



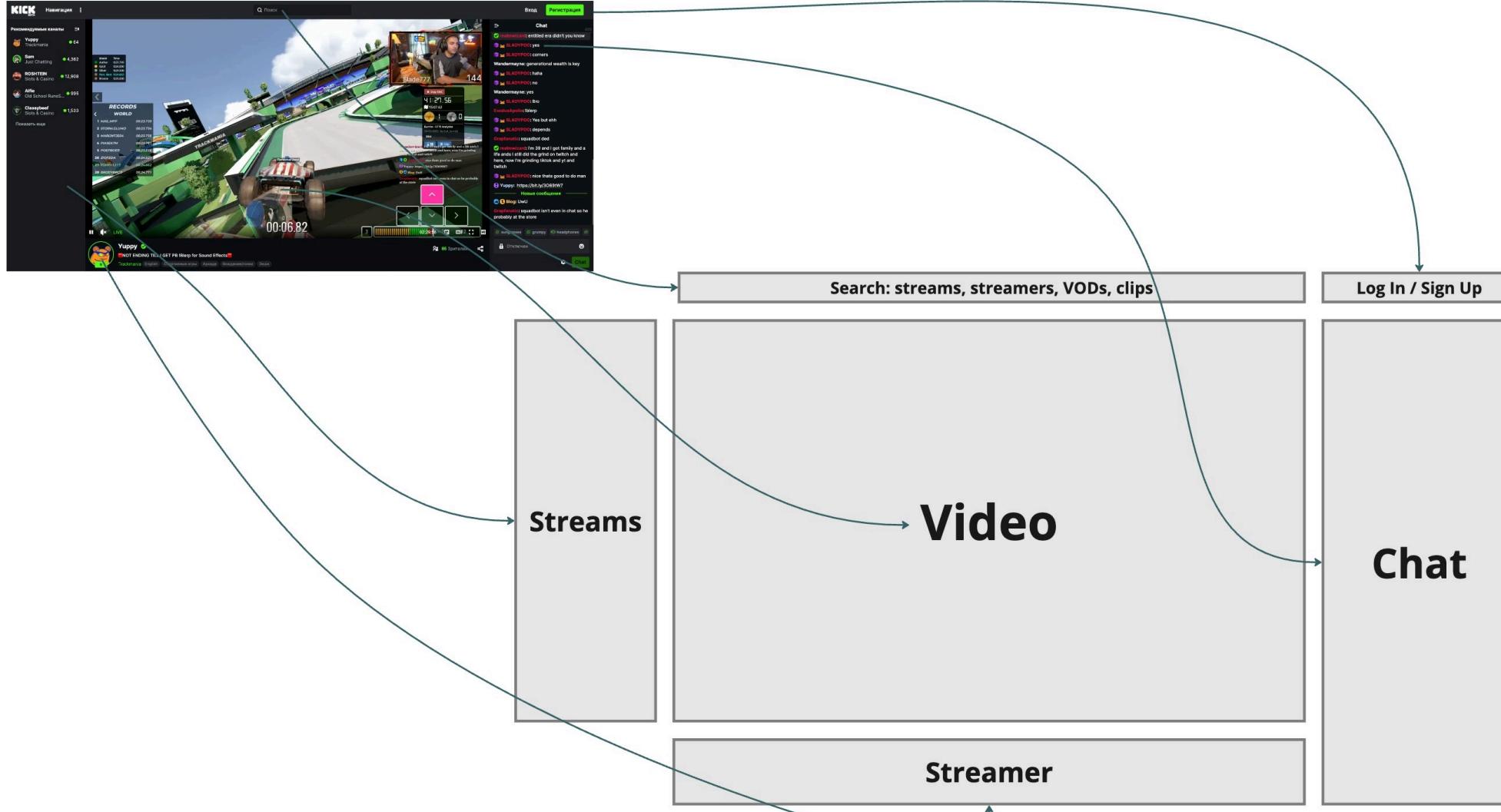
Факультет информационных технологий и анализа больших данных
Департамент анализа данных и машинного обучения

Разработка серверной части видеостримингового сервиса. Cloud-native подход

Подготовил студент ПИ19-3 Ковалев А.И.
Руководитель доцент, канд. пед. наук Никитин П. В.

Москва, 2023

ПОРТРЕТ ВИДЕОСТРИМИНГОВОГО СЕРВИСА





Мир

2,5 млн. постоянных зрителей
7 млн. зрителей в пике
100 тыс. постоянных стримов



Китай



Россия А

МОНЕТИЗАЦИЯ
МОНЕТИЗАЦИЯ
МОНЕТИЗАЦИЯ

95/5 vs 50/50
ОБТ - 12.2022
Мобильное приложение - 03.03.2023



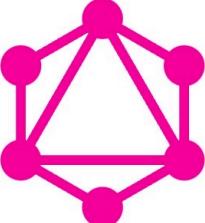
Россия АА

ЗБТ - 24.02.2022 + 6 месяцев
Релиз - 29.11.2022

РАЗРАБОТАТЬ современный
стабильный
масштабируемый
прозрачный
открытый к изменениям

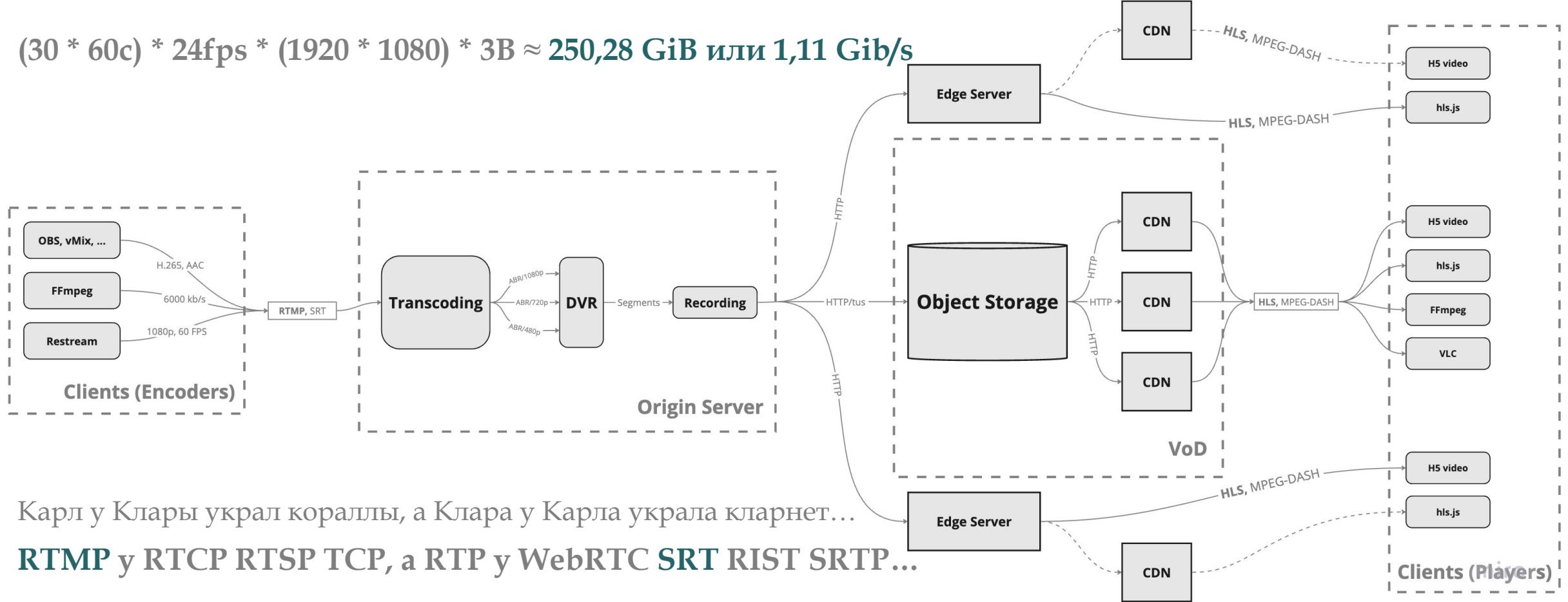
BACKEND ВИДЕОСТРИМИНГОВОГО СЕРВИСА

- Изучить принципы работы с потоковым видео:
протоколы передачи, способы хранения, технологии распространения
- Изучить устройство современных высоконагруженных систем
- Определить набор эффективных и передовых подходов и инструментов,
обеспечивающих надежность, управляемость и наблюдаемость системы
- Спроектировать и разработать отдельные компоненты системы, устойчивые к
различным уровням рабочих нагрузок

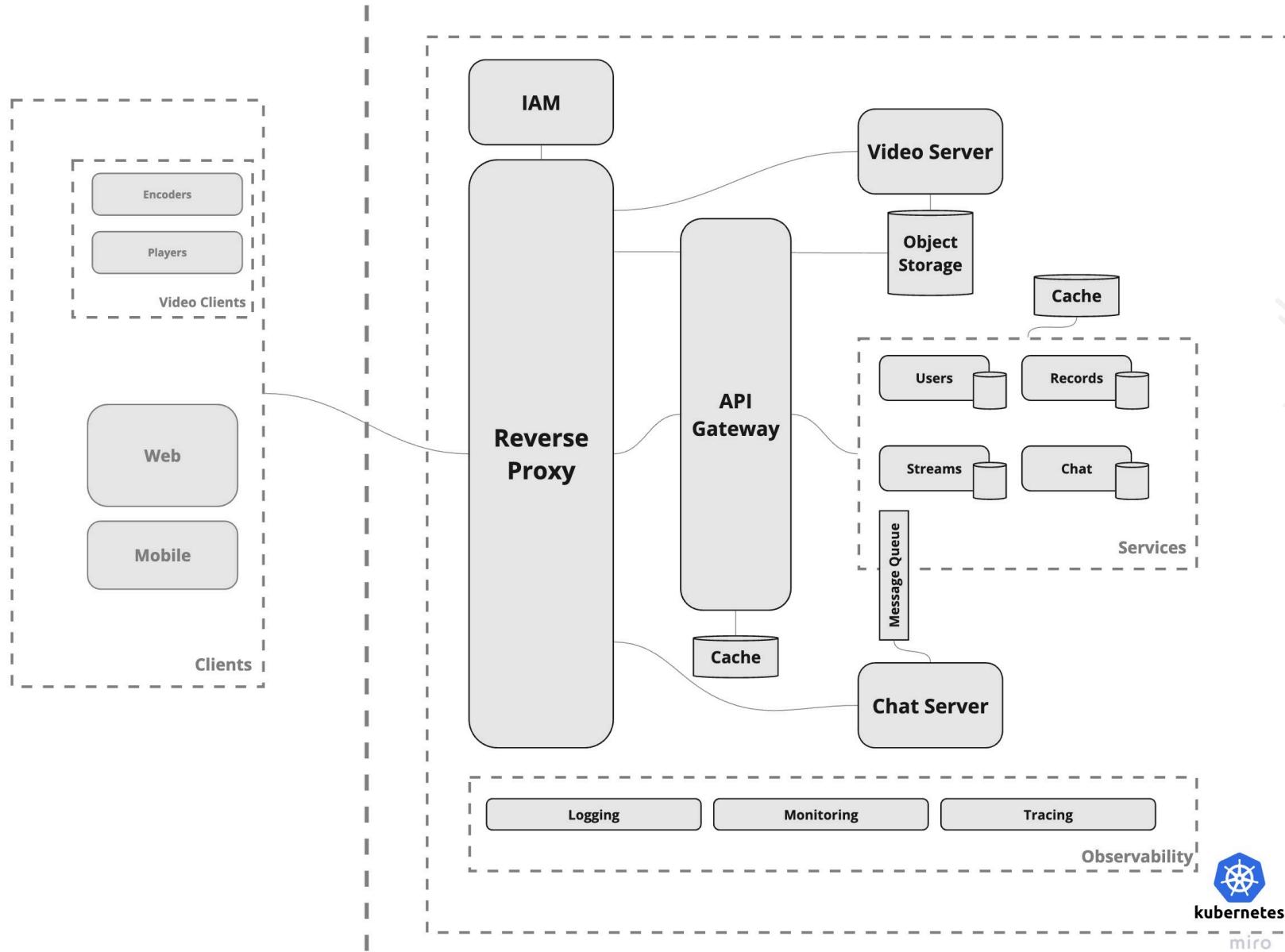
 kubernetes	 gRPC	 kafka	 LINKERD
 MINIO	 LINKERD	 docker	
 Caddy®	 redis	 PostgreSQL	 Prometheus
 Grafana	 Grafana loki	 JAEGER	 SENTRY
		 OpenTelemetry	 OPEN METRICS
		 git	 WebSocket
		 myo	

АРХИТЕКТУРА ПОТОКОВОГО ВИДЕО

$(30 * 60c) * 24\text{fps} * (1920 * 1080) * 3\text{B} \approx 250,28 \text{ GiB}$ или $1,11 \text{ Gib/s}$

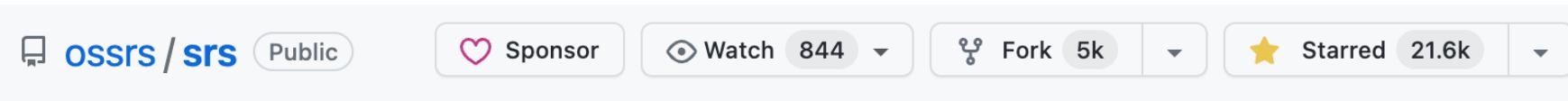


АРХИТЕКТУРА СЕРВИСА



C4, IDEF, DFD, UML,
ARIS, EPC, SysML

Boxes and Lines



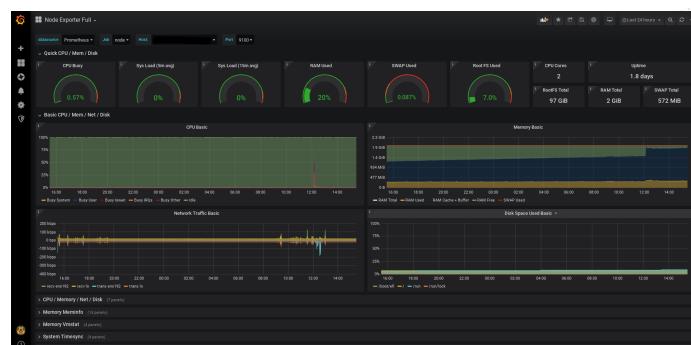
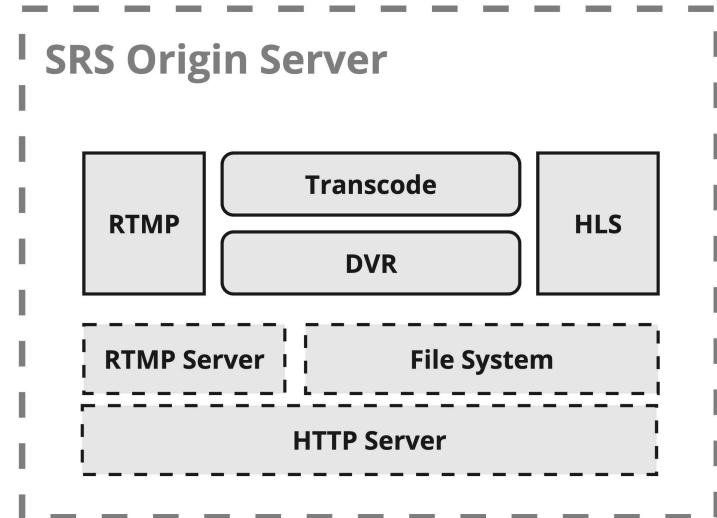
RTMP tuned (buff size, mr, mw, gop)

LL-HLS (1 сек.)

ABR:

2160p (30fps), 1440p, источник,
1080p, 720p, ~~480p, 360p~~, 160p (48kHz)

DVR



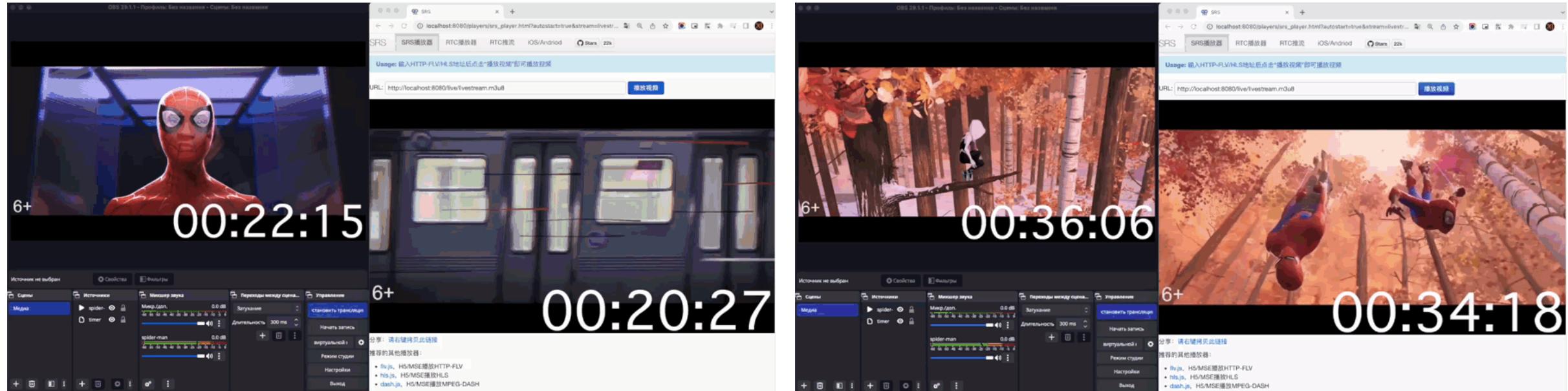
```

hls.conf

1 listen          1935;
2 max_connections 1000;
3 srs_log_tank    console;
4 daemon          off;
5 http_api {
6   enabled        on;
7   listen         1985;
8 }
9 http_server {
10  enabled        on;
11  listen         8080;
12  dir            ./objs/nginx/html;
13 }
14
15 vhost hls.transcode.vhost.com {
16   transcode {
17     enabled      on;
18     ffmpeg       ./objs/ffmpeg/bin/ffmpeg;
19     engine hls {
20       enabled      on;
21       vbitrate    6000;
22       vfps        60;
23       vwidth      1920;
24       vheight     1080;
25     }
26   }
27
28 vhost __defaultVhost__ {
29   hls {
30     enabled      on;
31     hls_m3u8_file [app]/[stream].m3u8;
32     hls_ts_file  [app]/[stream]-[seq].ts;
33     hls_fragment 10;
34     hls_window    180;
35     hls_acodec    aac;
36     hls_vcodec    h264;
37   }
38   dvr {
39     enabled      on;
40   }
41 }

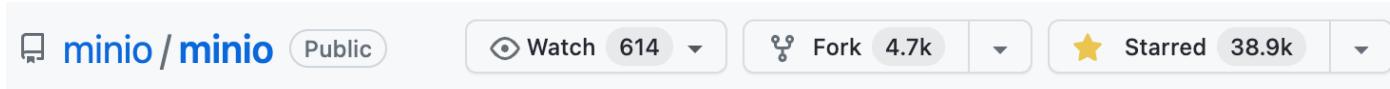
```

СЕРВИС ОБРАБОТКИ И СТРИМИНГА ВИДЕО



Задержка <2 сек

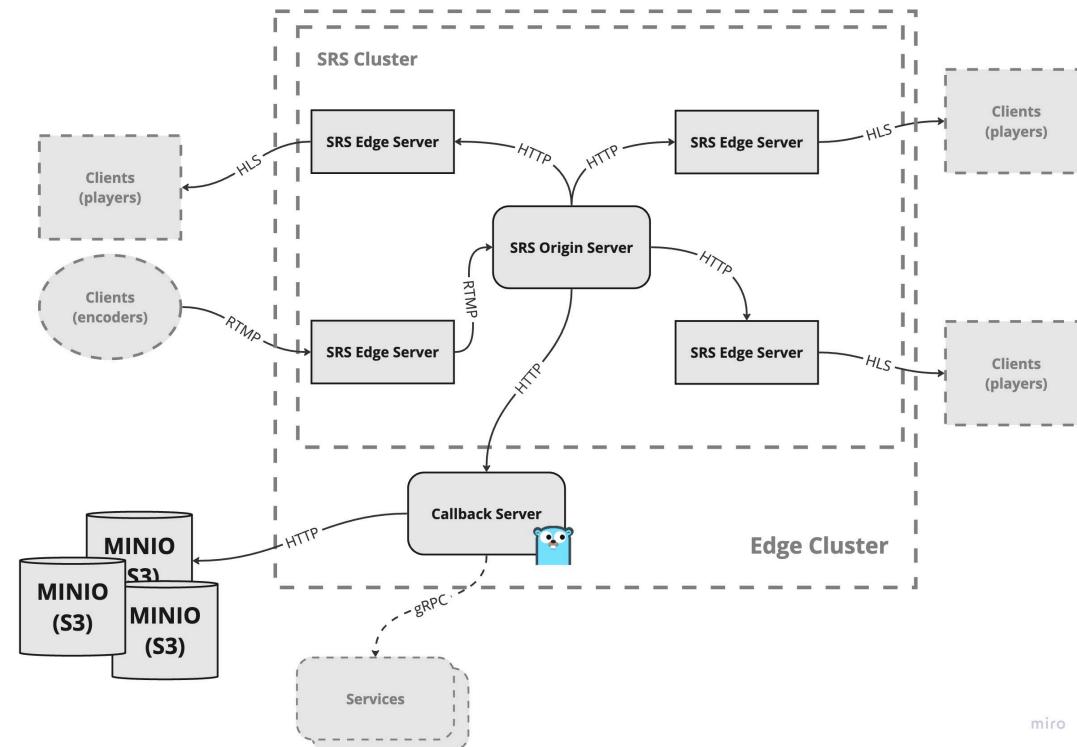
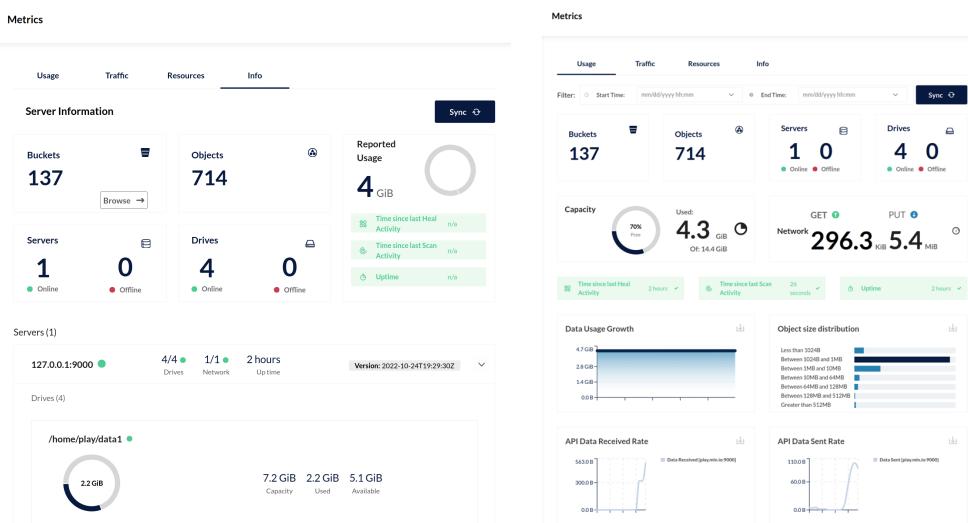
6000kbps, 1080p, 60fps; 48kHz



Кластер: x1 Origin Server, x1 Edge Server

Объектное хранилище: S3 (MinIO)

Микросервис: callback сервер



IRC, XMPP



```

IRC

1 CAP REQ :twitch.tv/tags twitch.tv/commands
2 PASS oauth:x3szxh7pkby3m0kn0x9sgbafj71ns8
3 NICK belo4ya
4 USER belo4ya 8 * :belo4ya
5 :tmi.twitch.tv CAP * ACK :twitch.tv/tags twitch.tv/commands
6 @badge-info=;badges=no_video/1;clientnonce=77b25f54e9bed8aa73a60f760e72e474;color=#9ACD32;display-name=rainnnnnnnnnnnnnnnnnnnnnnnnnnnn;emotes=;firstmsg=0;flags=59-65:P;7:id=e2a4aa2e-4bc9-44f2-a0a1-94ec7861ac63;mod=0;reply-parent-display-name=gachiburik;reply-parent-msg-body=@rainnnnnnnnnnnnnnnnnnn;reply-parent-msg-id=82fa1e0d-9baf-48e1-afdf-444c9e960dd7;reply-parent-user-id=793331902;reply-parent-user-login=gachiburik;returning-chatter=0;room-id=77964394;subscriber=0;tmi-sent-ts=1683901982500;turbo=0;user-id=510437192;
7

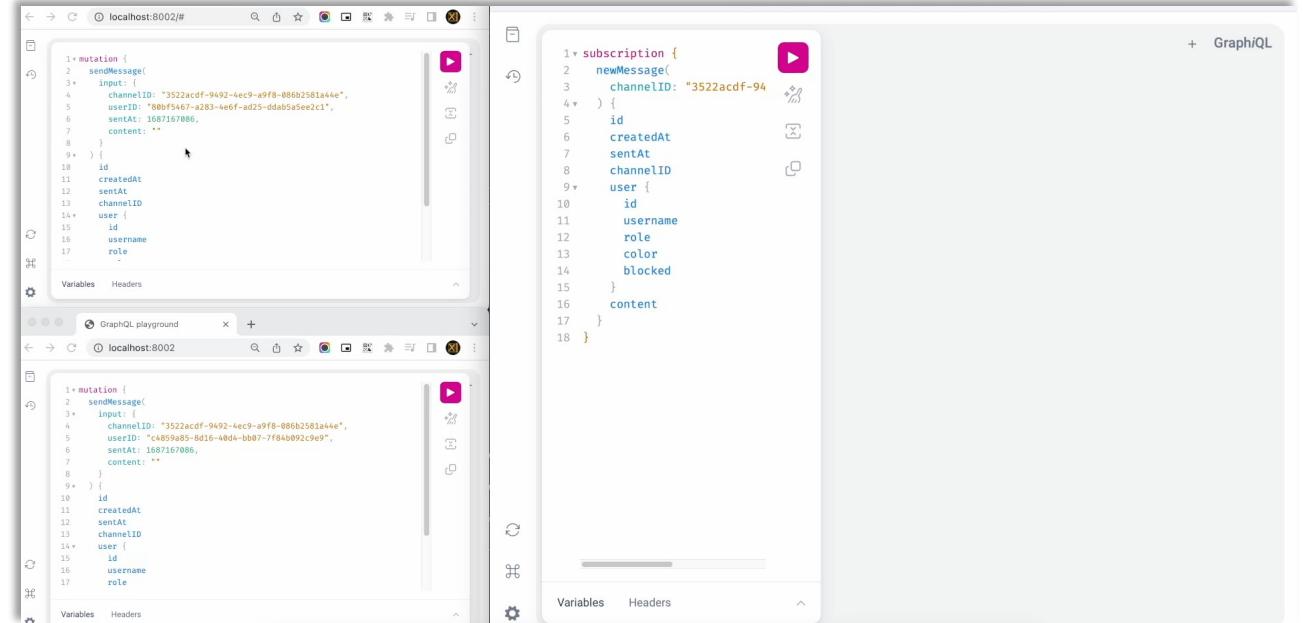
```

Собственный JSON-based протокол

WebSocket vs HTTP/2+SSE



GraphQL Subscriptions/Mutations



```

mutation {
  sendMessage(
    input: {
      channelId: "3522acdf-9492-4ec9-a9f8-086b2581a4e",
      userId: "080ff6407-a183-4e6f-ad23-dddd5d5e2c1",
      sentAt: 1687167086,
      content: ""
    }
  ) {
    id
    createdAt
    sentAt
    channelId
    user {
      id
      username
      role
    }
  }
}

subscription {
  newMessage(
    channelId: "3522acdf-94"
  ) {
    id
    createdAt
    sentAt
    channelId
    user {
      id
      username
      role
      color
      blocked
    }
    content
  }
}

mutation {
  sendMessage(
    input: {
      channelId: "3522acdf-9492-4ec9-a9f8-086b2581a4e",
      userId: "c4859a85-8d16-48d4-bb07-7f84b092c9e9",
      sentAt: 1687167086,
      content: ""
    }
  ) {
    id
    createdAt
    sentAt
    channelId
    user {
      id
      username
      role
    }
  }
}

```



Архитектура: Event Sourcing

Брокер сообщений: Kafka cluster без Zookeeper

Хранилище: NoSQL Cassandra ScyllaDB

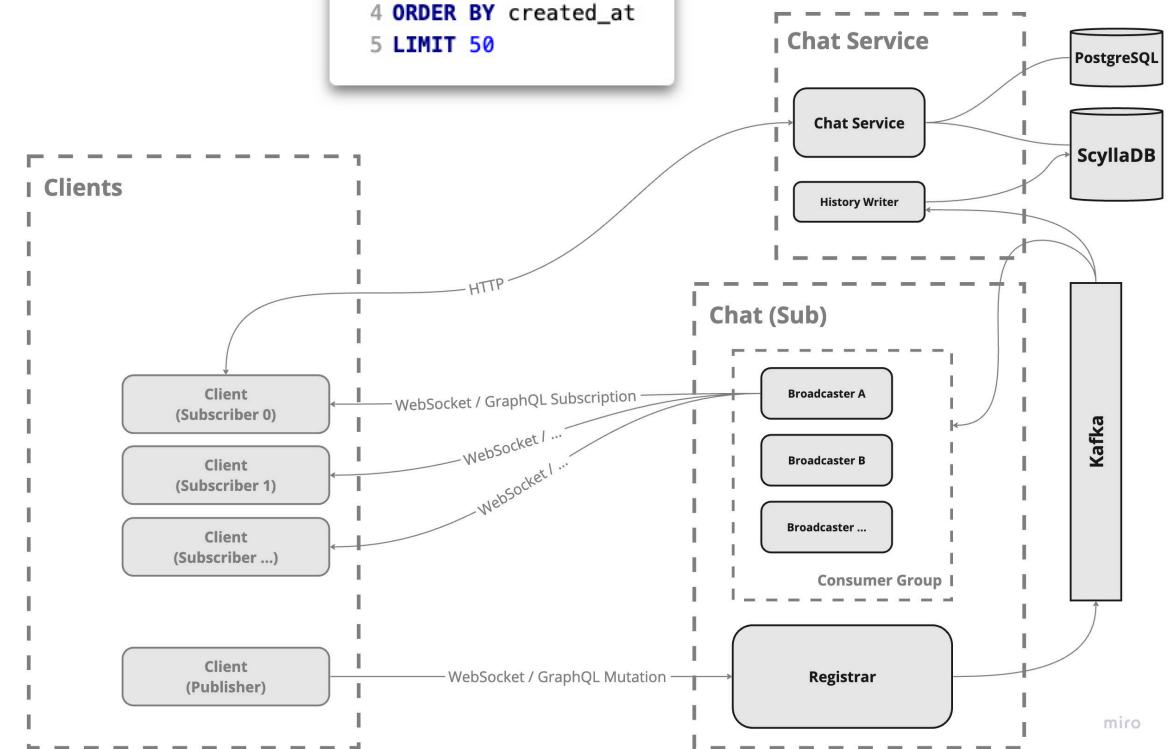
Микросервис: управление чатом

Offset	Partition	Timestamp	Key	Value	Headers
3352	0	20/02/2023, 12:16:20	9f8e1ab0-3d8d-4bde-8f9a-8318080f723a	+ {"version":0,"id":19761600+308d-4...	
3351	0	20/02/2023, 12:16:29	20f5a5e1a-9fe7-4993-a953-2177805f6437	+ {"version":0,"id":19761600+308d-4...	
3350	0	20/02/2023, 12:16:28	76dd6325-4ef7-4fff-a758-aa1aa785108c	+ {"version":0,"id":19761600+308d-4...	
3349	0	20/02/2023, 12:16:27	81ef1980-c34b-4c2e-942a-1a0b90bd0	+ {"version":0,"id":19761600+308d-4...	
3348	0	20/02/2023, 12:16:27	9367f6a5-6353-4949-8040-000000000000	+ {"version":0,"id":19761600+308d-4...	
3347	0	20/02/2023, 12:16:22	9367f6a5-6353-4949-8040-000000000000	+ {"version":0,"id":19761600+308d-4...	
3346	0	20/02/2023, 12:16:21	f778a3bf-cc18-4a8f-aed6-32745d882e92	+ {"version":0,"id":19761600+308d-4...	
3345	0	20/02/2023, 12:16:20	127fa51c9-71d5-488d-acd4-fa42c3de187d	+ {"version":0,"id":19761600+308d-4...	
3344	0	20/02/2023, 12:16:19	b77ff7cc-23f9-4ff7-af76-825a7ee909db	+ {"version":0,"id":19761600+308d-4...	
3285	2	20/02/2023, 12:16:30	176f4481-6d83-41f5-b247-dee5da3bc9b	+ {"version":0,"id":19761600+308d-4...	



```

    CQL
  1 SELECT *
  2 FROM chat_history
  3 WHERE chat_id = ?
  4 ORDER BY created_at
  5 LIMIT 50
  
```



Сервис управления трансляциями

- генерация ключа трансляции
- ограничение: 1 пользователь – 1 трансляция
- хранение метаданных трансляции: название, теги, время начала, настройки

Сервис управления записями

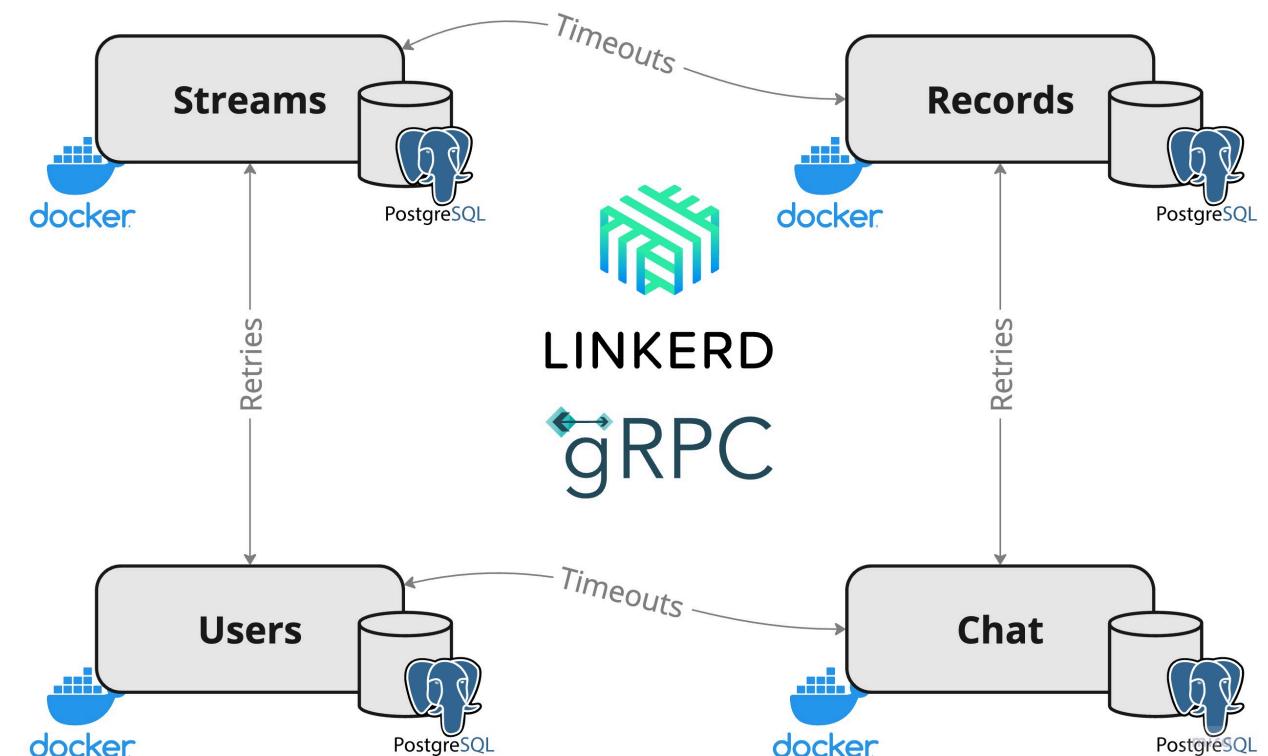
- хранение пути к записи
- хранение метаданных записи: название, теги, время начала, длительность, путь к обложке

Сервис управления чатом

- получение истории сообщений

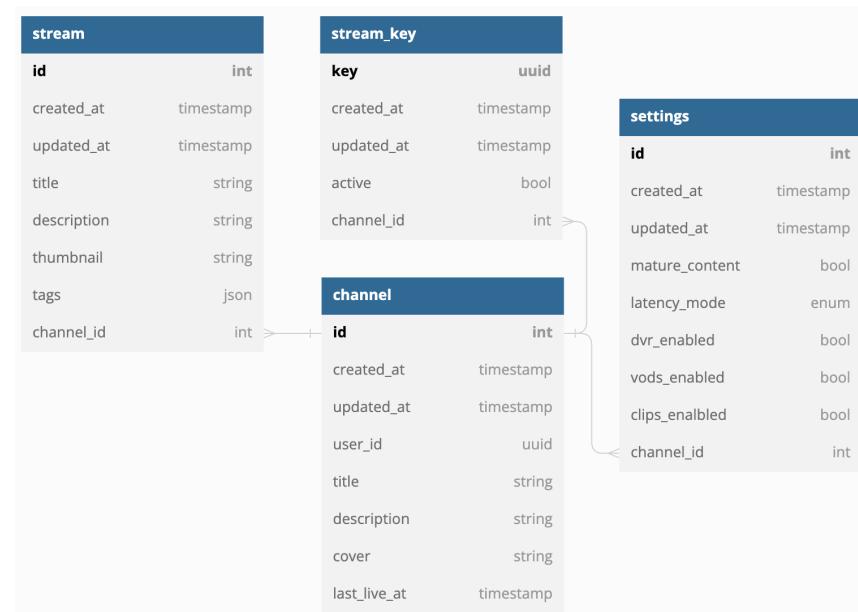
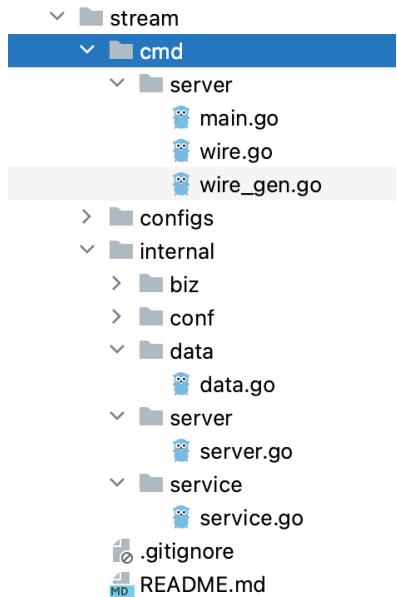
Сервис управления пользователями

- хранение пользовательских настроек и данных



Сервис управления трансляциями

- генерация ключа трансляции
- ограничение: 1 пользователь – 1 трансляция
- хранение метаданных трансляции:
название, теги, время начала, настройки



```

stream.proto

1 syntax = "proto3";
2 package stream.v1;
3 import "google/protobuf/empty.proto";
4 option go_package = "stream/v1;v1";
5
6 service StreamService {
7   rpc ListStreams(google.protobuf.Empty) returns (ListStreamsResponse) {}
8   rpc CreateStream(CreateStreamRequest) returns (CreateStreamResponse) {}
9 }
10
11 message ListStreamsResponse {
12   message Stream {
13     message Channel {
14       int64 id = 1;
15       string title = 2;
16       string avatar = 3;
17     }
18     int64 id = 1;
19     string title = 2;
20     string description = 3;
21     bytes thumbnail = 4;
22     google.protobuf.Struct tags = 5;
23     Channel channel = 6;
24   }
25   repeated Stream results = 1;
26 }
27
28 message CreateStreamRequest {
29   string title = 1;
30   string description = 2;
31   bytes thumbnail = 3;
32   google.protobuf.Struct tags = 4;
33 }
34
35 message CreateStreamResponse {
36   message Channel {
37     int64 id = 1;
38     string title = 2;
39     string avatar = 3;
40   }
41   int64 id = 1;
42   string title = 2;
43   string description = 3;
44   bytes thumbnail = 4;
45   google.protobuf.Struct tags = 5;
46   Channel channel = 6;
47 }

```

API Gateway

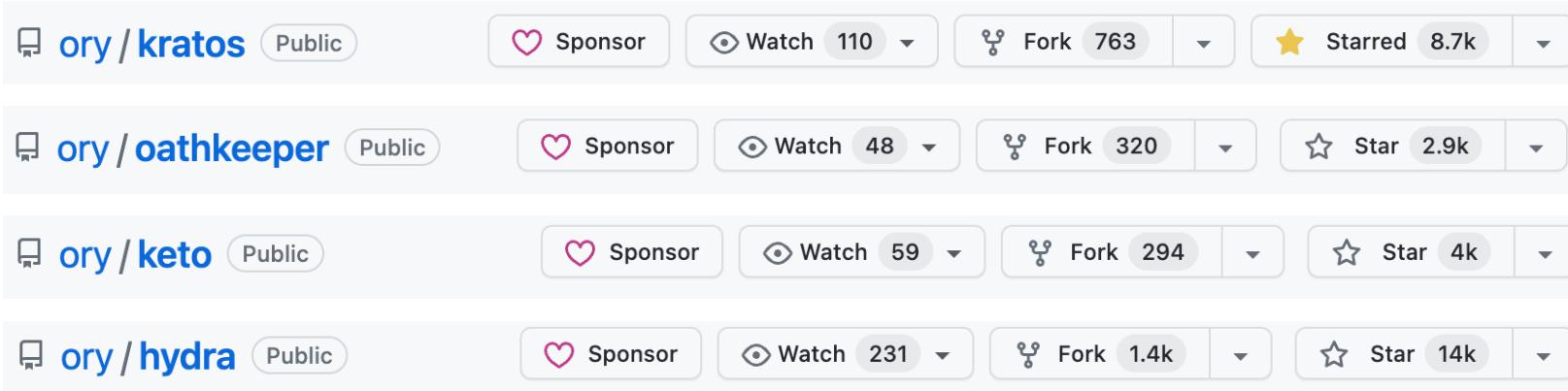
GraphQL:

- Пакетные запросы
- APQ



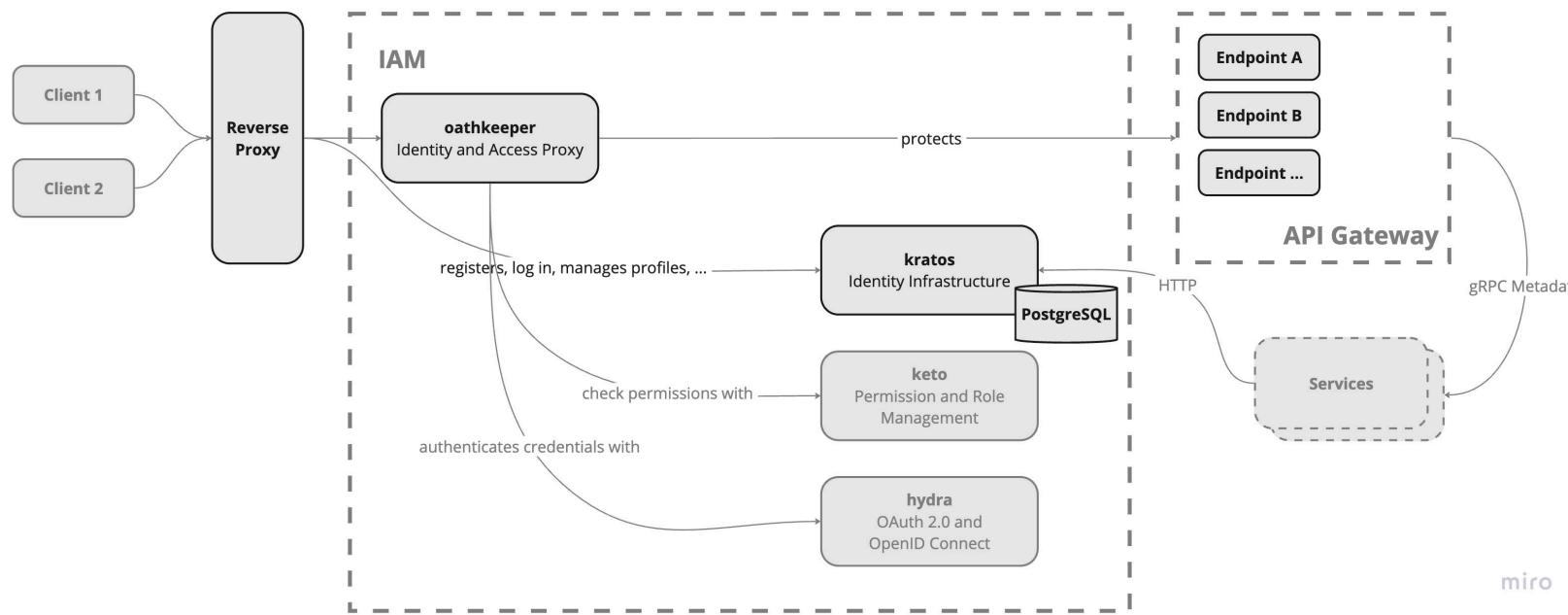
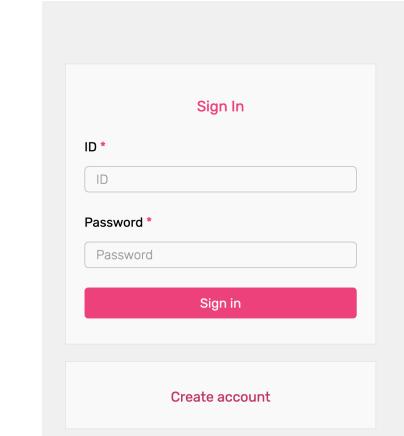
```
 1 [          batches&APQ
 2 {
 3   "operationName": "ListStreams",
 4   "variables": {...},
 5   "extensions": {
 6     "persistedQuery": {
 7       "version": 1,
 8       "sha256Hash": "aeb02ffde95392868a9da662631090526b891a2972620e6b6393873a39111564"
 9     }
10   },
11 },
12 {
13   "operationName": "CreateStream",
14   "variables": {...},
15   "extensions": {
16     "persistedQuery": {
17       "version": 1,
18       "sha256Hash": "9515480dee68a77e667cb19de634739d33f243572b007e98e67184b1a5d8369f"
19     }
20   },
21 },
22 {
23   "operationName": "GetStreamThumbnail",
24   "variables": {...},
25   "extensions": {
26     "persistedQuery": {
27       "version": 1,
28       "sha256Hash": "4d9da3e74d52b668ad9f163a641236f2c804e1129f717f2861b362310e6c64c7"
29     }
30   },
31 }
32 ]
```

```
 1 type Query {          GraphQL
 2   users: [User!]
 3   channels: [Channel!]
 4   streams: [Stream!]
 5   chats: [Chat!]
 6 }
 7
 8 type Mutation {
 9   createStream(input: NewStream!): Stream!
10 }
11
12 type Stream {
13   id: ID!
14   createdAt: Timestamp!
15   updatedAt: Timestamp!
16   title: String!
17   description: String!
18   tags: JSON!
19   thumbnail: String!
20   channel: Channel!
21 }
22
23 input NewStream {
24   title: String!
25   description: String!
26   tags: JSON!
27   thumbnail: ByteArray!
28   channel: Channel!
29 }
```



The screenshot shows four GitHub repository cards for Ory projects:

- ory / kratos** (Public) - Sponsor, Watch 110, Fork 763, Starred 8.7k
- ory / oathkeeper** (Public) - Sponsor, Watch 48, Fork 320, Star 2.9k
- ory / keto** (Public) - Sponsor, Watch 59, Fork 294, Star 4k
- ory / hydra** (Public) - Sponsor, Watch 231, Fork 1.4k, Star 14k

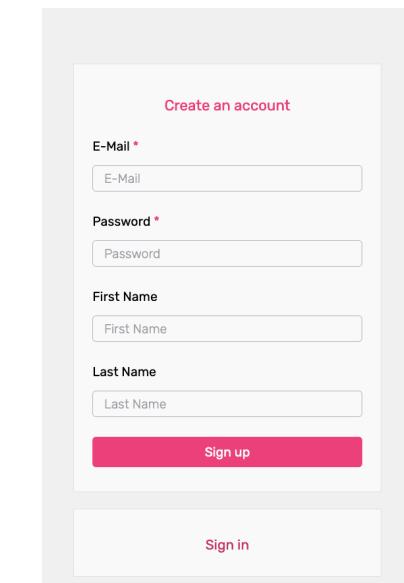
Sign In

ID *

Password *

Sign in

[Create account](#)



Create an account

E-Mail *

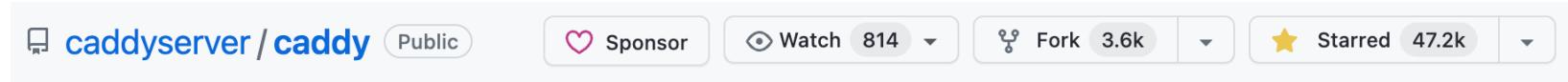
Password *

First Name

Last Name

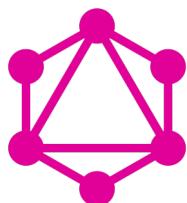
Sign up

Sign in

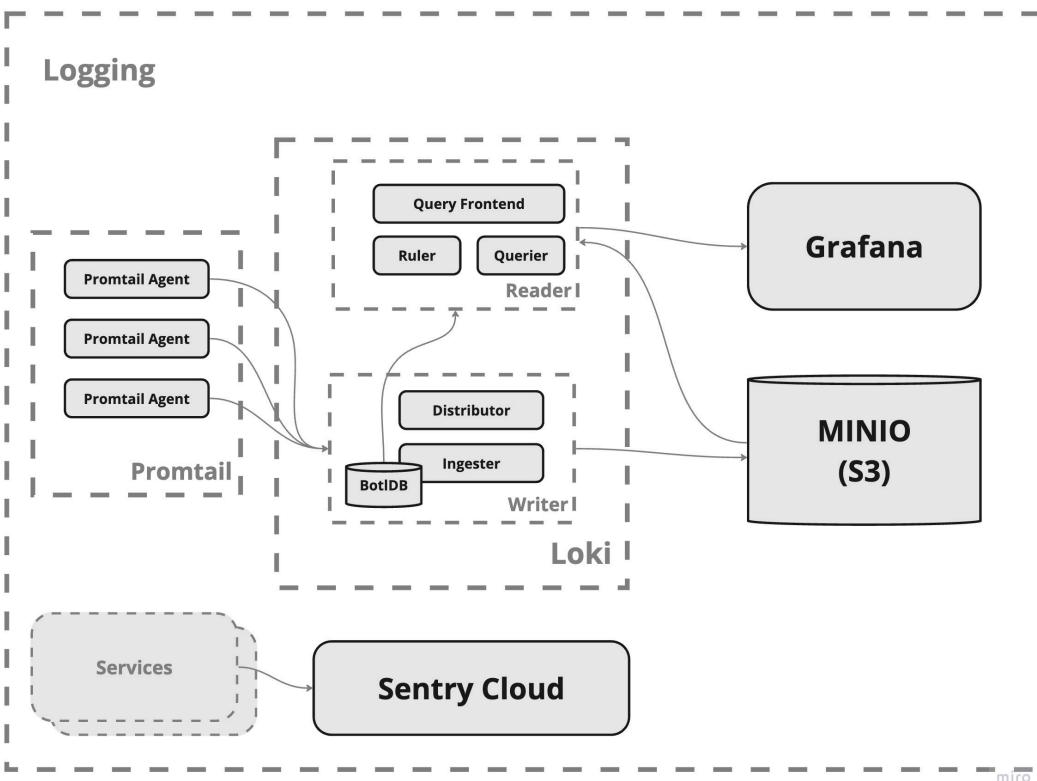


- + HTTPS по умолчанию, автоматически
- + Простая конфигурация: Caddyfile
- + Плагины

GBox: кэширование и мониторинг для GraphQL



```
1 {  
2   admin 0.0.0.0:2019  
3   servers {  
4     metrics  
5   }  
6 }  
7  
8 localhost {  
9   encode gzip  
10  
11   respond /healthz "OK"  
12  
13   # oathkeeper (gql gateway & chat): /api -> /  
14   @api path /api /api/*  
15   handle @api {  
16     reverse_proxy ${OATHKEEPER_URL}  
17   }  
18  
19   # srs RTMP: /stream -> /  
20   @live path /stream /stream/*  
21   handle {  
22     reverse_proxy ${SRS_RTMP_URL}  
23   }  
24  
25   # srs HLS: /live -> /  
26   @live path /live /live/*  
27   handle {  
28     reverse_proxy ${SRS_HLS_URL}  
29   }  
30  
31   # MINIO VoD bucket: /vod -> /  
32   @vod path /vod /vod/*  
33   handle {  
34     reverse_proxy ${MINIO_VOD_URL}  
35   }  
36  
37   # gql module: cache, metrics  
38   gbox {  
39     upstream @api  
40  
41     metrics {  
42       enabled true  
43       path ${GBOX_METRICS_PATH}:/metrics  
44       method GET  
45     }  
46  
47     caching {  
48       enabled true  
49       store_dsn ${REDIS_DSN}  
50     }  
51   }  
52 }
```



Logs / Loki Kubernetes Logs

Search Query: Enter variable value namespace: All stream: All container: All

Common labels: (no common labels)

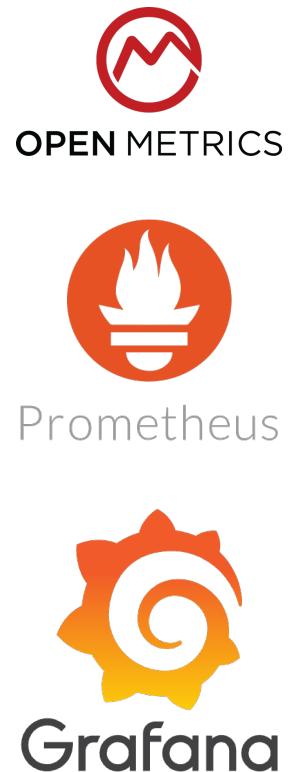
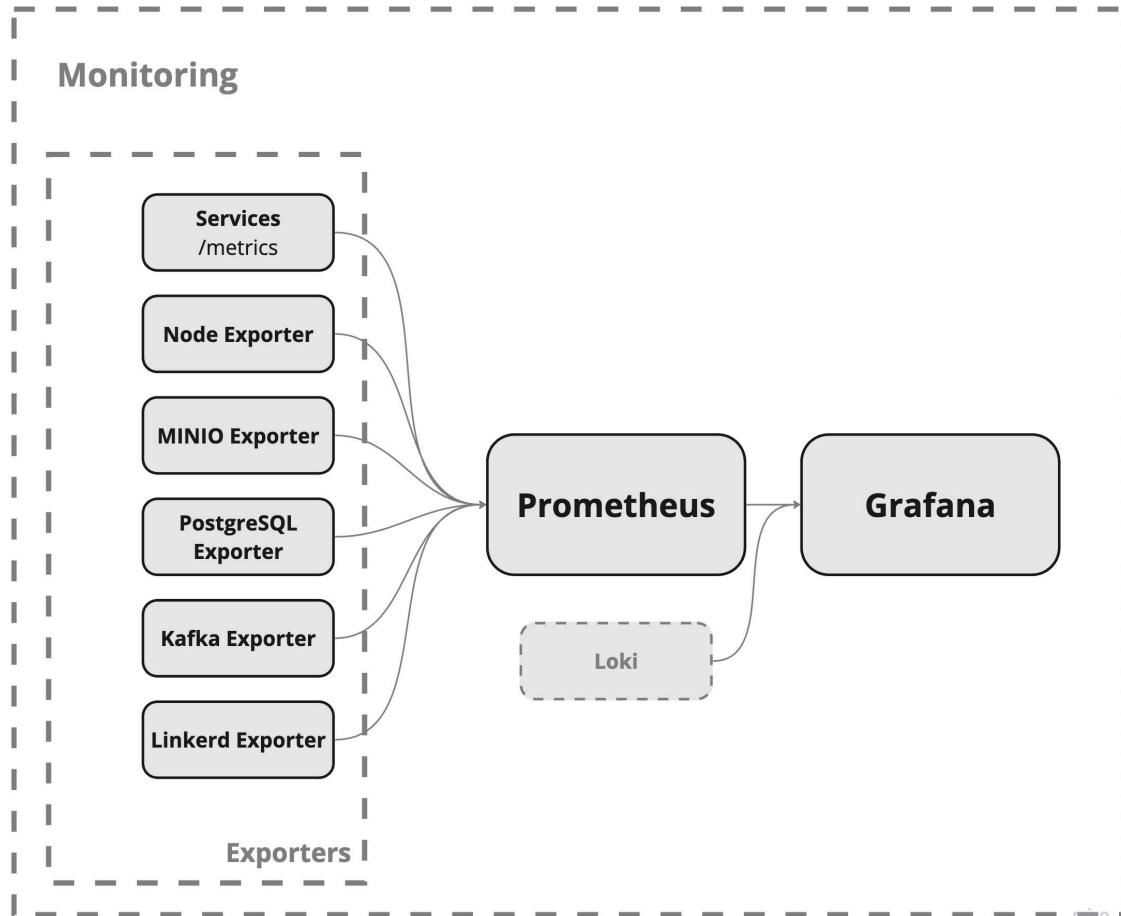
- > 2023-02-28 10:19:56 longhorn longhorn-manager 10.244.19.102 - - [28/Feb/2023:09:19:56 +0000] "GET /v1/volumes/pvc-7ed110bd-33cc-4a53-bea-6ca544f28db HTTP/1.1" 200 8176
 longhorn-longhorn
 longhorn-system node-2
 longhorn-manager:719d stdbuf
 loki-distributed querier ts=2023-02-28T09:19:55.786914569Z caller=spanLogger.go:80 table-name=loki_index_19408 user-id=fake org_id=fake level=info
 > 2023-02-28 10:19:55 querier longhorn-longhorn
 querier:719d loki-distributed
 grafana-loki node-3
 loki-loki-distributed querier-# stdbuf
 loki-distributed querier 10.244.19.102 - - [28/Feb/2023:09:19:55.638738617Z caller=table_manager.go:190 msg="downloading all files for table loki_index_194
 level=info ts=2023-02-28T09:19:55.638738617Z caller=table_manager.go:190 msg="downloading all files for table loki_index_194
 08"
 loki-distributed querier loki
 grafana-loki:719d
 grafana-loki node-3
 loki-loki-distributed querier-# stdbuf
 loki-distributed gateway nginx 10.244.84.147 - - [28/Feb/2023:09:19:51 +0000] 204 "POST /loki/api/v1/push HTTP/1.1" 0 "-" "promtail/2.7.3"
 level=info ts=2023-02-28T09:19:51.648098Z caller=table_manager.go:190 msg="downloading all files for table loki_index_194
 08"
 loki-distributed gateway nginx
 grafana-loki:719d
 grafana-loki node-3
 loki-distributed gateway-#
 stdbuf
 > 2023-02-28 10:19:51 operator operator 10.244.84.147 - - [28/Feb/2023:09:19:51 +0000] 204 "POST /loki/api/v1/push HTTP/1.1" 0 "-" "promtail/2.7.3"
 level=info ts=2023-02-28T09:19:51.648098Z caller=table_manager.go:190 msg="downloading all files for table loki_index_194
 08"
 operator operator
 minio-operator
 minio-minio/v2
 ResourceVersion:670806, Fi
 alDPath:"")
 type: "Normal", reason: "Updated", Service: "updated"
 stdbuf

structlog

```
1 {"method": "GET", "path": "/healthz", "status_code": 200, "response_body": "\"I'm fine\"", "level": "info"}
```

Projects

- chat
- chatsub
- golgw
- records
- srscallback
- streams
- users



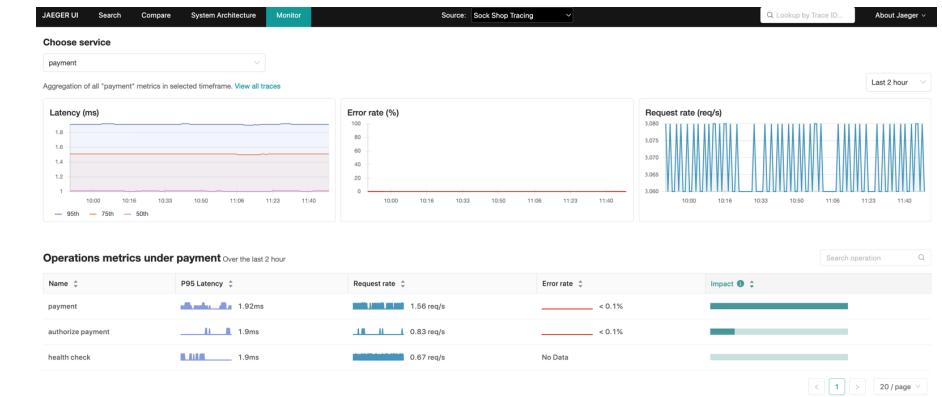
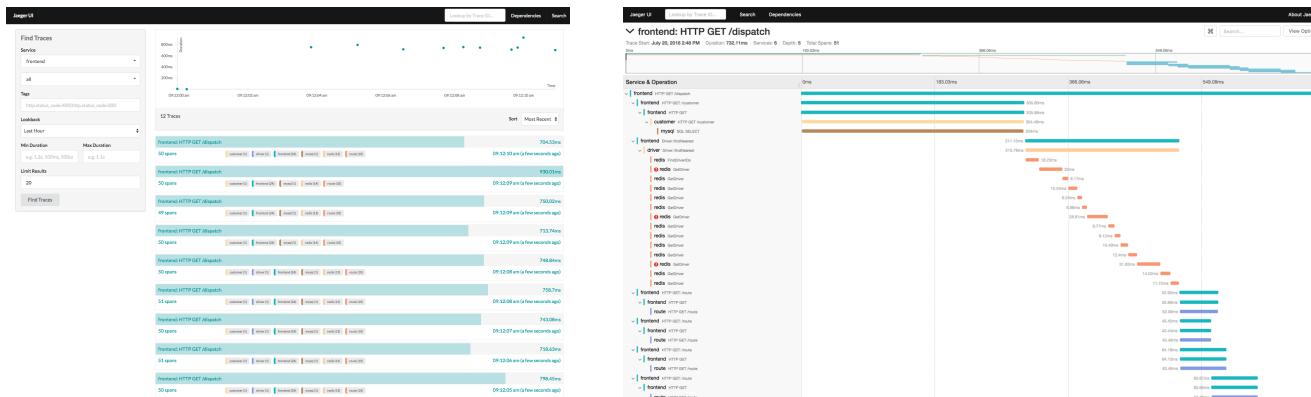
```

OpenMetrics

1 # HELP http_requests_total The total number of HTTP requests.
2 # TYPE http_requests_total counter
3 http_requests_total{method="post",code="200"} 1027 1395066363000
4 http_requests_total{method="post",code="400"} 3 1395066363000
5
6 # Escaping in label values:
7 msdos_file_access_time_seconds(path="C:\\DIR\\FILE.TXT",error="Cannot find file:\n\"FILE.TXT\"") 1.458255915e9
8
9 # Minimalistic line:
10 metric_without_timestamp_and_labels 12.47
11
12 # A weird metric from before the epoch:
13 something_weird(problem="division by zero") +Inf -3982045
14
15 # A histogram, which has a pretty complex representation in the text format:
16 # HELP http_request_duration_seconds A histogram of the request duration.
17 # TYPE http_request_duration_seconds histogram
18 http_request_duration_seconds_bucket{le="0.05"} 24054
19 http_request_duration_seconds_bucket{le="0.1"} 33444
20 http_request_duration_seconds_bucket{le="0.2"} 108392
21 http_request_duration_seconds_bucket{le="0.5"} 129389
22 http_request_duration_seconds_bucket{le="1"} 133988
23 http_request_duration_seconds_bucket{le="+Inf"} 144320
24 http_request_duration_seconds_sum 53423
25 http_request_duration_seconds_count 144320
26
27 # Finally a summary, which has a complex representation, too:
28 # HELP rpc_duration_seconds A summary of the RPC duration in seconds.
29 # TYPE rpc_duration_seconds summary
30 rpc_duration_seconds{quantile="0.01"} 3102
31 rpc_duration_seconds{quantile="0.05"} 3272
32 rpc_duration_seconds{quantile="0.5"} 4773
33 rpc_duration_seconds{quantile="0.9"} 9001
34 rpc_duration_seconds{quantile="0.99"} 76656
35 rpc_duration_seconds_sum 1.7560473e+07
36 rpc_duration_seconds_count 2693
  
```



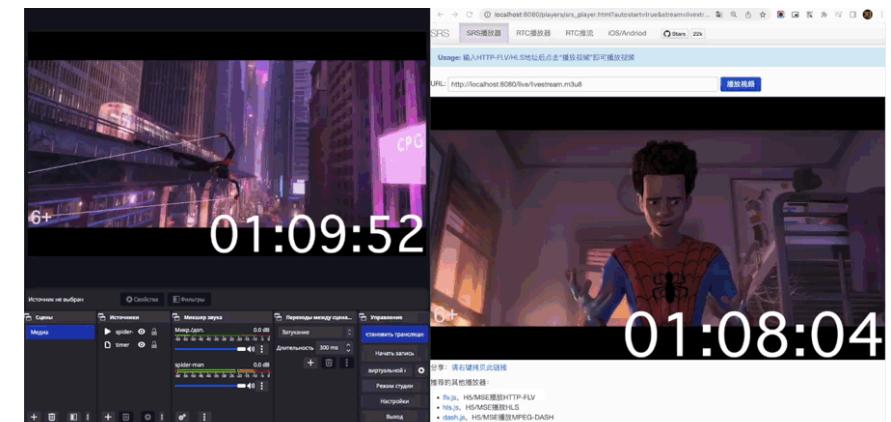
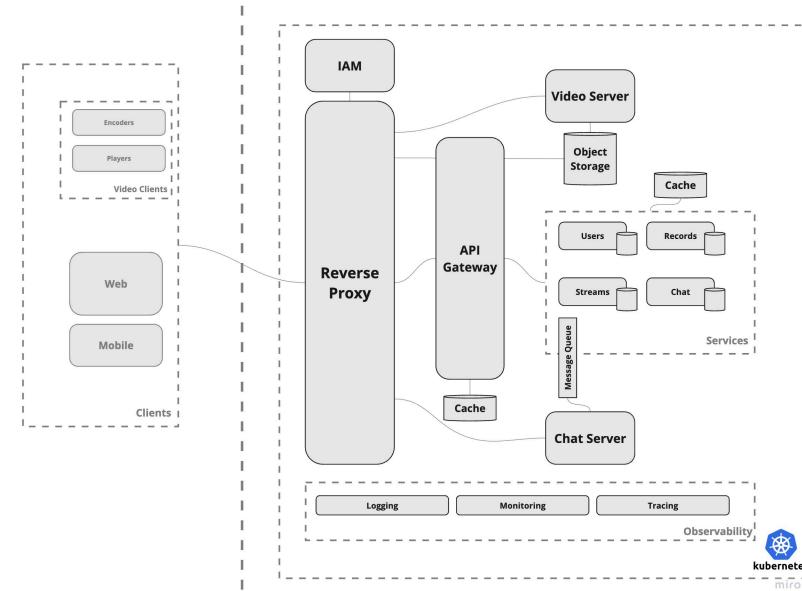
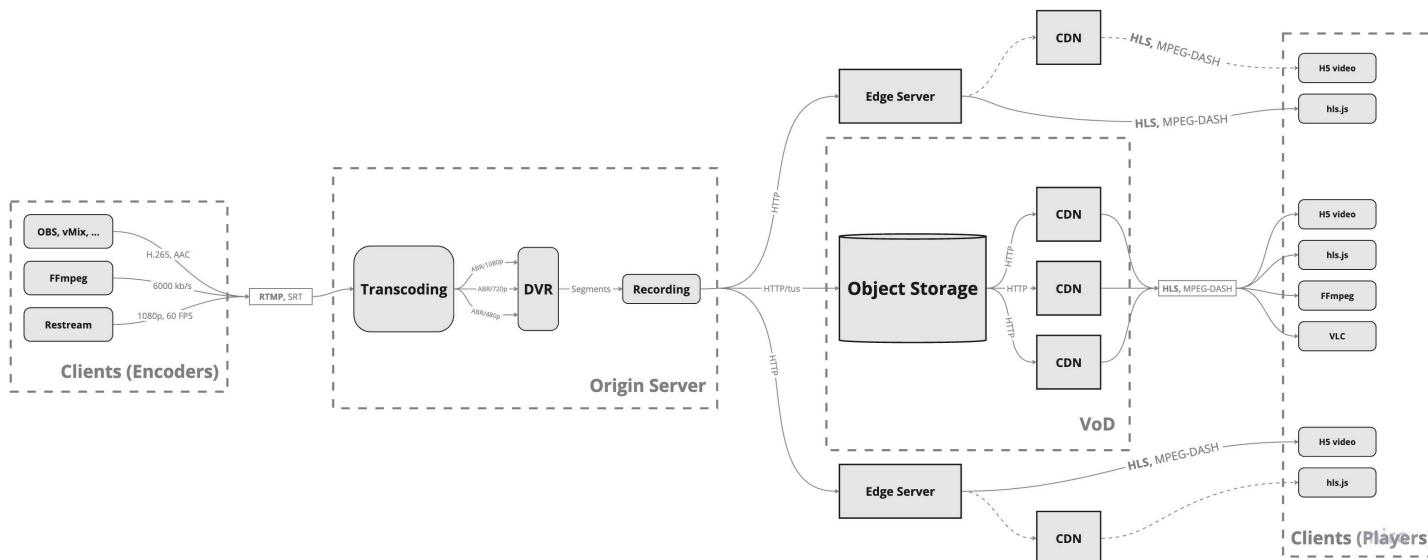
X-Request-ID: 2ae7a698-f2ae-419f-93da-e8bf67213428



	MVP	GoodGame	WASD	Trovo	VK Play Live	KICK	Twitch
Качество	4K, 2K	1080p	1080p	1080p	1080p	1080p	1080p
Стабильность*	+	+	-	-	+	+	++
Источник	+	-	+	-	+	+	+
DVR	+	-	-	-	+	-	-
Задержка*	++	+	+	+++	+	+	++
Функции*	+	-	+	++	?	?	+
Дешевая инфраструктура	+	-	-	-	-	-	-
Масштабируемость	+	-	-	+	+	+	+++
Капитализация	0	\$	\$\$	\$\$\$	\$\$	\$\$\$	\$\$\$\$\$

Импортозамещение

- СОВРЕМЕННЫЙ
- СТАБИЛЬНЫЙ
- МАСШТАБИРУЕМЫЙ
- ПРОЗРАЧНЫЙ
- ОТКРЫТЫЙ К ИЗМЕНЕНИЯМ



Спасибо за внимание!



Исходный код
github.com/belo4ya/live-streaming-service