ITU Kaleidoscope 2016

ICTs for a Sustainable World

A Popularity-based Caching Strategy for the Future Internet

Suhaidi Hassan *PhD SMIEEE*
InterNetWorks Research Laboratory
School of Computing
Universiti Utara Malaysia
suhaidi@uum.edu.my

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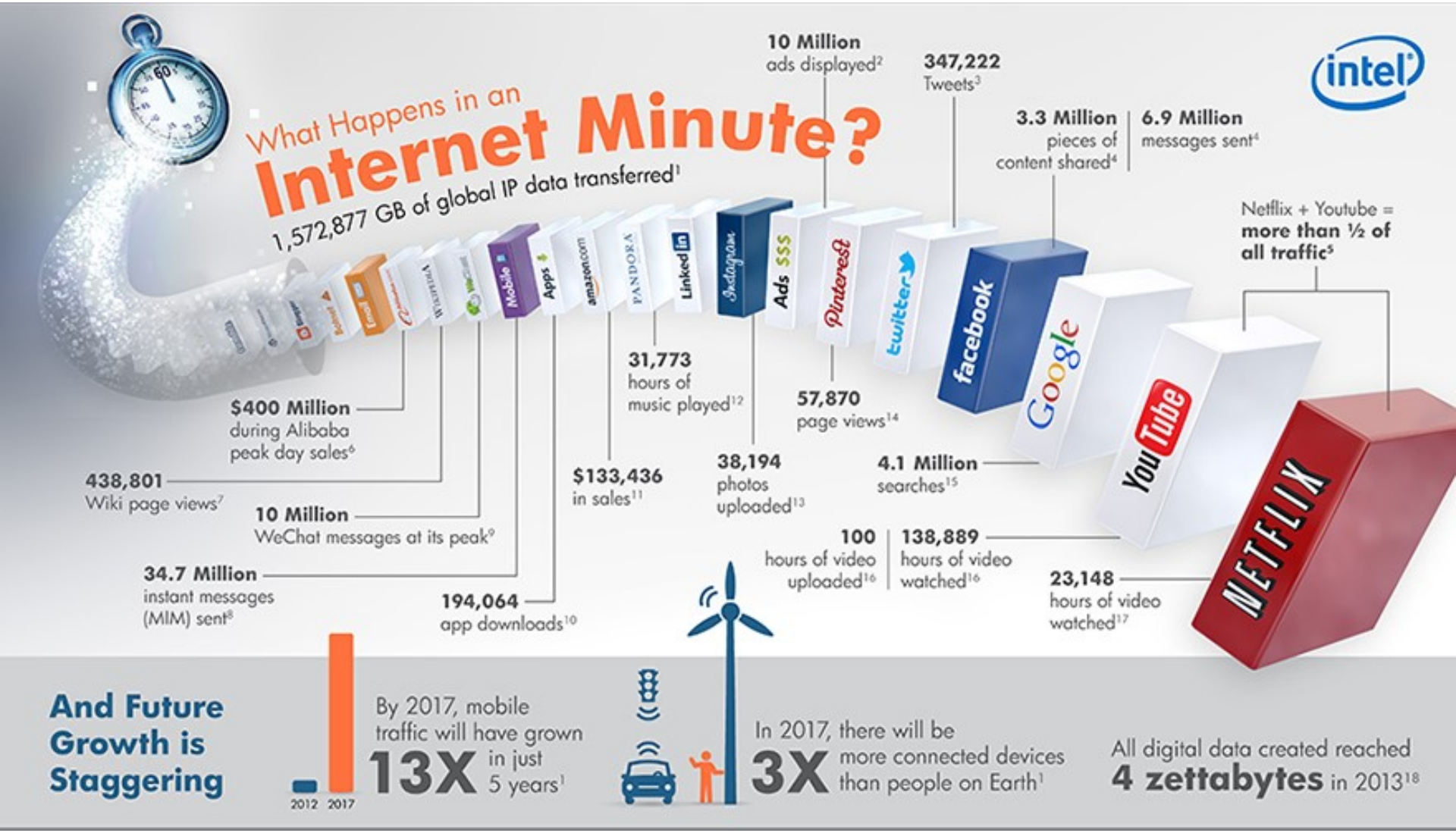
***Team researchers*: Ikram Ud Din, Adib Habbal, and Nur Haryani Zakaria**

Presentation Outline

- Overview & Motivation
- Information/Content Centric Internet
- Content Caching in Future Internet
- CPCE: The Proposed Caching Strategy
- CPCE Evaluation
- Contribution
- Conclusion

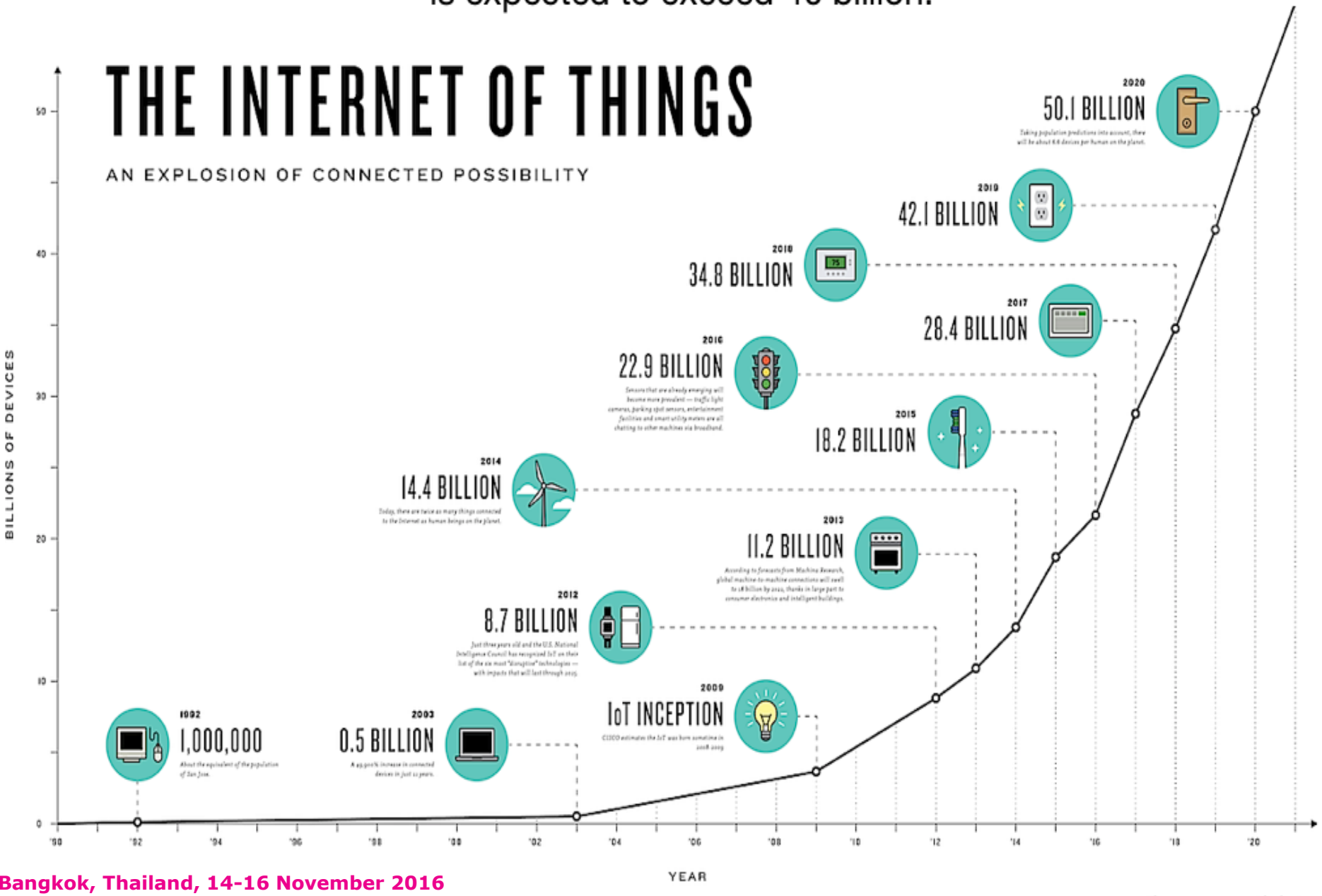
Internet Content Traffic Prediction



- **IP traffic in North America will reach 40.5 exabytes per month by 2018.**
- **IP traffic in Asia Pacific will reach 47.3 exabytes per month by 2018.**

Source: Cisco VNI 2015

By 2020, the number of devices connected to the Internet is expected to exceed 40 billion.



Big data—a growing torrent

$600 to buy a disk drive that can store all of the world's music

5 billion mobile phones in use in 2010

30 billion pieces of content shared on Facebook every month

40% projected growth in global data generated per year vs. **5%** growth in global IT spending

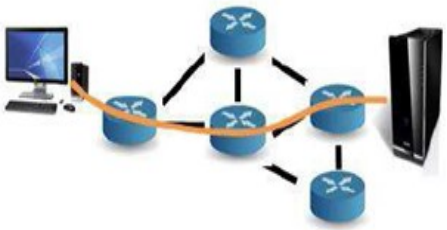
235 terabytes data collected by the US Library of Congress in April 2011

Source: http://www.stevens.edu/business/sites/business/files/McKinsey-BigData.p

The Evolution of Modern Communication

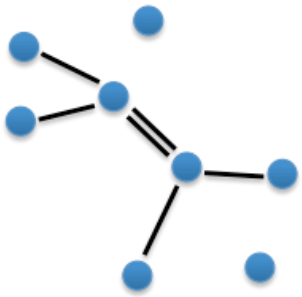
Past → **Present** → **Not-so-far Future**

Telephony

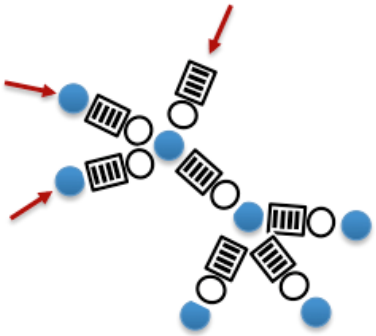


Internet

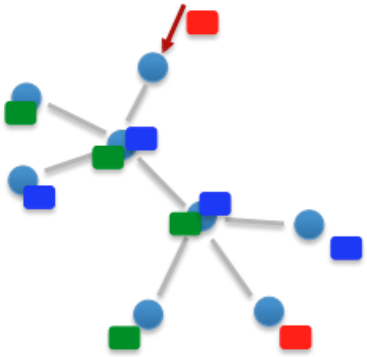
Content-centric Internet



Circuit Switching



Packet Switching

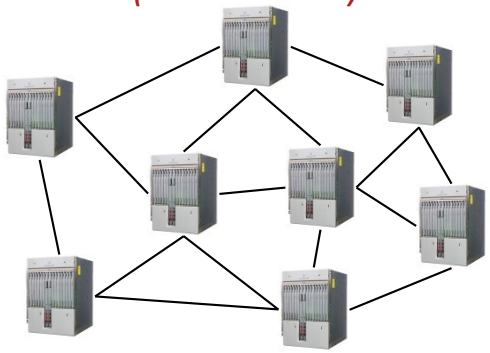


Content Caching

Information/Content Centric Networking

Today's Internet

Focus on
Nodes
(host-centric)



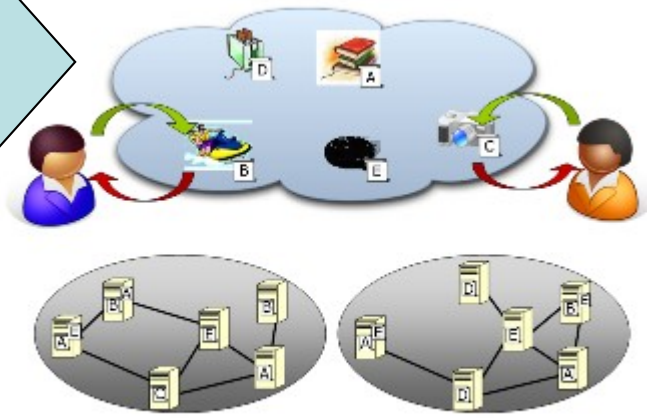
In today's Internet, accessing information is the dominating use case!

Evolution

Web | CDN | P2P

Information-Centric Internet

Focus on
information objects
(content-centric)

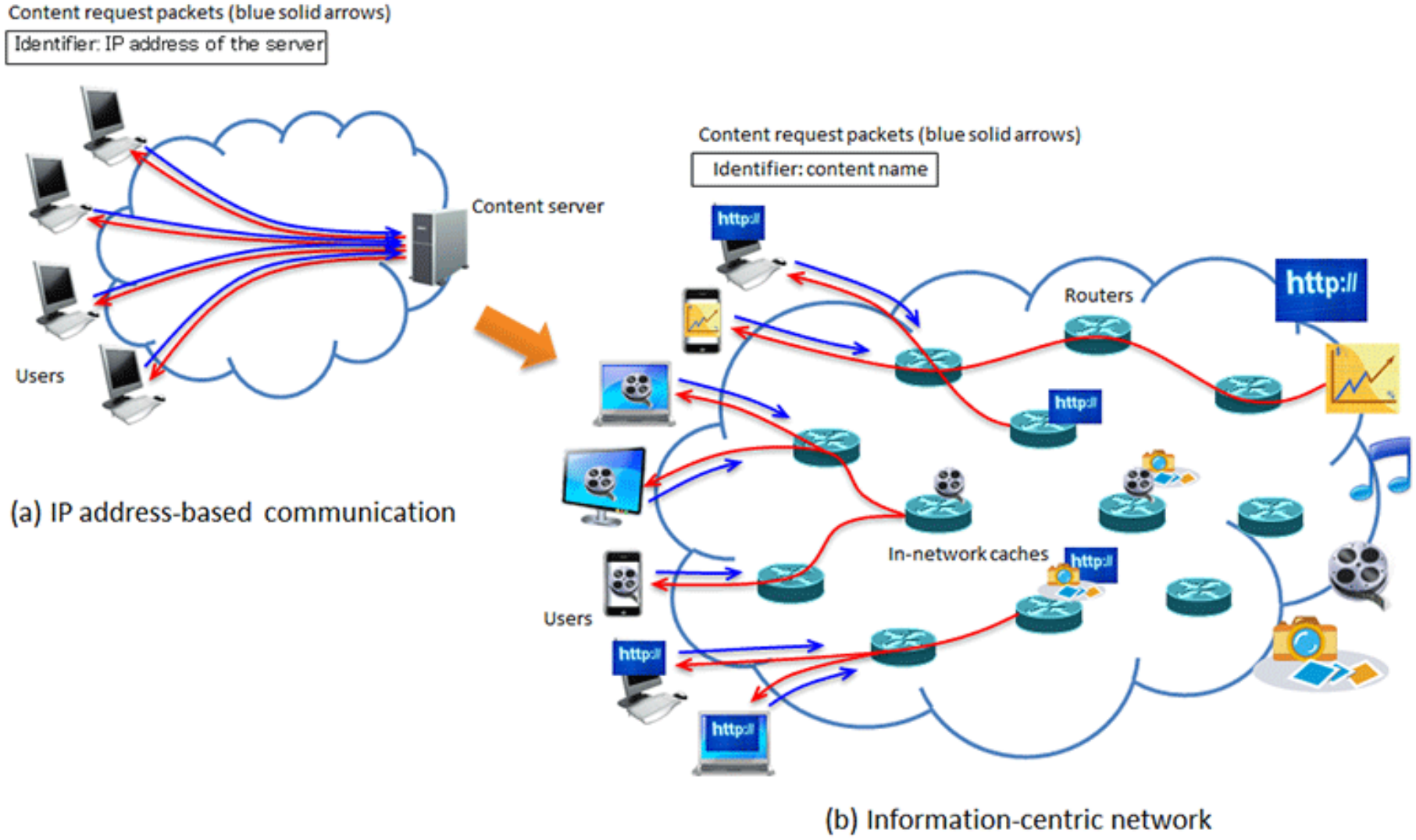


Source: www.irtf.org

Note: ICN variants exist, (with some differences):

- Content-centric networking (CCN)
- Named Data Networking (NDN)
- Data Oriented Network Architecture (DONA)
- Publish-Subscribe Internet (PSI)
- Content Oriented Networking (CONET)

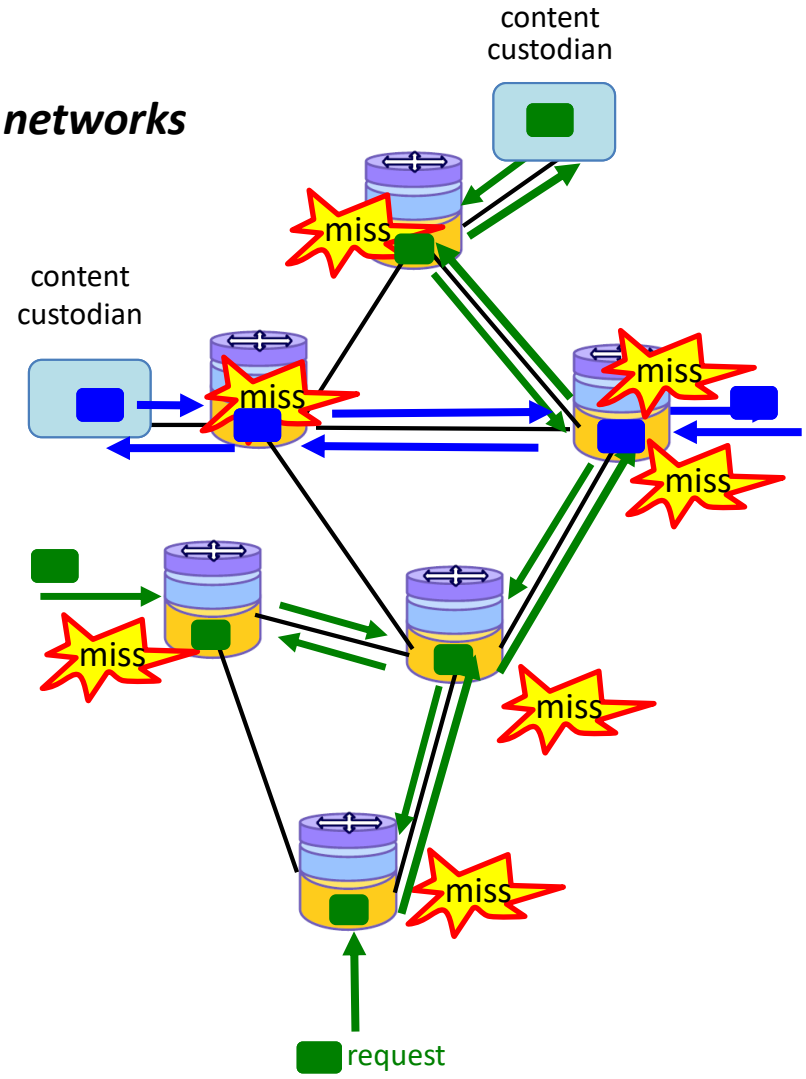
In-network Caches in Future Internet
(Rec. ITU-T Y.3033)



Content Caching in Future Internet

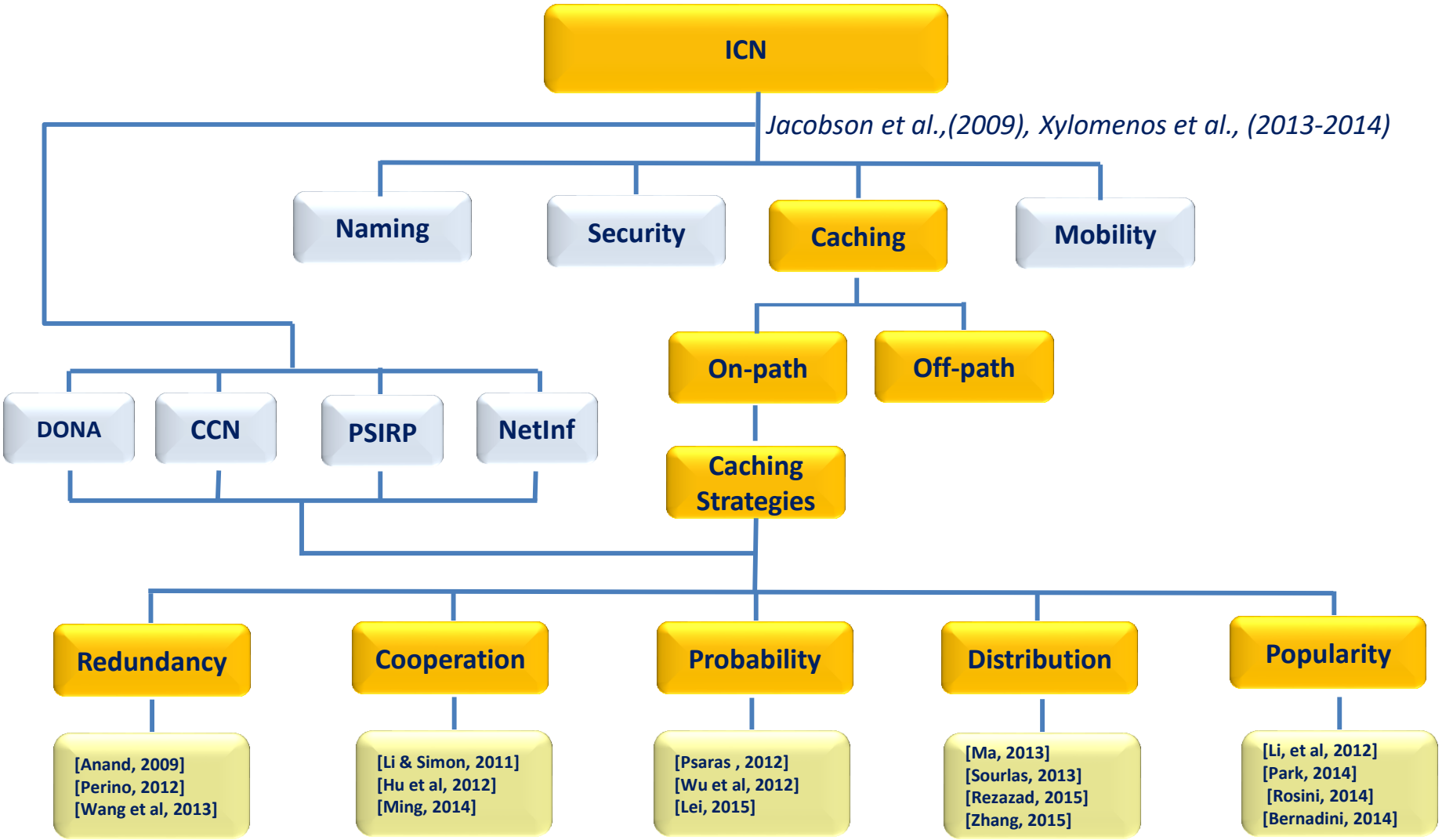
ITU-T Study Group 13: Recommendation Y.3033
Framework of data aware networking for future networks

- consumer *requests content*
- request *routed* (e.g., shortest path) to known *content custodian*
- en-route to custodian, *caches inspect* request
  - *hit:* return local copy
  - *miss:* forward request towards custodian
- during content download, *store* in caches along path



Source: Jim Kurose, SIGCOMM2013

Related Works



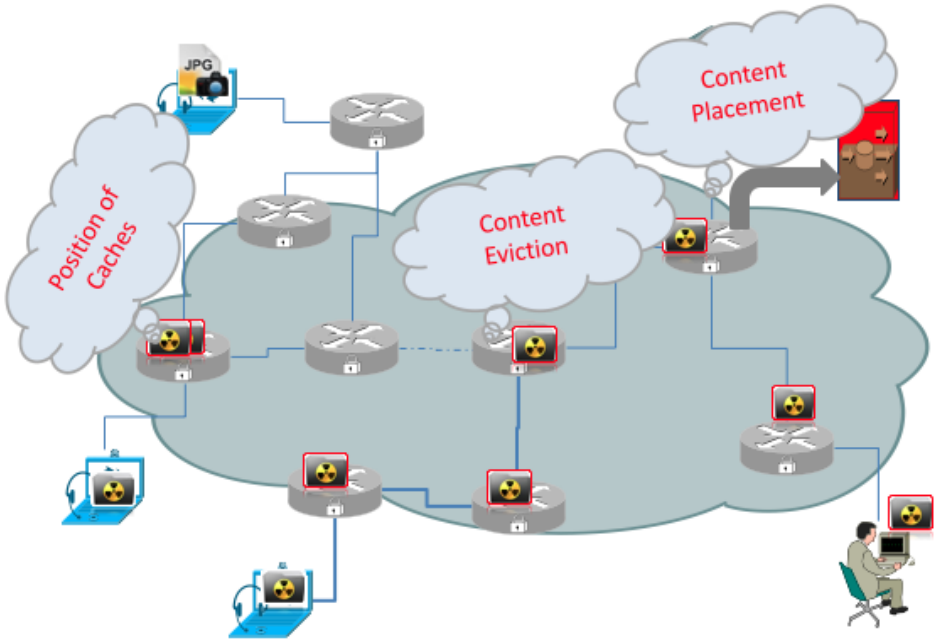
Caching Issues

What cache management strategies could be of effective benefits for ICN in mitigating the problems faced by the current practices?

i. What is the best way of storing requested content items in content store in order to increase cache hit rate?

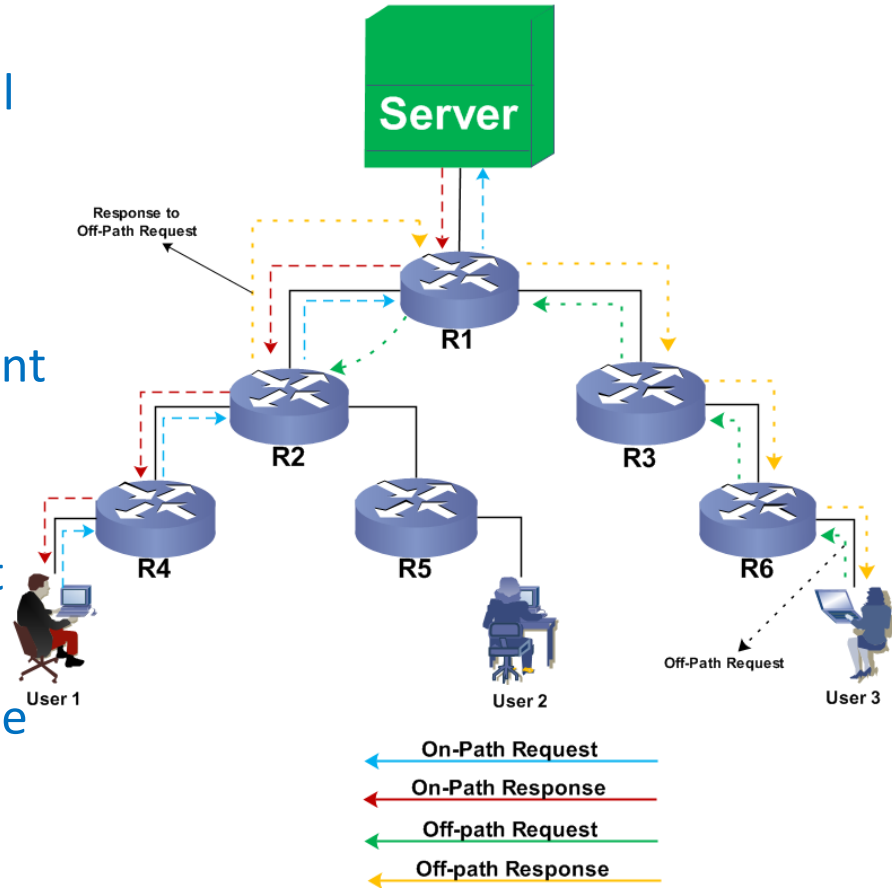
ii. How to minimize stretch ratio during content placement and eviction?

iii. How to determine the impact of the proposed strategy on cache hit rate and stretch ratio?



Cache Popular Content Everywhere (CPCE)

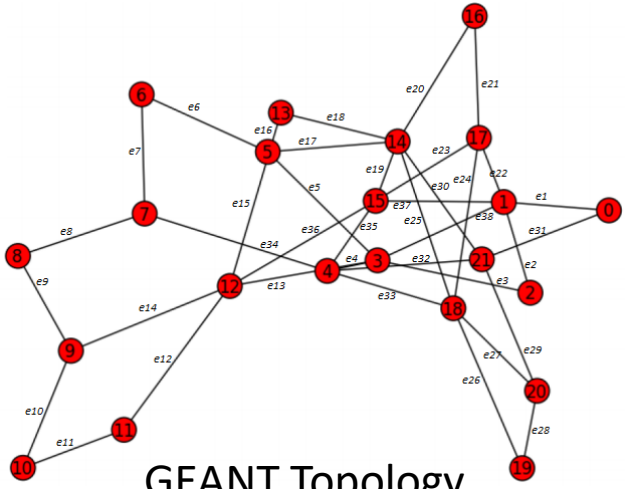
- Cache contents at all *on-path* routers once their popularity reaches specified threshold value (10).
- Use LRU policy to replace cached contents from each router if cache of all *on-path* routers overflows and a new content arrives
  - avoid maximum bandwidth utilization, as majority of the content requests pass through that router.
- Use LRU to evict cached contents accessed least recently. Evicted content is cached at underlying router.
- Use Random policy to accommodate the content coming from *R_max* if cache of underlying router is full



CPCE Evaluation Environment

- The CPCE strategy was evaluated on the GEANT and DTelecom topologies
- The contents were downloaded from Facebook social network topology, which consists of 4,039 nodes
- The simulations were run for 10 times: each time 1 hour for every cache size (i.e., 1GB-10GB)
- The Cache Hit was calculated as: $H_c = \frac{\sum_{i=1}^{n} hiti}{\sum_{i=1}^{n}(hiti+missi)}$
- The Stretch was calculated as: $S = \frac{\sum_{i=1}^{n} H_c}{H_t}$

CPCE Evaluation Parameters

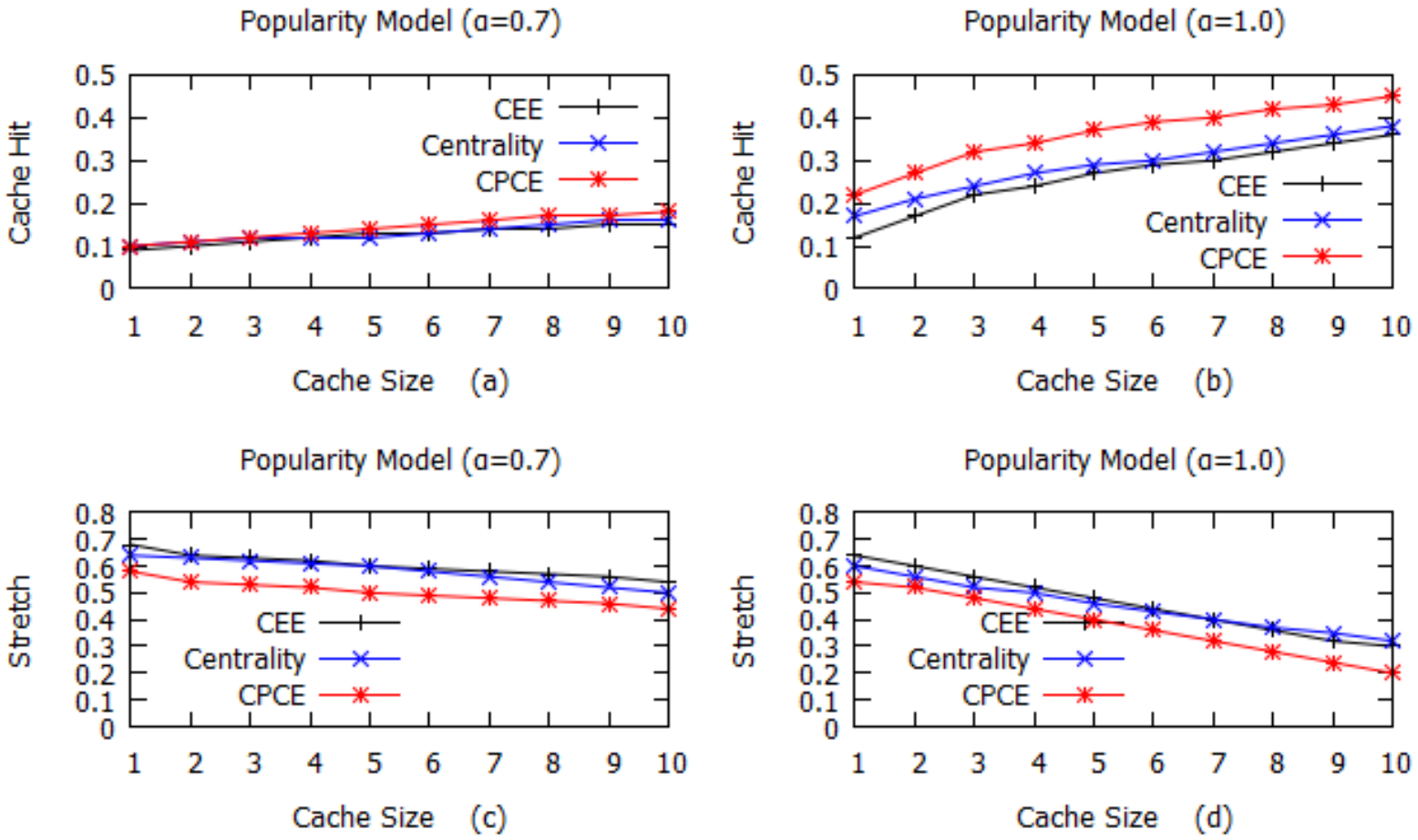


GEANT Topology

DTelekom Topology

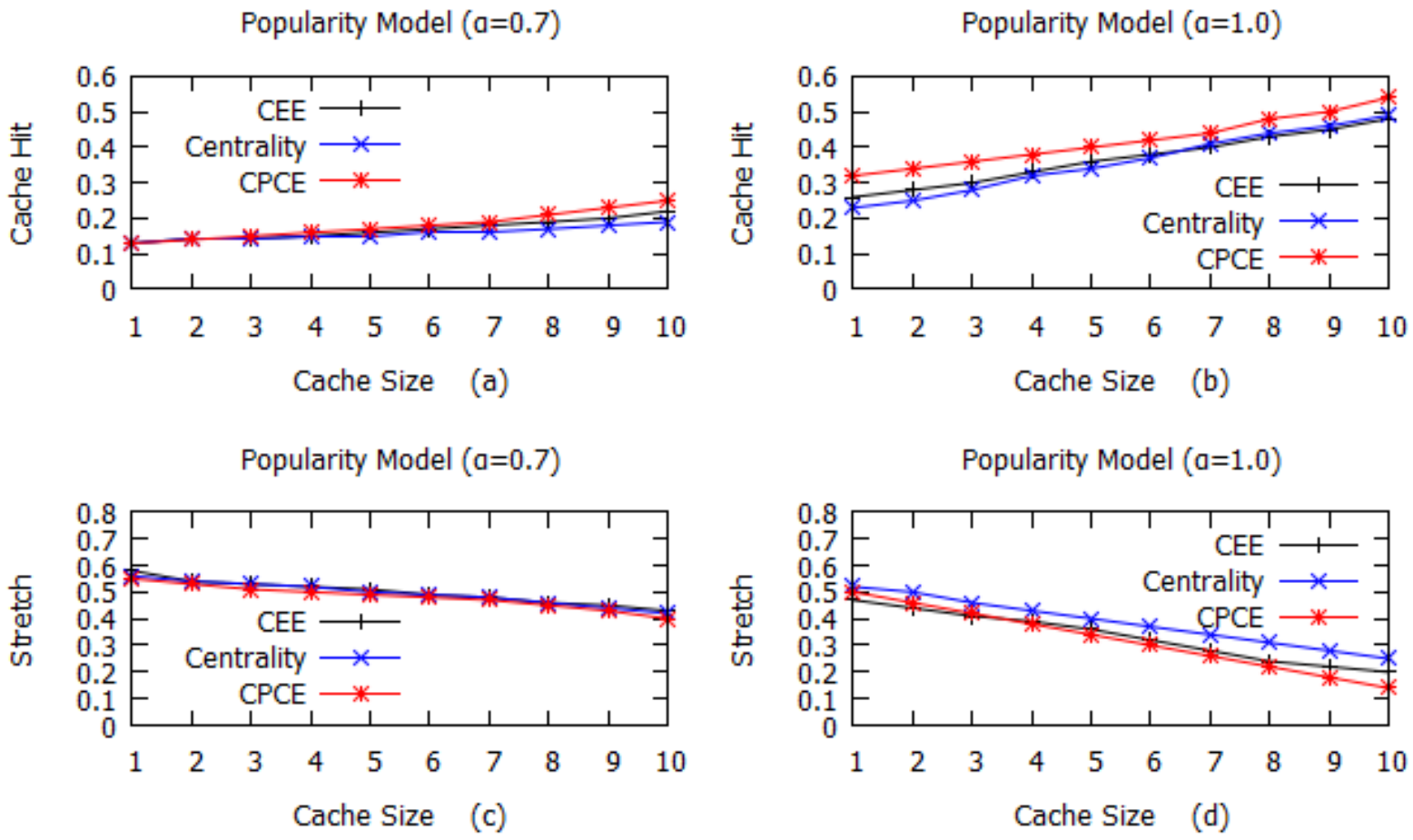
Zipf Categorization	α=0.7, 1.0
Cache Size	1GB-10GB
Catalog Size	10^8
Topology	GEANT, DTelekom
Replacement Policy	LRU
Traffic	SONETOR
Simulator	SocialCCNSim

Evaluation Result (GEANT Topology)



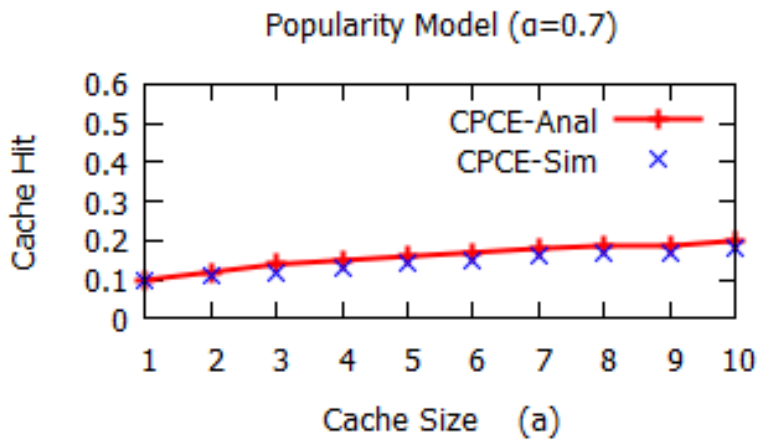
Observation: **CPCE outperforms CEE and Betweenness-Centrality caching in both Cache Hit and Stretch ratio.**

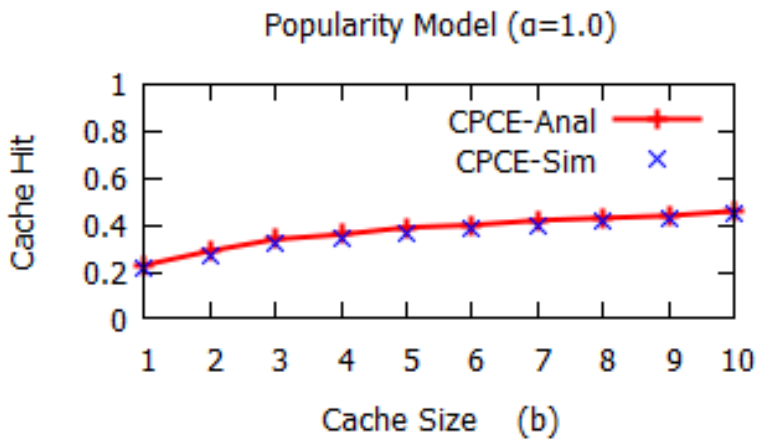
Evaluation Result (DTelekom Topology)

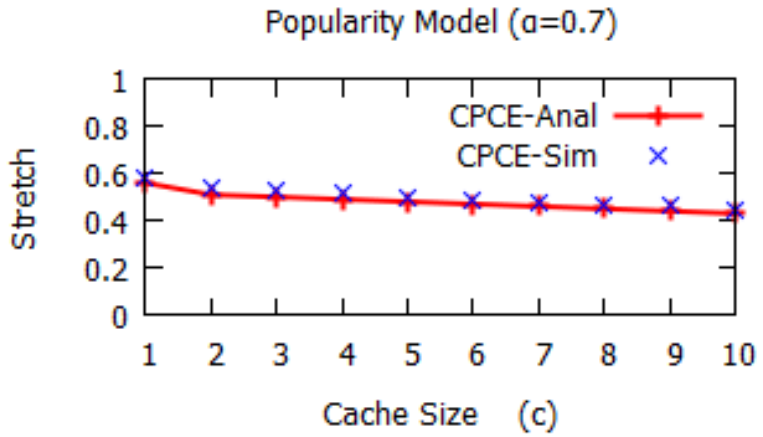


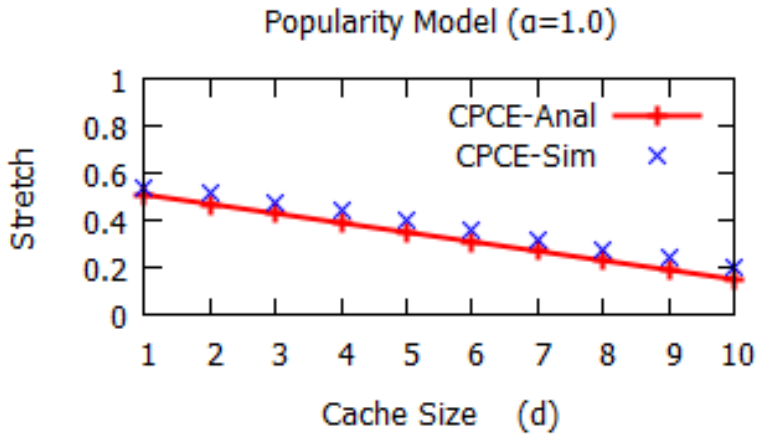
Observation: **CPCE also produces better results than CEE and Betweenness-Centrality caching on the DTelecom topology**

Comparing Analytical vs. Simulation Results









Average difference: ~ 1.7%;
Accuracy: ~ 98%

Contributions

CPCE Cache Management Strategy for ICN

Hypergraph Concept in ICN Caching

- Mathematical formulation for Path acquiring in ICN

Cache Management Model in ICN

- Framework design for Publisher-Subscriber Positions in ICN Caching

Extension of FlexPop to the SocialCCNSim Simulator

Conclusion

- ITU-T Recommendation Y.3033 (SG13): Every network segment in data aware networking (DAN) is recommended to support a caching component
- To support Recommendation Y.3033, we propose a caching strategy for caching popular contents to improve the performance of ICN caching in terms of *cache hit rate* and *stretch ratio*
- We evaluate performance of CPCE and compare with the default ICN strategies CEE, and Betweenness-Centrality
- We show that the proposed CPCE produced better results than the default ICN strategies CEE and Betweenness-Centrality

Future Work

- To evaluate CPCE against other ICN caching strategies
- To evaluate on different wireless networks, (e.g., VANET)
- To test for real-time applications
- To test for future network domains, e.g., 5G network and cloud infrastructure

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Image Source: https://goo.gl/CgGXXD

Thank You

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