State Schema Evolution for Apache Flink® Applications

Apache Flink® 流式应用中状态的数据结构定义升级

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Apache Flink PMC

Agenda

1. Evolving Stateful Flink Streaming Applications
   Flink 有状态流式应用升级的考虑要素
2. Schema Evolution for Flink Built-in Types
   Flink 内建类别的数据结构定义更新
3. Implementing Custom State Serializers
   自订状态序列化器的实现

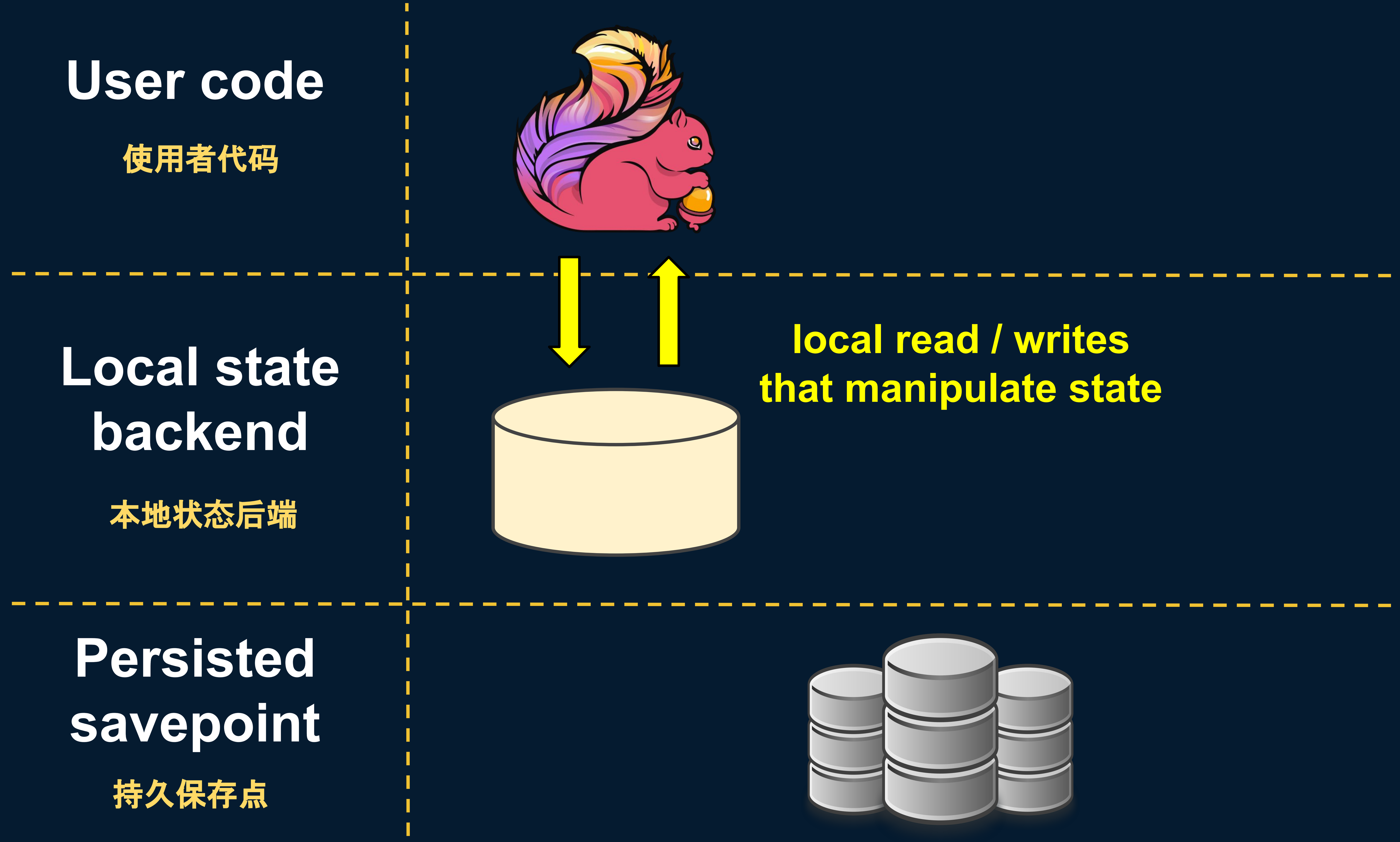
Evolving Stateful Flink Streaming Applications

Flink 有状态流式应用升级的考虑要素

FLINK FORWARD

Anatomy of a Flink stream job upgrade

Flink 流式应用升级流程解析



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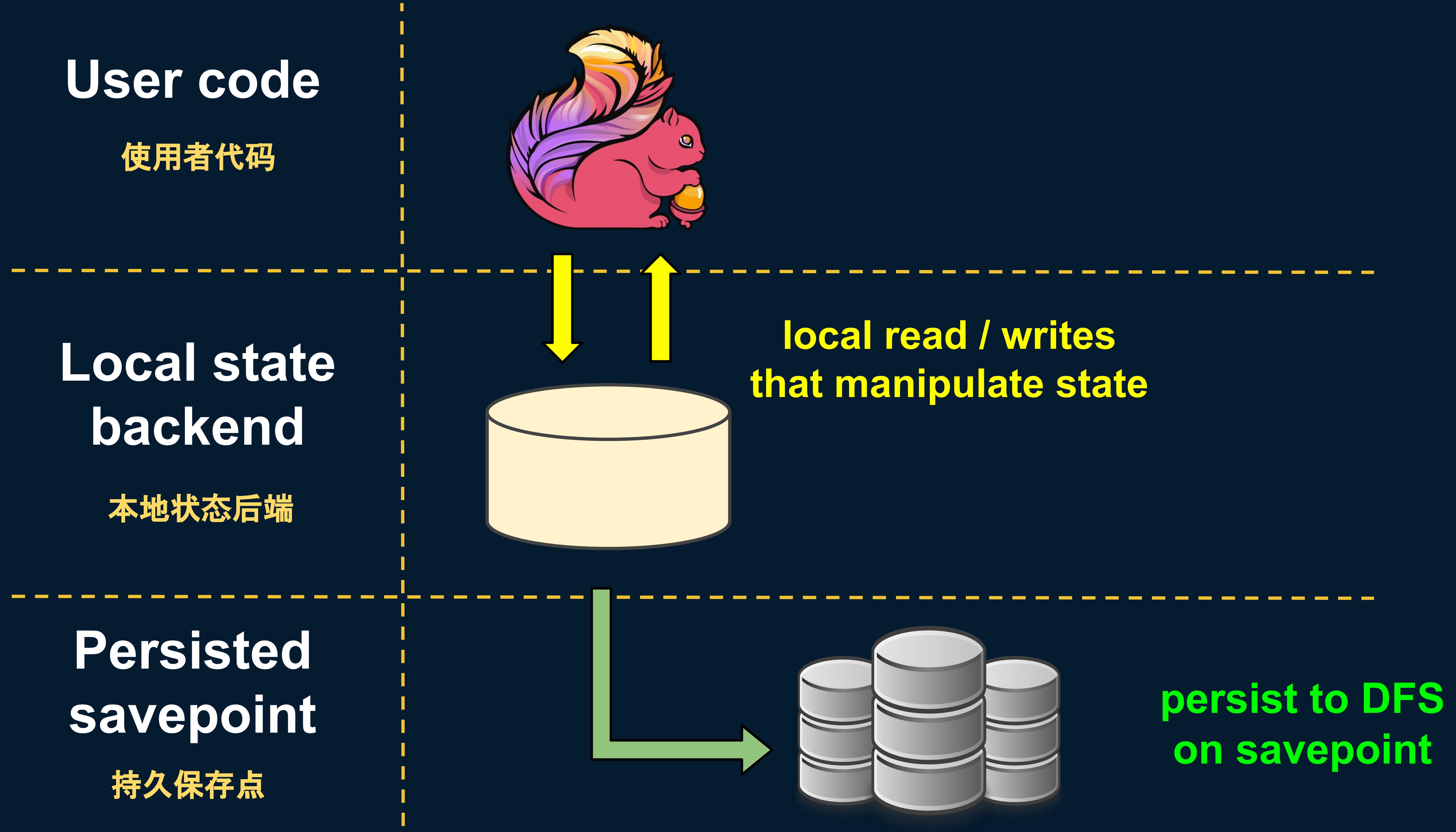

Anatomy of a Flink stream job upgrade

Flink 流式应用升级流程解析

User code

使用者代码

Local state backend

本地状态后端

Persisted savepoint

持久保存点

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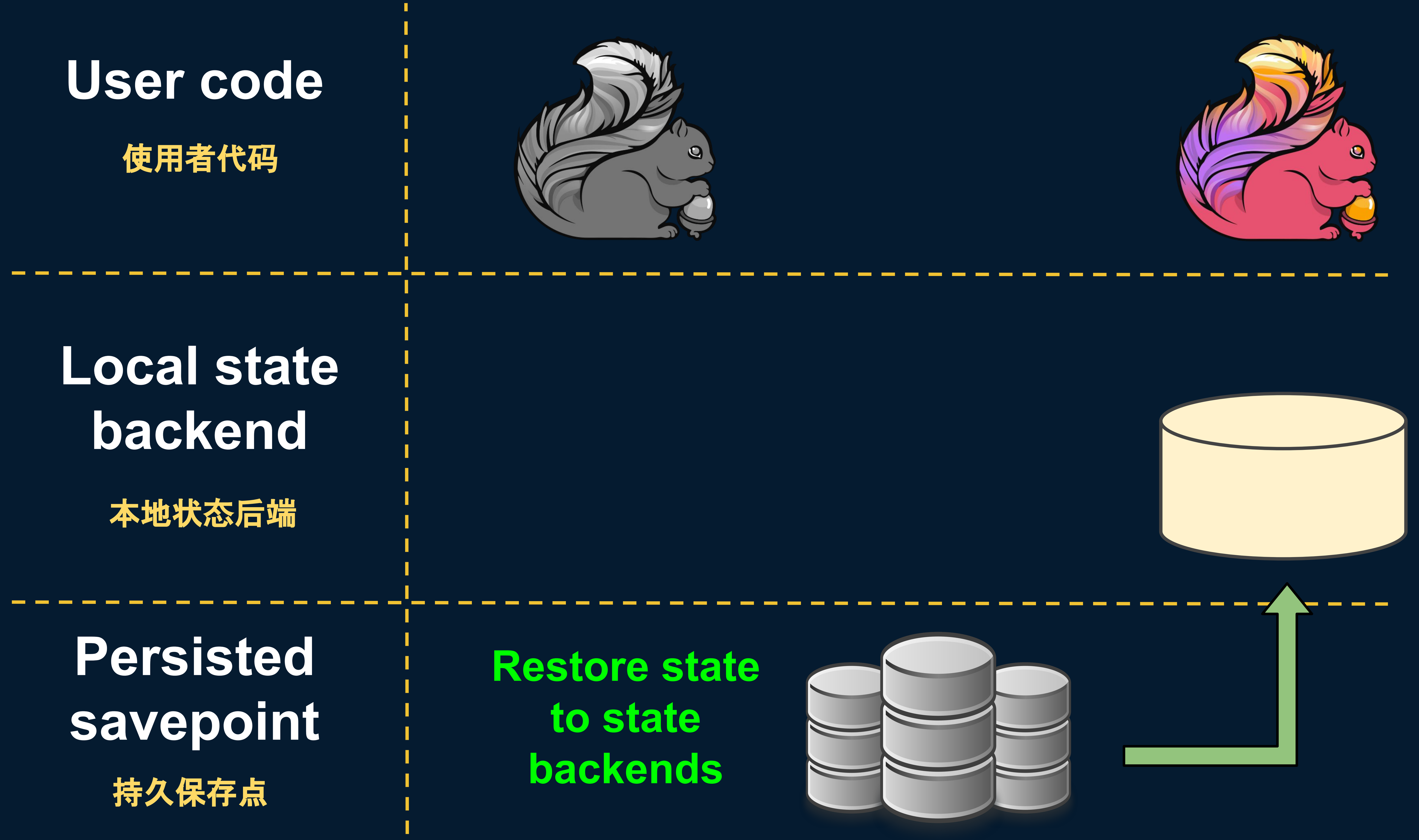

FLINK FORWARD

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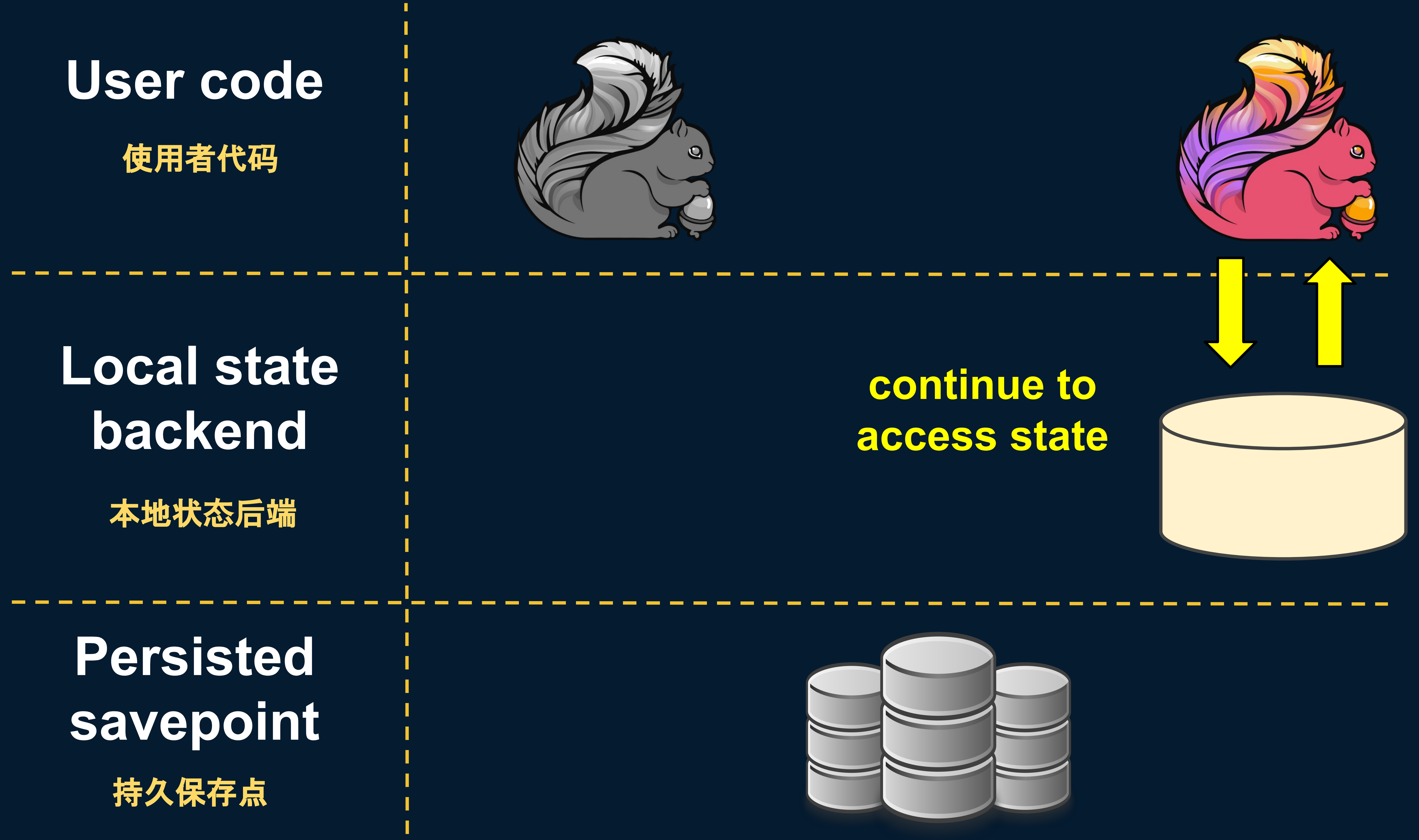

字体

Schema Evolution for Built-In Types

Flink 内建类别的数据结构定义更新

State registration with built-in serialization

状态注册时使用内建序列化器

```
ValueStateDescriptor<MyStateType> desc =
    new ValueStateDescriptor<>(
        “my-value-state”,
        MyStateType.class
    );

ValueState<MyStateType> state = getRuntimeContext().getState(desc);
```

State registration with built-in serialization

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type information for state

状态类别资讯

State registration with built-in serialization

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type information for state

状态类别资讯

- Flink infers information about the type and creates a serializer for it
  - Primitive types: `IntSerializer`, `DoubleSerializer`, `LongArraySerializer`, etc.
  - Tuples: `TupleSerializer`
  - POJOs / Scala case classes: `PojoSerializer`, `CaseClassSerializer`
  - Apache Avro types: `AvroSerializer`
  - Fallback is Kryo: `KryoSerializer`

Evolving state schema for Apache Avro types

以 Apache Avro 进行状态数据结构定义进化

- Can evolve schema according to Avro specifications*
  可依据 Avro 规范* 进化状态的**数据结构定义**
- Can swap between `GenericRecord` and code generated `SpecificRecords`
  可交替使用 `GenericRecord` **与代码生成的** `SpecificRecord` **类别**
- Cannot change namespace of generated `SpecificRecord` classes
  不可更动 `SpecificRecord` **类别的命名空间**

---

*Avro specifications: http://avro.apache.org/docs/1.7.7/spec.html#Schema+Resolution

Status quo of schema evolution support

内建型别的数据结构定义升级支援度现况

- Avro types are the only built-in types that support schema evolution (as of 1.7)
  目前仅有 Avro 型别有支援数据结构定义升级 (Flink 1.7 现况)

- More is planned for 1.8+: POJOs, Scala case classes, Rows (for Flink Tables)
  社群有规划支援 POJOs, Scala case class, Rows 等类别的数据结构定义升级

- Avoid using Kryo if you want evolvable schema for state
  若希望支援数据结构定义升级，请避免使用 `KryoSerializer`

Implementing Custom State Serializers

自订状态序列化器的实现

State registration with custom serializers

状态注册时使用自订序列化器

```
ValueStateDescriptor<MyStateType> desc =
    new ValueStateDescriptor<>(
        “my-value-state”,
        new MyStateTypeSerializer();
    );

class MyStateTypeSerializer extends TypeSerializer<MyStateType> { … }

ValueState<MyStateType> state = getRuntimeContext().getState(desc);
```

State Schema and Serialization

状态的数据结构定义和序列化

- The terms *data schema* and *serialization format* are interchangeable here
  在此，「数据结构定义」与「序列化格式」两词可交互替换

- Evolving state's data schema requires evolving the state's serializer
  欲升级状态的数据结构定义则必须升级状态的序列化器

- Depending on serialization behaviour of state backends (heap v.s. off-heap) state migration may be required
  基于不同状态后端 (内存 / 非内存) 的序列化模式，可能需要进行状态迁移

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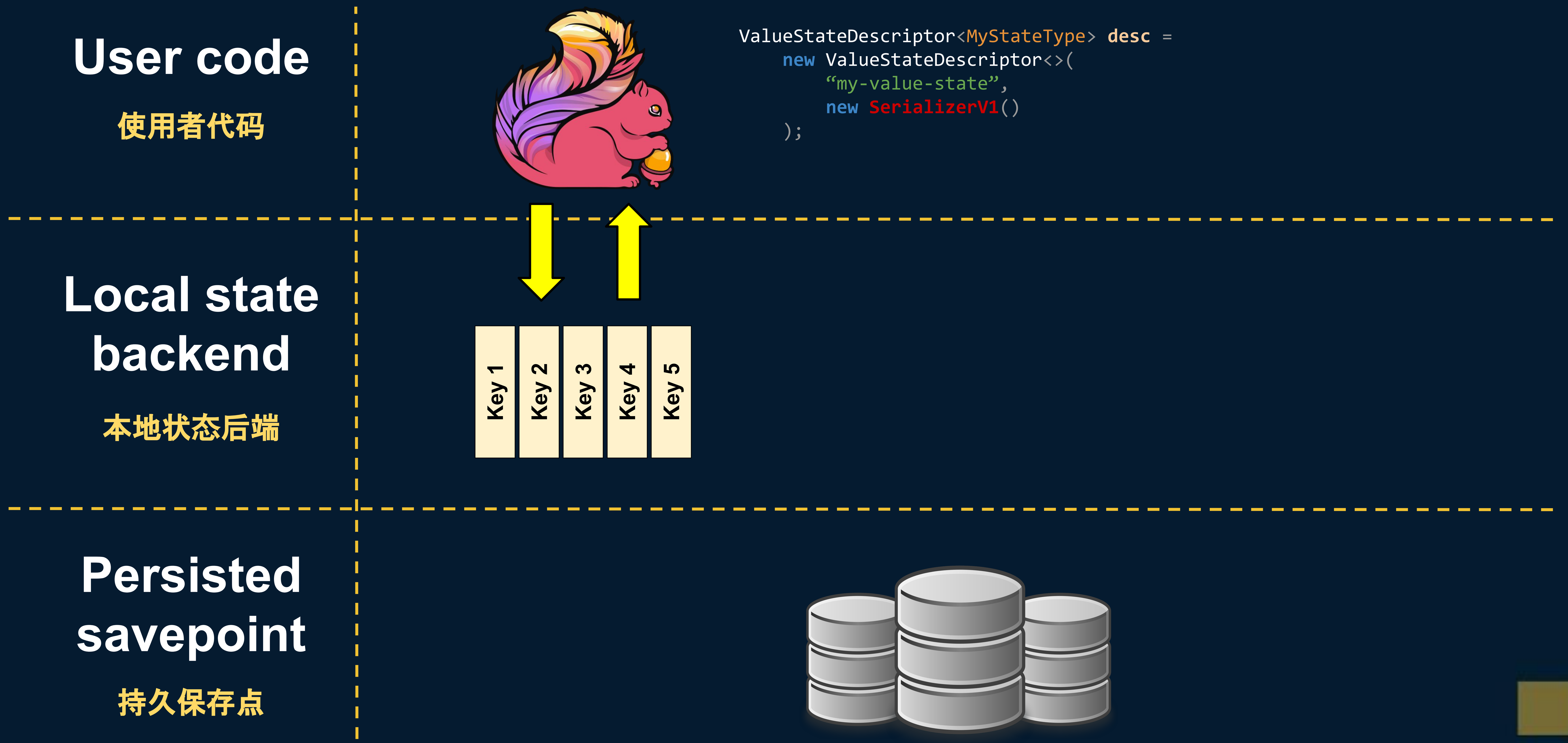
State Serialization for Heap Backends

内存式后端的状态序列化模式




```
ValueStateDescriptor<MyStateType> desc =
    new ValueStateDescriptor<>(
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```

FLINK FORWARD

State Serialization for Heap Backends

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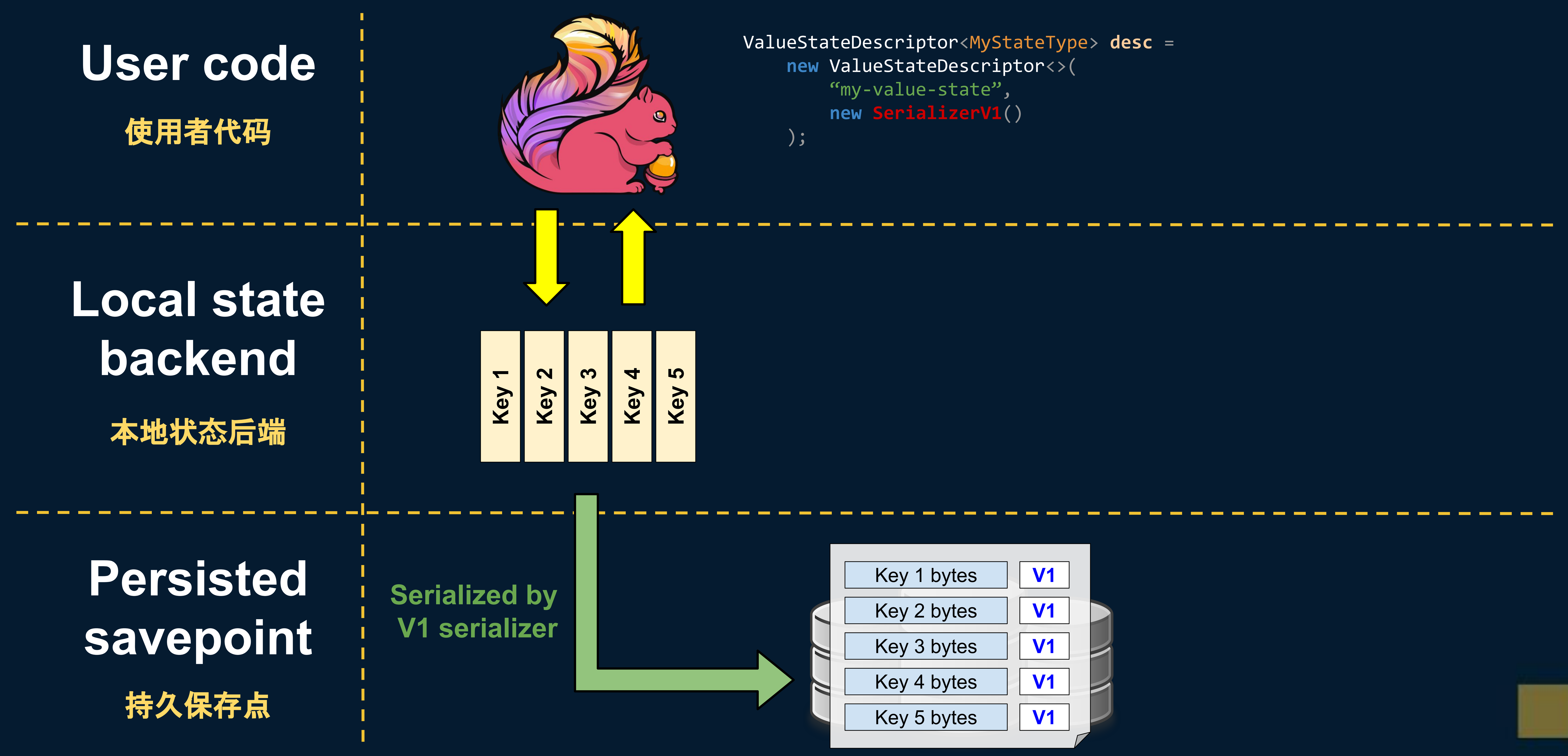

State Serialization for Heap Backends

内存式后端的状态序列化模式

User code

使用者代码

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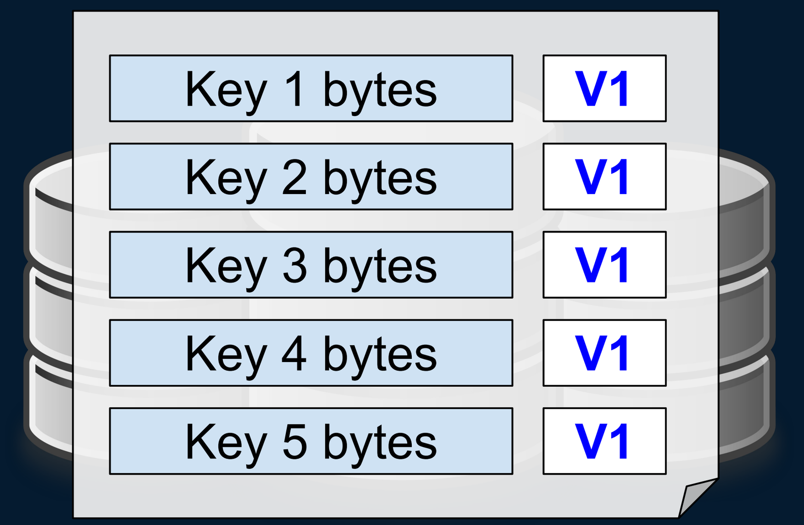
Local state backend

本地状态后端

Persisted savepoint

持久保存点



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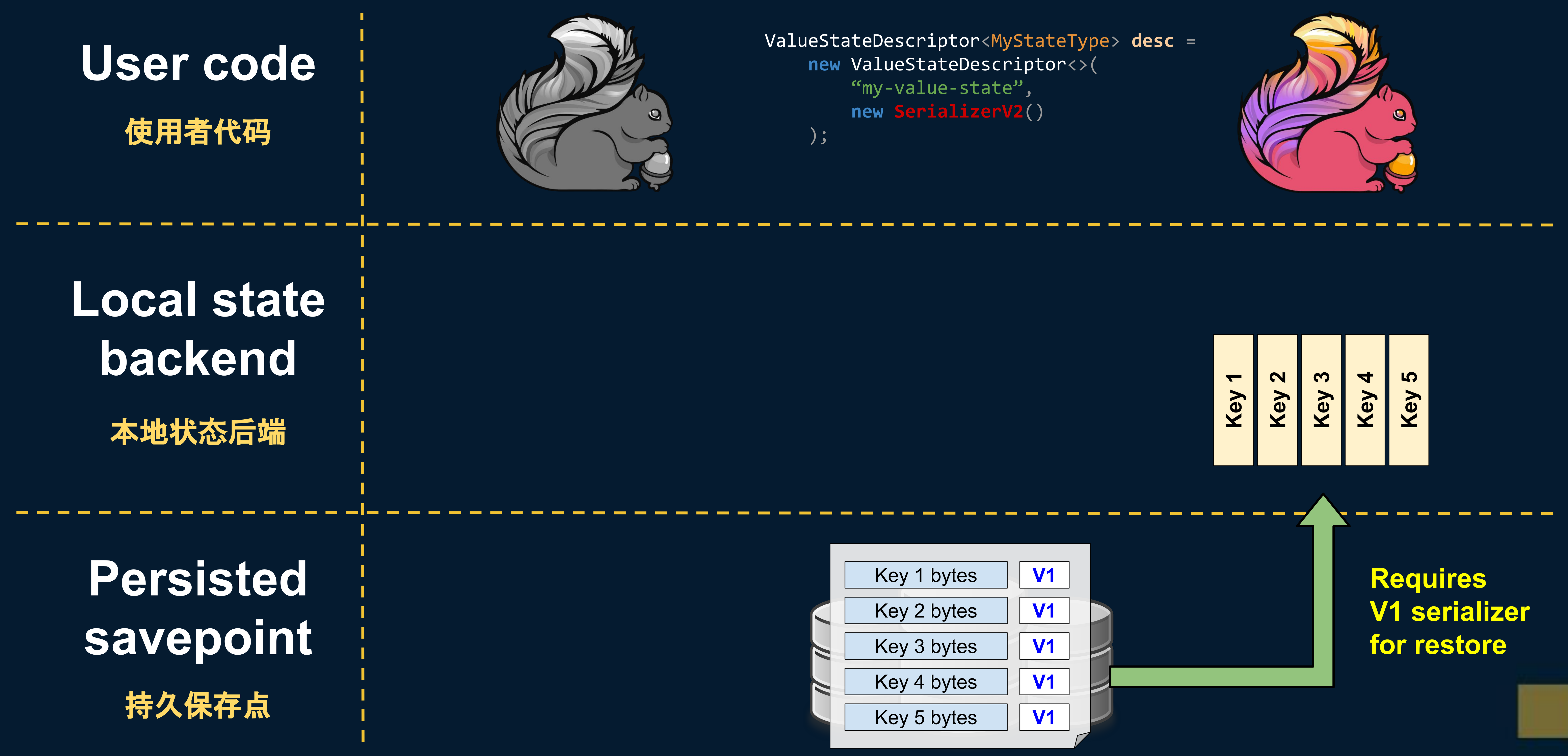

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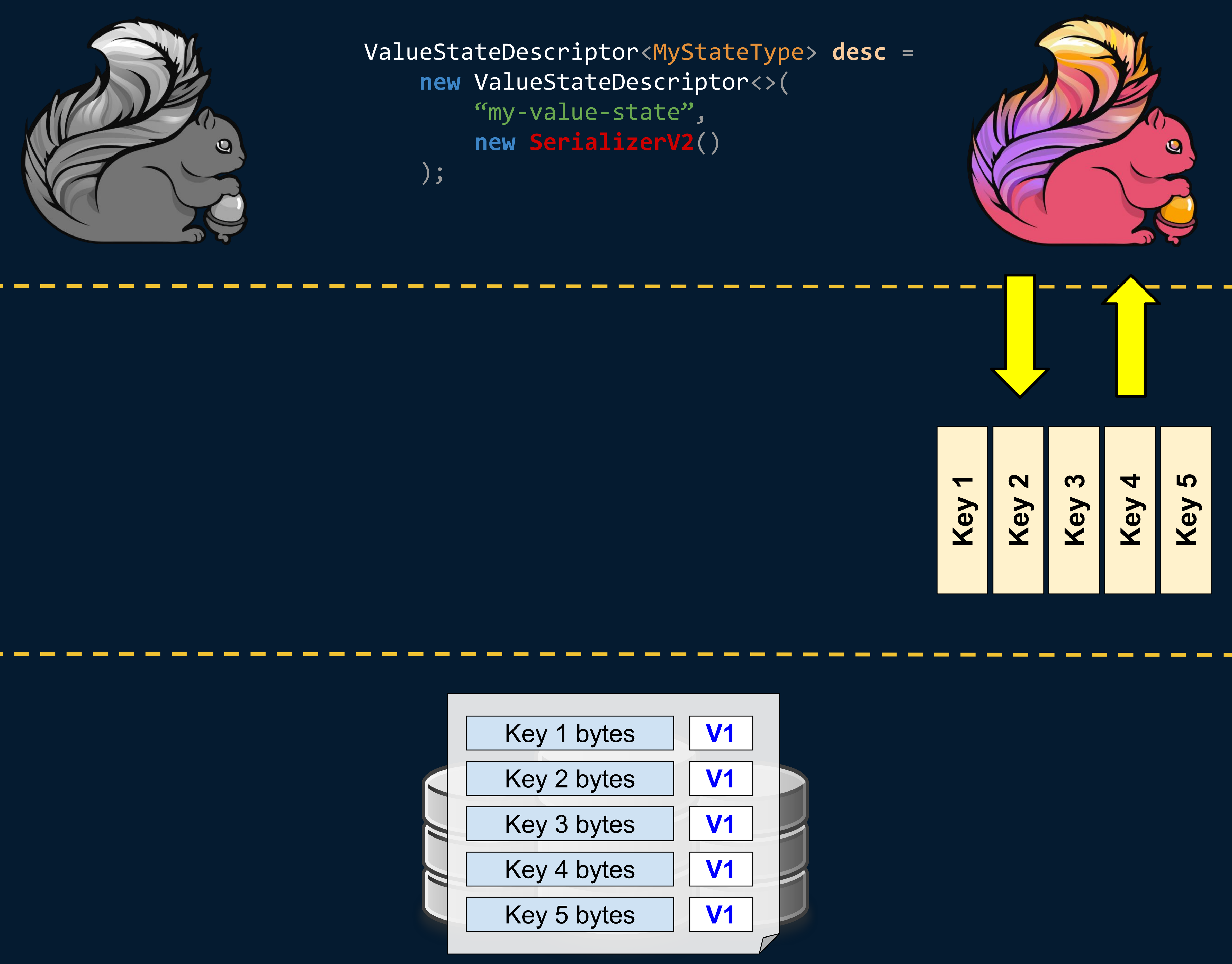

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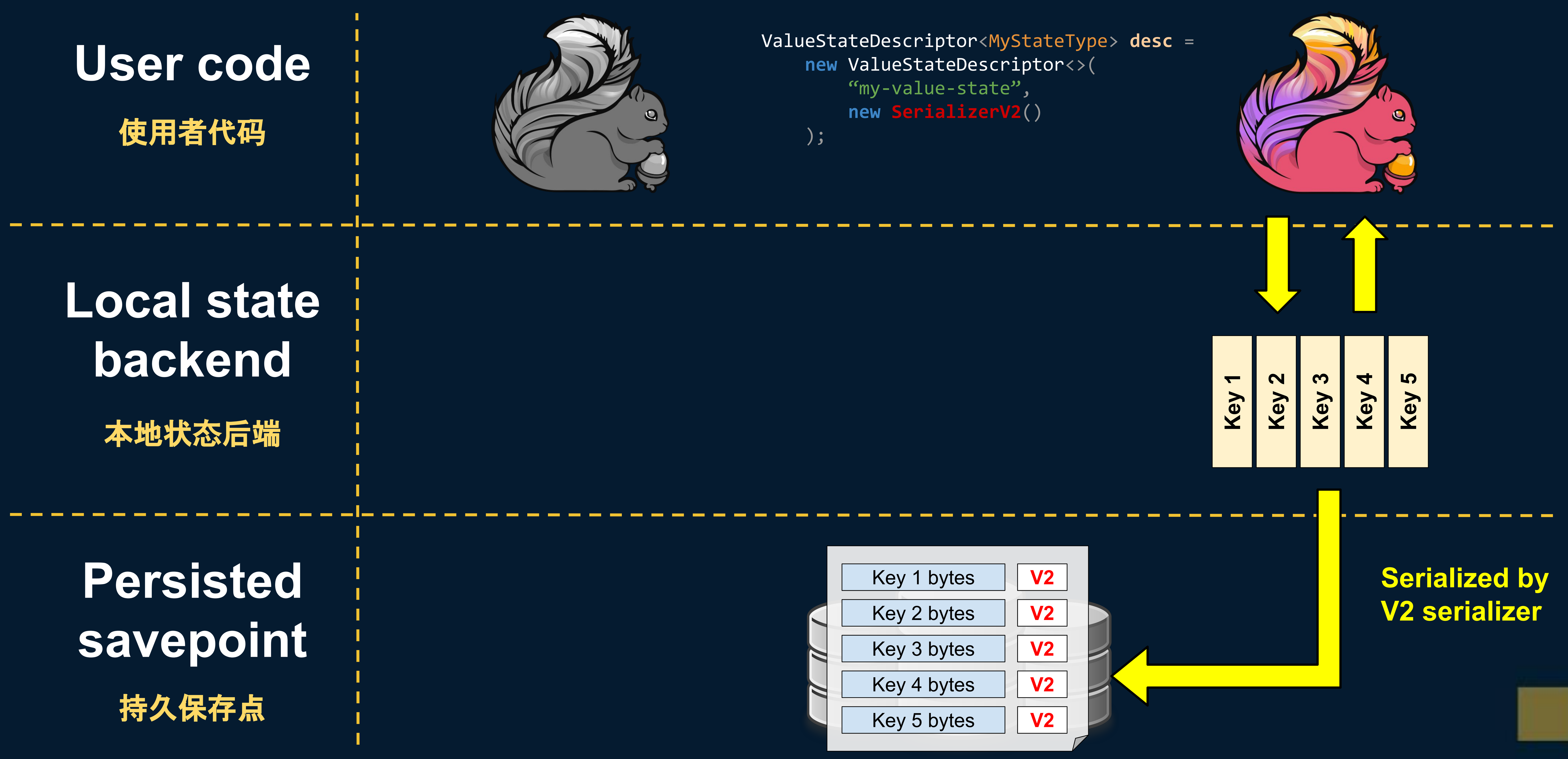


State Serialization for Heap Backends

内存式后端的状态序列化模式

- Serialization happens on restore + snapshot:
  lazy serialization, *eager* deserialization

  反序列化发生于状态恢復阶段、序列化发生于状态的保存点生成

- By nature, restoring + snapshotting state is already a state migration process

  状态的恢復与保存点生成本质上就是一个状态迁移的过程

- Requires a written form of the previous serializer in the snapshot

  需要状态之前的序列化器被写入于保存点中

State Serialization for Out-of-Core Backends

非内存式后端的状态序列化模式

User code

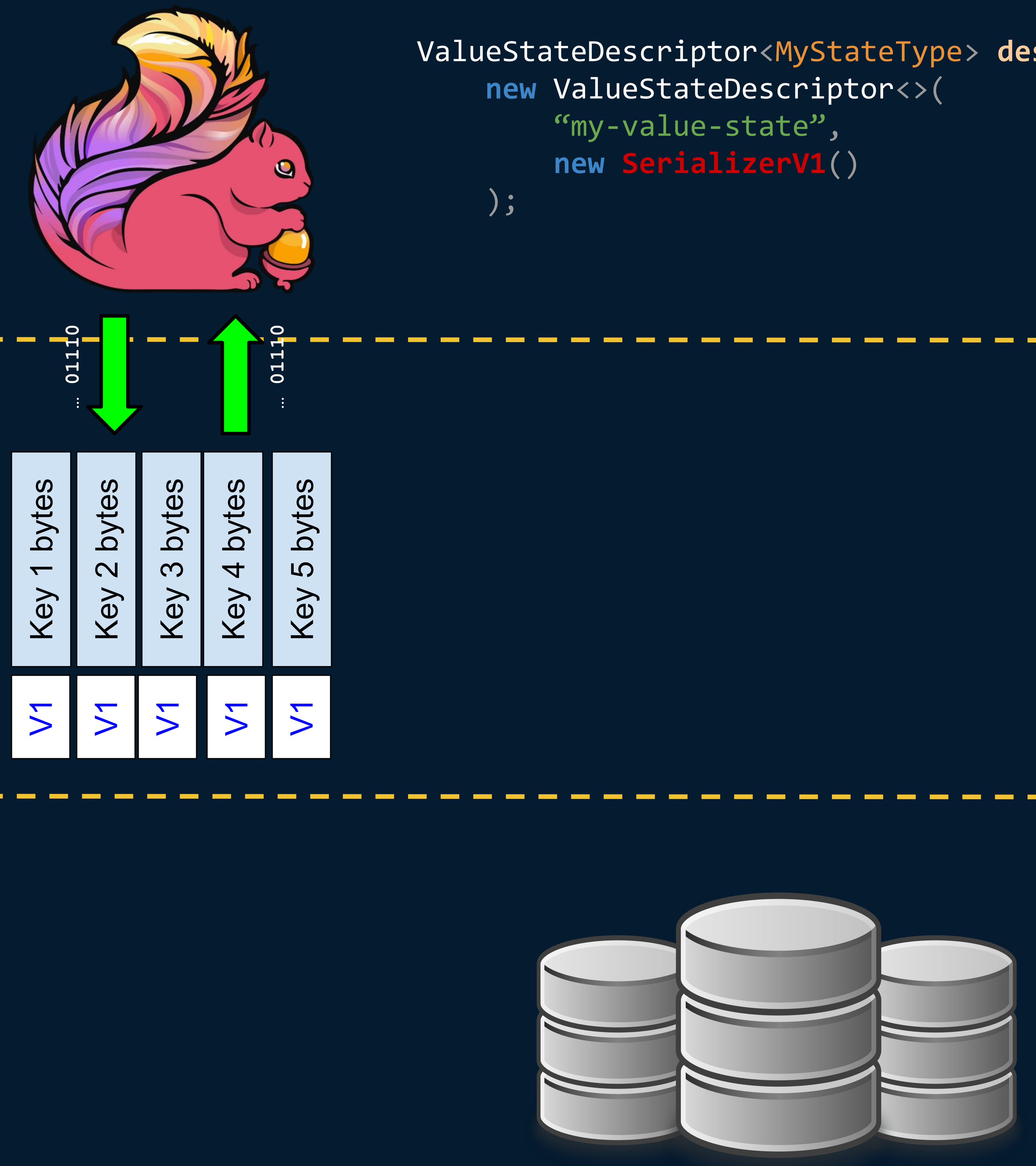
使用者代码

Local state backend

本地状态后端

Persisted savepoint

持久保存点

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```

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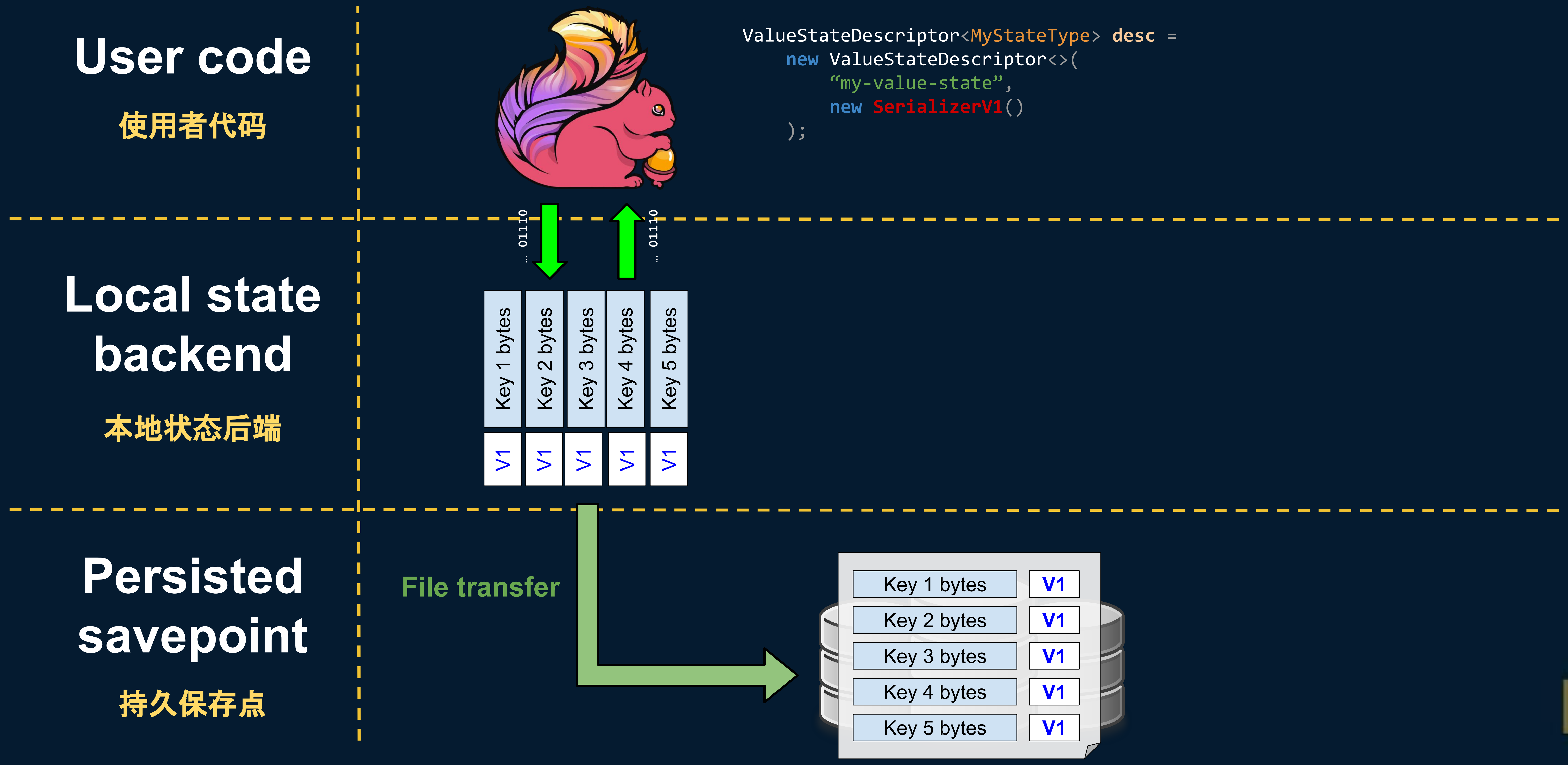


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FLINK FORWARD

State Serialization for Out-of-Core Backends

非内存式后端的状态序列化模式

User code

使用者代码

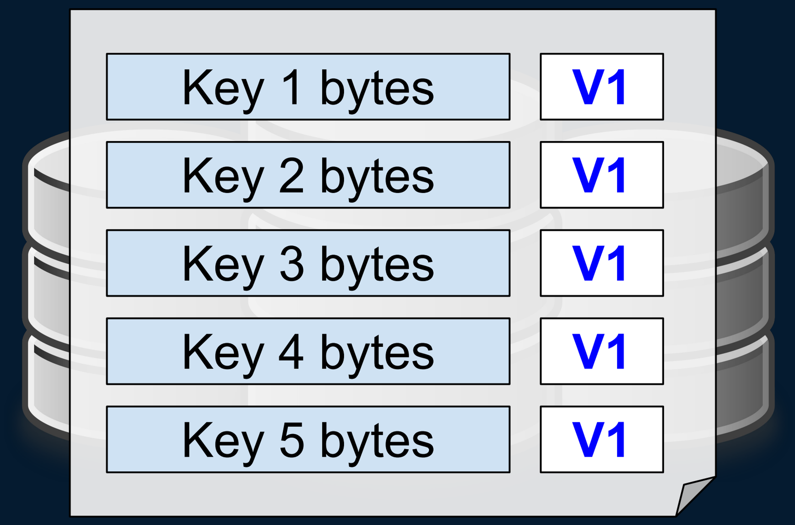
```
ValueStateDescriptor<MyStateType> desc =
    new ValueStateDescriptor<>(
        "my-value-state",
        new SerializerV2()
    );
```

Local state backend

本地状态后端

Persisted savepoint

持久保存点



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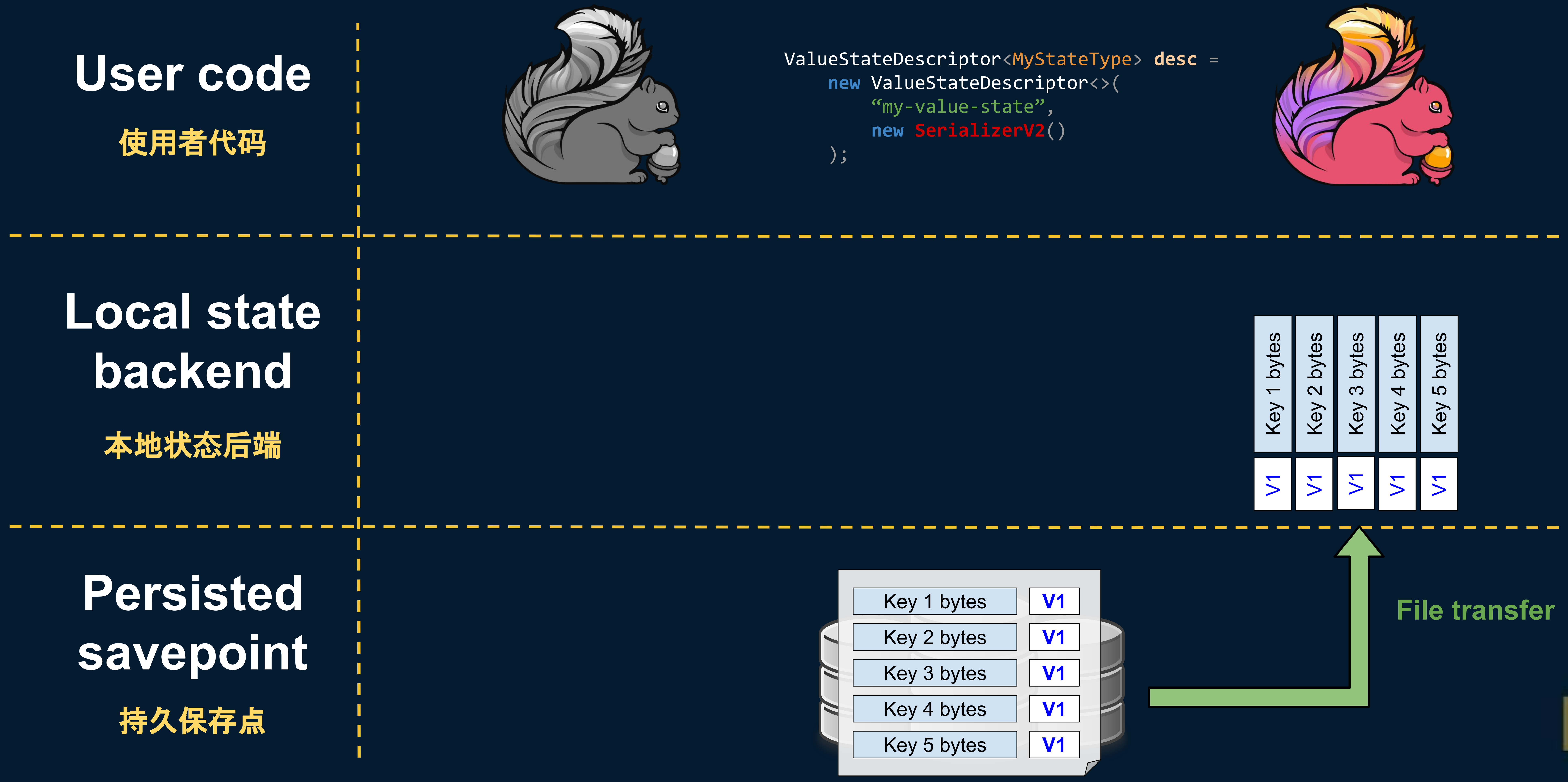

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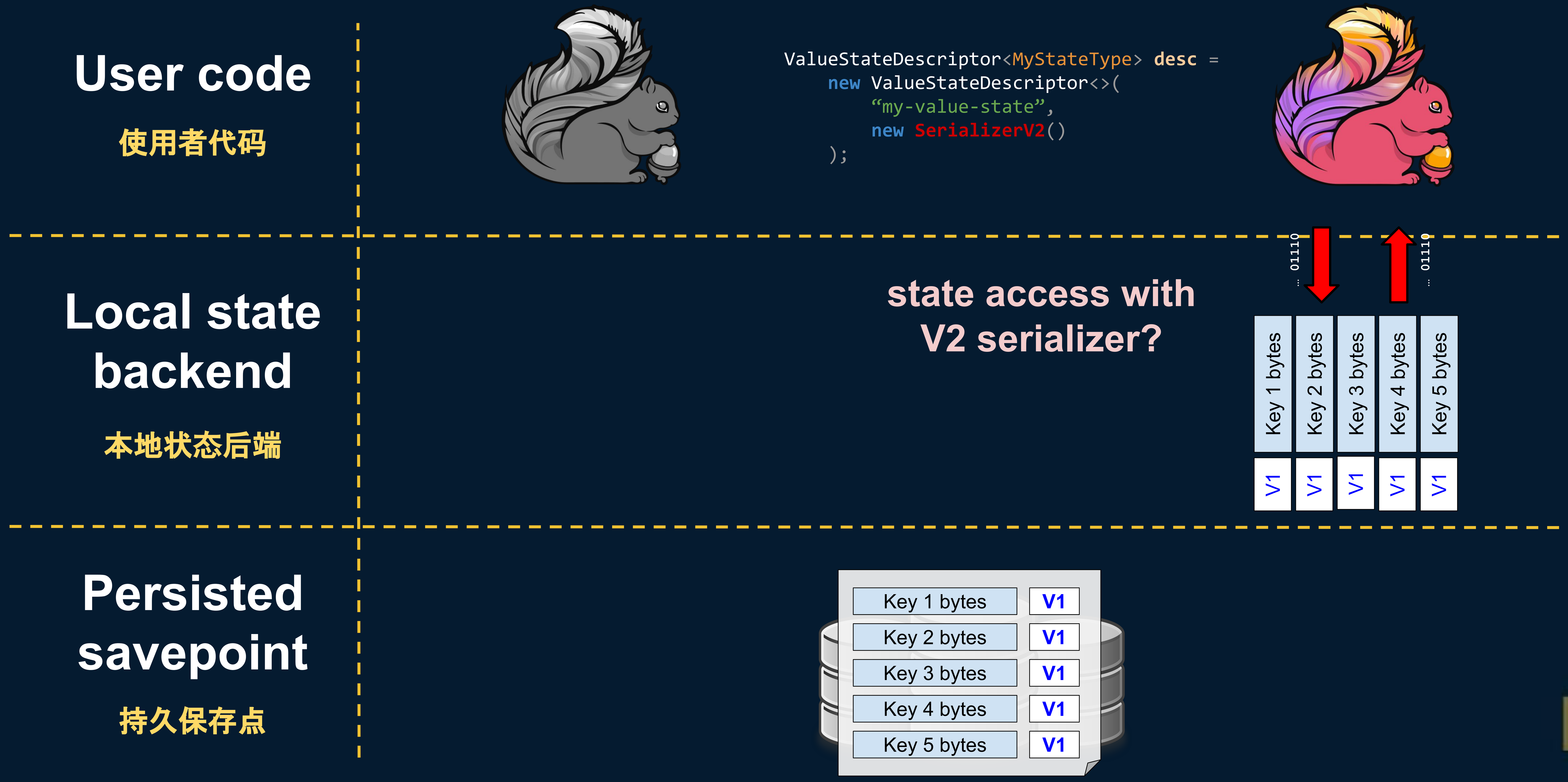

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    );
```

Local state backend

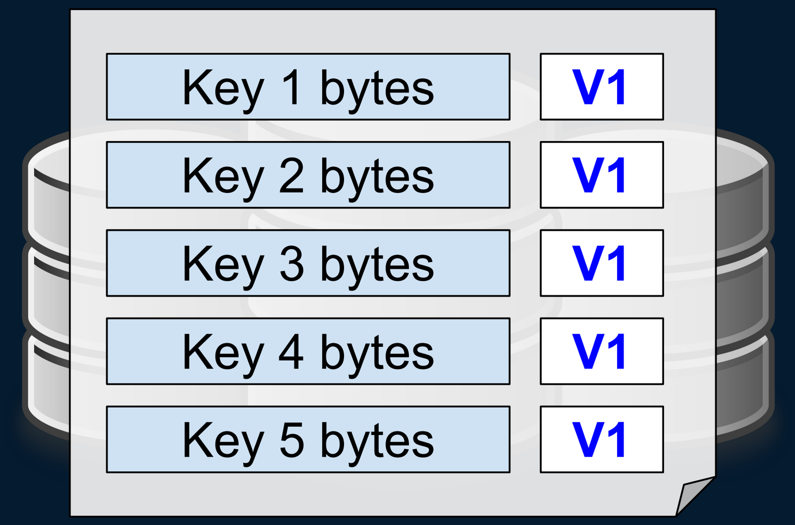
本地状态后端

state access with V2 serializer?

Requires Migration!

Persisted savepoint

持久保存点



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本地状态后端

Persisted savepoint

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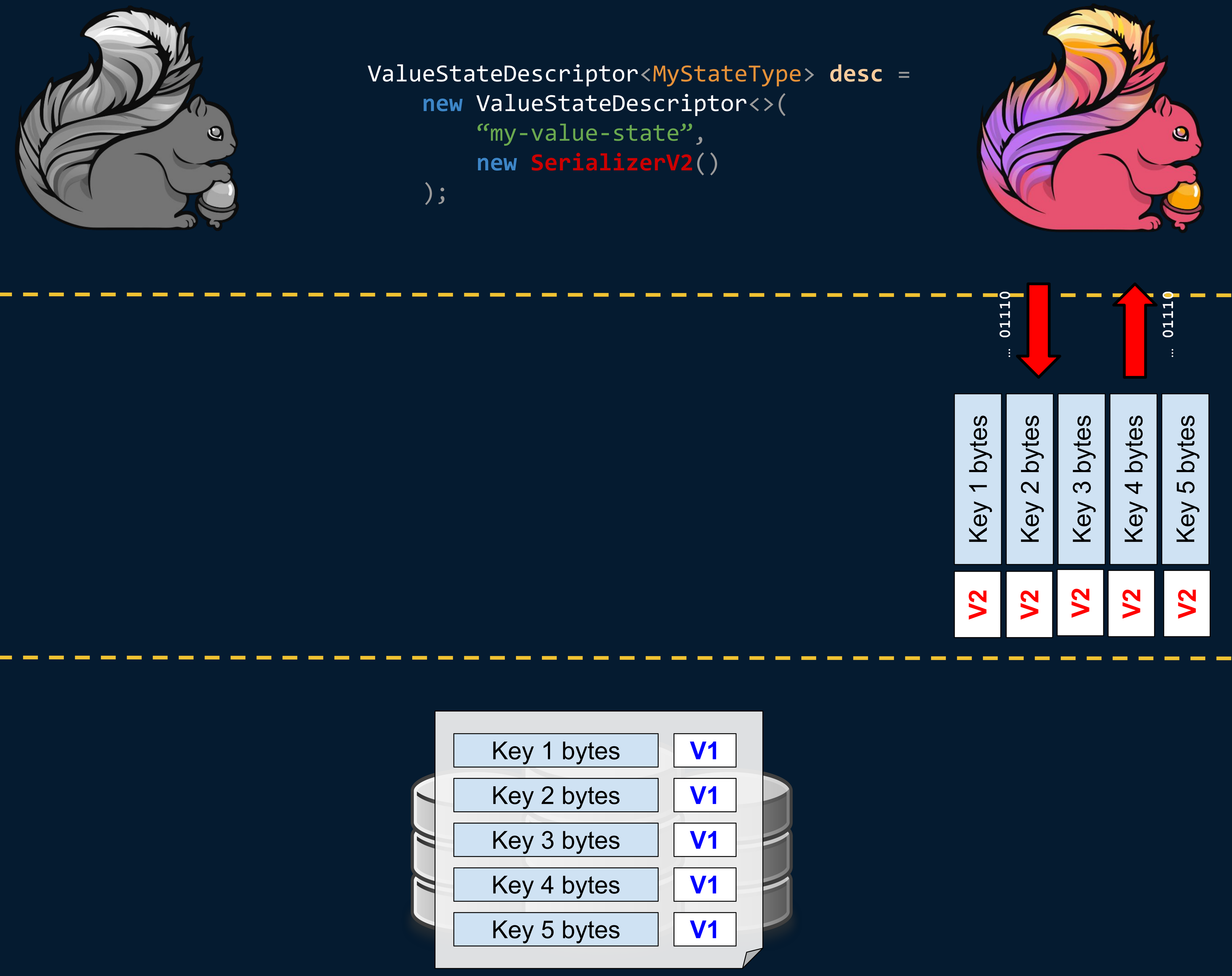

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State Serialization for Out-of-Core Backends

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Local state backend
本地状态后端

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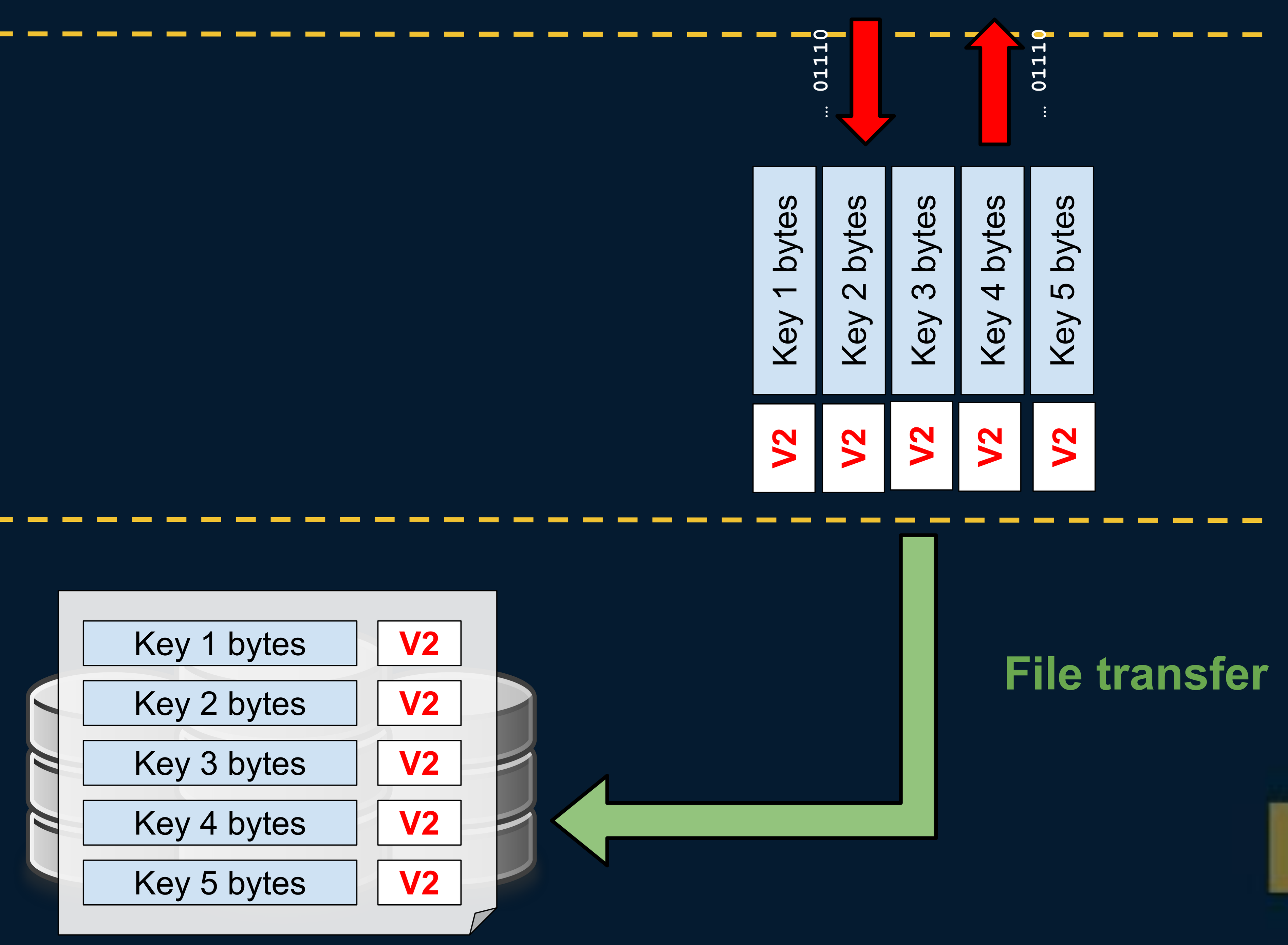
持久保存点



State Serialization for Out-of-Core Backends

非内存式后端的状态序列化模式

- Serialization happens on every state access:
  Eager serialization, *lazy* deserialization
  序列化、反序列化会发生于每一次状态的读写
- After restore, state migration occurs on first access if schema has changed
  状态恢复后，第一次的状态注册即视需求进行发生状态迁移
- The previous serializer is required if state migration occurs
  若需要进行状态迁移，则需要使用到状态的前一个序列化器

Main abstraction: TypeSerializerSnapshot

编程抽象类:TypeSerializerSnapshot

```
interface TypeSerializerSnapshot<T> {
    int getCurrentVersion();
    void writeSnapshot(DataOutputView out);
    void readSnapshot(int readVersion, DataInputView in, ClassLoader userCodeClassloader);
    TypeSerializer<T> restoreSerializer();
    TypeSerializerSchemaCompatibility<T> resolveSchemaCompatibility(TypeSerializer<T> newSerializer);
}
```

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    TypeSerializerSchemaCompatibility<T> resolveSchemaCompatibility(TypeSerializer<T> newSerializer);
}
```

- Represents the written form of a state’s serializer, written to snapshots
  代表着写入于保存点中状态的序列化器
- Encodes information about the state’s written schema + serializer configuration
  拥有关于状态被序列化的格式以及序列化器的设定相关资讯
- Serves as a factory for the previous serializer
  可用于建构状态被写入时所使用的序列化器

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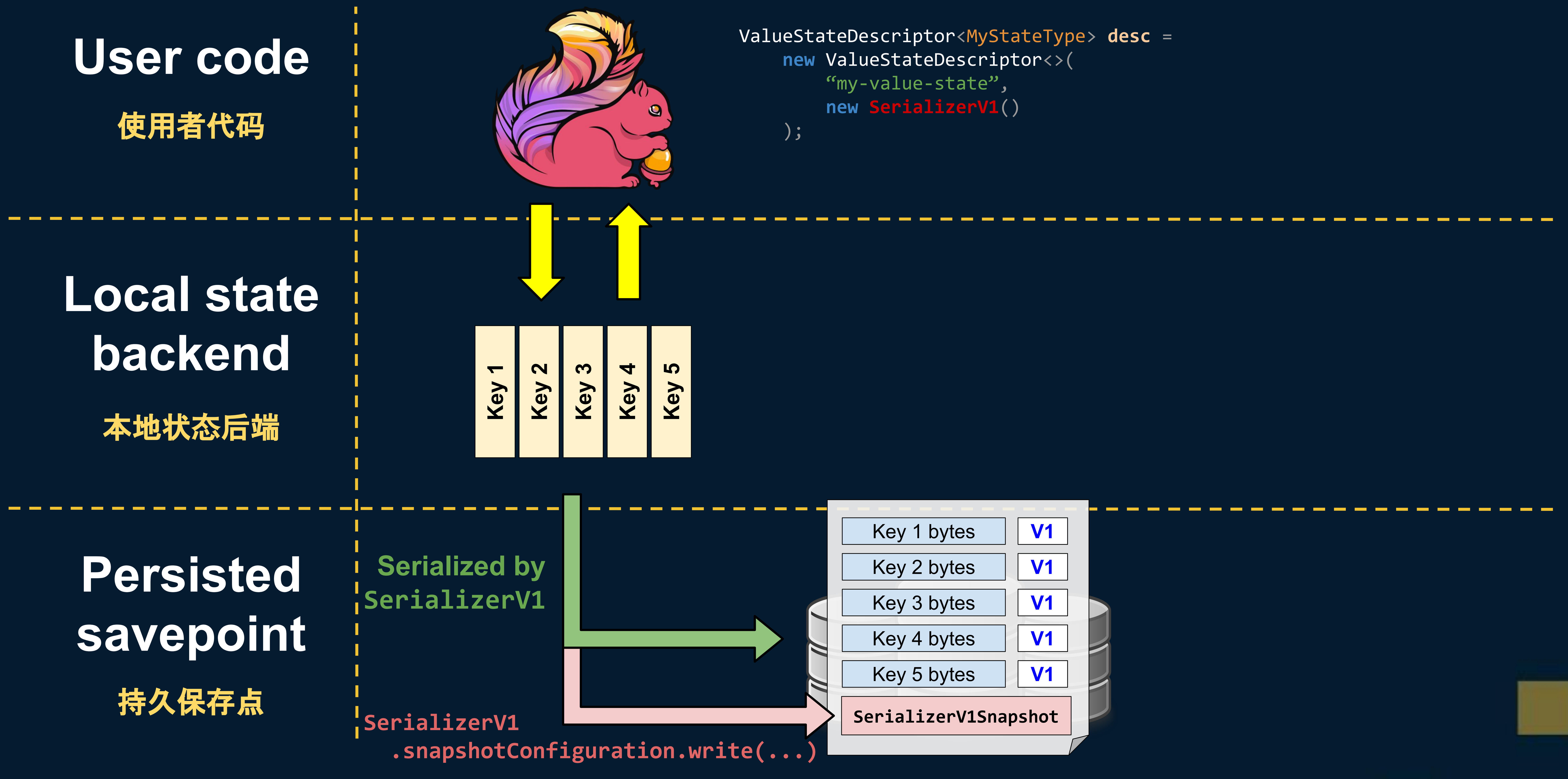
State Serialization for Heap Backends

内存式后端的状态序列化模式



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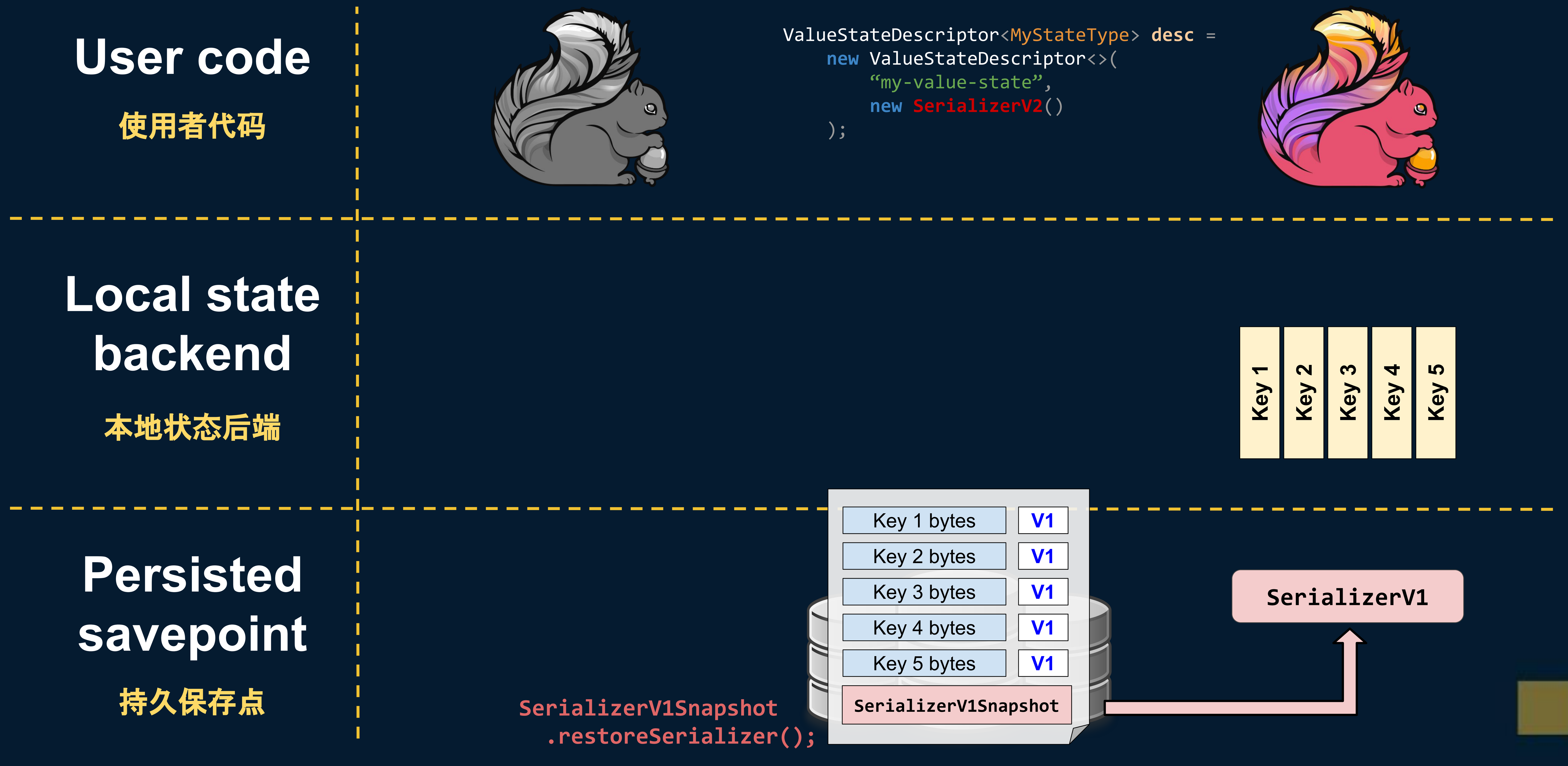

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State Serialization for Heap Backends

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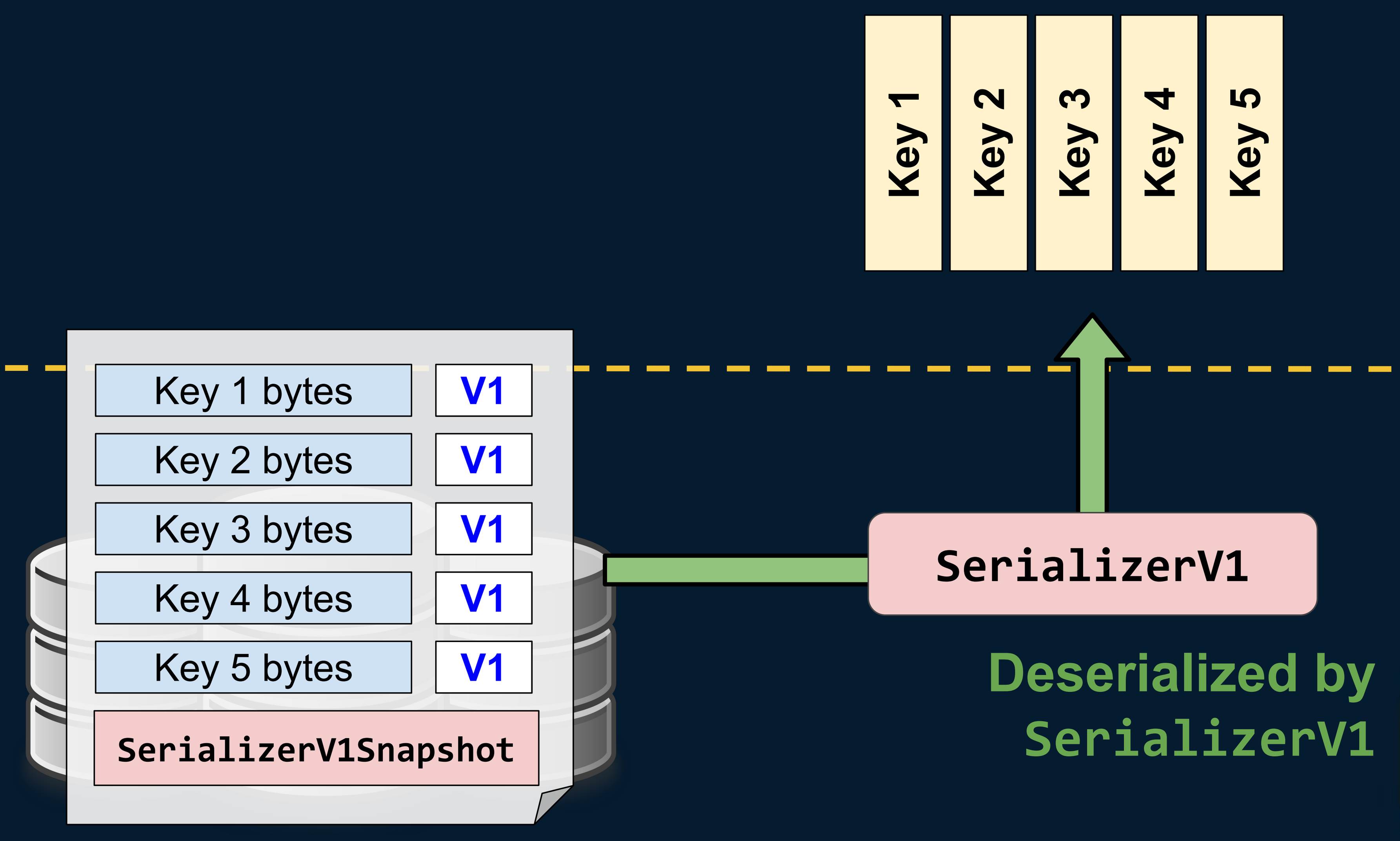
Local state backend

本地状态后端

Persisted savepoint

持久保存点



State Serialization for Out-of-Core Backends

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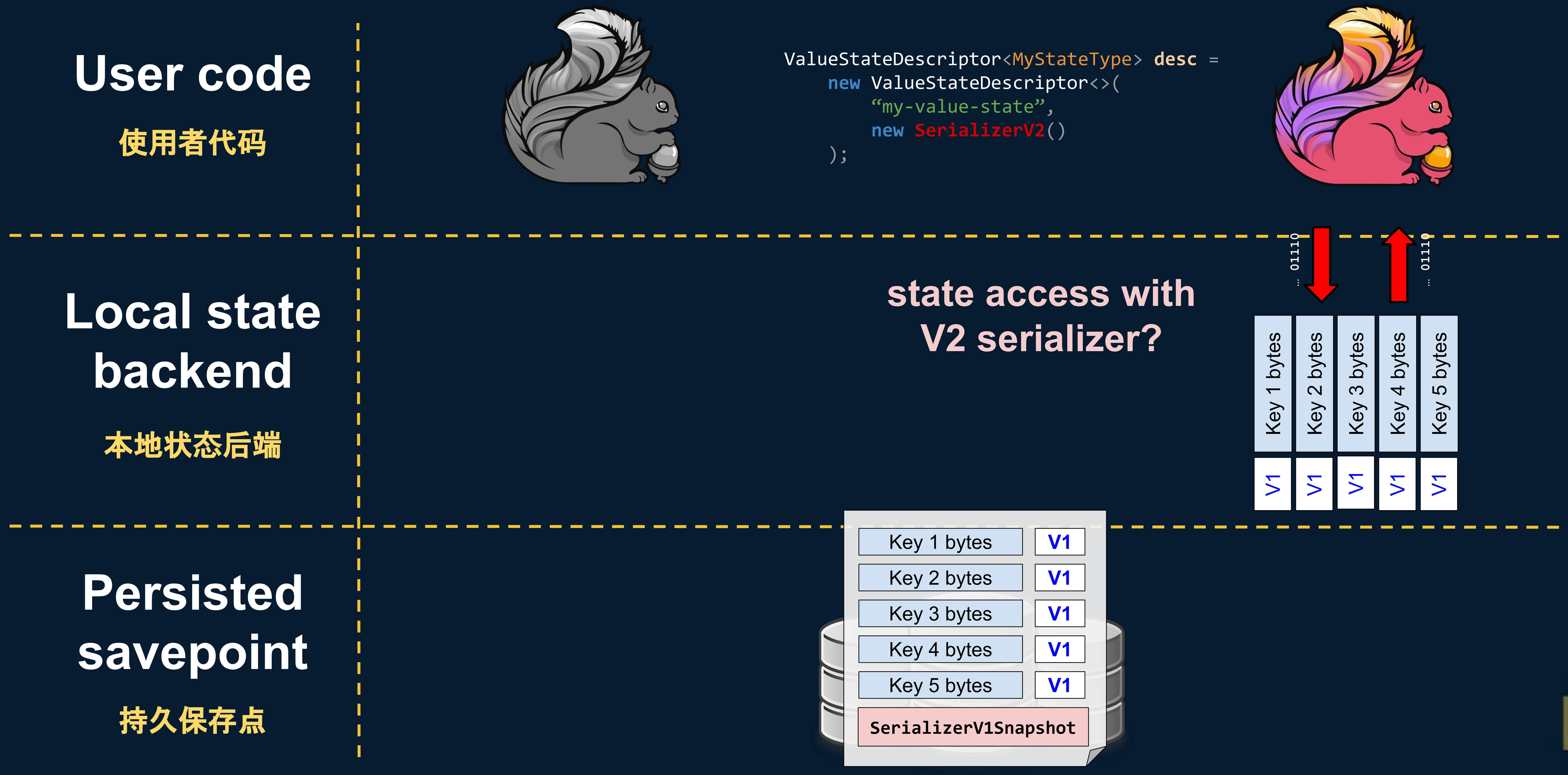

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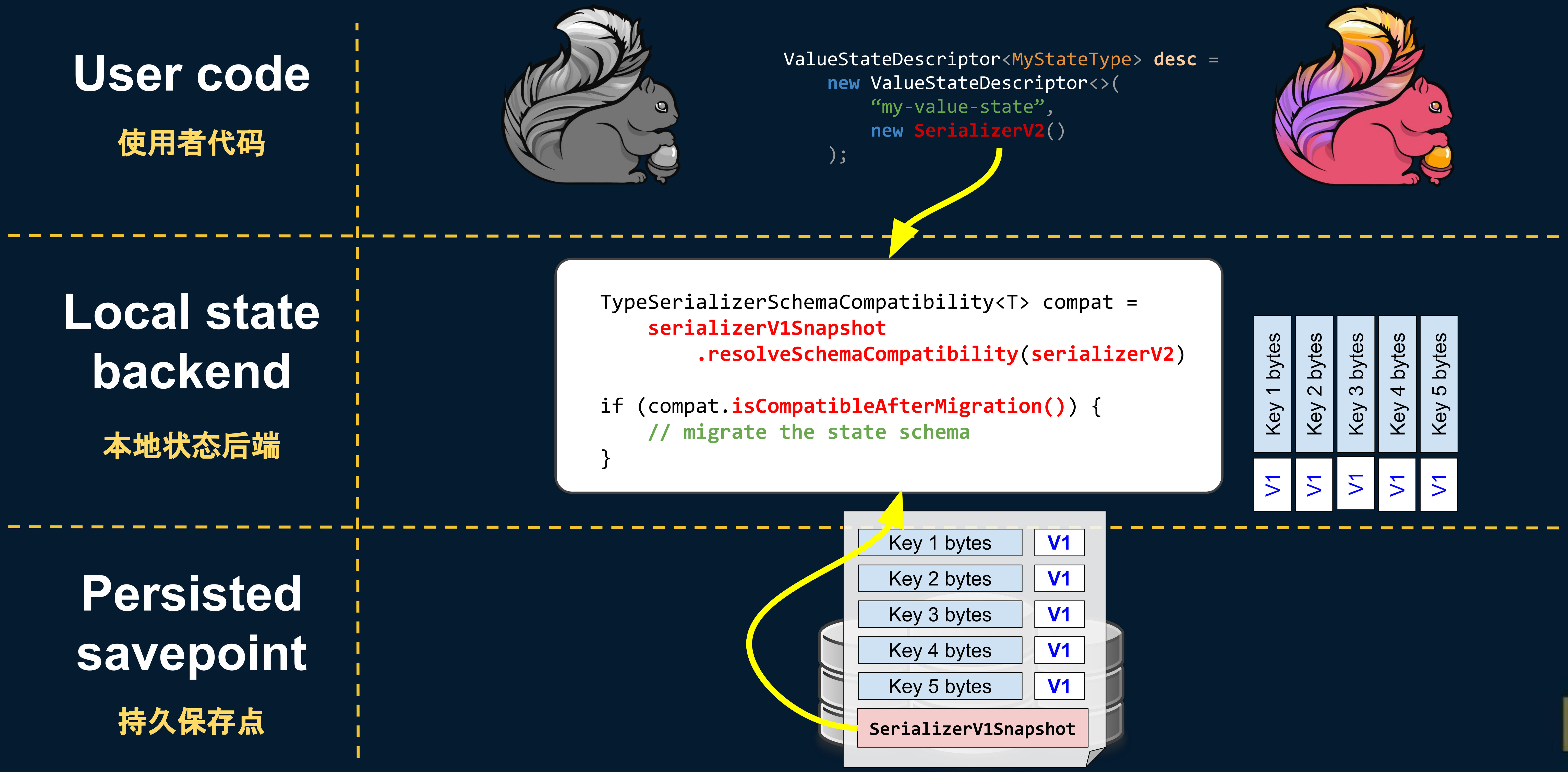

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    );
```
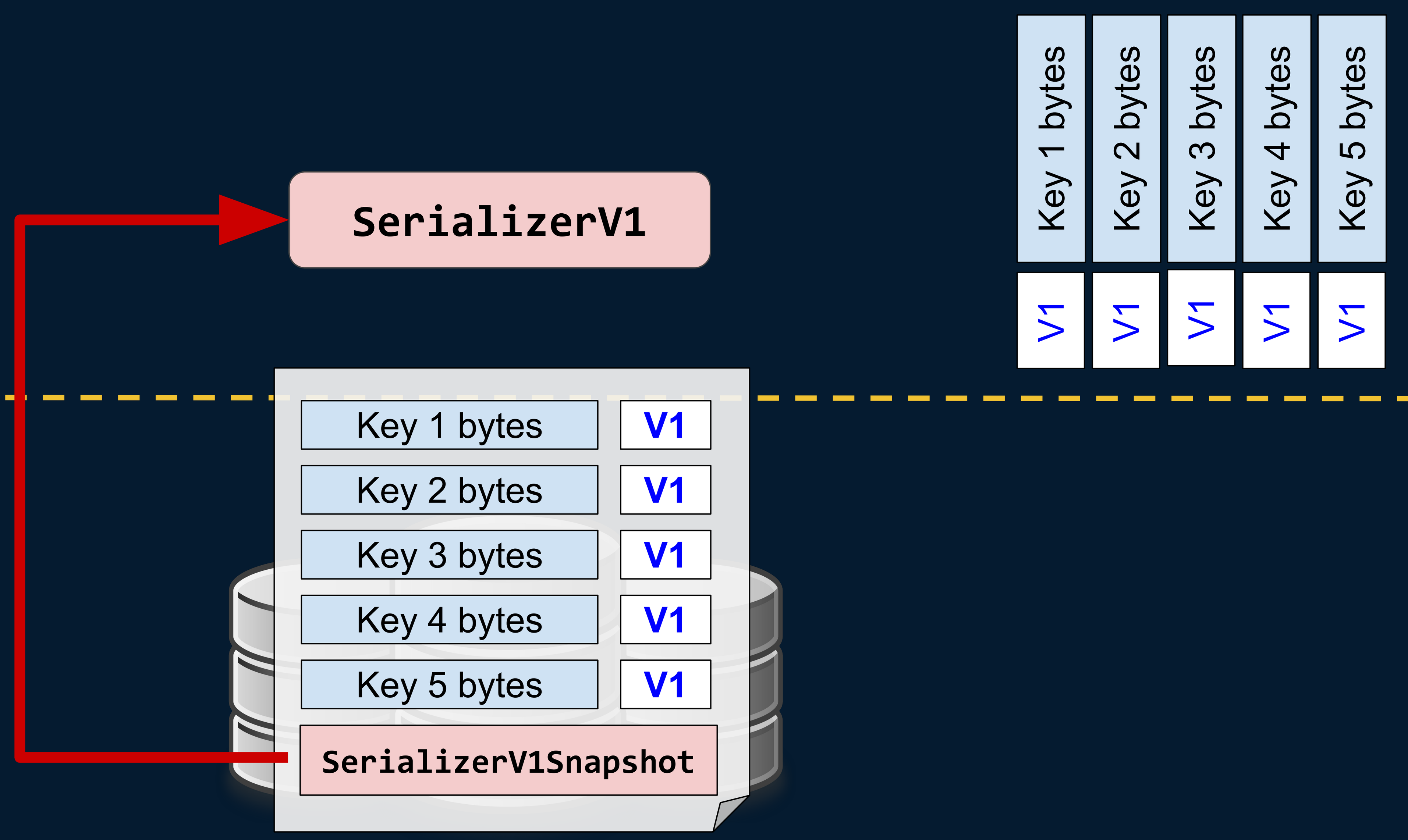

```
SerializerV1Snapshot
  .restoreSerializer();
```



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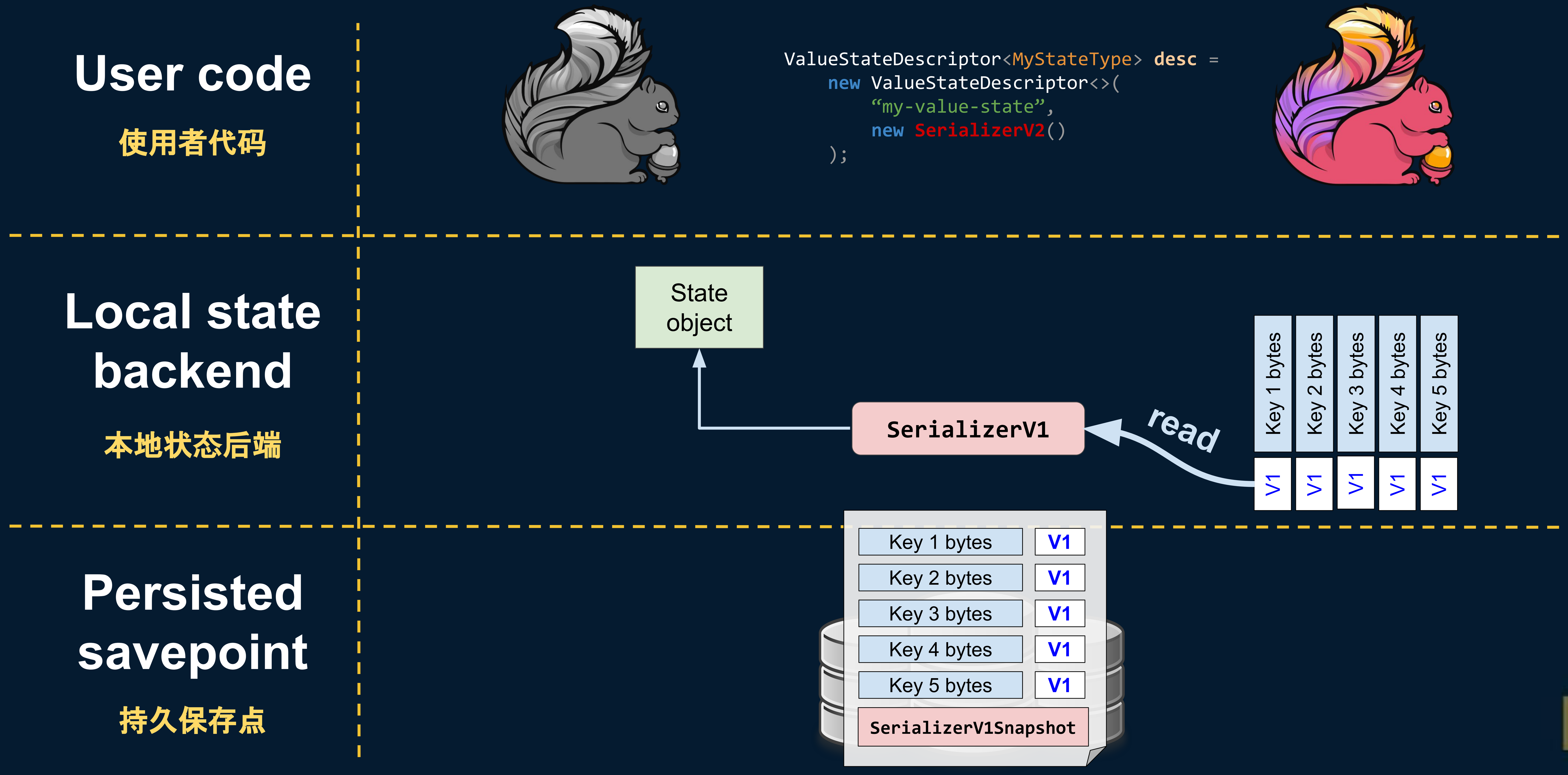

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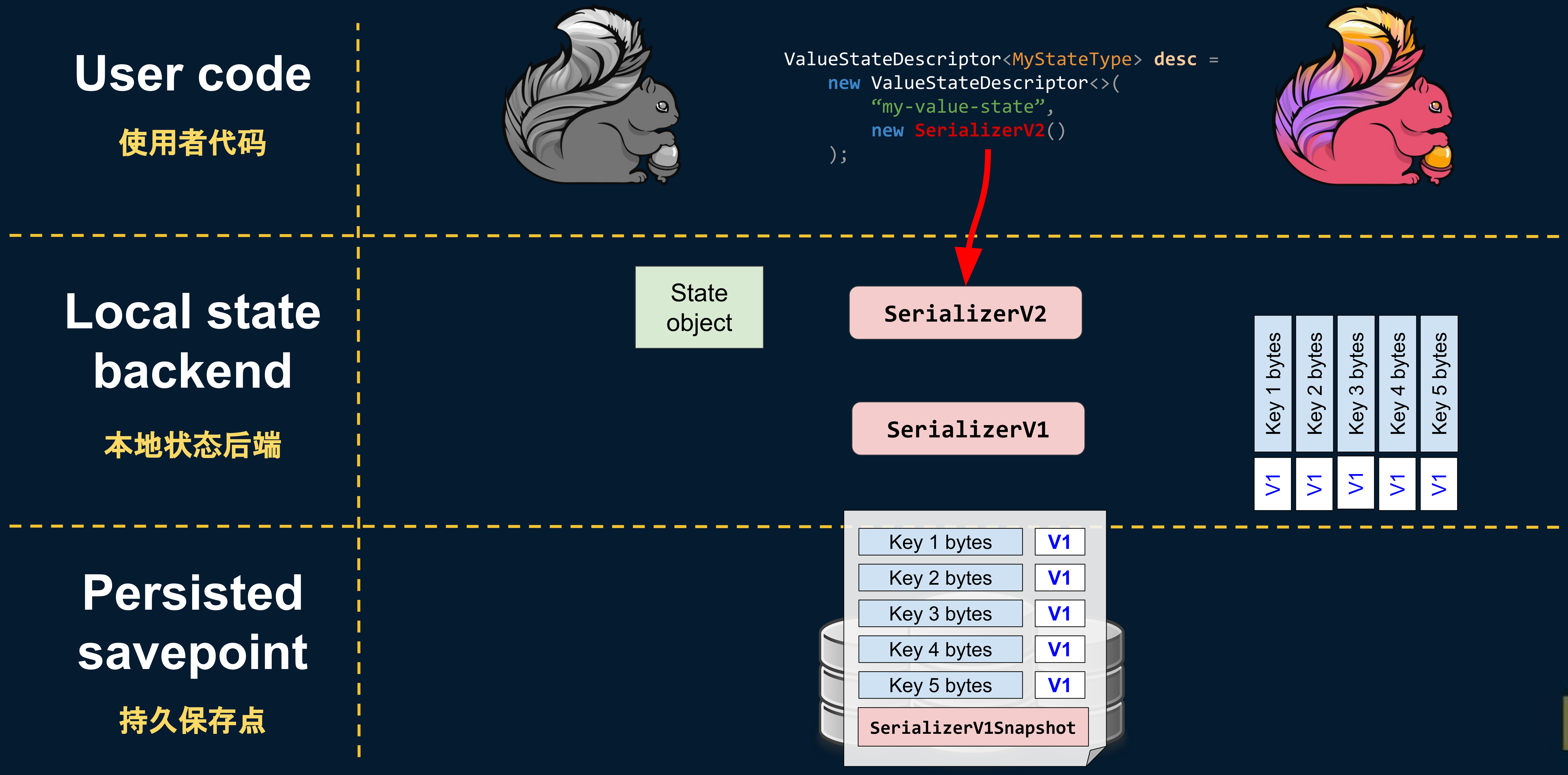

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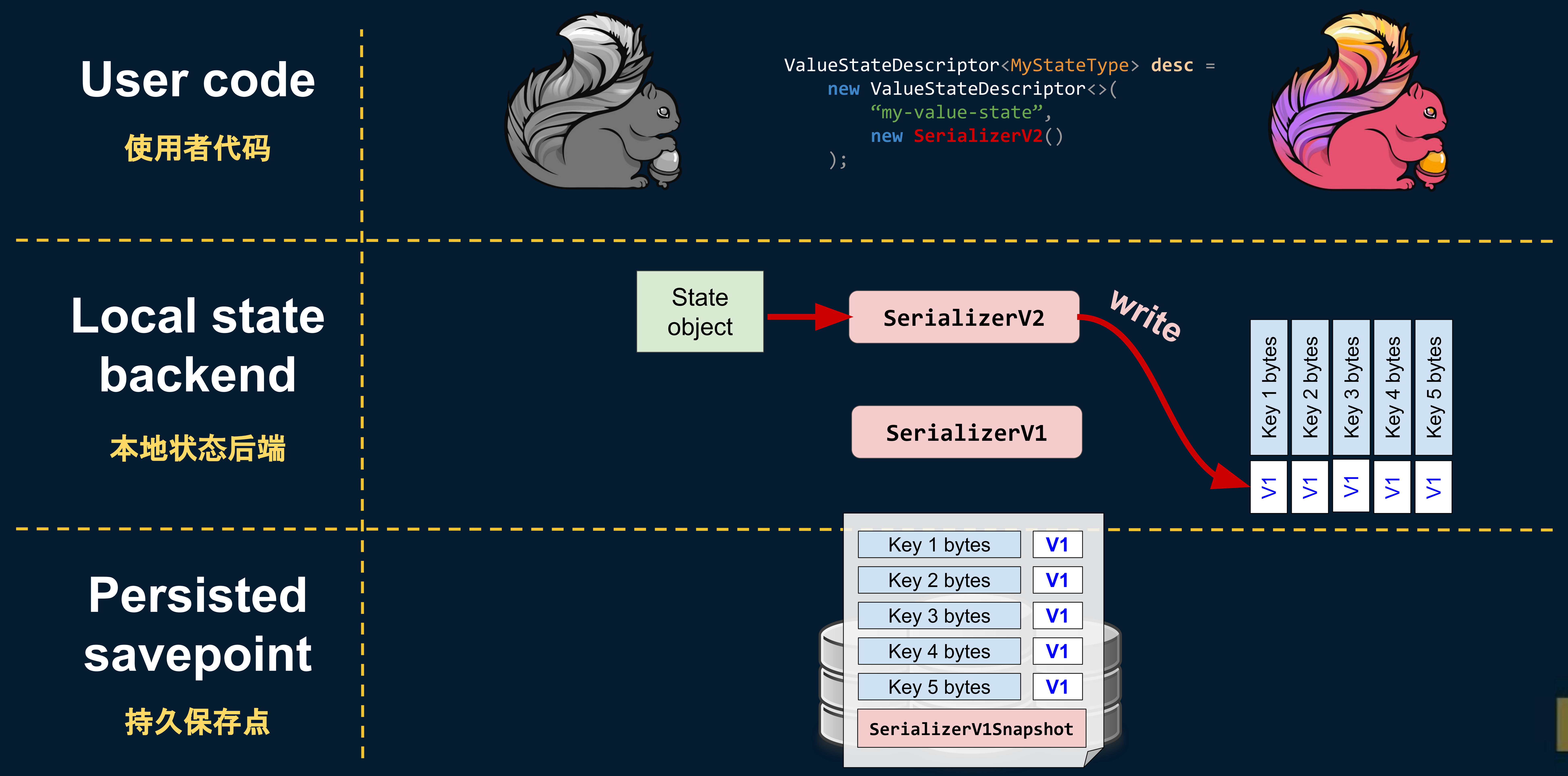

State Serialization for Out-of-Core Backends

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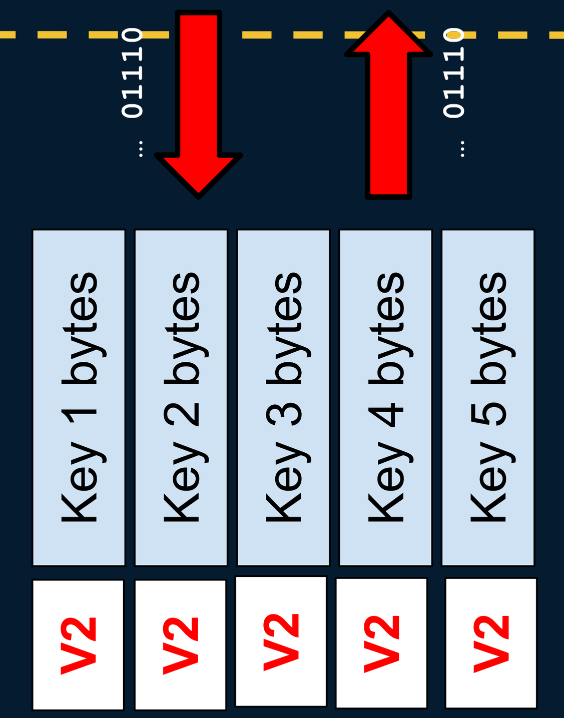
Local state backend

本地状态后端



Persisted savepoint

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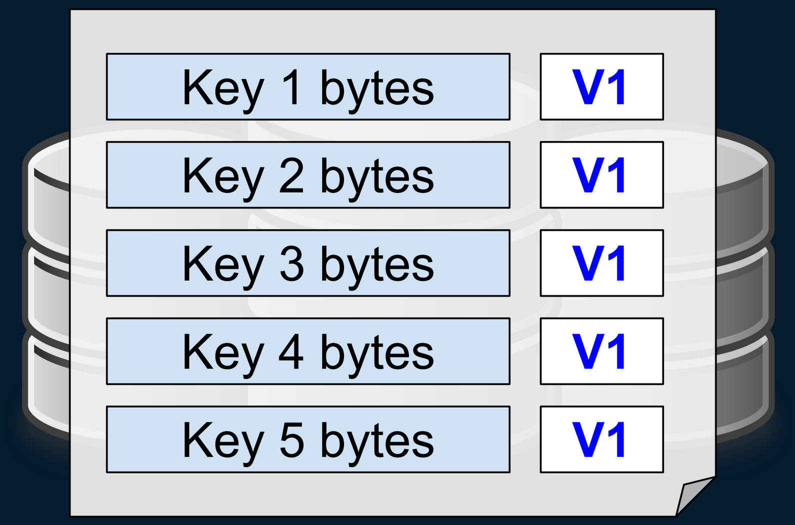

FLINK FORWARD

Example: Evolvable PojoSerializer [FLINK-10987]

范例:可进化序列化格式的 PojoSerializer

```
class Employee {
    int age,
    String name,
    Department dep,
    ...
}
```

Example: Evolvable PojoSerializer [FLINK-10987]

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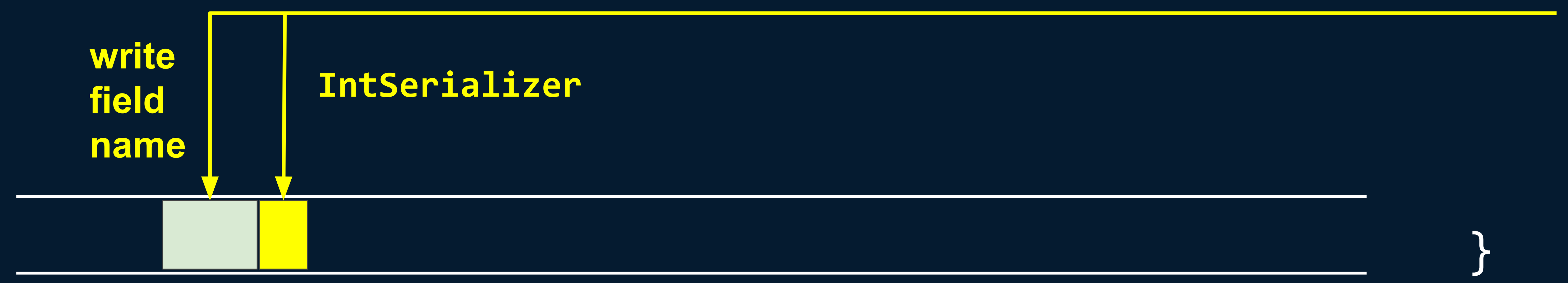


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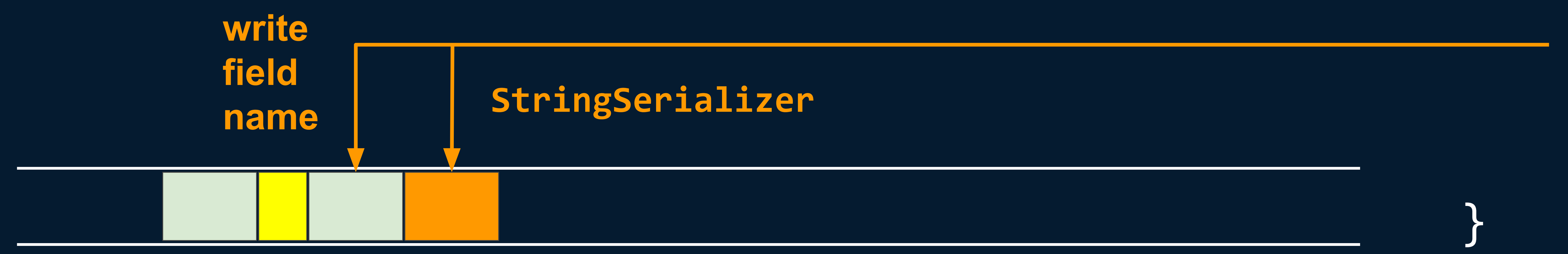


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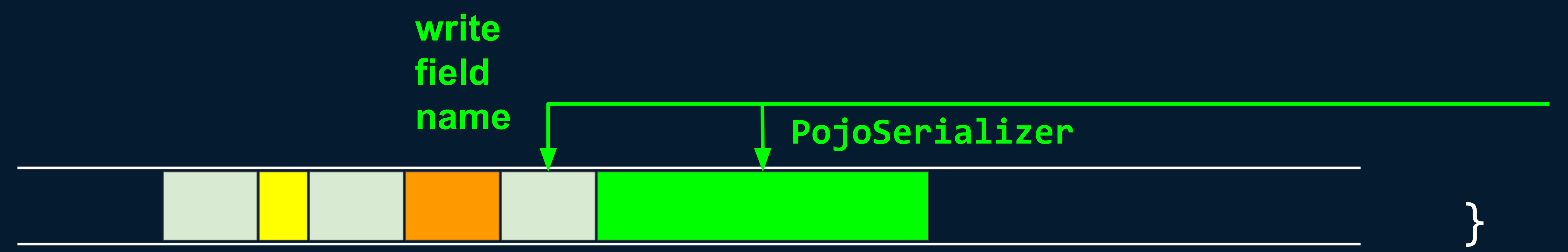


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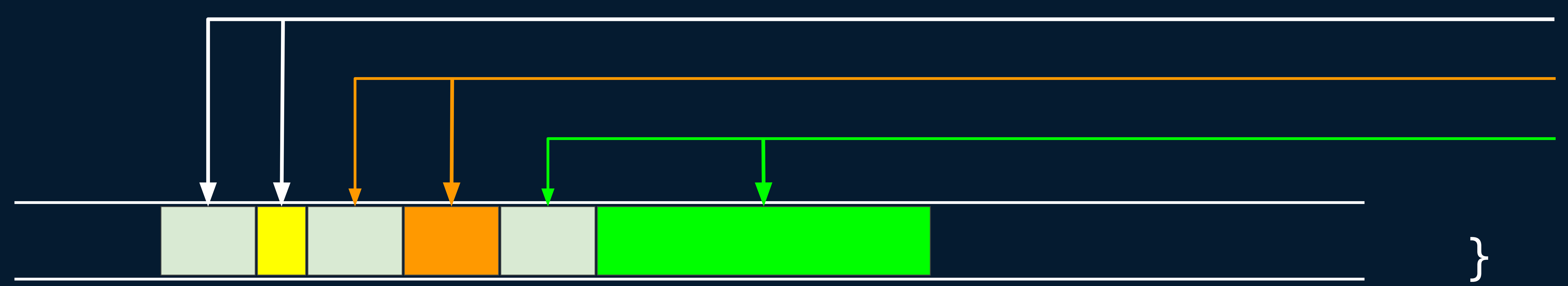

```
class Employee {
    int age,
    String name,
    Department dep,
    ...
}
```

```
class PojoSerializer<T> extends TypeSerializer<T> {

    private Field[] fields;
    private TypeSerializer<?>[] fieldSerializers;

    ...

    public TypeSerializerSnapshot<T> snapshotConfiguration {
        return new PojoSerializerSnapshot<>(fields, fieldSerializers);
    }
}
```

FLINK FORWARD

Example: Evolvable PojoSerializer [FLINK-10987]

范例:可进化序列化格式的 PojoSerializer

```java
class PojoSerializerSnapshot<T> implements TypeSerializerSnapshot<T> {

    private Field[] fields;
    private TypeSerializer<?>[] fieldSerializers;

    /**
     * Constructor for instantiating the snapshot when reading.
     */
    public PojoSerializerSnapshot() {}

    /**
     * Constructor to create a snapshot for writing.
     */
    public PojoSerializerSnapshot(Field[] fields, TypeSerializer<?>[]
fieldSerializers) {
        this.fields = fields;
        this.fieldSerializers = fieldSerializers;
    }

    ...
}
```

FLINK FORWARD

Example: Evolvable PojoSerializer [FLINK-10987]

范例:可进化序列化格式的 PojoSerializer

```
class PojoSerializerSnapshot<T> implements TypeSerializerSnapshot<T> {

    ...

    public TypeSerializerSchemaCompatibility<T> resolveSchemaCompatibility(TypeSerializer<T> newSerializer) {
        if (newSerializer instanceof PojoSerializer) {
            Field[] newFields = ((PojoSerializer<T>) newSerializer).getFields();

            if (hasDifferentTypedFields(this.fields, newFields)) {
                return TypeSerializerSchemaCompatibility.incompatible();
            } else if (hasNewFields(this.fields, newFields) || hasRemovedFields(this.fields, newFields)) {
                return TypeSerializerSchemaCompatibility.compatibleAfterMigration();
            }

            return TypeSerializerSchemaCompatibility.compatibleAsIs();
        }

        return TypeSerializerSchemaCompatibility.incompatible();
    }
}
```

Example: Evolvable PojoSerializer [FLINK-10987]

范例：可进化序列化格式的 PojoSerializer

```
class PojoSerializerSnapshot<T> implements TypeSerializerSnapshot<T> {

    ...

    public TypeSerializer<T> restoreSerializer() {
        return new PojoSerializer<>(fields, fieldSerializers);
    }
}
```

Miscellaneous Best Practices

实现最佳守则

- Avoid classname changes to the serializer snapshot class
  避免 `TypeSerializerSnapshot` 实现类名被更动
  - Classname is the entrypoint to reading a serializer snapshot
    类名为读取 `TypeSerializerSnapshot` 的入口点
  - Avoid using anonymous or nested classes for snapshot classes
    避免使用匿名类或巢状类作为 `TypeSerializerSnapshot` 的实现
- Use `CompositeSerializerSnapshot` to handle nested `TypeSerializers`
  可利用 `CompositeSerializerSnapshot` 类应付巢状的 `TypeSerializer`

字体

Conclusion

总结

- Flink 1.7 now supports state schema evolution
  自 Flink 1.7 开始支援状态的数据结构定义升级
- Avro schema evolution is supported; more support is on the radar
  支援 Avro 数据结构定义升级;支援其他原生类别的数据结构定义升级将会在未来持续增加
- Covered details on implementing custom state serializers with evolve-able schema
  针对可升级数据结构定义的状态序列化器的实现方法进行解析

THANKS