A Blockchain Controlled Content Fabric

VSF Meeting, May 2019

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VSF
VIDEO SERVICES FORUM

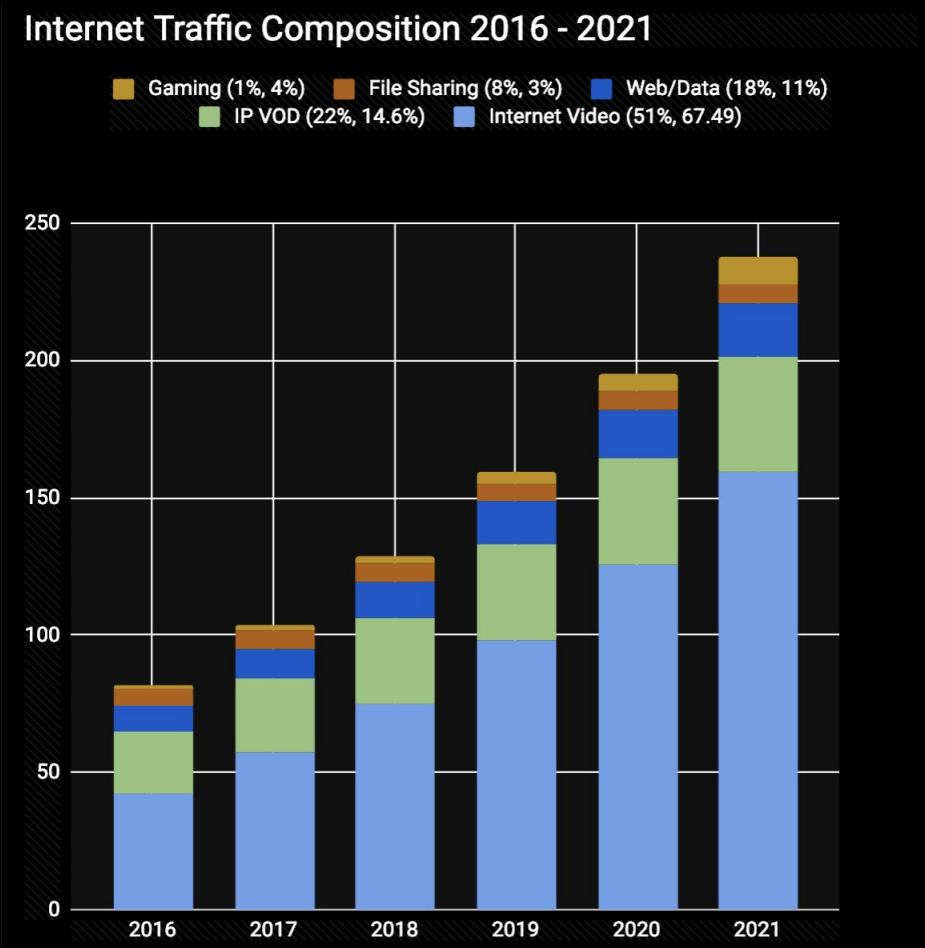
Introduction

April 2019

30th Anniversary of the World Wide Web

45 Years Since the first messages were communicated over the Internet Protocol (IP) .

The Internet, a 'network of networks' for host-to-host data is now a network for *video*...!



User Attention Outranks Data

Attention (is the) crucial resource of the digital economy…"

--Zenep Tufecki, Univ of North Carolina

(Not Data!)

Yet … Today's Internet was not Built for Video

- Distribution solutions are old & inefficient
  - 20 Year Old CDN technology
- User attention economy is not working well:
  - Viewers
  - Sponsors
  - Content providers
- Supply Chain is very complex

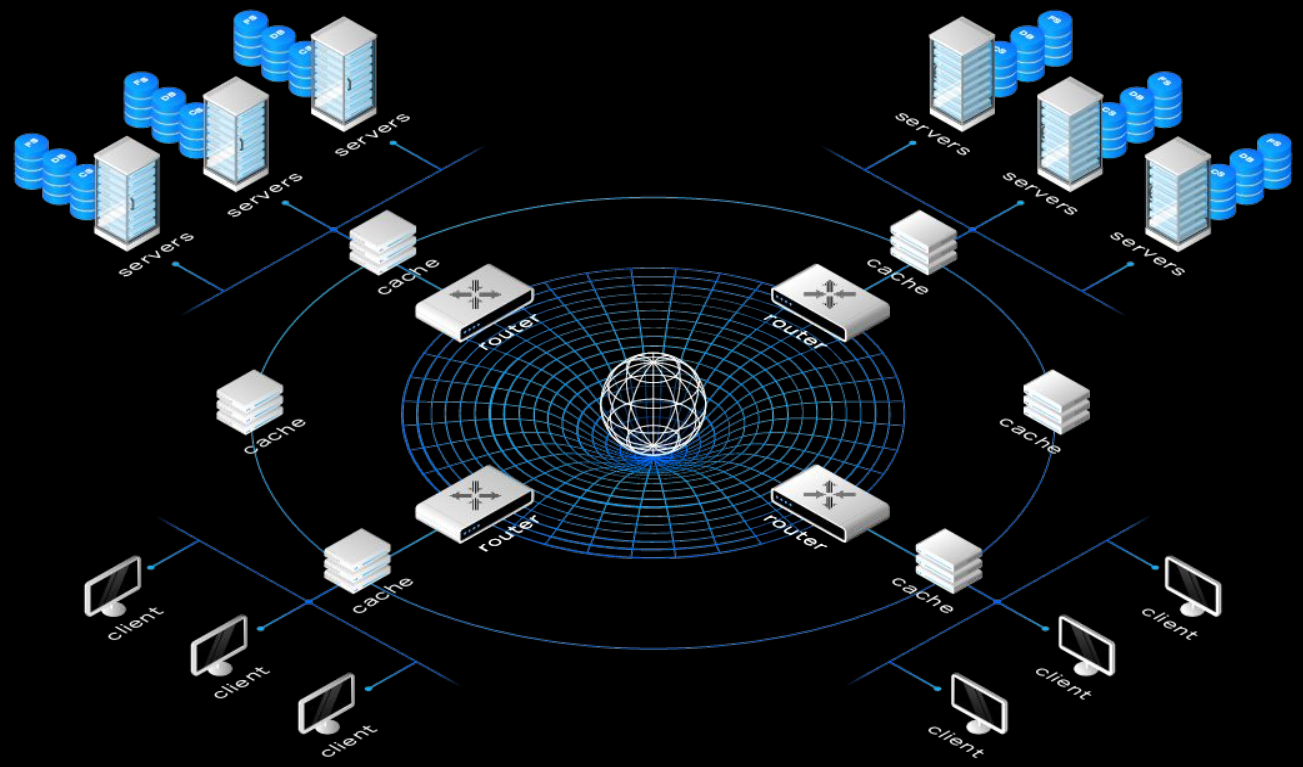
BUT …

- New Technologies have Emerged that can make a difference…
- Emergent Opportunity for *Content Centric* design

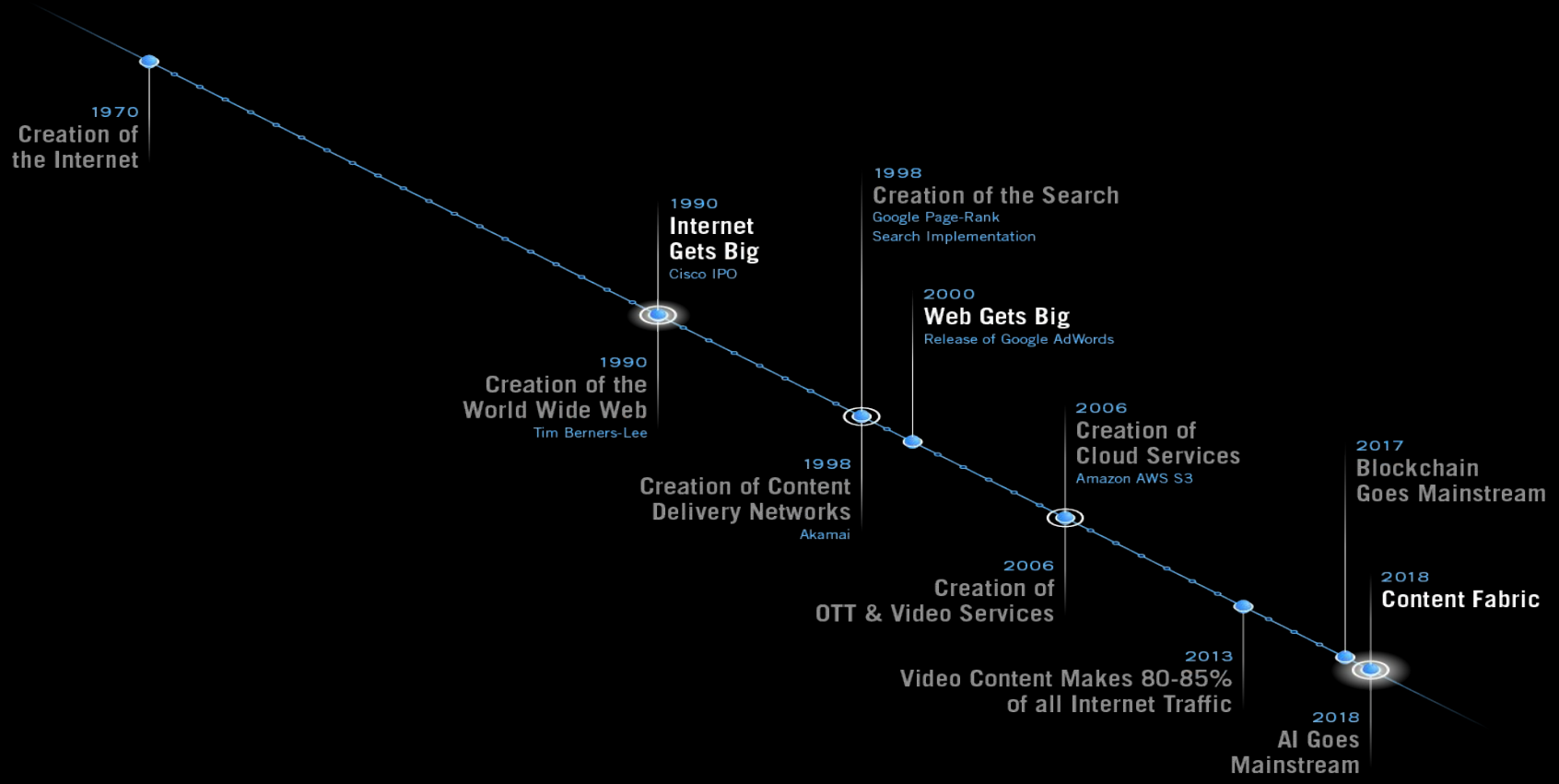
Video over the Internet

The Case for a New Content-Centric Design

Today's (Yesterday's) Content Distribution



Timeline of Content on the Internet



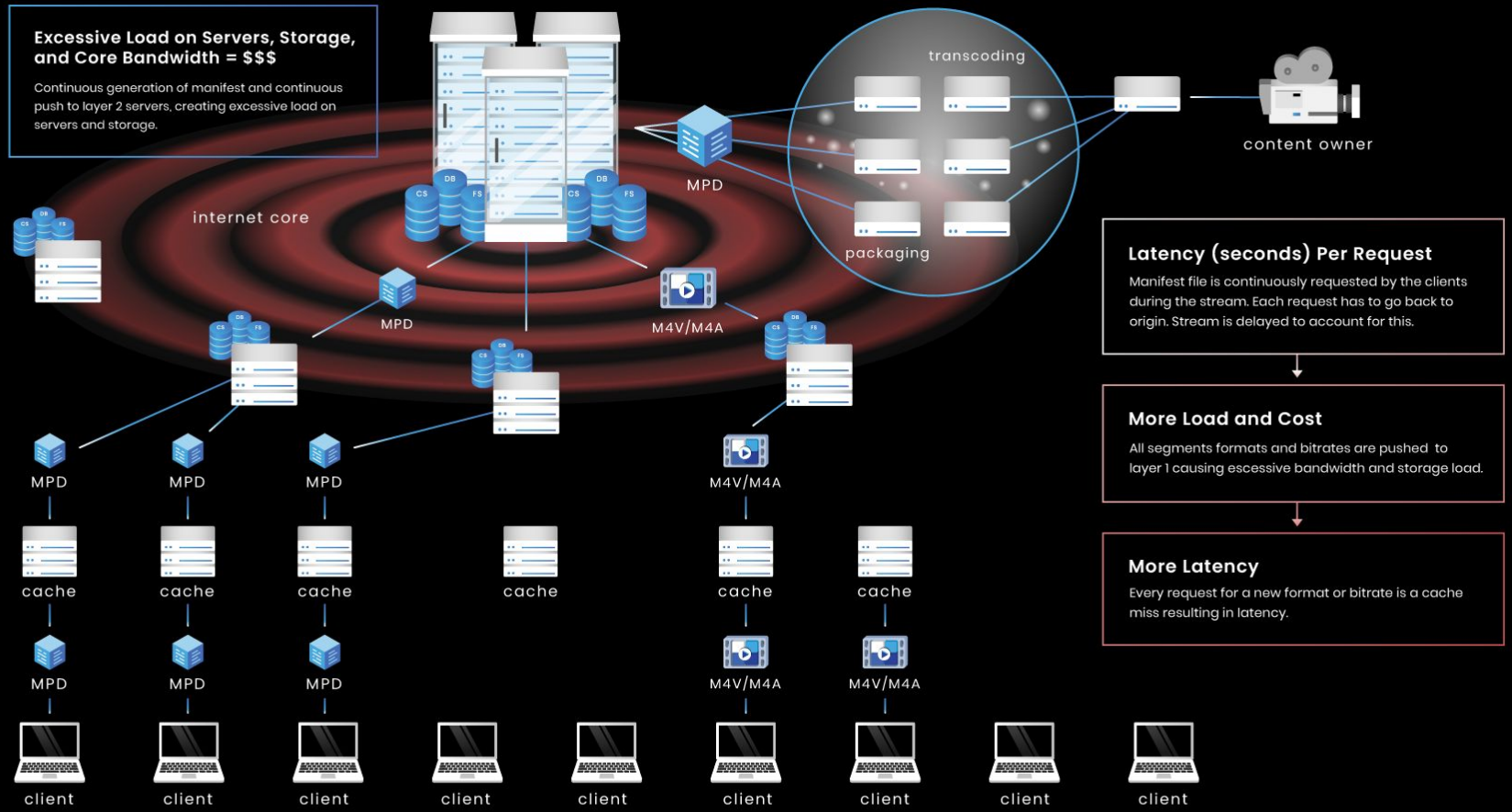
A single packet in a typical YouTube stream will “traverse the link between youtube.com and the user’s ISP millions of times …”

Jacobson, Van et al.
“Networking named content.” Communications of the ACM 55 (2009)

Typical Program for Digital Distribution

10+ Viewer Platforms (Mobile, Desktop, TV) x
12 Major Languages x
4 major DRM x
10 ABR resolutions
= 4800 “versions” !

Today's CDN


Excessive Load on Servers, Storage, and Core Bandwidth = $$$
Continuous generation of manifest and continuous push to layer 2 servers, creating excessive load on servers and storage.
internet core
transcoding
packaging
content owner
MPD
M4V/M4A
cache
client
Latency (seconds) Per Request
Manifest file is continuously requested by the clients during the stream. Each request has to go back to origin. Stream is delayed to account for this.
More Load and Cost
All segments formats and bitrates are pushed to layer 1 causing escessive bandwidth and storage load.
More Latency
Every request for a new format or bitrate is a cache miss resulting in latency.

User Attention Economy is Not Working Well

- 98% of digital advertising revenue accrues to 2 companies
  - Google, Facebook
- Digital/online advertising is broken
- Users don't have control over their data & UX is bad
- Sponsors can't get RoI on their digital advertising investment
- Content owners struggle to be profitable without an Internet distribution ecosystem
  - "Internet companies" are turning other profits to content production

Supply Chain is Very Complex

- Many silo'd vendor solutions that don't work together
- Separate digital on demand and linear broadcast businesses
- Different DRM for every device
- Physical security rather than content security
- Sales contracts and fulfillment ("availability") are separate
- Rights management is bespoke / manual
- Multi-CDN (and increasingly multi-cloud) workflows are the norm

Opportunity for a ‘Content Centric’ Solution

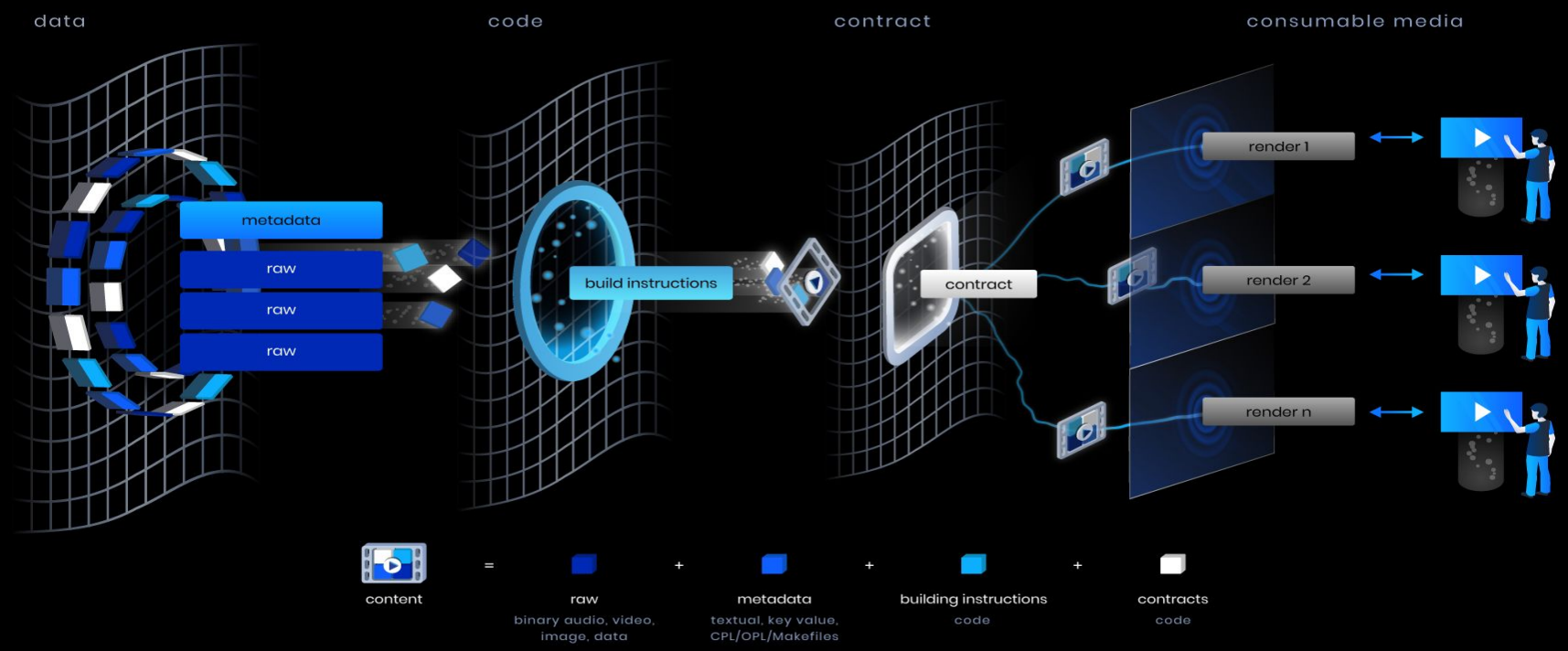
- Content-centric design originated with Van Jacobson
  - Originally focused on routing core
  - Now possible to extend and scale, via new tech:
- Machine / Deep Learning
  - Scalable Content Routing, Content Identification and Tagging
- Blockchain Ledgers & Decentralized Data
- Advanced Cryptography
- Low Cost Compute
  - CPU, GPU, TPU
- Abundant Edge Bandwidth (and SDN!)
  - e.g. 5G, 1-20 Gbps

A “Content Centric” Solution

Design Principles

- High performance, open software network, extending infinitely
- Content is a primary resource
  - Efficiently represented, stored, routed and output
- Core bandwidth and storage are minimized
  - To minimize cost
- Consumable media is built just-in time
  - For efficiency and personalization, with metadata
- Content transformation and transport are integrated
  - Pipelined and built for low latency and performance
- Content access is blockchain controlled
  - For flexible monetization, transparent user data sharing, auditable reporting
- Content is protected from the infrastructure and provable
  - Versions are recorded (with proof) in the ledger

Fabric Technology

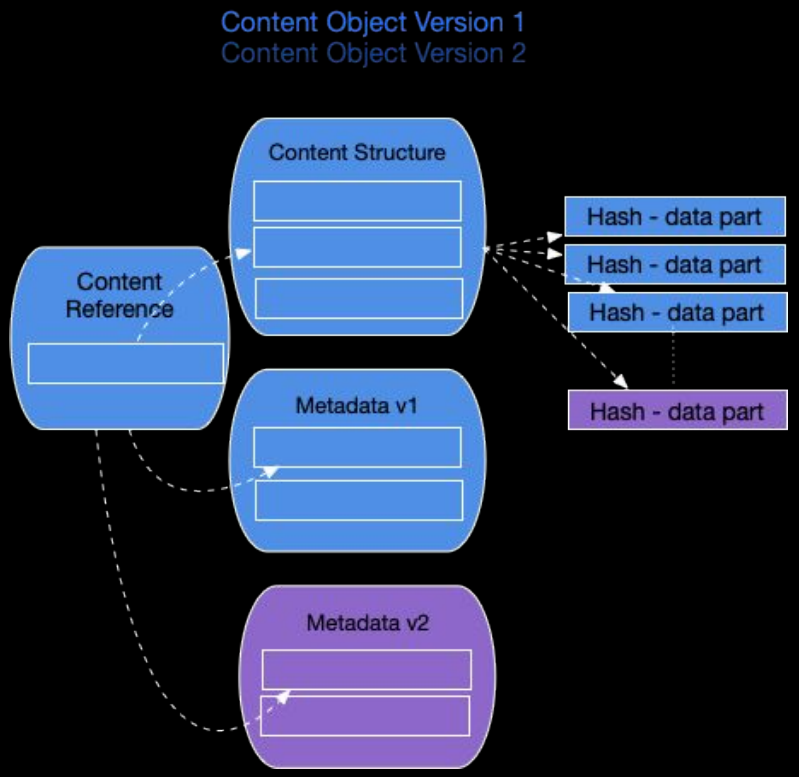


Technology

- Software overlay network with three functional layers:
- Data Layer
  - Stores and manages large form content
- Code Layer
  - Transforms and delivers consumable media
- Contract Layer
  - Controls content access with software contracts and protects and proves content

Data Layer

- Stores and manages large form content
- Decentralized, deduplicated novel distributed data structure
  - Multiple replicas
  - Infinitely scalable
  - Fast lookup
- Minimizes network traffic, eliminates file copies



Grows 1000x without Moving Parts

Partition: `0f 1a 66 aa 4d 5e 6f 7a ab bc cd de ef 76 e3 a8 44 98 b4 c5 11 00 ...`

Node ID: `0f 1a 00 00 …`

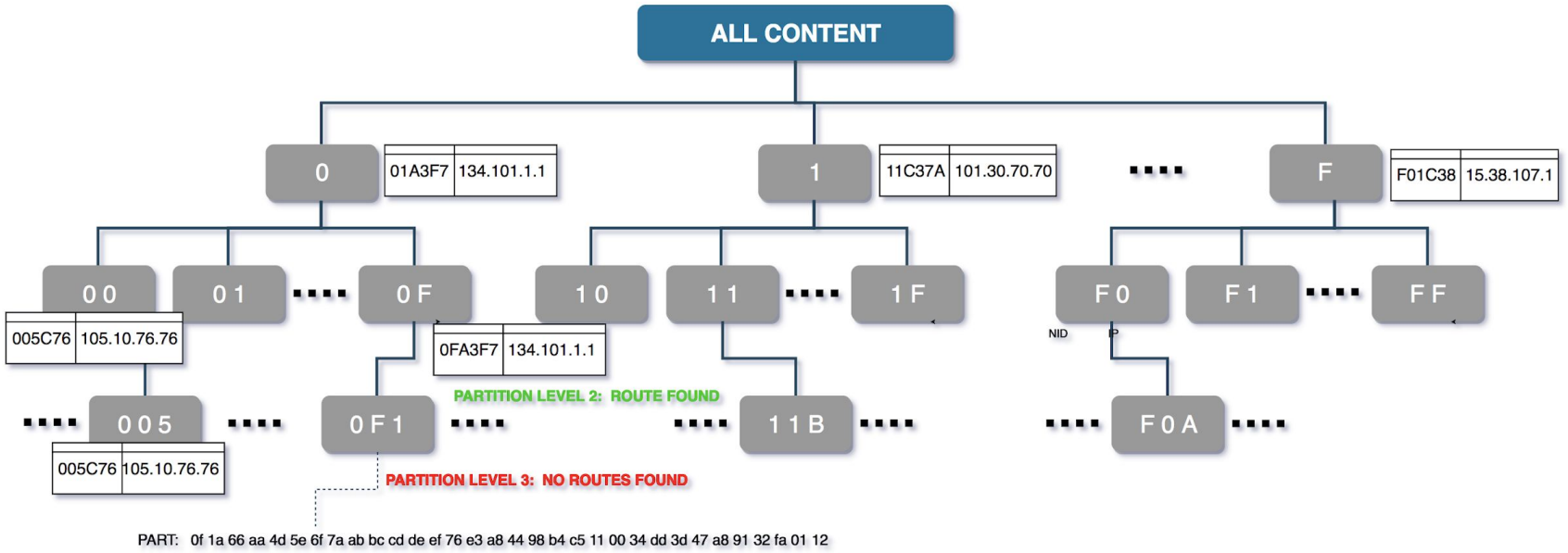
Each Partition has 6 Replicas

At level 6 the partition ID and node ID diverge and the partition is shed and assumed by a new node :

`XOR ( 0f 1a 66, 0f 1a 00) >> 6`

The data part will stay on the same node as the network grows 16 x 16 x 16 = 4096 times

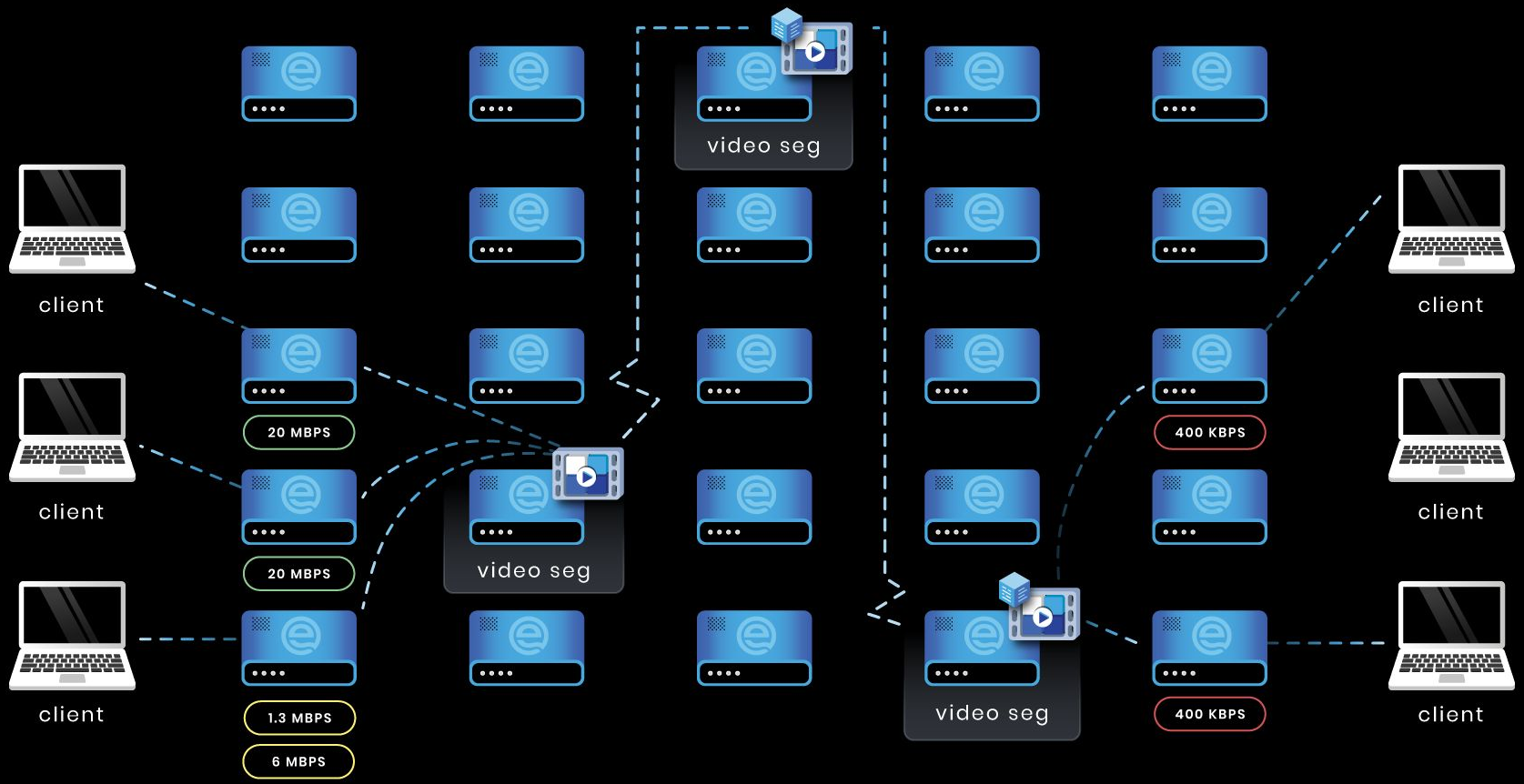
Finds Data Parts in <1 RTT (in), 1 RTT (out)



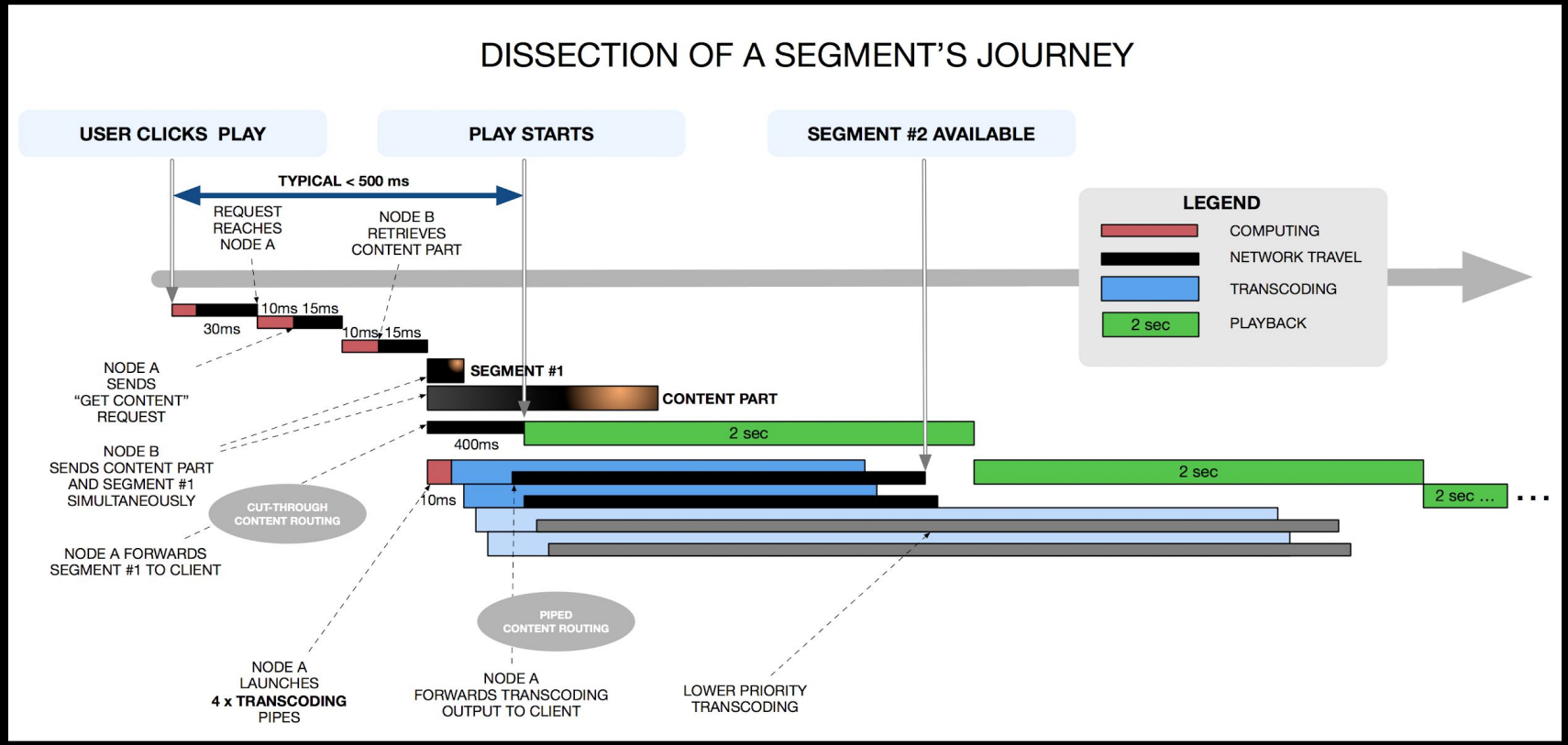
Code Layer

- Transforms and delivers consumable media in a single fast pipeline
  - Ultra low latency start up
  - Predictable quality
  - Scalable to mass audiences
- Routes content requests instantly
  - Via continuous machine learning, choosing highest bandwidth, lowest latency paths
- Automatically tags content via ML/DL
  - Content Classification and Object Identification
  - Entire program, per time period, and frame level
  - And reads 3rd party/manual tags
- Generates consumable media “just in time” on user request
  - Programmable, combining media, metadata, code and contracts
  - Dynamic, personalized output

Just-in-Time Composition & Dist.

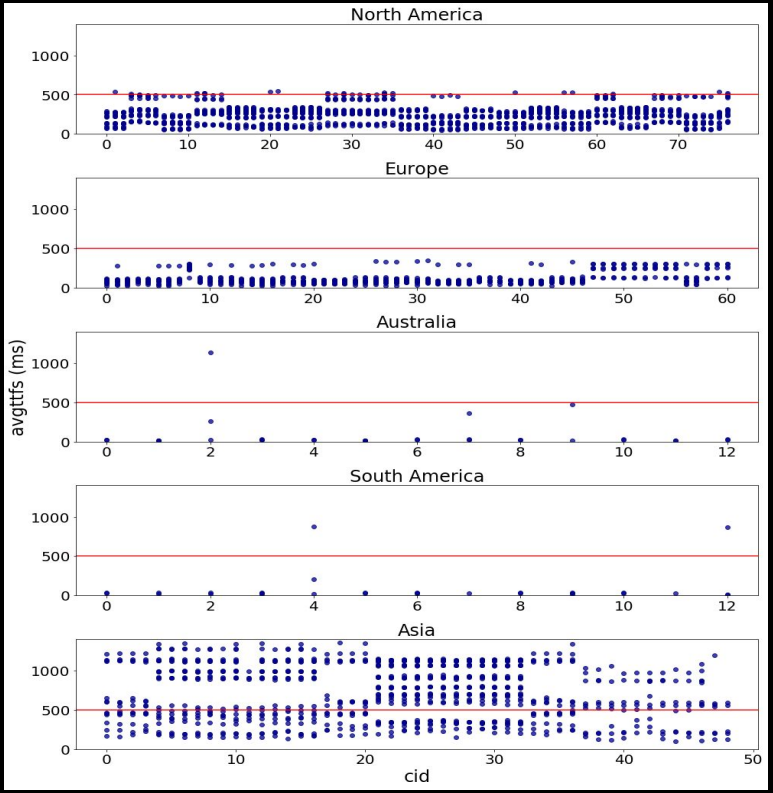


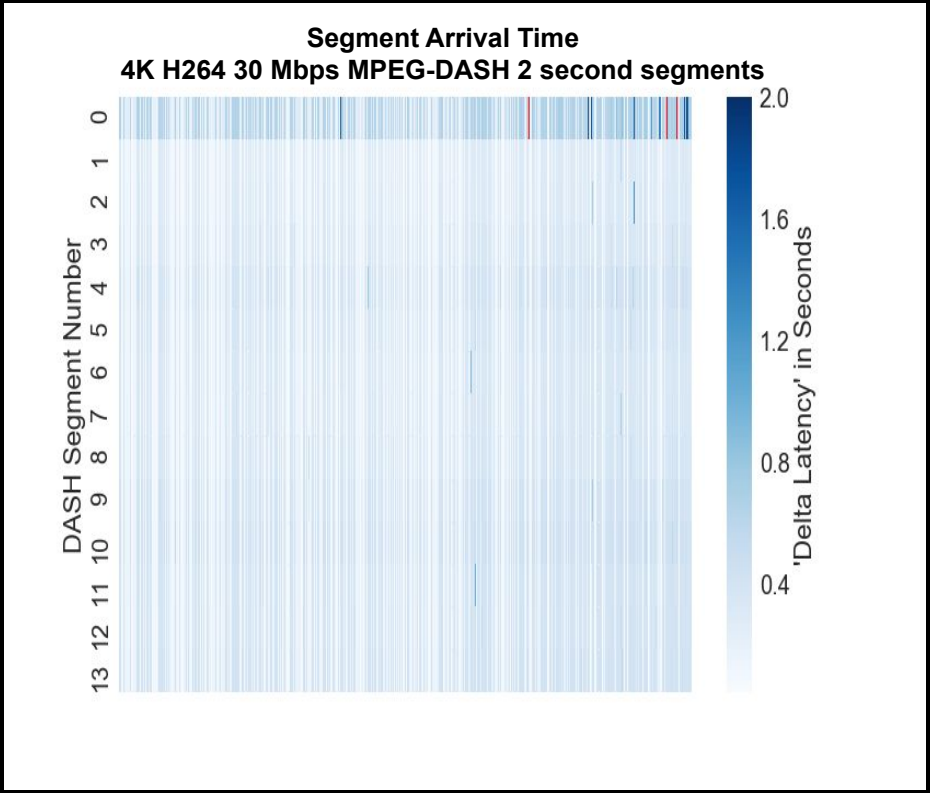
Transcode & Transport Pipeline ("AVPipe")



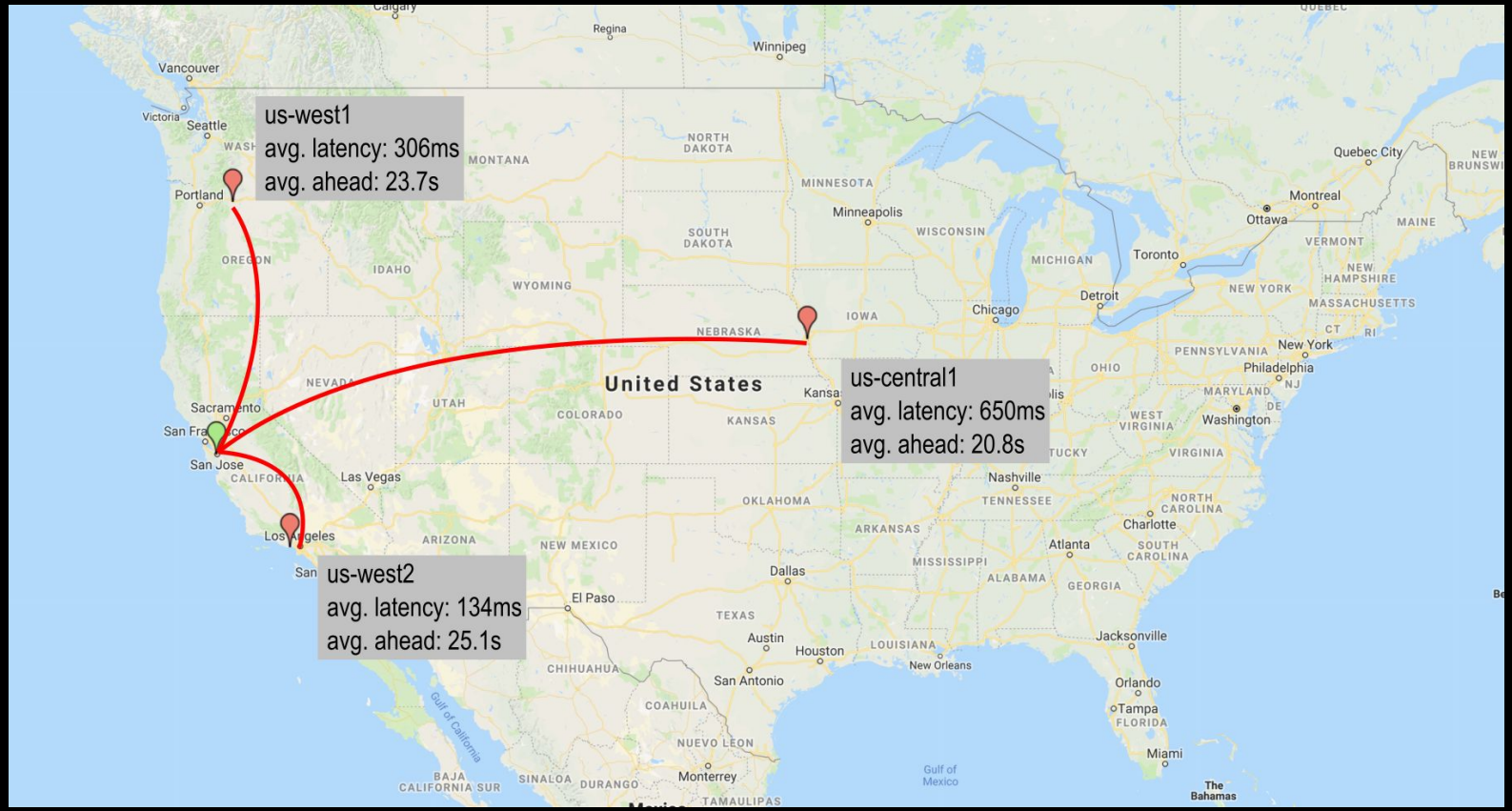
ML Content Routing + AV Pipe :

Predictable Segment Arrival Ahead of Play





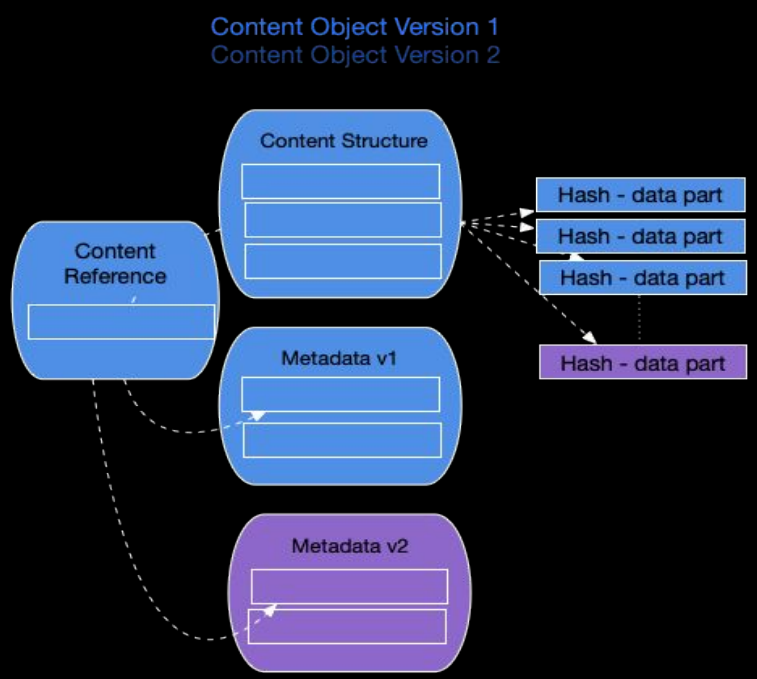
Client Experience …

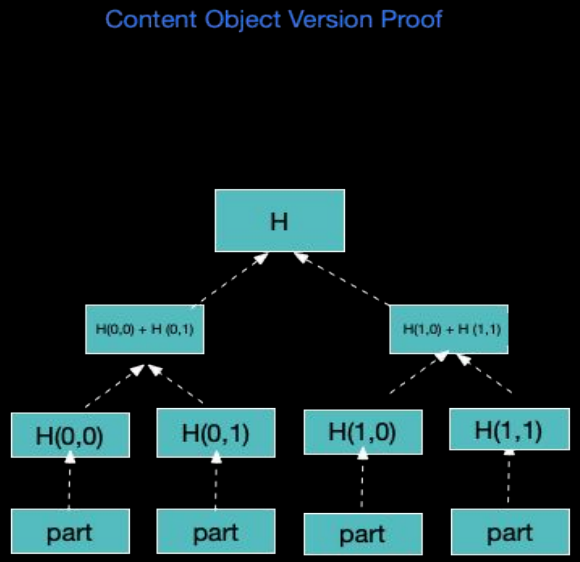


Contract Layer

- **Controls content access via a fabric blockchain ledger**
  - With software contracts for monetization
  - Any content access goes through a contract transaction
- **Protects content and user data from the infrastructure**
  - Accessed content is re-encrypted using trustless security
  - User data is protected in a cryptographic wallet & offered transparently
- **Proves all “versions” cryptographically**
  - Recording version and access history in the ledger
  - Records and compensates contribution of work by nodes (tx, delivery, store)

Versioning and Proofs of Content





‘Tampered’ Content fails!

Content Verification Info - VERIFIED!


```
{
 "hash": "hq__QmQedd9AuQSdoBjMzNUVp7BaqWRXAJiJGAdcLXLWWKyqiV",
 "qref": {
  "valid": true,
  "hash": "hqp_QmQedd9AuQSdoBjMzNUVp7BaqWRXAJiJGAdcLXLWWKyqiV"
 },
 "qmd": {
  "valid": true,
  "hash": "hqp_QmU4wn795KbSGvTH2uki6UwWT1xbv1yqDCM7bEdweYiad8",
  "check": {
   "valid": true,
   "invalidValues": []
  }
 },
 "qstruct": {
  "valid": true,
  "hash": "hqp_QmSHqXe9cr5EtgsYcg7dP9irZ4MHsTFo4Rc5e4hh8oHfPT",
  "parts": [
   {
    "hash": "hqp_QmUv75ETf9x22cjNNbTncVPMuKZpXLPHF7tVz2D9AChqD",
    "proofs": {
     "rootHash": "acda1564dfc542064b7becdbc2d107c84fe1f942337bfe3c06f2b4eec5e806b8",
     "chunkSize": 49,
     "chunkNum": 49,
     "chunkLen": 50,
     "finalized": 116
    },
    "size": 2634
   },
   {
```


Content Verification Info - FAILED!


```
{
 "hash": "hq__QmZ7oxvpECVgvED7QwMHgmKZGpEEoHkRhHWo2NNpeFZV2e",
 "qref": {
  "valid": true,
  "hash": "hqp_QmZ7oxvpECVgvED7QwMHgmKZGpEEoHkRhHWo2NNpeFZV2e"
 },
 "qmd": {
  "valid": true,
  "hash": "hqp_QmPaddxjFwCc9TPAg652MSRoV9iada8gjB1FSR2wKadbGf",
  "check": {
   "valid": true,
   "invalidValues": []
  }
 },
 "qstruct": {
  "valid": false,
  "error": "Hashes do not match",
  "hash": "hqp_QmUfPJ4ehcbi17fH26QvwY6ViFhACaMsENyvxyptdBPq4T"
 },
 "valid": false
}
```

What Can We Do with a Media Platform on such a Fabric?

Fast, Low Latency, Highest Quality (low cost)

SCALE DEMO W/ 3RD PARTY NODES

Hosts: 2-Eluvio, 2-3rd Party

Transcoding: 10 titles finishing in ⅓ the playout deadline

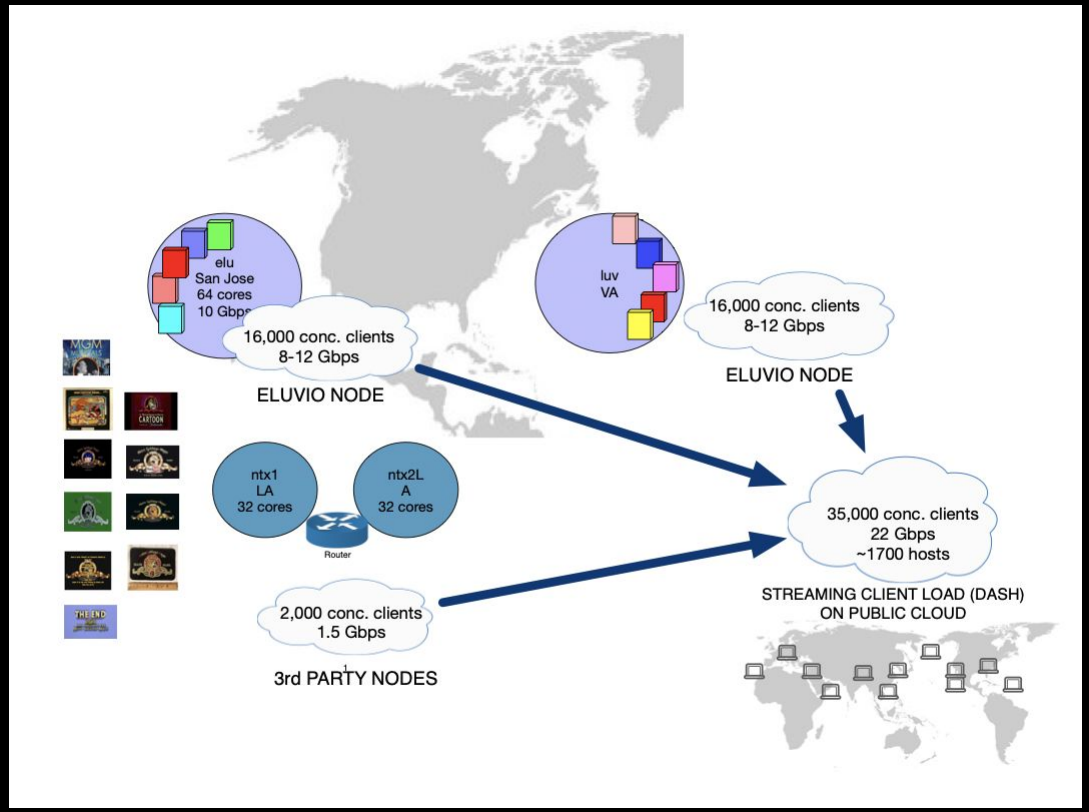
Core Bandwidth: ~100 Mbps

Edge Bandwidth: ~22 Gbps

Concurrent Clients: 34,000

Headroom Conc. Clients: >100,000

Bottleneck: Client Load, Edge BW



Simplified Supply Chain

- **One Platform for B2C and B2B, on-demand, linear, live**
  - DEMO
    - One Program: Linear Channel, VoD, OTT Retail Partners
- **Multiple versions from one mezz. source**
  - DEMO
    - Multi-language versions from mezz source and instant repair of bad tracks
    - 3rd Party Metadata stored and re-usable across all workflows
- **Release availability (“avails”) can be managed in place**
  - DEMO
    - Singles source, different availability windows for retail partners

New Monetization and Programming

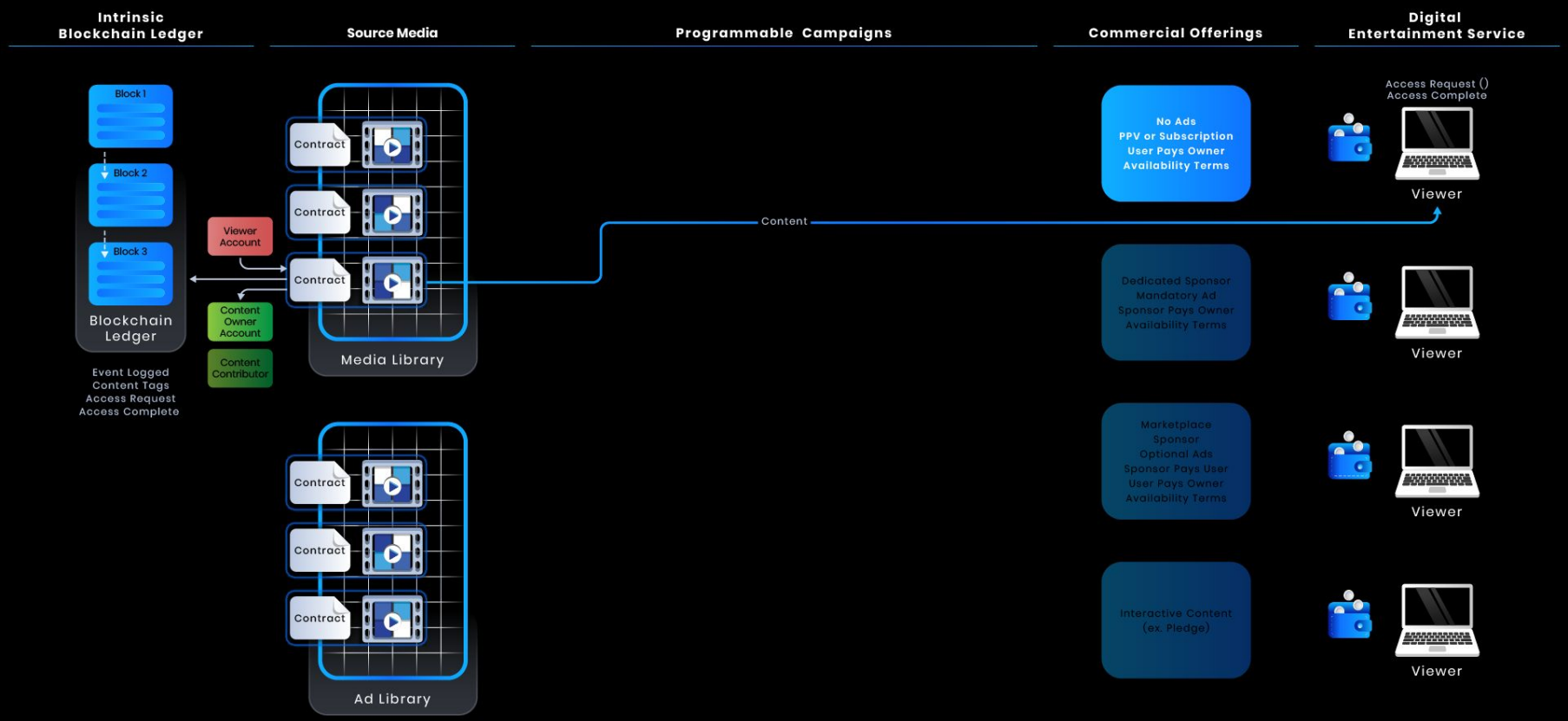
- Content and Advertising are personalized w/provable audience
  - DEMO
    - Linear Channel with Dynamic Regional Content
- Internet Scale Marketplaces of content, user engagement, sponsorship
  - DEMO
    - Pay per View/Subscription
    - Dedicated Sponsorship
    - Open Marketplace Sponsorship
    - Special/Interactive Sponsorship
- Archive content can be monetized in novel ways
  - DEMO
    - Automatic identification of objects/content, search, clip and download, etc.
- Counterfeit Free Original Content

Content Monetization

Intrinsic Blockchain Ledger	Source Media	Programmable Campaigns	Commercial Offerings	Digital Entertainment Service
Block 1 Block 2 Block 3 Blockchain Ledger	Contract Contract Contract Media Library		No Ads PPV or Subscription User Pays Owner Availability Terms	Viewer
			Dedicated Sponsor Mandatory Ad Sponsor Pays Owner Availability Terms	Viewer
	Contract Contract Contract Ad Library		Marketplace Sponsor Optional Ads Sponsor Pays User User Pays Owner Availability Terms	Viewer
			Interactive Content (ex. Pledge)	Viewer

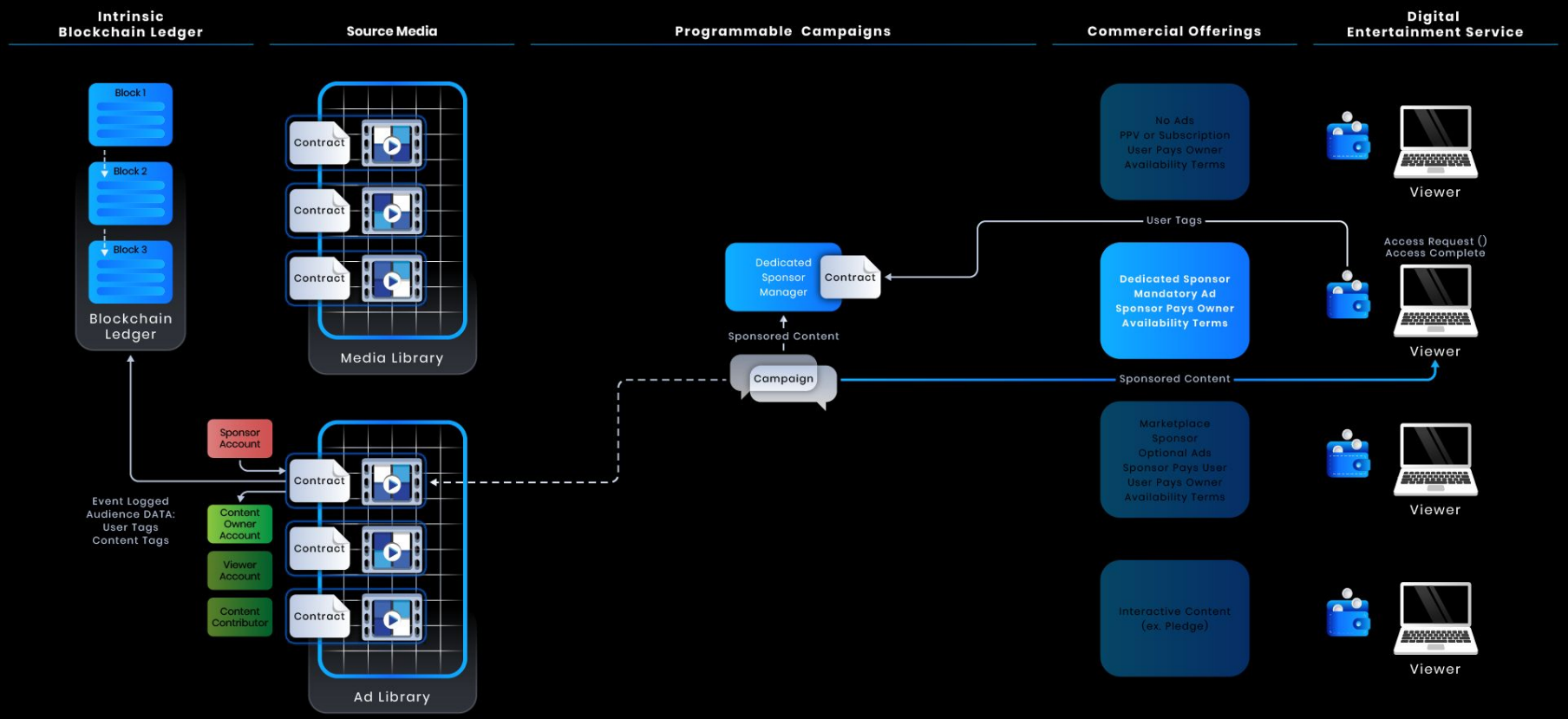
Content Monetization

Pay Per View/Subscription (No Ads)



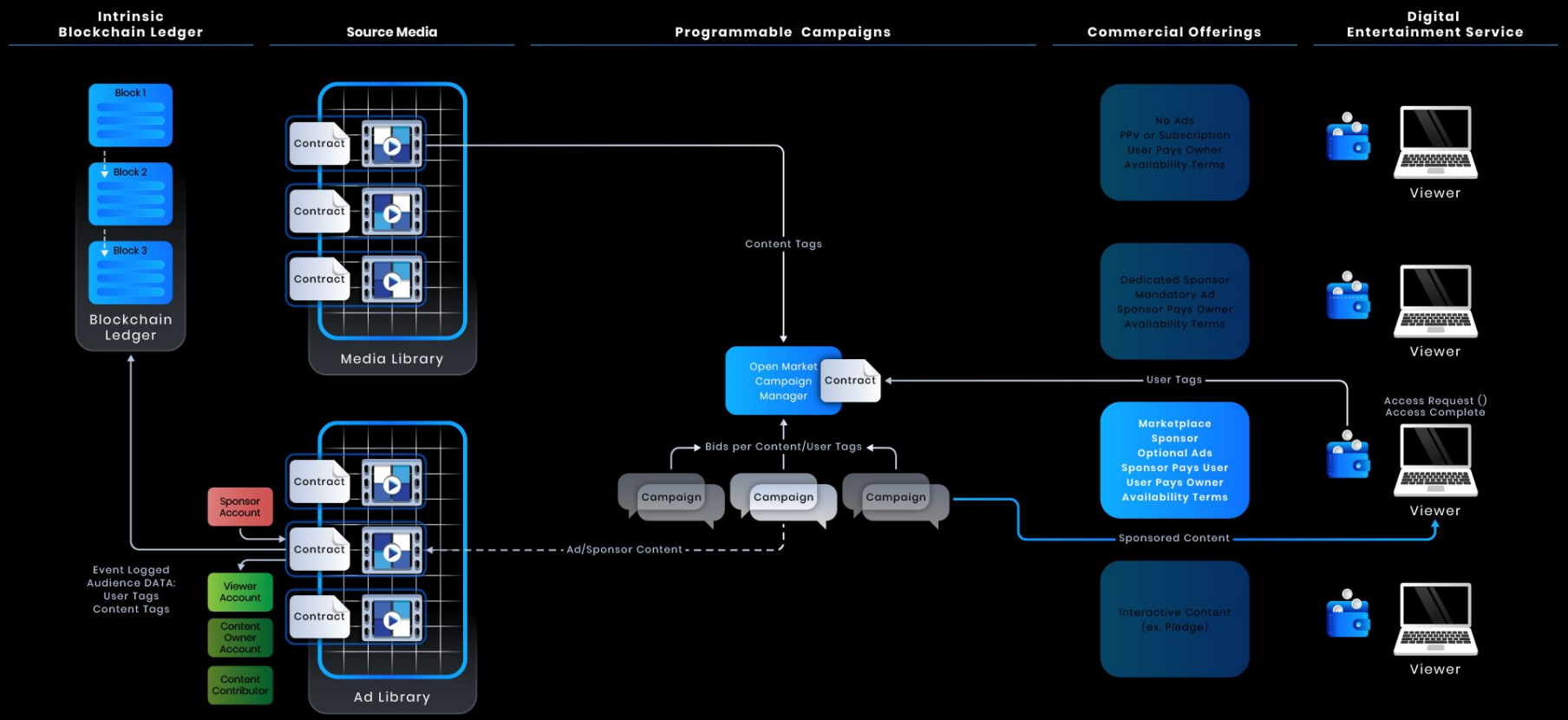
Content Monetization

Dedicated Sponsorship



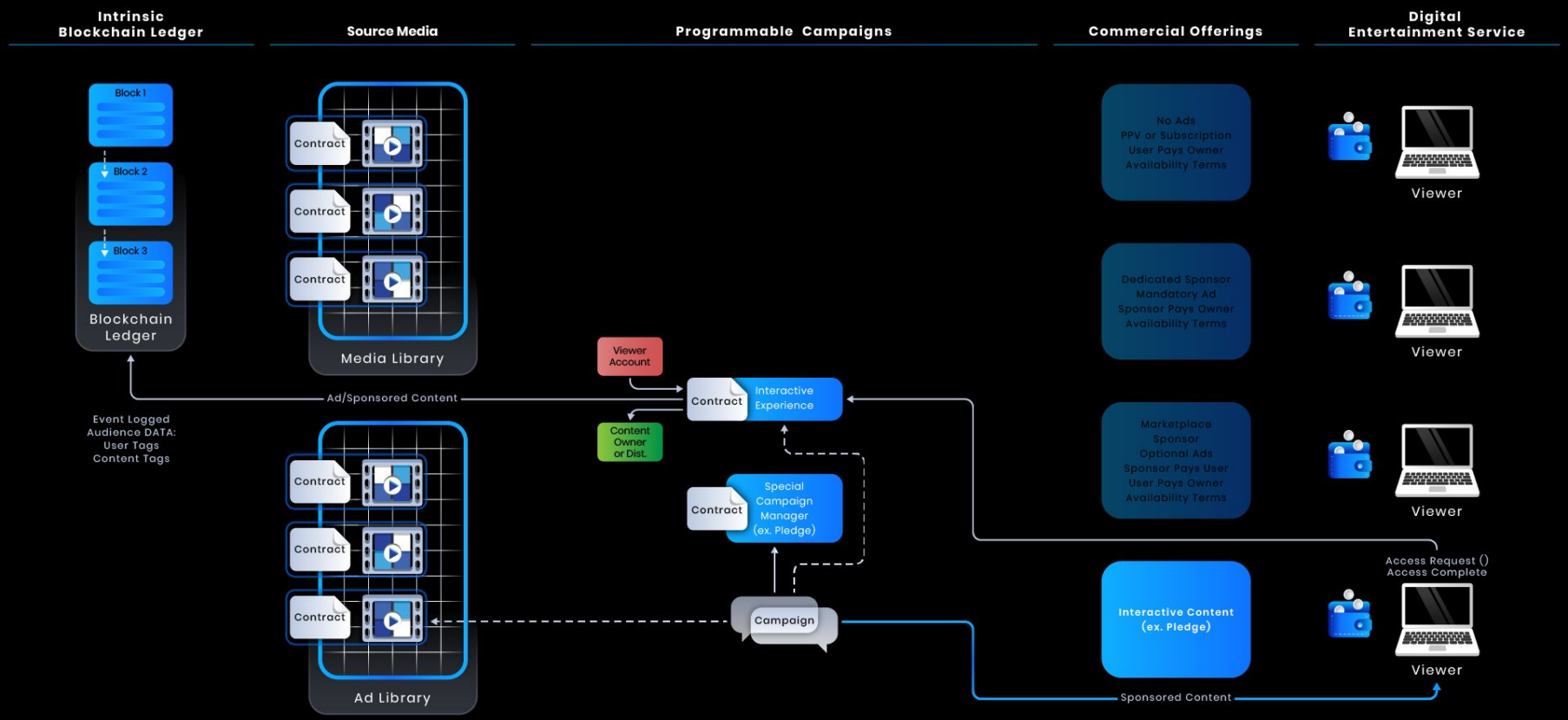
Content Monetization

Open Market Sponsorship



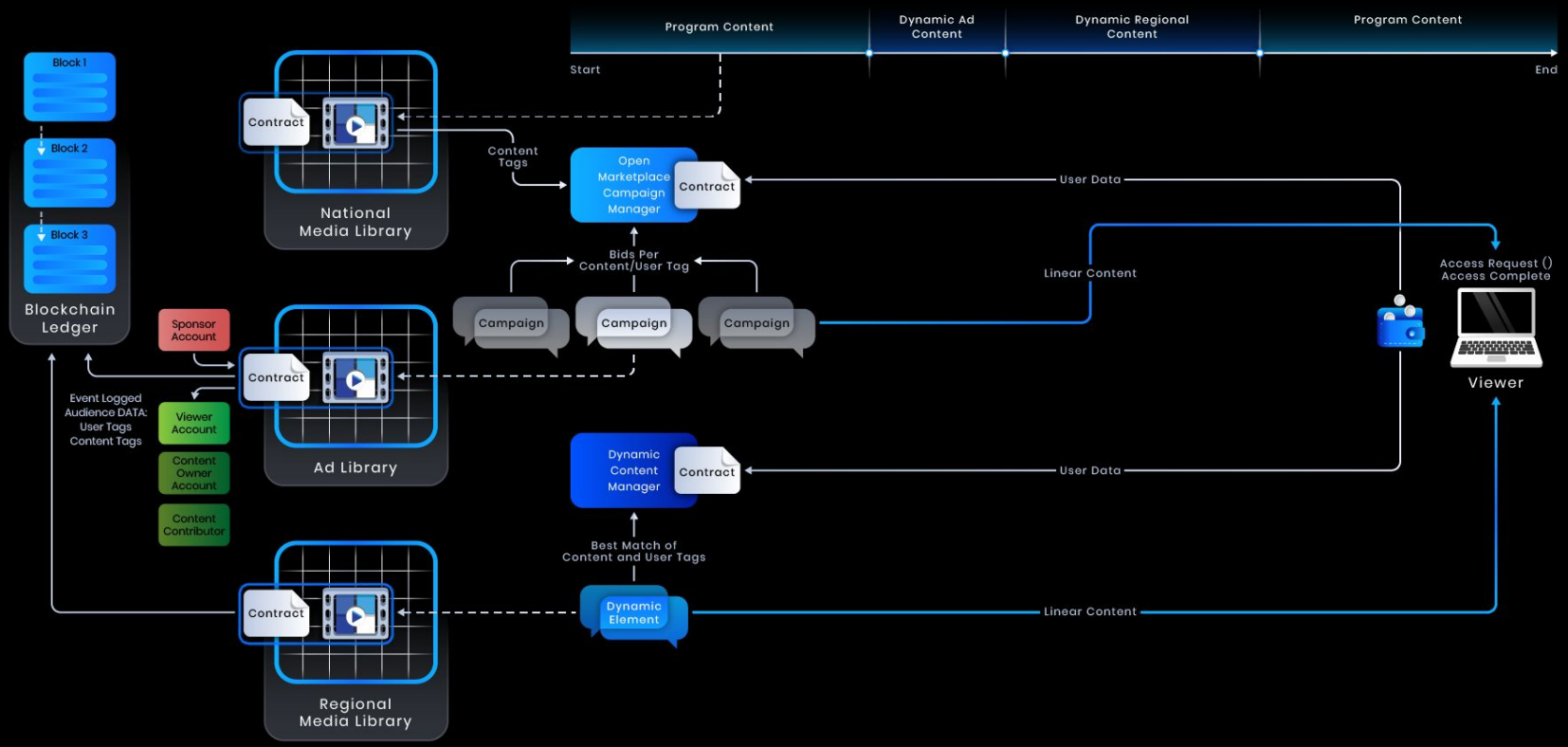
Content Monetization

Interactive Sponsorship



Content Personalization

Linear Channel



Breakthrough Cost Savings

- Hyper efficient architecture
  - Minimizes servers, storage and core bandwidth
- Distributors can offset distribution costs by contributing nodes to run the fabric
  - DEMO: node reporting through the blockchain
- Infrastructure can scale infinitely unlike today's clouds

Conclusion

Inflection Point for the Internet

- Content is dominant
- Video is the primary form of human communication
- Opportunity to further Internet communication and veracity
- Opportunity to re-balance in the digital content “economy”
- Possible through new technologies that are emergent
- Broadcasters can benefit and lead:
  - As content owners
  - As federations of stations
  - In their mission - in service to their viewers