Energy Efficient Content Distribution in an ISP network

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COATI

cnrs

Inria informatiques mathématiques

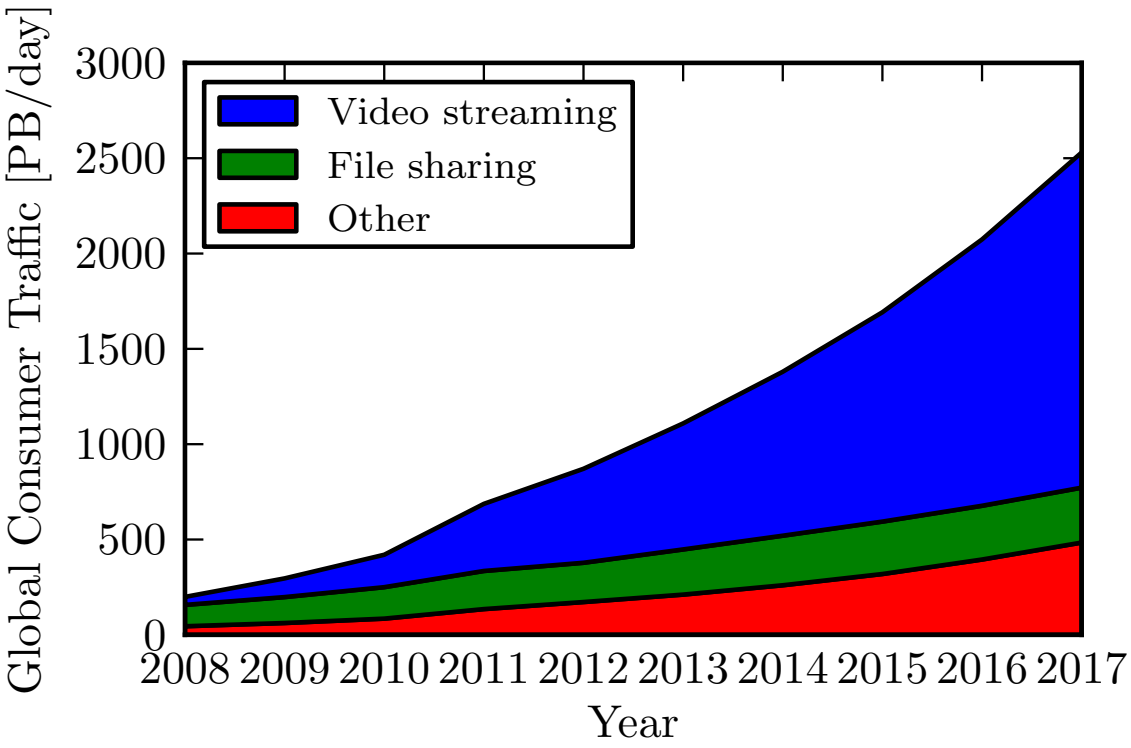
Energy Efficient Content Distribution

- Work presented at Globecom 2013

Giroire, Modrzejewski, Tahiri	Coati, Sophia Antipolis, France
Chiaraviglio	CNIT and University la Sapienza, Rome, Italy.
Le Rouzic	Orange/France Telecom, Lannion, France
Bonetto	Politecnico di Torino, Italy
Musumeci	CNIT and Politecnico di Milano, Italy
Gonzalez, Guerrero	Universidad Carlos III, Madrid, Spain

Context

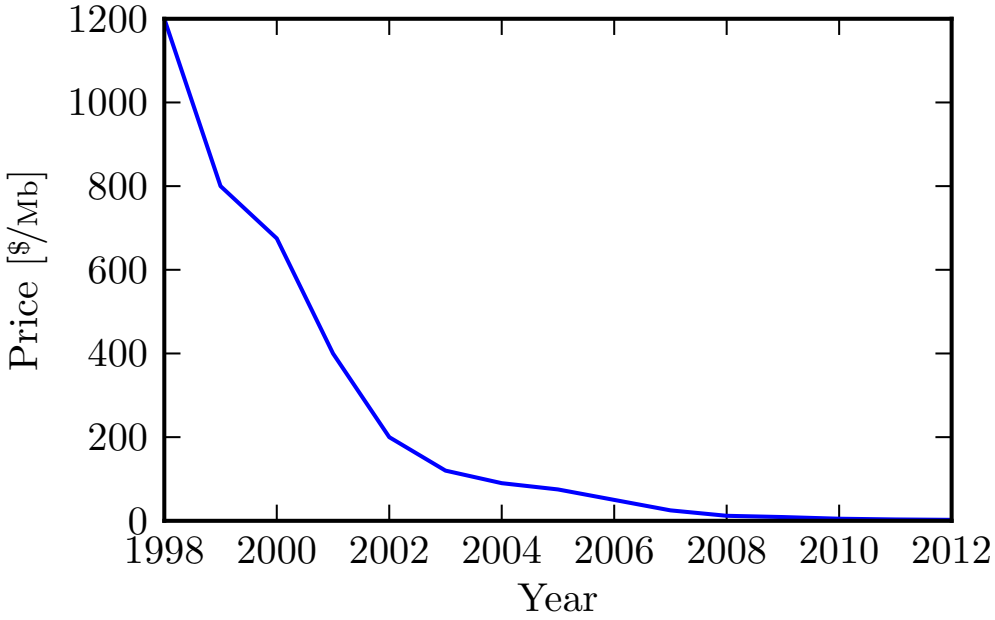
Huge increase in Traffic



Year-to-year peak increases around 40%

Context

Limited financial resources to accomodate growth



Year-to-year price falls around 35%

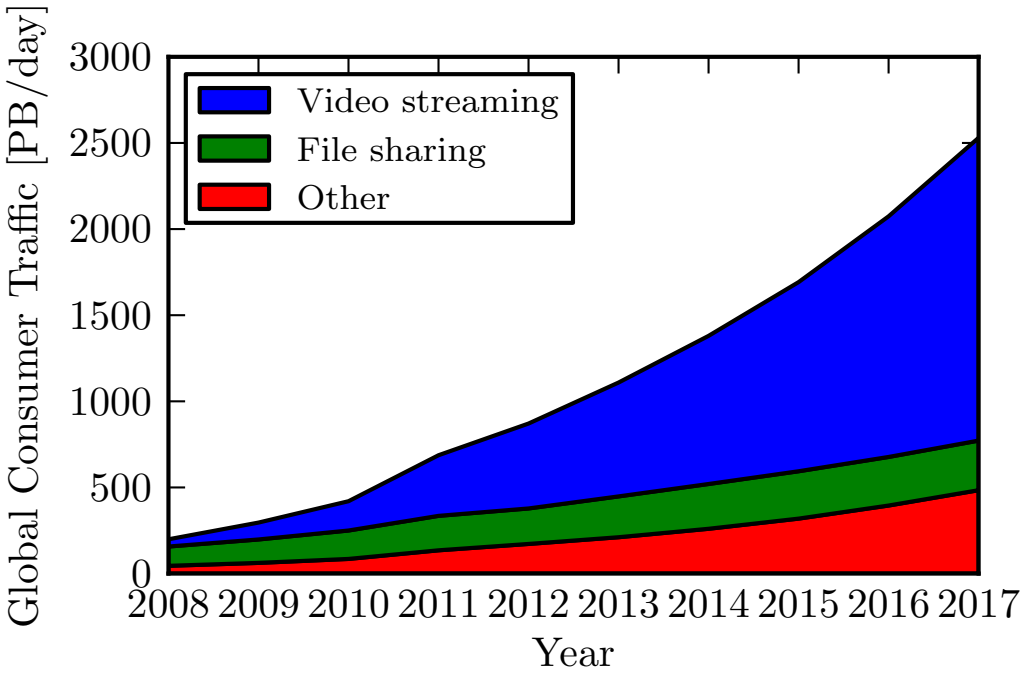
Context

Environmental pressure

2 to 10% of global energy consumption

Context

Crucial trend: Traffic is video.

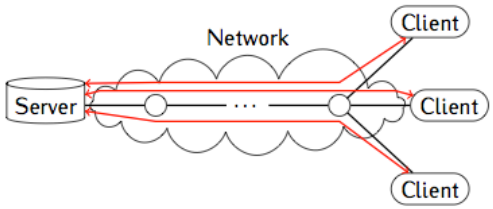


Video streaming already over 50%

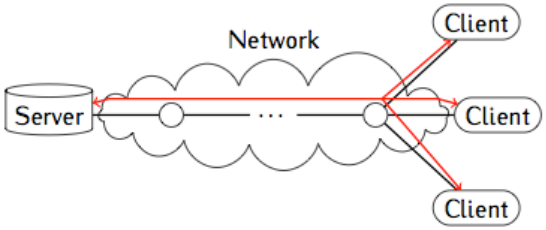
[CISCO Forecast] 86% by 2016

Context

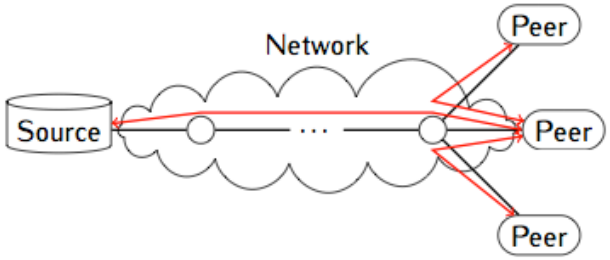
Different models to distribute (redondant) content



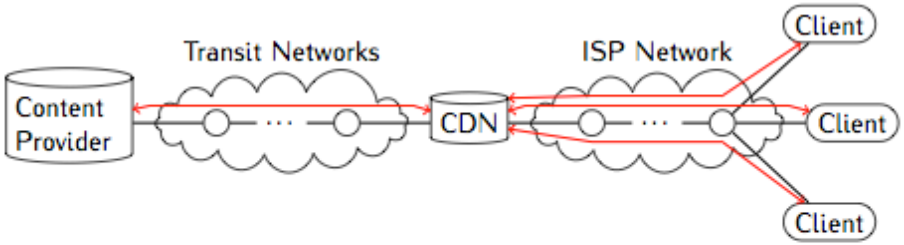
Copies of the same content transmitted in parallel



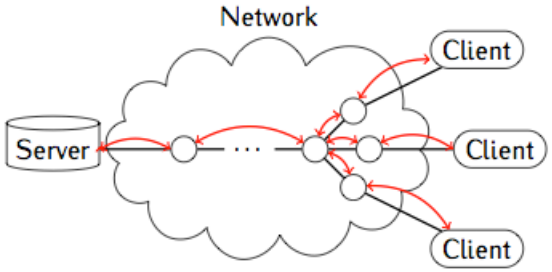
Multicast — good for live TV



Peer to Peer — control and robustness?

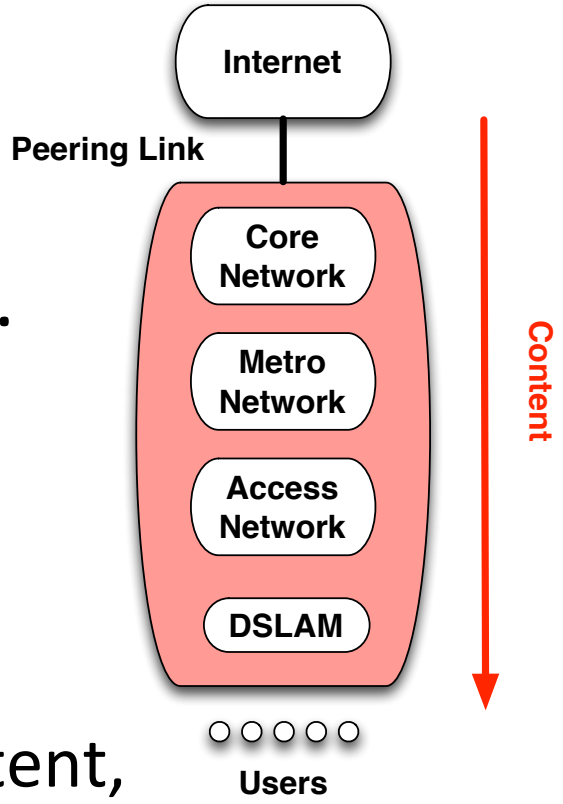


CDN — saves long-haul



Ubiquitous caching — cost effective?

Problem

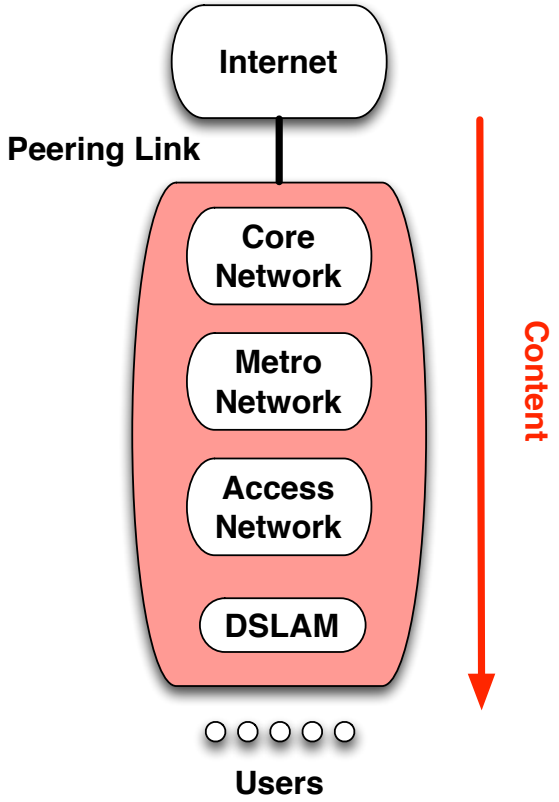


- We consider a **network operator**.
- The network operator distributes
  - Traffic of content providers
  - Its own traffic (money is in the content, less in the transport)
- 70% of traffic comes from the **peering link**

Problem

- **Problem:** How to **distribute this content** in order to be **energy efficient**?

- **Questions:**
  - Where to **place caching facilities**?
  - Where to **place storage facilities** for the operator's own content?



Contributions and Related Work

- Lots of work on distributing content and caching, e.g. :

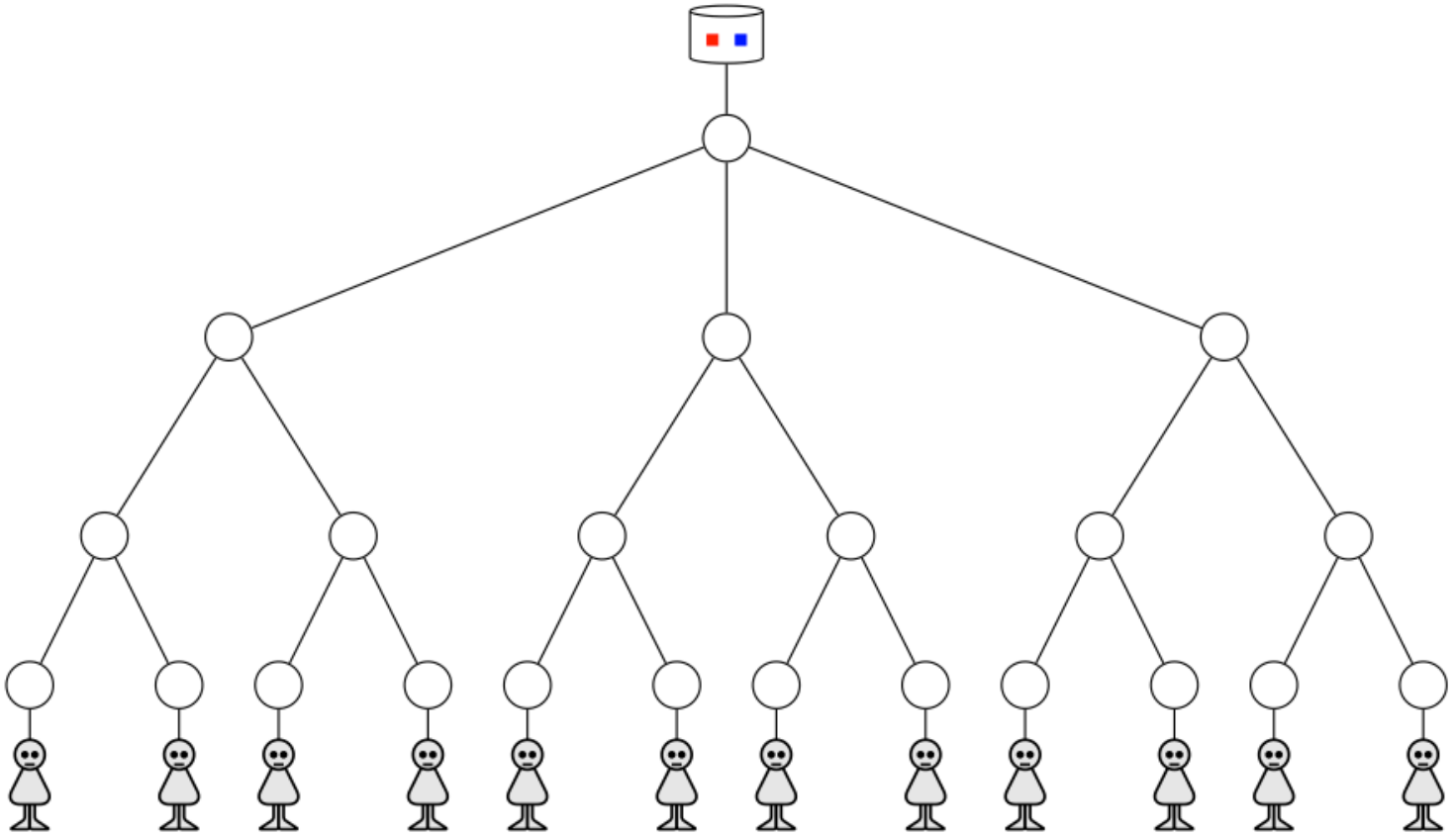
  [1] V. Jacobson, D. K. Smetters, J. D. Thornton, M. F. Plass, N. H. Briggs and R. L. Branard. Networking named content. ACM CoNEXT 2009.

  [2] D. Perino, M. Varvello. A reality check for content centric networking. ACM SIGCOMM 2011.

  [3]I. Baev, R. Rajaraman and C. Swamy. Approximation algorithms for data placement problems. SIAM Journal on Computing, 2008.

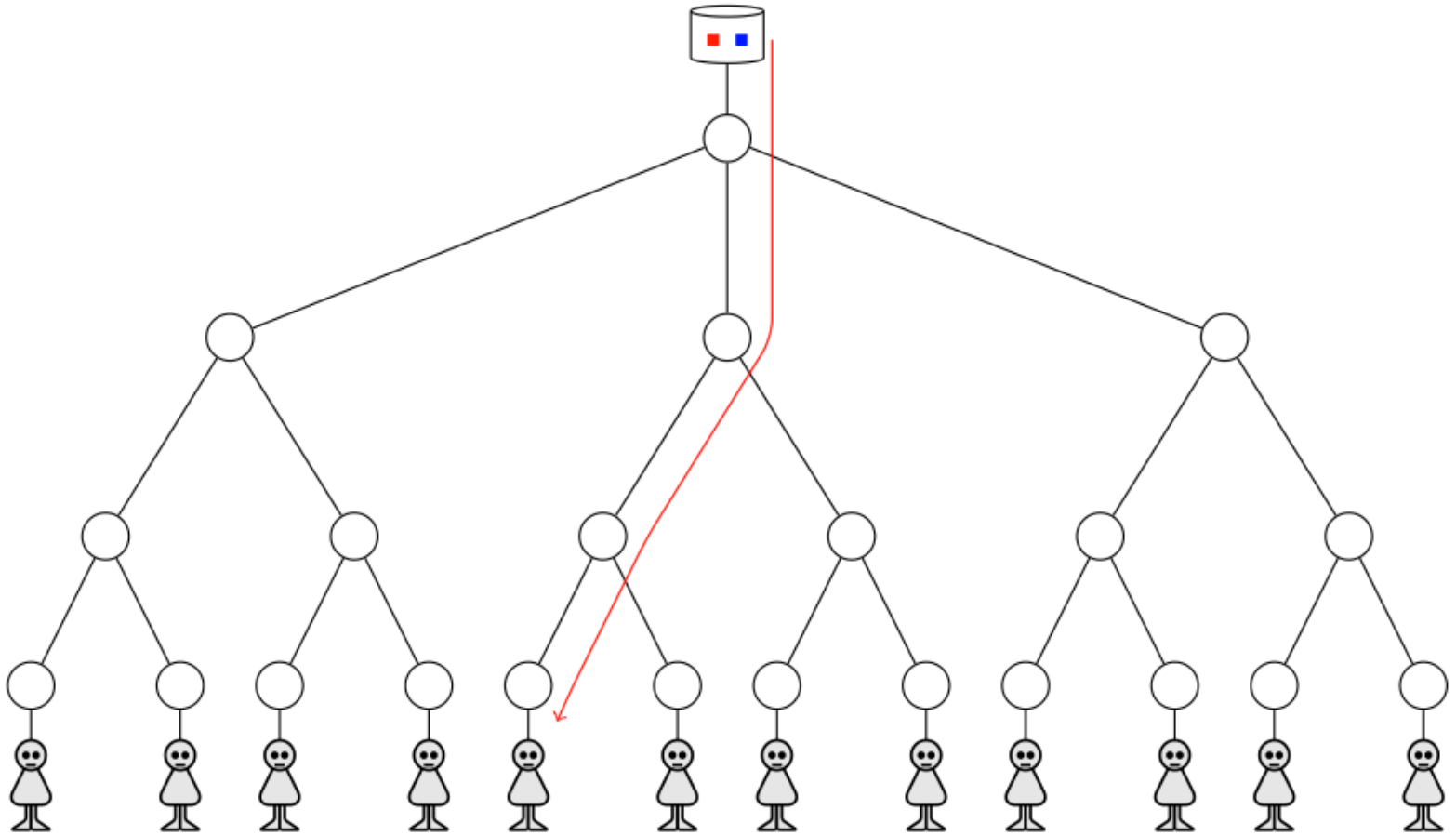
- Here,
  - Different question: How much can we save energy in an optimal content distribution when controling both transport and storage?
  - Realistic scenario, provided by Orange/France Telecom
  - Efficient analytical model for optimal dimensioning

Our Model



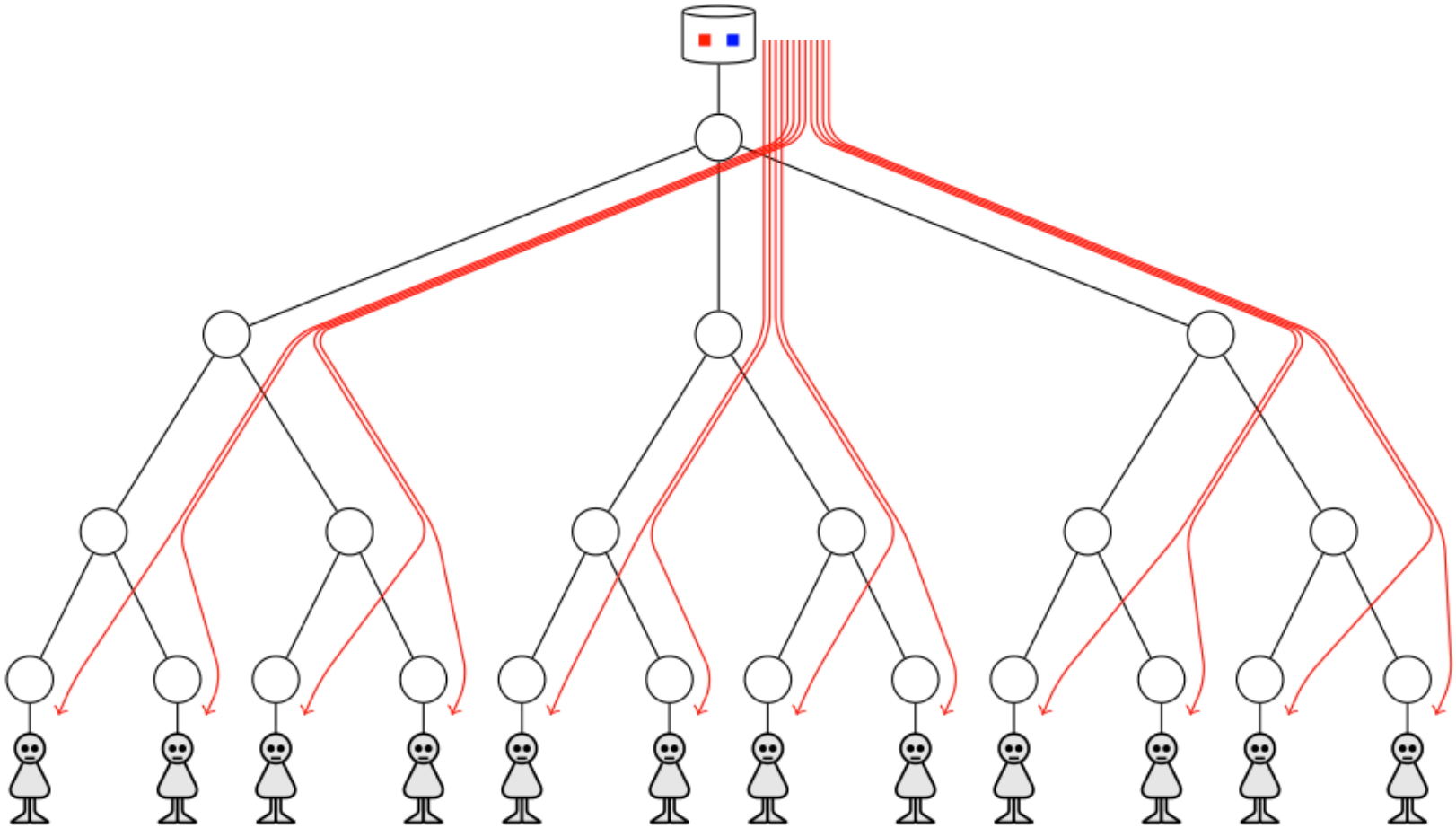
Diffusion of content is done via a logical tree

Our Model



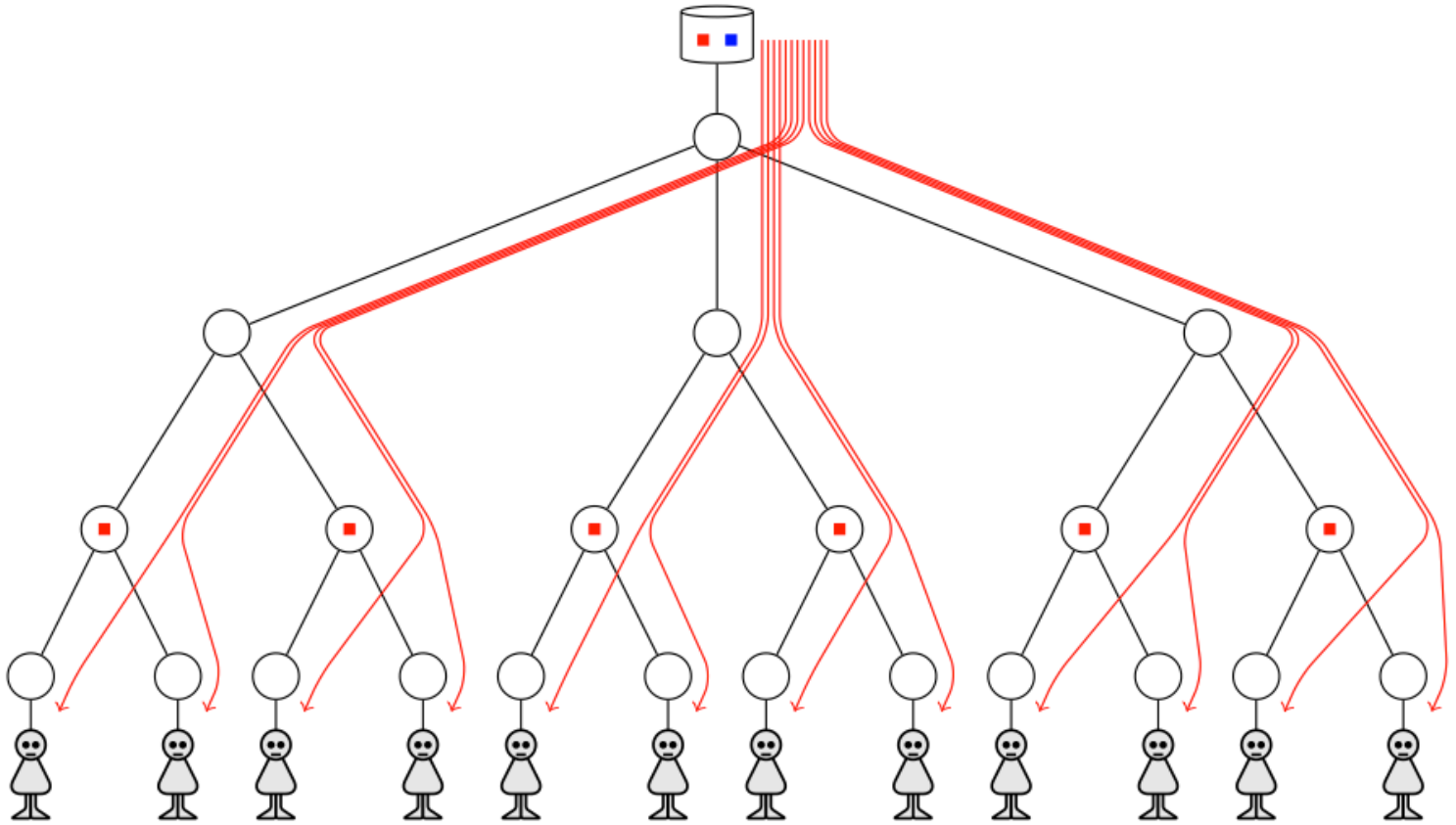
A video is sent to one user

Our Model



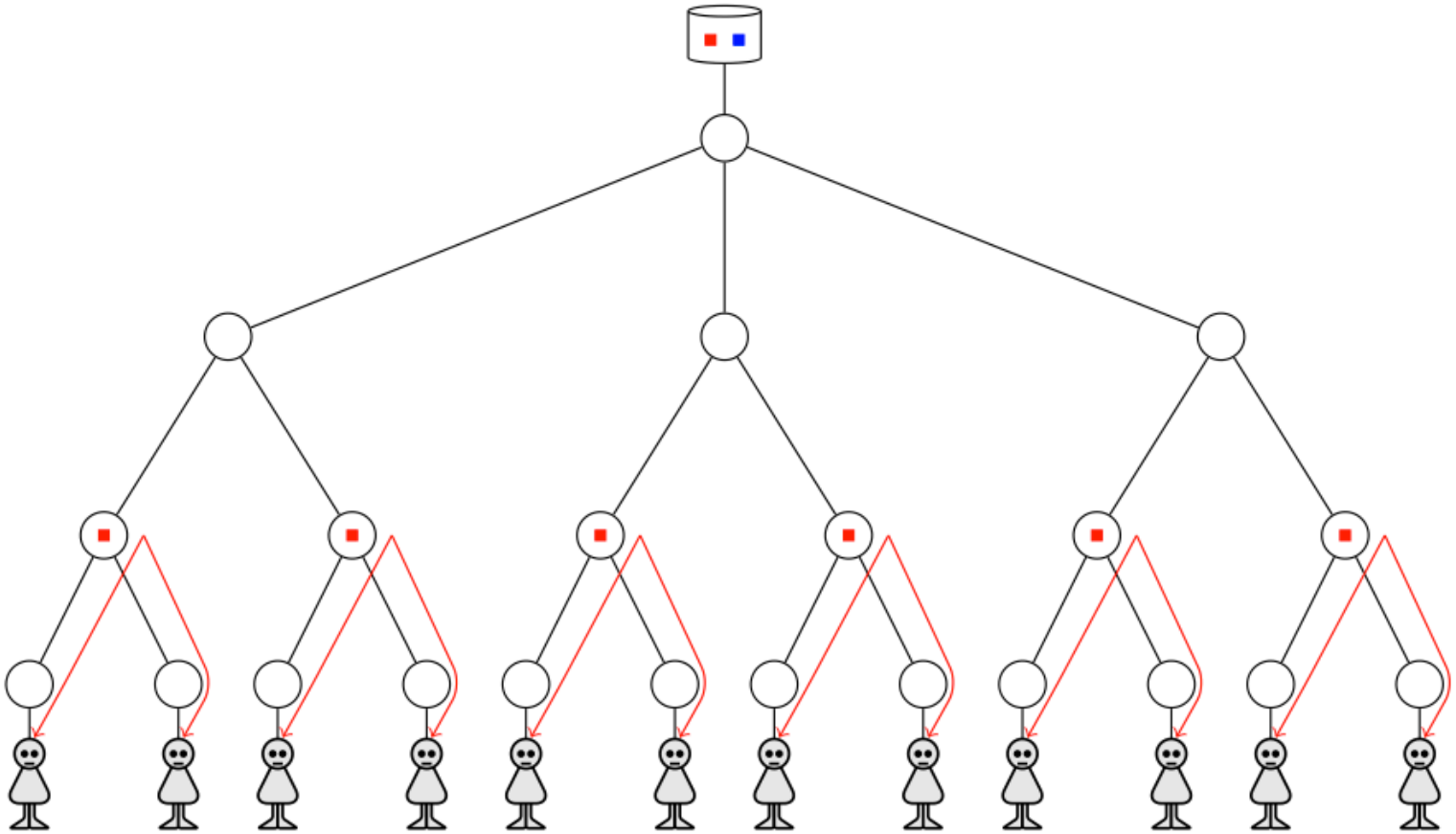
A video is sent to several users: not efficient use of energy

Our Model



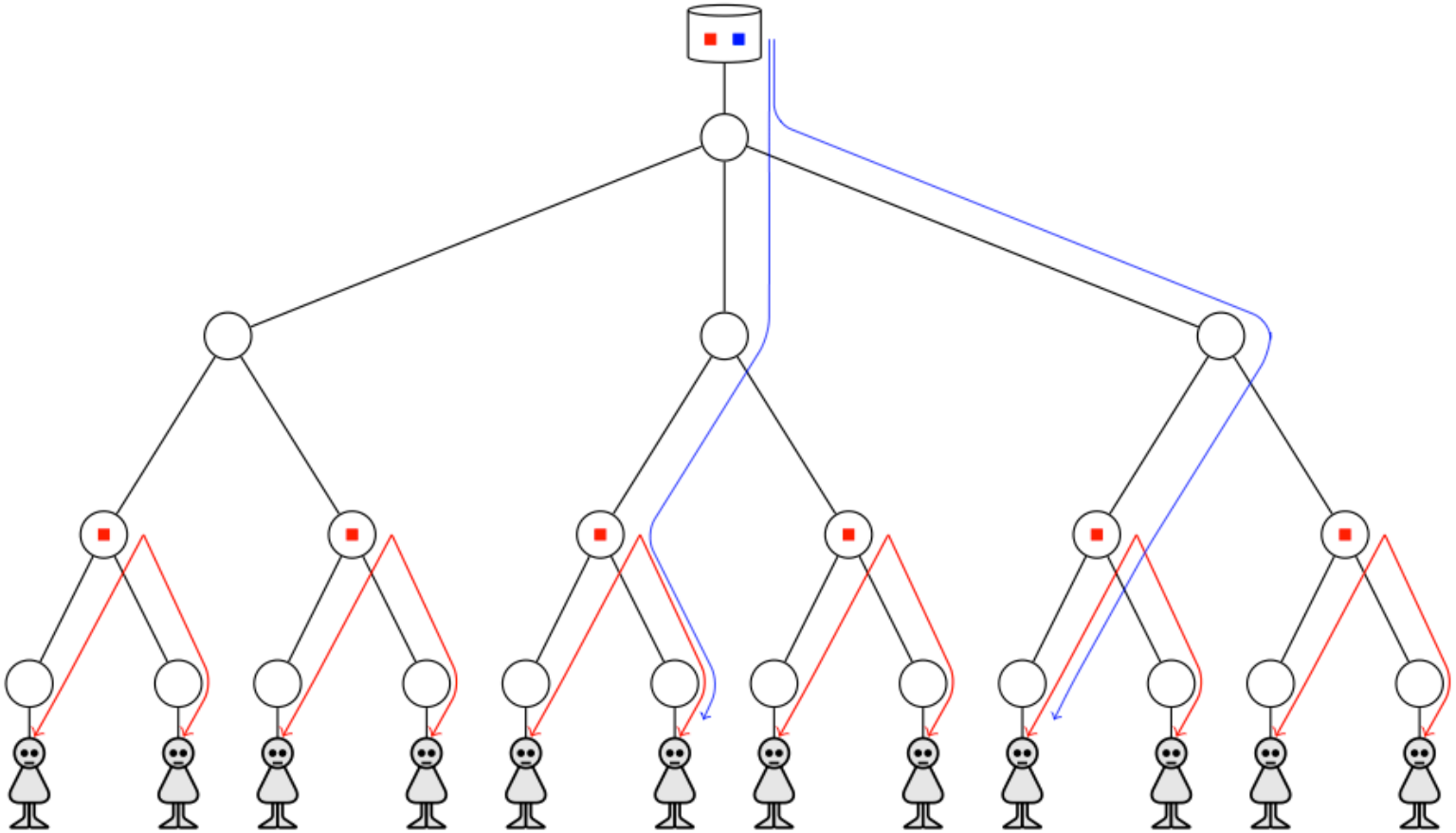
Placement of storage facilities

Our Model



Placement of storage facilities: energy is saved

Our Model



Not worth for non popular videos

Modeling Popularity

A Zipfian ($k^{-\beta}$) power law:

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PSY - GANGNAM STYLE (강남스타일) M/V

by **officialpsy** • 1 year ago • 1,791,659,290 views

PSY - **Gangnam Style** (강남스타일) ▷ NOW available on iTunes: http://Smarturl.it/psygangnam ▷ Official PSY Online Store US ...

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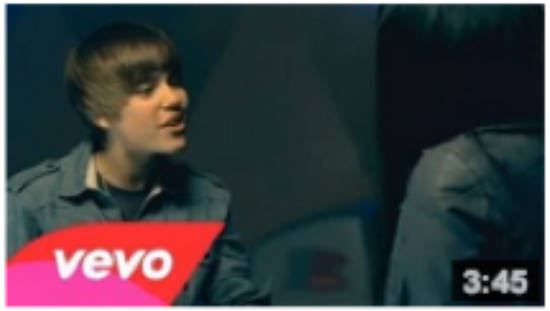

Justin Bieber - Baby ft. Ludacris

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Music video by **Justin Bieber** performing **Baby** feat. Ludacris. #VEVOCertified on April 25, 2010.

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...what would give us $\beta = 0.9$

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β values in the literature in [0.56, 1.5], mostly in [0.6, 0.8].

Power Models

Level 0		
Level 1		12.5 W/Gbps core (CRS3)
Level 2		25 W/Gbps metro-core (Juniper T1600)
Level 3		30 W/Gbps metro (ALu 7750)
Level 4		35–80 W/Gbps edge (ALu 7750 or Cisco 7507)
Level 5		300 W/Gbps DSLAM
Level 6		

Power Models

Level 0 

Level 1 
12.5 W/Gbps core (CRS3)

Level 2 
25 W/Gbps metro-core (Juniper T1600)

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30 W/Gbps metro (ALu 7750)

Level 4 
35–80 W/Gbps edge (ALu 7750 or Cisco 7507)

Level 5 
300 W/Gbps DSLAM

Level 6 

I/O: 24.5 J/Gb, idle: 0.001 W/Gb

Efficient Analytical Model

- We assume:
  - Network represented by a level-regular tree
  - Homogeneous user population
  - Linear power model, known devices for levels
  - Zipfian popularity model

Efficient Analytical Model

- For one class of videos: find the best level to cache it

k-th most popular video stored in level j

$$o(j) = \#devices_j \left(\sum_{i=1}^{j-1} routing_i + I/O + storage \right)$$

$$p(j,k) = \#views_k \left(I/O + \sum_{i=j}^{\#levels} routing_i \right)$$

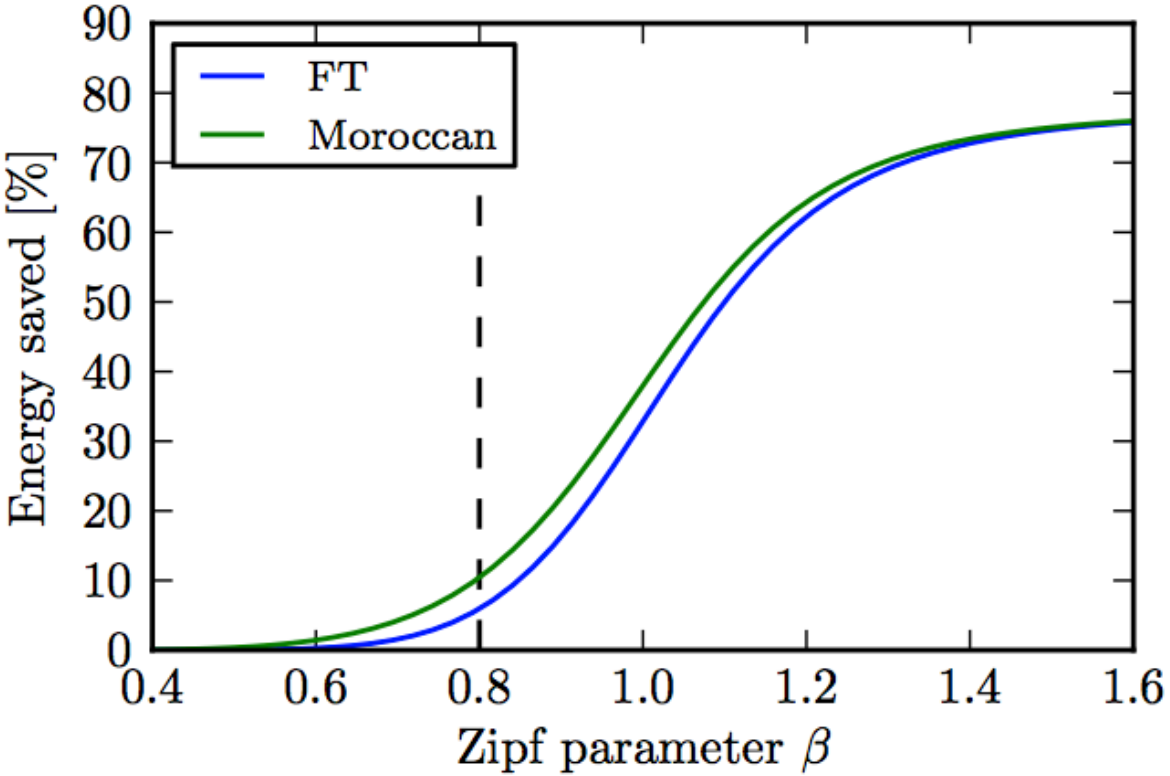
$$\#views_k = \#views_{total} \frac{k^{-\beta}}{\sum_{k=1}^{\#videos} k^{-\beta}}$$

- For efficiency: Compute the interval of popularity of videos cached at each level.

Results

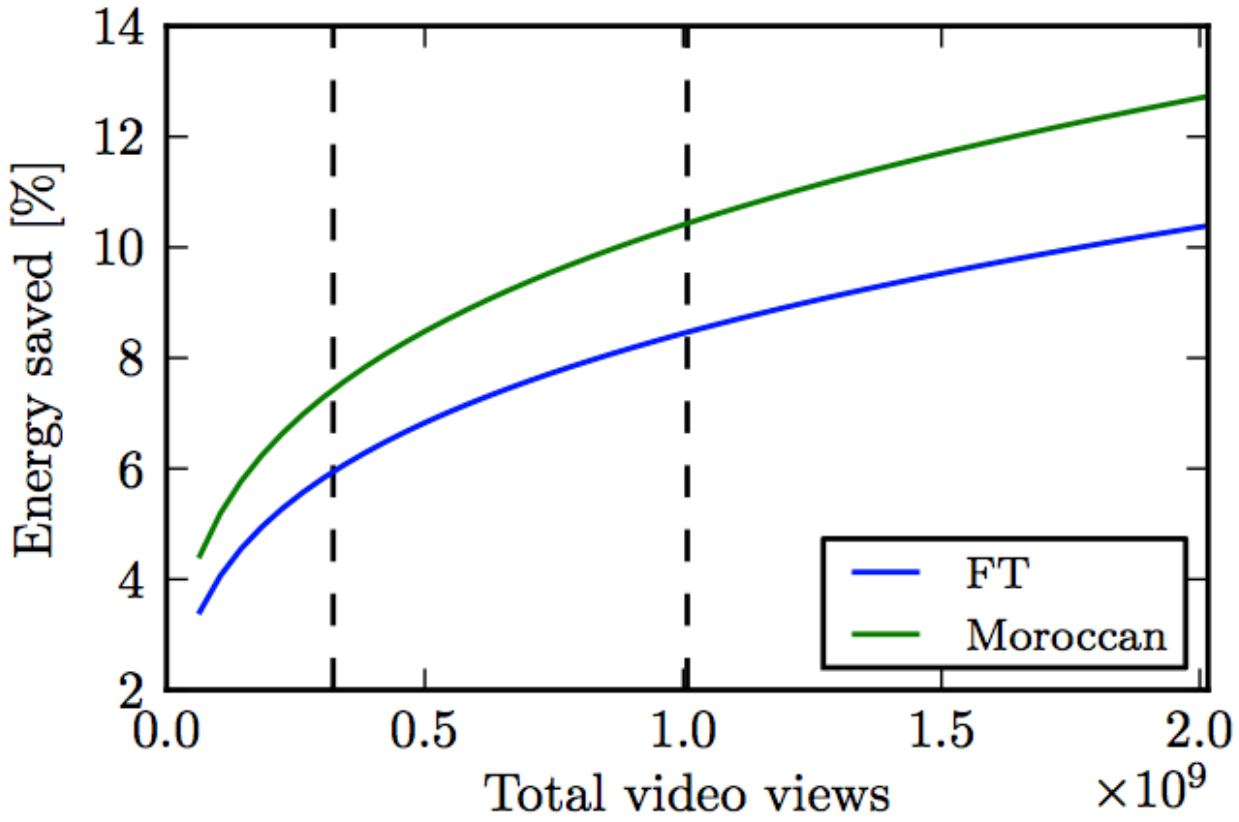
Metric		FT (2020)	Moroccan (2012)
Energy savings		8.7%	11.0%
Yearly monetary savings [k€]		769	122
Bandwidth savings		18.2%	30.2%
Collection Size [PB]		1800	72
Cache Size [GB]	core	0	0
	metro	32546	23510
	access	35878	5581
	DSLAM	2041	46

Results - Sentivity



Small changes in β – huge changes in results

Results - Sentivity



Changes in total throughput, small changes in results

Take-aways

- Around 10% savings
- Importance of model parameters:
  - Knowing popularity distribution is crucial
  - Optimizing cost of storage more important than I/O
- Optimal is feasible:
  - No changes in core networks
  - DSLAM augmented by a small flash module routers by single servers

Future Work

- Study other architectures:
  - with multiple peering points,
  - other tree degree distributions.
  - with Operator's datacenter.
- Here: optimal gain. Test caching on real traffic traces.
- Economic studies: Content providers are reluctant to allow caching of their content (contract, incentive…)

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THANKS !!!