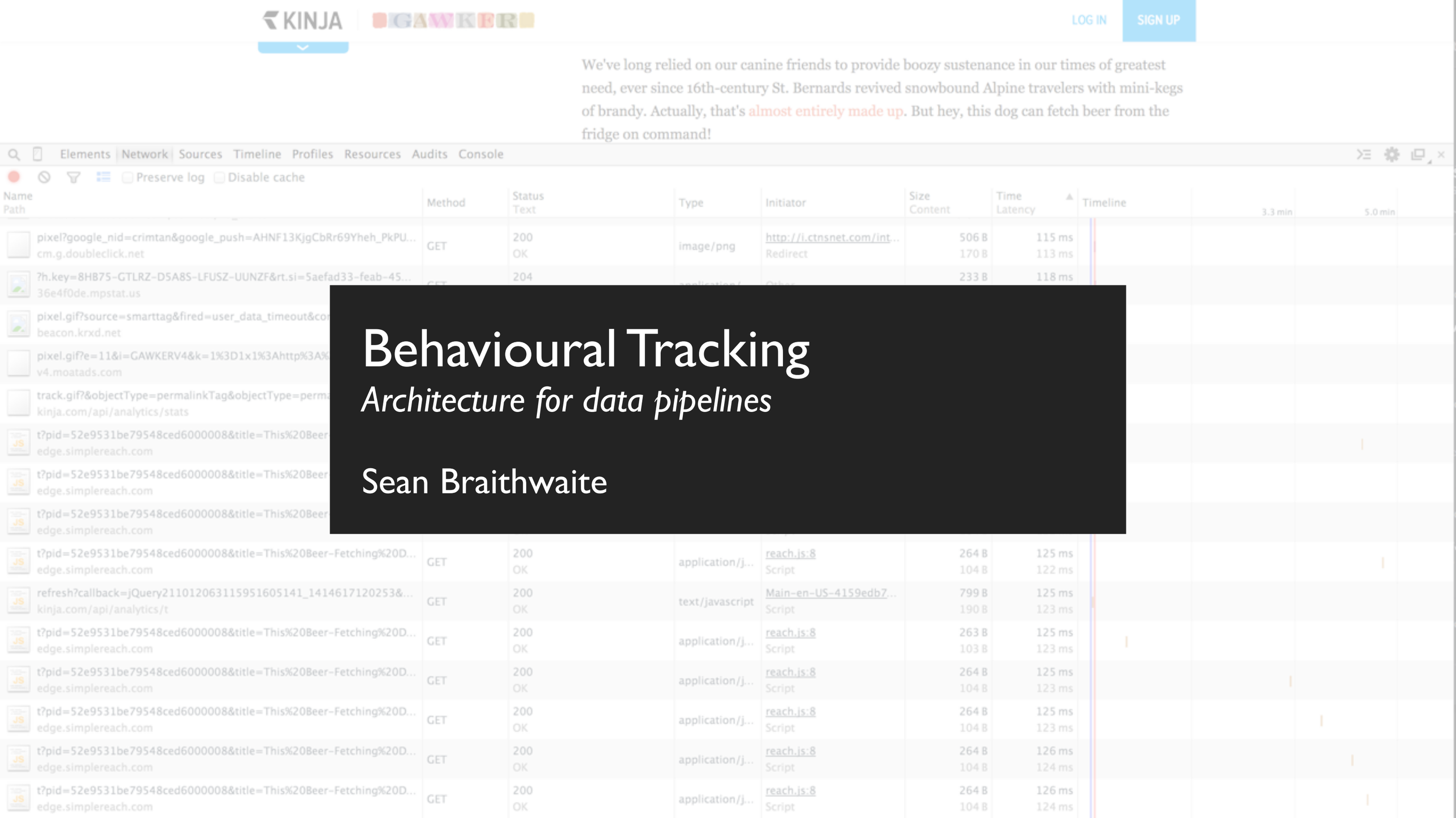


Behavioural Tracking

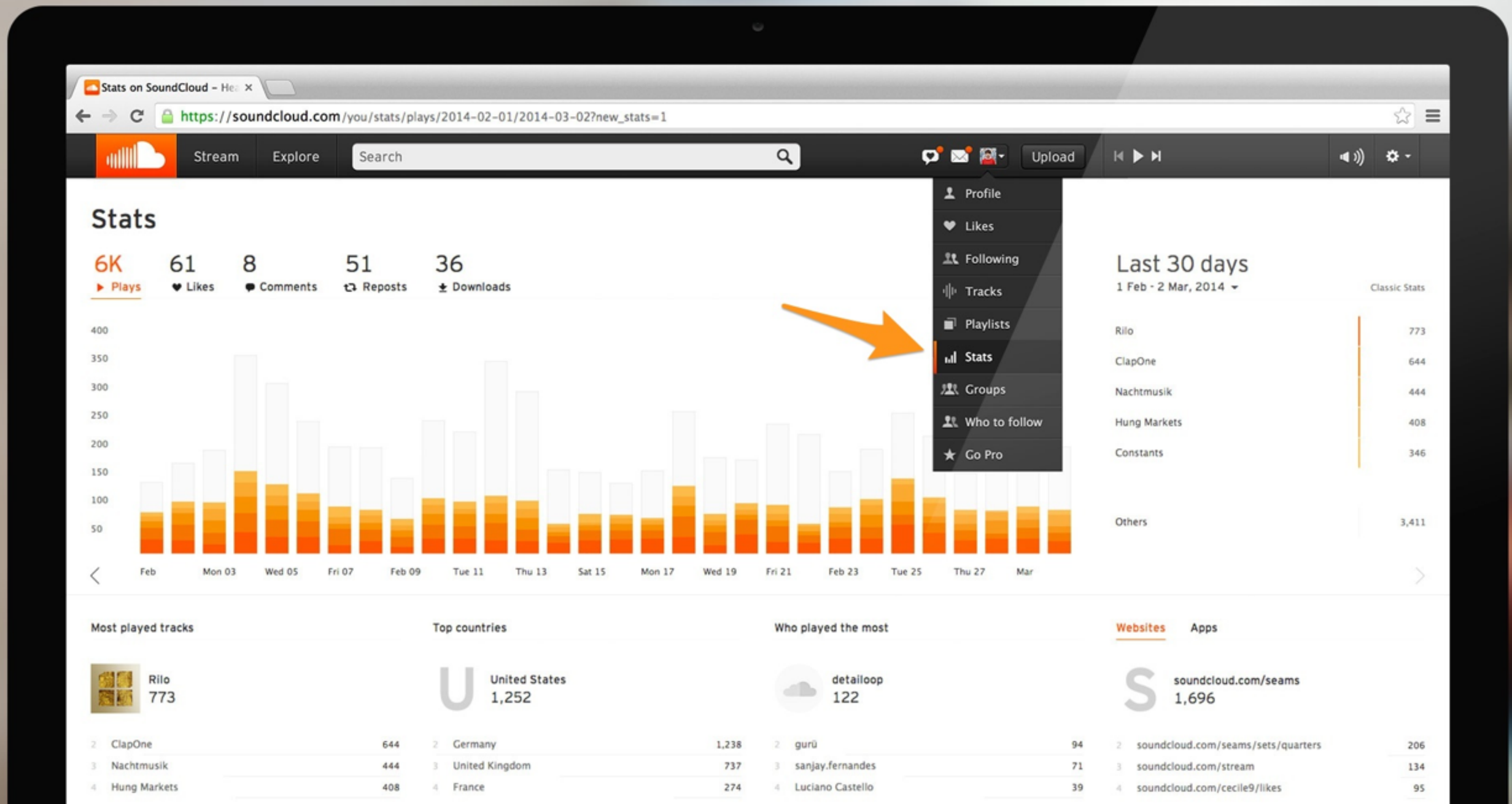
Architecture for data pipelines

Sean Braithwaite

Outline

- SoundCloud
- Problem definition
- Ethics
- Technical requirements
- Architecture
- Alternative implementation
- Cloud Computing
- Open problems
- Q and A


SOUNDCLOUD


Stats on SoundCloud – He
https://soundcloud.com/you/stats/plays/2014-02-01/2014-03-02?new_stats=1
Stream
Explore
Search
Upload
Profile
Likes
Following
Tracks
Playlists
Stats
Groups
Who to follow
Go Pro
Stats
6K
Plays
61
Likes
8
Comments
51
Reposts
36
Downloads
400
350
300
250
200
150
100
50
Feb
Mon 03
Wed 05
Fri 07
Feb 09
Tue 11
Thu 13
Sat 15
Mon 17
Wed 19
Fri 21
Feb 23
Tue 25
Thu 27
Mar
Last 30 days
1 Feb - 2 Mar, 2014
Classic Stats
Rilo 773
ClapOne 644
Nachtmusik 444
Hung Markets 408
Constants 346
Others 3,411
Most played tracks
Rilo
773
2 ClapOne 644
3 Nachtmusik 444
4 Hung Markets 408
Top countries
United States
1,252
2 Germany 1,238
3 United Kingdom 737
4 France 274
Who played the most
detailoop
122
2 gurú 94
3 sanjay.fernandes 71
4 Luciano Castello 39
Websites
Apps
soundcloud.com/seams
1,696
2 soundcloud.com/seams/sets/quarters 206
3 soundcloud.com/stream 134
4 soundcloud.com/cecile9/likes 95

Get ON SOUNDCLOUD
Make it happen

On SoundCloud is our new partner program for creators. It is a continuation of our commitment to the world's creative community. Whether you're uploading your first track or planning your next worldwide release, there's a place for you here, On SoundCloud.

PARTNER

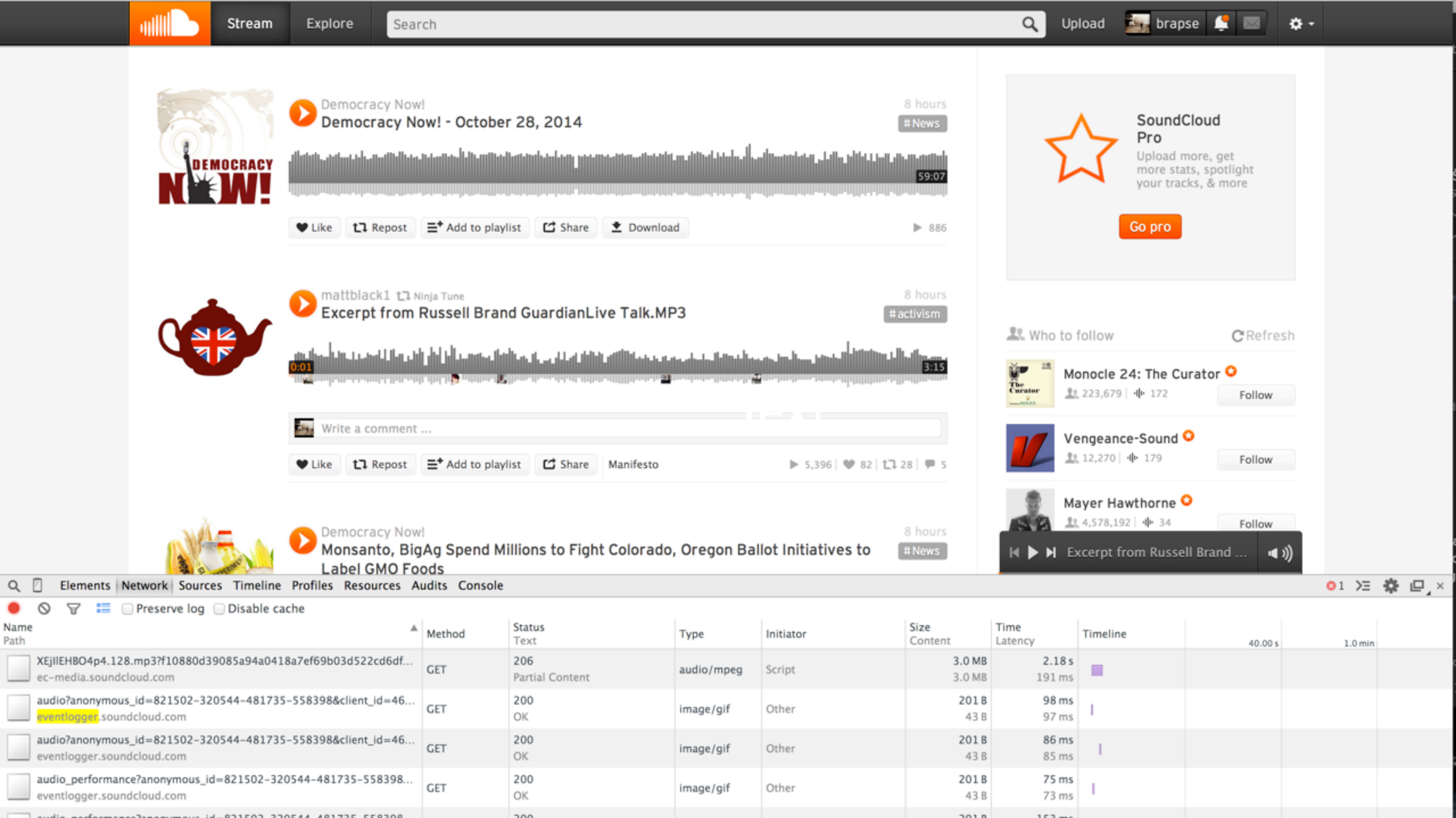
Free upload 3 hours
Creator profile
Basic stats

PRO

More upload time
Advanced tools & features
Detailed stats

PREMIER

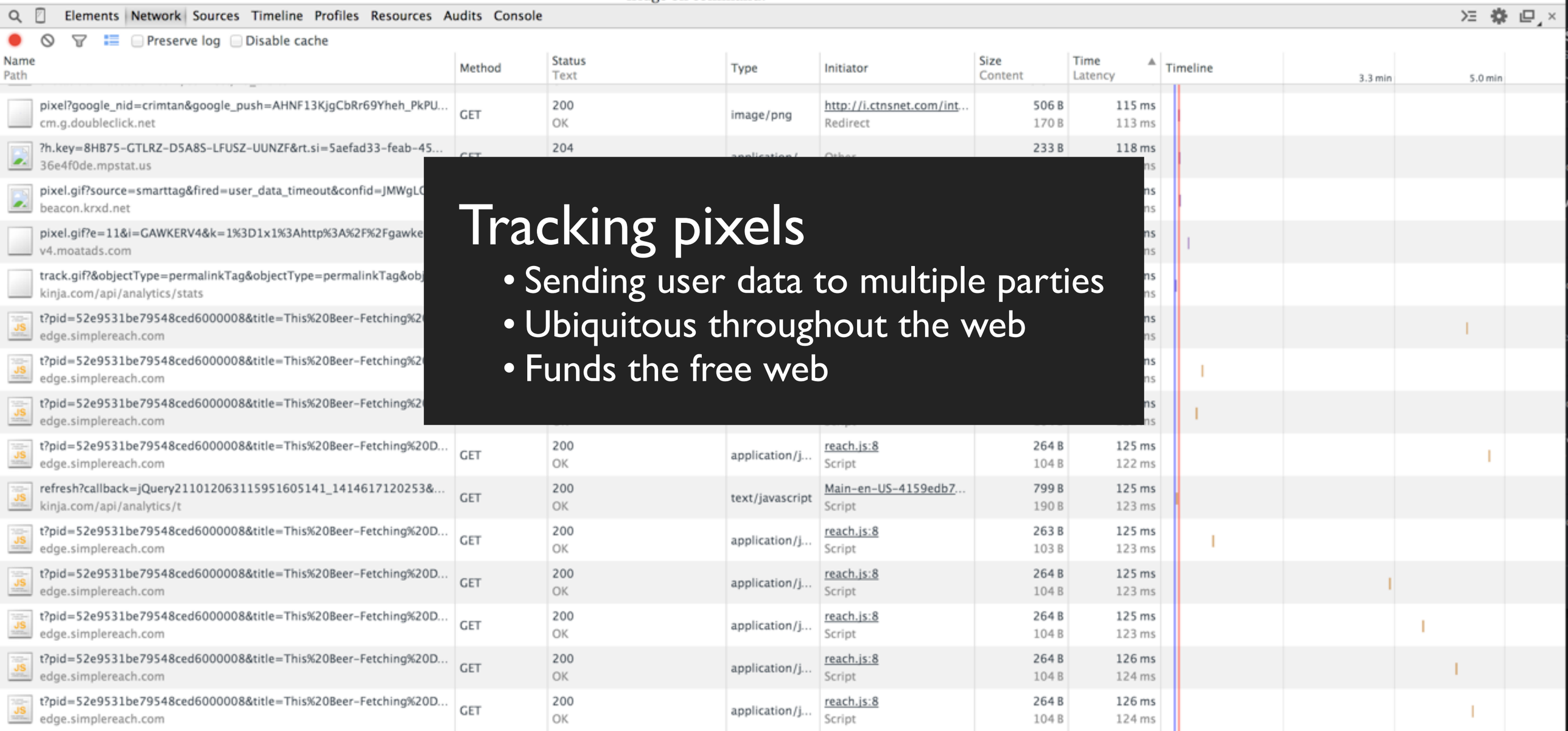
Unlimited upload time
Share of revenue
Exclusive promotional tools


Stream
Explore
Search
Upload
brapse
Democracy Now!
Democracy Now! - October 28, 2014
8 hours
#News
59:07
Like
Repost
Add to playlist
Share
Download
886
mattblack1
Ninja Tune
Excerpt from Russell Brand GuardianLive Talk.MP3
8 hours
#activism
0:01
3:15
Write a comment ...
Like
Repost
Add to playlist
Share
Manifesto
5,396
82
28
5
Democracy Now!
Monsanto, BigAg Spend Millions to Fight Colorado, Oregon Ballot Initiatives to Label GMO Foods
8 hours
#News
SoundCloud Pro
Upload more, get more stats, spotlight your tracks, & more
Go pro
Who to follow
Refresh
Monocle 24: The Curator
223,679
172
Follow
Vengeance-Sound
12,270
179
Follow
Mayer Hawthorne
4,578,192
34
Follow
Excerpt from Russell Brand ...
Elements
Network
Sources
Timeline
Profiles
Resources
Audits
Console
Preserve log
Disable cache
Name
Path
Method
Status
Text
Type
Initiator
Size
Content
Time
Latency
Timeline
40.00 s
1.0 min
XEjllEHBO4p4.128.mp3?f10880d39085a94a0418a7ef69b03d522cd6df...
ec-media.soundcloud.com
GET
206
Partial Content
audio/mpeg
Script
3.0 MB
3.0 MB
2.18 s
191 ms
audio?anonymous_id=821502-320544-481735-558398&client_id=46...
eventlogger.soundcloud.com
GET
200
OK
image/gif
Other
201 B
43 B
98 ms
97 ms
audio?anonymous_id=821502-320544-481735-558398&client_id=46...
eventlogger.soundcloud.com
GET
200
OK
image/gif
Other
201 B
43 B
86 ms
85 ms
audio_performance?anonymous_id=821502-320544-481735-558398...
eventlogger.soundcloud.com
GET
200
OK
image/gif
Other
201 B
43 B
75 ms
73 ms

KINJA GAWKER

LOG IN SIGN UP

We've long relied on our canine friends to provide boozy sustenance in our times of greatest need, ever since 16th-century St. Bernards revived snowbound Alpine travelers with mini-kegs of brandy. Actually, that's almost entirely made up. But hey, this dog can fetch beer from the fridge on command!



Tracking pixels

- Sending user data to multiple parties
- Ubiquitous throughout the web
- Funds the free web

Motivation

- Understanding product/content
- Understanding users
- Data is a business

The Ethical Dimension

- It’s surveillance
- Subject / observer asymmetry
- Evolving regulations

Technical Requirements

- Heterogeneous production
- Heterogeneous consumption
- Delivery Guarantees
- Insightful

Architecture Overview

Client side implementation

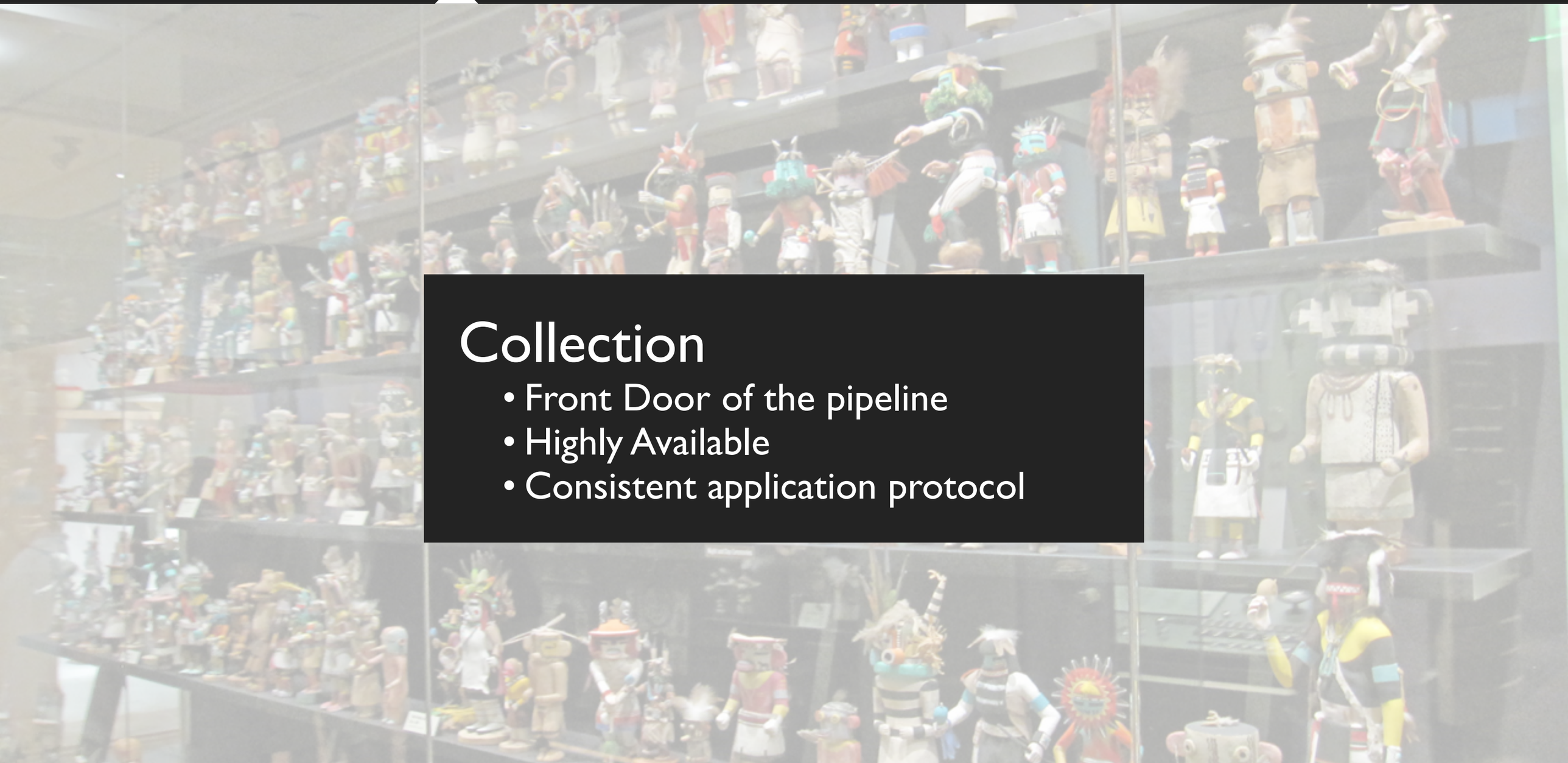
- Instrument application logic/state
- Schedule + Plan for HTTP Calls
- Handle Failure

HTTP Specifics

- Generate ASYNC HTTP requests
- POST is better than GET
- Cookie store unique user ID

Platforms Matter

- Battery life on mobile is an issue
- Keep Alive, Scheduling, Batching
- Device ID and local storage

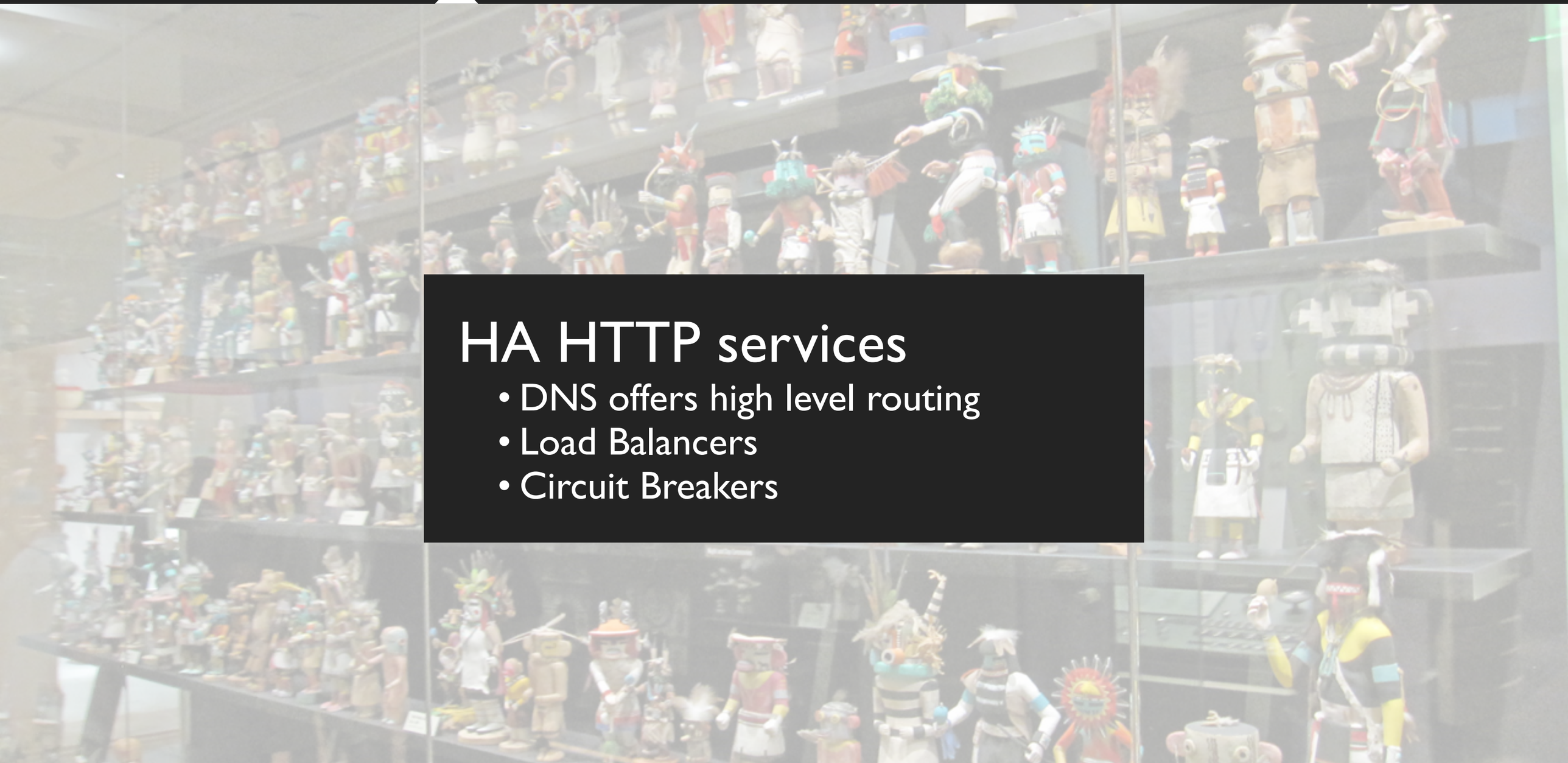


Collection

- Front Door of the pipeline
- Highly Available
- Consistent application protocol

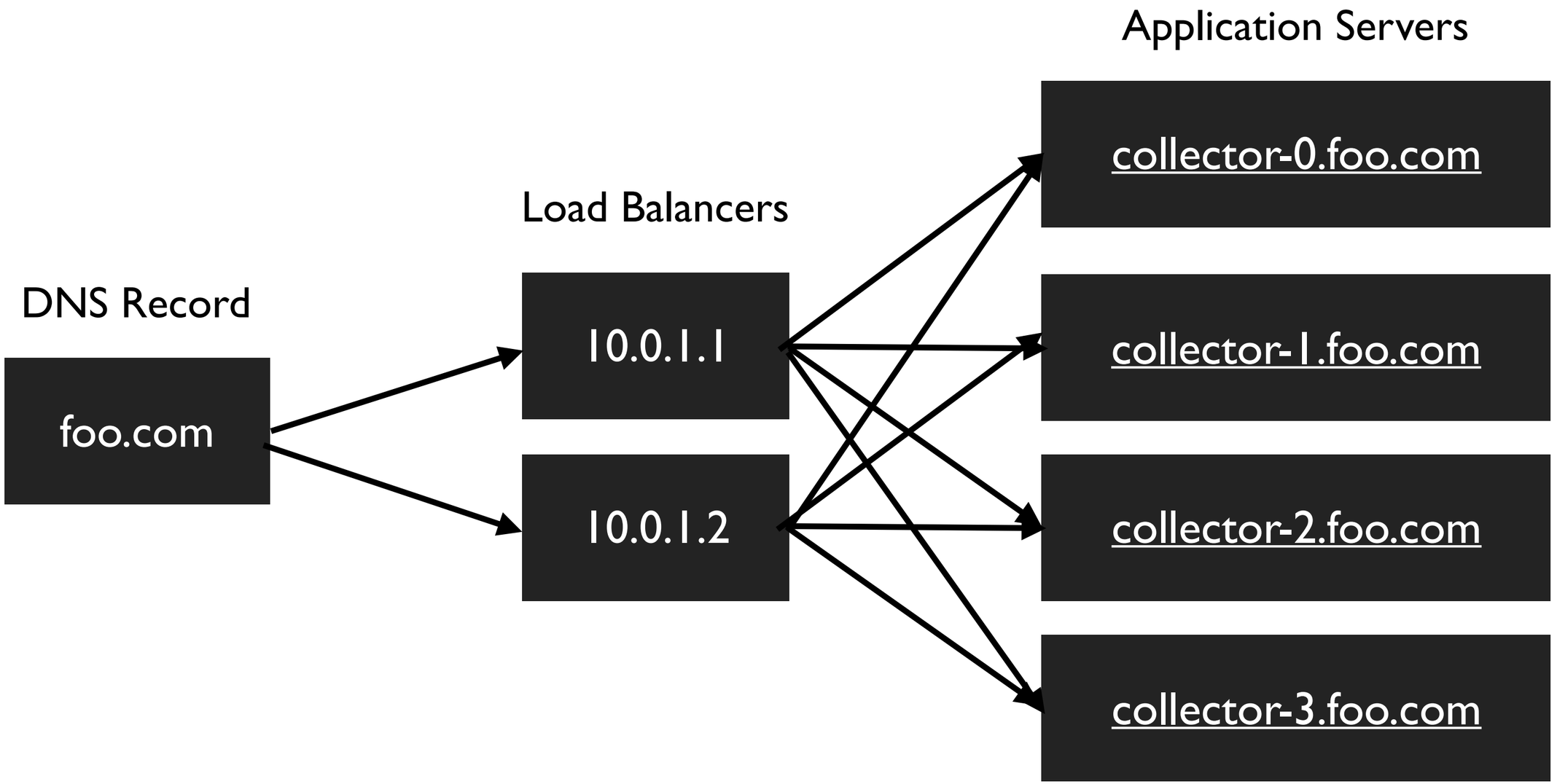
Application Protocol

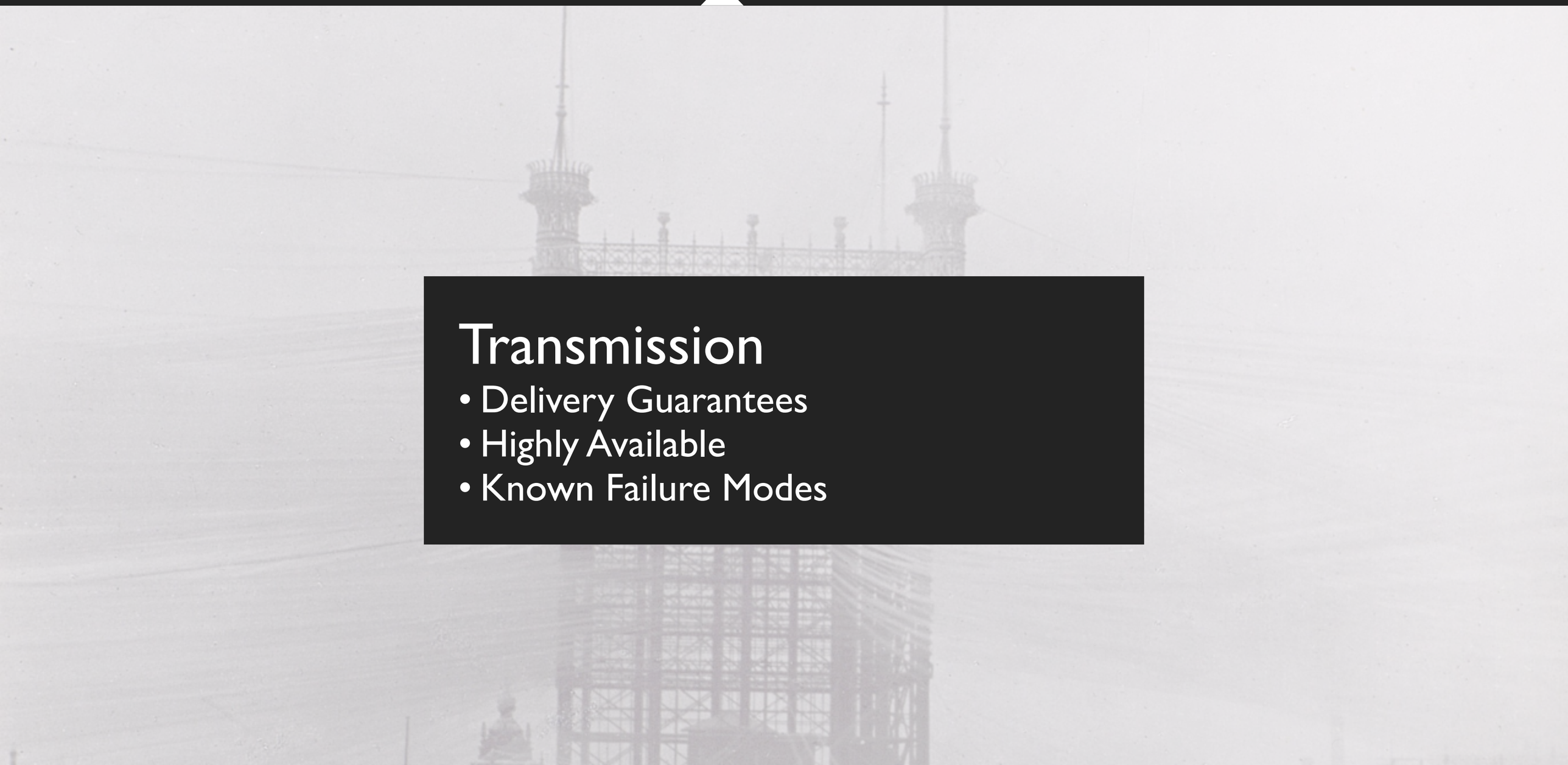
- Schemas matter
- Must communicate failure
- Evolutionary Path



HA HTTP services

- DNS offers high level routing
- Load Balancers
- Circuit Breakers

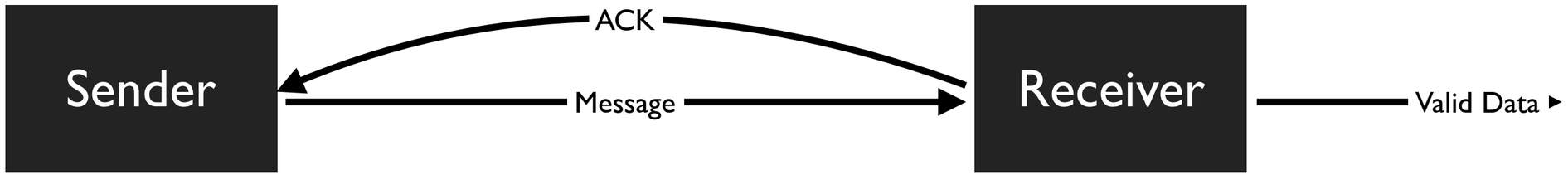

Application Servers
Load Balancers
DNS Record
foo.com
10.0.1.1
10.0.1.2
collector-0.foo.com
collector-1.foo.com
collector-2.foo.com
collector-3.foo.com



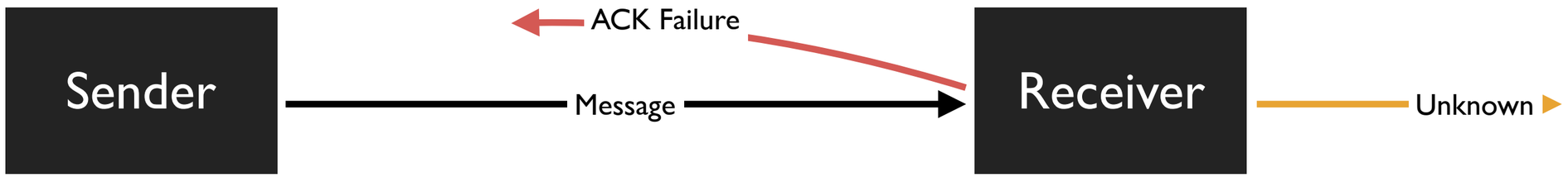
Transmission

- Delivery Guarantees
- Highly Available
- Known Failure Modes

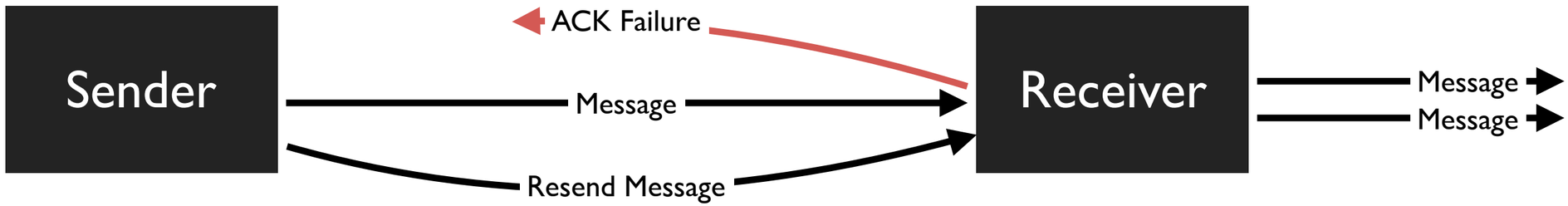
Ideal Case



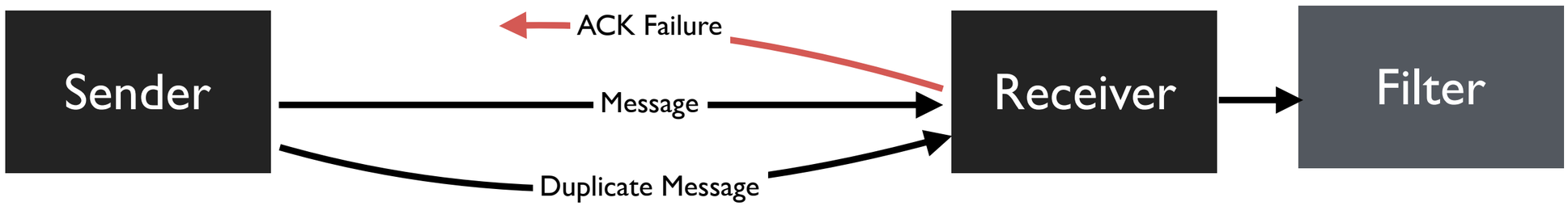
At most once



Duplicate Case: at least once



Exactly Once*: De-duplication



RabbitMQ

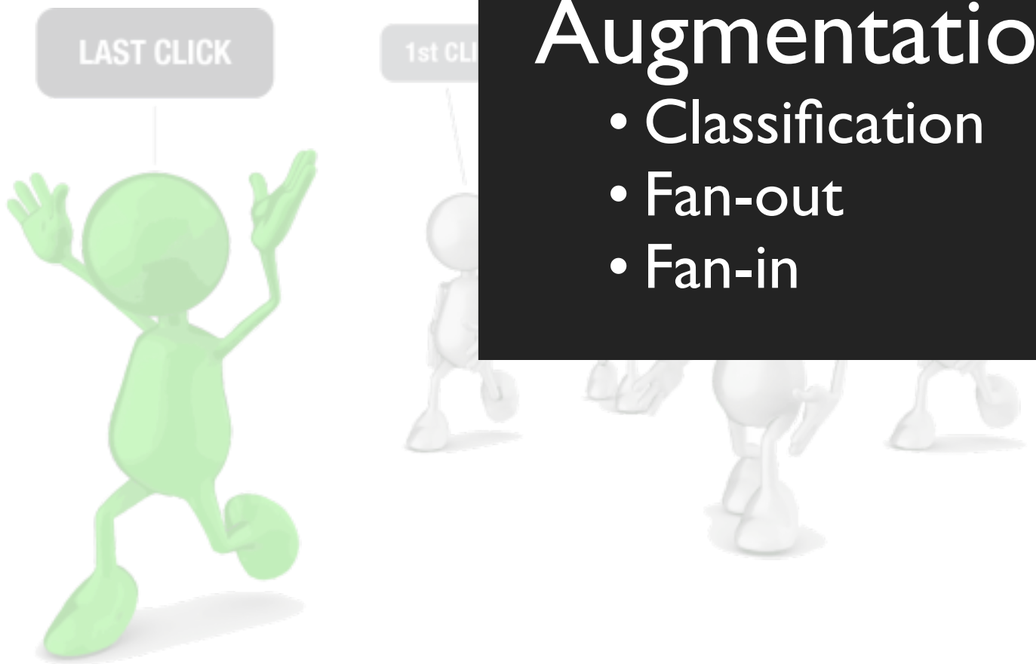
- Master/Slave
- Complex Topology
- At least once

Flume 0.94

- Master election
- Zookeeper
- At least once

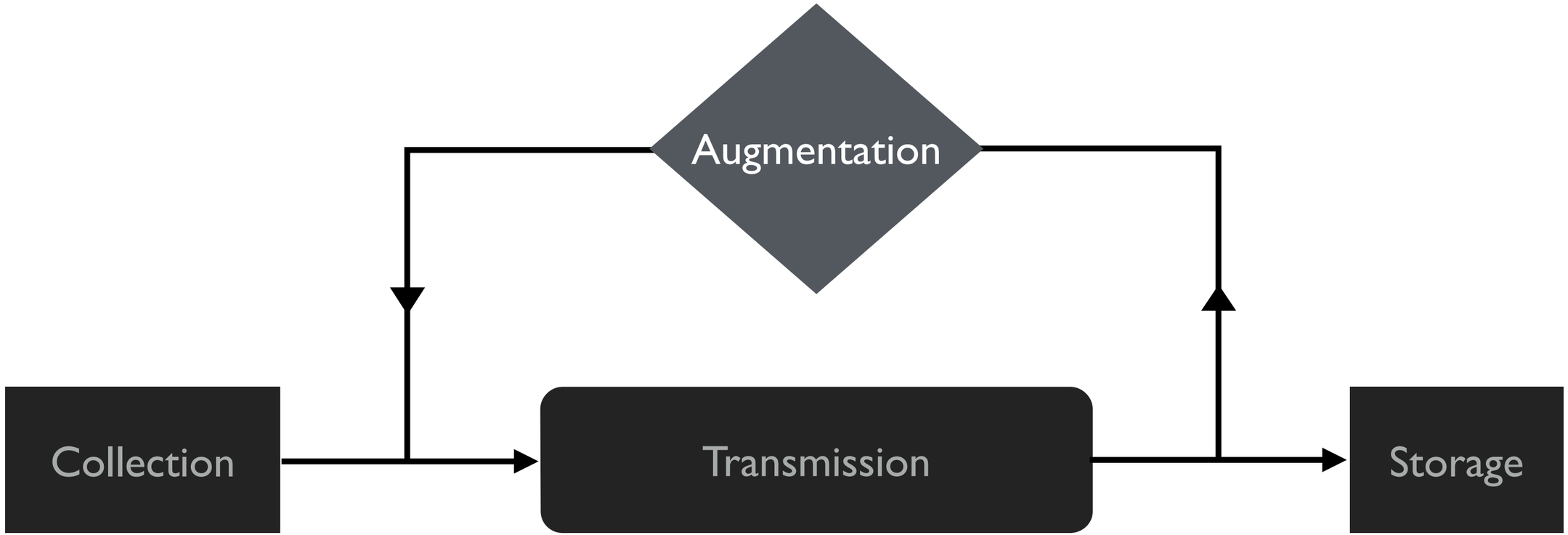
Kafka

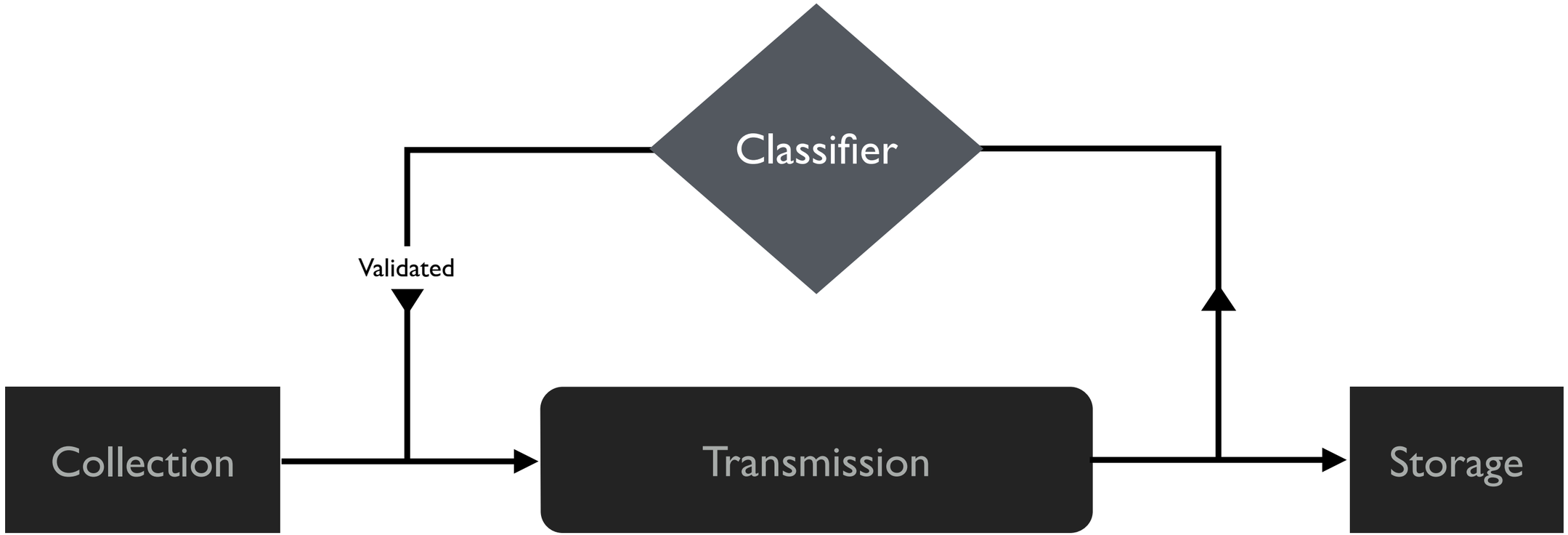
- Masterless
- Zookeeper
- At least once

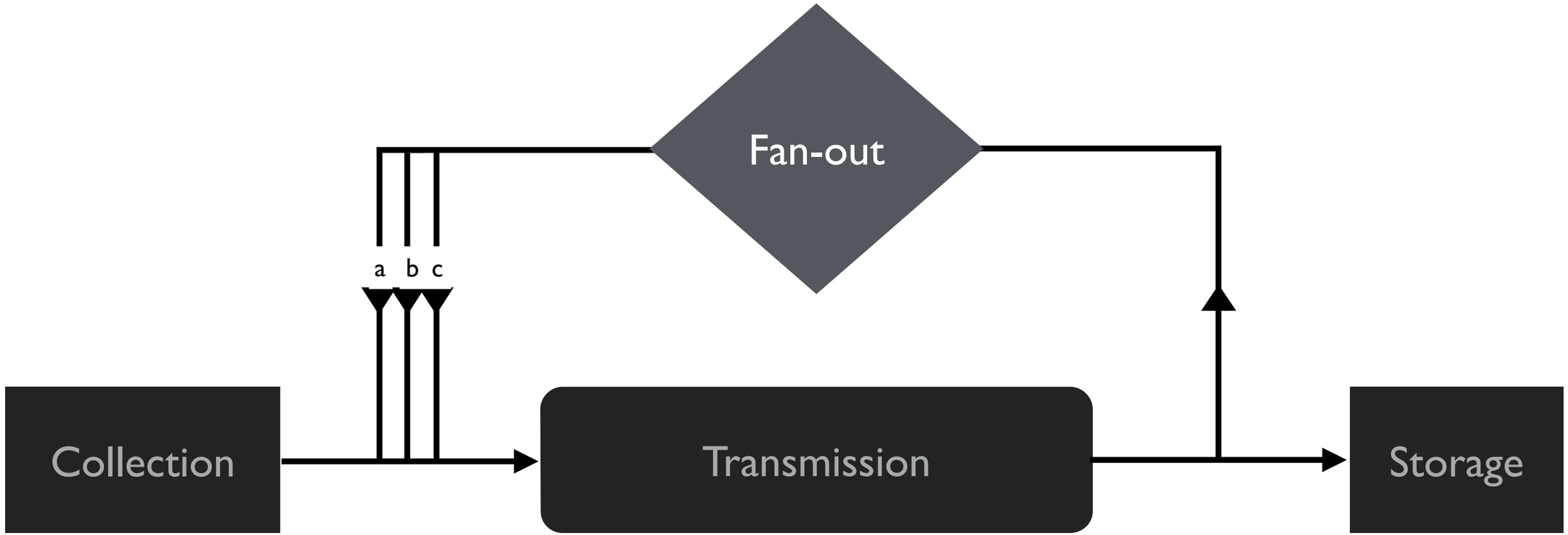


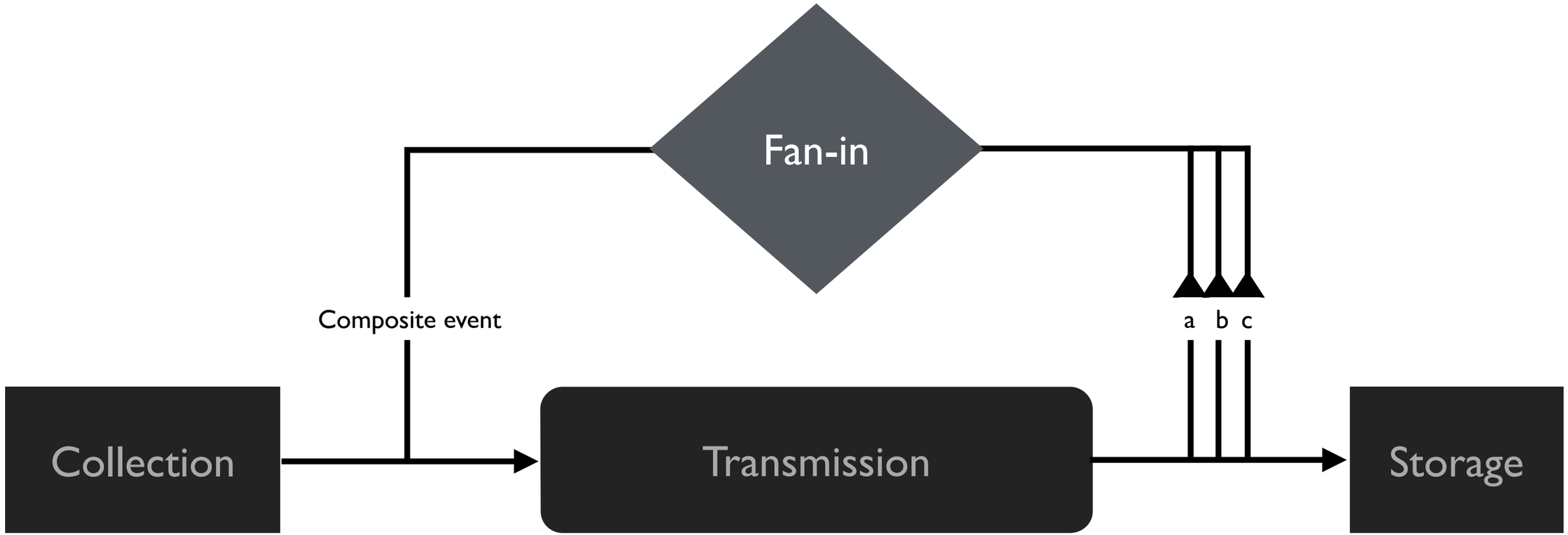
Augmentation

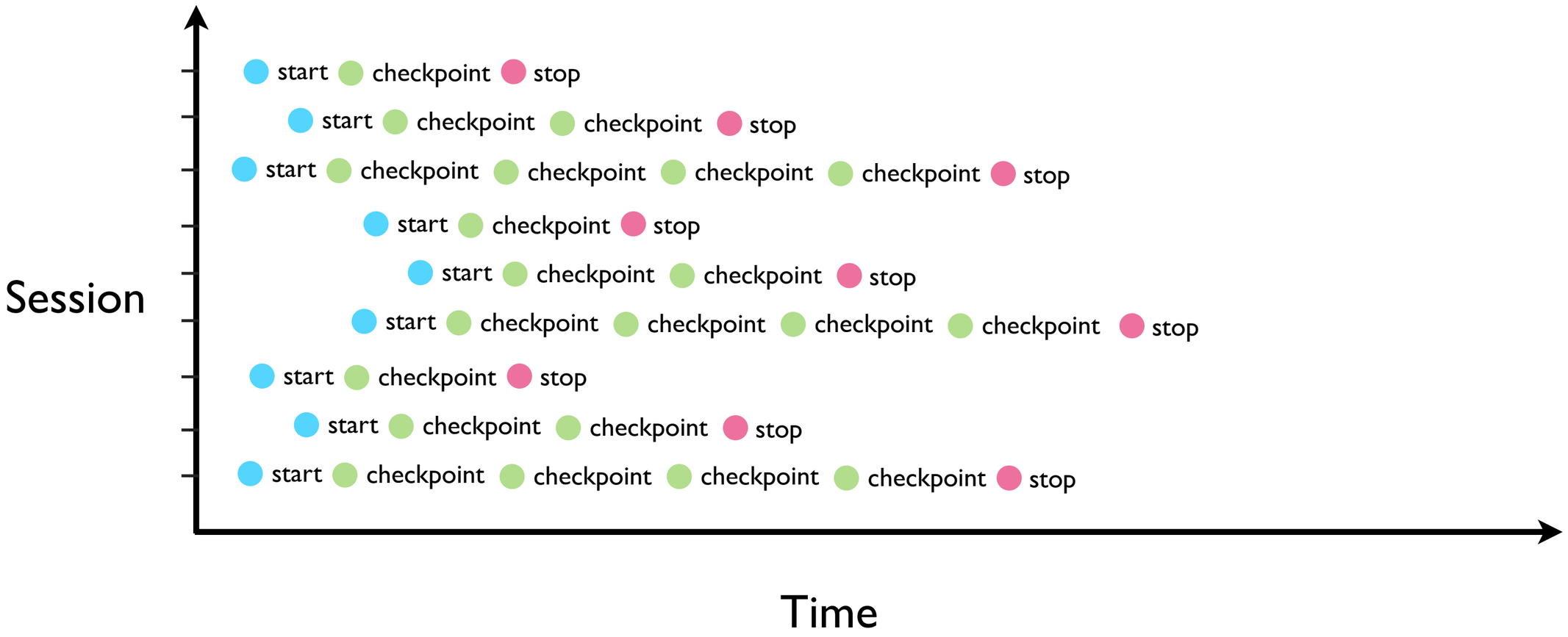
- Classification
- Fan-out
- Fan-in

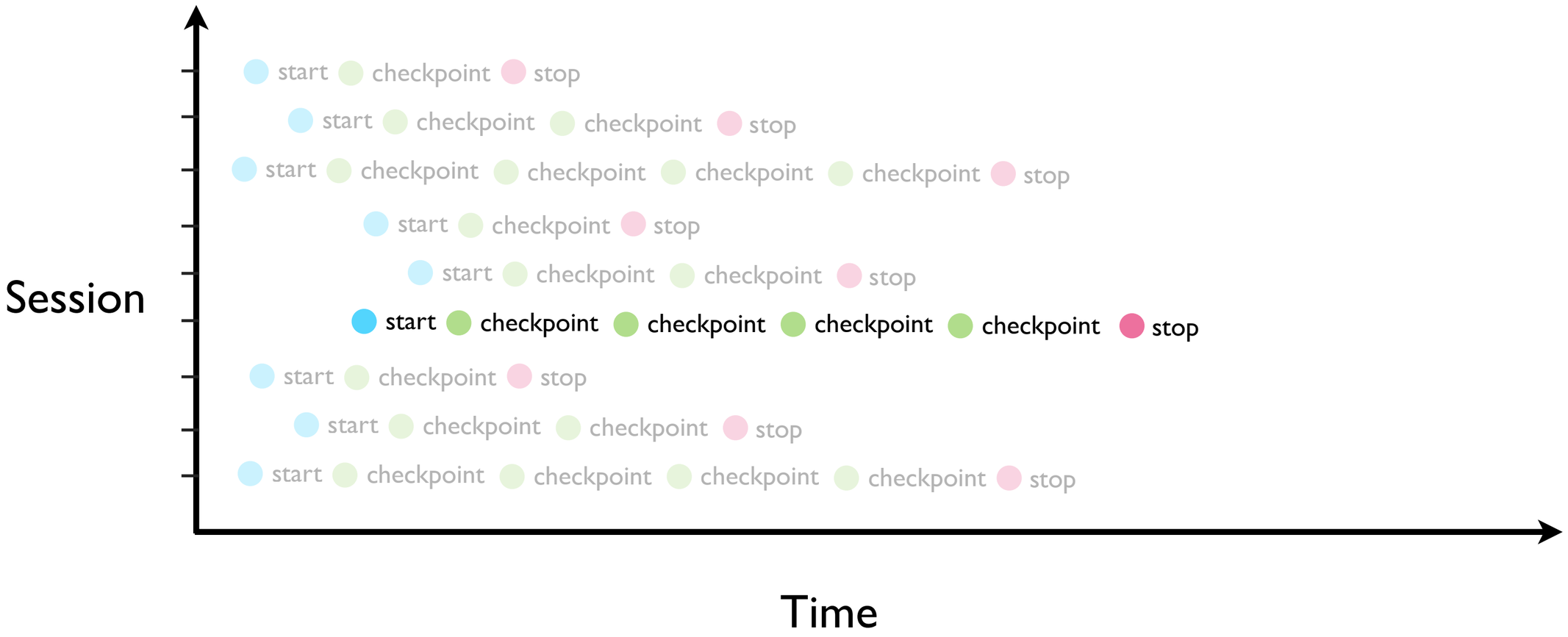

Augmentation
Collection
Transmission
Storage

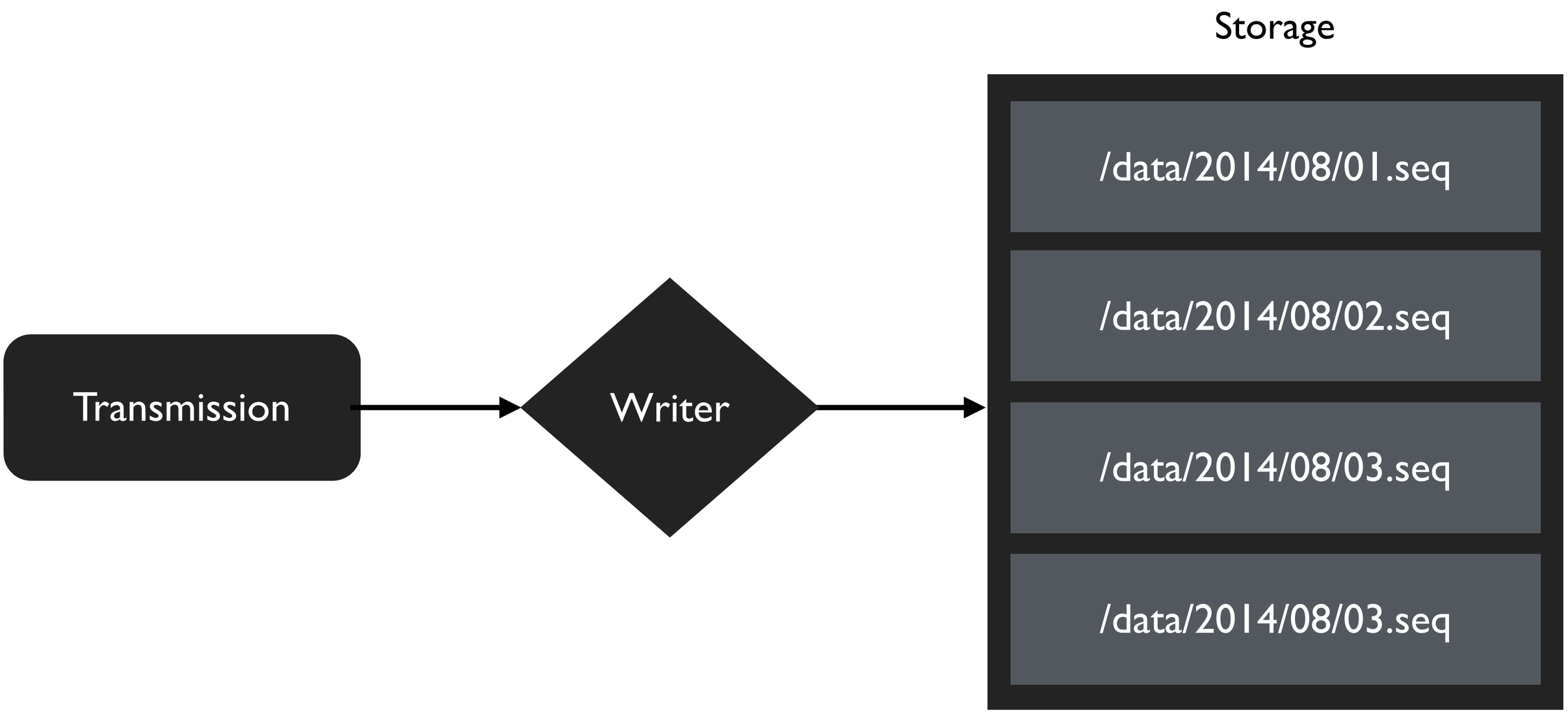

Classifier
Validated
Collection
Transmission
Storage

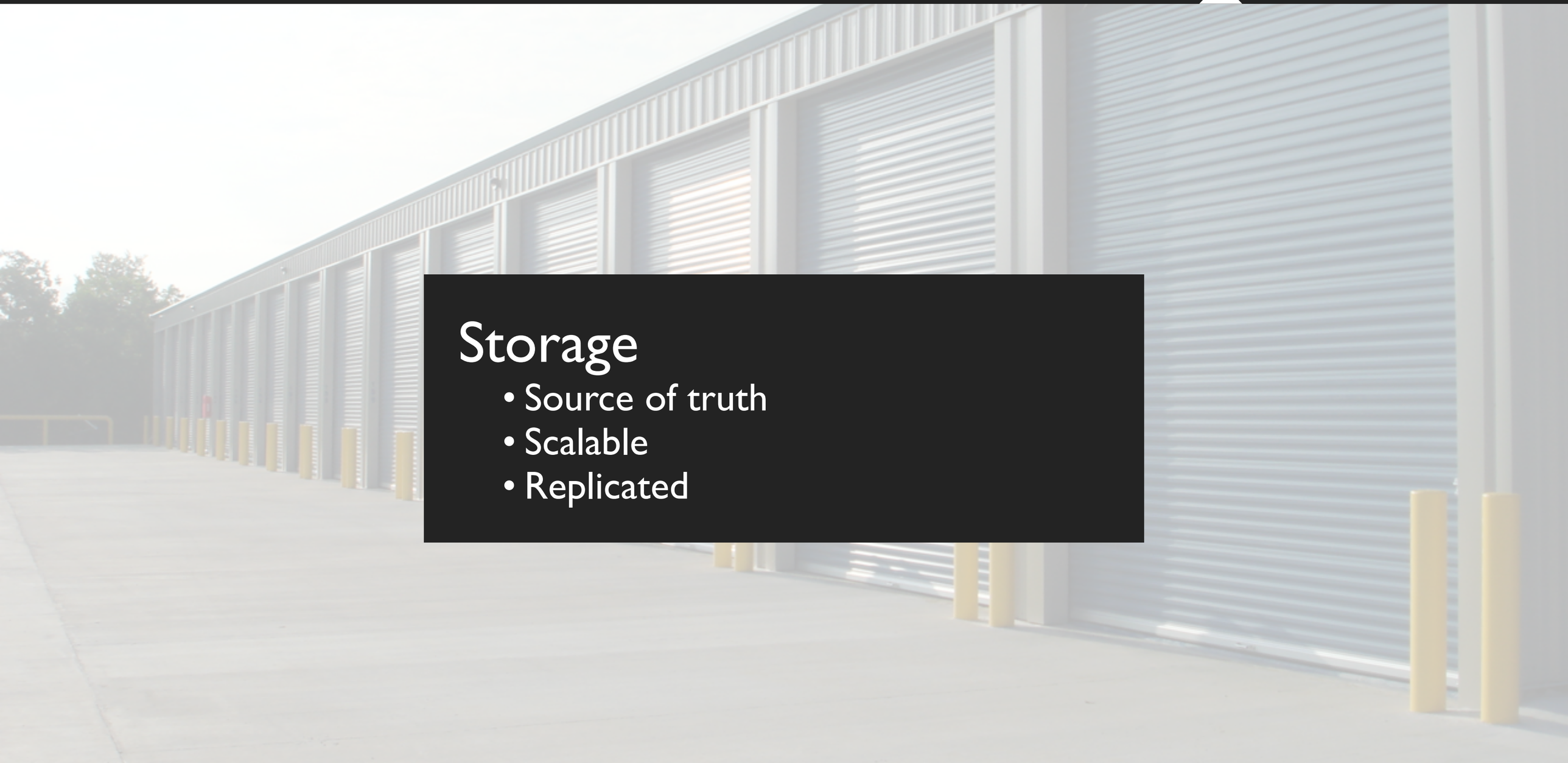

Fan-out
a b c
Collection
Transmission
Storage


Fan-in
Composite event
a b c
Collection
Transmission
Storage


start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
Session
Time


Session
start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
start checkpoint stop
start checkpoint checkpoint stop
start checkpoint checkpoint checkpoint checkpoint stop
Time


Storage
Transmission
Writer
/data/2014/08/01.seq
/data/2014/08/02.seq
/data/2014/08/03.seq
/data/2014/08/03.seq



Storage

- Source of truth
- Scalable
- Replicated

HDFS

- Self hosted
- Cost effective at scale
- Can run multi tenant
- Non trivial operational cost

S3

- Managed
- Cost prohibitive at scale
- Network to Map Reduce
- EMR cost

Query

- Able to handle Billion of Records
- Support for statistics
- Bulk Loadable

Different workloads

- Low vs. high latency
- Common vs custom operations
- Large working sets

Columnar Store

- Redshift/Vertica
- SQL
- Expensive

Hadoop Based

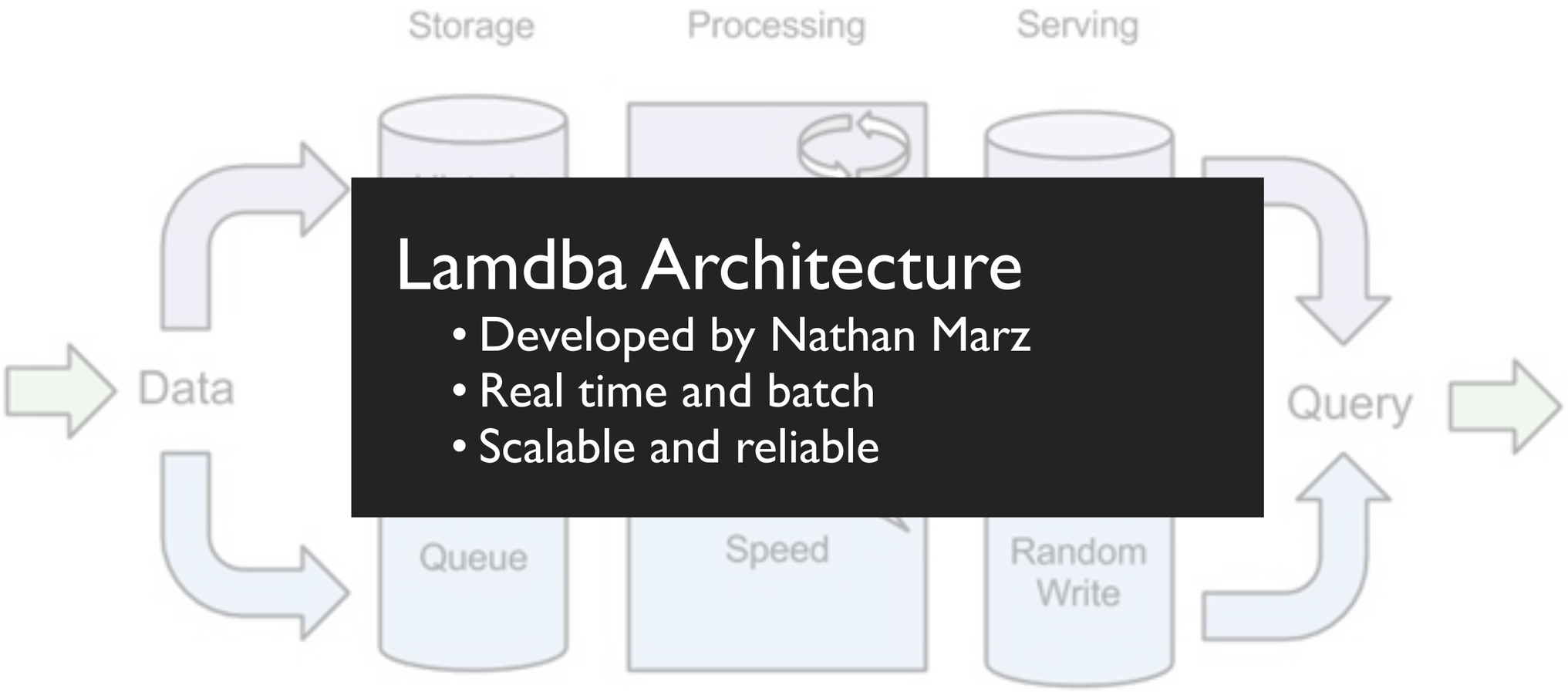
- Pig/Hive/Spark
- Shared tenancy
- Highly Scalable

Elastic Search

- Distributed Lucene
- Extendable
- Can’t Bulk Load

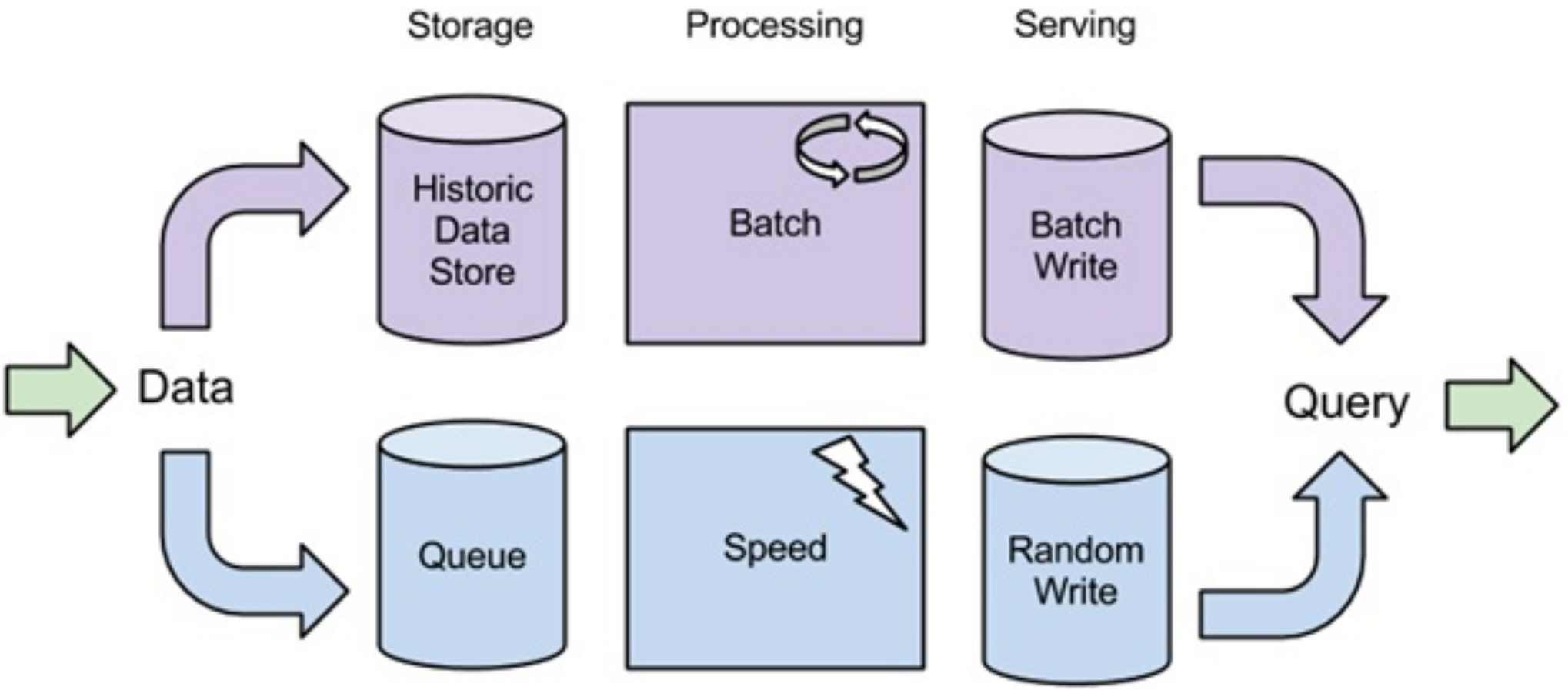
Architecture Summary

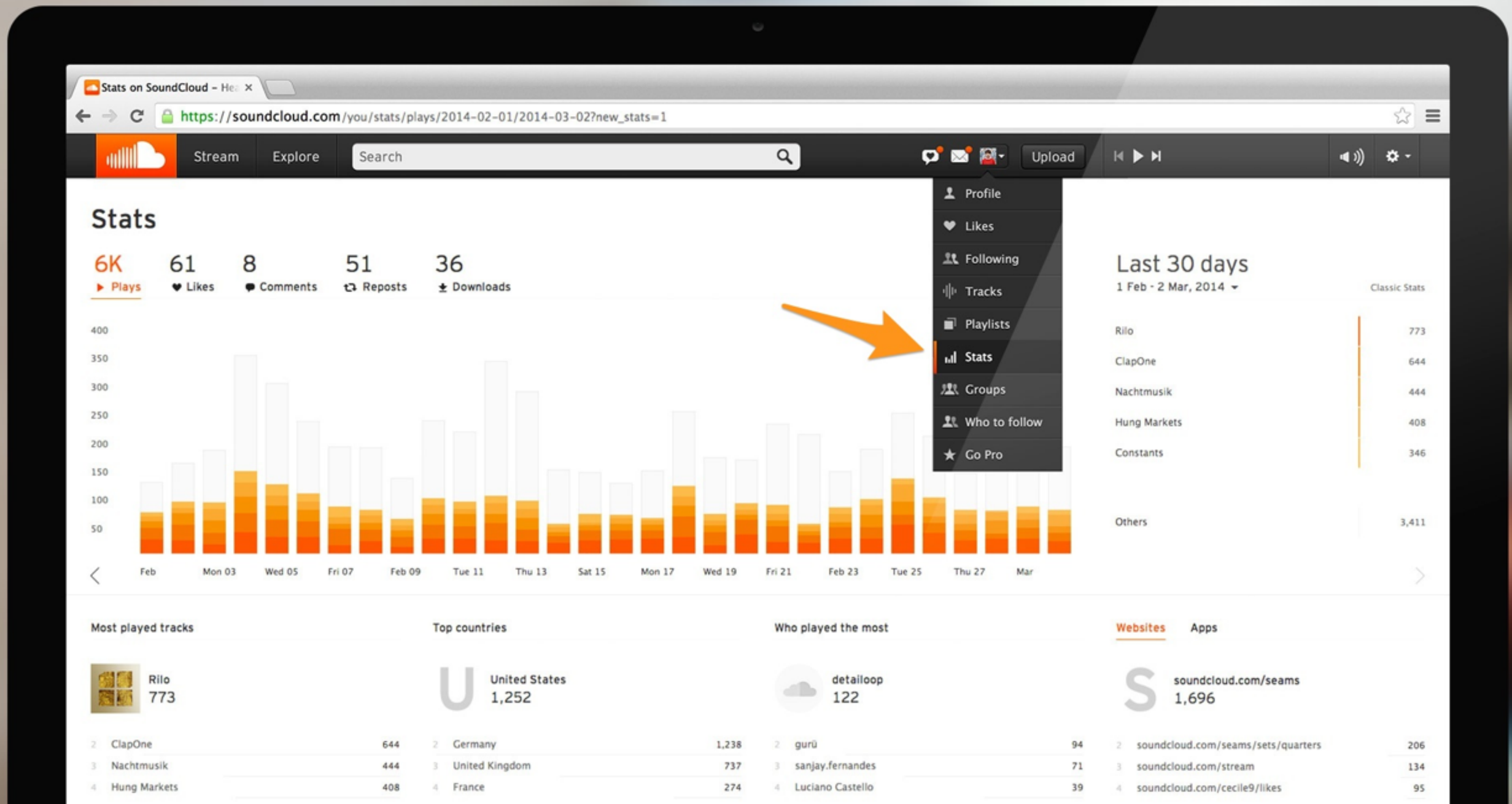
- Connected and exchangeable
- Failure modes are a priority
- Source of truth
- Accessible, Insightful

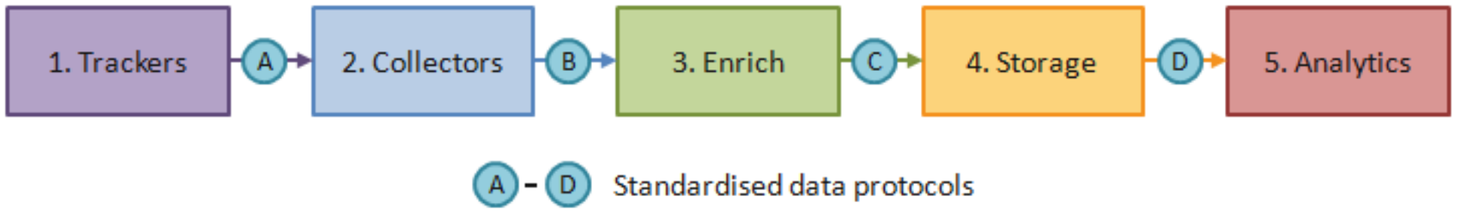


Lamdba Architecture

- Developed by Nathan Marz
- Real time and batch
- Scalable and reliable


Storage
Processing
Serving
Historic Data Store
Batch
Batch Write
Data
Query
Queue
Speed
Random Write


Stats on SoundCloud – He
https://soundcloud.com/you/stats/plays/2014-02-01/2014-03-02?new_stats=1
Stream
Explore
Search
Upload
Profile
Likes
Following
Tracks
Playlists
Stats
Groups
Who to follow
Go Pro
Stats
6K
Plays
61
Likes
8
Comments
51
Reposts
36
Downloads
400
350
300
250
200
150
100
50
Feb
Mon 03
Wed 05
Fri 07
Feb 09
Tue 11
Thu 13
Sat 15
Mon 17
Wed 19
Fri 21
Feb 23
Tue 25
Thu 27
Mar
Last 30 days
1 Feb - 2 Mar, 2014
Classic Stats
Rilo 773
ClapOne 644
Nachtmusik 444
Hung Markets 408
Constants 346
Others 3,411
Most played tracks
Rilo
773
2 ClapOne 644
3 Nachtmusik 444
4 Hung Markets 408
Top countries
United States
1,252
2 Germany 1,238
3 United Kingdom 737
4 France 274
Who played the most
detailoop
122
2 gurú 94
3 sanjay.fernandes 71
4 Luciano Castello 39
Websites
Apps
soundcloud.com/seams
1,696
2 soundcloud.com/seams/sets/quarters 206
3 soundcloud.com/stream 134
4 soundcloud.com/cecile9/likes 95

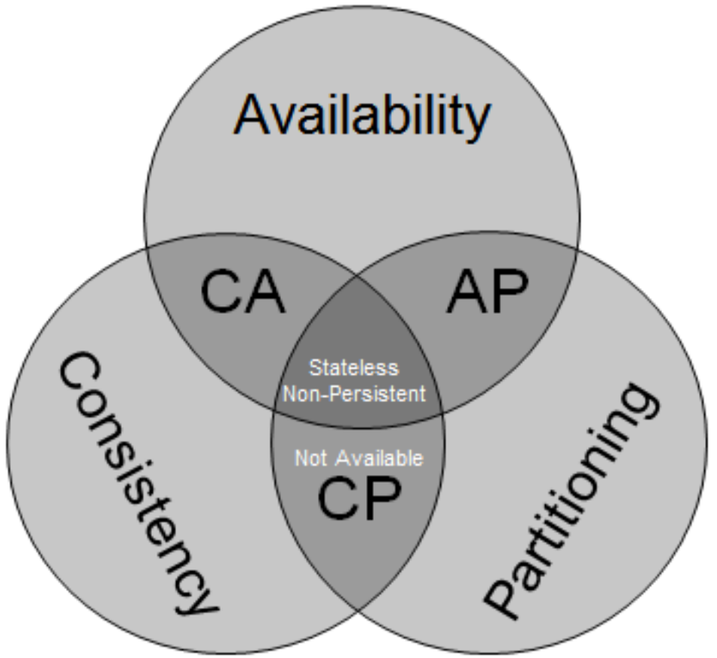

1. Trackers
A
2. Collectors
B
3. Enrich
C
4. Storage
D
5. Analytics
A – D
Standardised data protocols

Cloud Computing

- Commodity Computation
- Outsourced infrastructure
- Has two architectural properties


Immutable Infrastructure
• Atomic software
• Compile to AMI/Docker/X
• Reproducible


Coordination
• Complex distributed system
• Different for every component
• Can’t always buy


Availability
CA
AP
Stateless
Non-Persistent
Consistency
Not Available
CP
Partitioning

Conclusion

- Connected set of components
- Failure modes are a priority
- Build vs Adopt
- Components are volatile
- Architecture is “stable”

oordinates: (x,y,z)

elocity Components: (u,v,w)

Time : t Pressure: p Heat Flux: q

Density: ρ Stress: τ Reynolds Number: Re

Total Energy: Et Prandtl Number: Pr

ontinuity:

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

– Momentum:

$$\frac{\partial(\rho u)}{\partial t}$$

$$\frac{1}{Re_r}\left[\frac{\partial \tau_{xx}}{\partial x}+\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{x}}{\partial z}\right.$$

– Momentum:

$$\frac{\partial(\rho v)}{\partial t}$$

$$\frac{\partial x}{\partial}\quad\frac{\partial y}{\partial}\quad\frac{\partial z}{\partial}\quad\frac{\partial y}{\partial}$$

$$\frac{1}{Re_r}\left[\frac{\partial \tau_{xy}}{\partial x}+\frac{\partial \tau_{yy}}{\partial y}+\frac{\partial \tau_{y}}{\partial z}\right.$$

– Momentum

$$\frac{\partial(\rho w)}{\partial t}+\frac{\partial(\rho u w)}{\partial x}+\frac{\partial(\rho v w)}{\partial y}+\frac{\partial(\rho w^2)}{\partial z}=-\frac{\partial p}{\partial z}+\frac{1}{Re_r}\left[\frac{\partial \tau_{xz}}{\partial x}+\frac{\partial \tau_{yz}}{\partial y}+\frac{\partial \tau_{z}}{\partial z}\right.$$

nergy:

$$\frac{(E_T)}{}+\frac{\partial(uE_T)}{\partial x}+\frac{\partial(vE_T)}{\partial y}+\frac{\partial(wE_T)}{\partial z}=-\frac{\partial(up)}{\partial x}-\frac{\partial(vp)}{\partial y}-\frac{\partial(wp)}{\partial z}-\frac{1}{}\left[\frac{\partial q_x}{\partial x}+\frac{\partial q_y}{\partial y}+\frac{\partial}{}\right.$$

Open Problems

- Anomaly detection
- Data completeness
- Anonymous authentication

Questions?