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Powering the Internet Video Economy SM

Media Fingerprinting for Content Identification

OMA Meeting - Osaka, Japan
October 21, 2008

Creator of
VideoDNA™

Background

What's Media Fingerprinting

- A media fingerprint is some signature data *extracted* from the media data
  - Media can be text, audio, video, image…
  - Media fingerprints are often just string of bits to be read and processed by machines
  - Media *fingerprinting* refers to the process of extracting the fingerprints from the media, as well as the technology in general
  - Most notable development to date has been in video and audio fingerprinting, driven by industry demands

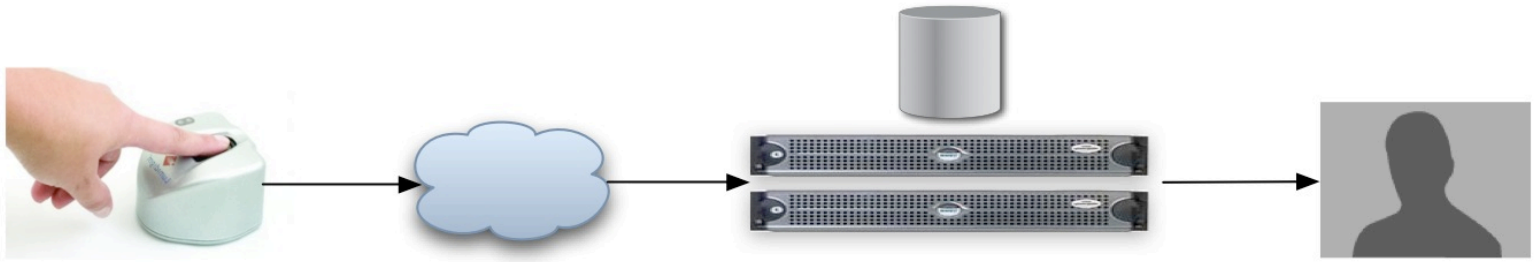
Human vs. Media Fingerprint

Human Fingerprint	**Video Fingerprint**
Uniquely identify human	Uniquely identify video
Physical form	Digital form
Pictorial	Time-based binary

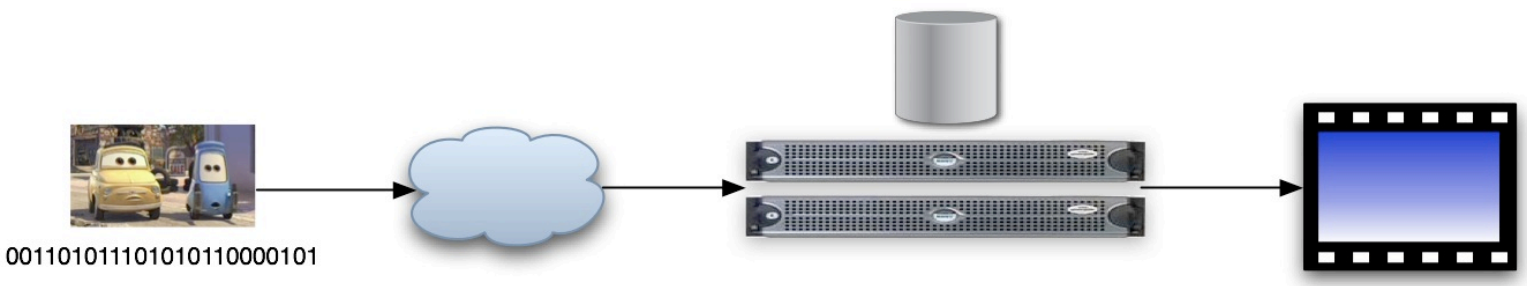
Why Fingerprinting?

- Content Identification (CI)
  - Copyright protection
  - Metadata services
  - Content distribution tracking
  - Content filtering
  - Asset management
  - Content-based search
  - Contextual advertising

Human vs. Content Identification



Human identification



Video identification

Driving Forces

- Two major applications driving technology development in the last few years:
  - Copyright enforcement in P2P and UGC services
    - BitTorrent and eDonkey
    - YouTube and other video sharing sites
  - Metadata services in digital music and video products
    - iTunes/iPod
    - Mobile entertainment devices

UGC & P2P – copyright concerns?

UGC

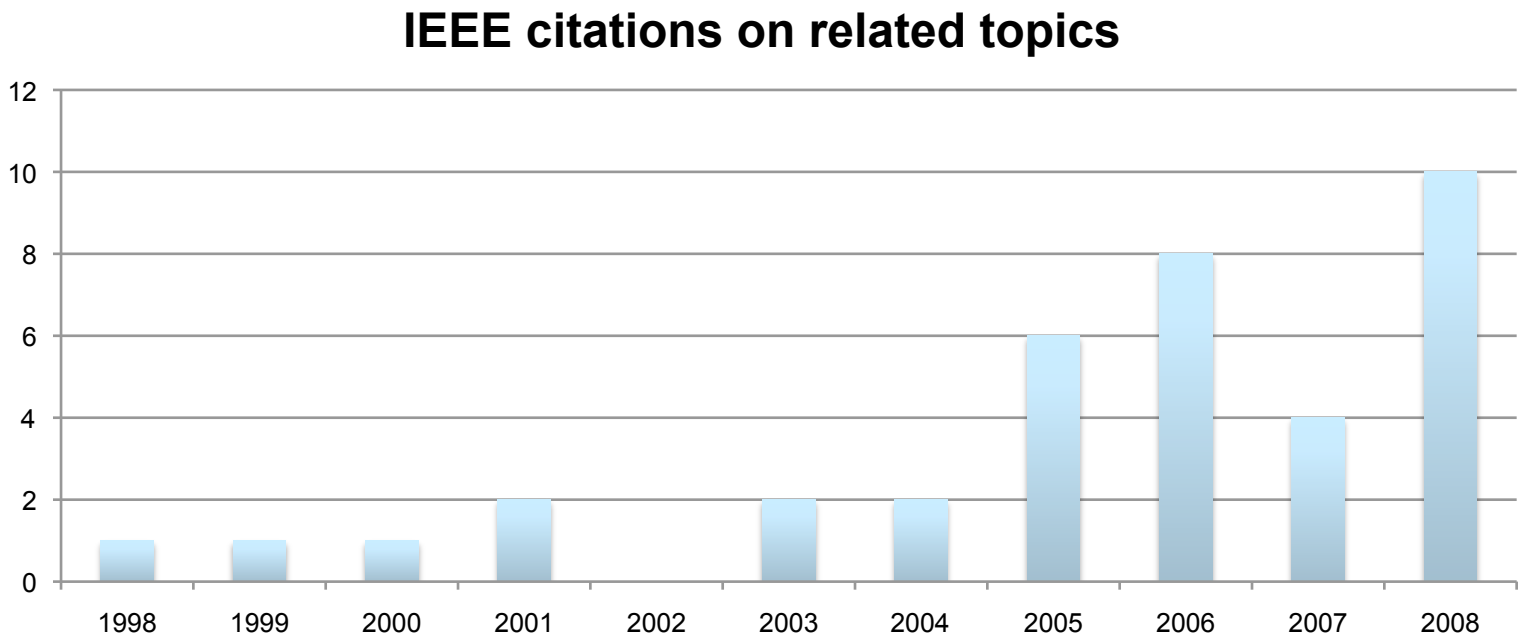
P2P

- UGC Traffic in 07/2007 (*Source: comScore, November 30, 2007*)
  - 70 million people viewed 2.5 billion videos on YouTube.com (39.4% of total UGC audience)
  - 38 million people viewed 360 million videos on MySpace.com (22.6% of total UGC audience)
- P2P Traffic 2007 (*Source: iPoque, November 28, 2007)*
  - Average 50-60% total Internet traffic: 49% in Middle East; 83% in Eastern Europe.
  - BitTorrent 66.7%, eDonkey 28.6% of total P2P traffic

Technology

Research Activities

- Earliest research work dates back to 1998-1999
- Research activities picked up in the last few years

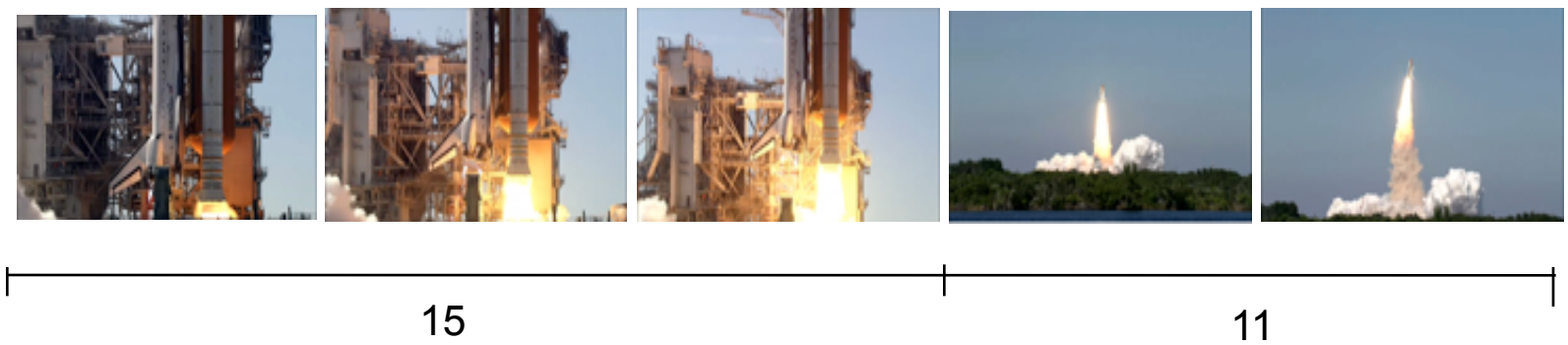


Elements of A Fingerprint

- Video
  - Features
    - Spatial signature
    - Temporal signature
    - Color, e.g., histogram
  - Granularity
    - Key frames only
    - Reduced frame rate
    - Every frame
- Audio
  - Features
    - Frequency signature
    - Temporal signature
  - Granularity
    - Audio “frame”
    - Reduced temporal sampling rate

An Example of Video Fingerprint

(N. Shivakumar, Stanford University, 1999)

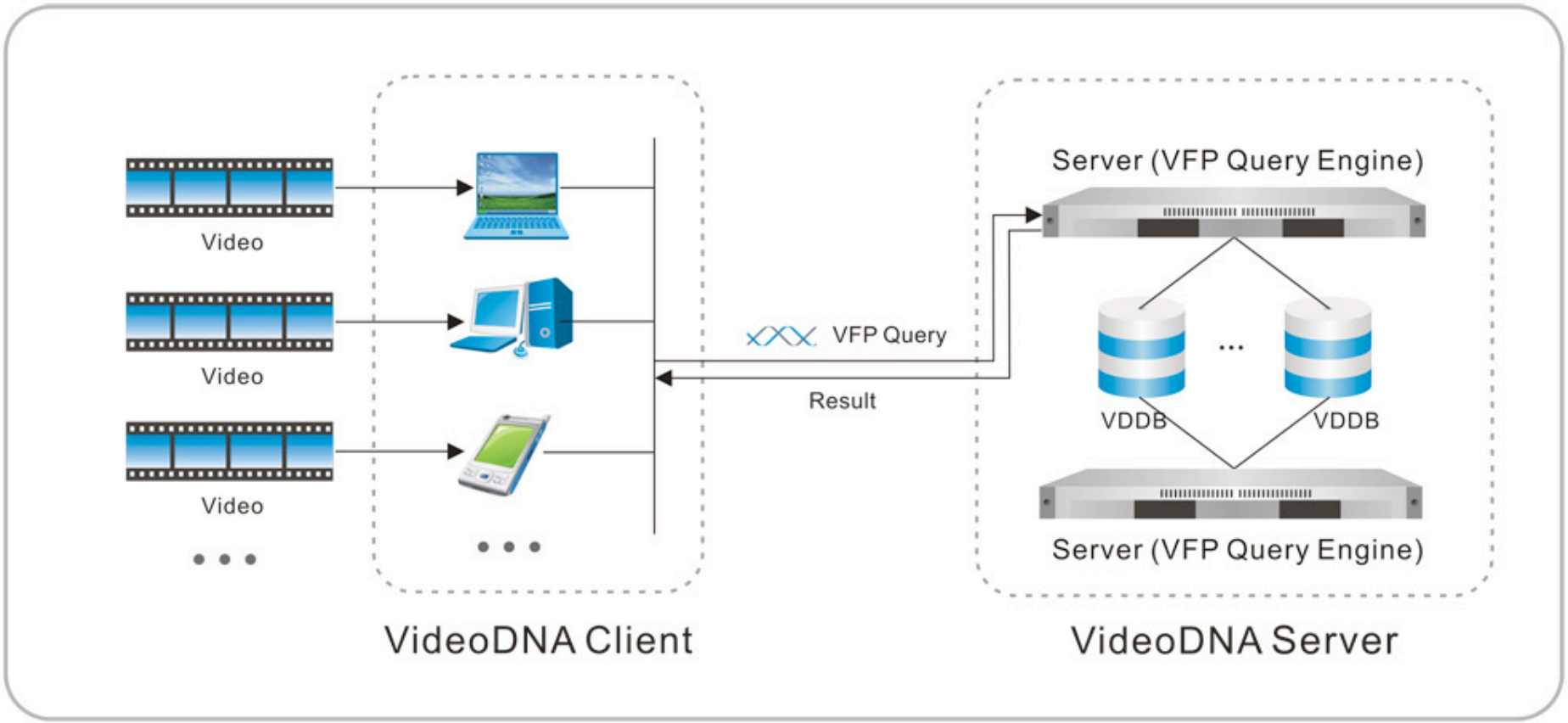


- Use shot duration sequence as fingerprint
  - Special kind of temporal signature
  - Non-constant fingerprint data rate
  - Robustness may be undermined by shots that are missed or detected inaccurately.
  - High complexity for matching due to irregular signature data

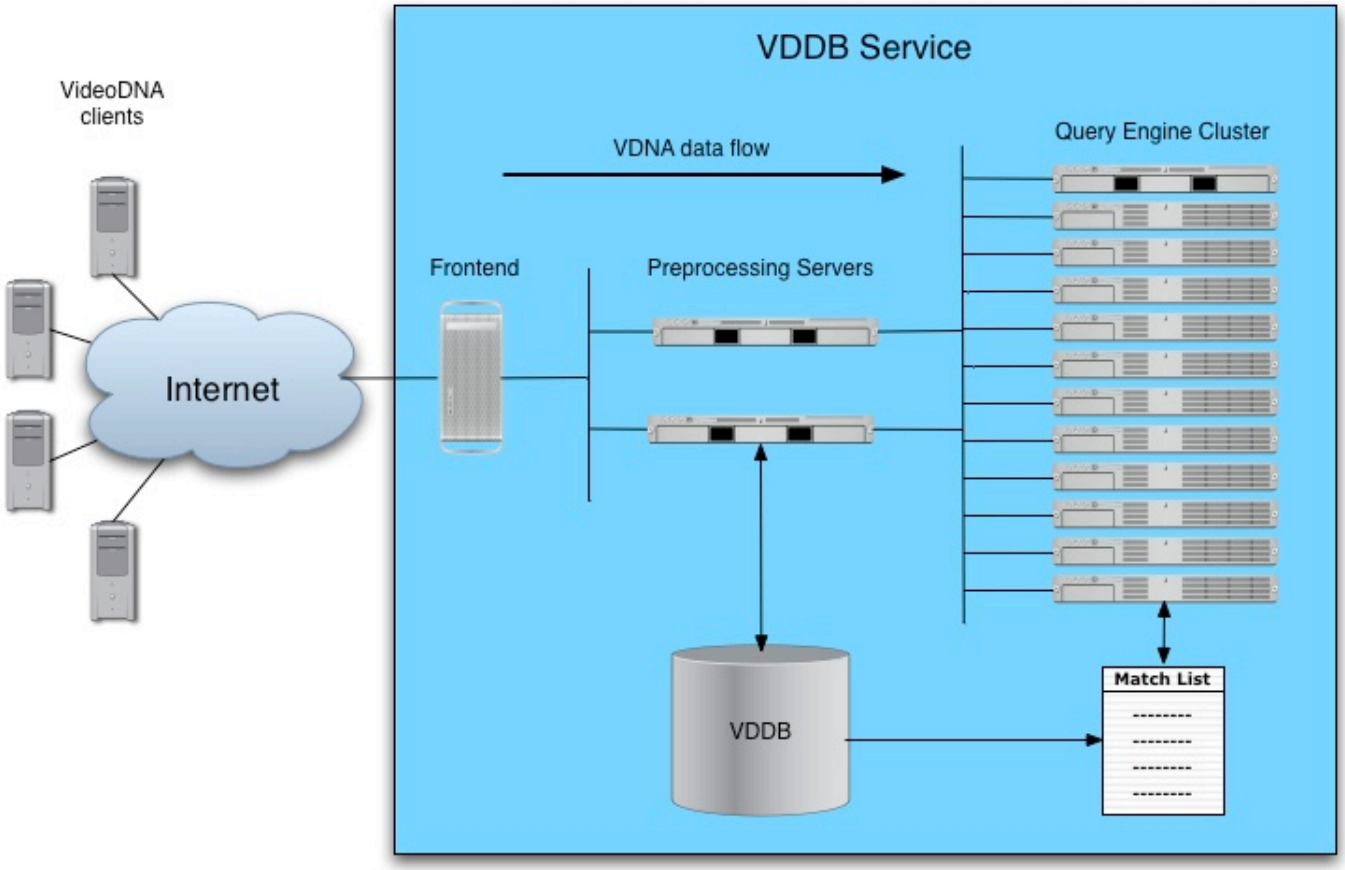
Major R&D Topics

- Robustness (FN, recall)
- Discriminability (FP, precision)
- Compactness (Storage & transmission)
- Identification speed (Query)
- System scalability
- Integrated A/V fingerprinting and identification

An Exemplar System – VideoDNA™



VideoDNA™ Query Processing



System Performance

- Fingerprinting
  - Data size:
    - 15 Kbps uncompressed for both audio and video
    - < 10 Kbps compressed
  - Speed
    - Video: < 1/10 playback time (10x RT)
    - Audio: < 1/40 playback time (40x RT)
- Query
  - Accuracy
    - FP < 1/100,000
    - FN < 1/10
  - Speed
    - Applications and system dependent
    - Typically a few seconds to 10s of seconds for UGC applications on off-the-shelf HW.

Watermarking, Hashing, & Fingerprinting

Watermarking	Hashing	Fingerprinting
Add signature	Extract binary signature	Extract content signature
Robust	Very fragile	Very robust
Very discriminating	Highly discriminating	Very discriminating
Non-legacy content	Any content	Any content
Moderate computation	Low computation	Moderate computation
Identify copy & content	Identify copy	Identify content
Tracking & tracing	Integrity check, security and cryptography	Filtering, tracking, and many more

Applications, Products and Market Players

Industry Events

- MPAA/MovieLabs Content Recognition Study (2006.8)
  - Paved the way for adoption of fingerprinting technology by major content owners
- MPEG-7 CFP for Visual Signature Tools (2007.7)
  - Start of standardization activities marked maturing of an emerging technology
- UGC Principles (2007.10)
  - Promoted acceptance of fingerprinting technology by UGC service providers
- MovieLabs Content Recognition Rules (2008.7)
  - Standardized the way of specifying and communicating the business rules for content

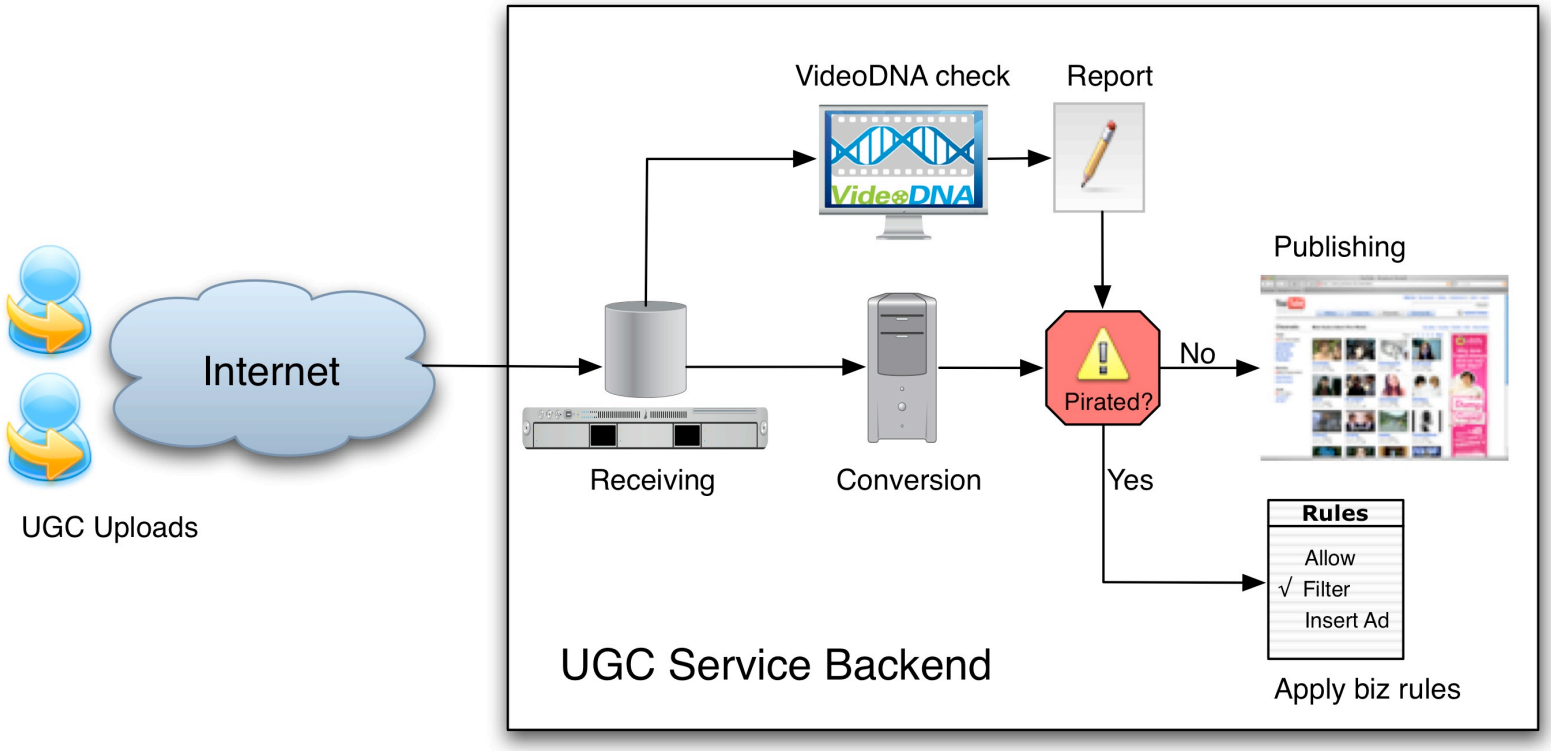
MPAA/MovieLabs Content Recognition Study

- RFI issued August 2006
- Focused on CI by video and audio fingerprinting
- Two phases of Study:
  - Phase 1: accuracy
  - Phase 2: system & scalability
- 12 vendors responded and submitted software and systems for Phase-1 study
- Phase-1 tests ran three rounds and lasted more than 6 months
- Phase-2 study included customer and site visits.

Major Applications

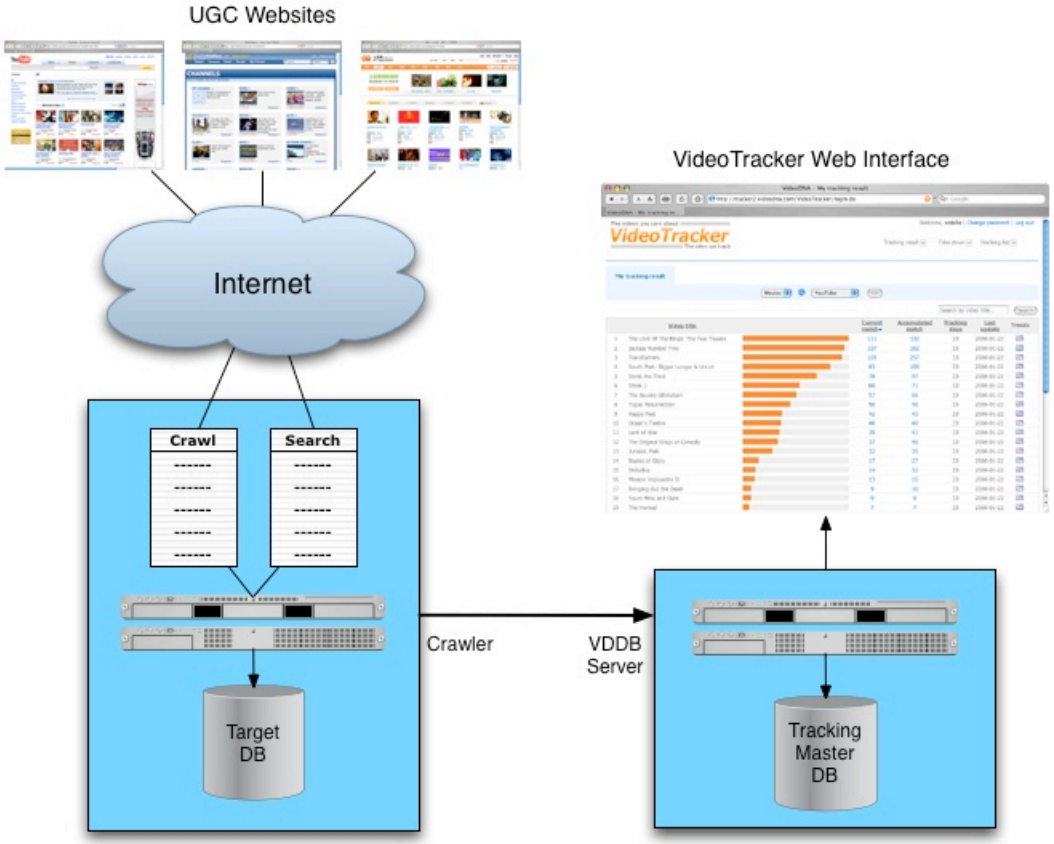
- Content filtering
- Content tracking
- Copyright enforcement
- Contextual Ads (monetization)
- Content management
- Content-based search

Content Management on UGC Backend



- Use fingerprint to check all uploads for copyright violation and then apply business rules

Tracking Copyrighted Video Content



- Track where it is, when it appears, and when it is taken down.

Tracking 2008 Beijing Olympics

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Video Piracy's Olympic Showdown

Beijing is finally tackling video piracy. China wants to prove it can protect the lucrative broadcasting rights for the Summer Games

by Peter Burrows

Performers carry out their routine 100 days ahead of the Beijing Summer Games Frederic J. Brown/AFP PHOTO/Getty Images

The People's Republic of China has long been a land of

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August 6, 2008 -- Updated 0343 GMT (1143 HKT)

Let the Games begin, online

STORY HIGHLIGHTS
- IOC has licensed sep
- Crack-down on illega
- New technology can

Next Article in Technol

By Kevin Voigt
For CNN

TEXT SIZE

(CNN) -- The Beijing Games have officially become the first "YouTube" Olympics.

Eyes down for a record: More people will watch the Beijing Games online than any other Olympics.

Earlier this week the IOC reached an agreement with Google, owner of YouTube, to allow highlights to be broadcast in 77 territories around the world where digital rights to the Games haven't been sold.

And in countries where digital rights have been sold the pressure to prevent illegal piracy is being stepped up.

As Beijing clears the streets in sweeps for pirated DVDs, the Chinese government's National Copyright Administration announced stiff new laws prohibiting the uploading of videos of Olympic events to unauthorized Web sites or face fines up $15,000.

With the profusion of social networking and peer-

Market Adoption - Customers

- Major movie studios and TV networks
  - Some committed to fingerprint entire catalogs
- Other content owners
  - Sports leagues, performing artists, advertisers, etc
- ISPs
  - Broadband service providers
- Content service providers including UGC service providers

Major Technology Providers

- Video + Audio
  - Philips
  - Vobile
- Video only
  - Google
  - Thomson
- Audio only
  - Auditude
  - Audible Magic

Products on the Market

- Filtering
  - Audible Magic – CopySense®
  - Vobile – MediaWise™
- Tracking
  - Vobile – VideoTracker™
- Metadata Services
  - Gracenote – MusicID®
- Advertising and monetization
  - Auditude
  - Vobile – MediaWise™

A New Player Was (Re)Born, Yesterday

Philips Content Identification announces spin out and becomes Civolution

Dear Customer,

It is our pleasure to announce to you today, October 20th 2008, that following the recent merger with Teletrax, Philips Content Identification has become a new company called **Civolution**. The spin out includes the Content Identification and Teletrax teams and assets, including all relevant IP.

It is our ambition to evolve from content identification technology and services supplier to become an integrated solutions provider across the

MPEG7 Video Signature Tool Dev Plan

- Issue of initial CFP: 2007.07
- Issue of final CFP: 2008.07.25
- Registration of Interest open: 2008.07.25
- Example dataset distribution to registered participants by post: 2008.08.01
- Complete dataset distribution to registered participants: 2008.10.17 (at 86th MPEG meeting in Korea)
- Registration of interest closed: 2008.11.30
- Proposal submission deadline: 2009.01.26 (by 23:59 GMT)
- Evaluation of proposals: 2009.02.02-2009.02.06 (at 87th MPEG meeting)
- PDAM (Proposed Draft Amendment, equivalent to Working Draft): 2009.04
- FPDAM (Final Proposed Draft Amendment, equivalent to Committee Draft): 2009.10
- FDAM (Final Draft Amendment, equivalent to FDIS or Final Draft International Standard): 2010.04
- AMD (Amendment, equivalent to IS or International Standard): 2010.07

MPEG7 VST Use Cases

- Metadata services
- Signature-based search services for replicated content
- Identification of lost or stolen content
- Sharing content in multi-user environment
- Unknown content identification
- Media usage monitoring
- Copyright management
- Content linking

Summary

- Media fingerprinting undergone almost 10 years of development by now.
- Digital music distribution and growth of online video created market demands
- MPAA Content Recognition Study was a turning point for market adoption
- Major Hollywood film and TV studios have started to fingerprint their entire catalogs
- Current major applications and products are content filtering, tracking, and metadata services; many more are being developed
- Maturing technology and growing applications motivated standardization of tools and interfaces

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Thank You!

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