高性能鸿蒙应用开发

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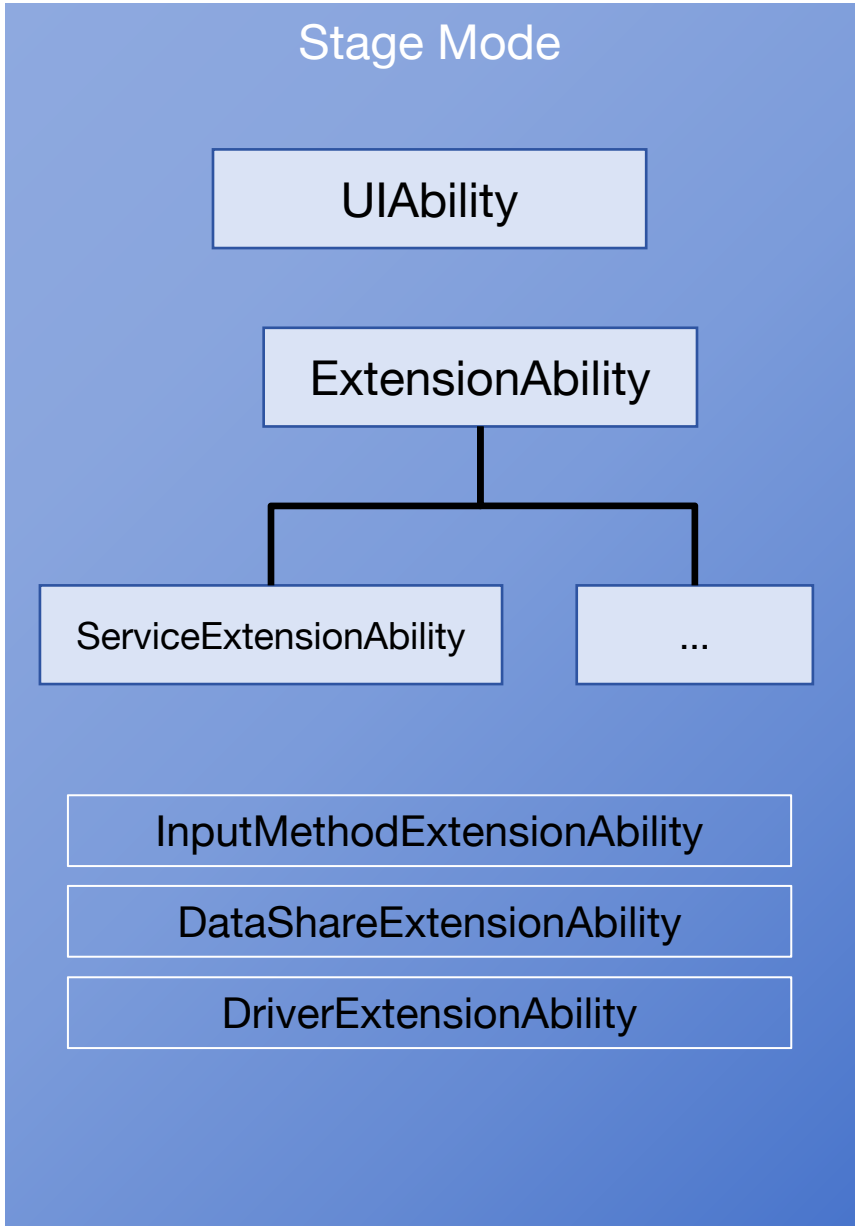
鸿蒙应用构成

构成	Stage模型
应用组件	1. 组件分类 stage-model-component - UIAbility组件：包含UI，提供展示UI的能力，主要用于和用户交互。详细介绍请参见UIAbility组件概述。 - ExtensionAbility组件：提供特定场景（如卡片、输入法）的扩展能力，满足更多的使用场景。详细介绍请参见ExtensionAbility组件概述。 2. 开发方式 采用面向对象的方式，将应用组件以类接口的形式开放给开发者，可以进行派生，利于扩展能力。
进程模型	1. 主进程 2. ExtensionAbility进程 3. 渲染进程
线程模型	1. ArkTS引擎实例的创建 一个进程可以运行多个应用组件实例，所有应用组件实例共享一个ArkTS引擎实例。 2. 线程模型 ArkTS引擎实例在主线程上创建。 3. 进程内对象共享：支持。
任务管理模型	每个UIAbility组件实例创建一个任务。 - 任务会持久化存储，直到超过最大任务个数（根据产品配置自定义）或者用户主动删除任务。 - UIAbility组件之间不会形成栈的结构。
配置文件	使用app.json5描述应用信息，module.json5描述HAP信息、应用组件信息。



性能影响纬度

- 语言纬度：ArkTS
- 线程模型：Worker & TaskPool
- UI构成：ArkUI框架
- 图形渲染：ArkGraphics渲染引擎
- 分析工具

ArkTS语言特性

高性能容器类库

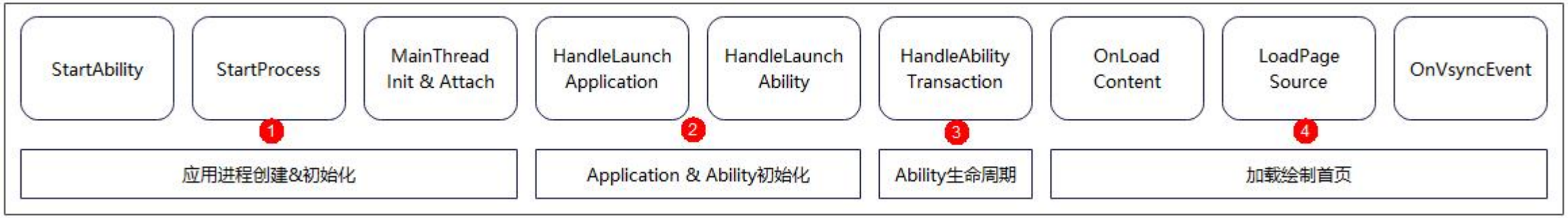
线性容器	非线性容器
ArrayList	HashMap
Vector	HashSet
List	TreeMap
LinkedList	TreeSet
Deque	LightWeightMap
Queue	LightWeightSet
Stack	PlainArray

```
import ArrayList from '@ohos.util.XXX';
```

ArkTS语言使用过程中性能提升方法

- 热点循环中常量提取，减少属性访问次数
- 避免频繁使用delete
- 数值计算避免溢出
- 避免使用稀疏数组
- 使用字面量进行对象创建
- 避免动态添加属性
- 避免使用type类型标注
- 声明参数要和实际的参数一致
- 避免动态声明function与class

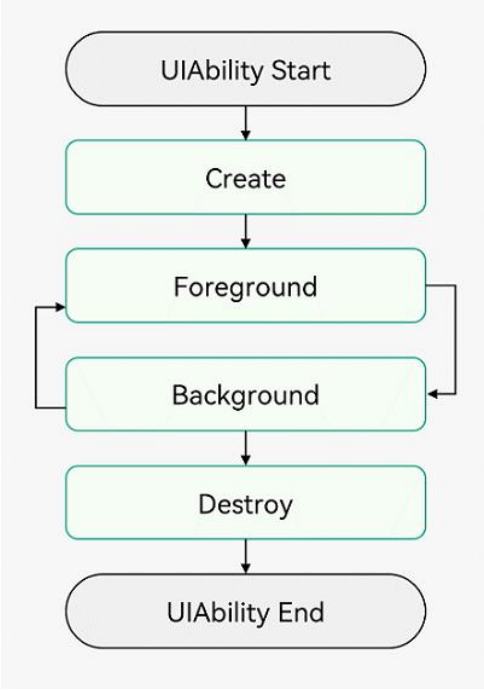
了解启动流程各阶段执行内容，合理配置应用结构，提升启动速度



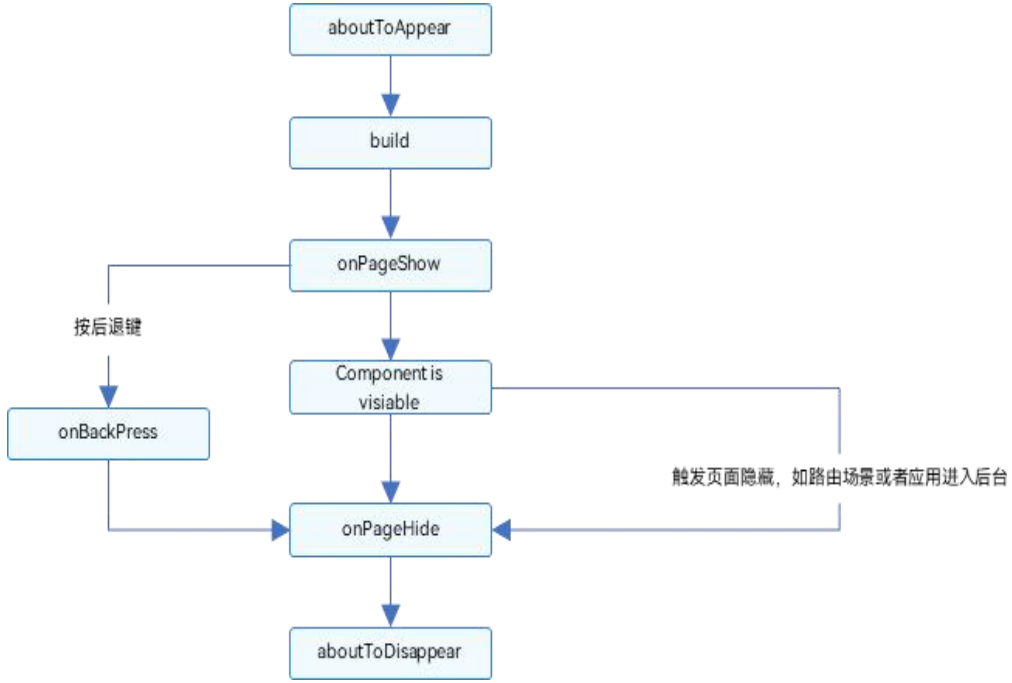
合理配置启动页面图标尺寸，减少解码开销

```
  "abilities": [
    {
      "name": "EntryAbility",
      "srcEntrance": "./ets/entryability/EntryAbility.ts",
      "description": "$string:EntryAbility_desc",
      "icon": "$media:icon",
      "label": "$string:EntryAbility_label",
      "startWindowIcon": "$media:startWindowIcon", // 在这
里修改启动页图标，建议不要超过256像素x256像素
      "startWindowBackground":
"$color:start_window_background",
      "visible": true,
      "skills": [
        {
          "entities": [
            "entity.system.home"
          ],
          "actions": [
            "action.system.home"
          ]
        }
      ]
    }
  ]
```

按需引入模块，合理使用生命周期，避免耗时操作

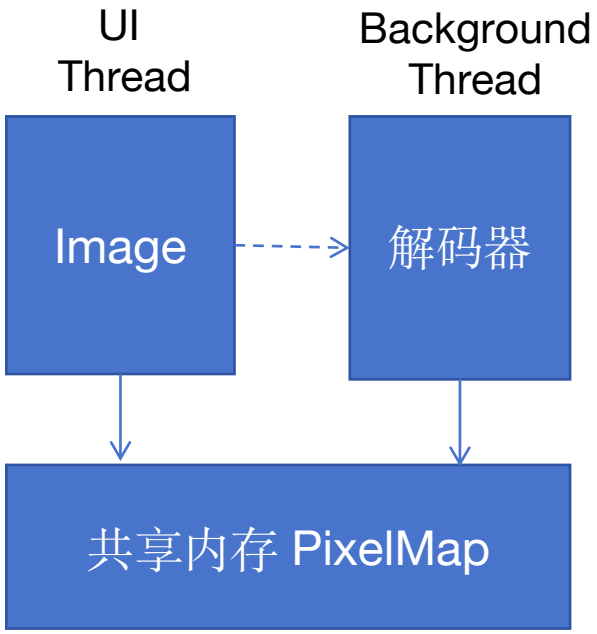


首页组件按需创建，页面生命周期避免耗时操作



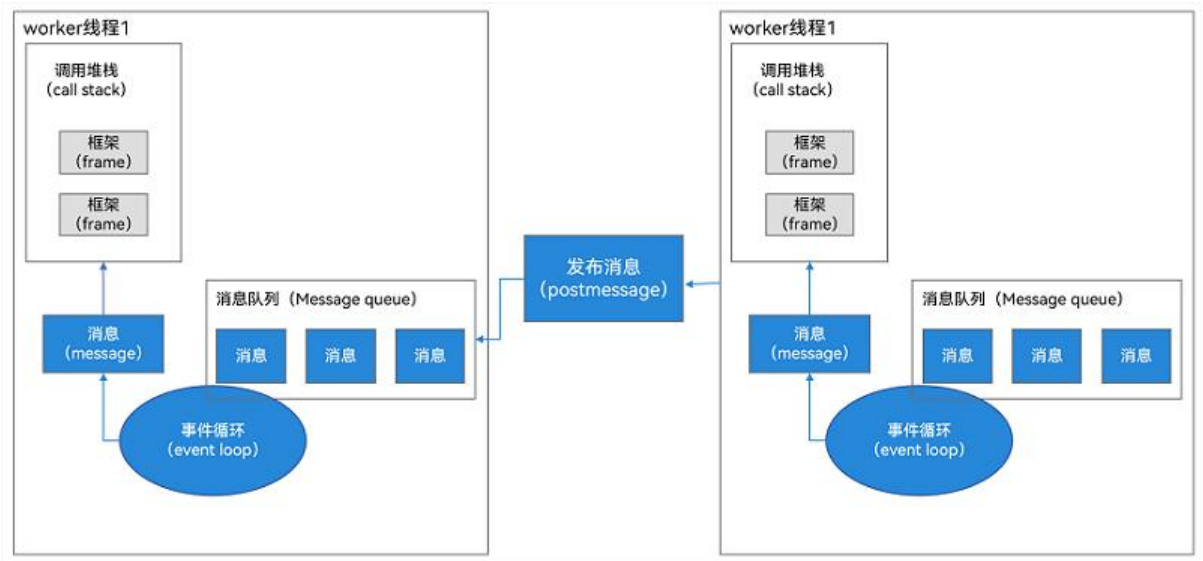
使用异步机制，降低UI线程同步操作负载

组件中的异步逻辑

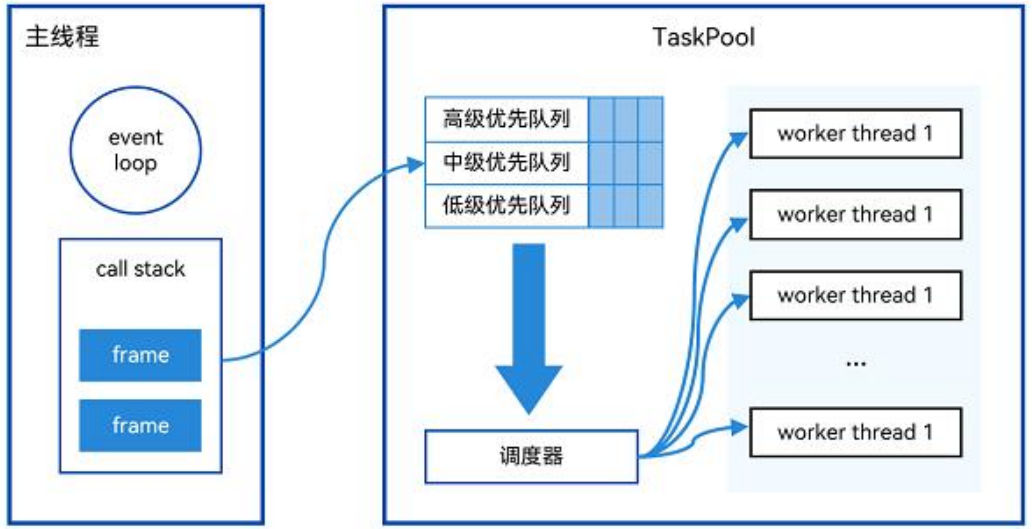


应用异步机制

worker机制

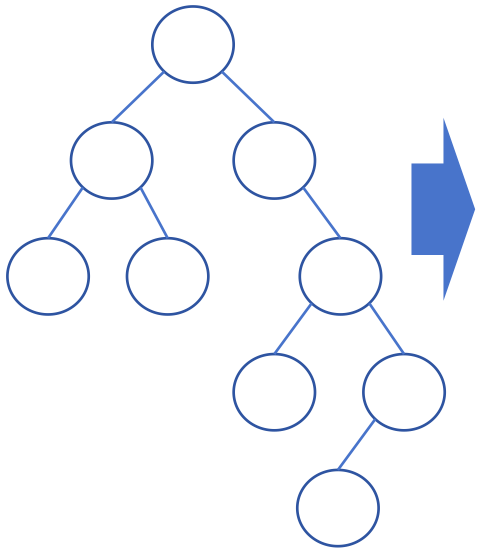


TaskPool机制



UI框架运行流程与性能影响点

应用组件树



阶段1: 数据处理

性能影响点:

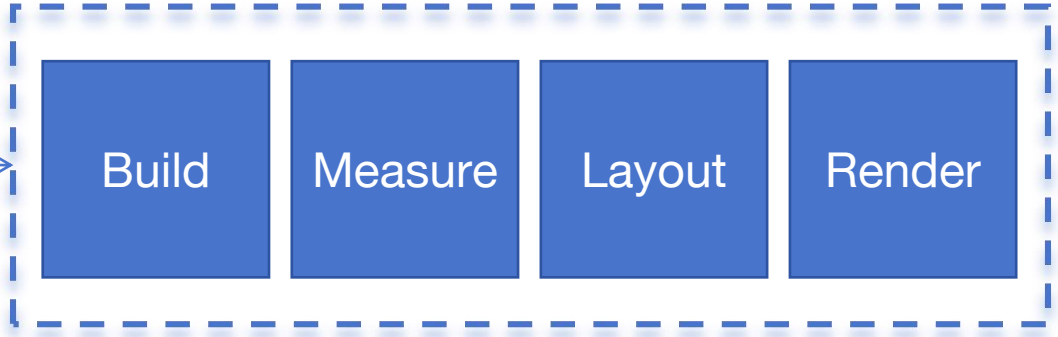
- 状态数据更新数量
- 更新脏组件数量

开发约束:

- 布局约束
- 状态更新约束
- 懒加载更新约束

脏节点
列表

阶段2: UI更新



性能影响点:

- 组件创建数量
- 属性更新数量
- 布局更新范围
- 绘制指令数量

开发约束:

- 布局合理使用
- 组件复用，避免重复创建

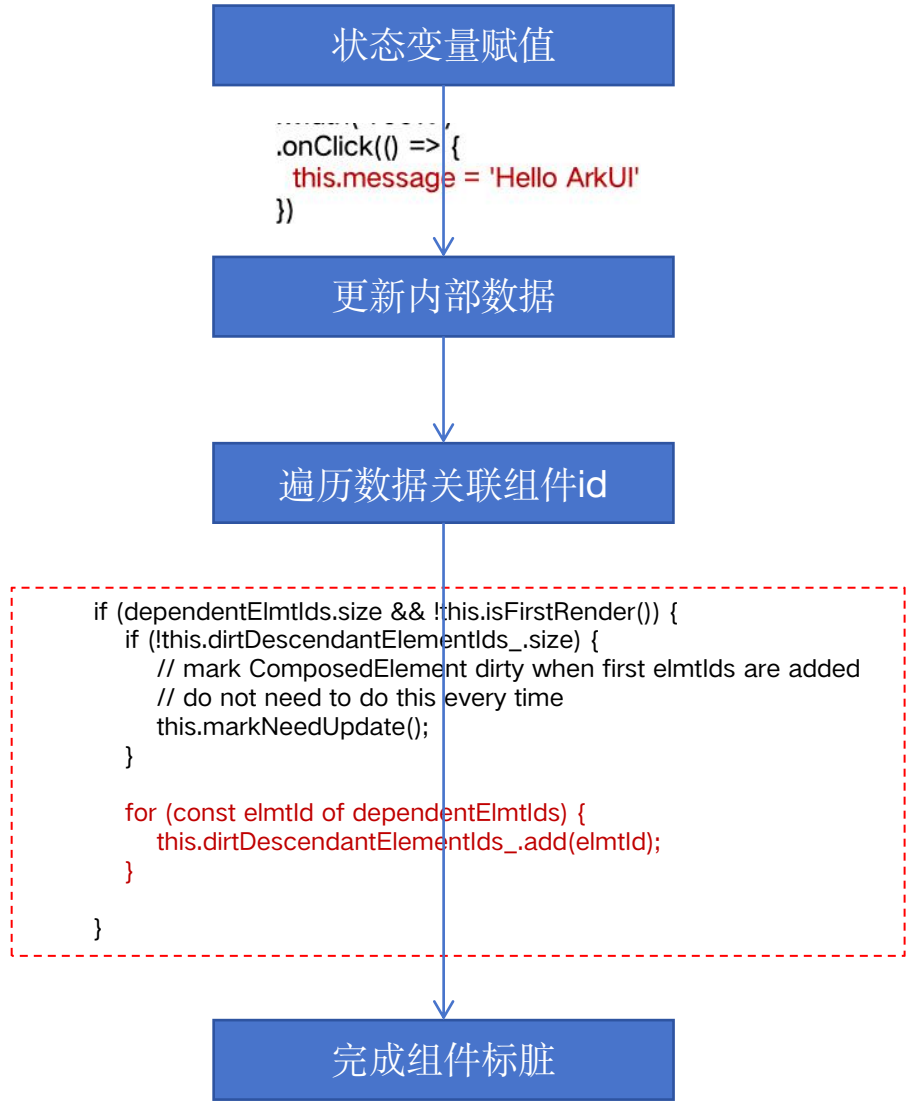
UI框架运行流程：数据处理流程

开发者视角

```
@Entry
@Component
struct Index {
  @State message: string = 'Hello World'

  build() {
    Row() {
      Column() {
        Text(this.message)
          .fontSize(50)
          .fontWeight(FontWeight.Bold)
      }
      .width('100%')
      .onClick(() => {
        this.message = 'Hello ArkUI'
      })
    }
    .height('100%')
  }
}
```

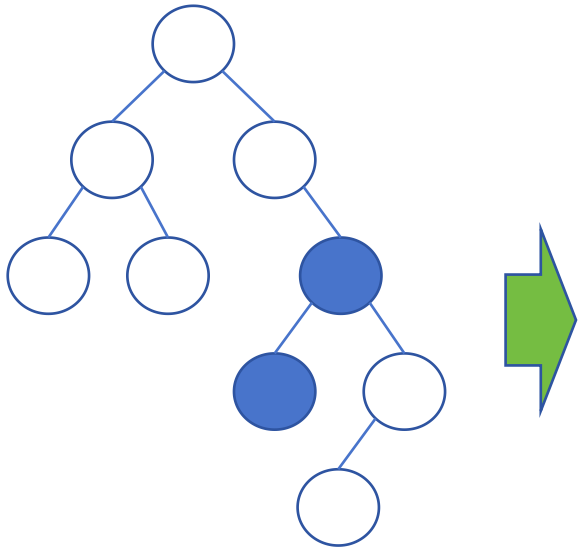
依赖收集过程

组件标脏过程



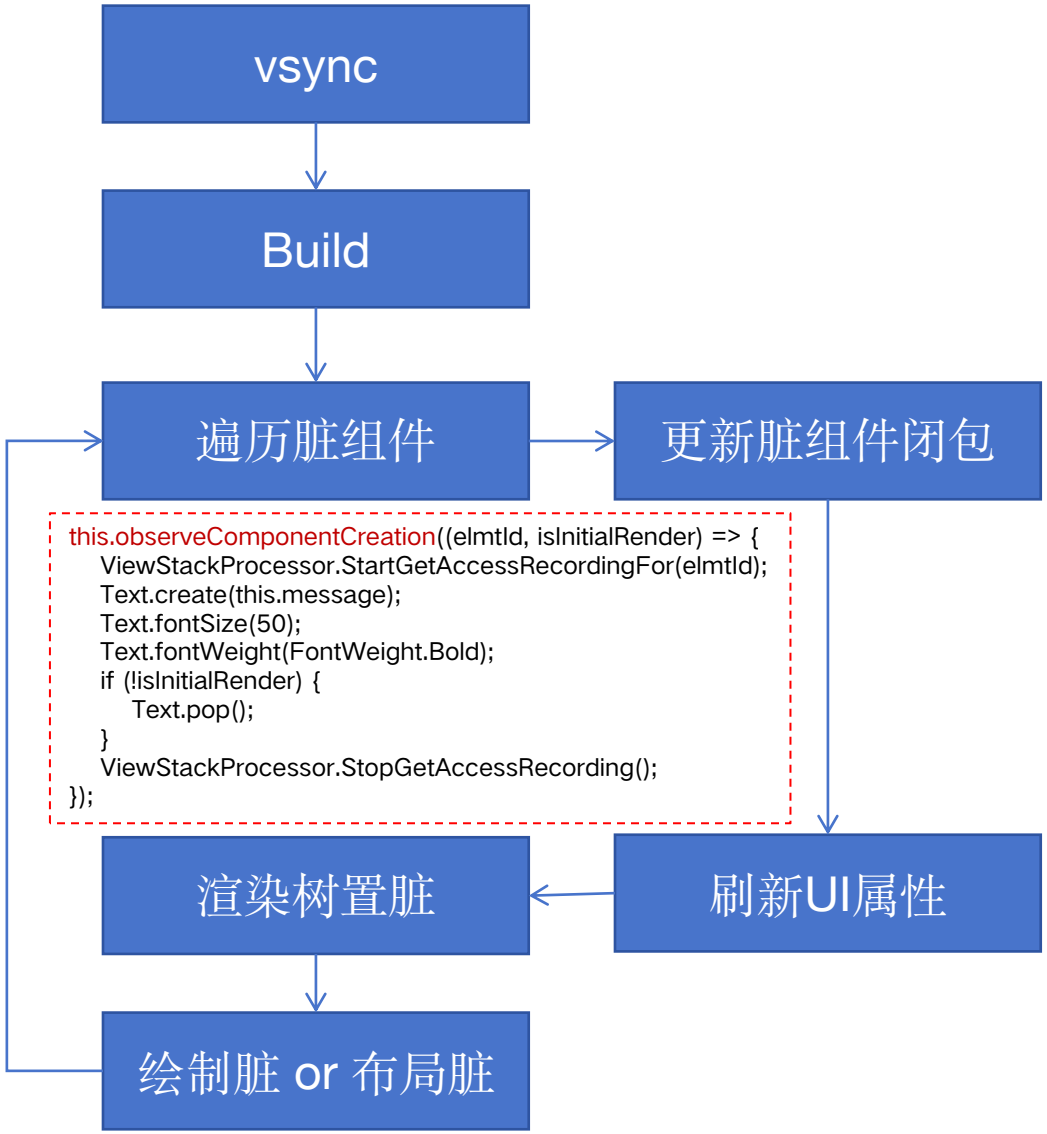
UI框架运行流程：UI更新流程

UITree

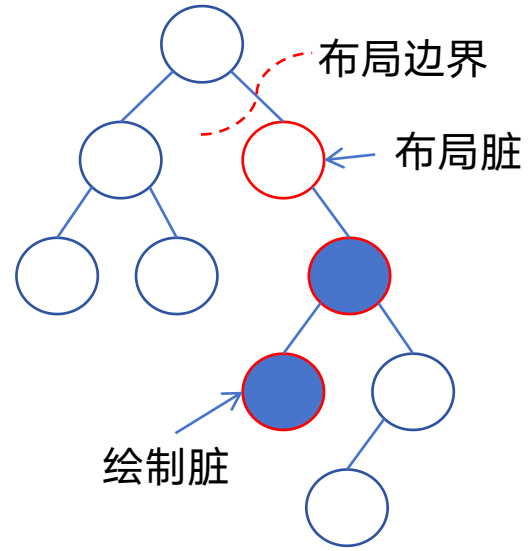


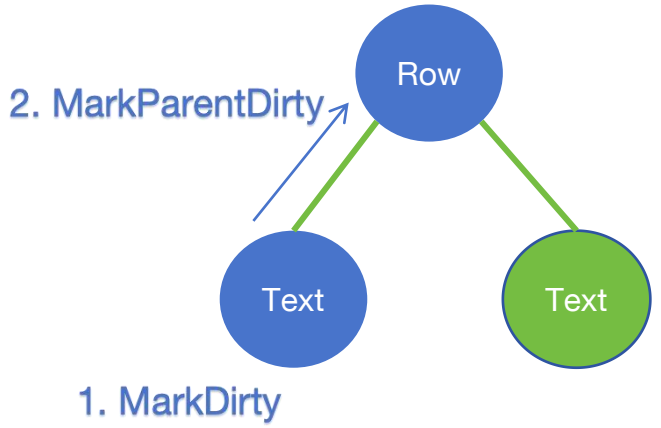
脏节点数组：保存脏节点id

Build过程



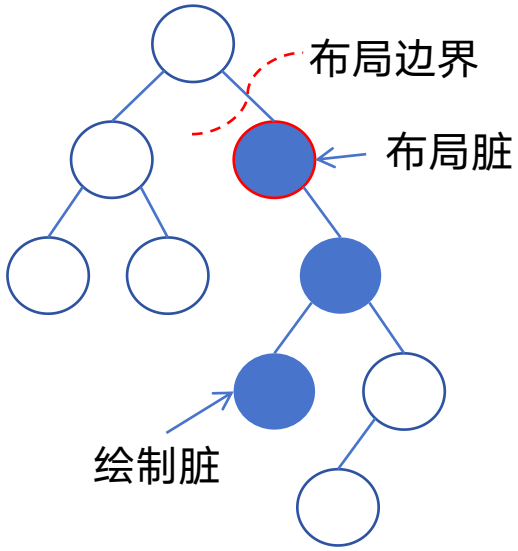
FrameNodeTree





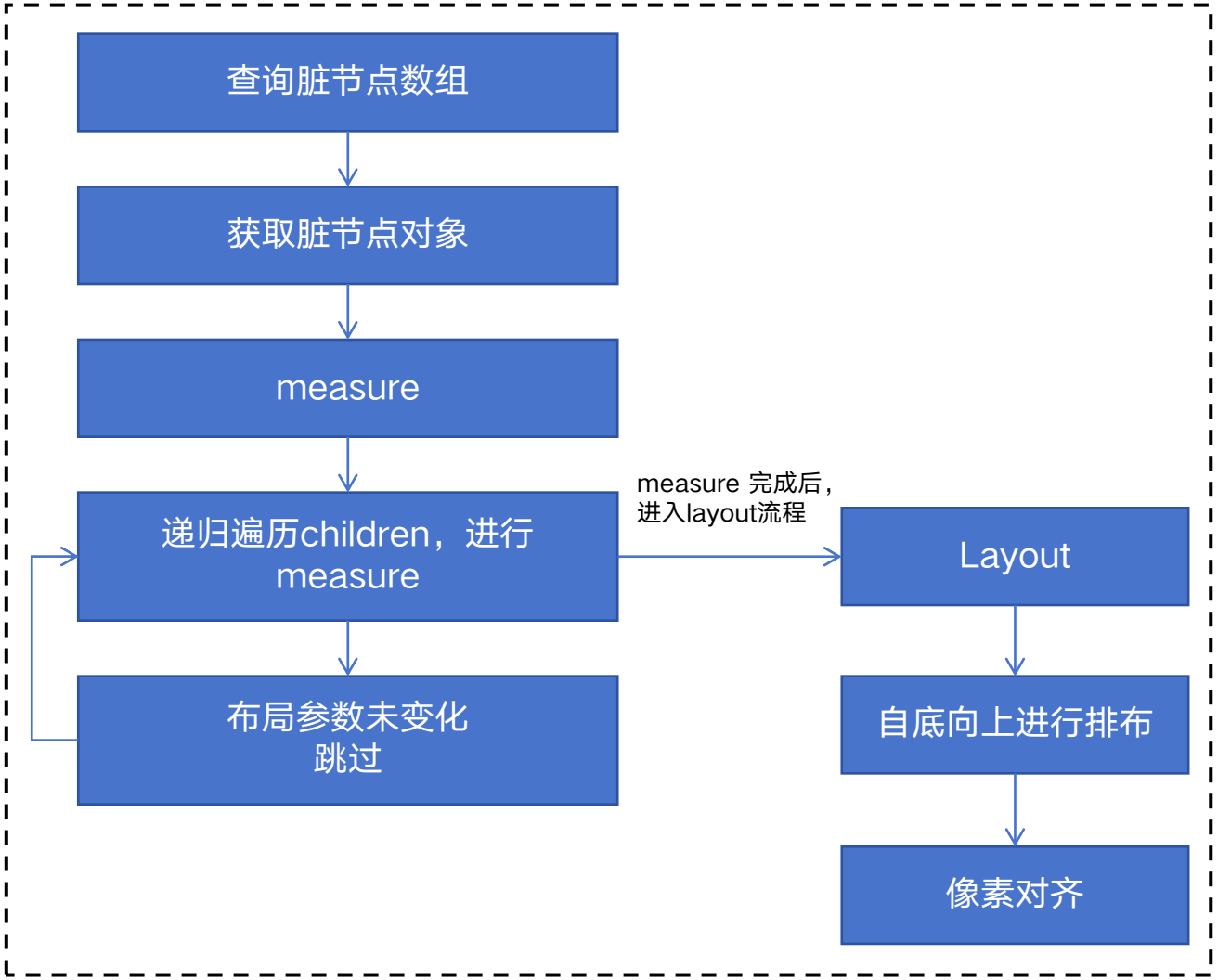
UI框架运行流程：UI更新流程

FrameNodeTree

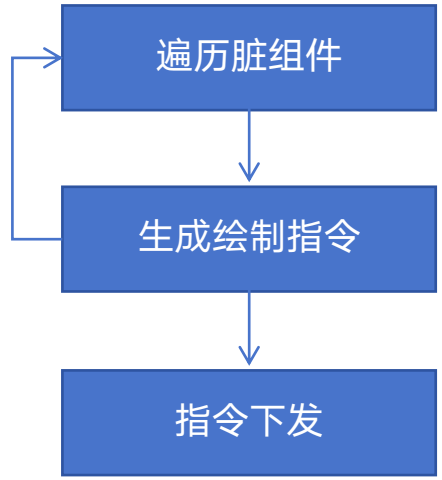


绘制脏不一定触发布局更新，
布局脏一定触发布局更新和
绘制更新

布局过程



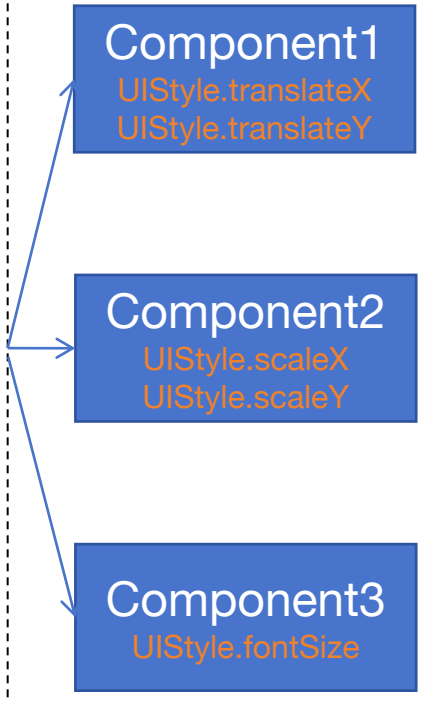
绘制过程

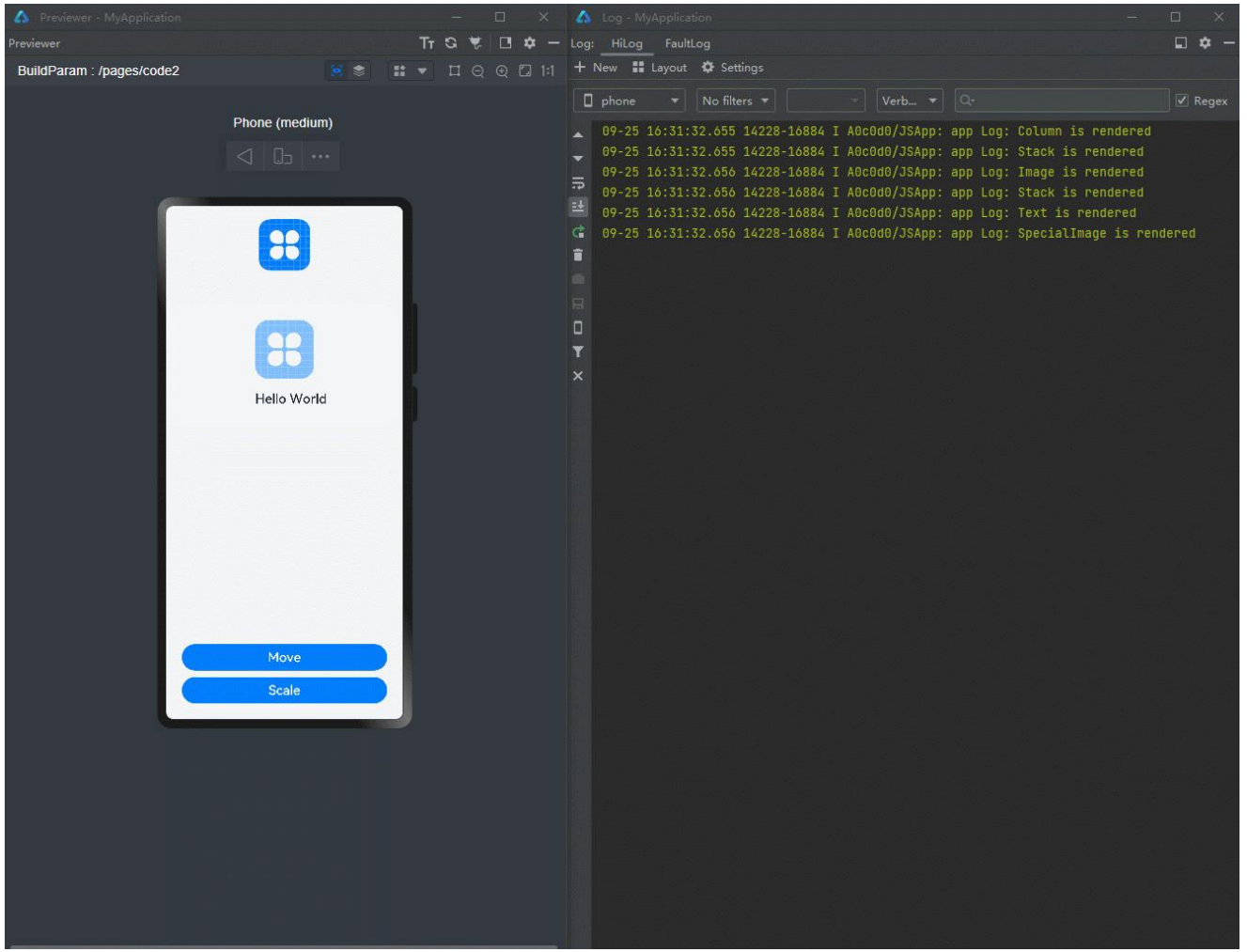


状态管理合理使用，精准控制组件更新范围

常见冗余刷新常见：大数据对象关联组件过多，造成刷新范围大

```
@Observed
class UIStyle {
  translateX: number = 0;
  translateY: number = 0;
  scaleX: number = 0.3;
  scaleY: number = 0.3;
  width: number = 336;
  height: number = 178;
  posX: number = 10;
  posY: number = 50;
  alpha: number = 0.5;
  borderRadius: number = 24;
  imageWidth: number = 78;
  imageHeight: number = 78;
  translateImageX: number = 0;
  translateImageY: number = 0;
  fontSize: number = 20;
}
```





同一数据对象中，不同属性被多个组件所使用，当数据对象任一属性值发生变化时，所有绑定该对象的组件都被标记为脏，发生刷新

状态管理合理使用，精准控制组件更新范围

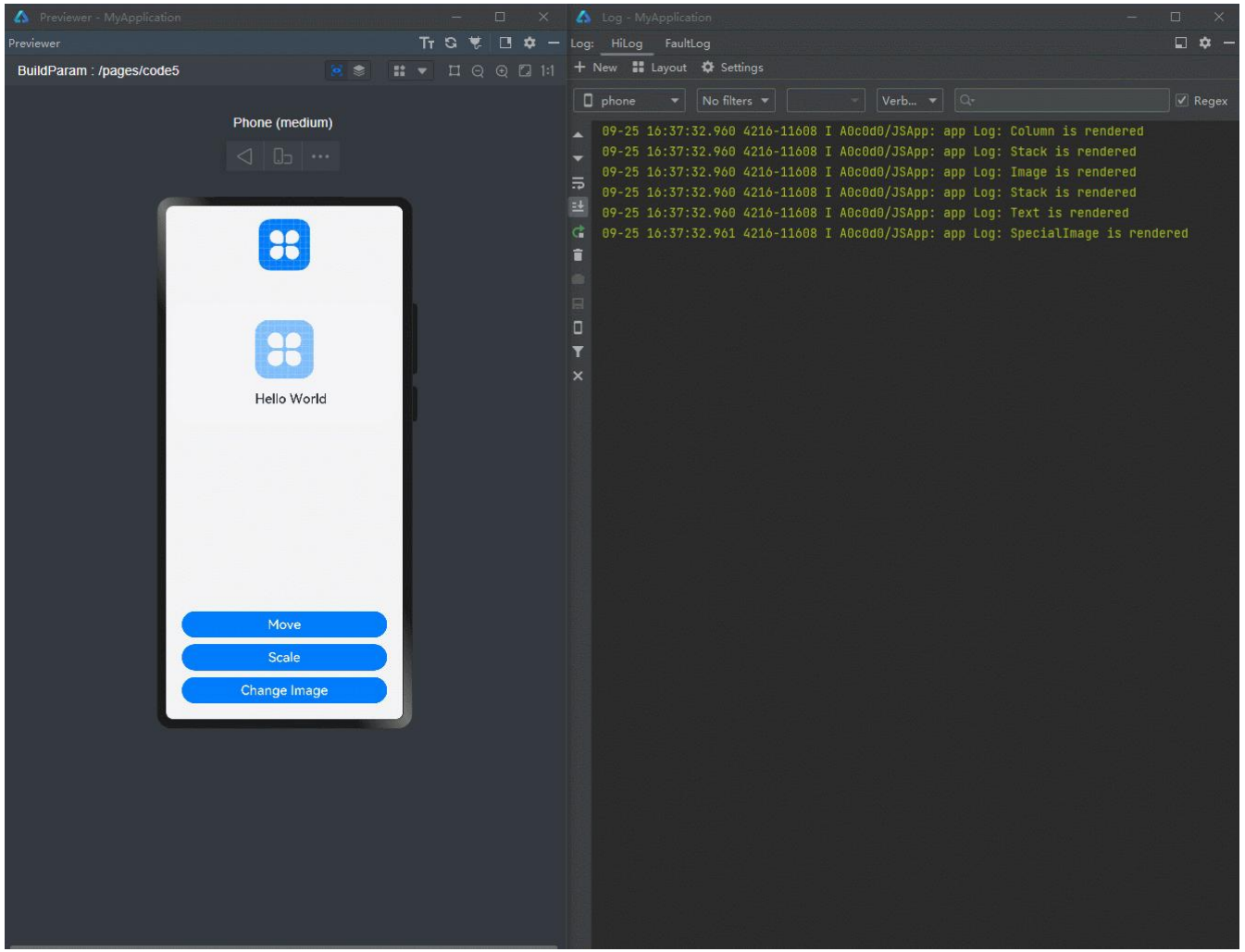
```
@Observed
class NeedRenderTranslate {
  public translateImageX: number = 0;
  public translateImageY: number = 0;
}
@Observed
class NeedRenderScale {
  public scaleX: number = 0.3;
  public scaleY: number = 0.3;
}
@Observed
class NeedRenderFontSize {
  public fontSize: number = 20;
}
@Observed
class NeedRenderOthers { // properties
usually used together can be divided
into the same new divided class
  // 。 。 。
}
@Observed
class UIStyle {
  needRenderTranslate:
NeedRenderTranslate = new
NeedRenderTranslate();
  needRenderFontSize:
NeedRenderFontSize = new
NeedRenderFontSize();
  needRenderScale: NeedRenderScale
= new NeedRenderScale();
// 。 。 。
}
```

通过@Observed装饰器，进行数据合理拆分，实现更新范围最小化

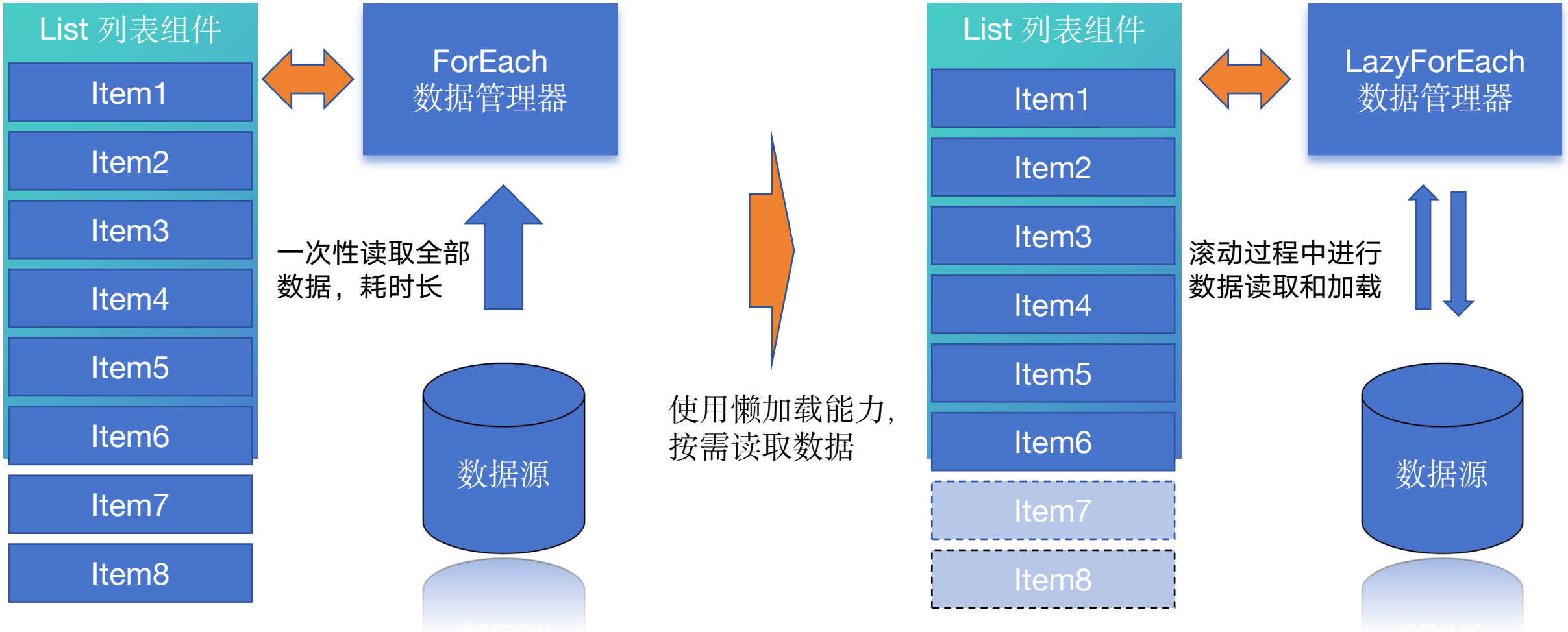
Component1
UIStyle.needRenderTranslate

Component2
UIStyle.needRenderscale

Component3
UIStyle.needRenderFontSize

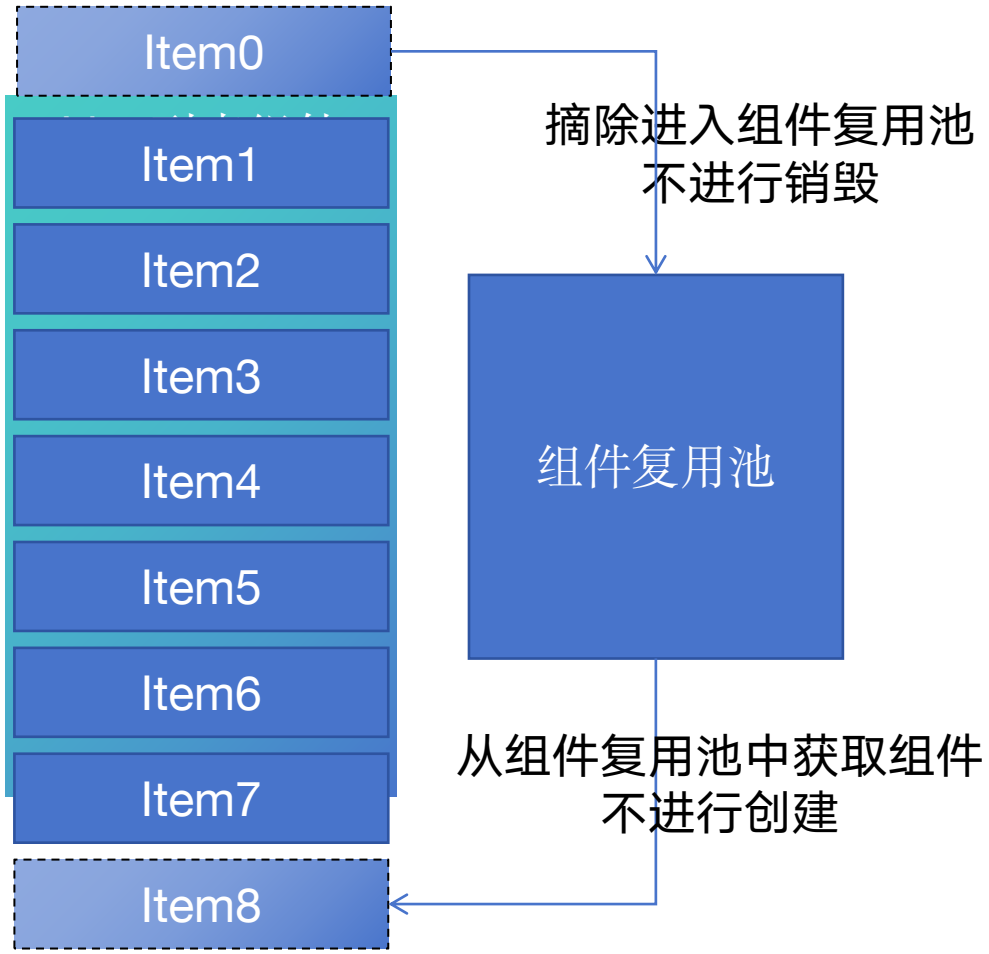


使用懒加载技术，控制列表更新范围，避免超长列表更新阻塞



适用于列表项数量不多或只有1屏数据场景，当列表项数量大时，会造成加载耗时阻塞

组件复用机制，减少组件创建




```
LazyForEach(this.GoodDataOne, (item, index) => {
  GridItem() {
    GoodItems({
      img:item.data.img,
      webimg:item.data.webimg,
      hei:item.data.hei,
    })
    .reuseId(this.CombineStr(item.type))
  }
}, (item) => JSON.stringify(item))
```

```
@Reusable
@Component
struct GoodItems {
  @State img: Resource = $r("app.media.photo61")
  @State webimg?: string = ''
  @State hei: number = 0
  @LocalStorageLink('storageSimpleProp') simpleVarName:
string = ''
  boo: boolean = true
  index: number = 0
  controllerVideo: VideoController = new VideoController();

  aboutToReuse(params)
  {
    this.webimg = params.webimg
    this.img = params.img
    this.hei = params.hei
  }

  build() {
    // ...
  }
}
```

懒加载机制与组件复用机制在组件中的使用——瀑布流布局

效果展示

懒加载能力与WaterFlow组合使用

```
build() {
  Column({ space: 2 }) {
    WaterFlow() {
      LazyForEach(this.datasource, (item: number) => {
        FlowItem() {
          Column() {
            Text("N" + item).fontSize(12).height('16')
            Image('res/waterFlowTest (' + item % 5 + ').jpg')
              .objectFit(ImageFit.Fill)
              .width('100%')
              .layoutWeight(1)
          }
        }
        .width('100%')
        // 提前设定FlowItem高度，避免自适应图片高度
        .height(this.itemHeightArray[item])
        .backgroundColor(this.colors[item % 5])
      }, (item: string) => item)
    }
    .columnsTemplate("1fr 1fr")
    .columnsGap(10)
    .rowsGap(5)
    .backgroundColor(0xFAEEE0)
    .width('100%')
    .height('80%')
  }
}
```

懒加载能力实现无限滚动

```
build() {
  Column({ space: 2 }) {
    WaterFlow() {
      LazyForEach(this.datasource, (item: number) => {
        FlowItem() {
          Column() {
            Text("N" + item).fontSize(12).height('16')
            Image('res/waterFlowTest (' + item % 5 + ').jpg')
              .objectFit(ImageFit.Fill)
              .width('100%')
              .layoutWeight(1)
          }
        }
        .onAppear(() => {
          // 即将触底时提前增加数据
          if (item + 20 == this.datasource.totalCount()) {
            for (let i = 0; i < 100; i++) {
              this.datasource.AddLastItem()
            }
          }
        })
        .width('100%')
        .height(this.itemHeightArray[item % 100])
        .backgroundColor(this.colors[item % 5])
      }, (item: string) => item)
    }
  }
```

懒加载机制与组件复用机制在组件中的使用——瀑布流布局

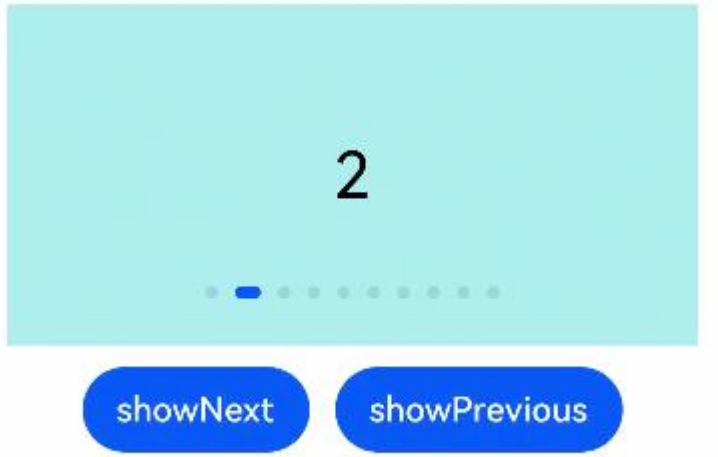
懒加载能力结合组件复用机制，达到最佳滚动性能体验

```
build() {
  Column({ space: 2 }) {
    WaterFlow() {
      LazyForEach(this.datasource, (item: number) => {
        FlowItem() {
          // 使用可复用自定义组件
          ResuableFlowItem({ item: item })
        }
        .onAppear(() => {
          // 即将触底时提前增加数据
          if (item + 20 == this.datasource.totalCount()) {
            for (let i = 0; i < 100; i++) {
              this.datasource.AddLastItem()
            }
          }
        })
        .width('100%')
        .height(this.itemHeightArray[item % 100])
        .backgroundColor(this.colors[item % 5])
      }, (item: string) => item)
    }
    .columnsTemplate("1fr 1fr")
    .columnsGap(10)
    .rowsGap(5)
    .backgroundColor(0xFAEEE0)
    .width('100%')
    .height('80%')
  }
}
```

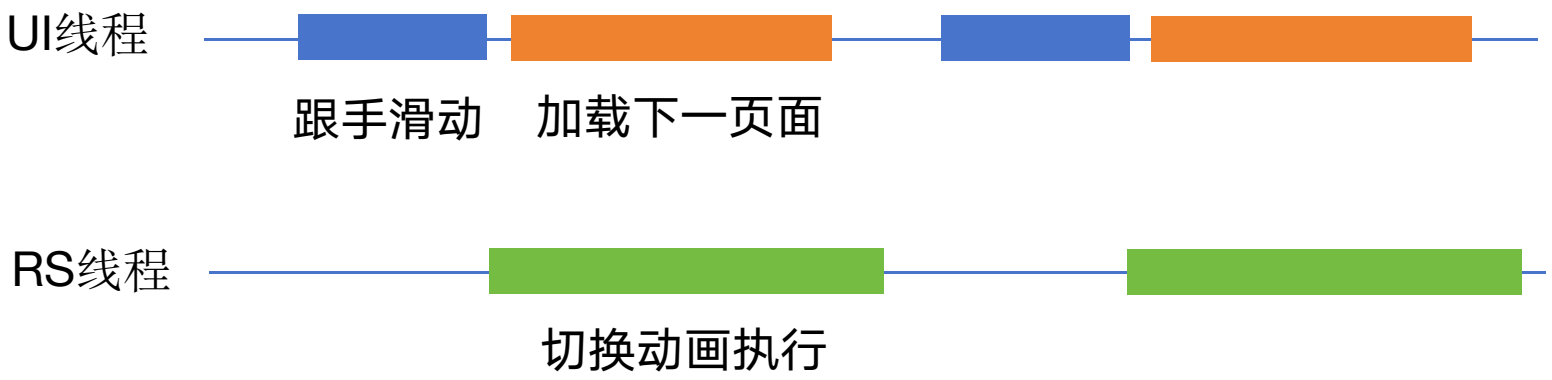
```
@Reusable
@Component
struct ResuableFlowItem {
  @State item: number = 0

  // 从复用缓存中加入到组件树之前调用，可在此处更新组件的状态变量以展示正确的内容
  aboutToReuse(params) {
    this.item = params.item;
  }

  build() {
    Column() {
      Text("N" + this.item).fontSize(12).height('16')
      Image('res/waterFlowTest (' + this.item % 5 + ').jpg')
        .objectFit(ImageFit.Fill)
        .width('100%')
        .layoutWeight(1)
    }
  }
}
```

懒加载机制与组件预加载机制在组件中的使用——页面滑动

翻页效果展示



滑动动画&页面创建并行

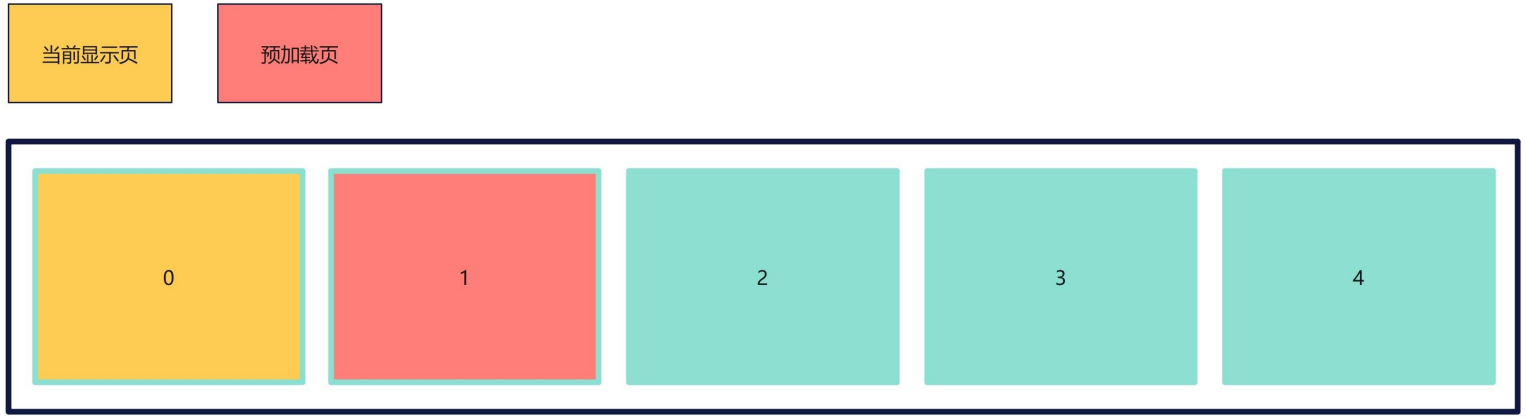


当页面较多数量大时，一次性创建全部页面显然并不划算

优化机制：

- 利用滑动过程动画时间，并行进行页面创建
- 控制加载的页面数量

通过cacheCount设置预加载页面数量



优化页面布局，高效组织UI结构

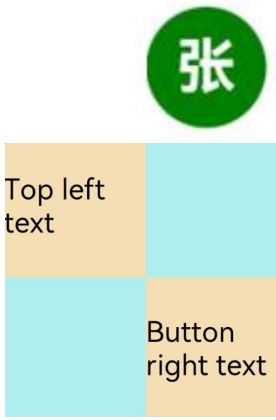
合理使用布局，降低UI层级

```
Scroll
  Grid
    GridItem
      Stack
        Stack
          Stack
            Text
    GridItem
    GridItem
```

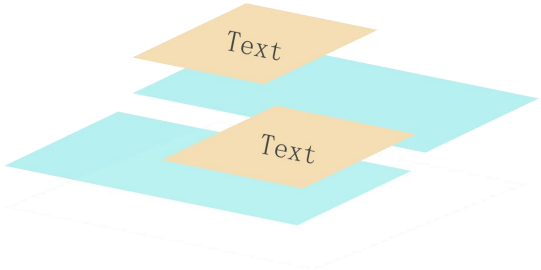
```
Scroll
  Grid
    GridItem
      Text
    GridItem
    GridItem
```

归并相同类型布局，避免冗余组件使用

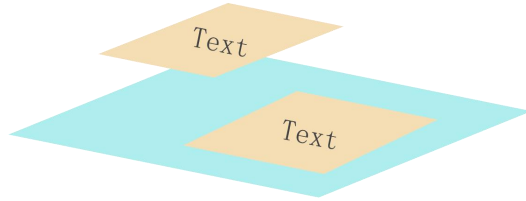
选用扁平化布局，降低UI层级



布局效果



线性布局实现



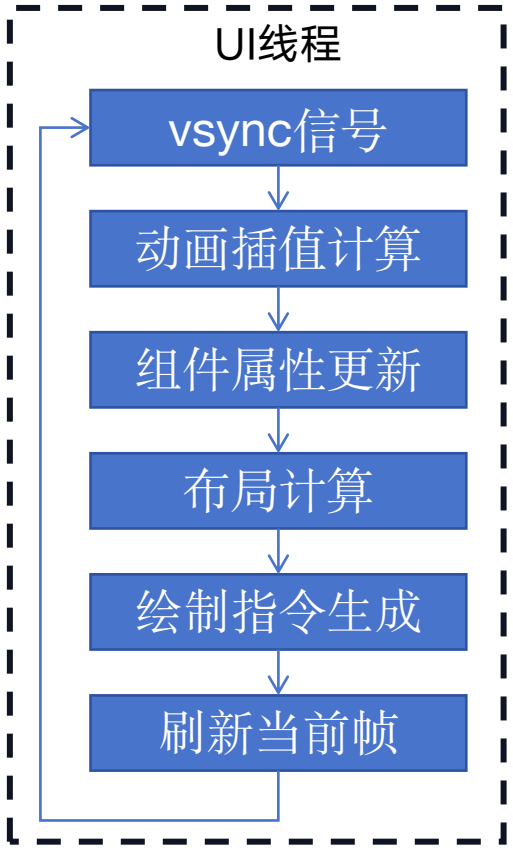
相对布局实现

```
Row
  Column
    Flex
      Text
  Flex
  Flex
    Flex
      Text
      Text
  Row
    Text
```

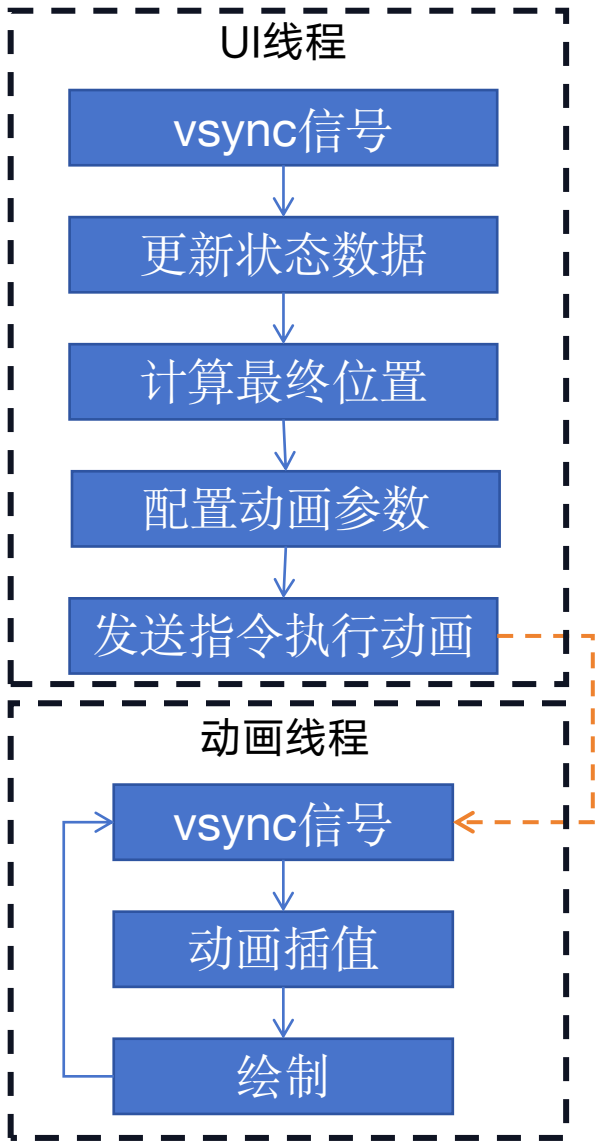
```
RelativeContainer
  Text
  Text
  Text
  Text
```

使用属性动画能力，避免帧动画占用UI线程

传统动画处理过程

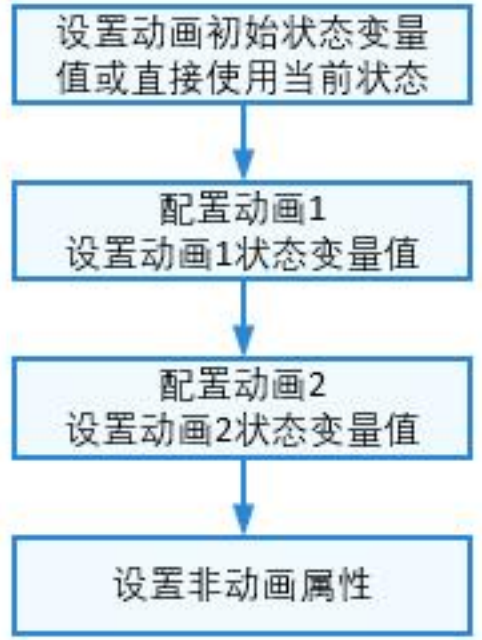


鸿蒙动画处理过程



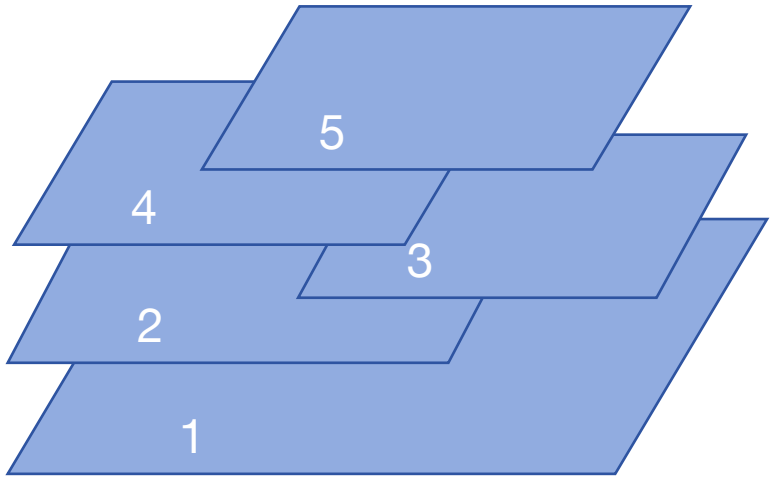
动画使用示例

```
@State textScaleX: number = 1;
@State textScaleY: number = 1;

Text()
  .backgroundColor(Color.Blue)
  .fontColor(Color.White)
  .fontSize(20)
  .width(10)
  .height(10)
  .scale({ x: this.textScaleX, y: this.textScaleY })
  .margin({ top: 100 })

Button('图形变换属性')
  .onClick(() => {
    animateTo({ duration: 1000 }, () => {
      this.textScaleX = 10;
      this.textScaleY = 10;
    })
})
```



通过节点组缓存（renderGroup），提升渲染性能

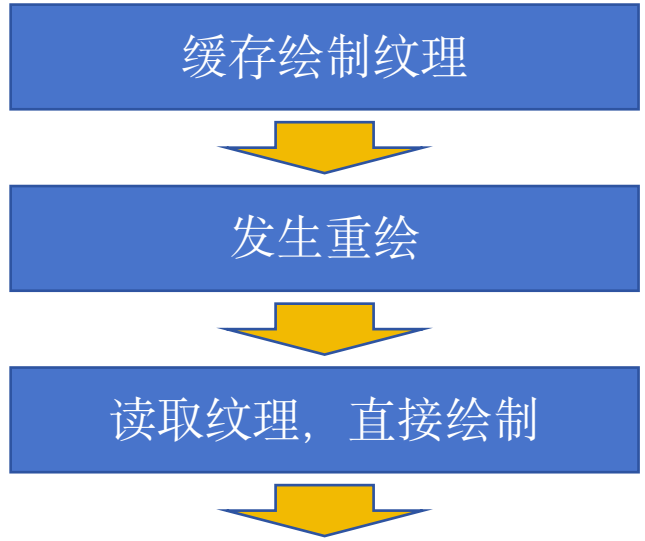
组件渲染顺序

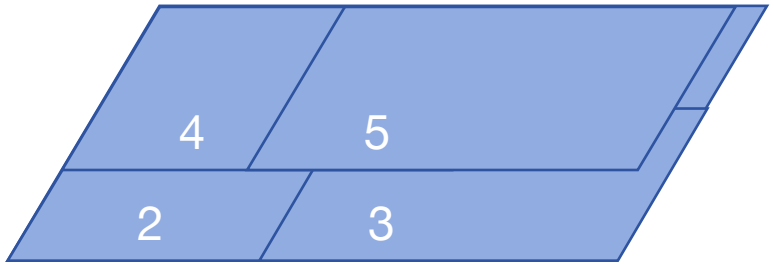


按Z序自底向上逐层绘制

节点组缓存，一次性绘制

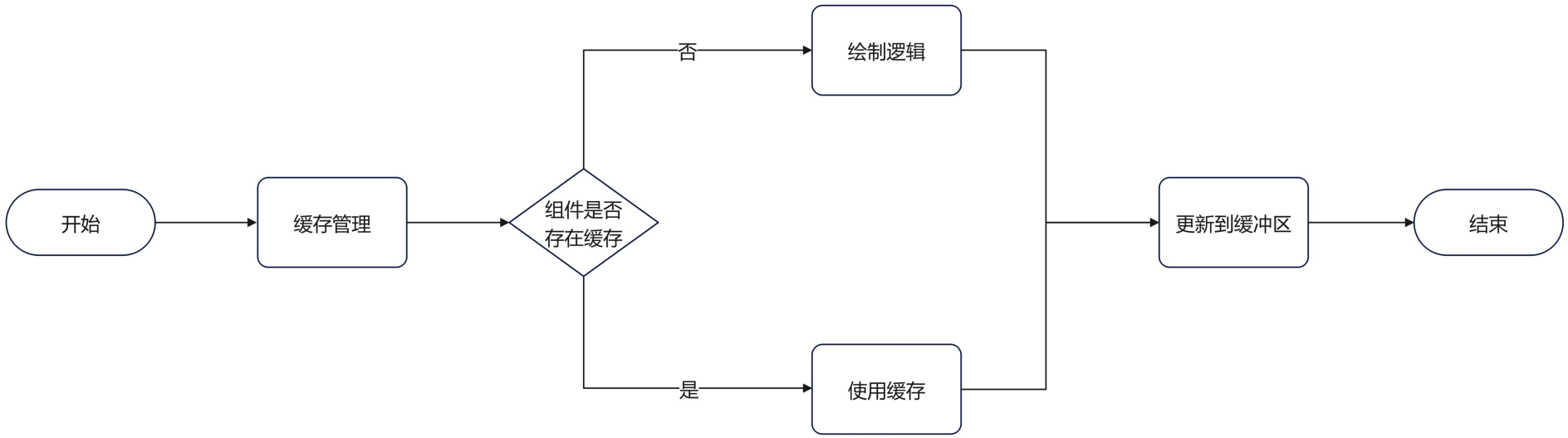
首次绘制：按Z序自底向上逐层绘制





通过节点组缓存（renderGroup），提升渲染性能

组件渲染流程



合理使用节点组缓存，平衡性能&内存

缓存更新条件：

① 组件在当前组件树上

② 组件renderGroup被标记为true

③ 组件内容被标脏

缓存清理条件：

① 组件不存在于组件树上

② 组件renderGroup被标记为false

适用场景

✓ **组件内容固定不变&内部无动效**

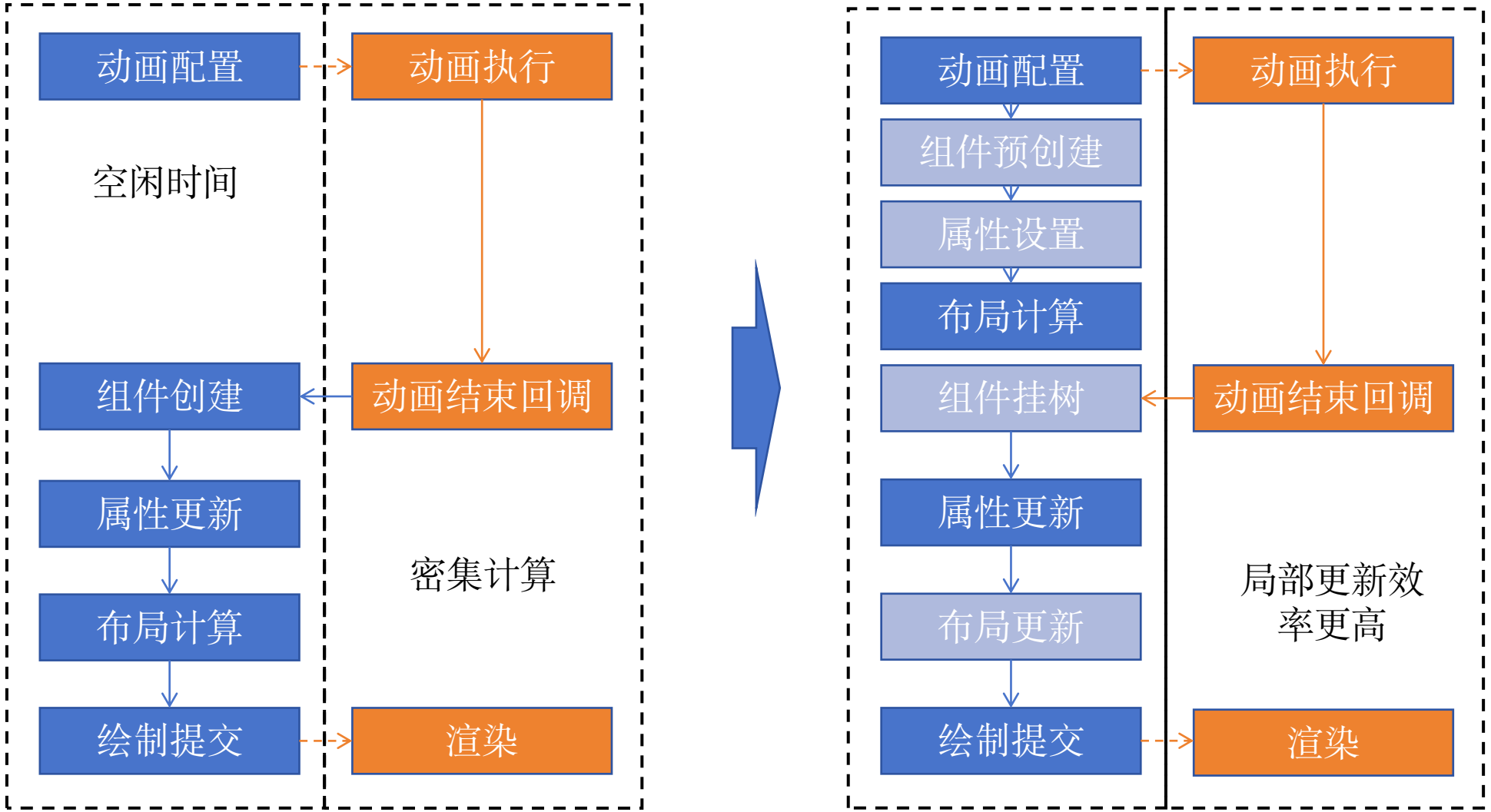
组件内容固定不变或更新频率低，会加大缓存的使用率，减少缓存更新增加的开销

✓ **执行动画的过程**

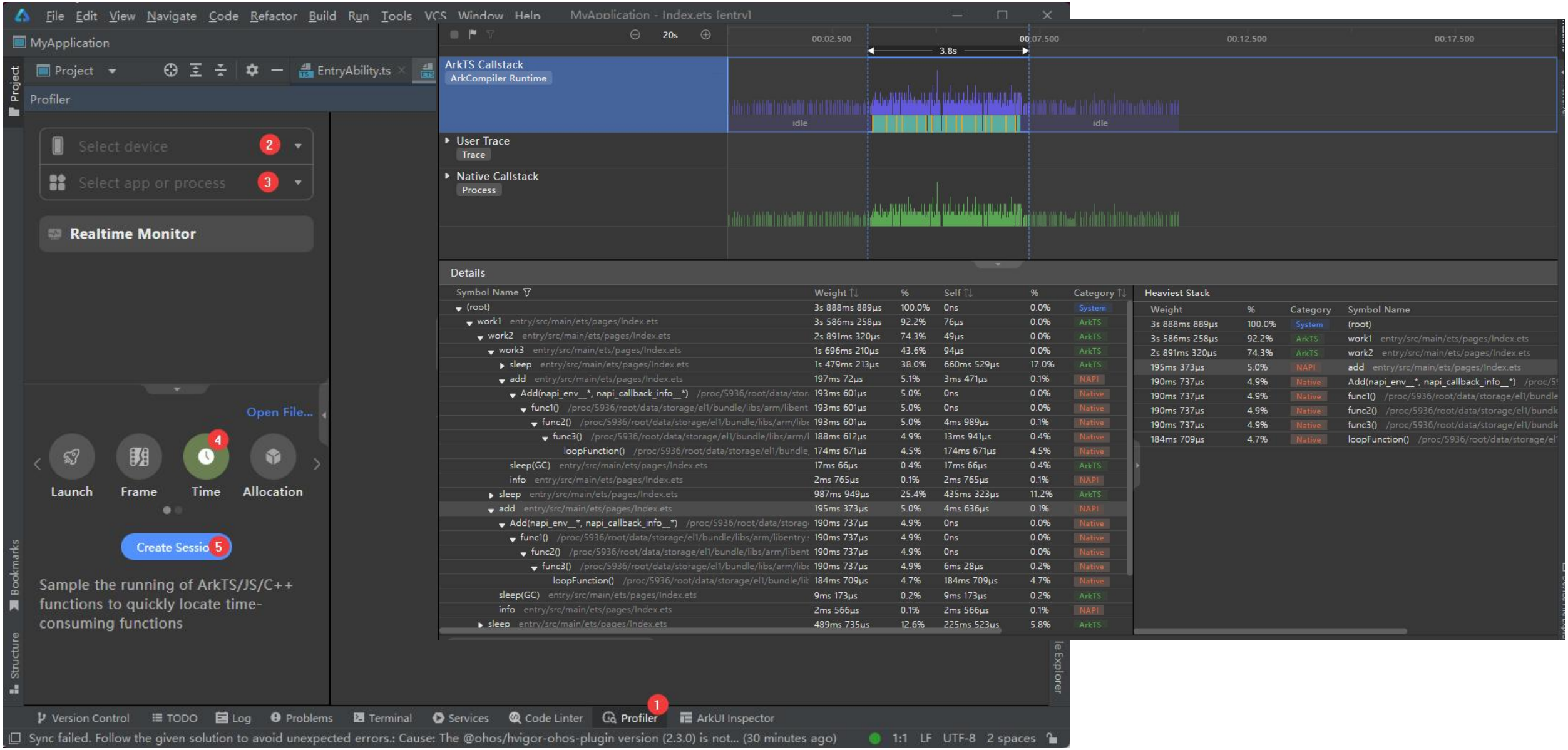
执行动画过程中内容通常没有变化，此时在动画执行前将动画目标组件标记为节点组，可提升动画帧率，动画结束后，恢复原始状态

探索中的性能提升思路

组件预创建能力
利用UI线程空闲时间，提前准备数据



应用性能分析工具CPU Profiler：查看ArkTS耗时分析



HiDumper命令行工具：查看UI结构

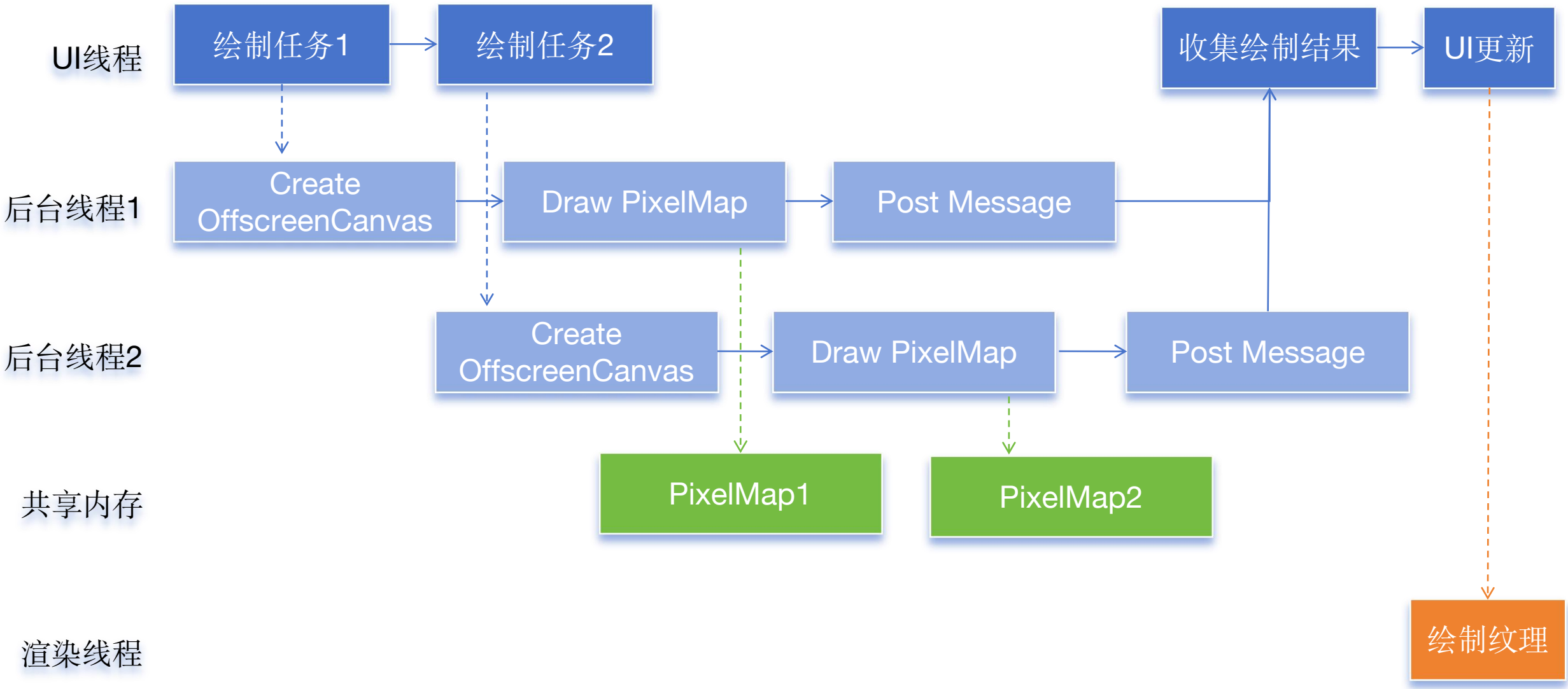
① 开启ArkUI的debug模式：hdc shell param set persist.ace.debug.enabled 1
② 重新启动应用
③ 获取当前页面对应应用的window ID：hdc shell hidumper -s WindowManagerService -a '-a'
④ 通过WinId获取对应页面的控件树文件：hdc shell hidumper -s WindowManagerService -a '-w 28 -element -c'
⑤ 查看 arkui.dump 文件

```
# hidumper -s WindowManagerService -a '-a'

-------------------------------[ability]--------------------


----------------------------------WindowManagerService-----
------------------------------------ScreenGroup 1---------
WindowName           DisplayId Pid     WinId Type Mode Flag
SystemUi_NavigationB 0         1045    7     2112 102  1
SystemUi_PrivacyIndi 0         1045    8     2111 102  1
SystemUi_StatusBar   0         1045    6     2108 102  1
demo0                0         22642   28    1    1    1
EntryView            0         1086    4     2001 1    0
------------------------------------------------------------
ScreenLockWindow     0         1045    1     2110 1    0
SystemUi_VolumePanel 0         1045    2     2111 1    1
imeWindow            0         1125    3     2105 102  1
RecentView           0         1086    5     2115 1    0
SystemUi_DropdownPan 0         1045    9     2109 1    1
SystemUi_BannerNotic 0         1045    10    2111 1    1
Focus window: 28
total window num: 11
```

```
# hidumper -s WindowManagerService -a '-w 28 -element -c'

-------------------------------[ability]--------------------------------


----------------------------------WindowManagerService------------------
WindowName: demo0
DisplayId: 0
WinId: 28
Pid: 22642
Type: 1
Mode: 1
Flag: 1
Orientation: 0
IsStartingWindow: false
FirstFrameCallbackCalled: 1
IsVisible: true
Focusable: true
DecoStatus: true
IsPrivacyMode: false
OnlySkipSnapshot: 0
WindowRect: [ 0, 72, 720, 1136 ]
TouchHotAreas: [ 0, 72, 720, 1136 ]
dumpFilePath: /data/storage/el2/base/haps/entry/files/arkui.dump
```

探索中的性能提升思路

多线程离屏绘制：并行绘制，UI线程显示纹理



HiDumper命令行工具：查看UI结构

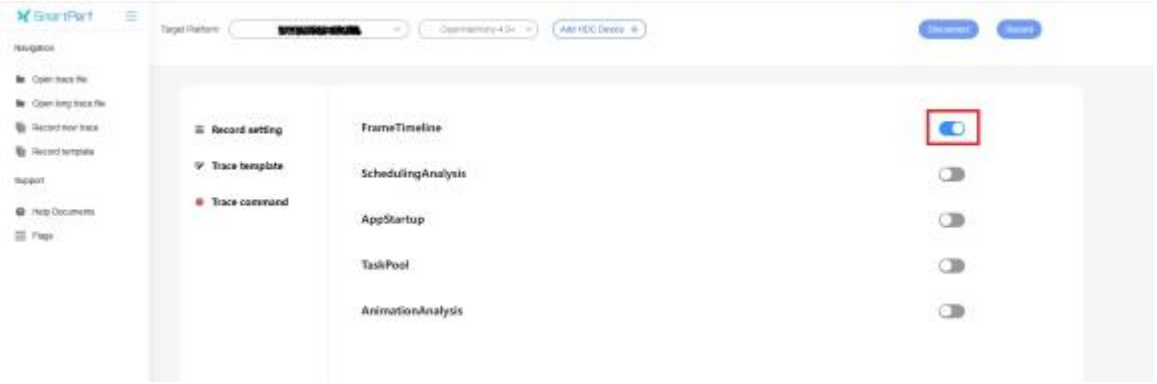
字段说明

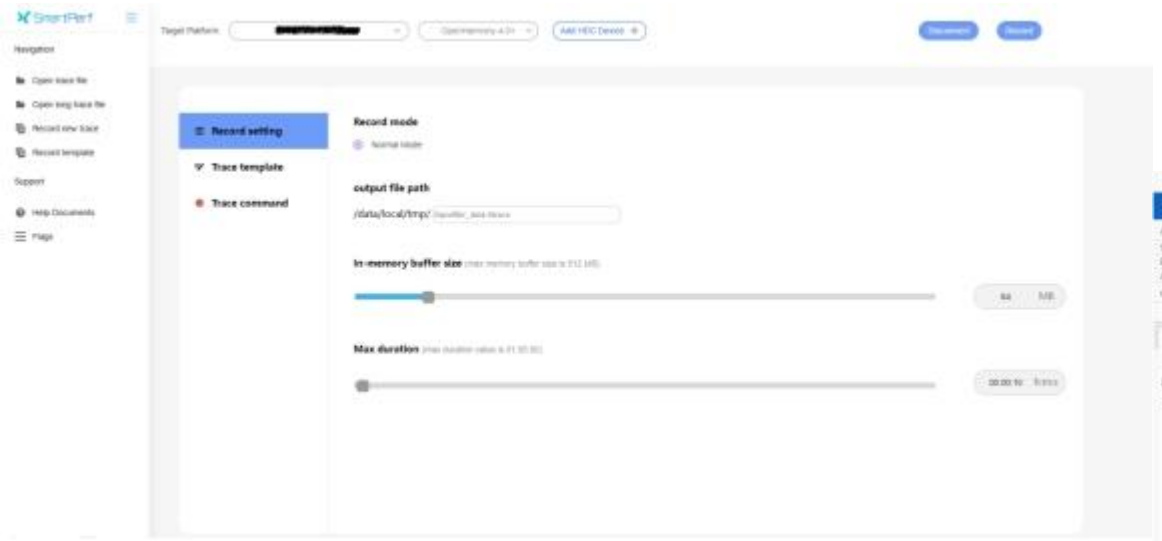
childSize：组件内子组件数量
ID：当前组件的ID值，此ID非应用设置，而是自增累加
Depth：当前组件在UI Tree中深度
IsDisappearing：显示状态
FrameRect：组件尺寸
Background：组件背景色
其他：各组件渲染属性都可查看

```
// arkui.dump文件内容片断
|-> GridItem childSize:1
  | ID: 22
  | Depth: 9
  | IsDisappearing: 0
  | FrameRect: RectT (360.00, 0.00) - [180.00 x 29.00]
  | BackgroundColor: #00000000
  ...
  |-> Stack childSize:1
    | ID: 23
    | Depth: 10
    | IsDisappearing: 0
    | FrameRect: RectT (0.00, 0.00) - [180.00 x 29.00]
    | BackgroundColor: #FFFFFF00
    ...
    |-> Stack childSize:1
      | ID: 24
      | Depth: 11
      | IsDisappearing: 0
      | FrameRect: RectT (0.00, 0.00) - [180.00 x 29.00]
      | BackgroundColor: #FF0000FF
      ...
      |-> Stack childSize:1
        | ID: 25
        | Depth: 12
        | IsDisappearing: 0
        | FrameRect: RectT (0.00, 0.00) - [180.00 x 29.00]
        | BackgroundColor: #00000000
        ...
        |-> Text childSize:0
            ID: 26
            Depth: 13
            IsDisappearing: 0
            FrameRect: RectT (83.00, 0.00) - [14.00 x 29.00]
            BackgroundColor: #00000000
            ...
```

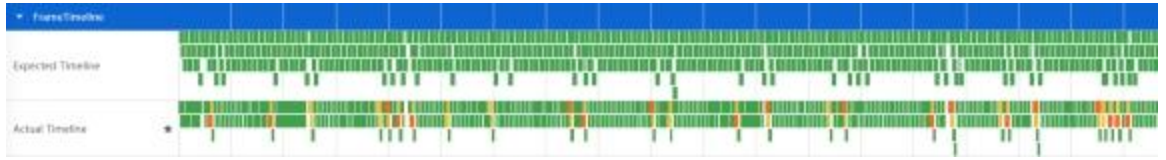
SmartPerf-Host工具分析应用性能

配置SmartPerf参数



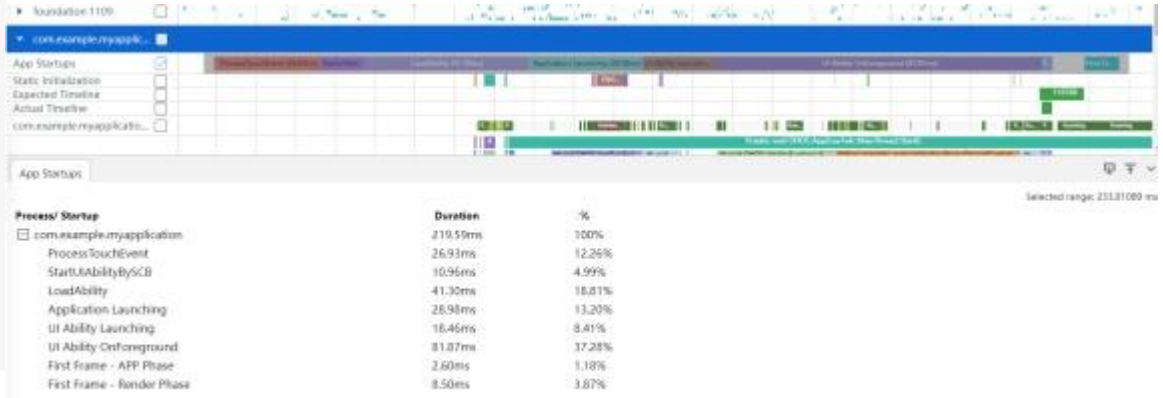


分析UI数据



帧率数据

线程Trace



耗时分析

ArkUI-X 跨平台项目期待您的加入共建

https://gitee.com/arkui-x