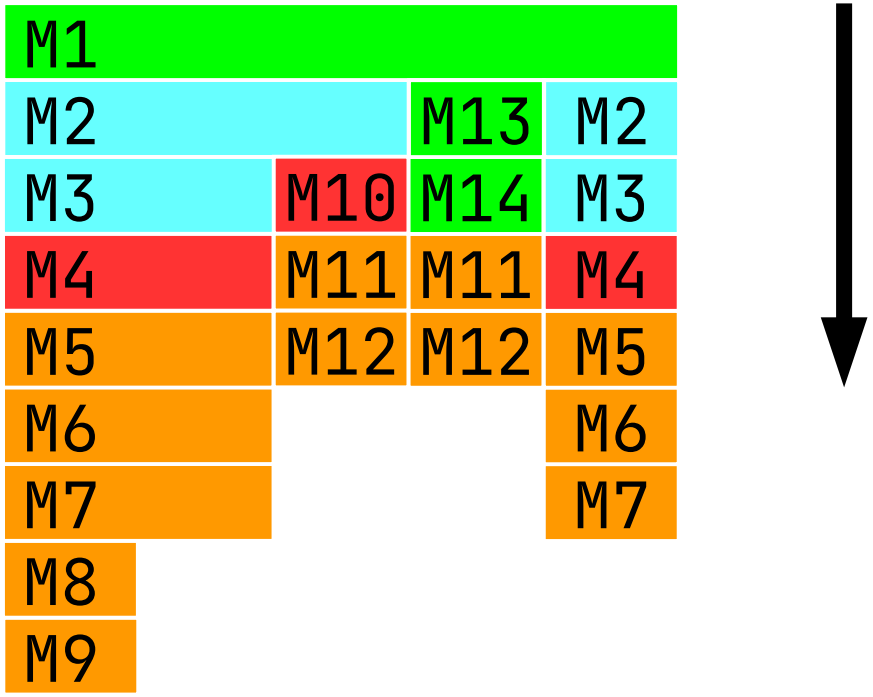
A. В глубину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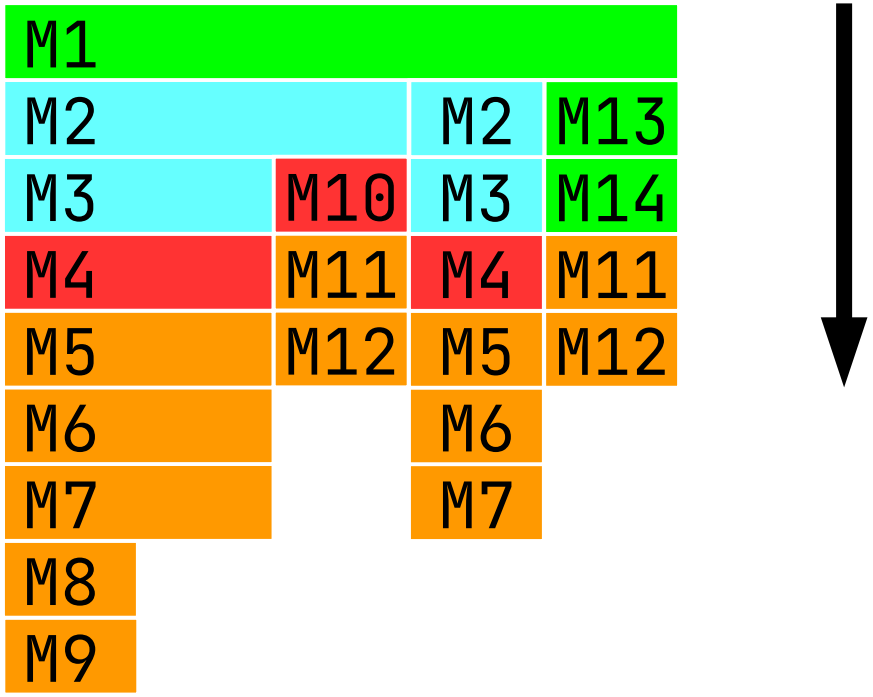
A. В глубину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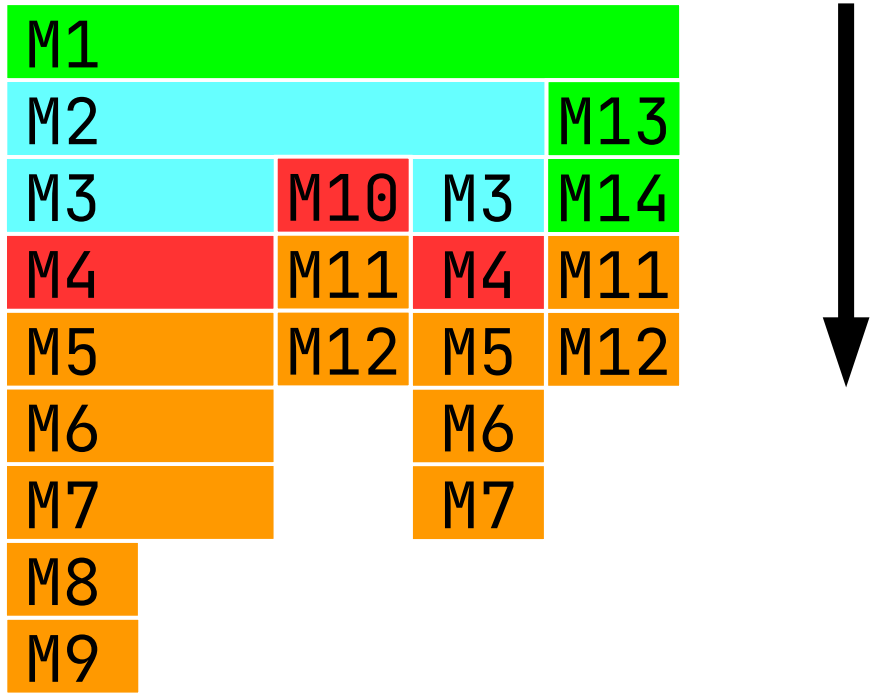
A. В глубину



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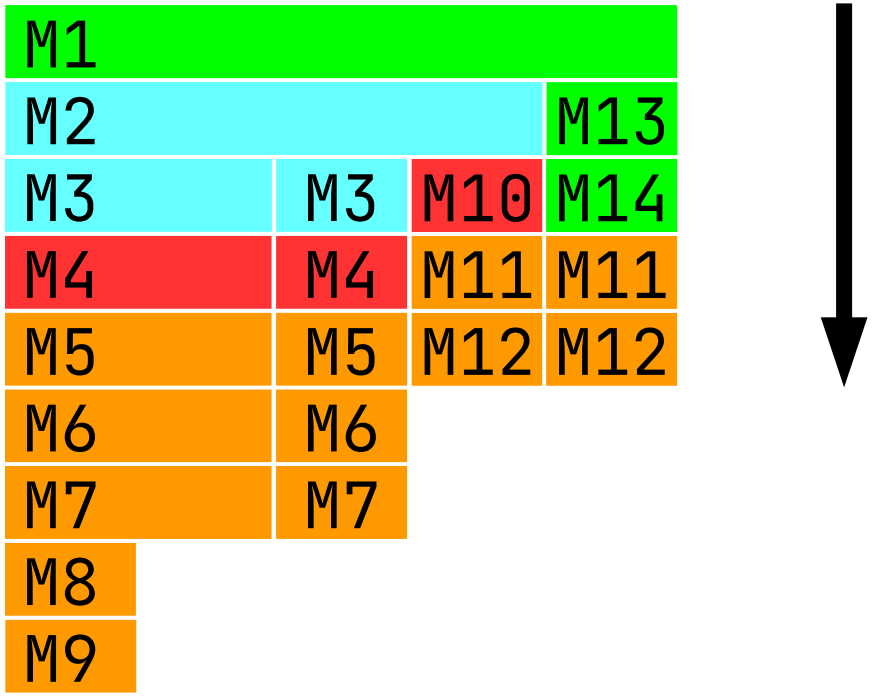
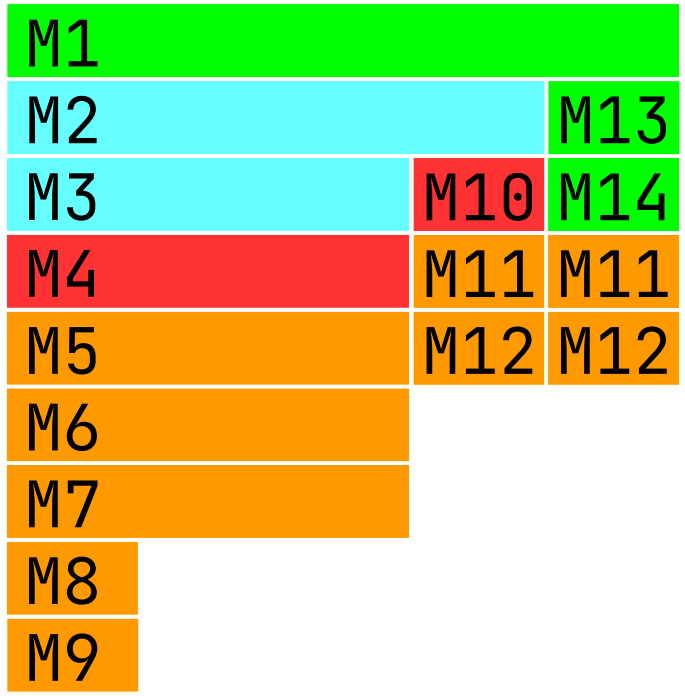


A. В глубину



A. В глубину

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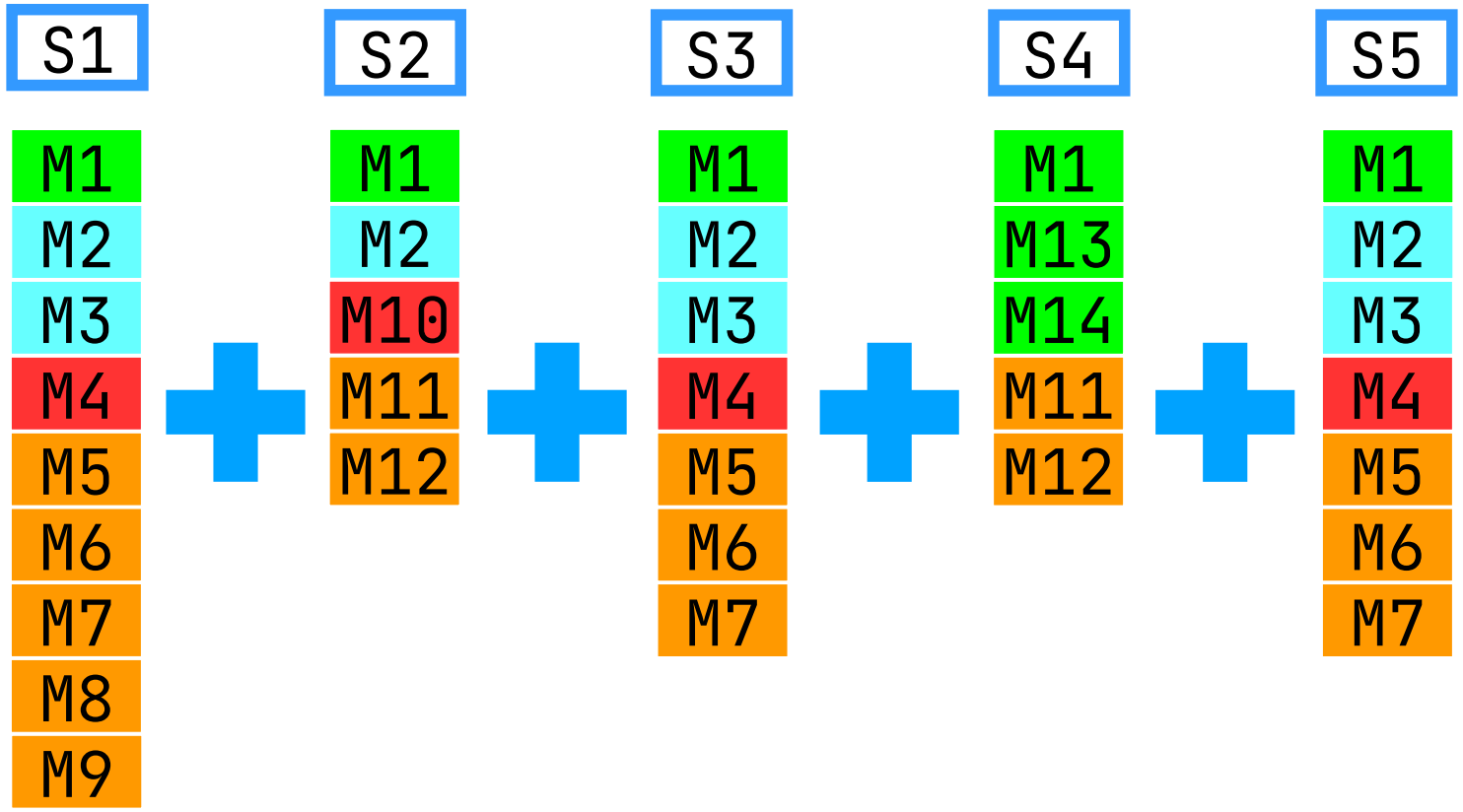
Б. В Ширину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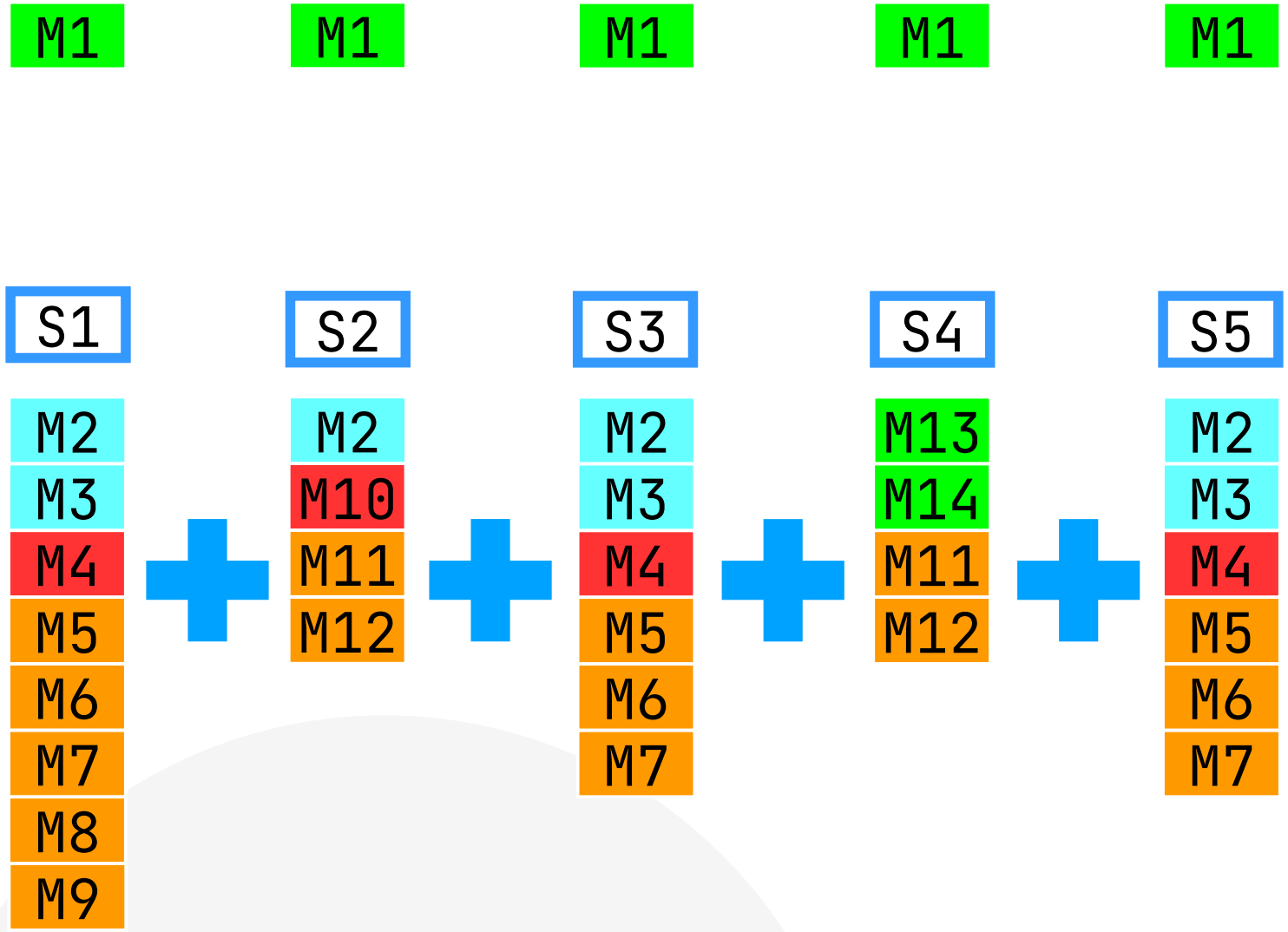
Б. В Ширину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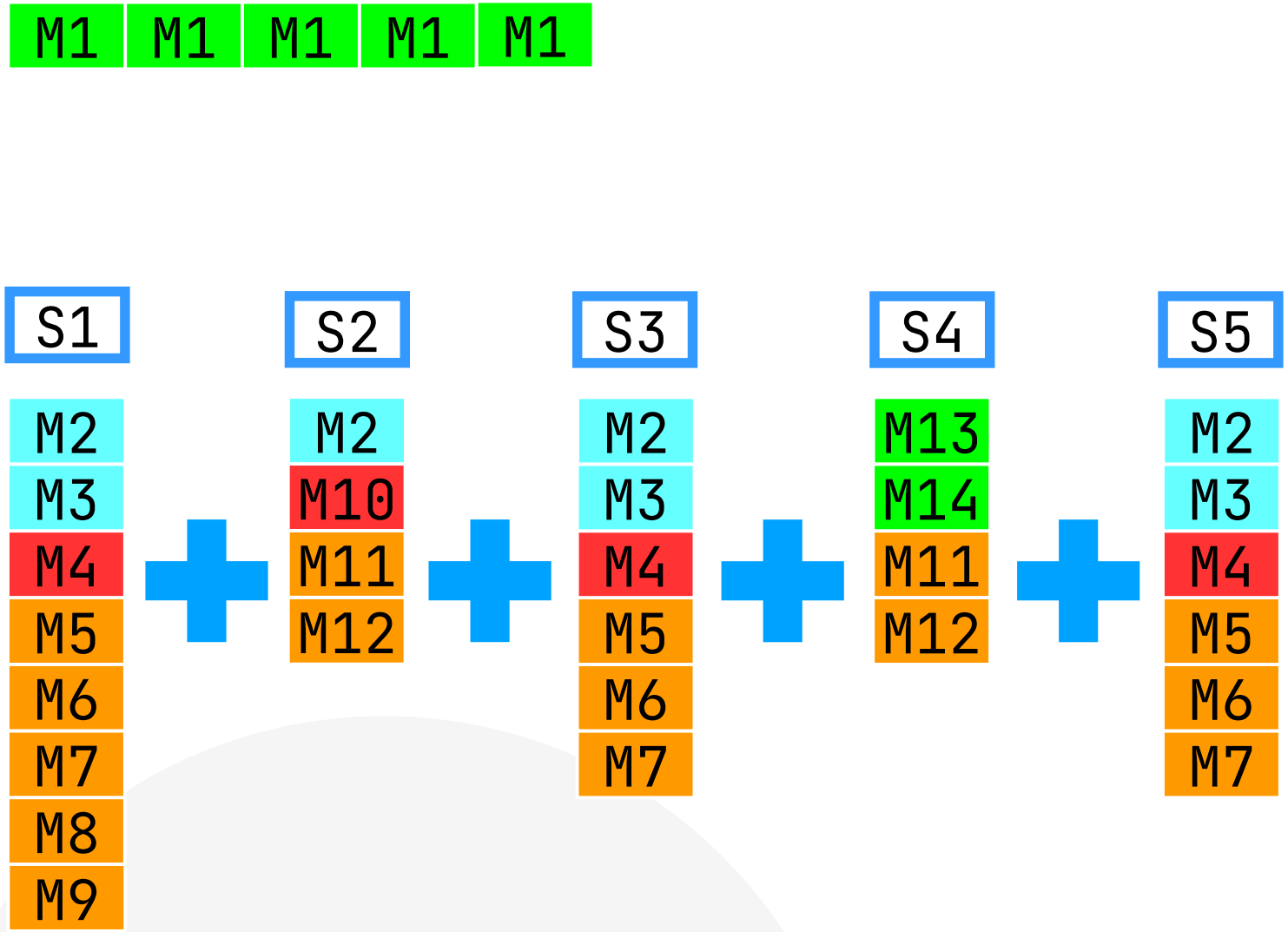
Б. В Ширину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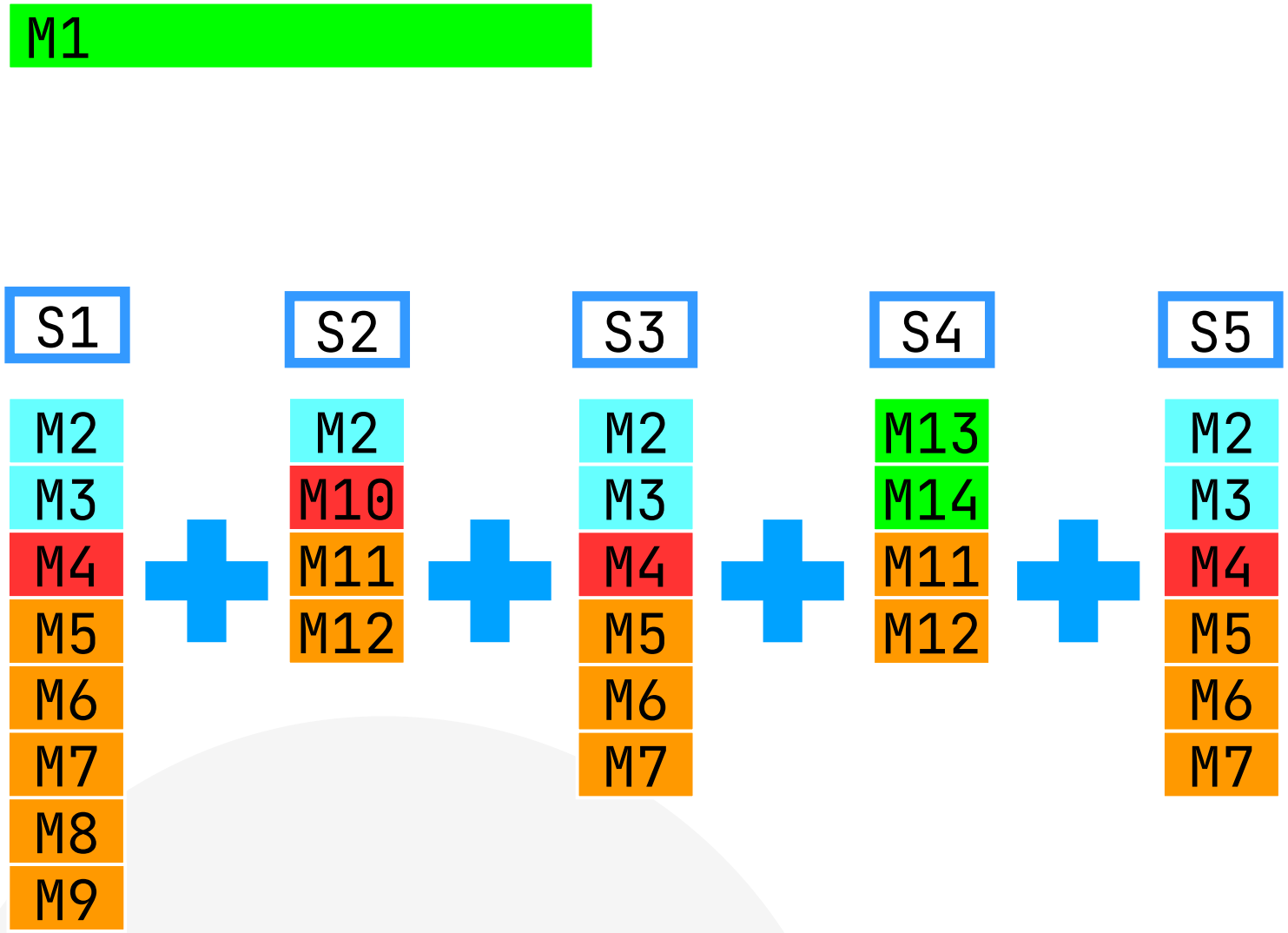
Б. В Ширину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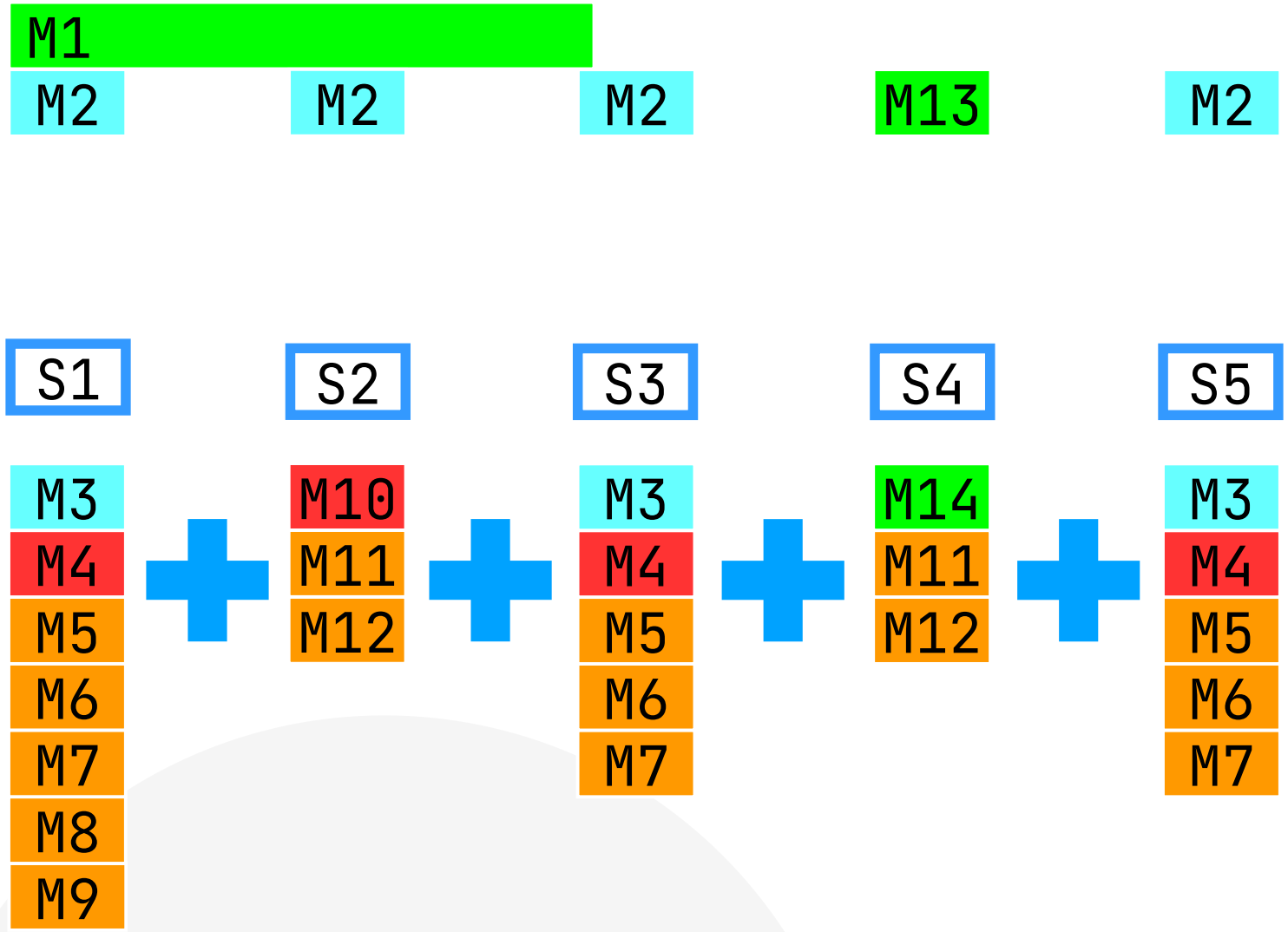
Б. В Ширину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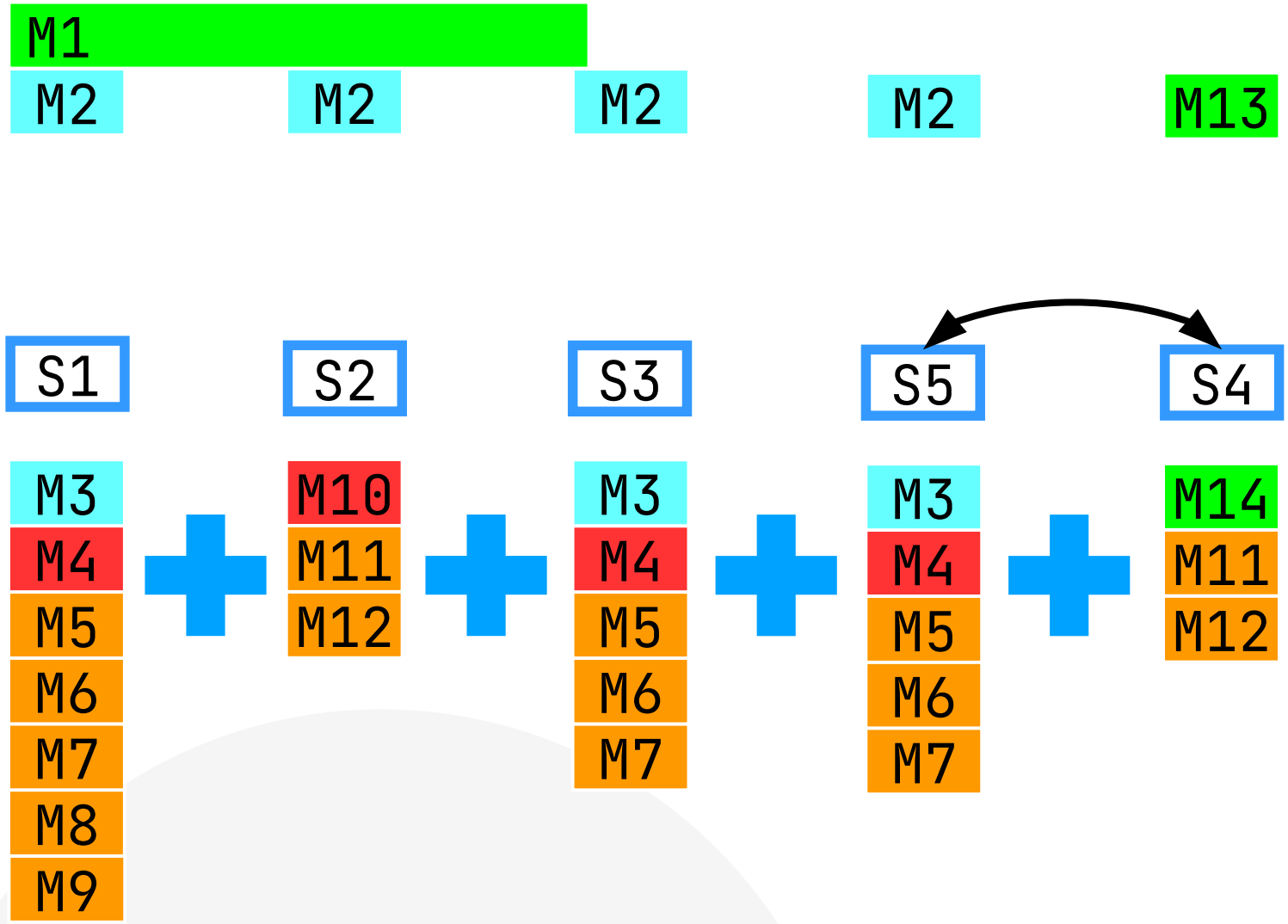
Б. В Ширину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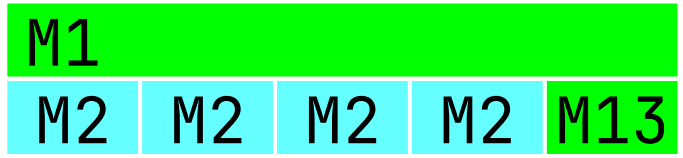
Б. В Ширину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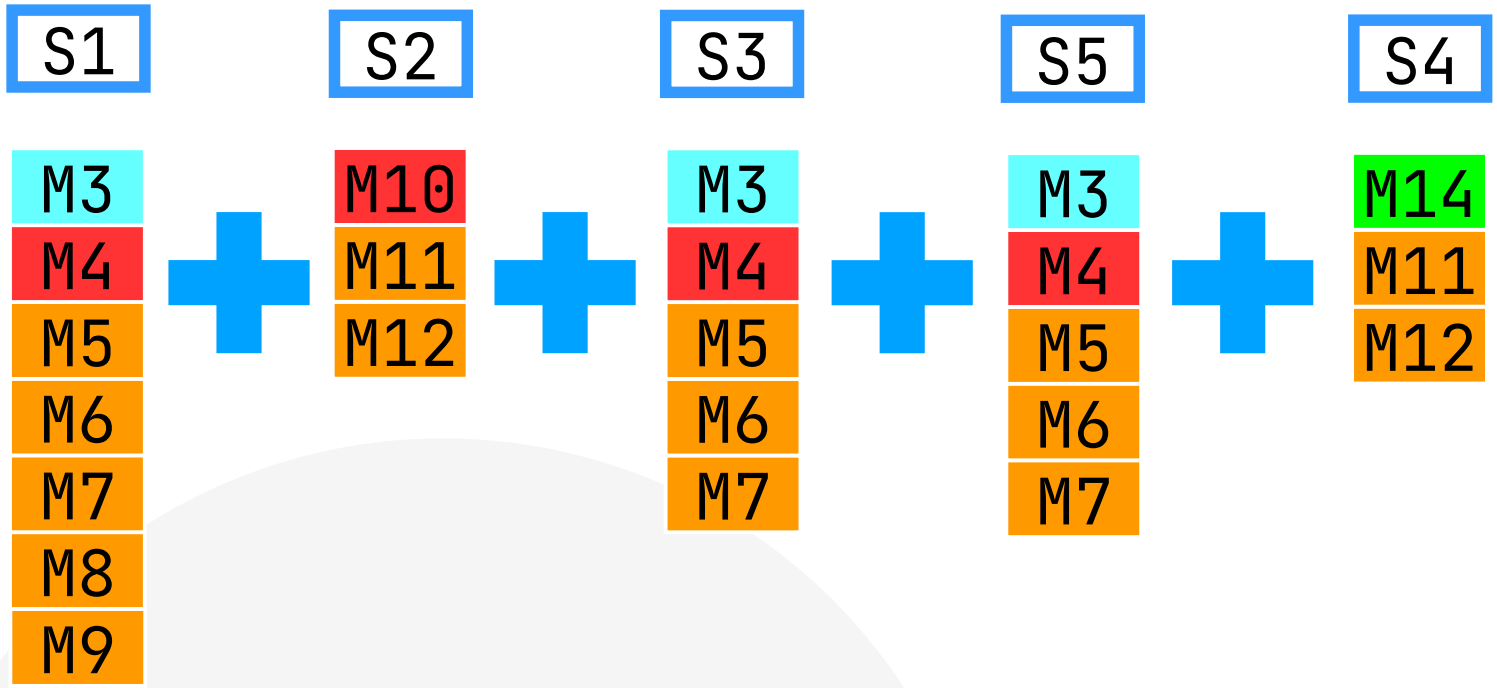
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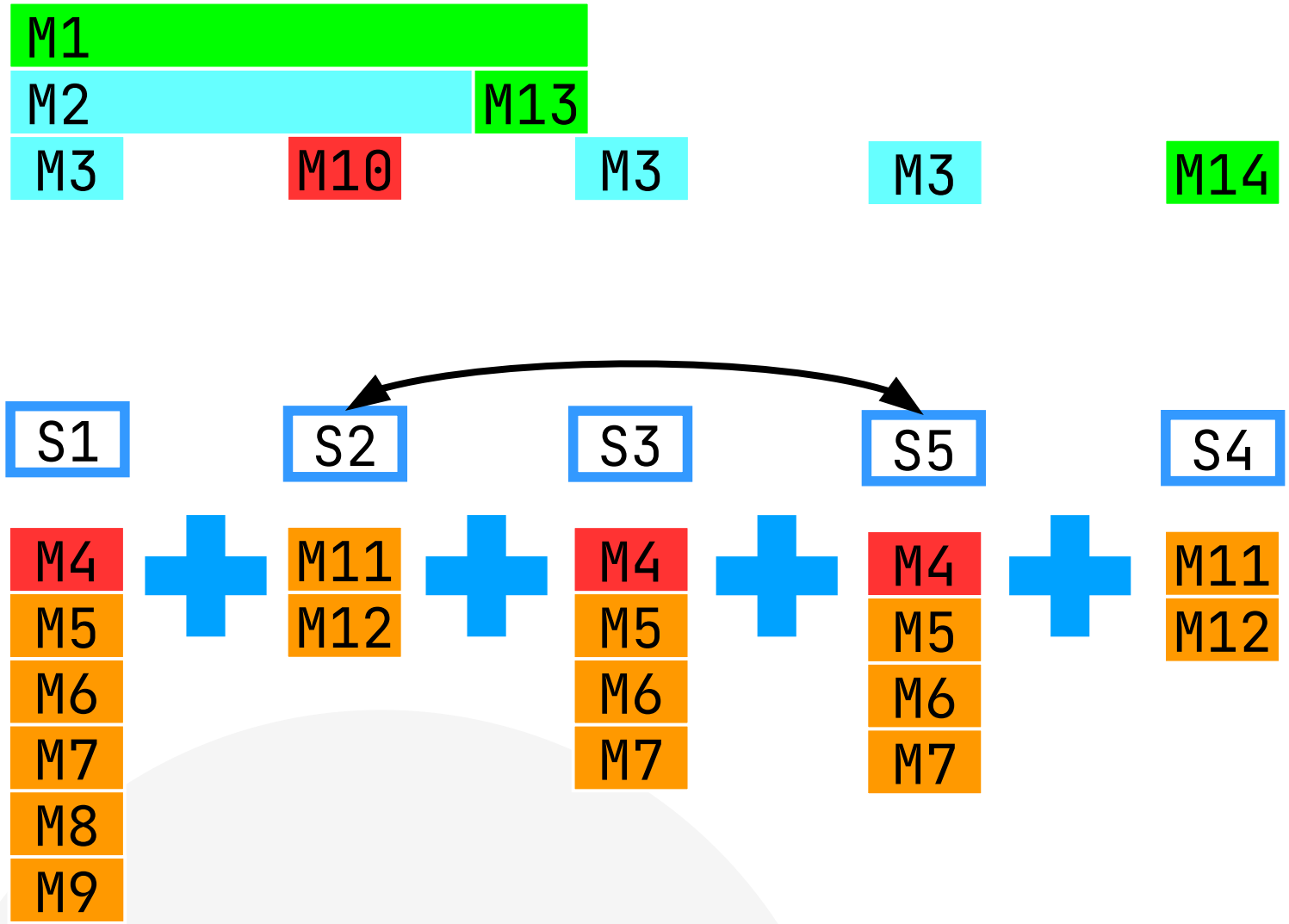
Б. В Ширину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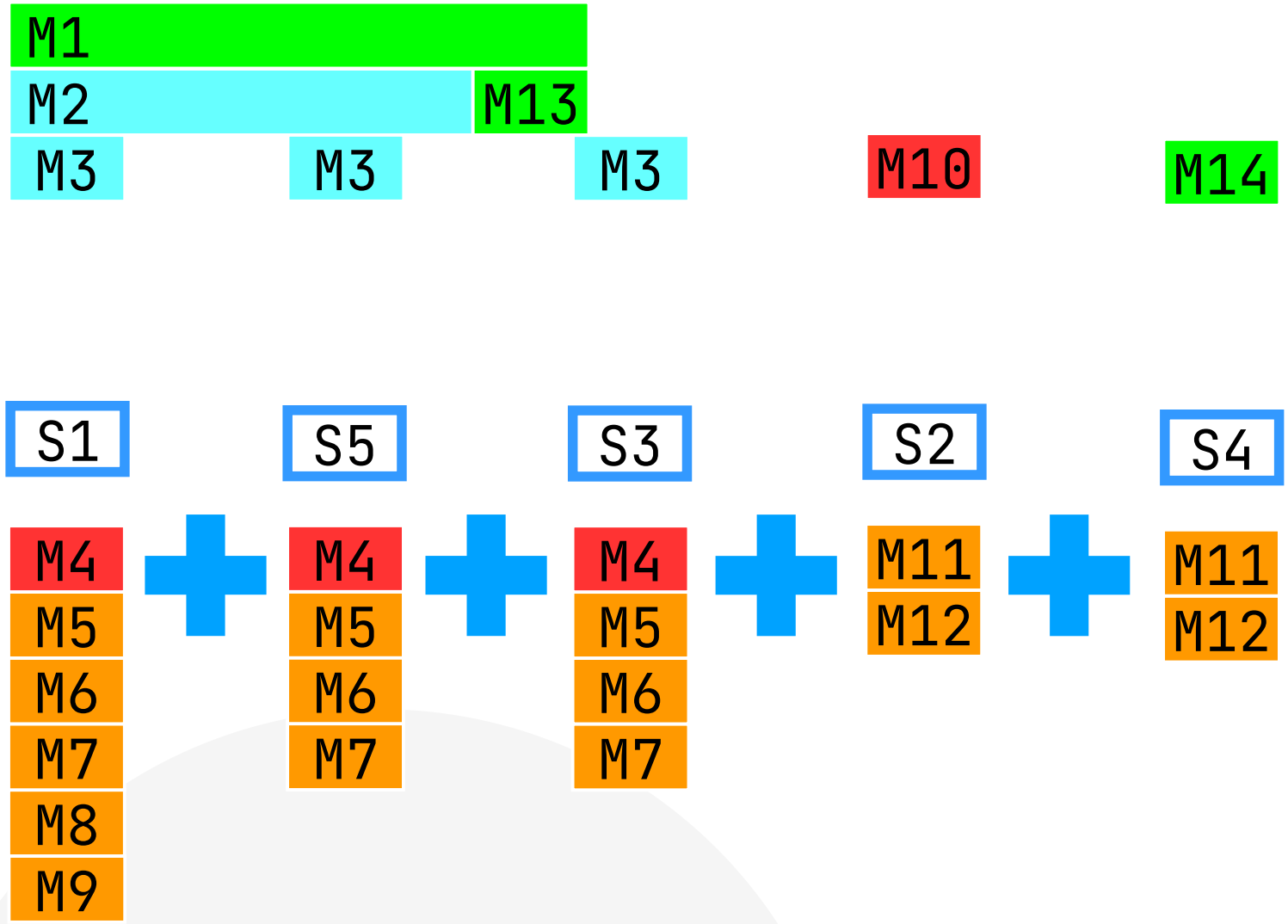
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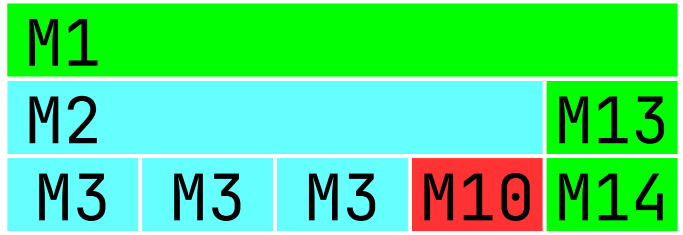
Б. В Ширину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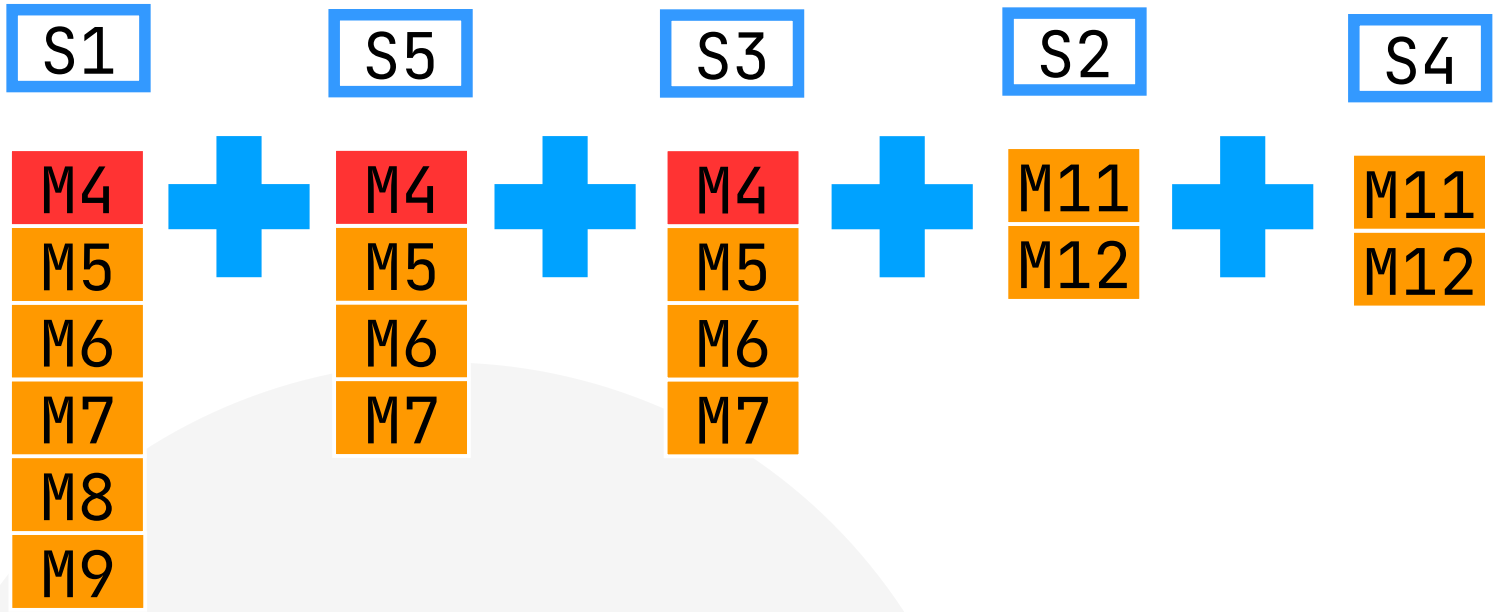
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Б. В Ширину


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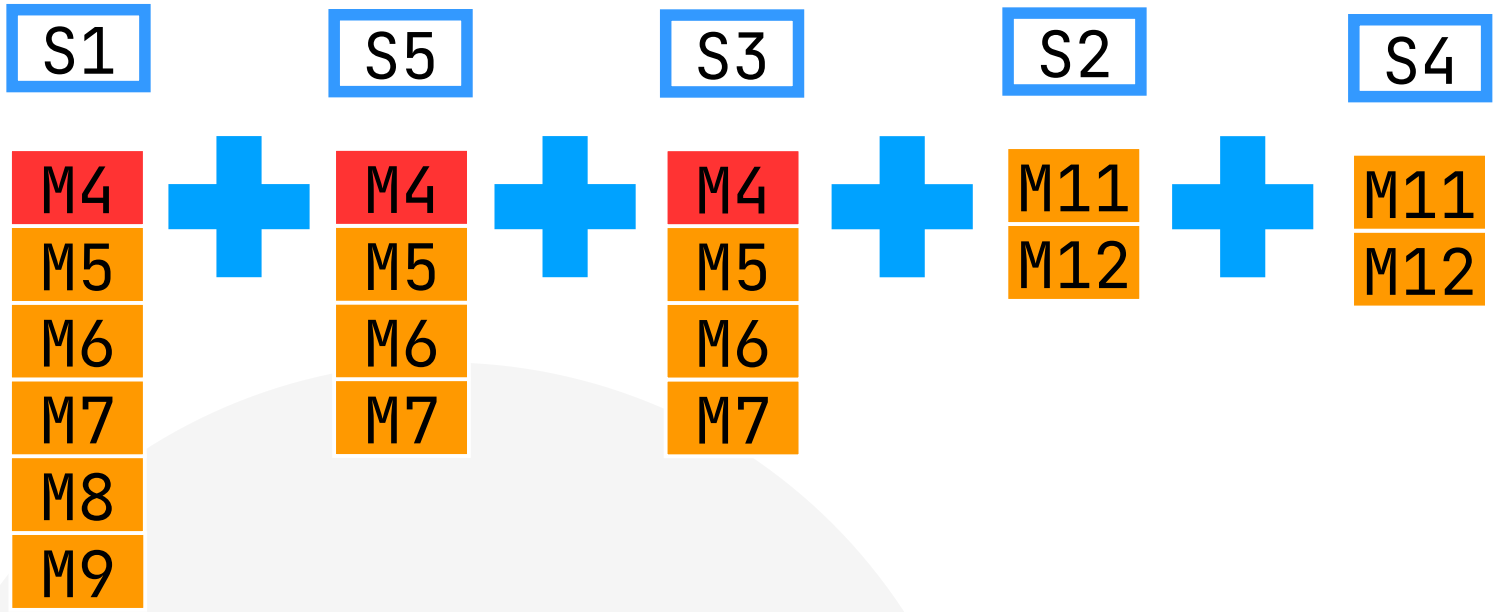
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Б. В Ширину


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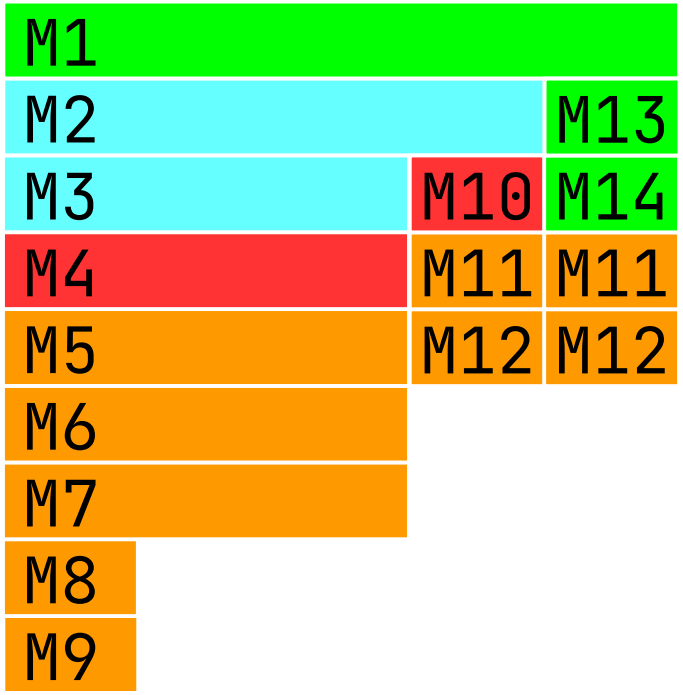
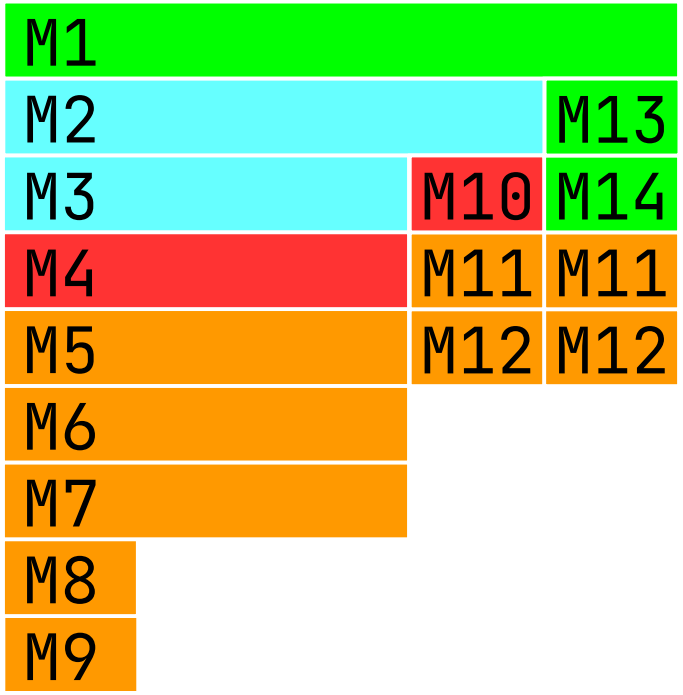
Б. В Ширину



Как рисуем?



в ширину vs в глубину

* в глубину (обычно) быстрее!

Как рисуем?

в ширину vs в глубину

* в глубину (обычно) быстрее, но докладчик растёт в ширину

Как рисуем?

- В глубину (обычно) быстрее

Как рисуем?

- В глубину (обычно) быстрее
- Но алгоритм потребует аллокаций

Как рисуем?

- В глубину (обычно) быстрее
- Но алгоритм потребует аллокаций
- Полная отрисовка > 10 секунд

Как рисуем?

- В глубину (обычно) быстрее
- Но алгоритм потребует аллокаций
- Полная отрисовка > 10 секунд
- Обход в ширину - итеративен!

Требования к отрисовке

CPU (6 млн сэмплов):

- < 1 секунды на первый уровень
- < 5 секунд на первые 20 уровней

Требования к отрисовке

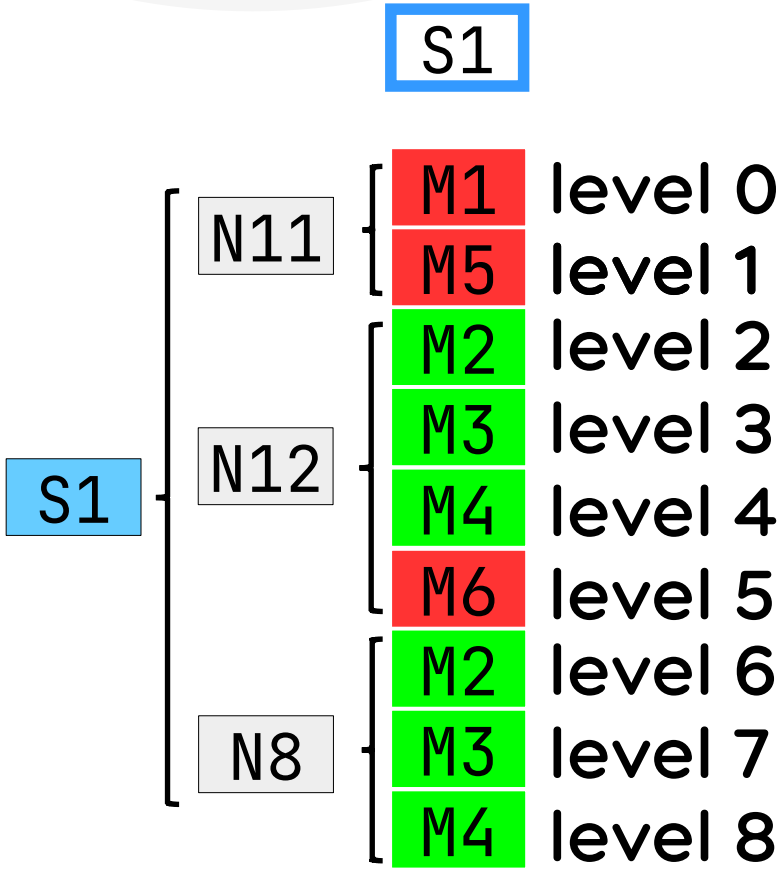
CPU (6 млн сэмплов):

- < 1 секунды на первый уровень
- < 5 секунд на первые 20 уровней

- Alloc (78 млн сэмплов):
- < 5 секунды на первый уровень
- < 10 секунд на первые 20 уровней

Рисуем

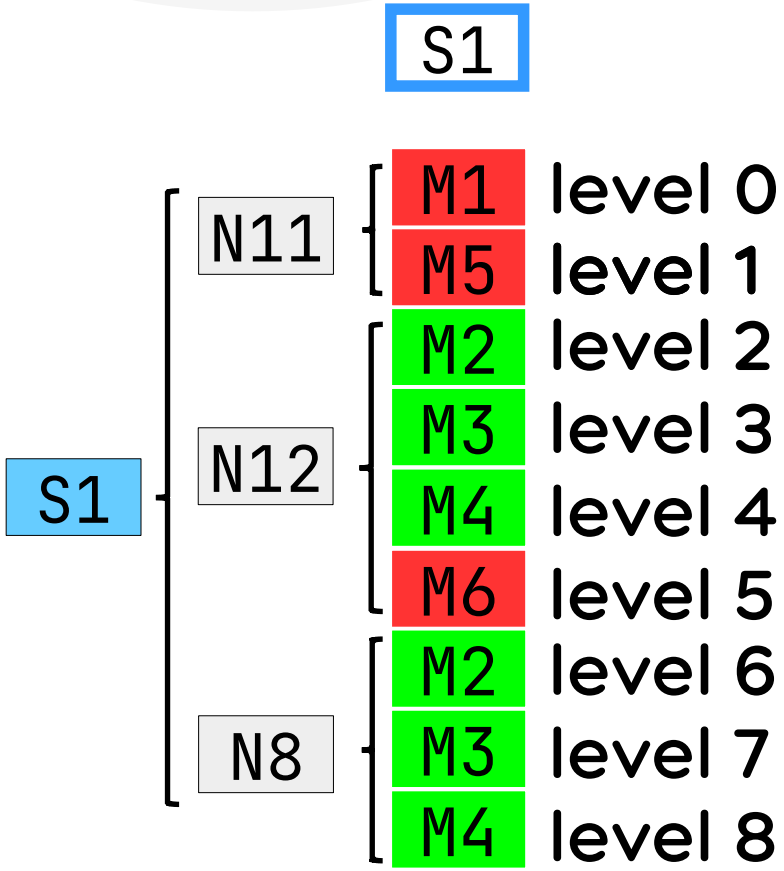
Frame: `{x, width, text, color}`



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

Frame: {x, width, text, color}

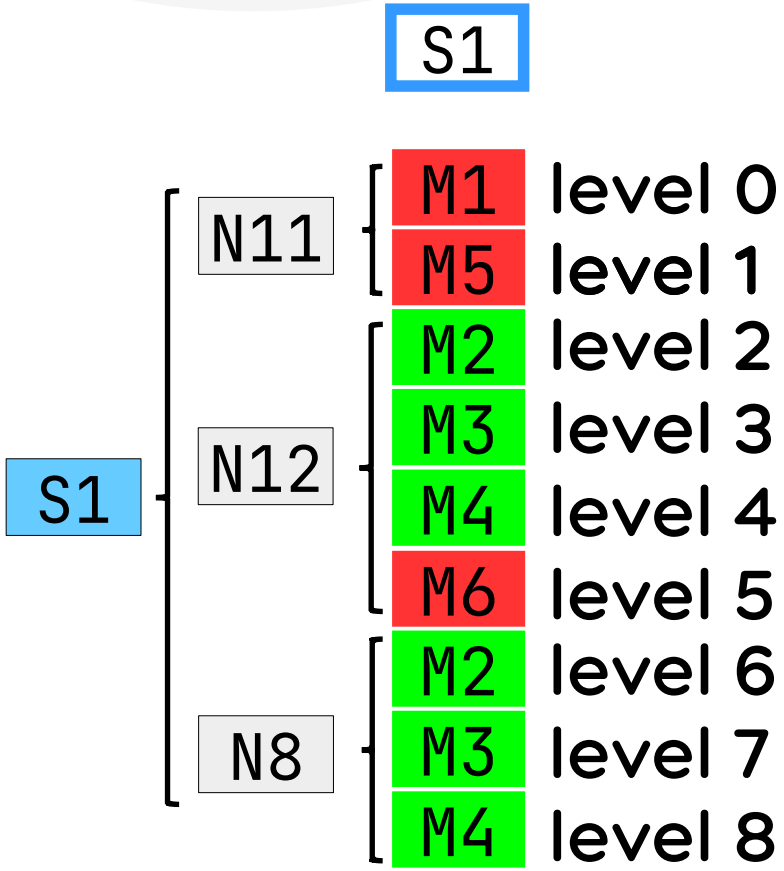


samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

Frame: {x, width, text, color}

f(index,node) = method



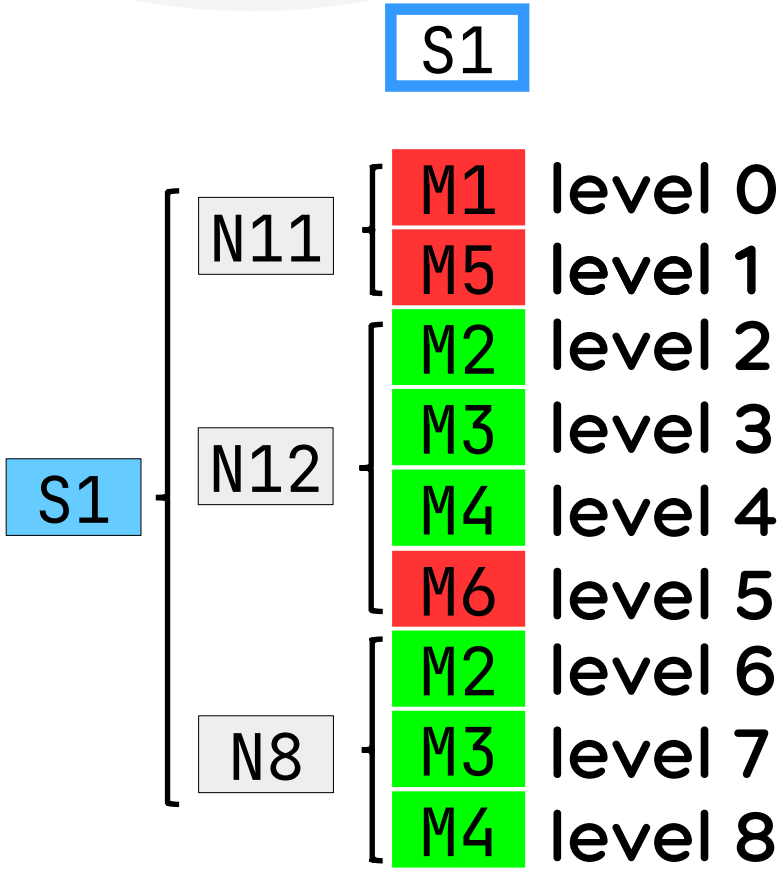
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

Frame: {x, width, text, color}

f(index,node) = method

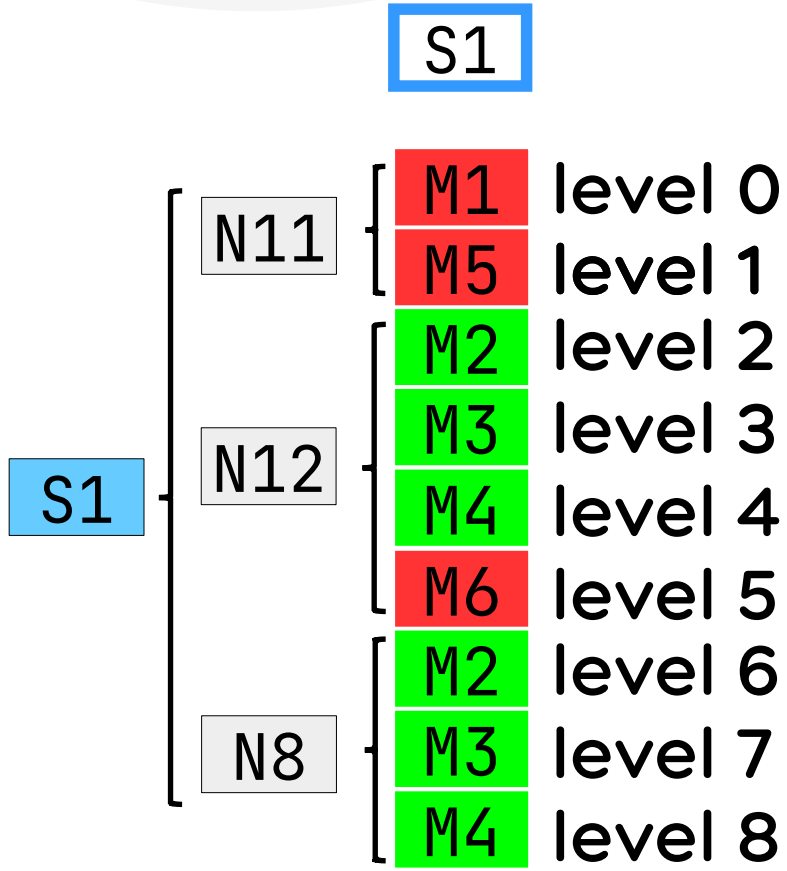
g(level,sample) = method



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

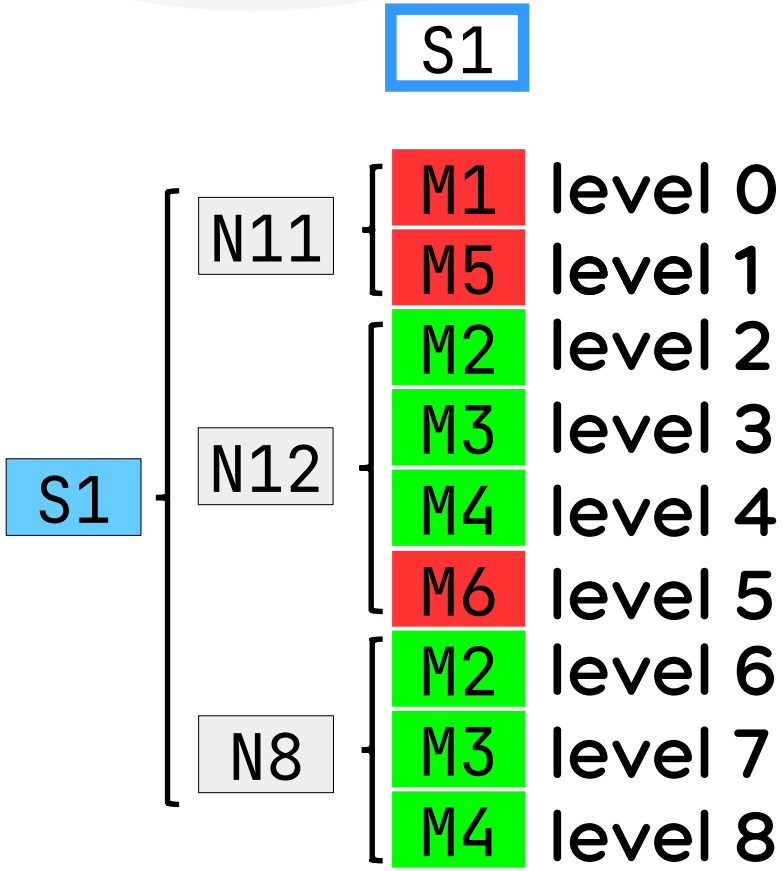
```
f(index,node) - O(1)

g(level,sample) = method
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

```
f(index,node) - O(1)
g(level,sample) - O(nodesCount(sample))
```

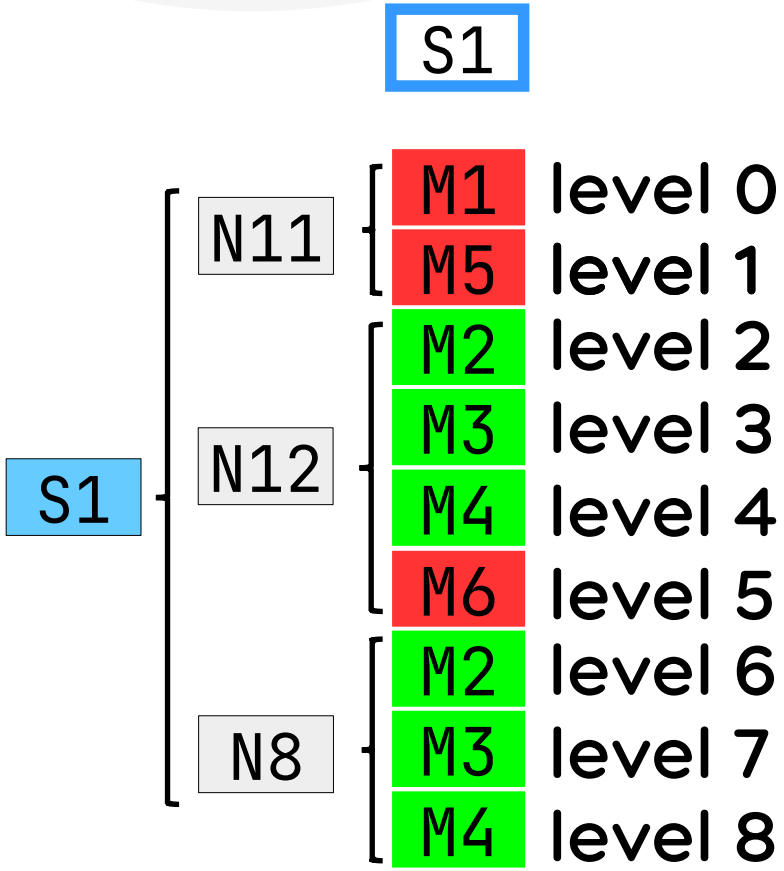


samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

f(index,node) - O(1)

g(level,sample) - ~~O(nodesCount(sample))~~

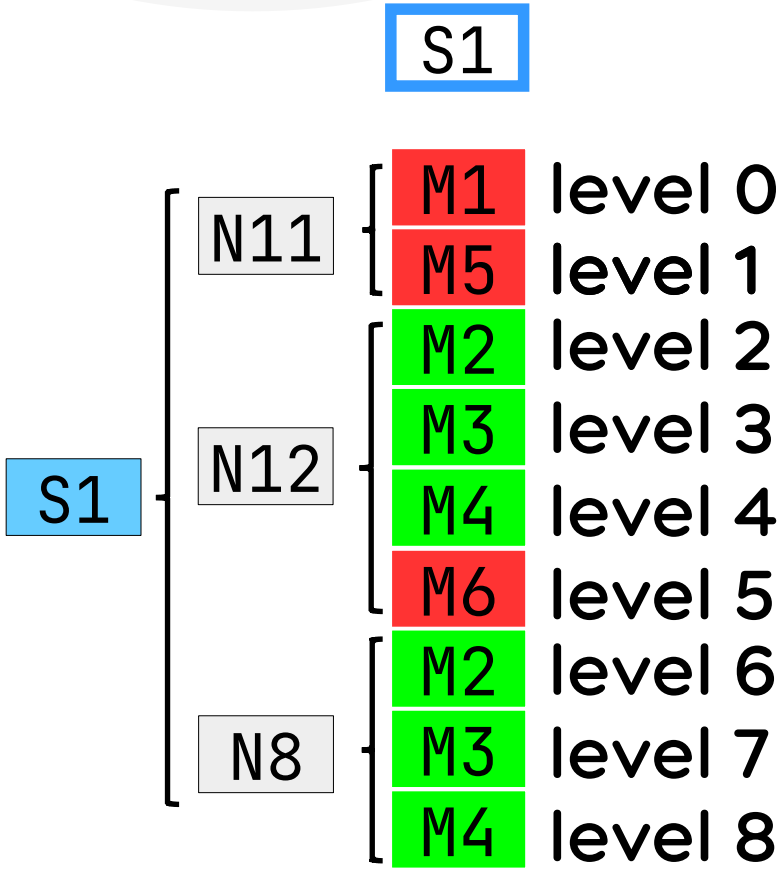


samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

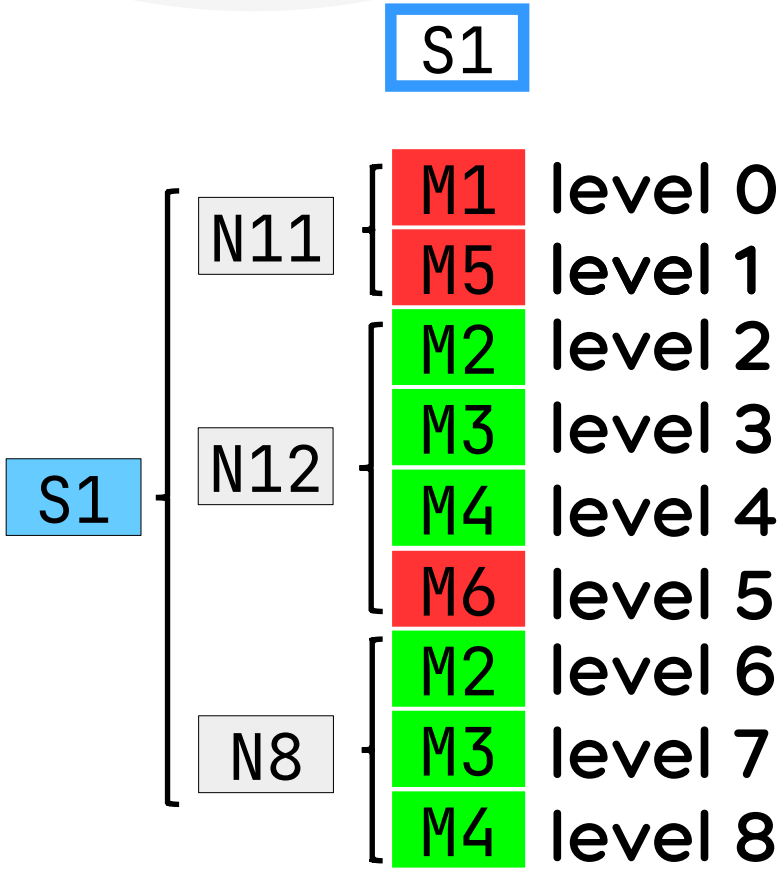
```
f(index,node) - O(1)

g(state,level,sample) - O(1)
```

samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...



Рисуем

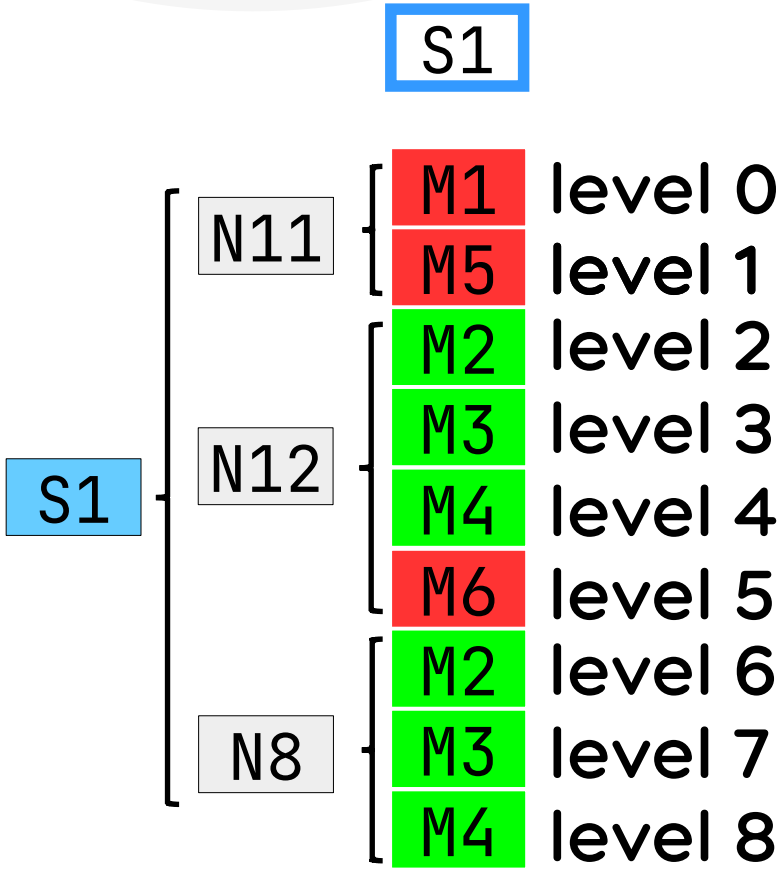
```
f(index,node) - O(1)

g(state,level,sample) = f(i(…),n(…))
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

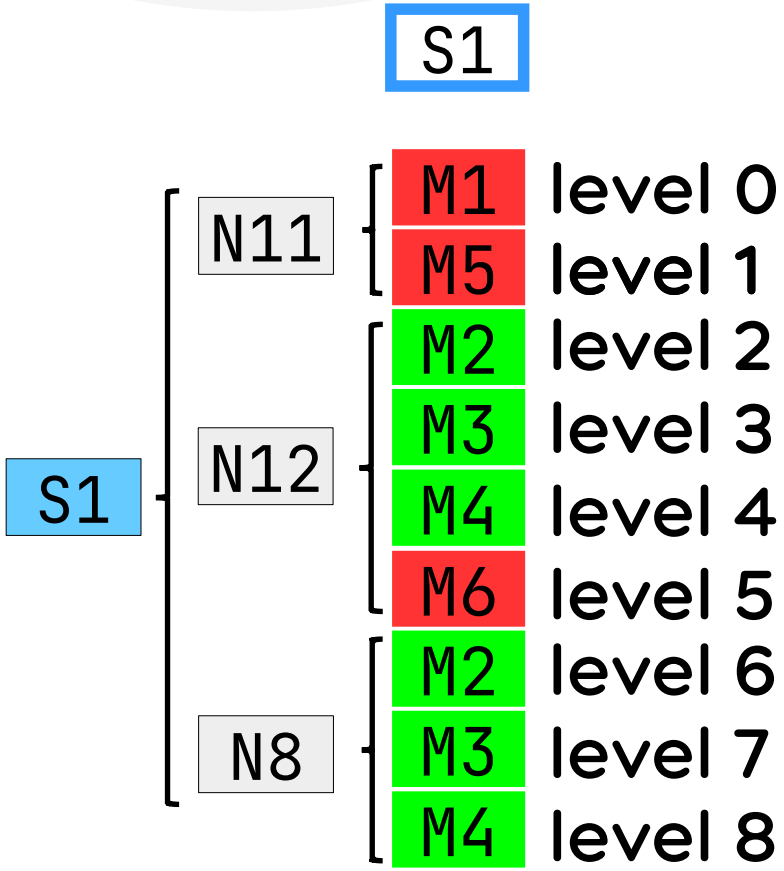
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 0
g(…) = M1 = N11[0]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

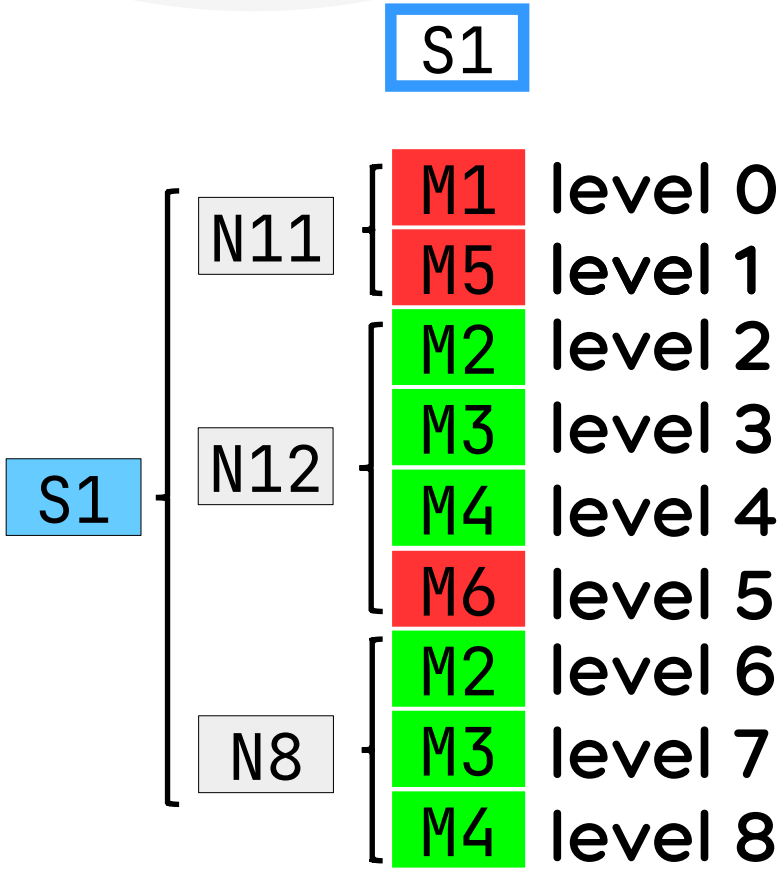
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 1
g(…) = M5 = N11[1]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

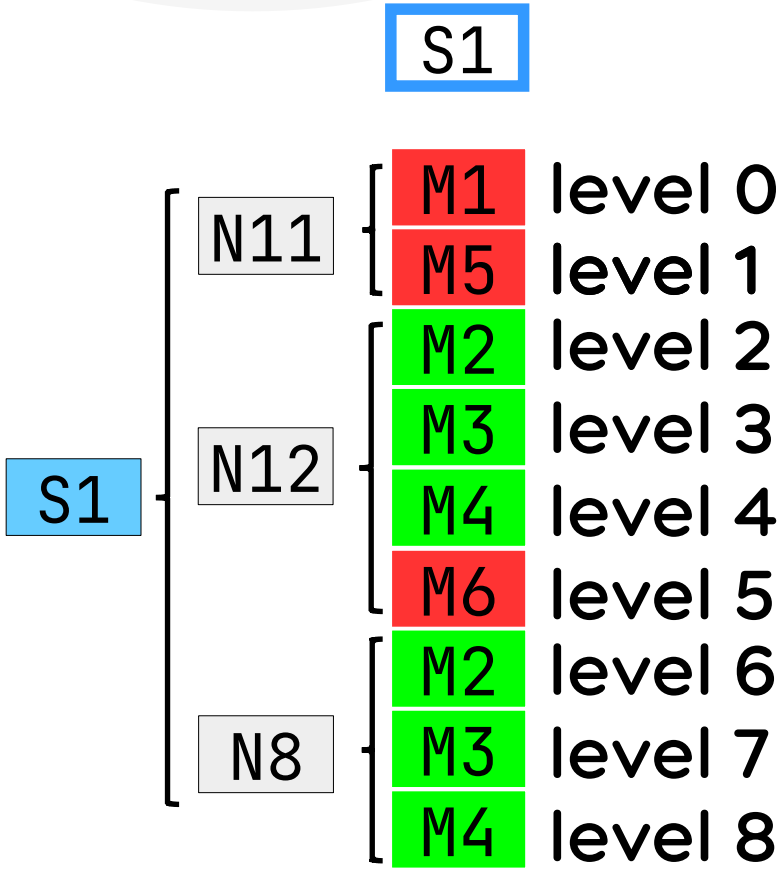
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 2
g(…) = M2 = N12[0]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

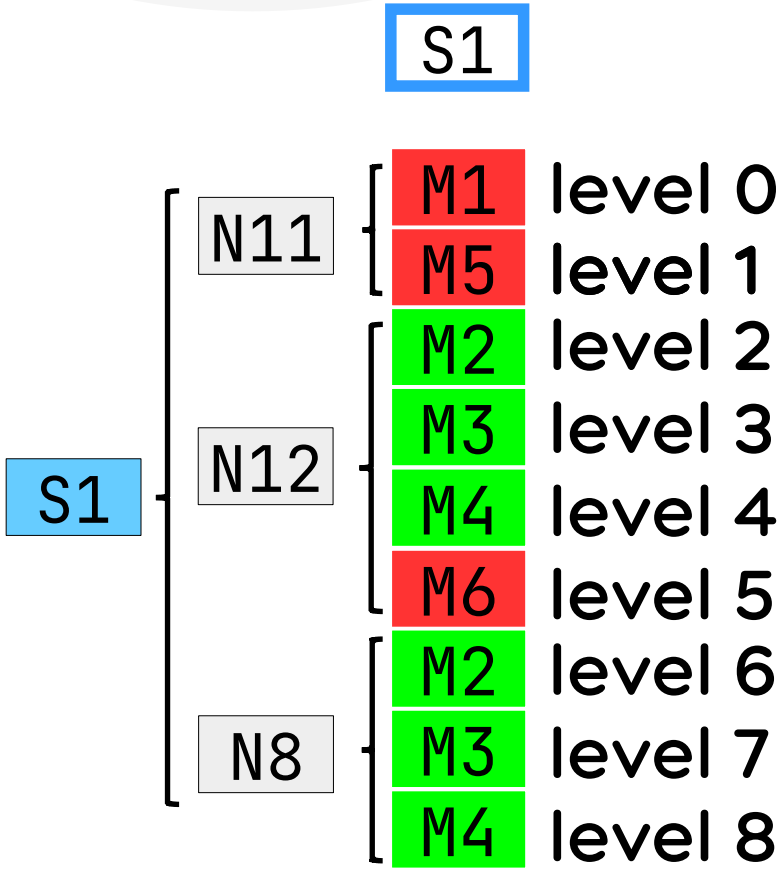
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 3
g(…) = M3 = N12[1]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

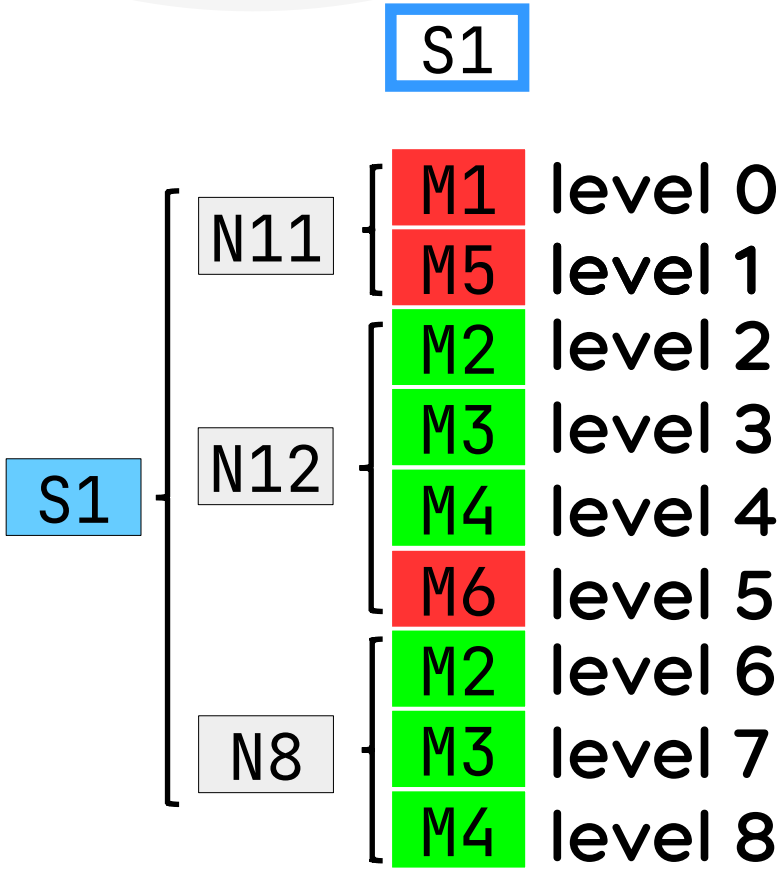
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 4
g(…) = M4 = N12[2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

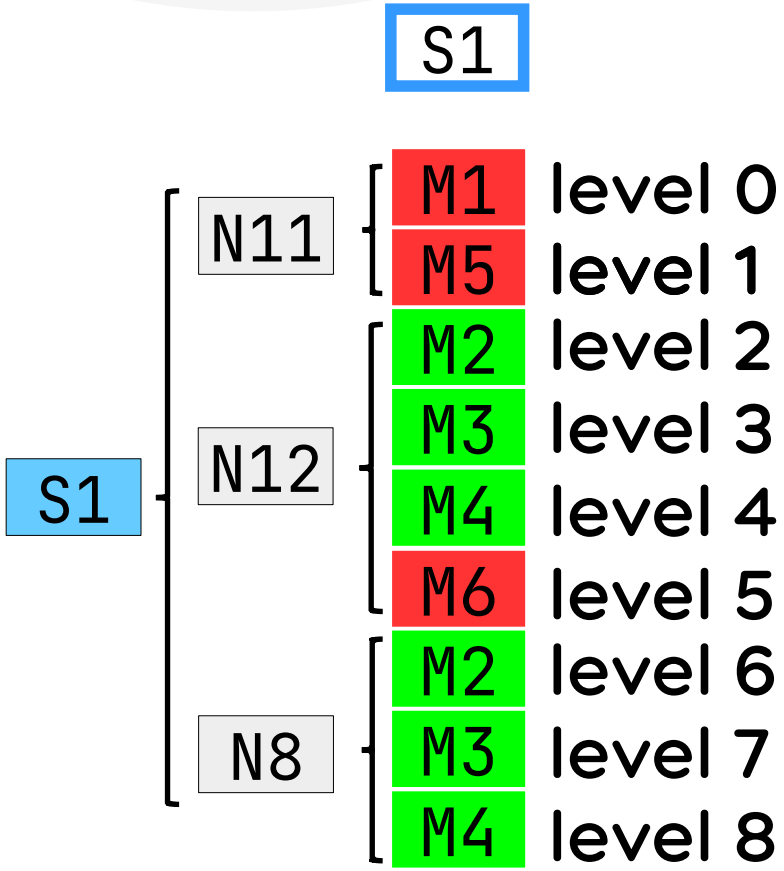
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 5
g(…) = M6 = N12[3]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

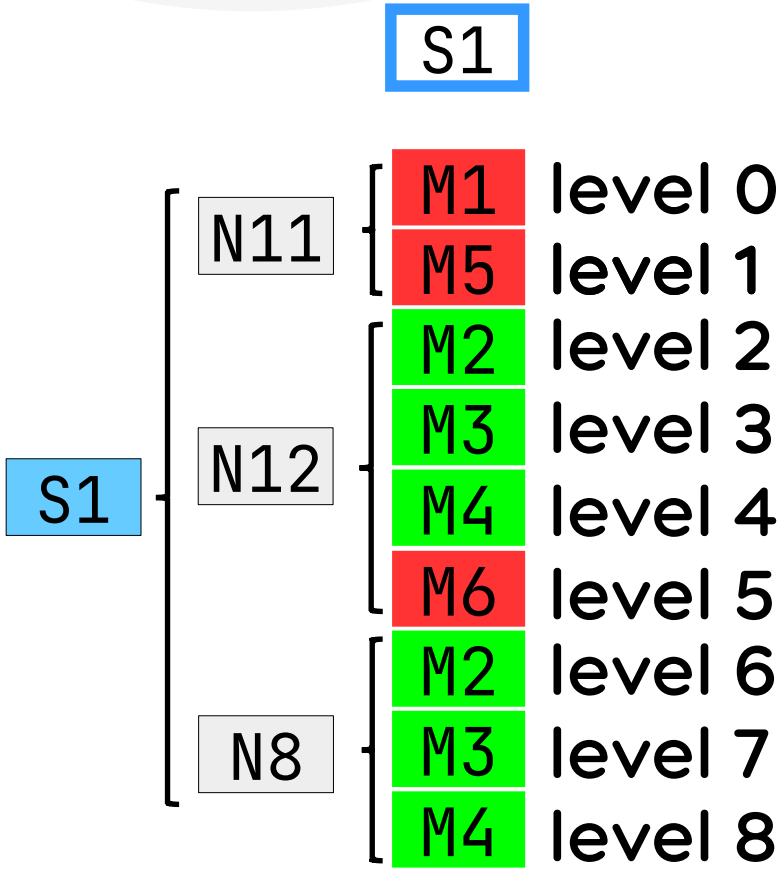
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 6
g(…) = M2 = N8[0]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

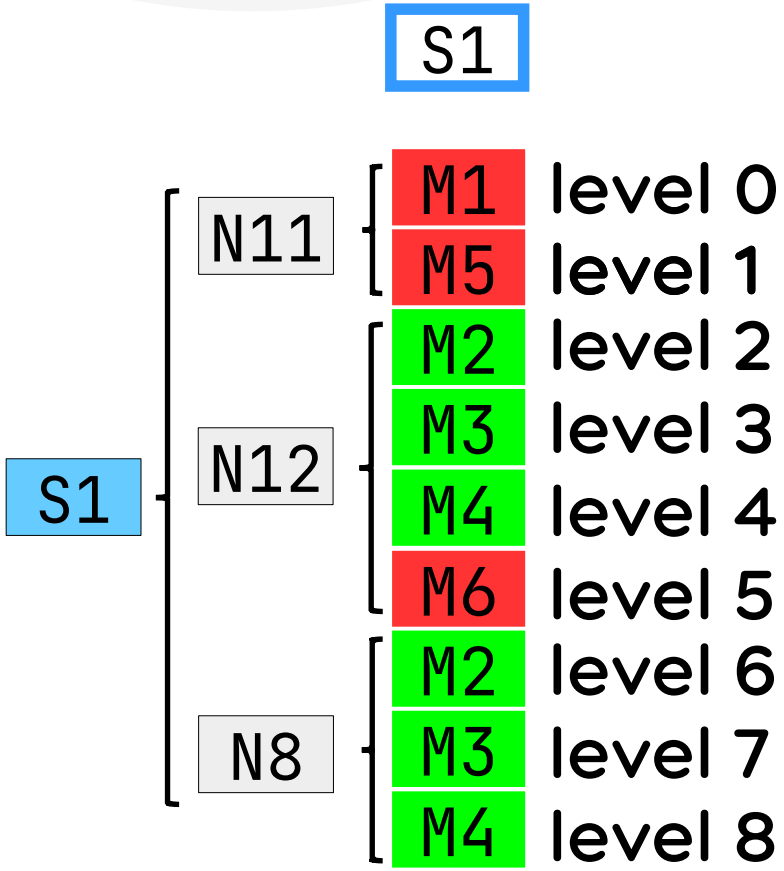
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 7
g(…) = M3 = N8[1]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

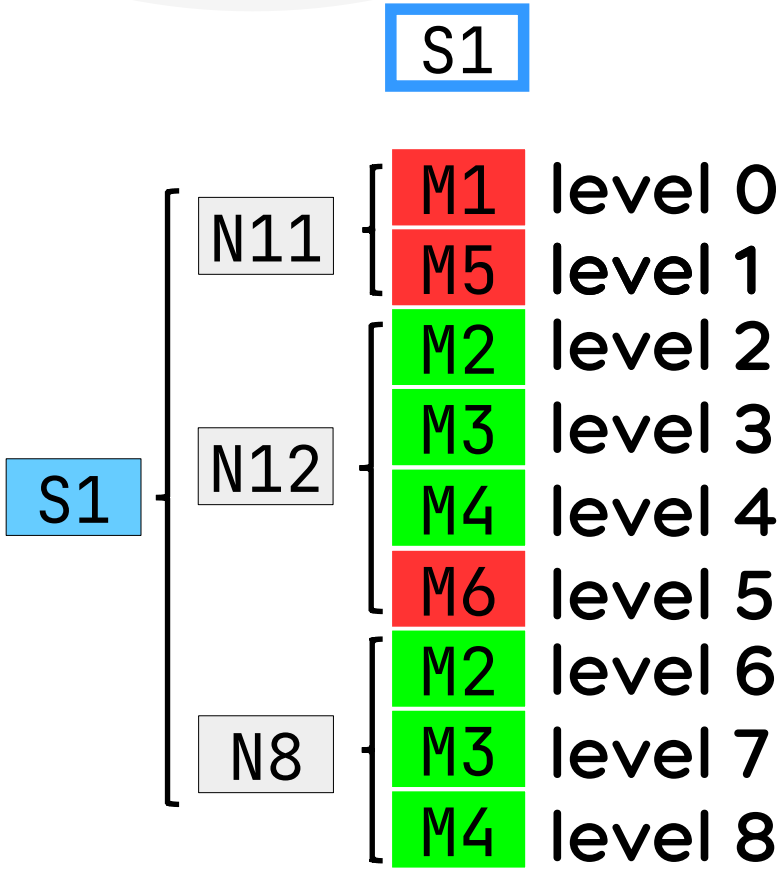
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = N8[2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

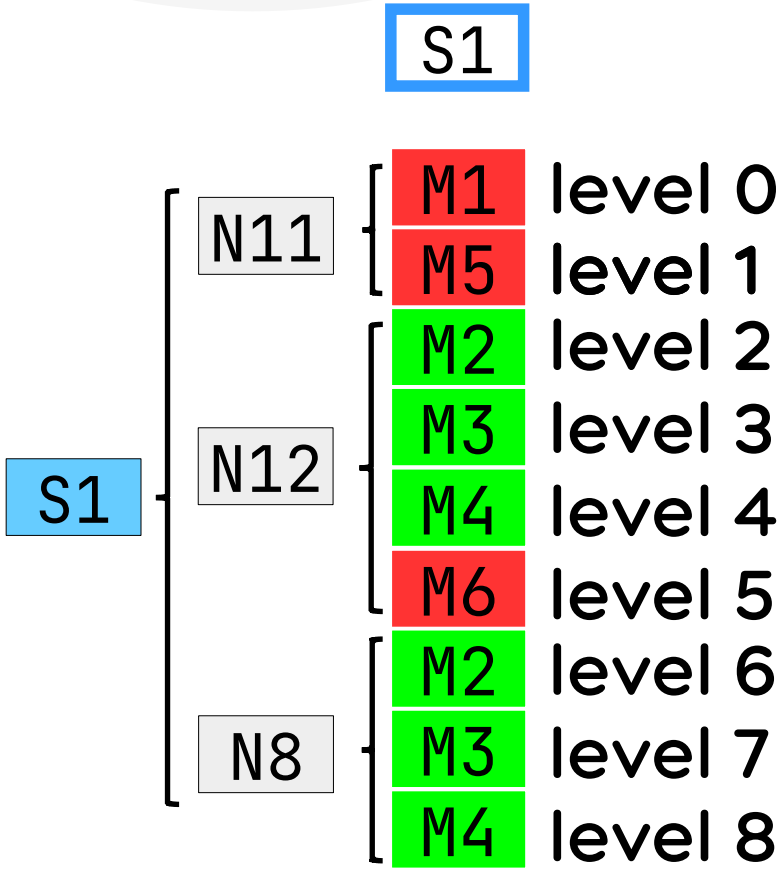
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = N8[2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

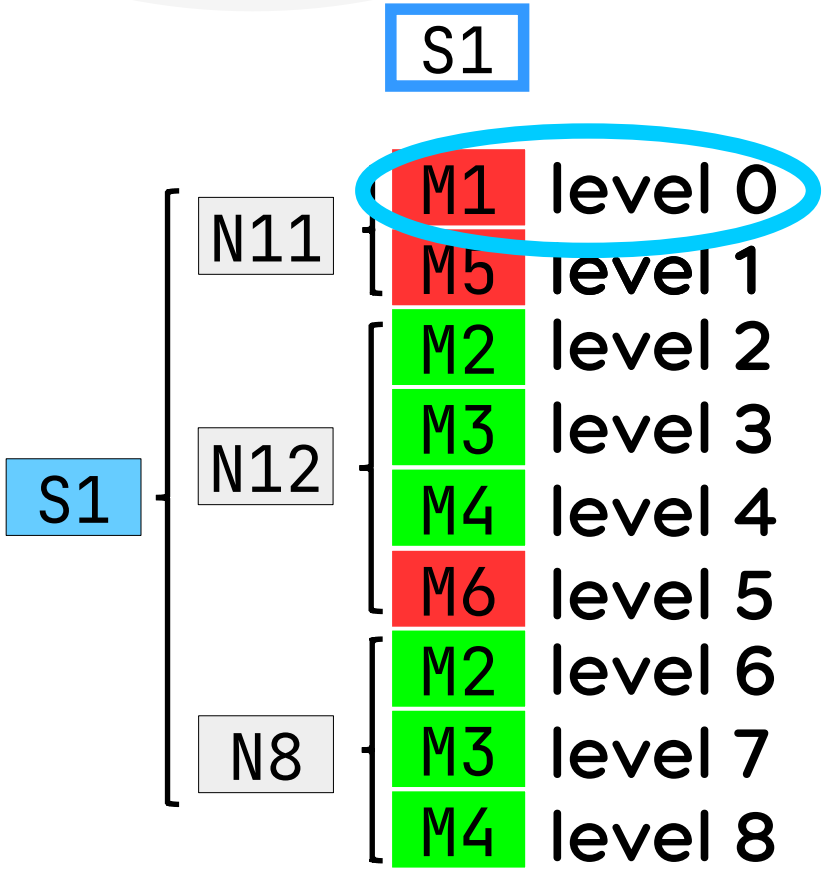
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = N8[2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

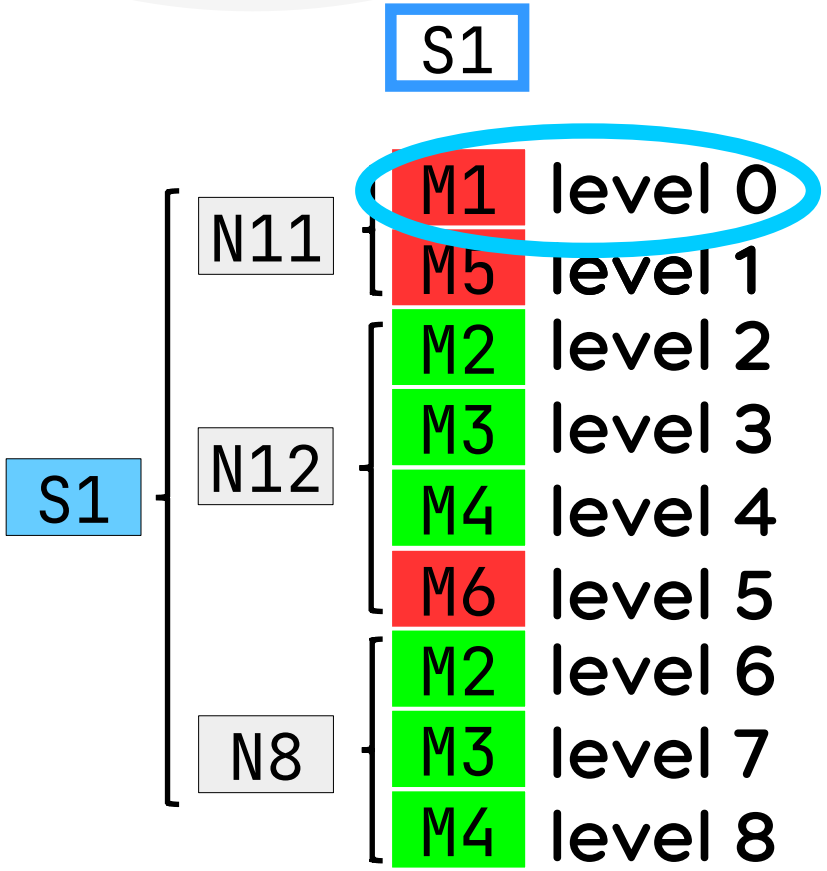
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 0
g(…) = M1 = N11[0]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

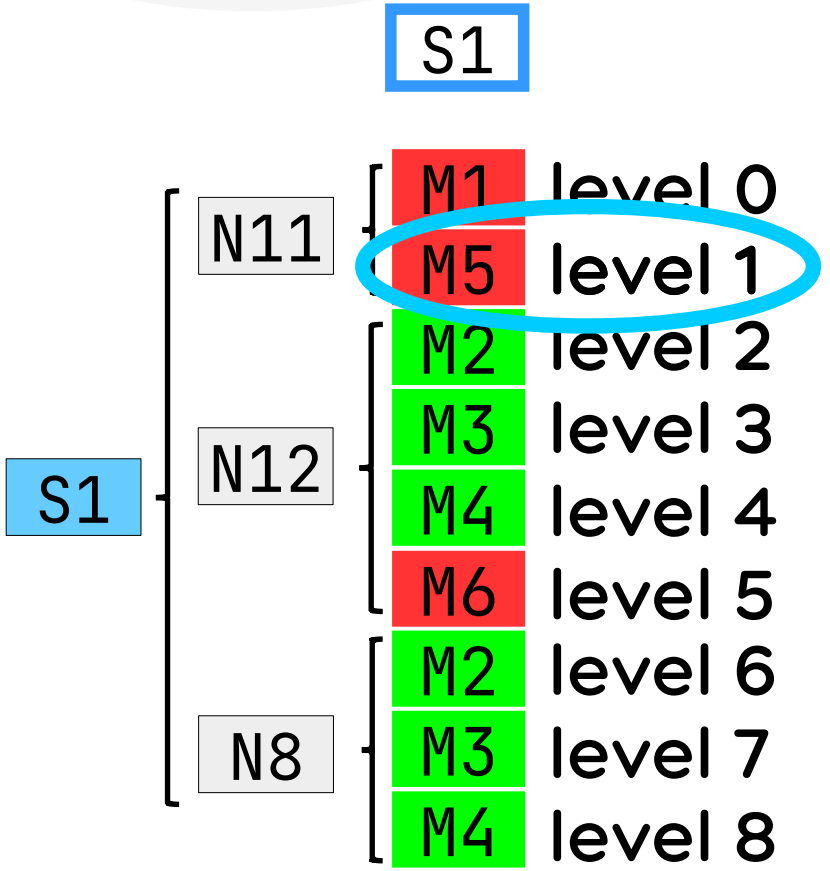
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 0
g(…) = M1 = S1[0][level]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

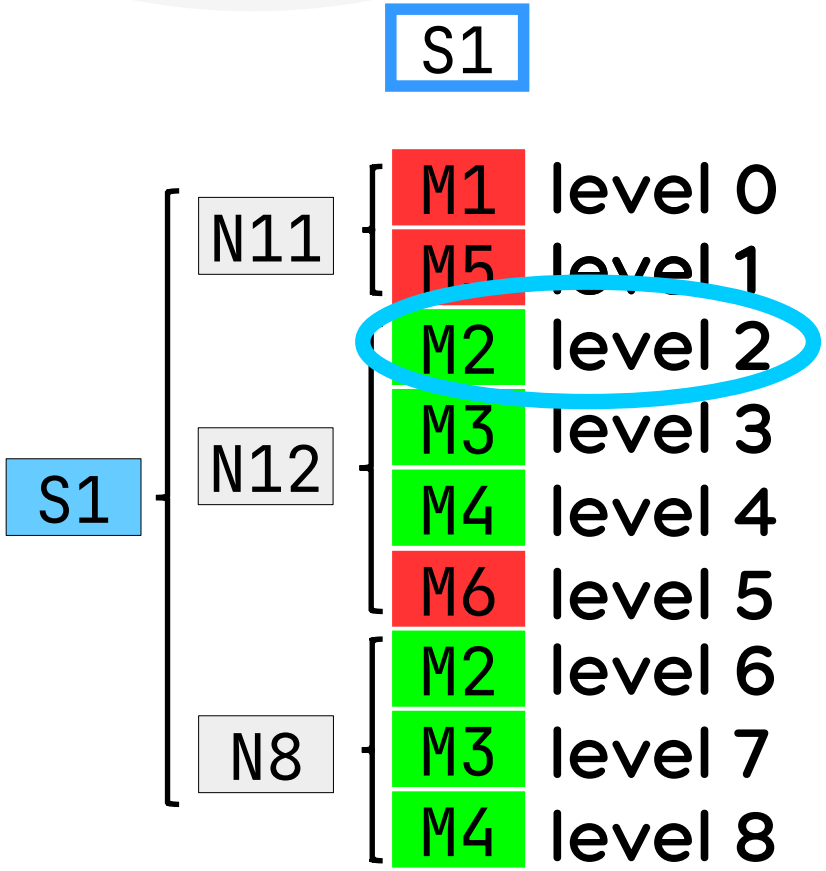
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 1
g(…) = M5 = S1[0][level]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

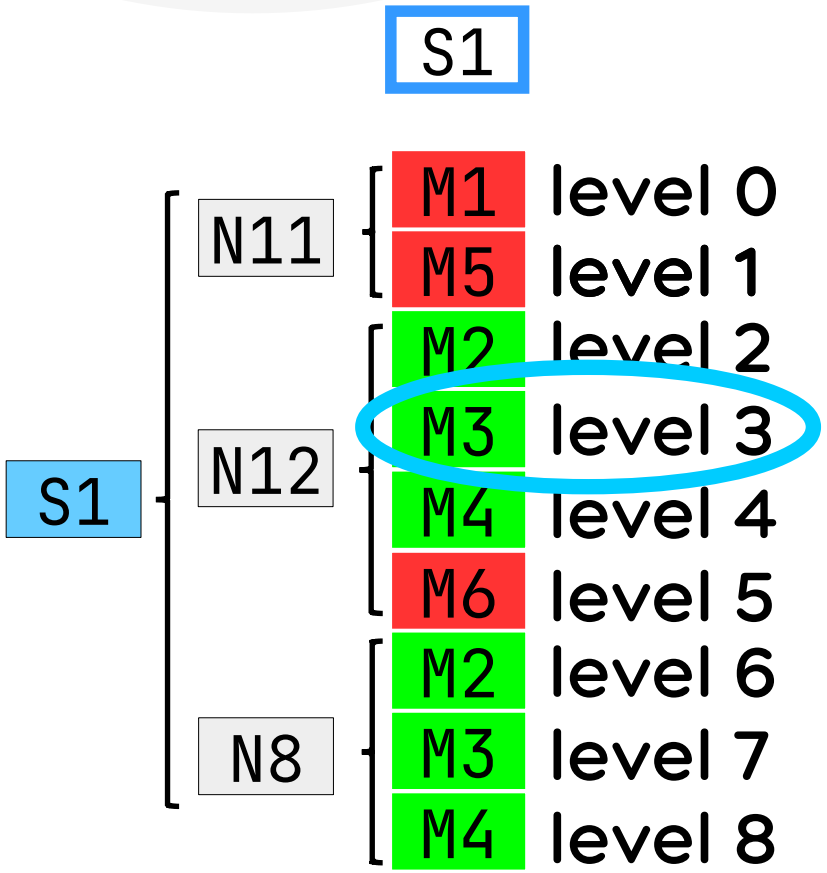
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 2
g(…) = M2 = S1[1][level - 2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

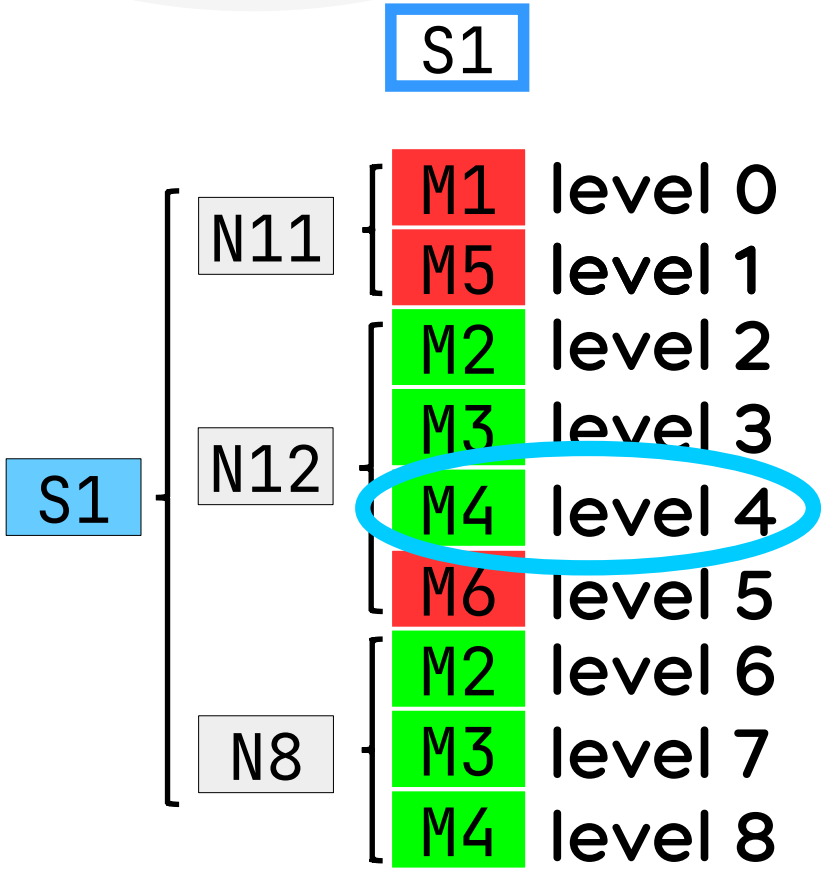
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 3
g(…) = M3 = S1[1][level - 2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

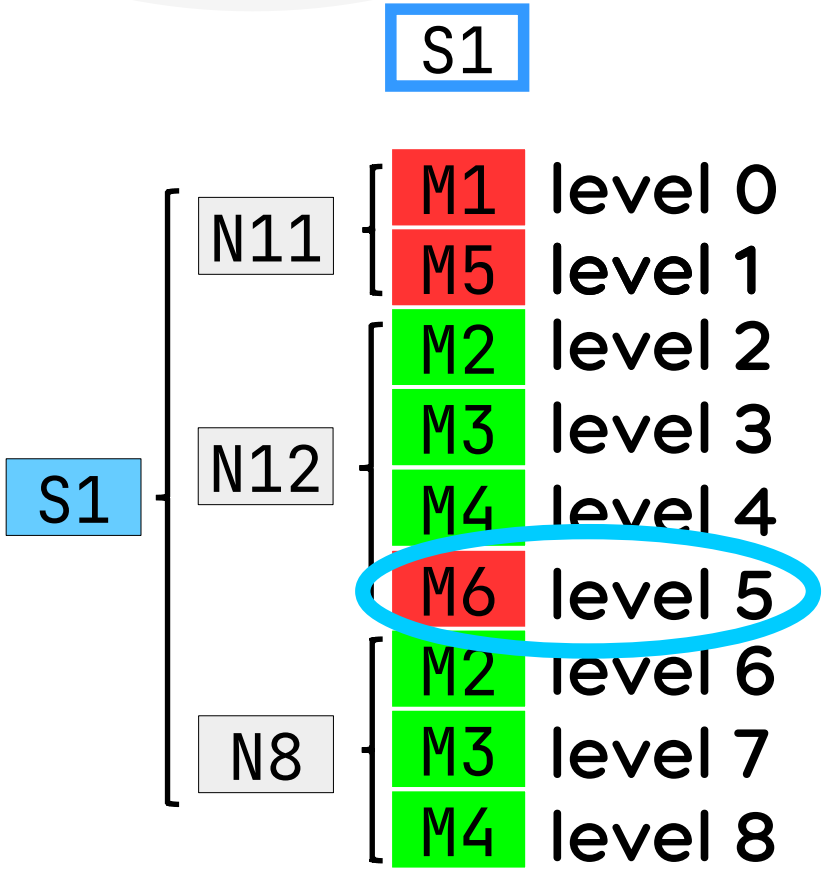
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 4
g(…) = M4 = S1[1][level - 2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

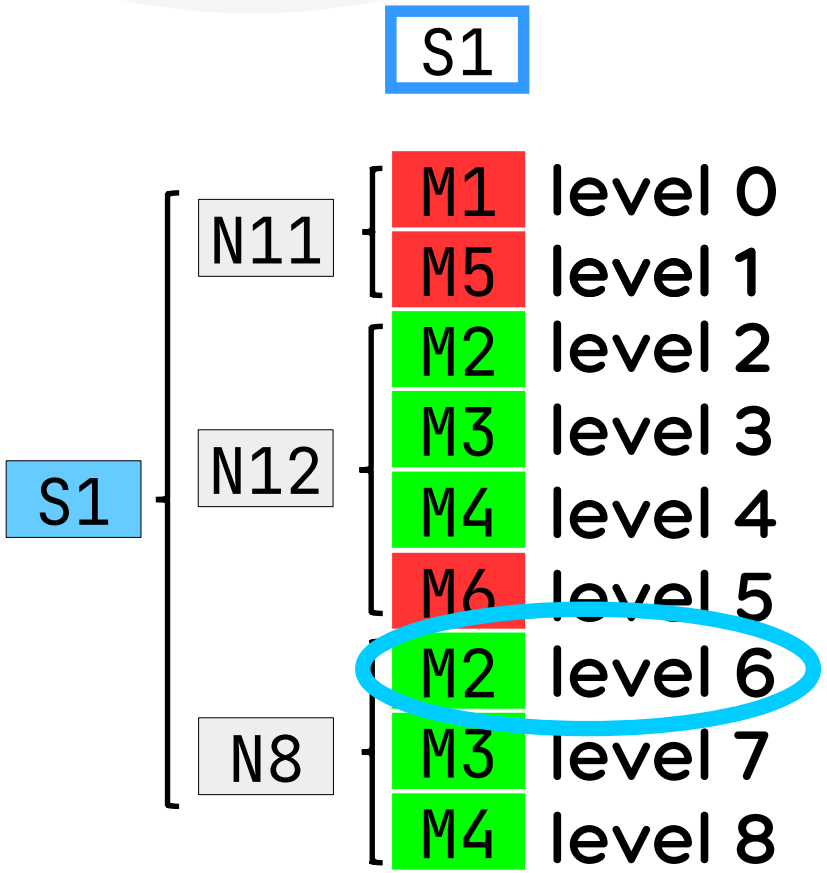
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 5
g(…) = M6 = S1[1][level - 2]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

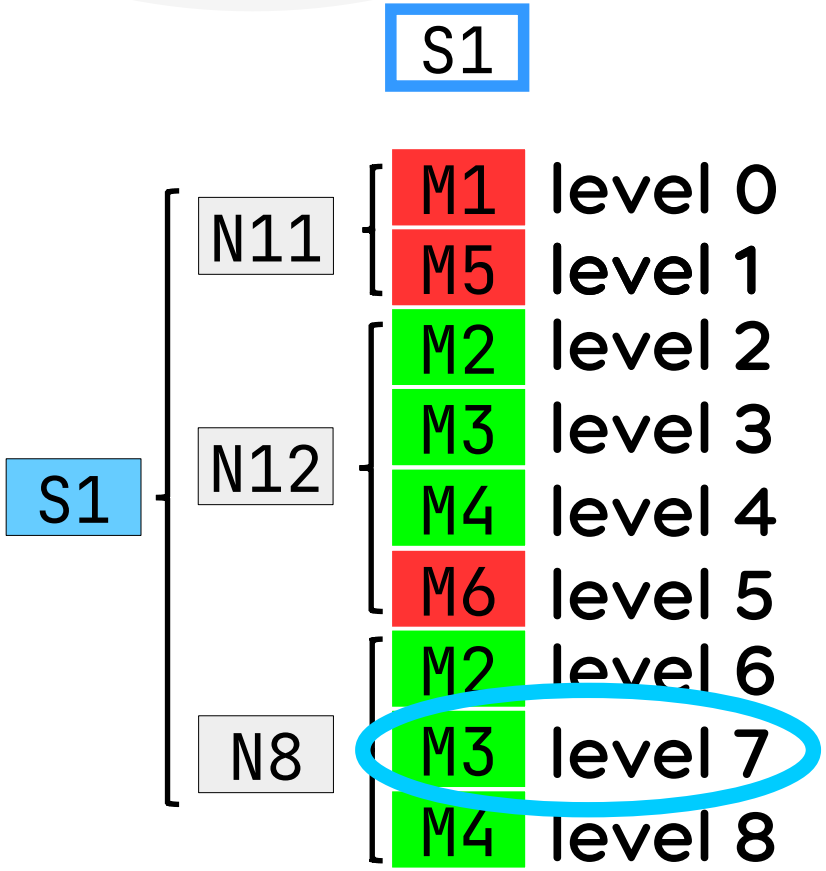
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 6
g(…) = M2 = S1[2][level - 6]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

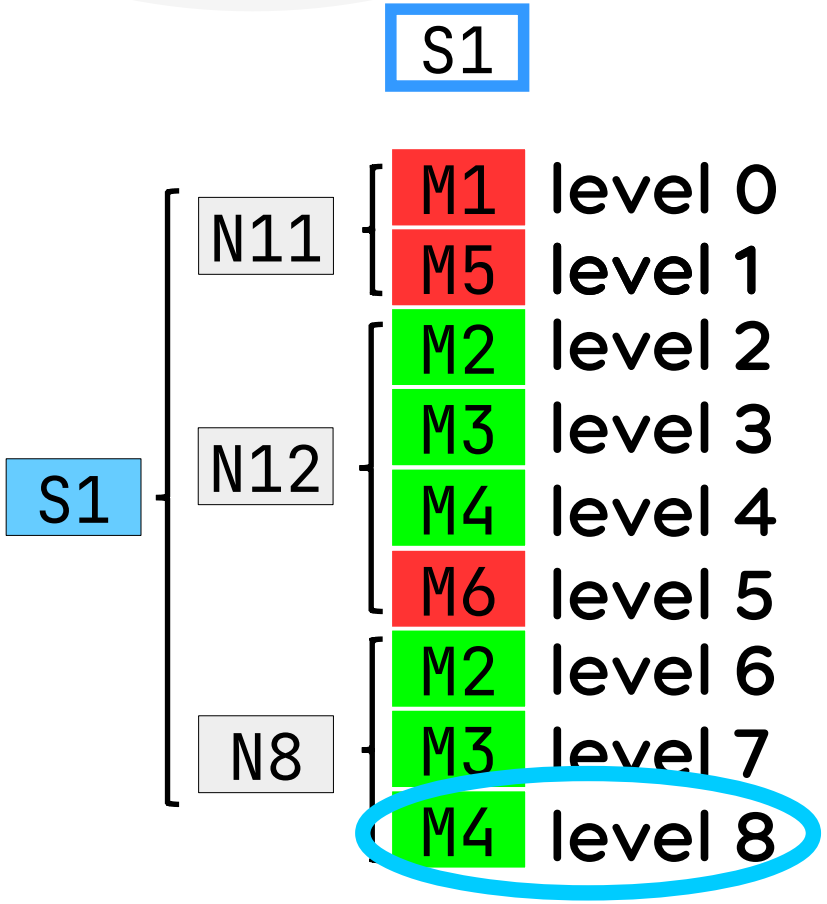
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 7
g(…) = M3 = S1[2][level - 6]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

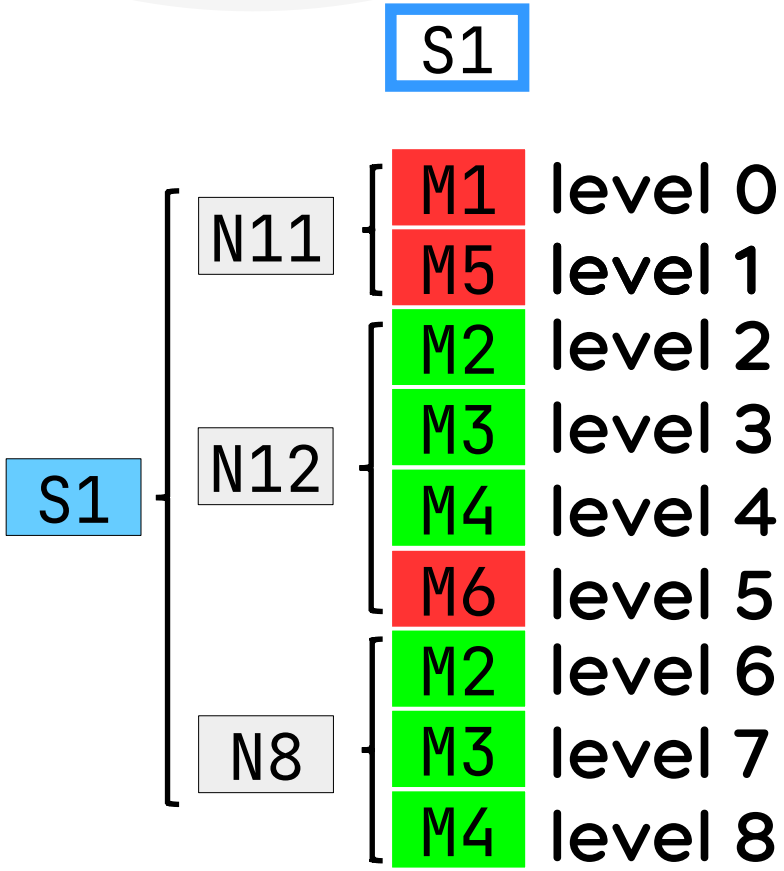
```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = S1[2][level - 6]
```



samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = S1[2][level - 6]

state.nodeIndex
```

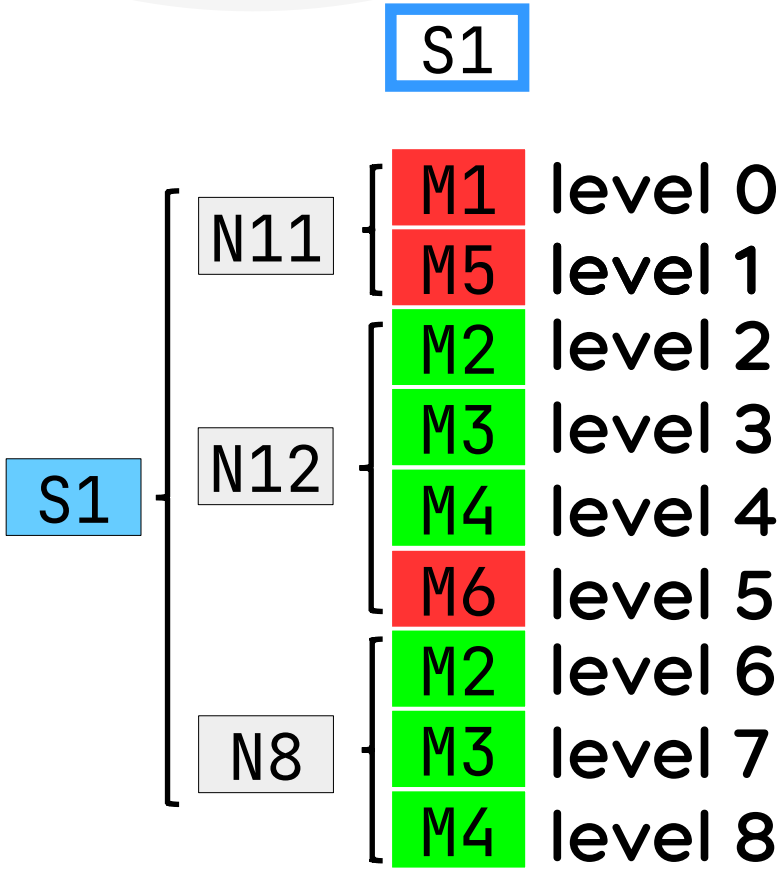


samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

Рисуем

```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = S1[2][level - 6]

state.nodeIndex
state.diff
```

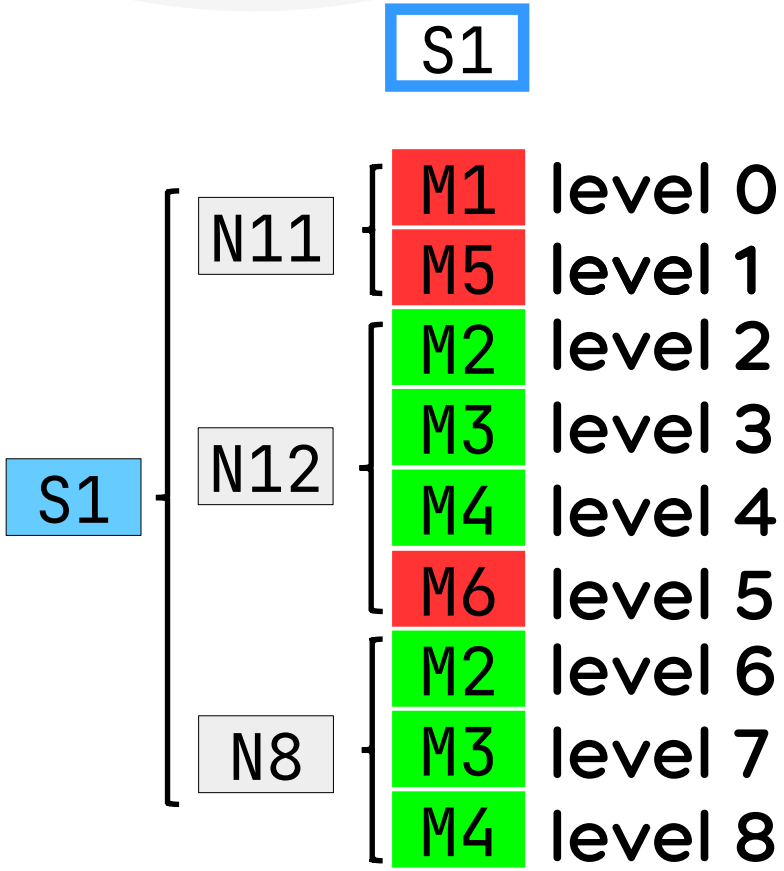
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...



Рисуем

```
g(state,level,sample) = f(i(…),n(…))

sample = S1
level = 8
g(…) = M4 = S1[2][level - 6]

node = sample[state.nodeIndex]
method = node[level - state.diff]
```

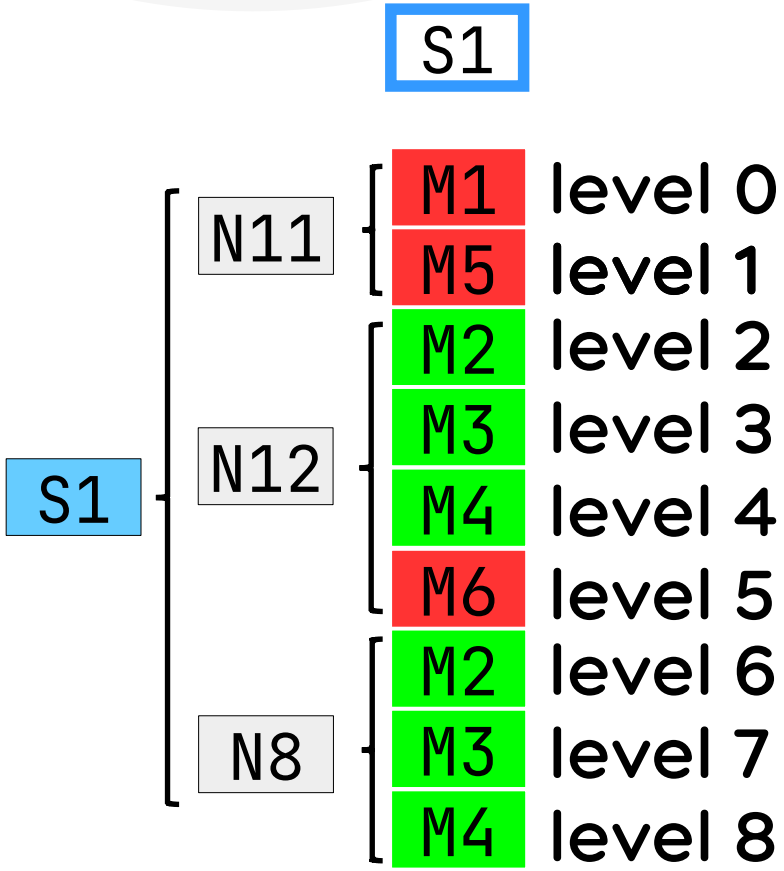
samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...



Рисуем

```
g(state,level,sample) = f(i(…),n(…))

node = sample[state.nodeIndex]
method = node[level - state.diff]

if (level - state.diff ⩾ node.size)
      state.nodeIndex += 1
      state.diff = level
```

samples	...	S1	S2	S3	S4	...
nodes	...	N1	N6	N11	N13	...
offsets	...	0	1	2	3	...
storage	...	M4	M6	M7	M8	...

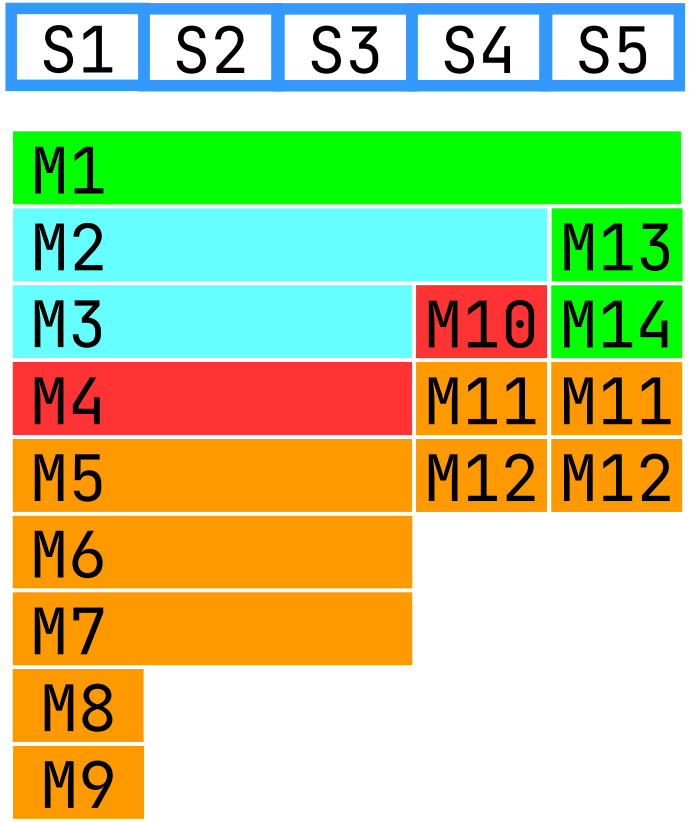


Рисуем

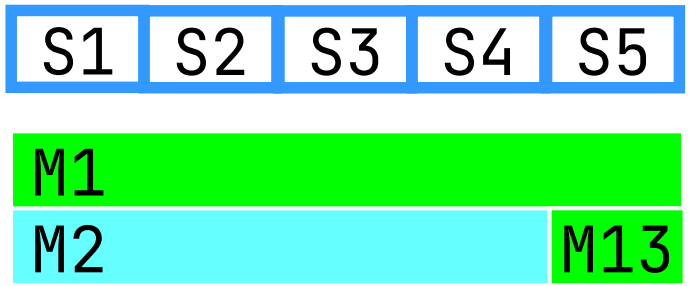
Frame: `{x, width, text, color}`

g(..., sample) = method

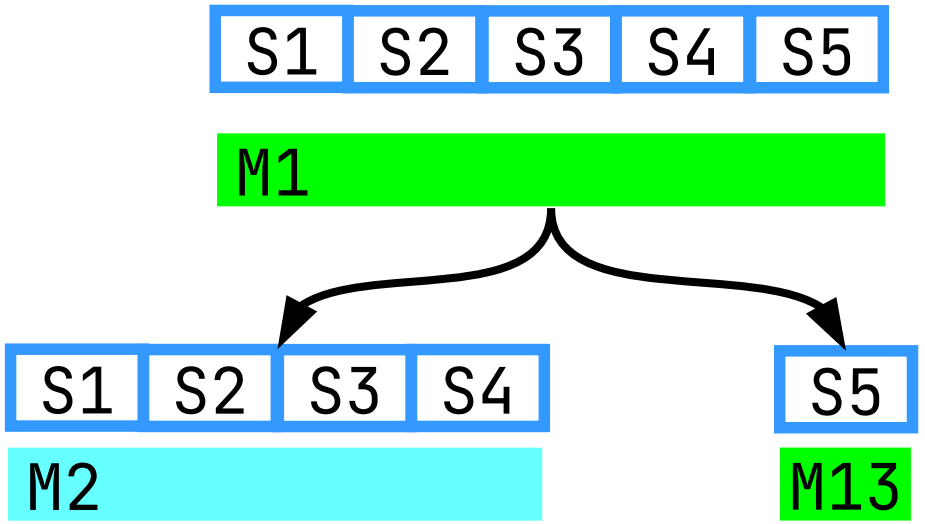
Рисуем



Рисуем

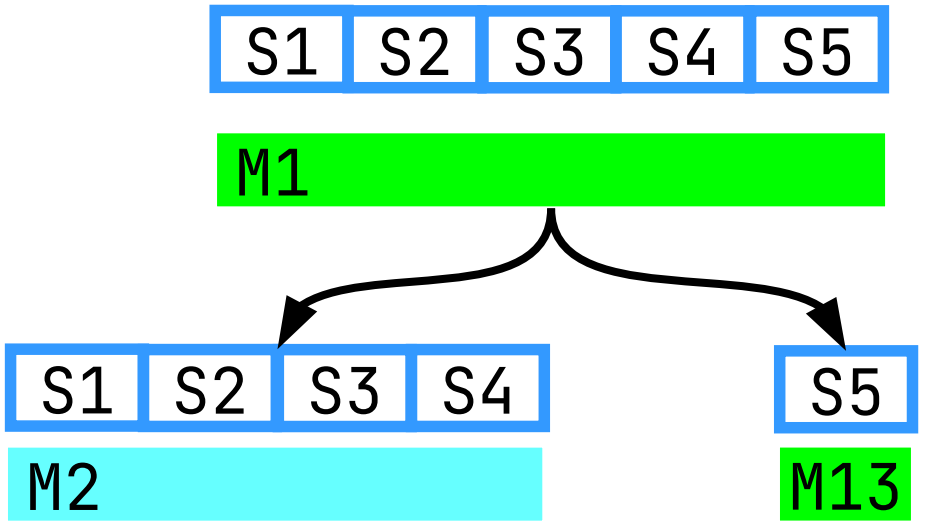


Рисуем



Рисуем

Frame: {x, width, text, color}



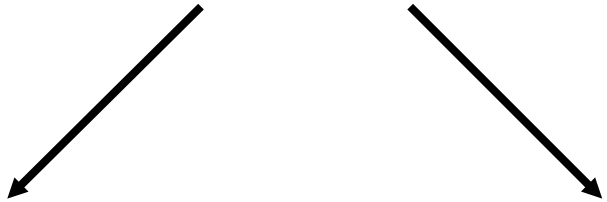
Frame: Map<Method, List<Sample>>

Рисуем

```
Map<Method, List<Sample>>

typeof(Method) = int
typeof(Sample) = int
```

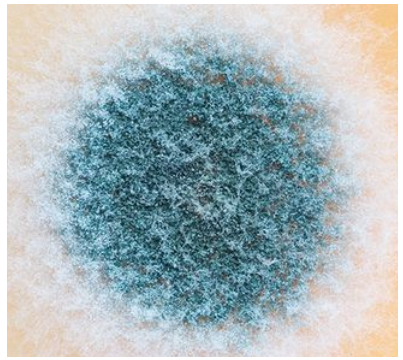
Рисуем

```
Map<Method, List<Sample>>
```

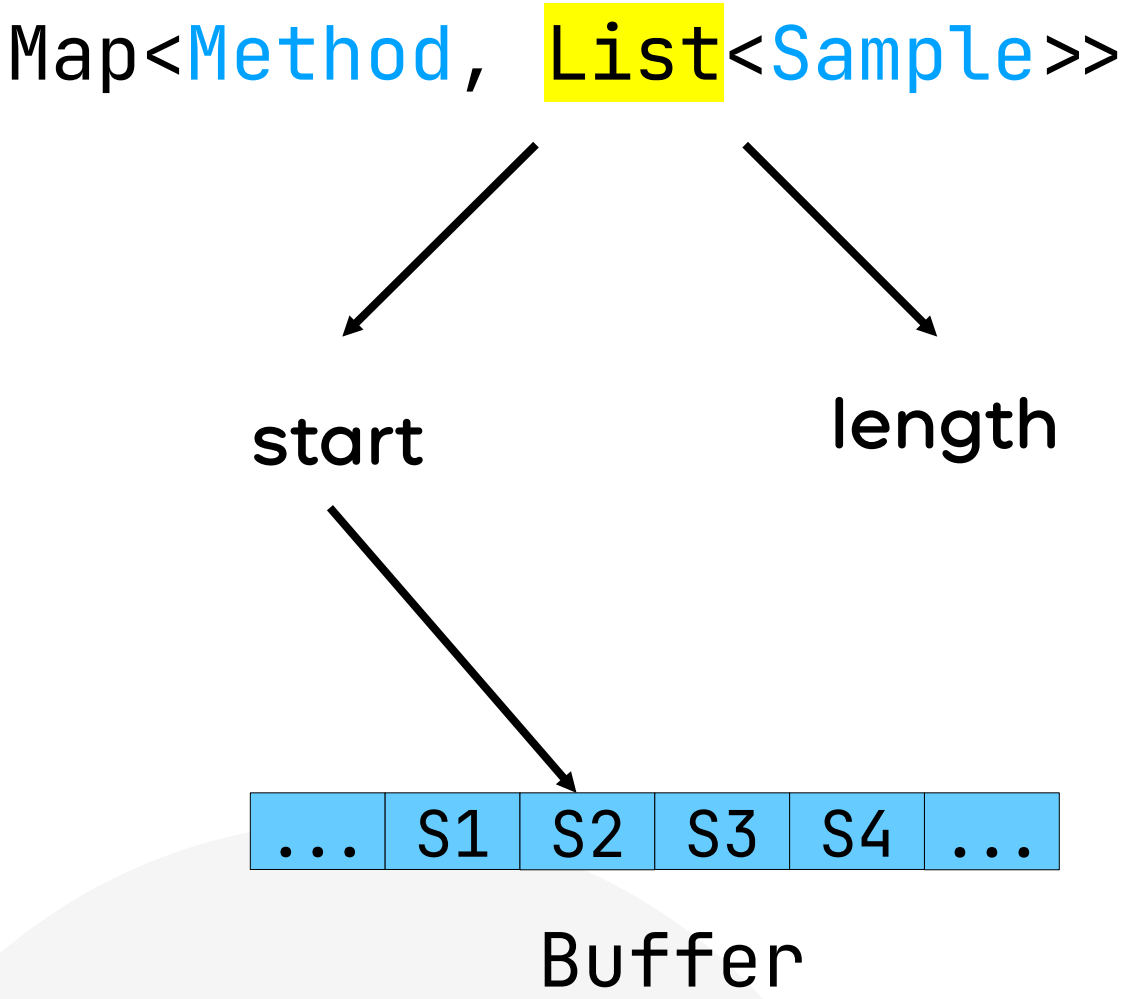


Рисуем

```
Map<Method, List<Sample>>
```

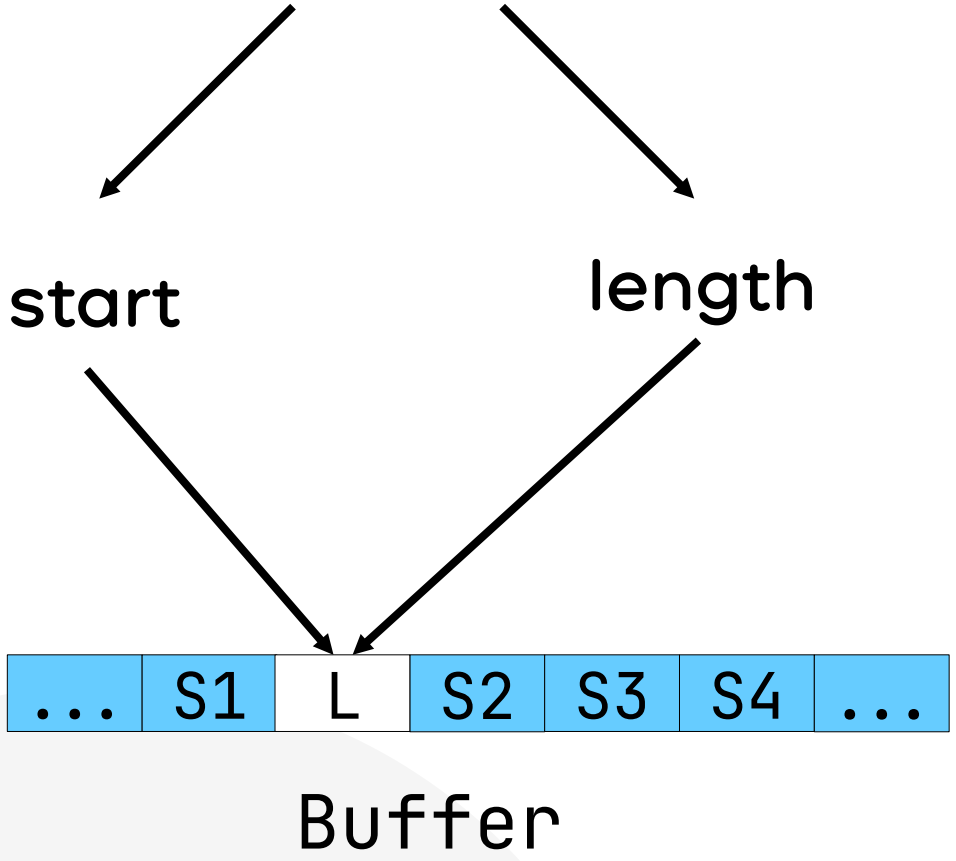


Рисуем



Рисуем

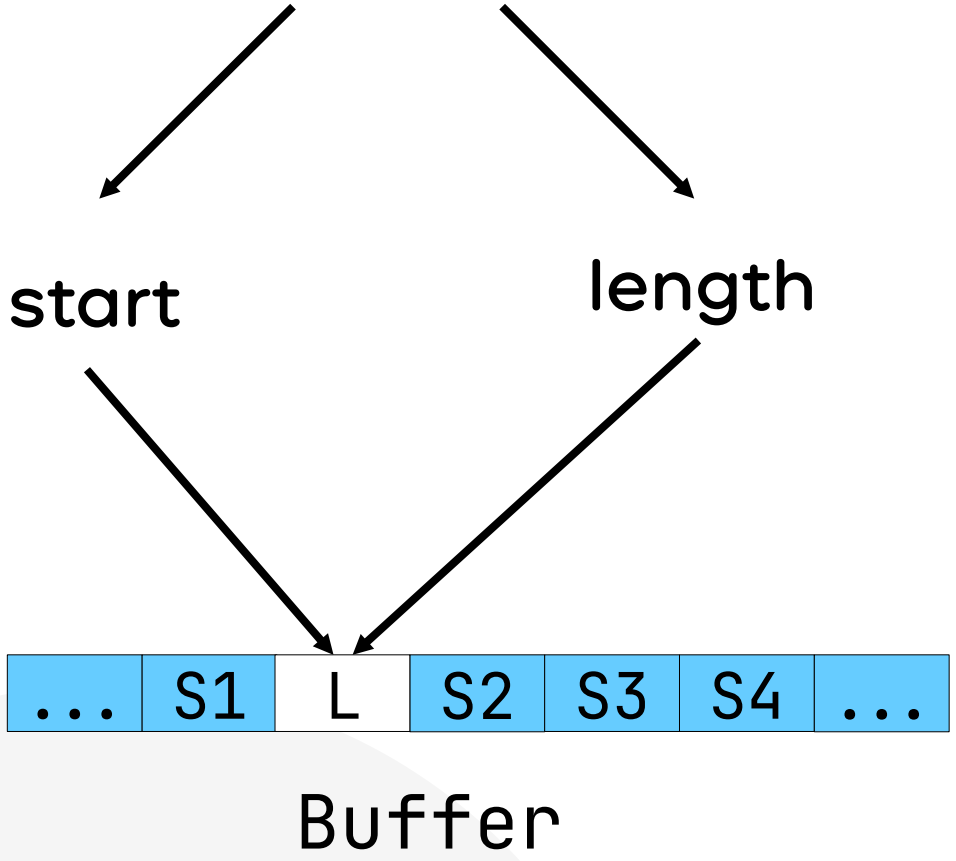
```
Map<Method, List<Sample>>
```



Рисуем

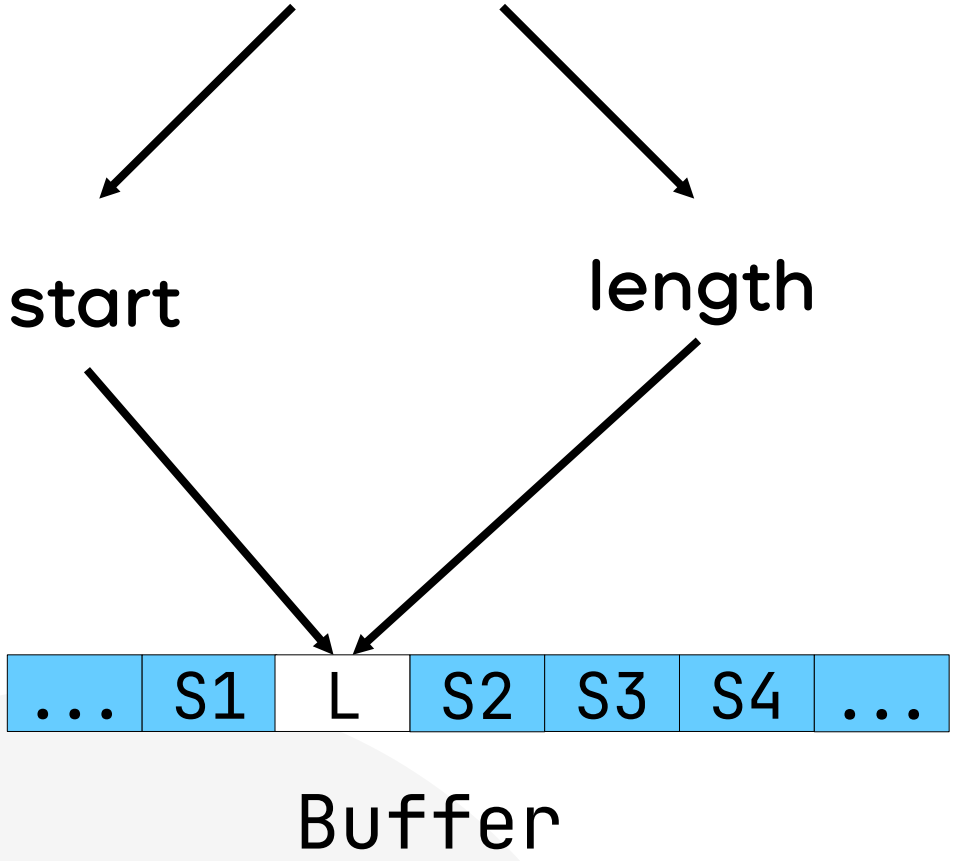
```
Map<Method, List<Sample>>
```

```
start[0] = 0
```



Рисуем

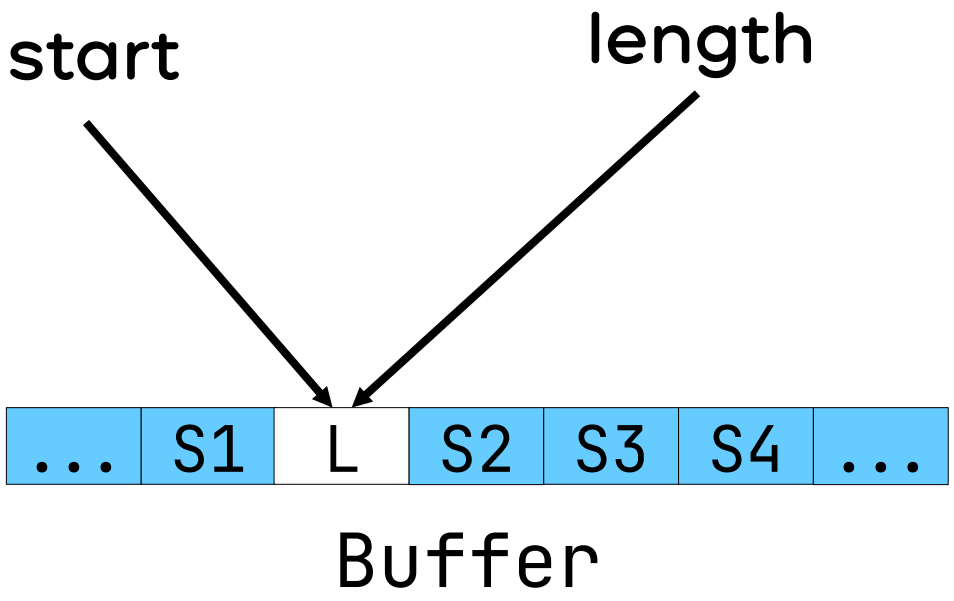
```
Map<Method, List<Sample>>
```




```
start[0] = 0

start[k] = start[k-1] +
    length[k-1] + 1
```

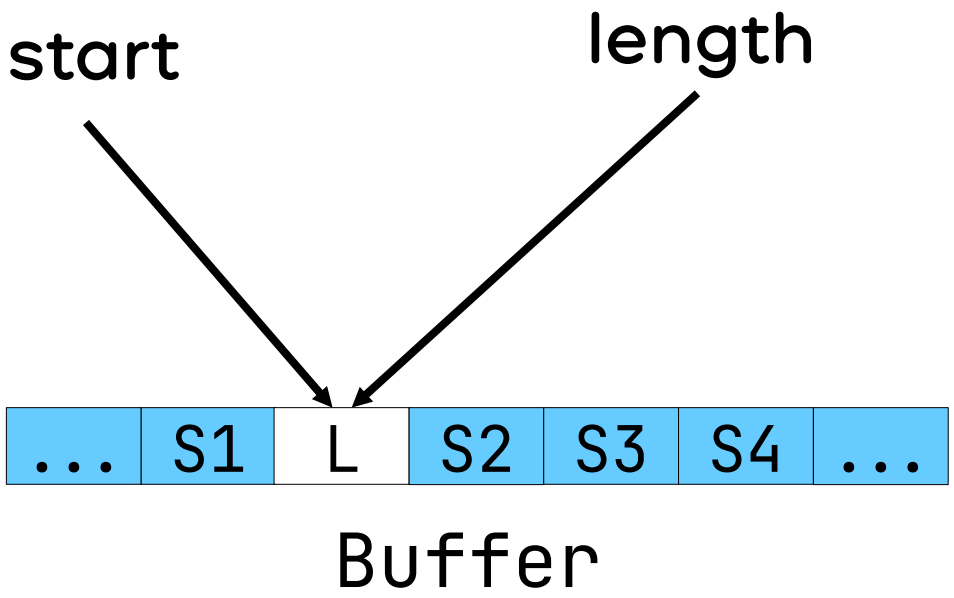
Рисуем

```
Map<Method, List<Sample>>
=
Map<Method, Length>
+
Map<Method, Start>
+
Buffer
```



Рисуем

```
Map<Method, List<Sample>>
=
Map<Method, Length>
+
Map<Method, Start>
+
Buffer
```



Рисуем

```
Map<Method, Length> - ???
```

```
typeof(Method) = int
typeof(Length) = int
```

Рисуем

```
Map<Method, Length> - ???
```

```
typeof(Method) = int 0..100_000
typeof(Length) = int
```

Рисуем

```
Map<Method, Length> - int[100_001]
```

```
typeof(Method) = int 0..100_000
typeof(Size) = int
```

Рисуем

```
Map<Method, Length> - int[100_001]
```

упрлс

```
typeof(Method) = int 0..100_000
typeof(Length) = int
```

Рисуем

```
Map<Method, Length> - int[100_001]
```

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
```

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
inc – put(x, get(x) + 1)
```

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
inc - O(1)
```

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
inc - O(1)
iterate - O(sizeOf(Method))
```

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
inc - O(1)
iterate - O(sizeOf(Method))
```

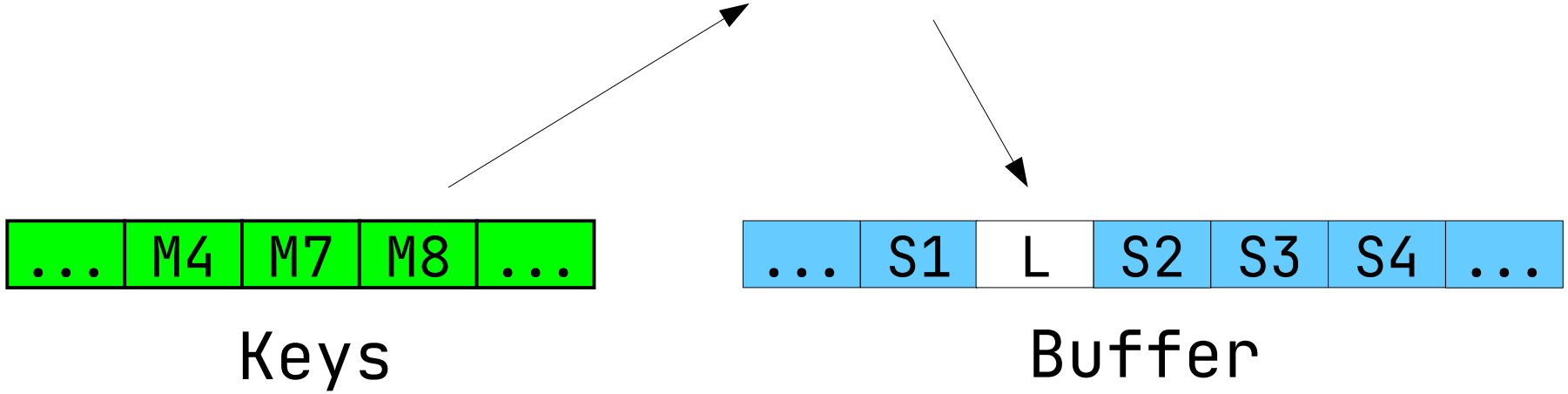
Добавим буфер ключей!

Рисуем

```
Map<Method, Length> - int[100_001]
get - O(1)
put - O(1)
inc - O(1)
iterate - O(entriesCount)

if (inc(x) == 1) keys[entriesCount++] = x
```

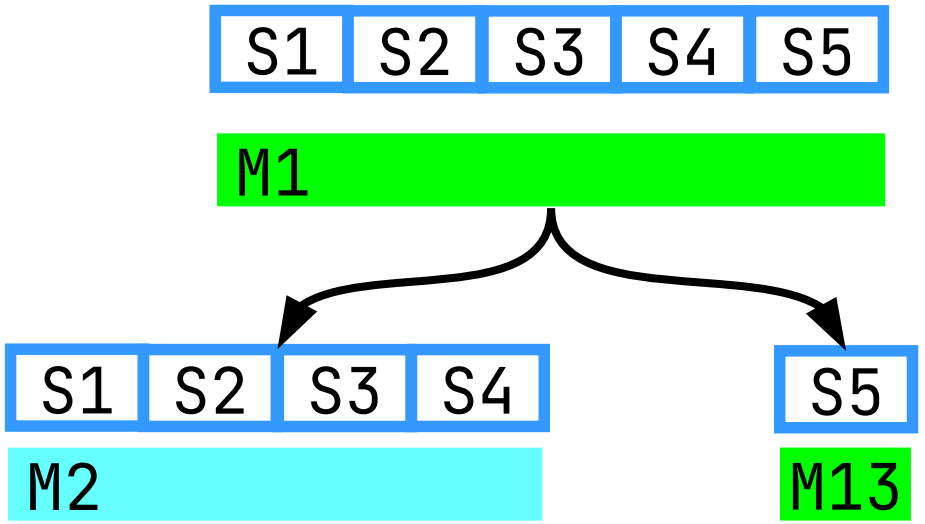
Рисуем

```
Map<Method, List<Sample>> - int[100_001]
```



Рисуем

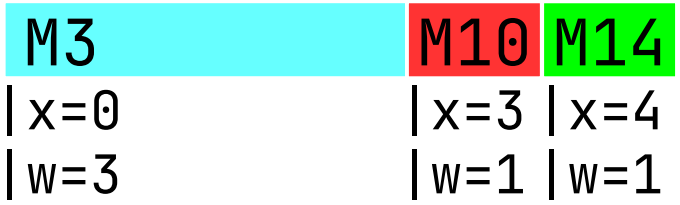
Frame: {x, width, text, color}



Frame: Map<Method, List<Sample>>

Рисуем

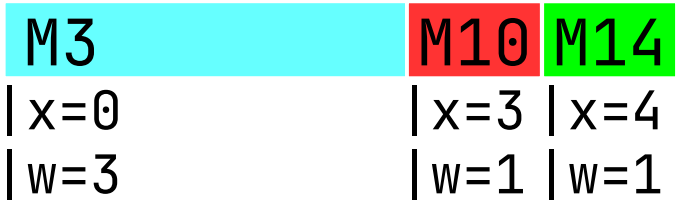
```
Frame: {x, width, text, color}
```



Рисуем

Frame: {x, width, text, color}

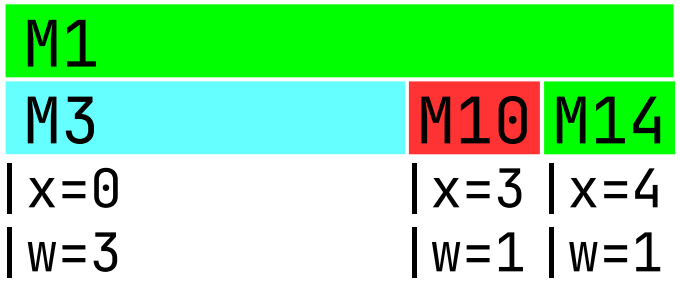
x[i] = x[i-1] + width[i-1]



Рисуем

Frame: {x, width, text, color}

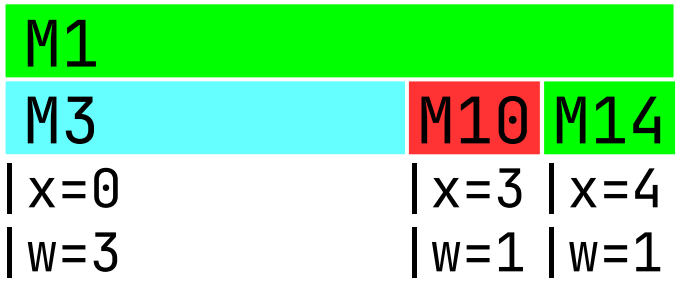
```
x[i] = x[i-1] + width[i-1]
x[0] = parent.x
```



Рисуем

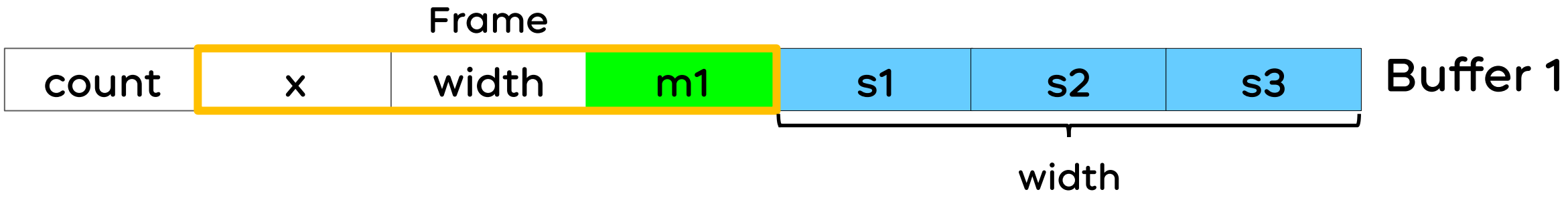
Frame: {x, width, text, color}

```
x[i] = x[i-1] + width[i-1]
x[0] = parent.x

width[i] ⩾ width[i+1]
```



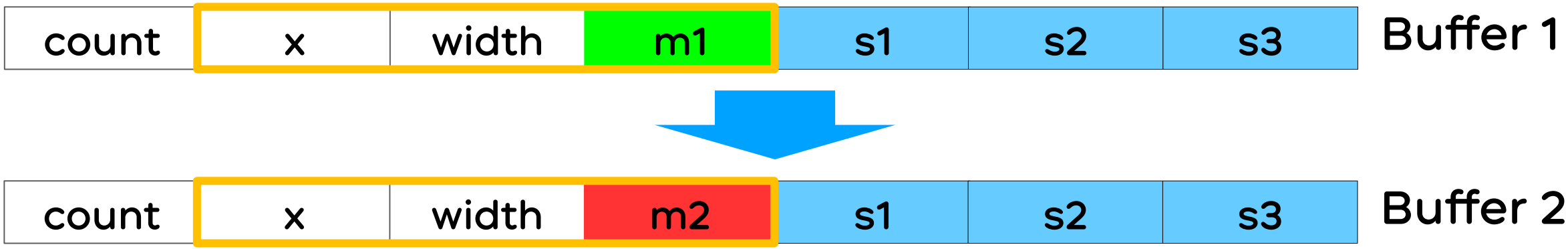
Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]
```



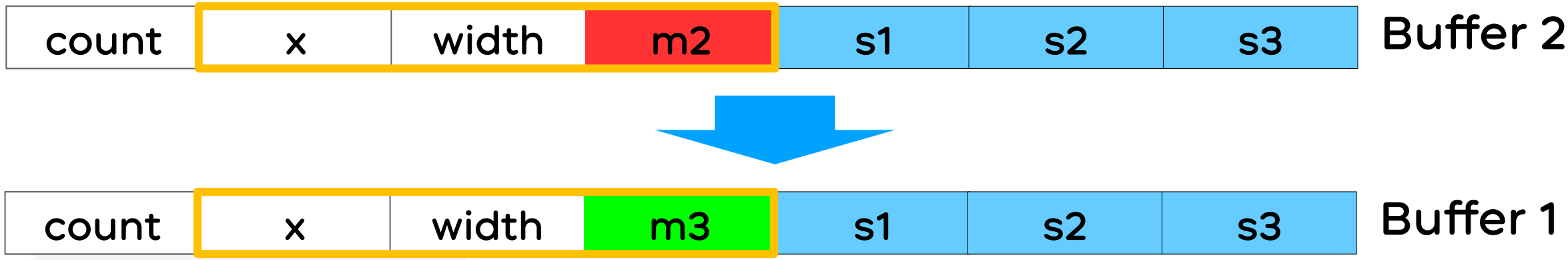
Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]
```



Рисуем

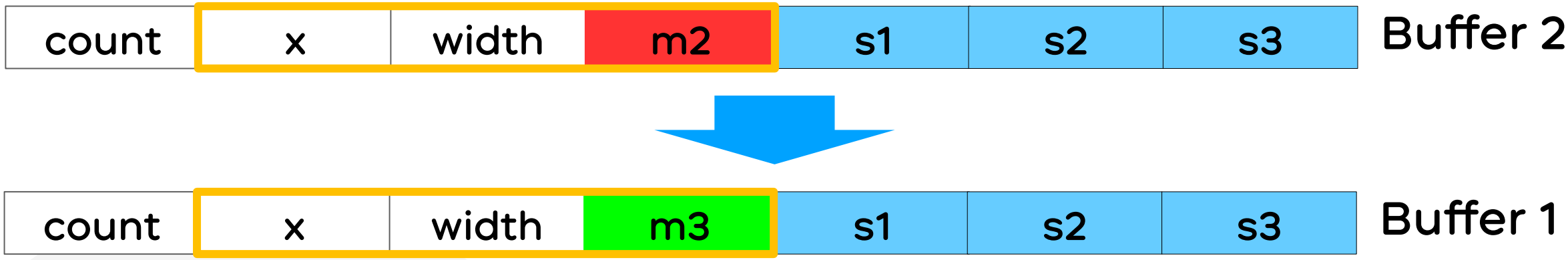
```
Frame: {x, width, text, color}
Level: Frame[]
```



Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]
```

Q: Почему не кольцевой буфер?



Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - ?
```

Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - 100 MB
```

Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - 1 GB
```

Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - 10 GB
```

Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - 10 GB ?????????
```

Рисуем

```
Frame: {x, width, text, color}
Level: Frame[]

SizeOf(Buffer) - 10 GB
```

Lazy
Allocation!

Рисуем

CPU (6 млн сэмплов):

< 1 секунды на первый уровень

3 секунды

Рисуем

CPU (6 млн сэмплов):

< 1 секунды на первый уровень

3 секунды

< 5 секунд на первые 20 уровней

15 секунд

Рисуем

CPU (6 млн сэмплов):

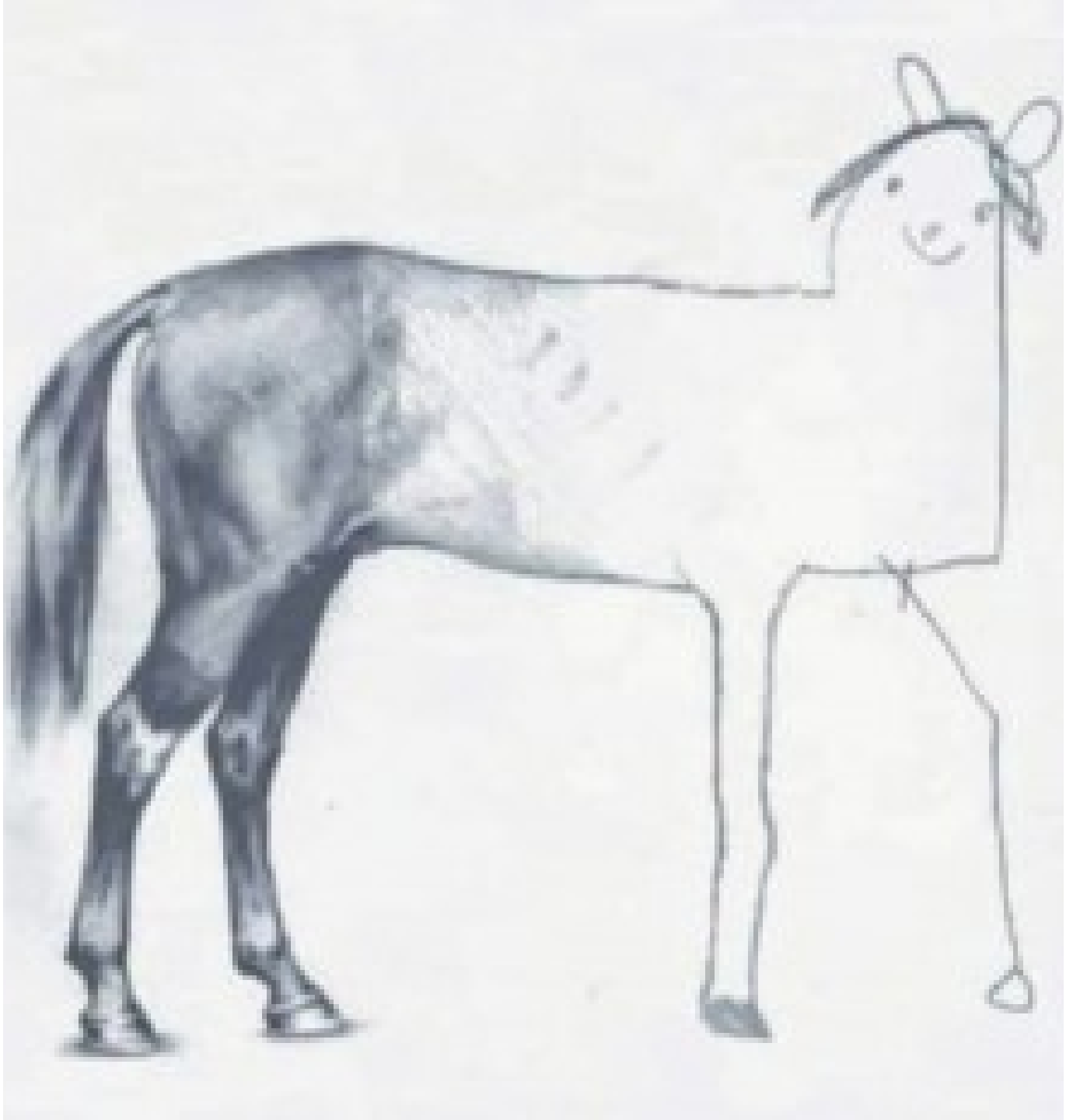
< 1 секунды на первый уровень

3 секунды

< 5 секунд на первые 20 уровней

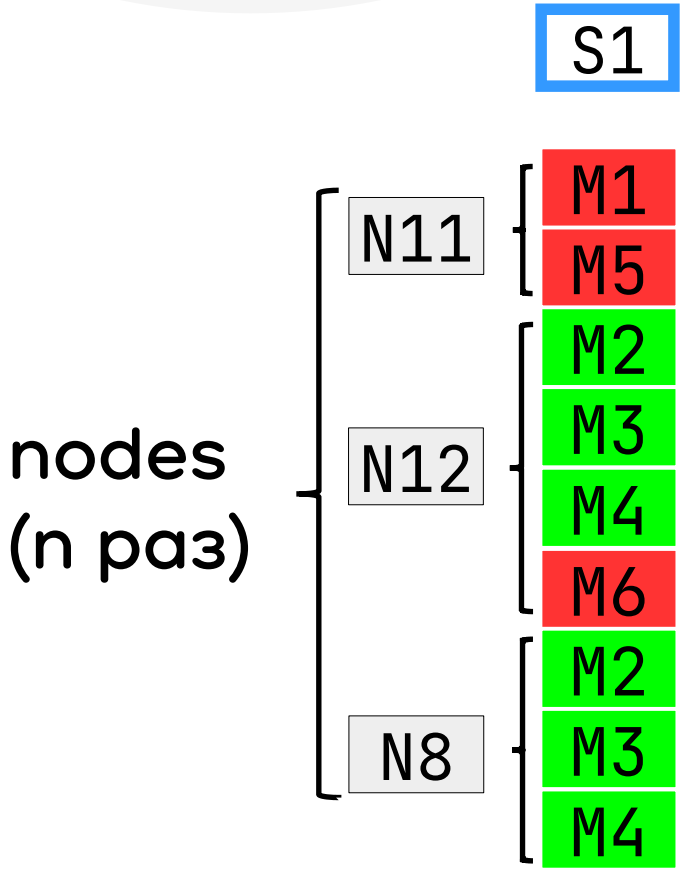
15 секунд

Оптимизация отрисовки



Оптимизируем

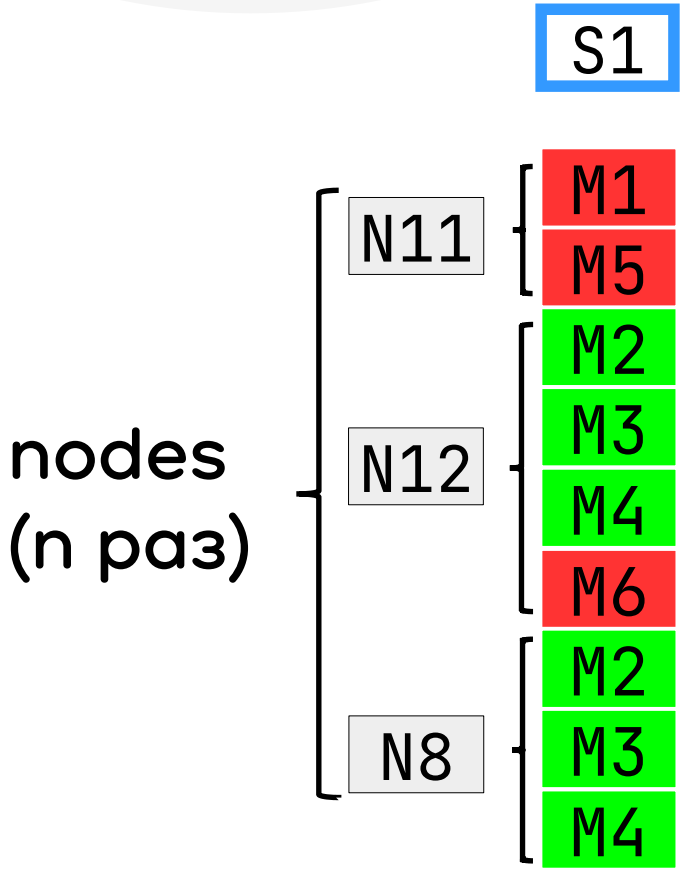
В 90% случаев n = 1



Оптимизируем

В 90% случаев n = 1

Потому что сэмплы часто повторяются!

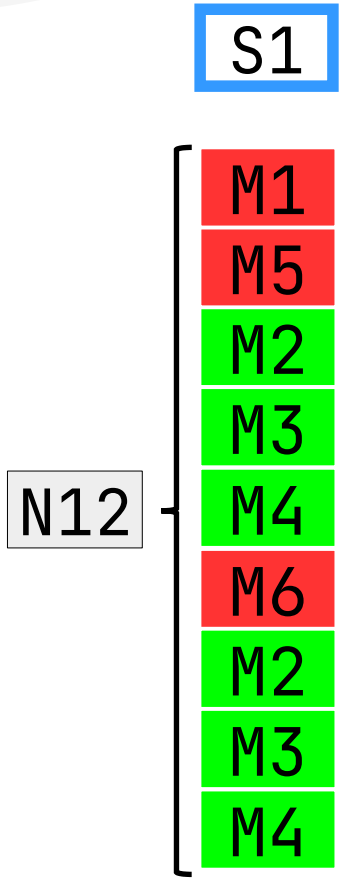


Оптимизируем

В 90% случаев n = 1

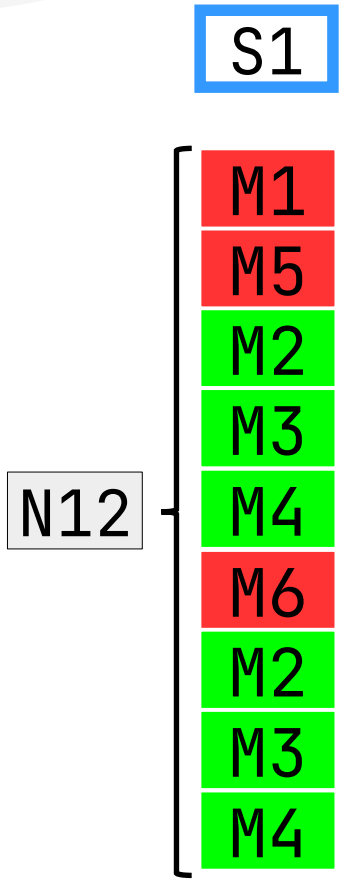
Потому что сэмплы часто повторяются!

И именно те, у которых n = 1!



Оптимизируем

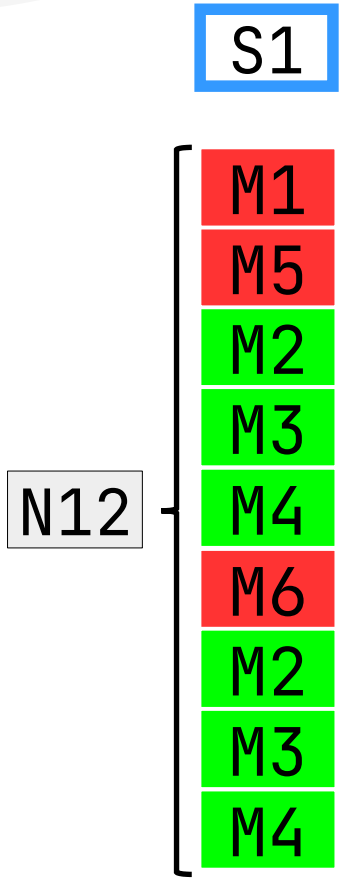
```
Map<Method, Length>
```



Оптимизируем

```
Map<Method, Length>
```

```
Map<Node, Count>
```

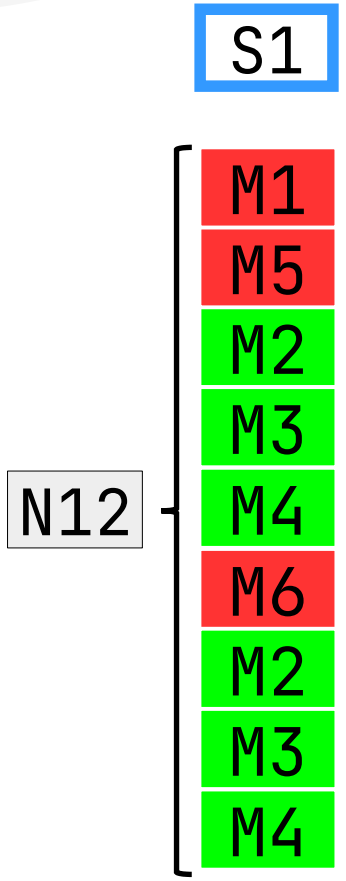


Оптимизируем

```
Map<Method, Length>
```

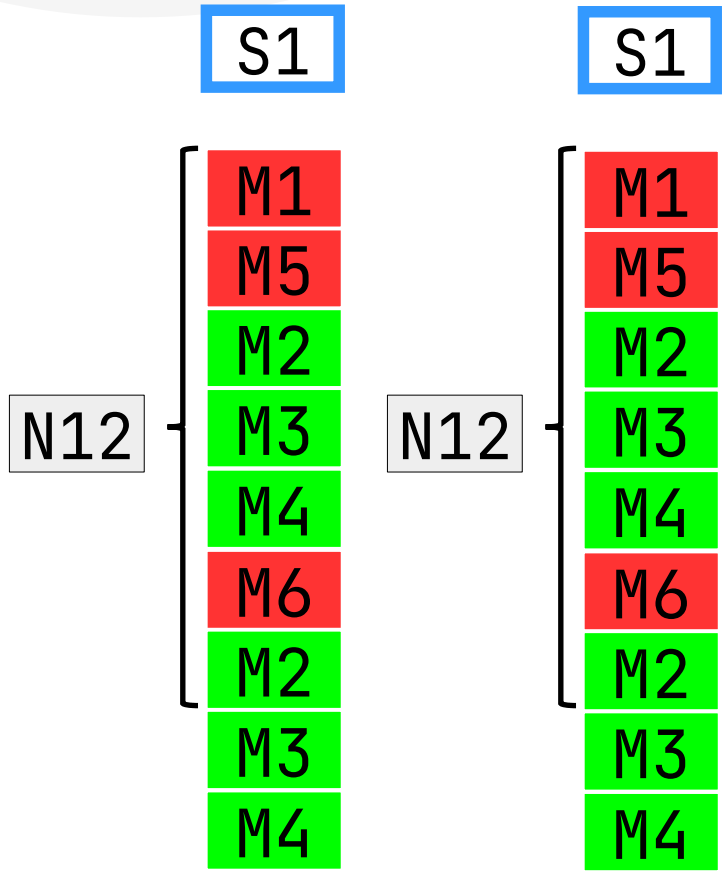
```
Map<Node, Count>
```

6 млн сэмплов  450 000



Оптимизируем ещё

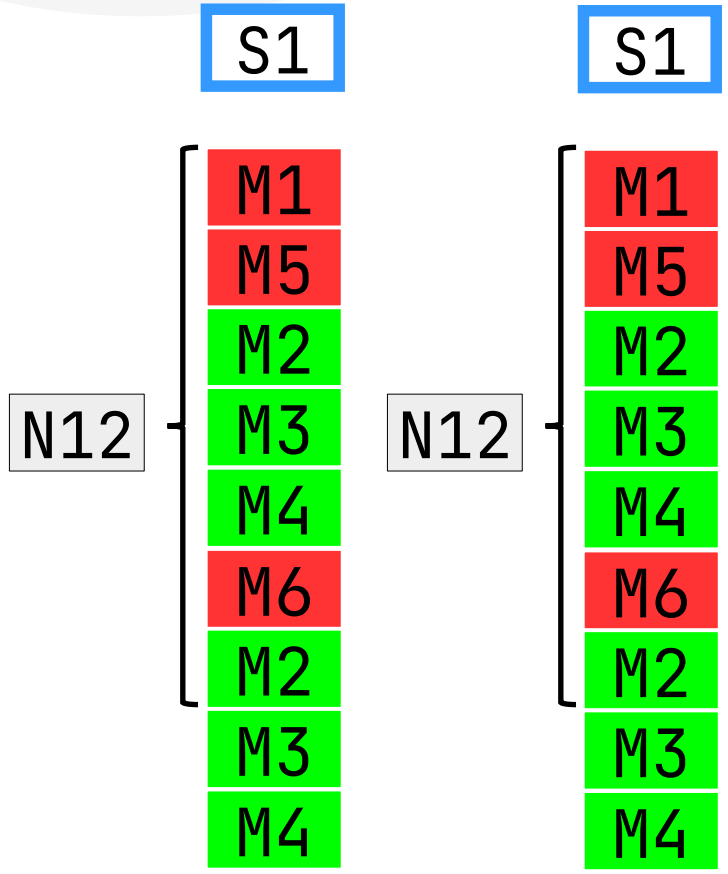
```
Map<Method, List<Sample>>
```



Оптимизируем ещё

```
Map<Method, List<Sample>>
```

```
Map<Node, List<Sample>>
```

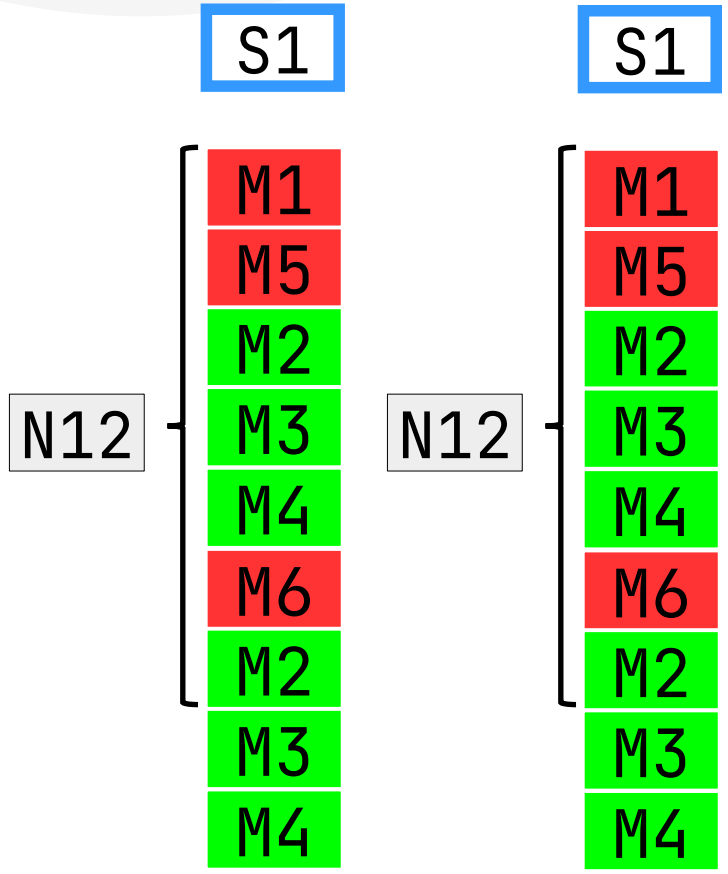


Оптимизируем ещё

```
Map<Method, List<Sample>>
```

```
Map<Node, List<Sample>>
```

450 000  250 000



Результат

CPU (6 млн сэмплов):

Результат

CPU (6 млн сэмплов):

- < 1 секунды на первый уровень

Результат

CPU (6 млн сэмплов):

- < 1 секунды на первый уровень
  - 0.5 секунды

Результат

CPU (6 млн сэмплов):

- < 1 секунды на первый уровень
  - 0.5 секунды

- < 5 секунд на первые 20 уровней

Результат

CPU (6 млн сэмплов):

- < 1 секунды на первый уровень
  - 0.5 секунды

- < 5 секунд на первые 20 уровней
  - 3 секунды

Результат

Alloc (78 млн сэмплов):

- < 5 секунд на первый уровень
  - 3 секунды

- < 10 секунд на первые 20 уровней
  - 2 секунды

Результат

Alloc (78 млн сэмплов):

- < 5 секунд на первый уровень
  - 3 секунды

- < 10 секунд на первые 20 уровней
  - 2 секунды на все уровни

https://github.com/Artyomcool/async-profiler/tree/heatmap

Выводы

Выводы

- Мы хотели...

Выводы

- Мы хотели...
- Мы добились...

Выводы

- Мы хотели...
- Мы добились...
- Бла-бла-бла...

Выводы

- Алгоритмы правда помогают, если данных много

Выводы

- Алгоритмы правда помогают, если данных много
- Высокой производительности нельзя достичь, не открыв “чёрные ящики”

Выводы

- Алгоритмы правда помогают, если данных много
- Высокой производительности нельзя достичь, не открыв “чёрные ящики”
- Частные решения зачастую эффективнее общих

Вопросы?

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