XIA Performance
Expressive ≠ Expensive

Srini Seshan and Hui Zhang
Peter Steenkiste, Aditya Akella, Dave Andersen,
John Byers, David Eckhardt, Sara Kiesler,
Jon Peha, Adrian Perrig, Marvin Sirbu,

San Diego FIA PI meeting

---

XIA’s Flat Addressing

<table>
<thead>
<tr>
<th>Current Internet</th>
<th>XIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP address</td>
<td>Principal type</td>
</tr>
<tr>
<td>128.2.10.162</td>
<td>Type-specific identifier</td>
</tr>
<tr>
<td></td>
<td>Host 0xF63C7A4...</td>
</tr>
<tr>
<td></td>
<td>Service 0x8A37037...</td>
</tr>
<tr>
<td></td>
<td>Content 0x47BF217...</td>
</tr>
<tr>
<td></td>
<td>Future ...</td>
</tr>
</tbody>
</table>

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.

DAG Incorporates Key Networking Features

Domain → Host

Scoping for routing scalability

Host → Service

Binding

Domain → Host → Service → Content

Nested fallback allows strong support for evolvable internetworking
Possible Performance Optimization “Knobs”

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

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
Can We Forward DAGs Rapidly?  
[NSDI 2012]

Click-based implementation on commodity hardware  
351 K table entries based on a Route Views snapshot

Intra-Packet Parallelism for Bounded Processing Cost

Parallel processing
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]

Comparing with Other Hash Tables

XIA packet processing can scale.
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

Fast Convergence/Accurate Feedback

Ideal

Overloaded when new flows arrive

Fairness AIMD

Sending Rate (Mbps)

Sending Rate (Mbps)

Sending Rate (Mbps)

Sending Rate (Mbps)

2 4 6 8 10 12 14

2 4 6 8 10 12 14

2 4 6 8 10 12 14

2 4 6 8 10 12 14

Time
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

XIA Packet Processing Pipeline

• 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
Control Plane: Video Case Study

How can XIA’s control plane optimize video?

CDN

Better Quality Video

$$$

Content Providers

Higher Engagement

Users

Diagram courtesy: Prof. Ramesh Sitaraman, IMC 2012

Internet Fault Management: The Opportunity of Video Layer Inference

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

- Performance issues can come from any of them

Akamai

Level 3

Limelight

Internet

......

CDN Service

Content

NID

Host
Performance Fault Isolation: Critical Clusters [CoNEXT 2013]

Live Content Delivery on a CDN

- 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.
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

Outline

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

- Join Time
- Buffering ratio
- Rate of buffering
- Rate of switching
- Average Bitrate

Diagram courtesy: Prof. Ramesh Sitaraman, IMC 2012

Better Quality Video

Higher Engagement

Users

Content Providers

CDN
Evaluation: Video Case Study

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

User studies not representative of “in-the-wild” experience

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

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

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

Quality metrics
Buffering Ratio, Average bitrate?

\[ f (\text{Buffering Ratio, Average bitrate},...) \]
Cast as a Learning Problem [Sigcomm 2013]

Possible Directions

- How do extend this to “network” satisfaction from “video” satisfaction?

- How much “training” data do we really need?
Outline

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