XIA Performance
Expressive ≠ Expensive

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San Diego FIA PI meeting

Carnegie Mellon

BOSTON UNIVERSITY

THE UNIVERSITY *of* **WISCONSIN** MADISON

XIA's Flat Addressing

Current Internet		XIA	
IP address		Principal type	Type-specific identifier
128.2.10.162		Host	0xF63C7A4...
		Service	0x8A37037...
		Content	0x47BF217...
		Future	...

Hash of host's public key

Hash of service's public key

Hash of content

XIA's DAG-Based Addressing

Packet sender

Routing choice

Intent

Content

Host

Another routing choice
(with lower priority)

This host knows how to
handle content request
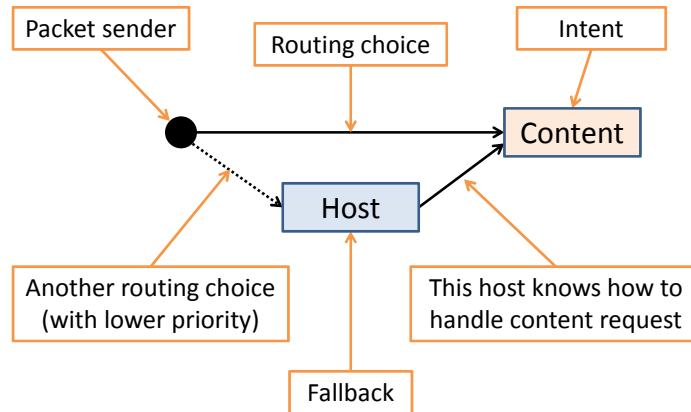
Fallback
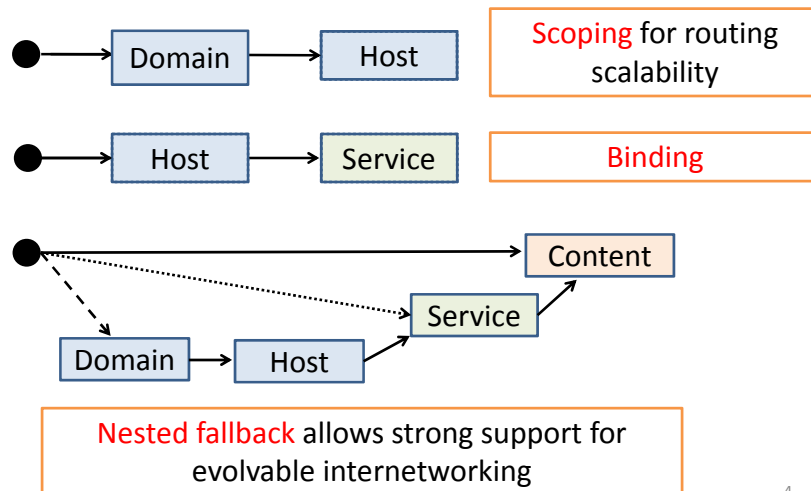
A node can have multiple outgoing edges.
Outgoing edges have priority among them.

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DAG Incorporates
Key Networking Features

Domain → Host

Scoping for routing
scalability

Host → Service

Binding

Content

Service

Domain → Host

Nested fallback allows strong support for
evolvable internetworking

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Possible Performance Optimization "Knobs"
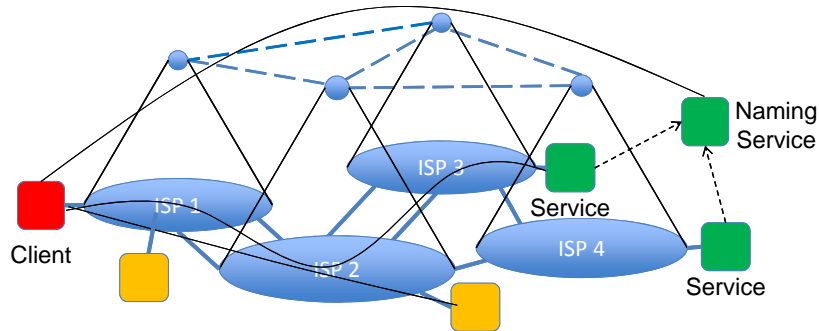
- Many choices: DAG, XID type, SID/CID routing, Scion vs NID, path selection, services, ..
- Examples: fault management, optimizing video distribution

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Outline

- XIA Performance Challenges/Opportunities
- Packet Processing Performance (Data Plane)
  - Processing DAGs
  - Large flat lookup tables
  - Congestion control
- Network-Wide Performance (Control Plane)
  - Application specific control planes
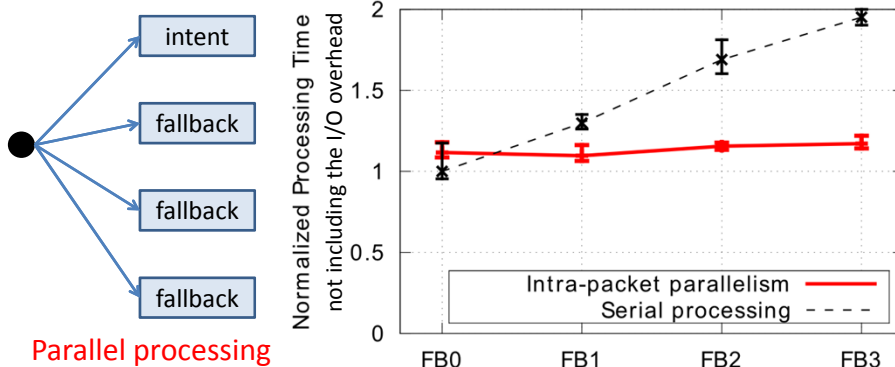- Evaluation Metrics

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Can We Forward DAGs Rapidly?
[NSDI 2012]

≤26% slowdown for small packets with 3 fallbacks
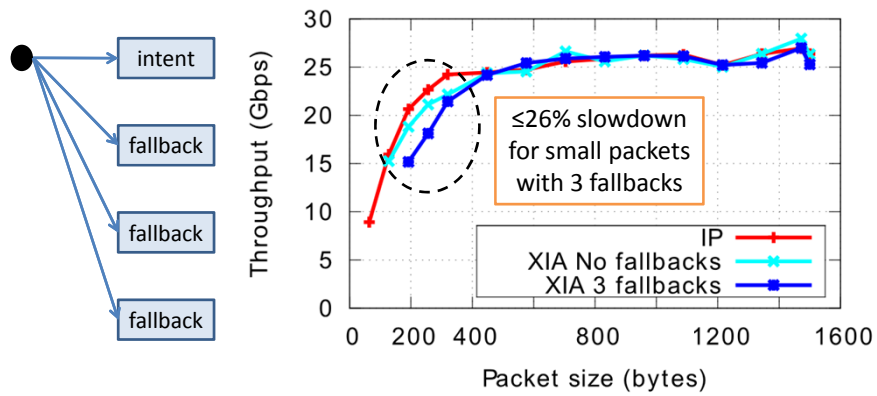
Click-based implementation on commodity hardware
351 K table entries based on a Route Views snapshot

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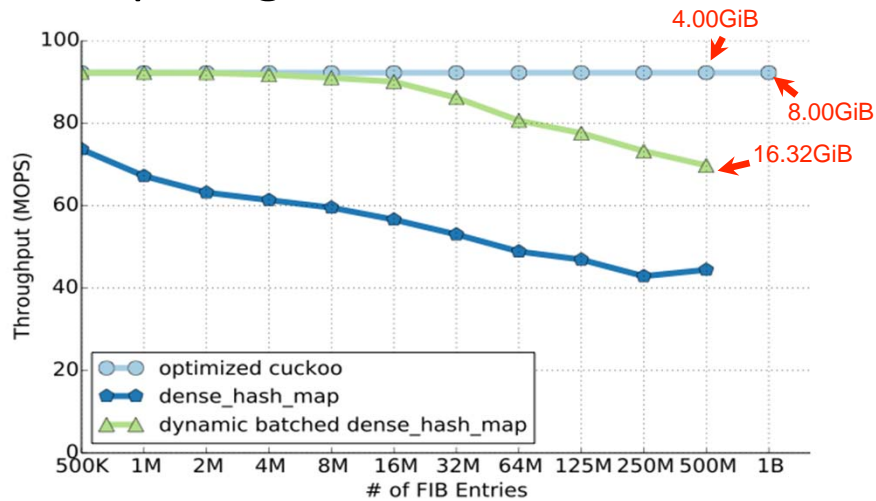## Intra-Packet Parallelism for Bounded Processing Cost

Parallel processing

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Large Flat Lookup Tables

- Can we build an x86-based software router that…
  - Handles 8x 10GbE ports at full line-rate
  - Handles arbitrarily large flat lookup fwd tables
    - Flow, host, and content routing as imagined uses; but
    - Also "build it, will come?" — raising expectations for what is possible from hardware!
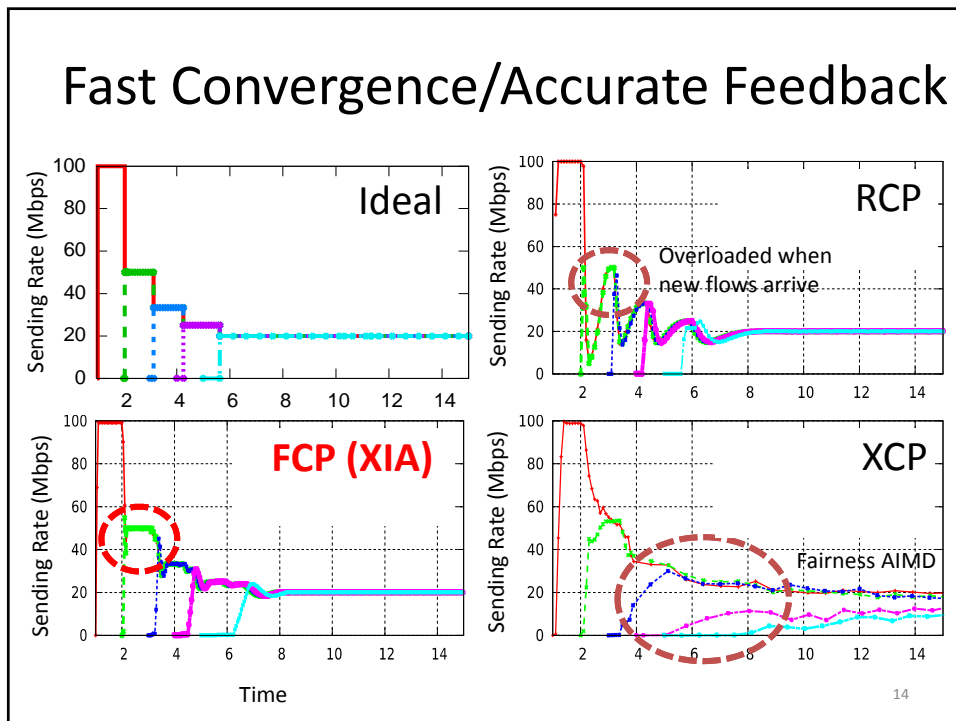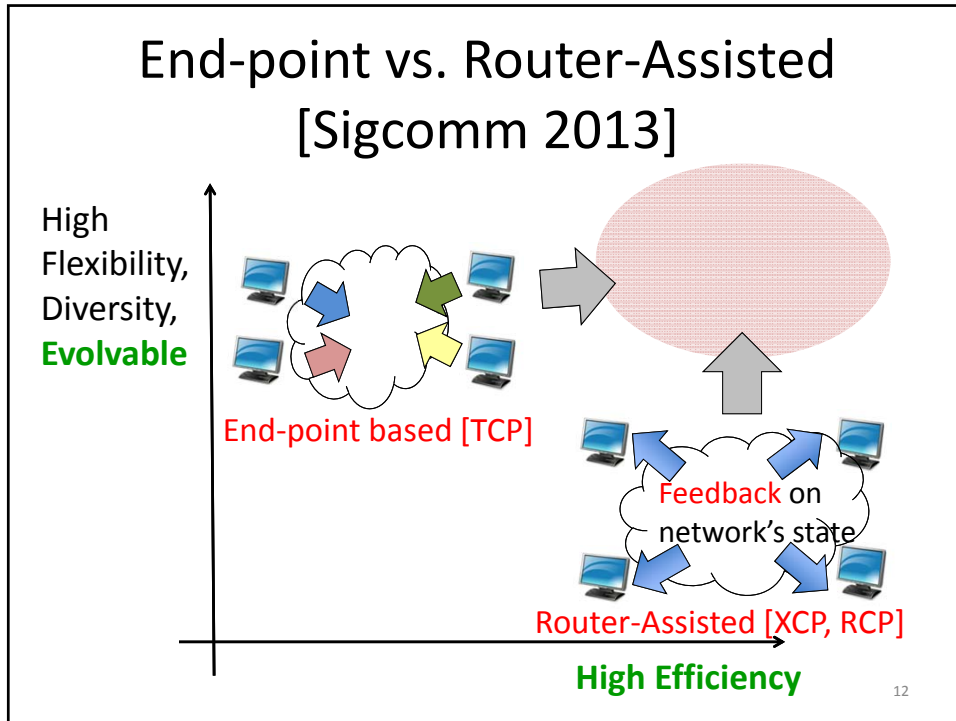- CuckooSwitch [CoNEXT 2013]

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Comparing with Other Hash Tables

XIA packet processing can scale.

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End-point vs. Router-Assisted [Sigcomm 2013]

High Flexibility, Diversity, **Evolvable**

End-point based [TCP]

Feedback on network's state

Router-Assisted [XCP, RCP]

High Efficiency

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Fast Convergence/Accurate Feedback

Ideal

RCP

Overloaded when new flows arrive

**FCP (XIA)**

XCP

Fairness AIMD

Time

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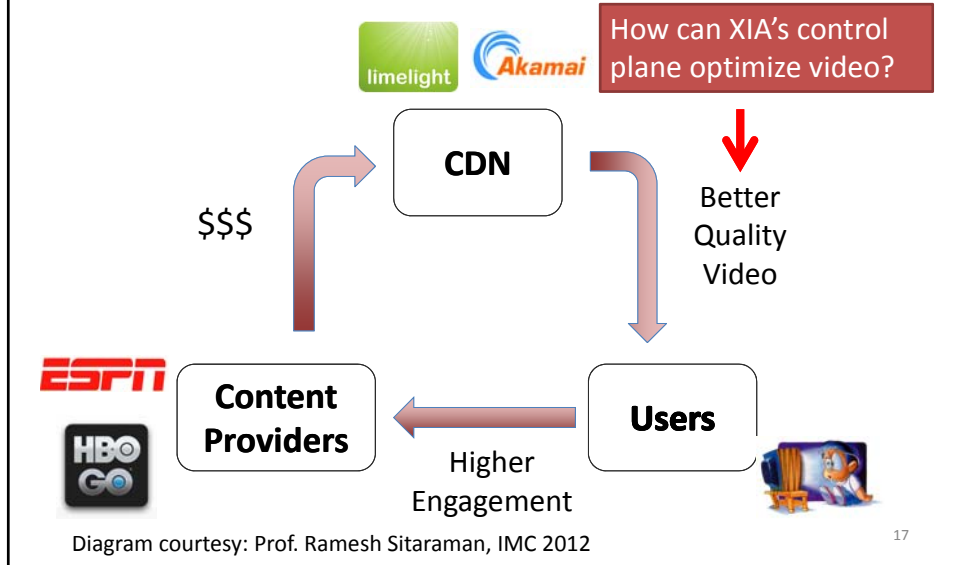 - Application specific control planes
- Evaluation Metrics

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XIA Packet Processing Pipeline

Control Plane Applications

NID
HID
SID
CID

Next-Dest XID Type Classifier

Route Success?

Input

Output
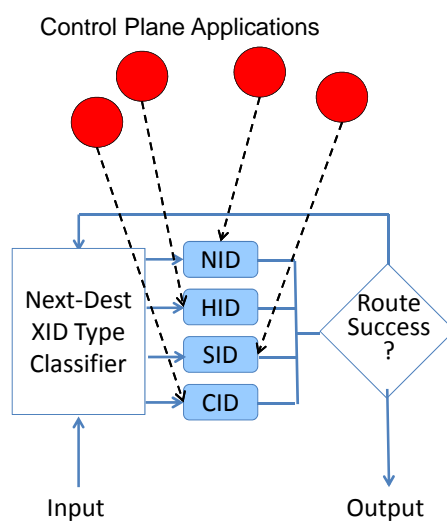
- Principal-independent processing defines how to interpret the DAG
  - Core architecture
- Principal-dependent processing realizes forwarding semantics for each XID type
  - Logically: one forwarding table per XID type
  - Reality: anything goes, e.g., no forwarding table
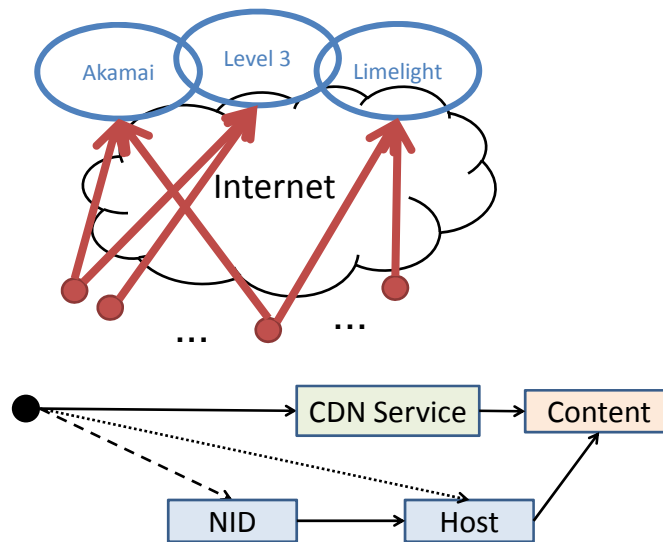- Control plane sets up forwarding for each principal type
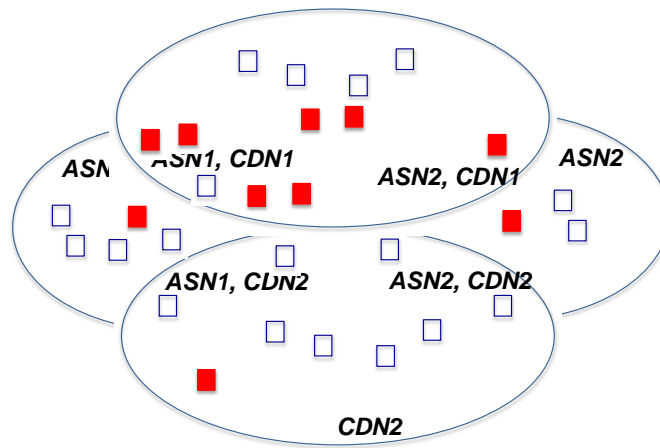
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Control Plane: Video Case Study

How can XIA's control plane optimize video?

CDN

$$$

Better Quality Video

Content Providers

Users

Higher Engagement

Diagram courtesy: Prof. Ramesh Sitaraman, IMC 2012

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Internet Fault Management: The Opportunity of Video Layer Inference

Akamai

Level 3

Limelight

Internet

- Video delivery involves many entities
  - Content providers
  - CDNs
  - ISPs

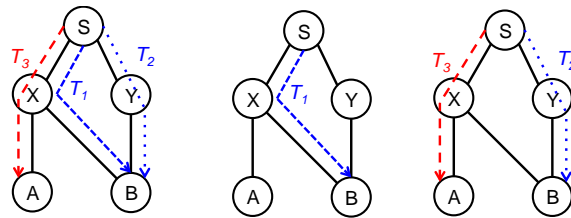...   ...

- Performance issues can come from any of them

CDN Service

Content

NID

Host

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Performance Fault Isolation:
Critical Clusters [CoNEXT 2013]

■ Problem session   ☐ Good quality session

ASN   ASN1, CDN1   ASN2, CDN1   ASN2

ASN1, CDN2   ASN2, CDN2

CDN2

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Live Content Delivery on a CDN

(a) Example scenario

m_1: {S} -> {B}
m_2: {S} -> {A}

(b) No central control

m_1: T_1
m_2: No bw.

(c) With central control

m_1: T_2
m_2: T_3

- Wide-area traffic-engineering critical for good video delivery performance
- Video is different from other services (or content)
  - Long-lived sessions, high-bandwidth constraints, adaptive behavior, etc.

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Possible Directions

- Naming → we can give different clients different DAGs to control their routing
- Routing → we can use controls over CID routing to optimize video without impacting other traffic
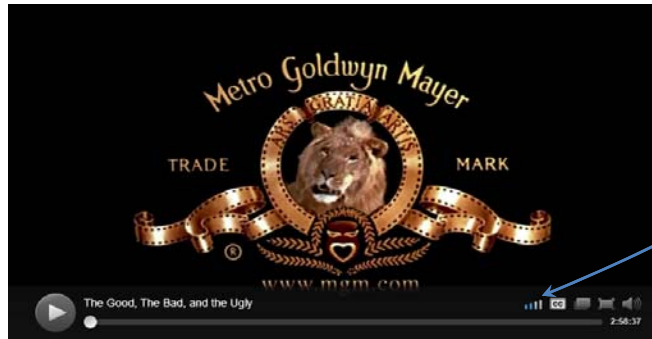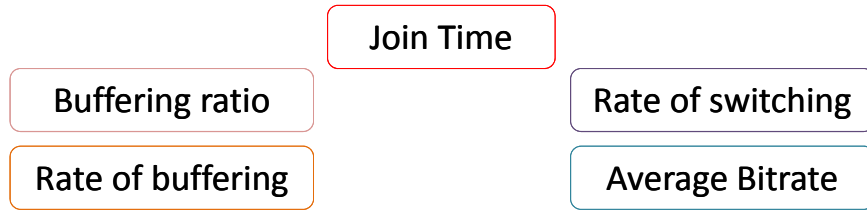- XID types → we can give video its own XID type

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How Do We Evaluate Performance?

Join Time

Buffering ratio

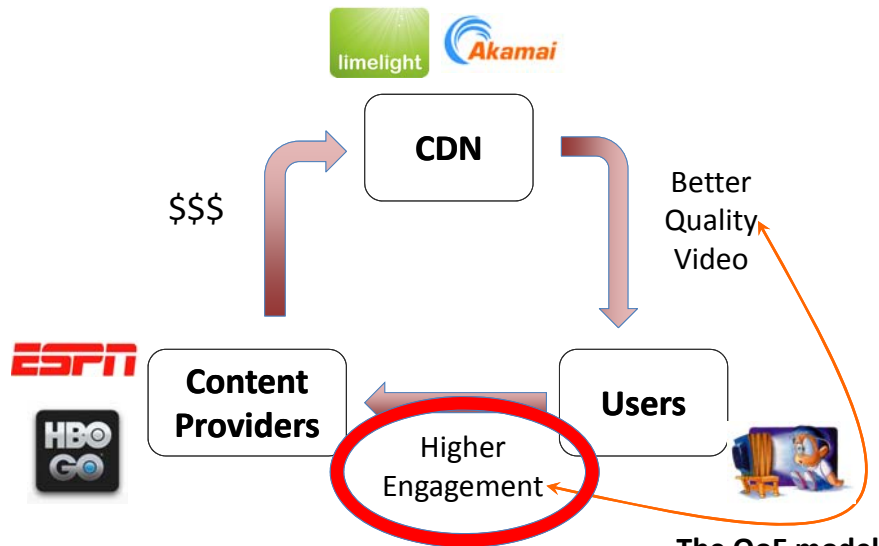Rate of switching

Rate of buffering

Average Bitrate

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How Do We Evaluate Performance?

$$$

CDN

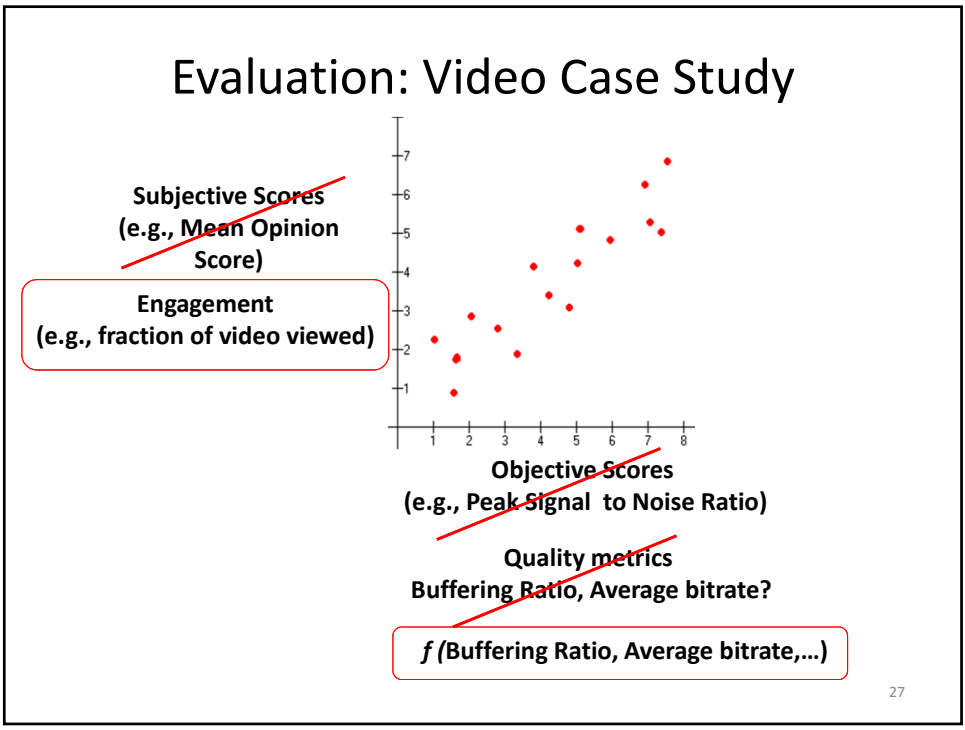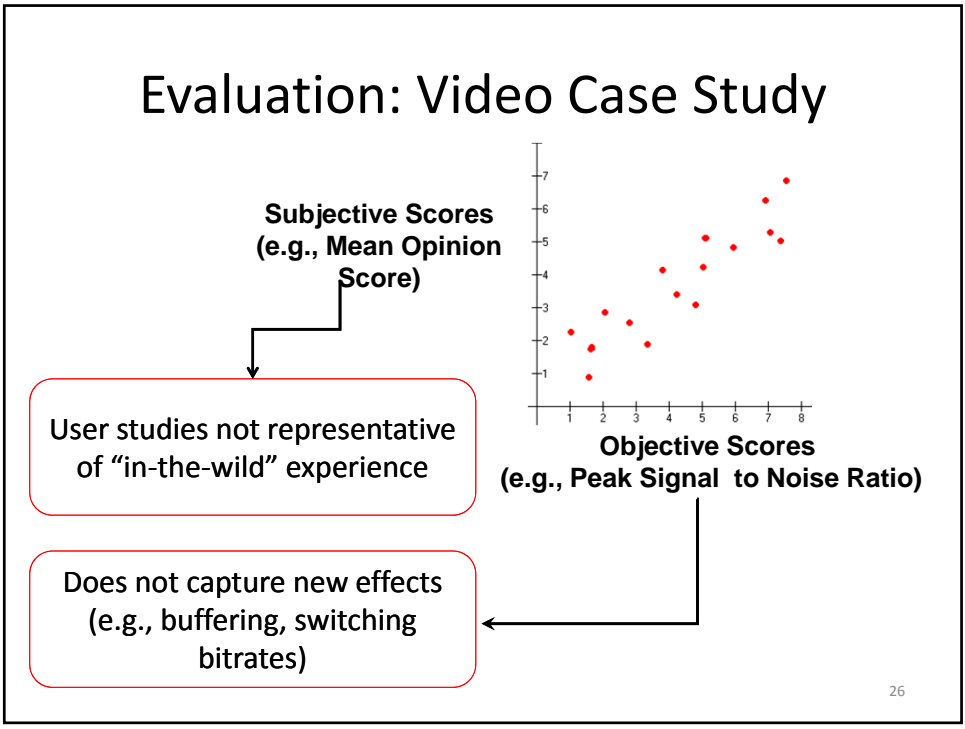Better Quality Video

Content Providers

Users

Higher Engagement

The QoE model

Diagram courtesy: Prof. Ramesh Sitaraman, IMC 2012

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Evaluation: Video Case Study

**Subjective Scores
(e.g., Mean Opinion
Score)**

**Objective Scores
(e.g., Peak Signal to Noise Ratio)**

User studies not representative
of "in-the-wild" experience

Does not capture new effects
(e.g., buffering, switching
bitrates)

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Evaluation: Video Case Study

**Subjective Scores
(e.g., Mean Opinion
Score)**

**Engagement
(e.g., fraction of video viewed)**

**Objective Scores
(e.g., Peak Signal to Noise Ratio)**

**Quality metrics
Buffering Ratio, Average bitrate?**

f **(Buffering Ratio, Average bitrate,…)**

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Cast as a Learning Problem [Sigcomm 2013]

Engagement   Quality Metrics

MACHINE LEARNING

QoE Model

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Possible Directions

- How do extend this to "network" satisfaction from "video" satisfaction?

- How much "training" data do we really need?

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