Greening the Internet with Content-Centric Networking

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Internet = Content Dissemination

Today's Internet is all about "content dissemination"

- IPTV, Hulu, Netflix, user generated content (Facebook, Twitter, YouTube)

Today's strategies for meeting ever increasing user demands:

- Service providers (e.g., Google) —enlarging data centers
- Network providers (e.g., AT&T) —increasing network capacity
- and some service providers even build their own private network (e.g., Google, Microsoft)

Content dissemination consumes lots of energy, ranging from servers in data centers to network routers to home PCs (and still increasing).

Energy-Aware Content Dissemination Today

Most research focused on energy consumption/optimization at data centers

- Dynamic resource provisioning (e.g., DVFS, sleeping)
- Request routing to a data center with lower $/J
- *Energy-proportional computing*: power consumption ~ utilization

Energy consumption/optimization of networking devices

- Current networking devices show poor energy efficiency (e.g., high idle power regardless of utilization)
- Researcher is seeking for *energy-proportional networking*
  - Low power idle/sleeping mode, dynamic rate adaptation (e.g., DVFS, tx power control), and sleeping (e.g., wake-on-LAN)

Energy-proportional computing/networking is not enough …
As user demands increase, so does the power consumption.

Can Content Distribution Networks (CDNs) Help?

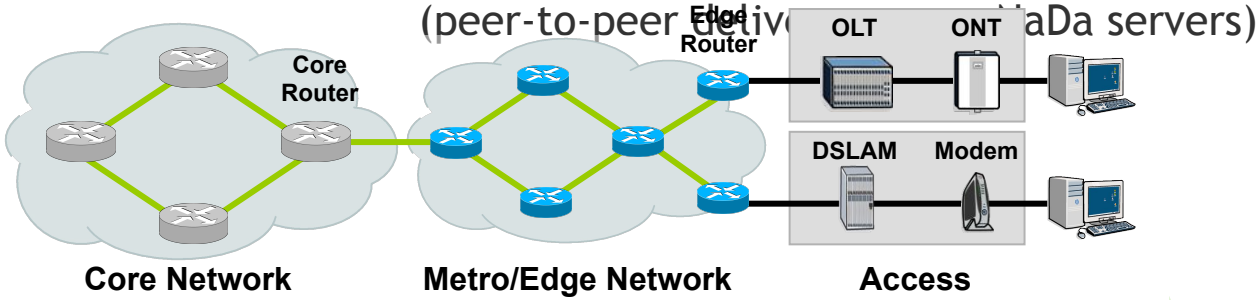
Pushing content closer to the users

- Hop count reduction (overall network traffic reduction) ▫ energy savings

CDN Strategies:

- Limelight —placing CDN servers near a small # of ISP core nets
- Akamai —placing CDN servers deep into a large # of ISP networks' sites
- Nano Data Center (NaDa) —home gateways (STBs/modems) as CDN servers

(peer-to-peer active NaDa servers)



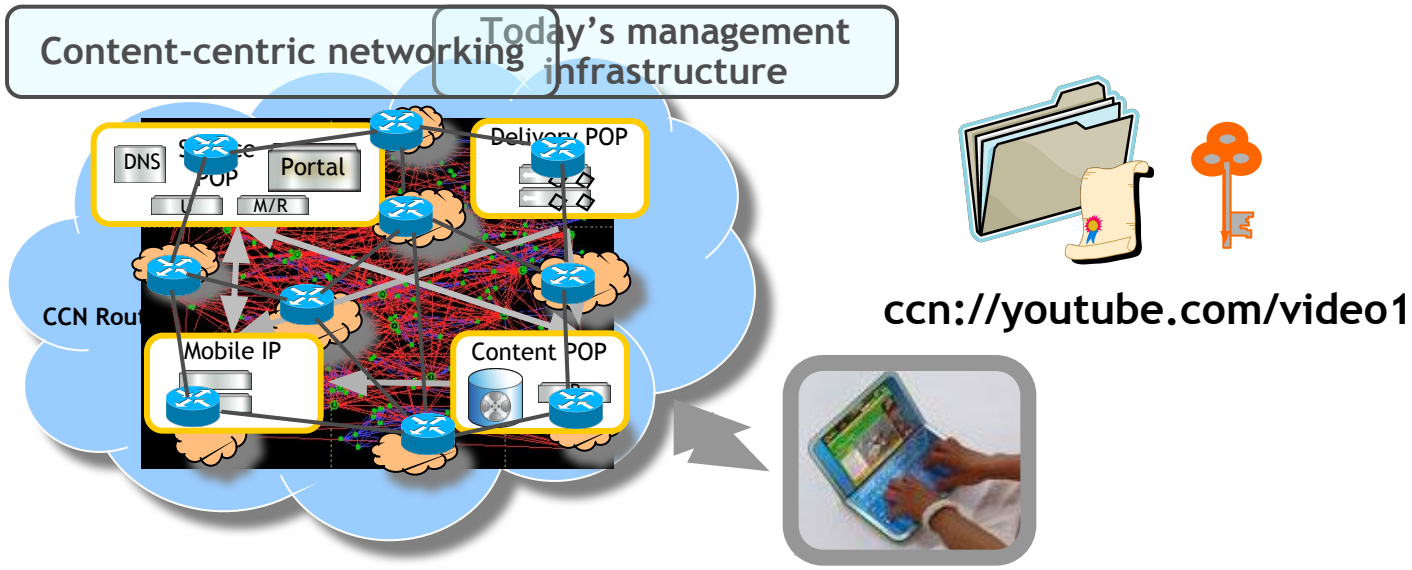
Limelight NETWORKS
Google
Akamai
VELOCIX
Digital Media Delivery Platform
NaDa
BitTorrent
ZATTOO
PPLIVE

Shifting Gears: Content-Centric Networking (CCN)

Simple, unified, flexible communication architecture

- Data has a name, not a location (+network wide content caching)
- Anything that moves bits in time or space can be used

CCN removes many layers of management infra (e.g., DNS, mobile IP, CDN)

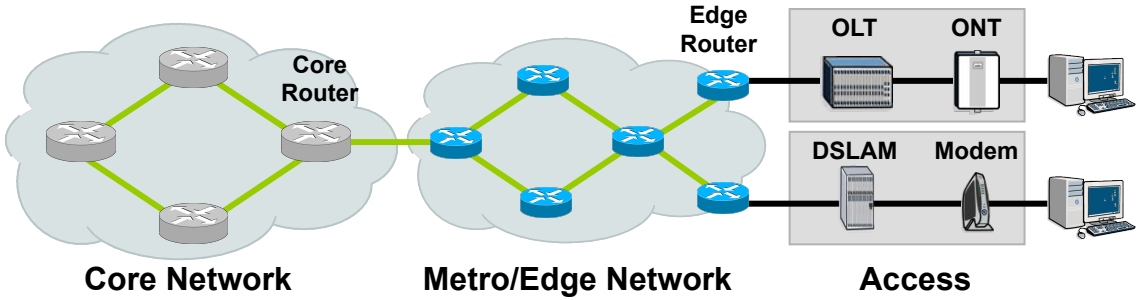


Content-Centric Networking (CCN)

CCN enables efficient content dissemination to users

Energy efficiency of CCN content routers

- Extra memory hierarchy that requires minimal power draws
- Ex) Memory 4G ~ 10W, SSD 32G ~ 1W, Disk ~ 12W (if needed)



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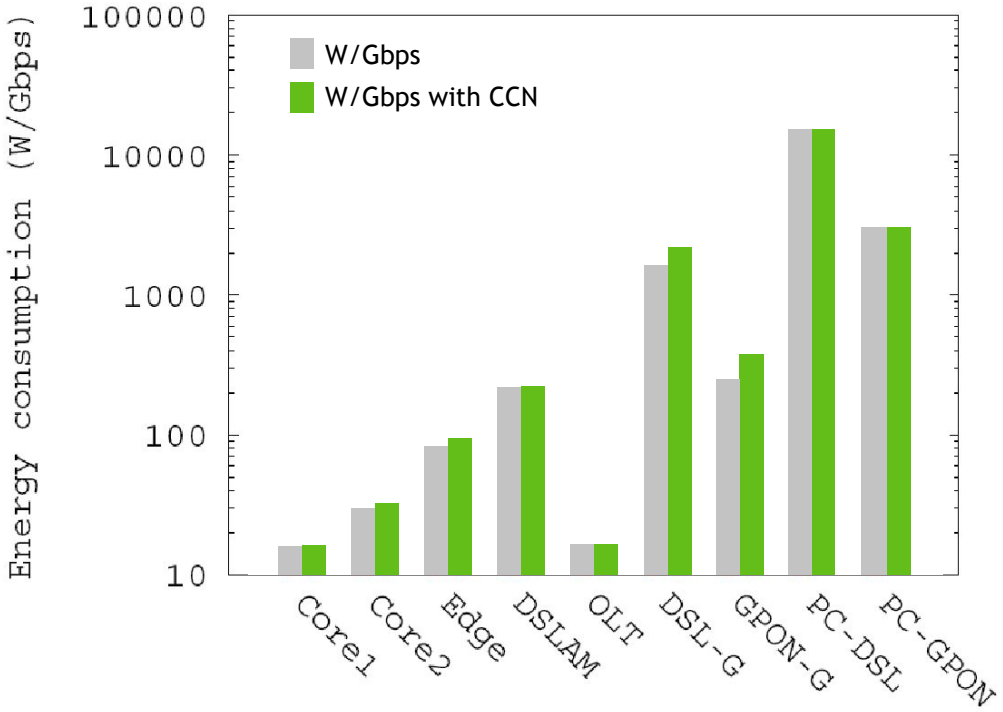
Content Centric Network (CCN)

Most energy efficient solution: P2P, NaDa, CDNs, CCN?

Energy Efficiency of Networking Devices: A Survey

Metric: W/Gbps (= nameplate power / max bandwidth)

- Assumption: energy proportional networking



Core1: Cisco CRS 1= 4834W/320G
Core2: Cisco CSR 12000 = 800W/28G
Edge: Cisco 7507 = 400W/5G
DSLAM: Zyxel IES-500M = 800W/3.84G
OLT: Fujitsu FA2232U = 400W/10G
DSL Modem: D-Link DSL 2320B = 15W/10M
ONT: Allied Data = 12W / 50M
PC: Dual Core = 150W / 10M or 50M

Energy consumption increases exponentially as content is being moved closer to end users.

Evaluation

Methodology:

- Traceroute data set —top 20 content providers ranked by Alexa
  - Querying these providers from 18 different traceroute servers in the US
- Tier 1/Non-Tier 1 classification (i.e., edge vs. core router)
  - Based on a publically available Tier-1 ISP list

Metric:

- Energy consumption (Joule) for downloading 1 Gbit of content (125MB)

Scenarios:

- CCN-enabled core/edge nodes: 0% (NonCCN), 20%, 100%

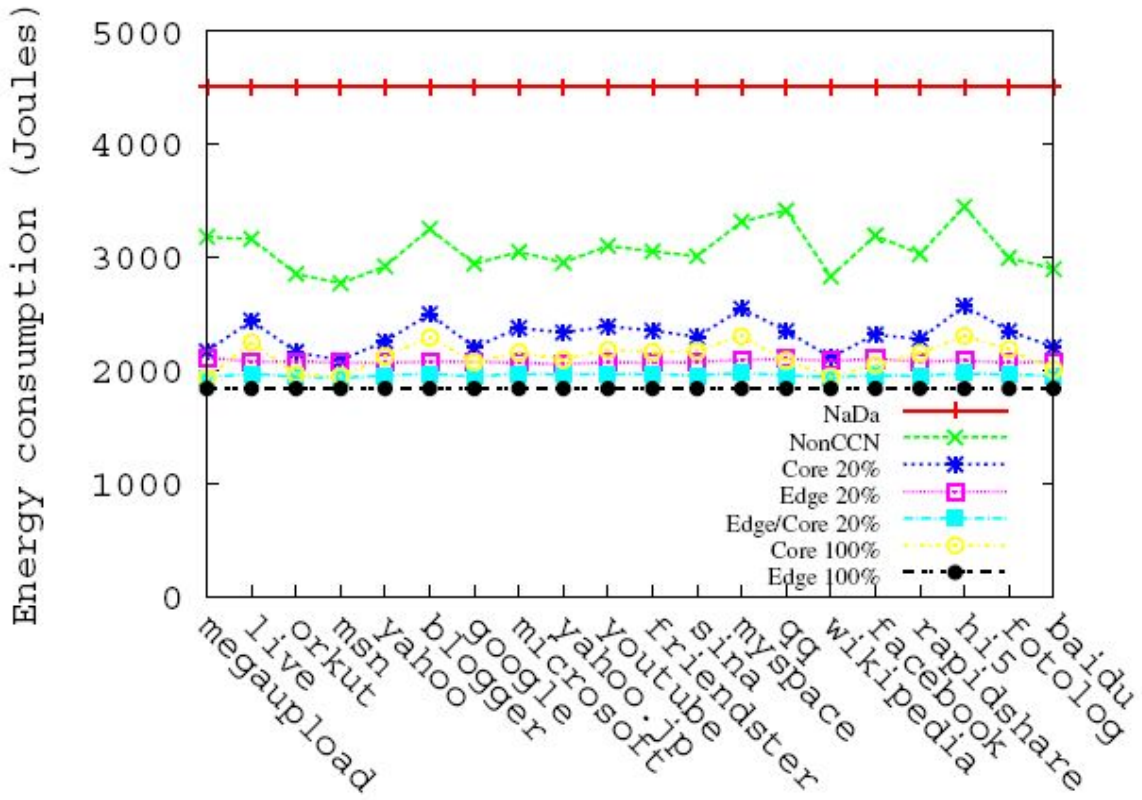
Assumption:

- Users access popular content (100% cache hit rate)

Energy Consumption (DSL Users)

CCN is the most energy efficient method (even with incremental deployment)

NaDa: content traverses expensive DSL gateways twice!

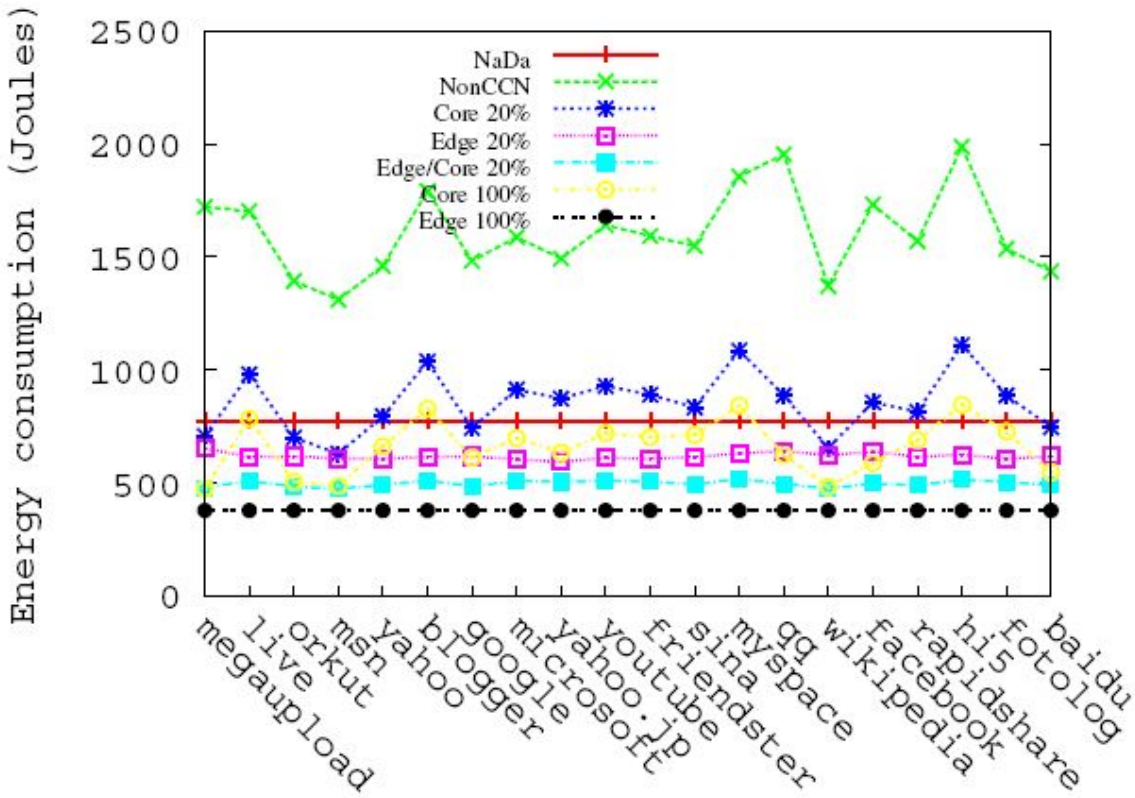


Top 20 content providers

Energy Consumption (GPON Users)

Efficiency of NaDa gets better as access link speed increases (GPON >> DSL)

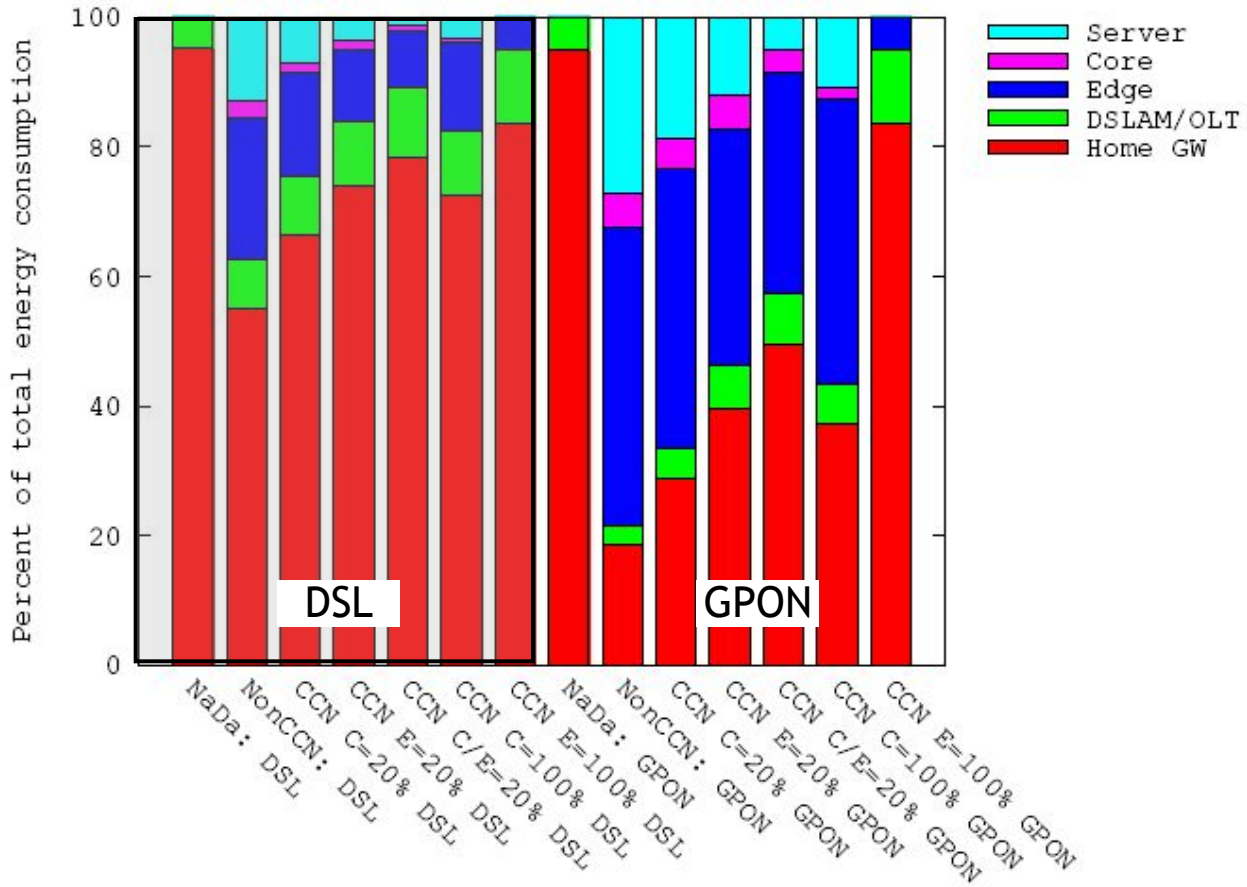
CCN still outperforms when content routers are sufficiently deployed



Energy Consumption Breakdowns

NonCCN: (DSL) **GW>Edge>Server**>Core>Access vs. (GPON) **Edge>Server>GW**>Core>Access

CCN: Home gateway dominates energy consumption



Summary

Content distribution networks enable energy-efficient data dissemination

- E.g., traditional CDN (Akamai/Limelight), Nano Data Center (NaDa), Content-centric networks (CCN).

Energy efficiency of networking devices must be considered for energy-efficient data dissemination

- E.g., DSL-based NaDa performs worse than direct fetching from origin servers.

Network-wide content caching via CCN is the most energy-efficient method even under incremental deployment scenarios.

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