NDN Live Video Broadcasting over Wireless LAN

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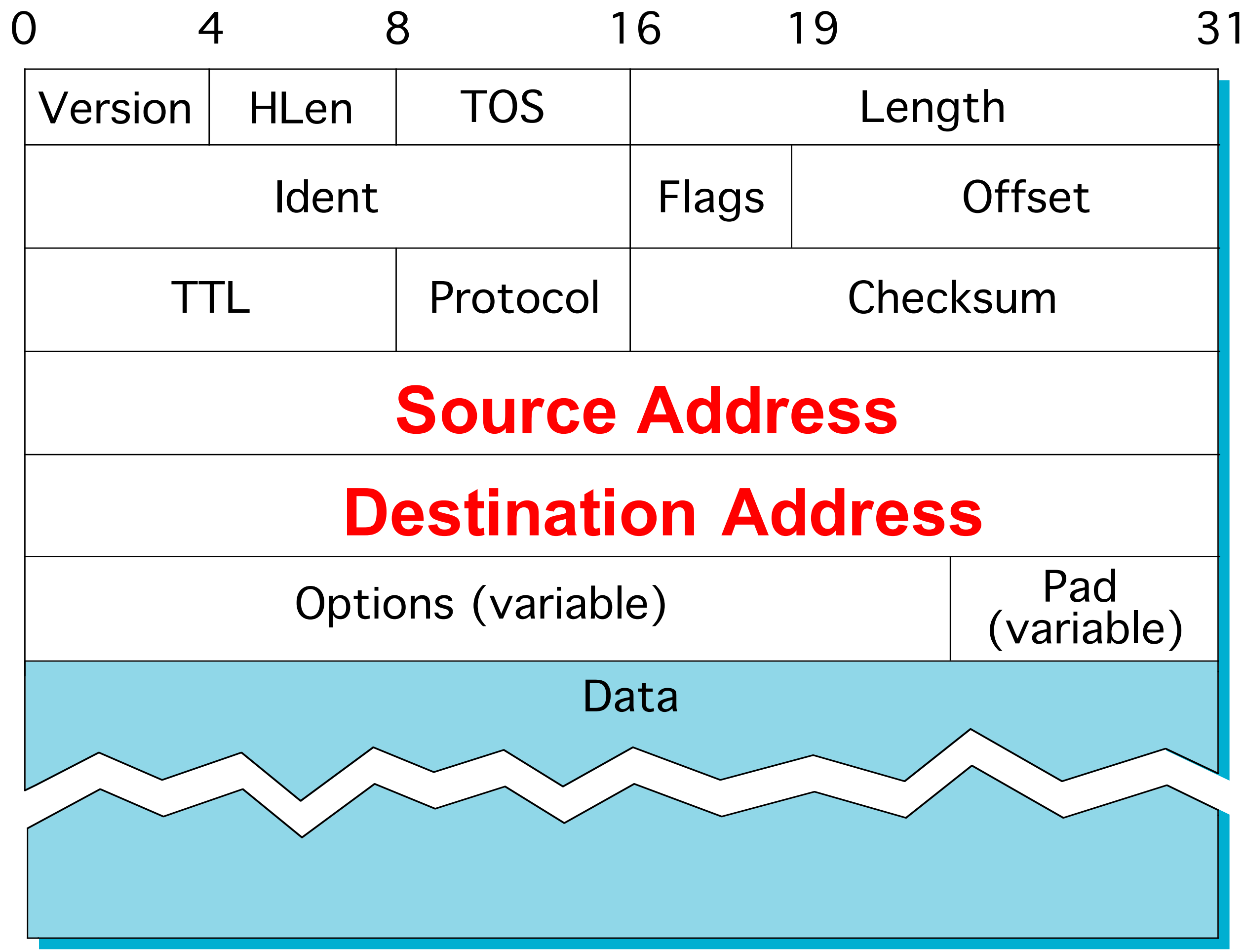
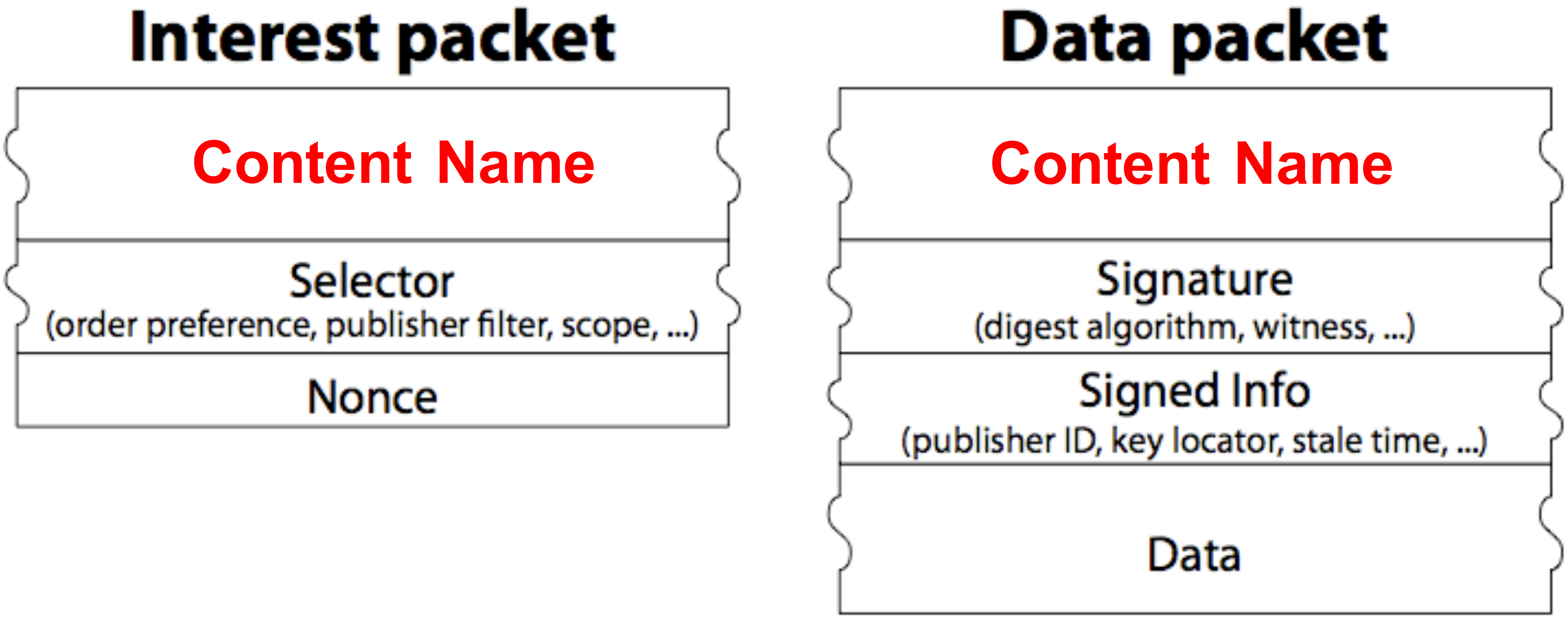
IP: Delivering packets to endpoints

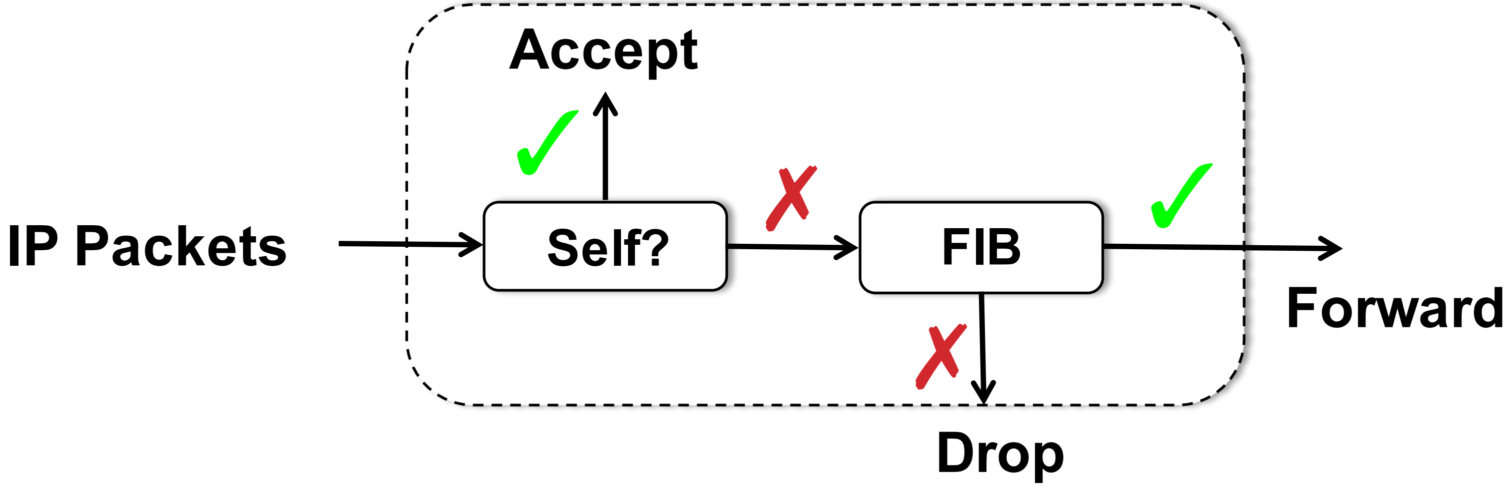


Named Data Networking (NDN)

Retrieving Named Data from the network



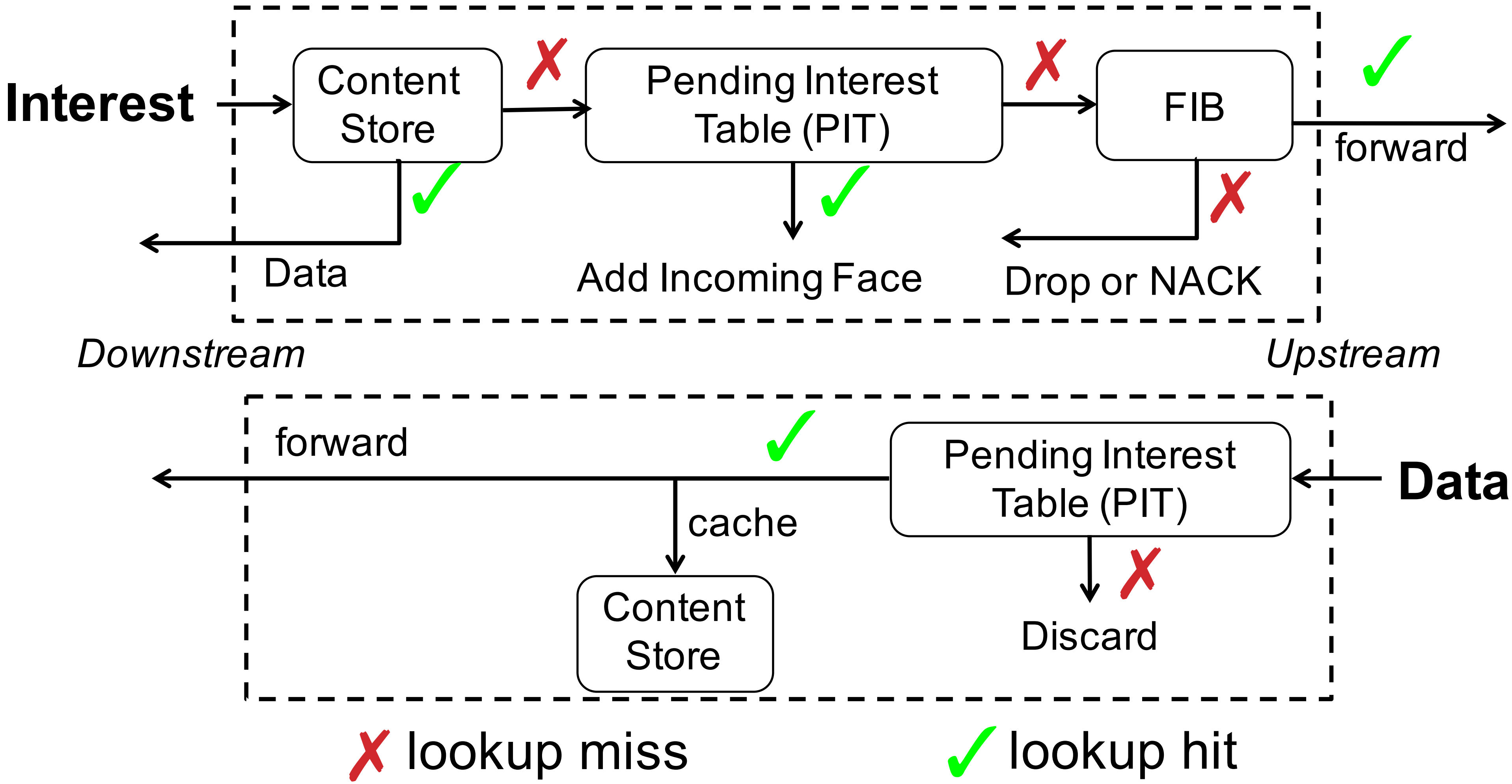
IP's Node Model



✗ lookup miss ✓ lookup hit

One-way traffic, stateless, no storage.

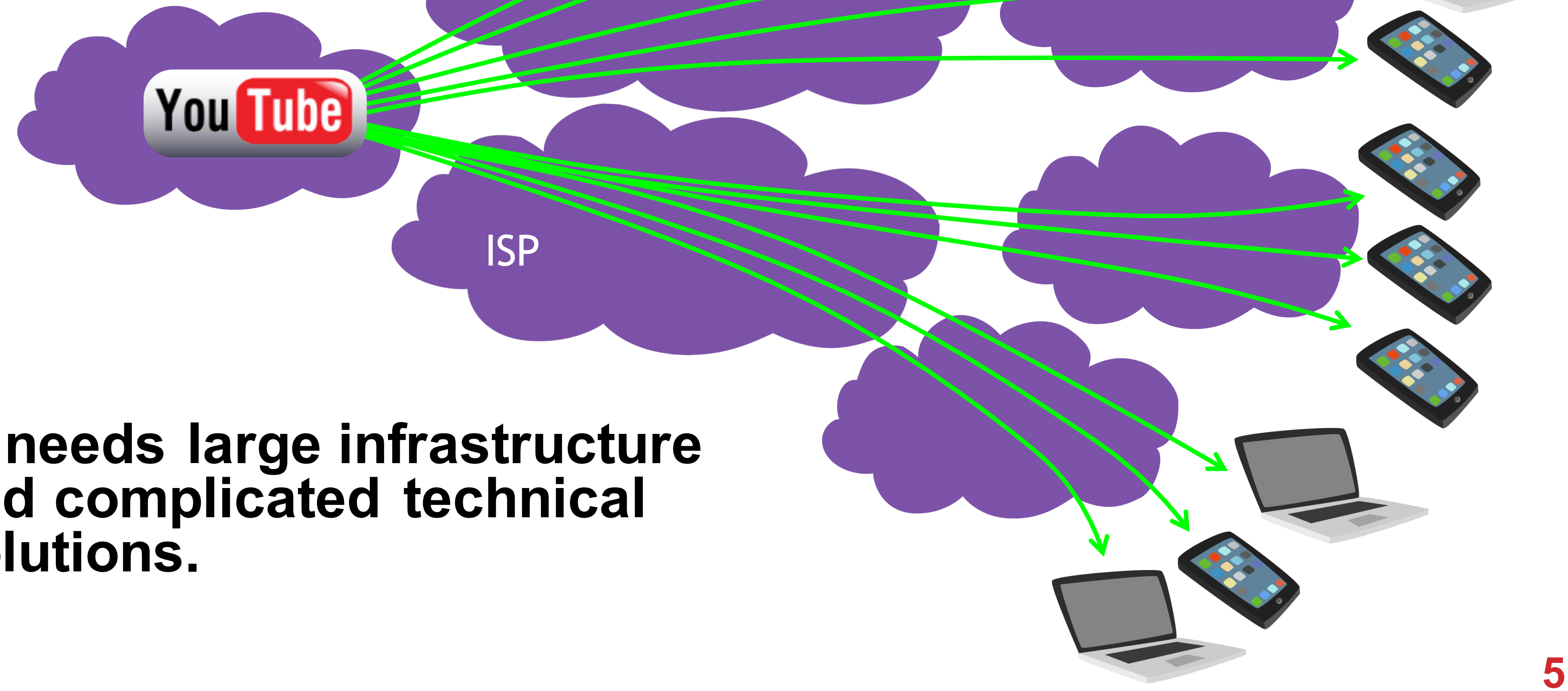
NDN's node model



Two-way traffic, stateful, explicit storage.

Content Distribution Example

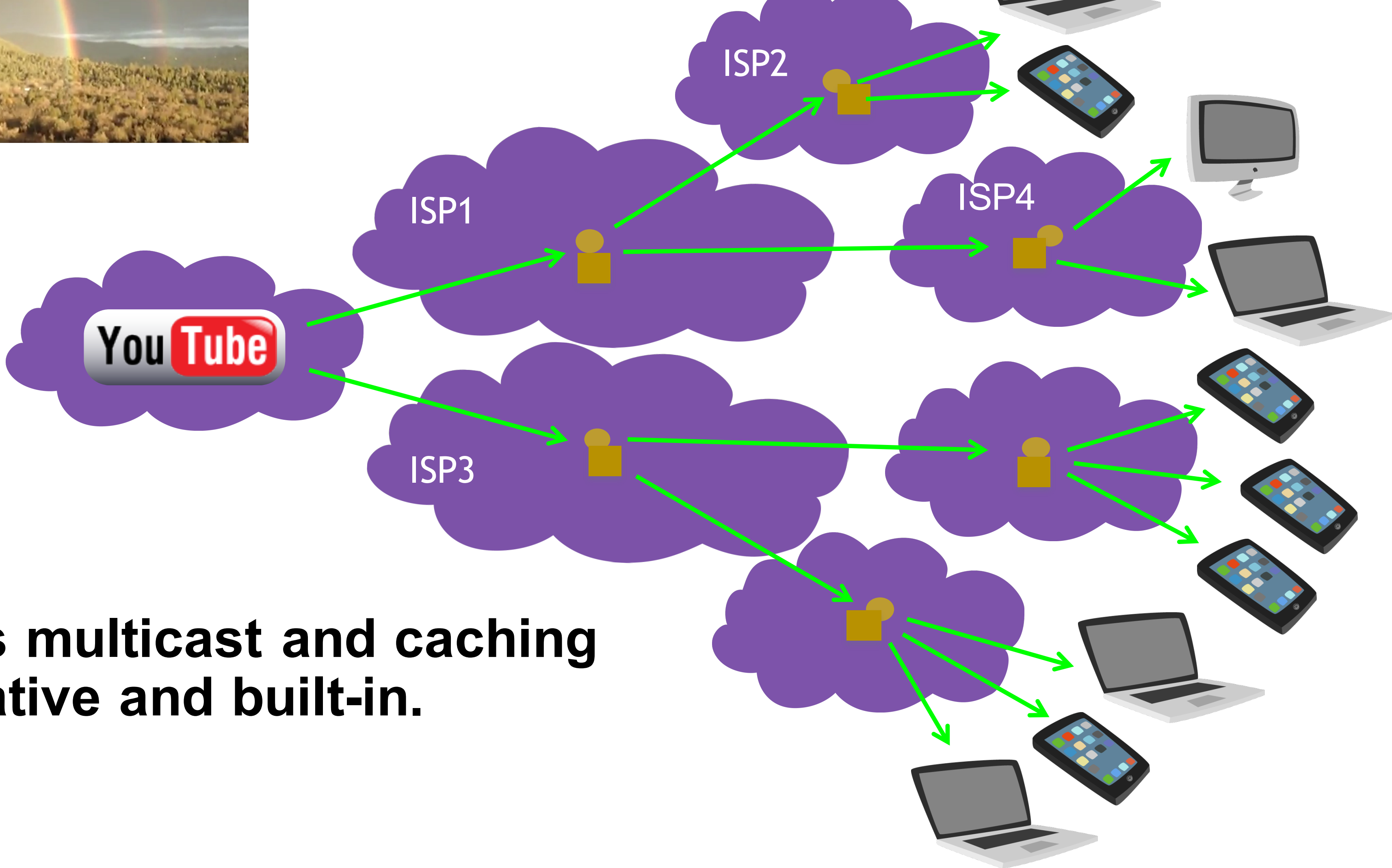
36.7M
Views



IP needs large infrastructure and complicated technical solutions.

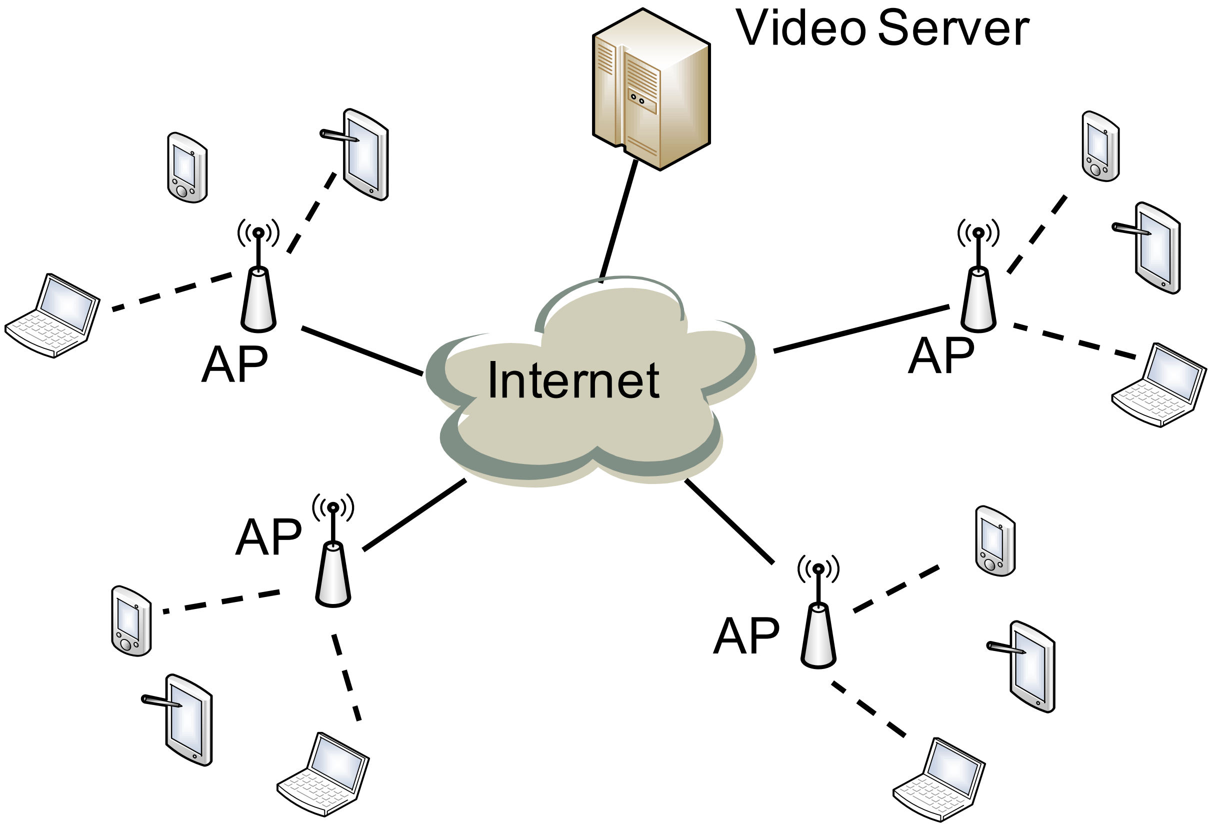
Content Distribution Example

36.7M
Views



NDN's multicast and caching are native and built-in.

The problem at the last hop



Increasingly over wireless broadcast medium, ie, WiFi. But current NDN implementation treats it as multiple unicast tunnels between clients and access point (AP).

Design Goals

Efficient and Scalable NDN-based live video broadcasting over WiFi

- Support a good number of clients watching the same live video streaming via the same WiFi AP at the same time.

No modification to the MAC layer

- WiFi doesn't support broadcast or multicast very well.
- Built our system based on NDN/UDP.

Design Overview

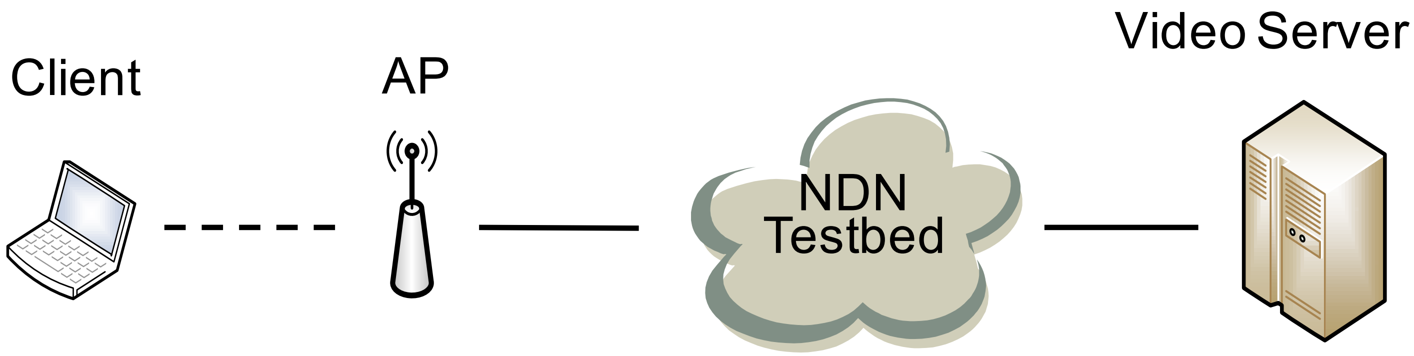
Regulate Interests so that ideally only one Interest is sent to retrieve one video packet regardless of the number of clients.

- One Interest unicast to the AP, which will forward it to the video server.
- One video data packet comes back to the AP, which broadcasts the packet to all clients.

How to regulate the generation of Interests?

How to regulate the transmission of Interests?

Regulating Interest Generation



Maintain an Interest sending window (W) at the client.

- For pipelining multiple Interests to retrieve multiple data.
- It needs to match data production at the server.

Client *periodically* asks for the *latest* data name to infer the rate of data production, and use that to set W.

$$W = RTT * (S_2 - S_1) / (T_2 - T_1)$$

Regulating Interest Transmission

Goal: suppress the transmission of duplicate Interests from different clients.

- Ideally only one Interest is sent (from the Leader) to retrieve one video packet.

The AP chooses one client (e.g., the first one) to be the Leader, and others are Followers.

- The Leader transmits Interests without delay.
- The Followers delay the transmission of their Interests.
- The AP periodically broadcasts a heartbeat packet to all clients, stating who the Leader is, the current number of Followers, and the current progress of video data retrieval.

Interest suppression at Followers

Outgoing Interests are delayed and stored in Delayed Interest Table (DIT).

- Consumed when corresponding data is received.
- Transmitted by certain probability when timeout or packet loss is inferred.

Inferring packet loss from data name or AP's heartbeat message.

- Significant out-of-order packets

The probability to transmit $P_f = 1/(N-R)$

- N is the number of clients, and R is the number of times that the application has been asking.

Keep track of clients

AP maintains who's the Leader and the number of Followers.

Every client periodically sends an Interest to learn the latest available data name.

- This Interest is not delayed.
- AP uses this Interest to keep track of the clients.

If a Follower leaves, AP just updates the count.

If the Leader leaves, AP will assign the next client as Leader.

- In absence of Leader sending Interests, clients will timeout and send Interests on their own, based on a probability.

Evaluation

Compare with two alternatives

Unicast: The clients and AP transmit all NDN packets over UDP unicast tunnels.

Broadcast: All clients send all Interests over UDP unicast, and the AP broadcasts the returned Data to all the clients.

Performance metrics

Buffering Rate: the number of buffering events per second.

Buffering Ratio: the percentage of time spend in buffering.

Interest Redundancy: the number of Interests sent vs. the number Data received.

Data Redundancy: Data sent by AP vs. received by clients.

Experiment setups

AP: commodity home router

- 5GHz WiFi, 6Mbps broadcast bandwidth, 720MHz CPU

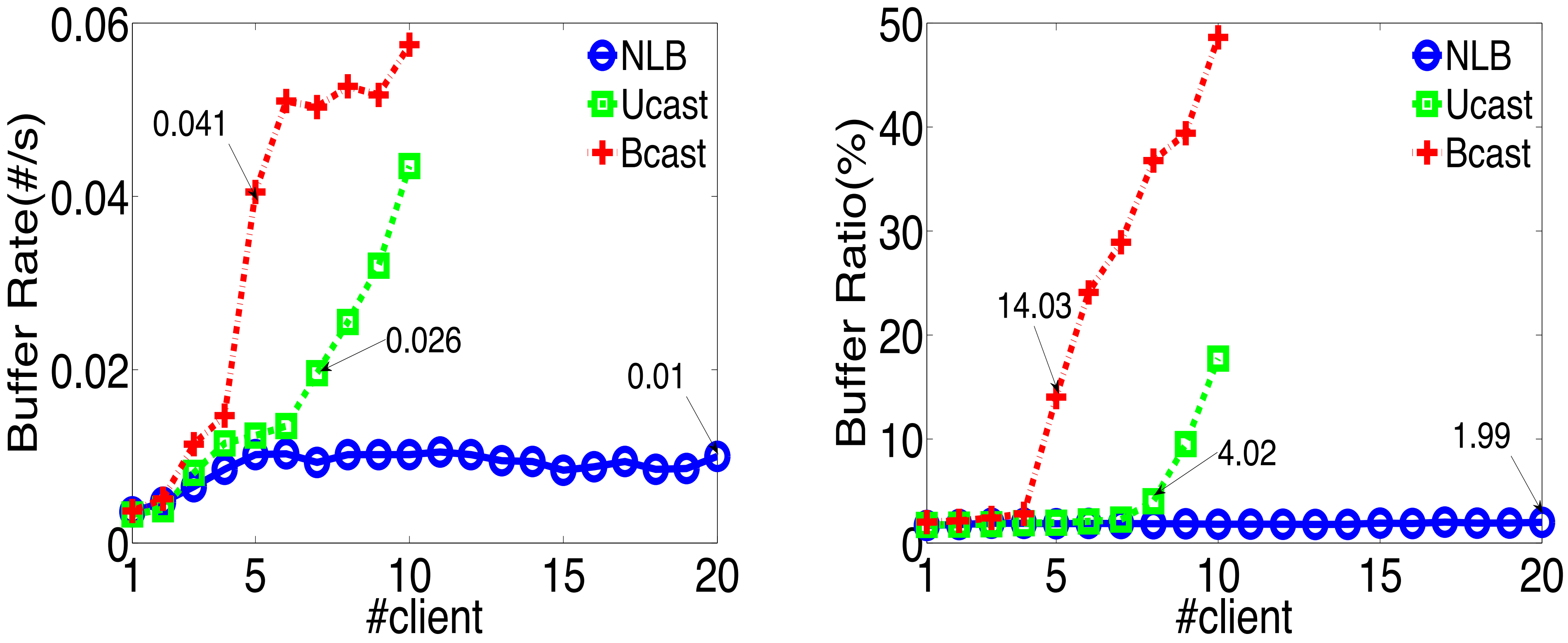
20 Clients

- Ubuntu VM running a single client app with a dedicated WiFi card.

Software:

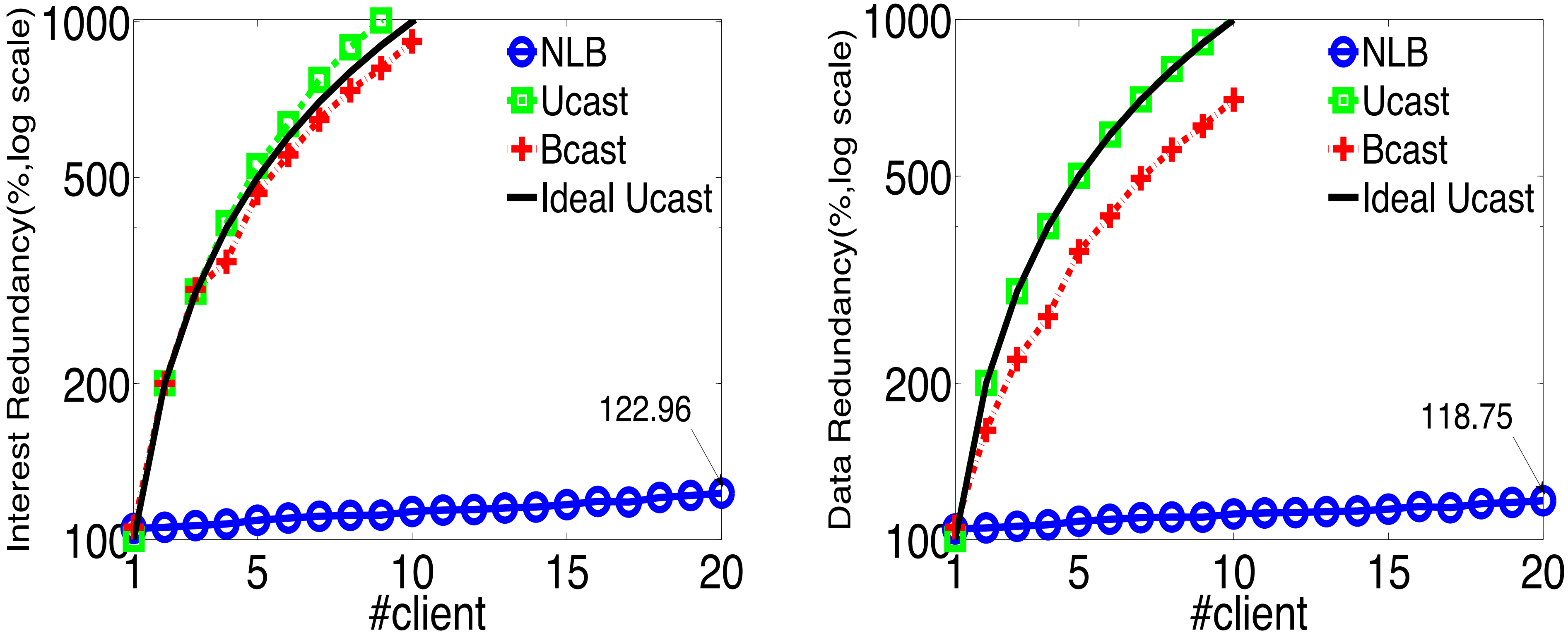
- NDNVideo: 1Mbps H.264/AVC video

Scalability to the number of clients



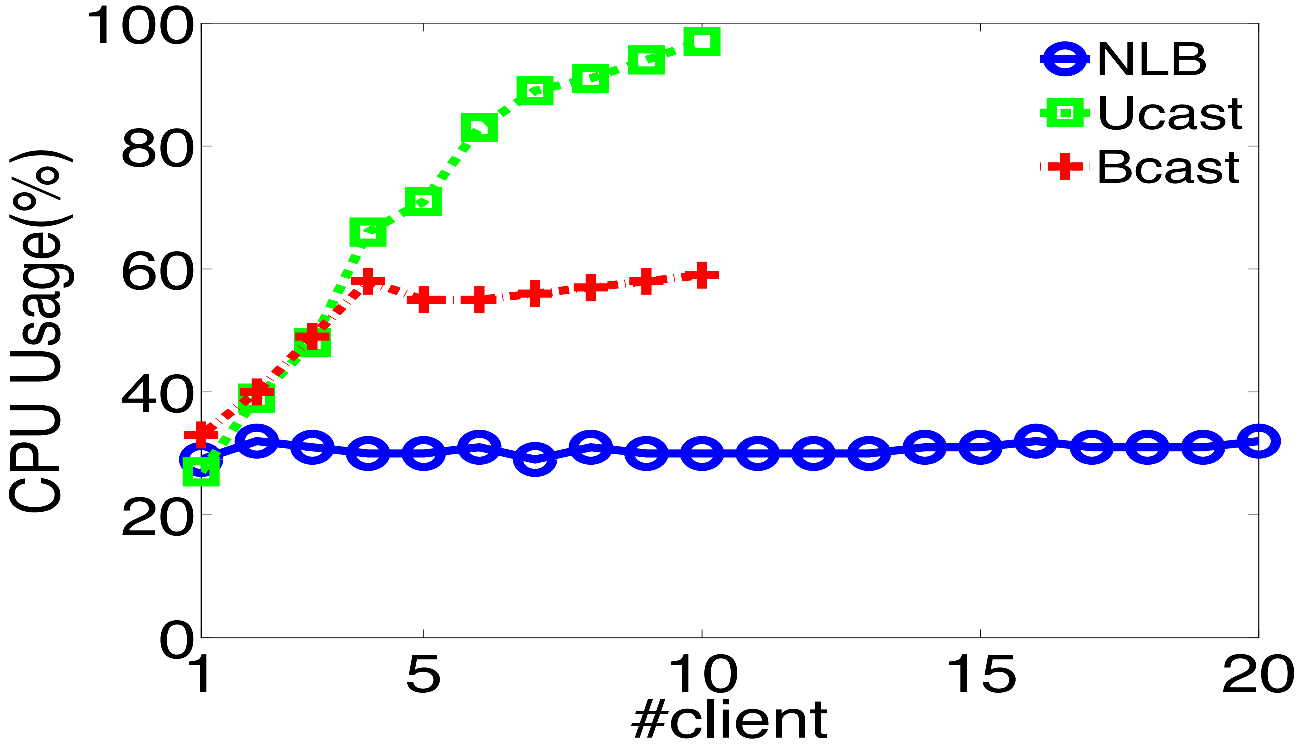
NLB supported 20 clients at ease, while unicast and broadcast schemes showed clear limit.

Packet redundancy



NLB is able to suppress the majority of redundant packets, Interest and Data.

AP's CPU usage



UCast: may be limited by CPU cycles
Bcast: limited by 6Mbps broadcast bandwidth
NLB: the total number of packets transmitted over WLAN grows very slowly

Summary

NLB is a scalable and efficient receiver-driven broadcasting mechanism in wireless medium.

It complements NDN's multicast and caching capability in the wired Internet.

It runs on commodity access points and mobile devices without any change to the MAC layer

For More Information about NDN

http://www.named-data.net/

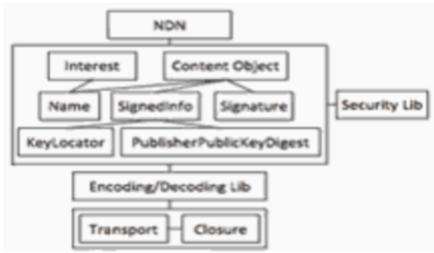
NAMED DATA NETWORKING

Project Architecture Codebase Testbed Publications

VAN JACOBSON TECH TALK @ FISS

NDN VIDEO FROM UCLA TO BEIJING

THE NDN TESTBED IS GROWING



NDN AT INFOCOMM NOMEN 2013