

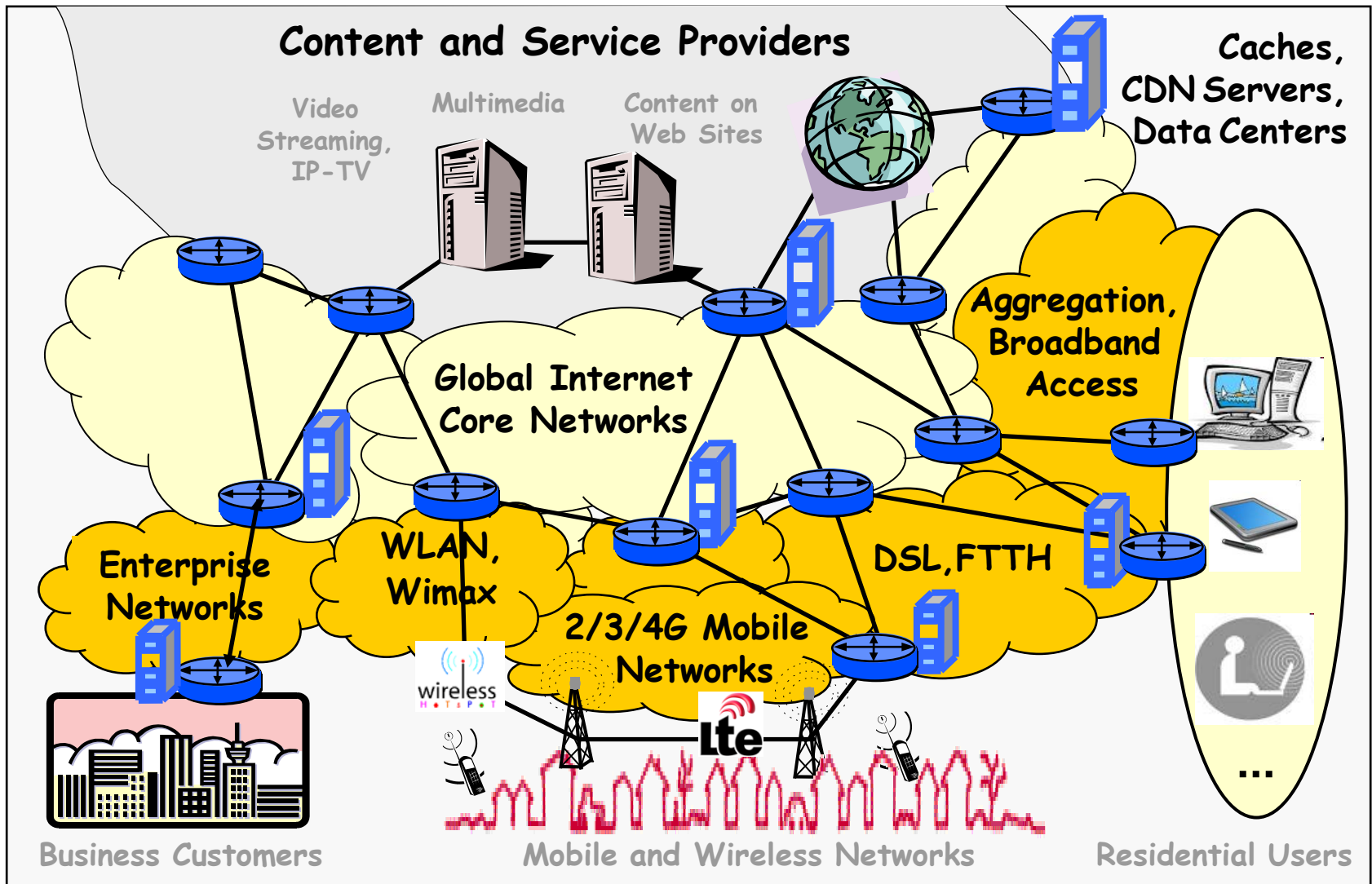
# Traffic , Caching & Traffic ACROSS Data Centers in Clouds, CDNs and ISP Networks

Gerhard Hasslinger, Deutsche Telekom, Darmstadt, Germany

E-Mail: [gerhard.hasslinger@telekom.de](mailto:gerhard.hasslinger@telekom.de)

- Caching options, main goals and benefits in Ip networks
- CDN, cloud traffic in ISP networks
- Cacheability and limitations
- Conclusion

# Caching options in the IP network infrastructure



## Main Goals & Benefits of Caching

- to shorten the transport paths and delays from an original server to the requesting users,
- to reduce the traffic load and costs for network providers
- to shift traffic load from the busy hour to low load phases by prefetching and overnight cache updates
- to increase the throughput due to shorter round trip times in TCP connections
- to replicate data in distributed caching infrastructures for enhanced availability and throughput from multiple caching servers in case of flash crowds

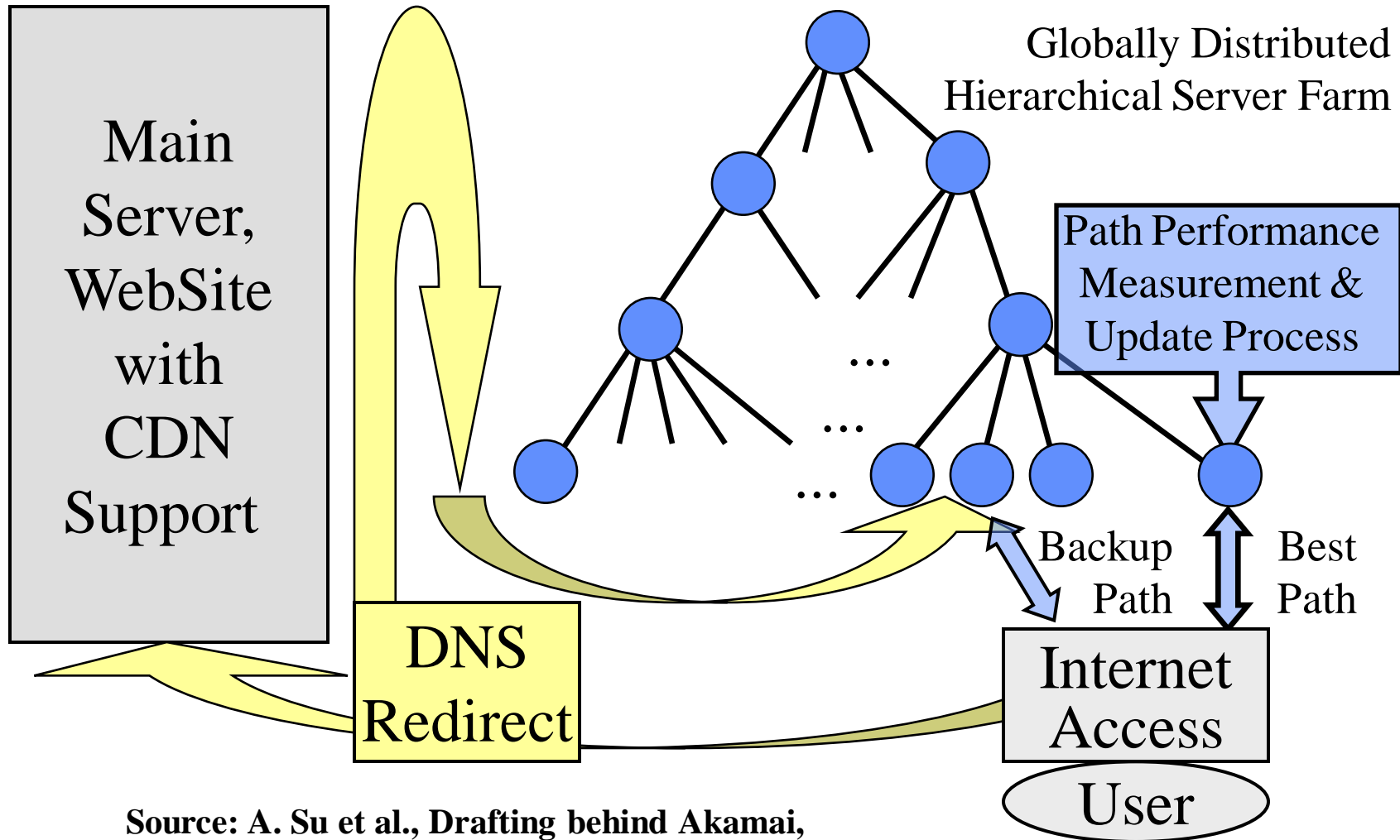
## Main Traffic Categories in ISP Core Networks

- CDN-to-User Traffic (OTTs, Google, Akamai etc.) (>40%\*)
- Cloud/Server-to-User Traffic (without global CDN) (>20%\*)
- User-to-User Traffic (P2P, Voice, Video Conf.) (>10%\*)

\* of traffic to end users

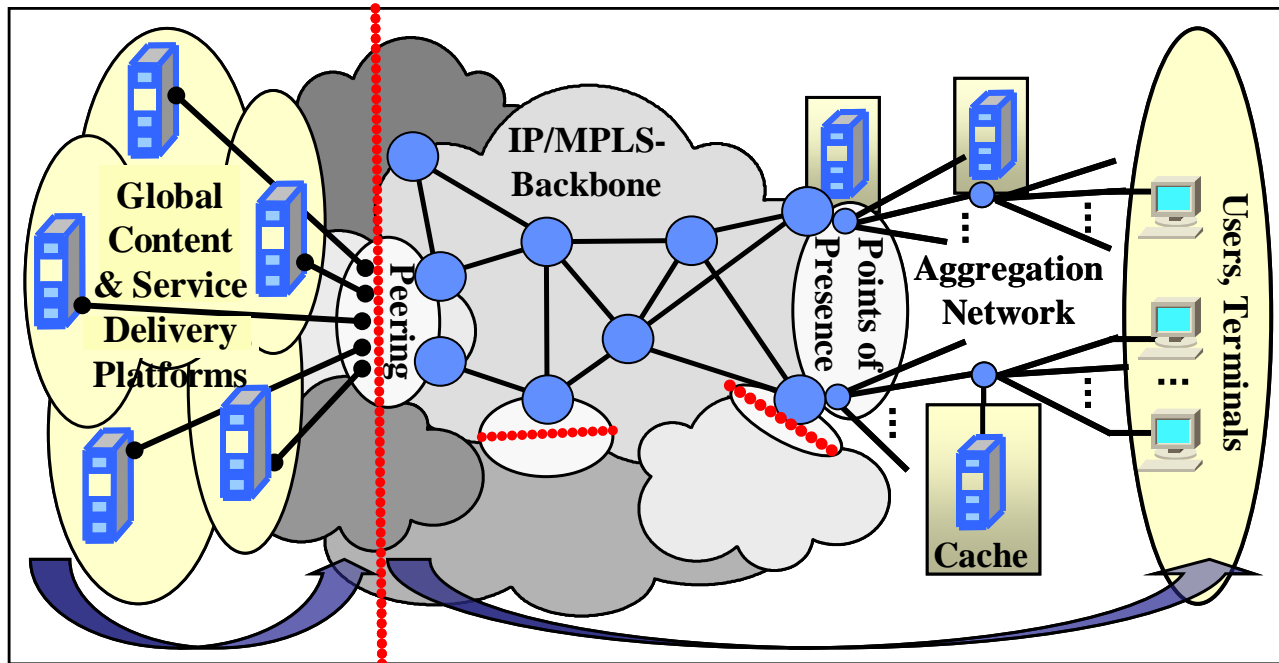
- Data-Center-to-Data-Center Traffic: >30% of traffic to end users according to Cisco's cloud networking index

# Content Delivery Overlays (CDN, Akamai, Limelight...)



Source: A. Su et al., Drafting behind Akamai,  
IEEE/ACM Trans. on Networking 17 (2009) 1752–1765

# CDN & Caching in broadband access networks



Caching is applied in global content delivery networks and partly in network provider platforms of large ISPs ... but usually without cooperation

IETF working group on CDN interconnection since 2011  
<<http://datatracker.ietf.org/wg/cdni/charter/>> (Up-/Downstream CDNs)

## Relevance of caching in the IP infrastructure

- Caching is crucial to reduce load on expensive inter-domain & inter-continental links → mostly achieved by global CDNs
- Caching can also reduce load in the core and aggregation but core network capacity for large ISPs is less expensive and many small caches are required in the aggregation
- Transparent caching by ISP: requires coop. with global CDNs is helpful for popular services without CDN support
- Caching in home gateways is an option (user or ISP control)
- Caching on user end systems e.g. in browsers still can save >20% of traffic load (most important in mobile networks)

## Interoperability between CDNs/clouds and ISPs

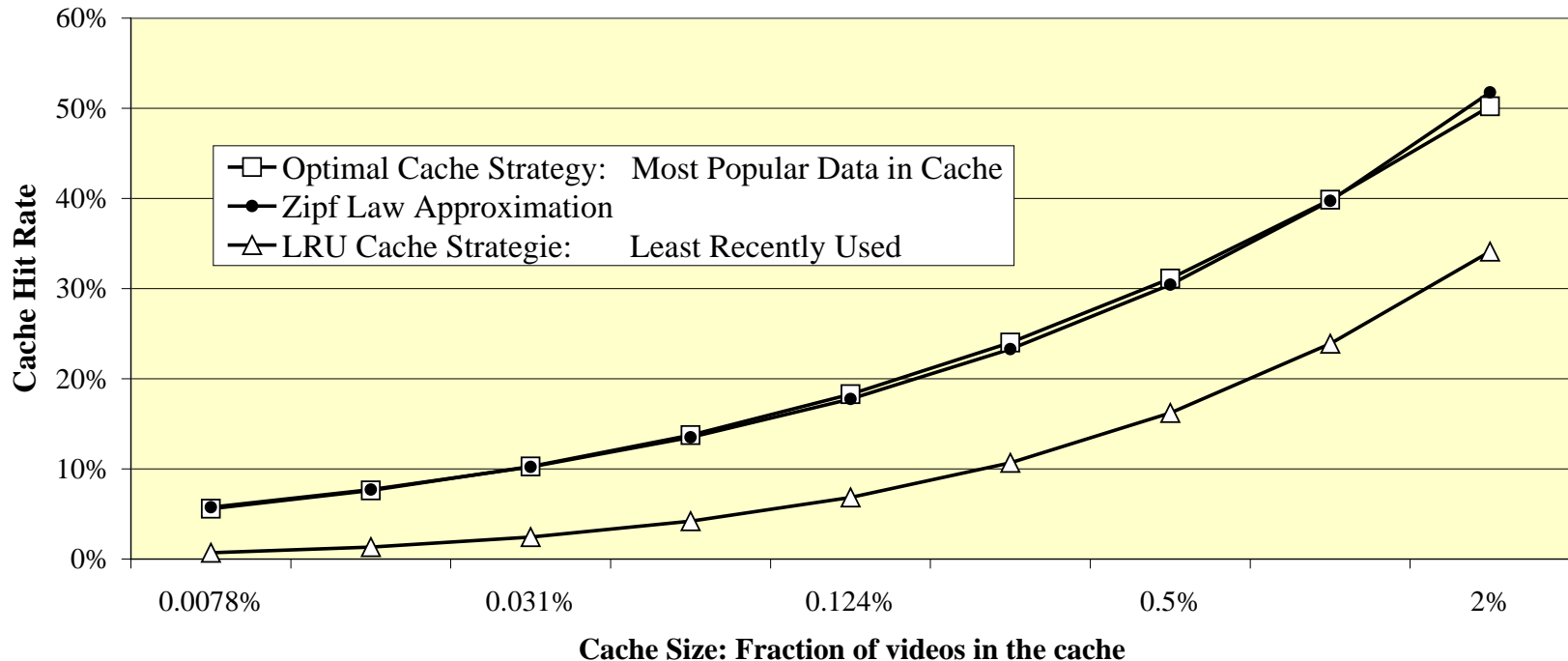
- Large CDNs offer cache servers in ISP networks but then large ISPs would have to manage Google/Akamai/Netflix caches in their core/aggregation
- ISPs are building up data centers in the core as IaaS
- In principle
  - clouds / CDNs should have control on application layer
  - ISPs should control the network layer for traffic engineeringbut currently no viable cooperation schemes seem to be applied beyond bilateral peering agreements
- Ongoing work in standardization, e.g. extended ALTO approaches by Nokia/ALU France and BENOCS



## Limited applicability & efficiency of caching

- Regulations / laws (in Germany) allow caching or in general, storing data in the network for improving performance, when a web sites removes data, a cache also has to remove it
- R. Fielding et al.: HTTP 1.1 Caching RFC 7234 (2014)  
Caching rules & recommendations
  - flags indicate whether data is cachable in the network and/or user equipment
  - on expiry of data on dynamically changing web sites
  - still on appropriate CDN ↔ ISP data exchange standardized
- Statistics-based caching strategies outperform LRU  
Simulation studies confirm LFU performance of large caches

# Cache Efficiency e.g. for YouTube Videos



Evaluation of statistics on YouTube accesses in Dec. 2006 with 3.7 billion accesses to 1.65 million videos over several months

Cache replacement strategies: LRU is simple but has non-opt. hit rate  
 Statistics-based, LFU-like cache methods achieve 10% hit rate gain

Source: M. Cha et al., I tube, you tube, everybody tubes, IMC, San Diego, USA (2007)

## Conclusions on caching

- Content distribution on the Internet depends on CDN & caching  
- for improved delay, throughput, availability & traffic saving
- Dominant HTTP traffic for video streaming & IP-TV is cacheable
- Zipf distributed request pattern, prefetching and appropriate caching strategies improve efficiency up to ~50% traffic savings
- Lack of cooperation between global content / CDN providers and network providers / users reduces cacheability in core & access
- Caches in end systems, browsers are useful esp. in mobile networks