

SACC 第八届中国系统架构师大会
2016 SYSTEM ARCHITECT CONFERENCE CHINA 2016

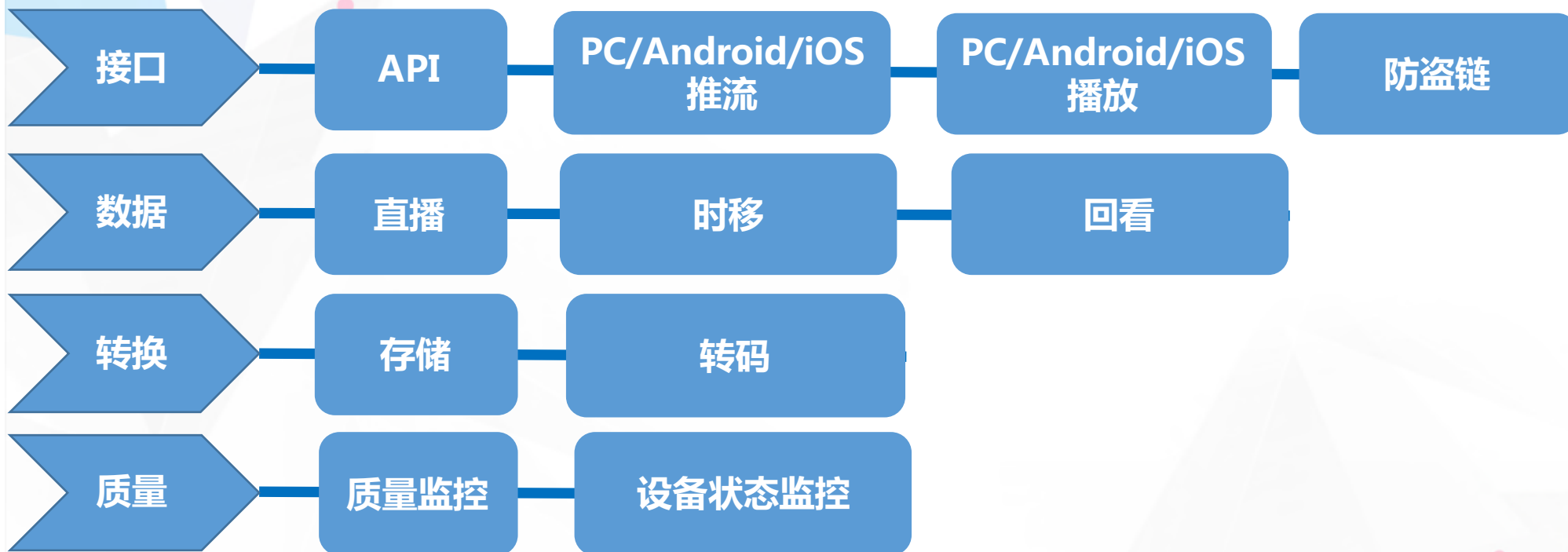
架构创新之路

CDN直播系统的优化

许开强

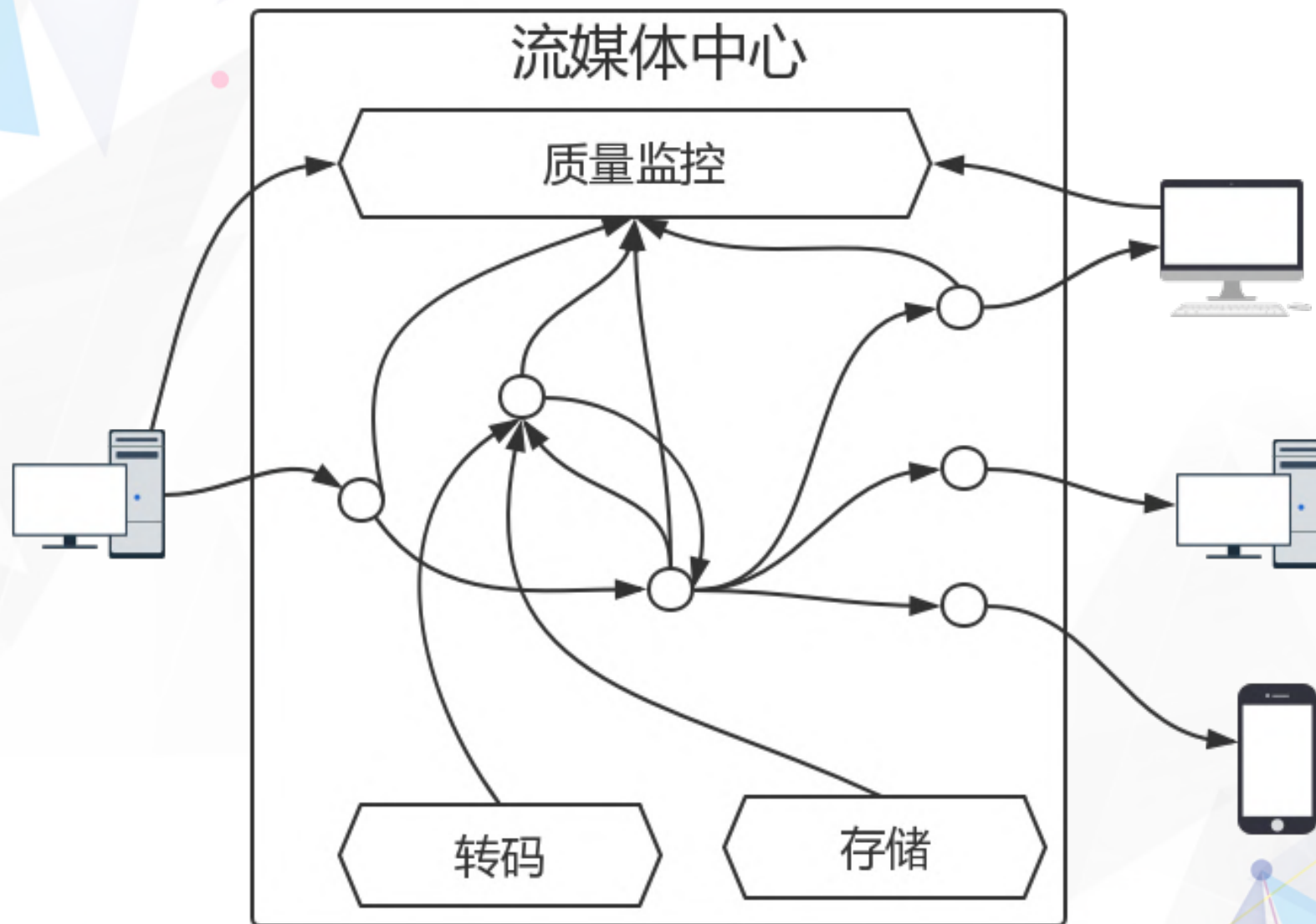
北京快网流媒体

业务架构

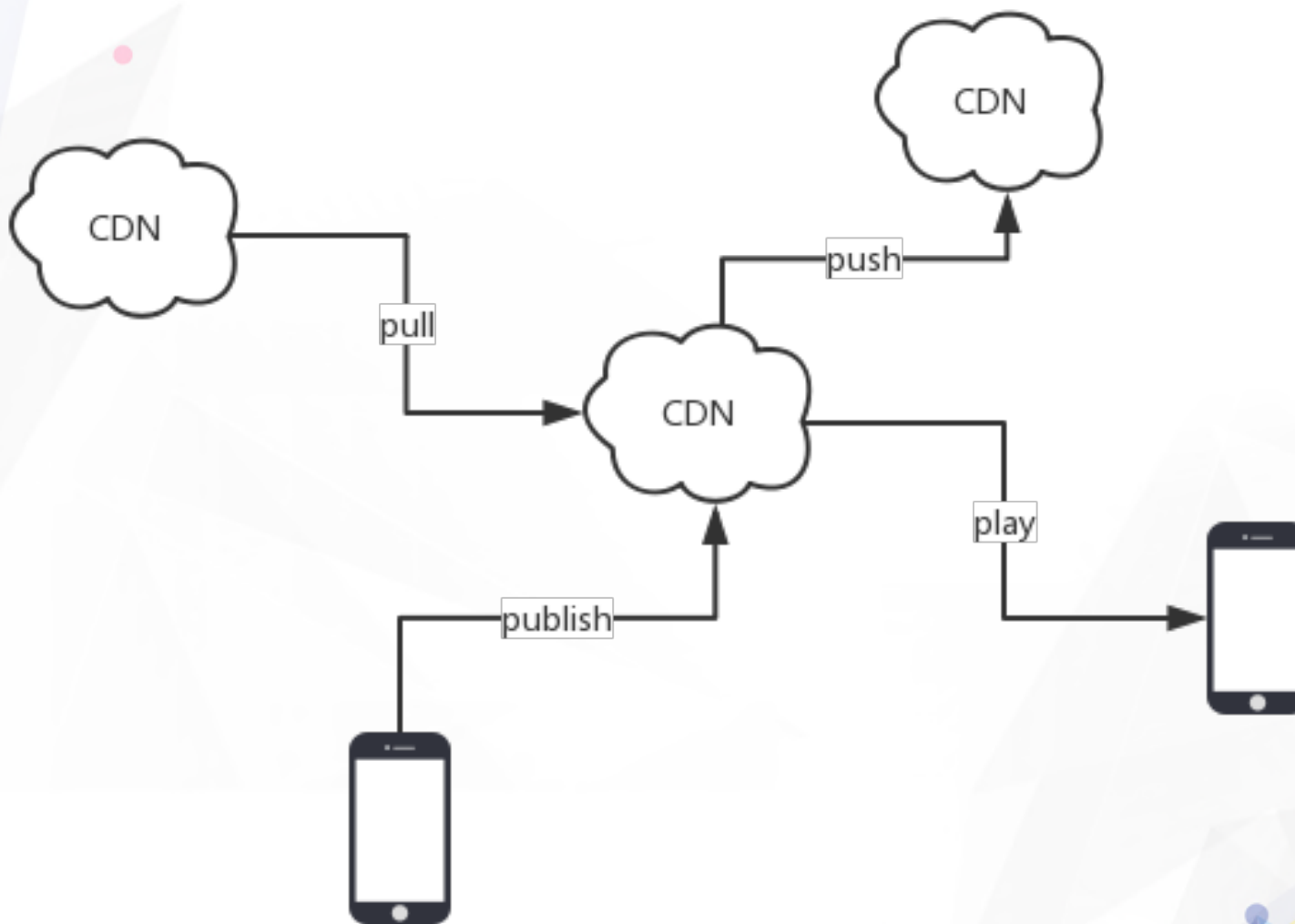


基于音视频实时数据的采集端、传输和播放端技术特性，优化延时、卡顿和首屏等重要性能指标

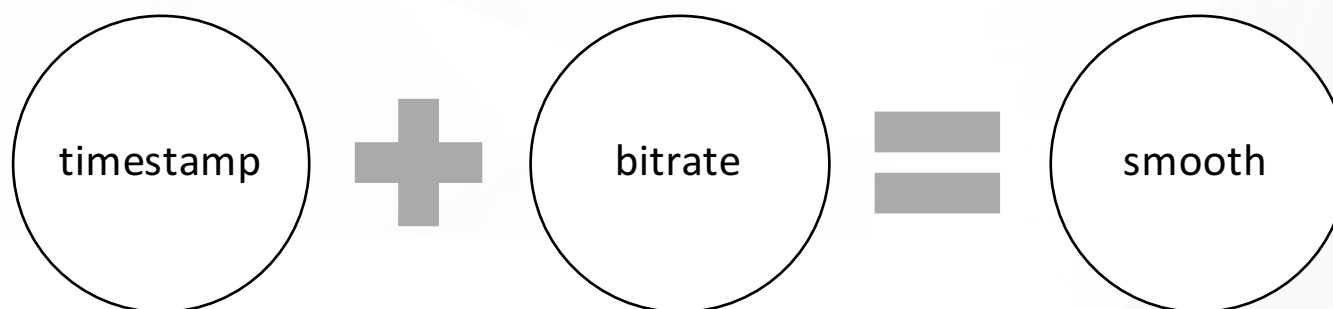
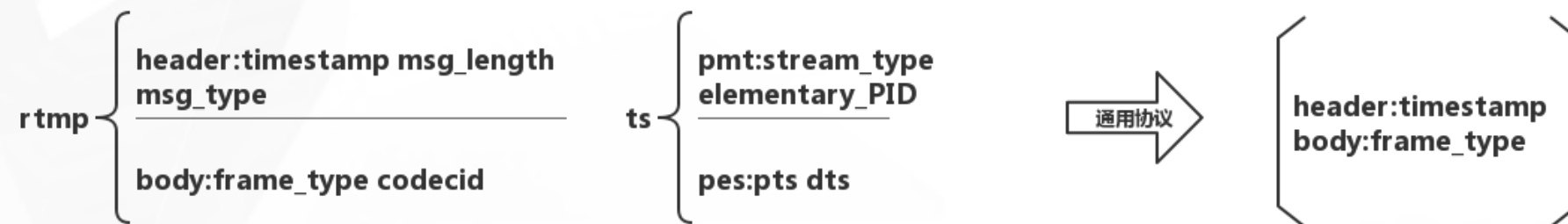
部署架构图



流传输

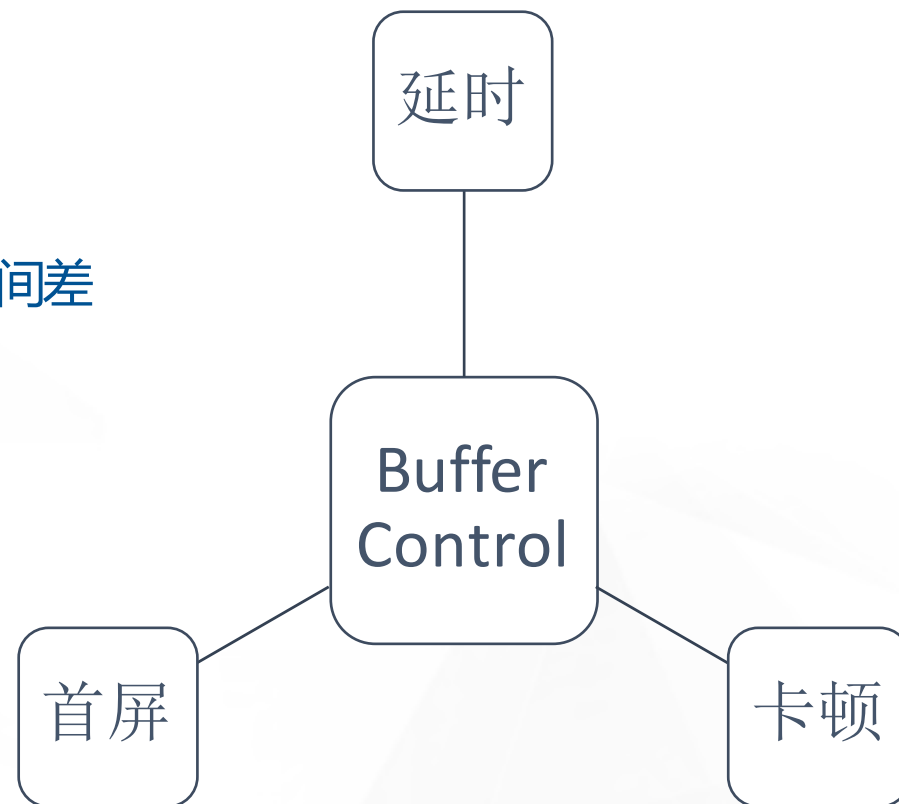


流媒体协议

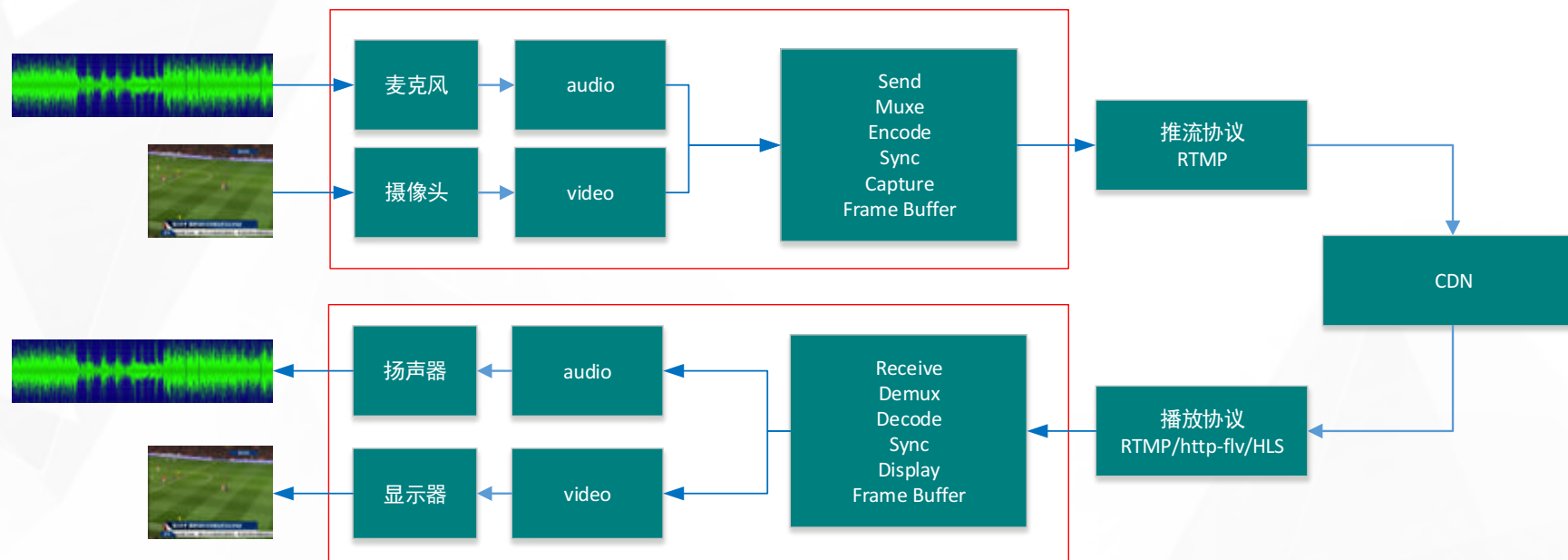


缓冲控制

- 延时：实时采集画面与播放展示画面的时间差
- 首屏：从点击播放到出图的时间
- 卡顿：播放过程中出现卡顿次数或时长



传输



流媒体服务器

- 基于nginx和nginx-rtmp-module，将多进程模式改造成多线程
- 线程间消息通信，保留基于event处理逻辑
- 解决合并回源的问题
- Reload：修改Master-Worker模式
 - 1) worker内open和close所有fd
 - 2) 重组connection与conf关系
- 实现rtmp/rtmp2flv/flv/hls分发
- 实现 Cache GOP、Cache Time、丢帧、时间戳修复
- 鉴权、防盗链、lua等
- 直播、时移、回看、录制、截图

时移-回看

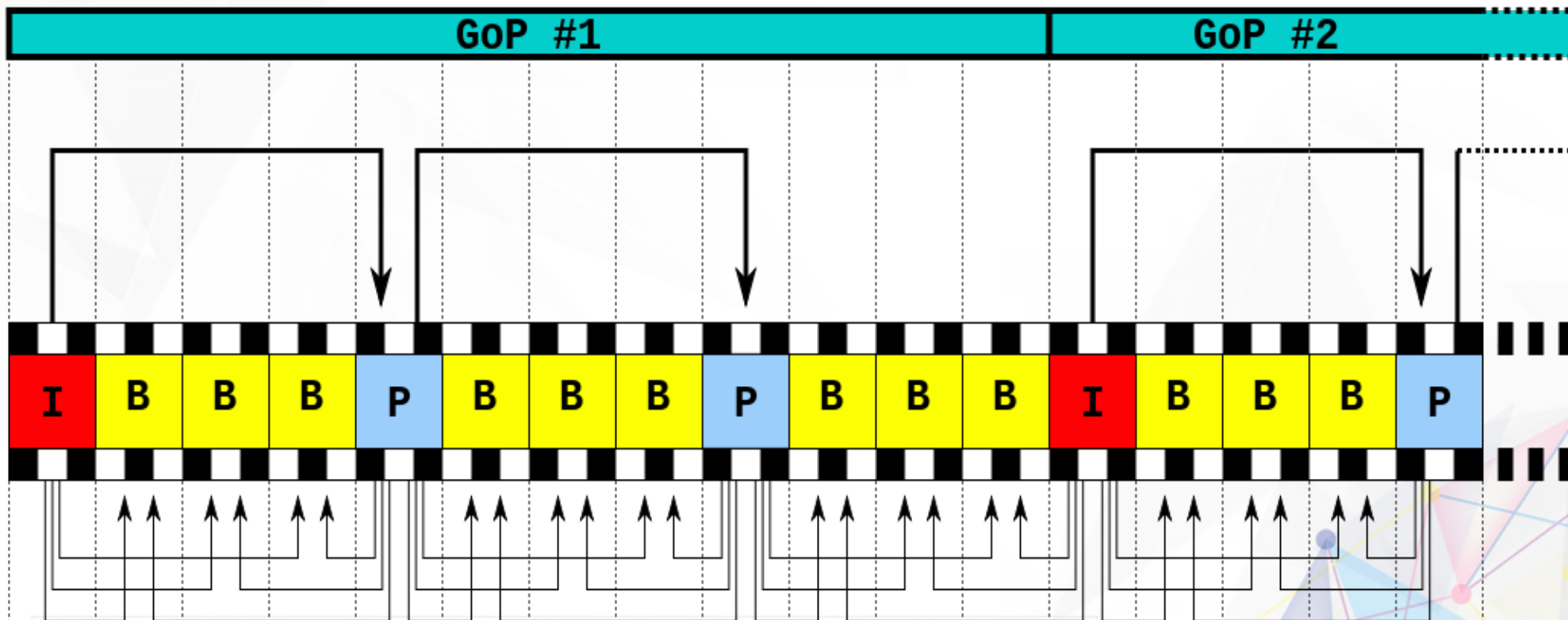


- 可配置时移存储时间
- 采用小文件切片作为数据存储单元
- 建立关键帧的索引，支持GOP级的拖动

GOP

Open GOP 和 Closed GOP :

1. I帧前面的B帧是否参考该帧
2. x264默认是Closed GOP , 很多解码器不支持Open GOP
3. IDR场景切换
4. Adaptive Streaming , 选择Closed GOP



帧分析-IDR

Offset	Length	Start Code & NAL	NAL Type	Info
0x0000000000000000	27	0x0000000167	Sequence parameter set	
0x0000000000000018	10	0x0000000168	Picture parameter set	
0x0000000000000025	674	0x0000000106	SEI	
0x00000000000002C7	1109	0x0000000165	Coded slice of an IDR picture	I Slice
0x000000000000071C	237	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000809	121	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000882	72	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000008CA	53	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000008FF	82	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000951	115	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000009C4	118	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000A3A	38	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000AA0	36	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000A84	73	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000ACD	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000AE1	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000AF5	80	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000B45	75	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000B90	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000BA4	20	0x0000000101	Coded slice of a non-IDR picture	B Slice


```
^
v NAL
  forbidden_zero_bit          : 0 (1 bit)
  nal_ref_idc                 : 3 (2 bits)
  nal_unit_type               : 5 (5 bits)
v slice_layer_without_partitioning_rbsp( )
  v slice_header( )
    first_mb_in_slice         : 0 (v bits)
    slice_type                 : 7 [I Slice] (v bits)
    pic_parameter_set_id      : 0 (v bits)
    frame_num                 : 0 (v bits)
    idr_pic_id                : 0 (v bits)
    pic_order_cnt_lsb         : 0 (v bits)
    ref_pic_list_modification( )
  dec_ref_pic_marking( )
    slice_qp_delta            : -7 (v bits)
    disable_deblocking_filter_idc : 0 (v bits)
    slice_alpha_c0_offset_div2 : 0 (v bits)
    slice_beta_offset_div2    : 0 (v bits)
  slice_data( )
  rbsp_slice_trailing_bits( )
```

帧分析-I

Offset	Length	Start Code & NAL	NAL Type	Info
0x0000000000000000	27	0x0000000167	Sequence parameter set	
0x0000000000000018	10	0x0000000168	Picture parameter set	
0x0000000000000025	674	0x0000000106	SEI	
0x00000000000002C7	1109	0x0000000165	Coded slice of an IDR picture	I Slice
0x000000000000071C	237	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000809	121	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000882	72	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000008CA	53	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000008FF	82	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000951	115	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000009C4	118	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000A3A	38	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000A60	36	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000A84	73	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000ACD	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000AE1	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000AF5	80	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000B45	75	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000B90	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000BA4	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000BB8	36	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000BDC	74	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000C26	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000C3A	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000C4E	36	0x0000000141	Coded slice of a non-IDR picture	P Slice
0x0000000000000CBC	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000CD0	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000D08	74	0x0000000141	Coded slice of a non-IDR picture	B Slice
0x0000000000000D52	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000D66	20	0x0000000101	Coded slice of a non-IDR picture	B Slice
0x0000000000000D7A	27	0x0000000167	Sequence parameter set	
0x0000000000000D95	10	0x0000000168	Picture parameter set	
0x0000000000000D9F	9	0x0000000106	SEI	
0x0000000000000DA8	1161	0x0000000141	Coded slice of a non-IDR picture	I Slice
0x0000000000001231	72	0x0000000101	Coded slice of a non-IDR picture	B Slice

```
NAL
  forbidden_zero_bit          : 0 (1 bit)
  nal_ref_idc                 : 2 (2 bits)
  nal_unit_type               : 1 (5 bits)
  slice_layer_without_partitioning_rbsp( )
    slice_header()
      first_mb_in_slice        : 0 (v bits)
      slice_type               : 7 [I Slice] (v bits)
      pic_parameter_set_id     : 0 (v bits)
      frame_num                : 15 (v bits)
      pic_order_cnt_lsb        : 60 (v bits)
      ref_pic_list_modification( )
    dec_ref_pic_marking( )
      slice_qp_delta           : -10 (v bits)
      disable_deblocking_filter_idc : 0 (v bits)
      slice_alpha_c0_offset_div2 : 0 (v bits)
      slice_beta_offset_div2    : 0 (v bits)
    slice_data( )
      rbsp_slice_trailing_bits( )
```

帧分析- Open GOP的SEI

Offset	Length	Start Code & NAL	NAL Type	Info
0x0000000000000000	27	0x000000167	Sequence parameter set	
0x000000000000001B	10	0x000000168	Picture parameter set	
0x0000000000000025	674	0x000000106	SEI	
0x000000000000002C7	1109	0x000000165	Coded slice of an IDR picture	I Slice
0x0000000000000071C	237	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000809	121	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000882	72	0x000000101	Coded slice of a non-IDR picture	B Slice
0x000000000000008CA	53	0x000000101	Coded slice of a non-IDR picture	B Slice
0x000000000000008FF	82	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000951	115	0x000000141	Coded slice of a non-IDR picture	B Slice
0x000000000000009C4	118	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000A3A	38	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000A60	36	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000A84	73	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000ACD	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000AE1	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000AF5	80	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000B45	75	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000B90	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000BA4	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000B88	36	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000BDC	74	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000C26	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000C3A	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000C4E	36	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000C72	74	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000CBC	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000CD0	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000CE4	36	0x000000141	Coded slice of a non-IDR picture	P Slice
0x00000000000000D08	74	0x000000141	Coded slice of a non-IDR picture	B Slice
0x00000000000000D52	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000D66	20	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000000D7A	27	0x000000167	Sequence parameter set	
0x00000000000000D95	10	0x000000168	Picture parameter set	
0x00000000000000D9F	9	0x000000106	SEI	
0x00000000000000DA8	1161	0x000000141	Coded slice of a non-IDR picture	I Slice
0x00000000000001231	72	0x000000101	Coded slice of a non-IDR picture	B Slice
0x00000000000001279	121	0x000000141	Coded slice of a non-IDR picture	P Slice

```
▼ NAL
- forbidden_zero_bit          : 0 (1 bit)
- nal_ref_idc                 : 0 (2 bits)
- nal_unit_type               : 6 (5 bits)
▼ sei_rbsp( )
  ▼ sei_message( )
    payloadType                : 6 (v bits)
    payloadSize                : 1 (v bits)
  ▼ sei_payload( )
    ▼ recovery_point( )
      recovery_frame_cnt       : 0 (v bits)
      exact_match_flag        : 1 [True] (1 bit)
      broken_link_flag        : 0 [False] (1 bit)
      changing_slice_group_idc : 0 (2 bits)
```

首屏

技术方面

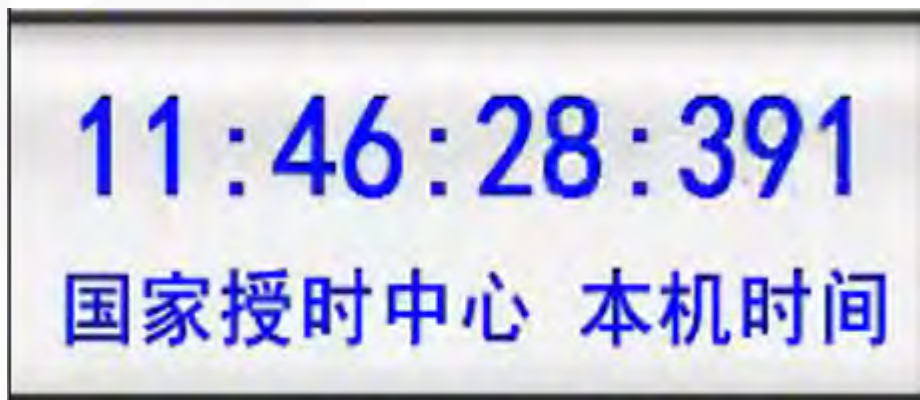
- GOP Cache : 缓存当前GOP , 时间戳修改
- 传输 : 简化协议交互 , writev
- X264编码 : 无延时编码zerolatency , 控制码率波动
- 播放 : key frame解码
- 协议 : http-flv

策略方面

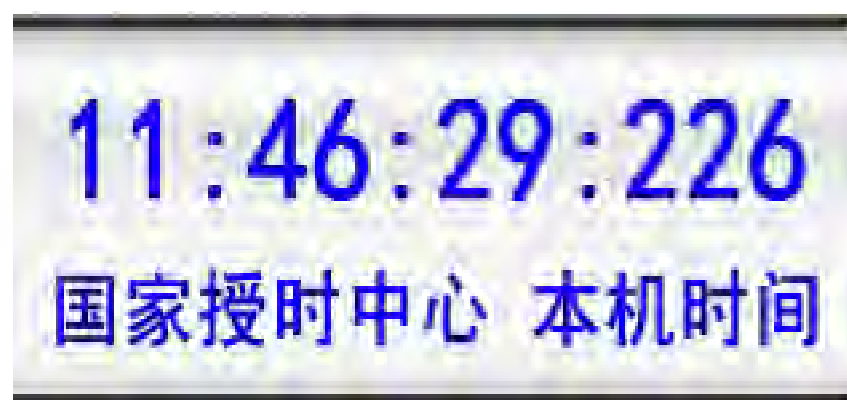
- 预热 : 提前拉取热门直播
- 集群 : 就近共享数据

延时

播放输出



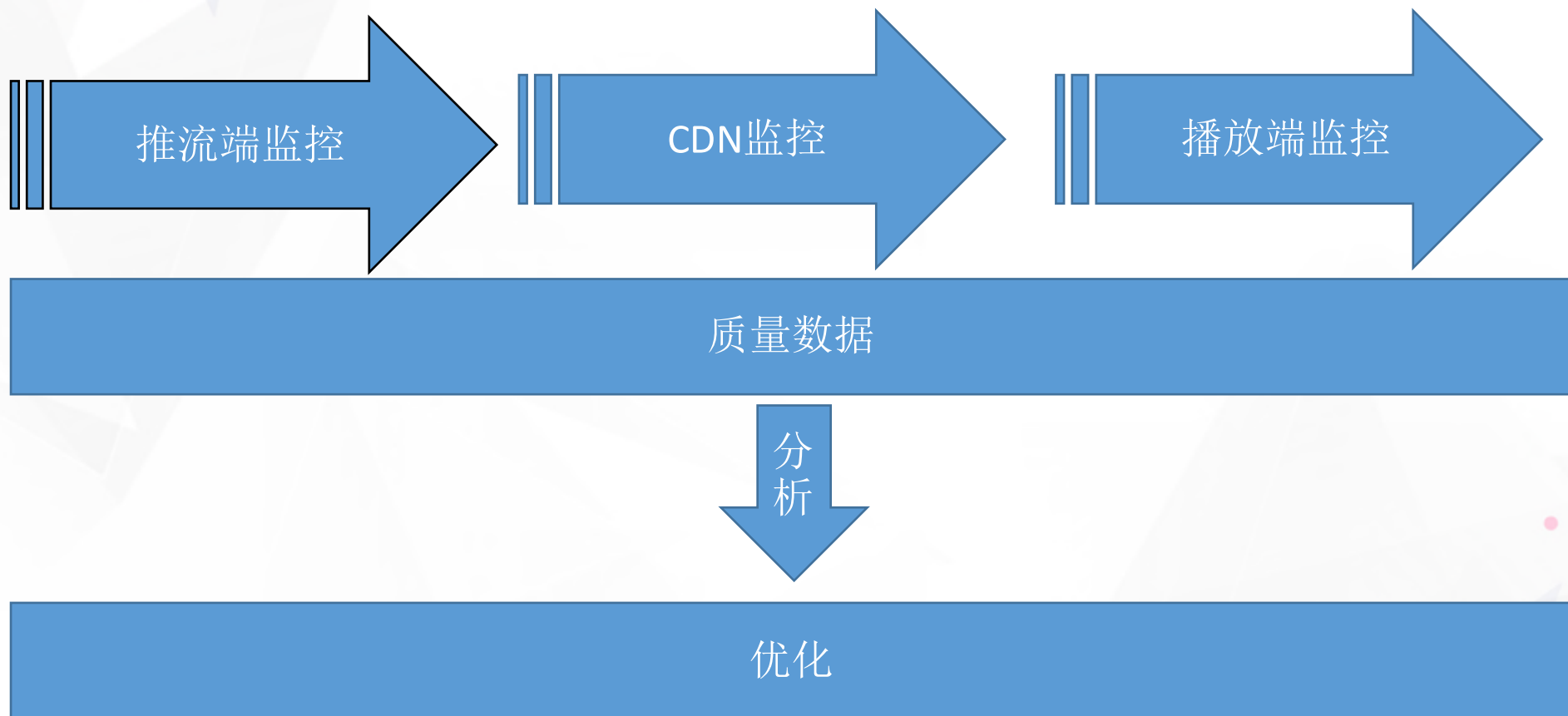
实时输入



全网延时控制

- 延时控制：在网络拥塞严重时采用丢帧策略，保障实时播放
- 参数更新：meta/video codec/audio codec
- 时间戳：递增

质量监控



监控排障

链路追踪

- 从任何入口都可查找完整链路
- 所有节点的指标对比

精准度

- 区分区域、挂载点、频道
- 监控全网所有流，排查首要原因

告警

- 主动推送
- 历史回溯

播放质量

■参数：

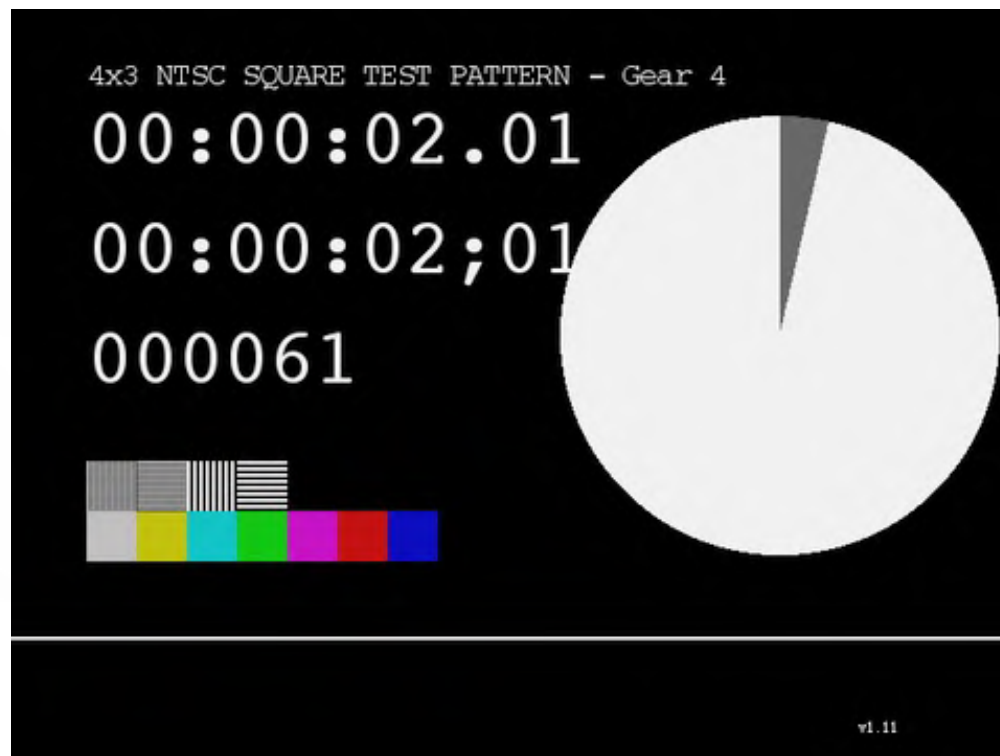
bitrate: 763 kb/s

resolution : 480x360

fps : 30

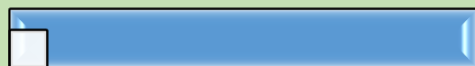
GOP : 30

■参考指标：毫秒级、帧数、动态旋转图像



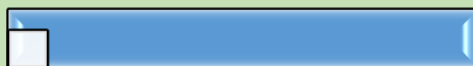
质量指标

CDN监控



- 建连时间
- 首帧时间
- 缓存
- 帧率
- 码率
- 丢帧

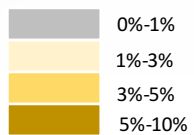
端监控



- DNS解析时间
- 建连时间
- 首帧时间
- 缓存
- 帧率
- 丢帧
- 码率
- 卡顿率
- 失败率

运营商、省份

移动直播用户省份分布图



移动直播用户量时间分布图



高峰期是20点-24点，运维繁忙，质量告警

低谷期是4点-8点，更新版本，部署机器

卡顿

卡顿原因

音视频不同步

丢视频

丢音频

画质低

帧率低

时间戳异常

解决办法

增加带宽

优化编码参数

调整资源

修复时间戳增量

动态缓冲区

THANKS

SequeMedia
盛拓传媒

IT168.com
中国网络 16 年

ChinaUnix

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