Comparative Study of Content-Centric vs. Content Delivery Networks: Quantitative Viewpoints

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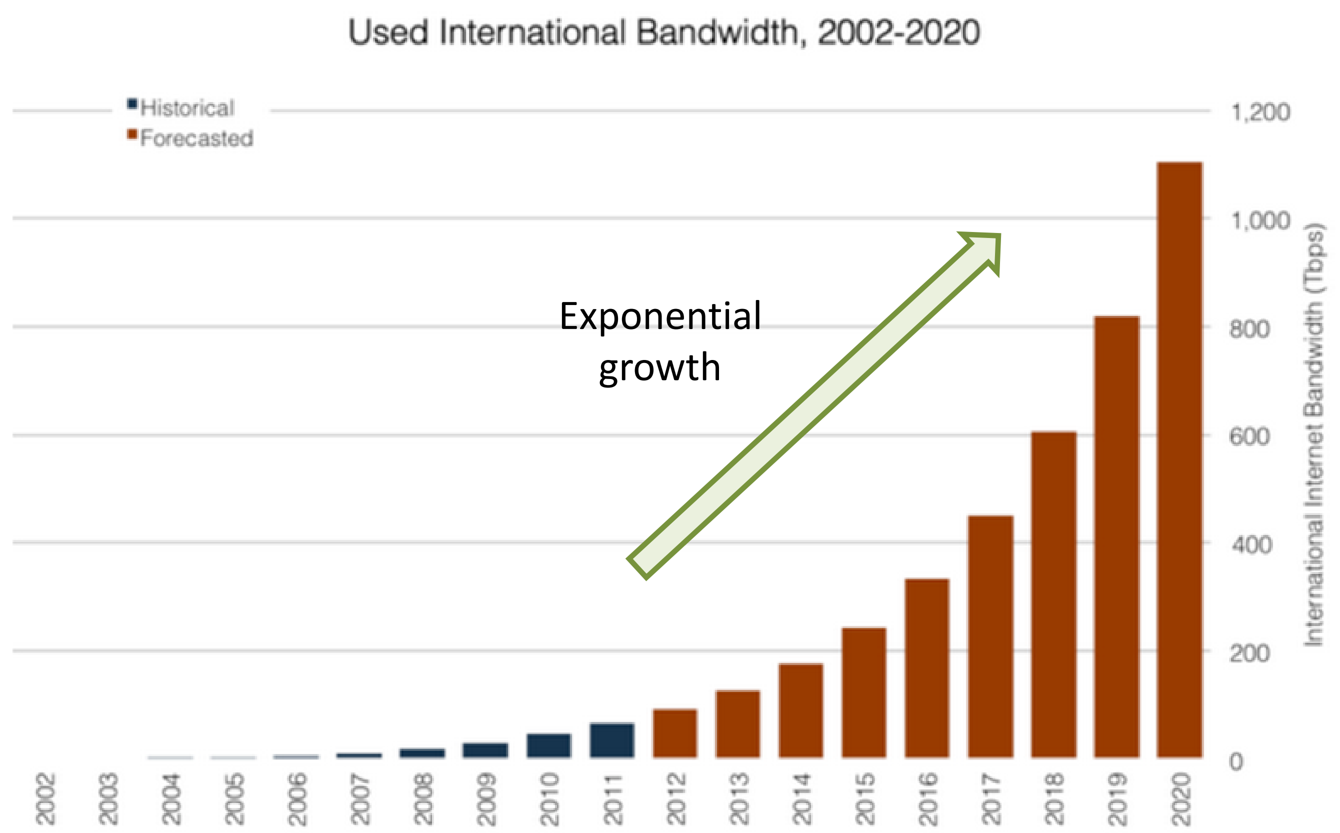
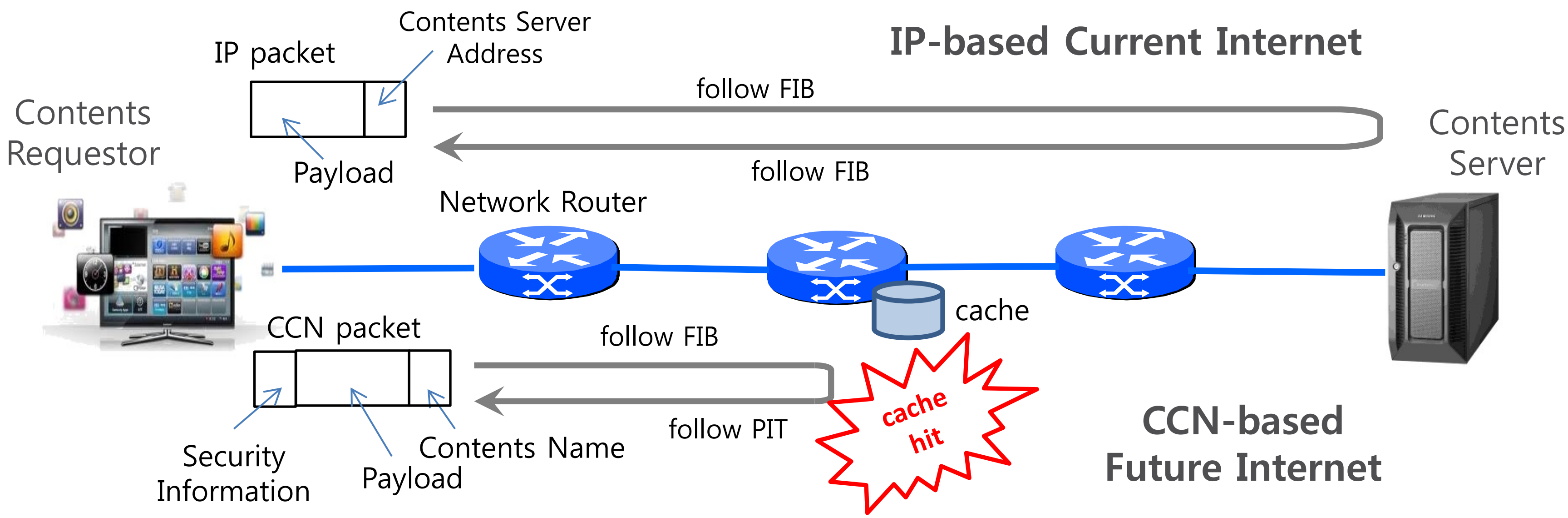
Internet Traffic Breakdown

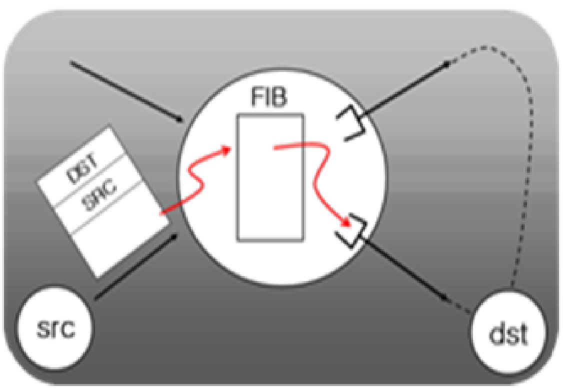
- Bandwidth explosion: As Internet use soars, can bottlenecks be averted?
  - ✓ Bandwidth usage is soaring, driven by the proliferation of Internet-connected devices.



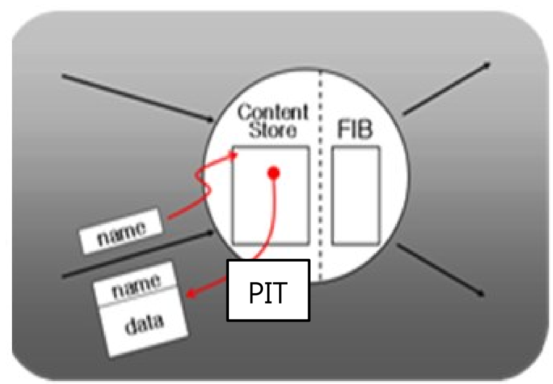
Source: ARS technica

Advent of Content-Centric Networking





What routers do (IP)

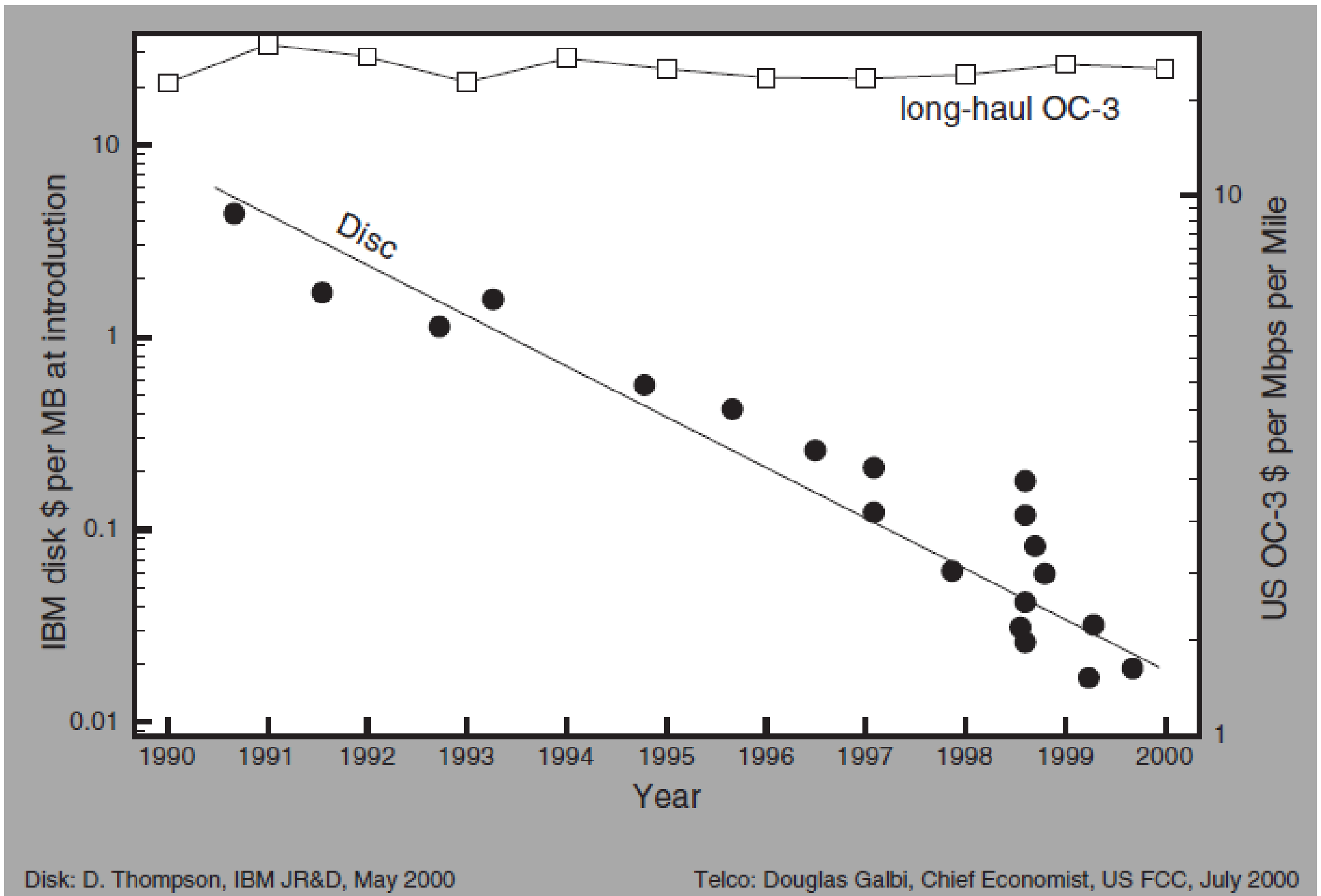


What routers do (CCN)

FIB: Forwarding Information Base, PIT: Pending Interest Table

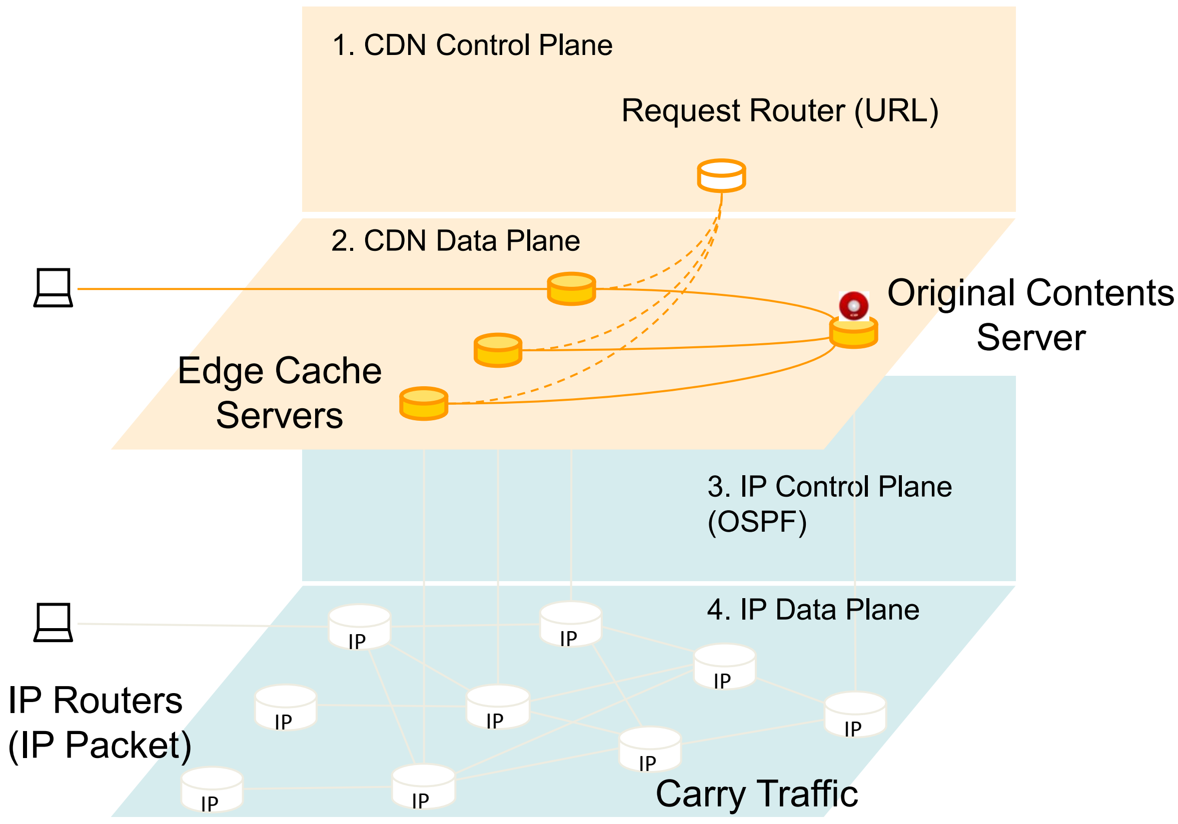
Storage-based Networking

- Can storage costs fall to zero?
  - ✓ Storage cost drops sharply compared with network



Existing Approach: Content-Delivery Network

- Content-Delivery Network (CDN)
  - ✓ a large distributed system of servers deployed in multiple data centers across the Internet



CCN vs. CDN

- Qualitative Comparison
  - ✓ Many studies

Patrick K. Agyapong and Marvin Sirbu, Economic Incentives in Information-Centric Networking: Implications for Protocol Design and Public Policy, IEEE Comm. Magazine, 2012.

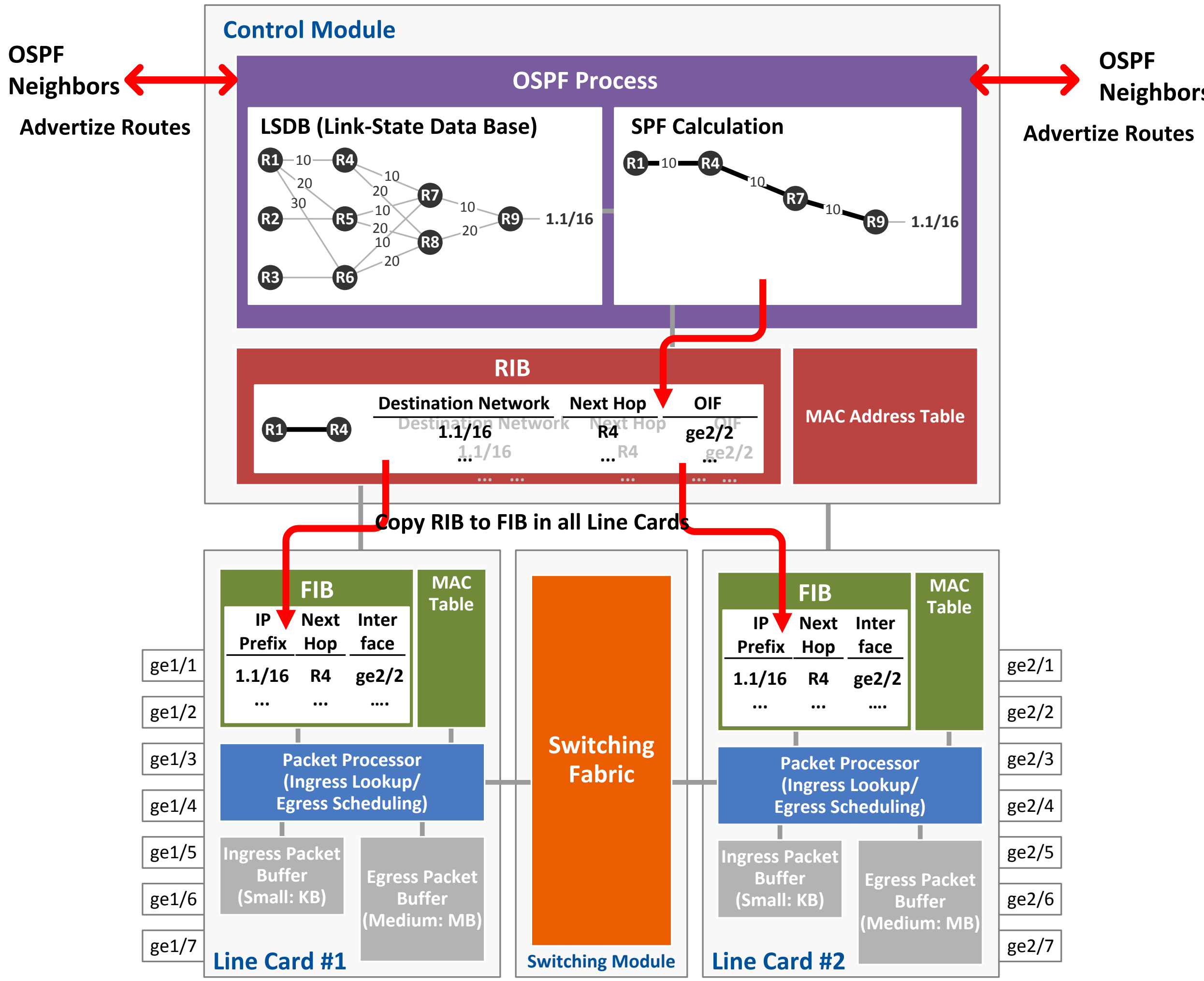
G. Carofiglio, G. Morabito, L. Muscariello, I. Solis and M. Varvello, From Content Delivery Today to Information Centric Networking, Computer Networks, 2013.

G. Xylomenos, C. Ververidis, V. Siris, N. Fotiou, C. Tsilopoulos, X. Vasilakos, K. Katsaros, and G. Polyzos, A Survey of Information-Centric Networking Research, IEEE communication Surveys & Tutorials, 2014.

- Quantitative Comparison
  - ✓ Not many, why?
    - no real CCN deployment with referenceable router implementation
    - specific CDN configuration in commercial deployment is generally not available to the public

IP Routers

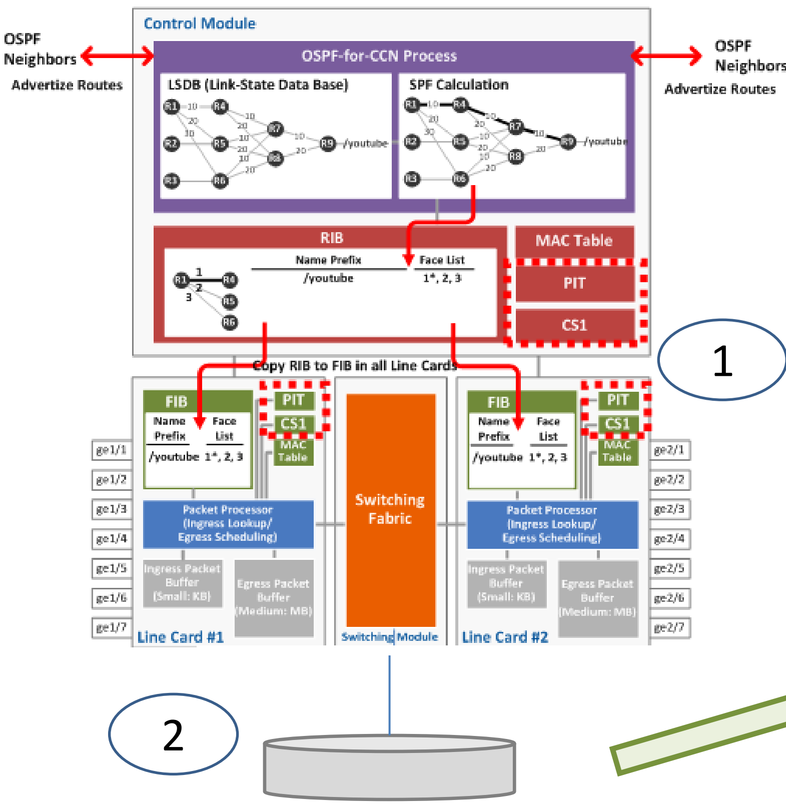
- Typical IP router architecture
  - ✓ Base for CCN router architecture



CCN Routers

Additional parts for CCN

1. Forwarding strategy, PIT (ignore cost)
2. CS index & CS



1

2

Content store

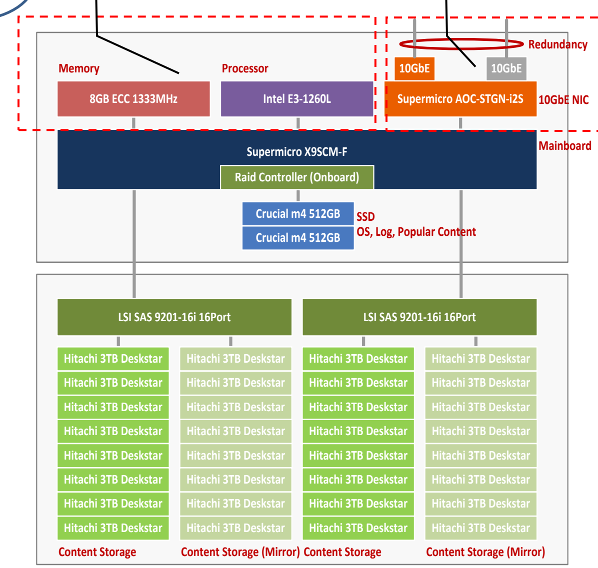
Netflix Cache Server

- Processor & Memory downsize since there is no TCP overhead

- LAN card → Connector & interface chip for backplane connection

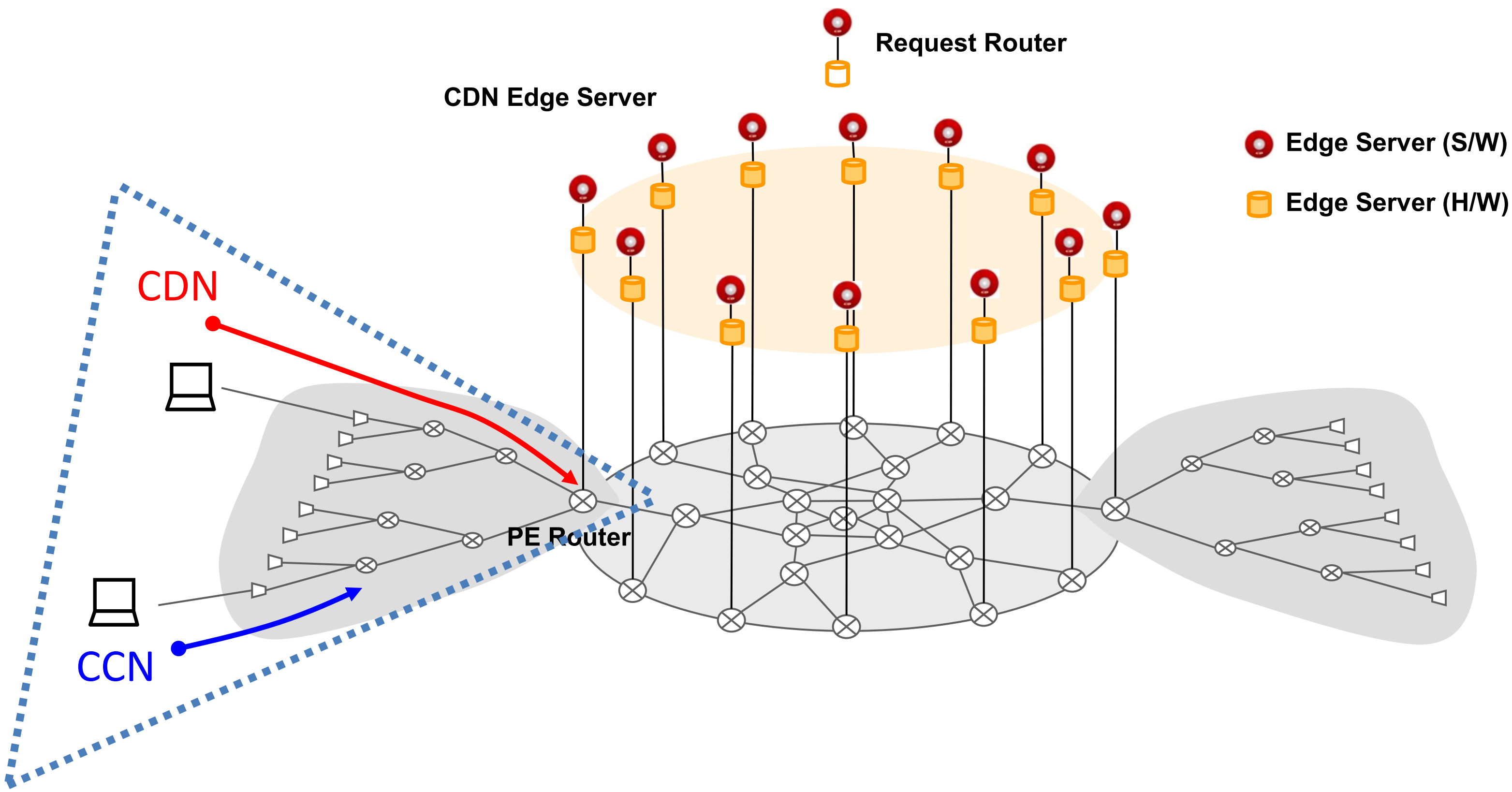
A

B

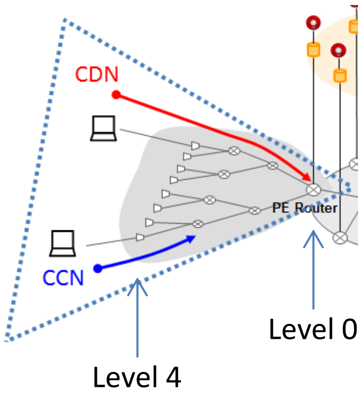


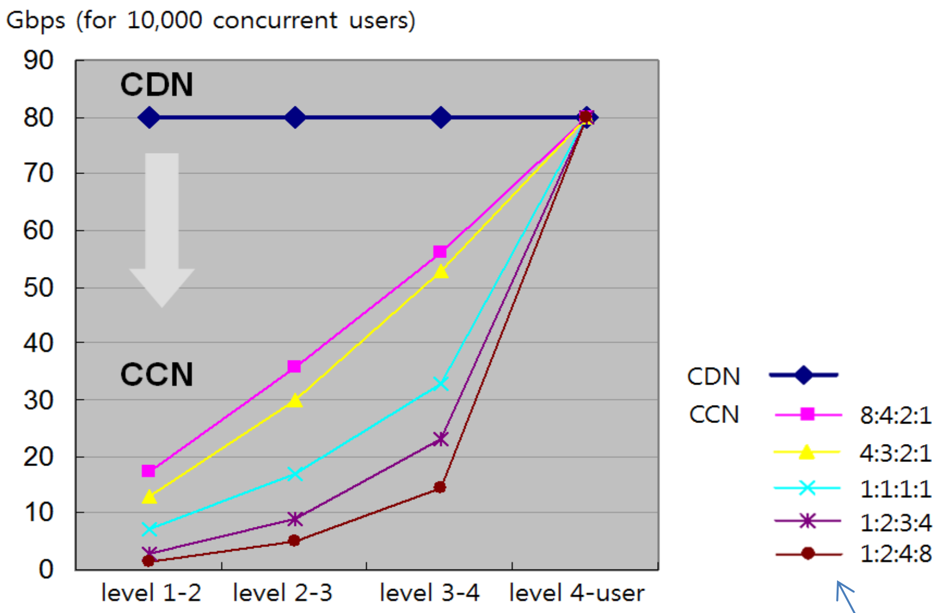
CDN Topology

- Typical IPTV CDN carrier topology
  - ✓ Base for CCN network topology for comparison



Network Cost

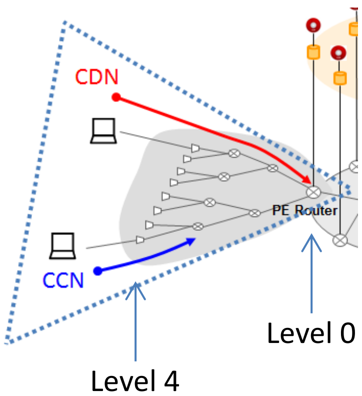




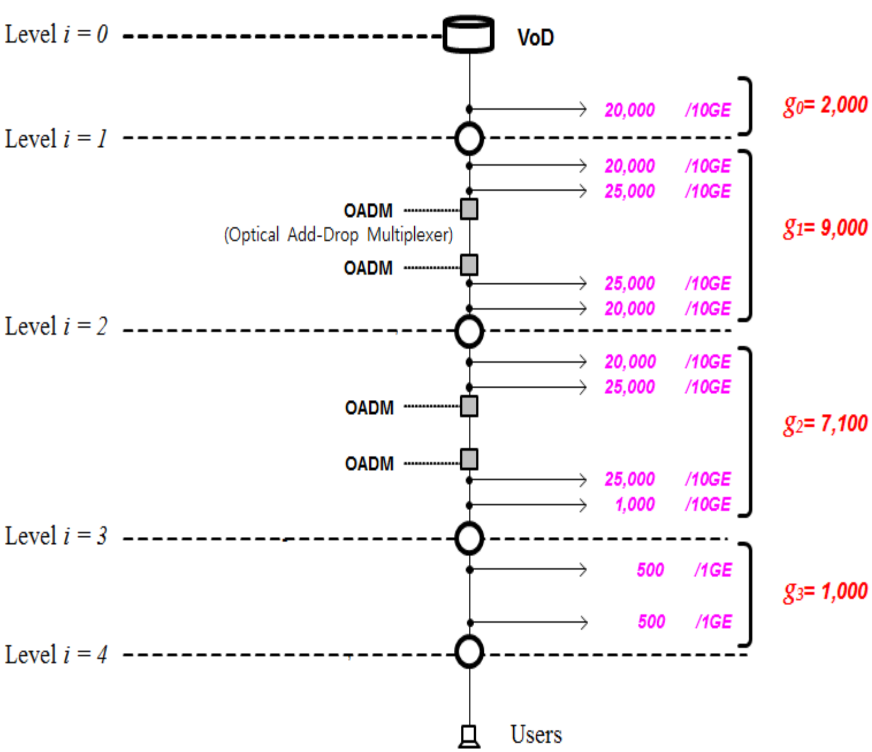
- total number of subscribers : 3million
- content encoding rate : 8Mbps (for High Definition TV)
- concurrent usage rate : 10%
- number of CDN edge servers : 30
- Each edge server holds 20TB of contents
- The content popularity observes Zipf's law with the exponent *s*

The ratio represents the caching capacity, for example, 4:3:2:1 means each level *i* (*i* = 1,2,3 and 4), node can store 40%, 30%, 20% and 10% of the total contents.

H/W & S/W Cost



H/W cost

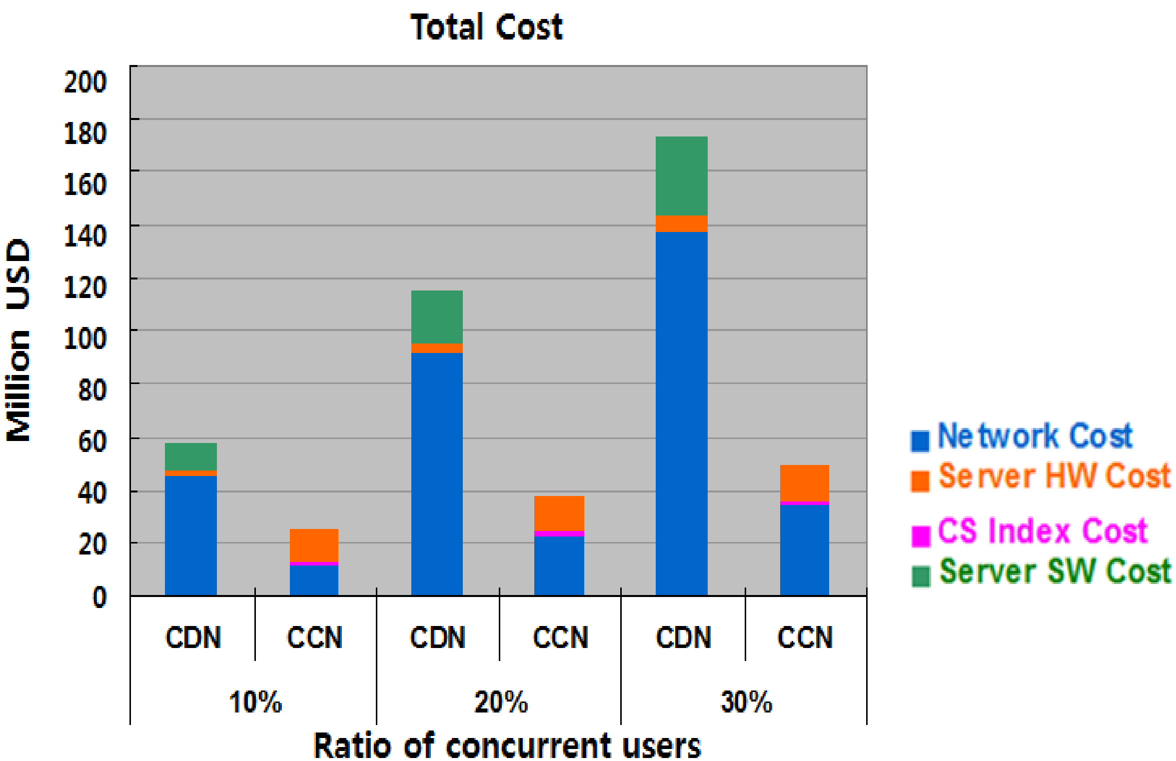


S/W cost

Product	Product Description	Discount Price*
CDN Edge Server (CDS-TV)	CDS-TV (RTSP Streaming, RTSP Session Management, Content Placement, Server Heath-Report, etc.)	$30.4 per Stream
Content Acquirer (CDS-CA)	CDS-CA (Reverse Proxy, Content Placement, etc.)	-

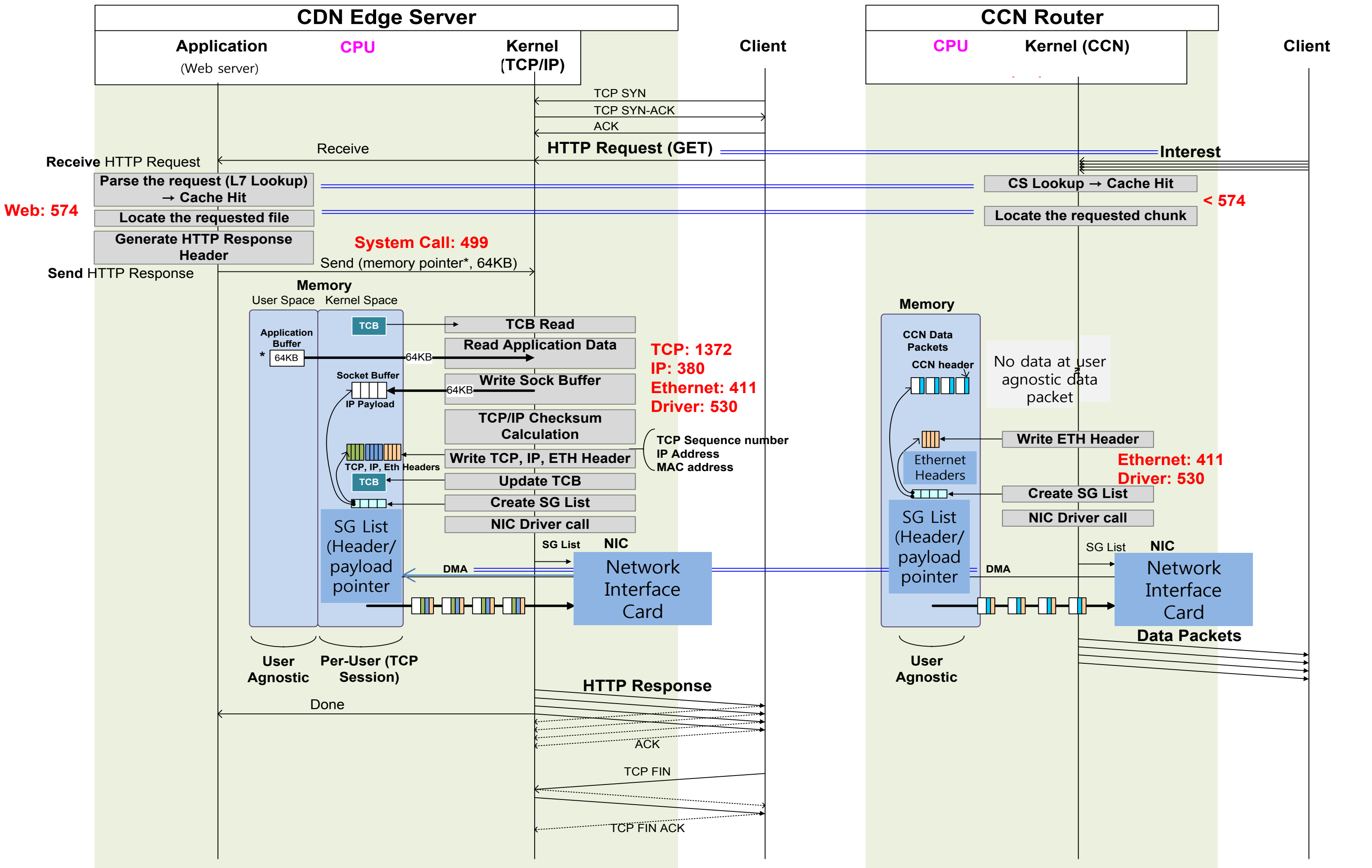
Total Cost

- As the ratio of the concurrent user increases, the costs for the CDN is doubled and tripled.
- On the contrary, with CCN, the increase rates are only 45% and 91%.



Protocol Overhead

- CDN: HTTP, TCP handling
- CCN: Interest, PIT handling



Protocol Overhead

CDN (HTTP/TCP/IP/Ethernet)		**CCN** (CCN/Ethernet)	
Processing Steps	**# of Instr.s**	**Processing Steps**	**# of Instr.s**
[Kernel TCP/IP] TCP Connection Setup	1372	No need	0
[Kernel TCP/IP] TCB (TCP Control Block) Read		No need	
[Kernel TCP/IP] Read Application Data from Application Buffer		No need	
[Kernel TCP/IP] Write Socket Buffer		No need	
[Kernel TCP/IP] TCP/IP Checksum Calculation		No need	
[Kernel TCP/IP] Write TCP Header		No need	
[Kernel TCP/IP] Update TCB		No need	
[Kernel TCP/IP] Congestion Control (Flow Control)		No need	
[Kernel TCP/IP] TCP Connection Termination		No need	
[Kernel TCP/IP] Write IP Header	380	[Kernel CCN] Write CCN header	380
[Kernel TCP/IP] Write Ethernet Header	411	same	411
[Kernel TCP/IP] NIC Driver Call	530	same	530
[Kernel TCP/IP] System Call (Receive)	499	No need	0
[Web Server] System Call (Send)		No need	
[Web Server] Parse the Request → Cache Hit	574	[Kernel CCN] Parse the Request → Cache Hit	<574
[Web Server] Locate the Requested File		[Kernel CCN] Locate the Requested Chunk	
[Web Server] Generate HTTP Response Header		[Kernel CCN] Generate CCN Response Header	
No need	0	PIT handling	<574
# of Instruction per packet	**3,776**	**# of Instruction per packet**	**<2,469**

Conclusion

In this paper, we proposed

- a typical nation-wide CDN topology, a corresponding CCN deployment
- the first feasible CCN router architecture.

Based on them, we estimated

- the total amount of network traffic,
- corresponding H/W and S/W costs and protocol overhead for both CCN and CDN.

We believe our work can be a design guide for how the CCN need to evolve to overcome IP-based services such as CDN.