BE Internet Video
RIPE 58

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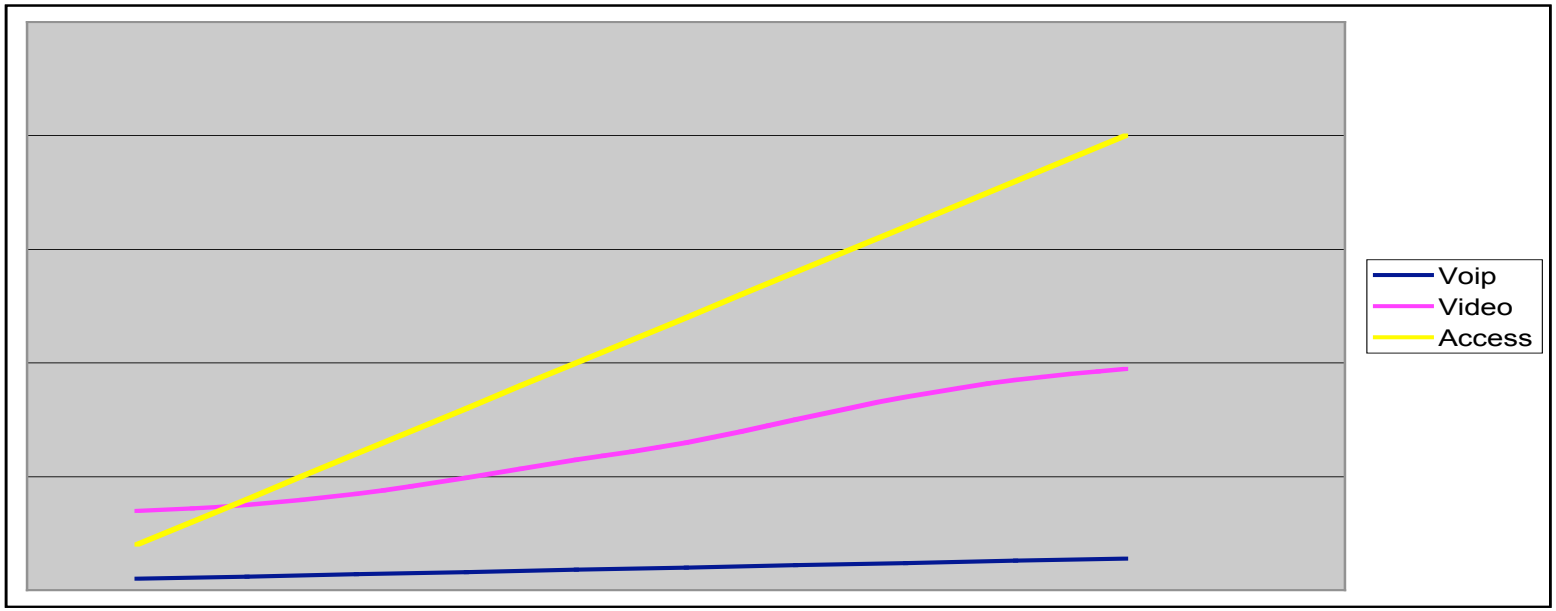
IPTV Today

- Current Multicast IPTV isolated in Walled Gardens
  - Edge provider “owns” the customer
  - Most content is region-specific (isolated)
  - Content/cost/ownership/distribution relationships control competition
- Will this last?

Future Challenges



- Access bandwidth is driven by competition
- Access bandwidth rapidly surpassing video bandwidth
- Video bandwidth is semi-bounded

Future Challenges

- IPTV works as a Value Added service today
- Access bandwidth growth opens up new applications
- Over-the-top video is already here - in some form..
  - Move, Joost, MacTV, YouTube, BitTorrent, AMT
  - AMT - the only network-based solution
- More available bandwidth will only improve these applications
- DVRs are changing how people watch TV
- Consumers don’t care how their DVRs are populated
- Will live-TV be relevant in the future?
  - Always!

Future Challenges

- What's the end-game?
  - Ubiquitous global video network
  - Mostly VOD/DVR-queued
  - What about live?
- Very little global multicast peering
- Multicast is a proven solution for one-to-many video distribution (walled-gardens)
- All global live content is forced to use unicast

What's Wrong?

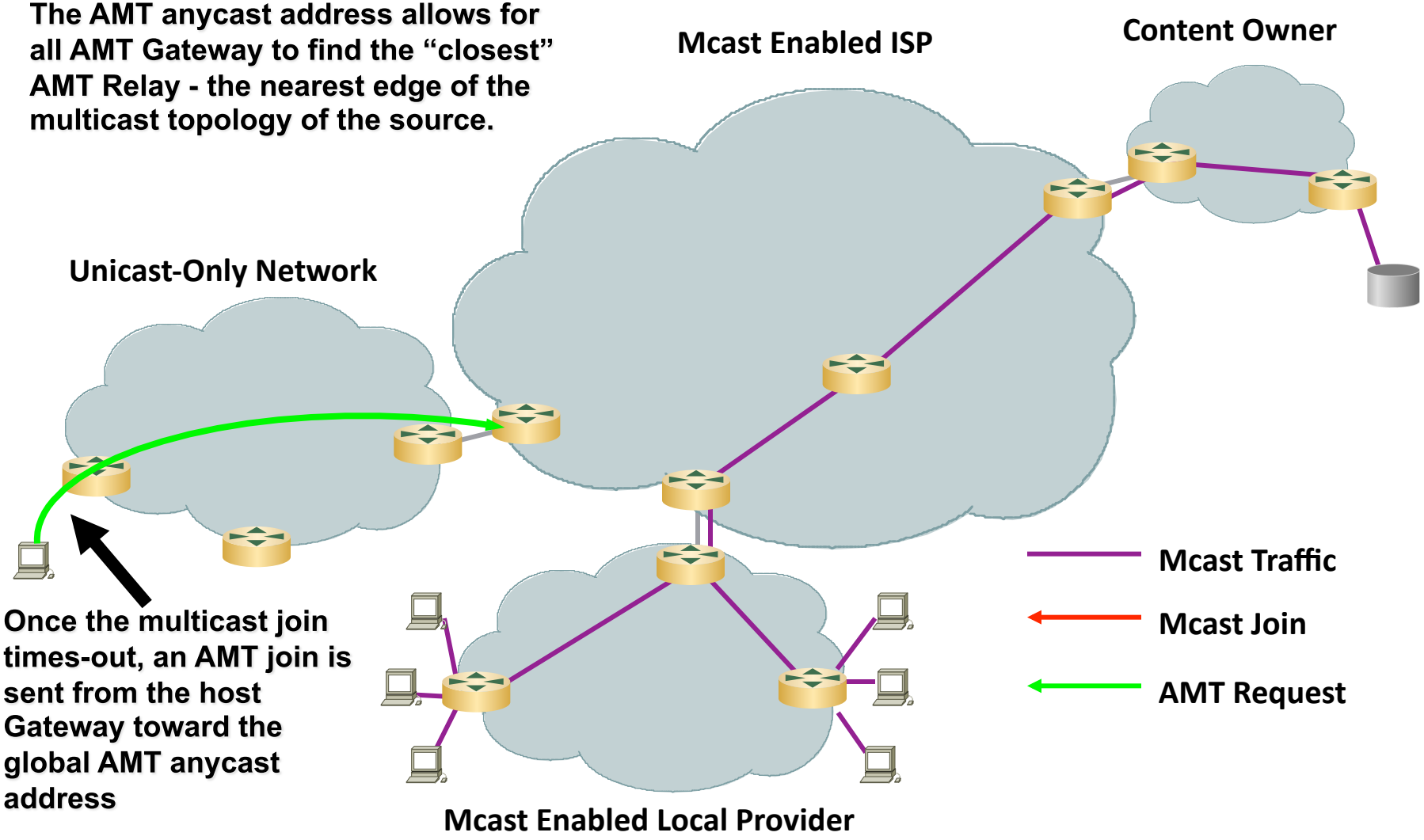
- Multicast in the Internet is an all-or-nothing solution
  - Each receiver must be on an IP Multicast enabled path.
  - Many core networks have IP Multicast enabled - but few edge networks do.
- Even Mcast-aware content owners are forced to provide unicast streams to gain audience size
- Unicast will never scale for streaming content
  - Splitters/Caches just distribute the problem
    - Still has a cost-per-user
- But is there a future for streaming?

AMT
Automatic Multicast Tunneling

- Automatic IP Multicast without explicit Tunnels
  - http://www.ietf.org/internet-drafts/draft-ietf-mboned-auto-multicast-0x.txt
  - Last call in the MBONED WG
- Allow multicast content distribution to extend to unicast-only connected receivers.
  - Bring the flat scaling properties of multicast to the Internet
- Provide the benefits of multicast wherever multicast is deployed.
  - Let the networks which have deployed multicast benefit from their deployment.
- Work seamlessly with existing applications
  - No OS kernel changes

AMT
Automatic Multicast Tunneling

The AMT anycast address allows for all AMT Gateway to find the "closest" AMT Relay - the nearest edge of the multicast topology of the source.



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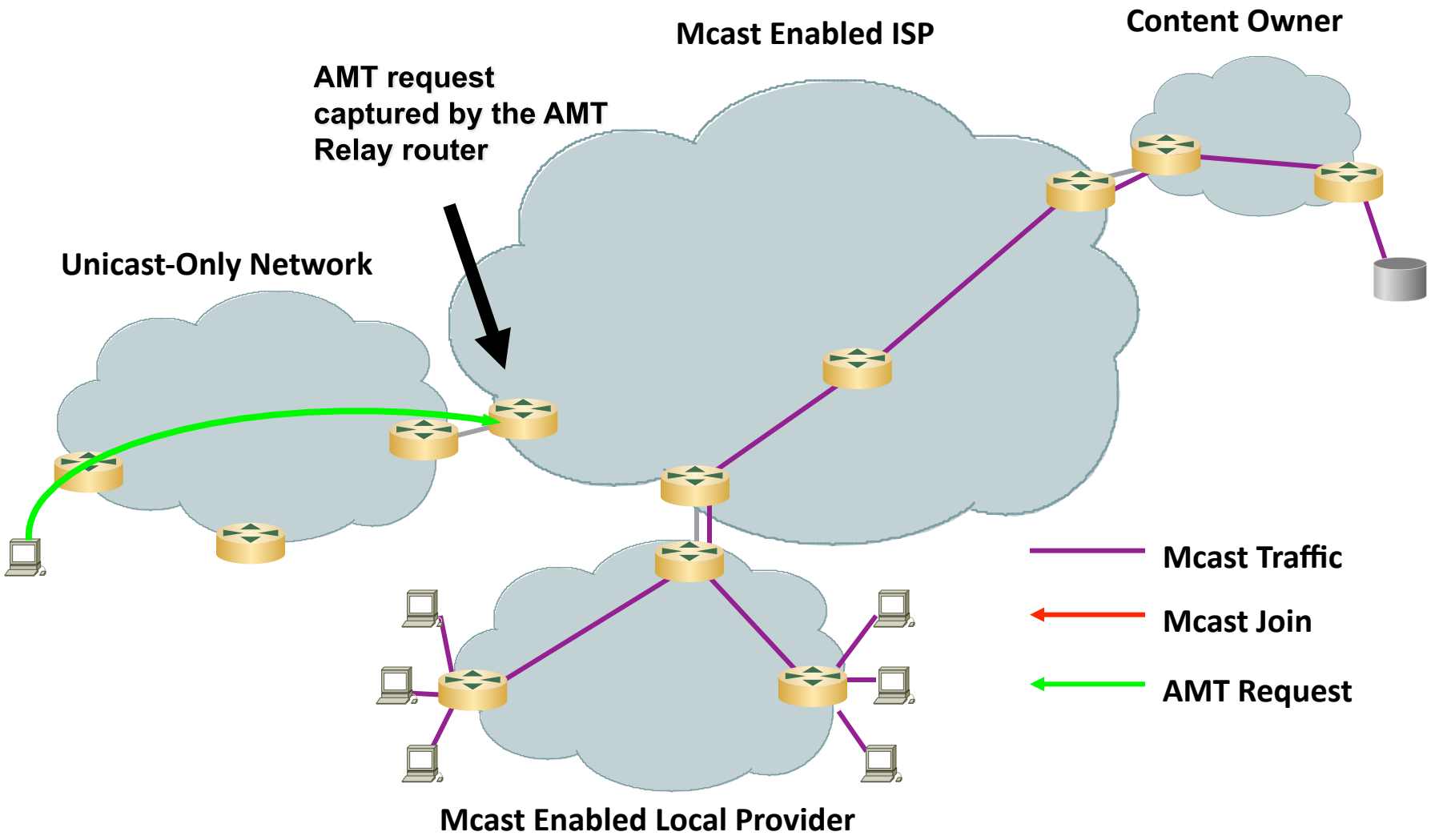

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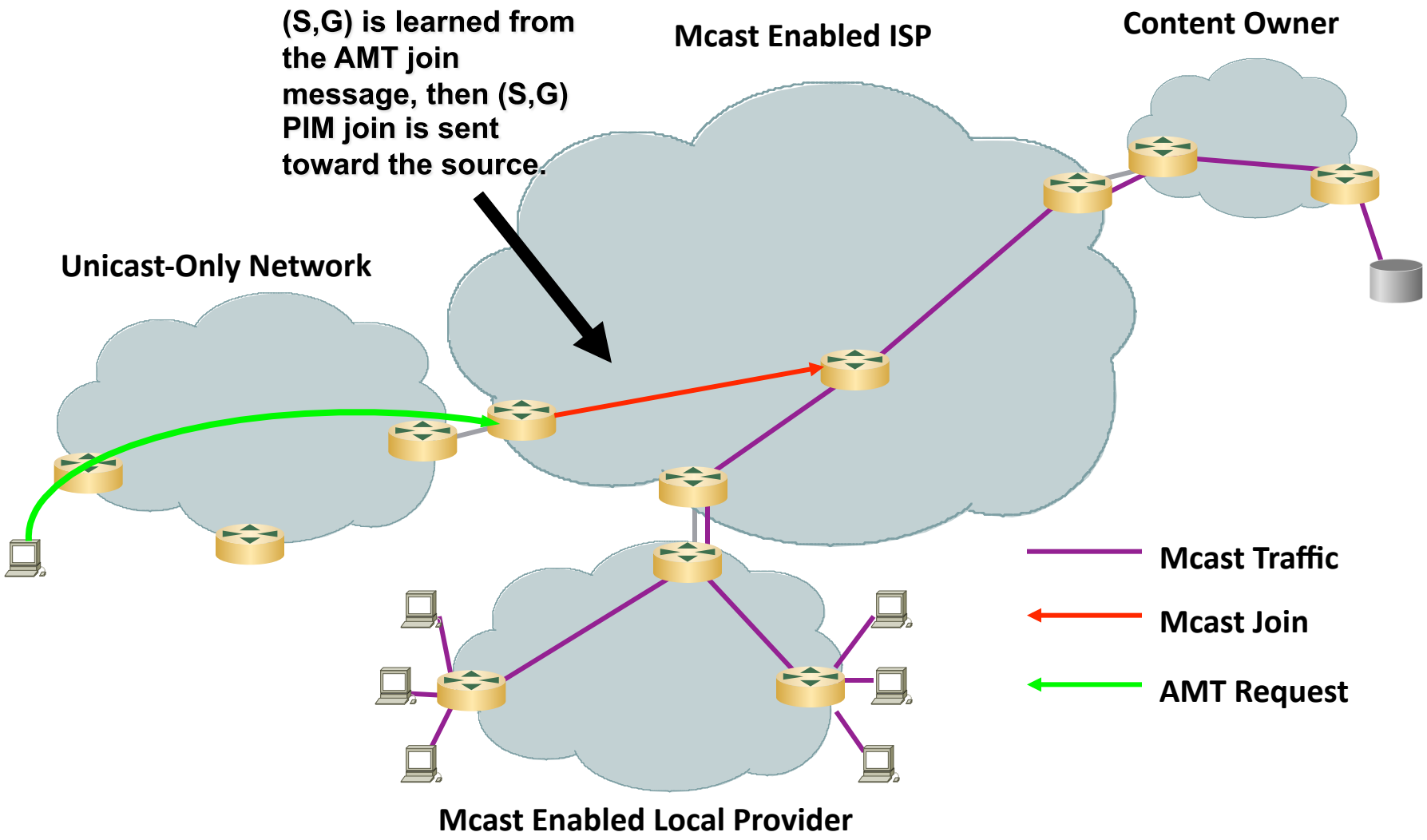

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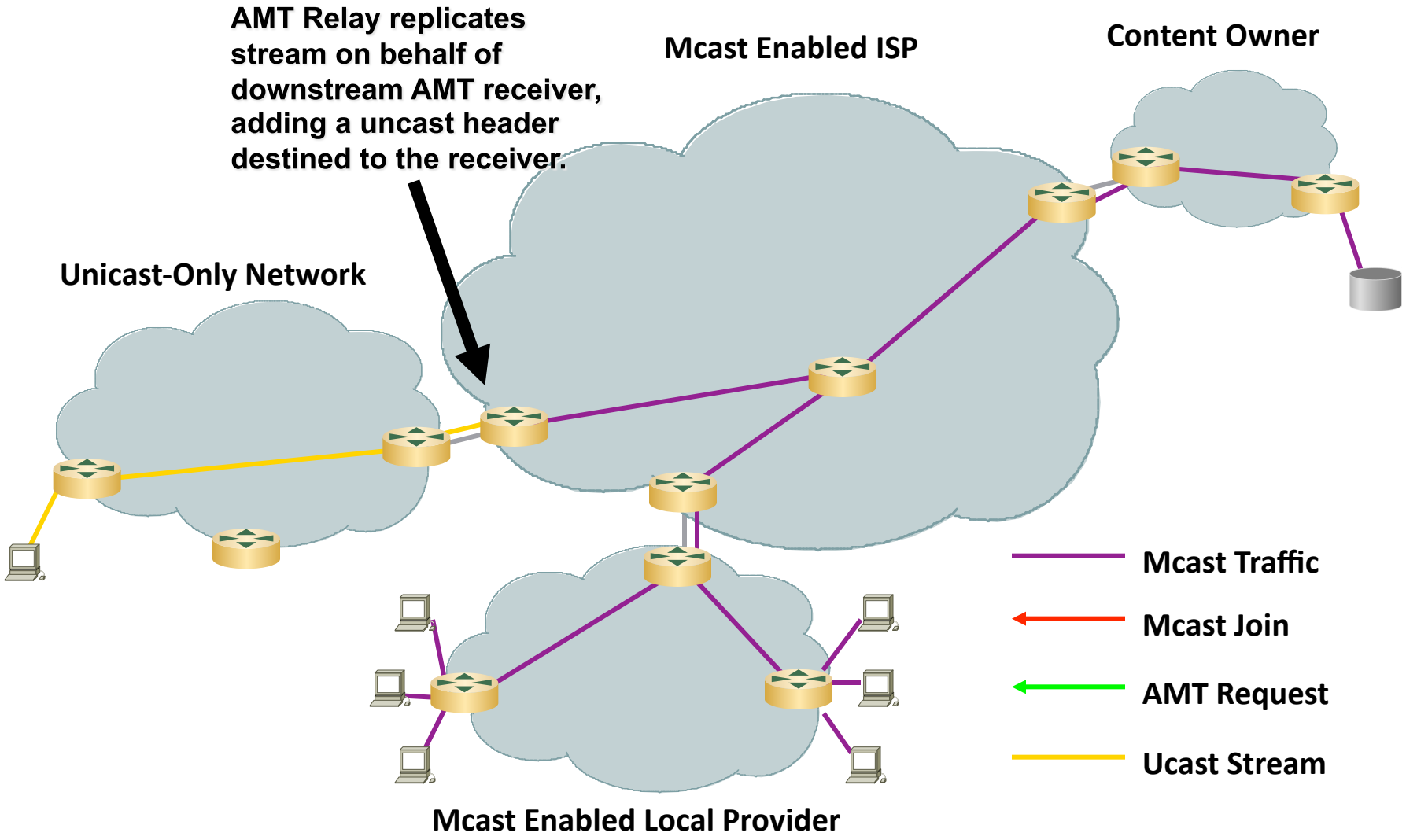

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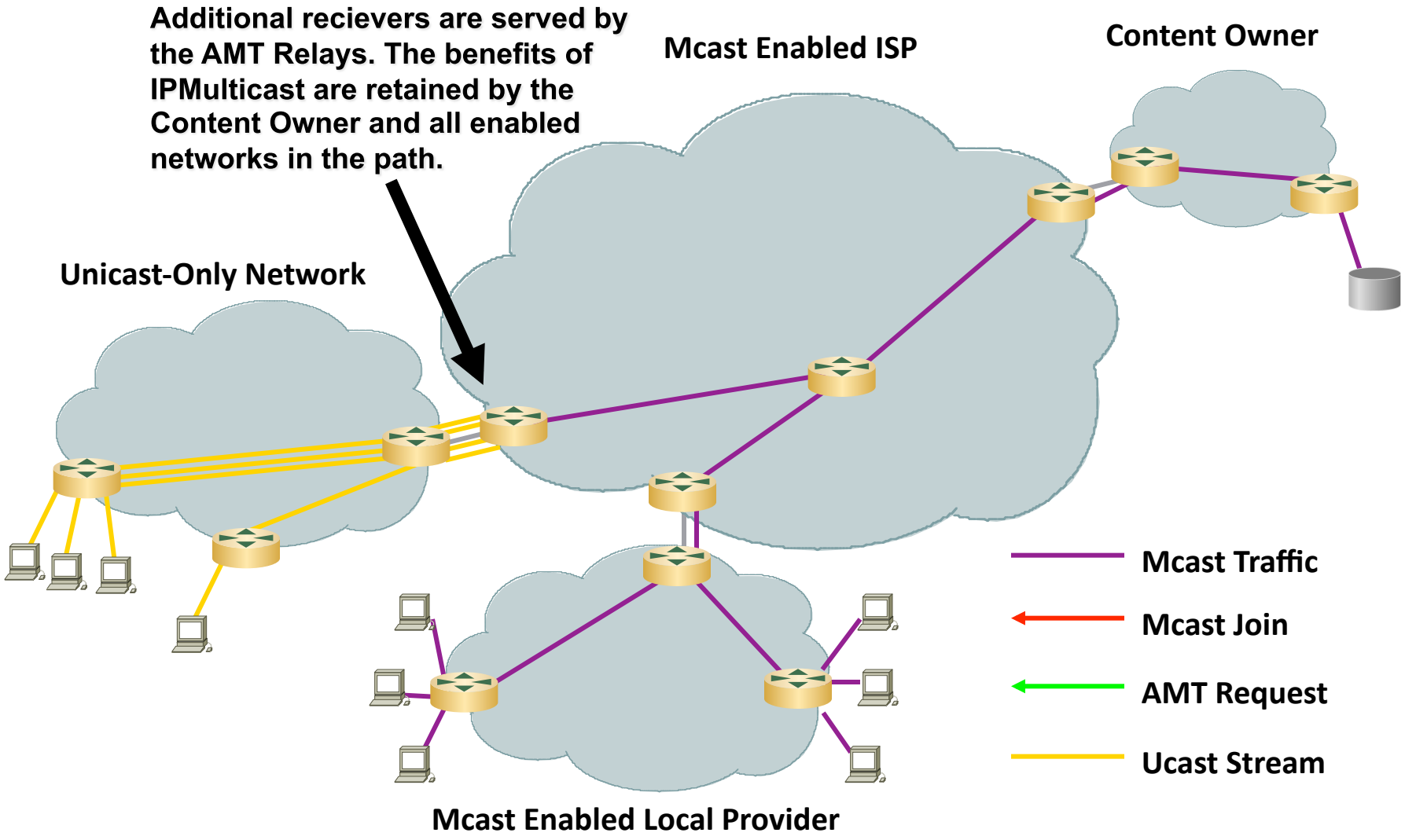

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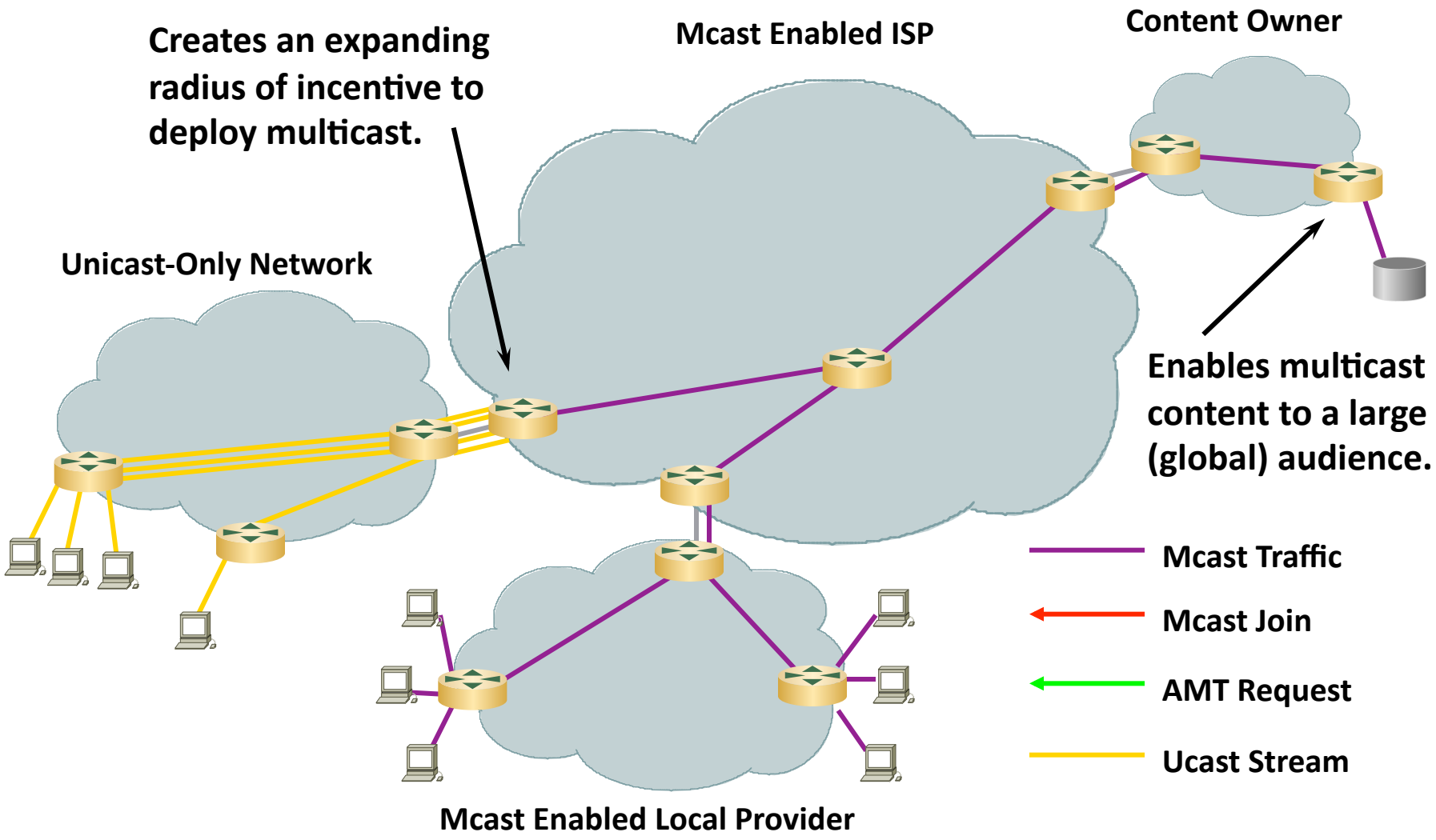

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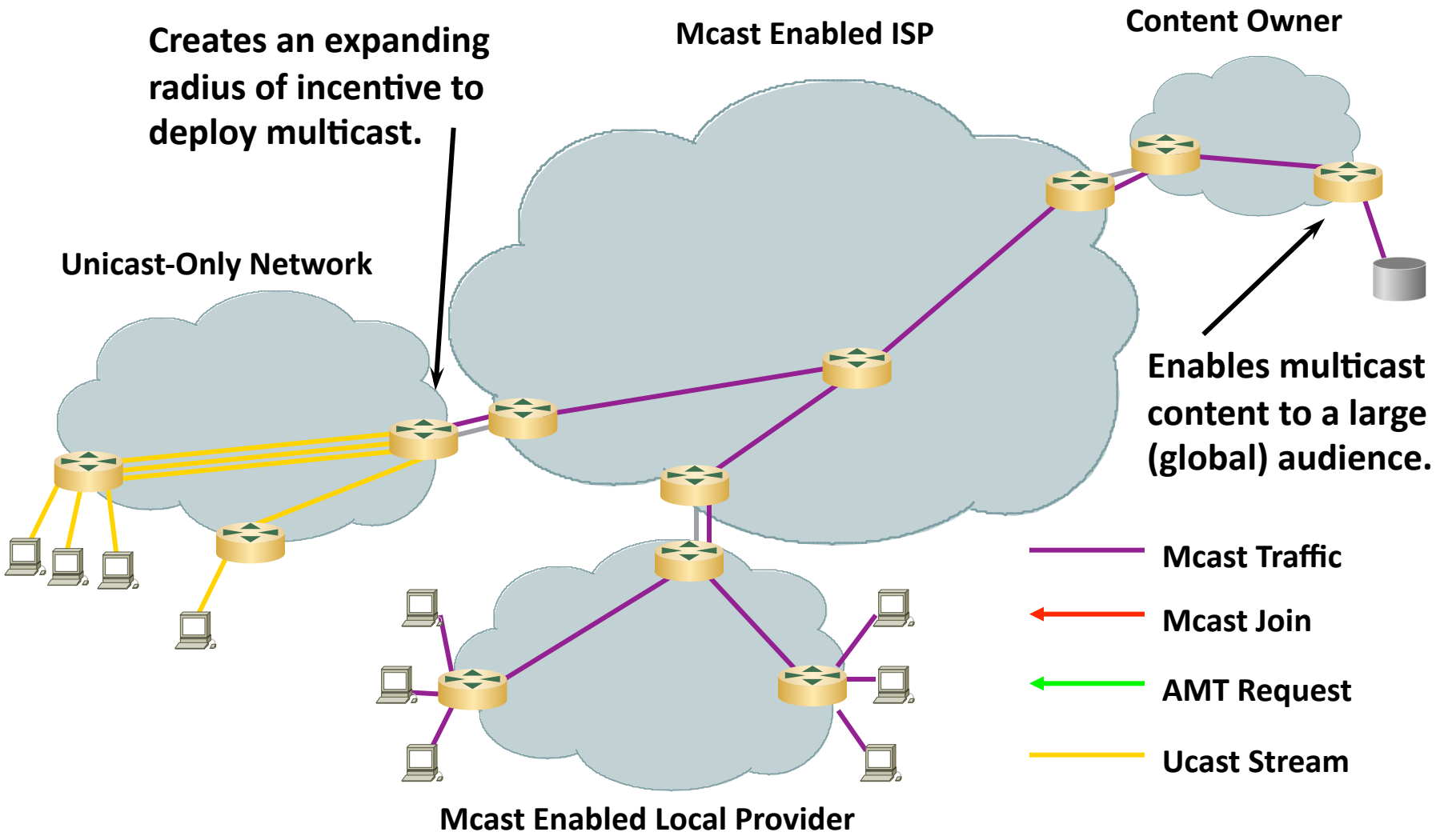

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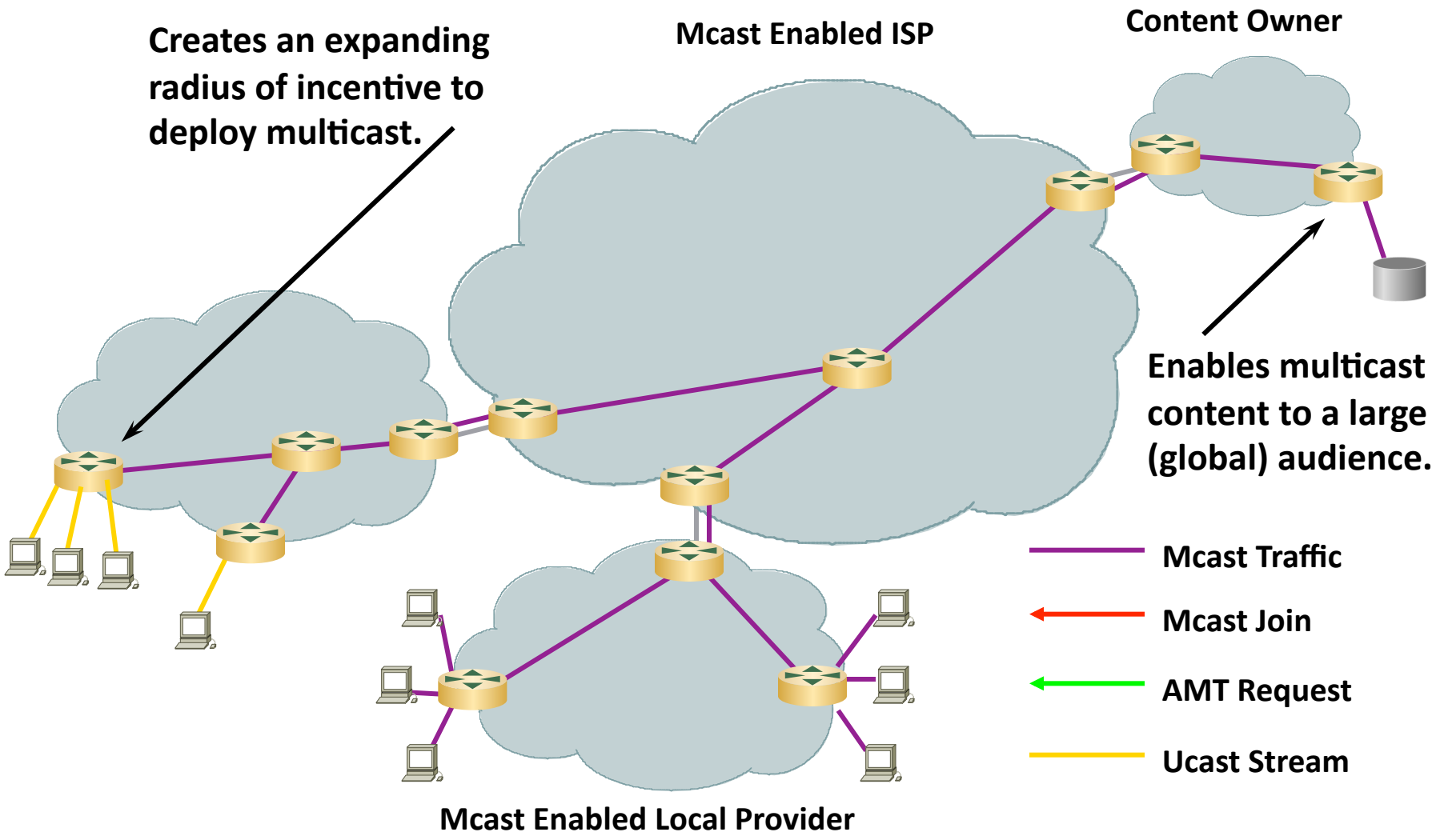

Current AMT status

- Cisco development in NX-OS
- Public reference implementation
  - Android Gateway in development
  - Cisco Research grant to UCSB/UTDallas
    - Relay/Gateway - Linux/FreeBSD
    - Gateway - VLC (Mac, Win), Linksy

AMT Deployment Trial

- Provider Testing
- LINX
  - GlobalMix IPTV content
- ISC.org
  - Global mcast mix network
- NETNOD - MIX in Sweden
  - Radio and IPTV content customers
- Open for more participants!!
  - shep@cisco.com

UDP Internet Video?

- No control once the content leaves your administrative domain
- Is the “quality” of the Internet ready for global video distribution?

Measuring and Understanding IPTV Networks

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Martin Ellis

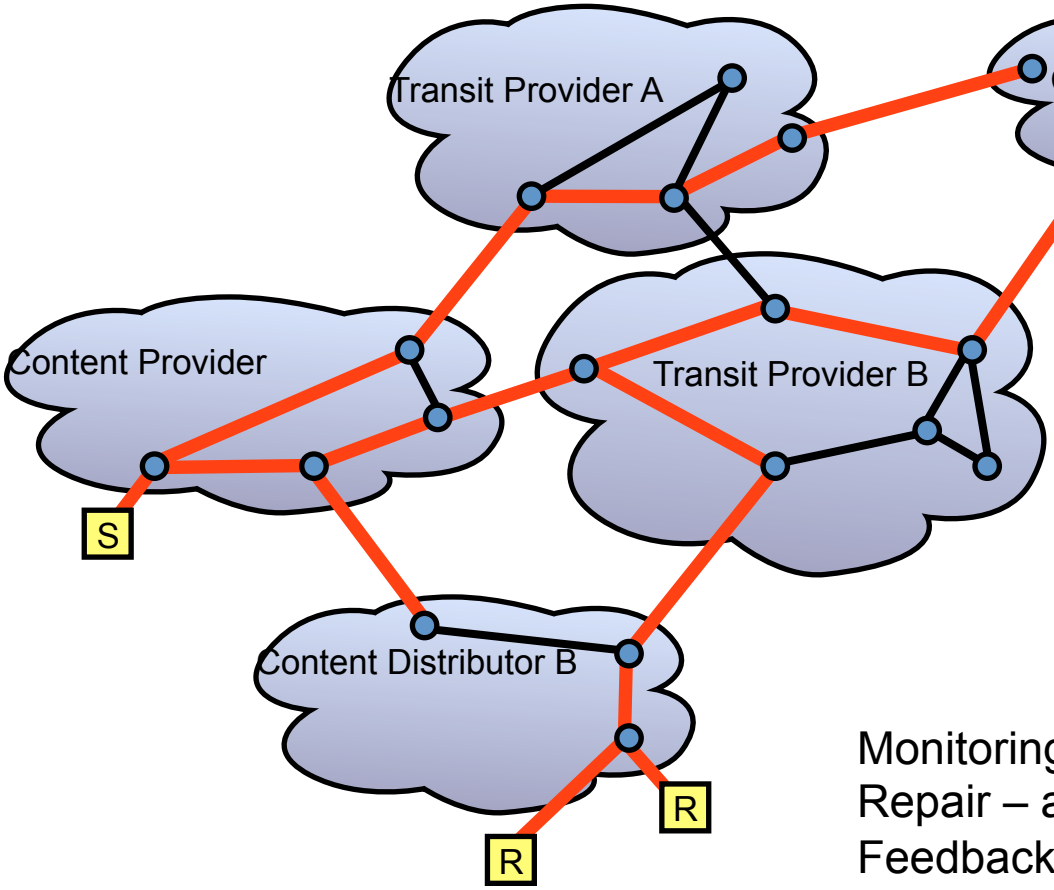
http://www.dcs.gla.ac.uk/~ellis/

Research Goals

- Measure and understand the impairments affecting IPTV network traffic
  - Packet loss/timing; media aware if possible
  - Intra- and inter-domain flows
- Improve techniques for on-line error repair and off-line network troubleshooting
  - Inform choice of FEC, retransmission, etc.
  - Consider network tomography for management

[Joint with Jörg Ott's group @ TKK]

IPTV System Model – Interdomain



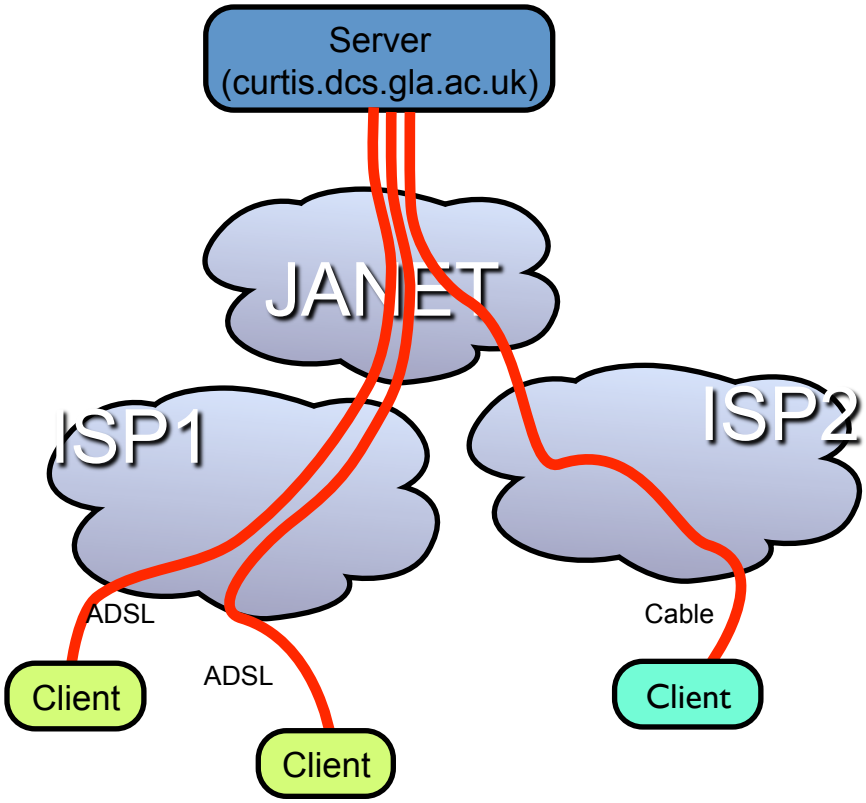
Expected future evolution; deployed IPTV systems a restricted subset – need to understand the end-to-end performance to evolve system

Monitoring – end-to-end and at domain borders
Repair – at edges of content distributor network
Feedback Aggregation – inter- and intra-domain

Understanding System Performance

- Only limited IPTV measurements available
  - Most studies either between well-connected sites or using TCP for media transport
  - Little data on UDP-based IPTV performance
    - Interdomain from well-connected servers to residential hosts, to understand end-to-end path
    - Intradomain to understand behaviour of edge networks, evaluate effectiveness of network tomography to diagnose edge problems
  - Beginning to collect data – *early interdomain results today…*

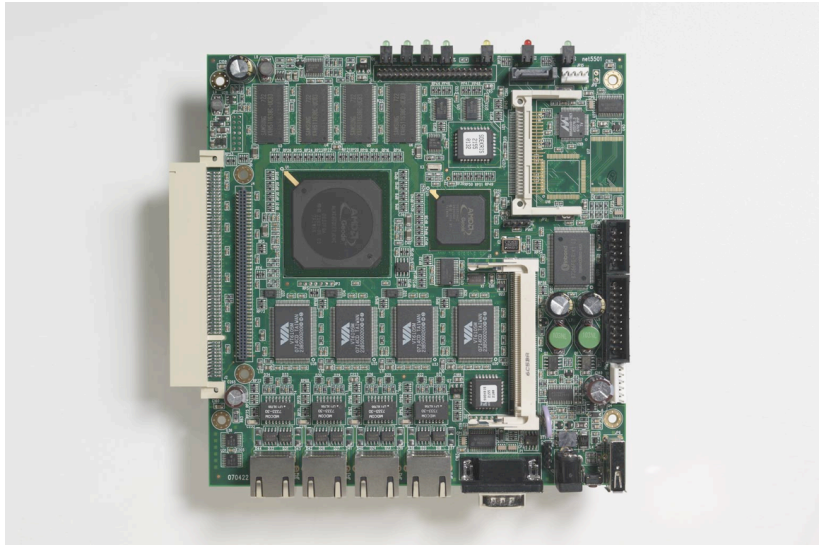
Interdomain Measurement Architecture



- Server well-connected on public Internet
- Clients on residential connections
- Inter-domain path from server to client
  - ~15 hops to UK ISPs; choke-point at Telehouse in London
  - Simulates interdomain IPTV scenario

Measurement Platform

- Deploy into home networks
  - ADSL - generally 8Mbps downstream
  - Cable modem
- Expect a mix of users
  - Technical - own Linux/Unix system at home, can run measurement tool
    - But uncontrolled measurement environment; undesirable variation
  - Non-technical - require unobtrusive, low-maintenance, measurement box
    - Soekris net5501 single-board computer with 120GB disk, running FreeBSD 7
    - <10W, silent, size of a book



Measurement Using Test Streams

- Aim: generate test traffic to (roughly) match IPTV flows
  - Measure loss/jitter characteristics
  - Looking to move to real-world streaming IPTV over time
- Input to simulation of repair mechanisms and topology inference

Initial Measurements

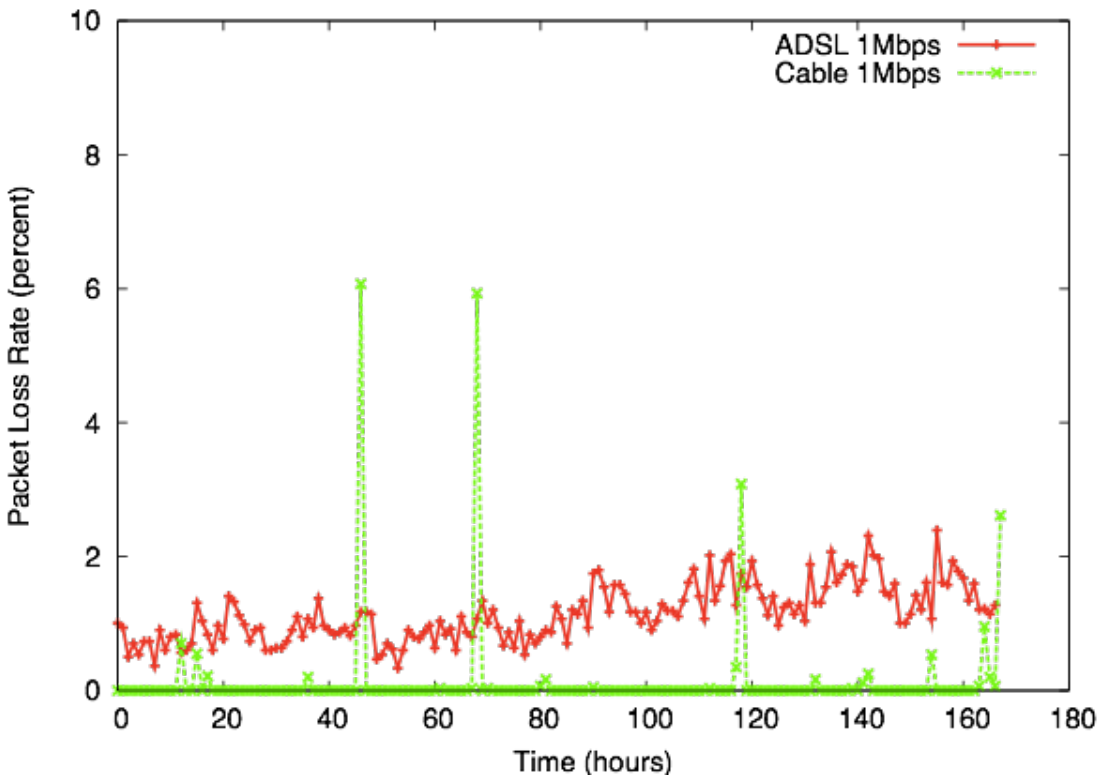
ADSL					
IPTV CBR 1Mbps	Hourly at :50				1min
IPTV CBR 2Mbps	03:15	10:15	15:15	20:15	10 mins
IPTV CBR 4Mbps	03:35	10:35	15:35	20:35	10 mins
VoIP CBR 64kbps	Hourly at :10				1 min

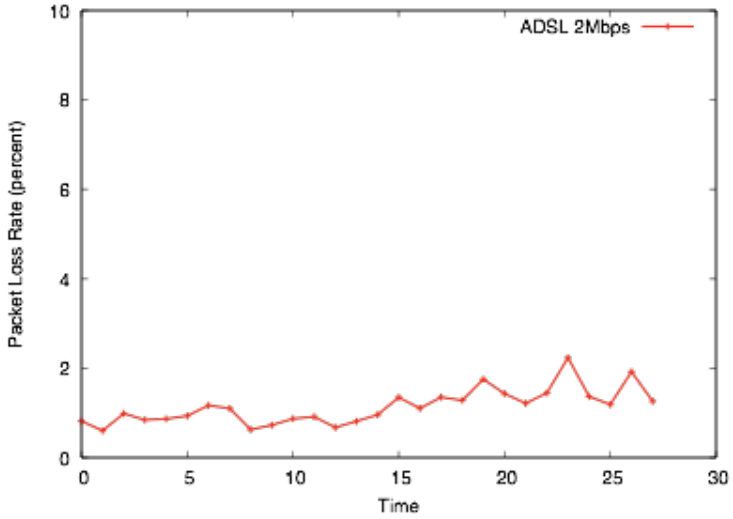
Cable Modem					
IPTV CBR 1Mbps	Hourly at :30				1 min
IPTV CBR 2Mbps	04:15	11:15	16:15	21:15	10 mins
IPTV CBR 4Mbps	(not supported by access link)				10 mins
VoIP CBR 64kbps	Hourly at :55				1 min

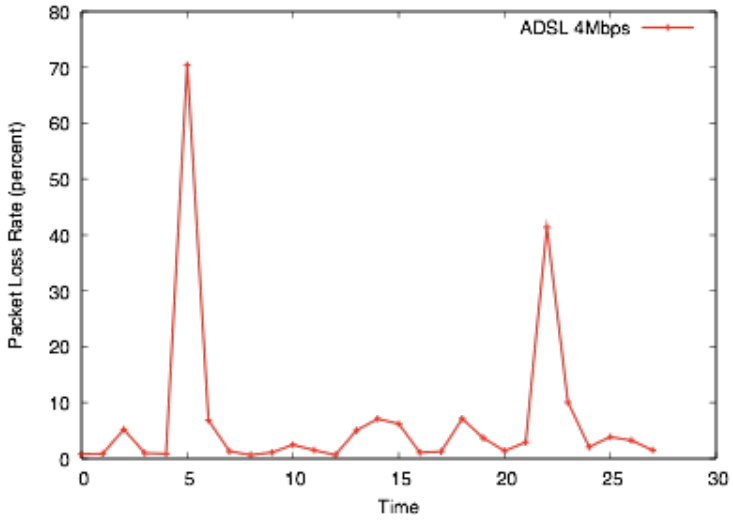
Initial trace duration:
1-7 November 2008

~16 million packets

Packet Loss – Loss Rates

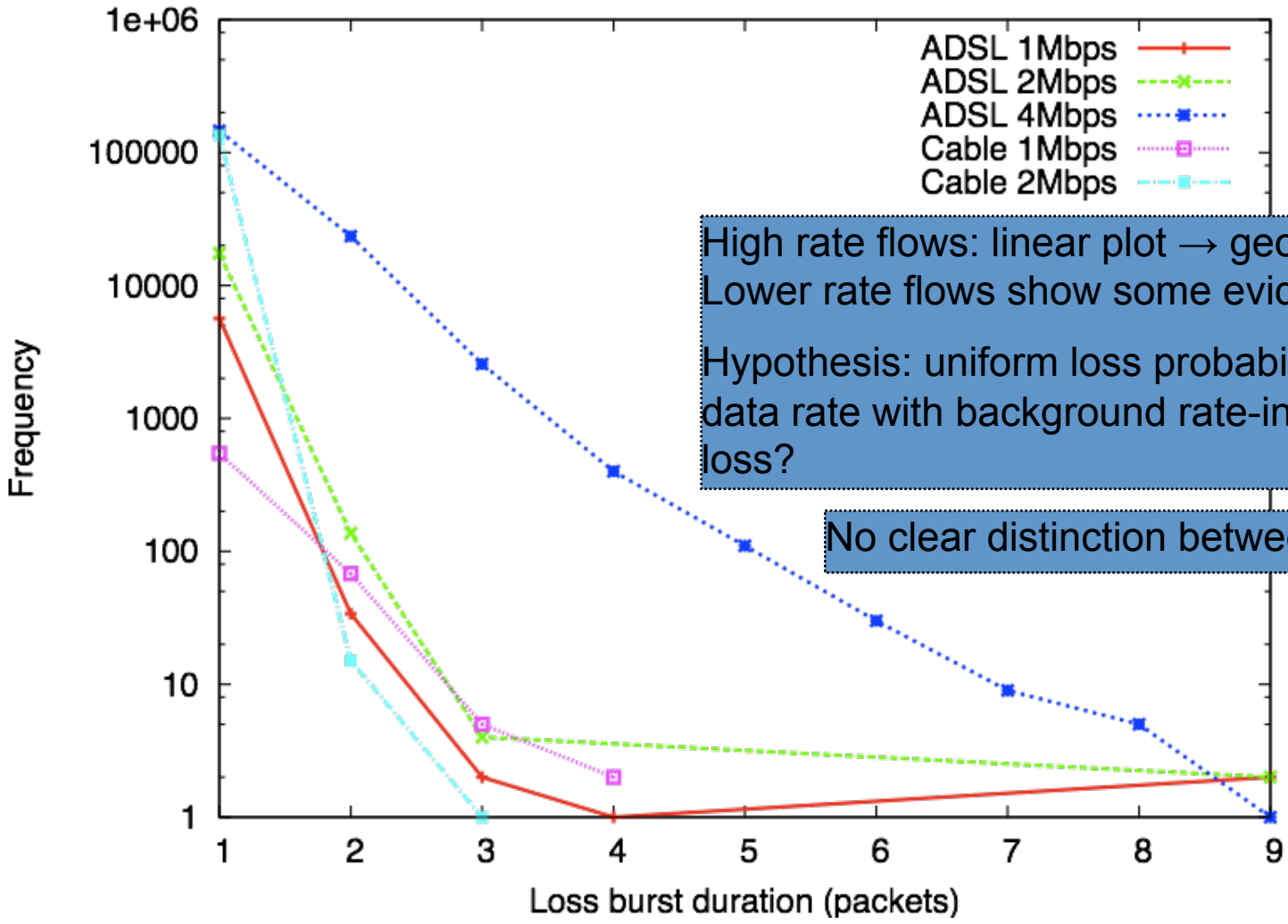






Non-negligible packet loss on ADSL network, unaffected by data rate below some threshold

Packet Loss – Loss Run Lengths

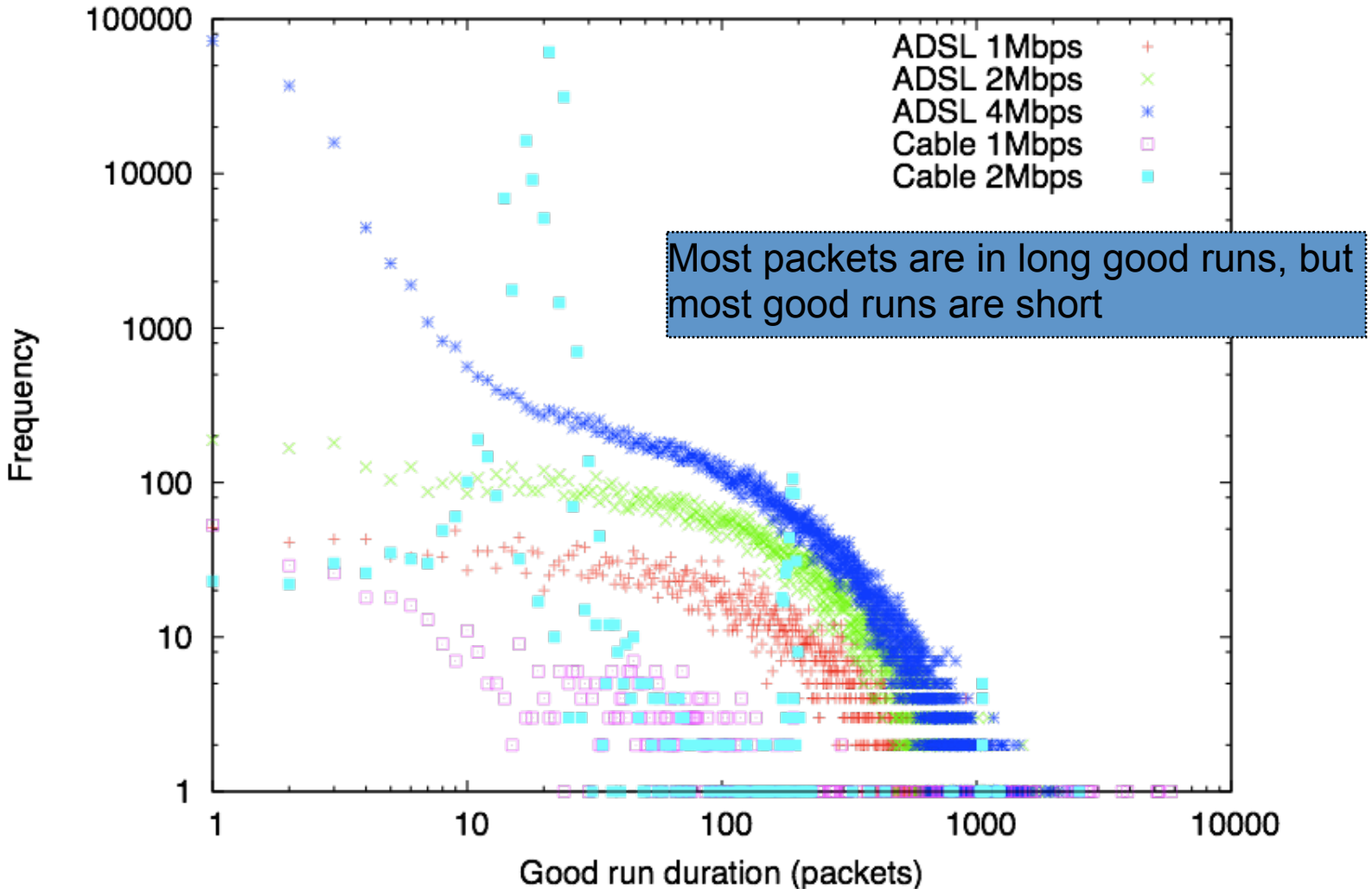


High rate flows: linear plot → geometric distribution
Lower rate flows show some evidence of longer tail

Hypothesis: uniform loss probability dependent on data rate with background rate-independent bursty loss?

No clear distinction between ADSL and cable

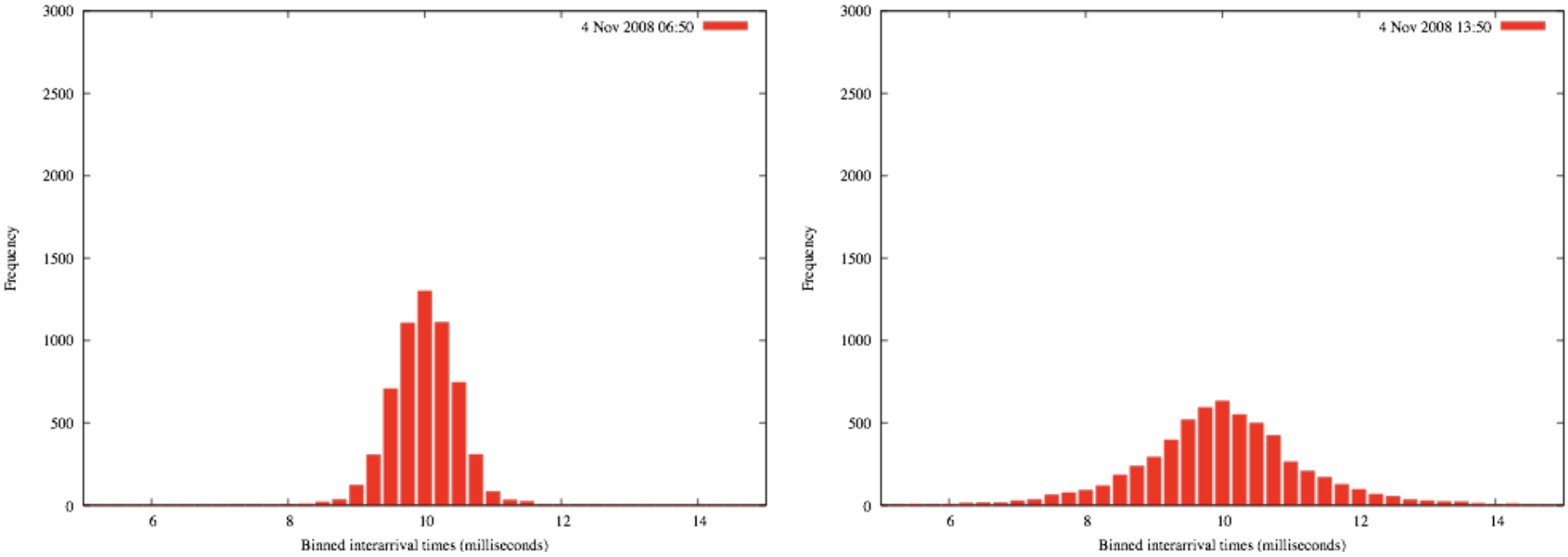
Packet Loss – Good Run Lengths



Packet Reordering

- Packet reordering infrequent
  - 4 packets reordered out of ~16 million sent
    - Worst was out-of-sequence (delayed) by 4 packets
  - 2 flows affected
  - Matches expectations: reordering due to route change or misbehaving load balancing at high rates

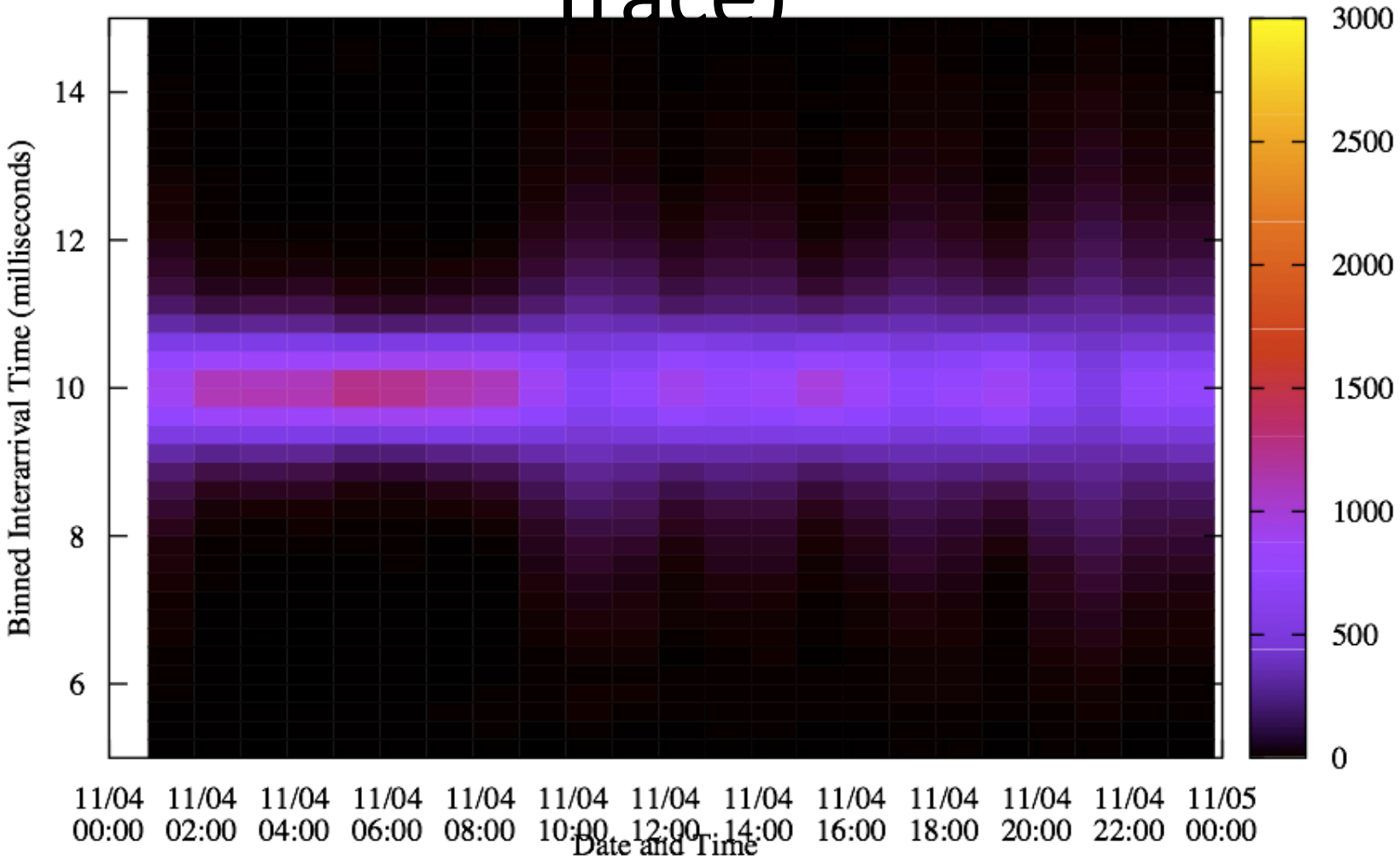
ADSL Inter-arrival Times



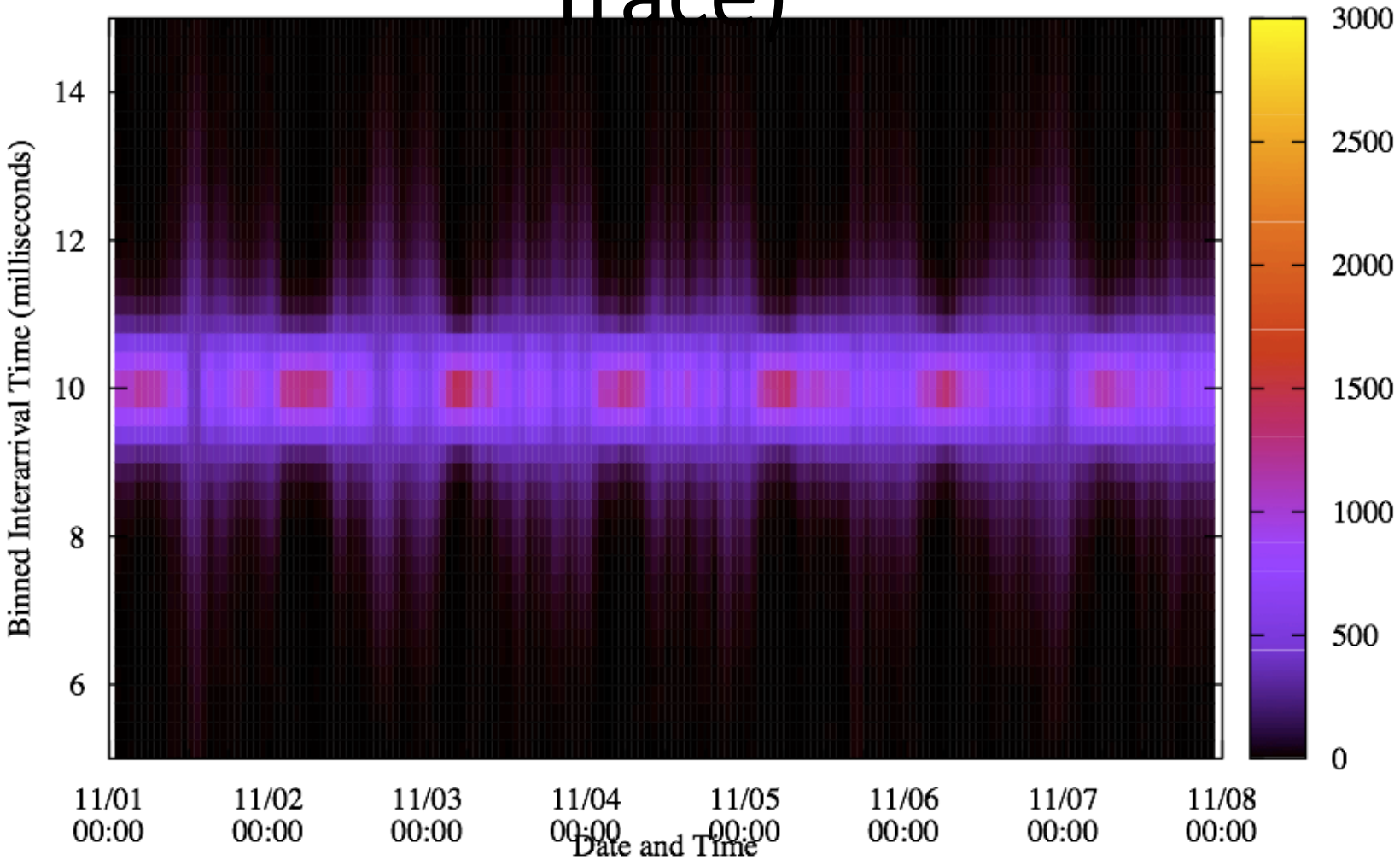
1 Mbps CBR flows

- Traffic dispersion pattern not unexpected
- Highly dependent on time-of-day

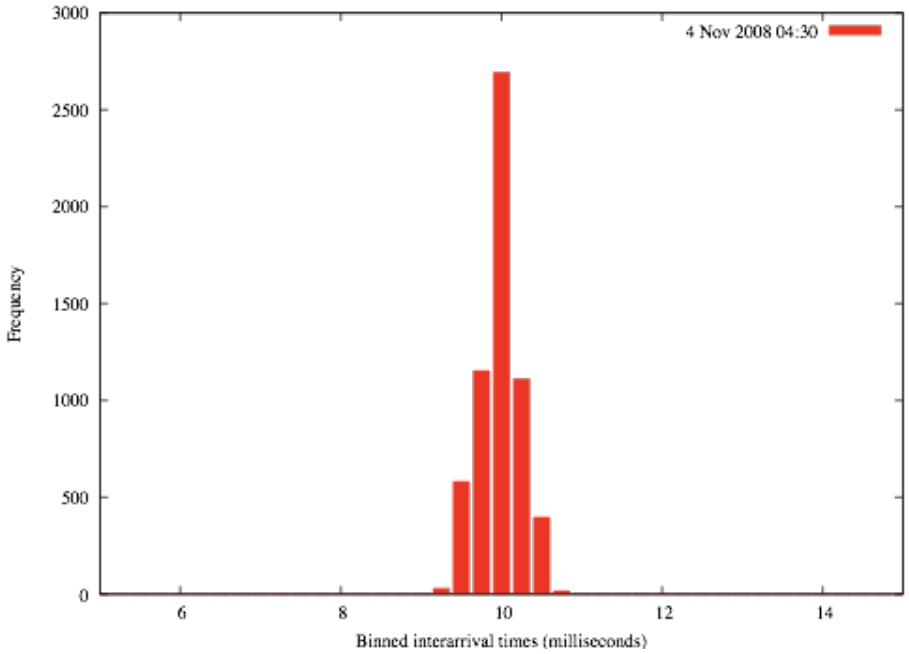
ADSL Inter-arrival Times (24 Hour Trace)

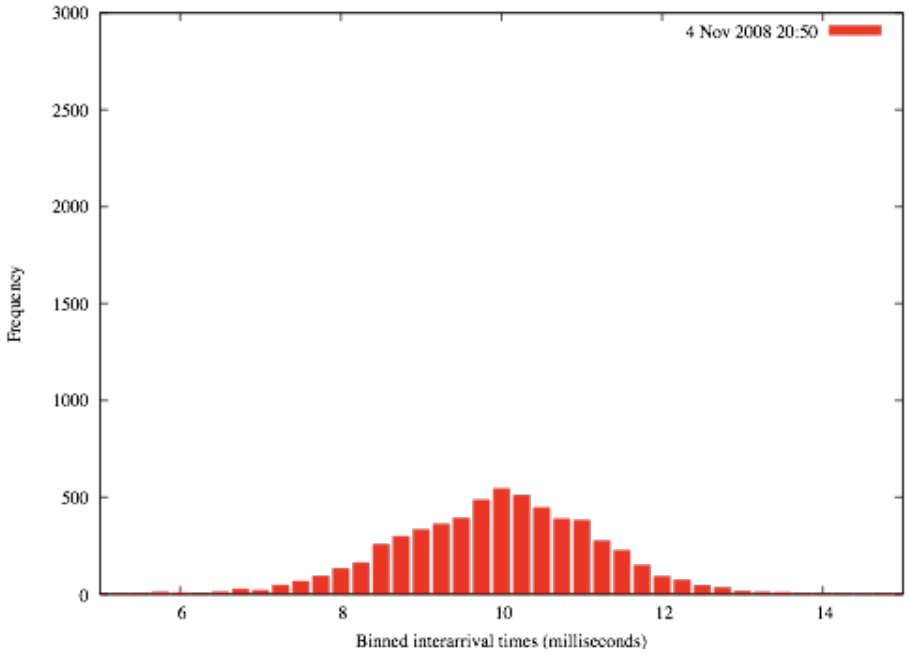


ADSL Inter-arrival Times (1 Week Trace)



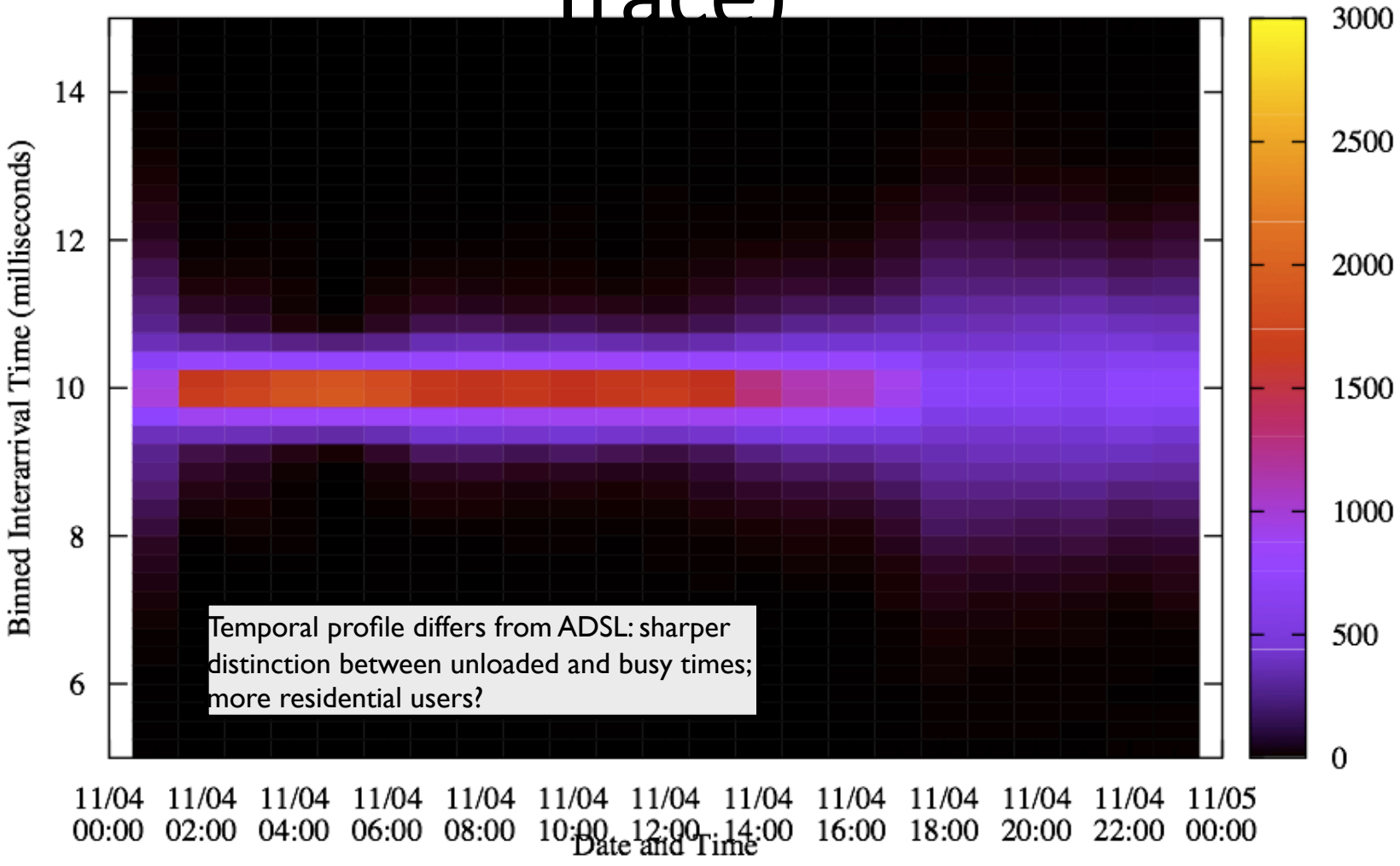
Cable Inter-arrival Times





- Slightly worse dispersion than ADSL at busy times, much better at quiet times

Cable Inter-arrival Times (24 Hour Trace)



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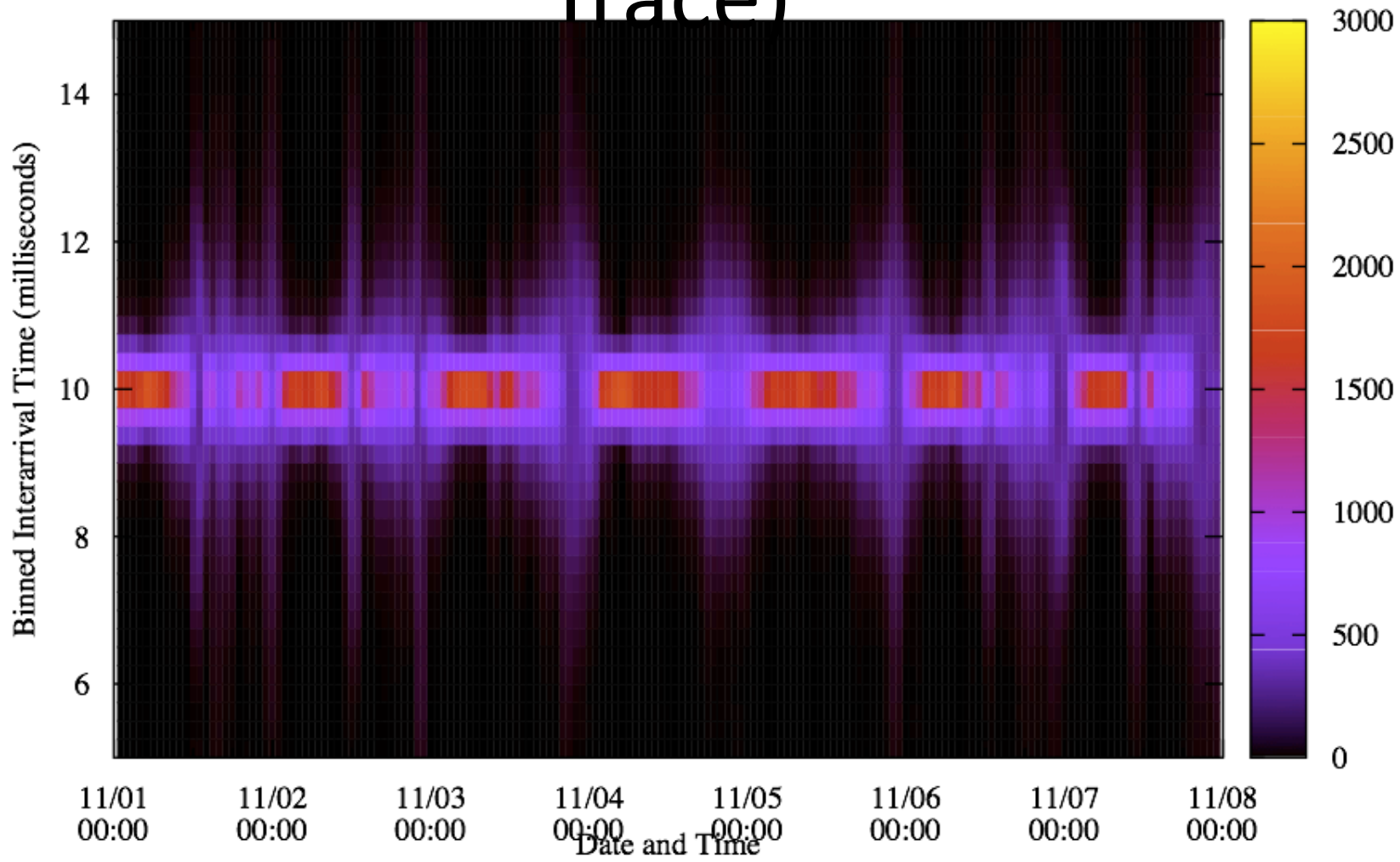
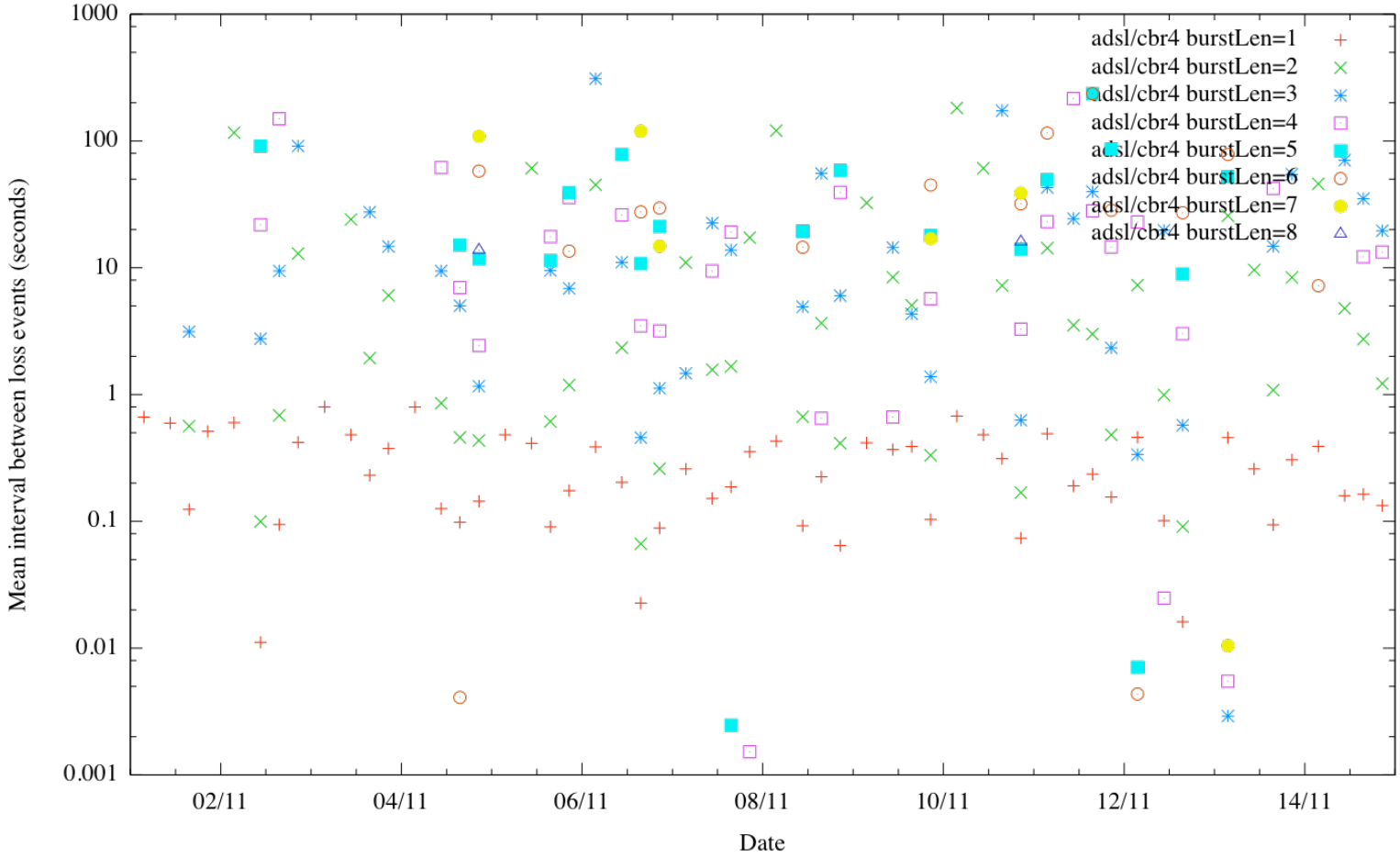


MTBArtifacts



Summary of Measurements

- Despite uncontrolled inter-domain path, see clear distinctions between edge networks
  - Analysis just starting...
- Very early results: planning to conduct more measurements
  - Range of different ISPs
  - Multiple users in the same ISP

Implications for Error Concealment

- *If these results are typical…*
  - Most loss bursts short (2-3 packets), but many short good runs → small amounts of FEC, but not on adjacent packets
  - Longer bursts infrequent → not worth overhead of FEC to protect against these; reactive repair
  - Need more data, from flows reflecting real IPTV traffic, to confirm repair effectiveness

University of Glasgow

BE Video

- Most loss is random
- Few large correlated losses seen in the limited testing
- But we know network failures can create larger correlated loss
  - Need to see MTBF of the previous data
- Lightweight FEC can correct small correlated losses
- How do we correct for large correlated losses
  - Even though these may have larger MTBF

MDC – Multi-Description Coding

- Most techniques and solutions are focused on path diversity
- All seem targeted for better error concealment
- Do not exploit temporal domain
- But what if you don’t have visibility or control over the path? …and all other network details?
- What if Best-Effort transport is all you can expect for all of your video content?

SVC – Scalable Video Coding

- H.264/AVC Annex G
- Allows the construction of bitstreams which contain sub-bitstreams that conform to H.264/AVC
- Aggregate bitstream contains a base-layer for minimum temporal and spatial resolution
- Sub-bitstreams are enhancement layers to add temporal or spatial resolution
- All enhancement sub-bitstreams are dependent upon the base-layer

Multi-Latticed Video Encoding

- All layers of equal importance
  - No base-layer dependency
  - Each layer independently decodable
- Transforms an unrecoverable “short” duration error into a long duration concealable error
- Can conceivably conceal multi-second network outages
- Practical concealment of 500ms outages without altering viewer experience.
  - Either startup latency or disruptive artifacts
- Other benefits are being discovered and explored through research implementations

The Internet is Dead

- Much work has been accomplished in the IETF for robust realtime streaming transport protocols
- Most end-sites now sit behind draconian firewalls
  - Many are configured to address operational requirements
    - "UDP is bad. HTTP is good!"
- Streaming solutions beginning to adopt HTTP to address this limitation
- Welcome to the Port80 network

Future Challenges

- What's the end-game?
- How does an IPTV provider say in the food-chain?
- How do content owners maintain brand-identity?
- Who will be the next wave of content providers?
- Will Tier1 providers have a play?
- Will AMT enable a new generation of IP content?
- Will firewalls force all internet video onto HTTP?? ☹

Thank you!

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