Review of:

Content Networks: Taxonomy and New Approaches

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Contribution of the paper…..

- Taxonomy for present and future CNs
  - Important for putting work in perspective
  - Identification of strengths and weaknesses of the various classes
  - Helps make reuse of the existing algorithms for new techniques
- Excellent set of references!
  - Summarizes the existing work (this helps in identifying important conferences and journals too!)

Content Networks Examples 1

- Peer to Peer networks
  - Freenet : A Distributed Anonymous Information Storage and Retrival System, ICSI 2000
  - PAST : A Large Scale persistent P2P Storage Utility, HotOS 2001 (uses Pastry)
  - Gnutella, Napster, Kazaa
  - OcenStore : An Architecture for Global-Scale Persistent Storage, ASPLOS 2000 (uses Tapestry)
  - CAN : A Scalable Content Addressable Network, SIGCOMM 2001
  - Chord: A Scalable p2p Lookup Service for Internet Applications

Content Networks Examples 2

- Cooperative Web Caching
  - Summary Cache: A Scalable Wide Area Web Cache Sharing Protocol, SIGCOMM 1998
  - Squid Web Proxy Cache Project, http://www.squid-cache.org
- Content distribution networks
  - Akamai
  - Cisco : Cisco Content Networking Architecture
  - Digital Island
- Subscribe-Publish Networks
  - Publius : A Robust, Tamper-evident, Censorship-Resistant, Web Publishing System, USENIX 2000
  - Design and Evaluation of a Wide-Area Event Notification Service, 2001
- Content based sensor networks
  - Next Century Challenges: Scalable coordination in Sensor Networks, MOBICOM 99
  - Adaptive protocol for Information Dissemination in Wireless Sensor Networks, MOBICOM 99

Content Networks

- Overlay IP network
- Messages are routed based on the content
- Content may not be bound permanently to a host
- Nodes of the overlay network route as well as store the content
- Overlay network are flexible to customize their topology to meet application needs

Some advantages of CN

- Content can move freely and hence
  - Improved content availablity
  - Minimum access time
  - Source anonymity
  - Secure and robust (Immune to DoS etc. since security based on the content)
  - QoS is content based

Classifying Dimensions of CN

- Content Aggregation
  - Grouping contents to simplify placement and routing
  - Results in highly scalable CN
- Content Placement
  - Physical placement of content on the network nodes
  - Affects the routing protocol and size of the routing table

Content Aggregation

- Step 1: Map the content to some “value” in a “value space” and
- Step 2: Group individual content on the basis of the mapped value
- Semantic vs. Syntactic

Semantic Content Aggregation

- A meaningful “value space” w.r.t. an external system
- E.g. Animal taxonomy is the system of interest and defines a value space
- Map the contents related to dogs and cats to the values “dogs” and “cats”
- Aggregate the values to form a group “mammals”
- Thus, contents in the same aggregate can be characterized, compared, related in terms of shared features
- Supports “proximity search”

Syntactic Content Aggregation

- Value space is not an external system of interest
- E.g. hash value on content and aggregating content based on hash values
- Content in the same group don’t necessarily share any common features
- Supports content anonymity
- No proximity search and consequent optimizations

Content Placement

- Once content is aggregated on the basis of its "value", where to place it in the network?
- Either dependent on the value :
  Content-sensitive placement
- Or independent on the value :
  Content-oblivious placement
- Note that it is orthogonal to the aggregation since the value can be any of the syntactic or semantic

Content sensitive placement

- Location of the content is a function of content or content group
- E.g. arrange the animal taxonomy (value space) as a tree and map it to the predetermined nodes with certain topology
- E.g. place the content within a hash range on predetermined nodes following a certain topology
- A topology can be : hyper cube, ring, d-dimensional plane, or just random
- Routing becomes easy for a deterministic topology

Advantages of content sensitive topology

- Quick routing
- Small routing tables
- Proximity search
- Properly provisioned network paths for content access

Content oblivious placement

- Groups can be placed anywhere irrespective of content
- How to find the content?
  - "learn" the route to the content dynamically
  - "find" the route to the content dynamically
- Centralized server to register content (Napster)
- Decentralized system
  - Everyone advertise content periodically and build a routing table (learning routes)
    - Summary caches use Bloom filters to advertise contents efficiently
  - Or broadcast queries to everyone (finding route)
    - Gnutella (Scaling problems)

Overhead with content oblivious placement

- Periodic advertisement of the content
- Building the network topology dynamically
- Big routing tables for big networks

Four classes

	Syntactic aggregation	Semantic aggregation
Content oblivious placement	•Content anonymity •Robust and fault tolerant A	•Content proximity search •Robust and fault tolerant B
Content sensitive placement	•Content anonymity •Easy routing C	•Content proximity search •Easy routing D

Syntactic content oblivious networks

- E.g. Web proxy servers
  - Contents : URLs
  - Nodes : Proxy servers
- Internet search engines
  - Contents : Web pages
  - Nodes : web servers
  - Locating content through centralized servers (Google, Yahoo etc.)
- Most existing p2p systems
  - Napster, Gnutella, Kazaa, FreeNet
- Subscribe-Publish network
  - SIENA, Publius
- Ad-hoc sensor networks
  - SCADDS, SPIN

Syntactic content sensitive network

- Organize the nodes in a definite topology and map the syntactic content to these nodes
  - PAST (a p2p storage utility) uses Pastry scheme which is based on Hypercube topology
  - OcenStore based on Tapestry too uses Hypercube topology along with Bloom filters
  - CAN uses a d-dimensional coordinate space
  - Chord uses ring topology

Semantic content oblivious networks

- TRIAD
  - Contents are mapped to URL and grouped by the domain name of the URL
  - Internet Name Resolution Protocol (INRP) performs name lookup (finding a route)
  - Name-Based Routing Protocol (NBRP) does routing advertisement

Semantic content sensitive networks

- Data-driven content grouping
  - Define a “content vector space”
  - Assign a “content vector” to each content and map it in the space
  - Cluster these vectors in a group using some algorithm and form a tree
  - Map the resultant topology to network nodes arranged in a similar topology
  - This process is dynamic, addition of content can change the tree
- Static content grouping
  - Cluster tree is predefined
  - E.g. Library catalog system, directory based search engines like of Yahoo and Google to classify web links
  - A self describing request forwards itself through the tree
  - A self classifying node keeps the entire topology with it and forwards the request to appropriate node

A Hybrid Semantic content network

- Hybrid content oblivious/ content sensitive placement
  - Content stub network : A semantic network with content sensitive placement, with content oblivious placement of the “root” on the backbone
  - Access stub network: A user network that connects to the backbone
  - The roots of the content stub networks exchange location information periodically