Augmented Reality & Video Service Emerging Technologies

CDN Video Streaming Technology

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CDN Advanced Technologies

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❖ CDN Research & Development

- Content Aspects
  - Content Type based Differentiated Support
    - Data, Multimedia, Mobile Apps, etc.
- Content Aging Control
  - Content Selection & Deletion
  - Content Replication Detection
- Dynamic Page Publishing
- Digital Rights Management
- Live Event Management

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❖ Measuring the CDN Market Value

- System Aspects
  - Surrogate Server Location (Dynamic)
  - Storage Memory Size (Dynamic)
  - Content Delivery Method
  - Mobile Device Characteristics, Location
  - Network Latency
  - Security & Information Assurance
    - Anomaly Detection
    - User Authentication
    - Content Authentication

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❖ CDN Caching Scheme

- Cooperative caching and content routing scheme
  - **Query based scheme**
    - A CDN server broadcasts a query for the requested content to other CDN servers inside the same cluster if it does not have the content
  - **Digest based scheme**
    - Each CDN server maintains a content digest which includes the information of other CDN servers of same cluster

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❖ CDN Caching Scheme

- Cooperative caching and content routing scheme
  - **Directory based scheme**
    - A directory server maintains the content information of the CDN servers of same cluster
  - **Hashing based scheme**
    - The CDN servers maintain the same hashing function
    - The contents are allocated by content's URL, unique IDs of the CDN servers, and the hashing function

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❖ CDN Caching Scheme

- Cooperative caching and content routing scheme
  - **Semi-hashing based scheme**
    - A CDN server allocates a certain portion of its storage to cache the most popular contents and the rest to share with other servers using hashing function

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❖ CDN Popularity Prediction

- **Zipf Distribution**
  - Zipf distribution is a verified by statistical model of content distribution in the real world
  - Popularity of the ith popular content is described as

$$p_i = \frac{\Omega}{i^{\alpha}} \qquad \text{where } \Omega = 1/\sum_{i=1}^{N} 1/i^{\alpha}$$

    - N total number of contents
    - α is the Zipf parameter
    - Determines the skewness of a content popularity

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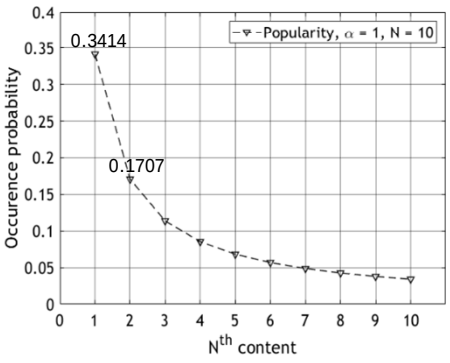
❖ CDN Popularity Prediction

- Zipf Distribution
  - Example: $\alpha = 1$, N=10, $p_i = \Omega / i^{\alpha}$

i	p_i	Value (Popularity)
1	Ω	0.3414
2	$\Omega/2$	0.3414/2 = 0.1707
3	$\Omega/3$	0.3414/3 = 0.1138
...	...	...
9	$\Omega/9$	0.3414/9 = 0.0379
10	$\Omega/10$	0.3414/10 = 0.0341



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❖ CDN Popularity Prediction

- LRU (Least Recently Used) strategy
  - Predict the popularity of contents according to observation to the requests based on time duration
    - Commonly consider at $t-1$, when we are at t
  - Replaces the least-recently-used contents in the CDN cache
    - Recently used contents are more likely to be requested in near future
    - Give higher priority to the contents that have been recently used

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❖ CDN Popularity Prediction

- LRU (Least Recently Used) strategy
  - Example: capacity = 3

Contents request	2	3	1	2	1	4	4	3

	1	2	3	4	5	6	7	8
Cache With capacity=3	2	2	2	3	3	2	2	1
		3	3	1	2	1	1	4
			1	2	1	4	4	3

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❖ CDN Popularity Prediction

- LFU (Least Frequently Used) strategy
  - Predict the popularity of contents according to observation to the requests based on time duration
    - Commonly consider until $t-1$, when we are at t
  - Puts in the CDN cache the contents having the highest request frequency within a specific time duration
    - Keep track of the frequency of content request to evaluate its popularity

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❖ CDN Popularity Prediction

- LFU (Least Frequently Used) strategy
  - Frequently used contents will be more likely to be request soon
  - If multiple contents have the same frequency, choose one of them according to LRU strategy

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❖ CDN Popularity Prediction

- LFU (Least Frequently Used) strategy
  - Example: capacity = 3

Contents request	2	3	1	2	1	4	4	3

	1	2	3	4	5	6	7	8
Cache With capacity=3	2	2	2	2	2	2	2	3
		3	3	3	3	4	4	4
			1	1	1	1	1	1

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❖ Mobile CDN Research & Development

- Mobile wireless networks have additional challenges in supporting CDN services
- Example systems
  - GPS & Navigation Information
  - Mobile TV
  - ITS (Intelligent Transportation System)
  - LBS (Location Based Service)

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❖ Mobile CDN Research & Development

- Efficient content provisioning is required to provide scalable control over wide coverage areas while providing high levels of QoS with limited resources

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❖ Mobile CDN Challenges

- Mobile node constraints (limited storage, processing power, input capability) due to the portable size of mobile devices
- Frequent network disconnections due to mobile users
- Location oriented services regarding user mobility
- Real time monitoring to obtain the real time status of mobile users

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❖ CDN vs. Mobile CDN

Features	CDN	Mobile CDN [Future]
Content Type	Static, Dynamic, Streaming	Static, Dynamic, Streaming
Users Location	Fixed	Mobile, Fixed
Surrogate Location	Fixed	Fixed, [Mobile]
Surrogate Topology	ISP (Internet Service Provider) Local, Center of Service Area	BSs (Base Stations), RAN (Radio Access Network) Systems, [Mobile Devices]
Maintenance Complexity	Low~Medium	Medium~High [Dynamic]
Services	Multimedia & Data Services, etc.	Mobile Apps, LBS, [Mobile] Cloud, etc.

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